SIEMENS

SIPROTEC 5
Overcurrent Protection
7SJ82/7SJ85

V7.30 and higher

Manual

C53000-G5040-C017-7

Preface

Open Source Software

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NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

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Preface

Purpose of the Manual

This manual describes the protection, automation, control, and supervision functions of the SIPROTEC 5 device functions for distance protection and line differential protection.

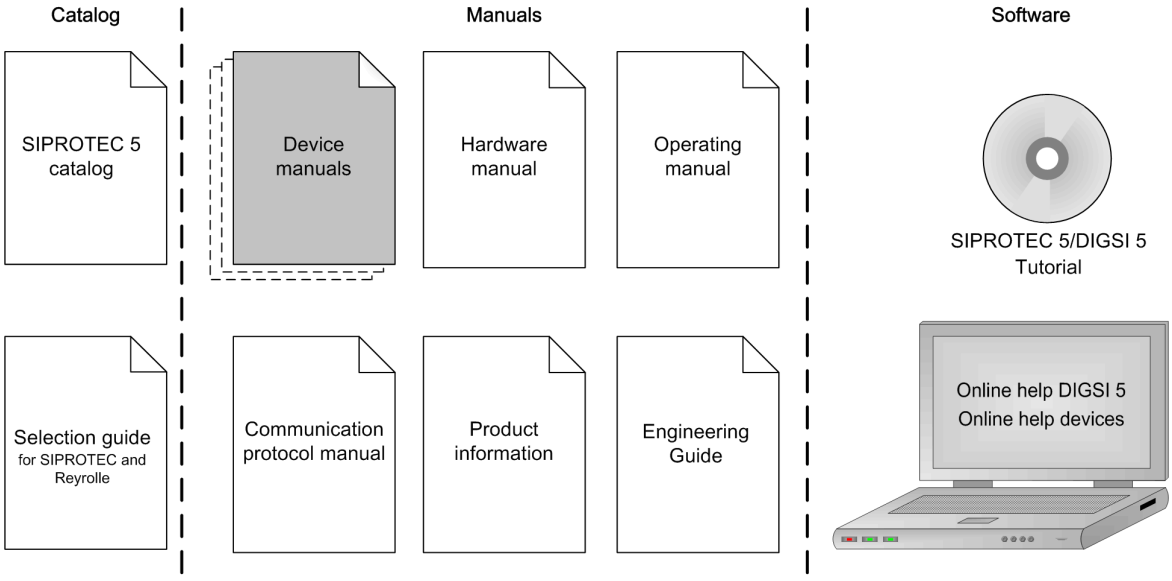
Target Audience

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



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- Device manuals
  Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.
- Hardware manual
  The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.
- Operating manual
  The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

- Communication protocol manual

  The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.

- Product information

  The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.

- Engineering Guide

  The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.

- DIGSI 5 online help

  The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.

  The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.

- SIPROTEC 5/DIGSI 5 Tutorial

  The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.

- SIPROTEC 5 catalog

  The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.

- Selection guide for SIPROTEC and Reyrolle

  The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Indication of Conformity

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive) and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Other Standards

IEEE Std C 37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see *www.ul.com*

Select **Online Certifications Directory** and enter **E194016** as **UL File Number**.

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Additional Support

For questions about the system, please contact your Siemens sales partner.

Support

Our Customer Support Center provides a 24-hour service.

Phone:	+49 (180) 524-7000
Fax:	+49 (180) 524-2471
E-Mail:	*support.energy@siemens.com*

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

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Siemens Power Academy TD

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Phone:	+49 (911) 433-7415
Fax:	+49 (911) 433-7929
E-Mail:	*poweracademy@siemens.com*
Internet:	*www.siemens.com/poweracademy*

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:



DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.



WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.



CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid property damage.



NOTE

Important information about the product, product handling or a certain section of the documentation which must be given particular attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this manual are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result:

- The equipment must be grounded at the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current-transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current-transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.

Open Source Software

The product contains, among other things, Open Source Software developed by third parties. The Open Source Software used in the product and the license agreements concerning this software can be found in the Readme_OSS. These Open Source Software files are protected by copyright. Your compliance with those license conditions will entitle you to use the Open Source Software as foreseen in the relevant license. In the event of conflicts between Siemens license conditions and the Open Source Software license conditions, the Open Source Software conditions shall prevail with respect to the Open Source Software portions of the software. The Open Source Software is licensed royalty-free. Insofar as the applicable Open Source Software License Conditions provide for it you can order the source code of the Open Source Software from your Siemens sales contact - against payment of the shipping and handling charges - for a period of at least 3 years since purchase of the Product. We are liable for the Product including the Open Source Software contained in it pursuant to the license conditions applicable to the Product. Any liability for the Open Source Software beyond the program flow intended for the Product is explicitly excluded. Furthermore any liability for defects resulting from modifications to the Open Source Software by you or third parties is excluded. We do not provide any technical support for the Product if it has been modified.

When using DIGSI 5 in online mode, you are provided with the option to go to the main menu **Show Open source information** and read and display the Readme_OSS file containing the original license text and copyright information.

To do this, the following steps are necessary:

- Switch to online mode.
- Select the device.
- Select **online** in the menu bar.
- Click **Show Open source information**.



NOTE

To read the Readme_OSS file, a PDF viewer must be installed on the computer.

In order to operate SIPROTEC 5 devices, a valid DIGSI 5 license is required.

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1 Introduction

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1.1 General

The digital multifunctional protection and bay controllers of the SIPROTEC 5 device series are equipped with a powerful microprocessor. As a result, all tasks, from acquiring measurands to entering commands in the circuit breaker, are processed digitally.

Analog Inputs

The measuring inputs transform the currents and voltages sent by the instrument transformers and adapt them to the internal processing level of the device. A SIPROTEC 5 device has a current transformer and, depending on the device type, a voltage transformer. The current inputs are therefore intended for the detection of phase currents and ground current. The ground current can be detected sensitively using a core balance current transformer. In addition, phase currents can be detected very sensitively for a particularly precise measurement. The voltage inputs detect the measuring voltage of device functions requiring current and voltage measured values.

The analog values are digitized in the internal microcomputer for data processing.

Microcomputer System

All device functions are processed in the microcomputer system.

This includes, for example:

- Filtering and preparation of the measurands
- Constant monitoring of the measurands
- Monitoring of the pickup conditions for the individual protection functions
- Querying of limiting values and time-outs
- Controlling of signals for the logic functions
- Decision about the trip and close commands
- Storage of indications, fault data, and fault values for fault analysis
- Administration of the operating system and its functions, such as data storage, real-time clock, communication, interfaces, etc.
- External distribution of information

Binary Inputs and Outputs

Using the binary inputs and outputs, the device receives information from the system or from other devices (such as locking commands). The most important outputs include the commands to the switching devices and the indications for remote signaling of important events and states.

Front Elements

For devices with an integrated or offset operation panel, LEDs and an LC display on the front provide information on the device function and report events, states, and measured values. In conjunction with the LC display, the integrated keypad enables on-site operation of the device. All device information such as setting parameters, operating and fault indications or measured values can be displayed, and setting parameters changed. In addition, system equipment can be controlled via the user interface of the device.

Serial Interfaces

The serial interface in the front cover enables communication with a personal computer when using the DIGSI operating program. As a result, the operation of all device functions is possible. Additional interfaces on the back are used to realize various communication protocols.

Power Supply

The individual functional units of the device are powered by an internal power supply. Brief interruptions in the supply voltage, which can occur during short circuits in the system auxiliary voltage supply are generally bridged by capacitor storage (see also the Technical Data).

1.2 Properties of SIPROTEC 5

The SIPROTEC 5 devices at the bay level are compact and can be installed directly in medium and high-voltage switchgear. They are characterized by comprehensive integration of protection and control functions.

General Properties

- Powerful multiprocessor
- Fully digital measured-value processing and control, from sampling and digitizing of measurands to closing and tripping decisions for the circuit breaker
- Complete galvanic and interference-free isolation of the internal processing switches from the system measuring, control, and supply circuits through instrument transformers, binary input and output modules, and DC and AC voltage converters
- Easy operation using an integrated operator and display panel, or using a connected personal computer with user interface
- Continuous display of measured and metered values at the front
- Storage of min/max measured values (slave pointer function) and storage of long-term average values
- Storage of fault indications for system incidents (faults in system) with real-time assignment and instantaneous values for fault recording
- Continuous monitoring of the measurands as well as the device hardware and software
- Communication with central control and storage devices possible via the device interface
- Battery-buffered, synchronizable clock

Modular Concept

The SIPROTEC 5 modular concept ensures the consistency and integrity of all functionalities across the entire device series. Significant features here include:

- Modular system design in hardware, software, and communication
- Functional integration of various applications, such as protection, control, and fault recorder
- The same expansion and communication modules for all devices in the family
- Innovative terminal technology with easy assembly and interchangeability and the highest possible degree of safety
- The same functions can be configured individually across the entire family of devices
- Ability to upgrade with innovations possible at all times through libraries
- Open, scalable architecture for IT integration and new functions
- Multi-layered security mechanisms in all links of the security chain
- Self-monitoring routines for reliable localization and indication of device faults
- Automatic logging of access attempts and safety-critical operations on the devices and systems

Redundant Communication

SIPROTEC 5 devices maintain complete communication redundancy:

- Multiple redundant communication interfaces
- Redundant and independent protocols to control centers possible (such as IEC 60870-5-103 and IEC 61850, either single or redundant)
- Redundant time synchronization (such as IRIG-B, SNTP, or IEEE 1588)

2 Basic Structure of the Function

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2.1 Function Embedding in the Device

General

SIPROTEC 5 devices offer great flexibility in the handling of functions. Functions can be individually loaded into the device. Additionally, it is possible to copy functions within a device or between devices. The necessary integration of functions in the device is illustrated by the following example.



NOTE

The availability of certain settings and setting options depends on the device type and the functions available on the device!

EXAMPLE

A 1 1/2 circuit-breaker layout of the 7SA86 distance protection device serves as an example. The following protection functions are required for implementation (simplified and reduced):

- Distance protection (21)
- Overcurrent protection, phases (51)
- Circuit-breaker failure protection (50BF), for circuit breakers 1 and 2
- Basic functionality (handling of tripping, etc.)

Several predefined function packages that are tailored to specific applications exist for each device family. A predefined functional scope is called an **application template**. The existing application templates are offered for selection automatically when you create a new device in DIGSI 5.

EXAMPLE

When creating the device in DIGSI 5, you must select the appropriate application template. In the example, select the application template **DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout**. This application template covers the required functional scope. Selecting this application template determines the preconfigured functional scope. This can be changed as necessary (see chapter *2.2 Adjustment of Application Templates/Functional Scope*).

Function Groups (FG)

Functions are arranged in function groups. This simplifies handling of functions (adding and copying). The function groups are assigned to primary objects, such as a line, transformer, or circuit breaker.

The function groups bundle functions with regard to the following basic tasks:

- Assignment of functions to current and/or voltage transformers (assignment of functions to the measuring points and thus to the protected object)
- Exchange of information between function groups

When a function is copied into a function group, it automatically works with the measuring points assigned to the function group. Their output signals are also automatically included in the configured interfaces of the function group.

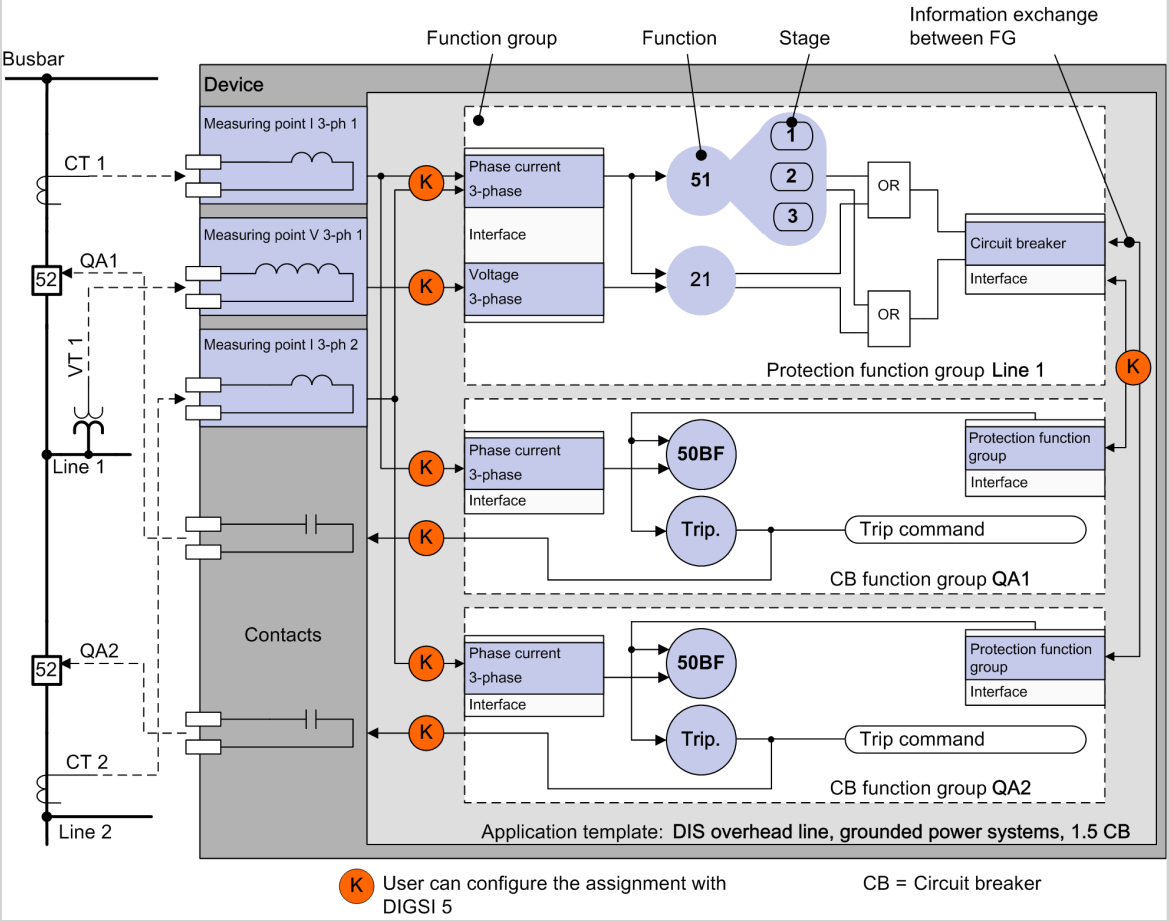
The number and type of function groups differ in the respective application templates, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. You can find detailed information on this in the DIGSI 5 Online help.

EXAMPLE

The selected application template **DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout** comprises 3 function groups:

- Protection function group **Line 1**
- Circuit-breaker function group **QA 1**
- Circuit-breaker function group **QA 2**

The following figure shows the embedding of functions via function groups.



[dweifkfg-021012-01.tif, 1, en_US]

Figure 2-1 Embedding the Functions via Function Groups

Depending on the type of device, there are different types of function groups:

- Protection function groups
- Circuit-breaker function groups

Protection function groups bundle functions that are assigned to one protected object – for example, to the linethe transformer. Depending on the device type and nature of the protected object, there are different types of protection function groups (line, voltage/current 3-phase, transformer, motor, generator, etc.).

Circuit-breaker function groups bundle functions assigned to the local switches – for example, circuit breakers and disconnectors (such as processing of tripping, circuit-breaker failure protection, automatic reclosing).

The number and type of function groups differ in the respective application templates, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. Detailed information on this can be found in the DIGSI 5 Online help.

Interface Between Function Group and Measuring Point

The function groups receive the measurands of the current and voltage transformers from measuring points. For this, the function groups are connected to one or more measuring points.

The number of measuring points and the assignment of function groups to the measuring points are preset by the selected application template in accordance with the specific application. Therefore, this specifies which measuring point(s) and the corresponding measurands have to be used by which function within the function group.

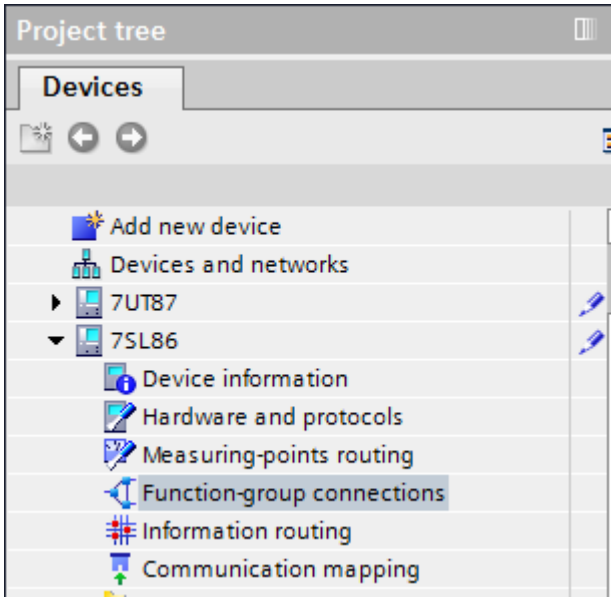
EXAMPLE

The measuring points are assigned to the function groups in the application template in *Figure 2-1* as follows:

- The protection function group **Line** is assigned to the measuring points **I-3ph 1**, **I-3ph 2** and **V-3ph 1**. The function group therefore receives the measured values from current transformers 1 and 2 and from voltage transformer 1. The currents of measuring points **I-3ph 1** and **I-3ph 2** are added geometrically for feeder-related processing.
- The circuit-breaker function group **QA1** is assigned to the measuring point **I-3ph 1** and receives the measured values from current transformer 1.
- The circuit-breaker function group **QA2** is assigned to the measuring point **I-3ph 2** and receives the measured values from current transformer 2.

The user can change the assignment as needed, that is, function groups can be assigned to any available measuring points of the device.

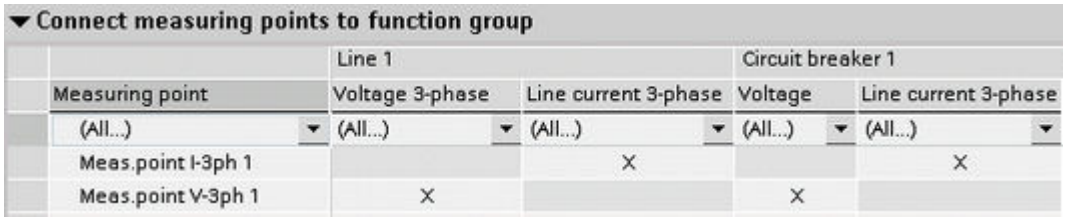
To check or change the assignment of measuring points to the function groups, double-click **Function-group connections** in the DIGSI 5 project tree.



[scfgverb-190214-01, 1, en_US]

Figure 2-2 Project Tree in DIGSI 5 (Detail)

The window for routing of the measuring points opens in the working area (see the following Figure, does not correspond to the example).



[scmscofg-180311-01.tif, 1, en_US]

Figure 2-3 Connecting Measuring Points and Function Groups

Interface Between Protection and Circuit-Breaker Function Groups

The protection function group(s) is/are connected to one or several circuit-breaker function groups. This connection generally determines:

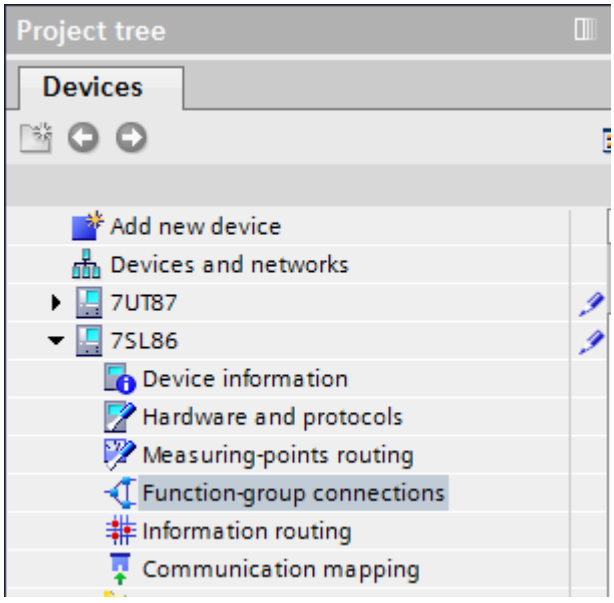
- Which circuit breaker(s) is/are started by the protection functions of the protection FG.
- Starting the **Circuit-breaker failure protection** function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the **Automatic reclosing** function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Further information on this is included later in the section. *Figure 2-6* shows how to reach the detail configuration. *Figure 2-7* shows the possible assignments in detail.

These definitions are also set appropriately for the specific application by the selected application template.

The user can change this linkage as needed, that is, protection function groups can be freely assigned to any Circuit-breaker function groups.

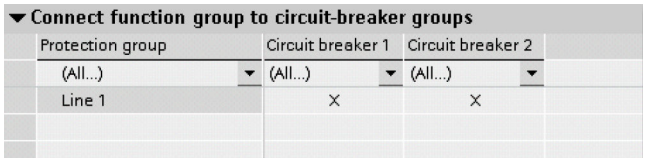
To check or change the allocation of the protection function groups to the circuit-breaker function groups, double-click **Function group connections** in the DIGSI 5 project tree → **Name of device** (see following figure).



[scfgverb-190214-01, 1, en_US]

Figure 2-4 Project Tree in DIGSI 5 (Detail)

The window for general routing of the function groups opens in the working area (see following figure).

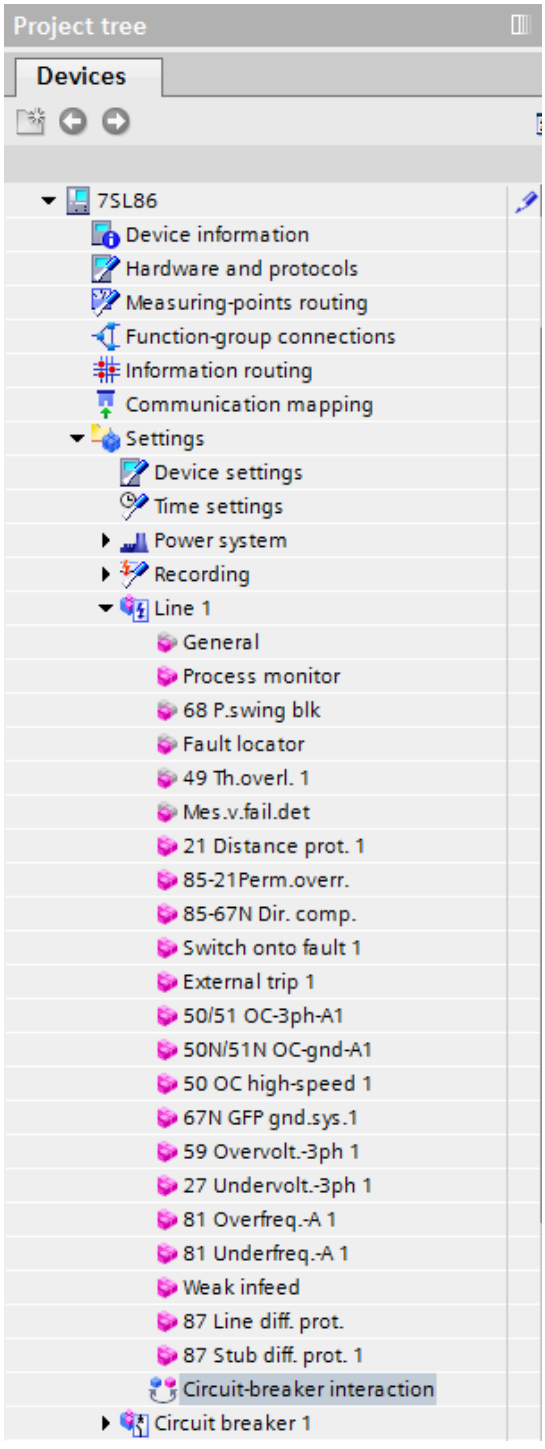


[scfgcols-220211-01.tif, 1, en_US]

Figure 2-5 Connection of Protection Function Group with Circuit-Breaker Function Group

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Proceed as follows:

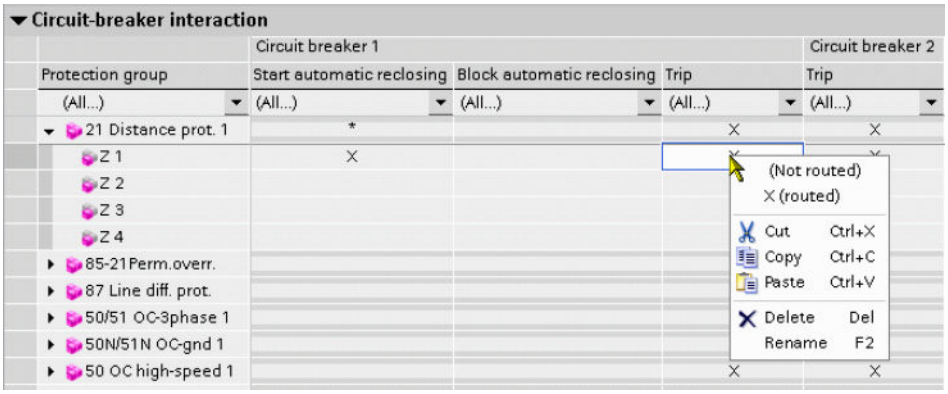
- Open the SIPROTEC 5 device folder in the DIGSI 5 project tree.
- Open the function settings folder in the DIGSI 5 project tree.
- Open the respective protection function group in the DIGSI 5 project tree, for example, **Line 1** (see the following figure)



[sclsinta-190214-01, 1, en_US]

Figure 2-6 Project Tree in DIGSI 5 (Detail)

- Double-click Circuit-breaker interaction (see *Figure 2-6*)
- The window for detailed configuration of the interface between the protection function group and the circuit-breaker function group(s) opens in the working area.
- In this view, configure the interface via the context menu (right mouse button), see *Figure 2-7*.



[scdetail-220211-01.tif, 1, en_US]

Figure 2-7 Detail Configuration of the Interface Between the Protection Function Group and the Circuit-Breaker Function Group(s)

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions block the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

Functions (FN), Tripping Stages/Function Blocks (FB)

As already illustrated in *Figure 2-1*, functions are assigned to the protected objects or other primary objects via function groups.

Functions can be further subdivided. For example, protection functions often consist of multiple protection stages (for example, the Overcurrent-protection function). Other functions can contain one or more function blocks.

Each stage, each function block, and each function (without stages/function blocks) can be individually switched into specific operating modes (for example, switch on/off). This is termed function control and is explained in chapter *2.3 Function Control*.

To adjust the functionality to the specific application, functions, tripping stages, and function blocks can be added, copied, and deleted (see chapter *2.2 Adjustment of Application Templates/Functional Scope*).

2.2 Adjustment of Application Templates/Functional Scope

Application Template

The application template defines the preconfigured functional scope of the device for a specific use case. A certain number of application templates is predefined for each device type. DIGSI 5 automatically offers the application templates for selection when a new device is installed. The available application templates with the respective functional scope are described in more detail in *4 Applications*.

The selection of the application template first predefines which function groups and functions are present in the device (see also *Figure 2-1* in chapter *2.1 Function Embedding in the Device*).

You can adjust the functional scope to your specific application.

Adjusting the Functional Scope

Adjust the functional scope based on the selected application template. You can add, copy or delete functions, tripping stages, function blocks, or complete function groups.

In the DIGSI 5 project tree, this can be done via the following Editors:

- Single-line configuration
- Information routing
- Function settings

Siemens recommends the **Single-line configuration** Editor to adjust the functional scope.

Complete missing functionalities from the Global DIGSI 5 Library. Then, the default settings of the added functionality are active. You can copy within a device and between devices as well. Settings and routings are also copied when you copy functionalities.



NOTE

If you delete a parameterized function group, function, or level from the device, all settings and routings will be lost. The function group, function, or tripping stage can be added again, but then the default settings are active.

In most cases, the adjustment of the functional scope consists of adding and deleting functions, tripping stages, and function blocks. As previously described, the functions, tripping stages, and function blocks automatically connect themselves to the measuring points assigned to the function group.

In few cases, it may be necessary to add a protection or circuit-breaker function group. These newly added function groups do not contain (protection) functions. You must individually load the (protection) functions for your specific application. You must also connect the protection or circuit-breaker function group to one or more measuring points (see chapter *2.1 Function Embedding in the Device*). You must connect newly added protection function groups to a circuit-breaker function group (see chapter *2.1 Function Embedding in the Device*).

Functions, tripping stages, function blocks, and function groups can be added up to a certain maximum number. The maximum number can be found in the respective function and function-group descriptions.

Function Points

Function points (FP) are assigned to specific functions, but not to other functions. Further information can be found in the description of application templates, in the chapter *4 Applications*.

The device is supplied with the acquired function-point credit. Functions with function points can be loaded into the device only within the available function-point credit. The functional scope cannot be loaded into the device if the required number of points of the functional scope is higher than the function-point credit. You must either delete functions or upgrade the function-point credit of the device.

No function points are required to add additional stages in functions.

Extending the Function-Point Credit

You can reorder function points if the function-point credit for the device is not enough.

Proceed as follows:

- Determine the function point requirement of certain functions, for example, with DIGSI 5 or the SIPROTEC 5 Configurator.
- Order the additional function points from your local distributor or at *http://www.energy.siemens.com*.
- Siemens will provide you with a signed license file for your device, either via e-mail or for downloading.
- Use DIGSI 5 to load the signed license file into your device. The procedure is described in the Online Help of DIGSI 5.

2.3 Function Control

Function control is used for:

- Functions that do not contain stages or function blocks
- Stages within functions
- Function blocks within functions

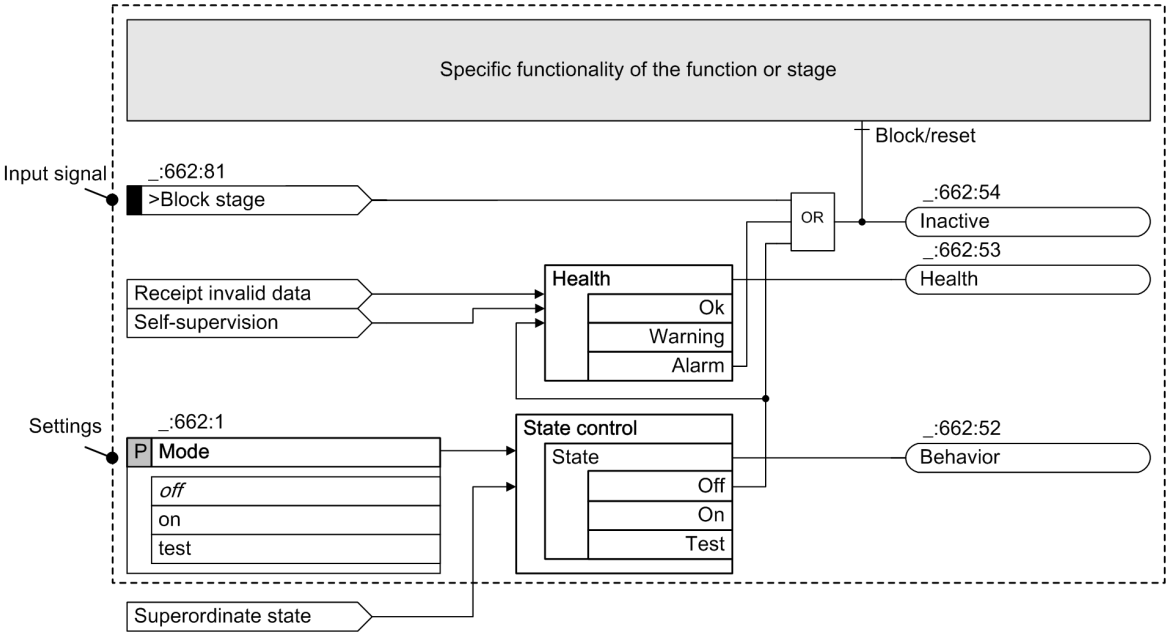
NOTE

Simplifying **Functions** and **Function control** will be discussed in the following. The description also applies to tripping stage control and function block control.

Functions can be switched to different operating modes. You use the parameter **Mode** to define whether you want a function to run (***On***) or not (***Off***). In addition, you can temporarily block a function or switch it into test mode for the purpose of commissioning (parameter **Mode** = ***Test***).

The function shows the current status – such as an *Alarm* – via the *Health* signal.

The following explains the different operating modes and mechanisms and how you set the functions into these modes. The function control is shown in *Figure 2-8*. It is standardized for all functions. Therefore, this control is not discussed further in the individual function descriptions.



[losteurg-040411-01.tif, 1, en_US]

Figure 2-8 General Control of a Function

State Control

You can control the state of a function via the parameter **Mode** and the input **Superordinate state**.

You set the specified operating state of the function via the parameter **Mode**. The function mode can be set to ***On***, ***Off***, and ***Test***. The operating principle is described in *Table 2-2*. You can set the parameter **Mode** via:

- DIGSI 5
- On-site operation at the device
- Certain systems control protocols (IEC 61850, IEC 60870-5-103)

The possibility to adjust the **superordinate state** is limited. For test purposes, the complete device can set into test mode.

The state of the function resulting from the parameter **Mode** and the superordinate state is shown in the following table.

Table 2-1 Resulting State of the Function (from Linkage of Parameter Mode and Superordinate State)

Inputs		**Function State**
Mode Parameter (of the function)	**Superordinate State**	
Off	(any)	Off
(any)	Off	Off
On	On	On
On	Test	Test
Test	On	Test
Test	Test	Test

The following table shows the possible function states:

Table 2-2 Possible Function States

Function State	**Explanation**
On	The function is activated and operating as defined. The prerequisite is that the health of the function is ***OK***.
Off	The function is turned off. It does not create any information. The health of a disabled function always has the value ***OK***.

<table>
<tr><th>Function State</th><th colspan="2">Explanation</th></tr>
<tr><td>Test</td><td colspan="2">The function is set to test mode. This state supports the commissioning. All outgoing information from the function (indications and, if present, measured values) is provided with a test bit. This test bit significantly influences the further processing of the information, depending on the target.
For instance, among other things, it is possible to implement the functionality Blocking of the command relay known from SIPROTEC 4.</td></tr>
<tr><td></td><td>Target of the Information</td><td>Processing</td></tr>
<tr><td></td><td>Log</td><td>The indications are provided with the identification Test in the log.</td></tr>
<tr><td></td><td>Contact</td><td>An indication routed to contact is not triggering the contact.</td></tr>
<tr><td></td><td>Light-emitting diode (LED)</td><td>An indication routed to the LED triggers the LED (normal processing)</td></tr>
<tr><td></td><td>CFC</td><td>Here, the behavior depends on the state of the CFC chart.
• CFC chart itself is not in test state:
The CFC chart is not triggered by a status change of information with a set test bit. The initial state of the information (state before test bit was set) is not processed during execution of the CFC chart.
• CFC chart itself is in test state:
The CFC chart continues to process the information (indication or measured value) normally. The CFC outgoing information is provided with a test bit. The definitions in this table apply to its continued processing.
A CFC chart can be set to the test state only by switching the entire device to test mode.</td></tr>
<tr><td></td><td>Protocol</td><td>Indication and measured value are transmitted with set test bit, provided that the protocol supports this functionality.
If an object is transmitted as a GOOSE message, the test bit is set spontaneously and the GOOSE message is transmitted immediately. The receiver of the GOOSE message is automatically notified of transmitter test mode.
If an object is transmitted via the protection interface, the test bit is not transmitted. The Test state must also be transmitted as information for this state to be taken into account in the application on the receiver end. You must route the Test signal in the DIGSI 5 project tree → Device → Communication routing.
The test mode of the differential protection will be dealt with separately in the application.</td></tr>
</table>

Health

Health signals if a selected function can perform its designated functionality. If so, the health is *OK*. In case the functionality is only possible in a limited way or not at all, due to state or problems within the device, the health will signal *Warning* (limited functionality) or *Alarm* (no functionality).

Internal self-supervision can cause the functions to assume the health *Alarm* (see chapter *9 Supervision Functions*). If a function assumes the health state *Alarm*, it is no longer active (indication *not active* is generated).

Only a few functions can signal the health state *Warning*. The health state *Warning* results from function-specific supervision and - where it occurs - it is explained in the function description. If a function assumes the *Warning* status, it will remain active, that is, the function can continue to work in a conditional manner and trip in the case of a protection function.

Not Active

The indication *Not active* signals that a function is currently not working. The indication *Not active* is active in the following cases:

- Function is switched off
- The function is in the health state *Alarm*
- Function is blocked by an input signal (see *Figure 2-8*)

Blocking of the Operate Indication, No Fault Recording at Pickup

You use the parameter **Blk. Op. Ind. & Fault Rec.** to define whether a function works as a protection or supervision function. Further, you use this to determine the type and scope of the logging (see following table)

Parameter Value	Description
No	The function works as a protection function. It generates an operate indication and starts fault recording with pickup. During fault recording, a fault is created and logged as a fault record in the fault log.
Yes	The function works as a supervision function. The logic runs normally, but without creating the operate indication. The time-out indication is still generated and can be processed further if necessary. No fault recording starts with pickup.

2.4 Text Structure and Reference Number for Settings and Indications

Each parameter and each indication has a unique reference number within every SIPROTEC 5 device. The reference number gives you a clear reference, for example, between an indication entry in the buffer of the device and the corresponding description in the manual. You can find the reference numbers in this document, for example, in the application and setting notes, in the logic diagrams, and in the parameter and information lists.

In order to form explicit texts and reference numbers, each function group, function, function block/stage, and indication or parameter has a text and a number. This means that structured overall texts and numbers are created.

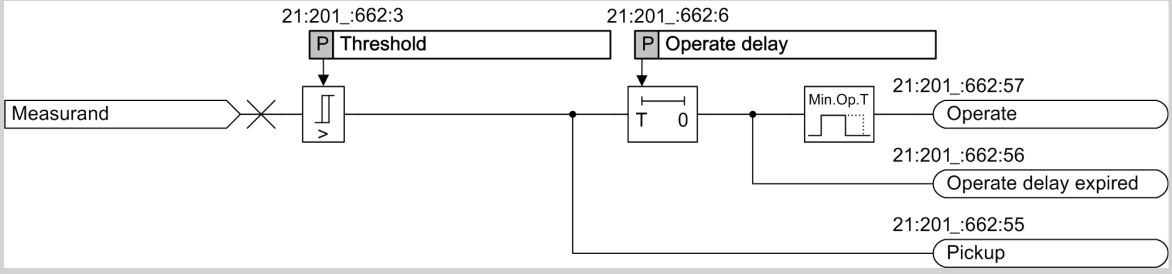
The structure of the texts and the reference numbers follow the hierarchy already shown in *Figure 2-1* :

- Function group:Function:Stage/Function Block:Indication
- Function group:Function:Stage/Function Block:Parameter

The colon serves as a structure element to separate the hierarchy levels. Depending on the functionality, not all hierarchy levels are always available. Function Group and Stage/Function block are optional. Since the function groups, functions as well as tripping stages/function blocks of the same type can be created multiple times, a so-called instance number is added to these elements.

EXAMPLE

The structure of the text and reference number is shown in the protection-function group **Line** as an example of the parameter **`Threshold value`** and the indication **`Pickup`** of the 2nd definite time-overcurrent protection stage of the function **Overcurrent protection, phases** (see *Figure 2-9*). Only one function and one function group exist in the device. The representation of the stage is simplified.



[lostuumz-180311-01.tif, 1, en_US]

Figure 2-9 Stage of the Overcurrent Protection Function, Phases (without Representation of Stage Control)

The following table shows the texts and numbers of the hierarchy elements concerned:

	Name	Number of the Type	Instance Number
Protection function group	Line	2	1
Function	Overcurrent 3ph	20	1
Stage	Definite time-overcurrent protection	66	2
Settings	Threshold value	3	–
Indication	Pickup	55	–

Die Instanznummern ergeben sich wie folgt:

- Function group: Line **1**
  1 instance, because only one **Line** function group exists in the device
- Function: Overcurrent 3ph **1**
  1 instance, because only one **Overcurrent 3ph** function exists in the **Line** function group

- Stage: Definite time-overcurrent protection **2**

  2 instances, because 2 definite time-overcurrent protection stages exist in the **Overcurrent 3ph** function (here the 2nd instance as an example)

This results in the following texts and numbers (including the instance numbers):

Parameter:	**Number**
Line 1:Overcurrent 3-ph 1:Definite time-overcurrent protection 2:Threshold value	21:201:662:3
Indication:	**Number**
Line 1:Overcurrent 3-ph 1:Definite time-overcurrent protection 2:Pickup	21:201:662:55

The structure is simplified accordingly for parameters and indications with fewer hierarchy levels.

2.5 Information Lists

For the function groups, functions, and function blocks, settings and miscellaneous signals are defined that are shown in the settings and information lists.

The information lists summarize the signals. The data type of the information may differ. Possible data types are ENS, ACD, ACT, SPS and MV, etc.

A type is assigned to the individual data types. The following table shows the possible types:

Type	Meaning
I	**I**nput – input signal
O	**O**utput – output signal
C	**C**ontrollable – control signal

EXAMPLE:

The following table shows the types for some data types as examples:

Data Type	Type
ENS	O
ACD	O
ACT	O
SPS	I or O
SPC	C
MV	O

3 System Functions

3.1	Indications	60
3.2	Measured-Value Acquisition	87
3.3	Processing Quality Attributes	89
3.4	Fault Recording	101
3.5	Protection Communication	107
3.6	Date and Time Synchronization	148
3.7	User-Defined Objects	156
3.8	Other Functions	161
3.9	General Notes for Setting the Threshold Value of Protection Functions	170
3.10	Device Settings	178

3.1 Indications

3.1.1 General

During operation, indications deliver information about operational states. These include:

- Measured data
- Power-system data
- Device supervisions
- Device functions
- Function procedures during testing and commissioning of the device

In addition, indications give an overview of important fault events after a failure in the system. All indications are furnished with a time stamp at the time of their occurrence.

Indications are saved in logs inside the device and are available for later analyses. The following number of indications are saved at least in the respective buffer (depending on the scope of the indications):

- Ground-fault log 100 indications
- Fault log 1000 indications
- User-defined log 200 indications
- Operational log 2000 indications

If the maximum capacity of the user-defined log or of the operational is exhausted, the oldest entries disappear before the newest entries. If the maximum capacity of the fault log or of the ground-fault log is reached, the number of the last fault is issued via the signal **Fault log is full**. During a supply-voltage failure, recorded data are securely held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and navigation using keys allow you to read and analyze the logs on site.

Indications can be output spontaneously via the communication interfaces of the device and through external demand via general interrogation. In DIGSI 5 indications can be tracked spontaneously in online operation in a special indication window. Indications can be made accessible to higher-level control systems through mapping on various communication protocols.



NOTE

All indications are assigned to certain device functions. The text of each indication contains the corresponding function designation. You will find explanations of the meaning of indications in the corresponding device functions. However, you can also define indications yourself and group them into your own function blocks. These can be set by binary inputs or CFC logic.

Reading Indications

To read the indications of your SIPROTEC 5 device you can use the on-site operation panel of the device or a PC on which you have installed DIGSI 5. The subsequent section describes the general procedure.

3.1.2 Reading Indications on the On-Site Operation Panel

Procedure

The menus of the logs begin with a header and 2 numbers at the top right corner of the display. The number after the slash signifies the number of indications that are available. The number before the slash indicates how many indications have just been selected or shown. The end of the indication list is closed with the entry ***END***.

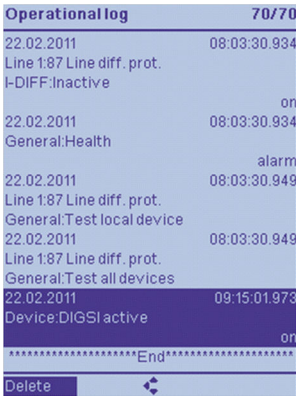


Figure 3-1
On-Site Display of an Indication List (Example: Operational Indications)

Menu Path	Log
Main menu → Indications →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2
Main menu → Test & Diagnosis → Indications →	Security indications Device diagnosis Communication indications

- ✧ To reach the desired log from the main menu, use the navigation keys of the on-site operation panel.
- ✧ Navigate inside the log using the navigation keys (top/bottom). You will find the most current indication at the top of the list. The selected indication is shown with a dark background.
- ✧ Which indications can be shown in the selected log depends on the assignments in the DIGSI 5 information routing matrix or is pre-defined. You will find information about this in chapter *3.1.5.1 General*.
- ✧ Every indication contains date, time and its state as additional information.
- ✧ In some logs you are given the option of deleting the entire indication list by softkey in the footer of the display. To know more about this, read chapter *3.1.6 Saving and Deleting the Logs*.

NOTE

No password entry is necessary to read indications from the device.

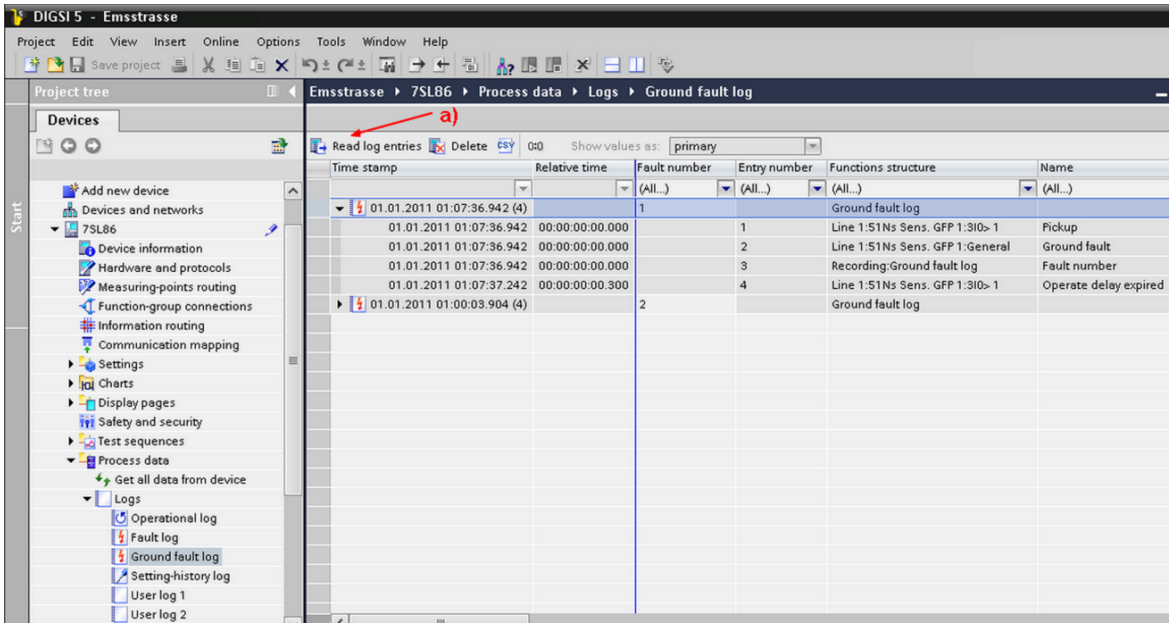
3.1.3 Reading Indications from the PC with DIGSI 5

Procedure

Menu Path (Project)	Log
Project → Device → Process data → Log →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2

Menu Path (Project)	Log
Project → Device → Device information → Log →	Security indication Device diagnosis Communication indications

- ✧ To read the indications with DIGSI 5 your PC must be connected via the **USB user interface** of the on-site operation panel or via an **Ethernet interface** of the device. A direct connection to your PC can be established via the Ethernet interfaces. It is also possible to access all connected SIPROTEC 5 devices via a data network from your DIGSI 5 PC.
- ✧ To reach the desired logs of the SIPROTEC 5 device, use the project-tree window. If you have not set up the device within a project, you can also attain this via **Online access**.
- ✧ After selecting the desired log, you are shown the last state of the log loaded from the device. To update, it is necessary to synchronize with the log in the device.
- ✧ To execute a synchronization with the logs, click the respective button in the headline of the log (see example of ground-fault log in *Figure 3-2* a)).



[scgrflmd-191012-01, 1, en_US]

Figure 3-2 DIGSI 5 Display of an Indication List (Example of Ground-Fault Log)

- ✧ You will find additional information about the deletion and saving of logs in chapter *3.1.6 Saving and Deleting the Logs*.
- ✧ To determine a relative time for all other indications, you can reference the display of log entries, if needed, to the real time of a certain entry. The real-time stamps of events remain unaffected.
- ✧ For this purpose click the respective button in the headline of the log (see example of ground-fault log in *Figure 3-2* a)).

Setting Relative Time Reference

- ✧ Which indications in the selected log can be displayed depends on the assignments in the DIGSI 5 information routing matrix or is predefined. You will find information about this in chapter *3.1.5.1 General*.

3.1.4 Displaying Indications

Displayed indications in DIGSI 5 and on the on-site operation panel are supplemented with the following information:

Table 3-1 Overview of Additional Information

Indications in	DIGSI 5 Information	Device Display Information
Log for operational indications and log for user-defined indications	Time stamp (date and time), Relative time, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Value
log for fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value
Log for ground-fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value
Spontaneous indication window (DIGSI 5)	Time stamp (date and time), Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value

DIGSI 5: Quality Indication Column

Quality	Meaning
Good	Indication is valid
Invalid	Indication is invalid

DIGSI 5: Additional Information Indication Column

The entries in the column for additional information are in the format Cause/Originator/Additional Cause:

- Cause → What was the cause?
- Originator → Who was the originator?
- Additional cause → Supplementary notes

Cause	Meaning
Data change	Value change in an indication
Data update	Update of notification value
General interrogation	General interrogation

Cause	Meaning
Cyclic	Cyclical general inquiry
Quality change	Change of the notification quality

Initiator	Meaning
Bay	Control local
Substation	Control via the substation
Remote control	Control via the network control center
Field (auto)	Control local via automatic function
Station (auto)	Control via the station via automatic function
Distance (auto)	Control via the network control center via automatic function
Maintenance	Maintenance
Process	Device operation (normal)

Additional Cause	Meaning
Switching authority test failed	Switching authority check failed
Selection failed	Selection failed
invalid position	invalid position
Position attained	Position attained
Settings change running	Settings change running
Final position attained	Final position attained
Impermissible mode	Impermissible mode
Blocking through process	Blocking by the process
Interlocked	Interlocked
Synchrocheck failed	Synchrocheck failed
Command already running	Command already running
Not ready	Not ready
1 out of N control failed	1 out of N control failed
Command cancellation	Command cancellation
Monitoring time expired	Monitoring time expired
Cancellation due to trip command	Cancellation due to trip command
Object not selected	Object not selected
No access right.	No access right
Final position exceeded	Final position exceeded
Target value not attained	Target value not attained
Loss of connection	Loss of connection
Unknown	Unknown
Blocking through command	Blocking through command
Object already selected	Object already selected
Inconsistent parameter(s)	Inconsistent parameter(s)
Blocked by foreign access	Blocked by foreign access
Select time-out	Select time-out
CB not open	Circuit breaker not open
Communication is interrupted	Communication is interrupted
Topology not stable	Topology not stable
FLO in process	Fault locator in processing
Trigger command active	Trigger command active
Close command active	Close command active

Additional Cause	Meaning
Blocked through protection	Blocked through protection
Fault occurred	Fault occurred
CB not closed	Circuit breaker not closed
CB not ready	Circuit breaker not ready
CB not open	Circuit breaker not open
Close command active	Close command active
CB check running	Circuit breaker check running

3.1.5 Logs

3.1.5.1 General

Indications are saved in logs inside the device and are available for later analyses. Different logs allow categorization of indication logging based on operating states (for example, operational and fault logs) and based on fields of application.

Table 3-2 Log Overview

Log	Logging
Operational log	Operational indications
Fault log	Fault indications
Ground-fault log	Ground-fault indications
Setting-history log	Setting changes
User-defined log	User-defined indication scope
Security log	Access with safety relevance
Device-diagnosis log	Error of the device (software, hardware) and the connection circuits
Communication log	Status of communication interfaces
Motor-startup log	Information on the motor startup

Managing Logs

Logs have a ring structure and are automatically managed. If the maximum capacity of a log is exhausted, the oldest entries disappear before the newest entries. If the maximum capacity of the fault or ground-fault log is reached, the number of the last fault is generated via the signal **Fault log is full**. You can route this signal in the information routing. If indications in the information routing of DIGSI 5 are routed to a log, then they are also saved. During a supply-voltage failure, recorded data are securely held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and the navigation allow you to read and evaluate the logs on site using keys.

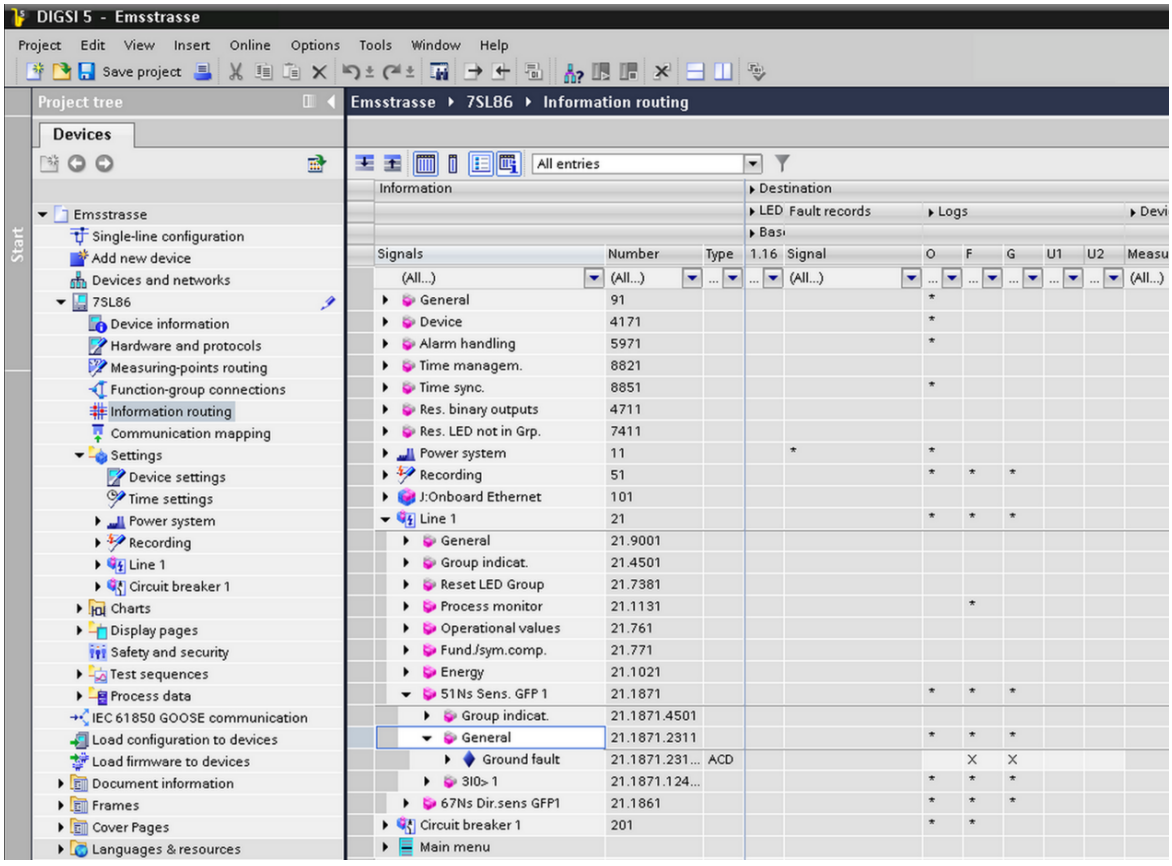
Configurability of Logs

The indication capacity to be recorded in configurable logs (for example, ground-fault log) is laid down in columns of the information routing (matrix) of DIGSI 5 specifically defined for this purpose.

Procedure

- To reach the information routing of your SIPROTEC 5 device, use the project-tree window. Access is only through the project:
  Project → Device → **Information routing**
- Select the associated routing column in the matrix from:
  Target → Log → **Column ground-fault log**

- The routing of the selected indication is done via right click. Select one of the options in the list box shown:
  - Routed (X)
  - Unrouted



[scinfpuf-191012-01, 1, en_US]

Figure 3-3 Indication Configuration in DIGSI 5 (Example: Ground-Fault Log)

For non-configurable logs (for example, setting-history logs) scope and type of logged indications are described separately (see following chapter about logs).

3.1.5.2 Operational Log

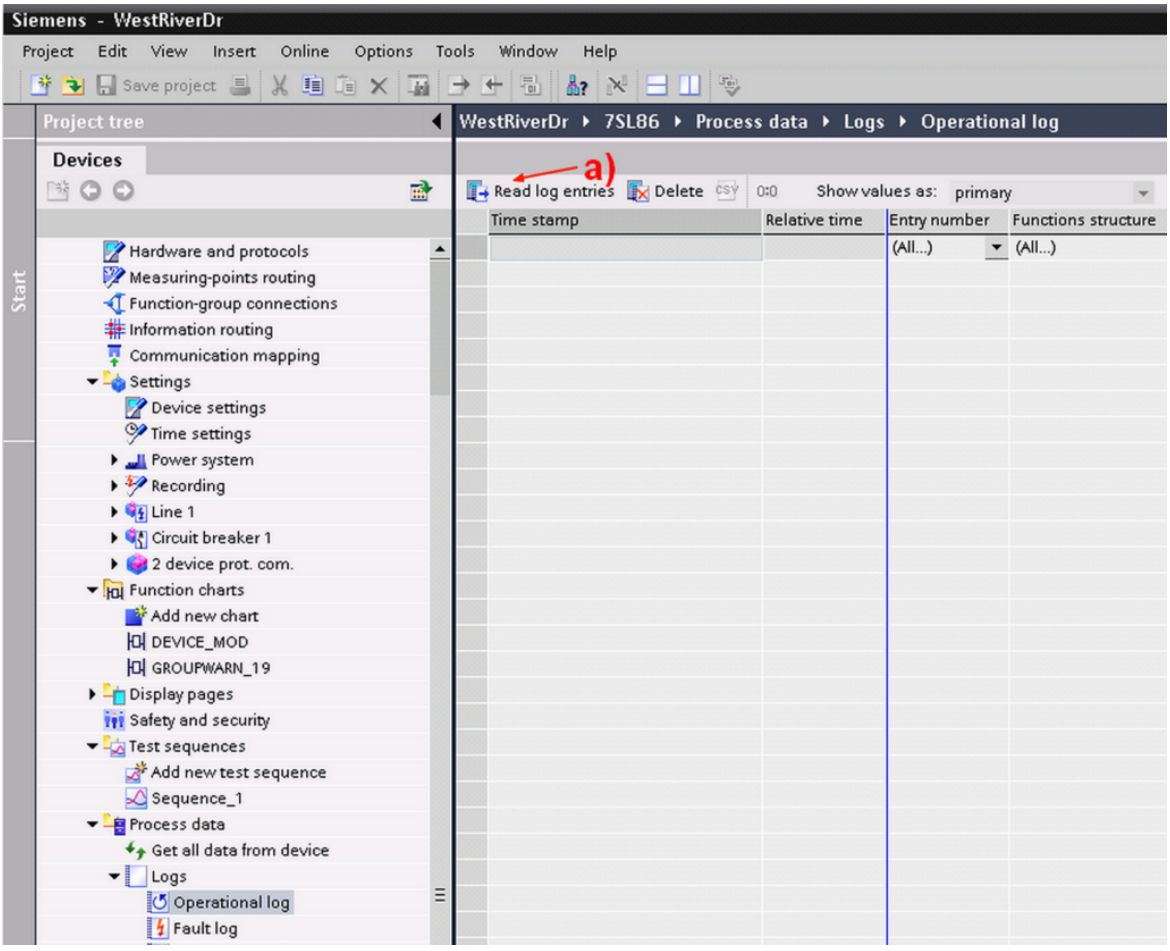
Operational indications are information that the device generates during operation. This includes information about:

- State of device functions
- Measured data
- Power-system data

Exceeding or dropping below limiting values is output as an operational indication. Short circuits in the network are indicated as an operational indication **Fault** with sequential fault number. For detailed information about the recording of system incidents, please refer to the description of the fault log (chapter *3.1.5.3 Fault Log*). Up to 2000 indications can be stored in the log.

Reading from the PC with DIGSI 5

- To reach the operational log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Operational log**
- The status of the operational log last loaded from the device is shown to you. To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list (*Figure 3-4* a)).



[scbetrmd-030211-01, 1, en_US]

Figure 3-4 Reading the Operational Log with DIGSI 5

Reading on the Device Through the On-Site Operation Panel

- To reach the operational log via the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Operational log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

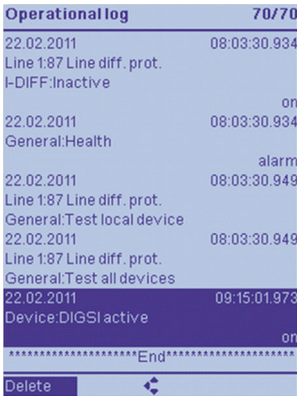


Figure 3-5
On-Site Display of an Indication List (Example: Operational Indications)

Deletability

The operational log of your SIPROTEC 5 device can be deleted. This is done usually after testing or commissioning the device. To know more about this, read chapter *3.1.6 Saving and Deleting the Logs* .

Configurability

The indication scope of the operational log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → **Operational log** column

Selected application templates and functions from the library bring with them a predefined set of operational indications which you can adjust individually at any time.

3.1.5.3 Fault Log

Fault indications are events which arise during a fault. They are logged in the fault log with real-time stamp and relative-time stamp (reference point: fault occurrence) . Faults are numbered consecutively in rising order. With fault recording engaged, a corresponding fault record with the same number exists for every fault logged in the fault log. A maximum of 128 fault logs can be stored. A maximum of 1000 indications can be recorded in each fault log.

Fault Definition

In general, a fault is started by the raising pickup of a protection function and ends with the cleared pickup after the trip command.

When using an automatic reclosing function, the complete reclosing cycle (successful or unsuccessful) is preferably integrated into the fault. If evolving faults appear within reclosing cycles, the entire clearing process is logged under one fault number even in multiple pickup cycles. Without automatic reclosing function every pickup is also recorded as its own fault.

User-defined configuration of a fault is also possible.

NOTE

The definition of the fault is done through settings of the fault recording (see Device manual). Events are logged in the fault log even when fault recording is switched off.

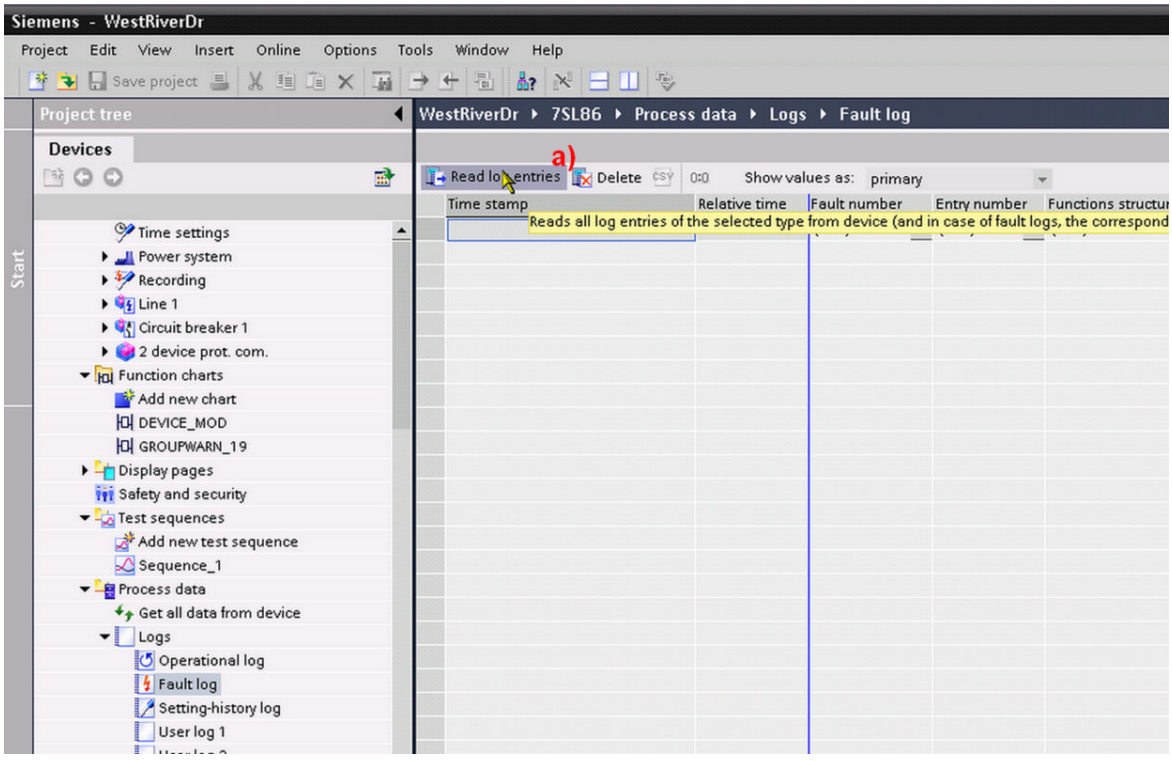
Apart from the recording of fault indications in the fault log, spontaneous display of fault indications of the last fault on the device display is also done. You will find details about this in chapter *3.1.8 Spontaneous Fault Display on the On-Site Operation Panel*.

Reading from the PC with DIGSI 5

- To reach the fault log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Fault logs**

The status of the fault log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list.



[scstflmd-030211-01, 1, en_US]

Figure 3-6 Reading the Fault Log with DIGSI 5

Deletability

The fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter *3.1.6 Saving and Deleting the Logs*.

Reading on the Device through the On-Site Operation Panel

- To reach the fault log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Fault logs**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

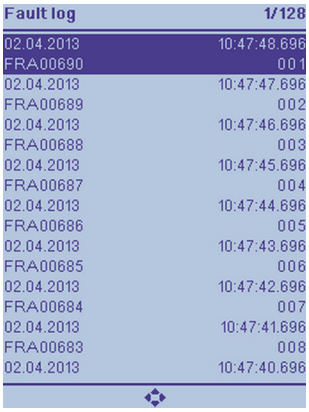


Figure 3-7
Reading the Fault Log on the On-Site Operation Panel of the Device

Configurability

The indication scope of the fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → **Fault log** column

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

The operational measured values and the measured values of the fundamental components and symmetrical components (see Equipment Manual) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

3.1.5.4 Ground-Fault Log

Ground-fault indications are events which arise during a ground fault. They are logged in the ground-fault log with real-time stamp and relative-time stamp (reference point: ground-fault occurrence) . Ground faults are numbered consecutively in rising order. A maximum of 10 ground-fault logs are stored and for each ground-fault log, it is guaranteed that at least 100 indications are recorded.

The following functions can start the logging of a ground fault with the raising ground-fault indication:

- **Directional sensitive ground-fault protection for deleted and isolated systems** (67Ns)
- **Sensitive ground current protection with I0** (50Ns/51Ns)
- **Intermittent ground-fault protection**

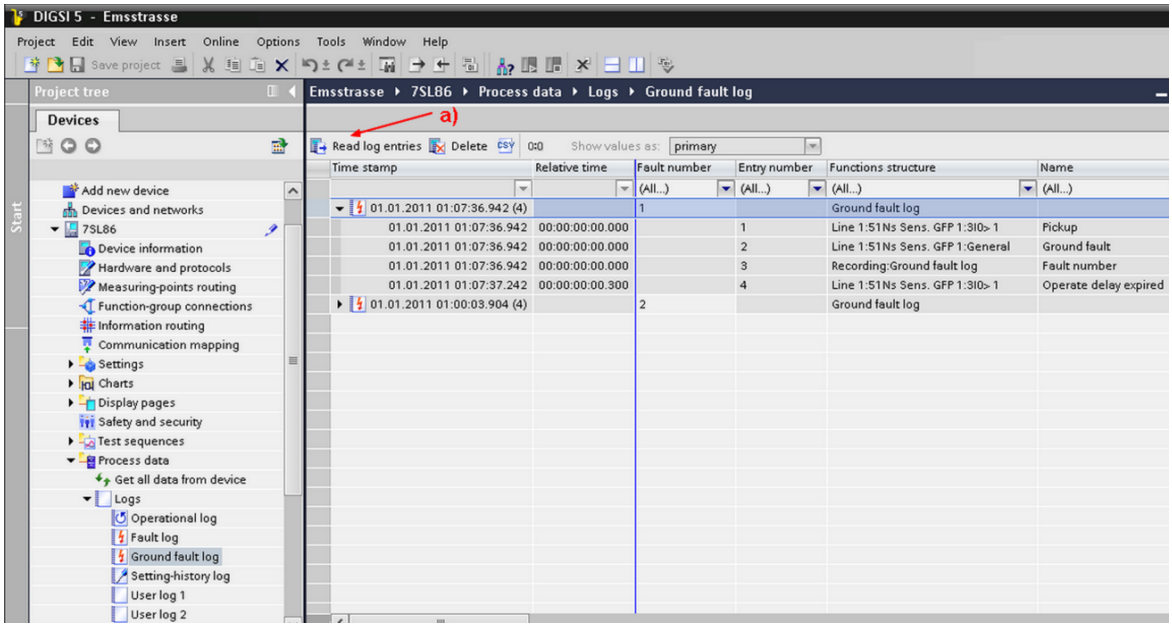
The logging ends with the going ground-fault indication.

Reading from the PC with DIGSI 5

- To reach the ground-fault log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process data → Logs → **Ground-fault log**

The status of the device-diagnosis log last loaded from the ground-fault log is shown to you.

- To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list (*Figure 3-8* a)).



[scgrflmd-191012-01, 1, en_US]

Figure 3-8 Reading the Ground-Fault Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the ground-fault log from the main menu, use the navigation keys of the on-site operation panel.

  Main Menu → Indications → **Ground-fault indication**

- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



Figure 3-9
Reading the Ground-Fault Log on the On-Site Operation Panel of the Device

Deletability

The ground-fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The indication scope of the ground-fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → Column **Ground-fault log**

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

3.1.5.5 User Log

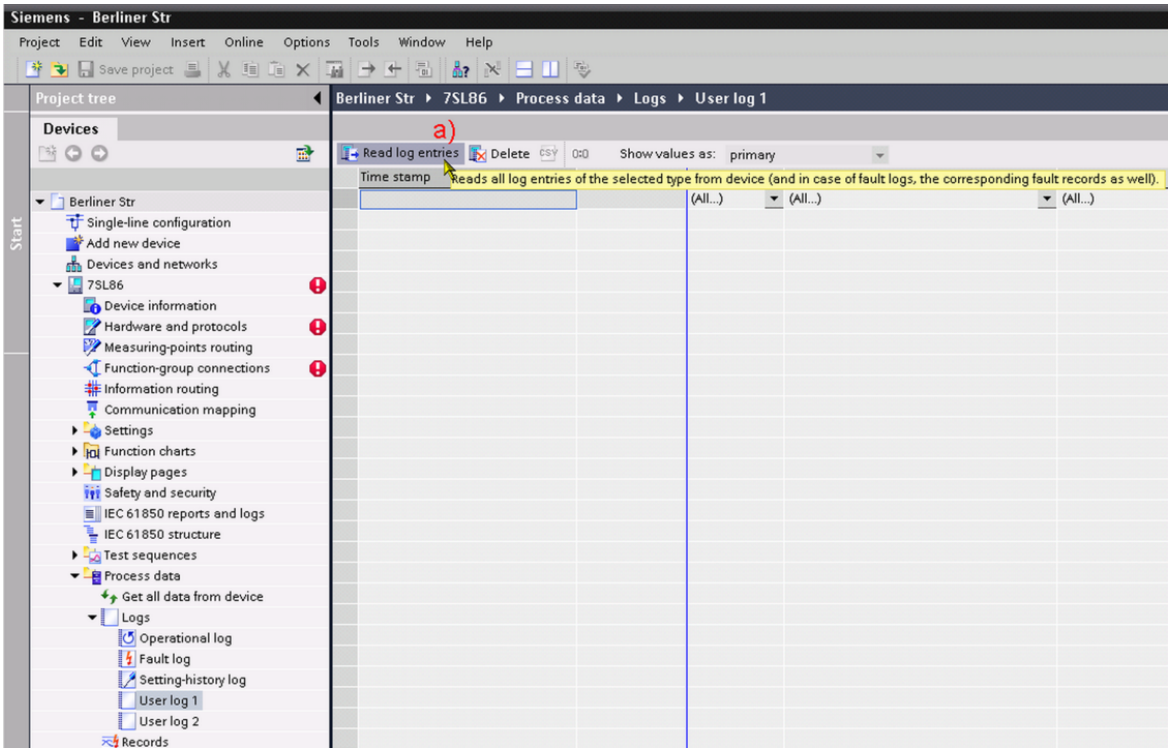
With the user-defined log (up to 2), you have the possibility of individual indication logging parallel to the operational log. This is helpful, for example, in special monitoring tasks but also in the classification into different areas of responsibility of the logs. Up to 200 indications can be stored in the user-defined log.

Reading from the PC with DIGSI 5

- To reach the user-defined log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **User log 1/2**

The status of the user-defined log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list (*Figure 3-10* a)).



[scanwnmd-030211-01, 1, en_US]

Figure 3-10 Reading the User-Defined Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach user-specific logs from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **User-defined log 1/2**

You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

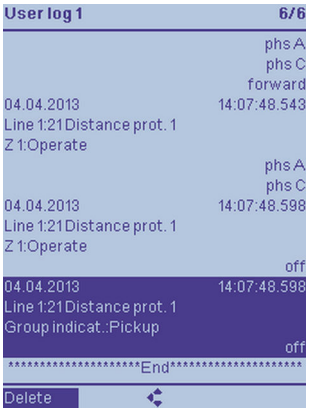


Figure 3-11
Reading the User-Defined Log on the On-Site Operation Panel of the Device

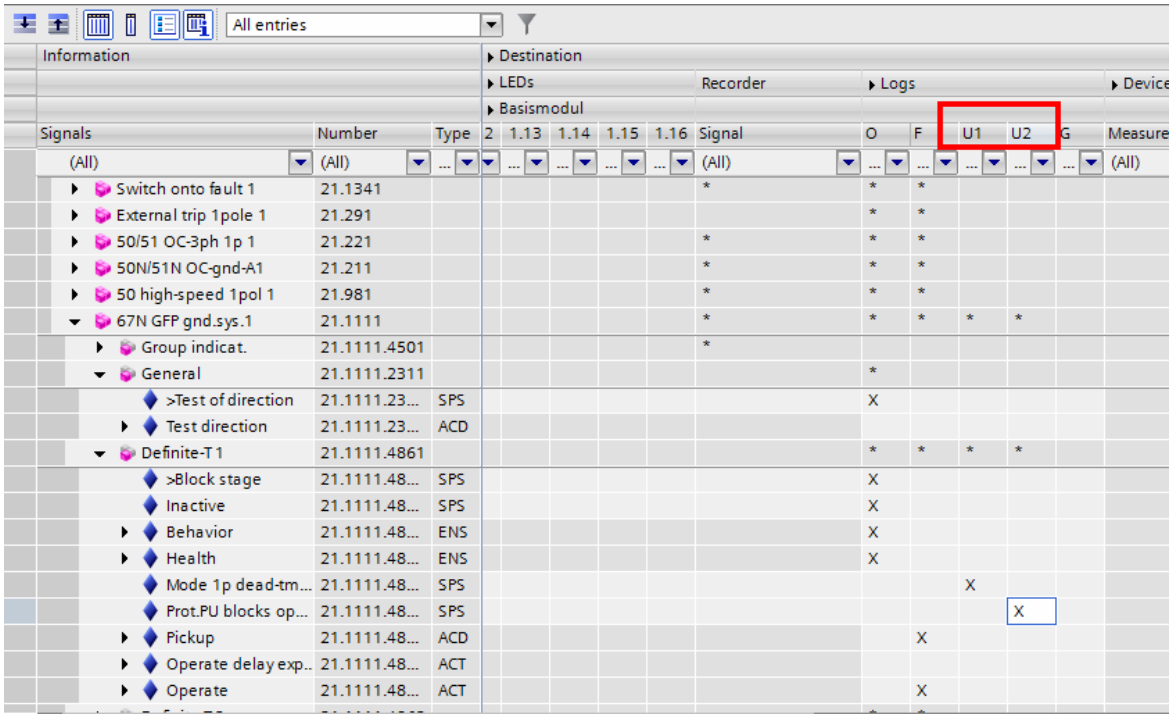
Deletability

The user-defined log of your SIPROTEC 5 device can be deleted. Read about it in chapter *3.1.6 Saving and Deleting the Logs*.

Configuration of a User-Defined Log

The indication capacity of a created user-defined log can be configured freely in the associated column of the information routing (matrix) of DIGSI 5:

Target → Log → U1 or U2



[scdiu1u2-280415-01, 1, en_US]

Figure 3-12 Indication Configuration in DIGSI 5 (Example: User-Defined Log U1/2)

3.1.5.6 Setting-History Log

All individual setting changes and the downloaded files of entire parameter sets are recorded in the log for setting changes. This enables you to determine setting changes made are associated with events logged (for

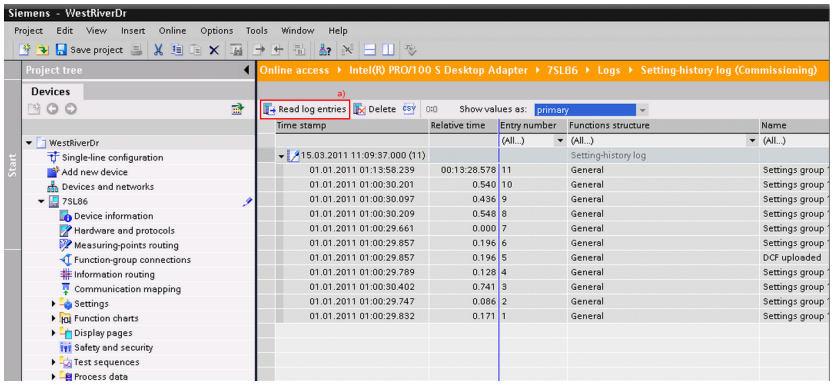
example, faults). On the other hand, it is possible to prove with fault analyses, for example, that the current status of all settings truly corresponds to their status at the time of the fault. Up to 200 indications can be stored in the setting-history log.

Reading from the PC with DIGSI 5

- To reach the log for setting changes of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Setting changes**

The status of the setting-history log last loaded from the device is shown to you.

- To update (synchronization with the device), click the **Read log entries** button in the headline of the indication list (*Figure 3-13*).



[scparamd-030211-01, 1, en_US]

Figure 3-13 Reading the Setting-History Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the setting-history log from the main menu, use the navigation keys of the on-site operation panel.
  Menu → Indications → **Setting changes**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

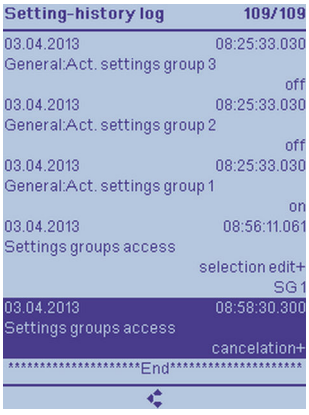


Figure 3-14
Reading the Setting-History Log on the On-Site Operation Panel of the Device

Indication Categories in the Setting-History Log

For this log, there is selected information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.

Table 3-3 Overview of Indication Types

Displayed Information	Explanation
Selection editing+	Selection of settings group to be edited
Reject+	Rejection of all changes successful
PG activation+	PG activation via command successful
PG activation-	PG activation via command failed
set+	Parameter value was changed
Acceptance+	Acceptance of change successful
Acceptance-	Acceptance of change failed
DCF loaded	DCF loaded into device
SG 1	Settings group 1
SG 2	Settings group 2
SG 3	Settings group 3
SG 4	Settings group 4
SG 5	Settings group 5
SG 6	Settings group 6
SG 7	Settings group 7
SG 8	Settings group 8

Example of Logging in Setting-History Log

For this log, there is selected information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.



From top downward:

- In the example at the left, a device has started with the active settings group 1.
- Then the settings group 1 is selected for changes.
- The individual parameter for phase-rotation reversal was changed.
- The changes were successfully accepted.

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer. cannot be deleted by the user!
- If you want to archive security-relevant information without loss of information, you must regularly read this log.
- You cannot route additional indication objects to the setting-history log.

3.1.5.7 Communication Log

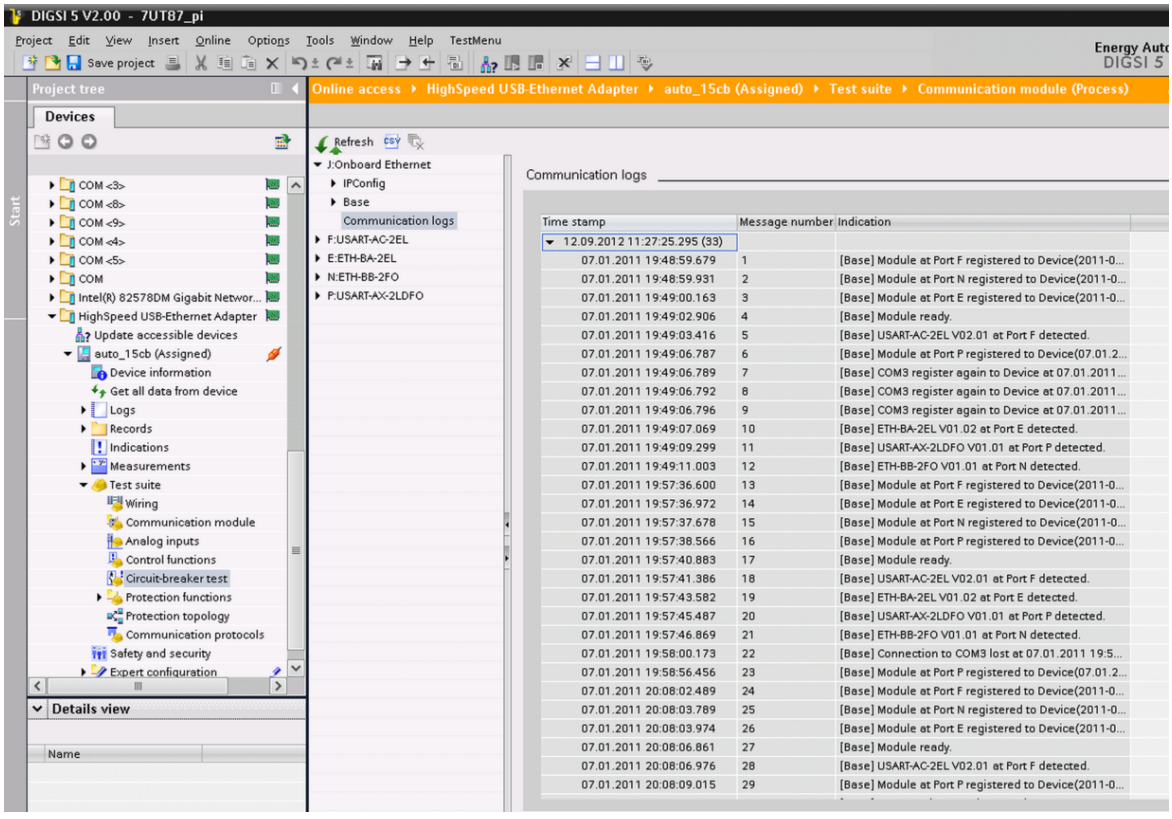
The logging of the respective status such as ensuing faults, test and diagnosis operation, and communication capacity utilizations is done for all hardware-based configured communication interfaces. Up to 500 indications can be stored in the communication log. Logging occurs separately for each communication port of the configured communication modules.

Reading from the PC with DIGSI 5

- Use the project-tree window to reach the communication logs of your SIPROTEC 5 device.
  Online access → USB → Project → Test suite → Communication module
- Then select:
  J:Onboard Ethernet → **Communication log**

The status of the communication log last loaded from the device is shown to you under the Time stamp item.

- To update (synchronization with the device) click the button **Update** in the headline of the indication list.



[sccompuf-140912-01, 1, en_US]

Figure 3-15 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the communication log from the main menu, use the navigation keys on the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → **Communication log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

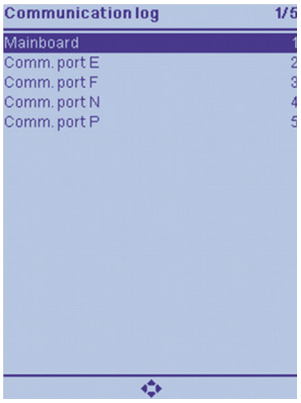


Figure 3-16
Reading the Communication Log on the On-Site Operation Panel of the Device

Deletability

The communication logs of your SIPROTEC 5 device can be deleted. Read details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The communication logs are not freely configurable. The entries are preconfigured.

3.1.5.8 Security Log

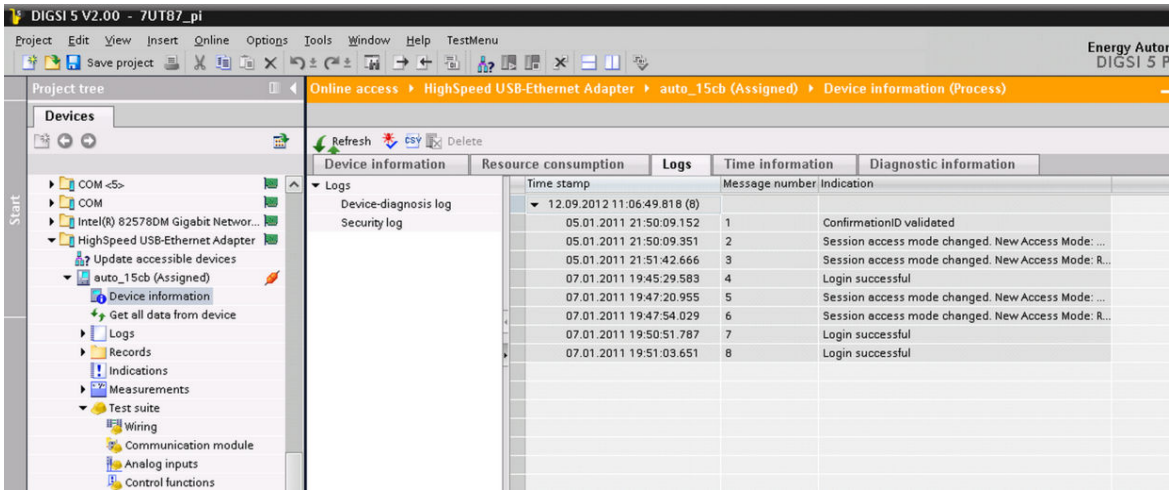
Access to areas of the device with restricted access right is recorded in the security log. Unsuccessful and unauthorized access attempts are also recorded. Up to 500 indications can be stored in the security log.

Reading from the PC with DIGSI 5

- To reach the security log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Device Information → Log → **Security log**

The status of the security log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Update** in the headline of the indication list.



[scsecmld-140912-01, 1, en_US]
Figure 3-17 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the security log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → **Security log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

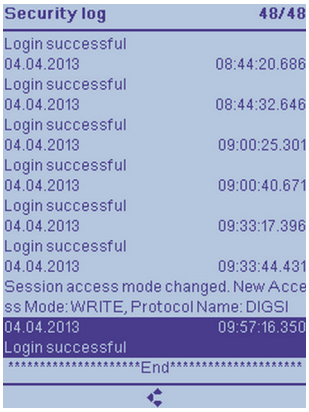


Figure 3-18
Reading the Security Log on the On-Site Operation Panel of the Device

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer. cannot be deleted by the user!
- If you want to archive security-relevant information without loss of information, you must regularly read this log.

3.1.5.9 Device-Diagnosis Log

The logging and the display of concrete instructions are done in the device-diagnosis log during

- Required maintenance (for example, battery supervision)
- Identified hardware defects
- Compatibility problems

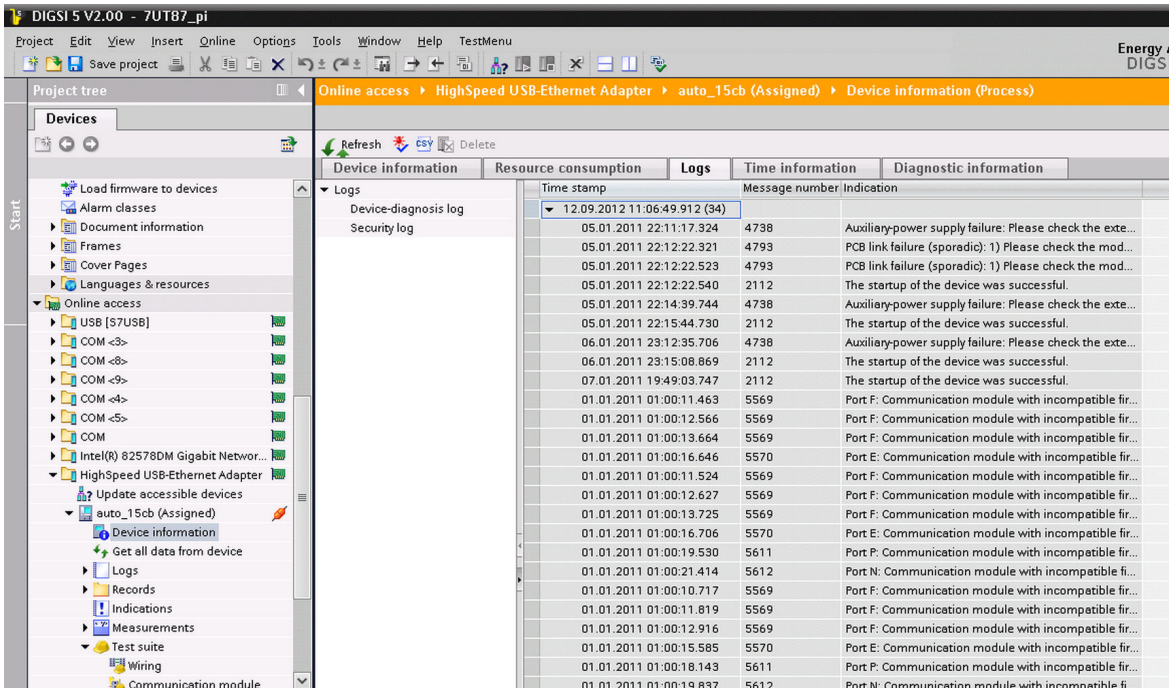
Up to 500 indications can be stored in the device-diagnosis log. In normal operation of the device, it is sufficient for diagnostic purposes to follow the entries of the operational log. This specific significance is assumed by the device-diagnosis log when the device is no longer ready for operation due to hardware defect or compatibility problems and the fallback system is active.

Reading from the PC with DIGSI 5 in Normal Operation

- To reach the device-diagnosis log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Device Information → Log → **Device-diagnosis log**

The status of the device-diagnosis log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Update** in the headline of the indication list.



[scdevdia-140912-01, 1, en_US]

Figure 3-19 Reading the Device-Diagnosis Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel in Normal Operation

- To reach the diagnosis log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → **Device diagnosis**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



Figure 3-20
Reading the Device-Diagnosis Log on the On-Site Operation Panel of the Device

NOTE

- The device-diagnosis log cannot be deleted!
- The logged indications are preconfigured and cannot be changed!

3.1.6 Saving and Deleting the Logs

Deleting the logs of the device in the operating state is unnecessary. If storage capacity is no longer sufficient for new indications, the oldest indications are automatically overwritten with new incoming events. In order for the memory to contain information about the new faults in the future, for example, after an inspection of the system, a deletion of the log makes sense. Resetting the logs is done separately for the various logs.

NOTE

Before you delete the content of a log on your SIPROTEC 5 device, save the log with DIGSI 5 on the hard disk drive of your PC.

NOTE

Not all logs of your SIPROTEC 5 device can be deleted. These limitations apply especially to logs with relevance for security and after-sales (security log, device-diagnosis log, setting-history log).

NOTE

Upon deletion of the fault log, the associated fault records are also deleted. In addition, the meters for fault number and fault-record number are reset to 0. In contrast, if you delete fault records, the content of the fault log, including the allocated fault numbers, remains.

NOTE

If the device executes an initial start, for example, after an update of the device software, the following logs are automatically deleted:

- Operational log
- Fault log
- Ground-fault log
- Setting-history log
- User log
- Motor-startup log

Back up the deletable logs using DIGSI 5.

NOTE

If a ground fault is currently active, the ground-fault log cannot be deleted.

Deleting Logs on the On-Site Operation Panel

- To reach the selected log from the main menu, use the navigation keys of the on-site operation panel (example operational log):
  Main Menu → Indications → **Operational log**

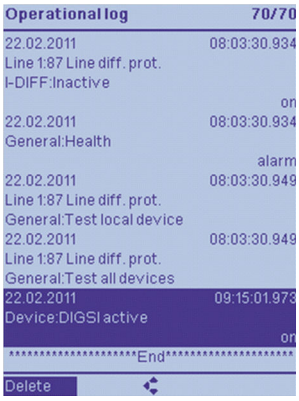


Figure 3-21
Deleting the Operational Log on the On-Site Operation Panel

- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.
- The option to delete the entire log is offered to you in the footer of the display at the bottom left. Use the softkeys below under the display to activate the command prompts. Confirm the request to **Delete**.
- After being prompted, enter the password and confirm with **Enter**.
- After being prompted, confirm the **Deletion of all entries** with **Ok**.

Deleting Logs from the PC with DIGSI 5

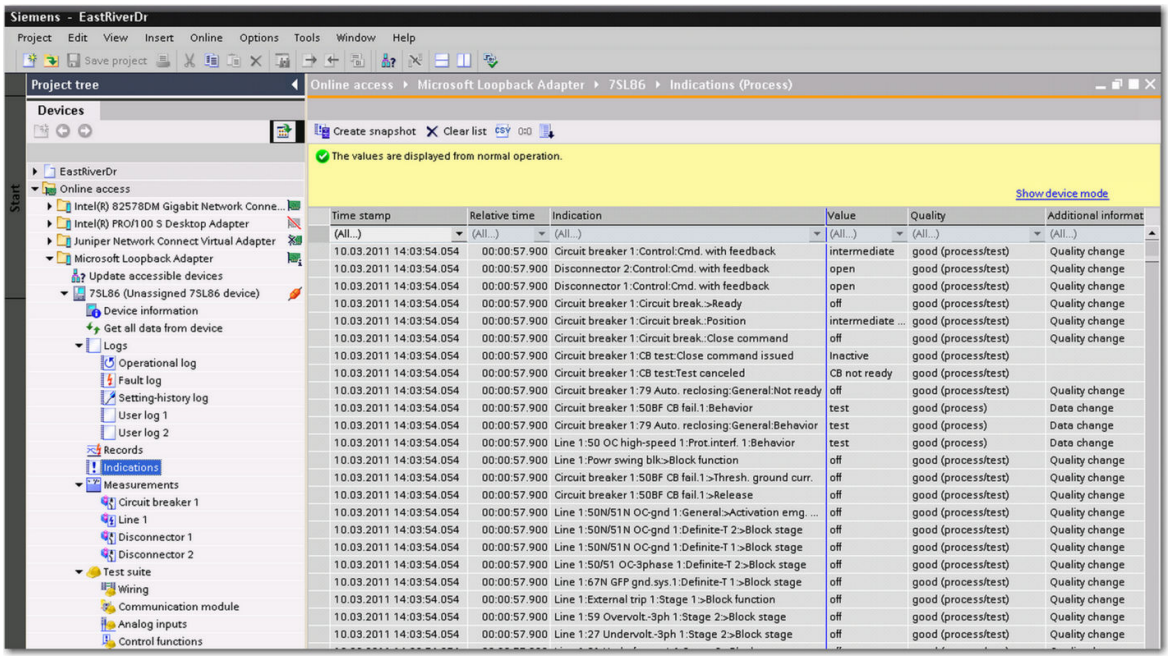
- To reach the selected log of your SIPROTEC 5 device, use the project-tree window (for example, operational log).
  Project → Device → Process data → Logs → **Operational log**

3.1.7 Spontaneous Indication Display in DIGSI 5

With DIGSI 5 you have the possibility of displaying all currently transmitted indications of the selected device in a special indication window.

Procedure

- Call up the spontaneous indications of your selected device in the navigation window under Online access.
- Click **Indications** in the path:
  Online access → Interface → Device → **Indications**
- The raising indications appear immediately without you having to wait for a cyclical update or initiate the manual update.



[scspnmld-230211-01, 1, en_US]

Figure 3-22 Displaying Spontaneous Device Indications in DIGSI 5

3.1.8 Spontaneous Fault Display on the On-Site Operation Panel

After a fault, the most important data of the last fault can be displayed automatically on the device display without further operational measures. In SIPROTEC 5 devices, protected objects and even circuit breakers can be freely created and configured depending on the application (even several instances). In DIGSI 5, several spontaneous fault displays can be configured, depending on the application, with each individual one being assigned a particular circuit breaker. These displays remain stored in the device until they are manually confirmed or reset by LED reset.

Configuration of a Spontaneous Fault Display with DIGSI 5

- To reach the **Fault-display configuration** of your SIPROTEC 5 device, use the project-tree window. Project → Device → Display pages → **Fault-display configuration**
- In the main window, all configured circuit breakers are displayed. A list of a maximum of 6 configurable display lines is offered for each circuit breaker. The activation of a spontaneous fault display occurs for each circuit breaker by selection via checkmark in the column **Display**.
- With the parameter **`(_:139) Fault-display`** (under Device → Parameter → Device settings) you determine whether spontaneous fault displays should be displayed for each pickup or only pickups with the off command.

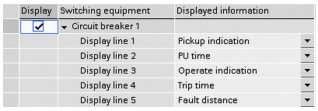


Figure 3-23 Configuration of the Spontaneous Fault Display on the Device

For every display line the following display options can be selected:

Table 3-4 Overview of Display Options

Displayed Information	Explanation
Pickup indication	Display of the first function stage picked up in a fault, as needed with additional information (phases, ground, direction).
PU time	Display of the entire pickup duration of the fault.
Operate indication	Display of the first function stage triggered in a fault, as needed with additional information (phases).
Trip time	Display of the operate time related to the beginning of the fault (pickup start).
Fault distance	Display of the measured fault-location distance.

Acknowledgement of the Spontaneous Fault Display on the Device

After faults, the last occurred fault is always displayed to you. In cases where more than one circuit breaker is configured, several stored fault displays can be present after faults, with the latest being displayed. These displays remain stored in the device until they are manually acknowledged or reset by LED reset.

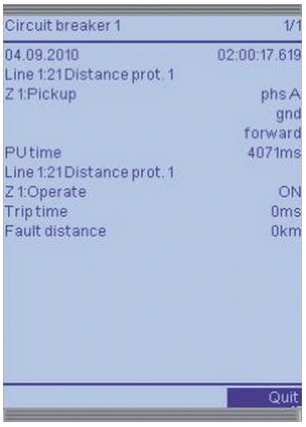


Figure 3-24
Spontaneous Fault Display on the Device

Method 1: Manual acknowledgement

- Press the softkey button **Quit** in the base bar of the display. The display is irretrievably closed. Repeat this step until no spontaneous fault display appears anymore.
- After completion of all confirmations the last display view is showed before the faults.

Method 2: Acknowledgement via LED reset

- An LED reset (device) causes the reset of all stored LEDs and binary output contacts of the device and also to the confirmation of all fault displays stored in the display.

You can find more details on the topic of LED reset in chapter *3.1.9 Stored Indications in the SIPROTEC 5 Device*.

3.1.9 Stored Indications in the SIPROTEC 5 Device

In your SIPROTEC 5 device, you can also configure indications as **stored**. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged. Acknowledgment occurs via:

- On-site operation panel
- DIGSI 5

- Binary input
- Protocol of substation automation technology

Configuration of Stored Indications with DIGSI 5

- In the **Information Routing** of each device set up in DIGSI 5, you can route binary signals, among others, to LEDs and output contacts. For this, go to the project tree.
  Project → Device → **Information routing**
- Right-click the routing field of your binary indication in the desired LED or binary output column in the routing range of the targets.

You are offered the following options:

Table 3-5 Overview of Routing Options

Routing Options		LEDs	BOs	BIs	Description
H	(active)			X	The signal is routed as active with voltage.
L	(active)			X	The signal is routed as active without voltage.
V	(unlatched)	X	X		The signal is routed as unlatched. Activation and reset of the output (LED, BA) occurs automatically via the binary-signal value.
L	(latched)	X	X		The binary signal is latched when the output (LED) is activated. To reset, a targeted confirmation must occur.
NT	(stored only with tripping)	X			Fault indications are stored when the output (LED) is activated. If the fault is ended via a trip command from the device, the stored state is maintained. In case of dropout of the pickup without trip command from the device (for example, external fault), the state displayed before the fault is restored. **Note**: Observe here the parameter **(_:91:139)Fault-display** with the setting options ***with trip*** or ***with pickup***. For this routing option, select the setting ***with trip***.
TL	(stored only with tripping)		X		Routing option TL (tripping stored) is only possible for the switching object circuit breaker. The output is saved with protection tripping. The contact remains activated until acknowledged. Control commands are not affected. A control command is pending above the parameterized command period until feedback has been successfully received. **Note**: You can realize the functionality of the **Lockout** (ANSI 86) by storing the output relay with the routing option TL.

Acknowledgment of Stored Indications on the On-Site Operation Panel

Acknowledgment via **LED Reset**

Operating the button first causes the activation of all LEDs (LED test) when pressed, and when released the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgment via the operating menu

Use the navigation buttons of the on-site operation panel, in order to reach the reset functions from the main menu.

- Select: Main menu → Device functions → **Reset functions**
  You are offered different reset options.
- Open the corresponding submenu.



Figure 3-25 Reset Functions on the On-Site Operation Panel

- Use **Res. binary outputs** to reset stored output contacts.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.
- Use **Reset LEDs not in FG** to reset stored LEDs that are not assigned to a special function group.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.

Depending on device configuration, the protection function group(s) are displayed to you as submenus for which separately corresponding, stored LEDs can be reset.

- Go to the submenu of the selected function group (example **Line 1**).
- Use **Reset LEDs** to reset stored LEDs in the selected function group.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.



Figure 3-26 Reset Functions on the On-Site Operation Panel (for Example, Line FG)

Acknowledgment of Stored Indications via Binary Inputs

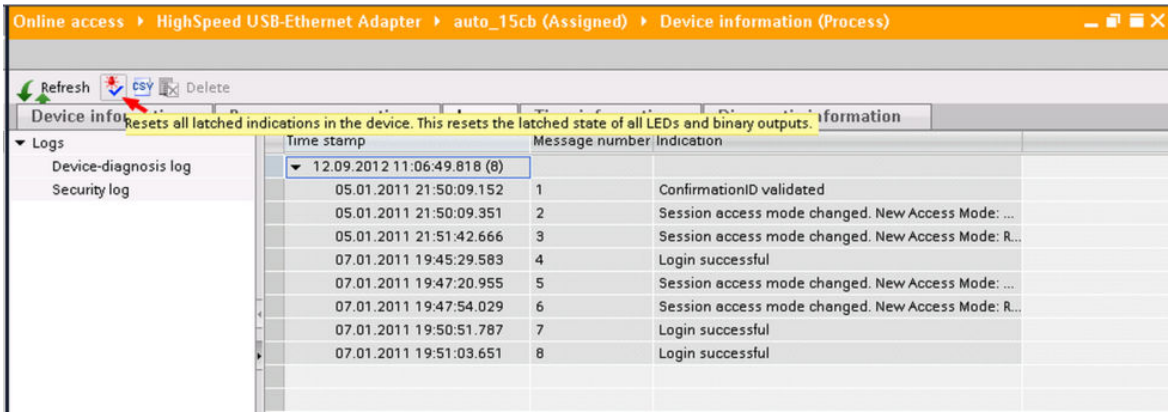
Acknowledgment via entry **>LED Reset**

Acknowledgment via binary input **>LED-Reset** brings about the activation of all LEDs (LED test) and, in case of dropout of signal, the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgment of Stored Indications with DIGSI 5

You can acknowledge stored indications via DIGSI 5 in online mode. For this, go to the project tree.

- Select Online access → Interface → Device → **Device information**



[scquiled-140912-01, 1, en_US]

Figure 3-27 LED Reset via DIGSI 5

- Click the LED reset button.
- Enter the confirmation ID.
- Confirm the process with OK.

Stored LEDs, output contacts and spontaneous fault displays are reset on the assigned device.

Acknowledgment of Stored Indications via Log

Initiation of acknowledgment of stored indications can also occur through communication via a connected substation automation technology. This can occur in conformance to standards (IEC 61850, IEC 60870-5-103) or via configuration (mapping) of the LED reset input signal for any protocol. Stored LEDs, output contacts, and spontaneous fault displays are reset.

NOTE

The acknowledgment of **stored** indications then leads to the resetting of configured LEDs and output contacts, as long as these active unstored indications are not present in parallel. That is, indications configured as **unstored** are not affected by the acknowledgment process.

3.1.10 Resetting Stored Indications of the Function Group

You can configure indications of individual functions as "stored" in a function group. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged.

The protection and the circuit-breaker function groups contain the block **Reset LED FG**. The block **Reset LED FG** is visible only in the Information routing under the corresponding function group in DIGSI 5. You use the binary input signal *>Reset LED* to reset the stored LEDs in the respective function group. The configured outputs (contacts) are not reset.

3.1.11 Test Mode and Influence of Indications on Substation Automation Technology

If the test mode of the device or of individual functions is switched on, the SIPROTEC 5 device marks indications sent to substation automation technology station control system with an additional test bit. This test bit makes it possible to determine that an indication was set during a test. Necessary reactions in normal operation on the basis of an indication can thus be suppressed.

3.2 Measured-Value Acquisition

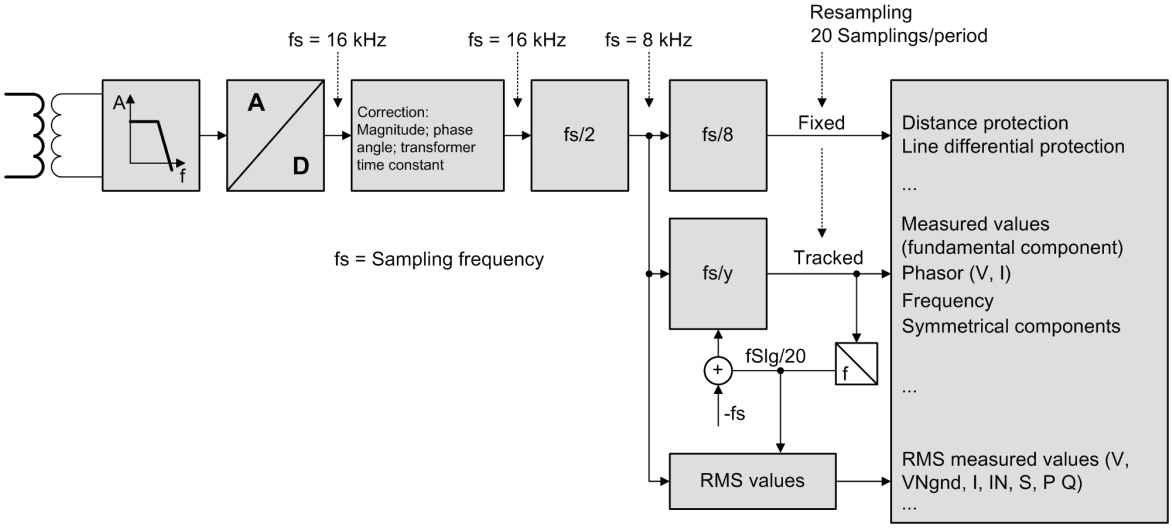
Basic Principle

SIPROTEC 5 devices are equipped with a powerful measured-value acquisition function. In addition to a high sampling frequency, they have a high measurand resolution. This ensures a high degree of measuring accuracy across a wide dynamic range. The 24-bit sigma/delta analog-digital converter represents the core of measured-value acquisition. In addition, the oversampling function supports the high measurand resolution. Depending on the requirements of the individual method of measurement, the sampling frequency is reduced (**Downsampling**).

In digital systems, deviations from the rated frequency lead to additional errors. In order to avoid this, 2 algorithm-dependent processes are used in all SIPROTEC 5 devices:

- Sampling-frequency tracking:
  The analog input channels are scanned for valid signals in cycles. The current power frequency is determined and the required sampling frequency is defined by using a **resampling algorithm**. The tracking is effective in the frequency range between 10 Hz and 80 Hz.
- Fixed sampling frequency – correction of the filter coefficients:
  This method operates in a limited frequency range (f_{rated} +/- 5 Hz). The power frequency is determined and, depending on the degree of the frequency deviation, the filter coefficients are corrected.

The following figure shows the basics of dealing with sampled values (SAV) in the measured-value acquisition chain. *Figure 3-28* shows to whom the various sampling frequencies are made available. In order to limit the bandwidth of the input signals, a low-pass filter (anti-aliasing filter to maintain the sampling theorem) is installed downstream. After sampling, the current input channels are adjusted. This means the magnitude, phase, as well as the transformer time constant are corrected. The compensation is designed to ensure that the current transformer terminal blocks can be exchanged randomly between the devices.



[dwmeserf-250211-01.tif, 1, en_US]

Figure 3-28 Measured-Value Acquisition Chain

The internal sampling frequency of the SIPROTEC 5 devices is fixed at 16 kHz (sampling rate: 320 samplings per 50-Hz cycle). All current and voltage inputs are sampled. If the magnitude, phase, and transformer time constant are corrected, the sampling frequency is reduced to 8 kHz (160 samplings per 50-Hz cycle). This is the basic sampling frequency to which various processes, such as fault recording, RMS measured values, refer. For the RMS measurement, the measured-value window is adjusted on the basis of the power frequency. For numerous measurement and protection applications , 20 samplings per cycle are sufficient (if f_{rated} = 50 Hz: sampling every 1 ms, at f_{rated} = 60 Hz: sampling every 0.833 ms). This sampling rate is an adequate compromise between accuracy and the parallel processing of the functions (multi-functionality).

The 20 samplings per cycle will be made available to the algorithms processed in the function groups, in 2 variants:

- Fixed (not resampled)
- Resampled (frequency range from 10 Hz to 80 Hz)

Depending on the algorithms (see function descriptions), the respective data flow is considered. A higher sampling frequency is used for selected methods of measurement. Detailed information can be found in the corresponding function description.



NOTE

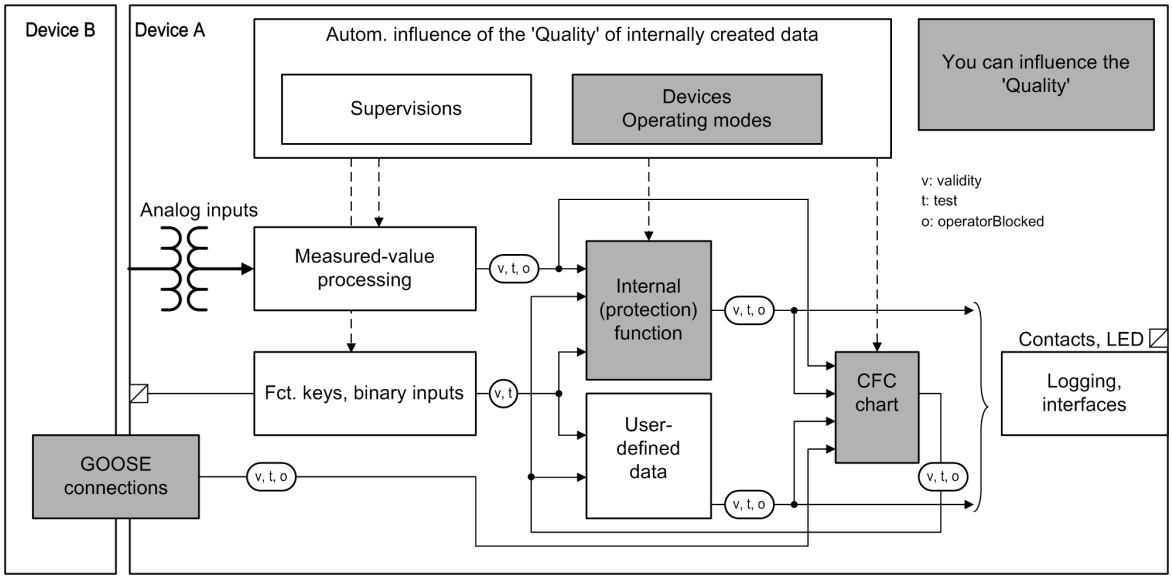
The measuring points for current and voltage are in the **Power-system data** (starting in chapter *6.1 Power-System Data*). Each measuring point has its own parameters.

3.3 Processing Quality Attributes

3.3.1 Overview

The IEC 61850 standard defines certain quality attributes for data objects (DO), the so-called Quality. The SIPROTEC 5 system automatically processes some of these quality attributes. In order to handle different applications, you can influence certain quality attributes and also the values of the data objects on the basis of these quality attributes. This is how you can ensure the necessary functionality.

The following figure describes roughly the general data flow within a SIPROTEC 5 device. The following figure also shows at which points the quality can be influenced. The building blocks presented in the figure are described in more detail in the following.



[loquali1-090212-02.tif, 2, en_US]

Figure 3-29 Data Flow within a SIPROTEC 5 Device

Supported Quality Attributes

The following quality attributes are automatically processed within the SIPROTEC 5 system.

- **Validity** using the values *good* or *invalid*

  The **Validity** quality attribute shows if an object transferred via a GOOSE message is received (valid, invalid) or not received (invalid). The *invalid* state can be suppressed in the receiver device by also setting a substitute value for the object that is not received (see *Figure 3-30*). The substitute value is forwarded to the functions.

  If the device receives one of these values, it is replaced by the *invalid* value and thus processed further as *invalid*.

  If one of the detailed quality attributes (detailQual) has the value *TRUE*, then **Validity** is set to the *invalid* value, unless this was already done at the transmitter end.

- **Test** using the values *TRUE*, *FALSE*

  The **Test** quality attribute indicates to the receiver device that the object received via a GOOSE message was created under test conditions and not operating conditions.

- **OperatorBlocked** using the values *TRUE*, *FALSE*

  The **OperatorBlocked** quality attribute indicates whether an object transferred via GOOSE message originates from a device that is in a *functional logoff* state. When the sending device is switched off, the object is no longer being received and assumes the *invalid* state. However, since the **OperatorBlocked** quality was previously identified on the receiver device, the object can be treated differently at the receiving end (see chapter *3.3.2 Quality Processing/Affected by the User for Received GOOSE Values*). At the receiving end, the object may be treated like a dropped signal.

- **Source** using the values *process*, *substituted*

  The **Source** quality attribute indicates whether the object was updated in the sending device.

  You can find more detailed information in chapter *3.8.2 Acquisition Blocking and Manual Updating*.

Influencing Quality by the Operating Modes

In addition to the normal operation, the device also supports further operating modes that influence quality:

- **Test mode of the device**

  You can switch the entire device to test mode. In this case, all data objects generated in the device (state values and measured values) receive the quality attribute **Test** = *TRUE*.

  The CFC charts are also in test mode and all output data receive the quality attribute **Test** = *TRUE*.

- **Test mode for individual functions, stages, or function blocks**

  You can switch individual functions, stages, or function blocks into test mode. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute **Test** = *True*.

- **Functional logoff of the device**

  If you take the device out of operation and want to isolate it from the supply voltage, you can functionally log off the device ahead of time. Once you functionally log off the device, all data objects generated in the device (state values and measured values) receive the quality attribute **OperatorBlocked** = *TRUE*. This also applies to the output from CFC charts.

  If objects are transferred via a GOOSE message, the receiver devices can assess the quality. The receiver device detects a functional logoff of the transmitting device. After shutting down the sending device, the receiver device identifies that the sending device has been logged off operationally and did not fail. Now the receiving objects can automatically be set to defined states (see chapter *3.3.2 Quality Processing/ Affected by the User for Received GOOSE Values*).

- **Switching off individual functions, stages, or function blocks**

  You can switch off individual functions, stages, or function blocks. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute **Validity** = *invalid*.

Influencing the Quality through Hardware Supervision

Supervision functions monitor the device hardware (see chapter *9.4 Supervision of the Device Hardware*). If the supervision functions identify failures in the data acquisition of the device, all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality through Voltage-Transformer Circuit Breakers

If tripping of the voltage-transformer circuit breaker is detected (see chapter *9.3.4 Voltage-Transformer Circuit Breaker*), all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality by the User

You can influence the processing of data and their quality differently. In DIGSI 5, this is possible at the following 3 locations:

- In the **Information routing** editor for external signals of GOOSE connections
- In the CFC chart
- In the **Information routing** editor for binary input signals of device-internal functions

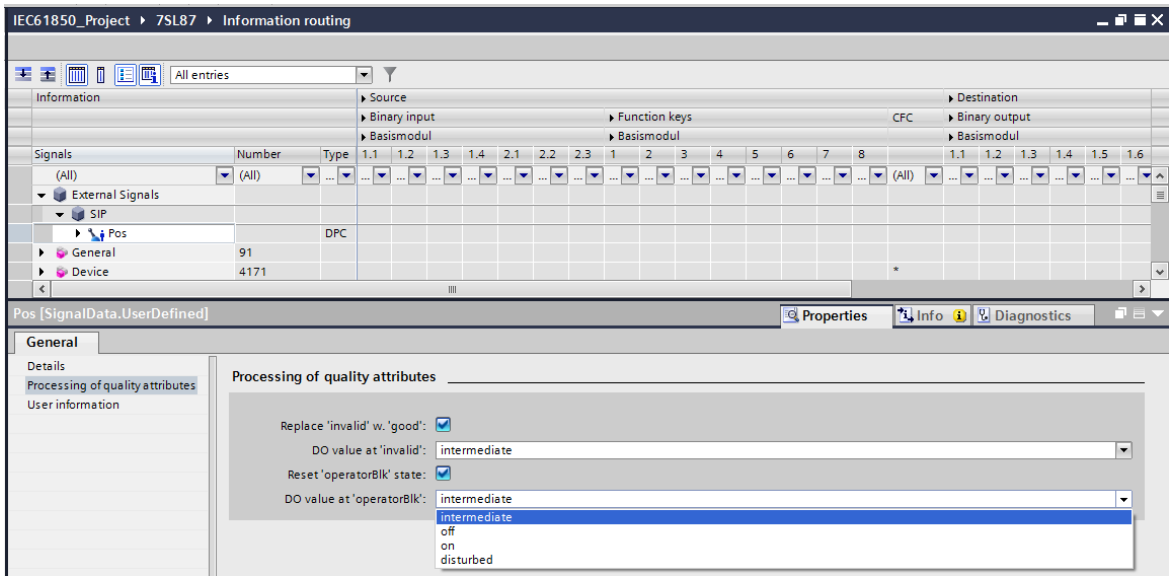
The following chapters describe in more detail the options regarding this influence as well as the automatic quality processing.

If a GOOSE connection is the data source of a binary input signal of a device-internal function, you can influence processing of the quality at 2 locations: at the GOOSE connection and at the input signal of the function. This is based on the following: A GOOSE date can be distributed within the receiving device to several functions. The GOOSE connection setting (influence) affects all functions. However, if different functions require customized settings, these are then set directly at the binary input signal of the function.

3.3.2 Quality Processing/Affected by the User for Received GOOSE Values

In the **Information Routing** editor, you can influence the data value and quality of all data types. The following figure shows the possible influence using the example of an DPC data type.

- In the DIGSI 5 project tree, double-click **Information Routing**.
- Select the desired signal in the **External Signals** group.
- Open the **Properties** window and select the **Processing Quality Attributes** sheet.



[sc_GOOSE values, 1, en_US]

Figure 3-30 Influence Option When Linking an DPC Type Data Object

The setting options work for the device receiving the data.

Quality Attribute: Validity	
The validity values *reserved* and *questionable* are replaced at the receiving end by the *invalid* value.	
• Check box is not set. • Check box is set and receipt of **Validity** = *good*	The validity attribute and data value are forwarded without change.
Check box is set and receipt of **Validity** = *invalid* is set (also applies to values *reserved* and *questionable*).	• The validity attribute is set to *good* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Quality Attribute: OperatorBlocked (opBlk)	
• Check box is not set. • Check box is set and received **OperatorBlocked** = *FALSE*	The OperatorBlocked attribute and data value are forwarded without change.

Quality Attribute: OperatorBlocked (opBlk)	
Check box is set and received **OperatorBlocked** = *TRUE*	• The OperatorBlocked attribute is set to *FALSE* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Interaction of the Quality Attribute Validity and OperatorBlocked	
OperatorBlocked check box is set and receipt of **OperatorBlocked** = *TRUE*	Regardless of whether the validity check box is set or not, and regardless of the current validity, the validity attribute is set to *good* and the substitute value of the OperatorBlocked data object is set. That is, the OperatorBlocked settings overwrite the Validity settings.
OperatorBlocked check box is not set and receipt of **OperatorBlocked** = *TRUE*	The OperatorBlocked attribute remains set and is forwarded. If the Validity check box is set and the receipt of validity = *invalid* is set, the respective data object substitute value is used. For continued signal processing and influence, it must be taken into account that in this configuration the data object substitute value for validity = *invalid* is set, but the quality attribute OperatorBlocked is not yet set.

Data Substitute Values

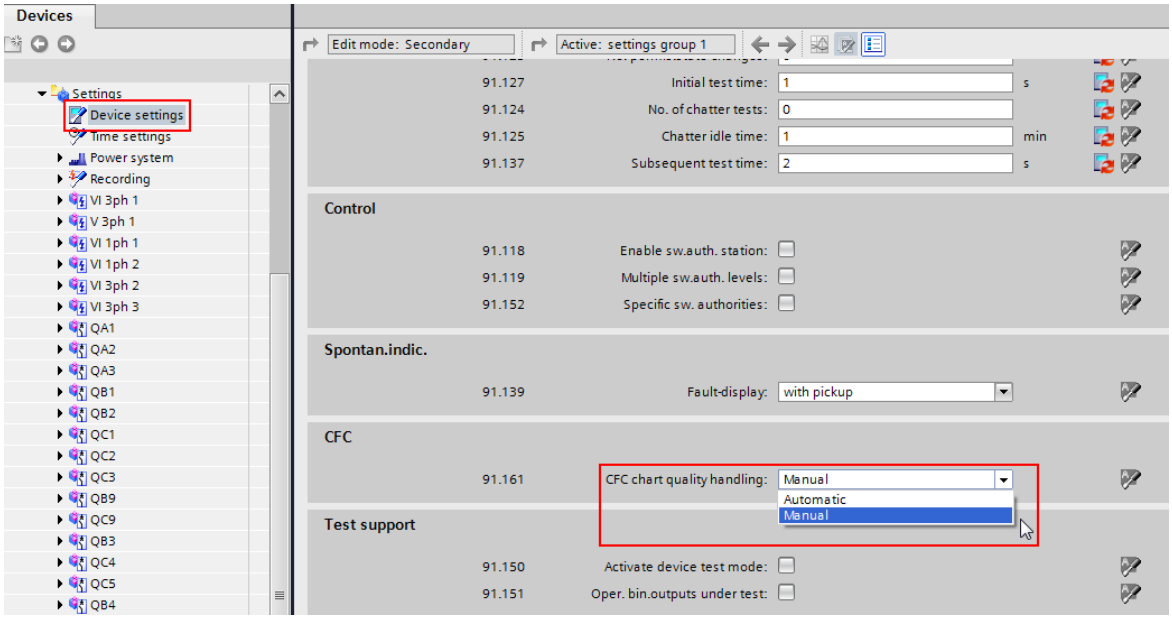
Depending on the data type, different data substitute values must be used.

Data Type	Possible Data Substitute Values	
ACD, ACT	general, phsA, phsB, pshC, neut	0 (False), 1 (True)
only ACD	dirGen	0, 1, 2, 3 (Unknown, Forward, Backward, Both)
	dirPhsA, dirPhsB, dirPhsC, dirNeut	0, 1, 2 (Forward, Backward, Both)
BAC, APC	mxVal	$1.401298 \cdot 10^{-45}$ to $7.922 \cdot 10^{28}$
	stSeld	0 (False), 1 (True)
	ctlNum	1 to 255
BCR	actVal, frVal, frTm	0 to 1 073 741 824
CMV	mag, ang	$1.401298 \cdot 10^{-45}$ to $7.922 \cdot 10^{28}$
DPC, DPS	stVal	0, 1, 2, 3 (intermediate-state, off, on, bad-state)
ENUM types (for example, ENS, EN, ENC)	SPS output	0 (False), 1 (True)
	INS output	The qualities of the object of the sending device are taken on.
INC	stVal	0 to 1 073 741 824
	stSeld	0 (False), 1 (True)
ING	setVal	0 to 1 073 741 824
INS	stVal	0 to 1 073 741 824
ISC, BSC	vWTpos	-64 to 64
	vWTInd	0 (False), 1 (True)
SEC	cnt	0 to 1 073 741 824
SPC, SPS	stVal	0 (False), 1 (True)
SPG	setVal	0 (False), 1 (True)

Data Type	Possible Data Substitute Values	
MV	mag	$1.401298 \cdot 10^{-45}$ to $7.922 \cdot 10^{28}$

3.3.3 Quality Processing/Affected by the User in CFC Charts

In DIGSI 5, you can control the quality processing of CFC charts. In the project tree, you can find the **CFC** block (see the following figure) under **Device name** → **Settings** → **Device settings** in the editor:



[sc quali cfc, 1, en_US]

Figure 3-31 Influencing CFC Quality Handling in DIGSI 5

With the **CFC chart quality handling** parameter, you control whether you want to influence the quality of CFC charts in a ***Manual*** or ***Automatic*** (default setting) manner.

If you select ***Manual***, the quality attribute of the CFC chart is always valid regardless of the quality of individual signals (**Validity** = ***good***)!

Only the **Test** quality attribute of the CFC chart is processed. If the device is in test mode or the input TEST of the CHART_STATE CFC block is set, the quality attribute of the CFC chart is set to ***Test***.

If you select ***Automatic***, the quality processing of the CFC charts is influenced as follows:

In the case of CFC charts, a distinction has to be made between the general quality processing and certain CFC blocks that are specifically designed for quality processing.

General Processing

Most of the CFC blocks do not have an explicit quality processing. For these blocks, the following general mechanisms shall apply.

Quality Attribute: Validity
If one *invalid* signal is received in the case of CFC input data, then **all** CFC output data will also be set to *invalid* if they originate from building blocks without explicit quality processing. In other words, the quality is not processed sequentially from building block to building block but the output data are set globally. This does not apply to CFC output data that originate from building blocks with explicit quality processing (see next section).

Quality Attribute: Test	
CFC chart is in **normal** state.	CFC input data with the **Test** = *TRUE* attribute are ignored. When the CFC chart is executed, then the data value that was used before the **Test** = *TRUE* attribute is used. The quality of this **old** value is also processed. This means that on the output side, the attribute **Test** = *FALSE*.
CFC chart is in **Test**[1)] state.	If the CFC chart is executed, then the attribute **Test** = *TRUE* is set for all data leaving the CFC chart. This does not depend on whether the data are formed via CFC blocks with or without quality processing.

[1)]A CFC chart can be switched to the test state by switching the entire device to test mode or the input TEST of the CFC block CHART_STATE is set.

Quality Attribute: OperatorBlocked	
CFC chart is in **normal** state.	In CFC charts for incoming data, the **OperatorBlocked** attribute is ignored.
CFC chart is in **functionally logged off**[1)] state .	In CFC charts for incoming data, the **OperatorBlocked** attribute is ignored. All CFC output data are labeled as functionally logged off.

[1)] This state only occurs if the device is functionally logged off. In this case, the quality attributes of all CFC outputs are labeled as **functionally logged off**.

Quality Processing Building Blocks (Condition Processing)

The first 3 blocks (x_SPS) process the quality automatically according to the stated logic. The other blocks are used to isolate the quality from a data object and add them back after separate logical processing.

<table>
<tr><th>Building Blocks</th><th colspan="3">Description</th></tr>
<tr><td rowspan="20">OR_SPS
AND_SPS
NEG_SPS</td><td colspan="3">The blocks also process the supported quality attributes according to their logic. The following tables describe the logic using input values in connection with the quality attribute Validity. The input values are 0 or 1, the quality attribute Validity can have the value good (=g) or invalid (=i).
x = placeholder for the input value and quality attribute Validity</td></tr>
<tr><td colspan="3">OR_SPS</td></tr>
<tr><td>A (Value, Attribute)</td><td>B (Value, Attribute)</td><td>Q (Value, Attribute)</td></tr>
<tr><td>0, i</td><td>0, x</td><td>0, i</td></tr>
<tr><td>0, g</td><td>0, g</td><td>0, g</td></tr>
<tr><td>1, g</td><td>x, x</td><td>1, g</td></tr>
<tr><td>1, i</td><td>0, x</td><td>1, i</td></tr>
<tr><td>1, i</td><td>1, i</td><td>1, i</td></tr>
<tr><td colspan="3">The output thus has the logical value 1 with Validity = good as soon as at least 1 input has the logical value 1 with Validity = good. Otherwise, the inputs are treated according to the OR operation and the INVALID bit is OR-gated for the quality.</td></tr>
<tr><td colspan="3">AND_SPS</td></tr>
<tr><td>A (Value, Attribute)</td><td>B (Value, Attribute)</td><td>Q (Value, Attribute)</td></tr>
<tr><td>0, g</td><td>x, x</td><td>0, g</td></tr>
<tr><td>0, i</td><td>1, x</td><td>0, i</td></tr>
<tr><td>1, i</td><td>1, x</td><td>1, i</td></tr>
<tr><td>1, g</td><td>1, g</td><td>1, g</td></tr>
<tr><td colspan="3">The output thus has the logical value 0 with Validity = good as soon as at least 1 input has the logical value 0 with Validity = good. Otherwise, the inputs are treated according to the AND operation and the INVALID bit is OR-gated for the quality.</td></tr>
<tr><td colspan="3">NEG_SPS</td></tr>
<tr><td>A (Value, Attribute)</td><td>Q (Value, Attribute)</td><td></td></tr>
<tr><td>0, i</td><td>1, i</td><td></td></tr>
<tr><td>0, g</td><td>1, g</td><td></td></tr>
<tr><td>1, i</td><td>0, i</td><td></td></tr>
<tr><td>1, g</td><td>0, g</td><td></td></tr>
<tr><td>SPLIT_SPS
SPLIT_DPS
SPLI_XMV</td><td colspan="3">The blocks isolate the data value and quality of a data object.
The requirement is that the quality is available from the input end. This is the case if the block is interconnected with CFC input data, or is connected downstream with a quality processing building block (x_SPS). In other cases, the CFC editor does not allow a connection.</td></tr>
<tr><td>SPLIT_Q</td><td colspan="3">The block performs binary separation of the quality into good, bad (= invalid), test, off and OperatorBlocked.
These 5 attributes can then be processed individually in a binary operation. The block must be connected downstream to a SPLIT_(DO) block.</td></tr>
<tr><td>BUILD_Q</td><td colspan="3">The building block enters a binary value for good and bad (= invalid) in each quality structure. Thus, with this building block the quality attributes good and bad (=invalid) can be set explicitly, for example, as the result of a monitoring logic.
All other quality attributes are set to the default state, for instance, Test = FALSE. If, for example, the entire CFC chart is in the test state (see Quality Attribute: Test Under General Processing), this default status can again be overwritten on the CFC output side.
The building block is normally connected downstream to a BUILD_(DO) building block.</td></tr>
</table>

Building Blocks	Description
BUILD_ACD **BUILD_ACT** **BUILD_BSC** **BUILD_DPS** **BUILD_ENS** **BUILD_SPS** **BUILD_XMV**	These blocks merge data value and quality. The block output is generally used as a CFC output. Generally, the BUILD_Q block is connected upstream from these building blocks.

CFC charts have a standard behavior in the processing of signals. If an input signal of the CFC chart has the quality *invalid*, all output signals of the CFC chart also get the quality *invalid*. This standard behavior is not desirable in some applications. If you use the building blocks for quality processing, the quality attributes of the input signals in the CFC chart are processed.

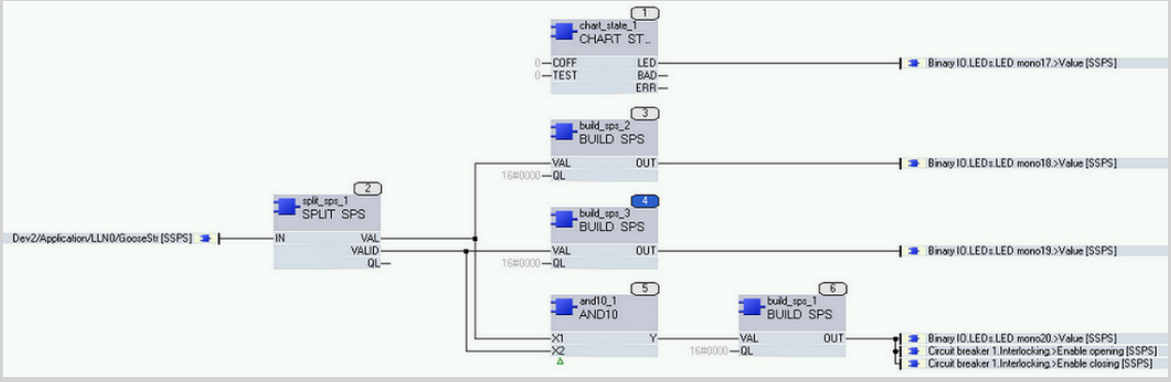
EXAMPLE: Switchgear Interlocking via GOOSE

The following conditions apply to the example:

- The interlocking condition for switchgear interlocking protection is stored in the device as a CFC chart.
- The removed device sends the release signal for the interlocking condition via a GOOSE telegram.

If the communication connection has been interrupted, the release signal (**GOOSEStr**) incoming via the GOOSE telegram gets the quality *invalid*. If the CFC chart obtains an invalid input signal, there are the following possibilities: The last signal valid before the communication interruption is used (quality = *good*) or a substitute data value with the quality *good* is used (True, False).

To do this, you have to create a separate CFC chart in addition to the interlocking plan of the switchgear interlocking. Use the building blocks for quality processing in a separate CFC chart. With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. You can then continue to process these signals separately in the CFC chart. Use the quality information as an input signal for a BUILD_SPS building block and assign the quality *good* to the signal. You obtain an SPS signal as a result, with the quality *good*. You can use this to process release messages correctly. You can process the release messages with the quality *good* in the CFC chart of the actual interlocking. Therefore, the release signal for a switch illustrated in the interlocking logic is available as a valid result with the quality *good*. The following figure shows an example of the CFC chart with the building blocks for quality processing:



[sccfcran-220415-01, 1, en_US]

Figure 3-32 CFC Chart with Building Blocks for Quality Processing (Switchgear Interlocking via GOOSE)

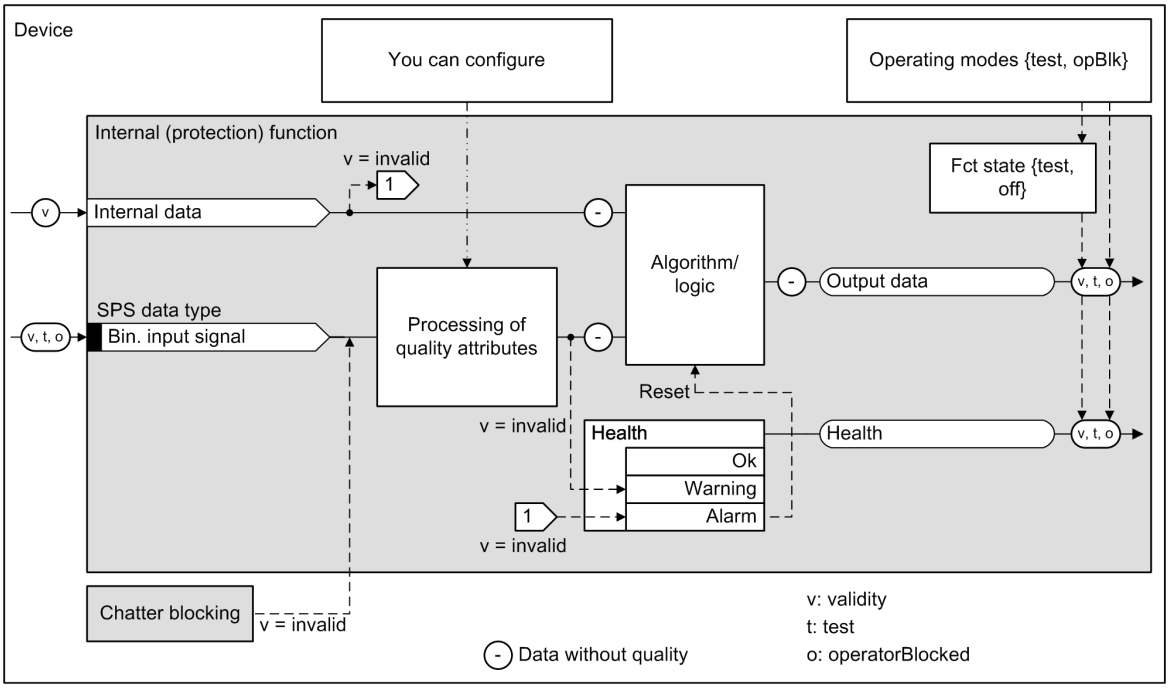
If you do not want to convert the invalid release signal to a valid signal, as described, during the communication interruption, you can also assign a defined data value to the release signal. Proceed as follows: With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. Link the VALID output of the SPLIT_SPS building block with the data value of the input signal (AND gate). This way, you can set the value to a non-risk state with the valid input signals. In the example, the output of the CFC chart is set to the value *FALSE* when the input signal is invalid.

3.3.4 Quality Processing/Affected by the User in Internal Device Functions

Figure 3-33 provides an overview for processing the quality of data objects within a device-internal function. A function can receive internal data or input data that is routable by the user (binary input signal or double commands). The respective quality attributes supported are evaluated by the function on the input side. The attributes are not passed through the specific algorithm/the specific logic of the function. The output data are supplied with a quality that is specified by the function state and device-operating mode.

NOTE

Take into account that pickup of chatter blocking (see chapter *3.8.1 Signal Filtering and Chatter Blocking for Input Signals*) sets the corresponding **Validity** attribute to *invalid*.



[loquali3-100611-01.tif, 2, en_US]

Figure 3-33 Overview for Processing Quality within an Internal Function

Internal Input Data

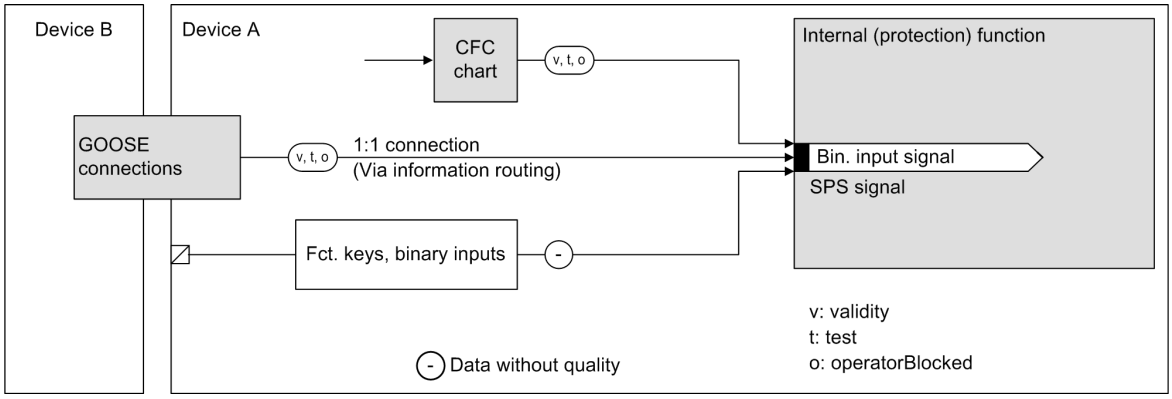
The quality processing is automatic for internal input data.

Supported Quality Attributes	Description
Validity	• At the receiving end, internal values can only be *invalid* or *good*. • If *invalid*, the function health is set to **Alarm** and the function is reset. Causes for invalid internal data are, for example: • The frequency operating range of the device was left. • The device is not calibrated. • The A/D converter monitoring identified an error.

Routable Binary Input Signals (SPS Data Type)

Figure 3-34 shows the possible sources for connecting a binary input signal. Depending on the source, different quality attributes can be set:

- CFC chart: See description in chapter *3.3.3 Quality Processing/Affected by the User in CFC Charts*
- GOOSE connection: See description in chapter *3.3.2 Quality Processing/Affected by the User for Received GOOSE Values*
- Device hardware: No quality attributes are set and supported.

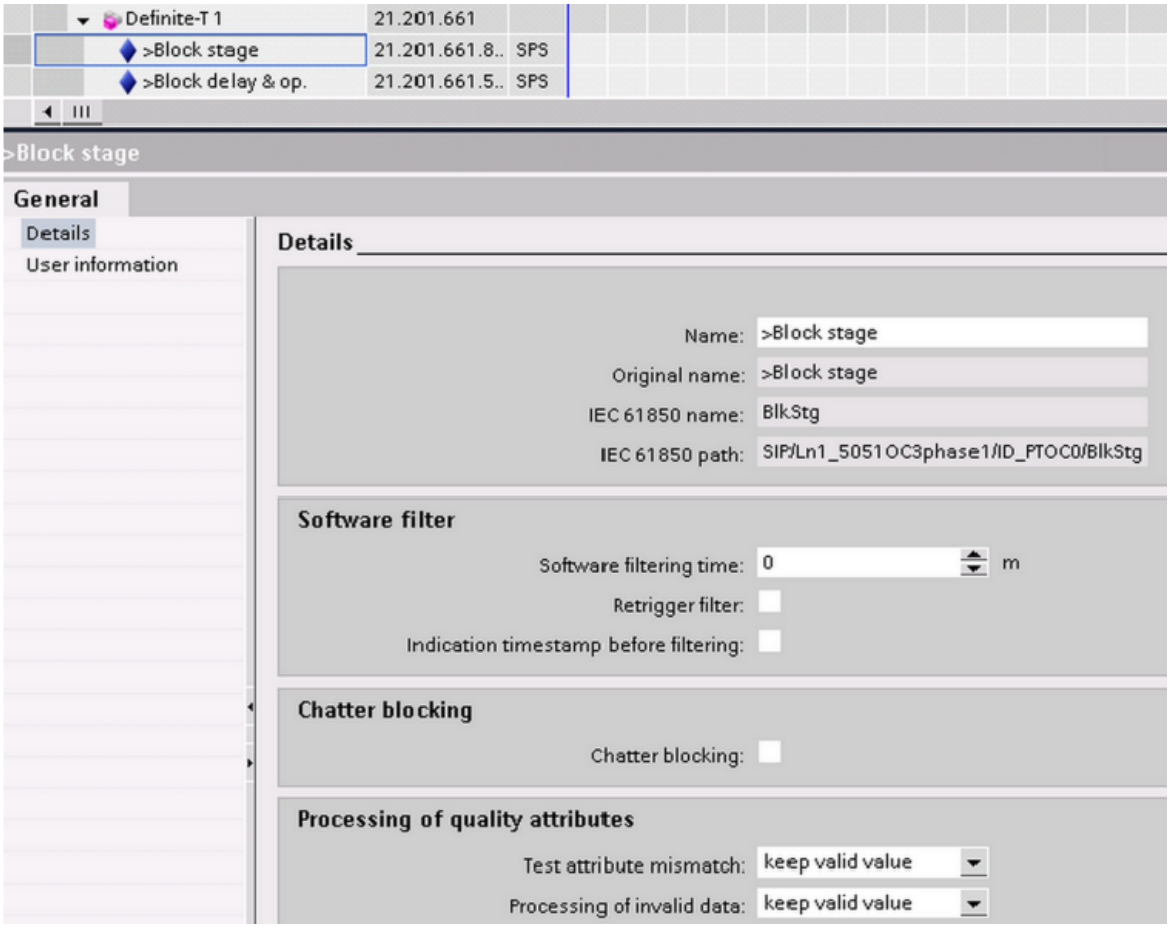


[loquali2-230212-01.tif, 2, en_US]

Figure 3-34 Sources for Connecting a Binary Input Signal

For this signal type (SPS), you can influence the processing of the quality, see overview in *Figure 3-33* .
The following figure shows the possible influence on a binary input signal of a protection stage.

- In the DIGSI 5 project tree, double-click **Information routing**.
- In the operating range, select the desired binary input signal.
- In the **Properties** window, select the **Details** entry. There, you will find the item **Processing quality attributes**.



[sceinflu de, 1, en_US]

Figure 3-35 Influence Options for a Binary Input Signal (SPS Input Signal)

Quality Attribute: Validity	
The **Validity** attribute can have the values *good* or *invalid (reserved* and *questionable* were already replaced at the input end of the device by the value *invalid*).	
The input signal source is *invalid*.	The current data value of the source signal is ignored. You can select between the following options: • Further process last valid data value of the source signal (this is the default setting with only a few exceptions) • Set the binary value to be processed further to **0**. • Set the binary value to be processed further to **1**. This configuration option is necessary to satisfy different applications. The function health switches to Warning.
The input signal source is *good*.	The source signal data value is processed further.

Quality Attribute: Test	
• The input signal source and processed function are in test state. • The input signal source is not in test state and the function to be processed is in test state.	The source signal data value is processed further.

Quality Attribute: Test	
The input signal source is in a test state and the function to be processed is in normal state.	The data value of the source signal is ignored. You can select between the following options: • Further processing of the last valid source signal data value, before the source switches to the test state (that is the default setting) • The binary value to be processed further is set to **0**. • The binary value to be processed further is set to **1**. This configuration option is necessary to satisfy different applications.

Quality Attribute OperatorBlocked
The quality cannot be influenced at this position and does not lead to a response within the logic

Output Data

The quality is not processed through the actual algorithm/logic of the function. The following table displays the conditions required to set the quality of output signals of a function.

Cause	D0 Value	Quality Attribute	
		After **internal** (to the SIPROTEC 5 system, for example, in the direction of a CFC chart)	To the IEC 61850 interface, in buffer
Functional state = **Test** (thus, result of device operating mode = **Test** or function mode = **Test**)	Unchanged	**Test** = *TRUE*	**Test** = *TRUE*
Functional state = **Off** (thus, result of device operating mode = **Off**)	Function-specific, corresponding to the definition for switched off	**Validity** = *good*	**Validity** = *invalid*
Function health = **Alarm** (for example, result of invalid receive data)	Function-specific, corresponding to the definition for reset	**Validity** = *good*	**Validity** = *invalid*
Device operating mode = **functionally logged off**	Unchanged	**Validity** = *good* **OperatorBlocked** = *TRUE*	**Validity** = *good* **detailQual** = *oldData* **OperatorBlocked** = *TRUE*

3.4 Fault Recording

3.4.1 Overview of Functions

All SIPROTEC 5 devices have a fault memory in which fault recordings are kept securely. Fault recording documents operations within the power system and the way in which protection devices respond to them. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA.

A fault record contains the following information:

- Sample values of the analog input channels
- Measured values calculated internally
- Any binary signals (for example, pickup signals and trip signals of protection functions)

You can individually configure the signals to be recorded. Furthermore, you can define the starting condition, the record duration, and the saving criterion of a recording. Fault records saved in the device are also available after a loss of auxiliary voltage.

3.4.2 Structure of the Function

The **Fault recorder** function is a central device function. Both the recording criterion and the measured-value and binary channels to be recorded are functionally preconfigured through the application templates. You are able to individually adapt the configuration in DIGSI 5. The fault recording and the fault log are subject to the same control. This ensures that real time, relative time, and numbering of the fault data are synchronized.

This means that all fault recordings function on the same real-time and relative-time basis.

The data read out via the DIGSI-PC are saved in COMTRADE format. Fault recording data can be transferred to the substation automation technology by request in accordance with the standards via existing communication connections (such as IEC 61850, IEC 60870-5-103). The central device analyzes the data using appropriate programs.

3.4.3 Function Description

The **Fault recorder** function records the sampled values, specific to each device, of all analog inputs, the internally calculated measured values and the binary signals. The configuration, which is predefined for each device via an application template, can be adapted individually.



NOTE

You can find detailed information about selecting and deleting fault records in the Operating Manual (C53000-G5000-C003).

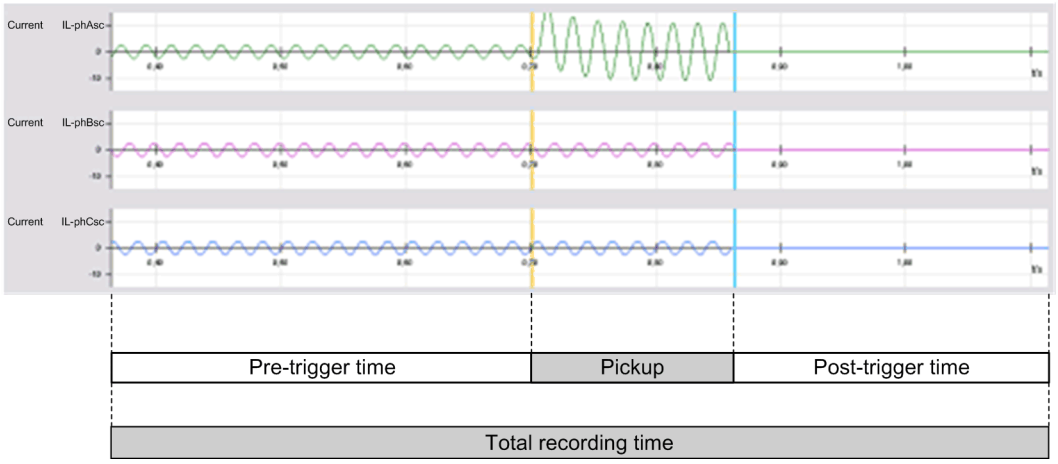
The fault memory of the device is automatically updated with every recording. When the fault memory is filled completely, the oldest records are overwritten automatically. Thus, the most recent recordings are always stored safely. The maximum number of recordings is 128.

Sampling Frequency

The analog measuring channels are sampled at a different sampling rate for fault recording. The **`Sampling frequency`** parameter is used to set the desired sampling frequency. Possible setting values are 1 kHz, 2 kHz, 4 kHz, and 8 kHz. This setting value applies only to fault recording and does not affect protection functions or calculated measured values.

Record Duration

The overall duration of a single fault recording comprises the total duration of the configurable recording criterion, the **`Pre-trigger time`** and the **`Post-trigger time`**. You can set the parameters for these components individually.



[dwsigrar-070813-01, 1, en_US]

Figure 3-36 Example of a Fault Recording

With the **Fault recording** parameter, you specify the start criterion of the recording.

You can set the following values:

- ***with pickup***:
  The fault recording records the complete fault until dropout. The resulting pickup signals of all function groups are taken into account.
- ***with pickup & AR cyc.***:
  In connection with an active automatic reclosing function (internal/external), the fault recordings record the fault including the short and long interruptions (automatic reclosing cycles).
- ***user-defined***:
  With this setting value, you can individually specify the recording criterion for the fault recording in DIGSI 5. Function-specific recording criteria can be realized in this way.

If a recording criterion reoccurs during the pickup time and post-trigger time, the recording which is currently active is extended to include a new post-trigger time.

For a sampling frequency of 8 kHz and 24 analog channels to be recorded, the duration of one individual fault recording can be up to 20 s.

The maximum record duration can be limited by the **Maximum record time** parameter.

In addition to starting the fault recording via the pickup, the following alternatives are possible:

- Externally via binary input signal *>External start* (for example, from an external protection device without fault recording by an object transferred via a GOOSE message)
- By way of a configurable input signal *>Manual start*, you can start fault records with a configurable length (parameter **Manual record time**).
- With DIGSI 5, you can start test fault records with a fixed length of 1 s.
- With a command from a central device via an existing communication connection (IEC 61850, IEC 60870-5-103)



NOTE

If a pickup signal is present continuously, the fault recording is closed after the **Maximum record time** expires and the fault record cannot be restarted!

Saving the Recording

Not every fault recording that is started actually needs to be saved. With the **Storage** parameter, you specify whether or not you want to save the fault recording that has started. You can also save only fault data for

which the pickup of a protection function also caused a tripping. With this setting, faults beyond the self-protection range will not lead to replacing fault recordings that have already been saved.

Configuration of Signals to Be Recorded

All analog inputs of the device that have been configured (currents and voltages) are recorded as sampled channels. Function-specific binary signals (for example, pickup and trip signals) and measured value channels can be configured individually for recording in the DIGSI information-routing matrix. For this purpose, a separate **Content** column is available.

The operational measured values and the measured values of the fundamental components and symmetrical components (see the Device Manual, chapters *10.3 Operational Measured Values* and *10.4 Fundamental and Symmetrical Components*) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

Numbering and Time Stamping

All fault recordings saved are automatically numbered in ascending order and assigned a real-time stamp for the start time. The fault recording logs the fault with a relative time. The reference-time point is the start of the recording. Every fault record has a corresponding fault log with the same number. This ensures that the fault recording can be uniquely assigned to the event log.

Fault Memory

The device manages its available fault memory dynamically, so that the maximum recording capacity is always available. When exceeding the limits of the fault memory, the oldest recordings are automatically overwritten. This means that the most recent records are always available. The sampling rate, type, and number of measured value trends to be recorded are the crucial variables when it comes to restricting the length and number of records possible. Parallel to the sampled tracks, up to 50 tracks with function-specific measured values and up to 100 binary tracks can be recorded. The following table provides an overview of the maximum storage capacities, in seconds, for different connection variations of the protection devices.

Table 3-6 Maximum Length of all Stored Records

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
Feeder: 4I, 6 measured values, 20 binary tracks	1365 s	819 s	455 s	241 s
Feeder: 4I, 4V, 20 binary tracks	1125 s	566 s	284 s	142 s
Feeder: 4I, 4V, 6 measured values, 20 binary tracks	890 s	500 s	266 s	137 s
Feeder 1.5 CB: 8I, 8V, 6 measured values, 20 binary tracks	525 s	281 s	145 s	74 s

Input and Output Signals

The **Fault recorder** function provides several input signals that allow the precise starting , deleting of records. The output signals provide information about the function status.

In the following table, you can find input signals of the **Fault recorder** function:

Name	Type	Description
Control: Start recording	SPC	Start recording via the function key
Control: Reset memory	SPC	Delete all recording via the function key. The error numbers are reset.
Control: Delete memory	SPC	Delete all recording via the function key. The error numbers remain as is.

Name	Type	Description
Control: >External start	SPS	Start recording by an external binary signal, for example, by the trip command of an external protection device without separate recording. The set pre and post-trigger time are taken into account.
Control: >Manual start	SPS	Start a recording of fixed duration (parameter **Manual record time**) by way of an external binary signal, for example, manually via the function key or by an external binary signal.

In the following table, you can find output signals of the **Fault recorder** function:

Name	Type	Description
General: Mode	ENC	Status feedback of the fault recording according to chapter *2.3 Function Control*
General: State	ENS	
General: Standby	ENS	
Control: Error number	INS	The indication of the current error number allows a unique allocation of entries in the message buffers for the recorded fault records.
Control: Recording started	SPS	Fault recording running

3.4.4 Application and Setting Notes

Parameter: Fault recording

- Recommended setting value **(_:2761:130) Fault recording** = ***with pickup***

With the **Fault recording** parameter, you define the time interval at which faults are recorded. The total record duration is defined as the duration of the fault plus the total of the parameters **Pre-trigger time**, **Post-trigger time** and is limited by the maximum record duration.

Parameter Value	Description
with pickup	The fault recording time is determined by the total number of all protection pickups. The resulting pickup signals of all function groups are taken into account. Note: When the post-trigger time has expired, the indications of an automatic reclosing function are not recorded. Evolving faults after expiry of the post-trigger time can result in the opening of a new fault with its own recording.
with pickup & AR cyc.	The fault recording time is determined by the total number of all protection pickups including short and long interruptions (automatic reclosing cycles). It includes the resulting pickup signals of all function groups and the runtimes of initiated automatic reclosing cycles for all active automatic reclosing functions.
user-defined	The fault recording time is defined user-specific. Note: You must specify all signals for individual definition of the fault recording time in the DIGSI 5 information-routing matrix. In the information routing matrix in the **Fault record** column, the fault recording has for this purpose a separate column **Trigger**. The record duration is calculated from the logical OR operation of all initiated, configured signals.

Parameter: Storage

- Recommended setting value **(_:2761:131) Storage** = ***always***

With the **Storage** parameter, you define the storage criterion for a fault recording that has already started.

Parameter Value	Description
always	Each fault recording that has been started is saved.
with trip	If at least one protection function issues an operate indication during the record time, any fault recording that has been started will be saved.

Parameter: Maximum record time

- Default setting **(_:2761:111) Maximum record time** = ***5.00 s***

With the **Maximum record time** parameter, you configure the maximum record duration for an individual fault recording. When the time configured expires, an ongoing fault recording is canceled. This parameter merely limits the duration of the fault recording. It does not affect the logging of faults in the fault log.

Parameter: Pre-trigger time

- Recommended setting value **(_:2761:112) Pre-trigger time** = ***0.50 s***

With the **Pre-trigger time** parameter, you configure the pre-trigger time for an individual fault recording. The set pre-trigger time is prepended to the actual recording criterion for the fault recording.

Parameter: Post-trigger time

- Recommended setting value **(_:2761:113) Post-trigger time** = ***0.50 s***

With the **Post-trigger time** parameter, you configure the post-trigger time for an individual fault recording. The post-trigger time that has been configured is added to the actual recording criterion for the fault recording after the dropout.

Parameter: Sampling frequency

- Recommended setting value **(_:2761:140) Sampling frequency** = ***8 kHz***

With the **Sampling frequency** parameter, you define the sampling frequency of the fault recording. Possible setting values are 8 kHz, 4 kHz, 2 kHz, and 1 kHz.

Parameter: Manual record time

- Recommended setting value **(_:2761:116) Manual record time** = ***0.50 s***

With the parameter **Manual record time**, you set the duration of a recording if the fault record is activated dynamically (edge-triggered) via a separately configured input signal *>Manual start*.

In this case, pre-trigger and post-trigger times do not take effect.

3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2731:1	General:Mode		• on • test	on
Control				
_:2761:130	Control:Fault recording		• with pickup • with pickup & AR cyc. • user-defined	with pickup
_:2761:131	Control:Storage		• always • with trip	always
_:2761:111	Control:Maximum record time		0.20 s to 20.00 s	5.00 s
_:2761:112	Control:Pre-trigger time		0.05 sto 4.00 s	0.50 s
_:2761:113	Control:Post-trigger time		0.05 sto 0.50 s	0.50 s

Addr.	Parameter	C	Setting Options	Default Setting
_:2761:116	Control:Manual record time		0.20 s to 20.00 s	0.50 s
_:2761:140	Control:Sampling frequency		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	2 kHz

3.4.6 Information List

No.	Information	Data Class (Type)	Type
Binary IO			
_:2731:51	General:Mode (controllable)	ENC	C
_:2731:52	General:Behavior	ENS	O
_:2731:53	General:Health	ENS	O
Binary IO			
_:2761:300	Control:Start record	SPC	C
_:2761:305	Control:Reset memory	SPC	C
_:2761:306	Control:Clear memory	SPC	C
_:2761:502	Control:>External start	SPS	I
_:2761:503	Control:>Manual start	SPS	I
_:2761:310	Control:Fault number	INS	O
_:2761:311	Control:Recording started	SPS	O
_:2761:314	Control:Record made	SPS	O
_:2761:327	Control:Tmax reduced	SPS	O

3.5 Protection Communication

3.5.1 Overview

Protection communication includes all functionalities required to exchange data via the protection interface (PI). It manages one or a maximum of 2 protection interfaces. The **Protection communication** is generated with the configuration of the channels as a protocol.

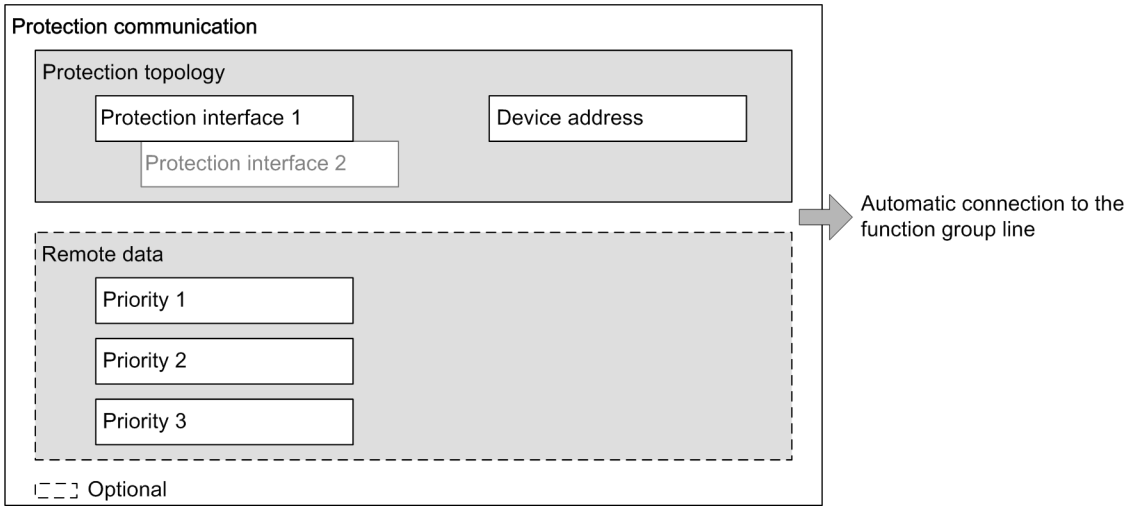
You can find detailed information in the section **Protection interface** in chapter *3.5.3.1 Overview of Functions*.

3.5.2 Protection-Communication Structure

The following **Protection communication** functions are visible:

- Topology recognition
- Remote data

The following figure shows the structure of **Protection communication**:



[dwstrufg-171012-01.tif, 1, en_US]

Figure 3-37 Protection-Data Communication Structure

Interface to VI 3-Phase Function Group

Binary signals, measured values, and other data are automatically exchanged between the **Protection-data communication** and the **VI 3-phase** protection function group.

Interface to Motor Function Group

Binary signals, measured values, and other data are automatically exchanged between the **Protection-data communication** and the **Motor** protection function group.

Remote Data

The **Remote data** functionality is applied if you route a specific signal or a measured value to the protection interfaces. The protection interface then attends to the transmitting and receiving of such signals. The maximum amount of remote data is defined by the available bandwidth.

3.5.3 Protection Interface and Protection Topology

3.5.3.1 Overview of Functions

The **Protection topology and protection interface**function enables data exchange between the devices via synchronous serial point-to-point connections from 64 Kbits/s to 2 Mbits/s. These connections can be established directly via optical fibers or via other communication media, for example, via dedicated lines or via communication networks.

A protection topology consists of 2 to 6 devices which communicate via protection interfaces. It can be set up either as a redundant ring or as a chain structure. Within a topology, the protection interfaces can have a different bandwidth. Depending on the bandwidth, a certain amount of binary information and measured values can be transmitted bi-directionally between the devices. The connection with the lowest bandwidth defines this amount (of binary information and measured values).

The following information that is significant for the function of the protection interface is also transferred. You cannot change this information:

- Topology data and values are exchanged for monitoring and testing the connection.
  The results are displayed on the device or with DIGSI 5.
- Protection data, for example, differential protection data or teleprotection scheme binary data, are transferred for distance protection and ground-fault protection.
- The devices can be synchronized in time via the connection, whereby a device of the protection topology assumes the role of the timing master.

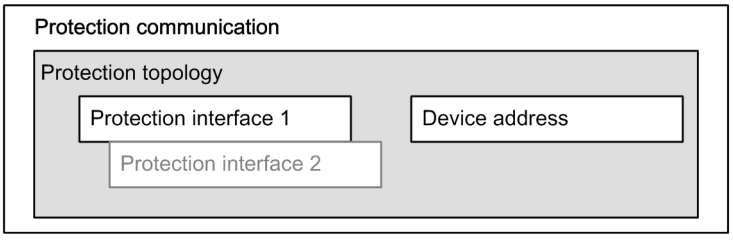
The connection is continuously monitored for data faults and outage, and the time delay of the data is measured.

The protection interfaces are typically used for differential protection and with the teleprotection scheme for distance protection and ground-fault protection. In SIPROTEC 5, you can configure protection interfaces in all devices and then use them for further protection applications. At the same time, any binary information and measured values can be transferred between the devices.

3.5.3.2 Structure of the Function

The protection interfaces of a device are located in the Protection communication function group. A device has 1 or 2 specifically parameterizable protection interfaces.

The **protection topology** is used for administration of that topology data relevant to the respective interfaces and containing data from other devices in the protection topology.



[dwstruct-030211-01.tif, 1, en_US]

Figure 3-38 Structure of the Protection Interface in a Device

The protection communication runs physically via a serial optical communication module. This module can have 1 or 2 channels. The protection communication can take place via various modules. This depends on the type of interface and the application. DIGSI 5 is used to configure 1 or 2 channels of a serial optical module as a protection interface. This enables communication with the values set at the **protection interface** via this channel.

3.5.3.3 Function Description

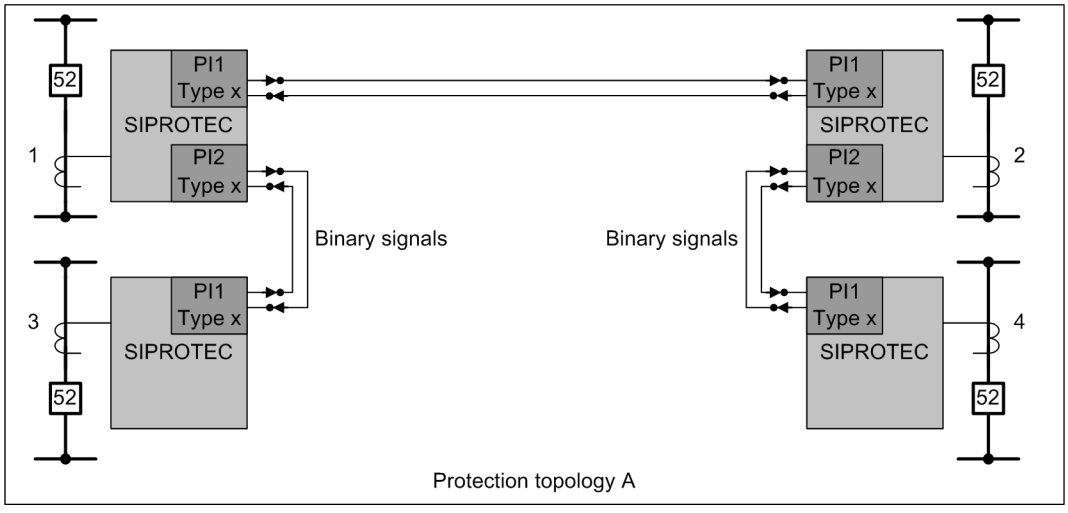
Topology and Type of Protection Communication

The protection interfaces (PI) establish a direct point-to-point connection between devices via different communication media. Data can be transferred within the switchgear or between switchgears.

Devices connected to one another with protection communication form a protection topology. Refer to *Figure 3-39*.

The protection communication in a device can be either type 1 or type 2. In the case of devices with differential protection function (7SD and 7SL), a protection communication of type 1 is automatically created. Type 2 is created for other devices, and is used for other data transmission. A device can contain only the same types of protection communication. Type 1 and type 2 protection communication do not work together in pairs via a protection function.

Types	Description
Type 1 Application using differential protection	With type 1, the differential protection function is the primary application. This application requires the greatest portion of the bandwidth, so that with type 1 the number of signals additionally available is lower. This becomes noticeable with a 64-kbps protection connection via a G703.1 or X21 interface. If a multiple-end differential-protection application is realized, all protection communications must be of type 1. A maximum of 6 line ends is possible. If the **Differential protection** und **Teleprotection scheme** functions are to operate in parallel in the device, the bit rate must not be less than 512 kbps!
Type 2 Application without using differential protection	Type 2 has a significantly higher amount of information that can be transferred as the differential-protection application is not used here. The transmission of protection data and other data, for example, measured values, is predominant here. Using type 2 protection communication, a maximum of 6 devices can be connected to one another and different device types (for example, 6MD, 7VK, 7SA, and 7SJ) can exchange data.



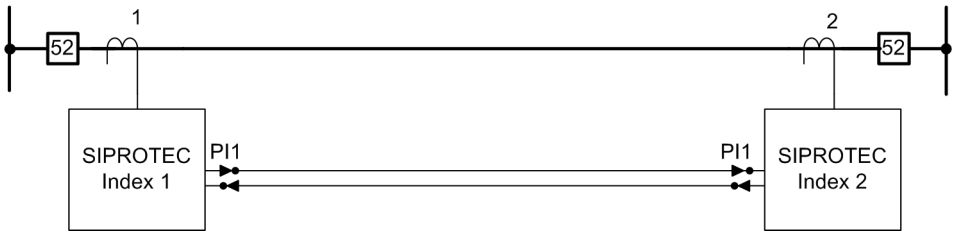
[dwintert-030211-02.tif, 1, en_US]

Figure 3-39 Data Exchange between 4 Devices with Protection Communications of Type 1 or Type 2 in a Protection Topology

2-Device Topology: Simple or Redundant Transfer

In the case of a simple 2-device topology, one protection communication per device is required (see next figure).

The most frequent application is the point-to-point exchange of data between 2 devices (the protection communication is of type 2), as performed by protection transmission devices.



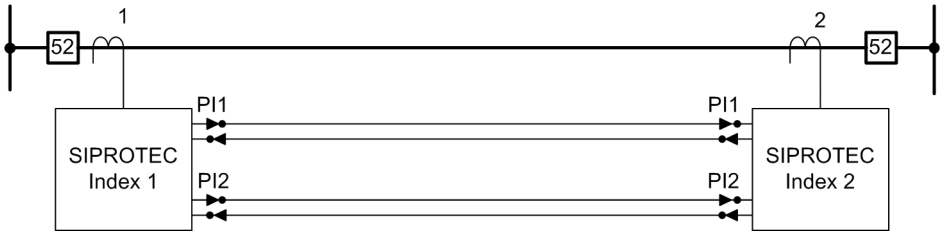
[dwinterf-030211-01.tif, 1, en_US]

Figure 3-40 Data Exchange for 2 Devices, Each Having Protection Communication

NOTE

The index describes the consecutive numbering of the devices in a protection topology (see parameter **`Local device is device`**).

A maximum of 2 protection communications can be integrated in one device (see next figure). If 2 protection communications of the same type are connected to one another, this results in 100 % redundancy regarding the transmission route. The devices then search for the communication connection with the highest bandwidth (for example, optical fiber). If this connection fails, the system switches over automatically to the 2nd connection until the 1st connection is available again. As the connection with lower bandwidth defines the maximum amount of transferable information, the same information is exchanged via both connections. Both protection communications in the device are then of type 1.



[dwintera-030211-02.tif, 1, en_US]

Figure 3-41 Data Exchange for 2 Devices, Each Having 2 Protection Communications/Redundant Transmission Route

Protection-Interface Information Transfer

With the protection-interface information transfer, customer-specific indications and measured values can be communicated via the protection interface with settable update cycles (priorities).

There are 3 different priorities when transferring protection-interface information:

- **Priority 1**: Use **Priority 1** for the transmission of fast protection signals that are transferred and updated at a maximum of every 20 ms in a telegram.
- **Priority 2**: Use **Priority 2** for the transmission of fast single-point or double-point indications that are transferred and updated at a maximum of every 40 ms.
- **Priority 3**: Use **Priority 3** for all indications, measured, and metered values that are transferred and updated a maximum of every 100 ms.

The number of customer-specific signals, indications, and measured values conform with the remaining bandwidth. The remaining bandwidth is lower than with all other protection functions (type 2) when using a differential protection (type 1). Customer-specific measured values consume more bandwidth than single-point indications.

Communication Media

The communication takes place via direct fiber-optic connections, via communication networks or via 2-wire copper conductors. Siemens recommends a direct fiber-optic connection, as this offers the highest transmission rate of 2 Mbps and is immune to failures in the communication route while offering the shortest trans-

mission time. This also enables the transmission of a large amount of additional information on differential protection routes and the remote control of devices at the remote end with DIGSI 5.

The distance to be bridged and the transmission paths available determine the settings of the protection interface. External communication converters are used for the connection to communication networks via G703.1-, X21-, or G703.6 interfaces. The connection to 2-wire copper cores also takes place via a communication converter. The C37.94 interface, for example, with 2 Mbps, offers a direct fiber-optic connection to a multiplexer with the corresponding interface.

Table 3-7 to *Table 3-8* show examples of communication connections.

In the case of a direct connection, the transmission distance depends on the fiber type of the optical fiber. This distance can also be extended via external repeaters.

The modules in the device can be replaced from outside, so that adaptation to a transmission route is possible. In the case of the 820-nm double module USART-AE-2FO with 2 channels, 2 protection interfaces can be operated on one module.

The modules can be located at slots E and F in the base device, and at slots N and P in the plug-in module assembly with integrated power supply.

When using communication converters, the connection from the device to the communication converter by a module is established via optical fibers.

Table 3-7 Plug-In Modules for Applications with the Protection Interface

Plug-In Modules	**Module Type: USART-AF-1LDFO**	**Module Type: USART-AW-2LDFO**	**Module Type: USART-AG-1LDFO**	**Module Type: USART-AU-2LDFO**	**Module Type: USART-AK-1LDFO**	**Module Type: USART-AV-2LDFO**	**Module Type: USART-AH-1LDFO[1]**	**Module Type: USART-AJ-1LDFO[2]**	**Module Type: USART-AX-2LDFO[3]**	**Module Type: USART-AY-2LDFO[4]**
Physical Connection										
1 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fibers, 4 km via 62.5/125 µm multimode optical fibers	●									
2 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fibers, 4 km via 62.5/125 µm multimode optical fibers		●								
1 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fibers			●							
2 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fibers				●						
1 x optical serial, 1550 nm, duplex LC plug, 100 km over 9/125 µm singlemode optical fibers					●					
2 x optical serial, 1550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fibers						●				
1 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Tx/Rx), simplex plug LC, 40 km via 9/125 µm singlemode optical fiber							●			

[1] USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[2] USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side
[3] USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[4] USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side

Plug-In Modules	Module Type: USART-AF-1LDFO	Module Type: USART-AW-2LDFO	Module Type: USART-AG-1LDFO	Module Type: USART-AU-2LDFO	Module Type: USART-AK-1LDFO	Module Type: USART-AV-2LDFO	Module Type: USART-AH-1LDFO[1]	Module Type: USART-AJ-1LDFO[2]	Module Type: USART-AX-2LDFO[3]	Module Type: USART-AY-2LDFO[4]
Physical Connection										
1 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Tx/Rx), simplex plug LC, 40 km via 9/125 µm singlemode optical fiber								●		
2 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Tx/Rx), 2 x simplex LC plug, 40 km via 9/125 µm singlemode optical fiber									●	
2 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Tx/Rx), 2 x simplex LC plug, 40 km via 9/125 µm singlemode optical fiber										●

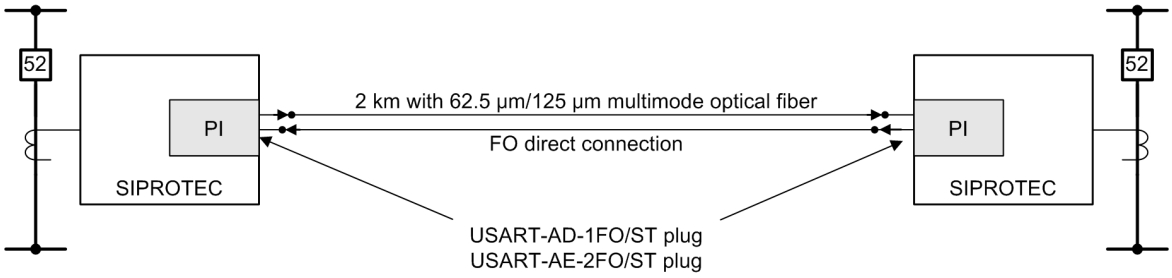
Table 3-8 Plug-In Modules USART-AD-1FO and USART-AE-2FO

Plug-In module	Plug-In Module USART-AD-1FO	USART-AE-2FO
Physical Connection		
1 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 µm multimode optical fibers	●	
2 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 µm multimode optical fibers		●
Application		
Protection interface (Sync. HDLC, IEEE C37.94)	X	X

NOTE

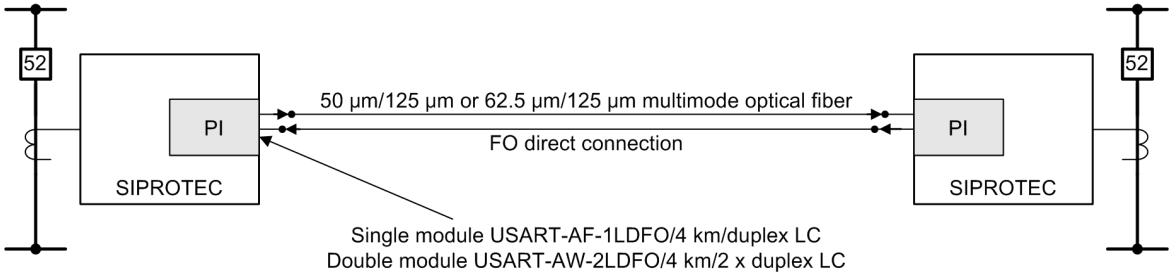
The **USART** plug-in module types can be used in slots **E** and **F** in the base module as well as in slots **N** and **P** in the CB202 expansion module. They are not suitable for use in port **M** in the **CB202** expansion module.

[1] USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[2] USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side
[3] USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[4] USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side



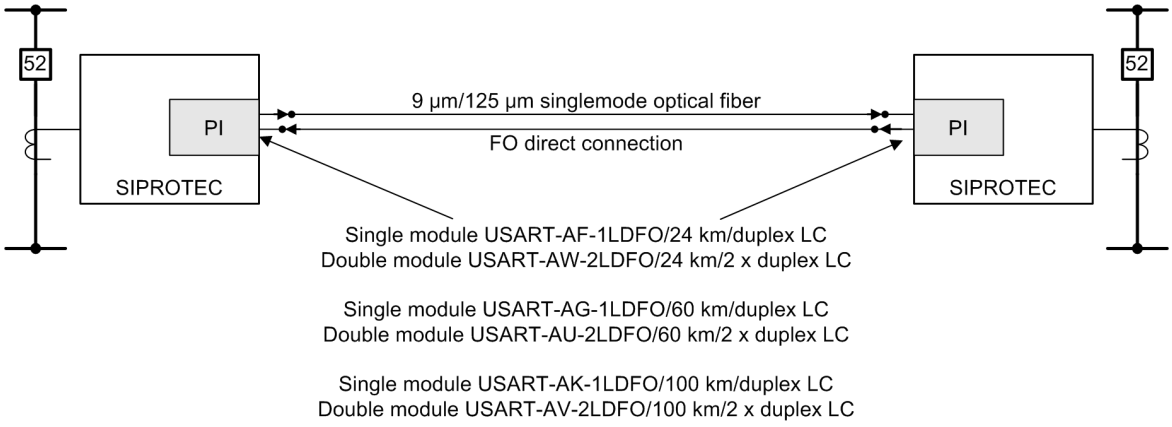
[dwmultim-070611-01.tif, 1, en_US]

Figure 3-42 Connection over Short Distances, 1.5 km to 2 km via Multimode Optical Fiber



[dwmultim-070611-02.tif, 1, en_US]

Figure 3-43 Connection over Maximum 4 km via Multimode Optical Fiber

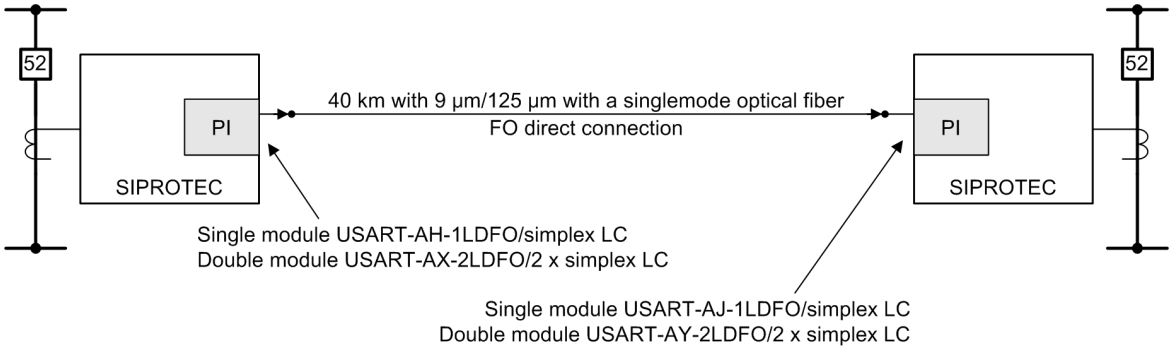


[dwsingle-070611-03.tif, 1, en_US]

Figure 3-44 Connection via Different Distances via Singlemode Optical Fiber

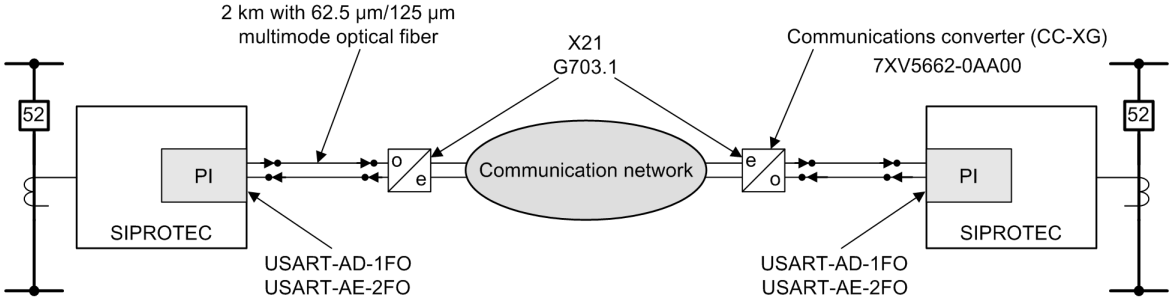
NOTE

In order to prevent optical overload of the receiver, a 7XV5107-0AA00 attenuator must be used on one side in the fiber-optic modules USART-AF, USART-AG, USART-AU, USART-AK, and USART-AV for distances of less than 25 km/50 km.



[dwsingle-020513-04.tif, 1, en_US]

Figure 3-45 Connection via Singlemode Optical Fiber

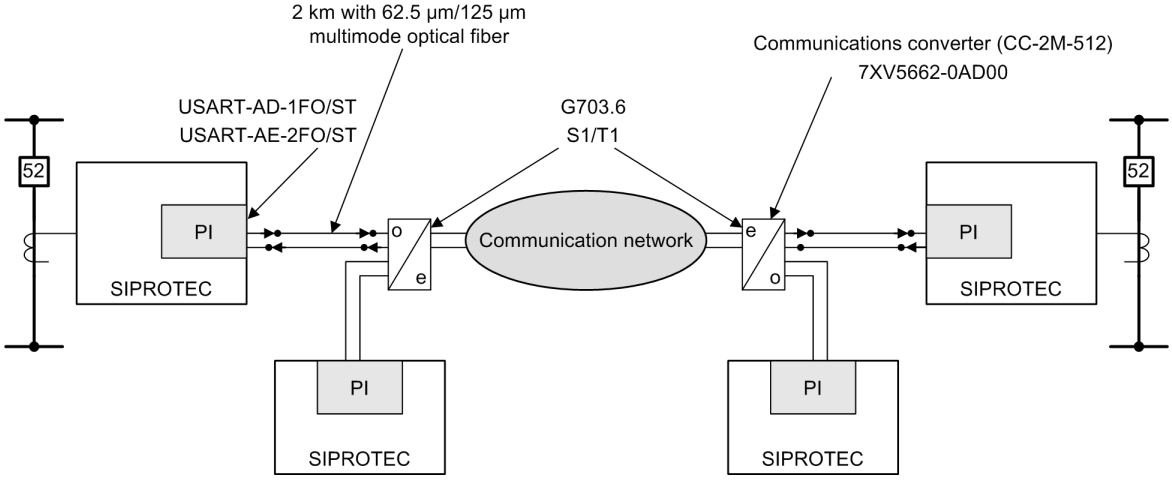


[dwmultim-070611-05.tif, 1, en_US]

Figure 3-46 Connection via Communication Network with a G703.1 Interface

The connection to the multiplexer is established via a communication converter with a G703.1 interface (64 kbps) or X21 interface (64 kbps to 512 kbps). You can set the bit rate for the KU-XG-512 (for X21), KU-XG-256 (for X21), KU-XG-128 (for X21), and KU-XG-64 (for X21 or G703.1) with the parameter **`Connection via`**.

You can find more detailed information in *Table 3-9*.

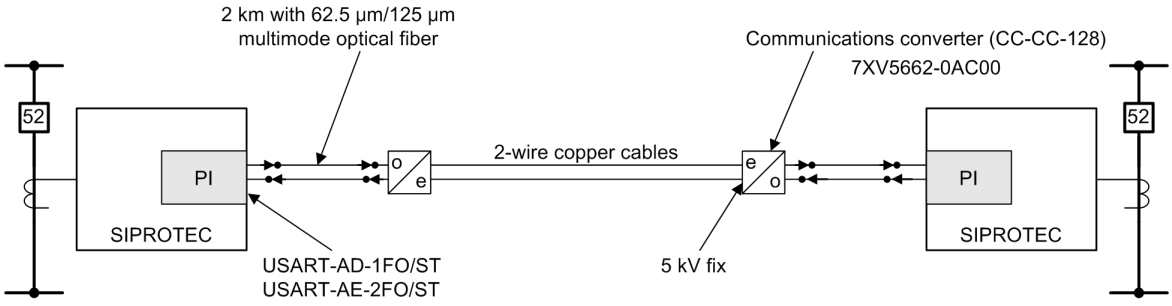


[dwmultim-070611-06.tif, 1, en_US]

Figure 3-47 Connection via Communication Network with a G703.6 Interface

The connection to the multiplexer is established with 512 kbps via a communication converter with a G703.6 interface (E1 with 2 Mbps or T1 with 1.44 Mbps). The communication converter offers a 2nd interface for connecting an additional protection interface.

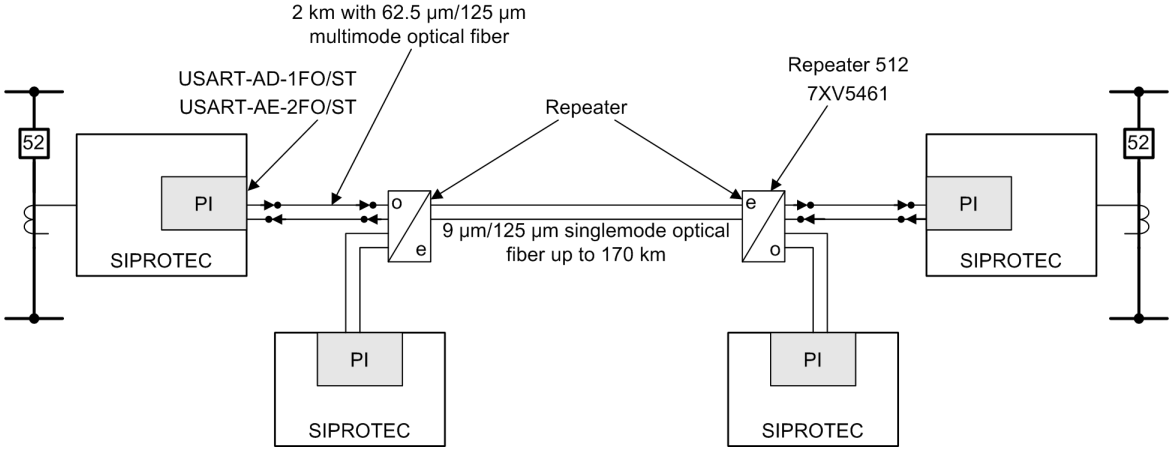
Make the setting for the bit rate with KU-2M-512 with 512 kbps in accordance with *Table 3-9* with the parameter **`Connection via`**.



[dwmulti7-070611-01.tif, 1, en_US]

Figure 3-48 Connection via 2-Wire Copper Cables

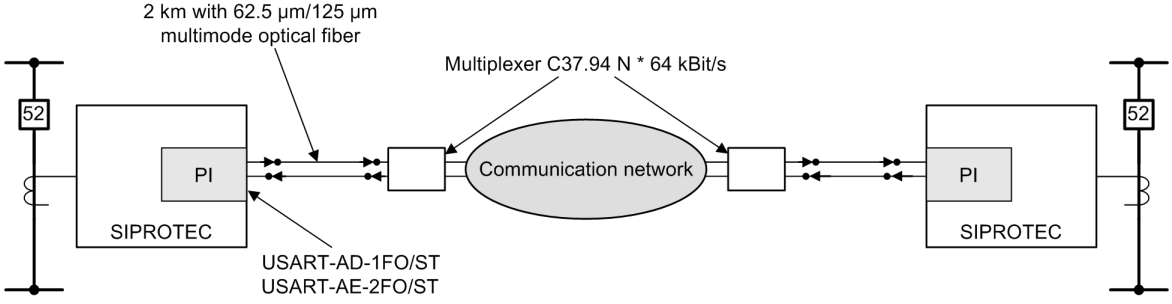
The connection to a communication converter with an integrated 5-kV isolation voltage is established with 128 kbps (KU-KU-128 setting in accordance with *Table 3-9*). A 20 kV isolation of the 2-wire connection is possible via an external 7XR9516 isolating transformer.



[dwrepeat-070611-10.tif, 1, en_US]

Figure 3-49 Direct Fiber-Optic Connection via an External Repeater

The repeater offers an interface for connecting an additional protection interface. The connection to a repeater is established with 512 kbps (repeater 512 setting in accordance with *Table 3-9*).



[dwmutip8-070611-01.tif, 1, en_US]

Figure 3-50 Direct Optical Connection to a Multiplexer with a C37.94 N * 64 kbps Interface (Time Slot N = 1; 2 or 8)

NOTE

The redundancy of different communication connections (for the ring topology) requires rigorous separation of all devices involved in the communication. Therefore, avoid different communication routes via the same multiplexer board, as no more substitute paths are possible if the board fails.

Supervision of the Communication

The communication is continuously monitored by the devices.

If a number of defective data telegrams, or no data telegrams at all, are received, this is regarded as a **failure** in the communication as soon as a failure time of 100 ms (default setting can be changed) is exceeded. A list of the measured values is shown in a window in DIGSI 5 (defective telegrams per minute/hour; transmitted and received telegrams per minute/hour, percentage fault rate per minute/hour). A corresponding failure indication is always available. If no alternative communication route exists (as in the ring topology), the protection function operating with the protection interface is not operating and the remote signals are not updated on the receiver side.

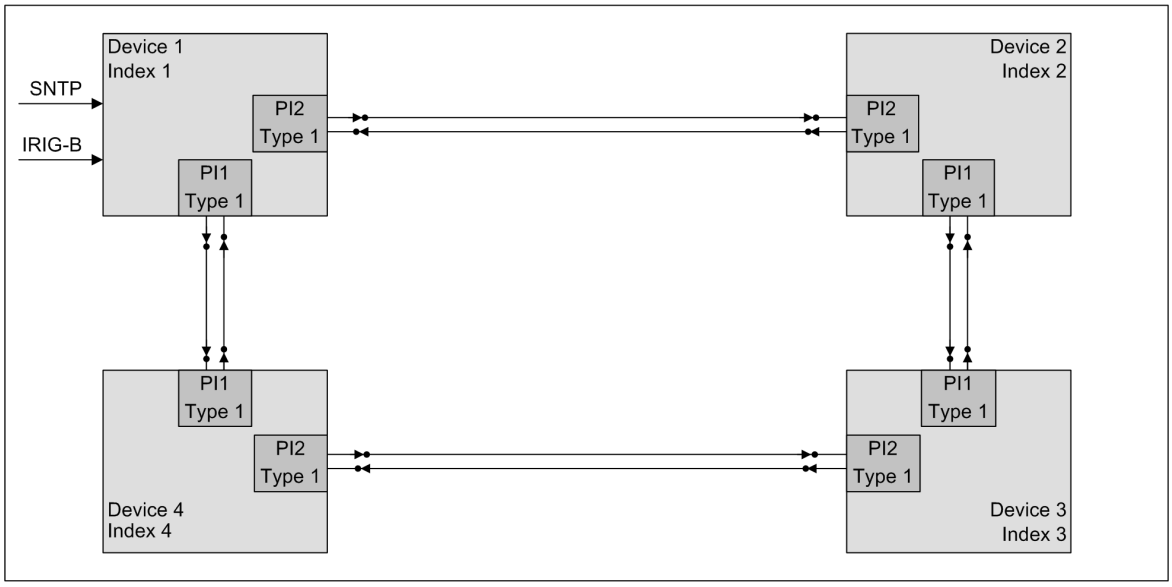
If the communication is interrupted for longer than an adjustable time **Data-connection failure**, this is regarded as a communication failure. A corresponding failure indication is always available.

Time Synchronization via the Protection Interface

All devices of a topology can be time-synchronized with one another. Synchronization is carried out with millisecond accuracy. The synchronization works independently of the protection function and is exclusively for simultaneous time keeping in the devices of a protection topology.

The device you set in the parameter **`Address of device 1`** is the device with index 1. This device functions as the timing master in a protection topology. If the timing master is logged off and switched off, the device with the next highest device index takes on the function of the timing master. The timing master synchronizes the clocks of the other devices of this topology via the protection interfaces. The time of the timing master is typically synchronized via a substation automation protocol (for example, Ethernet or SNTP) or via IRIG-B. For this, these time sources must be set as the 1st time source and optionally as the 2nd time source in the timing master. If available, the system switches over to the 2nd source upon outage of the 1st source in the timing master. This time is communicated with millisecond accuracy to the other devices of the topology.

Set the protection interface as the 1st time source in the other devices of the topology. In this way, all events in the devices of the protection topology are recorded with the same time and are time-synchronized even across different substations. This simplifies fault analysis and the fault records are recorded with the same time in all devices.



[dwtimesy-130212-01.tif, 1, en_US]

Figure 3-51 Time Synchronization in a Protection Topology

Figure 3-51 shows how device 1 with index 1 is synchronized with the devices 2, 3, and 4 via the protection interface. Device 1 is synchronized externally from 2 sources (IRIG-B and SNTP via Ethernet).

Time Synchronization of the Line Differential Protection Measured Values with Millisecond Accuracy

The measured values of the line differential protection for the various line ends are synchronized with each other with microsecond accuracy via the mechanisms of the protection interface. The protection interface displays this state with the RAISING indication *Protection interface synchronized*.

If communications problems occur, it is possible that the measured values may not be properly synchronized. In this case, the protection interface generates the CLEARED indication *Protection interface synchronized*. The line differential protection is blocked. This state can be corrected only by manual intervention.



NOTE

You can reset the synchronization of the protection interface directly in the device. Proceed as follows:
Device functions > x Device protection comm. > Protection interface y > Reset synchron.

Synchronization via GPS Second Pulse

Millisecond-accurate synchronization of the devices (1*10E-06 s), connected via protection interfaces, can take place via a high-precision GPS second pulse at the time-synchronous port G for special differential protection applications or synchrophasor measuring devices. As a result, the transmission time of the communication route can be measured and displayed separately in the forward and reverse directions. This ensures that the maximum responsivity can be obtained during differential protection, even if transmission times are unbalanced in the communication networks. Different transmission times are insignificant for the transmission of protection data with a protection communication of type 2.

Log Off the Device

A device can be logged off for protection-function tests, system inspections, or disconnection of a feeder for operational reasons. The device that is logged off no longer participates in the distributed functionality and is therefore no longer a component of the topology. The protection functions are still in operation for the other end or ends.

The following conditions are necessary for a successful logoff of the device from the point of view of protection communication:

- The protection topology is not in a transient state and is stable in operation without switchovers.
- The local device is one of the 2 token masters if there is a chain topology. The token masters are the devices at the ends of the chain.
- The circuit breaker must be open and current must not be flowing.



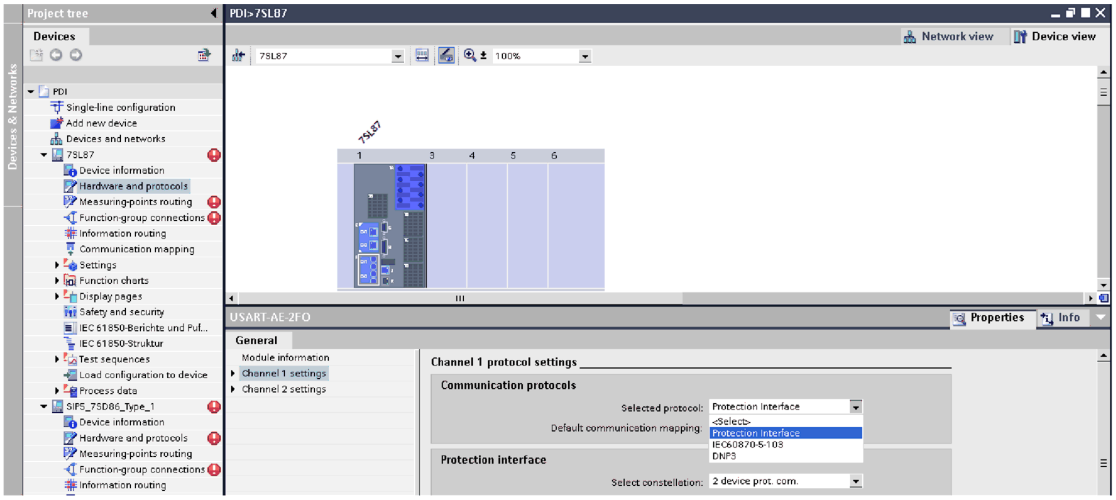
NOTE

If one of these conditions is not fulfilled, the device cannot be logged off.

3.5.3.4 Initialization and Configuration of the Protection Interface in DIGSI 5

If the device is provided with modules, proceed as follows:

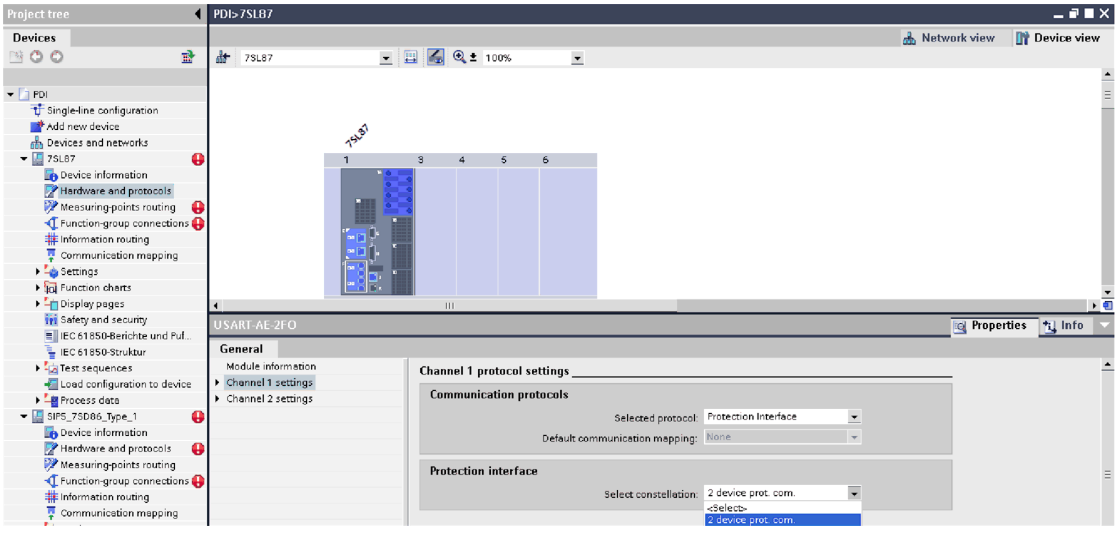
- Select the desired communication module in the rear view of the device.
- Use the **Communication protocols** text box to select the protection interface. A text box entitled **Protection interface** will then appear.



[scconfcp-241110-01.tif, 1, en_US]

Figure 3-52 Selection of the Communication Protocol

- Then select the **Select constellation** text box to select the number of devices (see next figure).



[scconfws-241110-01.tif, 1, en_US]

Figure 3-53 Selecting the Constellation

NOTE

You have the option of changing the number of devices (for example **2 protection communication devices**) depending on the product code any way you like via the **Select constellation** text box.

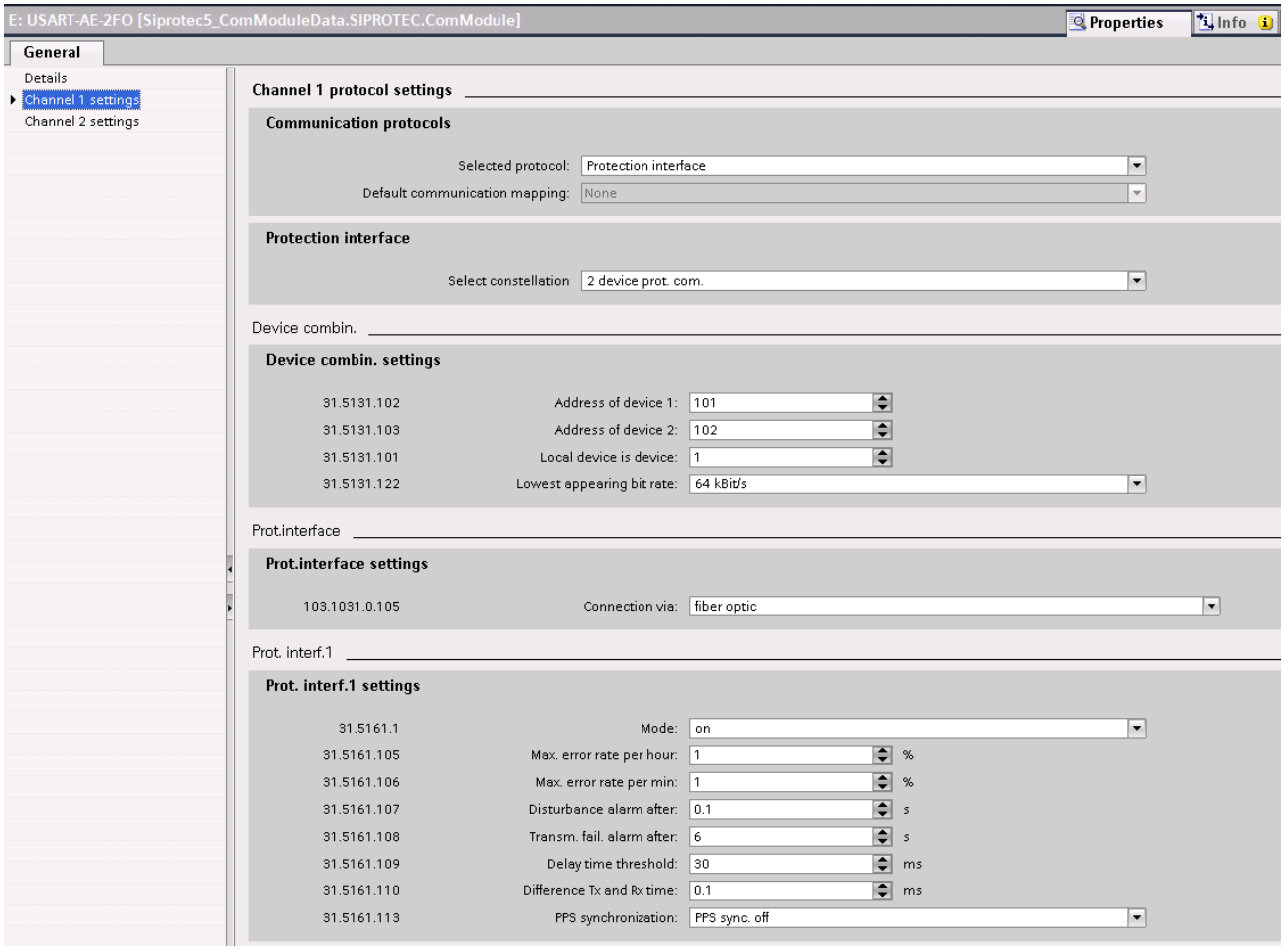
If you change the number of devices via the **Select constellation** text box, all activated constellation settings are lost.

If the module slot is not yet provided with modules, proceed as follows:

- Select the desired communication module in the rear view of the device.
- Select the module from the catalog and drag it to a channel. Thus is the channel configured with a module. DIGSI 5 indicates whether the module can be used for protection communication under **Device Information**.
- Use the **Communication protocols** text box to select the protection interface. A text box entitled **Protection interface** will then appear (see *Figure 3-52*).
- Then use the **Select constellation** text box to select the number of devices (for example **2 devices protection com.**) (see *Figure 3-53*).

3.5.3.5 Device-Combination Settings

Make the device-combination settings and the settings for protection communication (see next figure).



[scconfig-181013-01, 1, en_US]

Figure 3-54 Protection Interface Initialization and Configuration

Changes in a channel are always visible on the other channel as well. All further parameters can be set separately for individual channels.

Setting Device-Combination Settings

- Default setting **(_:5131:102) Address of device 1** = ***101***
- Default setting **(_:5131:103) Address of device 2** = ***102***
- Default setting **(_:5131:104) Address of device 3** = ***103***

- Default setting **(_:5131:105) Address of device 4** = ***104***
- Default setting **(_:5131:106) Address of device 5** = ***105***
- Default setting **(_:5131:107) Address of device 6** = ***106***

The parameters **Address of device 1** to **Address of device 6** can be used to give an address to each device. Set a unique and unambiguous address for each device.

- Default setting **(_:5131:101) Local device is device** = ***1***

With the **Local device is device** parameter, you set the index (number) of your device in the topology. A maximum of 6 devices can be present in one topology.

APPLICATION EXAMPLE

You have a topology with 2 devices.

For example, in DIGSI 5, select the parameter setting **Address of device 1** with the parameter value ***101*** for device 1 and the parameter setting **Address of device 2** with the parameter value ***102*** for device 2.

Then, use the **Local device is device** parameter to set the index of the local device.

The addresses must be configured identically for all devices involved in the constellation. A functional protection communication requires that you also assign the same index in all devices of a constellation for a device with a unique address.

- Default setting **(_:5131:122) Lowest appearing bit rate** = ***64 kBit/s***

The **Lowest appearing bit rate** parameter is used to set the smallest occurring bit rate in the device group. Set the smallest value in each device with a three-end constellation with 2 fiber-optic connections (2 MBit/s) and a 64-kBit/s connection with the lowest value (64 kBit/s). This value determines the maximum signals and measured values within a constellation.

Apart from the default value, you can also set the following bit rates:

- ***128 kBit/s***
- ***512 kBit/s***
- ***2048 kBit/s***

NOTE

If you use fiber-optic cables for the connection between the devices, set the value to ***2048 kBit/s*** .

3.5.3.6 Selecting the Connection

- Default setting **(_:105) Connection via** = ***fiber optic***

The **Connection via** parameter is used to set the bit rate required for the protection interface. Different discrete values can be entered depending on the means of communication (see following table).

Table 3-9 Means of Communication

Means of Communication	See	Setting Value	Bit Rate
Fiber-optic direct connection	*Figure 3-42* to *Figure 3-45*	***fiber optic***	2 MBit/s
CC-XG-512 communication converter	*Figure 3-46*	***CCXG 512 kBit/s***	512 kBit/s
CC-XG-128 communication converter	*Figure 3-46*	***CCXG 128 kBit/s***	128 kBit/s
CC-XG-64 communication converter	*Figure 3-46*	***CCXG 64 kBit/s***	64 kBit/s

Means of Communication	See	Setting Value	Bit Rate
Repeater 512 communication converter	*Figure 3-49*	***repeater 512 kBit/s***	512 kBit/s
CC-CC-128 Communication converter	*Figure 3-48*	***CCPW 128 kBit/s***	128 kBit/s
CC-2M-512 Communication converter	*Figure 3-47*	***CC2M 512 kBit/s***	512 kBit/s
Multiplexer with C37.94 interface	*Figure 3-50*	***C37.94 1 * 64 kBit/s*** ***C37.94 2 * 64 kBit/s*** ***C37.94 8 * 64 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s
Other (freely adjustable bit rates for a direct connection for special applications)		***64 kBit/s*** ***128 kBit/s*** ***512 kBit/s*** ***2048 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s

NOTE

Keep in mind that the **Teleprotection schemes** require a minimum bandwidth for communication via a protection interface.

If the **Line differential protection** function is available in the device, the bit rate must not be less than 512 kBit/s!

The minimum bit rate of 512 kBit/s is important for the **Teleprotection with distance protection** and **Teleprotection with ground-fault protection** functions.

3.5.3.7 Setting Notes for the Protection Interface

Parameter: Max. Error Rate/h

- Default setting **(_:5161:105) Max. error rate per hour** = ***1.0 %***

The **Max. error rate per hour** parameter allows you to receive an error message on the number of faults per hour. An indication is then generated.

Parameter: Max. Error Rate/min

- Default setting **(_:5161:106) Max. error rate per min** = ***1.0 %***

The **Max. error rate per min** parameter allows you to receive an error message on the number of faults per minute. An indication is then generated.

Parameter: Disturbance Alarm After

- Default setting **(_:5161:107) Disturbance alarm after** = ***100 ms***

The **Disturbance alarm after** parameter determines the time delay after which defective or missing telegrams are signaled as faulty.

Parameter: Transm. Fail. Alarm After

- Default setting **(_:5161:108) Transm. fail. alarm after** = ***6.0 s***

The **Transm. fail. alarm after** parameter is used to set the time after which a failure of the communication is signaled.

NOTE

If the setting values of the parameters **Disturbance alarm after** and **Transm. fail. alarm after** are exceeded, then an indication is generated.

Parameter: Delay time threshold

- Default setting **(_:5161:109) Delay time threshold** = ***30.0 ms***

For the **Delay time threshold**, the default setting is selected such that it is not exceeded by normal communication networks. If this time delay is exceeded during operation (for example, upon switchover to another transmission route), the indication **Time delay exceeded** is issued.

Parameter: Difference Tx and Rx time

- Default setting **(_:5161:110) Difference Tx and Rx time** = ***0.1 ms***

The **Difference Tx and Rx time** parameter can be used to set a maximum time-delay difference between the send and receive paths.

Set this value to ***0*** for a direct fiber-optic connection. A higher value is necessary for transmission via communication networks. Reference value: ***0.1 ms*** (recommended setting value).

NOTE

Only if the **Line differential protection** function is instantiated, the **Difference Tx and Rx time** parameter is displayed.

NOTE

If the user employs a multiplexer with a C37.94 interface as a communication medium, Siemens recommends a setting value of ***0.25 ms*** to ***0.6 ms***.

Parameter: PPS Synchronization

- Default setting **(_:5161:113) PPS synchronization**=***PPS sync. off***

If the SIPROTEC device operates with PPS synchronization (PPS: pulse per second), use the **PPS synchronization** parameter to define how the protection is activated after restoration of the communication connection (basic state or after transmission fault).

Refer to *Figure 3-55*.

NOTE

The PPS measurement is used to consider the time delay in the send and receive directions. If PPS fails due to a reception fault or due to a short-term unfavorable satellite position, synchronization via conventional communication media remains active.

The **PPS synchronization** parameter offers 3 different setting options:

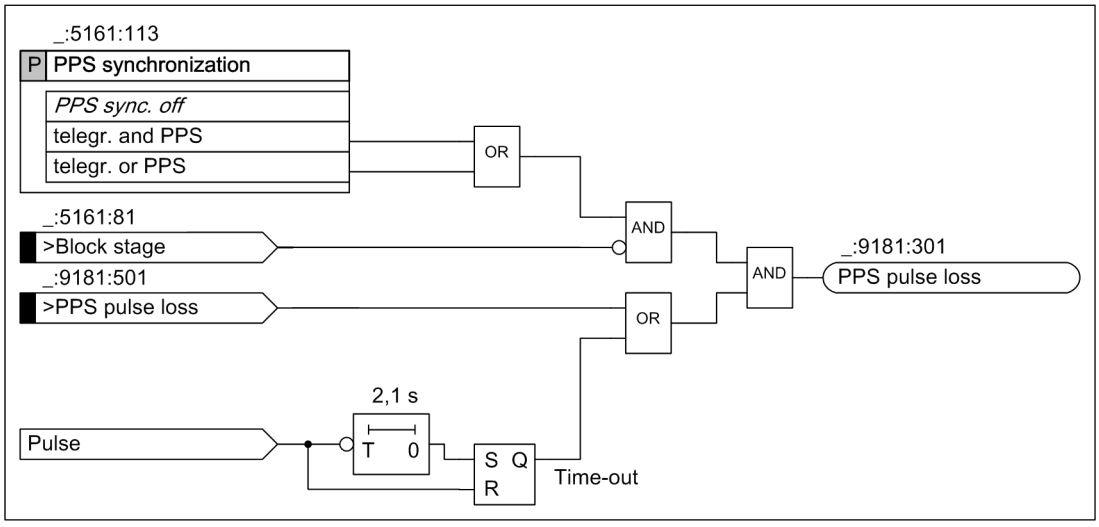
Parameter Value	Description
telegr. and PPS	With this setting, the differential protection is only enabled upon renewed establishment of the connection, if the communication section is synchronized via PPS or if symmetrical time delays are signaled by an external operation (binary input). This results in synchronization with the telegram measurement supported by the PPS measurement.
telegr. or PPS	In this setting, the differential protection is enabled immediately upon renewed establishment of connection (data telegrams are received). The conventional method is used up to synchronization. This results in synchronization with the telegram measurement supported by the PPS measurement.

Parameter Value	Description
PPS sync. off	This setting means that no synchronization is performed via PPS at the protection interface. This is typically the case if no time-delay differences are expected. The synchronization only takes place with the telegram measurement.

NOTE

The synchronization mode can be set separately for both protection interfaces.

If no further PPS pulse is received within 2.1 s, the time-out supervision responds. If no new 2nd pulse occurs after the expiry of the supervision time, the indication **PPS pulse loss** is issued.



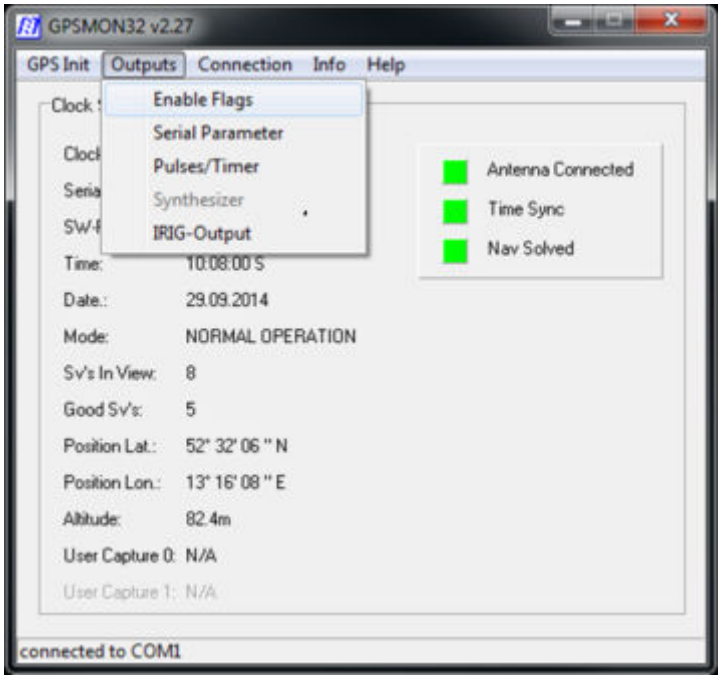
[loppssyn-100113-01.tif, 1, en_US]

Figure 3-55 Setting the PPS Synchronization

The binary input **>PPS pulse loss** can be used to signal an externally detected failure in the PPS signal (for example, error message from the receiver). Setting this binary input also leads to the indication **PPS pulse loss**.

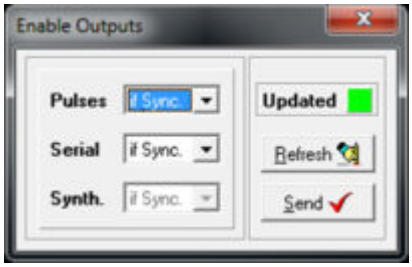
If you are using a second pulse from a GPS receiver, you must ensure that a loss of reception or reception disturbances do not generate a second pulse. The GPS receivers recommended by Siemens are set by default so that a loss of reception or reception disturbances do not generate a second pulse. In the event of problems, check the setting value for the second pulse.

Siemens recommends the **Meinberg 164** GPS receiver. Check the default setting for the second pulse using the **GPSMON32** program. The program is available in the SIPROTEC *download area*. You can find the setting value under **Outputs** →**Enable Flags**. The second pulse must be set to the value ***if Sync.***



[scGPS_1, 2, --_--]

Figure 3-56 Checking the Setting Value for the 2nd Pulse Using the GPSMON32 Program, Step 1



[scGPS_2, 2, --_--]

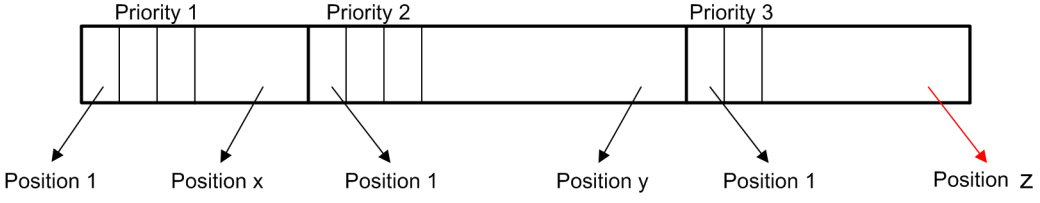
Figure 3-57 Checking the Setting Value for the 2nd Pulse Using the GPSMON32 Program, Step 2

3.5.3.8 Routing Information in DIGSI 5

Protection communications of the same type form a topology.

For more information on this, see chapter *3.5.3.3 Function Description* .

A data bar is exchanged between the devices of a topology connected via protection communication. This can be written into or read from by the devices. This can be used for exchanging various signals between the devices. In this case, each signal demands a certain number of data fields.



[dwdatenl-100113-01.tif, 1, en_US]

Figure 3-58 Data Bar Exchanged Between Devices

The data bar is divided into 3 priorities, which also have different transmission rates and data volumes.

The following basic principle applies for all messages: Only pure data contents are transmitted. The quality (for example, *valid*) is not automatically transmitted as well. If you want to transmit the quality as well (for

example, for further processing of GOOSE messages), the quality must be transmitted separately (for example, by using CFC). If a signal that has a test flag is transmitted (because its function is in test mode, for example), all signals are provided with a test flag on the receiving side. If the connection is broken, all received signals are flagged with the quality *Invalid*. If desired, the value can also be set to a secure state after a selectable dropout time, or the last value received can be retained (***Hold*** setting). This can be configured separately for each received signal (see *Table 3-13*).

NOTE

For **ACT** type signals, only the phase information is transmitted.

Indications that are transferred data fields of priority 1 are sent with every telegram. They are preferably used for the transmission of rapid signals, for example, release for circuit-breaker intertripping. A strictly deterministic, rapid transmission is required there.

Signals of priority 2 are transmitted with at least every 2nd telegram. For bit rates >256 kBit/s, there are no differences between priority 1 and priority 2.

Priority 3 information is transmitted at least every 100 ms. This priority is used for transmission of measured and metered values. Complex values must be routed separately as the real and the imaginary part for transmission. Measured-value thresholds that lead to an updating of a measured value are set centrally as a property of the measured value. These measured-value thresholds apply with the corresponding reporting, for example, also for the transfer via IEC 61850 to a substation automation technology.

Indications which are written to a data area x under a priority on the data bar must be routed to an indication of the same type in the device reading this information. Otherwise, they are processed incorrectly on the receiving side. The data bar is organized in terms of bits. For information on the bit requirement of each signal type, refer to *Table 3-12* .

Table 3-10 and *Table 3-11* show the number of data areas in the data bar in relation to the available baud rate.

NOTE

The **`Lowest appearing bit rate`** parameter, which has to be set in each device for the protection interfaces of a topology, defines the number of data areas as well as the topology type.

If, for example, in a three-end constellation with a type 2 chain topology two devices are connected via direct optical fibers and 2 devices via the 64-kBit/s weakest line, the 64-kBit/s section is the limiting factor for the entire constellation.

Table 3-10 Available Bits - Minimum Constellation Baud Rate 64/128 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	8 Bits	24 Bits	128 Bits
Type 2	32 Bits	64 Bits	256 Bits

Table 3-11 Available Bits - Minimum Constellation Baud Rate 512/2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	48 Bits	128 Bits	384 Bits
Type 2	96 Bits	200 Bits	1024 Bits

Table 3-12 Requirement in Bits

Signal Type	Size in Bits
SP (single-point indication)	1 Bit
DP (double-point indication)	2 Bits
IN (metered values)	32 Bits

Signal Type	Size in Bits
MW (measured values)[5]	32 Bits
ACT	4 Bits

Table 3-13 Possible Dropout Values

Signal Type	Dropout Values
SP (single-point indication)	Outgoing, Incoming, Hold
DP (double-point indication)	On, Off, Intermediate Position, Disturbed Position, Hold
IN (metered values)	0, Hold
MW (measured values)	0, Hold
ACT	Hold

NOTE

If the protection link fails, these values can be set on the receiver side.

EXAMPLE

2 devices are connected via a 64-kBits channel. This is a type 1 topology. 8 bits are freely available for priority 1. Now, for example, 4 SPS and 2 DPS can be routed:

4 x 1 Bit + 2 x 2 Bits = 8 Bits

NOTE

Measured values are transmitted as primary values.

EXAMPLE

For the rated current display in the receiving device

When I_{rated} = 1000 A in the transmitting device and I_{Load} = 200 A, the number 200 is displayed in the receiving device.

Remote Data Transmission: Routing of the Indications and Measured Values to the Protection Interface

The transmission is organized in the form of a data bar which is continuously exchanged between the devices. For this, see *Figure 3-58* .

A device indication or measured value is allocated to a definite data area of the bar.

Figure 3-59 to *Figure 3-62* show the routing for a communication topology of protection interface type 1.

To transmit signals to other devices, these signals must be routed in the communication matrix under **Transmit**. Binary inputs 1 and 2 are single-point indications (SPS) and are routed to position 1 and position 2 of the transmission with the highest priority (priority 1). For 64 kBit/s, for example, only 8 of these data areas are available for type 1; they are exchanged between the transmission routes with each telegram. Signals 3 and 4 are double-point indications (DPS), for example, a switch position that is transmitted by a device 1. A double-point indication occupies 2 positions on the data bar. In addition, a measured and metered value are communicated via priority 3.

As a measured or metered value uses 32 bits, value 2 starts at position 33. DIGSI 5 indicates the next available position.

[5] The complex vectors of a measuring point are pre-routed

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive					Transmit	
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61							*		
Binary inputs	61.1051							*		
Binary input1	61.1051.3151							*		
Value	61.1051.315...	SPS						X	1	1
Binary input2	61.1051.3152							*		
Value	61.1051.315...	SPS						X	1	2

[scransps-021210-01.tif, 1, en_US]

Figure 3-59 Routing of Single-Point Indications to the Protection Interface in Device 1

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive					Transmit	
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61							*		
F:USART-AE-2FO	101									
J:Integrated Ethernet interface	102									
Circuit breaker 1	201									
Line 1	21							*		
General	21.9001									
Group indicat.	21.4501									
Process monitor	21.1131									
Operational values	21.761							*		
Behavior	21.761.1147...	ENS								
Health	21.761.1147...	ENS								
f	21.761.1021...	MV						X	3	1

[scrangmw-021210-01.tif, 1, en_US]

Figure 3-60 Routing of Measured Values to the Protection Interface in Device 1

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61							*		
F:USART-AE-2FO	101									
J:Integrated Ethernet interface	102									
Circuit breaker 1	201									
Line 1	21							*		
2 device prot. com.	31							*		
Device combin.	31.5131							*		
Behavior	31.5131.52	ENS								
Health	31.5131.53	ENS								
Status of topo. recog.	31.5131.301	ENS								
Topology is	31.5131.302	ENS								
Devices form	31.5131.303	ENS								
Number of detect. dev.	31.5131.304	INS						X	3	33

[scrangzw-021210-01.tif, 1, en_US]

Figure 3-61 Routing of Metered Values to the Protection Interface in Device 1

This device also receives information (in the matrix under **Receive**). This must have been routed as a target for other devices (see next figure). The binary outputs 1 and 2 in device 1 receive their information via the protection interface. This is priority 1 information, which has been routed in another device to position 3 and 4 of the data bar. The secure state is defined in the **Fallback value** column. If the data connection fails, the single-point indication is reset to ***coming*** or **going** or its value is retained (***hold***). For data of the various priorities, you can also set a dropout time after which the resetting (see *Figure 3-61*) to the fallback value occurs, in order to retain the original state for a short time in the event of brief interruptions. These 3 dropout times apply for all data of one transmission priority and are set as parameters.

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61			*						
Binary inputs	61.1051									
Binary outputs	61.1061			*						
Binary output1	61.1061.3181			*						
Value	61.1061.318...	SPS		X	1	3	Hold			
Binary output2	61.1061.3182			*						
Value	61.1061.318...	SPS		X	1	4	Hold			

[scspsemp-021210-01.tif, 1, en_US]

Figure 3-62 Routing of Single-Point Indications (Receive) to the Protection Interface in Device 1

The following figure shows the routing in the 2nd device. Binary inputs 1 and 2 are routed with priority 1 to positions 3 and 4 there. In device 1, positions 1 and 2 are already occupied (see *Figure 3-59*). If you also route the signals to positions 1 and 2, the signals of the devices are then connected to the corresponding position with a logical **OR** operation. If measured and metered values are routed in the same data areas, this results in implausible values for the receivers that read the data. As a user, you are therefore responsible for the correct routing.

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61							*		
Binary inputs	61.1051							*		
Binary input1	61.1051.3151							*		
Value	61.1051.315...	SPS						X	1	3
Binary input2	61.1051.3152							*		
Value	61.1051.315...	SPS						X	1	4
Binary input3	61.1051.3153									

[scbaspsr-021210-01.tif, 1, en_US]

Figure 3-63 Routing of Single-Point Indications to be Sent to the Protection Interface in Device 2

The binary outputs 1 and 2 (**Receive**) in the 2nd device are connected to priority 1 signals 1 and 2 from the 1st device. This takes place via the data areas at positions 1 and 2 of the data bar, which transfer the state of the indications. Other devices can also read this information and link it to their internal signals. Here, too, the secure state, which is assumed when the protection connection is interrupted, is entered. This state depends on the information. In the case of single-point indications, the state is 0 or 1. In the case of double-point indications, the bit combinations 00, 01, 10, or 11 are possible, in order to directly signal a disturbed position upon failure of the data connection, for example.

Hold is used to retain the state.

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61			*				*		
Binary inputs	61.1051							*		
Binary outputs	61.1061			*						
Binary output1	61.1061.3181			*						
Value	61.1061.318...	SPS		X	1	1	Hold			
Binary output2	61.1061.3182			*						
Value	61.1061.318...	SPS		X	1	2	Hold			

[scbausps-021210-01.tif, 1, en_US]

Figure 3-64 Routing of Received Single-Point Indications to the Protection Interface in Device 2

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	...	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
Power system	11									
Circuit breaker 1	201									
Line 1	21			*						
General	21.9001			*						
userdefined MV		MV		X	3	1	Hold			
Operational values	21.761									
Fund./sym.comp.	21.771									
87 Line diff. prot.	21.821									
2 device prot. com.	31							*		

[scbausmw-021210-01.tif, 1, en_US]

Figure 3-65 Routing of Received Measured Values to the Protection Interface in Device 2

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	I...	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
Recording	51									
Circuit breaker 1	201									
Line 1	21			*						
General	21.9001			*						
userdefined INS		INS		X	3	33	Hold			
2 device prot. com.	31									
Device combin.	31.5131									
Number of detect. dev.	31.5131.304	INS								

[scbauszw-021210-01.tif, 1, en_US]

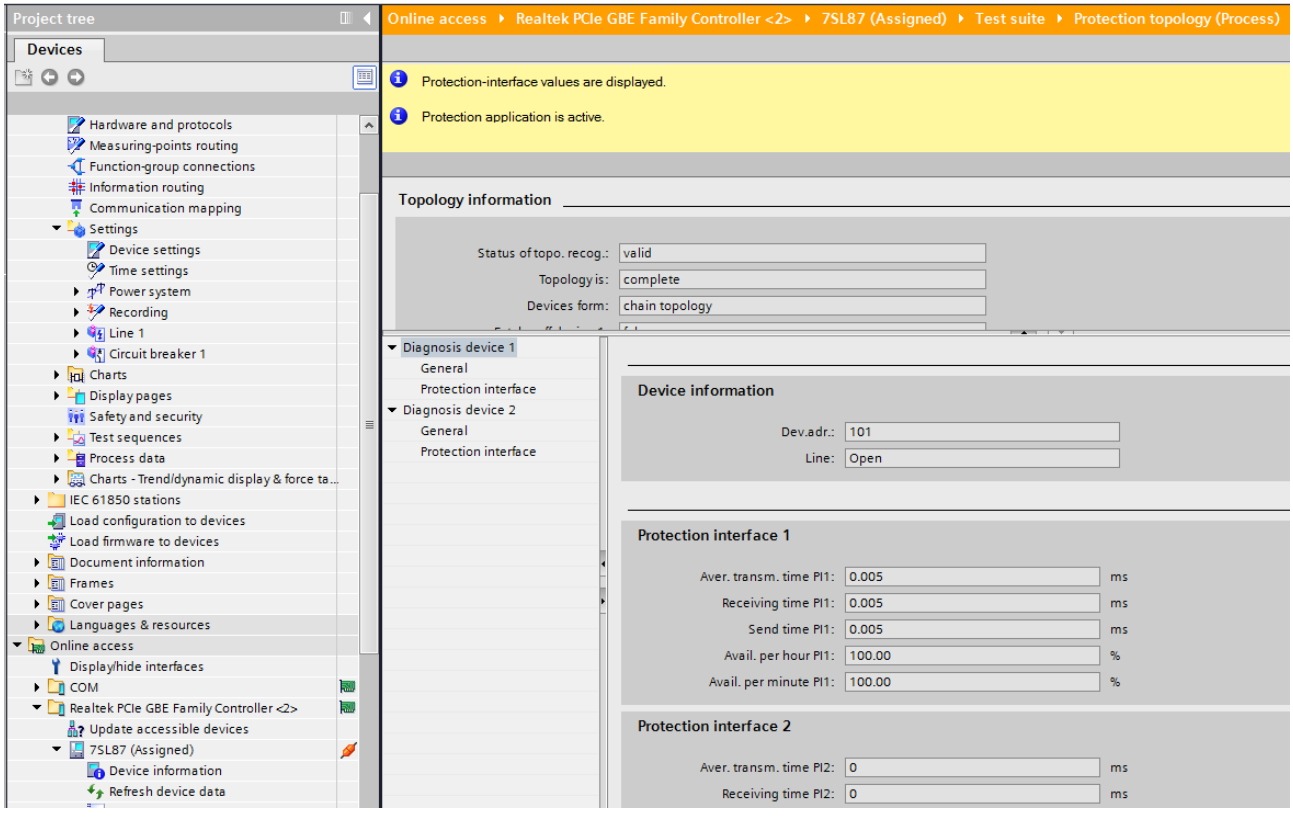
Figure 3-66 Routing of Metered Values to the Protection Interface in Device 2

3.5.3.9 Diagnostic Measured Values of the Protection Interface

The following diagnostic data is provided via the protection interfaces by the devices in the constellation:

- Address of the device in the constellation
- Circuit-breaker switch position (open/closed/undefined) (only for protection interfaces of type 1)
- Availability of protection-interface communication within the last minute, as percentage
  Availability of protection-interface communication within the last hour, as percentage
- Time delay in the send and receive direction of the telegrams between local and neighboring device

You can find this diagnostic data in DIGSI under the following menu structure (see *Figure 3-67*):



[sc_diagnose_wskanäle_geräteadresse, 2, en_US]

Figure 3-67 Protection-Interface Channel Diagnostic Data – Device Address

NOTE

You can use the following procedure to reset the measured values for the protection interface directly in the device:

Device functions > x Device protection comm. > Protection interface y > Reset measured values.

Output Signals of the Protection Interface

Each individual protection interface provides the following indications for commissioning and diagnosing communication:

Indication	Description
(_:5161:301) Status of lay. 1 and 2	The output signal gives you information about the state of communication layers 1 and 2 (1: Physical Layer, 2: Data Link Layer). The following indications values are possible: • *Initialized*: The protection interface is not connected and is in the Initial state. • *Protection interface connected*: The protection interface is connected to the protection interface of a device. • *Protection interface disturbance*: The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:107) Disturbance alarm after**. • *Protection interface failure*: The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:108) Transm. fail. alarm after**. • *not present*: The protection interface has not been assigned to a communication channel.

Indication	Description
(_:5161:302) Status of lay. 3 and 4	The output signal gives you information about the state of communication layers 3 and 4 (3: Network Layer, 4: Transport Layer). The following indications values are possible: • *no error*: The protection interface is operating correctly. • *Software version incompatible*: The firmware versions of the connected devices are incompatible. Update the firmware. • *System mirroring*: The protection interface is receiving its own data. Check the wiring. • *Dev. add. incorrect*: The device address of the partner device is incorrect. Check the settings for parameters **Address of device 1** to **address of device n** (_:5131:102 and following). • *Constell. incorrect*: The constellation settings of the devices are different. Check that the setting for the parameter **Select constellation** is identical in all devices. • *Const. param. incorrect*: Check that the same setting has been made for parameter **(_:5131:122) Lowest appearing bit rate** in all devices. • *Diff. Param. Error*: The line differential protection settings for the connected devices are incompatible. Check whether both devices are set to operate with or without line differential protection. The rated value of the line (parameter **(_:9001:101) Rated current** and **(_:9001:102) Rated voltage**) must have the identical setting at both ends of the line. If a transformer is installed in the line, both parameters must be set such that the rated apparent power is the same at both ends of the line (parameter **(_:9001:103) Rated apparent power**).

In order to clarify faults, each individual protection interface provides the following binary signals:

Binary Output Signal	Description
(_:5161:303) Connection broken	Signal *Connection broken* indicates that during a parameterized time (parameter **(_:5161:107) Disturbance alarm after**) faulty or missing telegrams were continuously received. If the 'Connection interrupted' indication occurs, the affected protection interface link will be terminated. This can cause the blocking of an active differential protection or a ring topology can change to a chain topology.
(_:5161:316) Error rate / min exc.	Signal *Error rate / min exc.* indicates that the set maximum error rate per minute (Parameter **(_:5161:106) Max. error rate per min**) has been exceeded.
(_:5161:317) Error rate / hour exc.	Signal *Error rate / hour exc.* indicates that the set maximum error rate per hour (Parameter **(_:5161:105) Max. error rate per hour**) has been exceeded.
(_:5161:318) Time delay exceeded	Signal *Time delay exceeded* indicates that the threshold value for the set signal-transit time (Parameter **(_:5161:109) Delay time threshold**) has been exceeded.
(_:5161:319) Time delay different	Signal *Time delay different* indicates that the threshold value for asymmetrical transit times has been exceeded. The setting value results from the setting value of the parameter **(_:5161:110) Difference Tx and Rx time**.
(_:5161:320) Time delay jump	Signal *Time delay jump* indicates that the data transit times changed abruptly. This is caused by switching the communication path in the communication network.

Binary Output Signal	Description
(_:5161:321) PI synchronized	Signal *PI synchronized* indicates that the protection-interface connection is synchronized with the opposite end.
(_:5161:340) Telegram lost	Signal *Telegram lost* indicates that an expected telegram has failed to arrive or a faulty telegram has been received. If you would like to allocate the communication failures or faults to other events, move the signal *Telegram lost* temporarily into the operational log. Such events can be switching operations in the primary system or operations on the components of the communication network. **Note:** If the signal is constantly routed, the operational log can overflow. Siemens recommends routing the signal only for clarification of faults.

Measured Values of the Protection Interface

The protection interface provides the following measured value to diagnose the protection interface communication:

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams sent during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams sent during the last minute
(_:5161:311) Rx tel/min	Telegrams received during the last minute
(_:5161:312) Tx err/h	Transmission failure rate during the last hour
(_:5161:313) Rx err/h	Reception failure rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute
(_:5161:315) Rx err/min	Reception failure rate during the last minute
(_:5161:325) Aver.Δt	Mean signal-transit time (average value of the transit time in transmission and reception direction divided by 2, without GPS synchronization)
(_:5161:326) Rec. Δt	Signal-transit time in reception direction (with GPS synchronization)
(_:5161:327) Sen. Δt	Signal-transit time in transmission direction (with GPS synchronization)
(_:5161:334) Miss.tel/min	Number of telegram failures within the last minute
(_:5161:335) Miss.tel/h	Number of telegram failures within the last hour
(_:5161:336) Miss.tel/d	Number of telegram failures within the last day
(_:5161:337) Miss.tel/w	Number of telegram failures within the last week
(_:5161:338) M. loss/d	Longest lasting telegram failure within the last day
(_:5161:339) M. loss/w	Longest lasting telegram failures within the last week

NOTE

You can reset the measured values of the protection interface directly in the device. Proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Reset measured values**.

3.5.3.10 Tunneling with DIGSI 5 via Protection Interface

Configuration of the Subnetworks

You can use a PC to access other devices within the constellation via the protection links. DIGSI 5 communication then operates exclusively via the connections and the protection-data communication is turned off. In this way, you operate the remote devices from the local device via DIGSI 5.

Remote control with DIGSI 5 is only possible if you are online with the local device and connected there with the integrated Ethernet interface RJ45

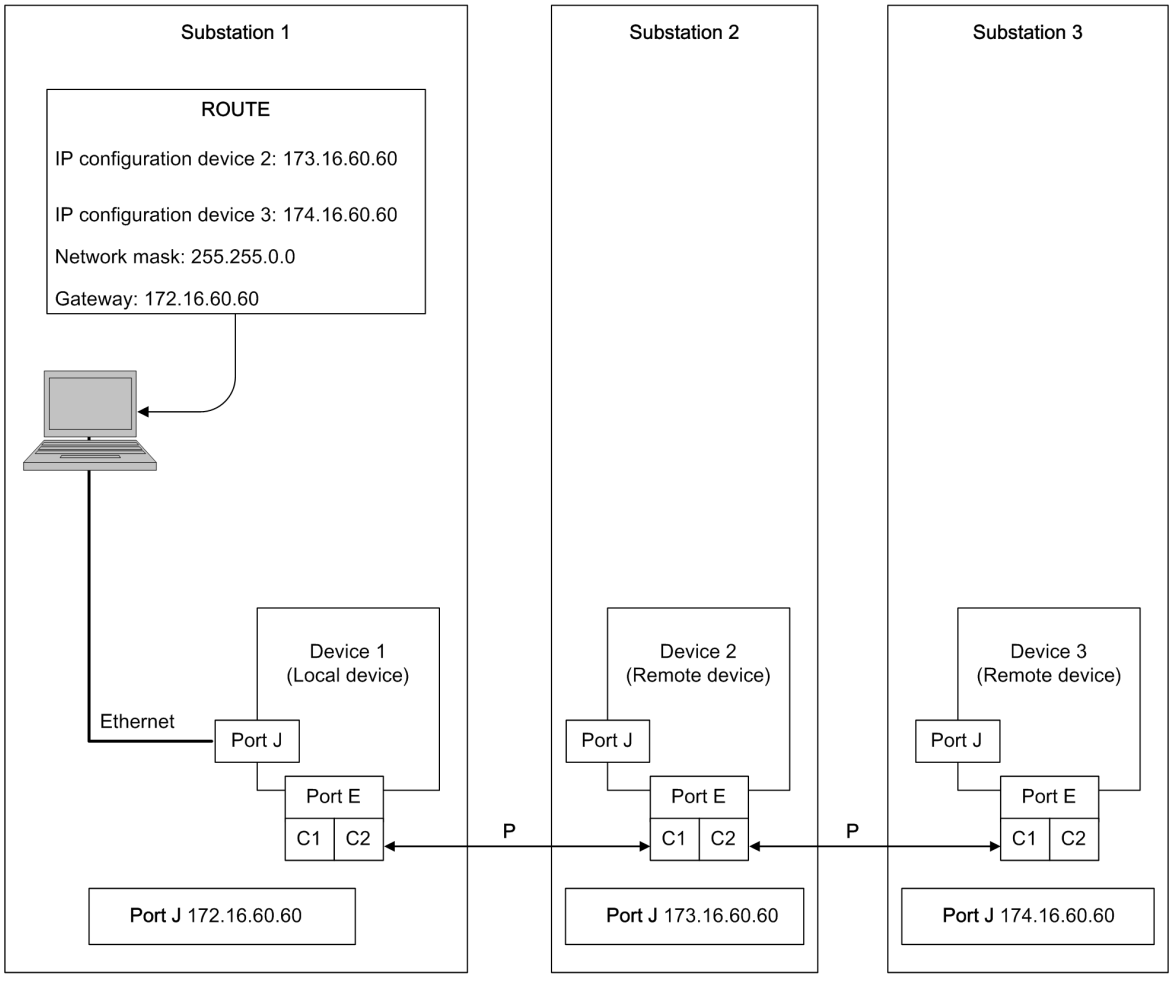
NOTE

All remote devices need an IP configuration for port J (integrated Ethernet interface) in all cases. The IP addresses of slots J of a protection topology must be in different subnetworks.

NOTE

If reparameterization requires a restart of the remote device, then the corresponding route is not available until after approx. 2 min. following a complete restart.

The following figure shows a configuration with 3 devices as an example.



[dwremote-030211-01.tif, 1, en_US]

Figure 3-68 Sample Configuration of a Remote Control with 3 Devices

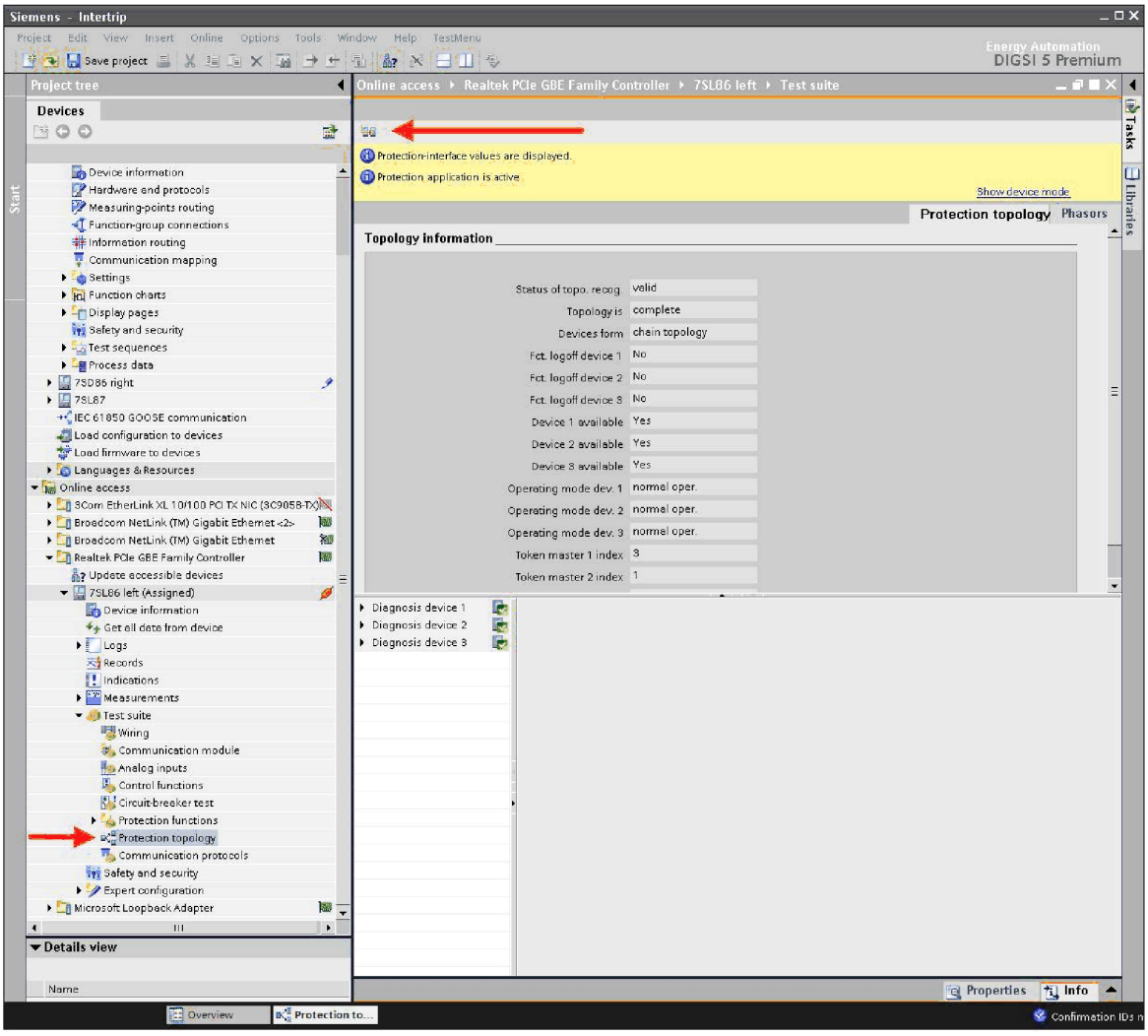
Tunneling with DIGSI 5 via Protection Interface: Procedure

If you want to perform tunneling (remote control)[6] via DIGSI 5, proceed as follows:

- You make a connection between DIGSI 5 and the device through the Ethernet RJ45.
- Open the device concerned in **Online access**.
- Go to **Test suite**/**Protection topology**.
- Open **Protection topology**. In the next window, press the button at top left (see arrow in the following figure). The dialog for deactivating the protection communication then opens.

  If you confirm the query, protection communication is interrupted and the communication channels are used exclusively for DIGSI 5. Note that the protection functions that use protection data communications (e.g. differential protection) are deactivated and no remote data can be updated in the constellation. Then, the remote signals fall back to the secure state the user has defined earlier.

[6] This function is not yet implemented and will first be activated with a later firmware version.



[sctunnel-200213-01.tif, 1, en_US]

Figure 3-69 Tunneling with DIGSI 5

NOTE

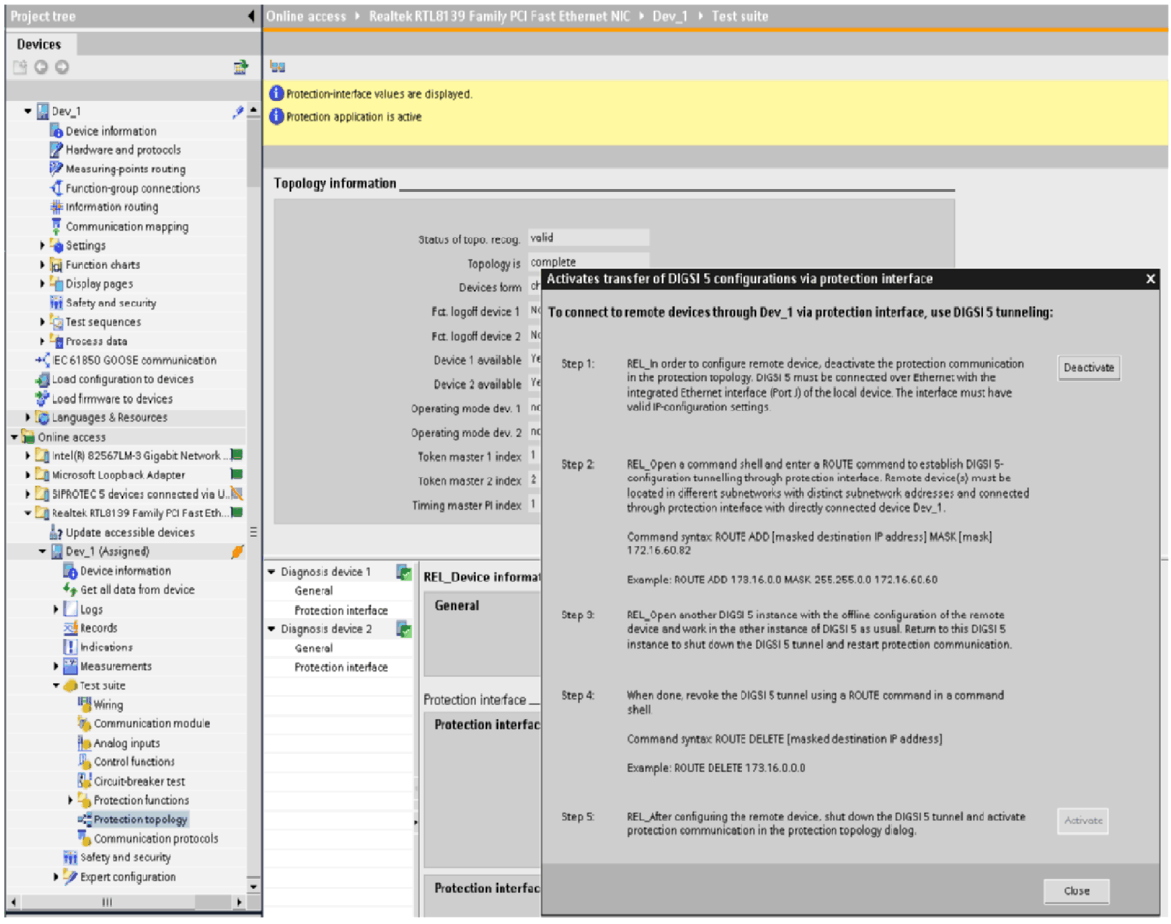
The protection communication remains interrupted until either the user reactivates it manually, or a maximum deactivation duration of 12 hours has been exceeded. After this, the connection reactivates itself. This ensures that the protection communication and protection function working with it are reactivated.

NOTE

Ensure that DIGSI 5 is connected via Ethernet to RJ45 of the local device. The local device must be configured with valid IP addresses.

Figure 3-70 to *Figure 3-71* show the steps for the deactivation of protection communication.

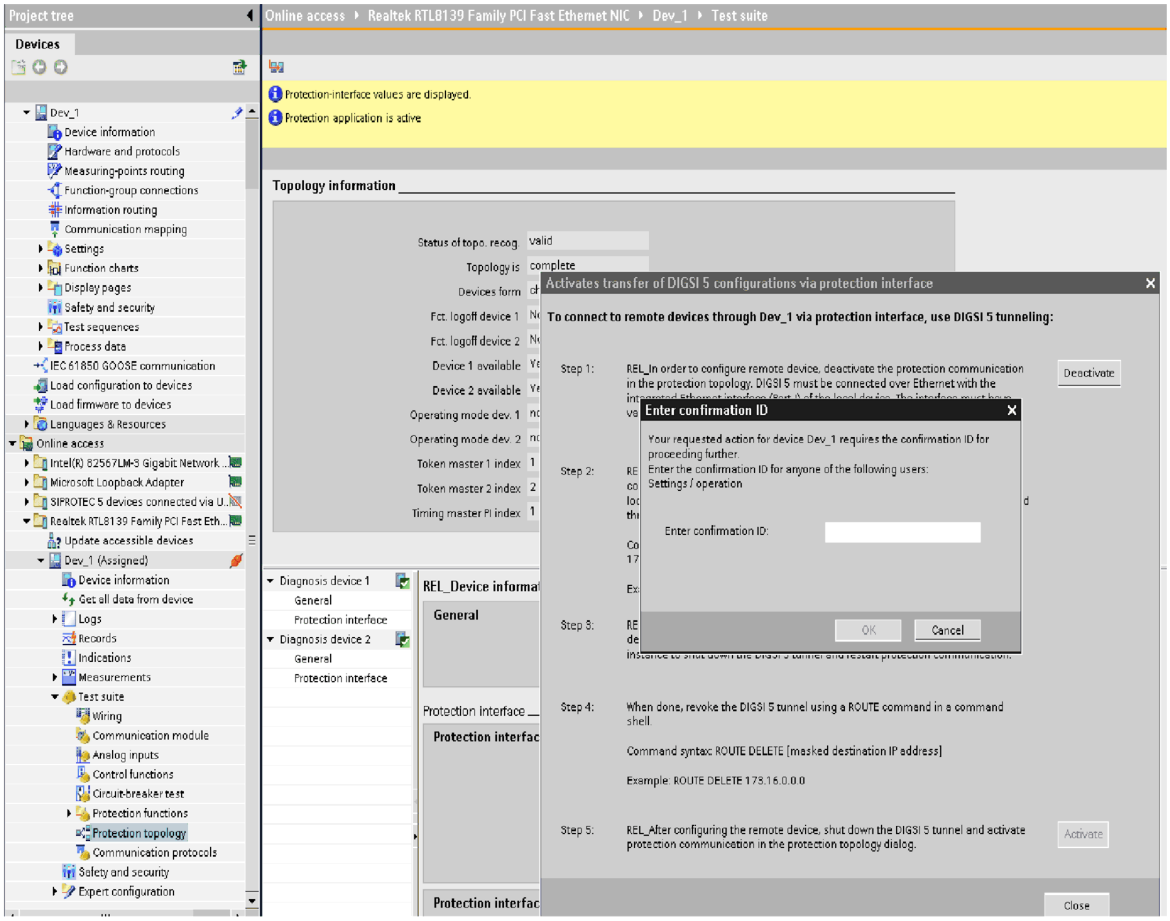
In the next step, a window appears in DIGSI 5 containing the instructions for deactivating the protection data communication (see next figure).



[scdeadig-061210-01.tif, 1, en_US]

Figure 3-70 Steps for the Deactivation of Protection Communication

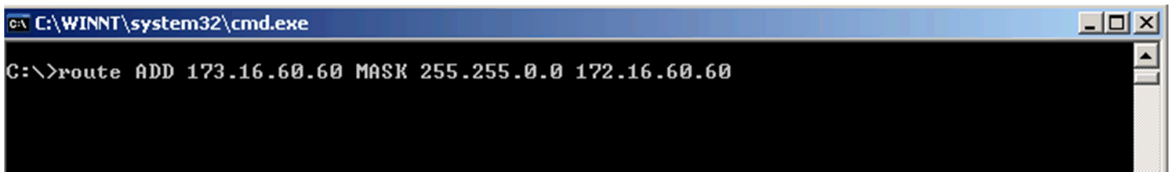
In order to be able to deactivate the protection-data communication, you must enter your confirmation ID if a security query is activated (see next figure). The default confirmation ID is **222222**.



[scdecode-061210-01.tif, 1, en_US]

Figure 3-71 Entering the Confirmation ID for the Deactivation of Protection Communication

- Under **Start ---> Run in Windows**, open an input window by entering **CMD**.
  Use the DOS box to enter a command line to set a route (see next figure). This is the prerequisite that DIGSI 5 can be routed further via the protection interface.



[scdosbox-310311-01.tif, 1, en_US]

Figure 3-72 Setting of the Route in the DOS Box

NOTE

To set the route, you must have administrator rights for the DIGSI PC.

- The following routing command is necessary to connect from device 1 to device 2 in the example shown (see *Figure 3-68*):
  - Route add 173.16.60.60 Mask 255.255.0.0 172.16.60.60
  - Route <Command> Destination (= Device 2) Mask (Routing Device) Local Device

  Remote devices must be available in different subnetworks and provided with unique IP addresses. For this, RJ45 of the relevant devices must already be configured so that these devices can now be accessed remotely.
- Now, select your DIGSI 5 project for substation 2 and connect this to the device. Although you are physically connected to the local device, this device now establishes a connection with the remote device. You can now fully operate the remote device with DIGSI 5.

  After completing the process, the protection communication must be reactivated. For this, end the connection with the remote device in DIGSI 5 at the local device for the protection interface.

  If this communication is not terminated properly, the protection-data communication then switches on again automatically after about 12 hours.
- Delete the route again by entering the following in the DOS box:
  - Route Delete 173.16.60.60
- If you wish to access device 3 via the protection interface, proceed in the same way. In this case, the DIGSI 5 communication is routed to device 3 via device 2 and you are connected from device 1 to device 3.
- To establish a connection with device 3, the following route is necessary:
  - Route add 174.16.60.60 Mask 255.255.0.0 172.16.60.60



NOTE

If there is no connection between the local device and DIGSI 5 for longer than an hour, the connection automatically resets to protection communication.

3.5.3.11 Diagnostic Data for the Protection Interface

Diagnostic Data of the Channel in DIGSI 5

Different diagnostic data can be read with DIGSI 5.

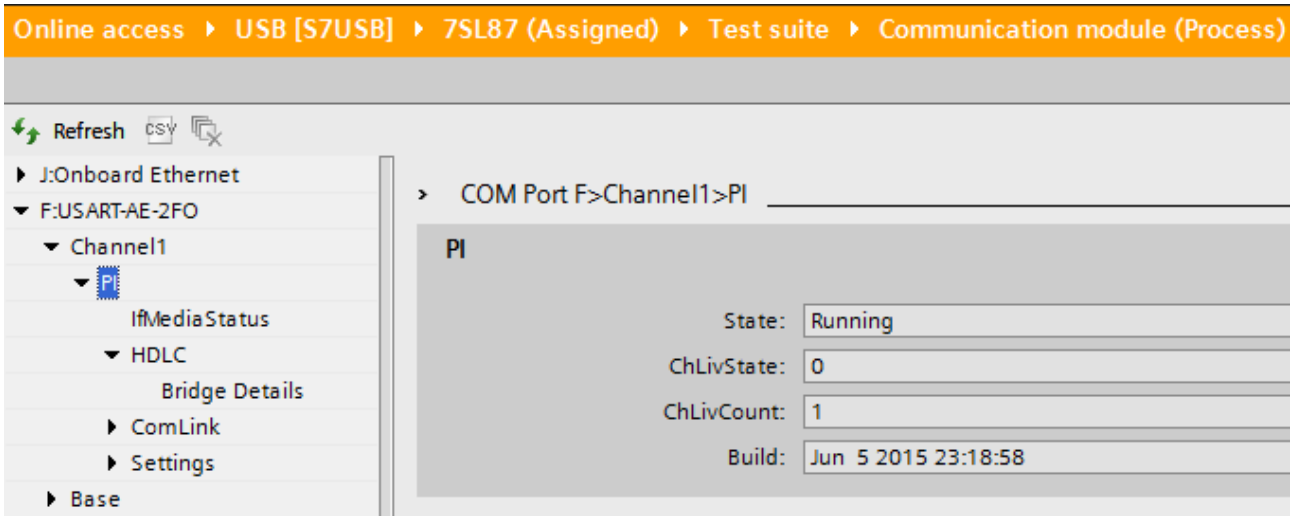
For this, connect with the device via DIGSI 5 and query the device information. Diagnostic data for a module whose channel is configured with the protection interface can be received by selecting the module slots (for example, F) and the corresponding channel (1 or 2). The following figures show the extensive diagnostic data for the protection interface. It is particularly helpful if data failures occur or other irregularities in a communication connection (for example, transmission time fluctuations).



NOTE

The diagnostic data can also be read via the device control on the display of the device. The overview of DIGSI 5 does not offer this option, however.

The following table describes the displays.



[scdiapin-140912-01, 1, en_US]

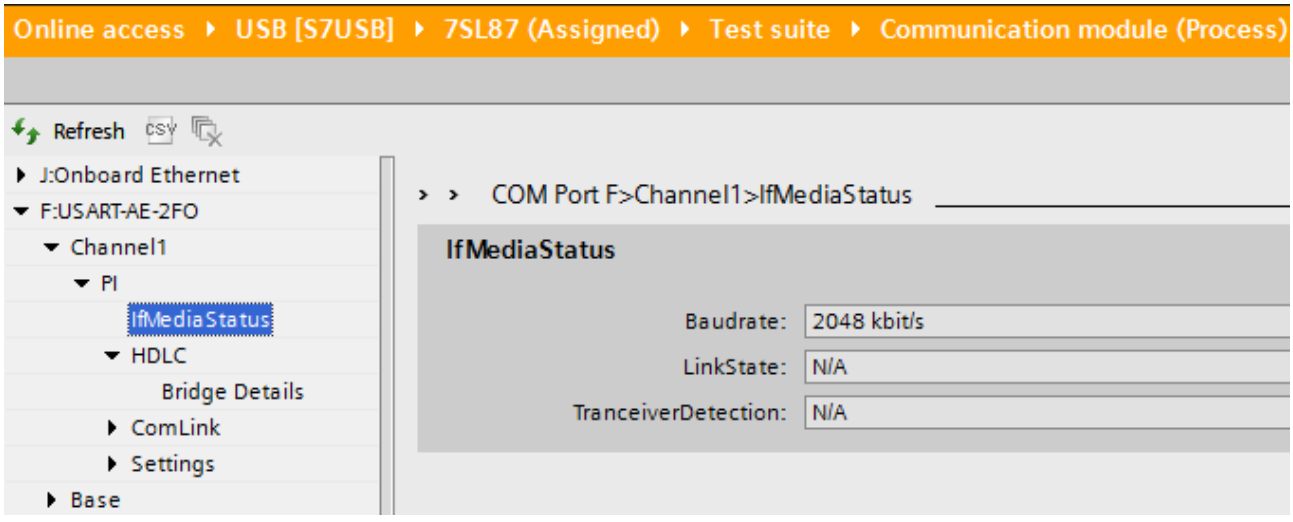
Figure 3-73 Diagnostic Data of a Channel Configured with the Protection Interface

Table 3-14 Description of the Diagnostic Data under Protection Interface

Channel Type	Name	Values	Description - Diagnostic Information for Log PI
Protection interfaces - log	Status	Initial, Running, Error	Runtime status of the log
Protection interfaces - log	Build	Date/time	Date and time of the log version

Diagnostic Data of the Protection-Interface Log in DIGSI 5

The following figures and tables describe the displays of the protection-interface log.

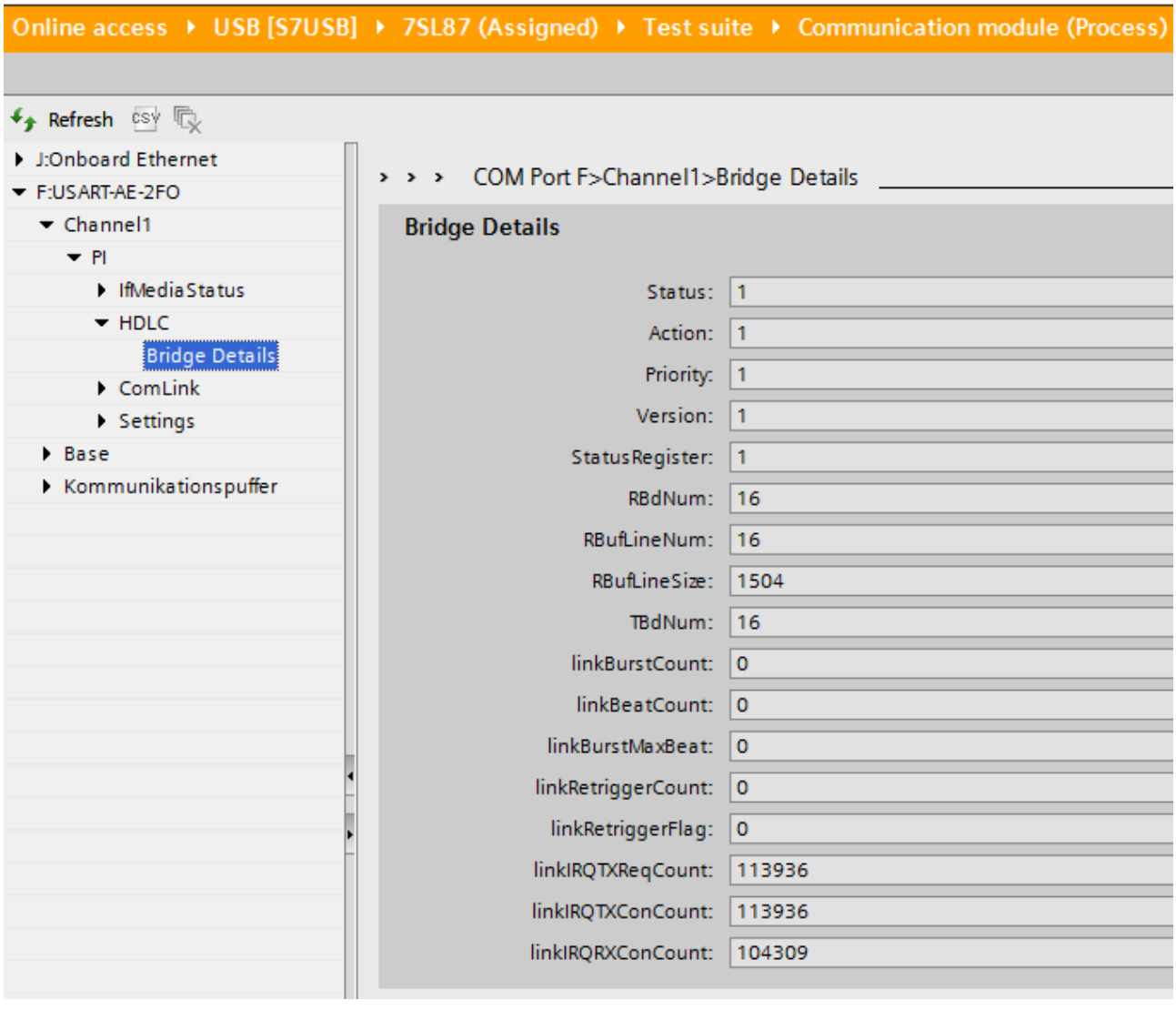


[scdiamed-140912-01, 1, en_US]

Figure 3-74 Diagnostic Data of the Protection-Interface Log - Media Status

Table 3-15 Description of Diagnostic Data under Media Status

Protection Interfaces - Log Type	Name	Values	Description - Media Status Interface (in Direction of Outside Interface)
Media Status	Baud rate	64 kBit/s; 128 kBit/s; 512 kBit/s; 2048 kBit/s; 30 MBit/s; <unknown>	HDLC baud rate: FO: 64 kBit/s to 2048 kBit/s for 820-Nm USART modules LDFO: 30 MBit/s for 1300/1500-Nm long-distance modules Error case: <unknown>
Media Status	LinkState	N/A, UP, DOWN	FO: N/A (always display N/A)
Media Status	TransceiverDetection	N/A, NO Transceiver detected, Transceiver detected	FO: N/A (always N/A) (NO Transceiver detected, Transceiver detected), Error case: N/A

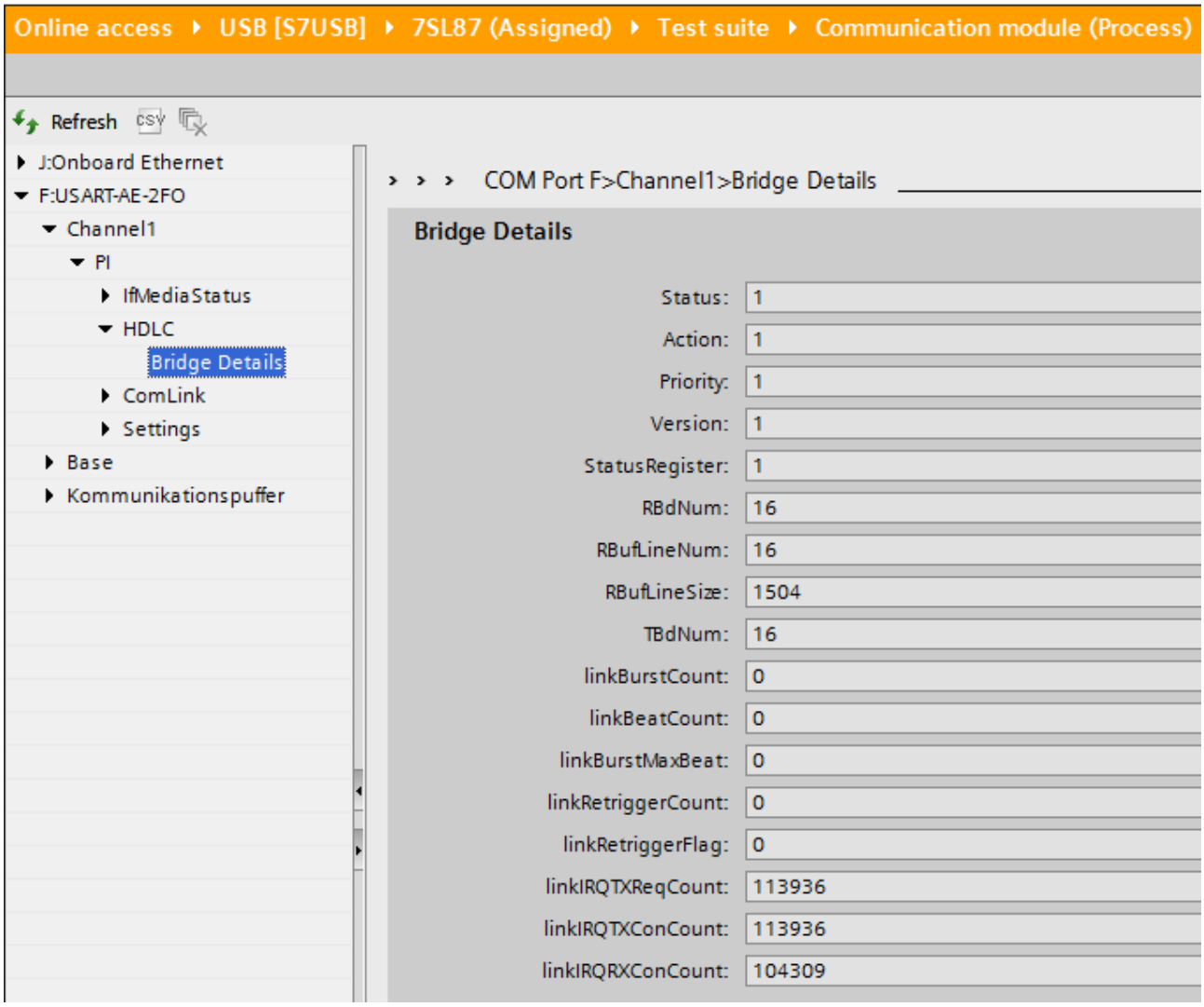


[scdiacom-140912-01, 1, en_US]

Figure 3-75 Diagnostic Data of the Protection-Interface Log - HDLC (Log - Layer)

Table 3-16 Description of Diagnostic Data of the Protection-Interface Log - HDLC (Log - Layer)

Protection Interfaces - Log Type	Name	Values	Description - HDLC Link Layer Diagnostic Information (in Direction of Outside Interface)
HDLC	RXHPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
HDLC	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
HDLC	RXHPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
HDLC	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty
HDLC	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
HDLC	TXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
HDLC	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
HDLC	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
HDLC	Bridge Details Sub-nodes	Sub-nodes	Siemens-internal special diagnostic for fault search



[scdiahdl-140912-01, 1, en_US]

Figure 3-76 Diagnostic Data of the Protection-Interface Log - COM Interface (Internal COM Link Interface Between Module and Mainboard)

Table 3-17 Description of Diagnostic Data of the COM Interface (Internal COM Link Interface Between Module and Mainboard)

Protection Interfaces - Log Type	Name	Values	Description - COM Interface Layer Diagnostic Information (Internal COM Link Interface in Mainboard Direction)
COM interface	RXHPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
COM interface	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
COM interface	RXHPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
COM interface	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty

Protection Interfaces - Log Type	Name	Values	Description - COM Interface Layer Diagnostic Information (Internal COM Link Interface in Mainboard Direction)
COM interface	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
COM interface	TXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
COM interface	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
COM interface	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
COM interface	Bridge Details Sub-nodes	Sub-nodes	Siemens-internal special diagnostic for fault search

Table 3-18 Description of Diagnostic Data of some Setting Values of the Protection Interface

Protection Interfaces - Log Type	Name	Values	Description - Protection Interface Setting Values
Settings	**Connection via**	Integer number - display of the internal coding of the settings variant	Protection interface is **Connection via**
Settings	**PDI bandwidth**	Bit-rate display	Bit rate (bit/s) for protection telegrams based on the parameter **Connection via**
Settings	**PDI Telegram.Overhead**	Display of bits	Overhead for every protection telegram in bit.

3.5.3.12 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device combin.				
_:5131:102	Device combin.:Address of device 1		1 to 65534	101
_:5131:103	Device combin.:Address of device 2		1 to 65534	102
_:5131:104	Device combin.:Address of device 3		1 to 65534	103
_:5131:105	Device combin.:Address of device 4		1 to 65534	104
_:5131:106	Device combin.:Address of device 5		1 to 65534	105
_:5131:107	Device combin.:Address of device 6		1 to 65534	106
_:5131:101	Device combin.:Local device is device		1 to 6	1
_:5131:122	Device combin.:Lowest appearing bit rate		• 64 kBit/s • 128 kBit/s • 512 kBit/s • 2048 kBit/s	64 kBit/s

Addr.	Parameter	C	Setting Options	Default Setting
Prot.interface				
_:105	Prot.interface:Connection via		• fiber optic • CCXG 512 kBit/s • CCXG 128 kBit/s • CCXG 64 kBit/s • repeater 512 kBit/s • CCPW 128 kBit/s • CC2M 512 kBit/s • C37.94 1 * 64 kBit/s • C37.94 2 * 64 kBit/s • C37.94 8 * 64 kBit/s • 64 kBit/s • 128 kBit/s • 512 kBit/s • 2048 kBit/s	fiber optic
Prot. interf.1				
_:5161:1	Prot. interf.1:Mode		• off • on	on
_:5161:105	Prot. interf.1:Max. error rate per hour		0.000 % to 100.000 %	1.000 %
_:5161:106	Prot. interf.1:Max. error rate per min		0.000 % to 100.000 %	1.000 %
_:5161:107	Prot. interf.1:Disturbance alarm after		0.05 s to 2.00 s	0.10 s
_:5161:108	Prot. interf.1:Transm. fail. alarm after		0.0 s to 6.0 s	6.0 s
_:5161:109	Prot. interf.1:Delay time threshold		0.1 ms to 30.0 ms	30.0 ms
_:5161:110	Prot. interf.1:Difference Tx and Rx time		0.000 ms to 3.000 ms	0.100 ms
_:5161:113	Prot. interf.1:PPS synchronization		• telegr. and PPS • telegr. or PPS • PPS sync. off	PPS sync. off

3.5.3.13 Information List

No.	Information	Data Class (Type)	Type
Channel 1			
_:307	Prot.interface:Health	ENS	O
_:304	Prot.interface:Channel Live	SPS	O
Device combin.			
_:5131:52	Device combin.:Behavior	ENS	O
_:5131:53	Device combin.:Health	ENS	O
_:5131:301	Device combin.:Status of topo. recog.	ENS	O
_:5131:302	Device combin.:Topology is	ENS	O
_:5131:303	Device combin.:Devices form	ENS	O
_:5131:304	Device combin.:Number of detect. dev.	INS	O
_:5131:305	Device combin.:Fct. logoff device 1	SPS	O
_:5131:306	Device combin.:Fct. logoff device 2	SPS	O
_:5131:307	Device combin.:Fct. logoff device 3	SPS	O
_:5131:309	Device combin.:Fct. logoff device 4	SPS	O

No.	Information	Data Class (Type)	Type
_:5131:310	Device combin.:Fct. logoff device 5	SPS	O
_:5131:311	Device combin.:Fct. logoff device 6	SPS	O
_:5131:312	Device combin.:Device 1 available	SPS	O
_:5131:313	Device combin.:Device 2 available	SPS	O
_:5131:314	Device combin.:Device 3 available	SPS	O
_:5131:315	Device combin.:Device 4 available	SPS	O
_:5131:316	Device combin.:Device 5 available	SPS	O
_:5131:317	Device combin.:Device 6 available	SPS	O
Prot. interf.1			
_:5161:81	Prot. interf.1:>Block stage	SPS	I
_:5161:500	Prot. interf.1:>Sync reset	SPS	I
_:5161:341	Prot. interf.1:Reset synchronization	SPC	C
_:5161:342	Prot. interf.1:Reset measurements	SPC	C
_:5161:52	Prot. interf.1:Behavior	ENS	O
_:5161:53	Prot. interf.1:Health	ENS	O
_:5161:301	Prot. interf.1:Status of lay. 1 and 2	ENS	O
_:5161:302	Prot. interf.1:Status of lay. 3 and 4	ENS	O
_:5161:303	Prot. interf.1:Connection broken	SPS	O
_:5161:316	Prot. interf.1:Error rate / min exc.	SPS	O
_:5161:317	Prot. interf.1:Error rate / hour exc.	SPS	O
_:5161:318	Prot. interf.1:Time delay exceeded	SPS	O
_:5161:319	Prot. interf.1:Time delay different	SPS	O
_:5161:320	Prot. interf.1:Time delay jump	SPS	O
_:5161:321	Prot. interf.1:PI synchronized	SPS	O
_:5161:340	Prot. interf.1:Telegram lost	SPS	O
_:5161:308	Prot. interf.1:Tx tel/h	MV	O
_:5161:309	Prot. interf.1:Rx tel/h	MV	O
_:5161:310	Prot. interf.1:Tx tel/min	MV	O
_:5161:311	Prot. interf.1:Rx tel/min	MV	O
_:5161:312	Prot. interf.1:Tx err/h	MV	O
_:5161:313	Prot. interf.1:Rx err/h	MV	O
_:5161:314	Prot. interf.1:Tx err/min	MV	O
_:5161:315	Prot. interf.1:Rx err/min	MV	O
_:5161:334	Prot. interf.1:Miss.tel/min	MV	O
_:5161:335	Prot. interf.1:Miss.tel/h	MV	O
_:5161:336	Prot. interf.1:Miss.tel/d	MV	O
_:5161:337	Prot. interf.1:Miss.tel/w	MV	O
_:5161:338	Prot. interf.1:M. loss/d	MV	O
_:5161:339	Prot. interf.1:M. loss/w	MV	O
_:5161:331	Prot. interf.1:Recept.	MV	O
_:5161:323	Prot. interf.1:PPS: time del. unsym.	SPS	O
_:5161:324	Prot. interf.1:PI with PPS synchron.	SPS	O
_:5161:325	Prot. interf.1:Aver.Δt	MV	O
_:5161:326	Prot. interf.1:Rec. Δt	MV	O
_:5161:327	Prot. interf.1:Sen. Δt	MV	O

No.	Information	Data Class (Type)	Type
Ext. Synchron.			
_:9181:500	Ext. Synchron.:>Block stage	SPS	I
_:9181:501	Ext. Synchron.:>PPS pulse loss	SPS	I
_:9181:301	Ext. Synchron.:PPS pulse loss	SPS	O
_:9181:302	Ext. Synchron.:PPS pulse	SPS	O
Meas.val.dev.1			
_:1351:6811:300	Meas.val.dev.1:Dev.adr.	INS	O
_:1351:6811:301	Meas.val.dev.1:Line	ENS	O
_:1351:6811:302	Meas.val.dev.1:Vph	WYE	O
_:1351:6811:303	Meas.val.dev.1:Iph	WYE	O
Meas.val.dev.2			
_:1351:6841:300	Meas.val.dev.2:Dev.adr.	INS	O
_:1351:6841:301	Meas.val.dev.2:Line	ENS	O
_:1351:6841:302	Meas.val.dev.2:Vph	WYE	O
_:1351:6841:303	Meas.val.dev.2:Iph	WYE	O
Meas.val.dev.3			
_:1351:6871:300	Meas.val.dev.3:Dev.adr.	INS	O
_:1351:6871:301	Meas.val.dev.3:Line	ENS	O
_:1351:6871:302	Meas.val.dev.3:Vph	WYE	O
_:1351:6871:303	Meas.val.dev.3:Iph	WYE	O
Meas.val.dev.4			
_:1351:6901:300	Meas.val.dev.4:Dev.adr.	INS	O
_:1351:6901:301	Meas.val.dev.4:Line	ENS	O
_:1351:6901:302	Meas.val.dev.4:Vph	WYE	O
_:1351:6901:303	Meas.val.dev.4:Iph	WYE	O
Meas.val.dev.5			
_:1351:6931:300	Meas val.dev.5:Dev.adr.	INS	O
_:1351:6931:301	Meas val.dev.5:Line	ENS	O
_:1351:6931:302	Meas val.dev.5:Vph	WYE	O
_:1351:6931:303	Meas val.dev.5:Iph	WYE	O
Meas.val.dev.6			
_:1351:6961:300	Meas.val.dev.6:Dev.adr.	INS	O
_:1351:6961:301	Meas.val.dev.6:Line	ENS	O
_:1351:6961:302	Meas.val.dev.6:Vph	WYE	O
_:1351:6961:303	Meas.val.dev.6:Iph	WYE	O

3.6 Date and Time Synchronization

3.6.1 Overview of Functions

Timely recording of process data requires precise time synchronization of the devices. The integrated date/time synchronization allows the exact chronological assignment of events to an internally managed device time that is used to time stamp events in logs, which are then transmitted to a substation automation technology or transferred via the protection interface. A clock module internal to the device and having battery backup is synchronized cyclically with the current device time so that the right device time is available and used even in case of auxiliary-voltage failure. At the same time, this permits hardware-supported monitoring of the device time.

3.6.2 Structure of the Function

The integrated date/time synchronization is a supervisory device function. Setting parameters and indications can be found in the following menus for the DIGSI and the device:

Set date and time:

- DIGSI: Online access -> Interface -> Device -> Device Information -> **Time Information**
- Device: Main menu → Device functions → **Date & Time**

Parameter:

- DIGSI: Project -> Device -> Parameter -> **Time Settings**

Indications:

- DIGSI: Project -> Device -> Information routing ->**Time keeping** or **Time Sync.**

3.6.3 Function Description

Every SIPROTEC 5 device maintains an internal device time with date. The date and time can also be set on the device via the on-site operation panel or via DIGSI 5. Within a system, or even beyond, it is usually necessary to record the time of process data accurately and to have exact time synchronization of all devices. For SIPROTEC 5 devices, the sources of time and synchronization options can be configured.

Configurable Synchronization Options:

- **None** (default setting)
  The device functions without any external time synchronization. The internal time synchronization continues to work with the help of the back-up battery even when the auxiliary voltage is shut down temporarily. The time can be adjusted manually.
- **Telegram**
  The time is synchronized via a telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 or DNP3 protocol.
- **Connection to a radio clock**
  The time synchronization takes place with the set time telegram from an external IRIG-B or DCF77 receiver via the time synchronization interface of the device.
- **Ethernet**
  The time synchronization is done via Ethernet-based SNTP protocol (Simple Network Time Protocol), for example with IEC 61850 stations or via IEEE 1588. If you enable both services during configuration of Ethernet interfaces, these protocols are available as an option for the time synchronization.
- **Protection interface**
  The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management.

Configurable Time Sources:

- 2 time sources can be taken into consideration with the SIPROTEC 5 devices. For each time source, the synchronization type may be selected based on the options provided.
- **Time source 1** takes precedence over **Time source 2**, that is, **Time source 2** will be effective for the synchronization of the device time only if **Time source 1** fails. If only one time source is available and it fails, then only the internal clock continues unsynchronized. The status of the time sources is indicated.
- For every time source it is possible to define via the **Time zone time source 1** parameter (or **Time zone time source 2**) if this source transmits its time by UTC (universal time) or if the settings correspond to the local time zone of the device.



NOTE

Make sure that the settings for the time sources coincide with the actual hardware configuration of your SIPROTEC 5 device. In any event, incorrect settings cause the status indications of time sources to pick up.

Configurable Date Format

Regardless of a feed time-synchronization source, a uniform format is maintained internally within the device. The following options are available for the customary local representation of the date format:

- Day.Month.Year: 24.12.2009
- Month/Day/Year: 12/24/2009
- Year-Month-Day: 2009-12-24

Taking Local Time Zones into Account

The internal device time is maintained in universal time (UTC). To display time stamps in DIGSI and on the device display, you can define the local time zone of the device (parameter Offset time zone for GMT), including the applicable daylight saving times (start, end, and offset of daylight saving time) using parameters. This allows the display of the local time.



NOTE

- For time sources that transmit the status of the switch to daylight saving time, this will be taken into account automatically when creating the internal device time in the UTC format. The differential time of the daylight saving time set in the device (parameter Offset daylight saving time) is taken into consideration. However, in contrast, the settings of the start of daylight saving time and end of the daylight saving times are ignored when converting into the device internal UTC format.
- For active time sources, it is not possible to set the time via the device display or DIGSI 5. An exception is setting the calendar year for active time protocol IRIG-B.

Status, Supervision, and Indications of Time Management

Your SIPROTEC 5 device generates status and monitoring indications that provide important information regarding the correct configuration of the time source and the status of the internal time management during start-up and device operation.

Internal time synchronization is monitored cyclically. Important synchronization processes, the status of the time sources and errors detected are reported. A device time that has become invalid will be marked accordingly so that affected functions can go to a safe state.

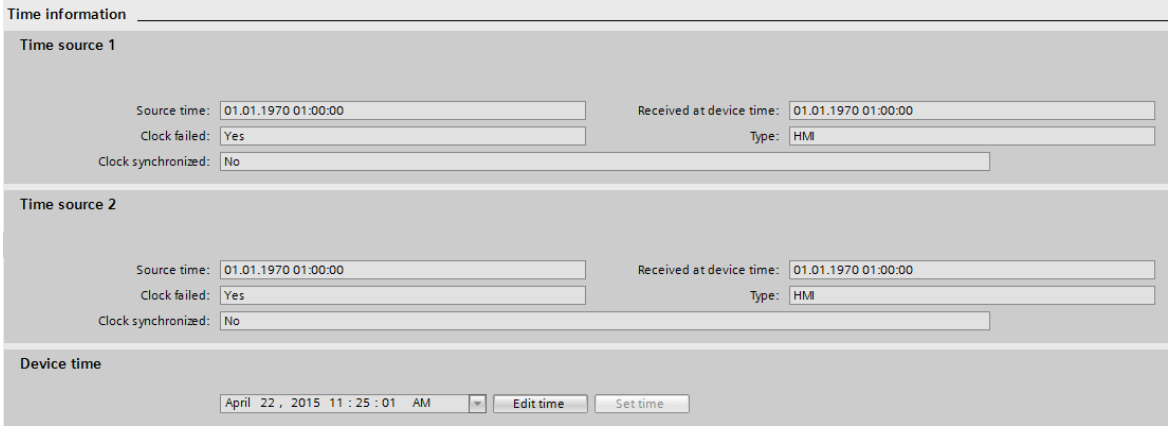
Indication	Description
Device: *Clock fail*	This indication signals a high difference between the internally managed time and the time of the clock module that is not permissible. The triggering of the indication can point to a defect in the clock module or to an unacceptable high drift of the system quartz crystal. The time maintained internally is marked as invalid.
Time management: *Daylight saving time*	This indication signals whether daylight saving time has been enabled.
Time management: *Clock set manually*	This indication signals that the device time has been set manually via the on-site operation panel or via DIGSI 5.
Time synchronization: *Status time source 1* *Status time source 2*	These 2 indications signal whether the active time sources are recognized as valid and active from the device point of view. When the indications get triggered, it can also be an indication that an incorrect configuration of the port or channel numbers was done at the on-site operation panel.
Time synchronization: *Time sync. error*	This indication signals after the parameterized time **Fault indication after** that synchronization using an external time source has failed.
Time synchronization: *High accuracy*	This indication signals that the device is synchronized with an accuracy better than 1 µs. The indication is only of significance when the PMU function is used.

NOTE

In case of a missing or discharged battery, the device starts without active external time synchronization with the device time 2011-01-01 00:00:00 (UTC).

For the device, DIGSI 5 provides a compact overview of the status of the time synchronization of your SIPROTEC 5 device in online mode. All displays are updated continuously. You can access the overview in the project-tree window via Online access.

DIGSI: Online access -> Interface -> Device -> Device Information -> **Time Information**



[sctimedg-220415, 1, en_US]

Figure 3-77 Time Information in DIGSI

For every time source, you see the following:

- Last received time (with date)
- Receipt time of the last received time telegram

- Configured type of timer
- Indication of timer outage or failure
- Whether the device time is currently synchronized from the time source

The lower section displays the device time, which is continuously updated. If the internal device time and the infeed time source were synchronous at the time of telegram receipt, both displayed times are identical.



NOTE

All times displayed (also the time source) take into consideration the local time settings (zone and daylight saving time of the device) in the form of a numerical offset for UTC (universal time).

3.6.4 Application and Setting Notes

Parameter: Date Format

- Default setting **Date format** = ***YYYY-MM-DD***

With the **Date format** parameter, you define the local customary format of the date display.

Parameter Value	Description
YYYY-MM-DD	Day.Month.Year: Typical European display Example: 24.12.2010
YYYY-MM-DD	Month/Day/Year: Typical US representation Example: 12/24/2010
YYYY-MM-DD	Year-Month-Day: Typical Chinese display Example: 2010-12-24

Parameter: Time zone time source 1,Time zone time source 2

- Default setting **Time zone time source 1** = ***local***, **Time zone time source 2** = ***local***

With the **Time zone time source 1** and **Time zone time source 2** parameters, you define the handling of time zones of the external timer.

Parameter Value	Description
local	Local time zone and daylight saving time are considered as time zone offsets to GMT.
UTC	Time format according to UTC (universal time)

Parameter: Time source 1,Time source 2

- Default setting **Time source 1** = ***none***, **Time source 2** = ***none***

With the **Time source 1** and **Time source 2** parameters, you can configure an external timer. The prerequisite is to have the corresponding hardware configuration of the communication interfaces of your SIPROTEC 5 device. This is listed as a prefix when making a selection in DIGSI 5.

Parameter Value	Description
none	The time source is not configured.

Parameter Value	Description
IRIG-B	Time synchronization by an external GPS receiver: SIPROTEC 5 devices support several protocol variants of the IRIG-B standards: • **IRIG-B 002(003)** The control function bits of the signal are not occupied. The missing year is formed from the current device time. In this case, it is possible to set the year via the online access in DIGSI 5. • **IRIG-B 006(007)** The bits for the calendar year are not equal to 00. The calendar year is set automatically by the time protocol. • **IRIG-B 005(004) with extension according to IEEE C37.118-2005** If, in the time signal, other control function bits are occupied in addition to the calendar year, then the device takes the additional information into consideration for leap seconds, daylight saving time, time offset (zone, daylight saving time) and time accuracy. **Time zone time source 1** or **Time zone time source 2**: The value of this setting is not evaluated by the device, since this protocol either transmits or in the case of local time, specifies the appropriate offset to UTC in each set time telegram.
DCF77	Time synchronization by an external DCF 77 receiver **Time zone time source 1** or **Time zone time source 2** = ***local*** Please note: There are also clocks that generate a DCF 77 signal representing UTC. In this case, UTC must be set.
PI	The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management. Signal-transit times of the protection interface communication are calculated automatically. **Time zone time source 1** or **Time zone time source 2** = ***UTC*** A slave that receives a time or a SIPROTEC 5 master, receives its system time kept in UTC.
SNTP	The time synchronization is done via the Ethernet service SNTP (SNTP server or via IEC 61850). SIPROTEC 5 devices support both Edition1 and Edition2 in accordance with IEC 61850-7-2. In Edition2, the logical attributes LeapSecondsKnown, ClockFailure, ClockNotSynchronized, and the value TimeAccuracy are maintained in each time stamp. For Edition1, these signals contain default settings. Thus, the inter-operability for substation automation technology is ensured for both editions! The SNTP service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. **Time zone time source 1** or **Time zone time source 2** = ***UTC***
IEC 60870-5-103	The time is synchronized via telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 protocol. **Time zone time source 1** or **Time zone time source 2** = ***local*** However, there are also T103 systems that send the UTC.

Parameter Value	Description
DNP3	The time is synchronized via telegram with the appropriately configured communication interface in accordance with the DNP3 protocol. Two characteristics are supported in the process: • **Time synchronization via UTC** • **Time synchronization with local time** The daylight saving time status is not transmitted. The device assumes that the DNP3 master follows the same rules for the start and end of the daylight saving time as those that were set for the device. **`Time zone time source 1`** or **`Time zone time source 2`** = ***`UTC`*** is the current implementation ***`local`*** concerns older implementations.
`IEEE 1588`	Time is synchronized via an IEEE 1588 timing master. In this case, SIPROTEC 5 devices operate as slave-only clocks. IEEE 1588 v2 is supported with P2P and Ethernet Transport. The IEEE 1588 service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. **`Time zone time source 1`** or **`Time zone time source 2`** = ***`UTC`***.

Parameter: Fault indication after

- Default setting **`Fault indication after`** = ***`600 s`***

With the **`Fault indication after`** parameter you set the time delay after which the unsuccessful attempts of time synchronization with external time sources configured are indicated.

Parameter: Time Zone and Daylight Saving Time

This parameter block contains all the settings for the local time zone and daylight saving time of your SIPROTEC 5 device. In addition to the individual parameters, configure the basic settings by preselecting via the radio buttons or check box.



[sctimezo-210415, 1, en_US]

Figure 3-78 Settings for Time Zone and Daylight Saving Time in DIGSI

Selection Button	Description
Manual settings (local time zone and daylight saving time regulation)	This setting must be selected if you want to select the local time zone and daylight saving time zone regulations of your SIPROTEC 5 device regardless of the PC settings. Input: **Offset time zone for GMT** [min] Selection: **Switchover to daylight saving time** [yes/no] via check box  • Input: **Start of daylight saving time** [Day and time] • Input: **End of daylight saving time** [Day and time] • Input: **Offset daylight saving time** [min] • Default settings as in the picture above

3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Time sync.				
_:102	Time sync.:Time source 1		• none • PPM • IRIG-B • DCF77 • Syncbox • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:103	Time sync.:Time source 1 port		• port J • port F • port E • port P • port N • port G	
_:104	Time sync.:Time source 1 channel		• Ch1 • Ch2	

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Time sync.:Time source 2		• none • PPM • IRIG-B • DCF77 • Syncbox • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:106	Time sync.:Time source 2 port		• port J • port F • port E • port P • port N • port G	
_:107	Time sync.:Time source 2 channel		• Ch1 • Ch2	
_:108	Time sync.:Time zone time source 1		• UTC • local	local
_:109	Time sync.:Time zone time source 2		• UTC • local	local
_:101	Time sync.:Fault indication after		0 s to 3600 s	600 s

3.6.6 Information List

No.	Information	Data Class (Type)	Type
Time managem.			
_:300	Time managem.:Daylight saving time	SPS	O
_:301	Time managem.:Clock set manually	SPS	O

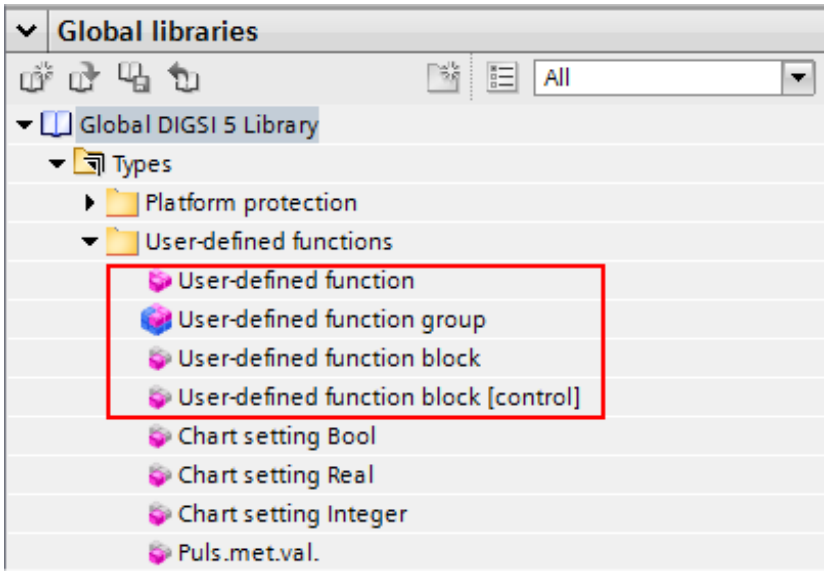
No.	Information	Data Class (Type)	Type
Time sync.			
_:303	Time sync.:Status time source 1	SPS	O
_:304	Time sync.:Status time source 2	SPS	O
_:305	Time sync.:Time sync. error	SPS	O
_:306	Time sync.:Leap second	SPS	O
_:307	Time sync.:High accuracy	SPS	O

3.7 User-Defined Objects

3.7.1 Overview

Within a **User-defined function group**, you can use the **User-defined function block** and the **User-defined function block [Control]** to group user-defined objects that you find in the DIGSI 5 library under **User-defined functions**.

With user-defined function groups and user-defined functions, a grouping of user-defined objects, for example, user-defined function blocks, can be performed. 2 user-defined function blocks are available (see following figure).



[scudef_lib, 1, en_US]

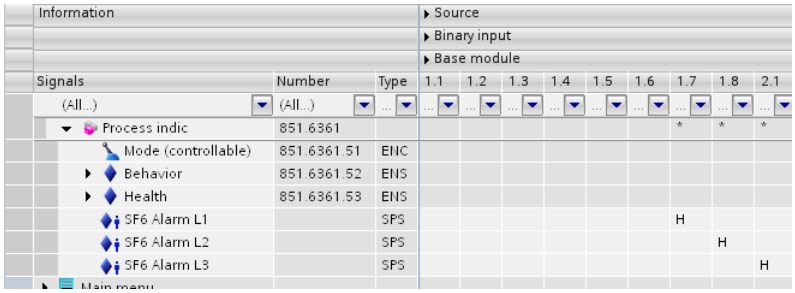
Figure 3-79 User-Defined Objects in the DIGSI 5 Library

You can insert single-point indications, pickup and operate indications (ACD, ACT), single or double commands, commands with a controllable whole number as well as measured values in the **User-defined function block** (see following figure). You can assign a superordinate name to the grouping (for example, **Process indications**, for a group of single-point indications that are read in via binary inputs). This function can be deactivated via the mode. Readiness is also evaluated and represented.

The user-defined function can be instantiated both at the highest level (in parallel to other function groups) and within the function groups and functions.

A **User-defined function block [control]** is also available. In addition to the mentioned option of a general **User-defined function block**, this block offers additional tests for user-defined control signals, for example, SPC or DP.

You can find more information in chapter *8.6.1 Overview of Functions*.



[scbenutz-260912-01.tif, 1, en_US]

Figure 3-80 Information Routing Through Use of Added User-Defined Function Block: Process Indications and Single-Point Indications

3.7.2 Basic Data Types

The following data types are available for user-defined objects in the DIGSI 5 library under the heading **User-defined signals**.

Single-Point Indication (Type SPS: Single-Point Status)

The status of a binary input can be registered in the form of a single-point indication or forwarded as the binary result from a CFC chart.

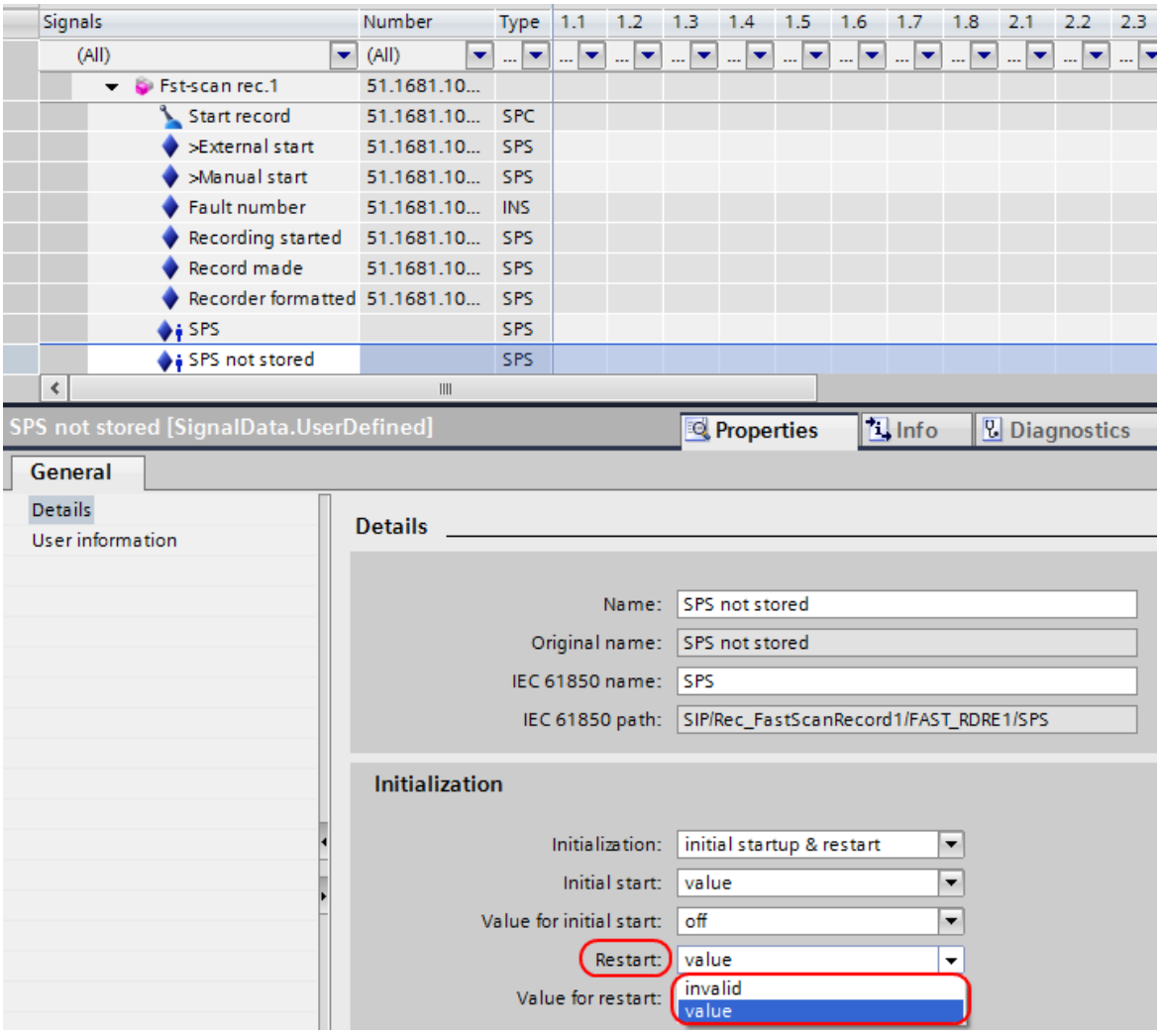
EXAMPLE

Acquisition using binary input, further processing in a CFC and/or signaling using an LED.

Single-Point Indication (Type SPS unsaved: Single-Point Status Unsaved)

In contrast to **SPS** single-point indications, the state of the **SPS unsaved** indication is not maintained after the device restarts.

For this purpose, go to **Properties > Details > Initialization > Restart** and set the ***Value***.



[scspsfas-140613-01.tif, 1, en_US]

Figure 3-81 Single-Point Indication SPS Unsaved (Example: 7KE85 Fault Recorder)

Double-Point Indication (Type DPS: Double-Point Status)

When using a double-point indication, the status of 2 binary inputs can be captured simultaneously and mapped in an indication with 4 possible conditions (***ON***, ***Intermediate position***, ***OFF***, ***Disturbed position***).

EXAMPLE

Acquisition of a disconnector or circuit-breaker switch position.

Marker Command (Type SPC, Single-Point Controllable)

This data type can be used as a command without feedback for simple signaling or as an internal variable (marker).

State of a Whole Number (Type INS)

The data type **INS** is used to create a whole number that represents a CFC result.

EXAMPLE

The output of the CFC block **ADD_D** can, for example, be connected with the data type **INS**. The result can be shown on the display of the device.

State of an Enumeration Value (Type ENS)

The data type **ENS** is used to create an enumerated value that represents a CFC result.

Controllable Single-Point Indication (SPC, Single-Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via a single feedback.

Command with Double-Point Feedback (DPC, Double Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via double-point indication as feedback.

Command with a Whole Number (INC, Controllable Integer Status)

This can be used to issue a command (to one or more relays, selectable under information routing) that is monitored via a whole number as feedback.

Complex Measured Values (CMV)

This data type provides a complex measured value that can be used as a CFC result, for example.

Measured Values (MV)

This data type provides a measured value that can be used as a CFC result, for instance.



NOTE

Additional data types can be found under other headings in the DIGSI 5 library as well as in the corresponding function blocks. This applies to the following data types:

- Pulse-metered values (see **User-defined functions** in the DIGSI 5 library)
- Transformer taps
- Metered values

Phase-to-Ground Measured Values (WYE)

This data type represents the phase-to-ground measured values of a 3-phase system.

Phase-to-Phase Measured Values (DEL, Delta)

This data type represents the phase-to-phase measured values of a 3-phase system.

Protection Activation Information (ACT)

This object type is used by the protection functions for **Tripping**. It is available in the library for receiving protection information via the protection interface, which could also indicate **Tripping**.

Protection Activation Information with Direction (ACD)

This object type is used by the protection functions for **Pickup**. It is available in the library for receiving protection information via the protection interface, which could also indicate **Pickup**. In addition, both ACD and ACT can be generated and processed by CFC charts.

3.7.3 Pulse- and Energy- Metered Values , Transformer Taps

Pulse-Metered Values

Pulse-metered values are available as data types **BCR** (Binary Counter Reading) in the DIGSI library under **User-defined Functions**.

The functionality and the settings of the pulse-metered values can be found in chapter *10.8.1 Pulse-Metered Values Function Description* .

Transformer Taps

Transformer taps are contained in the **Transformer tap changers** switching element. When the **Transformer tap changer** switching element is created in the device, the transformer tap position is available as a data object of type **BSC** (binary controlled tap changer with tap-position information).

You can find detailed information in *8.8.1 Function Description* .

Energy-Metered Values

Energy-metered values no longer need to be created by the user separately. They are available as active and reactive power in each **Line** function group for reference and output direction. The calculation is based on the current and voltage transformers associated with the protected object.

You can find more detailed information in chapter *10.7.1 Function Description of Energy Values* .

3.7.4 Additional Data Types

The following data types are also used in the system but are not available for general use as user-defined signals in the library:

- **ENC** (Enumerated Setting Controllable)
  The data type **ENC** models a command with which the user can set predefined values.
- **SEQ** (Sequence)
- **BSC** (Binary Controlled Step Position)
  The data type **BSC** can, for example, be used to control a transformer tap changer. The commands **up**, **down** can be given.



NOTE

Transformer taps are included in the **Transformer tap changer** switching element. If this switching element is created in the device, the transformer tap position is available as a data object of type **BSC** (binary controlled tap changer with tap-position information).

3.8 Other Functions

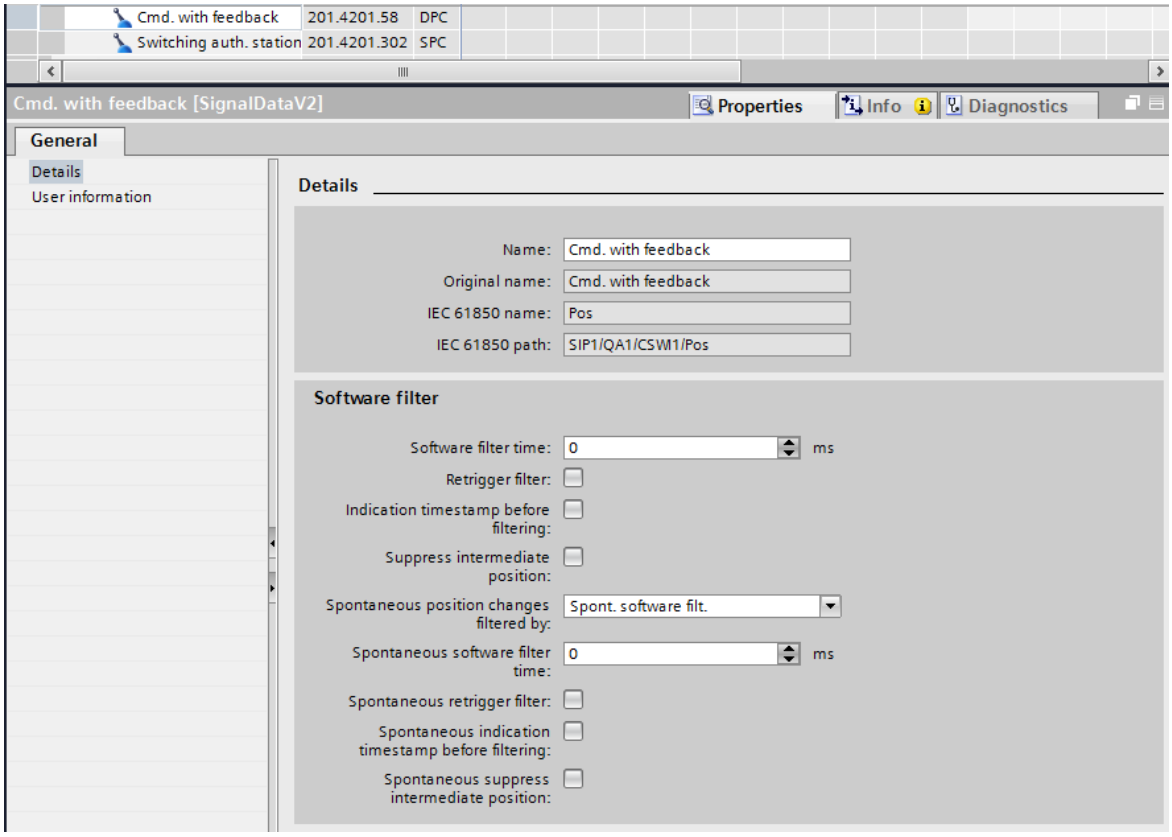
3.8.1 Signal Filtering and Chatter Blocking for Input Signals

Input signals can be filtered to suppress brief changes at the binary input. Chatter blocking can be used to prevent continuously changing indications from clogging the event list. After an adjustable number of changes, the indication is blocked for a certain period.

The settings for indication filtering can be found at the individual signals. The next figure shows the settings using the example of a controllable (circuit-breaker switch position).

NOTE

For the circuit breaker or the disconnector, the settings of the software filter for spontaneous position changes are available only in the **Control/Command with feedback** function block. These settings are not available in the **Circuit breaker** or **Disconnector** function blocks since these function blocks contain the actual unfiltered position of the switch in the bay.



[sclposi-260116, 1, en_US]

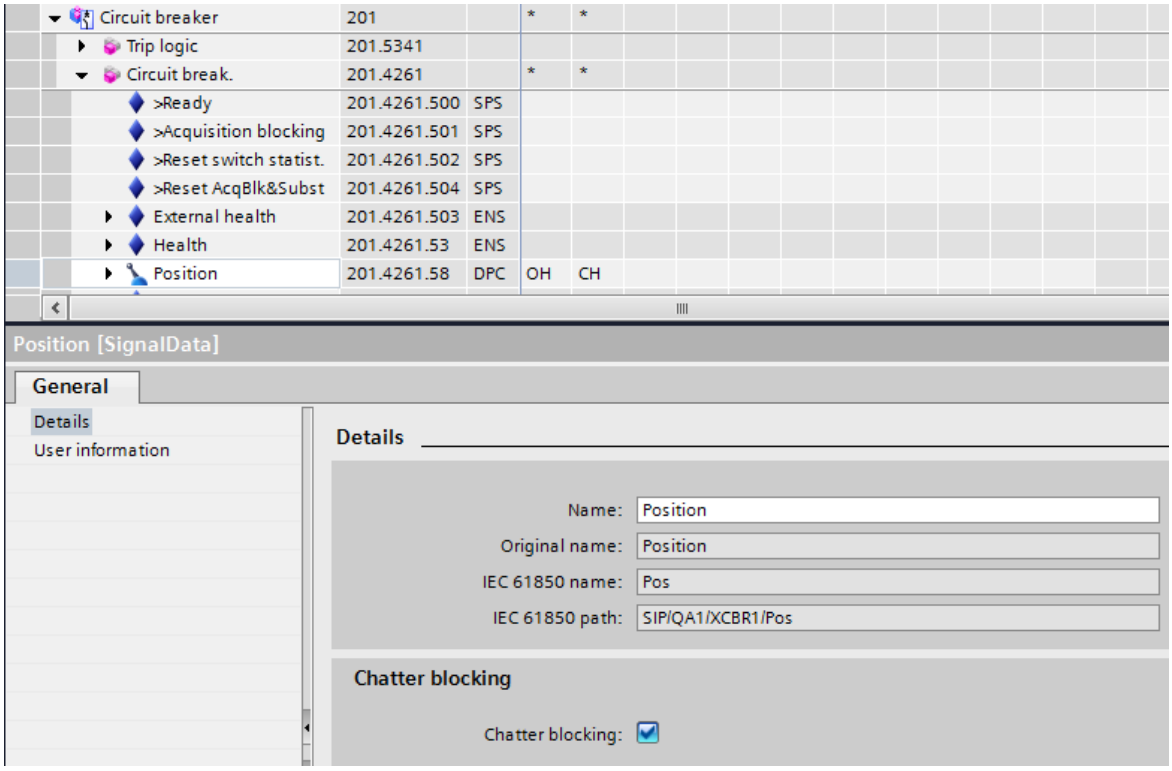
Figure 3-82 Settings for Circuit-Breaker Switch Position

The setting range for the **Software filtering time** parameter ranges from 0 ms to 86 400 000 ms (1 day) in ms increments. The **Retrigger filter** check box can be used to select whether the software filter should be restarted by a change from 1 to 0 and back. When activated, the **Indication timestamp before filtering** check box back dates the time stamp by the set software filtering time and the fixed hardware filtering time. In this case, the time stamp corresponds to the actual status change of the signal. If you activate the **Suppress intermediate position** check box, the intermediate position is suppressed for the duration of this software filter time.

With the parameter **Spontaneous position changes filtered by**, you set how such position changes are to be filtered. Spontaneous position changes are caused by external switching commands, for

example. If the ***General software filter*** setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. The settings for spontaneous position changes can then not be edited. A separate filtering for spontaneous position changes is activated with the ***Spontaneous software filter*** setting and you can edit the settings for this.

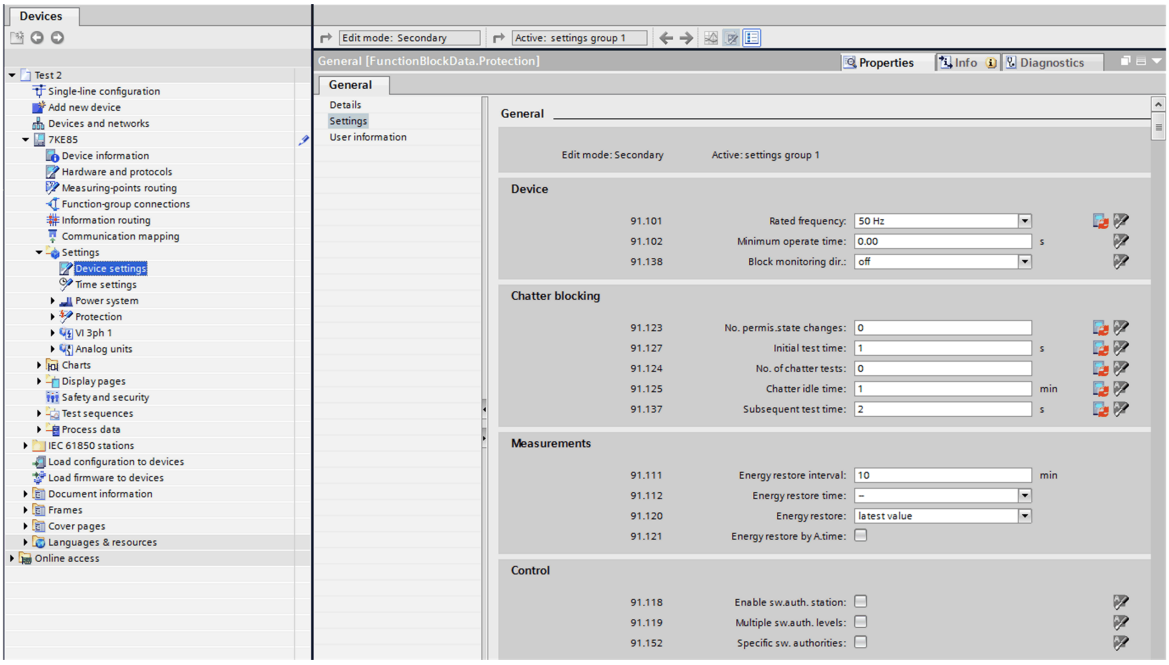
Chatter blocking can be activated or deactivated as a parameter of the position in the **Circuit breaker** or **Disconnector** function block.



[scflatte-180315, 1, en_US]

Figure 3-83 Setting Chatter Blocking

The settings for the chatter blocking function are set centrally for the entire device in DIGSI. They are accessible as settings in the **General** function group (see the following figure).



[scparafl-291110-01.tif, 2, en_US]

Figure 3-84 Chatter-Blocking Settings

The chatter-blocking settings have the following meaning (see also *Figure 3-85* and *Figure 3-86* in the examples shown in the following):

- **`No. permis.state changes`**

  This number specifies how often the state of a signal may toggle within the chatter-test time and the chatter-checking time. If this number is exceeded, the signal will be or remains blocked.

  Enter a number from 0 to 65535 in this field. If the entry is 0, chatter blocking is essentially inactive.

- **`Initial test time`**

  During this time, the number of times a signal changes its status is checked. This time is started if chatter blocking is configured for at least one signal and this signal changes its status. If the configured number of permissible state changes is exceeded during the initial test time, the signal is temporarily blocked and the indication *`Chatter blocking`* is set.

  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in seconds. When the set time has expired, the timer restarts automatically (cycle time).

- **`No. of chatter tests`**

  This number specifies the maximum number of test cycles to be run. If the number of permissible state changes stays exceeded during the initial test time of the last test cycle, the signal is finally blocked. In this case, the indication *`Group warning`* (**Alarm handling** group) and (**Device** group) are set additionally to the *`Chatter blocking`* indication after expiry of the set number. Restarting the devices removes this block again.

  Enter a number from 0 to 32767 in this field. The value Infinite (∞) is also permissible here.

  Enter this value as character string oo.

- **`Chatter idle time`**

  If the number of permissible status changes for a signal is exceeded during the initial test time or the subsequent test time, the **`Chatter idle time`** starts. Within this time, this signal is blocked temporarily and the *`Chatter blocking`* indication is set. The blocked input signal is assigned the **oscillatory** quality.

  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in minutes. An entry here is only considered if the number of chatter tests does not equal 0.

- **Subsequent test time**

  During this second test time, the number of times a signal changes its status is checked once again. The time begins when the **Chatter idle time** expires. If the number of status changes is within the permissible limits, the signal is released. Otherwise, an additional dead time begins, unless the maximum number of chatter tests has been reached.

  Enter a number between 2 and 65535 in this field. The number entered corresponds to the time in seconds. An entry here is only considered if the number of chatter tests does not equal 0.

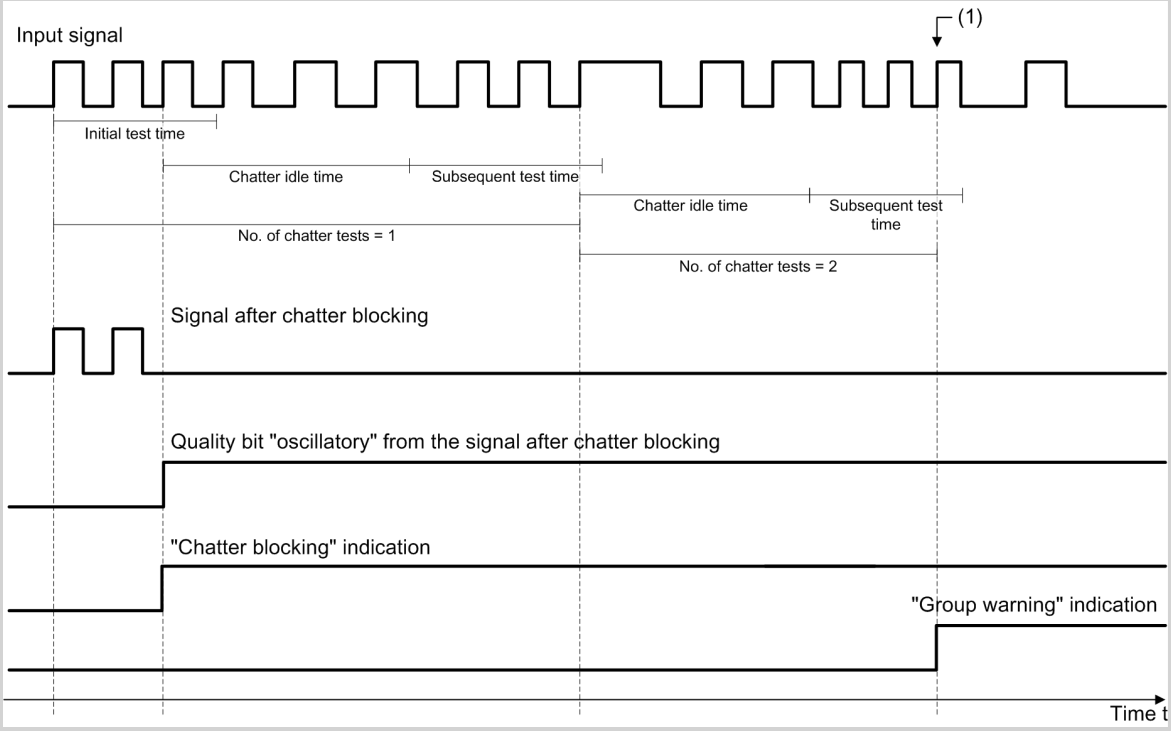
Example 1: Permanent Blocking

The chatter-blocking settings are set as follows:

- **No. permis.state changes** = 4
- **No. of chatter tests** = 2

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the **oscillatory** quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the *Chatter blocking* indication is set . After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to 2 in this example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of state changes of the input signal exceeds the set **No. permis.state changes**, the chatter blocking detects a persistent violation of the signal stability and sets the *Group warning* indication. The original state of the signal is permanently frozen. Only a device restart removes the chatter blocking again.



[dw_chatter-block-01, 1, en_US]

Figure 3-85 Signal Change during Chatter Blocking with too Important Number of Signal State Changes During 2nd Subsequent Test Time

(1) The input signal is permanently blocked starting from this point in time.

Example 2: Temporary Blocking

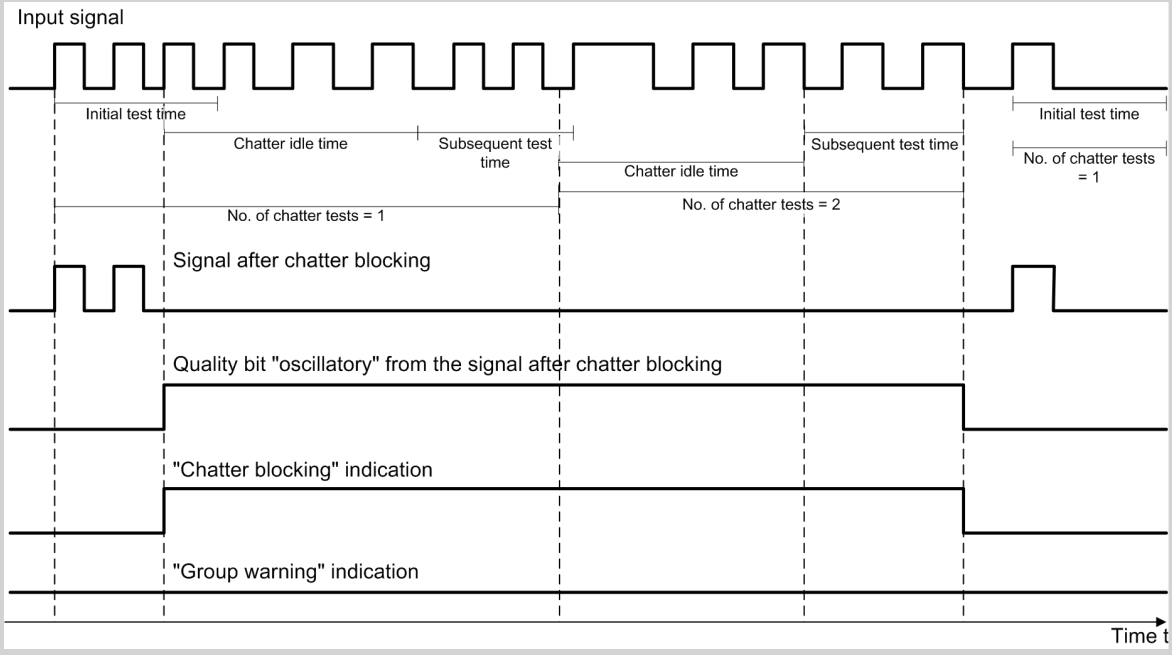
The chatter-blocking settings are set as follows:

- **No. permis.state changes** = 4
- **No. of chatter tests** = 2

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the **oscillatory** quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the *Chatter blocking* indication is set. After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to 2 in this example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of state changes of the input signal is within the set **No. permis.state changes**, the temporary blocking of state changes of the signal is removed and the actual signal state is released.

The quality bit **oscillatory** is removed and the *Chatter blocking* indication is reset. As the temporary blocking of the signal is removed, the *Group warning* indication is not set. The chatter test starts again.



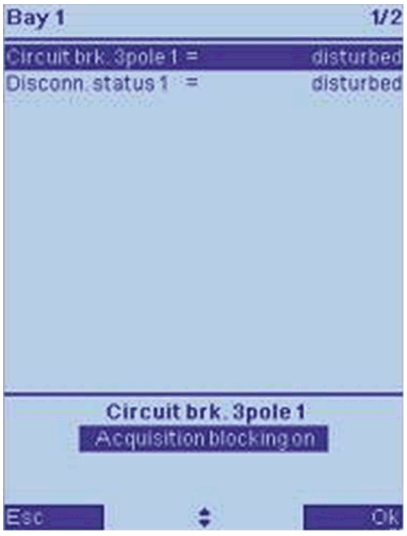
[dw_chatter-block-02, 1, en_US]

Figure 3-86 Signal Change during Chatter Blocking with Permissible Number of Signal State Changes During 2nd Subsequent Test Time

3.8.2 Acquisition Blocking and Manual Updating

During commissioning, maintenance, or testing, a brief interruption of the connection between the logical signals and binary inputs may be useful. It allows you to manually update the status of a switching device that is not providing feedback correctly. Before this can take place, you must first set acquisition blocking.

Set the Acquisition blocking function in the menu of the device display **Commands > Equipment >Aq.blk man. update**. If several switching devices are available, select the appropriate switching device. When pressing the **Change** key, the confirmation ID will be queried. After entering the confirmation ID, the acquisition blocking function is switched on when **OK** is pressed.



[scerfass-280513-01.tif, 1, en_US]

Figure 3-87 Activating the Acquisition Blocking

Manual updating of the switching device is possible from within the same menu. Use the menu item **Change** to select the **Manual updating** function. Subsequently, select the updating setting of the switching device manually and acknowledge the selection by pressing **OK**. The manually updated position of the switching device will be displayed.



[scstatus-280513-01.tif, 1, en_US]

Figure 3-88 Activate Manual Updating



[scstatu2-280513-01.tif, 1, en_US]

Figure 3-89 Selecting Position

NOTE

For safety reasons, manual updating is possible only directly through the on-site operation panel of the device and not through DIGSI 5.

NOTE

Setting acquisition blocking and the subsequent manual updating are also possible via the IEC 61850 system interface.

Acquisition blocking can also be set via a binary input. This way, acquisition blocking can be set for an individual or several switching devices in a feeder simultaneously with an external toggle switch in order to disable the feeder. For this purpose, every switching device in the **Switch** function block (circuit breaker or disconnector switch) has the input signal **`>Acquisition blocking`**. This signal can also be set from the CFC.

Information			Source											Destination		
			Binary input										CFC	Binary output		
			Basismodul											Basismodul		
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3		1.1	1.2	1.3
(All)	(All)	...	...	...	...	...	...	...	...	...	...	...	...	(All)	...	...	...
Trip logic	201.5341																
Circuit break.	201.4261		*	*											*	*	
>Ready	201.4261.500	SPS															
>Acquisition blocking	201.4261.501	SPS															
>Reset switch statist.	201.4261.502	SPS															
>Reset AcqBlk&Subst	201.4261.504	SPS															
External health	201.4261.503	ENS															

[scbeerfa-190215, 1, en_US]

Figure 3-90 Input signals *`>Acquisition Block`* and *`>Release Acquisition Block & Manual Updating`* on the Switching Device

NOTE

Interlockings are carried out with the status changes of the switching device. Remove acquisition blocking again manually. Otherwise, position changes of the switching device are not detected and interlockings are ineffective.

If the acquisition blocking and the manually updated position are set using the operation panel of the device or the system interface IEC 61850, these are retained until the acquisition blocking is manually deactivated. When you initially start the device, the acquisition blocking is deactivated.

Except for a restart, the acquisition blocking and the manually updated position are retained.

If the acquisition blocking is activated via the input signal **>Acquisition blocking**, it is retained as long as the binary input is active.

To set the acquisition blocking of a switching device, the following sources are possible:

- Operation panel of the device
- System interface IEC 61850
- Input signal **>Acquisition blocking**

All sources undergo OR operations, that is, the acquisition blocking remains set until all the sources are deactivated.

After deactivation of the acquisition blocking, the actual position of the switching device is adopted and displayed in the operation panel of the device.



NOTE

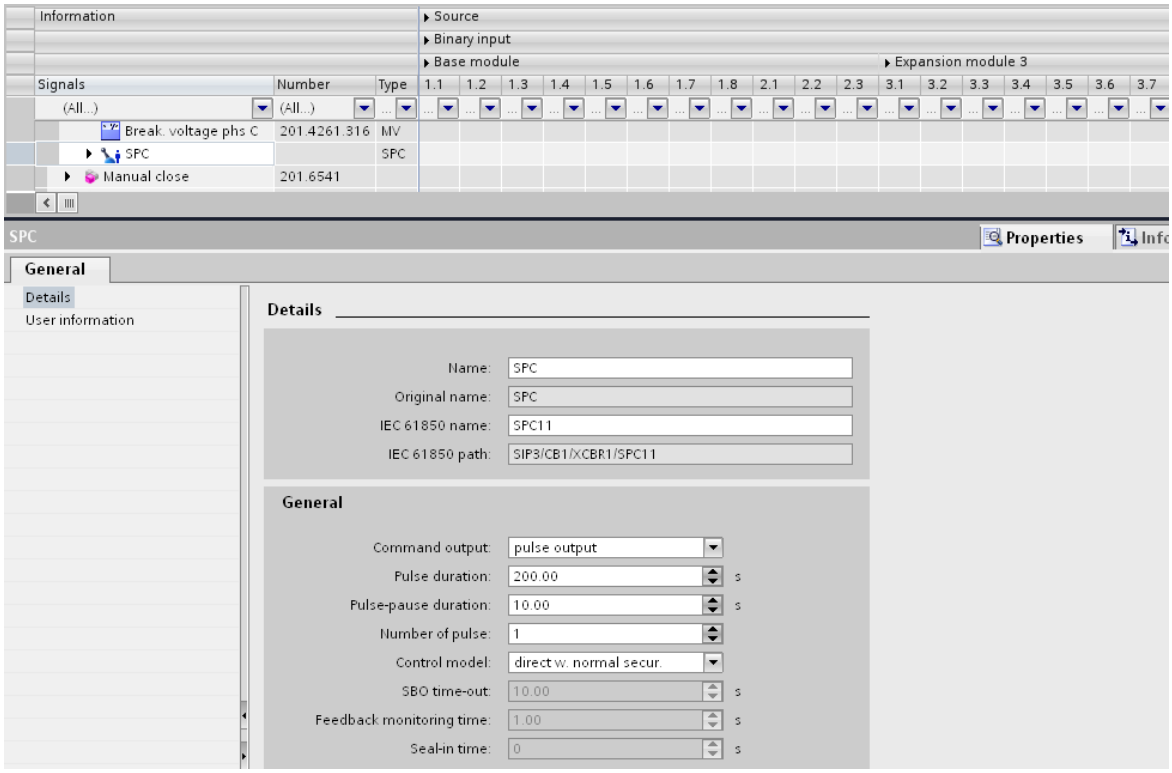
When the acquisition blocking is activated or the switching device updated manually while the entire device or the switching device is in test mode, these states are not saved. The acquisition blocking and the manual updating are not retained after a restart.

Acquisition blocking and manual update for the circuit breaker, the disconnector and the tap changer are reset by way of the **>Reset AcqBlk&Subst** binary input. Setting acquisition blocking and manual update is blocked with the input activated.

3.8.3 Persistent Commands

In addition to the switching commands, which are issued as pulse commands, and stored for the standard switching devices (circuit breaker, disconnector switch), persistent commands are also possible. In this case, a distinction must be drawn between controllables with the **Continuous output** operating mode and a stored signal output that is immune to reset.

You can change a controllable from pulse to persistent command with the **Command output** parameter.



[scbefehl-260912-01.tif, 1, en_US]

Figure 3-91 Setting the Command Type in DIGSI 5

Select ***Pulse output*** or ***Continuous output*** for the command output type. If a persistent command is selected, the Pulse parameter is irrelevant.

3.9 General Notes for Setting the Threshold Value of Protection Functions

3.9.1 Overview

You can set the threshold values of protection functions directly on the device or by using DIGSI 5.

An innovative design was implemented for the protection settings.

You can switchover the edit mode between the following setting views:

- Primary
- Secondary
- Percent

If you change settings in a setting view, DIGSI 5 calculates the settings of the 2 inactive views in the background. If you wish to save, for example, conversion to secondary values, then select the primary view. Configure all the settings and switchover to the secondary view.

Edit Mode: Primary

The parameters are set as primary values and thus refer directly to the primary system. The manual conversion on the secondary circuit omitted.

Edit Mode: Secondary

The settings refer to the secondary circuit of the transformer. This means that the settings must be converted. The secondary setting is the customary setting view. For secondary tests, the pickup values can be read directly.

Edit Mode: Percent

This setting type is beneficial for electric machines (generators, transformers, motors, and busbars). The setting values can be standardized regardless of the machine size. The reference values for the percentage settings are the rated values of the function groups, for example, rated voltage and rated current or rated apparent power . The setting values are, thus, related exclusively to the primary settings. If other reference values are used, then this is documented for the respective protection function in the application and setting notes.

If parameters are selected it may happen that they are set only in percent in all 3 setting views.

Recommendation for Setting Sequence

When setting the protection function, Siemens recommends the following procedure:

- First set the transformation ratios of the transformers. You can find these under **Power-system data**.
- In addition, set the reference parameters for the percent setting. You will find these parameters in function group .
- Next, set the parameter of the protection functions.

  If the transformer data have changed after completing the protection setting, remain in the setting sheet (for example, primary setting) and change the transformer data. In the background, DIGSI 5 obtains the new settings in the inactive setting views (for example, new secondary values).

The following section explains, by way of an example, how to modify the transformer ratios in DIGSI 5 using the corresponding alternatives.

3.9.2 Modifying the Transformer Ratios in DIGSI 5

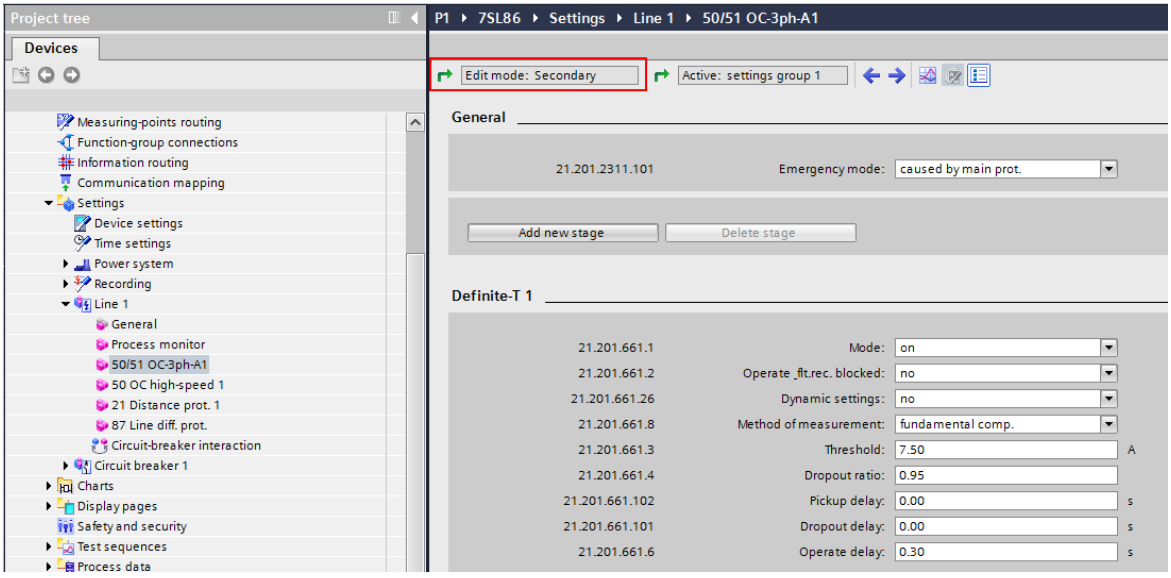
In the delivery setting, DIGSI 5 is set to the **Secondary** edit mode.

The following setting example shows how you can change the transformer ratio in DIGSI 5, and what impact this has on the settings in the setting views **Primary** and **Secondary**. The protection setting is observed in the example of the **Overcurrent protection** function.

The following output data are assumed:

Current transformer:	1000 A/1 A
Protection pickup value:	1.5 A

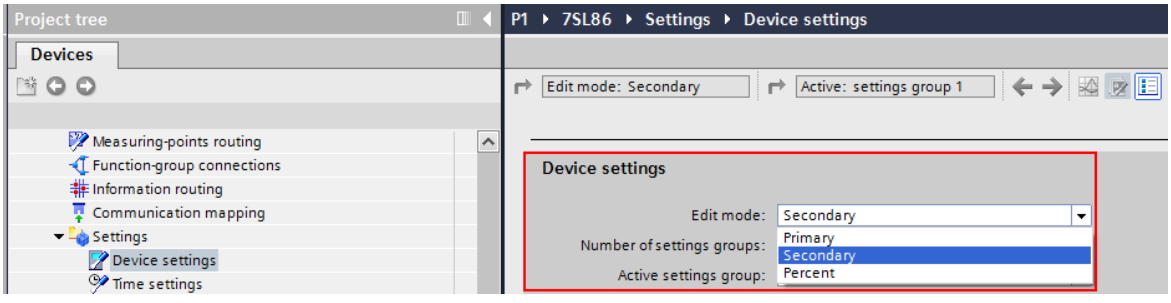
The following figure shows the protection setting of the **Overcurrent protection** function in the secondary view. The threshold value of the stage is set to 1.5 A.



[scmodsek_1, 1, en_US]

Figure 3-92 Protection Setting, Display of the Active Setting Sheet

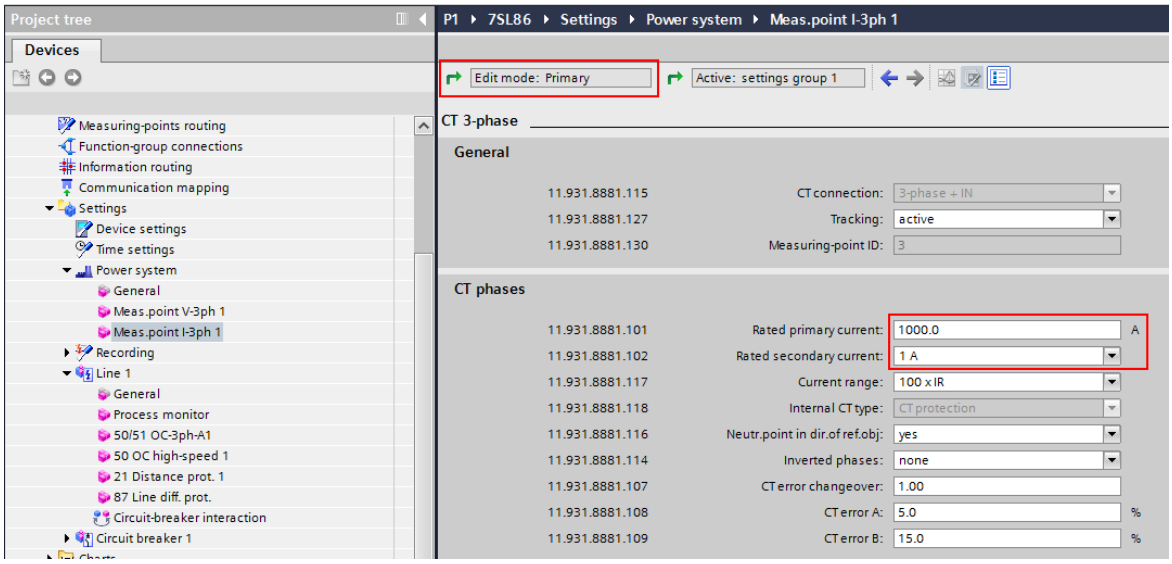
When you click the green arrow in the setting sheet at the upper left, you get to the window for switching over to the setting view (see the following figure). Select the setting view you prefer.



[scmodums_2, 1, en_US]

Figure 3-93 Switchover to the Desired Setting View

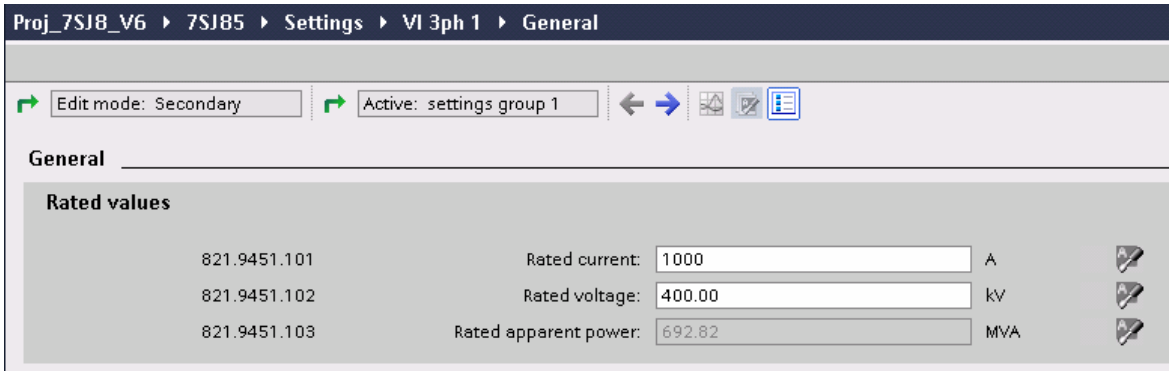
The following figures show the setting sequence in the **Primary** edit mode. Set the transformer data. In the example, the current transformer has a transformation ratio of 1000 A/1 A.



[scpwandl_3, 1, en_US]

Figure 3-94 Setting Sheet:Transformer Data

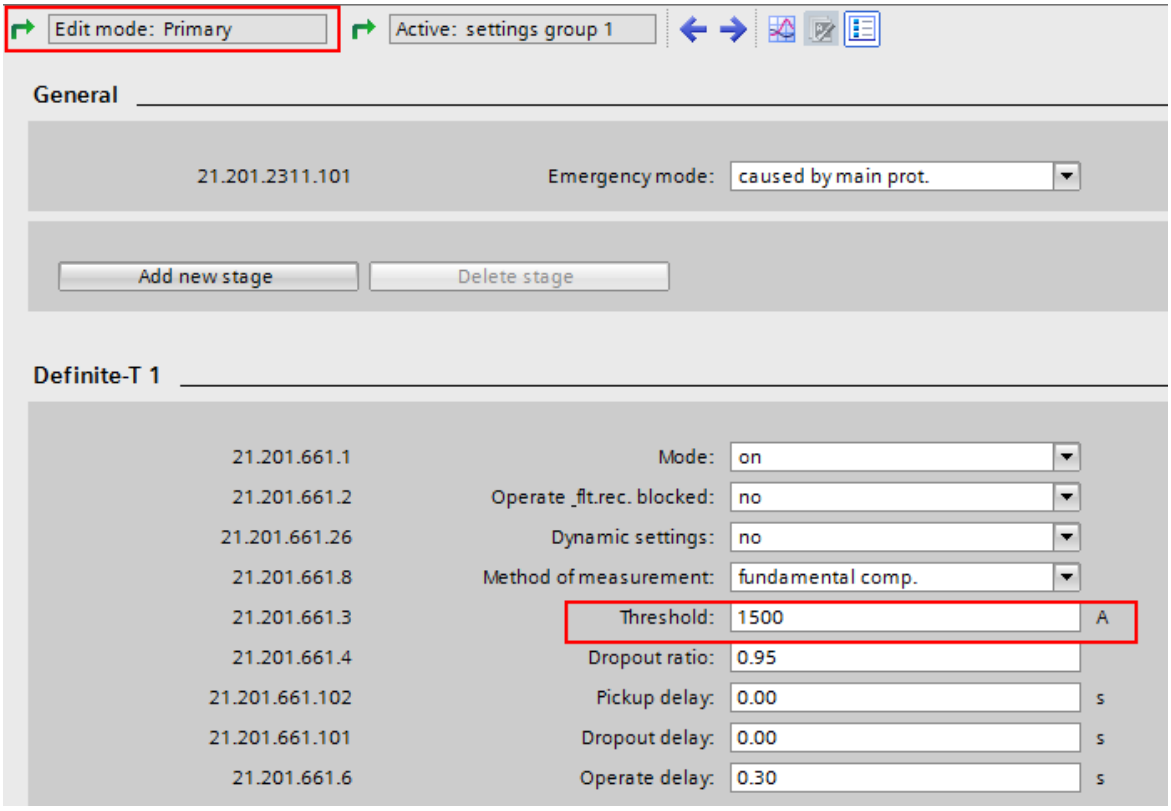
In the **Voltage/current 3-phase** function group, you set the rated current and rated voltage (see the following figure). Rated current, rated voltage are the reference variables for the percent setting.



[scui3phd, 1, en_US]

Figure 3-95 Reference Data for Percentage Settings

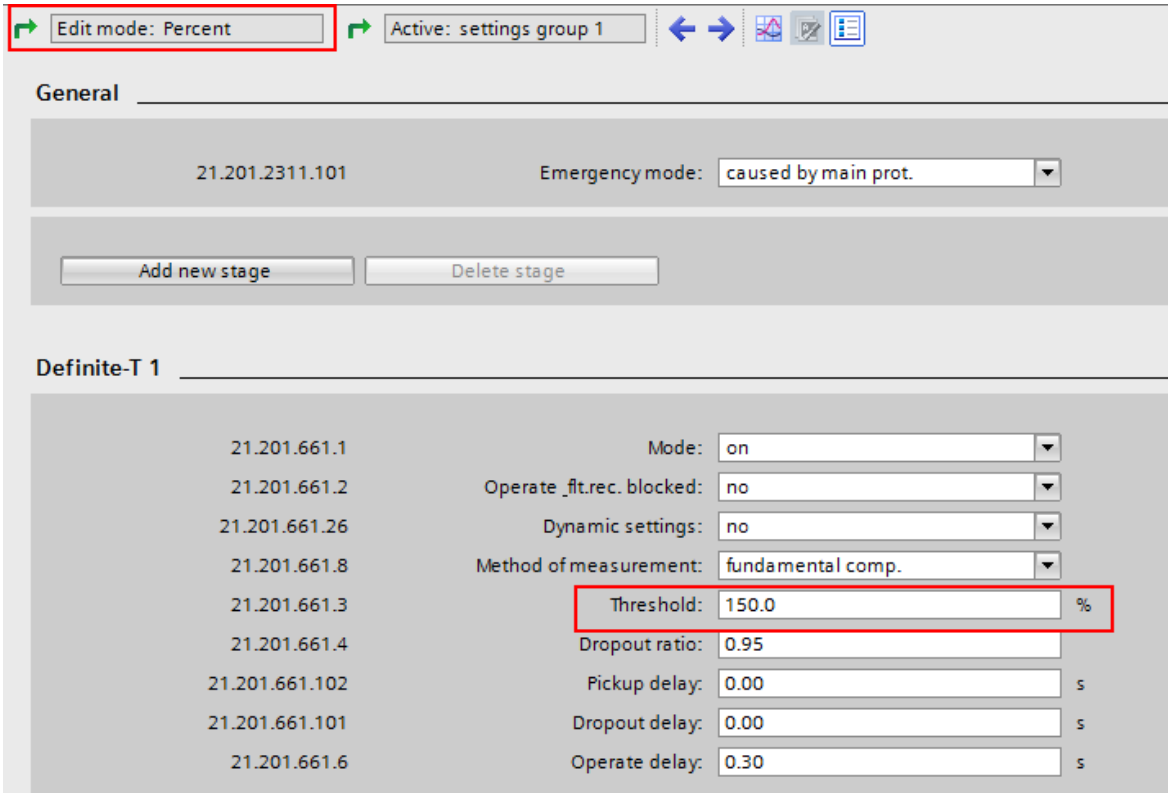
The following figure shows the threshold value of the **Overcurrent protection** function in the primary view at 1500 A.



[scumzpri_5, 1, en_US]

Figure 3-96 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Primary)

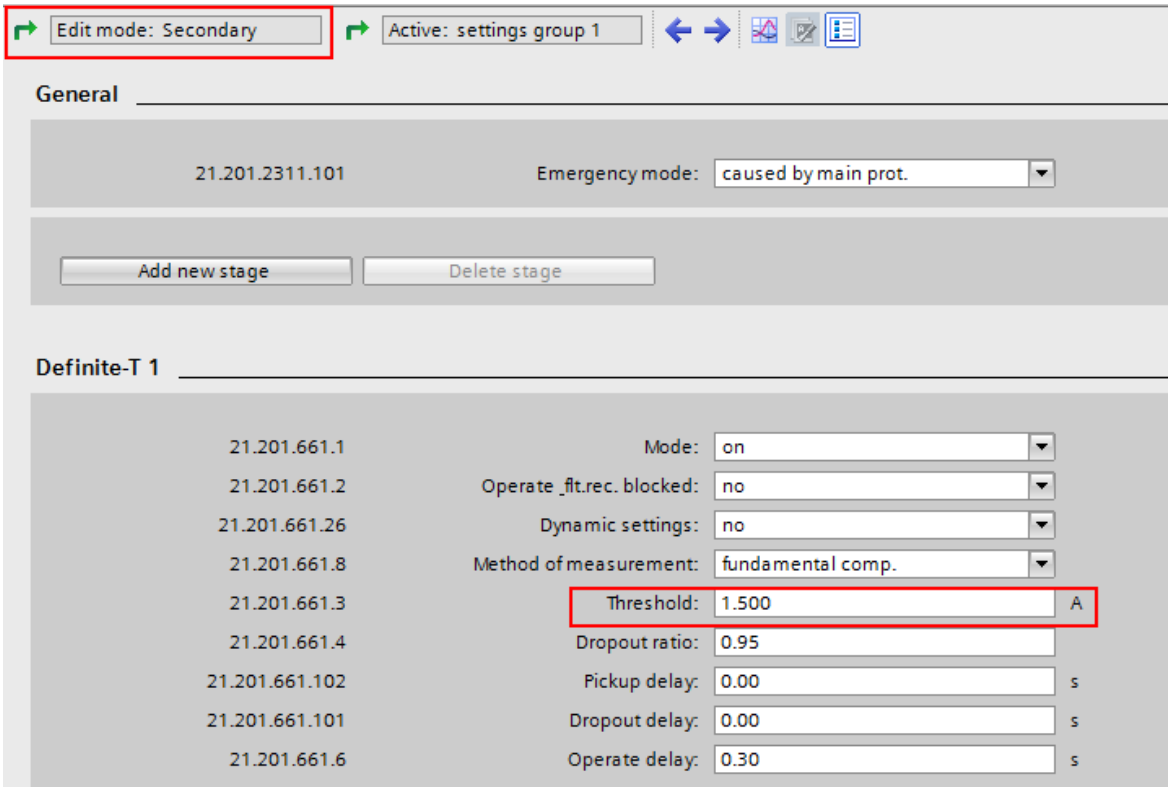
When switching over to the percent view, the result should be the following value:
1500 A/1000 A · 100 % = 150 %



[scumzpro_6, 1, en_US]

Figure 3-97 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Percent)

When switching over to the secondary view, the result should be the following value:
1500 A/(1000 A/1 A) = 1.5 A

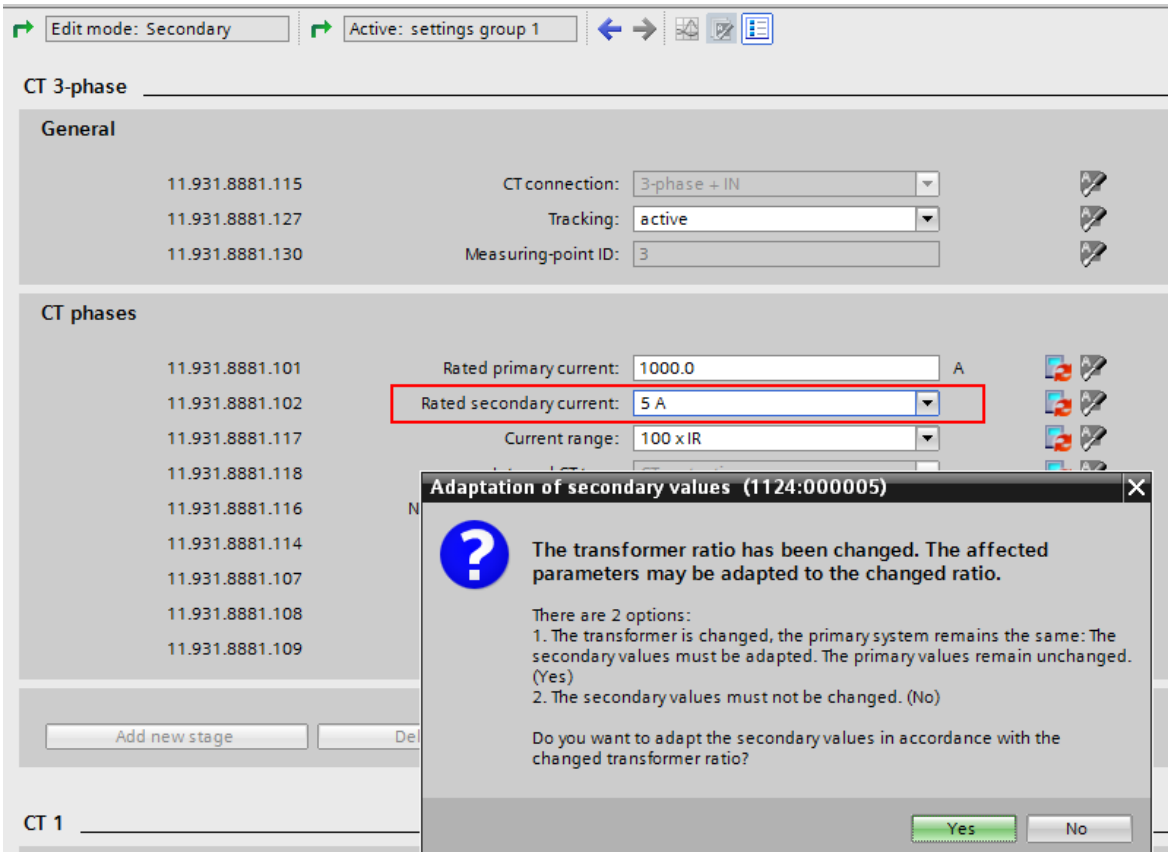


[scumzsek_7, 1, en_US]

Figure 3-98 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Secondary)

If you only want to work in the secondary view, DIGSI 5 supports you if the transformer ratio changes during the project phase.

In the example, the current-transformer ratio changes from 1000 A/**1 A** to 1000 A/**5 A**. Change the secondary rated current of the current transformer in the setting sheet of the transformer data from 1 A to 5 A (Edit mode: Secondary). If you change the transformer data, a window will appear (see the following figure) that will ask you for the action desired.

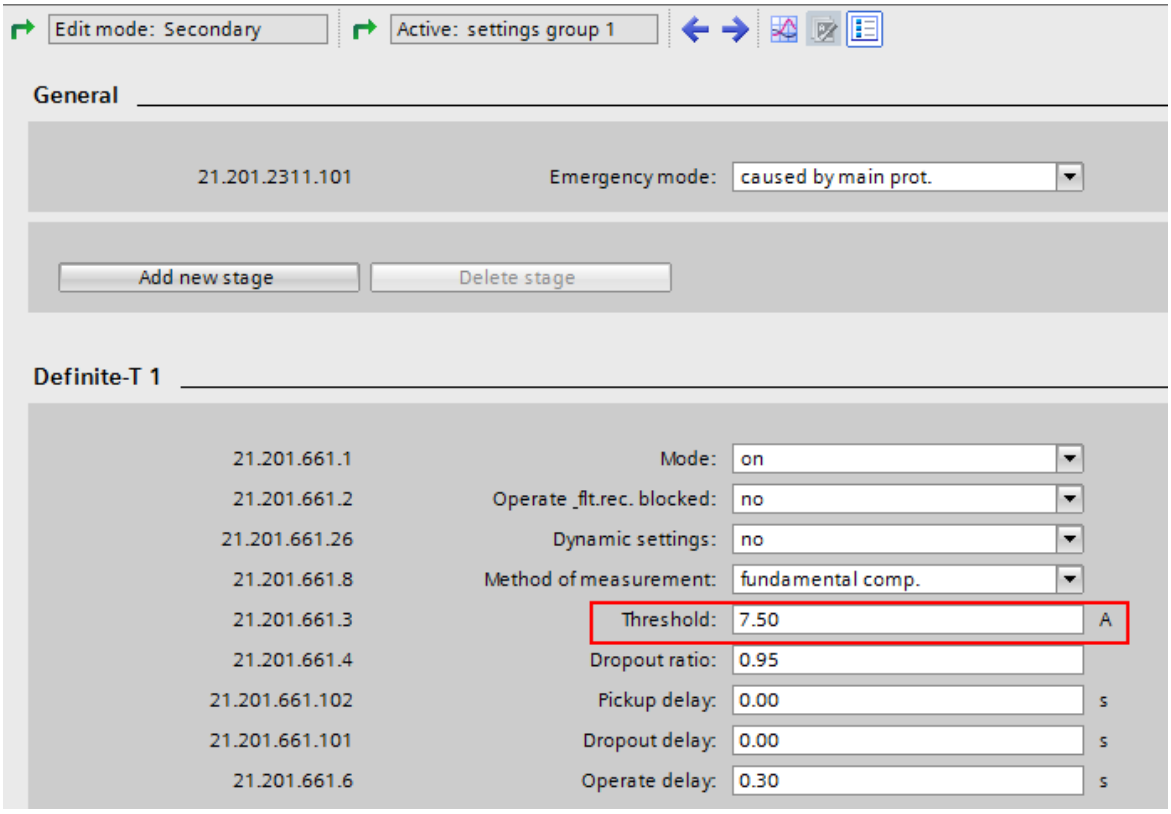


[scfragew_8, 1, en_US]

Figure 3-99 Query after Changing the Transformer Data (Setting View: Secondary)

If you answer the question with **Yes,** then DIGSI 5 will recalculate the pickup values (threshold values) in the active secondary view. For the new secondary transformer current 5 A, the new secondary threshold value obtained is 7.5 A (1.5 A * 5 = 7.5 A). The primary and percent values remain unchanged.

The following figure shows the newly calculated threshold value in the secondary view.



[scsekneu_9, 1, en_US]

Figure 3-100 Automatically Recalculated Secondary Values After Changes in the Transformer Data

If you have already set the settings in the secondary view by including the new transformation ratio of the transformer in the calculation, then you answer the question with **No**. In this case, the protection settings in the secondary view remain unchanged. DIGSI 5 recalculates the settings (threshold values) of the primary view. In the example, the primary threshold value is then 300 A (1.5 A * 1000 A/5 A = 300 A).

In the example, the current-transformer ratio changes from 1000 A/1 A to 1000 A/5 A. The following table summarizes the pickup values that DIGSI 5 will recalculate in the setting view. The new values (in bold) depend on the answer of your inquiry (see *Figure 3-99*).

	Reply to the Question	
	Yes	**No**
Threshold value secondary (active setting view)	**7.5** A	1.5 A
Threshold value primary (covered setting view)	1500 A	**300** A

3.9.3 Changing the Transformation Ratios of the Transformer on the Device

The device is preset to the secondary value at the time of delivery. Only secondary values can be set directly on the device.

If you change transformer data directly on the device, it is not followed by a query, like in DIGSI 5 (see *Figure 3-99*). Instead, the device assumes that all settings remain unchanged in the secondary view.



NOTE

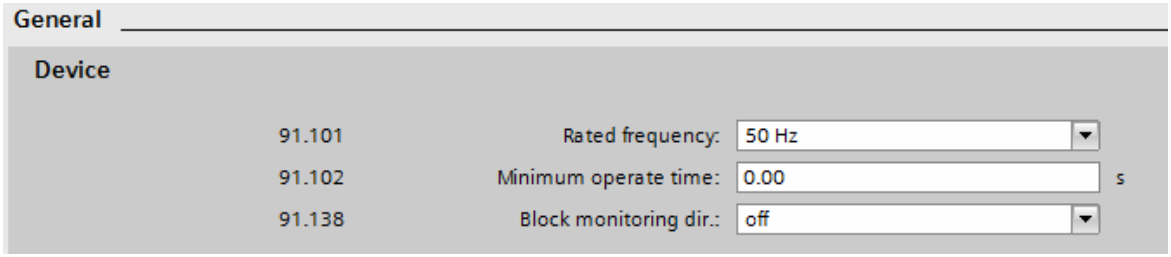
If the device works with IEC 61850 protocol, you change the transformer data only via DIGSI 5 and not directly on the device. If you change the transformer data directly on the device, the IEC 61850 configuration of the measurement and metered values can be faulty.

3.10 Device Settings

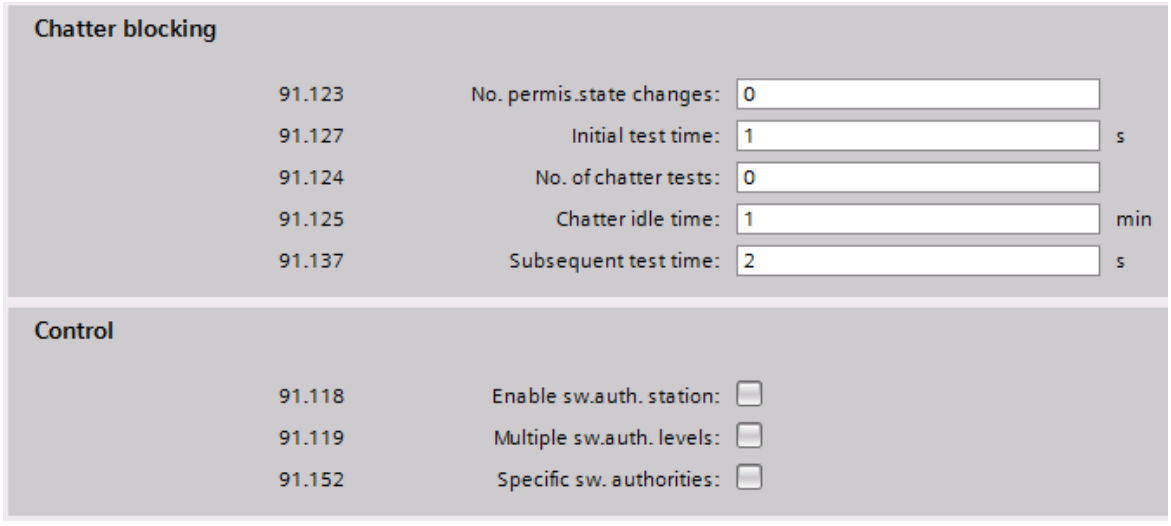
3.10.1 General Device Settings

3.10.1.1 Overview

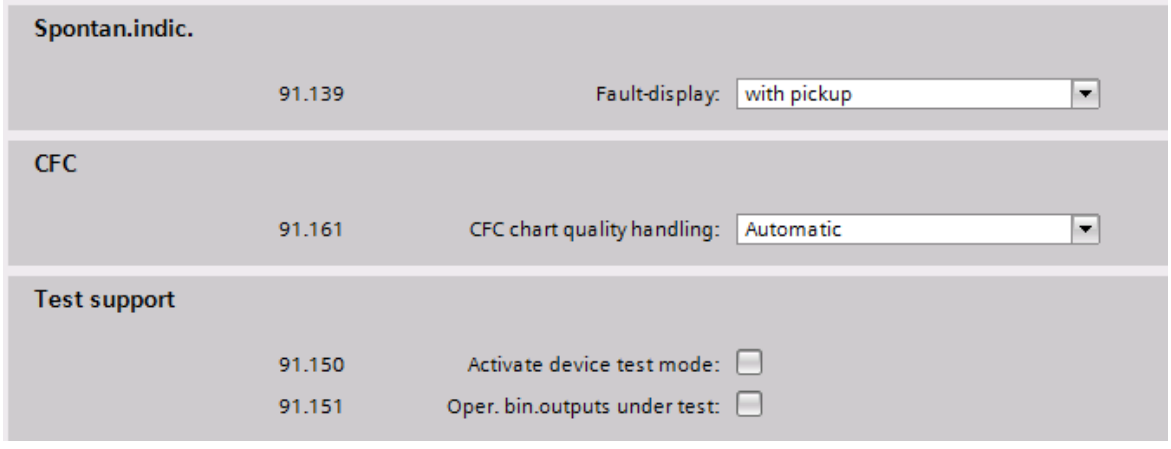
In **Device settings** in DIGSI 5, you find the following general settings.



[scDeSeDe1-310715-01, 1, en_US]



[scDeSeAl-310715-01, 1, en_US]



[scDeSeall-260815-01, 1, en_US]

Figure 3-101 General Device Settings

The following list shows you the chapters containing the desired information.

You can find more about:

- **Chatter blocking** in chapter *3.8.1 Signal Filtering and Chatter Blocking for Input Signals* .
- **Control** in chapter *8.3 Control Functionality* .
- **Spontaneous indications** in chapter *3.1.7 Spontaneous Indication Display in DIGSI 5* .
- **CFC Quality Processing** in Chapter *3.3.3 Quality Processing/Affected by the User in CFC Charts* .

Under **Device**, you set the parameters for the device that are valid across functions.

With the **Test support**, indications issued via communication interfaces are labeled with an additional test bit, if this is supported by the protocol. With this test bit, you can determine that an indication is generated as a test and that all or individual functions of the device are in test mode. In this way, the reactions that are necessary in normal operation due to an indication can be suppressed in other devices that receive these indications. You can also permit, for example, a trip command to close an energized binary output for test purposes. Siemens recommends deactivating the **Test support** again after the test phase.

3.10.1.2 Application and Setting Notes

The major part of the settings is described in the chapters cited above. In the following sections, you can find a description of the parameters of the sections **Device**, **Spontaneous indication**, and **Test support**.

Parameter: Rated frequency

- Default setting **(_:101) Rated frequency** = ***50 Hz***

With the **Rated frequency** parameter, you set the rated frequency of the electrical power system.

Parameter: Minimum operate time

- Default setting **(_:102) Minimum operate time** = **–**

With the **Minimum operate time** parameter, you set the minimum duration for the trip command of the functions. The trip command is maintained for the set duration.

Parameter: Block monitoring dir.

- Default setting **(_:138) Block monitoring dir.** = ***off***

With the **Block monitoring dir.** parameter, you set whether indications are issued via the system interface(s) of the SIPROTEC 5 device or not.

If transmission blocking is switched on, no indications are issued via the system interface(s) of a SIPROTEC 5 device.

Parameter: Fault-display

- Default setting **(_:139) Fault-display** = ***with pickup***

With the **Fault-display** parameter, you set whether spontaneous indications are issued for a pickup or for a tripping. Keep the DIGSI 5 routing options in chapters *3.1.7 Spontaneous Indication Display in DIGSI 5* and *Table 3-5* in mind.

Parameter: Activate device test mode

- Default setting **(_:150) Activate device test mode** = inactive

With the **Activate device test mode** parameter, you activate the test mode that adds a test bit to the issued indications.

Parameter: Oper.bin.outp. under test

- Default setting **(_:151) Oper.bin.outp. under test** = inactive

If you activate the parameter **Oper.bin.outp. under test** , you can allow the closing of a binary output for test purposes. In this way, indications are issued during a device-wide test mode and the relays are either

activated or not. If an individual function is in test mode, only indications are issued and the relays are not activated.



NOTE

The device remains in test mode during every startup until you set the device back into process mode intentionally. You switch to the process mode by switching the parameterActivate device test mode to inactive again (removing the check mark).

3.10.1.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device				
_:101	General:Rated frequency		• 50 Hz • 60 Hz	50 Hz
_:102	General:Minimum operate time		0.00 s to 60.00 s	0.00 s
_:138	General:Block monitoring dir.		• off • on	off
Spontan.indic.				
_:139	General:Fault-display		• with pickup • with trip	with pickup
Test support				
_:150	General:Activate device test mode		• 0 • 1	false
_:151	General:Oper.bin.outp. under test		• 0 • 1	false

3.10.1.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:510	General:>Test mode on	SPS	I
_:511	General:>Test mode off	SPS	I
_:507	General:>Device funct.logoff on	SPS	I
_:508	General:>Dev. funct.logoff off	SPS	I
_:512	General:>LED reset	SPS	I
_:52	General:Behavior	ENS	O
_:53	General:Health	ENS	O
_:51	General:Test mode	ENC	C
_:321	General:Protection on	SPC	C
_:54	General:Protection inactive	SPS	O
_:323	General:LED reset	SPC	C
_:320	General:LED have been reset	SPS	O

3.10.2 Settings-Group Switching

3.10.2.1 Overview of Functions

For different applications you can save the respective function settings in so-called **Settings groups**, and if necessary enable them quickly.

You can save up to 8 different settings groups in the device. In the process, only one settings group is active at any given time. During operation, you can switch between settings groups. The source of the switchover can be selected via a parameter.

You can switchover the settings groups via the following alternatives:

- Via the on-site operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to the substation automation technology.
  The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups.

A settings group includes all switchable settings of the device. Except for a few exceptions (for example, general device settings such as rated frequency), all device settings can be switched.

Detailed information about the settings groups can be found in the Operating Manual and DIGSI 5 Online Help.

3.10.2.2 Structure of the Function

The function of the **Settings group switching** is a supervisory device function. Accordingly, the settings and indications of the settings group switching can be found in DIGSI 5 and at the on-site operation panel of the device, below the general device settings respectively.

If you want to switchover a settings group, navigate to DIGSI 5 or proceed on the on-site operation panel of the device, as follows:

- Via the project tree in DIGSI 5:
  Project -> Device -> Settings -> Device settings
- Via the on-site operation panel of the device:
  Main menu → Settings → General → Group switchover

The indications for the settings group switching can be found in the DIGSI 5 project tree under:
Project → Device → Information routing → General

3.10.2.3 Function Description

Activation

If you want to use the **Settings group switching** function, you must first set at least 2 settings groups in DIGSI 5 (parameter **Number of settings groups** > 1). You can set up a maximum of 8 settings groups. The settings groups set in DIGSI 5 are subsequently loaded into the device.

Mechanism of the Switchover

When switching over from one settings group to another, the device operation is not interrupted. With the **Active settings group** parameter, you are either specifying a certain settings group or you allow switching ***via control*** (IEC 60870-5-103, IEC 61850) or ***via binary input***.

Switching via Control

When using the ***Control*** function for switching, the settings groups can be switched via a communication connection from the substation automation technology or via a CFC chart.

The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.

In order to use a CFC chart for switching, you must create a new CFC chart in DIGSI 5. Create the CFC chart in the DIGSI 5 project tree under **Name of the device → Charts → Add new chart**. Link the signals that control settings group switching in the CFC chart.

Switching via Binary Input

There are 3 appropriate input signals available for switching via binary inputs. These input signals allow selection of the settings group via a binary code. If one of the 3 signals changes, the signal image present will, after 100 ms (stabilization time), result in switching over to the appropriate settings group. If only 2 settings groups must be switched over, only 1 binary input is required. The following table shows the possible binary codes (BCD) and applicable settings groups (PG).

Table 3-19 Binary Codes of the Input Signals and Applicable Settings Groups

BCD Code via Binary Inputs	PG 1	PG 2	PG 3	PG 4	PG 5	PG 6	PG 7	PG 8
>PG selection bit 3	0	0	0	0	1	1	1	1
>PG selection bit 2	0	0	1	1	0	0	1	1
>PG selection bit 1	0	1	0	1	0	1	0	1

Copying and Comparing Settings Groups

In DIGSI 5, you can copy or compare settings groups with each other.

If you want to copy settings groups, select a source and target parameter group in DIGSI 5 in the device settings, and then start the copy process. The device settings can be found in the DIGSI 5 project tree under Project → Device → Settings → Device settings.

If you want to compare settings groups, it is possible to do so in all setting sheets for settings. You will then select in addition to the active settings group, a 2nd settings group for comparison. Active setting values and the comparable values are displayed next to each other. For settings that cannot be switched over, no comparable values are displayed.

Indication of Settings Group Switchings

Every settings group shows an applicable binary indication as well as its activation and deactivation. The process of settings group switching is also logged in the log for settings changes.

3.10.2.4 Application and Setting Notes

Parameter: Number settings groups

- Default setting **(_:113) Number settings groups** = ***1***

With the **Number settings groups** parameter, you can set the number of available settings groups; you can switch between these.

Parameter: Activat. of settings group

- Default setting **(_:114) Activat. of settings group** = ***settings group 1***

With the **Activat. of settings group** parameter, you specify the settings groups that you want to activate, or the mechanisms via which the switchover is allowed. You can switchover only between the settings groups specified with the **Number settings groups** parameter. Parameter Value

Parameter Value	Description
via control	The switchover between the settings groups can only be initiated via a communication connection from a substation automation technology or via a CFC chart. The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.
via binary input	The switchover between the settings groups functions exclusively via the binary input signals routed to the settings group switching.
settings group 1 ... ***settings group 8***	They define the active settings groups. You can define the active settings groups in DIGSI 5, or directly on the device via the on-site operation.

3.10.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Change group				
_:113	General:Number settings groups		1 to 8	1
_:114	General:Activat. of settings group		• via control • via binary input • settings group 1 • settings group 2 • settings group 3 • settings group 4 • settings group 5 • settings group 6 • settings group 7 • settings group 8	settings group 1

3.10.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>SG choice bit 1	SPS	I
_:501	General:>SG choice bit 2	SPS	I
_:502	General:>SG choice bit 3	SPS	I
_:300	General:Act. settings group 1	SPC	C
_:301	General:Act. settings group 2	SPC	C
_:302	General:Act. settings group 3	SPC	C
_:303	General:Act. settings group 4	SPC	C
_:304	General:Act. settings group 5	SPC	C
_:305	General:Act. settings group 6	SPC	C
_:306	General:Act. settings group 7	SPC	C
_:307	General:Act. settings group 8	SPC	C

4 Applications

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4.2	Application Templates and Functional Scope for the Devices 7SJ82/7SJ85	187

4.1 Overview

The Global DIGSI 5 library provides application templates for the applications of the devices. The application template

- Supports the fast realization of complete protection solutions for applications
- Contains the basic configuration for the use case
- Contains functions and default settings for the use case

When using an application template, please note the following:

- Adapt the application template to your specific use (check/adapt default settings, delete/add functions). You can find more detailed information in the *2.1 Function Embedding in the Device*.
- Check the routing of binary outputs with respect to fast and normal relays.
- Check the CFC charts for the group-warning indications and group-fault indications.

The following describes the application templates and maximum functional scope for the devices shown in this manual.



NOTE

The availability of certain settings and setting options depends on the device type and the functions available on the device!

4.2 Application Templates and Functional Scope for the Devices 7SJ82/7SJ85

Application templates are available in **DIGSI 5** for the applications of the device 7SJ82/7SJ85. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7SJ82 and 7SJ85 in the **DIGSI 5** function library:

- Non-directional OC (4*I)
- Non-directional OC (4*I, 4*V)
- Directional OC, grounded system
- Directional OC, resonant-grounded/isol. system
- Capacitor bank H-bridge + 1*RLC, **7SJ85 only**
- Capacitor bank MSCDN, **7SJ85 only**
- Capacitor bank H-bridge, **7SJ82 only**

To load the application templates to the device, the following minimum hardware configuration requirements must be met:

Application Template		**Hardware Configuration Minimum Requirement**
Template 1	Non-directional OC (4*I)	9 BI, 8 BO, 4 I
Template 2	Non-directional OC (4*I, 4*V)	9 BI, 8 BO, 4 I, 4 V
Template 3	Directional OC, grounded system	
Template 4	Directional OC, resonant-grounded / isol. system	
Template 5	Capacitor bank: H-bridge + 1*RLC	2 BI, 2 BO, 12 I
Template 6	Capacitor bank: MSCDN	2 BI, 2 BO, 28 I, 4 V
Template 7	Capacitor bank: H-bridge	2 BI, 2 BO, 8 I

The following table shows the functional scope and the required function points of the application templates for the device 7SJ82/7SJ85:

Table 4-1 Functional Scope of the Application Template for the Device 7SJ82/7SJ85

ANSI	**Function**	**Abbr.**	**Available in 7SJ82**	**Available in 7SJ85**	**Template 1**	**Template 2**	**Template 3**	**Template 4**	**Template 5**	**Template 6**	**Template 7**
	Protection functions for 3-pole tripping	3-pole	x	x	x	x	x	x	x	x	x
	Hardware quantity structure expandable	I/O	x	x	x	x	x	x	x	x	x
24	Overexcitation protection	V/f	x	x							
25	Synchrocheck, synchronizing function	Sync	x	x							
27	Undervoltage protection, 3-phase	V<	x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
27	Undervoltage protection, positive-sequence system	V1<	x	x							
27	Undervoltage protection, 3-phase, universal, Vx	Vx<	x	x							
27	Undervoltage protection, 1-phase, universal, Vx	Vx<	x	x							
27/Q	Undervoltage-controlled reactive-power protection	QU	x	x							
32R	Reverse power protection	-P<	x	x							
32, 37	Power protection active/reactive power	P<>, Q<>	x	x							
37	Undercurrent protection x	I<	x	x					x	x	x
38	Temperature Supervision	TmpUb	x	x							
46	Negative sequence overcurrent protection	I2>	x	x					x	x	x
46	Unbalanced-load protection (thermal)	$I2^2t$>	x	x							
46	Negative sequence overcurrent protection with direction	I2>, ∠ (V2, I2)	x	x							
49	Thermal overload protection	Θ, I^2t	x	x					x	3	x
49	Thermal overload protection with user-def. charac. curve	Θ, I^2t	x	x						3	x
49	Thermal overload protection for RLC element	Θ, I^2t	x	x					x		
50TD/ 51	Overcurrent protection, phases - advanced	I>	x	x					x		
50TD/ 51	Overcurrent protection, phases - basic	I>	x	x	x	x	x	x		3	x
50NTD/ 51N	Overcurrent protection, ground - advanced	IN>	x	x					x		
50NTD/ 51N	Overcurrent protection, ground - basic	IN>	x	x	x	x	x			x	x

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
50N/ 51N	Overcurrent protection, 1-phase - advanced	I>1pA	x	x							
50N/ 51N	Overcurrent protection, 1-phase - basic	I>1pB	x	x							
50HS	High speed instantaneous overcurrent protection	I>>>	x	x							
50Ns/ 51Ns	Sensitive ground-current protection for systems with resonant or isolated neutral	INs>	x	x							
50BF	Circuit-breaker failure protection		x	x						x	
RBRF	Restrike protection		x	x							
51-R	OC-3ph protection for RLC elements		x	x							
51V	OC-3phase voltage-dependent		x	x							
59	Overvoltage protection, 3-phase	V>	x	x						x	
59	Overvoltage protection, positive-sequence system	V1>	x	x							
47	Overvoltage protection, negative-sequence system	V2>	x	x							
47	Overvoltage protection with negative-sequence voltage/positive-sequence voltage	V2/V1>	x	x							
59N	Overvoltage protection, zero-sequence system	V0>	x	x							
59	Overvoltage protection, 3-phase or 1-phase, universal, Vx	Vx>	x	x							
59C	Peak overvoltage protection for capacitors		x	x					x	2	x
60C	Current unbalance protection for capacitors, 3-phase	Iunbal>	x	x					x	2	x
60C	Current Unbalance Protection for Capacitors, 1-phase	Iunbal>	x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
67	Directional overcurrent protection 1-pole			x							
67	Directional time-overcurrent protection, phases – advanced	I>, ∠(V,I)	x	x							
67	Directional time-overcurrent protection, phases – basic	I>, ∠(V,I)	x	x			x	x			
67N	Directional overcurrent protection, ground - advanced	IN>, ∠ (V,I)	x	x							
67N	Directional time-overcurrent protection, ground - basic	IN>, ∠ (V,I)	x	x			x				
67Ns	Directional sensitive ground-fault detection for systems with resonant or isolated neutral	INs>, ∠ (V,I)	x	x				x			
67Ns	Transient ground-fault function, for transient and permanent ground faults in resonant-grounded or isolated networks	W0p,tr>	x	x							
74TC	Trip circuit supervision	TCS	x	x							
79	Automatic reclosing	AREC	x	x							
81O	Overfrequency protection	f>	x	x							
81U	Underfrequency protection	f<	x	x							
81R	Rate of frequency change protection	df/dt	x	x							
86	Lockout		x	x	4	4	4	4	x	x	x
87C	Capacitor bank differential protection		x	x						x	
87V	Voltage-differential protection	ΔV		x							
87N	Restricted ground-fault protection	ΔIN	x	x							
90V	Voltage controller		x	x							
Arc Prot	Arc protection		x	x							
DIGFP	Directional intermittent ground-fault protection		x	x							
IGFP	Intermittent ground-fault protection		x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
FL	Fault locator, single-ended measurement	FL-one	x	x							
PMU	Synchrophasor measurement	PMU	x	x							
SOTF	Instantaneous tripping at switch onto fault	SOTF	x	x	x	x	x	x			
Monit	Circuit-breaker wear monitoring		x	x							
VSEL	Voltage measuring-point selection		x	x							
20mA MT	20-mA unit Ethernet		x	x							
20mA MS	20-mA unit serial		x	x							
RTDMT	RTD unit Ethernet		x	x							
RTDMS	RTD unit Serial		x	x							
	Signaling-Voltage Supervision		x	x							
	Measuring-voltage failure detection		x	x							
	Switch onto fault		x	x	x	x	x	x			
	CB Test		x	x	x	x	x	x	x	x	x
	Interlocking		x	x	4	4	4	4	x	x	x
	I-jump detection		x	x							
	V- jump detection		x	x							
	Pulse metered value		x	x							
	Measured values, standard		x	x	x	x	x	x	x	2	x
	User-defined function block		x	x							
	Measured values, extended: Min, Max, Avg		x	x							
	Switching statistic counters		x	x							
	CFC standard and control		x	x	x	x	x	x	x	x	x
	CFC arithmetic		x	x							
	Switching sequences function		x	x							
	Inrush current detection		x	x	x	x	x	x			
	External trip initiation		x	x							
	Control		x	x	4	4	4	4	x	x	x

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
	Fault recording of analog and binary signals		x	x	x	x	x	x	x	x	x
	Monitoring and supervision		x	x	x	x	x	x	x	x	x
	Protection interface, serial		x	x							
	Capacitor bank		x	x					x	2	x
	Circuit Breaker		x	x	x	x	x	x	x	x	x
	Circuit Breaker [control]		x	x							
	Circuit Breaker [status only]		x	x							
	Disconnector		x	x	3	3	3	3			
	Disconnector [status only]		x	x							
	Tap changer		x	x							
	Analog unit		x	x							
	Communication modules		x	x	x	x	x	x	x	x	x
	Function-points class:				0	0	30	45	90	295	80

5 Function-Group Types

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5.1 Function-Group Type Voltage-Current 3-Phase

5.1.1 Overview

All functions for protection and supervision of a protected object or equipment allowing 3-phase current and voltage measurement can be used in the function group **Voltage-current 3-phase**. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*).

You will find the **Voltage-current 3-phase** function group under each device type in the Global DIGSI 5 library. You will find all protection and supervision functions that you can use for this function-group type in the function group **Voltage-current 3-phase**. These functions are described in chapter *6 Protection and Automation Functions* .

You can find additional information on the embedding of the functions in the device in chapter *2 Basic Structure of the Function* . You can find the function scope of the application templates for the various device types in the chapter *4 Applications* .

5.1.2 Structure of the Function Group

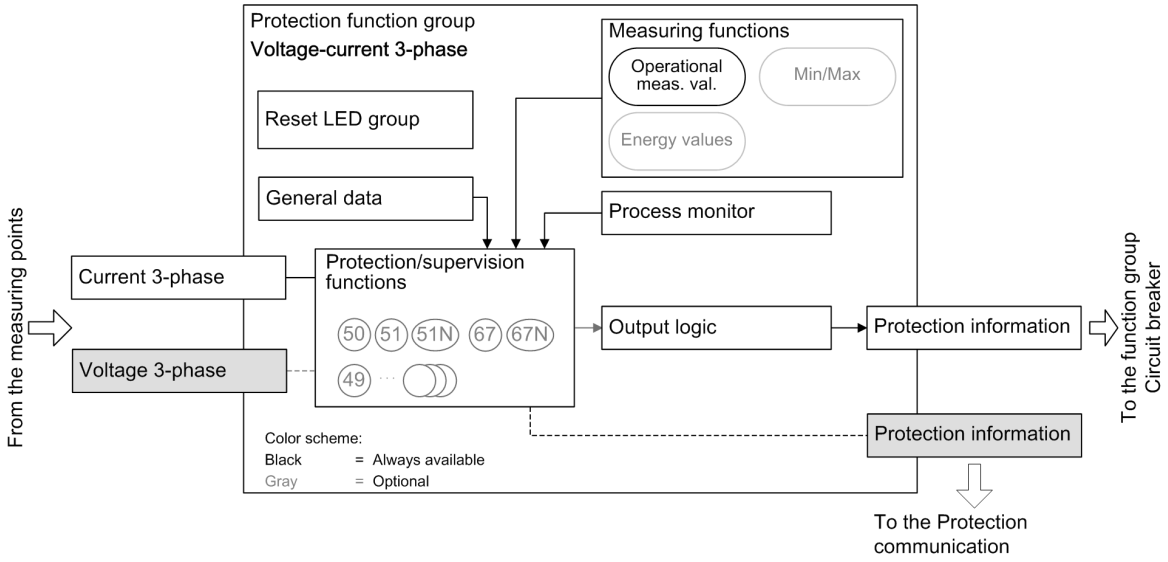
The function group always contains the following blocks:

- Protected object/equipment data (FB General)
- Operational measured values
- Process monitor
- Output logic of the function group
- Reset LED group

These blocks are essential for the function group under all circumstances, so they cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

The following figure shows the structure of the function group **Voltage-current 3-phase**.



[dwfgui3p-301112-01.tif, 4, en_US]

Figure 5-1 Structure of the Voltage-Current 3-Phase Function Group

The function group has interfaces with

- **Measuring points**
- **Circuit-breaker** function group

Interface with Measuring Points

The function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the function group is already connected to the necessary measuring points. If you add functions to the function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function group connections** editor. You can find more detailed information in chapter *2 Basic Structure of the Function*.

The function group has the following interfaces with the measuring points:

- **3-phase current**

  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are, for example, I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The function group must always be connected to the **I-3ph** measuring point.

  You can connect the **3-phase current** interface to a maximum of **four** 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts). If 2 current measuring points have been connected with the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the function group. All functions in the function group have access to these values.

- **3-phase voltage (optional)**

  The measurands from the 3-phase voltage system are supplied via this interface. There are various types of transformer connections possible. All values that can be calculated from the measurands are also provided via this interface. Connecting the function group to the **V 3ph** measuring point is optional.

  You can connect multiple measuring points with this interface. You can find more information in chapter *6.48 Voltage Measuring-Point Selection*.

  If you want to test or change the connection between the voltages and the V-3ph measuring point, double-click in the DIGSI 5 project tree → **(Name of the device)** on **Measuring point routing** (Connection type = 3 phase-to-ground voltage). For more information, refer to the description of the power-system data starting in chapter *6.1 Power-System Data*.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and **Circuit-breaker** function groups via the interface with the Circuit-breaker function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

The **Voltage-current 3-phase** function group is connected to one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the protection function group
- Starting the Circuit-breaker failure protection function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the Automatic reclosing function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

Besides the general allocation of the protection function group to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** editor in the protection function group.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2.1 Function Embedding in the Device*.

If the connection is missing, DIGSI 5 reports an inconsistency.

Protected Object/Equipment Data (FB General)

The rated voltage and rated current as well as the neutral-point treatment of the protected object or the equipment are defined here. These data apply to all functions in the **Voltage-current 3-phase** function group.

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

You can find more detailed information in chapter *3.1.10 Resetting Stored Indications of the Function Group* .

Process Monitor

The process monitor is always present in the **Voltage-current 3-phase** function group and cannot be removed.

The process monitor provides the following information in the **Voltage-current 3-phase** function group:

- Current-flow criterion:
  Detection of an open/activated protected object/equipment based on the flow of leakage current
- Closure detection:
  Detection of the switching on of the protected object/equipment
- Cold-load pickup detection (optional, only for protection devices):

These data apply to all functions in the **Voltage-current 3-phase** function group.

The description of the process monitor begins in chapter *5.8 Process Monitor*.

Operational Measured Values

The operational measured values are always present in the **Voltage-current 3-phase** function group and cannot be removed.

The following table shows the operational measured values of the **Voltage-current 3-phase** function group:

Table 5-1 Operational Measured Values of the Voltage-Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	Rated operating current of the primary values
I_{NS}	Sensitive ground current	A	mA	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P_{total}	Active power (total power)	MW	W	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$

Measured Values		Primary	Secon-dary	% Referenced to
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	W	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	var	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	VA	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

The operational measured values are explained in more detail in chapter *10.3 Operational Measured Values* .

Inversion of Power-Related Measured and Statistical Values (FB General)

The following directional values calculated in operational measured values are defined positively in the direction of the protected object.

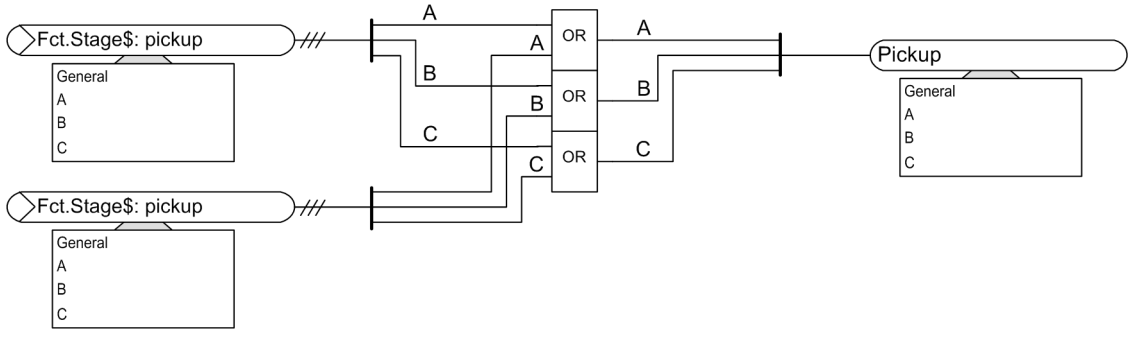
- Power
- Active power factor
- Energy
- Minimum, maximum values
- Average values

With the **`P, Q sign`** parameter, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.
More information can be found in chapter *10.1 Overview of Functions*.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions that are available in the function group separately, in a pickup logic and a trip logic, respectively. The pickup and trip logic generate the overreaching indications (group indications) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

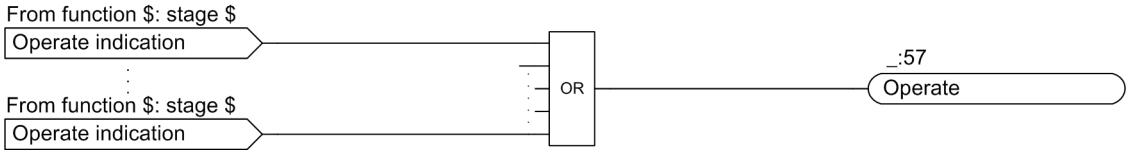
The pickup signals of the protection and supervision functions in the **Voltage-current 3-phase** function group are combined in a phase-selective manner and output as a group indication.



[loanrlin-150211-01.tif, 3, en_US]

Figure 5-2 Creation of the Pickup Indication of the Voltage-Current 3-Phase Function Group

The trip signals from the protection and supervision functions of the **Voltage-current 3-phase** function group always result in 3-pole tripping of the device.



[loauslin-150211-01.tif, 3, en_US]

Figure 5-3 Creation of the Operate Indication of the Voltage-Current 3-Phase Function Group

5.1.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

With this, you define which circuit-breaker(s) is/are affected by the protection functions of the Protection function group. A feasible default setting has already been provided in the application templates. You can find more information in chapter 2.

Protected Object/Equipment Data (FB General)

The set data applies to all functions in the function group.

Set the protected object/equipment data for your specific application.

Parameter: Rated current

- Default setting **(_:9451:101) Rated current** = ***1000 A***

With the **Rated current** parameter, you can set the primary rated current of the protected object or equipment. The **Rated current** parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting **(_:9451:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage of the protected object or equipment. The **Rated voltage** parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Power-sys. neutral point

- Default setting **(_:9451:149) Power-sys. neutral point** = ***grounded***

With the **Power-sys. neutral point** setting, you specify whether the system neutral is ***grounded*** , ***isolated*** , or ***suppress. coil grounded*** (grounded via arc-suppression coil). Currently, the parameter does not affect any protection function; only if the **Automatic reclosing function** uses the voltage measurement.

You can find more information in Chapter *6.43.1 Overview of Functions* .

Parameter: `P, Q sign`

- Default setting `(_:9451:158) P, Q sign` = ***not reversed***

The power and energy values are defined by the manufacturer such that power in the direction of the protected object is considered positive. You can also define the power output by the protected object (for example, as seen by the consumer) as positive. With the `P, Q sign` setting, you can invert the sign for these components. This inversion does not influence any protection function.

5.1.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Network data				
_:103	General:rated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA



NOTE

You can find more detailed information on the Process monitor in chapter *5.8 Process Monitor*.

5.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9451:101	General:Rated current		1 A to 100000 A	1000 A
_:9451:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9451:149	General:Power-sys. neutral point		• grounded • suppress. coil grounded • isolated	grounded
Measurements				
_:9451:158	General:P, Q sign		• not reversed • reversed	not reversed

5.1.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:9451:52	General:Behavior	ENS	O
_:9451:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

No.	Information	Data Class (Type)	Type
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

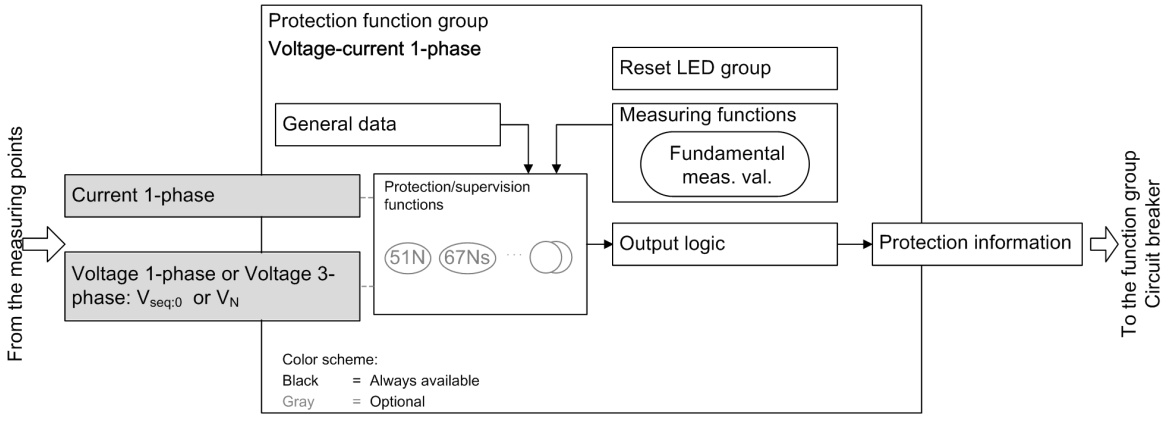
5.2 Function-Group Type Voltage-Current 1-Phase

5.2.1 Overview

In the **Voltage-current 1-phase** function group, all functions can be used for protecting and for monitoring a protected object or equipment which allow a 1-phase current and voltage measurement or a zero-sequence voltage measurement via a 3-phase voltage measuring point. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*).

5.2.2 Structure of the Function Group

The **Voltage-current 1-phase** function group has interfaces to the measuring points and the **Circuit-breaker** function group.



[dw1spstr-301112-01.tif, 3, en_US]

Figure 5-4 Structure of the Voltage-current 1-Phase Function Group

Interface with Measuring Points

You connect the **Voltage-current 1-phase** function group to the current and voltage measuring points via the interfaces to the measuring points. At least one measuring point has to be connected. The other is optional. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

The function group has the following interfaces to the measuring points:

- **1-phase current**

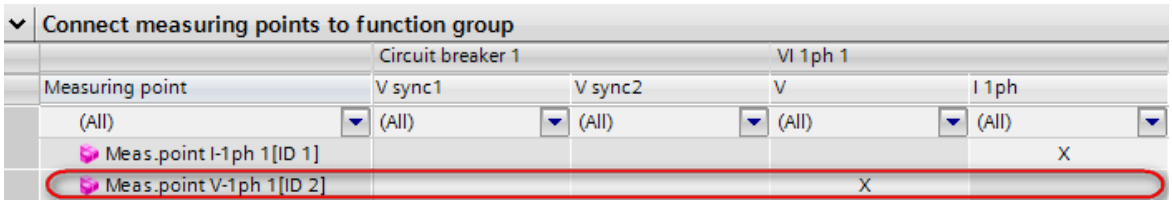
  The 1-phase current measured values are supplied via this interface.

  You can connect multiple measuring points with the **1-phase current** interface.

- 1-phase voltage or 3-phase voltage

  You can connect the voltage interface of the function group with a 1-phase or a 3-phase measuring point. The calculated zero-sequence voltage or the measured residual voltage are available for connection with a 3-phase measuring point. The phase-to-ground voltages are not available in the function group **Voltage-current 1-phase**. You can use both connection types at the same time.

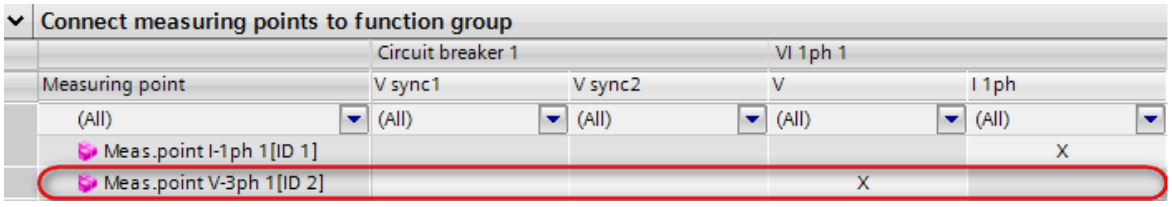
  You configure the 1-phase voltage measuring points via the voltage interface (see the following figure).



[scVl1ph_V1ph, 1, en_US]

Figure 5-5 Connecting Measuring Points to the Voltage-current 1-Phase Function Group

The converted, calculated zero-sequence voltage or measured residual voltage from the 3-phase voltage system is available via the voltage interface (see following figure).



[scVl1ph_V3ph, 1, en_US]

Figure 5-6 Connecting Measuring Points 3-Phase Voltage and 1-Phase Current to the 1-Phase Voltage-Current Function Group

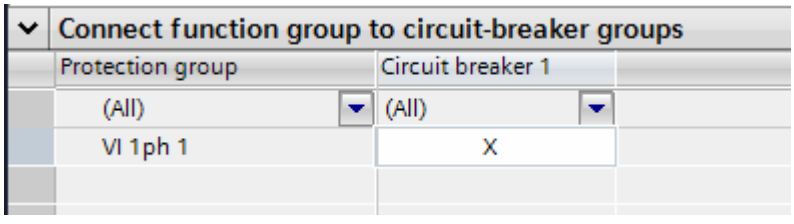
You can connect the voltage interface with precisely one 3-phase voltage measuring point. 3 types of 3-phase voltage measuring-point connections are supported. With the differenct connection types, the type of voltage input also changes in line with the functions. The following table shows the characteristics of the voltage input depending on the types of connection.

Connection Type of the 3-Phase Voltage Measuring Point	Voltage Input
3 ph-to-gnd voltages	The zero-sequence voltage is calculated from the phase-to-ground voltages and used as a voltage input for all funtions.
3 ph-to-gnd volt. + VN	The residual voltage VN is converted to the voltage equivalent of the zero-sequence voltage. The converted voltage is used as a voltage input for functions.
3 ph-to-ph volt. + VN	

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the **Circuit-breaker** function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the **Voltage-current 1-phase** function group with the **Circuit-breaker** function group. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix. If the interface is not connected, the functions operate as supervision functions in the **Voltage-current 1-phase function group**.



[sc1stspc-190214-01, 1, en_US]

Figure 5-7 Connecting Voltage-current 1-Phase Function Group with Circuit-Breaker Function Group

Fundamental Components

The fundamental components are always present in the **Voltage-current 1-phase** function group and cannot be deleted.

The following table shows the fundamental components of the **Voltage-current 1-phase** function group:

Table 5-2 Fundamental Components of the Voltage-current 1-Phase Function Group

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	**Rated operating current**
V[7]	1-phase voltage	kV	V	**Rated operating voltage**
V_0 [8]	Zero-sequence voltage	kV	V	**Rated operating voltage**/√3
V_N [9]	Residual voltage	kV	V	**Rated operating voltage**/√3

5.2.3 Application and Setting Notes

NOTE

Prior to creation of the protection functions in the function group, these functions should first be connected to the appropriate **Circuit-breaker** function group.

Parameter: Rated current

- Default setting **(_:9451:101) Rated current** = ***1000 A***

The **Rated current** parameter is used to set the primary rated current. The **Rated current** specified here is the reference value for the percentage-measured values and setting values made in percentages.

Parameter: Rated voltage

- Default setting **(_:9421:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the **Circuit-breaker** function group.

5.2.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:104	General:rated apparent power		0.20 MVA to 5000.00 MVA	400.00 MVA
Network data				
_:91:214	General:M I-1ph uses measuring point ID		0 to 100	0
_:91:223	General: Scale factor M I-1ph		0.01 to 100.00	1.00

[7] The 1-phase voltage V is only visible if it is connected to a 1-phase voltage measuring point

[8] The zero-sequence voltage V0 is only visible if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type

[9] The residual voltage VN is only visible if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type + VN or 3-phase phase-to-phase voltage + VN

5.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100000 A	1000 A
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:127	General:Number of Meas.point. 1ph		0 to 11	0

5.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:>LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

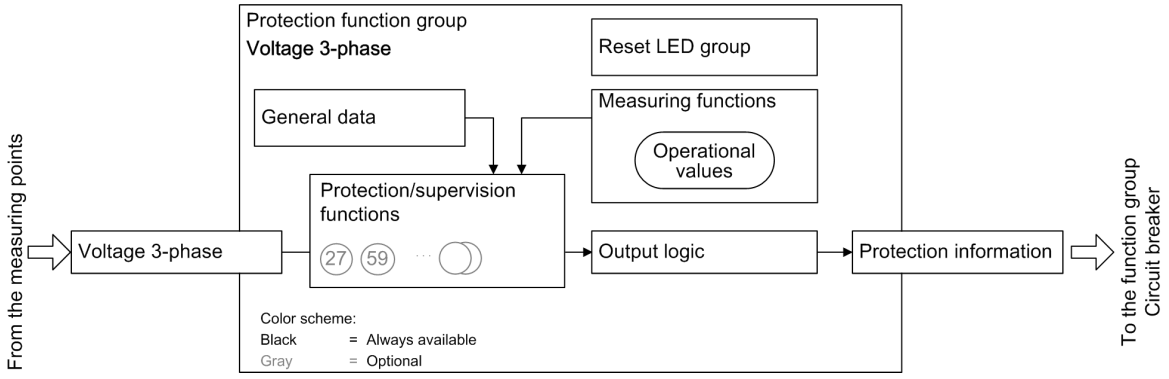
5.3 Function-Group Type Voltage 3-Phase

5.3.1 Overview

In the **Voltage 3-phase** function group, all functions can be used for protecting and for monitoring a protected object or equipment which allows a 3-phase voltage measurement. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*). Applicable functions are, for example, Voltage protection or Frequency protection.

5.3.2 Structure of the Function Group

The **Voltage 3-phase** function group has interfaces to the measuring points and the **Circuit-breaker** function group.

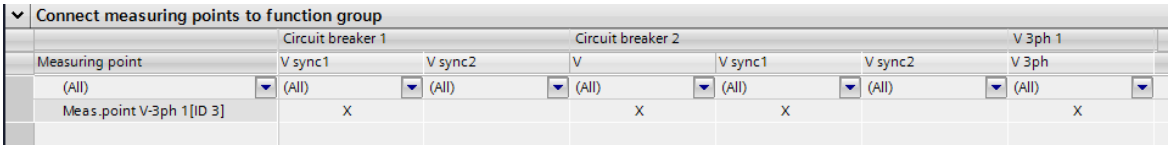


[dw3spann-300913, 1, en_US]

Figure 5-8 Structure of the Voltage 3-Phase Function Group

Interface with Measuring Points

You connect the **Voltage 3-phase** function group to the voltage measuring points via the interface to the measuring points. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



[sc3span1-190214-01, 1, en_US]

Figure 5-9 Connecting Measuring Points to the Voltage 3-Phase Function Group

If you add functions to the **Voltage 3-phase** function group, these are connected to the measuring point automatically.

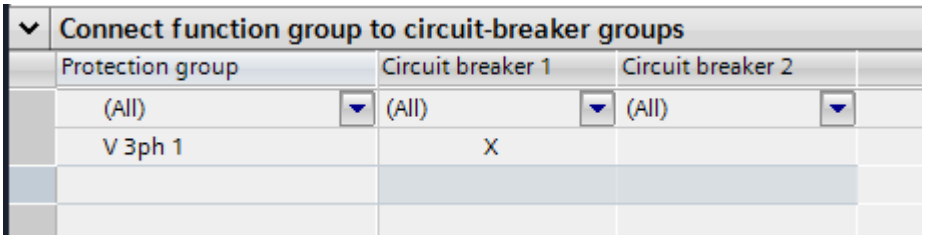
You can connect multiple measuring points with this interface. You can find more information in chapter *6.48 Voltage Measuring-Point Selection*.

The measurands from the 3-phase voltage system are supplied via the **V 3-ph** interface. Depending on the type of transformer connections, these are, for example, V_A, V_B, V_C, V_{gnd}. All values that can be calculated from the measurands are also provided via this interface.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the **Circuit-breaker** function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the **Voltage 3-phase** function group with the **Circuit-breaker** function group. This assignment can be made in DIGSI only via **Project tree** → **Connect function group**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



[sc3span2-190214-01, 1, en_US]

Figure 5-10 Connecting Voltage 3-Phase Function Group with Circuit-Breaker Function Group

Operational Measured Values

The operational measured values are always present in the **Voltage 3-phase** function group and cannot be deleted.

The following table shows the operational measured values of the **Voltage 3-phase** function group:

Table 5-3 Operational Measured Values of the Voltage 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

5.3.3 Application and Setting Notes

NOTE

Before creating the protection functions in the function group, you should first connect hese functions to the appropriate **Circuit-breaker** function group.

Parameter: Rated voltage

- Default setting **(_:9421:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you set the primary rated voltage. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

5.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV

5.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:>LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

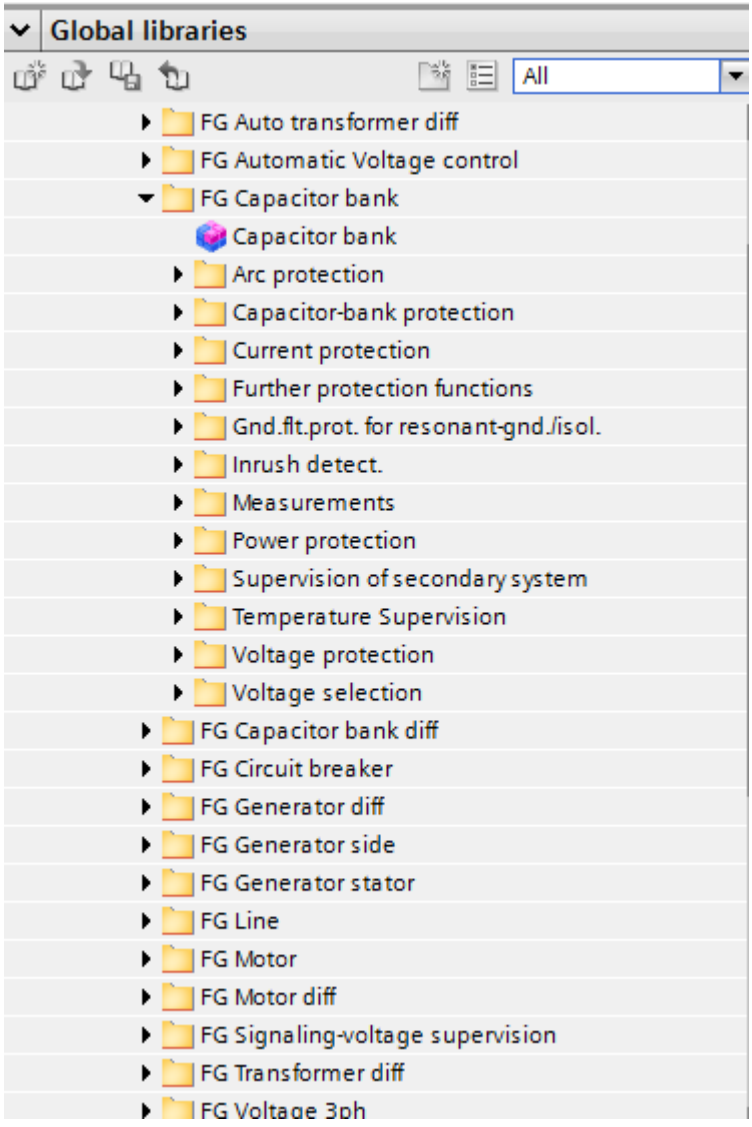
5.4 Function-Group Type Capacitor Bank

5.4.1 Overview

In the **Capacitor bank** function group, all the functions that are necessary for protecting and monitoring a capacitor bank can be used.

You can find the **Capacitor bank** function group under 7SJ82/7SJ85 device types in the Global DIGSI 5 Library. The **Capacitor bank** function group contains all of the protection and supervision functions that you can use for this device type.

Some of these functions are exclusively used for protecting capacitor banks, and others are universal standard functions which can be used for other protected objects as well. You find the exclusive protection functions in the directory **Capacitor-bank protection**.



[scfgcapb-250314-01, 2, en_US]

Figure 5-11 Capacitor Bank Function Group - Functional Scope for Device Type 7SJ85

For more information about the embedding of the functions in the device, refer to chapter 2. For information about the overall functional scope of the application templates for the various device types, refer to chapter 4.

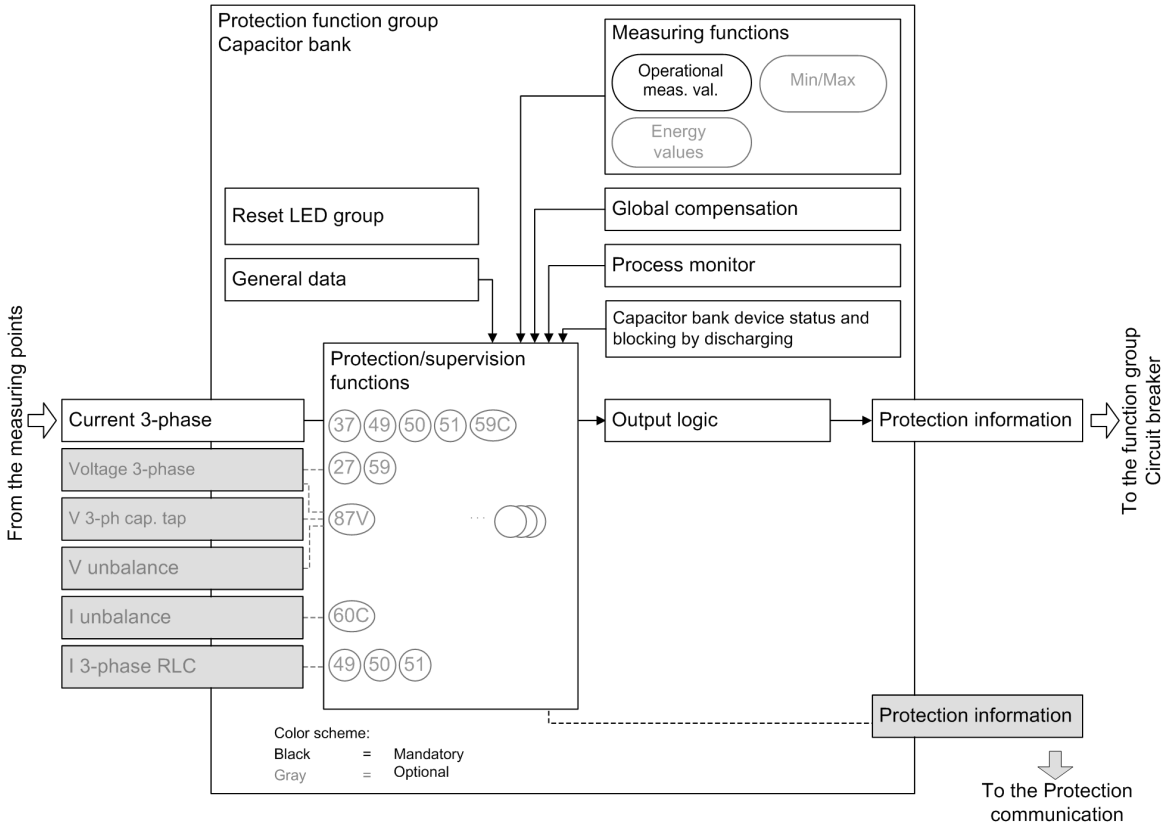
5.4.2 Structure of the Function Group

The **Capacitor bank** function group always contains the following functionality:

- Protected object/equipment data (function block **General**)
- Operational measured values
- Capacitor bank device status and blocking by discharging (function block **General**)
- Process monitor
- Global compensation (function block **General**)
- Output logic of the function group
- Reset LED group

This functionality is essential for the **Capacitor bank** function group, so it cannot be loaded or deleted.

You can load the protection functions and supervision functions required for your application in the **Capacitor bank** function group. The functions are available from the Global DIGSI 5 Library. Functions that are not needed can be deleted from the function group.



[Dwstrcap-20140619-01.vsd, 2, en_US]

Figure 5-12 Structure of the Capacitor Bank Function Group

The **Capacitor bank** function group has interfaces with the following parts:

- **Measuring points**
- **Circuit-breaker** function group

Interfaces with the Measuring Points

The **Capacitor bank** function group receives the required measured values via the interfaces with the measuring points. If you are using an application template, the **Capacitor bank** function group is already connected to the specific measuring points.

You can find more detailed information in Chapter 2.

The **Capacitor bank** function group has the following 6 interfaces with the measuring points. The universal standard functions only work with the standard interfaces **`3-phase current`** and/or **`3-phase voltage`**; the other 4 interfaces are provided for the functions which are exclusively used for the capacitor banks. Please also refer to the example given below.

The **Capacitor bank** function group has the following interfaces with the measuring points:

- **`3-phase current:`**

  The measurands from the 3-phase current system are supplied via this interface. Depending on the connection type of the current transformers, the measurands can be for example I_A, I_B, I_C, I_N, or $3I_0$. All values that can be calculated from the measurands are also provided via this interface.

  The **Capacitor bank** function group must always be connected to the **3-phase current measuring point**. You can connect the **3-phase current measuring point** interface to the maximum of two **3-phase current measuring points**. If 2 current measuring points have been connected to the 3-phase current interface, the total current is determined by adding the measured values from both measuring points in the function group. The functions in the **Capacitor bank** function group evaluate the total current.

- **`3-phase voltage`** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Depending on the connection type of the voltage transformers, these can be for example V_A, V_B, V_C, V_N, or $3V_0$. All values that can be calculated from the measurands are also provided via this interface.

  The connection of the **3-phase voltage** interface is optional. This connection is only required if protection functions or supervision functions are applied, which require voltage measurements.

- **`3-phase voltage CB tap`** (optional):

  The measurands of a 3-phase tap voltage within a capacitor bank are supplied via this interface.

  The connection of the **3-phase voltage CB tap** interface is optional. You can connect the 3-phase voltage CB tap interface to a maximum of one **3-phase voltage measuring point**.

- **`Voltage unbalance`** (optional):

  The unbalanced-voltage measurands (for example, an isolated neutral point of the capacitor bank) are supplied via this interface.

  The connection of the **voltage unbalance** interface is optional. You can connect the **voltage unbalance** interface to a maximum of one **1-phase voltage measuring points**.

- **`Current unbalance`** (optional):

  The unbalanced-current measurands are supplied via this interface.

  The connection of the **current unbalance** interface is optional. You can connect the **current unbalance** interface to a maximum of two **3-phase current measuring points** and six **1-phase current measuring points**.The interface allows mixed connections to 3-phase current measuring point and 1-phase current measuring point; however the sum of the connections is no more than 6.

  For an overview which function are applicable on this interface, please refer to Figure 1-5.

- **`3-phase current RLC`** (optional)

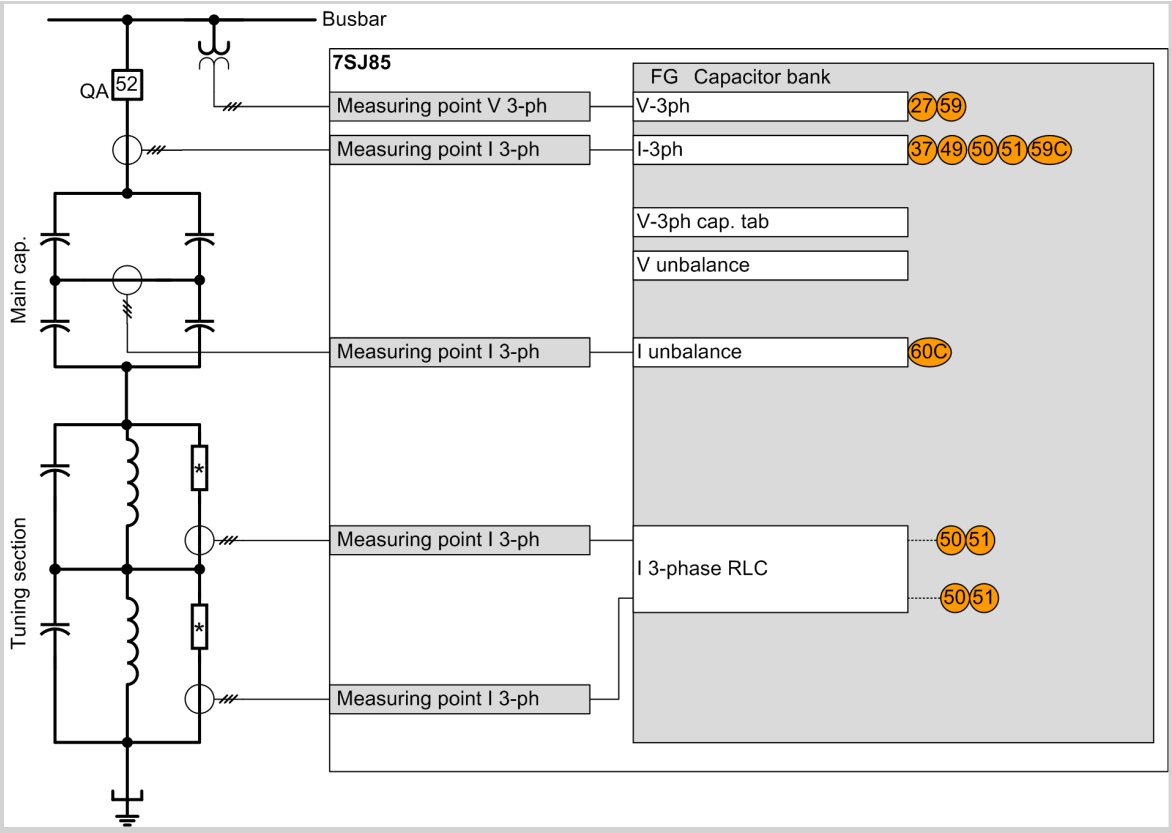
  The measurands from a tuning or filtering section (R, L, or C) of a capacitor bank are supplied via this interface.

  The connection of the **3-phase current RLC** interface is optional. You can connect the **3-phase current RLC** interface to a maximum of nine **3-phase current measuring points**.

  For an overview which function are applicable on this interface, please refer to *Figure 5-13*.

Example

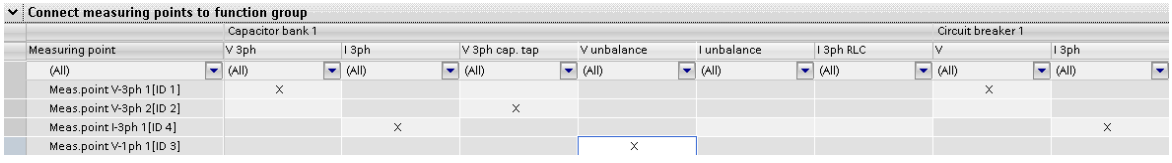
The following figure shows an example of a capacitor in H-configuration and tuning section. In the single line, the primary current and voltage measurement are shown. The required device measuring points and their connections to the function group interfaces are shown as well. In addition, it is indicated which protection function receives its measuring value from which measuring point.



[dwasscap-180713-01.tif, 2, en_US]

Figure 5-13 An Example of Assignment of Measuring Points to the Capacitor-Bank Functions

You can connect the **Capacitor bank** function group to the current and voltage measuring points via interfaces. You make this assignment in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



Connect measuring points to function group

	Capacitor bank 1						Circuit breaker 1	
Measuring point	V 3ph	I 3ph	V 3ph cap. tap	V unbalance	I unbalance	I 3ph RLC	V	I 3ph
(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-3ph 1[ID 1]	X						X	
Meas.point V-3ph 2[ID 2]			X					
Meas.point I-3ph 1[ID 4]		X						X
Meas.point V-1ph 1[ID 3]				X				

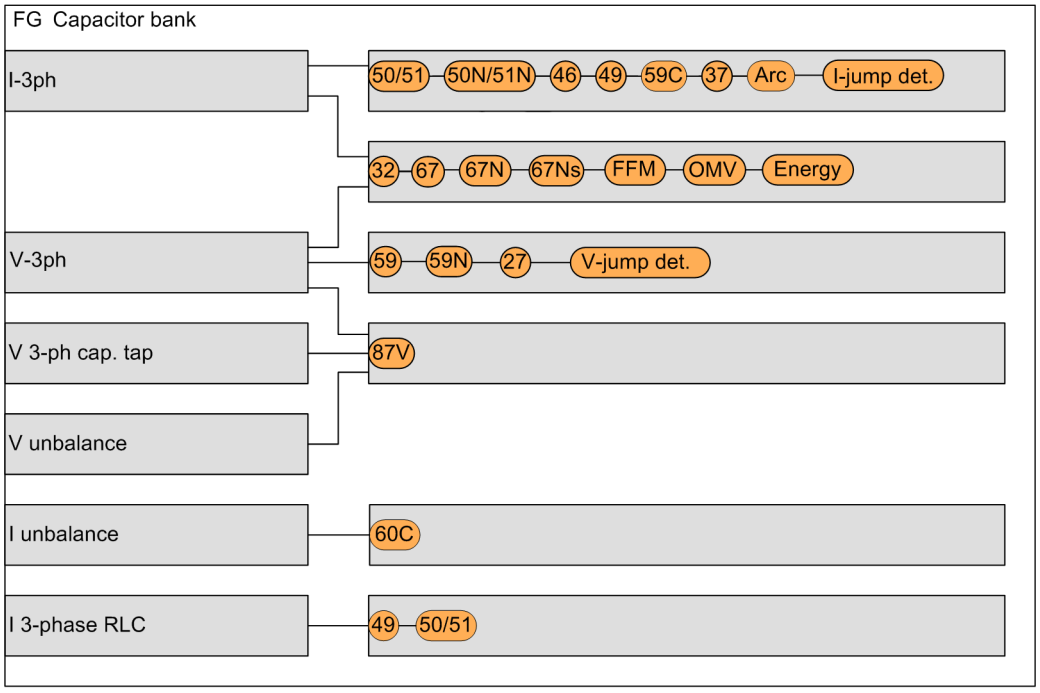
[scrconba-110314-03, 2, en_US]

Figure 5-14 Connecting Measuring Points to the Capacitor Bank Function Group

For the protection functions applied on the interfaces **3-phase current** and **3-phase voltage**, if you add these functions to the **Capacitor bank** function group, these functions will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary interface is not connected to any measuring point, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 using the **Function group connections** editor.

For the protection functions applied on the interfaces **Current unbalance** and **3-phase current**, you have to select the desired measuring points via a setting **`MP selection`**, which offers a list of all measuring points connected to the specific interface. The setting **`MP selection`** is located on the setting page of the protection function.

The following figure shows an overview of the protection functions and the interface assignment in the **Capacitor bank** function group.



27	Undervoltage protection
32	General power protection
37	Undercurrent protection
46	Negative-sequence protection
49	Overload protection
50/51	Overcurrent protection, phases
50N/51N	Overcurrent protection, ground
59	Overvoltage protection
59C	Peak overvoltage protection
59N	Overvoltage protection with zero-sequence voltage/residual voltage
60C	Current-unbalance protection
67/67N	Directional overcurrent protection for ground faults
67Ns	Directional sensitive ground-fault detection
87V	Voltage-differential protection
OMV	Operational values
FFM	Fuse-failure monitor

[DwCapBank-180713-01, 4, en_US]

Figure 5-15 Overview of the Protection Functions and Interface Assignment in the Capacitor Bank Function Group

Interfaces with Circuit-Breaker Function Group

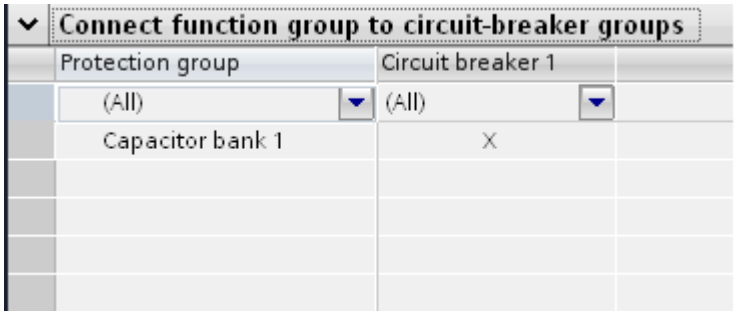
All required data are exchanged between the protection function group and the **Circuit-breaker** function group via the interface with the **Circuit-breaker** function group. These data include, for example, the pickup and operate indications of the protection functions sent in the direction of the **Circuit-breaker** function group and, for another example, the information about the circuit-breaker condition sent in the direction of the protection function group.

The **Capacitor bank** function group is connectable to a **Circuit-breaker** function group. This connection generally determines:

- Which circuit breaker is activated by the protection functions of the **Capacitor bank** function group
- Starting of the **Circuit-breaker failure protection** function (if available in the **Circuit-breaker** function group) through the protection functions of the connected **Capacitor bank** function group
- Starting of the **Automatic reclosing** function (if available in the **Circuit-breaker** function group) through the protection functions of the connected **Capacitor bank** function group

NOTE

For capacitor bank protection, the **Automatic reclosing** function is not applied in most cases. However, due to flexibility and standardization, the respective interface is offered.



[scrconb1-180713-01.tif, 1, en_US]

Figure 5-16 Connecting Capacitor Bank Function Group with Circuit-Breaker Function Group

Besides the general assignment of the **Capacitor bank** function group to the **Circuit-breaker** function group, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit breaker interaction** editor in the Capacitor bank function group.

In the detailed configuration of the interface, define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the **Circuit-breaker failure protection** function
- Which protection functions start the **Automatic reclosing** function

	Circuit breaker 1	
	Trip logic	50BF CB fail.1
Protection group	Trip	Start CB failure
(All)	(All)	(All)
50/51 OC-3ph-A1	X	X
Definite-T 1	X	X
Definite-T 2	X	X
Inverse-T 1	X	X

[scconcap-150713-01.tif, 2, en_US]

Figure 5-17 Connecting Protection Functions and Stage Using the Circuit-Breaker Interaction Editor

If an application template is used, the function groups have already been connected to each other because this link is essential to ensure proper operation. You can modify the link in DIGSI 5 using the **Function-group connections** editor.

You can find more information in chapter *2.1 Function Embedding in the Device*. If this link is missing, DIGSI 5 reports an inconsistency.

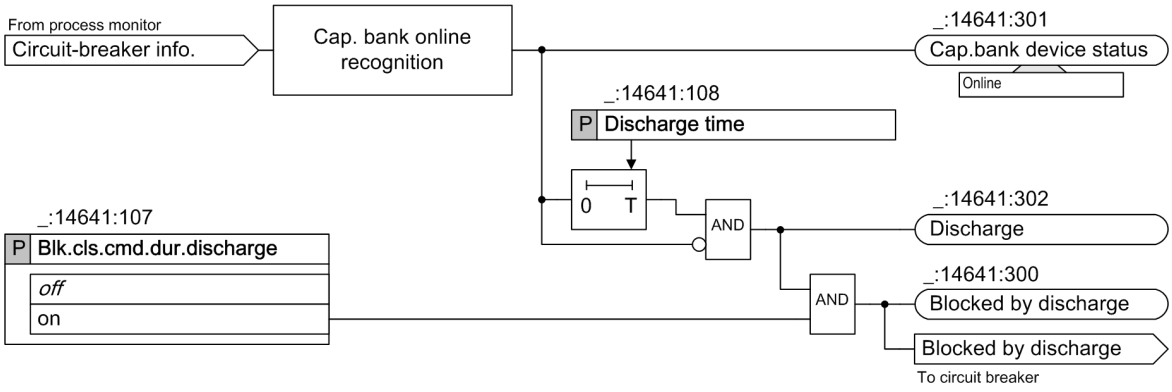
Protected Object/Equipment Data (FB General)

Capacitor-bank rated and reference data are defined as well as further protected object/equipment data. The data applies for all functions in the **Capacitor bank** function group.

For further information, refer to chapter *5.4.3 Application and Setting Notes*.

Capacitor Bank Device Status and Blocking by Discharging (FB General)

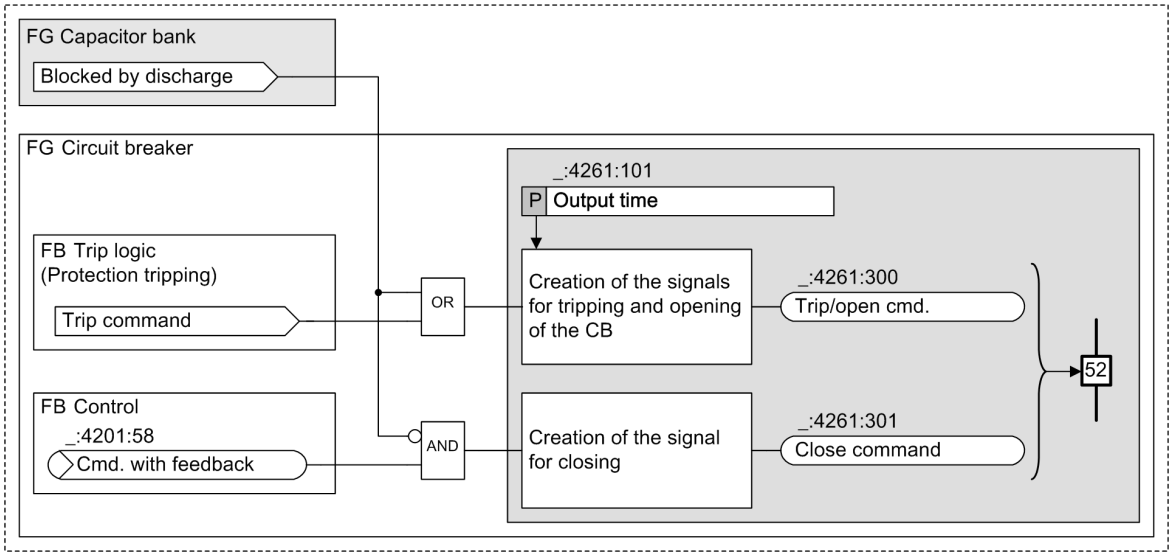
The functionality detects whether a capacitor bank is **online** or **offline**. When the status of the capacitor bank changes from **online** to **offline**, the signal *Discharge* is issued during the capacitor-bank discharging time.



[Lo-CapZap-20140617-01, 1, en_US]

Figure 5-18 Logic Diagram of Capacitor Bank Device Status and Blocking by Discharging

The device can block the closing of the circuit breaker automatically when a capacitor bank discharges. The configuration is made with the parameter **Blk.cls.cmd.dur.discharge**. If the parameter **Blk.cls.cmd.dur.discharge** is set to ***on***, the device generates a trip/open command during the discharge time and blocks closing commands additionally, see the following figure. This blocking condition is signaled via the message *Blocked by discharge*.



[Lo-discharge-20140617-01, 1, en_US]

Figure 5-19 Logic Diagram of Processing the Blocked by Discharge Signal

Global Compensation (FB General)

The **Global compensation** function block provides the binary input signal *>Compensate* to carry out the manual compensation for all functions in the FG using compensated measuring values.

In addition, the binary input signal *>Reset comp. val.* is provided to reset all compensation values for the functions using compensated measuring values.

Process Monitor

The **Process monitor** detects the current state of the protected object. It is always present in the function group and cannot be removed.

For detailed description of the **Process monitor**, refer to *5.8.1 Overview of Functions*.

Reset LED Group

The **Reset LED group** function block allows you to reset only the stored LEDs of the functions contained in the respective function group, while stored LEDs activated from functions in other function groups remain active.

For more information refer to chapter *3.1.10 Resetting Stored Indications of the Function Group* .

Operational, Fundamental, Symmetrical Components Measurements

The operational fundamental, symmetrical components and functional measurements are always available in the **Capacitor bank** function group and cannot be deleted.

Table 5-4 Operational Measured Values (True RMS) of the Function Group Capacitor Bank

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
$3I_0$	Residual current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary system
V_0	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P_{tot}	Active power (total power)	MW	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{tot}	Reactive power (total power)	MVAr	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{tot}	Apparent power (total power)	MVA	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
Q_A, Q_B, Q_C	Phase-related reactive power	MVAr	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$

Table 5-5 Fundamental and Symmetrical Components Measurement Values of the Function Group Capacitor Bank

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system

Measured Values		Primary	Secondary	% Referenced to
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
$I_{seq:0}$	Zero-sequence current	A	A	Rated operating current of the primary system
$I_{seq:1}$	Positive-sequence current	A	A	Rated operating current of the primary system
$I_{seq:2}$	Negative-sequence current	A	A	Rated operating voltage of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary system
V_N	Neutral-point phase voltage	kV	V	Rated operating voltage of the primary system/√3
$V_{seq:0}$	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
$V_{seq:1}$	Positive-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
$V_{seq:2}$	Negative-sequence voltage	kV	V	Rated operating voltage of the primary system/√3

Voltage and power measurements are only available if **V-3ph measuring point** connected to the **Capacitor bank** function group.

The energy measurements are not predefined. If required, they must be loaded from the Global DIGSI 5 Library.

Inversion of Power-Related Measured and Statistical Values (FB General)

The following values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Power factor
- Energy
- Minimum, maximum values of the power
- Average values of the power

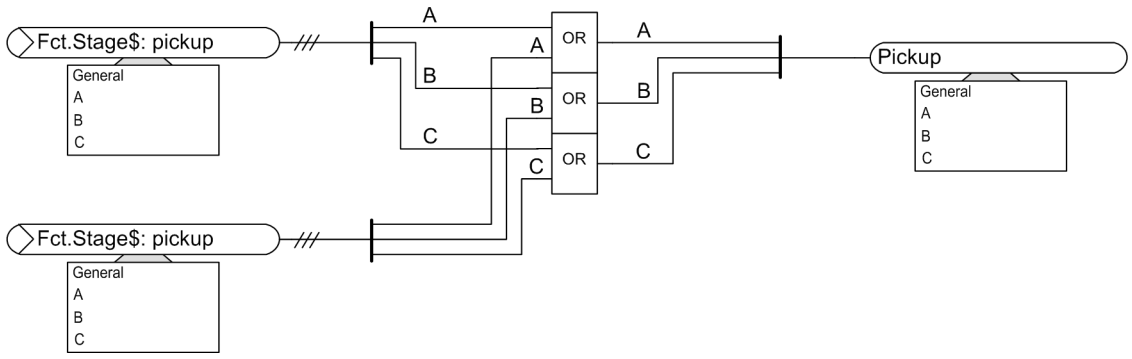
With the **P, Q sign** setting, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.

More information can be found in Chapter *10.1 Overview of Functions*.

Output Logic

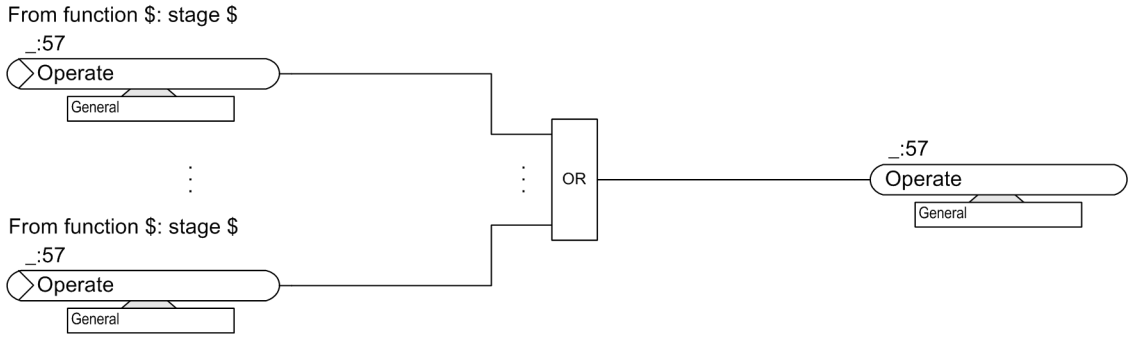
The output logic treats the pickup and operate indications of the protection functions and supervision functions in the **Capacitor bank** function group separately, in a pickup logic and an output logic respectively. The pickup and output logics generate the group indications of the function group. These group indications are transferred to the **Circuit-breaker** function group via the **protection-information** interface and are processed further there.

The pickup and operate indications of the protection functions and the supervision functions in the **Capacitor bank** function group are combined according to the following figures of group indications.



[logepiin-230812-02.tif, 1, en_US]

Figure 5-20 Generation of the Pickup Indication of the Capacitor Bank Function Group



[logeopin-230812-02.tif, 1, en_US]

Figure 5-21 Generation of the Operate Indication of the Capacitor Bank Function Group

5.4.3 Application and Setting Notes

Interface to Circuit-Breaker Function Group

The **Capacitor bank** protection function group is linked to one **Circuit-breaker** function group. This **Circuit-breaker** function group is assigned to the circuit breaker of the capacitor bank.

Protected Object/Equipment Data (FB General)

The following application and setting notes apply for the general data. The data are configured in the function block **General** of the **Capacitor bank** function group and apply for all functions in the function group.

Parameter: **`Capacitor reference curr.`**

- Default setting **`(_:14641:101) Capacitor reference curr. = 1000 A`**

With the **`Capacitor reference curr.`** parameter, you set the reference current for the capacitor bank to be protected. This **`Capacitor reference curr.`** specified here is the reference value for the percentage-measured values and setting values made in percentages.

Depending on the user philosophy, the reference value could be the capacitor-bank rated current, which includes harmonics, or the capacitor-bank fundamental current.

Parameter: **`Capacitor reference volt.`**

- Default setting **`(_:14641:102) Capacitor reference volt. = 400.00 kV`**

With the parameter **`Capacitor reference volt.`**, you set the reference voltage of the capacitor bank to be protected. This **`Capacitor reference volt.`** specified here is the reference value for the percentage-measured values and setting values made in percentages.

Depending on the user philosophy, the reference value could be the system rated voltage (bus voltage), or the capacitor rated voltage

Parameter: **Capacitor element type**

- Default setting **(_:14641:106) Capacitor element type** = ***fused***

With the parameter **Capacitor element type**, you set if the capacitor elements contain internal fuses or not. This information is required in the current-unbalance protection for the fault position annunciation.

Parameter: **Blk.cls.cmd.dur.discharge**

- Default setting **(_:14641:107) Blk.cls.cmd.dur.discharge** = ***off***

With the parameter **Blk.cls.cmd.dur.discharge**, you set whether closing of the circuit breaker is blocked automatically or not when a capacitor bank discharges.



NOTE

If the parameter **Blk.cls.cmd.dur.discharge** is set to ***on***, the device generates a trip/open command during the discharge time.

Parameter: **Discharge time**

- Default setting **(_:14641:108) Discharge time** = ***300 s***

With the parameter **Discharge time**, you define capacitor-bank discharging duration. You get the value from the capacitor manufacturer.

Parameter: **Cap.-bank neutral point**

- Default setting **(_:14641:109) Cap.-bank neutral point** =***isolated***

With the parameter **Cap.-bank neutral point**, you can specify whether the neutral point of capacitor bank is ***isolated*** or ***grounded***. This information is required when applying the function **87V voltage differential protection**.

Parameter: **P, Q sign**

- Default setting **(_:14611:158) P, Q sign** =***not reversed***

The power and energy values are defined by the manufacturer such that power in the direction of the protected object is considered positive. You can also define the power output by the protected object as positive. With the **P, Q sign** parameter, you can invert the sign for these components. This inversion does not influence any protection function.

5.4.4 Write-Protected Settings

The settings listed here are primarily to aid understanding when configuring the function groups. They are calculated as a function of other settings and cannot be changed directly.

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:14641:103	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA



NOTE

You can find more detailed information on the Process monitor in Chapter *5.7.1 Overview* .

5.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:14641:101	General:Capacitor reference curr.		1 A to 100000 A	1000 A
_:14641:102	General:Capacitor reference volt.		0.20 kV to 1200.00 kV	400.00 kV
Cap.bank data				
_:14641:106	General:Capacitor element type		• fused • unfused	fused
_:14641:107	General:Blk.cls.cmd.dur. discharge		• off • on	off
_:14641:108	General:Discharge time		1 s to 1200 s	300 s
_:14641:109	General:Cap.-bank neutral point		• grounded • isolated	isolated
Measurements				
_:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

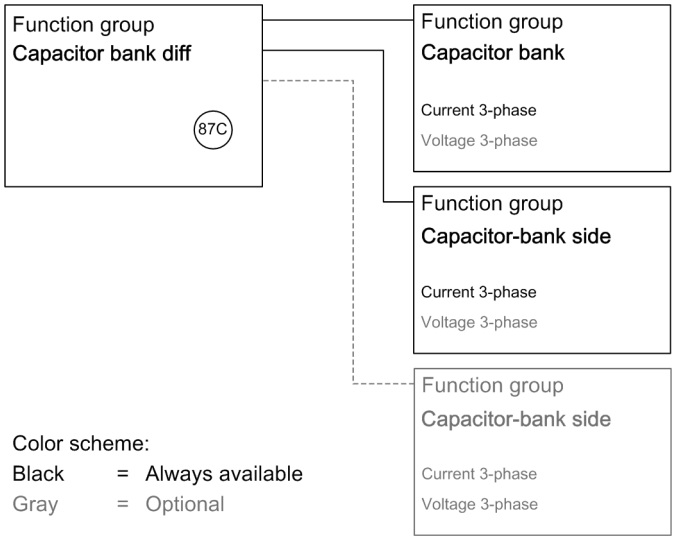
5.4.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
General			
_:14641:500	General:>Compensate	SPS	I
_:14641:501	General:>Reset comp. val.	SPS	I
_:14641:300	General:Blocked by discharge	SPS	O
_:14641:302	General:Discharge	SPS	O
_:14641:301	General:Cap.bank device status	SPC	C

5.5 Function-Group Type Capacitor Bank Differential Protection

5.5.1 Function-Group Types

In the following graphic, you can see the structural association of the function-group types to the **Capacitor bank differential protection**.



[dwfgueca-120214-01, 2, en_US]

Figure 5-22 Function-Group Types Capacitor Bank Diff

The following function-group types are summarized in the Global DIGSI 5 library: Motor diff

- **Capacitor bank diff**
- **Capacitor bank side**

You can find the description of the function group**Capacitor bank** in chapter *5.4.1 Overview*.

The individual function-group types are stored in the **Capacitor bank diff function group** folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. A **Capacitor bank diff** function group always includes the **Capacitor bank** and **Capacitor bank side** function groups. In total, you can assign a maximum of 3 function groups **Capacitor bank** or **Capacitor bank side** to the **Capacitor bank diff** function group.

The following table shows you the number of function-group types that can be instantiated for device 7SJ85.

Table 5-6 Function-Group Types in the Device

	Function-Group Type		
Device	**Capacitor Bank Diff**	**Capacitor Bank**	**Capacitor Bank Side**
7SJ85	Max. 2	Max. 9	Max. 9

Interconnection of the function groups is necessary so that the capacitor bank differential protection functions properly. The **Circuit-breaker** function group is not listed.

Table 5-7 Assignment of Protection Function Groups to Protection Function Groups

	Capacitor Bank Diff 1
	Side (2 to 3)
Capacitor bank	X
Capacitor bank side 1	X

	Capacitor Bank Diff 1
	Side (2 to 3)
Capacitor bank side 2	X

The individual function-group types are described in the following.

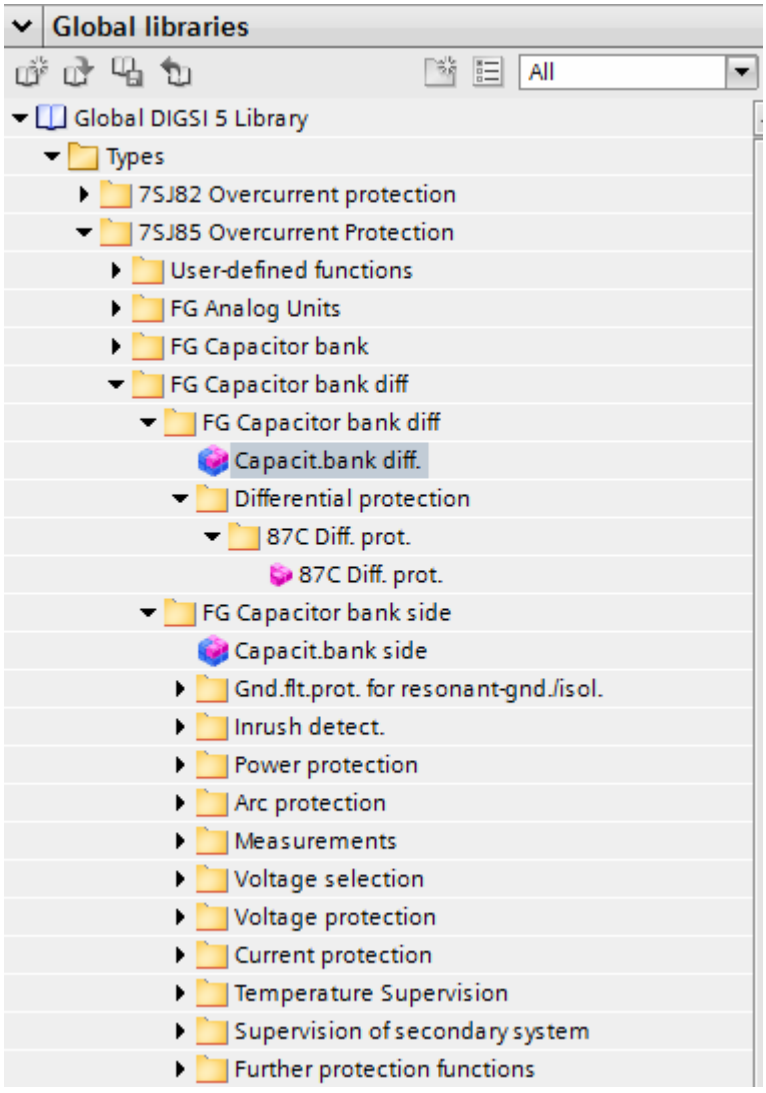
5.5.2 Function-Group Type Capacitor Bank Diff

5.5.2.1 Overview

The **Capacitor bank diff.** function group contains the differential protection function and protection-function-relevant measured values.

You can find more information in the chapter *10 Measured Values, Energy Values, and Supervision of the Primary System* .

You will find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI library under each device type. In the **Capacitor bank diff.** function group, you can load only the differential protection functions.



[scfgcadf-300414-01, 2, en_US]

Figure 5-23 Function Group Capacitor Bank Diff. - Functional Scope

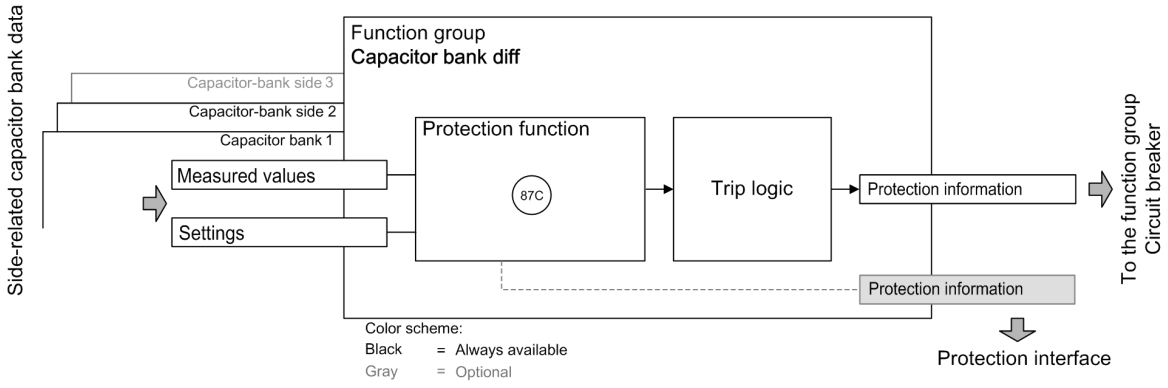
For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function* . For application templates of the various device types, refer to chapter *4 Applications* .

5.5.2.2 Structure of the Function Group

The **Capacitor bank diff.** function group, according to *5.5.2.1 Overview* , has interfaces with the **Capacitor bank**, the **Capacitor bank side**, and the **Circuit-breaker** function groups. The **Capacitor bank diff.** function group contains the function blocks:

- Protection function (execution of the differential protection function)
- Trip logic (generation of forwarding of the operate indication)

In the **Capacitor bank diff.** function group, the differential protection function must always be available so that the protection functionality can be ensured. If you do not use an application template, load the differential protection function from the Global DIGSI library.



[dwfgcadf-030314-01, 3, en_US]

Figure 5-24 Structure of the Capacitor Bank Diff. Function Group

The **Capacitor bank diff.** function group has interfaces to the following components:

- Function group **Capacitor bank**
- Function group **Capacitor bank side**
- **Circuit-breaker** function group

Interfaces with the Circuit-Breaker Function Group

The interface with the **Circuit-breaker** function group is used to exchange all required data between the protection function group and the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

You can connect the **Capacitor bank diff.** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Capacitor bank diff.** function group
- Start of the **Circuit-breaker failure protection** function, if available in the **Circuit-breaker** function group, through the protection functions of the connected **Capacitor bank diff.** function group

Besides the general assignment of the **Capacitor bank diff.** function group to the **Circuit-breaker** function group, you can also configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 via the **Circuit-breaker interaction** Editor in the **Capacitor bank side diff.** function group.

For the detail configuration of the interface, define the following:

- Which operate indications of the protection functions are included when the trip command is generated
- Which protection functions activate the **Circuit-breaker failure protection** function

If an application template is used, the function groups are connected to each other because this link is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Function Embedding in the Device* .

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Interface with Protection Communication (optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**. These are for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.5 Protection Communication* .

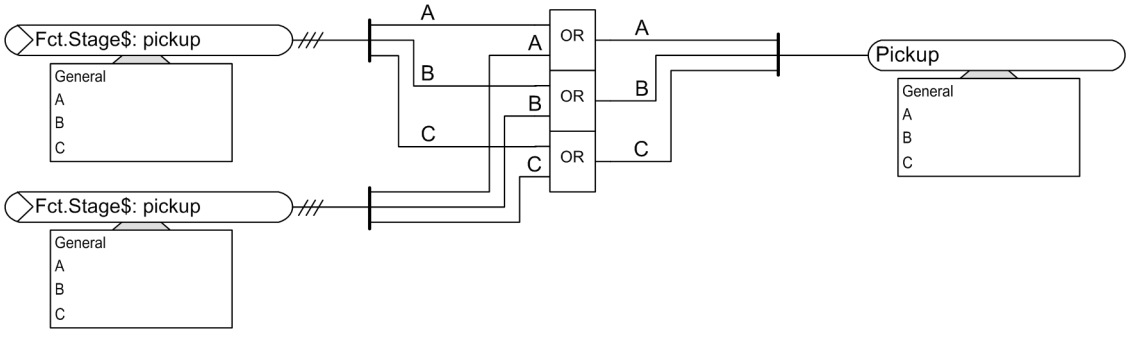
Capacitor-Bank Data (General)

The capacitor-bank data characterizes the data of the capacitor bank to be protected. The data relevant for the differential protection is shown. The **Capacitor bank diff.** function group takes the data from the coupled function groups **Capacitor bank** and **Capacitor bank side**.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overarching indications (group indications) of the function group. These group indications are transferred via the **Protection-information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and operate indications of the protection and supervision functions in the **Capacitor bank diff.** function group are combined into one group indication using the following numbers and outputs.



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Figure 5-25 Generation of Pickup Indication of the Capacitor Bank Diff. Function Group

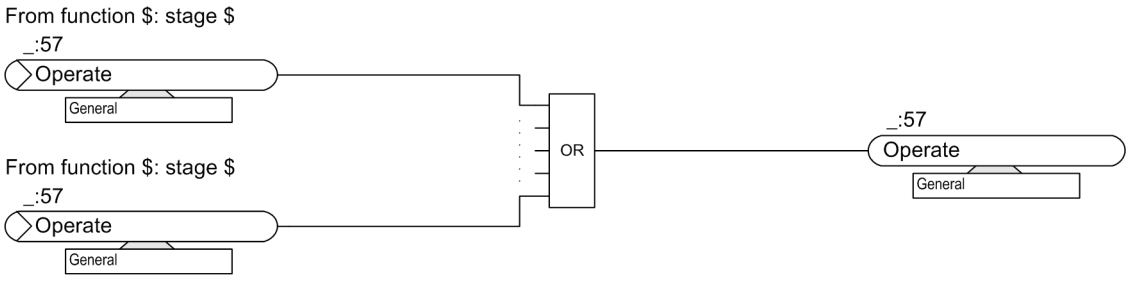


Figure 5-26 Generation of Operate Indication of the Capacitor Bank Diff. Function Group

5.5.2.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.5.3 Function-Group Type Capacitor Bank Side

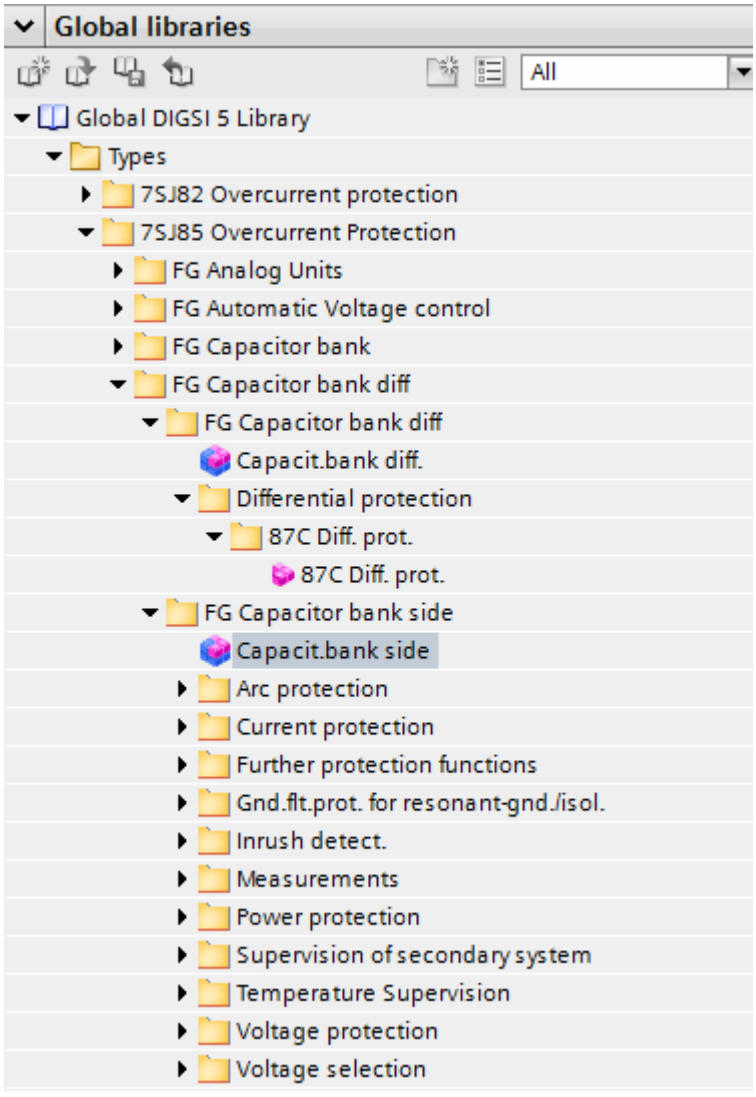
5.5.3.1 Overview

In the **Capacitor bank side** function group, all of the functions that are necessary for protecting and supervising a capacitor bank side can be used. The **Capacitor bank side** function group also contains the measuring functions.

You can find more information in chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*.

The **Capacitor bank side** function group must always have interfacing to the **Capacitor bank diff.** function group.

You will find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI library under each device type. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Capacitor bank side** function group. The functions are described in chapter *6 Protection and Automation Functions* .



[scfgcasd-300414-01, 2, en_US]

Figure 5-27 Capacitor Bank Side Function Group - Functional Scope

For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function* . For application templates for the various device types, refer to chapter *4 Applications* .

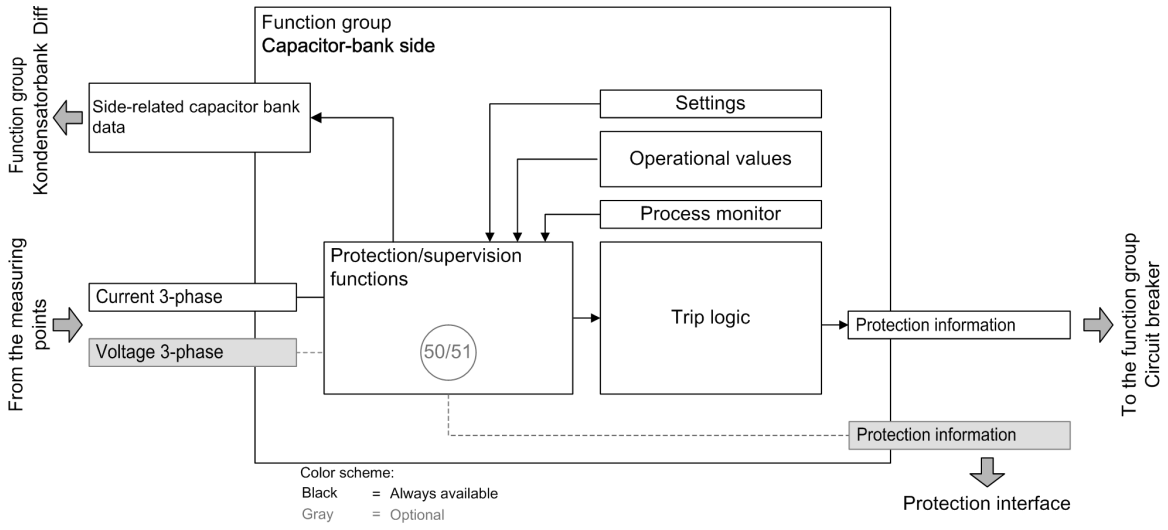
5.5.3.2 Structure of the Function Group

The **Capacitor bank side** function group always contains the following function blocks:

- Side-dependent capacitor-bank data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required for the **Capacitor bank side** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Capacitor bank side** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



[dw_fgcabsi-201114-01, 2, en_US]

Figure 5-28 Structure of the Capacitor Bank Side Function Group

The **Capacitor bank side** function group has interfaces to the following components:

- **Measuring points**
- **Capacitor bank diff.** function group
- **Circuit-breaker** function group

Interfaces with Measuring Points

The **Capacitor bank side** function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the **Capacitor bank side** function group is connected to the necessary measuring points.

If you add functions to the **Capacitor bank side** function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function* .

The **Capacitor bank side** function group has the following interfaces with the measuring points:

- **3-phase current**

  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example: I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Capacitor bank side** function group must always be linked to the **I-3ph measuring point**.

  You can connect the **3-phase current** interface with a maximum of **two** 3-phase current measuring points. If 2 current measuring points have been connected to the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the **Capacitor bank side** function group. All functions in the **Capacitor bank side** function group have access to these values.

- **3-phase voltage** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.

  The connection of the **3-phase voltage** is optional. This connection is necessary only if protection or supervision functions that require voltage measurements are used.

Interfaces to the Circuit-Breaker Function Group

The interface with the **Circuit-breaker** function group is used to exchange all required data between the protection function group and the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

You can connect the **Capacitor bank side** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Capacitor bank side** function group
- Start of the **Circuit-breaker failure protection** function, if available in the **Circuit-breaker** function group, through the protection functions of the connected **Capacitor bank side** function group

Besides the general assignment of the **Capacitor bank side** function group to the **Circuit-breaker** function group, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the **Capacitor bank side** function group.

For the detail configuration of the interface, define the following:

- Which operate indications of the protection functions are included when the trip command is generated
- Which protection functions activate the **Circuit-breaker failure protection** function

If an application template is used, the function groups are connected to each other because this link is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Function Embedding in the Device* .

Interface with Protection Communication (optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.5 Protection Communication* .

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Process Monitor

The process monitor is always present in the **Capacitor bank side** function group and cannot be removed. The process monitor provides the following information in the **Capacitor bank side** function group:

- Current-flow criterion:
  Detection of an open/activated capacitor bank side based on the flow of leakage current
- Closure detection:
  Detection of closure of the capacitor bank side
- Cold-load pickup detection (optional):

This information is in the **Capacitor bank side** function group and is available to all the functions in the function group.

Operational Measured Values

The operational measured values are always present in the **Capacitor bank side** function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. If only current is connected, only the first 3 lines apply.

Table 5-8 Possible Operational Measured Values of the Capacitor Bank Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated residual current	A	A	Rated operating current of the primary system
I_N	Measured residual current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating current of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating current of the primary system/√3
V_r	Measured neutral-point displacement voltage	kV	V	Rated operating current of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	MVAr	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to c os φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
Q_A, Q_B, Q_C	Phase-related reactive power	MVAr	–	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

If a **V-3ph measuring point** was connected to the **Capacitor bank side** function group, voltage and phase measurements are available.

The energy measurements are not predefined. If necessary, you must load them from the Global DIGSI 5 library.

Depending on the protection and supervision functions used, additional function measurements may be available. The function values are listed in the **information list** of the appropriate protection or supervision function (see chapter *6 Protection and Automation Functions*).

NOTE

With the **`P, Q sign`** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Power-Related Measured and Statistical Values):

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B, Q_C

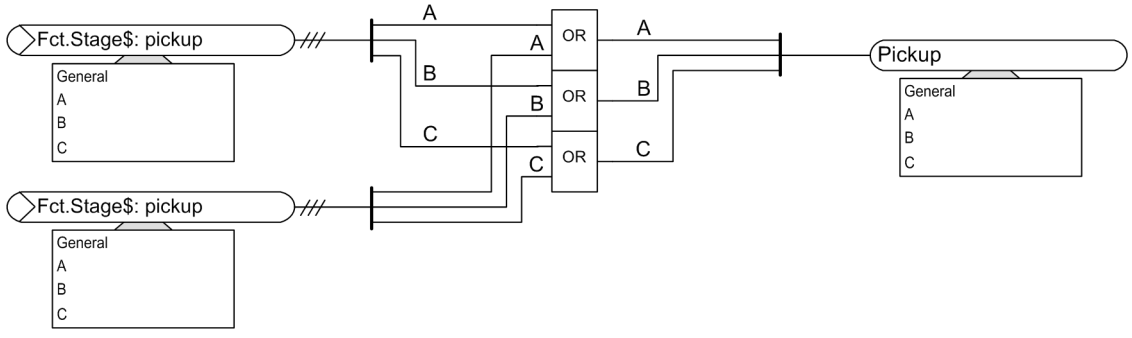
Capacitor-Bank Data (Side-Dependent)

The capacitor-bank data characterizes the data of the capacitor bank to be protected. The side-dependent capacitor-bank data applies to all of the functions in the **Capacitor bank side** function group.

Output Logic

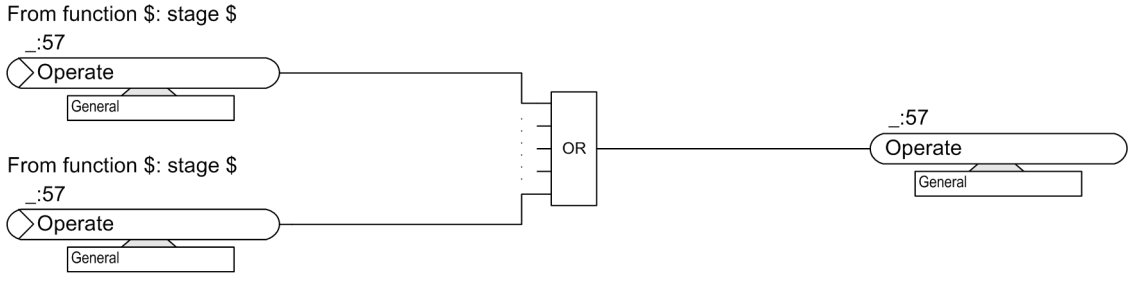
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overarching indications (group indications) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and operate indications of the protection and supervision functions in the **Capacitor bank side** function group are combined into one group indication using the following numbers and outputs.



[loanrlin-150211-01.tif, 3, en_US]

Figure 5-29 Generation of Pickup Indication of the Capacitor Bank Side Function Group



[logeopi1-231013-01.vsd, 2, en_US]

Figure 5-30 Generation of Operate Indication of the Capacitor Bank Side Function Group

5.5.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

The **Capacitor bank side** function group is usually connected to 1 **Circuit-breaker** function group. The **Circuit-breaker** function group is assigned to the circuit breaker of the capacitor bank.

Parameter: **Rated apparent power**

- Default setting **(_:1781:15571:103) Rated apparent power** = ***692.82 MVA***.

  The **Rated apparent power** parameter shows the primary rated apparent power of the capacitor bank to be protected. The setting value is determined of the **Capacitor reference volt.** and the **Capacitor reference curr.** parameters.

Parameter: **Capacitor reference volt.**

- Default setting **(_:1781:15571:102) Capacitor reference volt.** = ***400.00 kV***

You can use the **Capacitor reference volt.** parameter to set the reference voltage of the capacitor bank to be protected. The reference voltage set here is the reference value for the percentage measured values and setting values made in percent.

Depending on user philosophy you can use the system rated voltage (busbar voltage) or the capacitor rated voltage as a reference value.

Parameter: **Capacitor reference curr.**

- Default setting **(_:1781:15571:101) Capacitor reference curr.** = ***1000 A***

You can use the **Capacitor reference curr.** parameter to set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and setting values in percent.

For Differential protection, these values are used for absolute-value correction (rated current of the protected object).

If the capacitor bank is part of a delta connection, the value to be set here can differ from the capacitor reference current set in the **Capacitor bank** function group (by factor √3). Otherwise, set always the same values.

Depending on user philosophy, you can use the capacitor-bank rated current including the harmonics or the capacitor-bank fundamental-component current as a reference value.

Parameter: **Neutral point**

- Default setting **(_:1781:15571:149) Neutral point** = ***isolated***

With the **Neutral point** parameter, you specify whether the neutral point in the protection range of the differential protection is ***grounded*** or ***isolated***. If there is no neutral point in the protection zone, use the parameter ***isolated***. The neutral point of a capacitor bank is usually not in the protection zone. Therefore, even if the neutral point is grounded, set ***isolated*** here.

You can find further information in the Device manual 7UT8 Chapter 6.2.3 function description neutral point-current handling.

Parameter: **Winding configuration**

- Default setting **(_:1781:15571:104) Winding configuration** = ***Y (Wye)***

You can use the **Winding configuration** parameter to set ***D (Delta)*** for a delta connection. Another setting option is ***Y (Wye)*** for a star connection. The **Winding configuration** parameter is relevant for the Differential protection function.

Parameter: **Vector group numeral**

- Default setting **(_:1781:15571:100) Vector group numeral** = ***0***

This parameter is used to account for phase-angle rotation, which is expressed by a numeral.

Phase-angle rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Adaptation factor for the 3-phase measuring point (with reference to the side)

Each **Vector group numeral** can be set from 0 to 11 to the extent possible. Thus, for example, only even numbers are possible for the vector group Yy and Dd and only odd numbers are possible for Yd and Dy.

Parameter: Side number

- Default setting **(_:1781:14611:130) Side number** = ***not assigned***

The **Side number** parameter shows you which capacitor bank side is currently valid for the following parameters. The side number (***Side 1*** to ***Side 3***) is automatically assigned with the connection to a capacitor bank side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting **(_:1781:14611:210) MI3ph1 usesMeasP with ID** = ***0***

The **MI3ph1 usesMeasP with ID** parameter shows you which 3-phase measuring point is connected to the capacitor bank side. Every measuring point is assigned a unique ID.

Parameter: MI3ph2 usesMeasP with ID

- Default setting **(_:1781:14611:211) MI3ph2 usesMeasP with ID** = ***0***

The **MI3ph2 usesMeasP with ID** parameter shows you which 3-phase measuring point is connected to the capacitor bank side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting **(_:1781:14611:215) CT mismatch M I-3ph 1** = ***0.000***

The **CT mismatch M I-3ph 1** parameter shows you the magnitude adaptation of the phase currents of the 1st assigned measuring point. The numerical value results from the ratio of the primary rated current of the current transformer to the rated current of the side.

Parameter: CT mismatch M I-3ph 2

- Default setting **(_:1781:14611:217) CT mismatch M I-3ph 2** = ***0.000***

The **CT mismatch M I-3ph 2** parameter shows you the magnitude adaptation of the phase currents of the 2nd assigned measuring point.

5.5.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:1781:15571:103	Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA

Addr.	Parameter	C	Range of Values	Default Setting
Side data				
_:1781:14611:130	Side number		• not assigned • Side 1 • Side 2 • Side 3	Side 2
_:1781:14611:210	MI3ph1 usesMeasP with ID		0 to 100	8
_:1781:14611:215	CT mismatch M I-3ph 1		0.010 to 100.000	1.000

5.5.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:1781:15571:101	General:Capacitor reference curr.		1 A to 100 000 A	1000A
_:1781:15571:102	General:Capacitor reference volt.		0.20 kV to1200.00 kV	400.00 kV
Side data				
_:1781:15571:149	General:Neutral point		• grounded • isolated	isolated
_:1781:15571:104	General:Winding configuration		• Y (Wye) • D (Delta)	Y (Wye)
_:1781:15571:100	General:Vector group numeral		0 to 11	0
Measurements				
_:1781:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

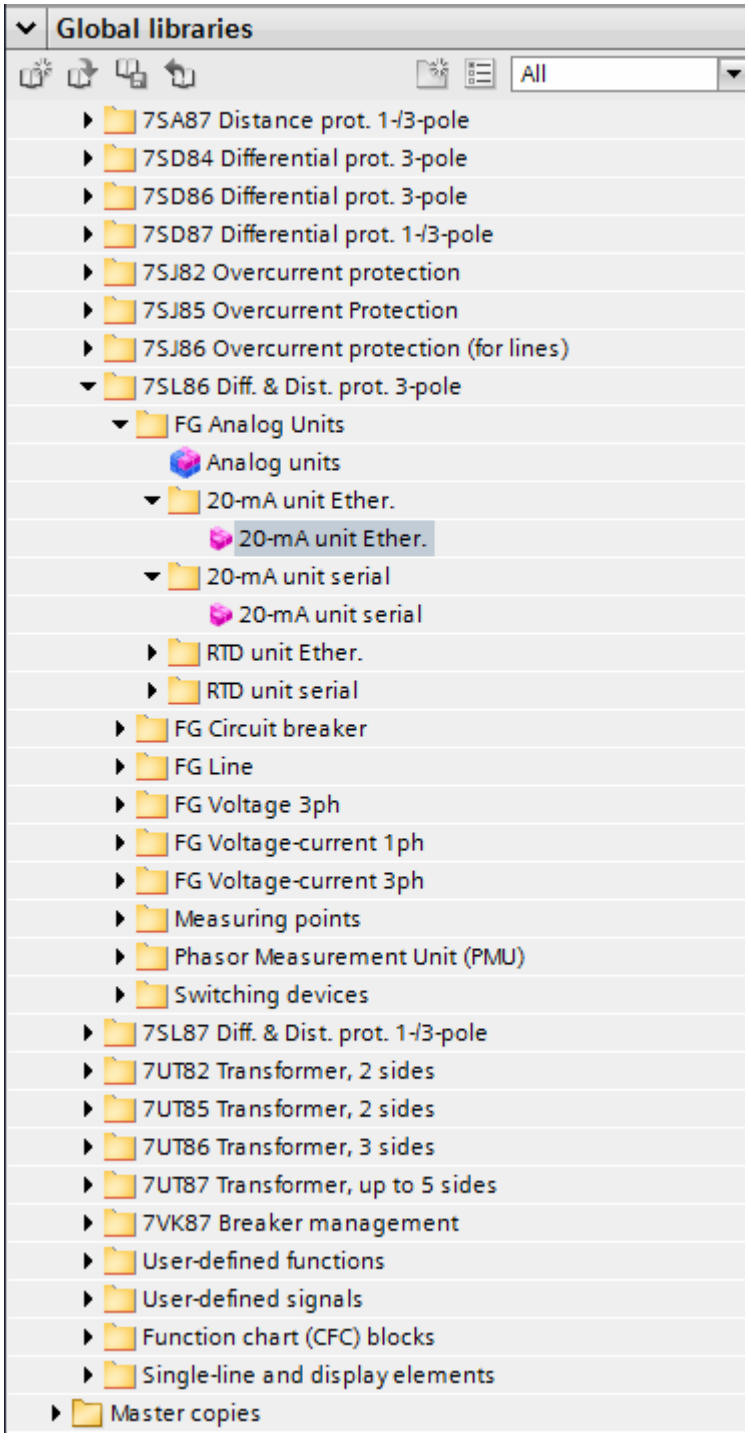
5.5.3.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.6 Function-Group Type Analog Units

5.6.1 Overview

The **Analog units** function group is used to map analog units and communicate with them. Analog units are external devices, such as RTD units, or analog plug-in modules, such as measuring-transducer modules.
You will find the **Analog units** function group for many device types in the Global DIGSI 5 library.



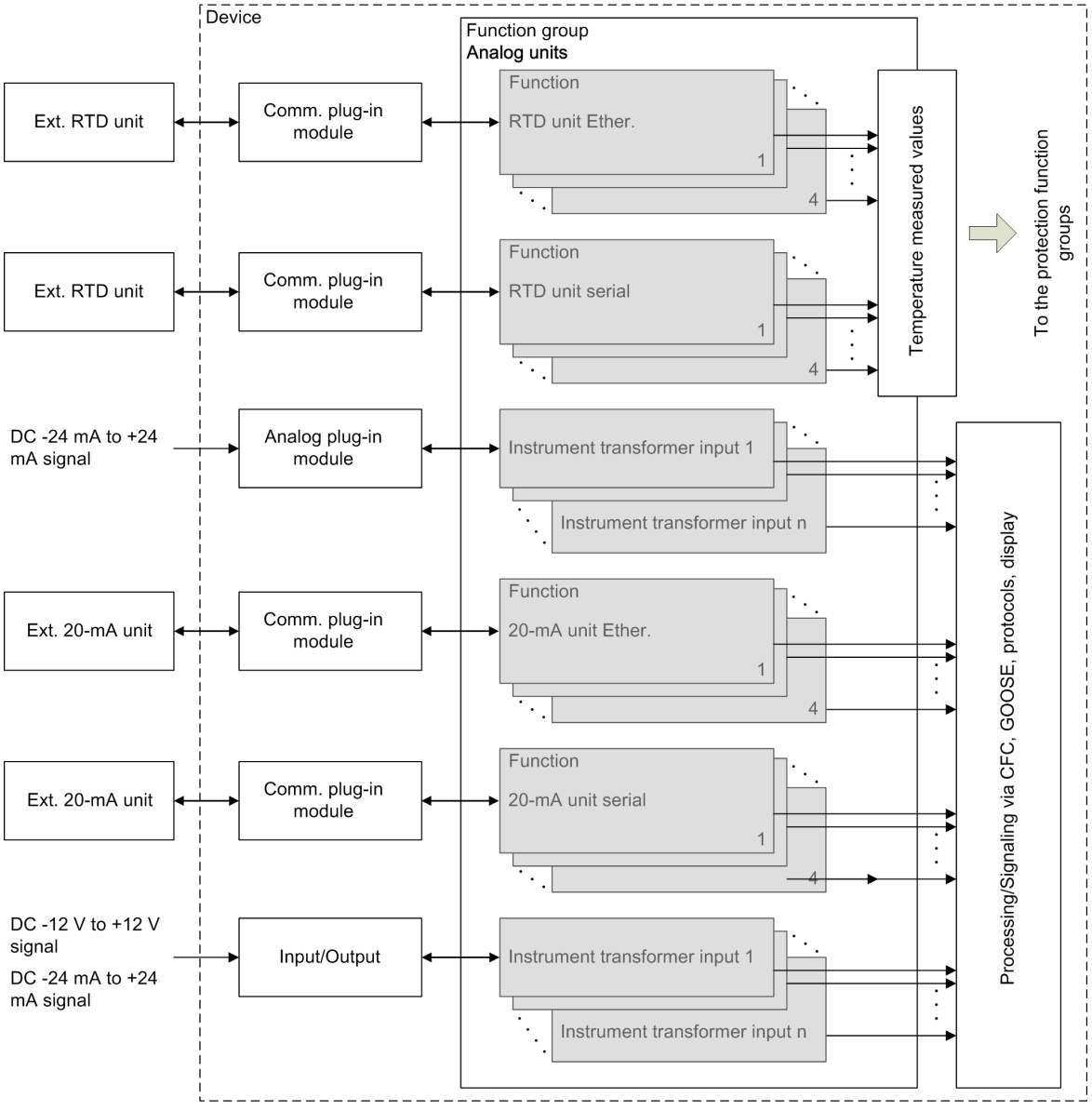
[sc20maee-190214-01, 1, en_US]

Figure 5-31 Analog Unit Function Group in DIGSI

5.6.2 Structure of the Function Group

If the device has a measuring transducer, it is automatically mapped in the **Analog units** function group. If one or more RTD units are connected to the device, you have to load one or more **RTD unit Ether.** or **RTD unit serial** functions from the Global DIGSI library in order to map the RTD units.

The following figure shows the structure of the function group.



[dwstrthe-030615-01.vsd, 1, en_US]

Figure 5-32 Structure of the Analog Unit Function Group

The **Analog units** function group has interfaces to protection function groups. The **Analog units** function group provides measured temperature values that come from an external RTD unit. These measured temperature values are available for all protection function groups in which a temperature monitoring function works.

The **RTD unit Ether.** function is not preconfigured by the manufacturer. A maximum of 20 function instances can work simultaneously.

The **RTD unit serial** function is set up structurally exactly in the same manner as the **RTD unit Ether.** function.

5.6.3 20-mA Unit Ethernet

5.6.3.1 Overview

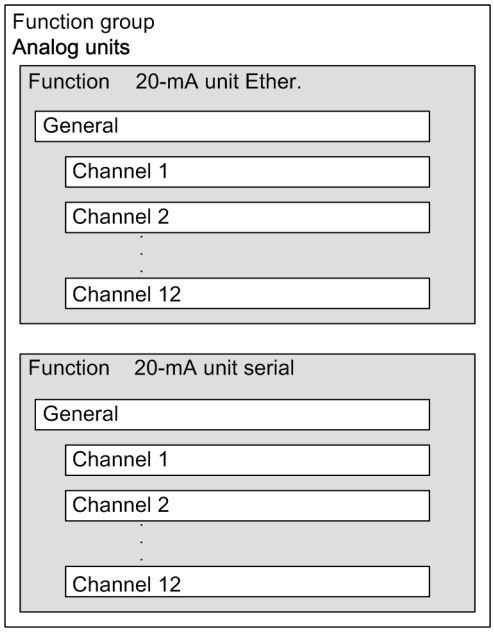
The function **20-mA unit Ether.**:

- Communicates in series with a 20-mA unit via the Slave Unit Protocol (SUP) and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process tags such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

5.6.3.2 Structure of the Function

The function **20-mA unit Ether.** can work only in the function group **Analog units**. A maximum of 4 function instances can work simultaneously. Each instance contains 12 preconfigured channel function blocks.

The function **20-mA unit Ether.** contains input and output channels which can be configured independently of one another.

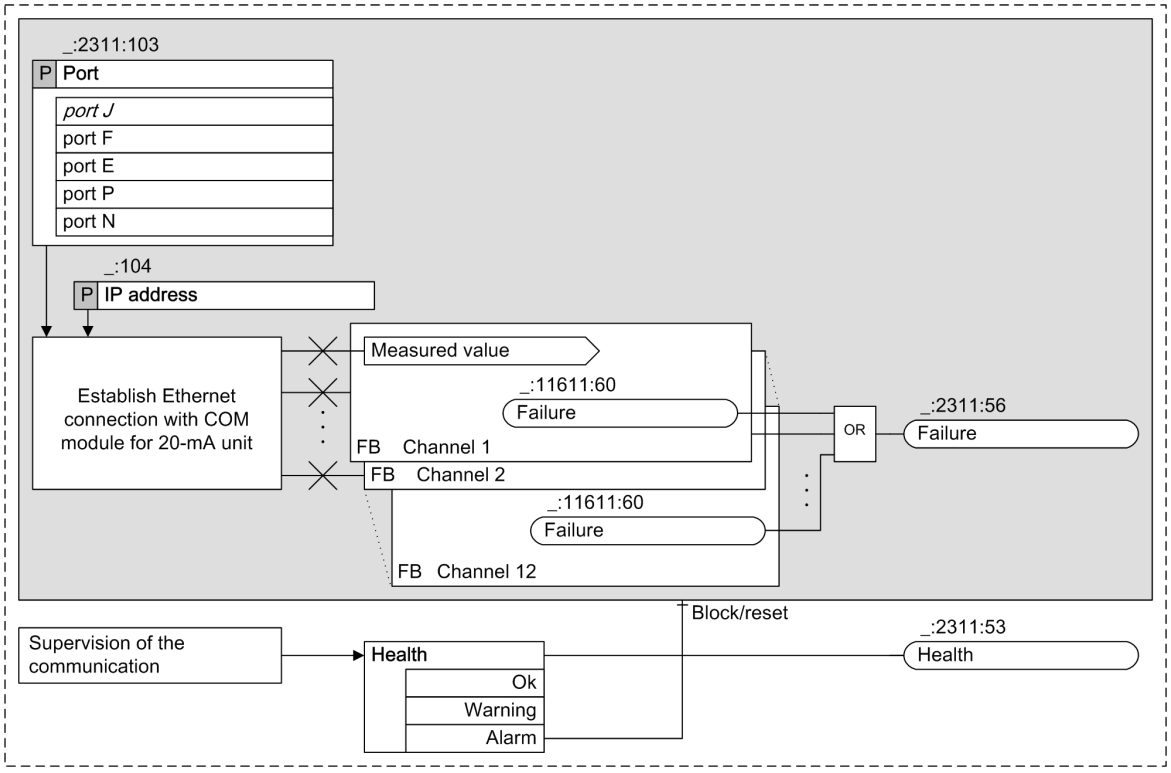


[dwstrfn2-150113-01.tif, 2, en_US]

Figure 5-33 Structure/Embedding of the Function

5.6.3.3 Communication with 20-mA Unit Ethernet

Logic



[lo20mtcp-150113-01.tif, 1, en_US]

Figure 5-34 Logic of the Function 20-mA Unit Ethernet

Communication with 20-mA Unit

The function is used to communicate with a 20-mA unit connected via an Ethernet connection. When a connection of the function to an external 20-mA unit via an Ethernet interface has successfully been established, the 20-mA unit sends the measured values of all connected channels to the function **20-mA unit. Ether.**. For the connection to be established successfully, specific communication settings must be specified.

You can find more detailed information in Chapter *5.6.3.4 Application and Setting Notes* .

The 20-mA measurement unit **7XV5674** is supported.

Error Responses

The following table lists the conditions under which the *Health* status transitions to the Alarm or Warning state.

Table 5-9 Error Responses

Error Description	Status Health
The function **20-mA unit Ether.** cannot establish a connection with a communication module.	Alarm
The function **20-mA unit Ether.** sends TCP settings to the communication module, which evidently would like to connect to the 20-mA unit via a serial protocol. This communication module does not establish a connection to the 20-mA unit.	Alarm
The connection between the communication module and the 20-mA unit causes a time-out indication.	Warning

Error Description	Status Health
A communication module has not received any more data from the 20-mA unit for 9 sec.	Warning

The *Failure* signal is set as soon as one of the channel function blocks reports a failure.

5.6.3.4 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***port J***

Use the **Port** setting to define the port connecting the 20-mA unit to the SIPROTEC 5 device.

Parameter: IP address

- Default setting **(_:2311:104) IP address** = ***10.16.60.1***

With the **IP address** settings, you set the IP address of the 20-mA unit connected to the communication module via the TCP protocol. You must assign each 20-mA unit an unambiguous IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. First set an IP address for the **7XV5674 20-mA unit**. Then specify the **IP address** settings for the communication module to the same address.

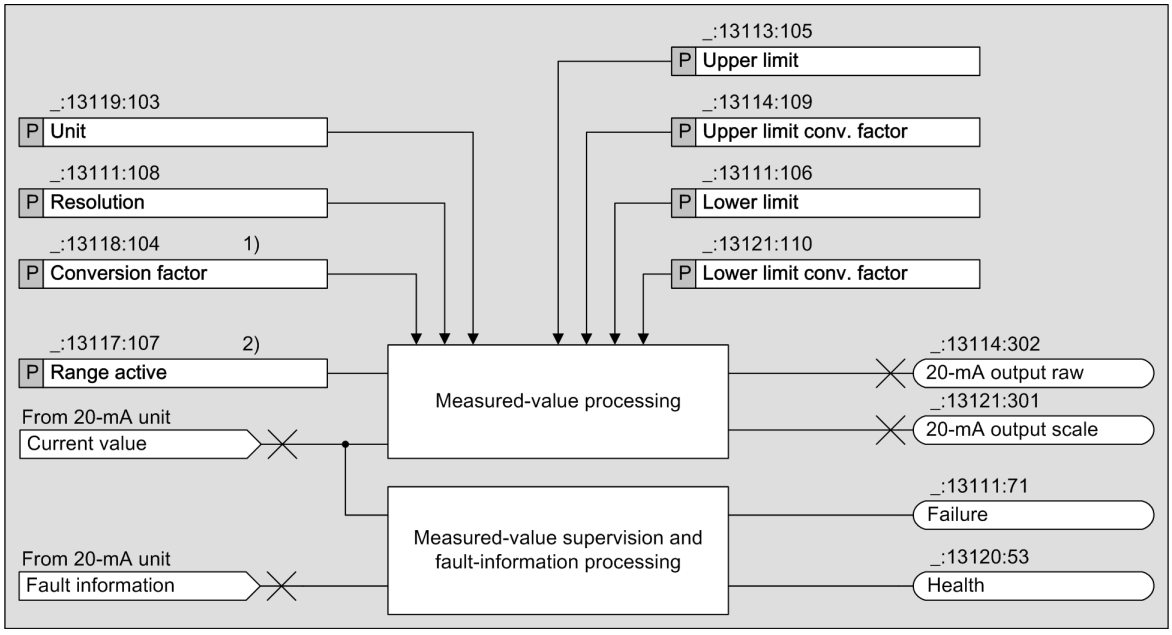
Settings on the 20-mA Unit

The **7XV5674 20-mA unit**is set with a web browser on the laptop computer via the latter's Ethernet interface. Set ***Modbus TCP*** as bus protocol/operating mode.

You can find detailed notes on the settings in the 7XV5674 manual that accompanies the 20-mA unit. The documents are also available in the SIPROTEC download area *http://www.energy.siemens.com*.

5.6.3.5 20-mA Channel

Logic



[lo20mcha-160113-01.tif, 1, en_US]

Figure 5-35 Logic Diagram of the Function 20-mA Channel

(1) If the setting **Range active** is set to ***test***, the setting **Transformation ratio** is not displayed.

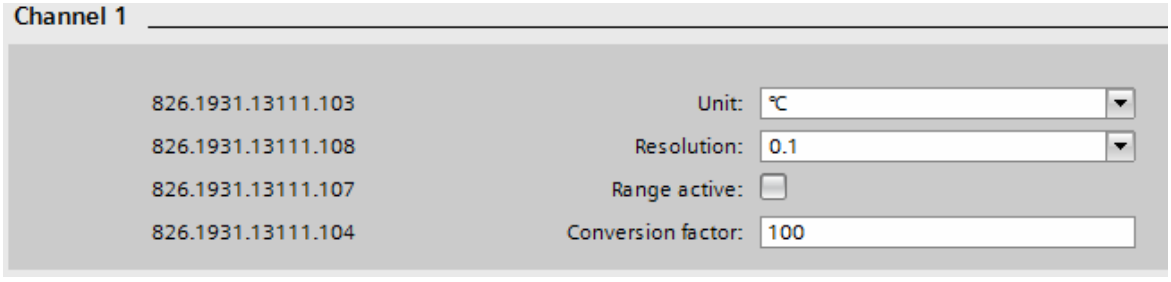
(2) If the setting **Range active** is set to ***false***, the settings **Upper limit**, **Transformation ratio upper limit**, **Lower limit** and **Transformation ratio** are not displayed.

Measured-Value Calculation

The function **20-mA channel** processes a single 20-mA current signal supplied by the 20-mA unit of the corresponding channel. The 20-mA current measured value is converted into the correct physical quantities such as temperature or pressure. In each 20-mA functional unit (Ether. and serial) there are always 12 of the 20-mA channel function blocks, even if fewer channels are connected with the 20-mA unit. The calculated values are available for further processing via CFC, GOOSE, protocols, and the display image.

Measured-Value Processing

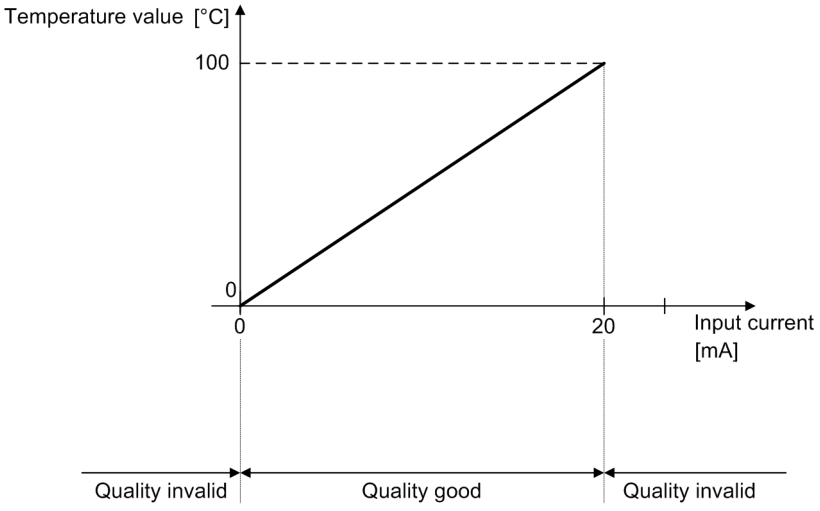
The 20-mA unit typically transmits a value which represents a physical quantity, such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that maps the physical quantity to the 20-mA value. If you do not activate the **Range active** setting (no x in the check box), the function operates over the range 0 mA to 20 mA. If a value smaller than 0 mA or greater than 20 mA is active at the input of the 20-mA unit, the measured value is identified as invalid. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA. The following figure shows an example.



[sckanumw-190214-01, 1, en_US]

Figure 5-36 Settings for Example 1

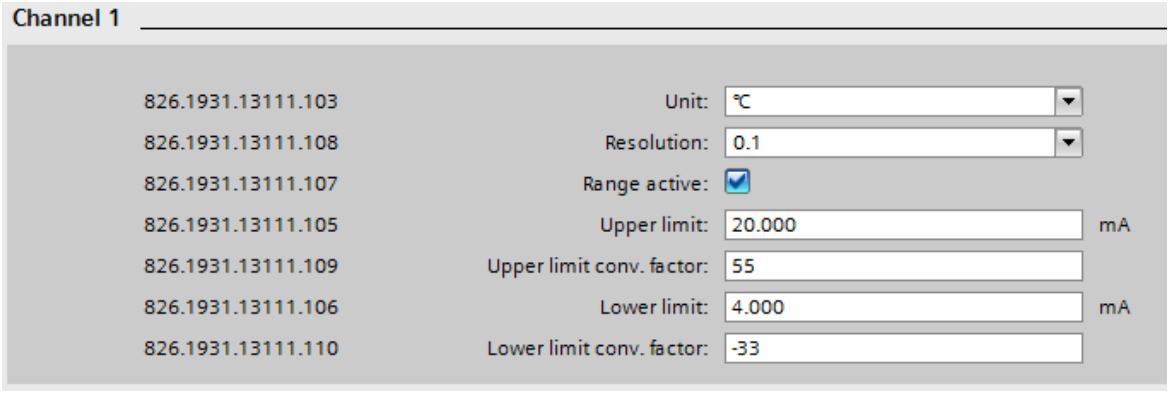
In this example, the measured value 0 mA means a temperature of 0 °C and the measured value 20 mA means a temperature of 100 °C. So enter as **Unit** = ***°C*** and **Conversion factor** = ***100***. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select **Resolution** = ***0.1***.



[dwknges3-020513-01.tif, 1, en_US]

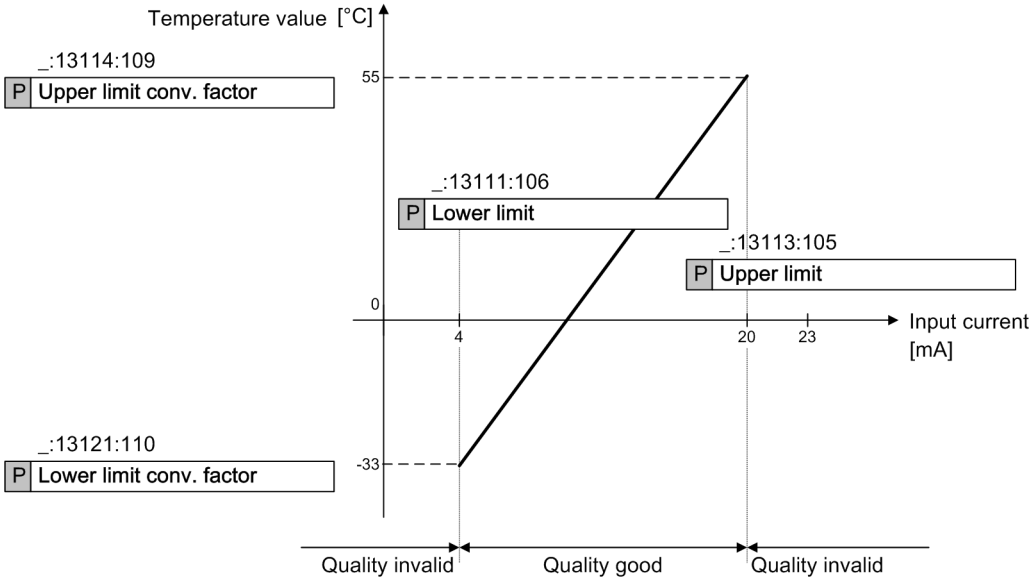
Figure 5-37 Characteristic Curve of a 20-mA Input (Example 1)

If you activate the **Range active** setting, then 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The parameters **Upper limit** and **Lower limit** indicate the range of the input current in mA. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting. The setting of the range for the scaled value corresponds to the useable range between **Lower limit** and **Upper limit** (see following figure).



[sckanumf-190214-01, 1, en_US]

Figure 5-38 Settings for Example 2



[dwknges2-020513-01.tif, 1, en_US]

Figure 5-39 Characteristic Curve of a 20-mA Unit (Example 2)

In this example, the **Range active** setting is selected. The setting **Upper limit** is at 20 mA, the setting **Lower limit** is at 4 mA. The setting **Upper limit - Sensor** is at 55 and the setting **Lower limit - Sensor** is at -33. If the input current is smaller than 4 mA or greater than 20 mA, the quality of the scaled measured value in this example is invalid.

Each 20-mA channel makes available the scaled measured value in the information routing (these are the temperature values in the examples) and the original current measured value in mA for further processing.

The 20-mA values can be displayed in the display page and processed with CFC charts.

Error Responses

If the current input value is determined to be incorrect, the quality attribute of the output value is set to *invalid* That status for *Health* and the defect status assume the states displayed in the table.

Table 5-10 Error Responses

Error Description	Status *Health*	Error Status
The input value lies outside the given limits	OK	Yes
Channel not connected	OK	No

5.6.3.6 Application and Setting Notes

Parameter: Unit

- Default setting **(_:13111:103) Unit** = ***°C***

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = ***100***

The **Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = ***0.1***

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = ***false***

If you do not activate the **Range active** setting (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting **(_:13111:105) Upper limit** = ***20000 mA***
- Default setting **(_:13111:109) Upper limit - Sensor** = ***100***
- Default setting **(_:13111:106) Lower limit** = ***4000 mA***
- Default setting **(_:13111:110) Lower limit - Sensor** = ***100***

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.6.3.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	m
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.6.3.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.6.4 20-mA Unit Serial

5.6.4.1 Overview

The function **20-mA unit Serial**:

- Provides serial communications with a 20-mA unit via the Modbus protocol and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process variables such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

The function **20-mA unit Serial** is structured in the same way as the function **20-mA Unit Ether.**. The mode of operation is also identical. The only difference is that the measured values are transferred to the communication module via a serial connection instead of an Ethernet connection.

You can find more information in Chapter *5.6.3.2 Structure of the Function*.

5.6.4.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***Port J***

With the **Port** setting, you specify the slot for the communication module that will be used for the connection with an external 20-mA unit.

Parameter: Channel number

- Default setting **(_:2311:105) Channel number** = ***1***

A serial communication module optionally uses 2 channels. With the **Channel number** setting, you specify the channel number (1 or 2) used to connect the 20-mA unit to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting **(_:2311:106) Slave address** = *1*

Use the **Slave address** setting to define the device address of the 20-mA unit. If only one 20-mA unit is connected to the serial bus, the default value *1* can be used. Set the same device address as used with the 20-mA unit. The device address is important for distinguishing several 20-mA units that are connected to a serial bus. Set an unambiguous device address on every 20-mA unit, for example, 1, 2 and 3 when connecting 3 of the 20-mA units. On every 20-mA unit, set for the **Slave address** setting in the 3 functions **20-mA Unit Serial** the same device address for each.

Parameter: Unit

- Default setting **(_:13111:103) Unit** = *°C*

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = *100*

The **Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = *0.1*

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = *false*

If you do not activate the **Range active** setting (no x in the check box), the function operates over the range 0 mA to 20 mA. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Upper limit - Sensor**, **Lower limit** and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting **(_:13111:105) Upper limit** = *20 mA*
- Default setting **(_:13111:109) Upper limit - Sensor** = *100*
- Default setting **(_:13111:106) Lower limit** = *4 mA*
- Default setting **(_:13111:110) Lower limit - Sensor** = *100*

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Lower limit**, **Upper limit - Sensor** and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 247	1
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	m

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.6.4.4 Information List

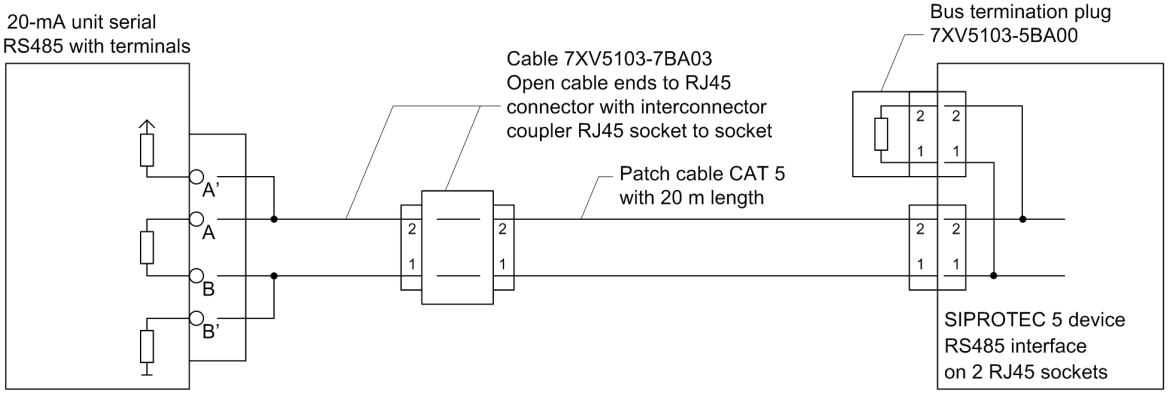
No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.6.5 Communication with 20-mA Unit

5.6.5.1 Integration of a Serial 20-mA Unit

Connection of the Communication Lines

Figure 5-40 shows how to connect the 20-mA unit to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.

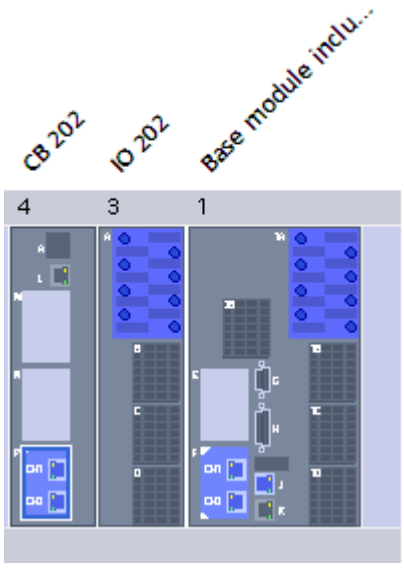


[dwve20au-150213-01.tif, 1, en_US]

Figure 5-40 Connection of the 20-mA Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

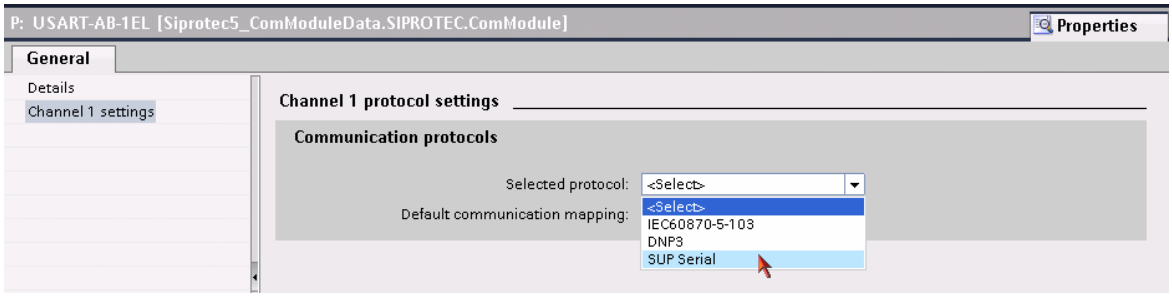


[sc20ser3-220114-01-DE, 1, en_US]

Figure 5-41 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the 20-mA unit.



[scauser4-220114-01-DE, 1, en_US]

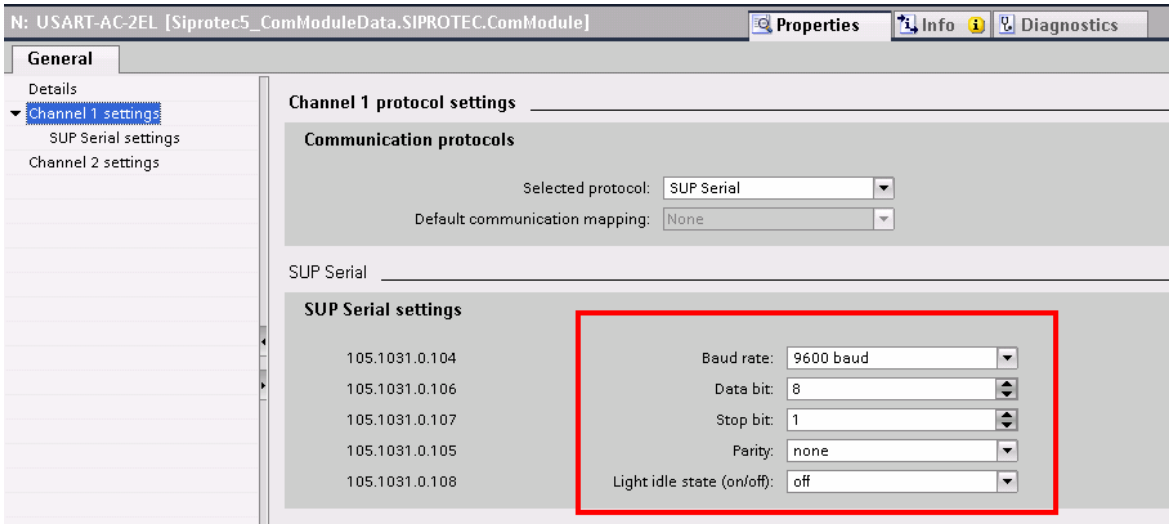
Figure 5-42 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the 20-mA unit. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the 20-mA unit. Make sure that the setting values in both devices are the same. The settings of the **`Non-flickering light (on/off):`** is not relevant for the RS485 interface.

NOTE

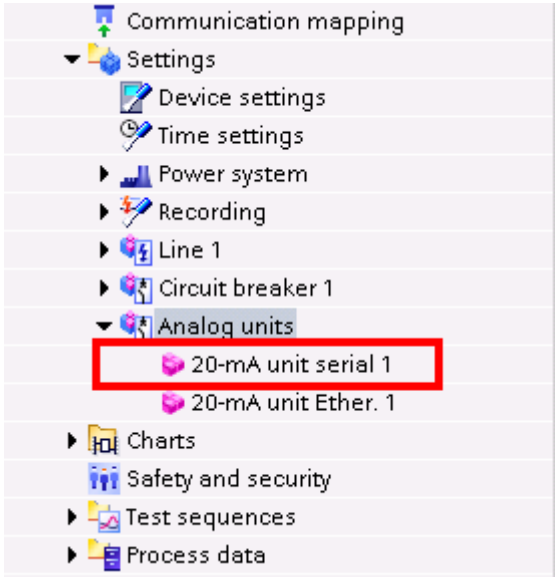
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-220114-01-DE, 1, en_US]

Figure 5-43 Making the Communication Settings

With the selection of the SUP protocol for the 20-mA unit DIGSI automatically adds the function group **Analog units** to your device configuration. You can now instantiate the function **20-mA unit serial 1** (see following figure).



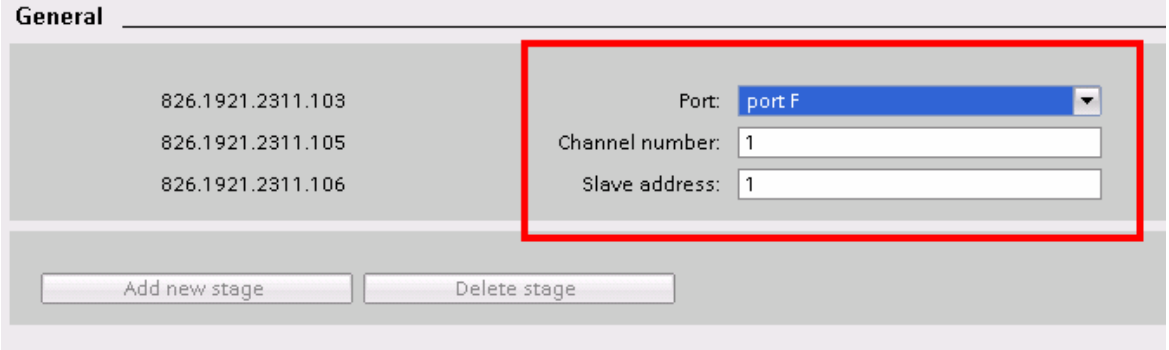
[sc20ser6-220114-01-DE, 1, en_US]

Figure 5-44 Insertion of the Function 20-mA Unit Serial 1

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the 20-mA unit. This address must be set with the same value in the 20-mA unit (refer to the following figure).

For the first use of the 20-mA unit, the following device configuration must be set on the 20-mA unit:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no



[scauser7-220114-01-DE, 1, en_US]

Figure 5-45 Setting the Port, Channel Number, and Device Address

Finally, load the configuration in the device.

5.6.5.2 Integration of a 20-mA Unit Ethernet

Device Configuration

In DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. *Figure 5-46* displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

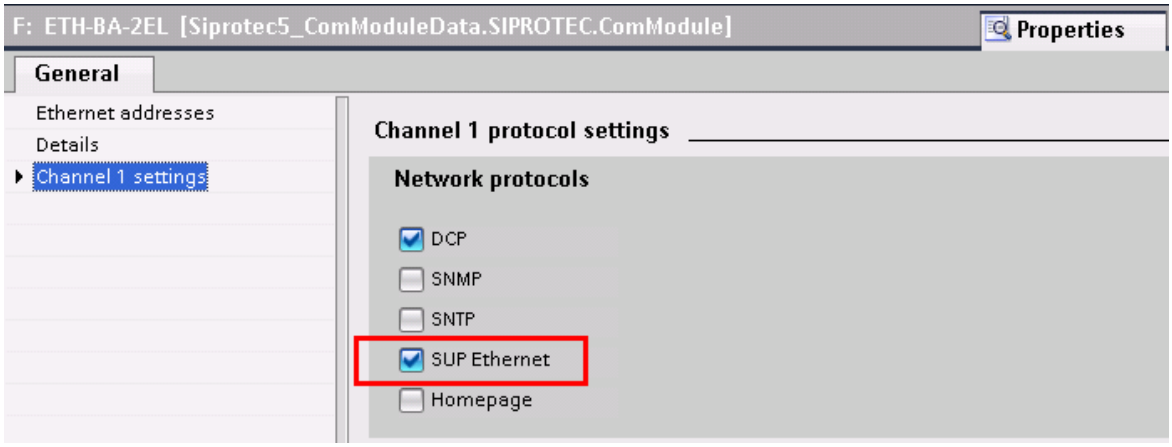


[scautcp1-220114-01-DE, 1, en_US]

Figure 5-46 Inserting an Ethernet Module

Communication Settings

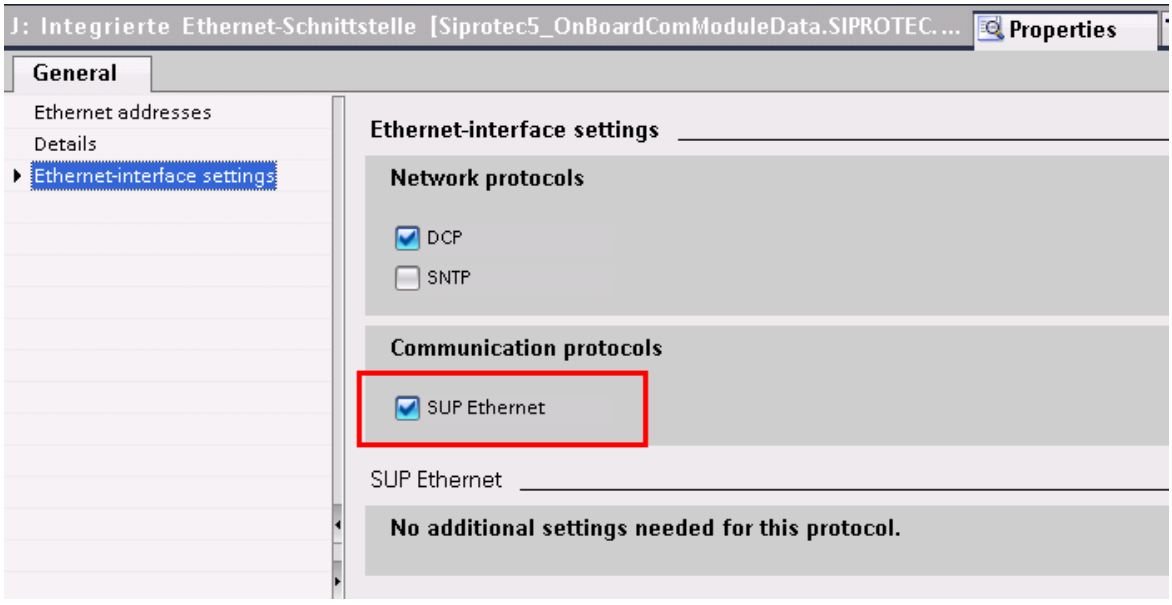
Activate the SUP Ethernet protocol for the Ethernet module.



[scautcp2-220114-01-DE, 1, en_US]

Figure 5-47 Activation of the protocol

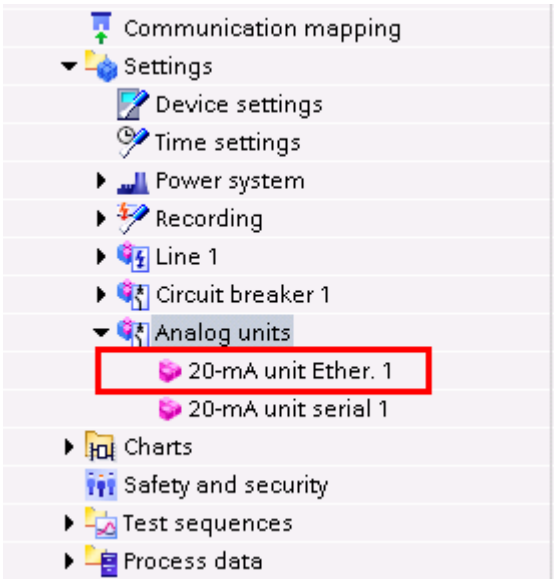
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[scautcp3-220114-01-DE, 1, en_US]

Figure 5-48 Selection of the Protocol

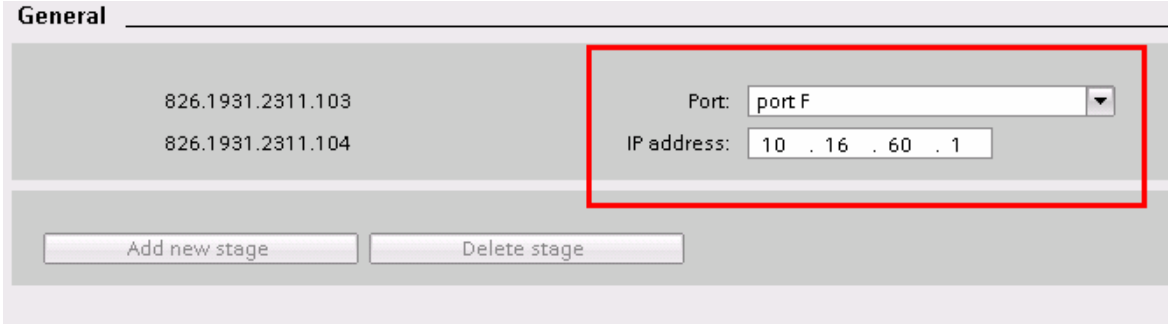
With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the **Analog units** function group and the **20-mA unit Ether.** function to your device configuration (refer to the following figure).



[sc20tcp4-220114-01-DE, 1, en_US]

Figure 5-49 Insertion of the Function 20-mA Unit Ether. 1

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the 20-mA unit (refer to the following figure). This address must be set with the same value in the 20-mA unit.



[scautcp5-220114-01-DE, 1, en_US]

Figure 5-50 Setting the Port and IP Address

Finally, load the configuration in the device.

5.6.6 V/I-Measuring-Transducer Unit with Fast Inputs

5.6.6.1 Overview

The fast analog measuring-transducer inputs process voltage values (DC -10 V to +10 V) as well as current values (DC -20 mA to 20 mA).

The function **MT fast input**:

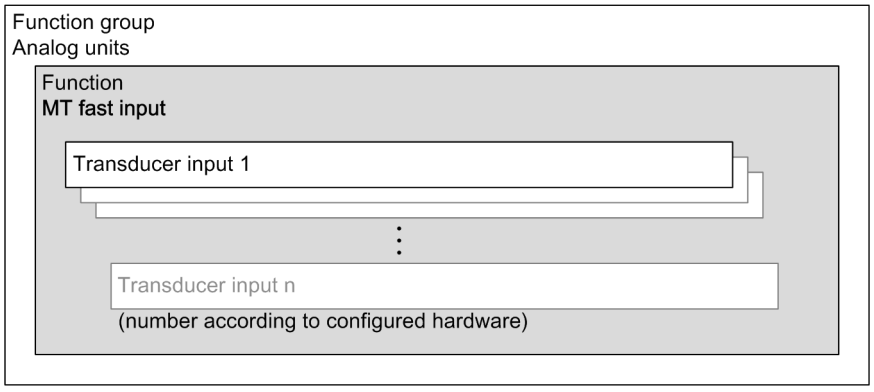
- Provides sampled values for recording in the fault record (the maximum sampling frequency is 8 kHz for all other SIPROTEC 5 devices). The recorded sampling frequency results from the setting of the fault-recorder function.
- Calculated measured values from the sampled values. These measured values have been deduced from the arithmetic mean values. The measuring range for the mean-value calculation is adjustable in the interval from 10 ms to 100 ms.

- Converts the measured current or voltage values into process values, for example, temperature, gas pressure, etc.
- Provides the recorded process variables for further processing by the fault recorder, the CFC, and in GOOSE-applications for transmission via communication protocols, and for visualization

The fast measuring-transducer inputs are located on the IO212 module with 8 inputs (optionally current or voltage inputs), and the IO210 module with 4 inputs (optionally current or voltage inputs).

5.6.6.2 Structure of the Function

The function **MT fast input** works in the function group **Analog units** and contains the number of available measuring-transducer inputs, depending on the hardware configuration. You can configure these channels independently from one another either as current or voltage inputs.



[dw_mu-structure, 1, en_US]

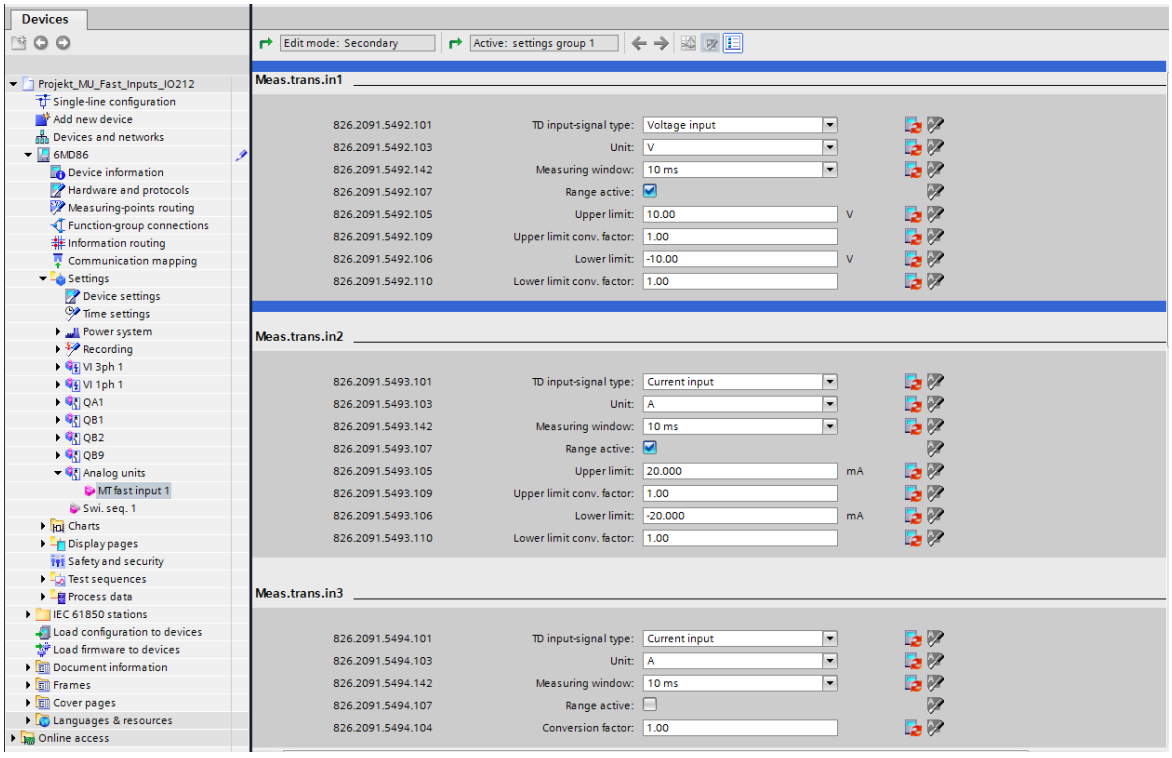
Figure 5-51 Structure/Embedding of the Function

5.6.6.3 Function Description

Once you have instantiated the **MT fast input** function, it will be visible in the project tree in the function group **Analog units**. You can find the function group **Analog units** in DIGSI in the **Settings** folder.

If you open the subdirectory **MT fast input**, you reach the setting sheet for the respective input (for more details, see Application and Setting Notes).

The hardware is designed in such a way that either a current or a voltage can be processed at each input. Use the corresponding terminals (see Hardware manual). Configure the input in accordance with the selected connection (Parameter **`TD input-signal type`**). With the parameter **`Measuring window`**, you set the measuring range with which the arithmetic mean value is determined. With the parameter **`Measuring window`**, you also determine measurement speed for the input. For example, a setting of 100 ms means that the measured value is updated every 100 ms.



[scmuio212, 1, en_US]

Figure 5-52 Parameters of the Measuring-Transducer Channels.

The fast measuring-transducer channels can be configured either as current or as voltage inputs. Apart from this, their function corresponds to the basic function of the 20-mA-channels (see chapter *5.6.3.5 20-mA Channel*).

5.6.6.4 Application and Setting Notes

Parameter: `TD input-signal type`

- Default setting **`(_:101) TD input-signal type`** = ***`Current input`***

With the parameter **`TD input-signal type`**, you determine whether the measuring-transducer input channel works as a ***`Current input`*** or as a ***`Voltage input`***.

Make sure that the selected channel has also been wired correctly (see Hardware manual, Input and Output Module IO212).

Parameter: `Unit`

- Default setting **`(_:103) Unit`** = ***`A`***

With the parameter **`Unit`**, you set the physical unit of measurement of the measured values. The possible setting values are listed in the settings table.

Parameter: `Measuring window`

- Default setting **`(_:142) Measuring window`** = ***`10 ms`***

With the parameter **`Measuring window`**, you set the measuring window that is used to determine the arithmetic mean value from the sampled values. In case of slowly varying signals, Siemens recommends setting the top value to 100 ms. With this value, a new, current measured value is provided every 100 ms for further processing.

Parameter: `Range active`

- Default setting **`(_:107) Range active`** = ***`false`***

If you do not activate the **`Range active`** parameter, the function assumes a range of -20 mA to +20 mA or -10 V to +10 V. The setting of the range for the scaled value then assumes a usable range of -20 mA to +20 mA or -10 V to +10 V.

If you activate the **`Range active`** parameter, then 4 additional parameters **`Upper limit`**, **`Upper limit - Sensor`**,**`Lower limit`**, and **`Lower limit - Sensor`** appear.

Note that this setting is activated by either placing, or not placing the relevant check mark in DIGSI (see *Figure 5-52*).

Parameter: Conversion factor

- Default setting **`(_:104) Conversion factor`** = ***`1.00`***

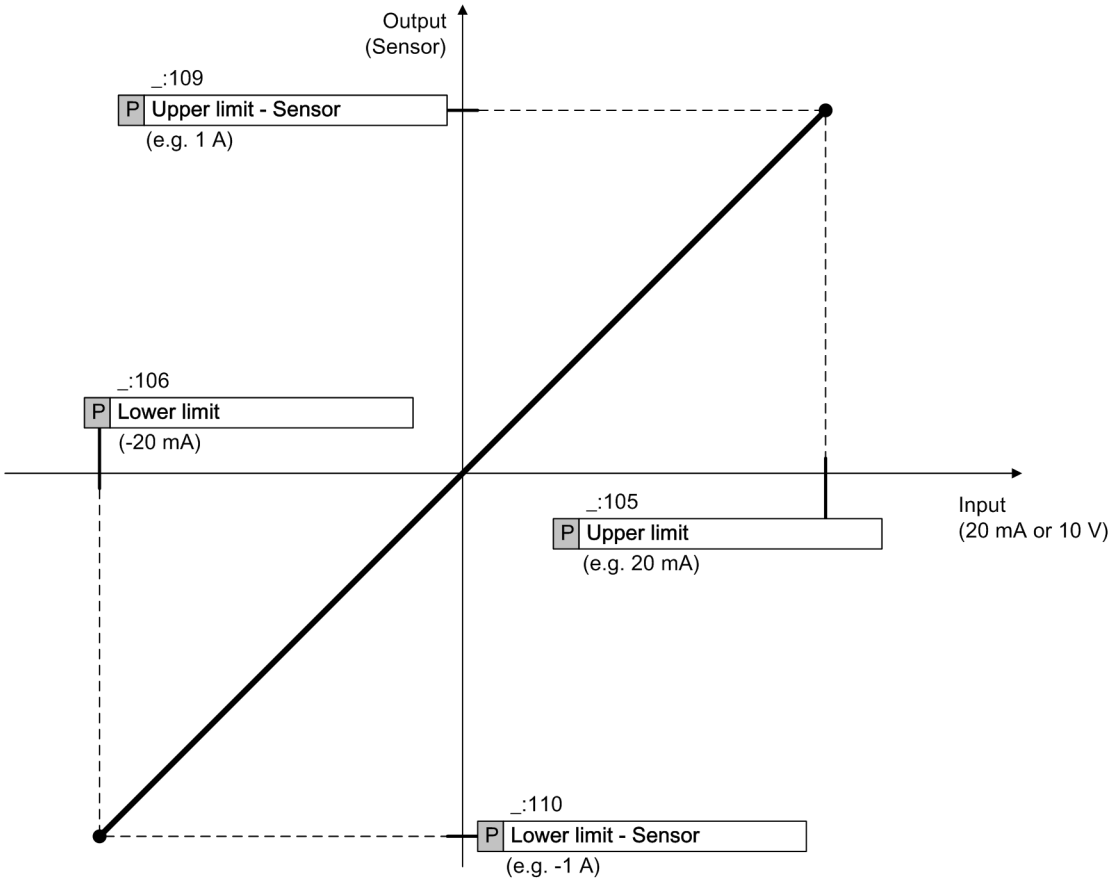
With the parameter **`Conversion factor`**, you set the conversion factor for the measuring transducer.

Parameter: Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor

With the following parameters, you set the scaling of the measuring variables. By that, you can scale in an application-specific way:

- Default setting **`Upper limit`** = ***`20.00 mA`***
- Default setting **`Upper limit - Sensor`** = ***`1.00`***
- Default setting **`Lower limit`** = ***`-20.00 mA`***
- Default setting **`Lower limit - Sensor`** = ***`1.00`***

With these setting parameters, you set the operating range of the measuring transducer as well as the conversion of the values transmitted to the sensor values. Harmonize the operating range of the measuring transducer with the transmitter of the sensor. Using the free scalability of the system, you can meet different requirements. The following figure shows the setting parameters in general terms.

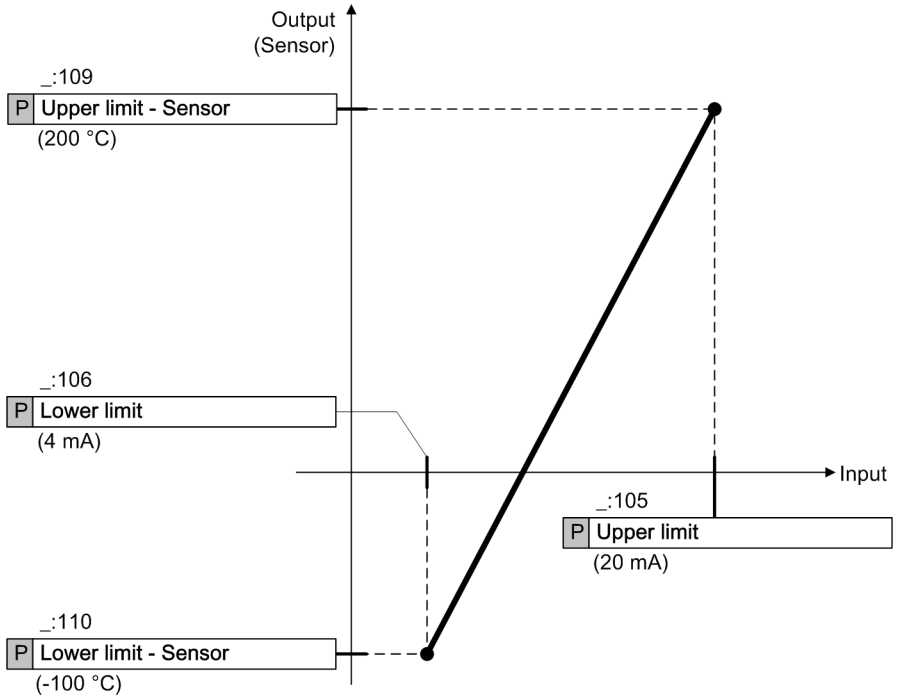


[dw_measured-value-scaling, 1, en_US]

Figure 5-53 Scaling Principle

Setting Example 1:

A measuring transducer transmitting a current signal of 4 mA to 20 mA is used as a transmitter. Currents well below 4 mA indicate a transmitter failure; currents around 0 mA indicate a broken wire. A sensor detecting a temperature is attached to the transmitter. The upper value corresponds to 200 °C and the lower value to -100 °C. This results in the following characteristic. In accordance with the set characteristic curve, the function calculates the sensor value from the measured current. The coefficients of the linear equation (gradient and foot point) are calculated from the set threshold and the sensor values are determined. A supplied current of 9.333 mA corresponds to a temperature of 0 °C.



[dw_measuring-transducer-characteristic, 1, en_US]

Figure 5-54 Characteristic Curve of Setting Example 1

NOTE

The hardware of the measuring transducer has been designed in such a way that measured values are transmitted and analyzed using the setting range (**`Upper limit`** or **`Lower limit`**). Therefore, special applications are possible, if necessary. The limits lie at approximately +20 mA and -20 mA or +10 V and -10 V. If the measured values are supplied above or below these limits, the quality ***`invalid`*** is assigned.

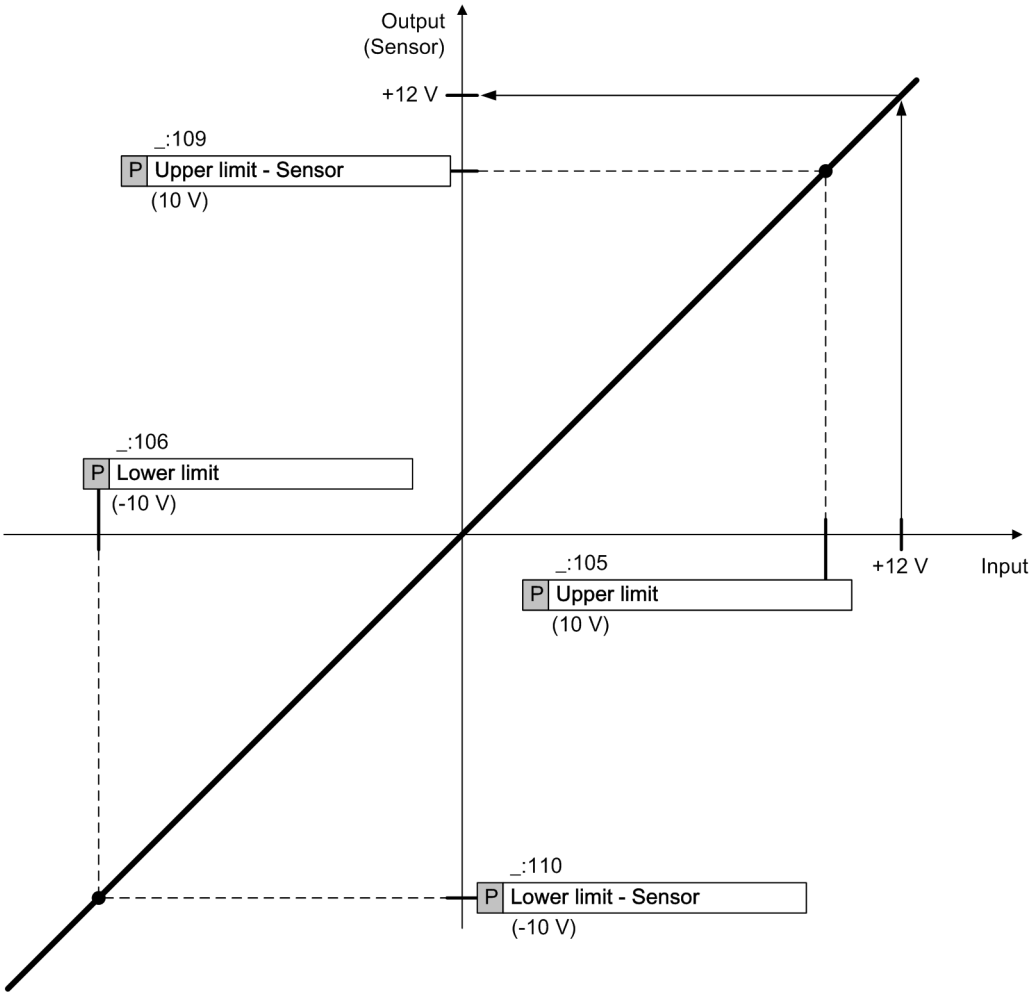
Setting Example 2:

For special applications, the transmitter sends a maximum of ±12 V. This voltage shall be issued accordingly as sensor voltage.

Set the parameters as follows:

- **`Upper limit`** = ***`10.00 V`***
- **`Upper limit - Sensor`** = ***`10.00 V`***
- **`Lower limit`** = ***`-10.00 V`***
- **`Lower limit - Sensor`** = ***`-10.00 V`***

With this setting, a signal of 12 V is issued as a 12-V measured value (see following figure).



[dw_measuring-transducer-setting, 1, en_US]

Figure 5-55 Parameter Settings and Representation of an Input Signal Greater than 10 V

5.6.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT fast #				
_:101	MT in #:TD input-signal type		• Voltage input • Current input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• • % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	A
_:142	MT in #:Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	10 ms
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		-10000.00 to 10000.00	1.00
_:105	MT in #:Upper limit		-20.00 mA to 20.00 mA	5.00 mA
_:109	MT in #:Upper limit - Sensor		-10000.00 to 10000.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
_:106	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-10000.00 to 10000.00	1.00

5.6.6.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:302	MT in #:TD scale MV	MV	O
_:306	MT in #:TD scale SAV	SAV	O

5.6.7 RTD Unit Ethernet

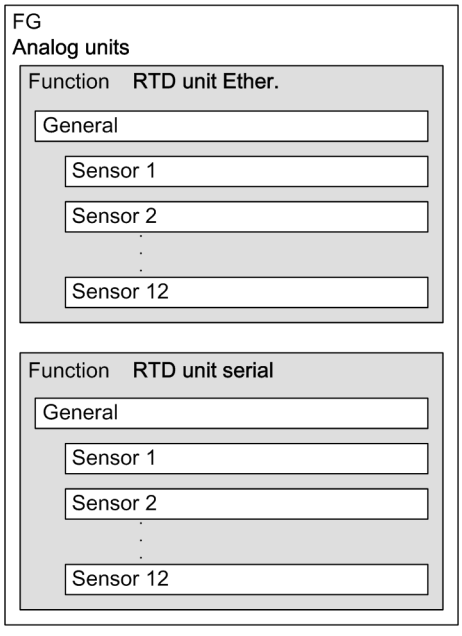
5.6.7.1 Overview

The **RTD unit Ether.** function:

- Communicates with an external RTD unit via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature monitoring function
- Monitors communication with the RTD unit

5.6.7.2 Structure of the Function

The **RTD unit Ether.** function can only work in the **Analog units** function group. A maximum of 20 function instances can work simultaneously. Each instance contains 12 preconfigured sensor function blocks.

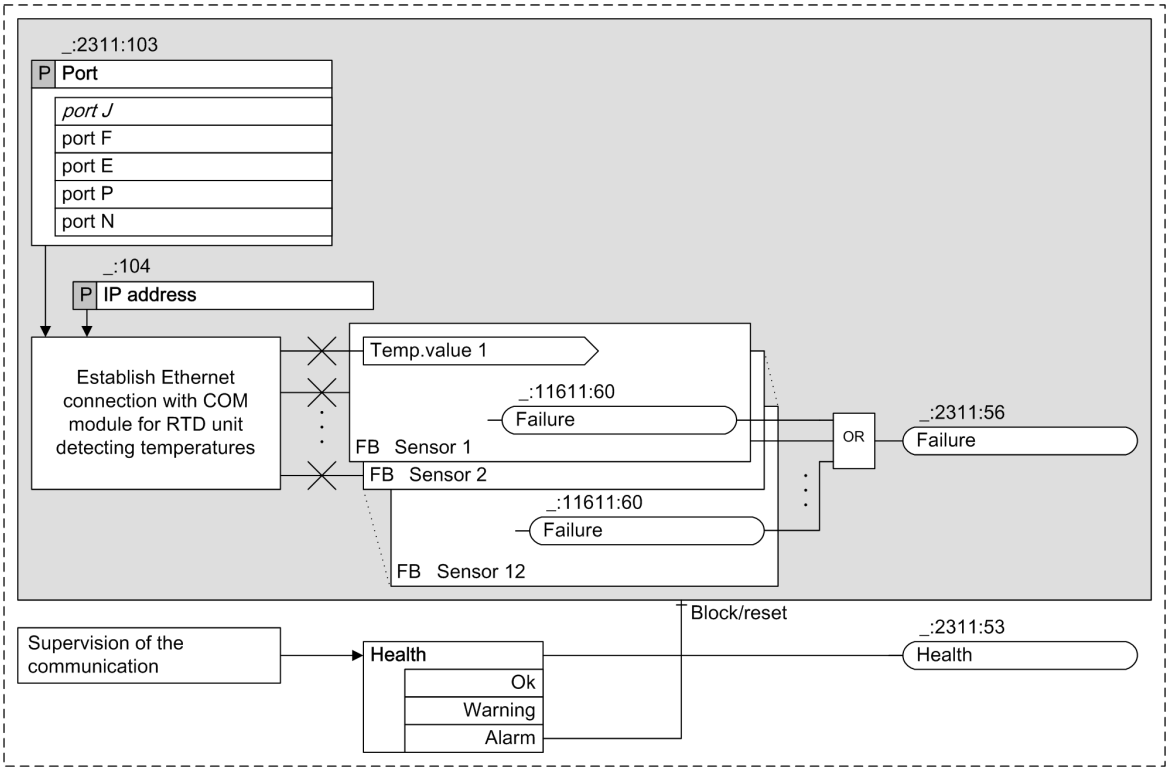


[dwstrfnc-291112-01.tif, 2, en_US]

Figure 5-56 Structure/Embedding of the Function

5.6.7.3 Communication with an RTD Unit

Logic



[lortdtcp-311012-01.tif, 1, en_US]

Figure 5-57 Logic of the RTD Unit Ether. Function

Communication with an RTD Unit

The function is used to communicate with an RTD box connected via an Ethernet connection. If the connection of the function is successfully established to the external RTD box via the Ethernet interface, the RTD box transmits the temperatures of all connected sensors to the **RTD box Ether.** function. For the connection to be established successfully, specific communication settings must be set, see chapter *5.6.7.4 Application and Setting Notes*.

The RTD box **Ziehl TR1200 IP** supports only an Ethernet connection of 10 MBit/s. A direct connection to a 100-Mbit communication module is therefore not possible. For this reason, you must connect the RTD box to the communication module via a 10/100 MBit/s autosensing switch which automatically recognizes the transmission rates and adapts them accordingly. Further information can be found in the Application and setting notes, see chapter *5.6.7.4 Application and Setting Notes*.

Error Responses

The following table lists the conditions under which the *Health* status transitions to the Alarm or Warning state.

Table 5-11 Error Responses

Error Description	Status Health
The **RTD unit Ether.** function cannot establish a connection with a communication module.	Alarm
The connection between the communication module and the RTD unit causes a time-out.	Warning

Error Description	Status Health
A communication module has not received any more data from the RTD unit for 9 sec.	Warning

The *Failure* signal is set as soon as one of the sensor function blocks reports a failure.

5.6.7.4 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***port J***

Use the **Port** parameter to define over which port the external RTD unit is connected to the SIPROTEC 5 device.

If you want to connect the external RTD unit to the integrated Ethernet interface, set the parameter **Port** = ***Port J***. If you want to connect the external RTD unit to an Ethernet plug-in module, set the parameter **Port** = ***Port F***, ***Port E***, ***Port P***, or ***Port N***.

You can connect directly the RTD unit to the device via the internal 10-Mbit Ethernet port J. If you operate the RTD unit on another port via a 100-Mbit communication module, you need an interconnected 10/100-Mbit autosensing switch, which adapts transmission rates accordingly.

Parameter: IP address

- Default setting **(_:2311:104) IP address** = ***10.16.60.1***

With the **IP address** parameter, you set the IP address of the RTD unit connected to the communication module via the SUP protocol. Every RTD unit has to be assigned a unique IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. Set an appropriate IP address first at the **Ziehl TR1200 IP** RTD unit. Then specify the **IP address** parameter for the communication module to the same address.

Settings on the RTD Unit

The **Ziehl TR1200 IP** RTD unit is set with the front keys or in a Web browser on a laptop computer via its Ethernet interface. Set the connection type of the sensors (3-wire connection or resistance value for 2-wire connection), the idle state of the fault-indication relay, as well as the IP interface setting.

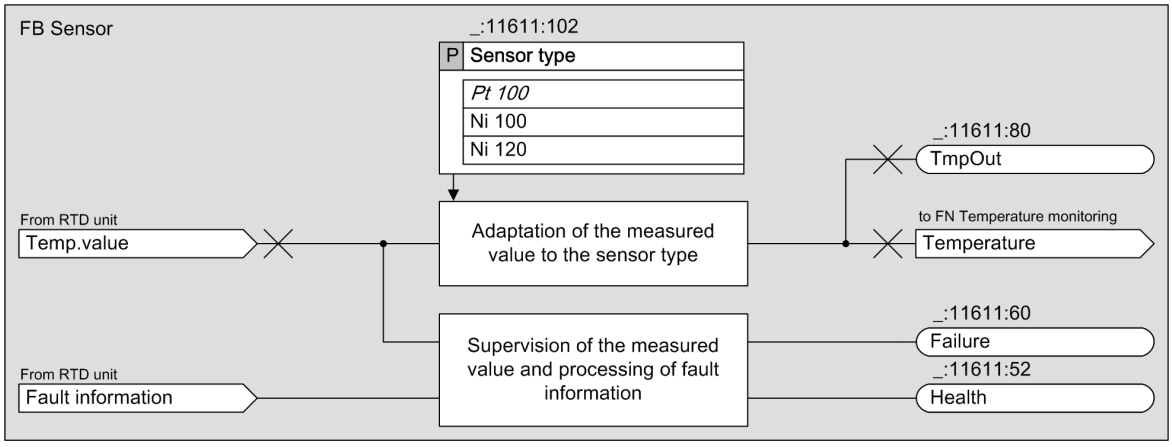
The code lock has to be switched off for parameterization. This is only possible using the front keys of the RTD unit. The code lock is **off** (switched off) in as-delivered condition and has pin **504**.

For detailed information on the settings, refer to the TR1200 IP manual that comes with the RTD unit. The documents are also available in the SIPROTEC download area (http://www.siprotec.de) under **Accessories -> 7XV5662-xAD**.

For an Ethernet connection to a SIPROTEC 5 device communicating with the RTD unit TR1200 IP via the **SUP protocol** (Slave Unit Protocol), the **Modbus TCP** setting must be activated in the RTD unit. You can activate the Modbus TCP protocol using the function keys under the **TcP - mod** menu item or with the Web browser in the **TCP/UDP Config** tab. The **RTD** (RTD protocol) and **UDP Port** settings have no effect here. The Modbus TCP port is permanently set to 502 and cannot be changed.

5.6.7.5 Temperature Sensor

Logic



[lotmpval-311012-01.tif, 1, en_US]

Figure 5-58 Logic Diagram of the Temperature Sensor Function Block

Measured Temperature Value

The **Temperature sensor** function block processes one single measured temperature value delivered from the RTD box for the assigned sensor. 12 temperature sensor function blocks are always available in each RTD box function (both via Ethernet and serial), even if fewer sensors are connected to the RTD box.

Various temperature sensor types are supported: Pt100, Ni100, and Ni120 sensors. The function block is notified regarding the selection of connected type via the **`Sensor type`** parameter.

The function block delivers a measured temperature value in °C or °F as an output variable. The measured temperature value is available as an operational measured value and can be monitored by the **Temperature supervision** function.

Error Responses

If the measured input value is determined to be incorrect, the quality attribute of the output measured temperature value is set to *`invalid`*. The statuses for Health and Error take the statuses in accordance with the following table:

Table 5-12 Error response

Error Description	Health Status	Error Status
Sensor or line short circuited	Alarm	Yes
Sensor or line interrupted	Alarm	Yes
Measured temperature value outside the valid measuring range specified in the technical data. The valid measuring range depends on the sensor type.	Alarm	Yes
Sensor not connected	OK	No

5.6.7.6 Application and Setting Notes

Parameter: Sensor type

- Default setting **`(_:11611:102) Sensor type`** = ***`Pt 100`***

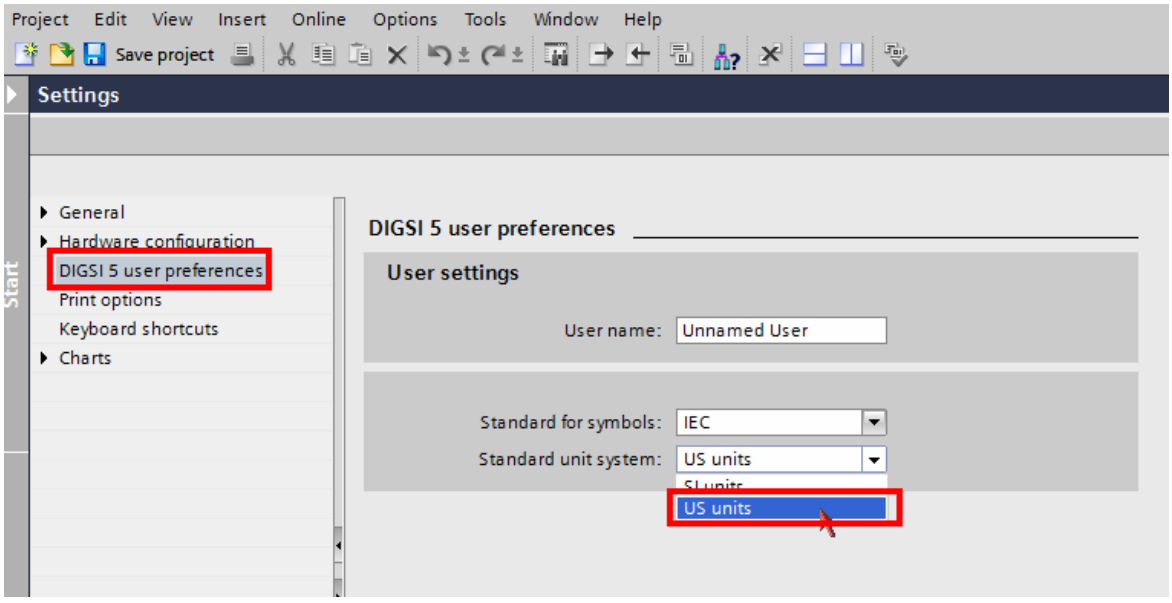
The **`Sensor type`** parameter is used to set the sensor element used. You can select between ***`Pt 100`***, ***`Ni 100`*** and ***`Ni 120`***.

Parameter: Temperature unit

To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly.

Proceed as follows:

- In DIGSI select the menu item **Extras** --> **Settings**.
- In the **Settings** view select the menu item **DIGSI 5 User preferences**.
- Under **Standard unit system** change the setting value of the unit system used from *SI units* to *US units*.



[scfahrht-190214-01, 1, en_US]

Figure 5-59 Change of the Display Between °C and °F

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.6.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.7.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O

No.	Information	Data Class (Type)	Type
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O

5.6.8 RTD Unit, Serial

5.6.8.1 Overview

The **RTD unit serial** function:

- Communicates with an external RTD unit serial via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature supervision function
- Monitors communication with the RTD unit

The **RTD unit Serial** function is set up structurally in the same manner as the **RTD unit Ether.** function. The mode of operation is also identical (see *5.6.7.3 Communication with an RTD Unit*).

5.6.8.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***F***

With the **Port** parameter, you set the slot for the communication module that will be used for the connection with an external RTD unit.

If you want to connect the external RTD box to an Ethernet plug-in module, set the parameter **Port** = ***Port F***, ***Port E***, ***Port P***, or ***plug-in module position***.

Parameter: Channel number

- Default setting **(_:2311:105) Channel number** = ***1***

A serial communication module optionally uses 2 channels. With the **Channel number** settings, you set the channel number (1 or 2) through which the RTD unit is connected to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting **(_:2311:106) Slave address** = ***1***

Use the **Slave address** parameter to define the device address of the RTD unit. If only one RTD unit is connected to the serial bus, the default value *1* can be used. The same device address has to be set on the RTD unit. The device address is important for distinguishing among several RTD units connected to a serial bus. Set a unique device address (for example 1, 2 and 3 when connecting 3 RTD units) for each RTD unit and the same device address for the parameter **Slave address** in the 3 **RTD unit serial** functions.

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.6.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port F • port E • port P • port N • port J	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 254	1
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 2				
_:11612:102	Sensor 2:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 3				
_:11613:102	Sensor 3:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 4				
_:11614:102	Sensor 4:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 5				
_:11615:102	Sensor 5:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 6				
_:11616:102	Sensor 6:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 7				
_:11617:102	Sensor 7:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 8				
_:11618:102	Sensor 8:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 9				
_:11619:102	Sensor 9:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 10				
_:11611:102	Sensor 10:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

Addr.	Parameter	C	Setting Options	Default Setting
Sensor 11				
_:11611:102	Sensor 11:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 12				
_:11611:102	Sensor 12:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.8.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O
Sensor 2			
_:11612:52	Sensor 2:Health	ENS	O
_:11612:60	Sensor 2:Failure	SPS	O
_:11612:80	Sensor 2:TmpOut	MV	O
Sensor 3			
_:11613:52	Sensor 3:Health	ENS	O
_:11613:60	Sensor 3:Failure	SPS	O
_:11613:80	Sensor 3:TmpOut	MV	O
Sensor 4			
_:11614:52	Sensor 4:Health	ENS	O
_:11614:60	Sensor 4:Failure	SPS	O
_:11614:80	Sensor 4:TmpOut	MV	O
Sensor 5			
_:11615:52	Sensor 5:Health	ENS	O
_:11615:60	Sensor 5:Failure	SPS	O
_:11615:80	Sensor 5:TmpOut	MV	O
Sensor 6			
_:11616:52	Sensor 6:Health	ENS	O
_:11616:60	Sensor 6:Failure	SPS	O
_:11616:80	Sensor 6:TmpOut	MV	O
Sensor 7			
_:11617:52	Sensor 7:Health	ENS	O
_:11617:60	Sensor 7:Failure	SPS	O
_:11617:80	Sensor 7:TmpOut	MV	O
Sensor 8			
_:11618:52	Sensor 8:Health	ENS	O
_:11618:60	Sensor 8:Failure	SPS	O
_:11618:80	Sensor 8:TmpOut	MV	O

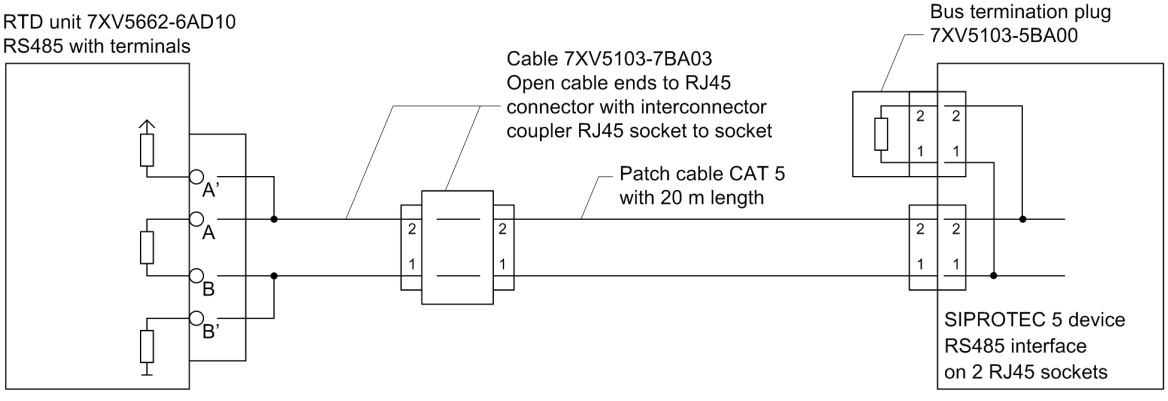
No.	Information	Data Class (Type)	Type
Sensor 9			
_:11619:52	Sensor 9:Health	ENS	O
_:11619:60	Sensor 9:Failure	SPS	O
_:11619:80	Sensor 9:TmpOut	MV	O
Sensor 10			
_:11611:52	Sensor 10:Health	ENS	O
_:11611:60	Sensor 10:Failure	SPS	O
_:11611:80	Sensor 10:TmpOut	MV	O
Sensor 11			
_:11611:52	Sensor 11:Health	ENS	O
_:11611:60	Sensor 11:Failure	SPS	O
_:11611:80	Sensor 11:TmpOut	MV	O
Sensor 12			
_:11611:52	Sensor 12:Health	ENS	O
_:11611:60	Sensor 12:Failure	SPS	O
_:11611:80	Sensor 12:TmpOut	MV	O

5.6.9 Communication with RTD Unit

5.6.9.1 Integration of a Serial RTD Unit (Ziehl TR1200)

Connection of the Communication Lines

Figure 5-60 shows how you connect the RTD box to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.



[dwverbau-201112-01.tif, 1, en_US]

Figure 5-60 Connection of the RTD Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

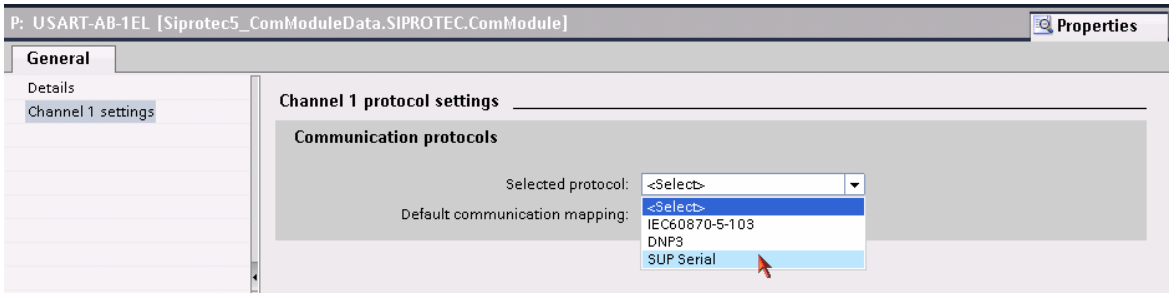


[scauser3-190214-01, 1, en_US]

Figure 5-61 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the RTD Unit.



[scauser4-220114-01-DE, 1, en_US]

Figure 5-62 Selecting the SUP Protocol

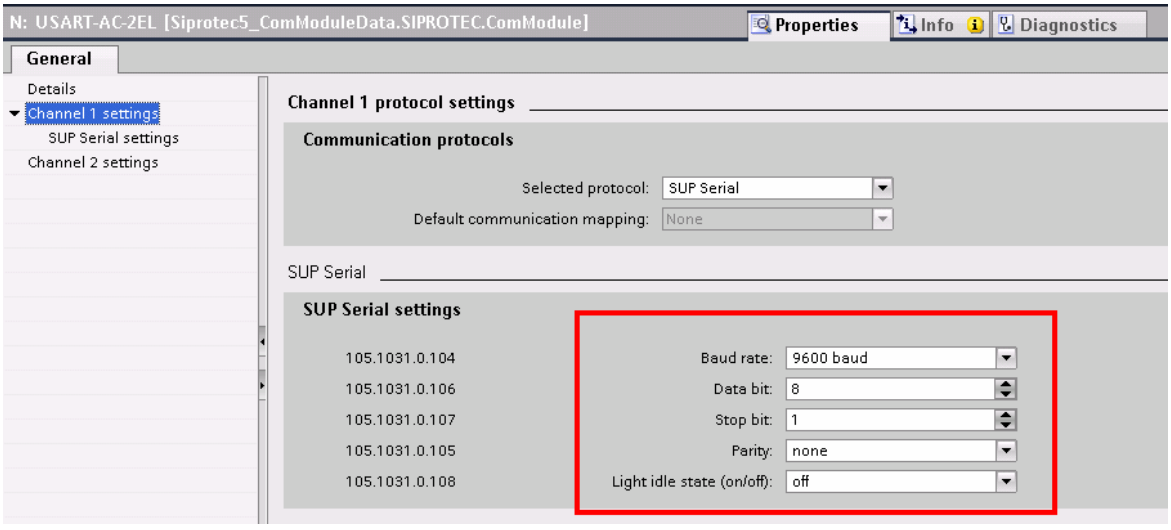
Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the RTD box. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the RTD box. Make sure that the setting values in both devices are the same. The settings of the **`Non-flickering light (on/off):`** is not relevant for the RS485 interface.



NOTE

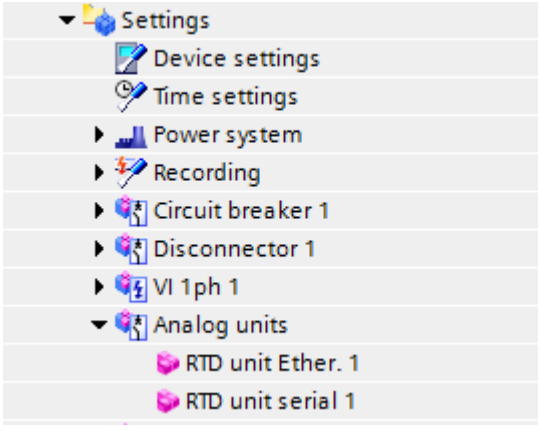
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-220114-01-DE, 1, en_US]

Figure 5-63 Making the Communication Settings

With the selection of the SUP protocol for the RTD box DIGSI automatically adds the function group **Analog units** to your device configuration. You can now instantiate the function **RTD box serial 1** (refer to the following figure).



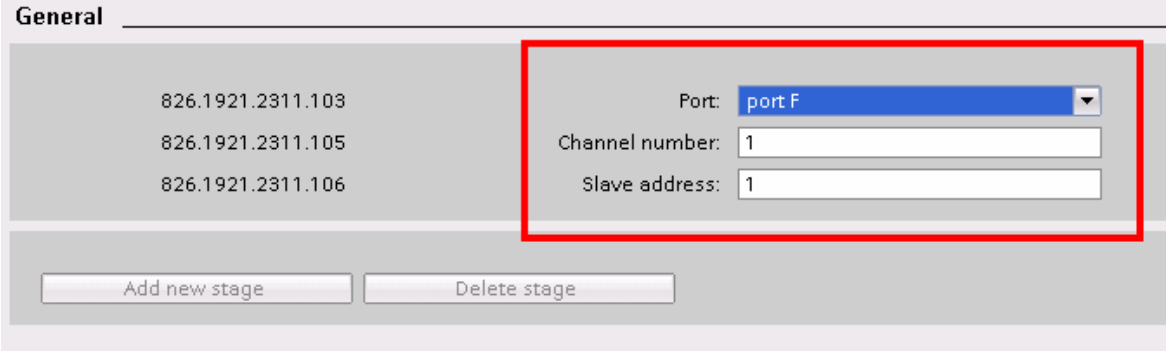
[scauser6-190214-01, 1, en_US]

Figure 5-64 Analog-Unit Instance

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the RTD box. This address must be set with the same value in the RTD box (refer to the following figure).

The following device configuration must be set on the TR1200 RTD unit when the RTD unit is used for the first time:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no



[scauser7-220114-01-DE, 1, en_US]

Figure 5-65 Setting the Port, Channel Number, and Slave Address

Finally, load the configuration in the device.

5.6.9.2 Integration of an RTD-Unit Ethernet (TR1200 IP)

Device Configuration

In the DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. *Figure 5-66* displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

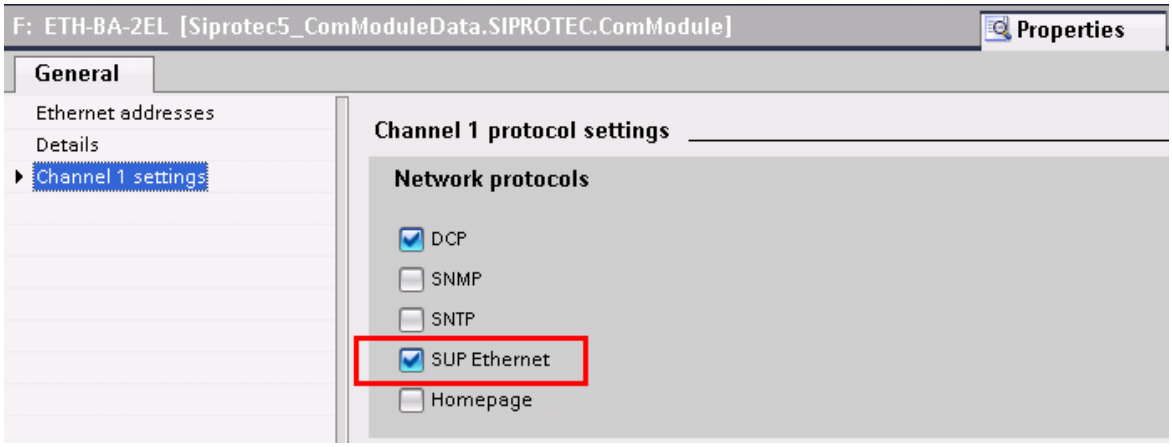


[scautcp1-220114-01-DE, 1, en_US]

Figure 5-66 Inserting an Ethernet Module

Communication Settings

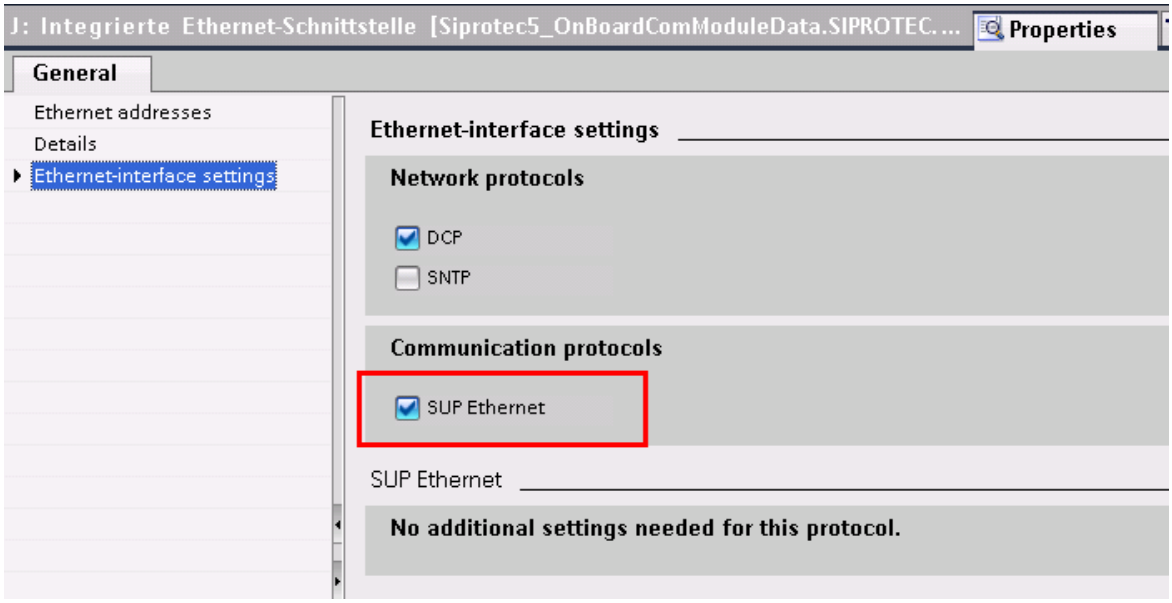
Activate the SUP Ethernet protocol for the Ethernet module.



[scautcp2-220114-01-DE, 1, en_US]

Figure 5-67 SUP Ethernet Protocol Activation

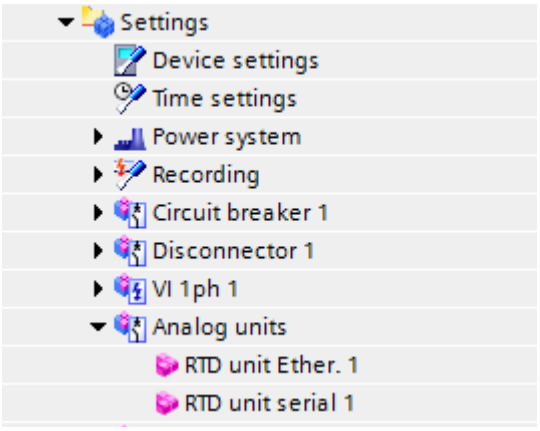
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[scautcp3-220114-01-DE, 1, en_US]

Figure 5-68 SUP Ethernet Protocol Activation (base module)

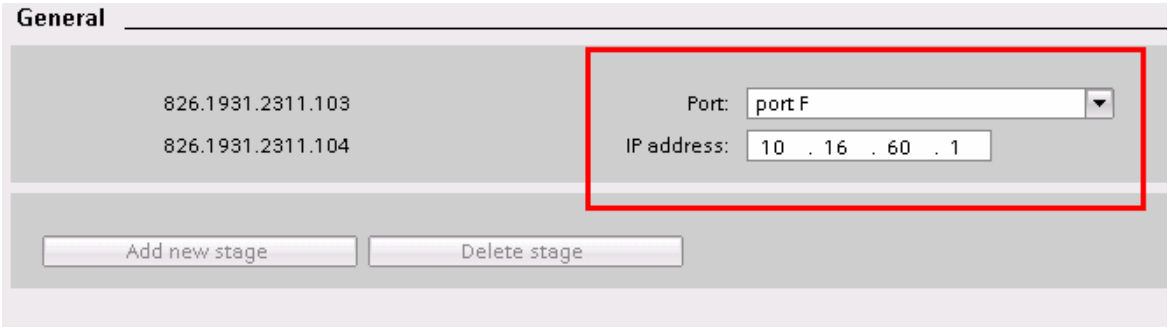
With the selection of the SUP protocol for the RTD unit, DIGSI automatically adds the **Analog units** function group and the **RTD unit Ether.** function to your device configuration (refer to the following figure).



[scauser6-190214-01, 1, en_US]

Figure 5-69 Analog Unit Instance

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the RTD box (refer to the following figure). This address must be set with the same value in the RTD box.



[scautcp5-220114-01-DE, 1, en_US]

Figure 5-70 Setting the Port and IP Address

Finally, load the configuration in the device.

5.6.9.3 Temperature Simulation without Sensors

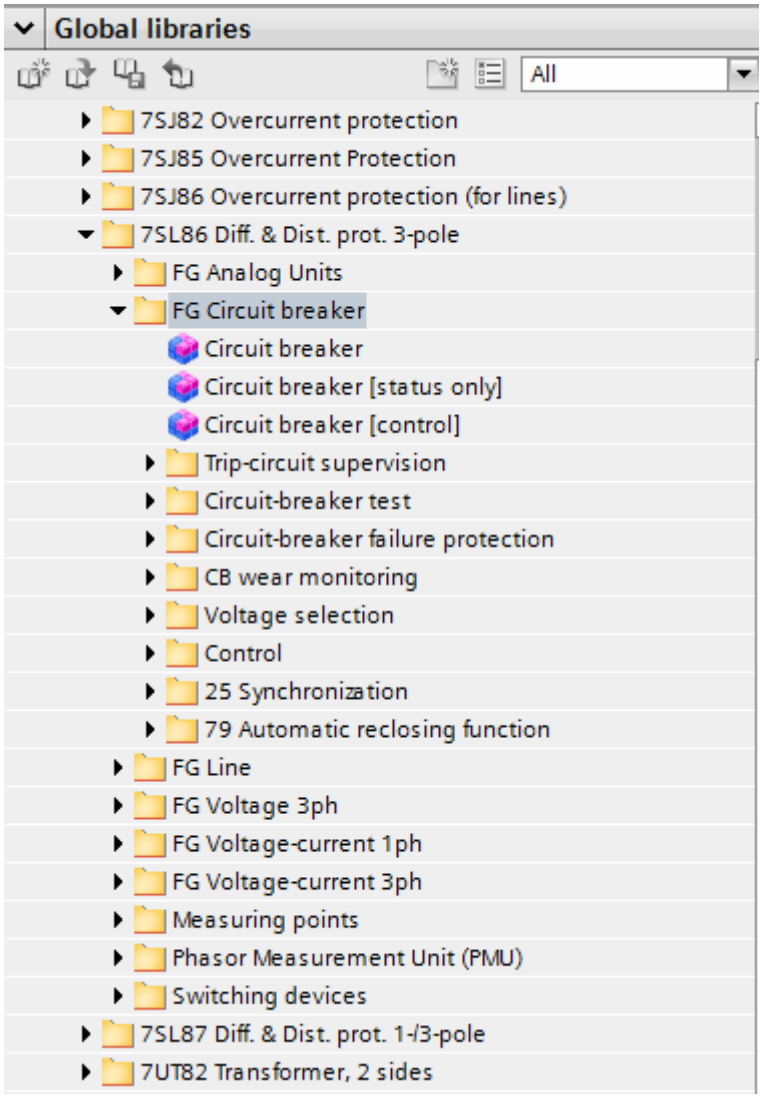
Connect a resistor on the sensor terminals of the RTD unit. Using this resistor, simulate a constant temperature. The resistance value should be around 50 Ω to 200 Ω.

If you want to simulate a changeable temperature, connect an adjustable resistor of maximum 470 Ω instead of a fixed resistor.

5.7 Function-Group Type Circuit Breaker

5.7.1 Overview

The **Circuit-breaker** function group combines all the user functions that relate to a circuit breaker.
You will find the **Circuit-breaker** function group under each device type in the function library in DIGSI 5. The **Circuit-breaker** function group contains all of the protection, control, and supervision functions that you can use for this device type. The following figure shows, for example, the functional scope of the **Circuit-breaker** function group.



[scfgleis-200214-01, 1, en_US]

Figure 5-71 Circuit-Breaker Function Group - Example of the Functional Scope

The Circuit-breaker function group includes 3 different types of circuit breakers:

- Circuit breaker
- Circuit-breaker control
- Circuit breaker [status only]

The circuit-breaker type can accept additional basic function blocks for protection functions along with the actual circuit breaker control.

The circuit breaker [status only] is used only for acquiring the circuit-breaker switch position. This type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

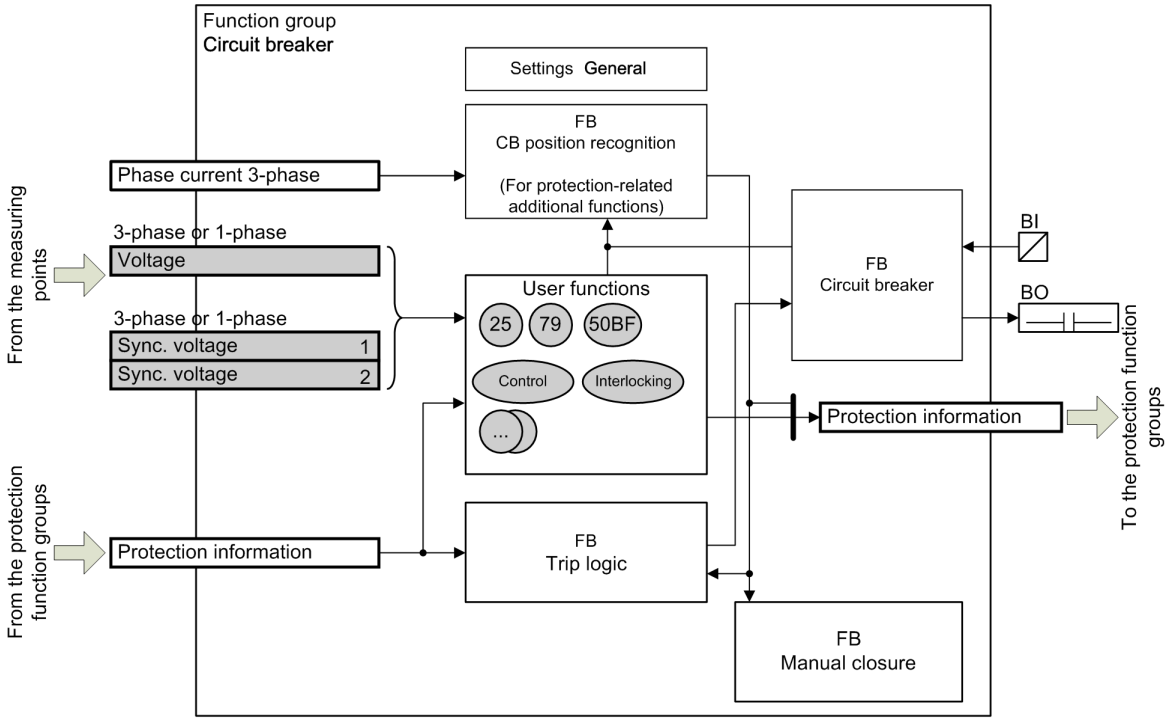
The available functions are described in the chapters *6 Protection and Automation Functions* and *8 Control Functions*.

5.7.2 Structure of the Function Group

Besides the user functions, the **Circuit-breaker** function group contains certain functionalities that are essential for general purposes and therefore cannot be loaded or deleted:

- Trip logic
- Mapping the physical circuit breaker
- Circuit-breaker position recognition for protection functions
- Detection of manual closure
- General settings

The following figure shows the structure of the **Circuit-breaker** function group. The individual function blocks in the image are described in the following chapters.



[dwfgstru-080812-01.tif, 1, en_US]

Figure 5-72 Structure of the Circuit-Breaker Function Group

The **Circuit-breaker** function group has interfaces with:

- **Measuring points**
- Protection function groups

Interfaces with Measuring Points

The function group contains the measured values needed from the measuring points associated with this function group.

If an application template is used, the function group is connected to the measuring point of the 3-phase current because this connection is essential. It can be necessary to connect additional measuring points to the function group, depending on the nature of the user functions used. Configuration is carried out using the **Function-group connections** editor in DIGSI 5. You can find more detailed information on this in chapter *2.1 Function Embedding in the Device*.

If a user function, for example, synchronization, is used in the function group but the required measuring point has not linked to it, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The **Circuit-breaker** function group has interfaces with the following measuring points:

- `3-phase line current`

  The measurands from the 3-phase power system are supplied via this interface. The function group must always be connected to this measuring point.

- `Voltage`

  The measurands of the 3-phase voltage system or 1-phase voltage are supplied via this interface. Depending on the connection type of the transformers, in the 3-phase voltage system these are, for example, V_A, V_B, V_C of the line or feeder.

  The connection to the corresponding measuring point is necessary only if a user function that needs the measurand of the 3-phase voltage system is used, for example, to make use of the **Synchronization** or **Automatic reclosing** function.

- `Sync. Voltage1, Sync. Voltage2`

  A 1-phase synchronization voltage (for example, voltage of the busbar with a 1-phase connection) or a 3-phase synchronization voltage (for example, voltage of the busbar with a 3-phase connection) is supplied via this interface.

  The connection to the corresponding measuring point is necessary only if synchronization is used.

Interface with Protection-Function Groups

All required data is exchanged between the Protection and Circuit-breaker function groups via the interface with the Protection function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

If an application template is used, the function groups are connected to each other because this connection is essential to ensure proper operation. You can modify the connection using the **Function-group connections** editor in DIGSI 5.

You can find more detailed information in chapter *2.1 Function Embedding in the Device*.

If the connection is missing, DIGSI 5 reports an inconsistency.

Besides the general assignments of the Protection function group or groups to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Automatic reclosing** function?
- Which protection functions activate the **Circuit-breaker failure protection** function?

You can find more detailed information in chapter *2.1 Function Embedding in the Device*.

5.7.3 Application and Setting Notes

Interface with Measuring Points

The interface with the 3-phase power system must have been configured. Otherwise, DIGSI 5 supplies an inconsistency message.

If the **Synchronization** function is used, the measuring points that represent voltages V1 and V2 of the parts of the electrical power system to be synchronized must be connected.

You can find more detailed information in the chapter *8.4 Synchronization Function* .

The **Automatic reclosing** function provides the auxiliary functions **Dead-line check** and **Reduced dead time**. For these auxiliary functions, the 3-phase voltage system has to be measured. If you want to use these auxiliary functions, the measuring point of the 3-phase voltage system must be connected to the **Voltage** function group interface. This connection is also necessary if the **Automatic reclosing function with adaptive dead time** function type is used.

Interface with Protection-Function Groups

The protection-function group is connected to 2 circuit breakers (2 **Circuit-breaker** function groups) for 1 1/2 circuit-breaker layouts.

Parameter: Rated Normal Current for % Values

- Default setting **(_:2311:101) Rated normal current** = ***1000 A***

With the **Rated normal current** parameter, you set the primary current which serves as a reference for all current-related % values within the Circuit-breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated current of the protected object here.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated Voltage for % Values

- Default setting **(_:2311:102) Rated voltage** = ***400 kV***

With the **Rated voltage** parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the Circuit-breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated voltage of the protected object (for example, the line) here.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Current Threshold Circuit Breaker Open

- Default setting **(_:2311:112) Current thresh. CB open** = ***0.10 A***

With the **Current thresh. CB open** parameter, you specify the threshold value below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the **Current thresh. CB open** parameter so that the current measured when the circuit-breaker pole is open will certainly fall below the parameterized value. If parasitic currents (for example, due to induction) are excluded with the line deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to ***0.05 A*** for example.

If no special requirements exist, Siemens recommends retaining the setting value of ***0.10 A*** for secondary purposes.

5.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing
Trip logic				
_:5341:103	Trip logic:Reset of trip command		• with I< • with I<< & aux.contact • with dropout	with I<<
Circuit break.				
_:4261:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:4201:104	Control:Check switching authority		• no • yes • advanced	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
_:4201:107	Control:Check blk. by protection		• no • yes	yes
Switching authority				
_:4201:151	Control:Swi.dev. related sw.auth.		• 0 • 1	false
_:4201:152	Control:Specific sw. authorities		• 0 • 1	true
_:4201:115	Control:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:4201:153	Control:Num. of specific sw.auth.		2 to 5	2
_:4201:155	Control:Ident. sw.auth. 1		Freely editable text	
_:4201:156	Control:Ident. sw.auth. 2		Freely editable text	
_:4201:157	Control:Ident. sw.auth. 3		Freely editable text	

Addr.	Parameter	C	Setting Options	Default Setting
_:4201:158	Control:Ident. sw.auth. 4		Freely editable text	
_:4201:159	Control:Ident. sw.auth. 5		Freely editable text	
_:4201:154	Control:Multiple specific sw.auth.		• 0 • 1	false
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

5.7.5 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:5341:300	Trip logic:Trip indication	ACT	O
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch statist.	SPS	I
_:4261:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position	DPC	C
_:4261:300	Circuit break.:Trip/open cmd.	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	BCR	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C	MV	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	INS	O
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O

No.	Information	Data Class (Type)	Type
Control			
_:4201:503	Control:>Sw. authority local	SPS	I
_:4201:504	Control:>Sw. authority remote	SPS	I
_:4201:505	Control:>Sw. mode interlocked	SPS	I
_:4201:506	Control:>Sw. mode non-interl.	SPS	I
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
_:4201:302	Control:Switching auth. station	SPC	C
_:4201:308	Control:Enable sw. auth. 1	SPC	C
_:4201:309	Control:Enable sw. auth. 2	SPC	C
_:4201:310	Control:Enable sw. auth. 3	SPC	C
_:4201:311	Control:Enable sw. auth. 4	SPC	C
_:4201:312	Control:Enable sw. auth. 5	SPC	C
_:4201:313	Control:Switching authority	ENS	O
_:4201:314	Control:Switching mode	ENS	O
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:53	Interlocking:Health	ENS	O
CB test			
_:6151:53	CB test:Health	ENS	O
_:6151:301	CB test:Test execution	ENS	O
_:6151:302	CB test:Trip command issued	ENS	O
_:6151:303	CB test:Close command issued	ENS	O
_:6151:304	CB test:Test canceled	ENS	O
_:6151:311	CB test:3-pole open-close	SPC	C

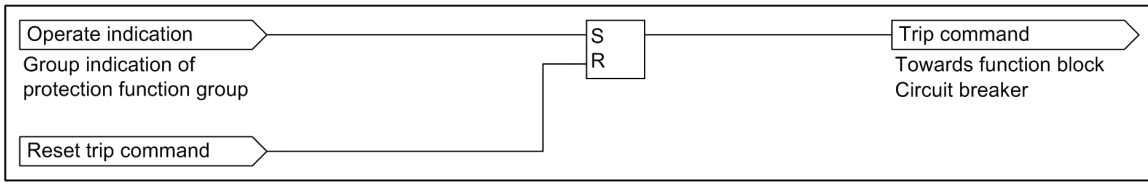
5.7.6 Trip Logic

5.7.6.1 Function Description

The **Trip logic** function block receives the group operate indication from the Protection function group or Protection function groups and forms the protection trip command that is transmitted to the **Circuit-breaker** function block.

The **Circuit-breaker** function block activates the device contact and thus causes the circuit breaker to open (see *5.7.7 Circuit Breaker*). The command output time is also effective here.

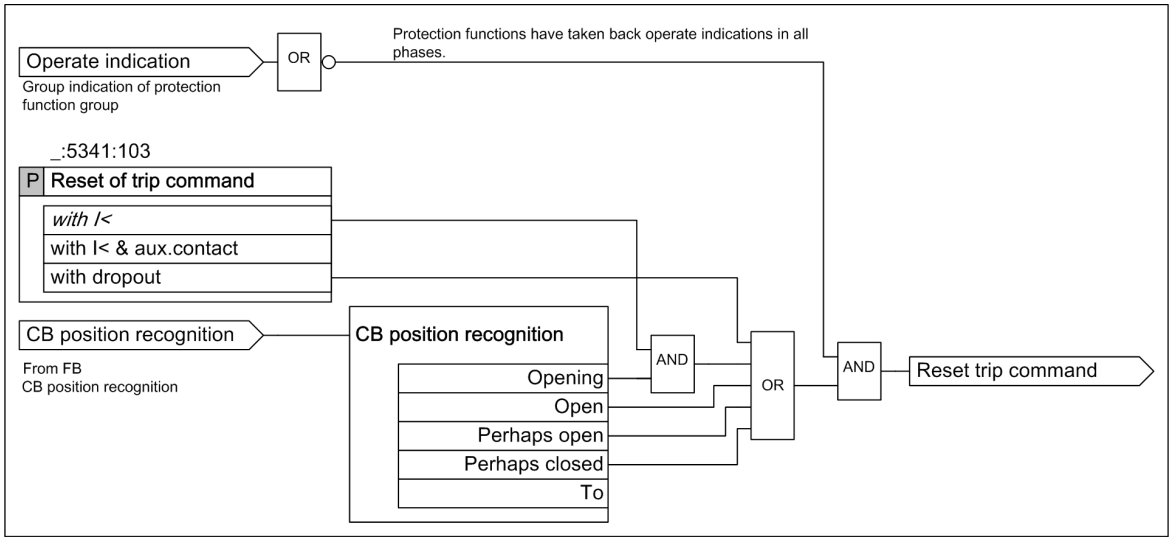
The trip logic also decides when the protection trip command is reset (see *Figure 5-74*).



[loausbef-140113-01.tif, 1, en_US]

Figure 5-73 Trip Command

Trip-Command Reset



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Figure 5-74 Trip-Command Reset

Once a trip command is issued, it is stored (see *Figure 5-73*).

You determine the criteria for resetting a trip command that has been issued with the parameter **`Reset of trip command`**.

- **`with dropout`**

  The trip command is reset if the function that initiated tripping resets its operate indication. This occurs typically with dropout. Command reset of the trip command takes place regardless of verification of the circuit-breaker condition.

- **`with I<`**

- **`with I< & aux.contact`**

  For these criteria, the state of the circuit breaker is also taken into account as a further criterion in addition to the dropout of the tripping function (operate indication is reset by command). You can select whether the state is determined by means of the current (**`with I<`**) or by means of the current in conjunction with the circuit-breaker auxiliary contacts (**`with I< & aux.contact`**). The behavior of these setting options only differs in one situation of the circuit-breaker state. If the circuit breaker is in the **opening** state, the trip command is reset in the case of the option **`with I<`**, whereas it is not reset yet in the case of the option with **`with I< & aux.contact`**. The **opening** state is detected if the auxiliary contacts still detect the circuit breaker as being closed and opening is detected via the decreasing current flow.

  As long as the circuit breaker is detected unambiguously as closed (**fully closed**), the trip command will not be reset with these setting options.

  The information about the condition of the circuit breaker is supplied by the **Circuit-breaker position recognition** function block (see *5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*). The determination of the various conditions is also described in this chapter.

5.7.6.2 Application and Setting Notes

Parameter: Reset of trip command

- Recommended setting value **`(_:5341:103) Reset of trip command`** = ***`with I<`***

Parameter Value	Description
with I<	With this setting, the trip command is reset as soon as the current is removed, provided the tripping function has dropped out. The most important factor for recognition of the open circuit breaker is the current falling short of the value set in the parameter **(_:2311:112) Current thresh. CB open**.
with I< & aux.contact	For this setting not only the current has to be removed, but also the circuit-breaker auxiliary contact has to report that the circuit breaker is open. This setting assumes that the setting of the auxiliary contact has been routed via a binary input (for more information, see *5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).
with dropout	The setting can be selected for special applications in which the trip command does not result in complete interruption of the current in every case. In this case, the trip command is reset if the pickup of the tripping protection function drops out. The setting is useful if the load current in the system cannot be interrupted during the protection device test and the test current is fed in parallel with the load current.

5.7.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<

5.7.6.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O

5.7.7 Circuit Breaker

5.7.7.1 Overview

The **Circuit-breaker** function block represents the physical switch in the SIPROTEC 5 device.

The basic tasks of this function block are the operation of the circuit breaker and the acquisition of the circuit-breaker auxiliary contacts and other circuit-breaker information.

The **Circuit-breaker** function block provides information about:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

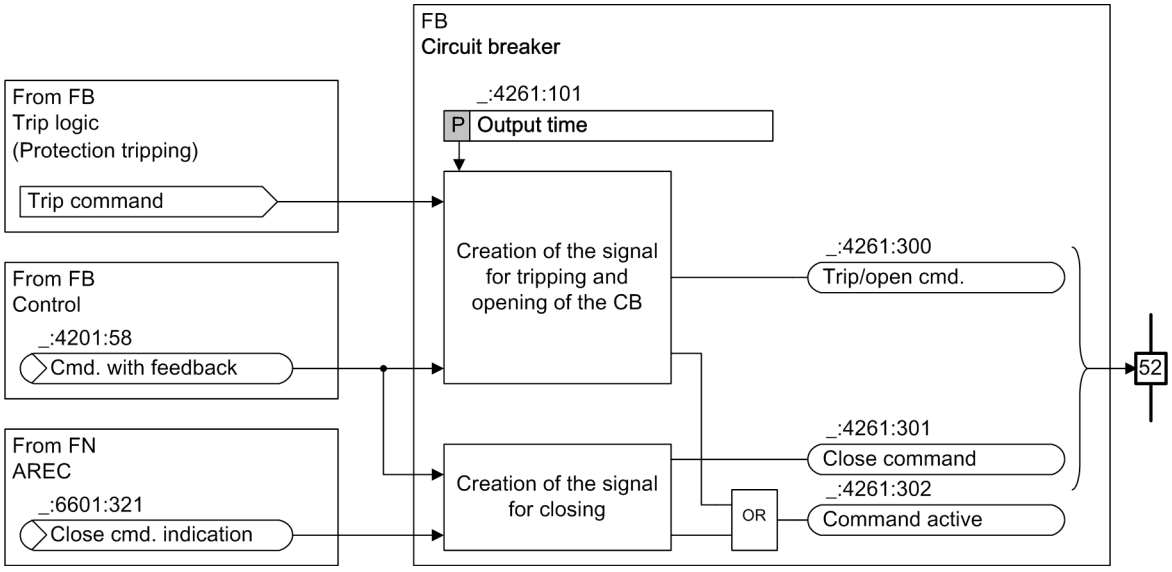
5.7.7.2 Tripping, Opening, and Closing the Circuit Breaker

The circuit breaker is operated in the following situations:

- Tripping of the circuit breaker as a result of a protection trip command
- Opening of the circuit breaker as a result of control operations
- Closing of the circuit breaker as a result of automatic reclosing or control operations

Tripping is always the result of a protection function. The operate indications of the individual protection functions are summarized in the **Trip logic** function block. The trip command that causes the tripping in the **Circuit breaker** function block is generated there.

To operate the circuit breaker, the **Circuit-breaker** function block provides the output signals that must be routed to the corresponding binary outputs of the device (see *Table 5-13*).



[loausssc-090211-01.tif, 1, en_US]

Figure 5-75 Tripping, Opening, and Closing the Circuit Breaker

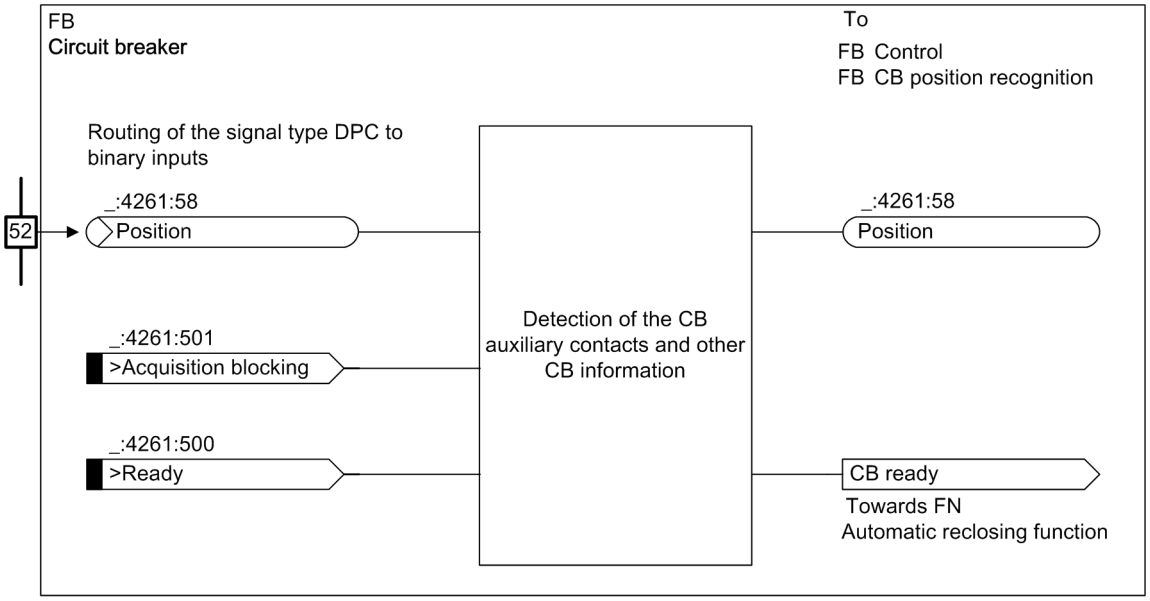
Table 5-13 Description of the Output Signals

Signal	Description	Routing Options
Trip/open cmd.	This signal executes all tripping and opening operations. The **Output time** parameter affects the signal. The signal is pending for the duration of this period, with the following exceptions: • Only when switched off by the control: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is open before expiration of the period. • Only in the event of protection tripping: The signal remains active as long as the trip command is still active after expiration of the period (see also *5.7.6.1 Function Description*). • Only in the event of protection tripping: With the routing option **Only saved in the event of tripping**, the signal remains pending until it is acknowledged manually. This only applies for protection tripping.	• Unlatched • Only saved in the event of protection tripping (not when opened)
Close command	This signal executes all closing operations. The **Output time** parameter affects the signal. The signal is pending for the duration of this period, with the following exception: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is closed before expiration of the period.	Normal routing
Command active	This signal is active as long as one of the binary outputs assigned to the signals **Trip/open cmd.** and **Close command** is active because a switching command is being executed by the control.	Normal routing

5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit breaker position, the **Circuit-breaker** function block provides position signals (see next figure).

These signals are of the **Double-point indication** (DPC) type. A double-point indication can be routed to 2 binary inputs so that the open and closed circuit-breaker positions can be reliably acquired.



[loerfass-101210-01.tif, 1, en_US]

Figure 5-76 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker position The position **3-pole circuit breaker open** and/or the position **3-pole circuit breaker closed** can be acquired by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is connected with the CB auxiliary contacts. The **open** and **closed** signals do not necessarily have to be routed in parallel. The advantage of parallel routing is that it can be used to determine an intermediate or disturbed position. On the other hand, this is not possible if only one signal is routed.

In the monitoring direction, the position signals generate the following information when the **open** and **closed** positions are acquired (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Off	SPS	Circuit-breaker position is **opened**.
On	SPS	Circuit-breaker position is **closed**.
Intermediate position	SPS	Circuit-breaker position is in **intermediate position**.
Disturbed position	SPS	Circuit-breaker position is in **disturbed position**.
Not selected	SPS	The circuit breaker is **not selected** for a control operation.

Other input signals are:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see Other Functions *3.8.3 Persistent Commands* for a description of acquisition blocking).

Signal	Type	Description
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. Setting acquisition blocking and tracking is blocked with the input activated.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an **OFF-ON-OFF cycle**. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the **Automatic reclosing** and **Circuit-breaker test** functions.

Another output signal is:

External health	SPS	This can be used to indicate the health of the physical circuit breaker. For this, you must acquire any failure information for the circuit breaker via a binary input. This failure information can set the appropriate state of the **External health** signal with a CFC chart (using the **BUILD_ENS** block). The signal has no effect on the health of the function block.

5.7.7.4 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

Definitive Tripping

Definitive tripping is always pending whenever the **Automatic reclosing (AREC)** function does not carry out any reclosing after tripping. It follows that this is the case whenever an automatic reclosing is not present or the AREC has been switched off.

Circuit-Breaker Tripping Alarm Suppression

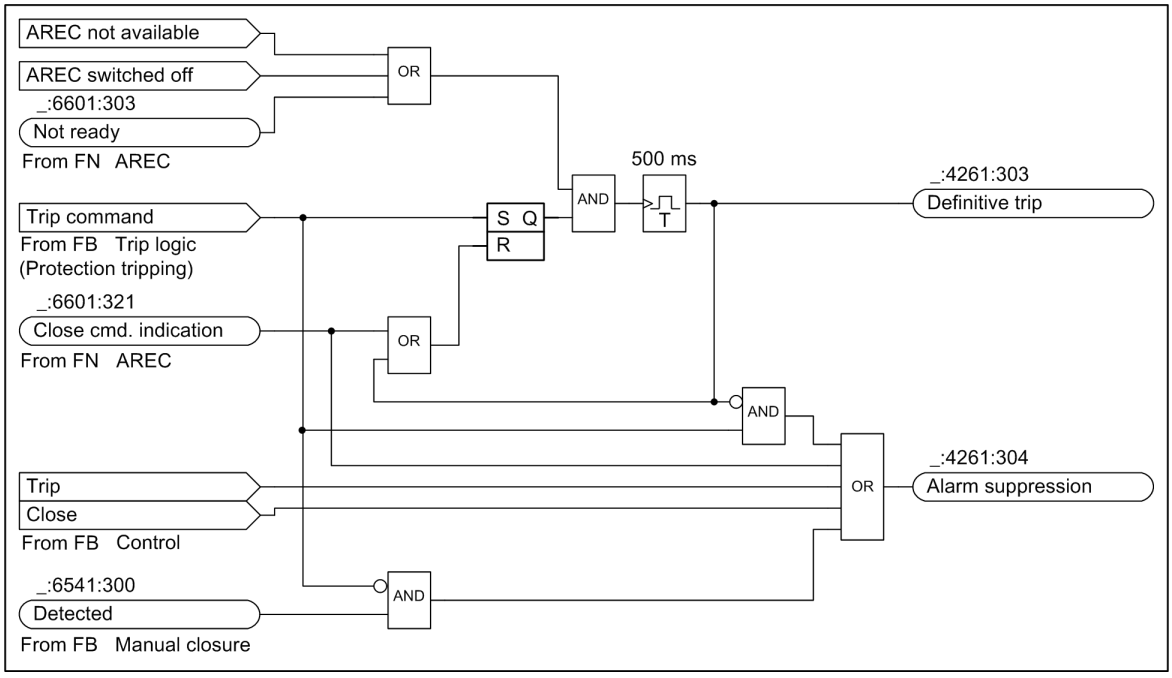
In certain systems, the user may wish to actuate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not to be issued if the circuit breaker is to be reclosed automatically after tripping or if it is to be closed or opened via the control. The alarm is only to be issued in the event of final tripping.

Depending on how the alarm is generated (for example, triggered by a fleeting contact of the circuit breaker), the **Alarm suppression** signal can be used to suppress the alarm.

The signal is generated if:

- A definitive protection tripping is not present
- The automatic reclosing function executes a closure
- The integrated control executes a closure or opening action
- External closing is detected via the **Manual close** function

For further information about its use, please refer to *5.7.9.2 Application and Setting Notes* .

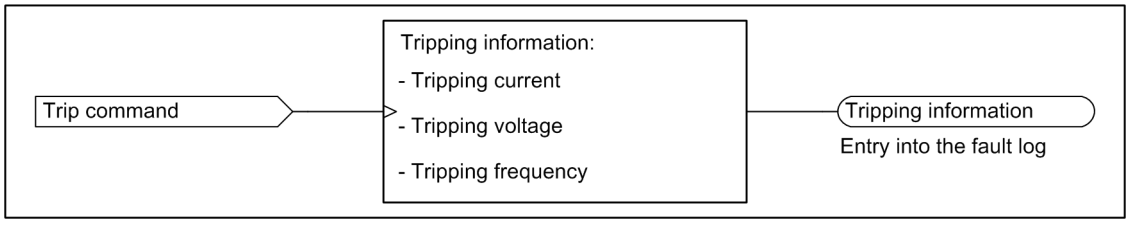


[lounterd-100611-01.tif, 1, en_US]

Figure 5-77 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

5.7.7.5 Tripping and Opening Information

When a trip command is issued, the tripping information shown in the next figure is saved in the fault log.



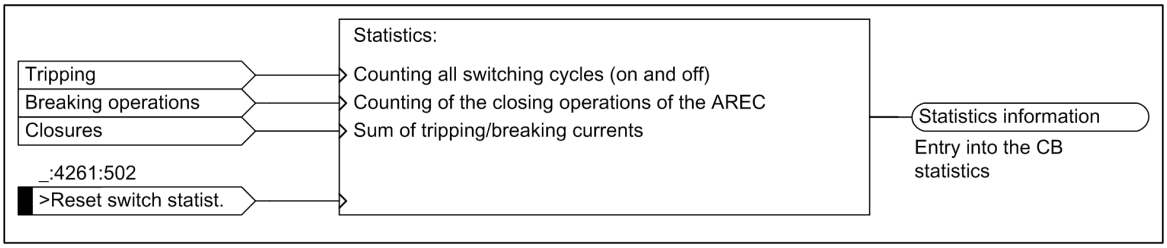
[loausloe-081210-01.tif, 1, en_US]

Figure 5-78 Tripping Information

The following statistics information is saved for the circuit breaker:

- Number of switching cycles:
  All tripping, opening, and closing operations are counted.
- Number of closing operations by the automatic reclosing function
- Total of tripping and breaking currents

The statistics information can be individually set and reset via the device control. It is also possible to reset all values via the binary input signal **>Reset switch statist.**.



[lostatis-140113-01.tif, 1, en_US]

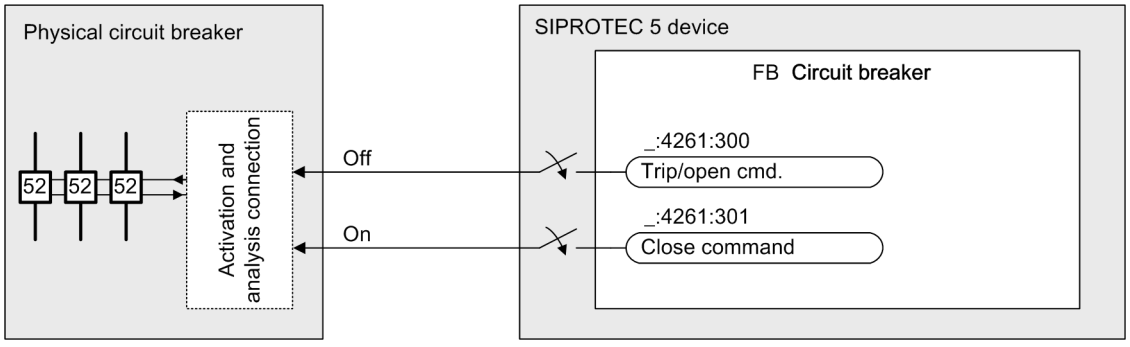
Figure 5-79 Statistics Information About the Circuit Breaker

5.7.7.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-80 shows the necessary routings:

- The device can execute 3-pole tripping (via the protection device).
- The device can execute 3-pole opening (via the control).
- The device can execute 3-pole closing (via AREC or via the control).



[loansteu-230311-01.tif, 1, en_US]

Figure 5-80 Activation of the Circuit Breaker

By routing the **`Trip/open cmd.`** signals to 1 or 2 binary outputs, you can carry out 1, 1.5, and 2-pole activations of the circuit breaker. You will find a detailed description of this in *8.2.2.3 Connection Variants of the Circuit Breaker*.

NOTE

Do not confuse these 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker with 1-pole or 3-pole tripping of the circuit breaker.

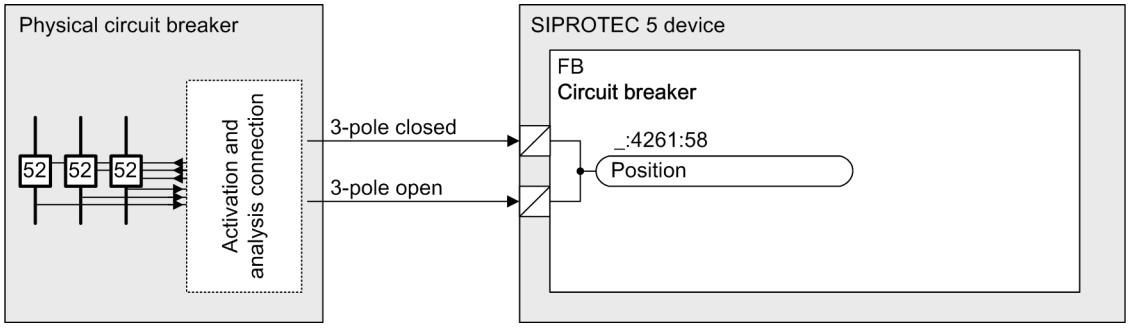
Routing for Analysis of the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. These are for example:

- **Circuit-breaker position recognition** function block
- **Circuit-breaker failure protection** function
- **Control** function block

The operating principle of the auxiliary contacts is described in the individual functions.

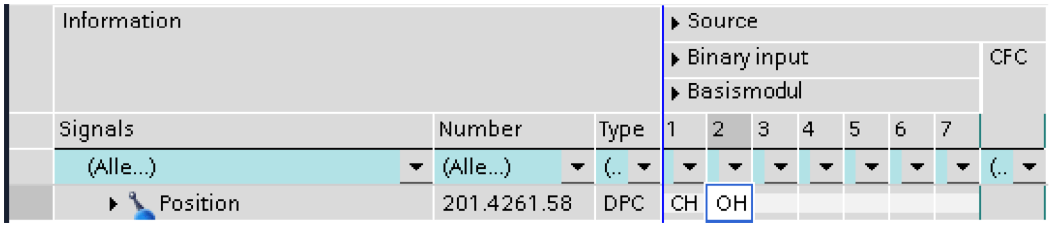
Siemens recommends capturing the *`Circuit breaker is open in 3 poles`* and *`Circuit breaker is closed in 3 poles`* information via auxiliary contacts. This is the optimal configuration for the control functionality. For purely protection applications, it is also enough to capture just one of the 2 circuit-breaker positions.



[loauswer-230311-01.tif, 1, en_US]

Figure 5-81 Recommended Analysis of the Circuit-Breaker Switch Position when Used as a Protection and Control Device

The following diagram shows the recommended routing, in which **H** stands for **active with voltage**.



[scpolg3p-230311-01.tif, 1, en_US]

Figure 5-82 Routing for Acquisition of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

The device can also function without the analysis from the circuit-breaker auxiliary contacts, that is, routing of the auxiliary contacts is not absolutely necessary. However, this is a requirement for control functions.

Parameter: Output time

- Default setting **(_:101) Output time** = ***0.10 s***

The **Output time** parameter acts on the signals for tripping, opening, and closing of the circuit breaker.

CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

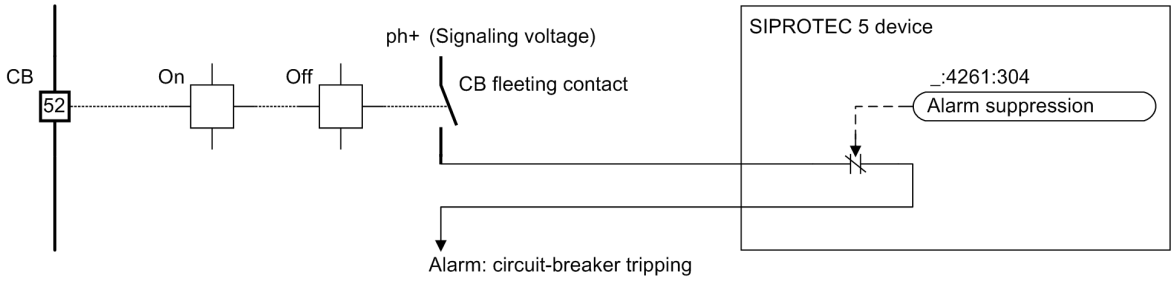
✧ Set a time that is long enough to ensure that the circuit breaker reliably reaches its final position (**open** or **closed**) after a control operation.

Output Signal: Indication Suppression

Whereas in the case of feeders without an automatic reclosing function every trip command is final due to a protection function, the use of an automatic reclosing function should only cause the motion detector of the circuit breaker (fleeting contact on the circuit breaker) to trigger an alarm if tripping of the circuit breaker is definitive (see next figure for more details). Likewise, a tripping alarm should not be triggered for switching operations by the control.

For this, the alarm activation circuit should be looped via a suitably routed output contact of the device (output signal **Alarm suppression**). In the idle state and when the device is switched off, this contact is permanently closed. For this, an output contact with a break contact must be routed. The contact opens whenever the output signal **Alarm suppression** becomes active, so that tripping or a switching operation

does not cause an alarm (see the logic in *5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information* for more details).



[loschalt-081210-01.tif, 1, en_US]

Figure 5-83 Circuit-Breaker Tripping Alarm Suppression

5.7.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Circuit break.				
_:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s

5.7.7.8 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:500	Circuit break.:>Ready	SPS	I
_:501	Circuit break.:>Acquisition blocking	SPS	I
_:502	Circuit break.:>Reset switch statist.	SPS	I
_:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:503	Circuit break.:External health	ENS	I
_:53	Circuit break.:Health	ENS	O
_:58	Circuit break.:Position	DPC	C
_:300	Circuit break.:Trip/open cmd.	SPS	O
_:301	Circuit break.:Close command	SPS	O
_:302	Circuit break.:Command active	SPS	O
_:303	Circuit break.:Definitive trip	SPS	O
_:304	Circuit break.:Alarm suppression	SPS	O
_:306	Circuit break.:Op.ct.	INS	O
_:307	Circuit break.:ΣI Brk.	BCR	O
_:308	Circuit break.:ΣIA Brk.	BCR	O
_:309	Circuit break.:ΣIB Brk.	BCR	O
_:310	Circuit break.:ΣIC Brk.	BCR	O
_:311	Circuit break.:Break.-current phs A	MV	O
_:312	Circuit break.:Break.-current phs B	MV	O
_:313	Circuit break.:Break.-current phs C	MV	O
_:314	Circuit break.:Break. voltage phs A	MV	O
_:315	Circuit break.:Break. voltage phs B	MV	O
_:316	Circuit break.:Break. voltage phs C	MV	O
_:322	Circuit break.:CB open hours	INS	O
_:323	Circuit break.:Operating hours	INS	O

5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.7.8.1 Overview

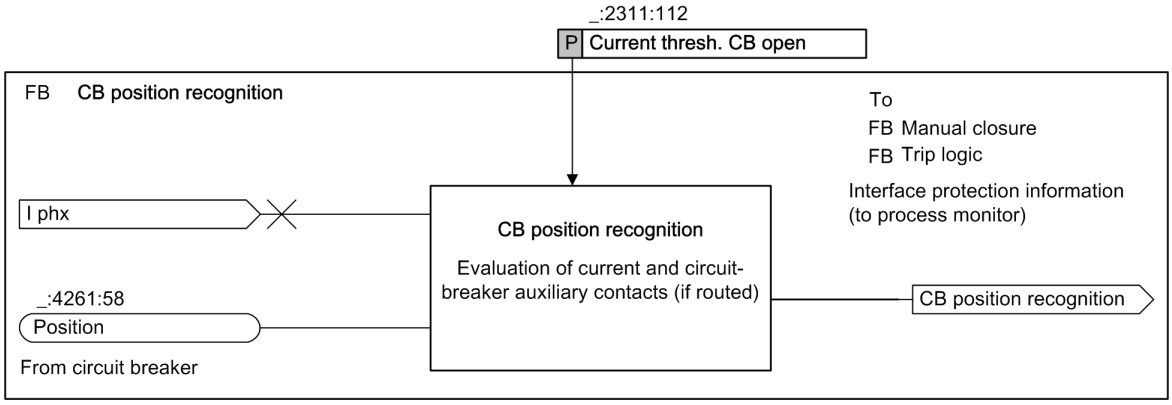
This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see *5.7.6.1 Function Description*)
- Detection of manual closing (see *5.7.9.1 Function Description*)
- Process monitor (Standard V/I) *5.8 Process Monitor*)

Its use is described in the respective chapters.

The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.



[lozust3p-070611-01.tif, 1, en_US]

Figure 5-84 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, the circuit breaker can assume the following positions:

Circuit-Breaker Condition	Description
Open	The circuit-breaker pole is detected unambiguously as **open** according to both criteria.
Closed	The circuit-breaker pole is detected unambiguously as **closed** according to both criteria.
Possibly open, possibly closed	These conditions can occur if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. These **uncertain conditions** are evaluated differently by certain functions.
Opening	This is a dynamically occurring condition that results when, while a trip command is active and the auxiliary contact is still closed, the current is detected to have fallen below the threshold value because the current-flow criterion takes effect faster than the auxiliary contact can open.

5.7.9 Detection Manual Closure (for AREC and Process Monitor)

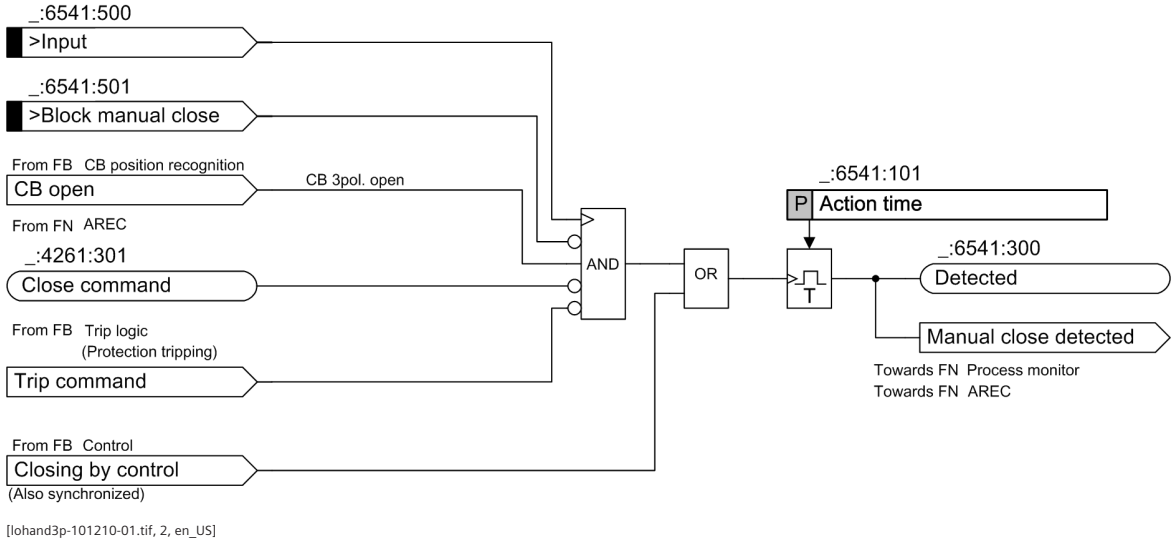
5.7.9.1 Function Description

Detection of Manual Closure (for AREC and Process Monitor)

The **Manual closure** function block detects any closure carried out by hand. This information is used in function, the **automatic reclosing (AREC)** and **Process monitor** (functions (within protection function groups).

You will find detailed information in the chapters Automatic reclosing function and Process monitor.

The following figure shows the logic for manual closure detection.



[lohand3p-101210-01.tif, 2, en_US]

Figure 5-85 Logic for Manual Closure Detection

External Manual Closure

An external manual closure is communicated to the device via the input signal **>Input**. The input signal can also be connected directly to the control circuit of the circuit-breaker closing coil. For this reason, detection is suppressed in the event of a close command by the AREC function. Detection via the input signal **>Input** is also blocked if the circuit breaker is closed or if a protection trip is active.

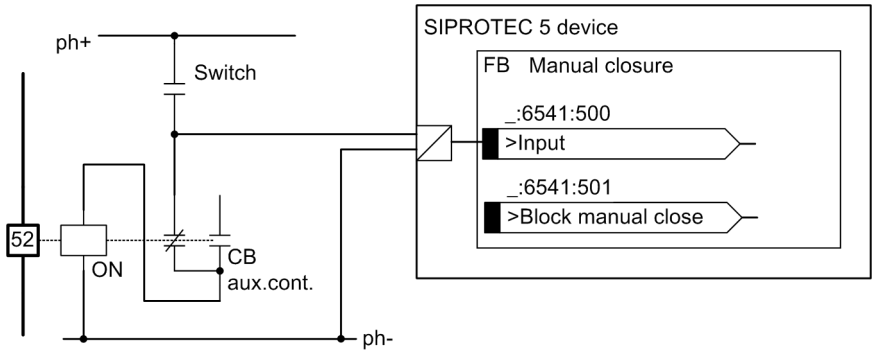
Internal Manual Closure

Manual closure is detected in all cases if a close command is transmitted by the internal control function of the device. This is possible because the control carries out plausibility checks itself and is also subject to interlocking.

5.7.9.2 Application and Setting Notes

Input Signals: >Input, >Blocking of Manual Closure

In practice, the input signal **>Input** is connected directly to the control circuit of the circuit-breaker closing coil (see following figure).



[losteuer-150113-01.tif, 1, en_US]

Figure 5-86 Connection of the Input Signal to the Control Circuit of the Circuit-Breaker Closing Coil

Every closure of the circuit breaker is recorded in the process. Therefore, detection is suppressed in the event of a close command by the internal AREC function of the device.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to prompt detection of a manual closure (for example, with an external reclosing device), this can be ensured in 2 ways:

- The input signal is connected in such a way that it is not activated in the event of external close commands.
- The external close command is connected to the blocking input **>Block manual close** for manual closure detection.

Parameter: Action time

- Recommended setting value **(_:101) Action time** = ***300 ms***

In order to ensure independence from manual activation of the input signal, the detection function is extended for a defined length of time using the parameter **Action time**.

Siemens recommends an action time of ***300 ms***.

5.7.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual close				
_:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s

5.7.9.4 Information List

No.	Information	Data Class (Type)	Type
Manual close			
_:501	Manual close:>Block manual close	SPS	I
_:500	Manual close:>Input	SPS	I
_:300	Manual close:Detected	SPS	O

5.8 Process Monitor

5.8.1 Overview of Functions

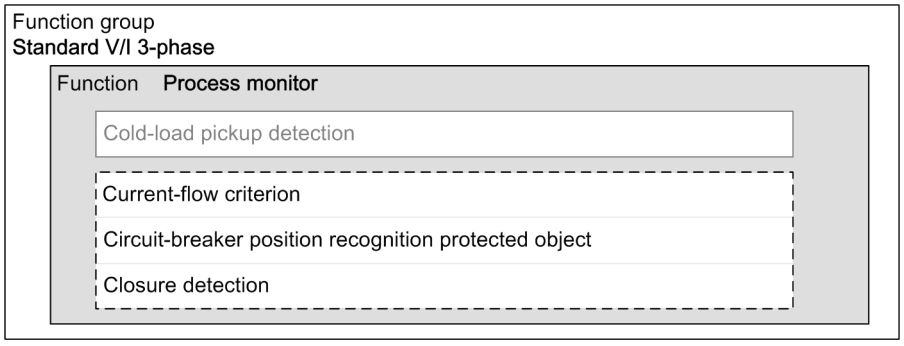
All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

5.8.2 Structure of the Function

The **Process monitor** function is used in the **Standard V/I 3-phase** protection function group.

The **Process monitor** function is provided by the manufacturer with the following function blocks:

- Cold-load pickup detection (optional)
- Current-flow criterion
- Circuit-breaker condition
- Closure detection

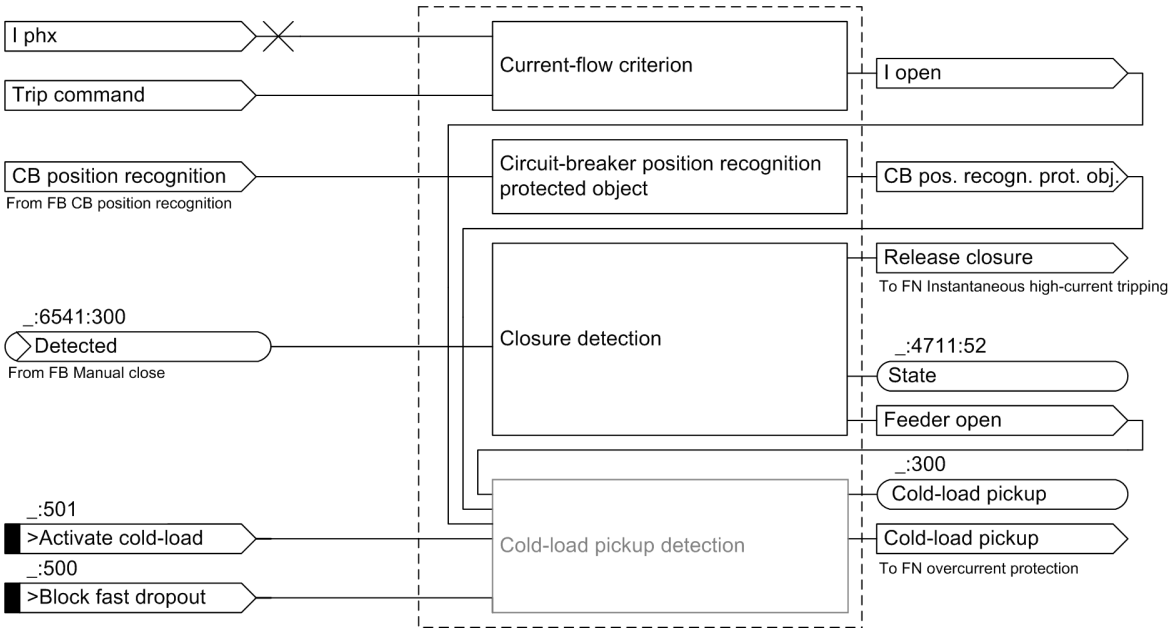


[dwpro3pt-061212-01.tif, 2, en_US]

Figure 5-87 Structure/Embedding of the Function

You can activate the cold-load pickup detection as needed. All other stages of the process monitor run permanently in the background and are not displayed in DIGSI.

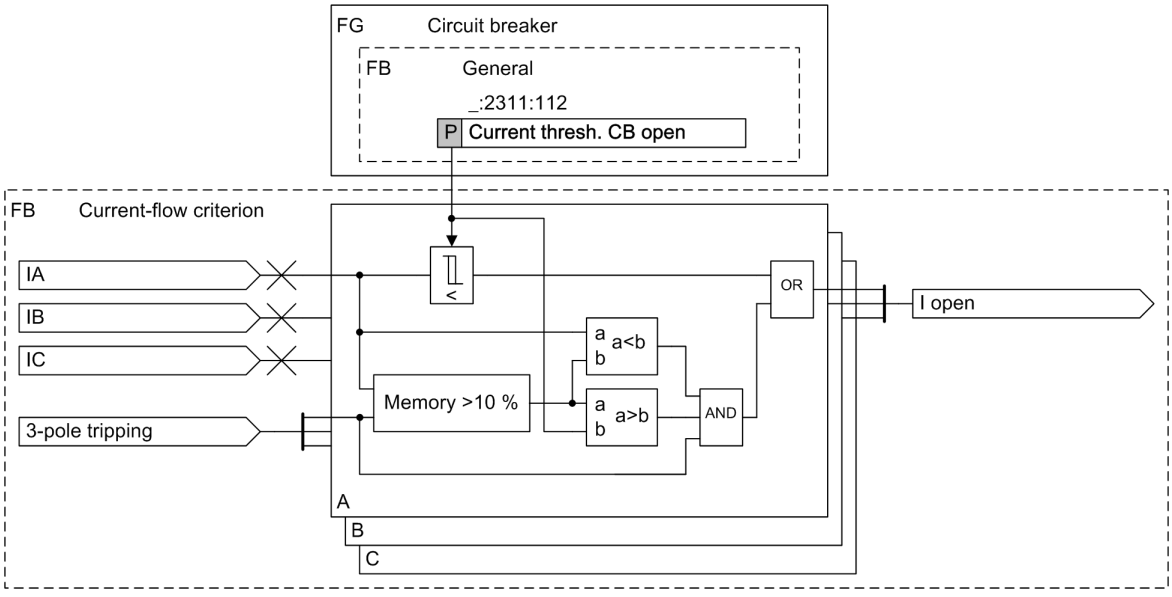
The following figure shows the relationships of the individual function blocks.



[lopro3pt-171012-01.tif, 2, en_US]

Figure 5-88 Logic Diagram of the Overall Function Process Monitor

5.8.3 Current-Flow Criterion



[loproikr-011112-01.tif, 1, en_US]

Figure 5-89 Logic Diagram of the Current-Flow Criterion Function Block

The **I open** signal of one phase is generated if one of the following conditions is met:

- A phase current falls below the set threshold of the **Current thresh. CB open** parameter. The hysteresis stabilizes the signal.
- The corresponding phase current, for example, **I A**, falls below 10 % of the phase current when the trip command arrives. If the current does not drop until after a delay due to current transformer influences, an open pole can therefore be detected quickly even after a high-current fault on the line.

With the **Current thresh. CB open** parameter, you define the minimum current as the criterion for a deactivated line. The parameter lies in the **Circuit-breaker** function group. It acts both in the **Circuit-breaker** function group, for example circuit-breaker position recognition, and also for the process monitor in the Protection-function group.

5.8.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value **(_:2311:112) Current thresh. CB open** = ***0.100 A***

The **Current thresh. CB open** parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.

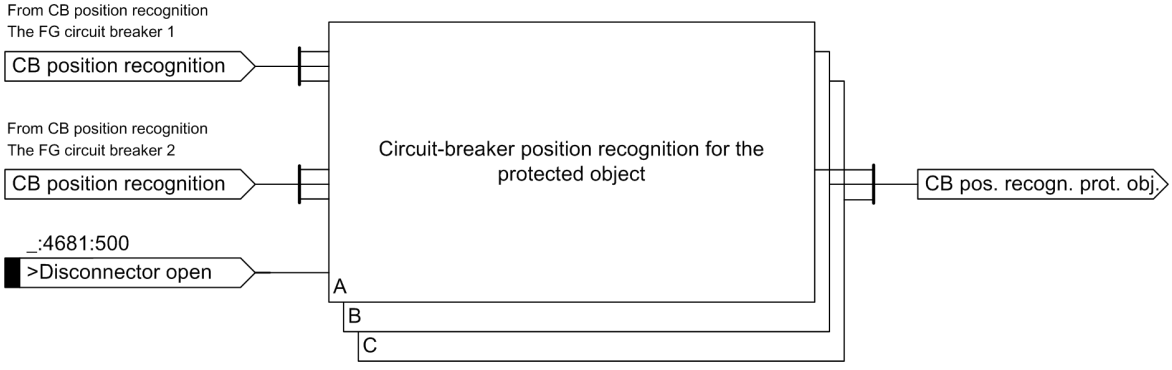
Set the **Current thresh. CB open** parameter so that the current measured when the feeder is deactivated falls below the value of the **Current thresh. CB open** parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the **Current thresh. CB open** parameter sensitively.

Siemens recommends a setting value of ***0.100 A***.

5.8.5 Circuit-Breaker Condition for the Protected Object

Logic



[loprolsz-140611-01.tif, 2, en_US]

Figure 5-90 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit-breaker position recognition in the **Circuit breaker** (CB) function group provides the circuit-breaker condition by way of the internal signal ***CB pos. recogn. prot. obj.***.

If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit-breaker layout, then the circuit-breaker switch position of the protected object must be determined with the aid of both circuit breakers. In this case, the **Circuit-breaker position recognition for the protected object** function block connects the individual CB states. The connection provides the internal ***CB pos. recogn. prot. obj.*** signal to the other function blocks of the process monitor and to other functions, for example, **Trip in the event of weak infeed** and **Echo function for teleprotection method**, within the same function group.

If one of the following 2 conditions is met, the ***CB pos. recogn. prot. obj.*** signal is in the ***Open*** state:

- All connected circuit breakers signal the ***Open*** state internally.
- The **>Disconnector open** input is active.

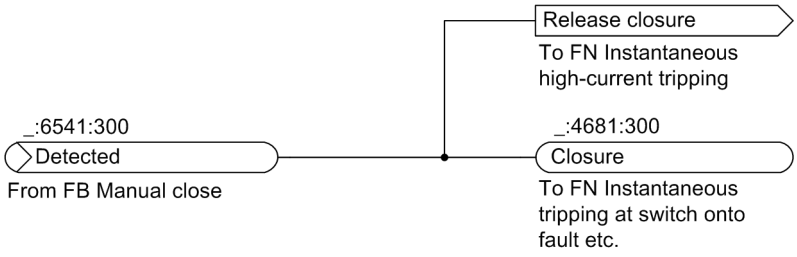
If the following 2 conditions are met, the ***CB pos. recogn. prot. obj.*** signal is in the ***Closed*** state:

- At least one of the connected circuit breakers signals the ***Closed*** state internally.
- The **>Disconnector open** input is not active.

5.8.6 Closure Detection

The closure detection enables the immediate tripping of selected protection functions or protection stages when switching to short circuit or the reduction of the responsivity. The closure detection determines whether the protected object is switched on.

Logic



[loein6md-171012-01.tif, 1, en_US]

Figure 5-91 Logic Diagram of Closure Detection

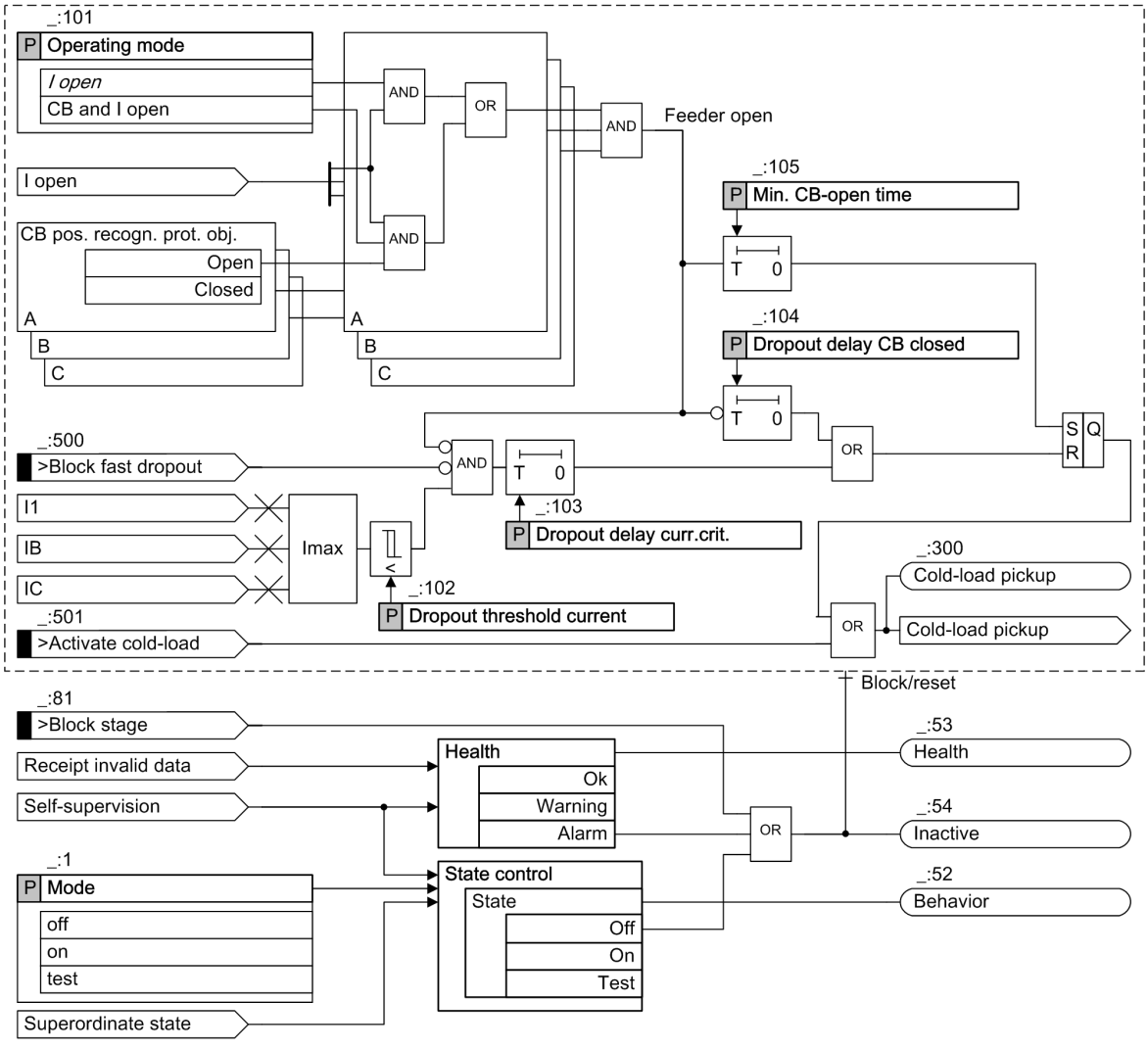
For an applied binary input signal **`Detected`** (from Manual close function block), the indication **`Closure`** is active.

5.8.7 Information List

No.	Information	Data Class (Type)	Type
`Closure detec.`			
_:4681:500	Closure detec.:>Disconnector open	SPS	I
_:4681:300	Closure detec.:Closure	SPS	O

5.8.8 Cold-Load Pickup Detection (Optional)

Logic



[loprocls-180912-01.tif, 1, en_US]

Figure 5-92 Logic Diagram of the Cold-Load Pickup Detection Function Block

The **Cold-load pickup detection** function block detects that a specific time has been exceeded after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load-current requirement exists for a limited time after connection. This results from the nature of the load.

The **Cold-load pickup detection** function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the **`Min. CB-open time`** parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the **Cold-load pickup detection** function block detects an open feeder and the set time of the **`Min. CB-open time`** parameter has expired, the indication **`>Activate cold-load`** is generated.

With the **`>Activate cold-load`** indication, you can activate a parameter set of the **Cold-load pickup** function. Via the binary input signal **`>Activate cold-load`**, you can also activate the **`>Activate cold-load`** indication directly.

If the **Cold-load pickup detection** function block detects closure and the corresponding load current, it starts the time set in the **`Dropout delay CB closed`** parameter. The **`>Activate cold-load`** indication and the activated parameter set are deactivated after this time has elapsed.

If, for the time set in the **Dropout delay curr.crit.** parameter, the maximum phase current falls below the threshold value **Dropout threshold current**, the parameter set for the **Cold-load pickup detection** function block is also deactivated. As a result, if the load current is very low, the action time **Dropout delay curr.crit.** of the **>Activate cold-load** indication can be shortened.

5.8.9 Application and Setting Notes (Cold-Load Pickup Detection)



NOTE

The settings and indications described in this chapter are only available when using the optional **Cold-load pickup detection** function block.

Parameter: Operating mode

- Default setting **(_:101) Operating mode** = ***I open***

With the **Operating mode** parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
I open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the **Current thresh. CB open** parameter is set lower than the possible load current. If this is not the case, open is detected continuously and each fault current that exceeds the **Current thresh. CB open** parameter is interpreted as closure.
CB and I open	Closure is detected if one of the following conditions is met: • Analysis of the circuit-breaker auxiliary contact detects a clearing open condition in at least one phase. • The current-flow criterion detects a clearing open condition.

Parameter: Dropout threshold current

- Default setting **(_:102) Dropout threshold current** = ***1.00 A***

With the **Dropout threshold current** parameter, you set the threshold at which the output signal **Cold-load pickup** is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting **(_:103) Dropout delay curr.crit.** = ***600 s***

With the **Dropout delay curr.crit.** parameter, you set the time for which the actual value must be below the **Dropout threshold current** threshold so that the output signal **Cold-load pickup** can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting **(_:104) Dropout delay CB closed** = ***3600 s***

With the **Dropout delay CB closed** parameter, you set the action time for the dynamic parameter set switching in the event of cold-load pickup detection.

Parameter: Min. CB open time

- Default setting **(_:105) Min. CB-open time** = ***3600 s***

With the **Min. CB-open time** parameter, you set the time after which the dynamic parameter set is activated in the event of **cold-load pickup** when the line is opened.

5.8.10 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operating mode		• I open • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1 s to 600 s	600 s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Min. CB-open time		0 s to 21600 s	3600 s

5.8.11 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:>Block stage	SPS	I
_:500	Cold-load PU:>Block fast dropout	SPS	I
_:501	Cold-load PU:>Activate cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:52	Cold-load PU:Behavior	ENS	O
_:53	Cold-load PU:Health	ENS	O
_:300	Cold-load PU:Cold-load pickup	SPS	O

6 Protection and Automation Functions

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6.30	Undervoltage Protection with Positive-Sequence Voltage	726
6.31	Undervoltage Protection with Any Voltage	733
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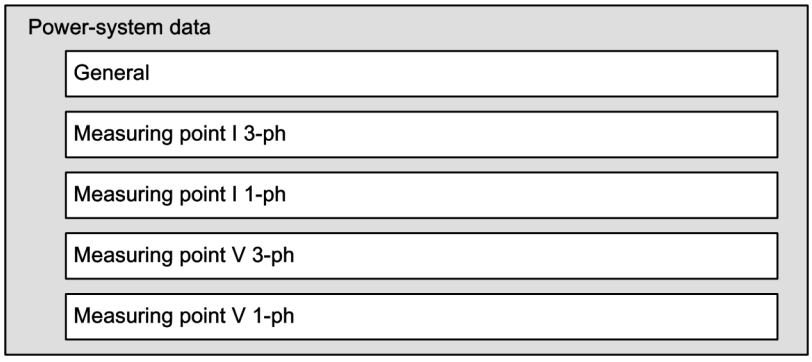
6.1 Power-System Data

6.1.1 Overview

The **Power-system data** are provided with each SIPROTEC 5 device and cannot be deleted. You will find them in DIGSI under **Settings** → **Power-system data**.

6.1.2 Structure of the Power-System Data

The **Power-system data** contain the block **General** and the **Measuring points** of the device. The following figure shows the structure of the **Power-system data**:



[dwandata-180912-01.tif, 2, en_US]

Figure 6-1 Structure of the Power-System Data

In order to adjust its functions to the application, the device requires some data about the power system. The necessary settings can be found in the Power-system data under **General** as well as in the **Measuring points**.



NOTE

You can find information on the supervision-function parameters in chapter *9.3 Supervision of the Secondary System*.

Type and scope of the required measuring points depend on the application. Possible measuring points are:

- Voltage 3-phase (measuring point V 3-ph)
- Current 3-phase (measuring point I 3-ph)
- Voltage 1-phase (measuring point V 1-ph)
- Current 1-phase (measuring point I 1-ph)

The measuring points have interfaces to the function groups requiring voltage and/or current measured values of the power system.

6.1.3 Application and Setting Notes – General Settings

Parameter: Phase sequence

- Recommended setting value **(_:2311:101) Phase sequence**= ***ABC***

The parameter **Phase sequence** is used to set the phase sequence (***ABC***) or (***ACB***). The setting value applies to the entire SIPROTEC 5 device.

Use the **General** function to set the settings in the power-system data.

6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)

The following example describes the settings of the voltage measuring point **Measuring point V-3ph** (voltage 3-phase). Settings for the supervision functions are also located in the voltage measuring point. The description of these settings can be found in chapter Supervision Functions .

Parameter: Rated primary voltage

- Default setting **(_:8911:101) Rated primary voltage** = ***400.000 kV***

The **Rated primary voltage** parameter is used to set the primary rated voltage of the voltage transformer.

Parameter: Rated secondary voltage

- Default setting **(_:8911:102) Rated secondary voltage** = ***100 V***

The **Rated secondary voltage** parameter is used to set the secondary rated voltage of the voltage transformer.

Parameter: Matching ratio Vph / VN

- Default setting **(_:8911:103) Matching ratio Vph / VN** = ***1.73***

With the parameter **Matching ratio Vph / VN**, you set the deviation between the calculated zero-sequence voltage and the residual voltage measured directly via a measuring input. The different transmission ratio of the voltage transformers is the cause for the deviation (see *Figure 6-2*).

The **Matching ratio Vph / VN** is equal to the ratio $3V_{0\,sec}/V_{N\,sec}$

with

$V_{0\,sec}$	Calculated zero-sequence voltage
$V_{N\,sec}$	Measured residual voltage

The zero voltage is calculated as phase-to-ground voltages. The residual voltage is measured on the open delta winding of the voltage transformer. For 1-phase voltage transformers, the residual voltage is measured in the generator or the transformer neutral point.

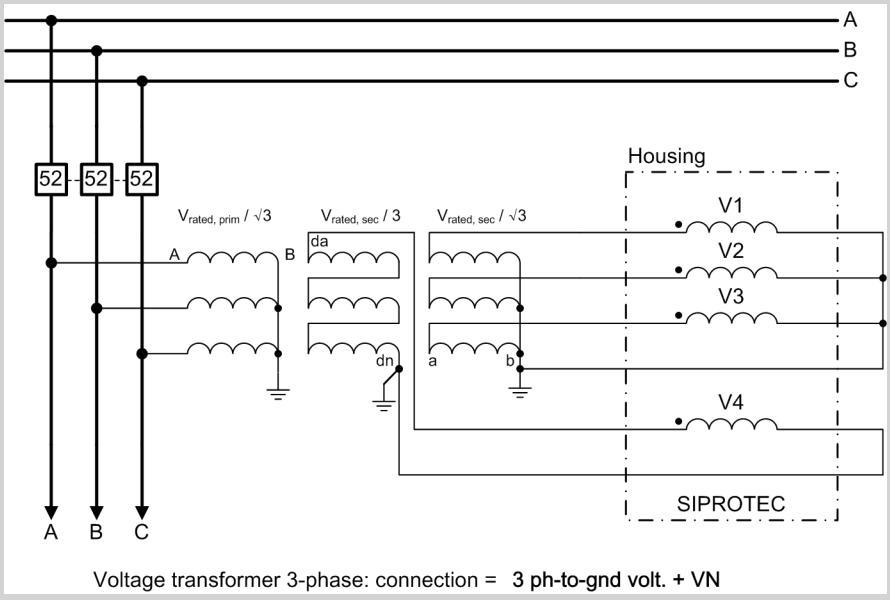


NOTE

The measurement residual voltage $V_{N\,sec}$ is converted to a zero-sequence voltage in the device as follows:

$$V_{0\,sec} = V_{N\,sec} \cdot \frac{\text{Matching ratio Vph/VN}}{3}$$

EXAMPLE 1:



[dw_bsp1uwdl_anpassfaktor, 2, en_US]

Figure 6-2 3-Phase Voltage Transformer: Connection = 3 Phase-to-Ground Voltage + VN

If the connection type of the voltage transformer is ***3 ph-to-gnd volt. + VN*** (parameter: **VT connection**) and the voltage input V4 is connected to the broken-delta winding of the voltage transformer (da/dn), the **Matching ratio Vph / VN** is as follows:

When changing the neutral point according to *Figure 6-2* , this results in the following values:

- The calculated secondary zero-sequence voltage $V_{0\,sec}$ is equal to the secondary phase-to-ground voltage. Expressed as secondary transformer rated voltage, then $V_{rated\,sec}/\sqrt{3}$.
- The measured residual voltage on the open delta winding is the sum of the voltage drops on the 3 sides. Expressed with the side ratio, the result is $V_{N,\,sec} = 3\,V_{rated,sec}/3$.

Calculate the **Matching ratio Vph / VN** parameter as follows:

$$\text{Matching ratio } \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\,sec}}{V_{N\,sec}} = \frac{3 \cdot \frac{V_{nom\,sec}}{\sqrt{3}}}{3 \cdot \frac{V_{nom\,sec}}{3}} = \frac{3}{\sqrt{3}} = \sqrt{3} = 1.73$$

[fo_bsp1, 1, en_US]

Set **Matching ratio Vph / VN** = ***1.73***.

In **example 1** $V_{rated\,sec}$, the phase-to-ground voltage and the secondary voltage on the open delta winding were identical. If these voltages are different, use the actual numerical values in the calculation.

EXAMPLE 2:

Phase-to-ground voltage	$V_{rated\,sec}$ = 100 V
Broken-delta winding (for example, grounding transformer in generator protection)	$V_{rated\,sec}$ = 500 V The voltage input of the device is designed for a continuous operation using 230 V max. Therefore, the voltage on the open delta winding (500 V) is reduced to a 5:2 ratio, using an Ohmic divider. In order to calculate the matching factor, the secondary voltage of 200 V will be applied.

Calculate the **Matching ratio Vph / VN** parameter as follows:

$$\text{Matching ratio}\ \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\ \text{sec}}}{V_{\text{N sec}}} = \frac{3 \cdot \frac{V_{\text{nom sec}}}{\sqrt{3}}}{3 \cdot \frac{V_{\text{nom sec}}}{3}} = \frac{3 \cdot \frac{100\ \text{V}}{\sqrt{3}}}{3 \cdot \frac{200\ \text{V}}{3}} = \frac{3}{2 \cdot \sqrt{3}} = \frac{\sqrt{3}}{2} = 0.866$$

[fo_bsp2, 1, en_US]

Set **Matching ratio Vph / VN** = ***0.866***.

Interpretation of the result:

The zero-sequence voltage calculated from the phase-to-ground voltage is 57.73 V (= 100V/√3). The measured residual voltage is 200 V. The calculated adaptation factor is 0.866. The measured residual voltage is converted to a zero-sequence voltage inside the device:

$$V_{0\ \text{sec}} = V_{\text{N sec}} \cdot \frac{\text{Matching ratio Vph/VN}}{3} = 200\ \text{V} \cdot \frac{0.866}{3} = 57.73\ \text{V}$$

[fo_umrechnung2, 2, en_US]

NOTE

During the ground-fault test, the set adaptation factor can be checked by comparing the operational measured values. The operational measured values contain the calculated zero-sequence voltage $V_{0\ \text{sec}}$ and the measured residual voltage $V_{\text{N sec}}$. Proceed with the compilation as follows:

$$\text{Matching ratio.}\frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\ \text{sec}}}{V_{\text{N sec}}}$$

The **Matching ratio Vph / VN** parameter is significant for the following functions:

- Overvoltage protection with zero-sequence voltage/residual voltage
- Measured-value supervision
- Scaling of the faulty and measured values

Parameter: VT connection

- Default setting **(_:8911:104) VT connection** = ***3 ph-to-gnd volt. + VN***

The parameter **VT connection** shows the connection type of the voltage transformer for the 3-phase voltage measuring point. The parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Settings** → **Power-system data** → **Measuring point V 3-phase**. You cannot change the connection type of the voltage transformer in the power-system data.

You can change the connection type of the voltage transformer only under measuring point routing in DIGSI 5. Under **Name of the device** → **Measuring-points routing** → **Voltage measuring points**, select the desired connection type under **Connection type**. The following types of connections are possible:

- ***3 ph-to-gnd volt. + VN***
- ***3 ph-to-gnd voltages***
- ***3 ph-to-ph volt. + VN***
- ***3 ph-to-ph voltages***
- ***2 ph-to-ph volt. + VN***
- ***2 ph-to-ph voltages***
- ***2 ph-to-gnd volt. + VN***
- ***2 ph-to-gnd voltages***

Depending on the connection type selected, you must route the measured values to the terminals of the voltage measuring point in DIGSI 5. You can find connection examples for voltage transformers in the chapters

A.8 Connection Examples for Voltage Transformers for 7SJ85 and *A.9 Connection Examples for Voltage Transformers for 7SJ82*. The connection examples provide assistance when selecting the type of connection.

Parameter: Inverted phases

- Default setting **(_:8911:106) Inverted phases** = ***none***

The **Inverted phases** parameter is intended for special applications, for example, pumped-storage hydropower plants (see chapter Phase-rotation reversal). This default setting may be retained for power-system protection applications.

Parameter: Tracking

- Default setting **(_:8911:111) Tracking** = ***active***

The **Tracking** parameter is used to determine whether the measuring channels of this measuring point shall be used to determine the sampling frequency.

The sampling frequency of the device is adjusted to the power frequency. The device selects a measuring channel, through which the sampling frequency is determined. Preferably, this should be a voltage metering channel. This validity of the signal is monitored (minimum level, frequency range). If these values are invalid, the device switches to another channel (etc.). Once switched to a current channel, the system automatically switches back to this channel if a voltage channel is valid again.

Parameter Value	Description
active	If the parameter **Tracking** = ***active*** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. **Note:** If the parameter **Tracking** = ***active*** , the determined sampling frequency applies to all functions in the device that do not use fixed sampling rates.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value ***inactive***.

Parameter: Magnitude correction

- Default setting **(_:3811:103) Magnitude correction** = ***1.000***

When using the **Magnitude correction** parameter, the magnitude (magnitude correction) is adjusted for the voltage input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.



NOTE

The **Magnitude correction** parameter has nothing to do with the internal adjustment of the input circuit.

6.1.5 Application and Setting Notes for Measuring Point Current 3-Phase (I-3ph)

The following example describes the settings for the current **Measuring point I 3-ph** (Current 3-phase). The supervision function settings are also located in the current measuring point. The description of these settings can be found in chapter *9 Supervision Functions*.

Parameter: CT connection

- Default setting **(_:8881:115) CT connection** = ***3-phase + IN-separate***

The parameter **CT connection** shows the connection type of the current transformer for the 3-phase current measuring point. The parameter can be found in the DIGSI 5 project tree under **Name of the device → Settings → Power-system data → Measuring point I 3-phase**. You cannot change the connection type of the current transformer in the **Power-system data**.

You can change the connection type of the current transformer only under measuring point routing in DIGSI 5. Under **Name of the device → Measuring point routing → Current measuring points**, select the desired connection type under Connection type. The following types of connections are possible:

- ***3-phase + IN-separate***
- ***3-phase + IN***
- ***3-phase***
- ***3-phase, 2 primary CT***
- ***3ph,2prim.CT + IN-sep***
- ***2ph, 2p. CT + IN-sep***

Depending on the connection type selected, you must route the measured values to the terminals of the current measuring point in DIGSI 5. You can find connection examples for current transformers in chapter *A.7 Connection Examples for Current Transformers* . The connection examples provide assistance when selecting the type of connection.

Parameter: Tracking

- Default setting **(_:8881:127) Tracking** = ***active***

With the parameter**Tracking**, you specify whether you would like to work with the sampling-frequency tracking function.

Parameter Value	Description
active	If the parameter **Tracking** = ***active*** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. **Note:** If the parameter **Tracking** = ***active***, the determined sampling frequency applies to all functions in the device not using fixed sampling rates.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value ***inactive***.

Parameter: Rated primary current

- Default setting **(_:8881:101) Rated primary current** = ***1000 A***

With the **Rated primary current** parameter, the active rated primary current of the current transformer is set.

Parameter: Rated secondary current

- Default setting **(_:8881:102) Rated secondary current** = ***1 A***

With the **Rated secondary current** parameter, you set the current rated secondary current of the current transformer.

Parameter: Current range

- Default setting 7SJ82 **(_:8881:117) Current range** = ***50 x IR***
- Default setting 7SJ85 **(_:8881:117) Current range** = ***100 x IR***

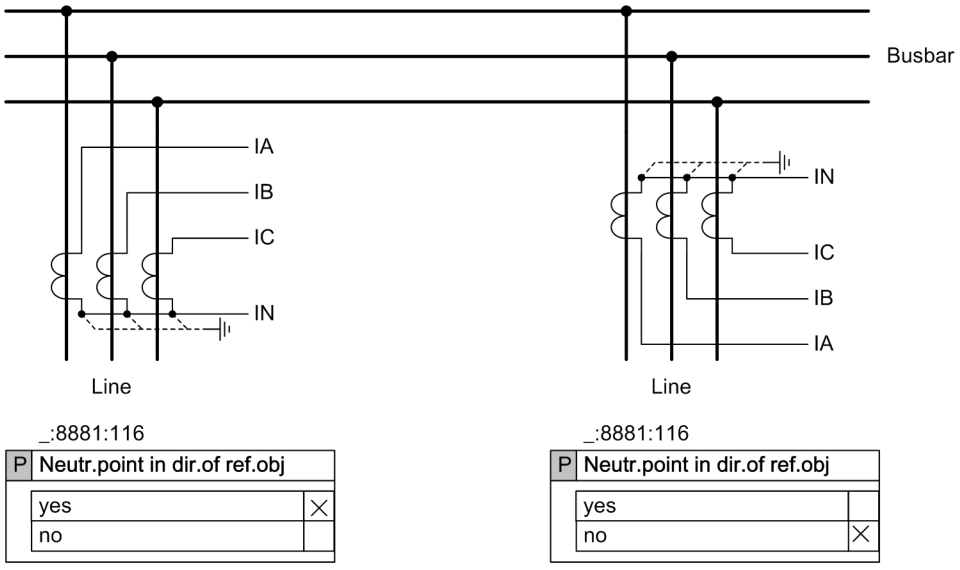
The **Current range** parameter allows you to set the dynamic range for the current input. Please retain the default setting for power-system protection applications. The current measuring range 1.6 x Irated applies for the connection type ***3-phase + IN-separate*** and the sensitive current input or for the measuring inputs.

Parameter: Neutr.point in dir.of ref.obj

- Default setting **(_:8881:116) Neutr.point in dir.of ref.obj** = ***yes***

The **Neutr.point in dir.of ref.obj** parameter is used to set the direction of the neutral point of the current transformer (see following figure). Often, the neutral point of the current transformer is determined by the direction of the protected object (for example, in the direction of the line, cable, transformer). For this reason, the default setting of the parameter was defined as ***yes***.

When switching the parameter, the direction of the phase currents and of the ground current IN or IN-separate is rotated device-internally.



[dwpolstromwdl-251013, 1, en_US]

Figure 6-3 Polarity of Current Transformers

Parameter: Inverted phases

- Default setting **(_:8881:114) Inverted phases** = ***none***

The **Inverted phases** parameter is intended for special applications, for example, pumped-reservoir plants (see Chapter Phase-rotation reversal). This default setting may be retained for power-system protection applications.

Parameter: Magnitude correction

- Default setting **(_:3841:103) Magnitude correction** = ***1.000***

When using the **Magnitude correction** parameter, you adjust the amplitude (amplitude correction) for the current input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.

NOTE

The **Magnitude correction** parameter has nothing to do with the internal adjustment of the input circuit.

Note Regarding Routable Data

Indications for the current rotating field and the information pertaining to the sampling-frequency tracking can be found in **Information routing** under **Power-system data** → **General** in DIGSI 5. The indication *Freq.out of oper.range* means that the frequency operating range has been exceeded. Either the

frequency is out of range (10 Hz to 80 Hz) or the input signals are too small for a manual update. Should this condition occur, the system switches the update frequency to a sampling rate that corresponds to the rated frequency.

Furthermore, there are 2 additional measured frequency values available. The measured value *f sys* displays the current system frequency, and the measured value *f track* displays the sampling frequency currently set. Siemens recommends routing both measured values as fault-recording channel.

6.1.6 Settings

General Information

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Phase sequence		• ABC • ACB	ABC

Measuring Point I-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:2311:102	General:Rated secondary current		• 1 A • 5 A	1 A
_:2311:103	General:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:2311:104	General:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:2311:116	General:Term. 1,3,5,7 in dir. of obj.		• no • yes	yes
_:2311:105	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• I A • I B • I C • IN • INsens • Ix	

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8881:115	CT 3-phase:CT connection		• not assigned • 3-phase + IN • 3-phase • 3-phase + IN-separate • 3-phase, 2 primary CT • 3ph,2prim.CT + IN-sep • 2ph, 2p. CT + IN-sep	3-phase + IN
_:8881:127	CT 3-phase:Tracking		• inactive • active	active
_:8881:130	CT 3-phase:Measuring-point ID		0 to 100	0
CT phases				
_:8881:101	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:102	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:117	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:118	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:8881:116	CT 3-phase:Neutr.point in dir.of ref.obj		• no • yes	yes
_:8881:114	CT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8881:107	CT 3-phase:CT error changeover		1.00 to 10.00	1.00
_:8881:108	CT 3-phase:CT error A		0.5 % to 50.0 %	5.0 %
_:8881:109	CT 3-phase:CT error B		0.5 % to 50.0 %	15.0 %
CT IN				
_:8881:104	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:105	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:119	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:120	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT IN2				
_:8881:106	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:113	CT 3-phase:Rated secondary current		1 A to 5 A	1 A

Addr.	Parameter	C	Setting Options	Default Setting
_:8881:121	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	1.6 x IR
_:8881:122	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 2				
_:3842:103	CT 2:Magnitude correction		0.010 to 10.000	1.000
_:3842:117	CT 2:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 3				
_:3843:103	CT 3:Magnitude correction		0.010 to 10.000	1.000
_:3843:117	CT 3:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 4				
_:3844:103	CT 4:Magnitude correction		0.010 to 10.000	1.000
_:3844:117	CT 4:Phase		• I A • I B • I C • IN • INsens • Ix	
Brk.wire det.				
_:5581:1	Brk.wire det.:Mode		• off • on • test	off
Supv. balan. I				
_:2491:1	Supv. balan. I:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2491:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:2491:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:2491:6	Supv. balan. I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.I				
_:2551:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:2551:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum I				
_:2431:1	Supv. sum I:Mode		• off • on • test	off
_:2431:102	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2431:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:2431:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv.ADC sum I				
_:2401:1	Supv.ADC sum I:Mode		• off • on • test	off

Measuring Point V-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:2311:102	General:Rated secondary voltage		80 V to 340 V	100 V
_:2311:103	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_:3811:108	VT 1:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB •	
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

Measuring Point V-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8911:101	VT 3-phase:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:8911:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:8911:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:8911:104	VT 3-phase:VT connection		• not assigned • 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages • 2 ph-to-ph volt. + VN • 2 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:8911:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8911:111	VT 3-phase:Tracking		• inactive • active	active
_:8911:130	VT 3-phase:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000
_:3811:108	VT 1:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	

Addr.	Parameter	C	Setting Options	Default Setting
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT 2				
_:3812:103	VT 2:Magnitude correction		0.010 to 10.000	1.000
_:3812:108	VT 2:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	
_:3812:107	VT 2:Sequence number device		1 to 2147483647	2147483647
VT 3				
_:3813:103	VT 3:Magnitude correction		0.010 to 10.000	1.000
_:3813:108	VT 3:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB •	
_:3813:107	VT 3:Sequence number device		1 to 2147483647	2147483647
VT 4				
_:3814:103	VT 4:Magnitude correction		0.010 to 10.000	1.000
_:3814:108	VT 4:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB •	
_:3814:107	VT 4:Sequence number device		1 to 2147483647	2147483647
Supv. balan. V				
_:2521:1	Supv. balan. V:Mode		• off • on • test	off
_:2521:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:2521:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75

Addr.	Parameter	C	Setting Options	Default Setting
_:2521:6	Supv. balan. V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.V				
_:2581:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:2581:6	Supv. ph.seq.V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum V				
_:2461:1	Supv. sum V:Mode		• off • on • test	off
_:2461:3	Supv. sum V:Threshold		0.300 V to 170.000 V	25.000 V
_:2461:6	Supv. sum V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

6.1.7 Information List

General

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Phs-rotation reversal	SPS	I
_:2311:501	General:>Invert Phases	SPS	I
General			
_:2311:319	General:Phase sequence ABC	SPS	O
_:2311:320	General:Phase sequence ACB	SPS	O
_:2311:321	General:Freq.out of oper.range	SPS	O
_:2311:322	General:f sys	MV	O
_:2311:323	General:f track	MV	O

Measuring Point I-1ph

No.	Information	Data Class (Type)	Type
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O

Measuring Point I-3ph

No.	Information	Data Class (Type)	Type
General			
_:8881:319	CT 3-phase:Phases AB inverted	SPS	O
_:8881:320	CT 3-phase:Phases BC inverted	SPS	O
_:8881:321	CT 3-phase:Phases AC inverted	SPS	O

No.	Information	Data Class (Type)	Type
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O
CT 2			
_:3842:300	CT 2:Sampled val. current	SAV	O
CT 3			
_:3843:300	CT 3:Sampled val. current	SAV	O
CT 4			
_:3844:300	CT 4:Sampled val. current	SAV	O
Brk.wire det.			
_:5581:82	Brk.wire det.:>Block function	SPS	I
_:5581:54	Brk.wire det.:Inactive	SPS	O
_:5581:52	Brk.wire det.:Behavior	ENS	O
_:5581:53	Brk.wire det.:Health	ENS	O
_:5581:301	Brk.wire det.:Phs A BW suspected	SPS	O
_:5581:302	Brk.wire det.:Phs B BW suspected	SPS	O
_:5581:303	Brk.wire det.:Phs C BW suspected	SPS	O
_:5581:304	Brk.wire det.:Phase A broken wire	SPS	O
_:5581:305	Brk.wire det.:Phase B broken wire	SPS	O
_:5581:306	Brk.wire det.:Phase C broken wire	SPS	O
_:5581:307	Brk.wire det.:Broken wire suspected	SPS	O
_:5581:308	Brk.wire det.:Broken wire confirmed	SPS	O
Supv. balan. I			
_:2491:82	Supv. balan. I:>Block function	SPS	I
_:2491:54	Supv. balan. I:Inactive	SPS	O
_:2491:52	Supv. balan. I:Behavior	ENS	O
_:2491:53	Supv. balan. I:Health	ENS	O
_:2491:71	Supv. balan. I:Failure	SPS	O
Supv. ph.seq.I			
_:2551:82	Supv. ph.seq.I:>Block function	SPS	I
_:2551:54	Supv. ph.seq.I:Inactive	SPS	O
_:2551:52	Supv. ph.seq.I:Behavior	ENS	O
_:2551:53	Supv. ph.seq.I:Health	ENS	O
_:2551:71	Supv. ph.seq.I:Failure	SPS	O
Supv. sum I			
_:2431:82	Supv. sum I:>Block function	SPS	I
_:2431:54	Supv. sum I:Inactive	SPS	O
_:2431:52	Supv. sum I:Behavior	ENS	O
_:2431:53	Supv. sum I:Health	ENS	O
_:2431:71	Supv. sum I:Failure	SPS	O
Supv.ADC sum I			
_:2401:82	Supv.ADC sum I:>Block function	SPS	I
_:2401:54	Supv.ADC sum I:Inactive	SPS	O
_:2401:52	Supv.ADC sum I:Behavior	ENS	O
_:2401:53	Supv.ADC sum I:Health	ENS	O
_:2401:71	Supv.ADC sum I:Failure	SPS	O

Measuring Point V-1ph

No.	Information	Data Class (Type)	Type
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
Definite-T 1			
_:2641:500	VT miniatureCB:>Open	SPS	I

Measuring Point V-3ph

No.	Information	Data Class (Type)	Type
General			
_:8911:315	VT 3-phase:Phases AB inverted	SPS	O
_:8911:316	VT 3-phase:Phases BC inverted	SPS	O
_:8911:317	VT 3-phase:Phases AC inverted	SPS	O
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
VT 2			
_:3812:300	VT 2:Sampled val. voltage	SAV	O
VT 3			
_:3813:300	VT 3:Sampled val. voltage	SAV	O
VT 4			
_:3814:300	VT 4:Sampled val. voltage	SAV	O
Supv. balan. V			
_:2521:82	Supv. balan. V:>Block function	SPS	I
_:2521:54	Supv. balan. V:Inactive	SPS	O
_:2521:52	Supv. balan. V:Behavior	ENS	O
_:2521:53	Supv. balan. V:Health	ENS	O
_:2521:71	Supv. balan. V:Failure	SPS	O
Supv. ph.seq.V			
_:2581:82	Supv. ph.seq.V:>Block function	SPS	I
_:2581:54	Supv. ph.seq.V:Inactive	SPS	O
_:2581:52	Supv. ph.seq.V:Behavior	ENS	O
_:2581:53	Supv. ph.seq.V:Health	ENS	O
_:2581:71	Supv. ph.seq.V:Failure	SPS	O
Supv. sum V			
_:2461:82	Supv. sum V:>Block function	SPS	I
_:2461:54	Supv. sum V:Inactive	SPS	O
_:2461:52	Supv. sum V:Behavior	ENS	O
_:2461:53	Supv. sum V:Health	ENS	O
_:2461:71	Supv. sum V:Failure	SPS	O
Definite-T 1			
_:2641:500	VT miniatureCB:>Open	SPS	I

6.2 Group Indications of Overcurrent Protection Functions

6.2.1 Description

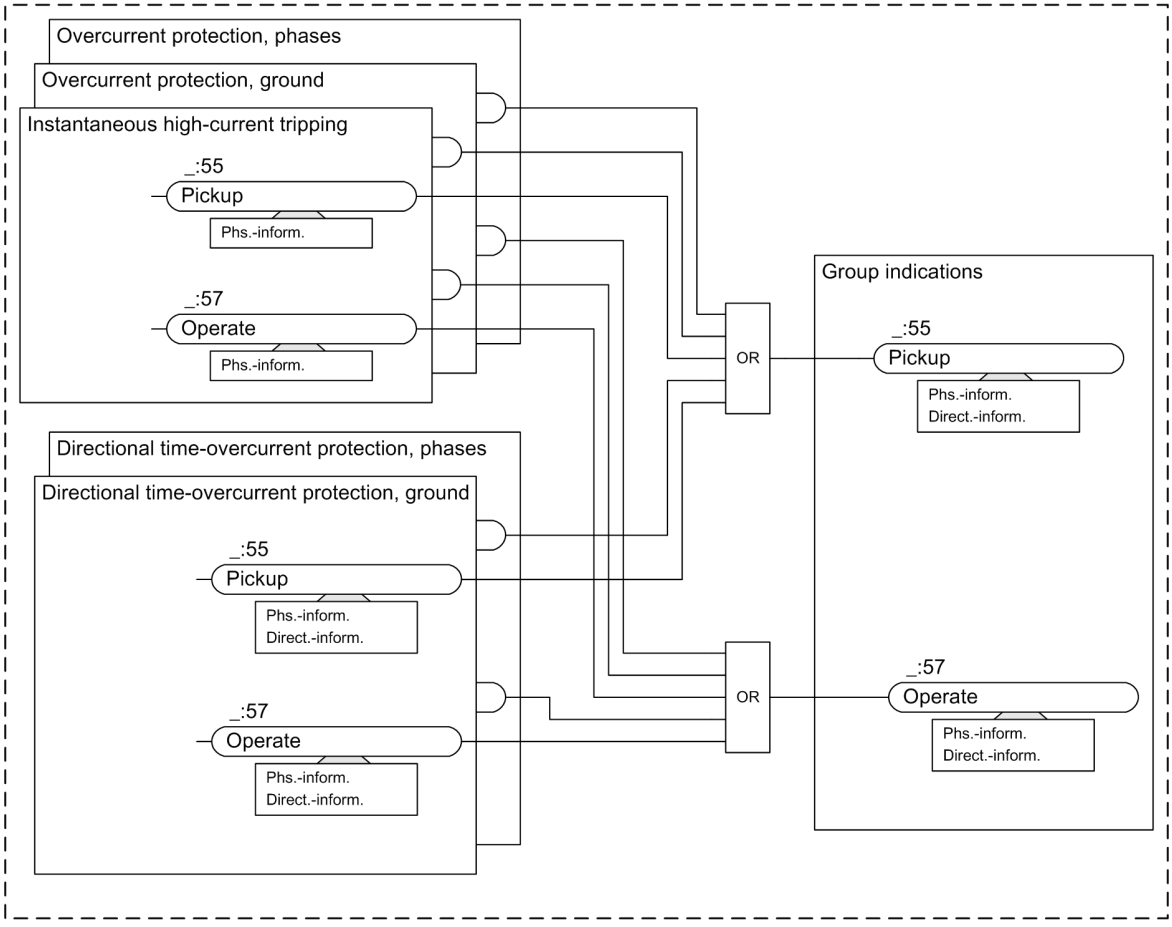
The function block **Group indications of the overcurrent protection functions** uses the pickup and operate indications of the following functions:

- Overcurrent Protection, Phases
- Overcurrent Protection, Ground
- Directional time-overcurrent protection, phases
- Directional Overcurrent Protection, Ground
- Instantaneous High-Current Tripping

The group indications of the overcurrent protection are generated by a logical OR of the stage-selective pickup and operate indications of the functions listed above (see also *Figure 6-4*):

- **`Pickup`**
- **`Operate`**

The pickup and operate indications are output, where present, with direction information.



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Figure 6-4 Logic Diagram of the Overcurrent Protection Group Indications

6.3 Overcurrent Protection, Phases

6.3.1 Overview of Functions

The **Overcurrent protection, phases** function (ANSI 50/51):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.3.2 Structure of the Function

The **Overcurrent protection, phases** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, phases – advanced** (50/51 OC-3ph-A)
- **Overcurrent protection, phases – basic** (50/51 OC-3ph-B)

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the **Overcurrent protection, phase– advanced** function type, the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite time-overcurrent protection – advanced**
- 2 stages **Inverse time-overcurrent protection – advanced**
- 2 stages **User-defined overcurrent protection characteristic curve**

In the **Overcurrent protection, phases – basic** function type, the following stages can be operated simultaneously:

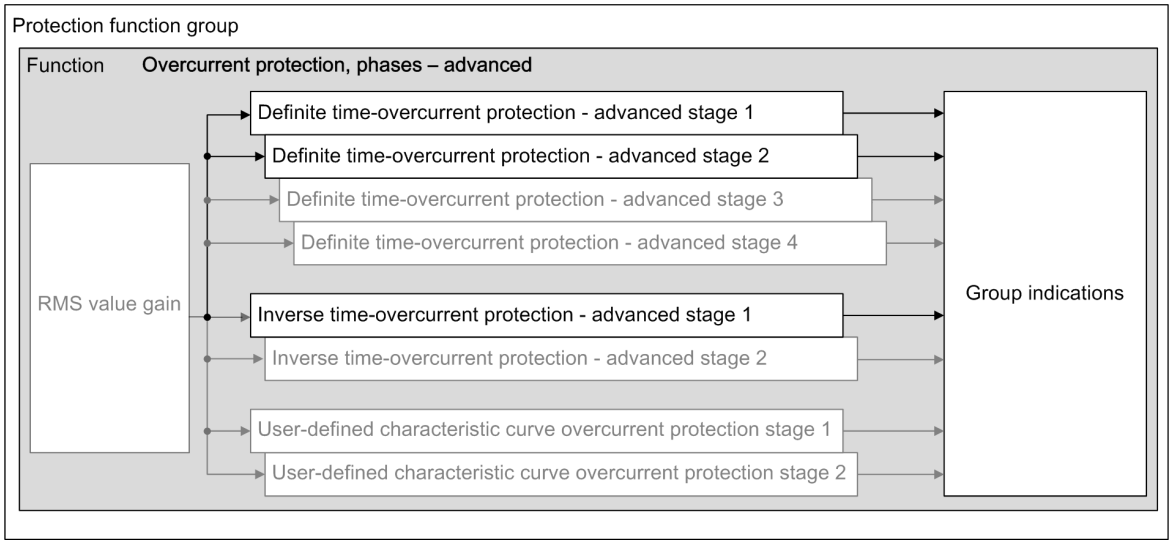
- Maximum of 4 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The optional function block **Filter** offered in the advanced function allows to gain harmonics or to compensate the amplitude attenuation for the RMS value.

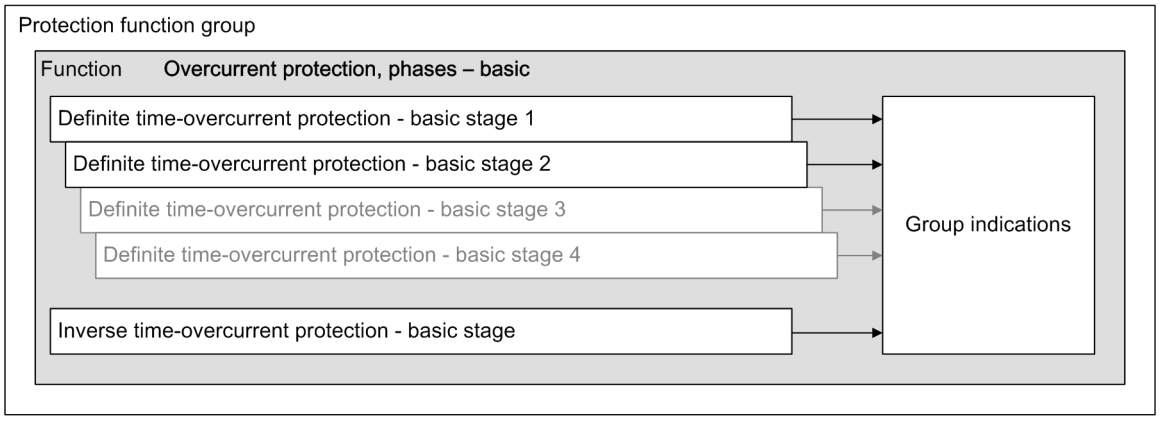
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_ocp_ad with Filter.tif, 1, en_US]

Figure 6-5 Structure/Embedding of the Function Overcurrent Protection, Phases – Advanced



[dwocpbp1-210113-01.tif, 2, en_US]

Figure 6-6 Structure/Embedding the Function Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with an **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.3.3 Filter for RMS Value Gain

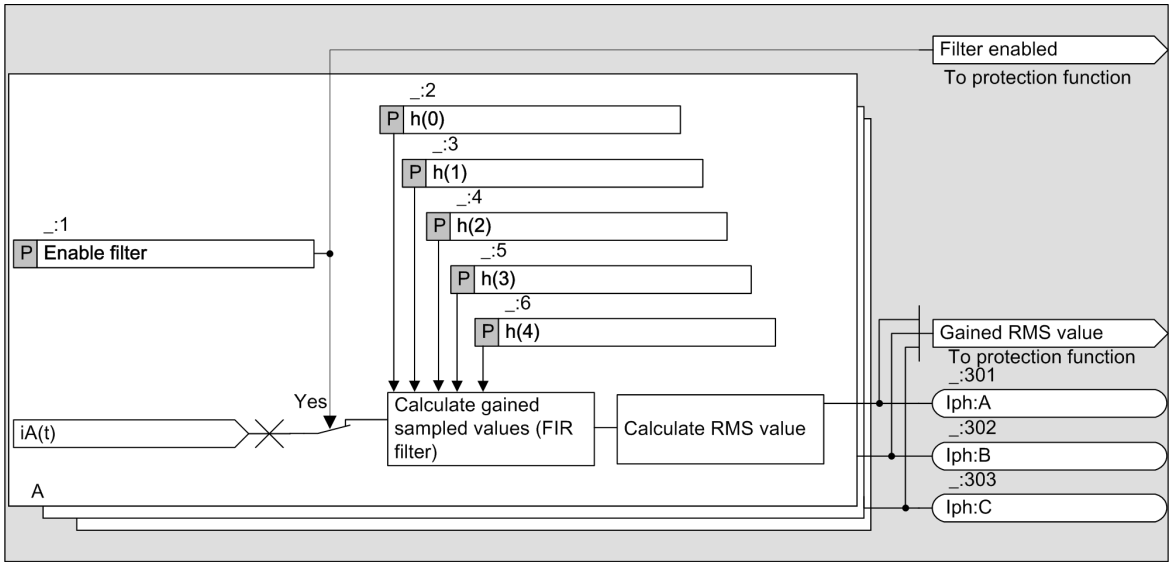
6.3.3.1 Description

The function block **Filter** can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter
- To only compensate the amplitude attenuation of higher frequencies due to the anti-aliasing filter

The filter gain (amplitude response) is realized by a 9-order FIR filter.

Logic



[lo_TOLP_FilterStage, 1, en_US]

Figure 6-7 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards, the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the values of the respective parameters **`h(0)`**, **`h(1)`**, **`h(2)`**, **`h(3)`**, and **`h(4)`**.

NOTE

A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block **Filter** is instantiated and the parameter **`Enable filter`** is set as ***`yes`***. Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Gained RMS measured value of current A	kA	A	Parameter **`Rated current`**
Iph:B	Gained RMS measured value of current B	kA	A	Parameter **`Rated current`**

Values	Description	Primary	Secondary	% Referenced to
Iph:C	Gained RMS measured value of current C	kA	A	Parameter **Rated current**

You can find the parameter **Rated current** in the **FB General** of function groups where the **Overcurrent protection, phases – advanced** function is used.

If the parameter **Enable filter** is set to ***no***, the functional measured values are shown as **---**.

6.3.3.2 Application and Setting Notes

Parameter: Enable filter

- Default setting **(_:1) Enable filter** = ***no***.

With the parameter **Enable filter**, you set whether the **Filter** is enabled.

Parameter Value	Description
yes	If gained RMS values should be used in one of the protection stages, set parameter **Enable filter** = ***yes***.
no	If no gained RMS values are needed, set the parameter **Enable filter** = ***no***.

Parameter: h(0),h(1),h(2),h(3),h(4)

- Default setting **(_:2) h(0)** = ***0.000***
- Default setting **(_:3) h(1)** = ***0.000***
- Default setting **(_:4) h(2)** = ***0.000***
- Default setting **(_:5) h(3)** = ***0.000***
- Default setting **(_:6) h(4)** = ***1.000***

With the default value of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.3.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

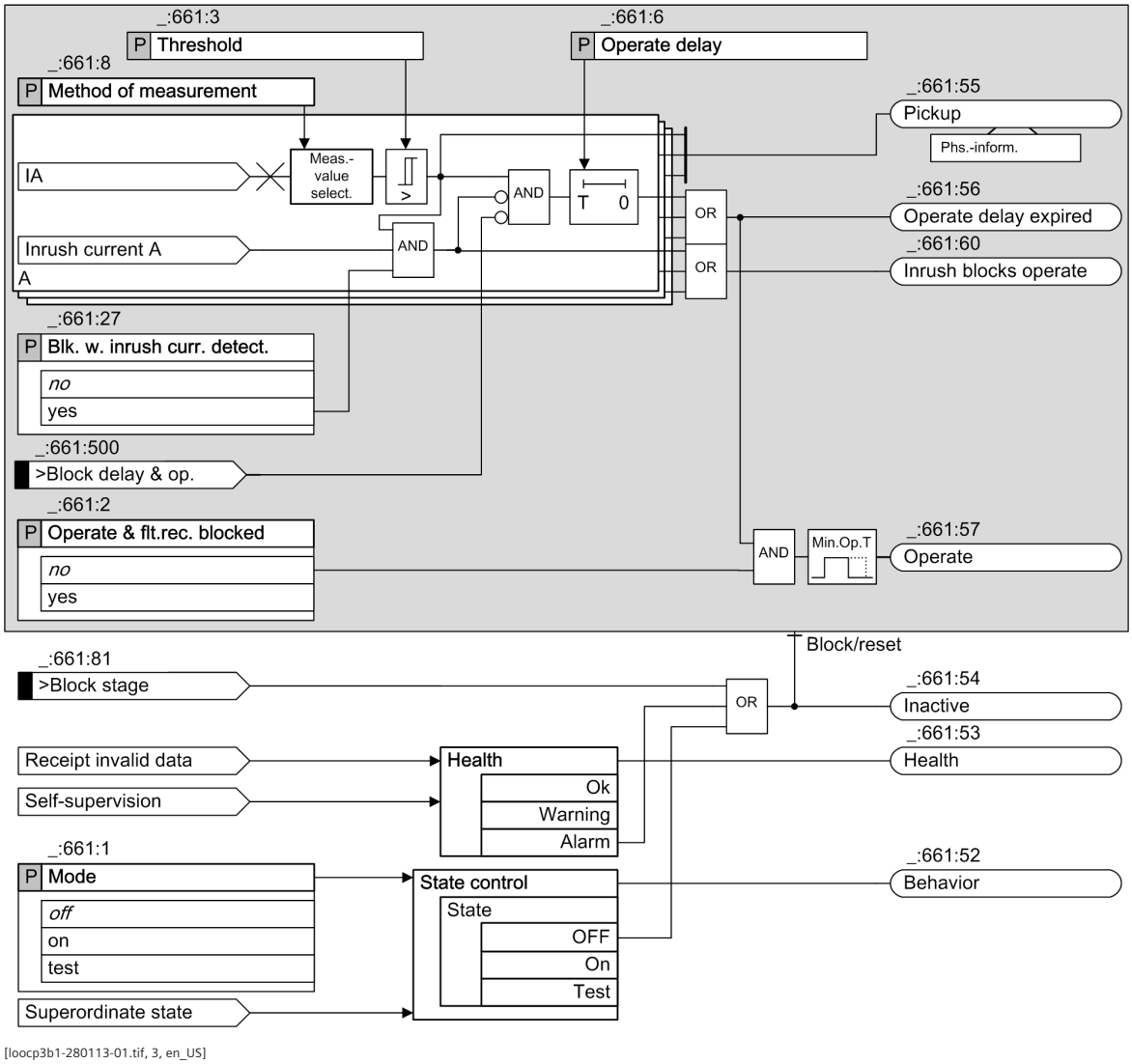
6.3.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O

6.3.4 Stage with Definite-Time Characteristic Curve

6.3.4.1 Description

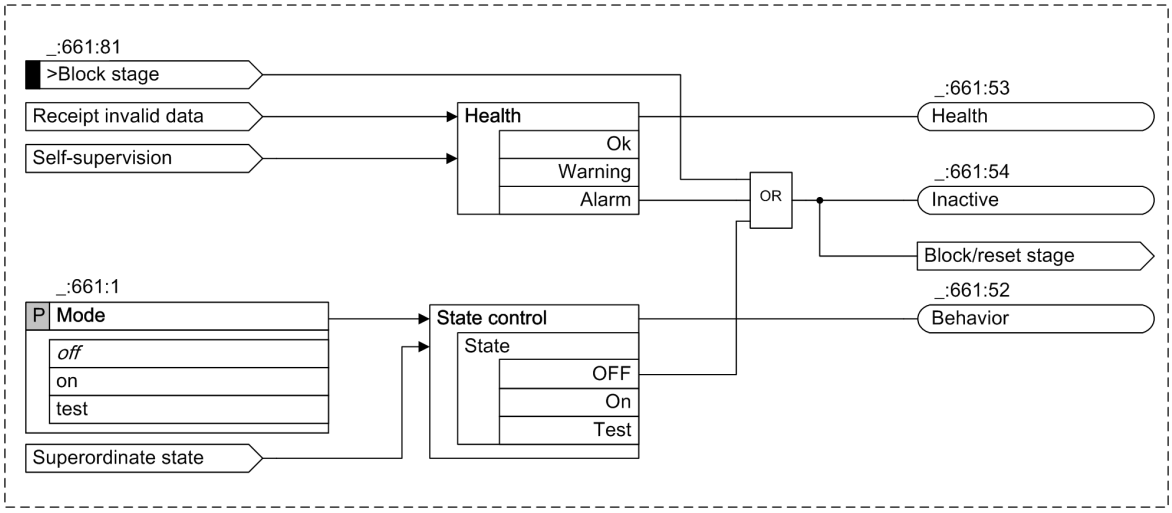
Logic of the Basic Stage



[loocp3b1-280113-01.tif, 3, en_US]

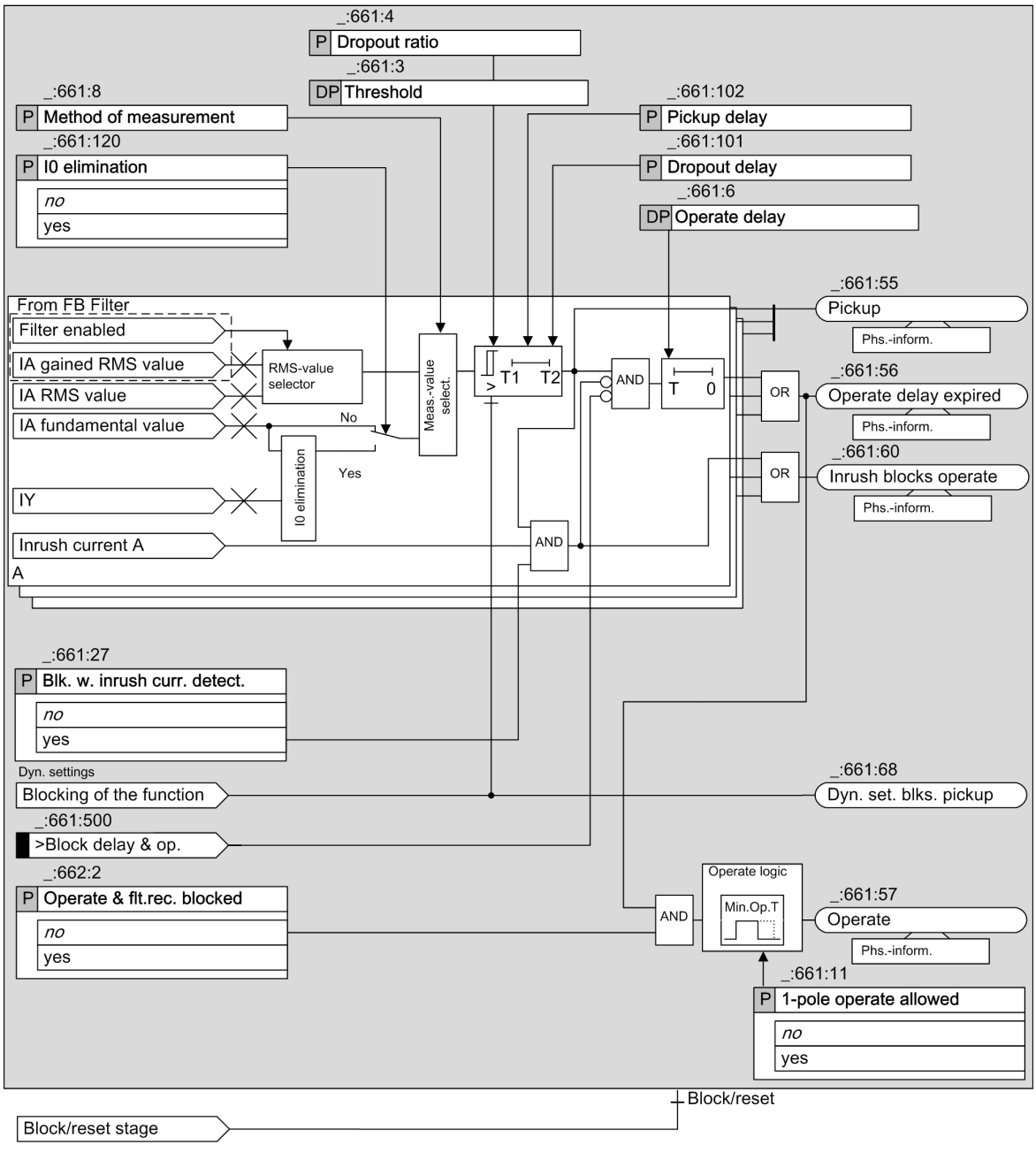
Figure 6-8 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage



[lo_OCP_Adv_UMZ_StageControl, 1, en_US]

Figure 6-9 Logic Diagram of the Stage Control



[loocp3p1-310511-01.tif, 3, en_US]

Figure 6-10 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Advanced

Method of measurement (Basic and Advanced Stage)

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

RMS-Value Selection (Advanced Stage)

If ***RMS value*** is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block **Filter**

If the function block **Filter** is configured and if you have enabled the filter, the gained RMS value is automatically used.

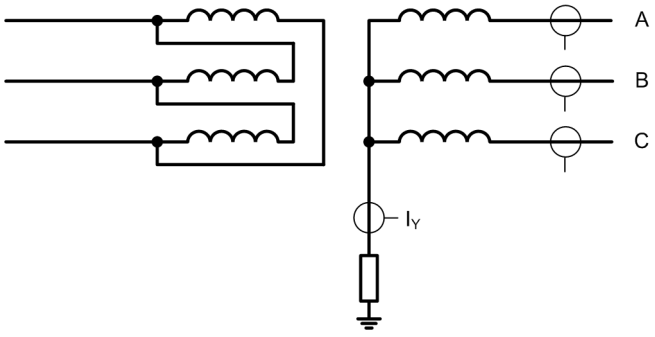
NOTE

When the function block **Filter** is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the phase-to-phase faults on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection application on one transformer.

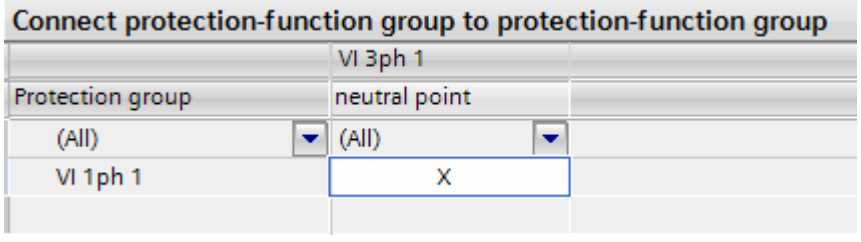
In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.



[dwsgaocp-230414-01, 1, en_US]

Figure 6-11 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the **Voltage/current 1-phase**. The function group **Voltage/current 1-phase** must be connected to the function group **Voltage/current 3-phase** in which the function **Overcurrent protection, phases** is being used.



[sccpfoint-230414-01, 1, en_US]

Figure 6-12 Connection of the Voltage/Current 1-Phase Function Group with the Neutral Point Input of the Voltage/Current 3-Phase Function Group

In case of an I0 elimination, the following calculations result:

$\underline{I}_{A\text{-elim.}} = \underline{I}_A - 1/3\ \underline{I}_Y$

$\underline{I}_{B\text{-elim.}} = \underline{I}_B - 1/3\ \underline{I}_Y$

$\underline{I}_{C\text{-elim.}} = \underline{I}_C - 1/3\ \underline{I}_Y$

The phase current $\underline{I}_{phx\text{-elim.}}$ is necessary for the following protection process.

If the **Method of measurement** parameter is set to ***fundamental comp.***, the I0 elimination is applied.

The currents $I_{phx\text{-}elim.}$ are available as functional values.

Pickup delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay is generated. If the threshold remains exceeded during the pickup delay time, the pickup signal is generated.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (only available in the Advanced function type, see subtitle **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic Reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.3.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:661:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value*** parameter Value

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: `Threshold` , `Operate delay`

- Default setting **`(_:661:3) Threshold`** = ***`1.500 A`*** (for the 1st stage)
- Default setting **`(_:661:6) Operate delay`** = ***`0.30 s`*** (for the 1st stage)

Set the **`Threshold`** and **`Operate delay`** parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Therefore, set the **`Threshold`** parameter for lines to approx. 10 %, for transformers and motors to approx. 20% above the maximum load that is expected.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power	
P_{max}	= 120 MVA
Correspondingly	
I_{max}	= 630 A
Current transformer	= 600 A/5 A
Safety factor	= 1.1

Settings in primary and secondary values result in the setting values:

Threshold value 1st stage (primary) $= 1.1 \cdot 630\ A = 693\ A$

Threshold value 1st stage (secondary) $= 1.1 \cdot \frac{630\ A}{600\ A} \cdot 5\ A = 5.8\ A$

[foocpph1-030311-01.tif, 2, en_US]

The **`Operate delay`** to be set is derived from the time-grading schedule that has been prepared for the system.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the **`Threshold`** parameter to ensure that the stage does not pick up in case of a short circuit at the end of the line.

Set the **`Operate delay`** parameter to ***`0`*** or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length)	= 60 km
Z_L/s	= 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_{L0}/Z_{L1} = 4$

Short-circuit power at the beginning of the line:

S_{sc}'	= 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_{P0}/Z_{P1} = 2$

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/\mathrm{km} \cdot 60\mathrm{km} = 27.6\ \Omega$$

[fo_OCP002_030311, 1, en_US]

$$Z_P = \frac{110\ \mathrm{kV}^2}{2500\ \mathrm{MVA}} = 4.84\ \Omega$$

[fo_OCP003_030311, 1, en_US]

The 3-phase short-circuit current at the end of the line is $I_{sc\ end}$:

$$I_{sc\ end} = \frac{1.1 \cdot V_{rated}}{\sqrt{3} \cdot (Z_P + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (4.84\ \Omega + 27.6\ \Omega)} = 2150\ A$$

[fo_ocpph4_030311, 1, en_US]

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) = $1.1 \cdot 2150\ \mathrm{A} = 2365\ \mathrm{A}$

Threshold value 2nd stage (secondary) = $1.1 \cdot \frac{2150\ \mathrm{A}}{600\ \mathrm{A}} \cdot 5\ \mathrm{A} = 19.7\ \mathrm{A}$

[foocp004-030311-01.tif, 2, en_US]

If short-circuit currents exceed 2365 A (primary) or 19.7 A (secondary), there is a short circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance and line impedance have different angles, you have to use complex numbers to calculate the **Threshold** .

Parameter: I0 elimination

- Default setting **(_:661:120) I0 elimination** = ***no***

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase fault on the transformer low-voltage side. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter **Method of measurement** is set to ***fundamental comp.*** .

With the **I0 elimination** parameter, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting **(_:661:102) Pickup delay** = ***0.00 s***

This parameter is not visible in the basic stage.

For special applications, it is desirable that a short exceeding of the current threshold does not lead to the pickup of the stage and start fault logging and recording. If this stage is used as a thermal overload function, that is considered a special application.

When using the **Pickup delay** parameter, a time interval is defined during which a pickup is not triggered if the current threshold is exceeded.

For all short-circuit protection applications, this value is 0.00 s as a default.

Parameter: **Dropout delay**

- Recommended setting value **(_:661:101) Dropout delay** = ***0.00 s***

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting ***0*** since the dropout of a protection stage must be done as fast as possible.

You can use the **Dropout delay** parameter ≠ ***0*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: **Dropout ratio**

- Recommended setting value **(_:661:4) Dropout ratio** = ***0.95***

This parameter is not visible in the basic stage.

The recommended set value of ***0.95*** is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter **Dropout ratio** can be reduced, for example, to ***0.98***. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter **Dropout ratio**. This avoids chattering of the tripping stage.

Parameter: **1-pole operate allowed**

- Default setting **(_:661:11) 1-pole operate allowed** = ***no***

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group **Circuit-breaker**) is always 3-pole because the device does not support phase-selective tripping.

6.3.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:661:1	Definite-T 1:Mode		• off • on • test	off
_:661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:661:11	Definite-T 1:1-pole operate allowed		• no • yes	no
_:661:26	Definite-T 1:Dynamic settings		• no • yes	no
_:661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:661:120	Definite-T 1:I0 elimination		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:661:102	Definite-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:661:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:661:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:661:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:661:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:661:36	Definite-T 1:Stage blocked		• no • yes	no
_:661:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:661:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:661:37	Definite-T 1:Stage blocked		• no • yes	no
_:661:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:661:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:661:38	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:661:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:661:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:661:39	Definite-T 1:Stage blocked		• no • yes	no
_:661:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:661:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:661:40	Definite-T 1:Stage blocked		• no • yes	no
_:661:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:661:34	Definite-T 1:Effected by binary input		• no • yes	no
_:661:41	Definite-T 1:Stage blocked		• no • yes	no
_:661:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

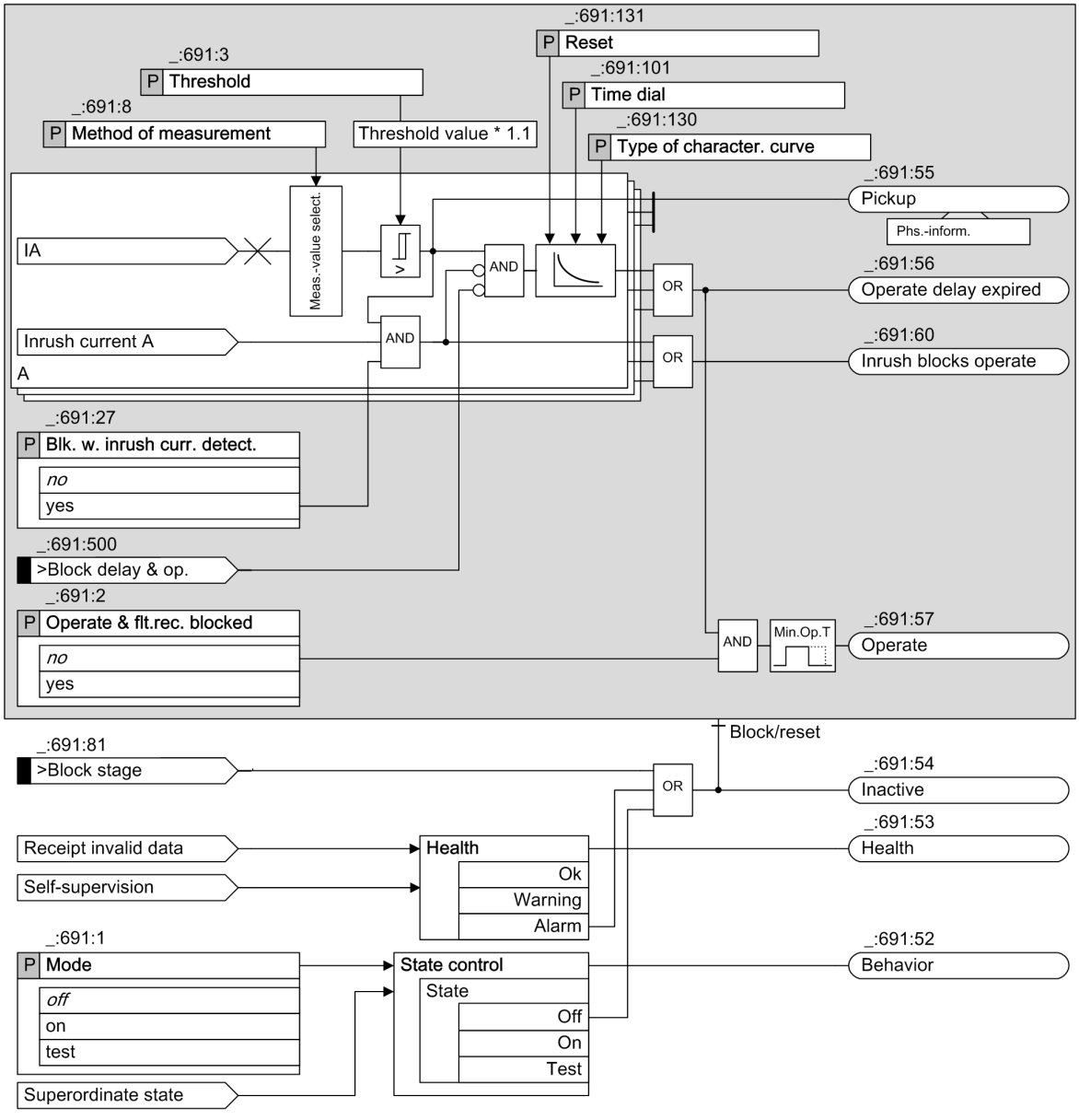
6.3.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:661:81	Definite-T 1:>Block stage	SPS	I
_:661:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:661:500	Definite-T 1:>Block delay & op.	SPS	I
_:661:54	Definite-T 1:Inactive	SPS	O
_:661:52	Definite-T 1:Behavior	ENS	O
_:661:53	Definite-T 1:Health	ENS	O
_:661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:661:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:661:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:661:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:661:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:661:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:661:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:661:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:661:55	Definite-T 1:Pickup	ACD	O
_:661:56	Definite-T 1:Operate delay expired	ACT	O
_:661:57	Definite-T 1:Operate	ACT	O
_:661:302	Definite-T 1:I0el.Iph	WYE	O

6.3.5 Stage with Inverse-Time Characteristic Curve

6.3.5.1 Description

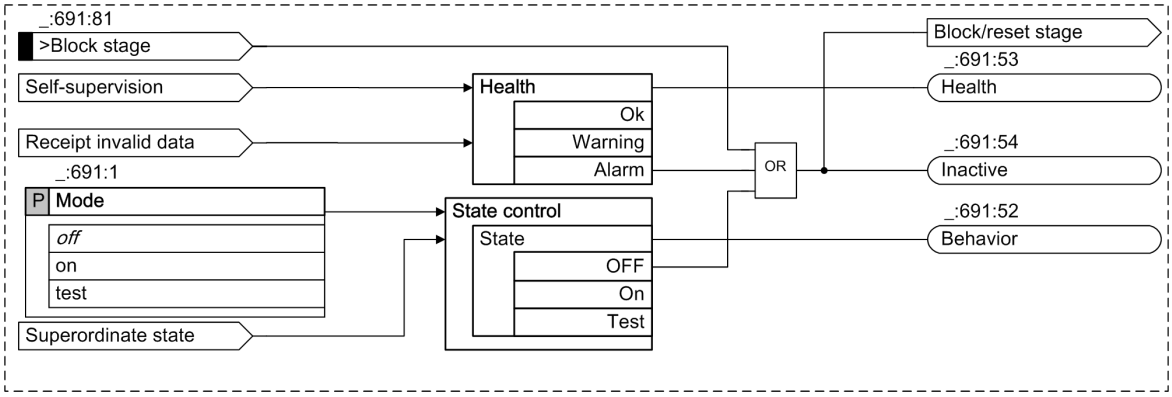
Logic of the Basic Stage



[loocp3b2-280113-01.tif, 2, en_US]

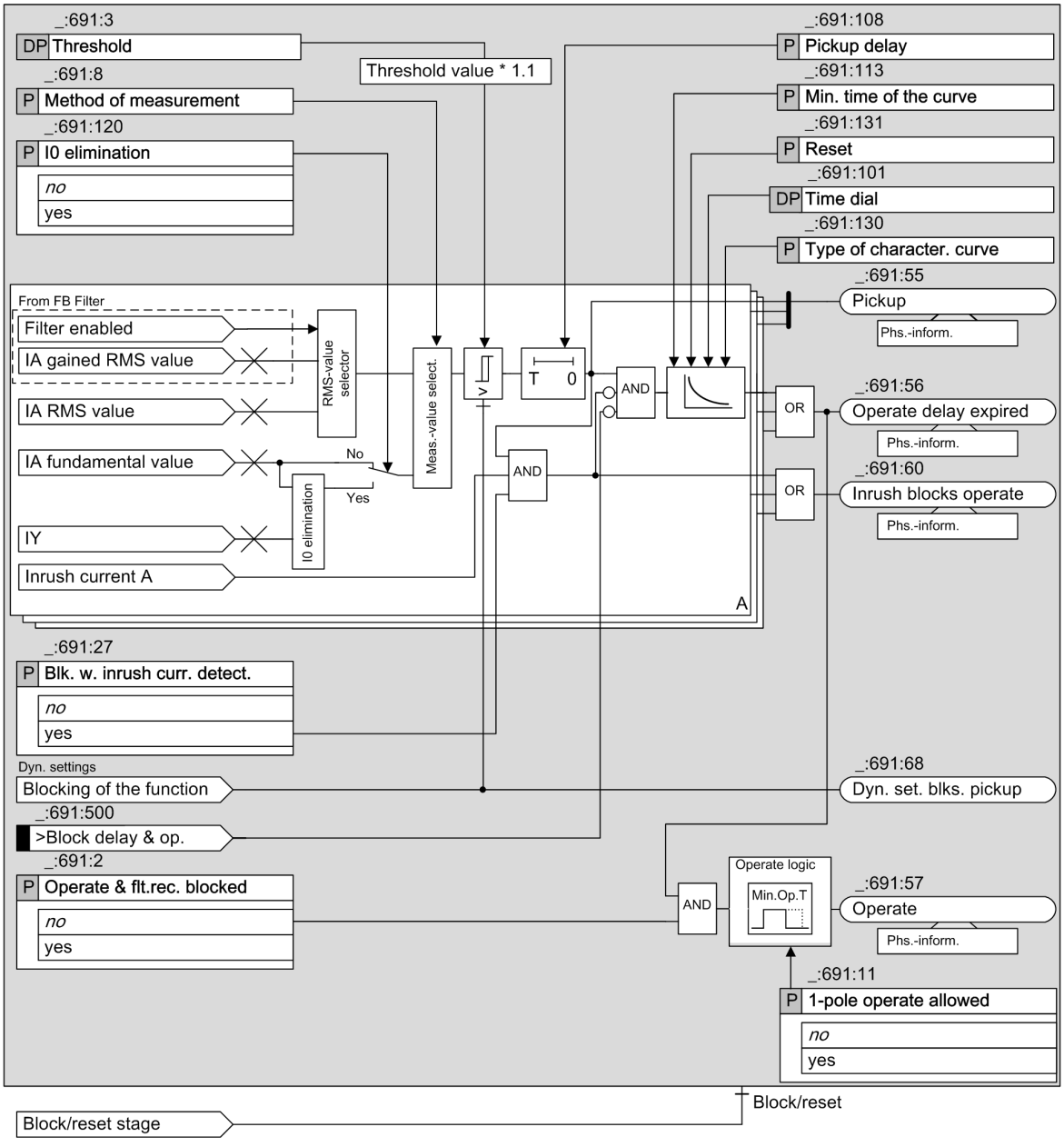
Figure 6-13 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage



[lo_Stage Control, 1, en_US]

Figure 6-14 Logic Diagram of the Stage Control



[loocp3p2-310511-01.tif, 3, en_US]

Figure 6-15 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Advanced

RMS-Value Selection (Advanced Stage)

If ***RMS value*** is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block **Filter**

If the function block **Filter** is configured and if youSelf practise_LG_OCP_Inverse time_Advanced, 1, en_US have enabled the filter, the gained RMS value is automatically used.

NOTE

When the function blcok **Filter** is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

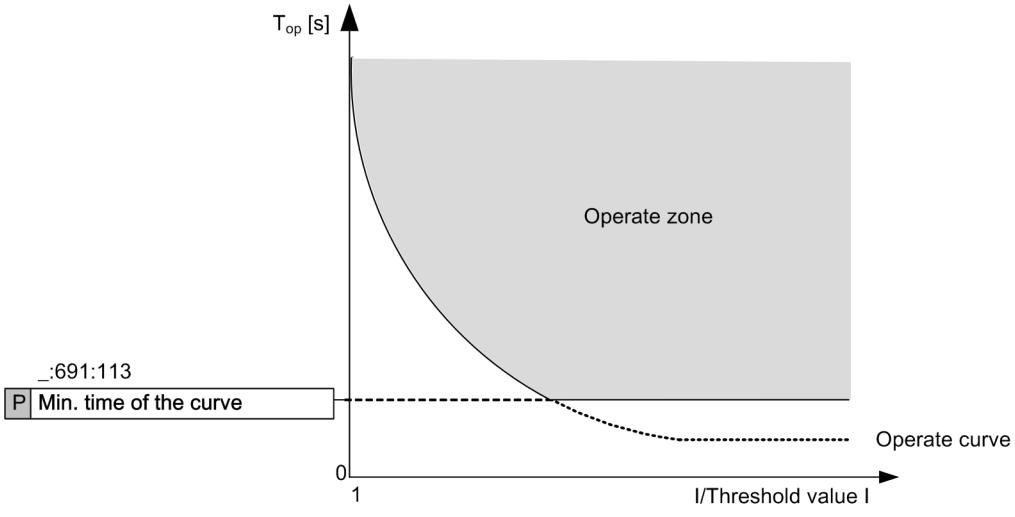
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **`Min. time of the curve`**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwOcp3Mi_20140715-01, 1, en_US]

Figure 6-16 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

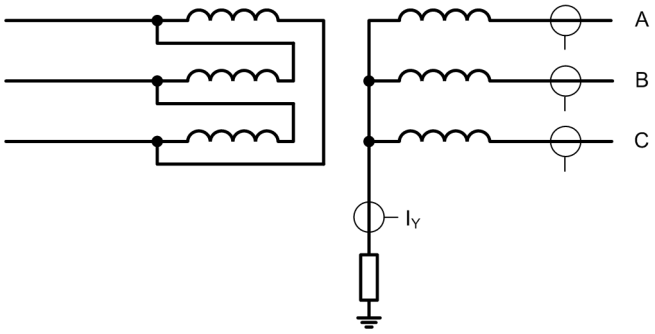
Method of Measurement (Basic and Advanced Stage)

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the phase-to-phase fault on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection applications on one transformer.
In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.



[dwsgaocp-230414-01, 1, en_US]

Figure 6-17 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the **Voltage/current 1-phase**. The function group **Voltage/current 1-phase** must be connected to the function group **Voltage/current 3-phase** in which the function **Overcurrent protection, phases** is used.

Connect protection-function group to protection-function group

	VI 3ph 1
Protection group	neutral point
(All)	(All)
VI 1ph 1	X

[sccpfoint-230414-01, 1, en_US]

Figure 6-18 Connection of the Function Group Voltage/Current 1-Phase with the Neutral Point Input of the Voltage/Current 3-Phase Function Group

In case of an I0 elimination, the following calculations must be considered:

$\underline{I}_{A\text{-elim.}} = \underline{I}_A - 1/3\ \underline{I}_Y$

$\underline{I}_{B\text{-elim.}} = \underline{I}_B - 1/3\ \underline{I}_Y$

$\underline{I}_{C\text{-elim.}} = \underline{I}_C - 1/3\ \underline{I}_Y$

The phase current $\underline{I}_{phx\text{-elim.}}$ is necessary for the following protection process.

If the **`Method of measurement`** parameter is set to ***`fundamental comp.`***, the I0 elimination is operating.

The currents $\underline{I}_{phx\text{-elim.}}$ are available as functional values.

Pickup Delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay starts. If the threshold is exceeded during the pickup delay time, the pickup signal is generated.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **`>Block stage`** from an external or internal source
- Via the functionality of the **`dynamic settings`** (only available in the Advanced function type, see subtitle **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic Reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.3.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:691:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value*** Parameter Value

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Type of character. curve

- Default setting **(_:691:130) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Min. time of the curve

- Default setting **(_:691:113) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: `Additional time delay`

- Default setting **`(_:691:115) Additional time delay`** = ***`0.00 s`***

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic time.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: `Threshold`

- Default setting **`(_:691:3) Threshold`** = ***`1.500 A`***

Set the **`Threshold`** and **`Type of character. curve`** parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Set the **`Threshold`** parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **`Threshold`**.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power	
P_{max}	= 120 MVA
Correspondingly	
I_{max}	= 630 A
Current transformer	= 600 A/5 A

Settings in primary and secondary values result in the setting values:

Threshold value I> (primary) = 630 A

$$\text{Threshold value I> (secondary)} = \frac{630\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 5.25\ \text{A}$$

[foocp005-030311-01.tif, 2, en_US]

Parameter: `I0 elimination`

- Default setting **`(_:661:120) I0 elimination`** = ***`no`***

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase faults on the low-voltage side of the transformer. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter **`Method of measurement`** is set to ***`fundamental comp.`***.

With the **`I0 elimination`** setting, you can switch the I0 elimination function on or off.

Parameter: `Pickup delay`

- Default setting **`(_:661:102) Pickup delay`** = ***`0.00 s`***

This parameter is not visible in the basic stage.

For special applications it is desirable if the current threshold is briefly exceeded, that this will not lead to the pickup of the stage and starts fault logging or recording. If this stage is used as a thermal overload function, that is considered a special application.

When using the **`Pickup delay`** parameter, a time interval is defined during which a pickup is not trigger if the current threshold is exceeded.

For all short-circuit protection applications, this value is 0.00 s and is considered as a default.

Parameter: `Time dial`

- Default setting **`(_:691:101) Time dial`** = ***`1.00`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **`Time dial`** at ***`1`*** (default setting).

Parameter: `Reset`

- Default setting **`(_:691:131) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `1-pole operate allowed`

- Default setting **`(_:691:11) 1-pole operate allowed`** = ***`no`***

The parameter must be set for the specific application.

Parameter Value	Description
`no`	The stage always operates 3-pole.
`yes`	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group **Circuit-breaker**) is always 3-pole because the device does not support phase-selective tripping.

6.3.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:691:1	Inverse-T 1:Mode		• off • on • test	off
_:691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:691:11	Inverse-T 1:1-pole operate allowed		• no • yes	no
_:691:26	Inverse-T 1:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:691:120	Inverse-T 1:I0 elimination		• no • yes	no
_:691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:108	Inverse-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:691:130	Inverse-T 1:Type of character. curve			
_:691:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:691:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:691:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:691:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:691:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:691:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:691:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:691:36	Inverse-T 1:Stage blocked		• no • yes	no
_:691:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:691:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:691:37	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:691:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:691:38	Inverse-T 1:Stage blocked		• no • yes	no
_:691:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:691:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:691:39	Inverse-T 1:Stage blocked		• no • yes	no
_:691:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:691:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:691:40	Inverse-T 1:Stage blocked		• no • yes	no
_:691:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:691:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:691:41	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.3.5.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:691:81	Inverse-T 1:>Block stage	SPS	I
_:691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:691:54	Inverse-T 1:Inactive	SPS	O
_:691:52	Inverse-T 1:Behavior	ENS	O
_:691:53	Inverse-T 1:Health	ENS	O
_:691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:691:59	Inverse-T 1:Disk emulation running	SPS	O
_:691:55	Inverse-T 1:Pickup	ACD	O
_:691:56	Inverse-T 1:Operate delay expired	ACT	O
_:691:57	Inverse-T 1:Operate	ACT	O

6.3.6 Stage with User-Defined Characteristic Curve

6.3.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.3.5.1 Description*). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

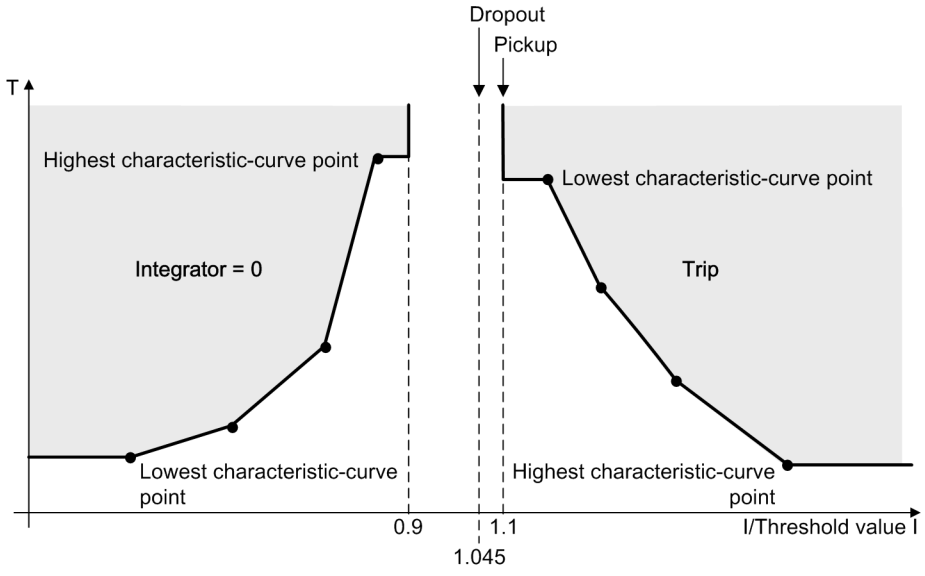
Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The

dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dwocpken-140611-02.tif, 1, en_US]

Figure 6-19 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

The currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.3.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage. The only difference is that you can define the characteristic curve as desired. This chapter provides only application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1***.

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation but an instantaneous dropout is desired.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.



NOTE

The value pairs must be entered in continuous order.

Parameter: 1-pole operate allowed

- Default setting **(_:11) 1-pole operate allowed** = ***no***

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group **Circuit breaker**) is always 3-pole because the device does not support phase-selective tripping.

6.3.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:11	User curve #:1-pole operate allowed		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:120	User curve #:I0 elimination		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:111	User curve #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

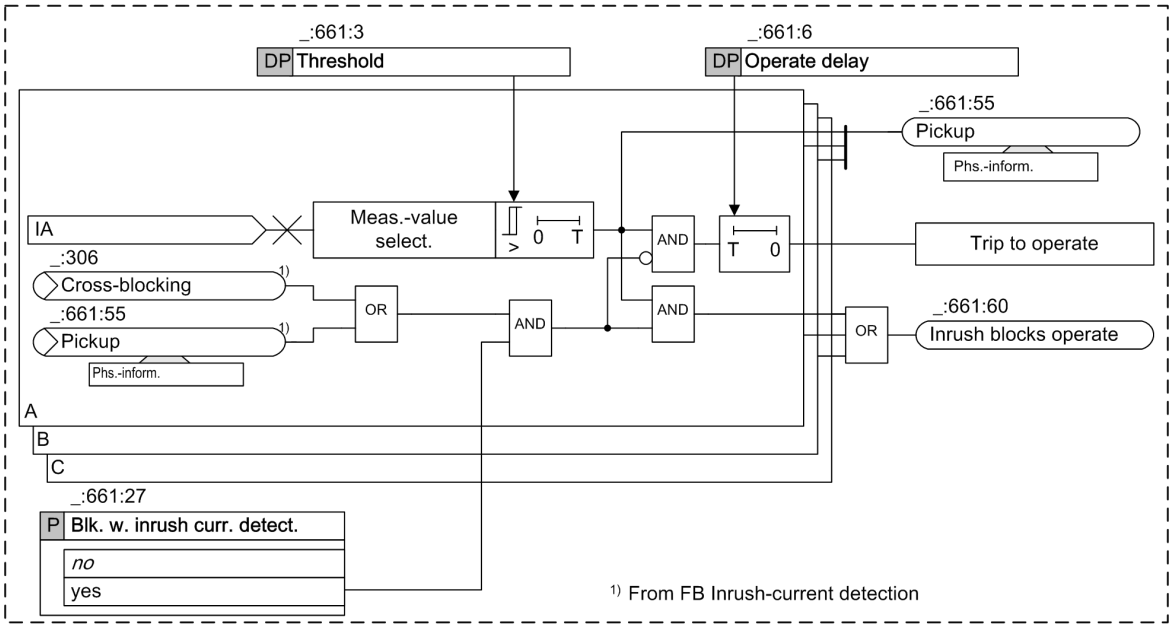
6.3.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.3.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.3.7.1 Description

With the **`Blk. w. inrush curr. detect.`** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite time-overcurrent protection stage 1) that illustrates the influence of the blocking. Only if the central function **Inrush-current detection** (see chapter *12.10 Inrush-Current Detection*) is in effect can the blocking be set.



[loocp3pha-210812-01.vsd, 1, en_US]

Figure 6-20 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite Time-Overcurrent Protection Stage

6.3.7.2 Application and Setting Notes

Parameter: **`Blk. w. inrush curr. detect.`**

- Default setting **`(_:661:27) Blk. w. inrush curr. detect.`** = ***`no`***

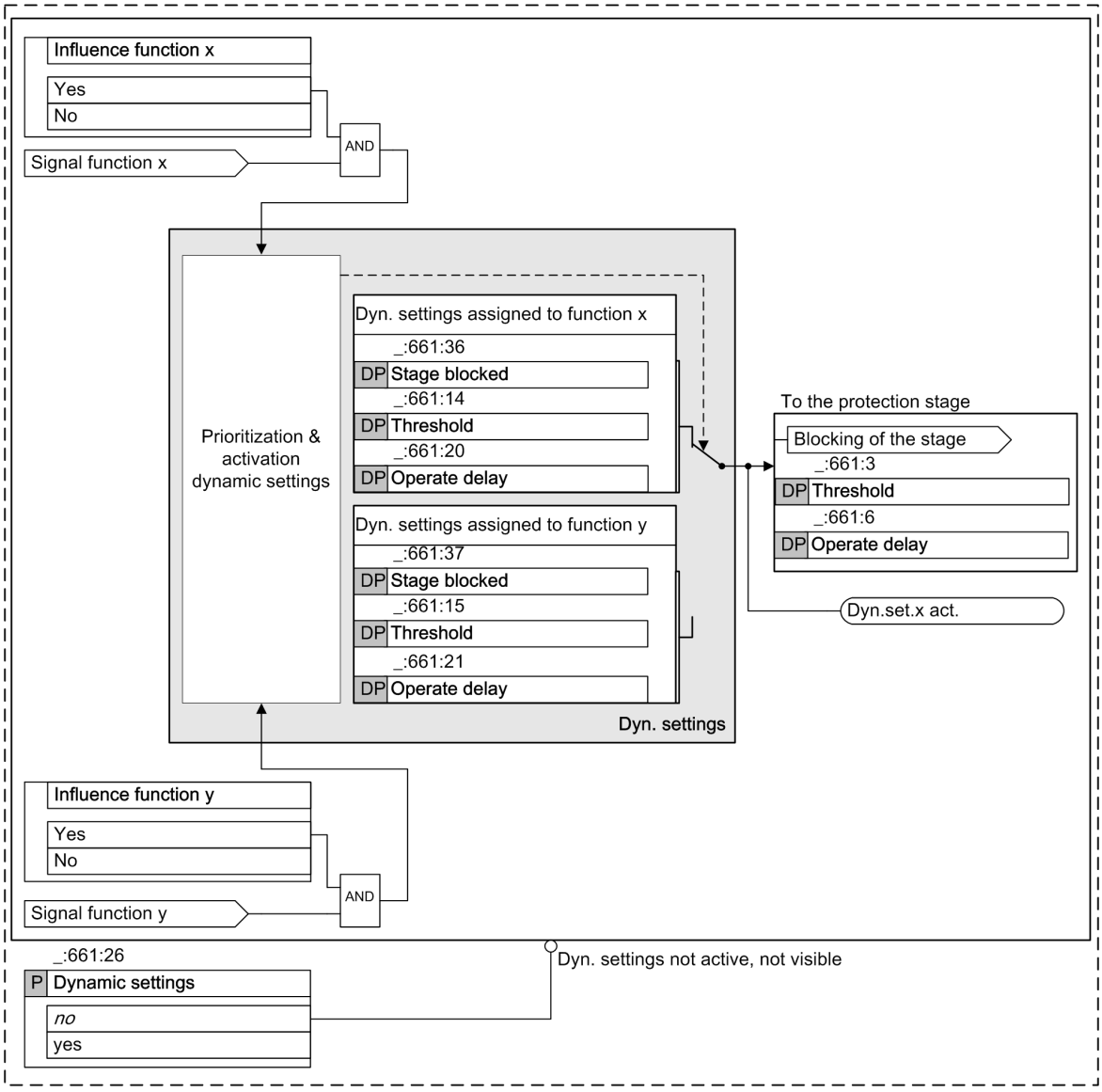
Parameter Value	Description
`no`	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
`yes`	When the transformer inrush current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.3.8 Influence of Other Functions via Dynamic Settings

6.3.8.1 Description

The parameters **`Threshold`** and **`Operate delay`** used for tripping are so-called **`dynamic settings`**. Depending on other functions, the settings of these parameters can be changed dynamically (see

Figure 6-21). Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.



[loocp3dpa-030311-01.vsd, 1, en_US]

Figure 6-21 Principle of the Dynamic Settings Exemplified by 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

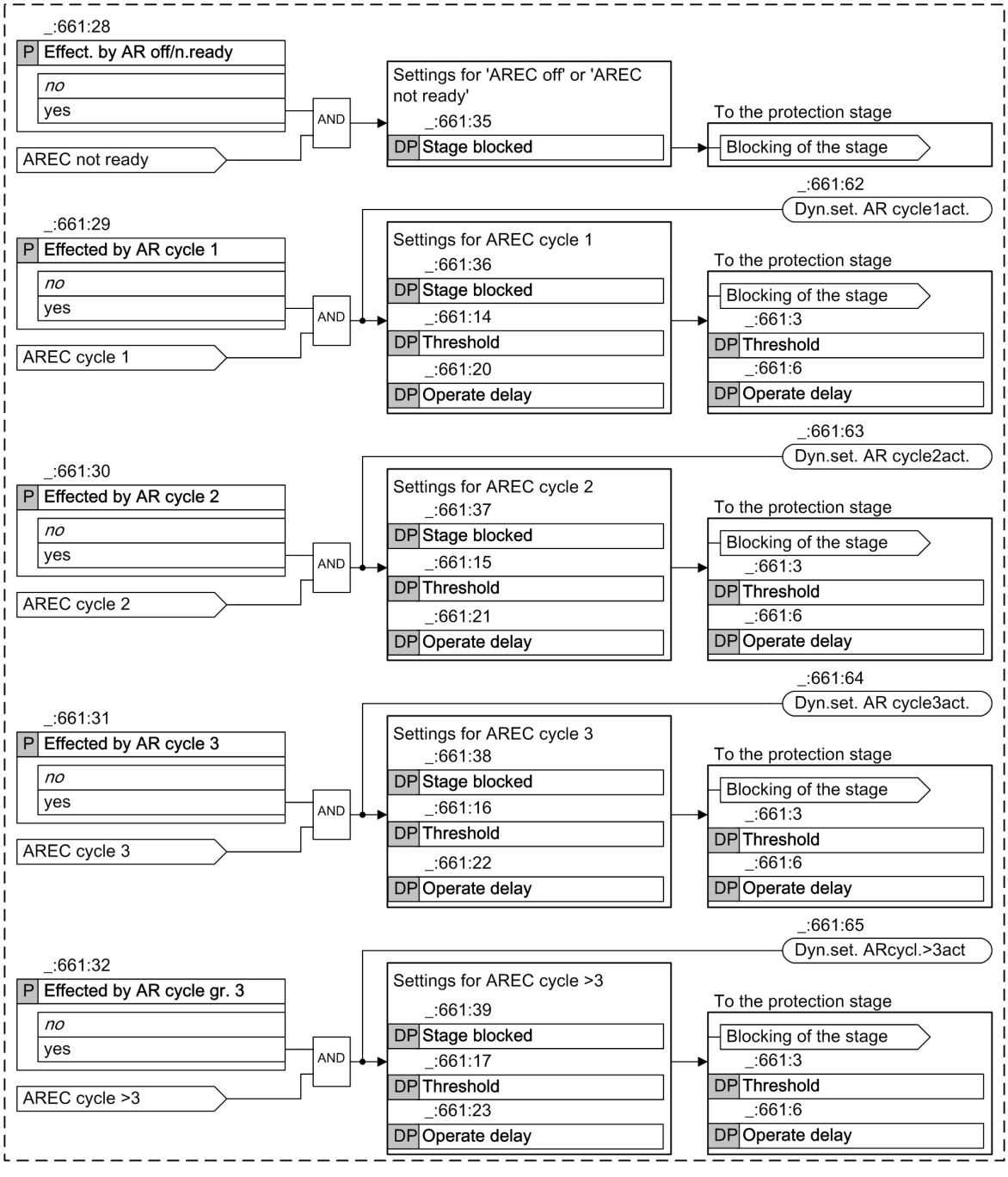
These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings of the **Threshold** and **Operate delay** parameters are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter **Influence of function ...** and its own dynamic settings (**Operate delay** and **Threshold**). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for

example, signal function x) becomes active and is to take effect, these settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Automatic Reclosing (Advanced Stage)*



[loocp3awe-040311-01, 1, en_US]

Figure 6-22 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several AREC signals can affect the setting for the **Threshold** and **Operate delay** parameters of the protection stage and its blocking.

- AREC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- AREC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- AREC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- AREC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

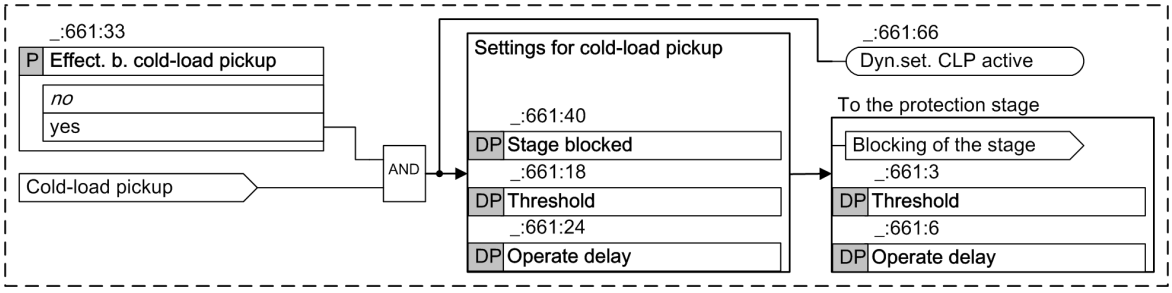
- AREC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the AREC is ready and the protection stage is in the idle state, the settings for **AREC cycle 1** are active and not the standard settings. The standard settings are active in the case of **AREC off/not ready**.

The influence can be activated for each signal individually. You also have to set the **Threshold** and **Operate delay** or **Stage blocked** parameters, which take effect when the signal is active.

The way AREC signals are generated is described in chapter *6.43.1 Overview of Functions*.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*



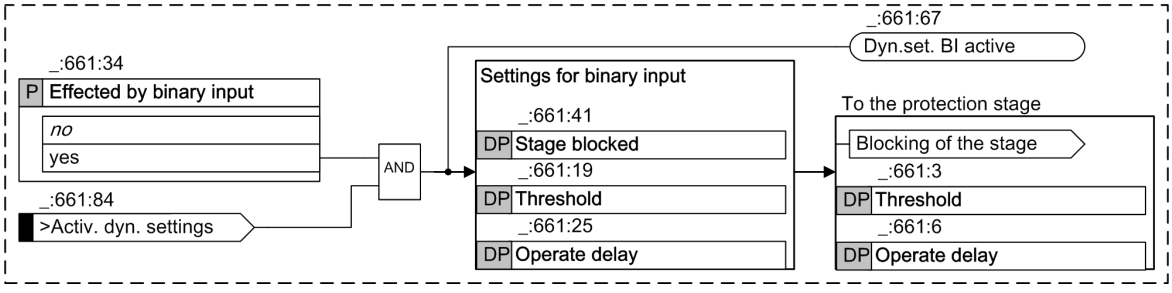
[loocp3kal-030311-01.vsd, 1, en_US]

Figure 6-23 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

In the case of cold-load pickup, you have the option to change the settings for the **Threshold** and **Operate delay** parameters of the protection level. You can also block the level. To do so, you must activate the influence of the cold-load pickup. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

The way signals are generated **Cold-load pickup** is described in chapter *5.8.1 Overview of Functions*.

Link to an External *Function via a Binary Input Signal (Advanced Stage)*



[loocp3bin-030311-01.vsd, 1, en_US]

Figure 6-24 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal **>Activ. dyn. settings** to change the settings for the **Threshold** and the **Operate delay** parameters of the protection stage. You can also block the level. To do so, you must activate the influence of the binary input. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

6.3.8.2 Application and Setting Notes (Advanced Stage)

Parameter: **Dynamic settings**

- Default setting **(_:661:26) Dynamic settings** = ***no***

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (automatic reclosing function or cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters **Influence of function...** as well as the dynamic settings **Threshold**, **Operate delay** and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

Influence of AREC

The example of how the overcurrent stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by AREC.

The setting of the overcurrent stage (1st stage) results from the time-grading schedule. Additionally, it is to be used as fast stage before an automatic reclosing. Because a fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the tripping delay can be set to ***0*** or a very small value. To achieve the selectivity, the final disconnection must be done with the grading time.

AREC is set to 2 reclosings. A secondary **Threshold** of ***1.5 A*** and a **Operate delay** of ***600 ms*** are assumed (according to the time-grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings **Effected by AR cycle 1** and **Effected by AR cycle 2** are changed in the example to ***yes*** (= influenced). This activates the **AR cycle 1** and **AR cycle 2** input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings **Operate delay** assigned to these input signals (sources of influence) are set to the time delay ***0*** (instantaneous tripping). The two dynamic settings **Threshold** assigned to these input signals are set to the normal threshold value of ***1.5 A***.

If the threshold value (***1.5 A***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***600 ms*** according to the time-grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the AREC function is performed by an external device.

To realize the application, the configuration setting **Effected by binary input** must be changed to ***yes*** (= influenced). This activates the **>Activ. dyn. settings** input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings. The external device must provide the **Cycle 1** and **Cycle 2** signals or, alternatively, the **AR ready** signal. The signals must be connected with the binary input signal **>Activ. dyn. settings**.

The dynamic setting **Operate delay**, which is assigned to the input signal (source of influence) **>Activ. dyn. settings**, is set to the time delay ***0*** (instantaneous tripping). The dynamic setting **Threshold** assigned to this input signal is set to the normal threshold value of ***1.5 A***.

If the threshold value (***1.5 A***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***600 ms*** according to the time-grading schedule.

6.4 Voltage-Dependent Overcurrent Protection, Phases

6.4.1 Overview of Functions

The **Voltage-dependent overcurrent protection** (ANSI 51V) function:

- Detects short circuits affecting electric equipment
- Can be used for special network conditions where the overcurrent pickup level should be decreased depending on the fault voltage
- Can be used for generators where the excitation voltage is derived from the machine terminals and the overcurrent pickup should be kept depending on the fault voltages

6.4.2 Structure of the Function

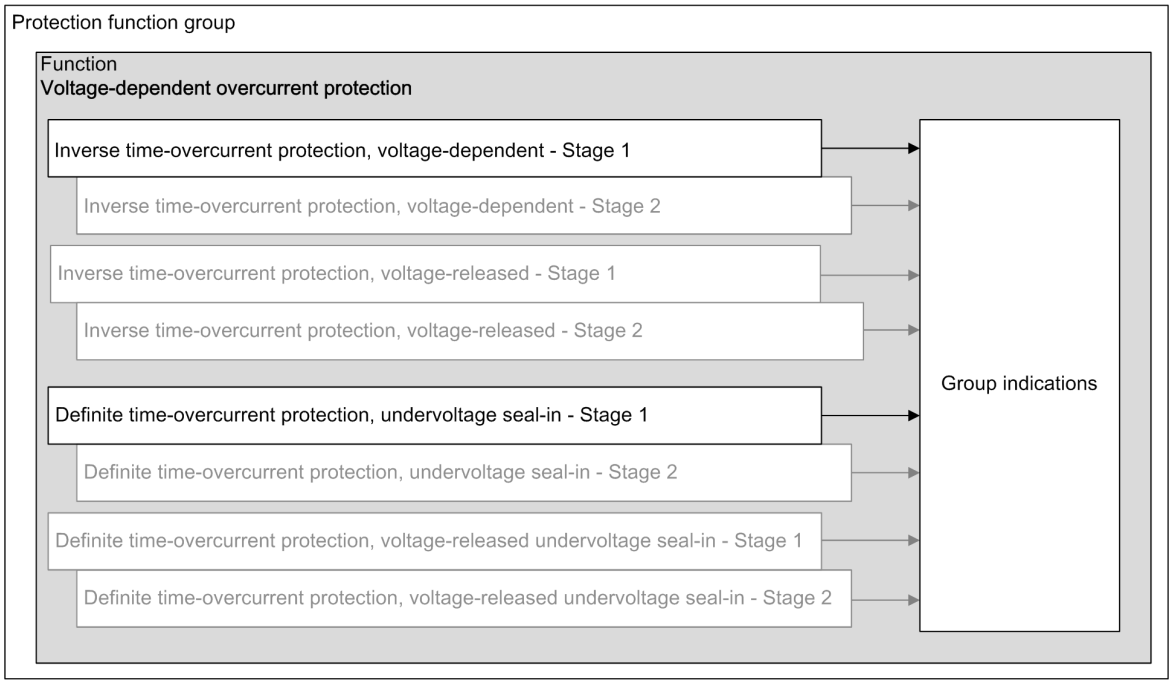
The **Voltage-dependent overcurrent protection** function is used in protection function groups with 3-phase current and voltage measurement.

The function **Voltage-dependent overcurrent protection** comes with the following factory-set stages:

- Inverse time-overcurrent protection, voltage-dependent stage
- Definite time-overcurrent protection, undervoltage seal-in stage

In this function, the following stages can operate simultaneously:

- A maximum of 2 inverse time-overcurrent protection, voltage-dependent stages
- A maximum of 2 inverse time-overcurrent protection, voltage-released stages
- A maximum of 2 definite time-overcurrent protection, undervoltage seal-in stages
- A maximum of 2 definite time-overcurrent protection, voltage-released undervoltage seal-in stages



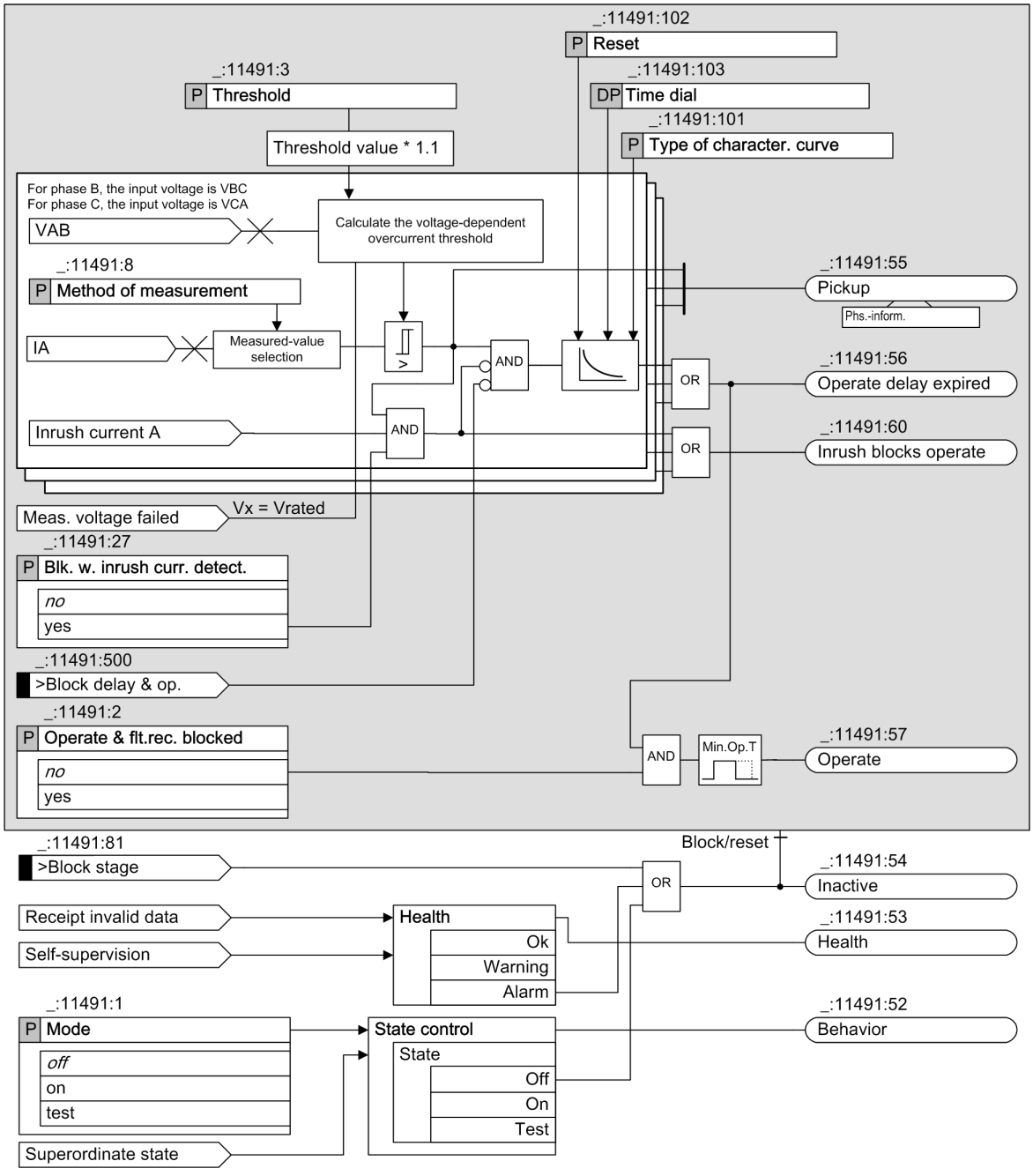
[dwstuvol-210713-03_Release.vsd, 2, en_US]

Figure 6-25 Structure/Embedding of the Function

6.4.3 Stage with Inverse Time-Overcurrent Protection, Voltage-Dependent

6.4.3.1 Description

Logic of the Stage



[lovoldep-210713-01.tif, 1, en_US]

Figure 6-26 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Dependent

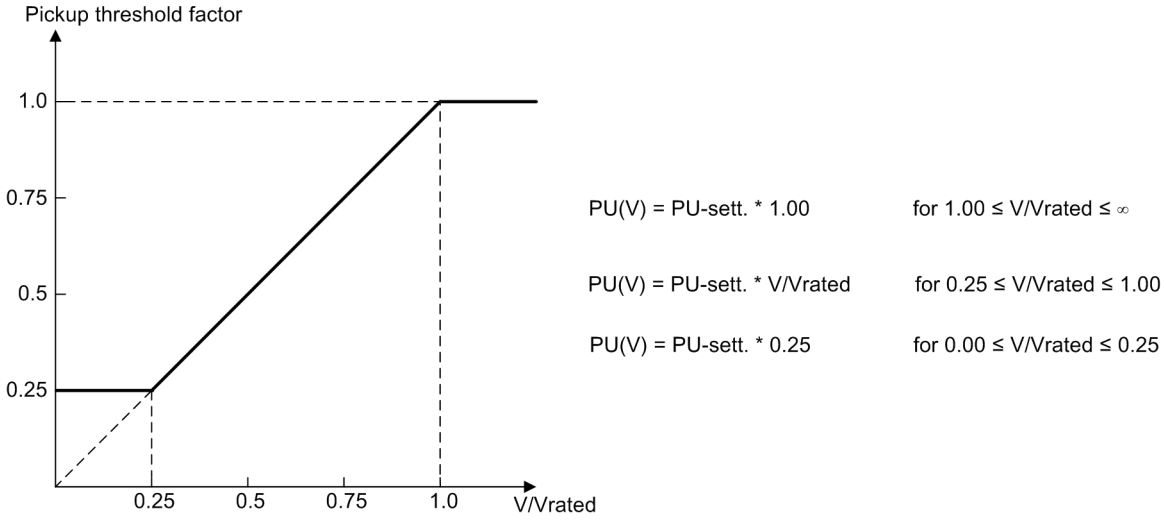
Method of Measurement

You use the **`Method of measurement`** parameter to define whether the stage uses the *`fundamental comp.`* (standard method) or the calculated *`RMS value`*.

- Measurement of the fundamental comp.:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Voltage-Dependent Pickup Threshold

The pickup threshold of the overcurrent stage depends on the voltage magnitude. A lower voltage decreases the current pickup value (see *Figure 6-27*). In the range between V/V_{rated} = 1.00 to 0.25 a linear, directly proportional dependence is realized.



[dwvolpic-220713-01.tif, 1, en_US]

Figure 6-27 Voltage Influence of the Pickup Threshold

With:

V	=	Measured phase-to-phase voltage
V_{rated}	=	Rated voltage (parameter Rated voltage in the function block General of the protection function group)
PU sett.	=	Pickup threshold setting (parameter address: _11491:3)
PU(V)	=	Applied pickup threshold according to the voltage influence

The minimum current pickup threshold value is 0.03 * Irated. This value cannot be decreased any further even not by voltage-dependent pickup threshold factor.

Decreasing the pickup threshold is carried out phase-selectively. The assignment of voltages to current-carrying phases is shown in *Table 6-1*.

Table 6-1 Controlling Voltages in Relation to the Fault Current

Current	Controlling Voltage
I_A	V_{AB}
I_B	V_{BC}
I_C	V_{CA}

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by 1.045 times (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to the characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical data.

Influence On the Operate Curve

The current pickup threshold is decreased proportional to the voltage decrease. Consequently, for a constant current I the I/Threshold-value ratio is increased and the operate time is reduced. Compared with the standard curves represented in the **Technical Data**, the operate curve shifts to the left side as the voltage decreases.

Measuring-Voltage Failure Detection

In case of a measuring-voltage failure detection the input voltage value is automatically set to V_{rated}, so that the pickup threshold factor will be 1.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

6.4.3.2 Application and Setting Notes

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:11491:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: `Method of measurement`

- Recommended setting value **`(_:11491:8) Method of measurement`** = ***`fundamental comp.`***

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** (standard method) or the calculated ***`RMS value`***.

Parameter Value	Description
`fundamental comp.`	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
`RMS value`	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).

Parameter: `Threshold`

- Default setting **`(_:11491:3) Threshold`** = ***`1.500 A`***

The recommended setting value of 1.500 A is suitable for most applications.

Set the **`Threshold`** and **`Type of character. curve`** parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection.

Set the **`Threshold`** parameter for lines to approx.10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **`Threshold`**.

Parameter `Type of character. curve`

- Default setting **`(_:11491:101) Type of character. curve`** = ***`IEC normal inverse`***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **`Type of character. curve`** required for your specific application.

Parameter: `Reset`

- Default setting **`(_:11491:102) Reset`** = ***`disk emulation`***

The **`Reset`** parameter allows you to define whether the stage decreases according to the dropout characteristic curve (behavior of a disk emulation = rotor disc) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

Parameter: `Time dial`

- Default setting **`(_:11491:103) Time dial`** = ***`1`***

You can use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The setting value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **`Time dial`** at 1 (default setting).

6.4.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-dependent 1				
_:11491:1	V-dependent 1:Mode		• off • on • test	off
_:11491:2	V-dependent 1:Operate & flt.rec. blocked		• no • yes	no
_:11491:27	V-dependent 1:Blk. w. inrush curr. detect.		• no • yes	no
_:11491:8	V-dependent 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:11491:3	V-dependent 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:11491:101	V-dependent 1:Type of character. curve			
_:11491:102	V-dependent 1:Reset		• instantaneous • disk emulation	disk emulation
_:11491:103	V-dependent 1:Time dial		0.05 to 15.00	1.00

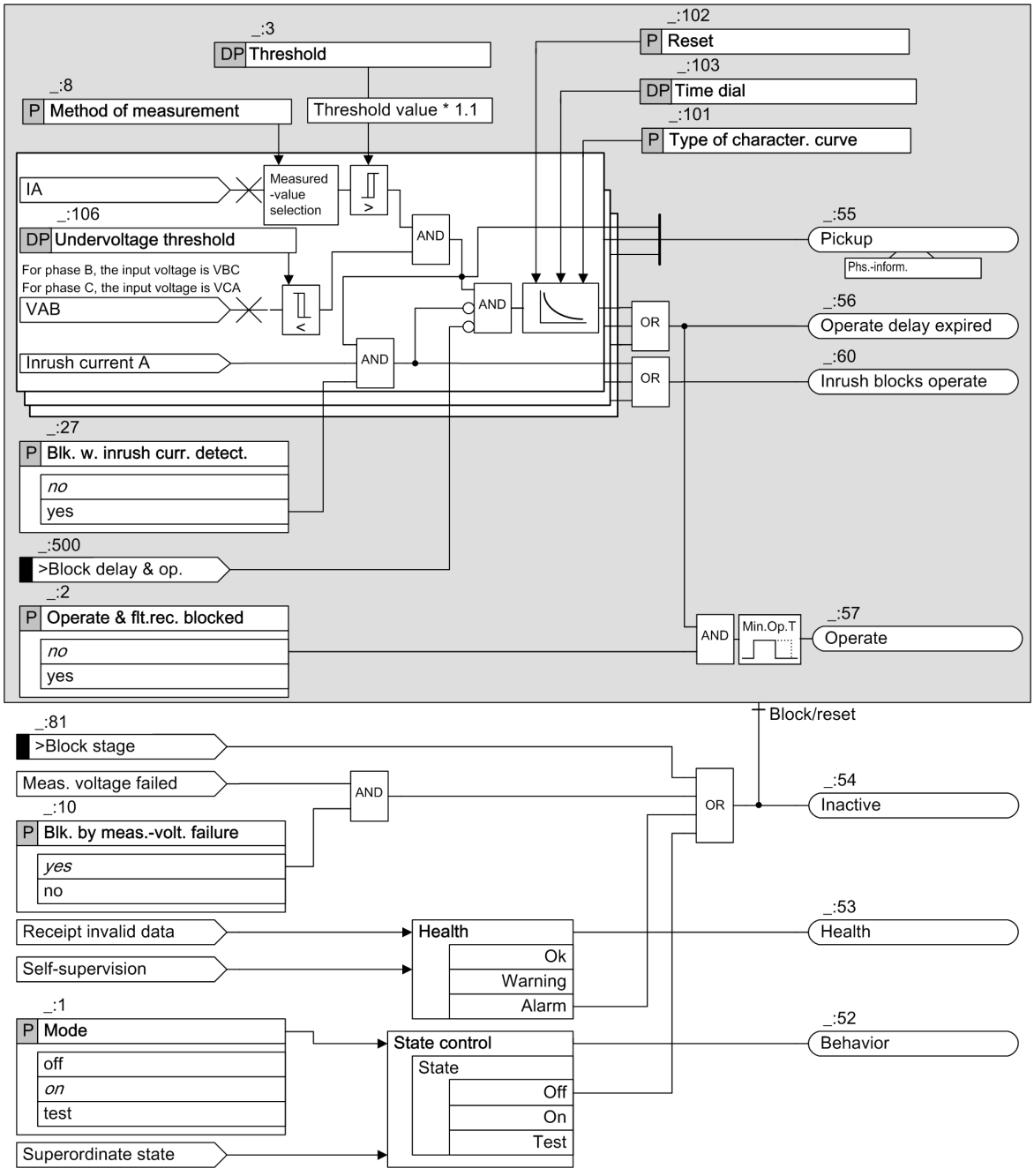
6.4.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
V-dependent 1			
_:11491:81	V-dependent 1:>Block stage	SPS	I
_:11491:500	V-dependent 1:>Block delay & op.	SPS	I
_:11491:54	V-dependent 1:Inactive	SPS	O
_:11491:52	V-dependent 1:Behavior	ENS	O
_:11491:53	V-dependent 1:Health	ENS	O
_:11491:60	V-dependent 1:Inrush blocks operate	ACT	O
_:11491:59	V-dependent 1:Disk emulation running	SPS	O
_:11491:55	V-dependent 1:Pickup	ACD	O
_:11491:56	V-dependent 1:Operate delay expired	ACT	O
_:11491:57	V-dependent 1:Operate	ACT	O

6.4.4 Stage with Inverse Time-Overcurrent Protection, Voltage-Released

6.4.4.1 Description

Logic of the Stage



[lovolrel-210713-01.tif, 1, en_US]

Figure 6-28 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Released

This stage is structured in the same way as the Inverse time-overcurrent, voltage-dependent stage (see chapter *6.4.3.1 Description*). The only differences are the conditions for the pickup and the influence on the operate curve.

Measuring-Element Release

When the controlling voltage drops below the setting **Undervoltage threshold**, the respective measuring element is released.

The release of the measuring elements is carried out phase-selectively. The assignment of voltages to current-carrying phases is shown in *Figure 6-27*.

Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In case of a blocking, the picked up stage is reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.4.4.2 Application and Setting Notes

This stage is structured in the same way as the **Inverse time-overcurrent, voltage-dependent** stage. The only differences are the conditions for the pickup and the influence on the operate curve. This chapter only provides the application and setting notes for the setting **Blk. by meas.-volt. failure** and **Undervoltage threshold**. For guidance on the other parameters of this stage, refer to chapter *6.4.3.2 Application and Setting Notes*.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You can use the **Blk. by meas.-volt. failure** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
no	The overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.
yes	The overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

Parameter: **Undervoltage threshold**

- Default setting **(_:104) Undervoltage threshold** = ***75.0 V***

When the controlling voltage is below the set value, the inverse time-overcurrent stage is released.

The parameter is set to a value just below the lowest phase-to-phase voltage admissible during operation, for example, from 75 % to 80 % of V_{rated}.

6.4.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-release #				
_:1	V-release #:Mode		• off • on • test	off
_:2	V-release #:Operate & flt.rec. blocked		• no • yes	no
_:10	V-release #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	V-release #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	V-release #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	V-release #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:101	V-release #:Type of character. curve		• ANSI long-time inv. • ANSI short-time inv. • ANSI extremely inv. • ANSI very inverse • ANSI normal inverse • ANSI moderately inv. • ANSI definite inverse • IEC normal inverse • IEC very inverse • IEC extremely inv. • IEC long-time inverse	IEC normal inverse
_:102	V-release #:Reset		• instantaneous • disk emulation	disk emulation
_:103	V-release #:Time dial		0.05 to 15.00	1.00
_:104	V-release #:Undervoltage threshold		0.300 V to 175.000 V	75.000 V

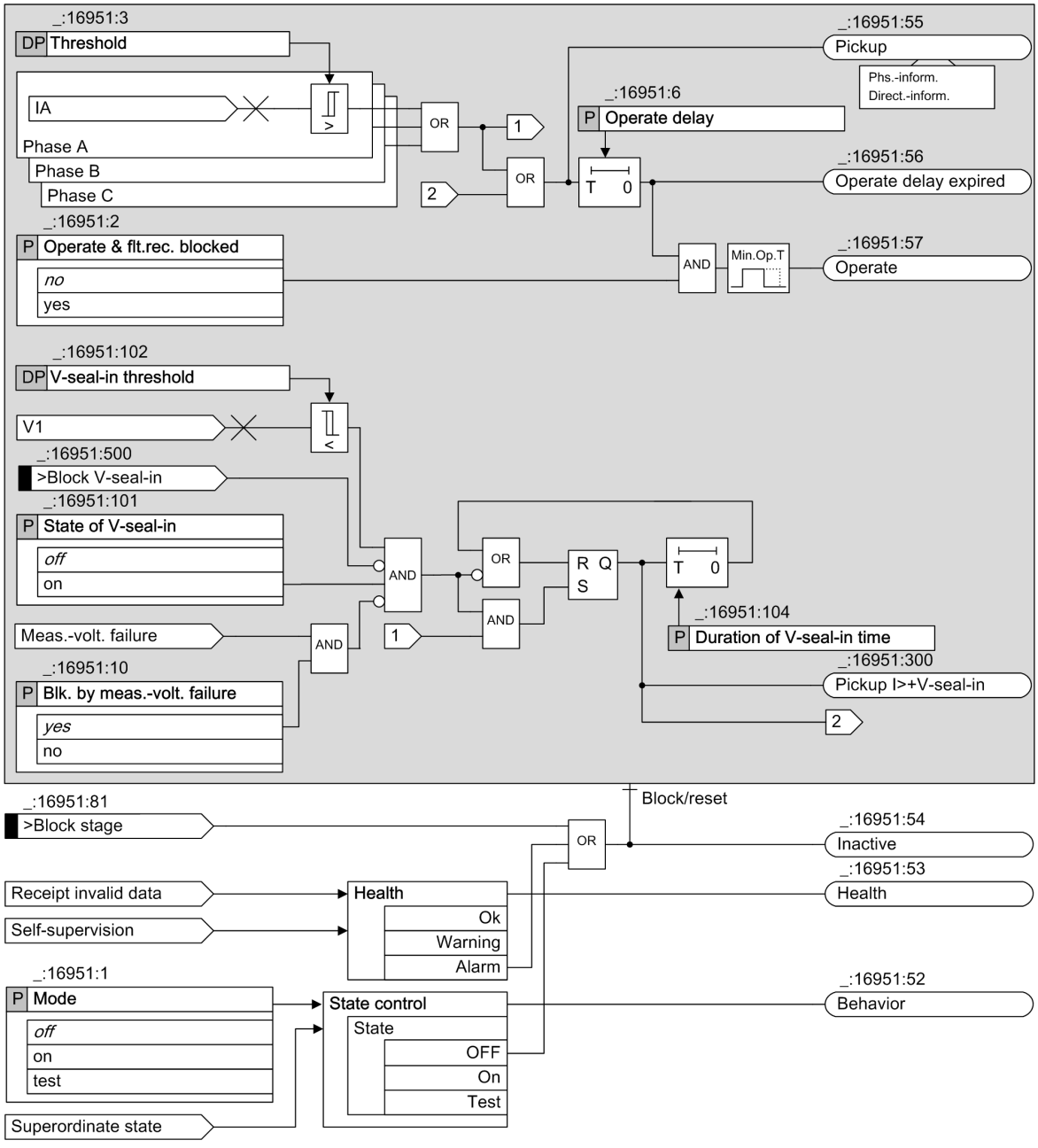
6.4.4.4 Information List

No.	Information	Data Class (Type)	Type
V-release #			
_:81	V-release #:>Block stage	SPS	I
_:500	V-release #:>Block delay & op.	SPS	I
_:54	V-release #:Inactive	SPS	O
_:52	V-release #:Behavior	ENS	O
_:53	V-release #:Health	ENS	O
_:60	V-release #:Inrush blocks operate	ACT	O
_:59	V-release #:Disk emulation running	SPS	O
_:55	V-release #:Pickup	ACD	O
_:56	V-release #:Operate delay expired	ACT	O
_:57	V-release #:Operate	ACT	O

6.4.5 Stage with Definite Time-Overcurrent Protection, Undervoltage Seal-In

6.4.5.1 Description

Logic of the Stage



[lo_Seal-in_20150215, 2, en_US]

Figure 6-29 Logic Diagram of the Definite Time-Overcurrent Protection, Undervoltage Seal-in

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short-circuit fault.

The pickup signal is maintained for a settable seal-in time **Duration of V-seal-in time**, if the positive-sequence voltage falls below a settable threshold **V-seal-in threshold** after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input *>Block V-seal-in*, the signal *Pickup I>+V-seal-in* drops out immediately.

You can switch off the undervoltage seal-in via the parameter **State of V-seal-in**.

Blocking of the Undervoltage Seal-in with Measuring-Voltage Failure

The **Undervoltage seal-in** can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal *Pickup I>+V-seal-in* drops out immediately. The following blocking options are available for the **Undervoltage seal-in**:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function.
- From an external source via the binary input signal *>Open* of the function block **VT miniature CB**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be used to control the measuring-voltage failure detection. The **Undervoltage seal-in** remains unaffected if the parameter **Blk. by meas.-volt. failure** is switched off.

6.4.5.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:16951:2) Operate & flt.rec. blocked** = ***no***

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting **(_:16951:3) Threshold** = ***1.350 A***

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the **Threshold** parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting **(_:16951:6) Operate delay** = ***3.00 s***

The parameter **Operate delay** must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:16951:10) Blk. by meas.-volt. failure** = ***yes***

With the parameter **Blk. by meas.-volt. failure**, you can activate (***yes***) or deactivate (***no***) the blocking by the **Measuring voltage failure detection** function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting **(_:16951:101) State of V-seal-in** = ***off***

With the parameter **State of V-seal-in**, the seal-in functionality can be activated (switched ***on***). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: `V-seal-in threshold`

- Default setting **`(_:16951:102) V-seal-in threshold`** = ***`46.2 V`***

The **`V-seal-in threshold`** (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, VT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, VT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{\text{rated ,Gen}}}{I_{\text{rated ,CT ,prim}}} \times I_{\text{rated ,VT ,sec}} = \frac{1.4 \times 483\ \text{A}}{500\ \text{A}} \times 1\ \text{A} = 1.35\ \text{A}$$

[fo_OCP_UVSI_threshold, 1, en_US]

$$\text{Undervoltage seal} - \text{in} = \frac{0.8 \times V_{\text{rated ,Gen}}}{V_{\text{rated ,VT ,prim}}} \times \frac{V_{\text{reated ,VT ,sec}}}{\sqrt{3}} = \frac{0.8 \times 6.3\ \text{kV}}{6.3\ \text{kV}} \times \frac{100\ \text{V}}{\sqrt{3}} = 46.200\ \text{V}$$

[fo_OCP_UVSI_Seal-in, 1, en_US]

Parameter: `Duration of V-seal-in time`

- Default setting **`(_:16951:104) Duration of V-seal-in time`** = ***`4.00 s`***

The parameter **`Duration of V-seal-in time`** limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter **`Operate delay`**. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

6.4.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`V-seal-in 1`				
_:16951:1	V-seal-in 1:Mode		• off • on • test	off
_:16951:2	V-seal-in 1:Operate & flt.rec. blocked		• no • yes	no
_:16951:3	V-seal-in 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:16951:6	V-seal-in 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:16951:10	V-seal-in 1:Blk. by meas.-volt. failure		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:16951:101	V-seal-in 1:State of V-seal-in		• off • on	off
_:16951:102	V-seal-in 1:V-seal-in threshold		0.300 V to 175.000 V	80.019 V
_:16951:104	V-seal-in 1:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s

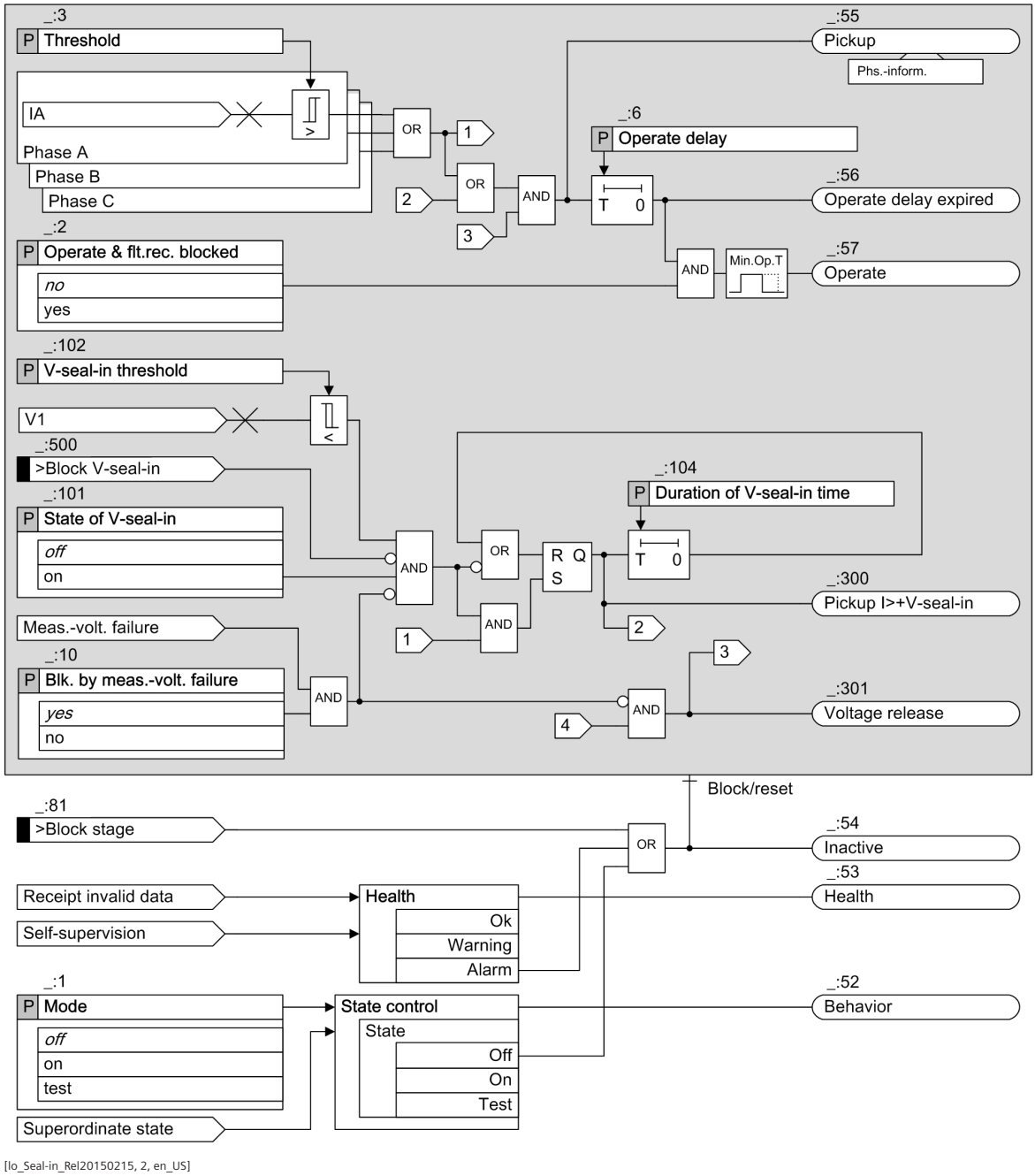
6.4.5.4 Information List

No.	Information	Data Class (Type)	Type
V-seal-in 1			
_:16951:81	V-seal-in 1:>Block stage	SPS	I
_:16951:500	V-seal-in 1:>Block V-seal-in	SPS	I
_:16951:52	V-seal-in 1:Behavior	ENS	O
_:16951:53	V-seal-in 1:Health	ENS	O
_:16951:54	V-seal-in 1:Inactive	SPS	O
_:16951:55	V-seal-in 1:Pickup	ACD	O
_:16951:300	V-seal-in 1:Pickup I>+V-seal-in	SPS	O
_:16951:56	V-seal-in 1:Operate delay expired	ACT	O
_:16951:57	V-seal-in 1:Operate	ACT	O

6.4.6 Stage with Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In

6.4.6.1 Description

Logic of the Stage



[lo_Seal-in_Rel20150215, 2, en_US]

Figure 6-30 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-in, Part 1

Signal 4 in the following figure refers to *Figure 6-30*.

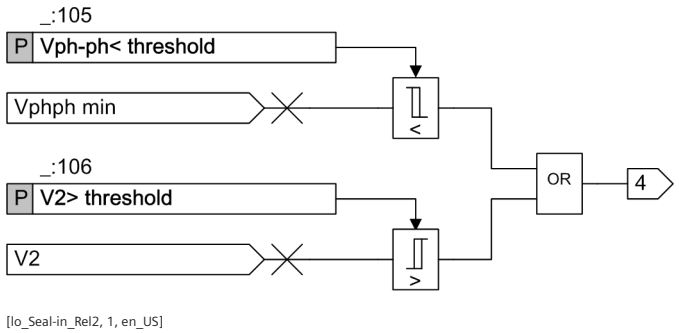


Figure 6-31 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-in, Part 2

Voltage Release

In addition to the current criterion with undervoltage seal-in, a voltage-released logic must be present to issue the indication *Pickup*. The voltage-released logic monitors the negative-sequence voltage and phase-to-phase voltages respectively for detecting unsymmetrical faults and symmetrical faults. With the voltage-released logic, the setting value of the parameter **Threshold** can be reduced in a certain range and the reliability and sensibility of this function can be improved correspondingly.

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short-circuit fault.

The pickup signal is maintained for a settable seal-in time **Duration of V-seal-in time**, if the positive-sequence voltage falls below a settable threshold **V-seal-in threshold** after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input *>Block V-seal-in*, the signal *Pickup I>+V-seal-in* drops out immediately.

You can switch off the undervoltage seal-in via the parameter **State of V-seal-in**.

Blocking of the Undervoltage Seal-in with Measuring-Voltage Failure

The **Undervoltage seal-in** can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal *Pickup I>+V-seal-in* drops out immediately. The following blocking options are available for the **Undervoltage seal-in**:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function.
- From an external source via the binary input signal *>Open* of the function block **VT miniature CB**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be used to control the measuring-voltage failure detection. The **Undervoltage seal-in** ramains unaffectecd if the parameter **Blk. by meas.-volt. failure** is switched off.

6.4.6.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = *no*

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1.350 A***

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the **Threshold** parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***3.00 s***

The parameter **Operate delay** must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:10) Blk. by meas.-volt. failure** = ***yes***

With the parameter **Blk. by meas.-volt. failure**, you can activate (***yes***) or deactivate (***no***) the blocking by the **Measuring voltage failure detection** function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting **(_:101) State of V-seal-in** = ***off***

With the parameter **State of V-seal-in**, the seal-in functionality can be activated (switched ***on***). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: V-seal-in threshold

- Default setting **(_:102) V-seal-in threshold** = ***46.2 V***

The **V-seal-in threshold** (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, VT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, VT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{\text{rated ,Gen}}}{I_{\text{rated ,CT,prim}}} \times I_{\text{rated ,VT,sec}} = \frac{1.4 \times 483\ \text{A}}{500\ \text{A}} \times 1\ \text{A} = 1.35\ \text{A}$$

[fo_OCP_UVSI_threshold, 1, en_US]

$$\text{Undervoltage seal-in} = \frac{0.8 \times V_{\text{rated ,Gen}}}{V_{\text{rated ,VT,prim}}} \times \frac{V_{\text{reated ,VT,sec}}}{\sqrt{3}} = \frac{0.8 \times 6.3\ \text{kV}}{6.3\ \text{kV}} \times \frac{100\ \text{V}}{\sqrt{3}} = 46.200\ \text{V}$$

[fo_OCP_UVSI_Seal-in, 1, en_US]

Parameter: **Duration of V-seal-in time**

- Default setting **(_:104) Duration of V-seal-in time** = ***4.00 s***

The parameter **Duration of V-seal-in time** limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter **Operate delay**. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

Parameter: **Vph-ph< threshold**

- Default setting **(_:105) Vph-ph< threshold** = ***60.000 V***

With the parameter **Vph-ph< threshold**, you can set the threshold at which the output signal *Voltage release* is activated when the minimum phase-to-phase voltage falls below this threshold.

Parameter: **V2> threshold**

- Default setting **(_:106) V2> threshold** = ***4.600 V***

With the parameter **V2> threshold**, you can set the threshold at which the output signal *Voltage release* is issued when V2 exceeds the threshold.

6.4.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Vseal-in+Vrel#				
_:1	Vseal-in+Vrel#:Mode		• off • on • test	off
_:2	Vseal-in+Vrel#:Operate & flt.rec. blocked		• no • yes	no
_:3	Vseal-in+Vrel#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:6	Vseal-in+Vrel#:Operate delay		0.00 s to 60.00 s	3.00 s
_:10	Vseal-in+Vrel#:Blk. by meas.-volt. failure		• no • yes	yes
_:101	Vseal-in+Vrel#:State of V-seal-in		• off • on	off
_:102	Vseal-in+Vrel#:V-seal-in threshold		0.300 V to 175.000 V	46.200 V
_:104	Vseal-in+Vrel#:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s
_:105	Vseal-in+Vrel#:Vph-ph< threshold		0.300 V to 175.000 V	60.000 V
_:106	Vseal-in+Vrel#:V2> threshold		0.300 V to 200.000 V	4.600 V

6.4.6.4 Information List

No.	Information	Data Class (Type)	Type
Vseal-in+Vrel#			
_:81	Vseal-in+Vrel#:>Block stage	SPS	I
_:500	Vseal-in+Vrel#:>Block V-seal-in	SPS	I
_:52	Vseal-in+Vrel#:Behavior	ENS	O
_:53	Vseal-in+Vrel#:Health	ENS	O
_:54	Vseal-in+Vrel#:Inactive	SPS	O
_:55	Vseal-in+Vrel#:Pickup	ACD	O
_:300	Vseal-in+Vrel#:Pickup I>+V-seal-in	SPS	O
_:301	Vseal-in+Vrel#:Voltage release	SPS	O
_:56	Vseal-in+Vrel#:Operate delay expired	ACT	O
_:57	Vseal-in+Vrel#:Operate	ACT	O

6.5 Overcurrent Protection, Ground

6.5.1 Overview of Functions

The **Overcurrent protection, ground** function (ANSI 50N/51N):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.5.2 Structure of the Function

The **Overcurrent protection, ground** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, ground – advanced** (50N/51N OC-gnd-A)
- **Overcurrent protection, ground – basic** (50N/51N OC-gnd-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the function type **Overcurrent protection, ground – advanced** the following stages can be operated simultaneously:

- Maximum of 3 stages **Definite time-overcurrent protection – advanced**
- 1 stage **Inverse time-overcurrent protection – advanced**
- 1 stage **User-defined characteristic curve overcurrent protection**

In the function type **Overcurrent protection, ground – basic** the following stages can be operated simultaneously:

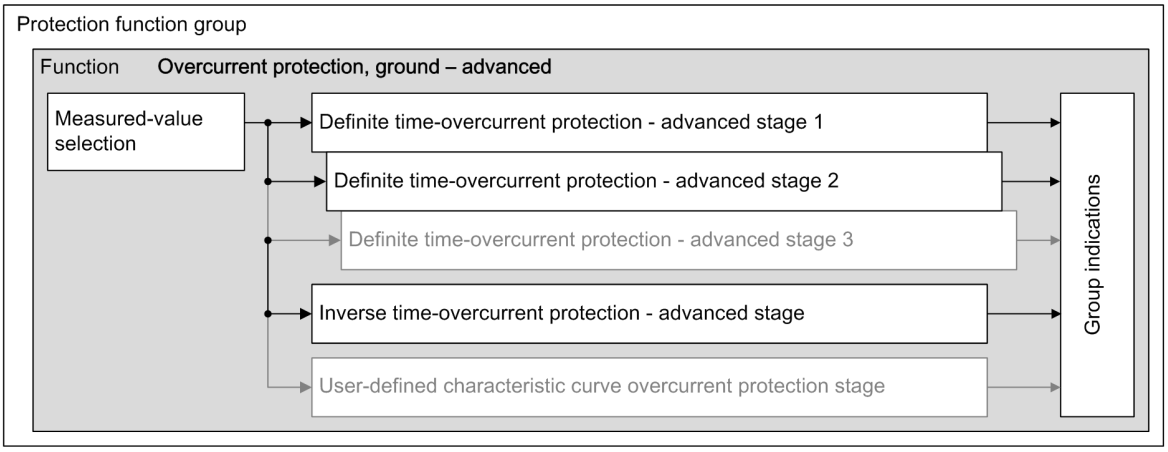
- Maximum of 3 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

The non-preconfigured stages are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The measured-value selection (only advanced stage) is general functionality and has a uniform effect on the stages (see *Figure 6-32* and chapter *6.5.3.1 Description*). This ensures that all stages of the function receive the same measured current value.

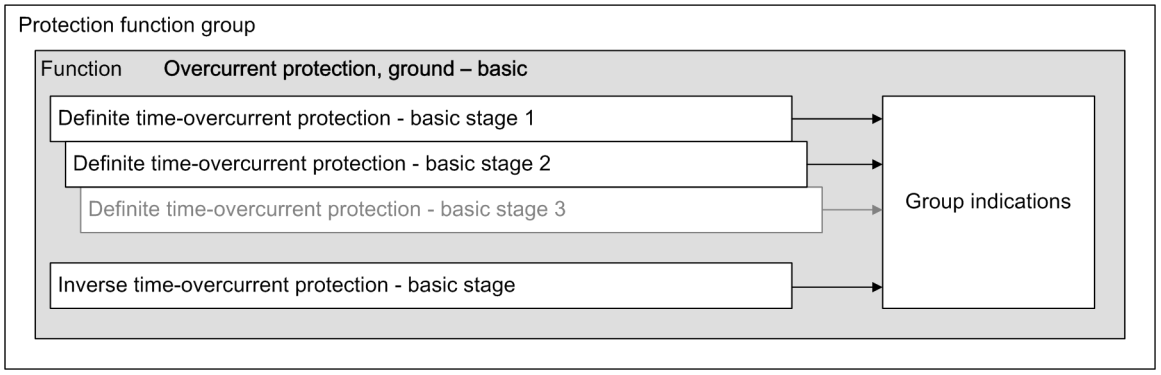
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dwocpga2-060213-01.tif, 4, en_US]

Figure 6-32 Structure/Embedding the Function Overcurrent Protection, Ground – Advanced



[dwocpgb1-060213-01.tif, 3, en_US]

Figure 6-33 Structure/Embedding the Function Overcurrent Protection, Ground – Basic

If the following listed, device-internal functions are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with an **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.5.3 General Functionality

6.5.3.1 Description

Measured-Value Selection

The function provides the option to select between the values ***IN measured*** or ***3I0 calculated***.

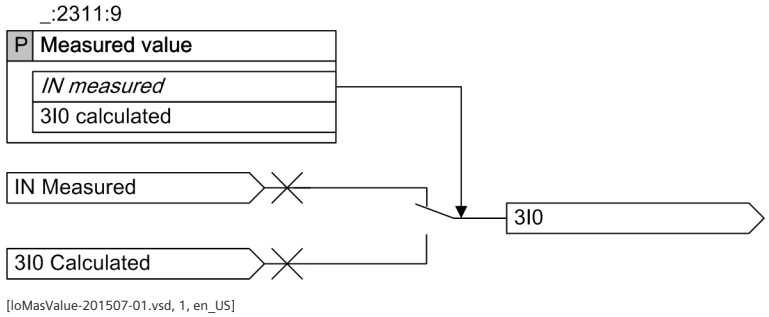


Figure 6-34 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types ***3-phase + IN*** and ***3-phase + IN-separate***. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

Table 6-2 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	0.15 A to 175.00 A	0.030 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.5.3.2 Application and Setting Notes

Parameter: `Measured value`

- Recommended setting value **`Measured value`** = ***`IN Measured`***

This parameter is not available in the basic function.

Parameter Value	Description

IN Measured	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
3I0 Calculated	The function operates with the calculated zero sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

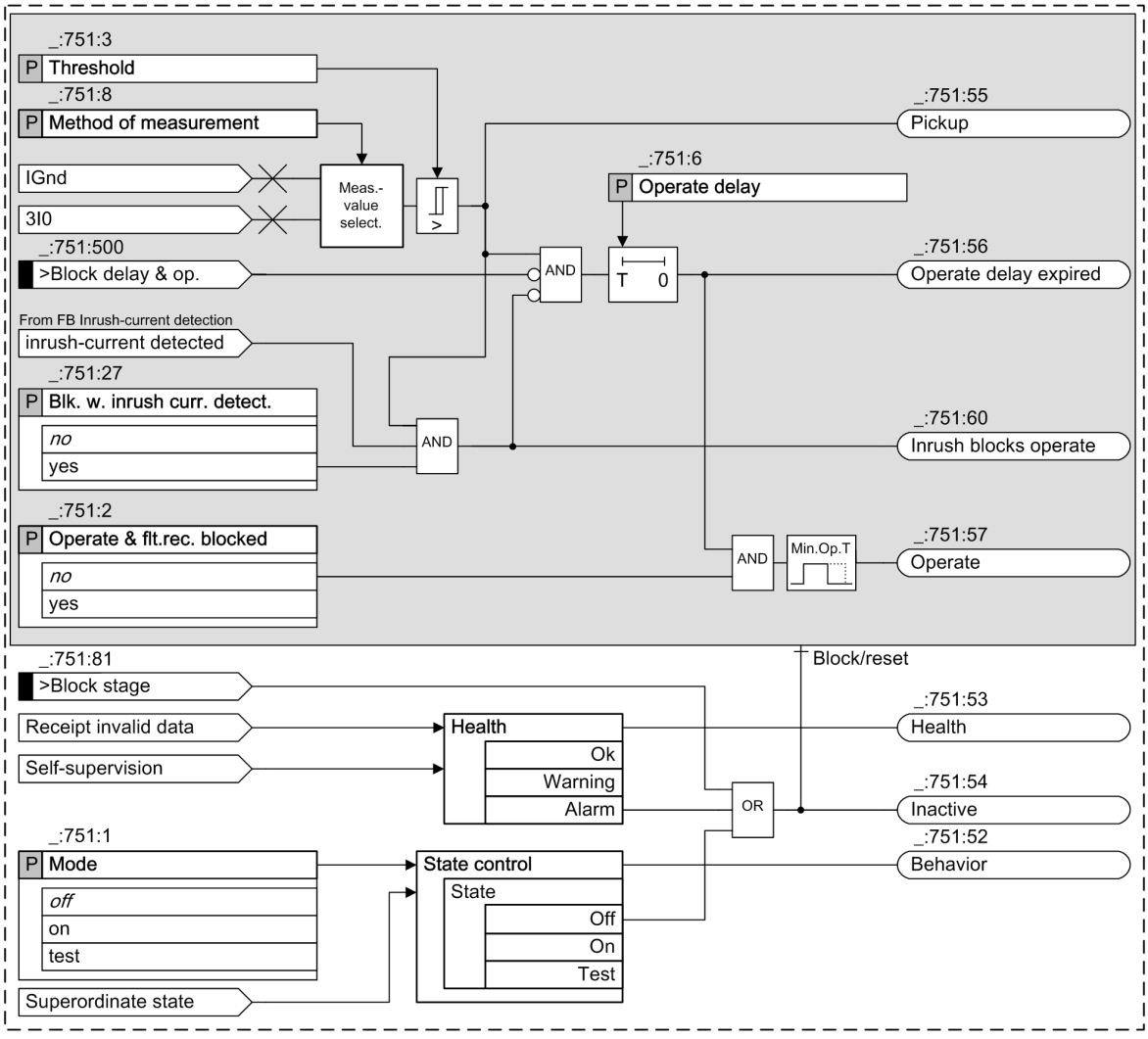
6.5.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

6.5.4 Stage with Definite-Time Characteristic Curve

6.5.4.1 Description

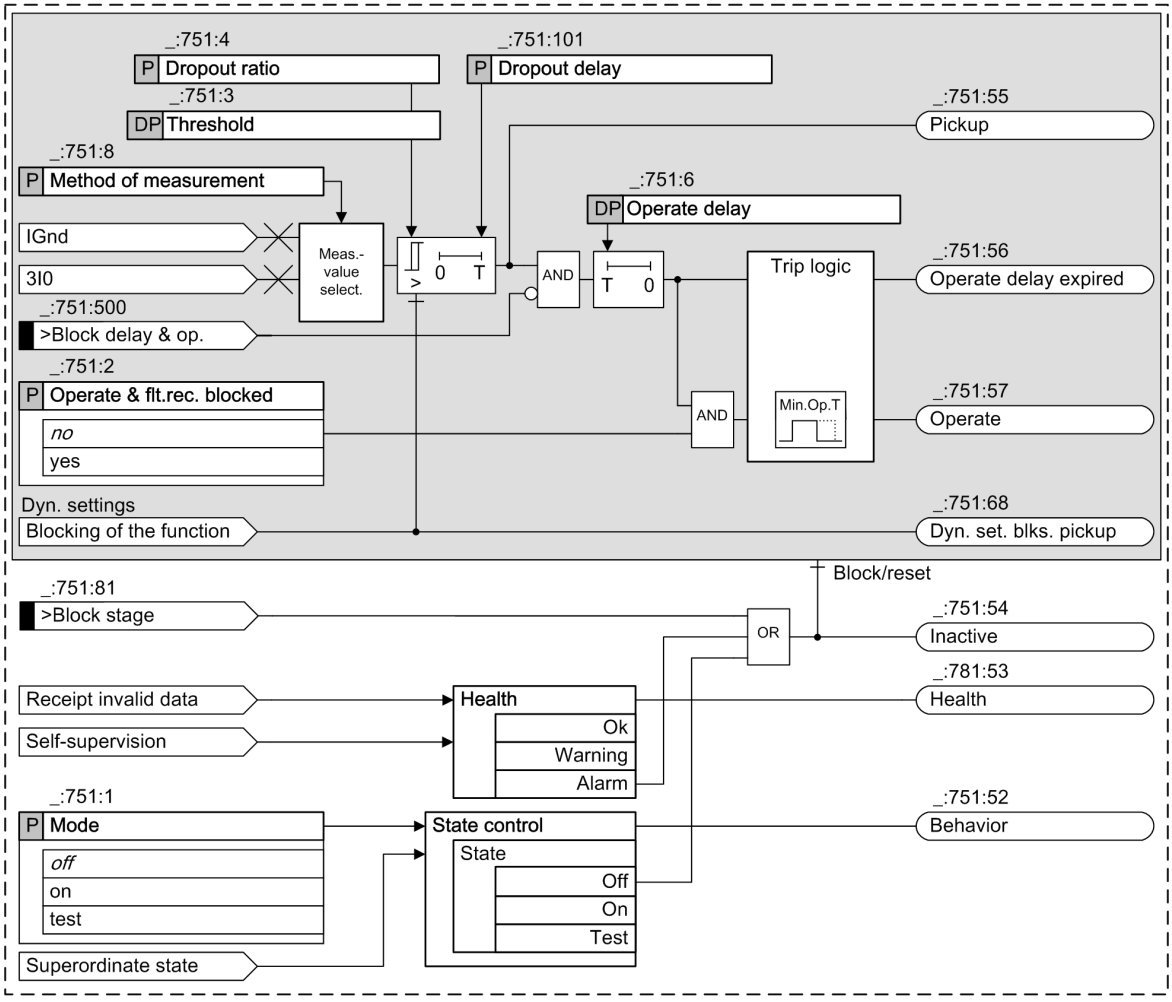
Logic of the Basic Stage



[loocpgb1-060213-01.tif, 2, en_US]

Figure 6-35 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[loocpgn1-291112-01.tif, 1, en_US]

Figure 6-36 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Advanced

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (see chapter **Influence of other functions via dynamic settings** and section *6.5.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.5.7.1 Description*.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.5.8.1 Description* .

6.5.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:751:8) Method of measurement** = ***fundamental comp.***

The **Method of measurement** parameter allows you to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Threshold, Operate delay

- Default setting **(_:751:3) Threshold** = ***1.20 A*** (for the first stage)
- Default setting **(_:751:6) Operate delay** = ***0.300 s*** (for the first stage)

Set the **Threshold** and **Operate delay** parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the minimal occurring ground-fault current. This must be determined.

The **Operate delay** to be set is derived from the time-grading schedule that has been prepared for the system.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the **Threshold** parameter to ensure that the stage does not pick up in case of a short-circuit at the end of the line.

Set the **Operate delay** parameter to ***0*** or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length) = 60 km

Z_L/s = 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_{L0}/Z_{L1} = 4$

Short-circuit power at the beginning of the line:

S_{sc}' = 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_{P0}/Z_{P1} = 2$

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/\mathrm{km} \cdot 60\mathrm{km} = 27.6\ \Omega$$

[fo_OCP002_030311, 1, en_US]

$$Z_P = \frac{110\ \mathrm{kV}^2}{2500\ \mathrm{MVA}} = 4.84\ \Omega$$

[fo_OCP003_030311, 1, en_US]

The 1-pole short-circuit current at the end of the line is $I_{scG\ end}$:

$$I_{sc\ gnd\ end} = \frac{1.1 \cdot V_N \cdot 3}{\sqrt{3} \cdot \left[Z_P \cdot \left(2 + \frac{Z_{P0}}{Z_{P1}}\right) + Z_L \cdot (2 + \frac{Z_{L0}}{Z_{L1}})\right]} = \frac{1.1 \cdot 110\mathrm{kV} \cdot 3}{\sqrt{3} \cdot [4.84\ \Omega \cdot (2+2) + 27.6\ \Omega \cdot (2+4)]} = 1133\ \mathrm{A}$$

[fo_ocp005_030311, 1, en_US]

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

$$\text{Threshold value 2nd stage (primary)} = 1.1 \cdot 1133\ \mathrm{A} = 1246.3\ \mathrm{A}$$

$$\text{Threshold value 2nd stage (secondary)} = 1.1 \cdot \frac{1133\ \mathrm{A}}{600\ \mathrm{A}} \cdot 5\ \mathrm{A} = 10.39\ \mathrm{A}$$

[foocpgr4-030311-01.tif, 3, en_US]

In case of short-circuit currents exceeding 1246 A (primary) or 10.39 A (secondary) there is a short-circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance, line impedance and zero-sequence impedance have very different angles, you have use complex numbers to calculate the **Threshold**.

Parameter: **Dropout delay**

- Recommended setting value **(_:751:101) Dropout delay** = ***0***

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting ***0*** since the dropout of a protection stage must be done as fast as possible.

You can use the **Dropout delay** parameter ≠ ***0*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: **Dropout ratio**

- Recommended setting value **(_:751:4) Dropout ratio** = ***0.95***

This parameter is not visible in the basic stage.

The recommended set value of ***0.95*** is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter **Dropout ratio** can be reduced, for example, to ***0.98***. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter **Dropout ratio**. This avoids chattering of the tripping stage.

6.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:751:1	Definite-T 1:Mode		• off • on • test	off
_:751:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:751:26	Definite-T 1:Dynamic settings		• no • yes	no
_:751:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:751:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:751:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:751:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:751:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:751:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:751:35	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 1				
_:751:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:751:36	Definite-T 1:Stage blocked		• no • yes	no
_:751:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:751:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:751:37	Definite-T 1:Stage blocked		• no • yes	no
_:751:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:751:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:751:38	Definite-T 1:Stage blocked		• no • yes	no
_:751:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:751:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:751:39	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:751:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:751:40	Definite-T 1:Stage blocked		• no • yes	no
_:751:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:751:34	Definite-T 1:Effected by binary input		• no • yes	no
_:751:41	Definite-T 1:Stage blocked		• no • yes	no
_:751:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.5.4.4 Information List

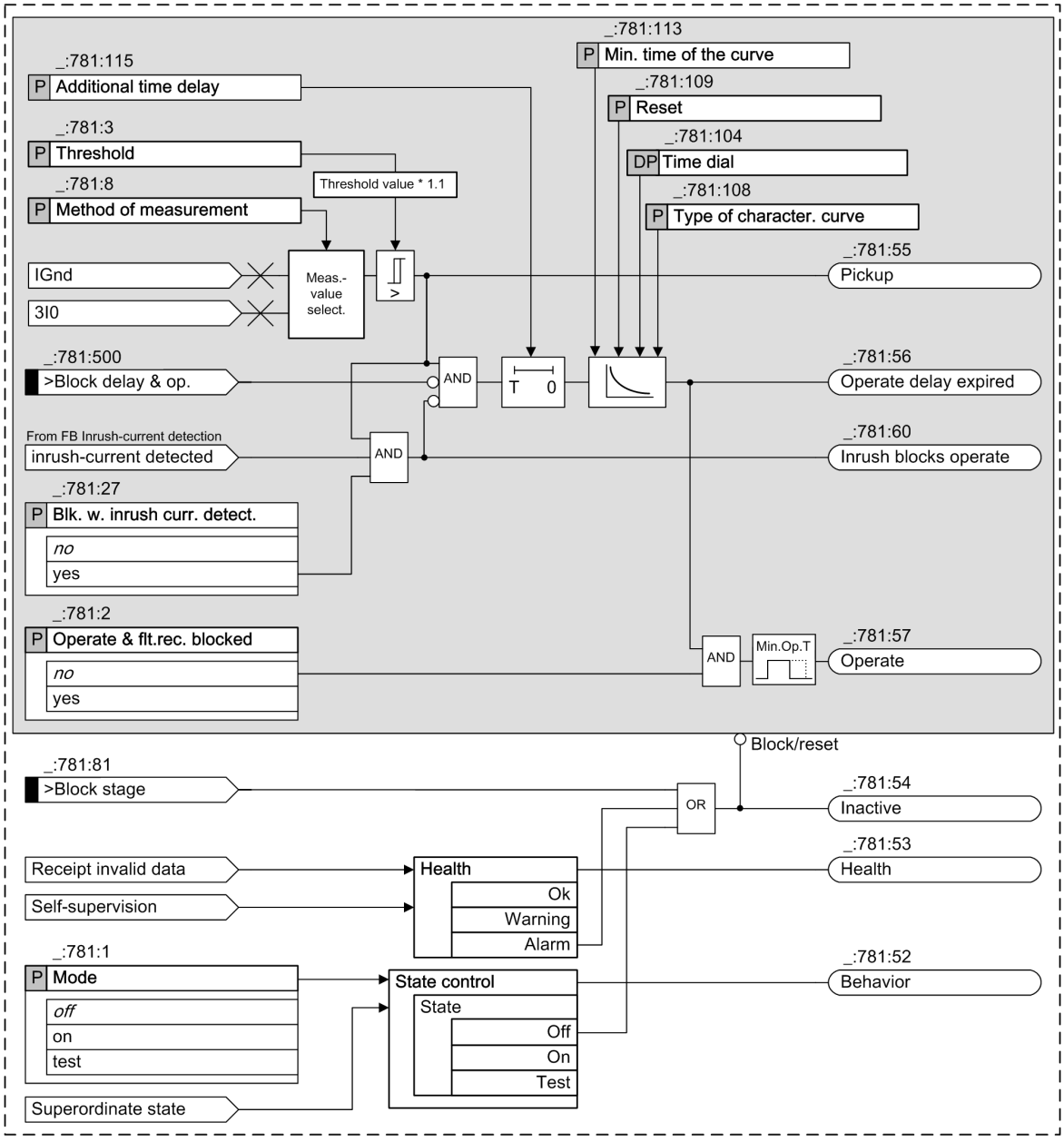
No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:751:81	Definite-T 1:>Block stage	SPS	I
_:751:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:751:500	Definite-T 1:>Block delay & op.	SPS	I
_:751:54	Definite-T 1:Inactive	SPS	O
_:751:52	Definite-T 1:Behavior	ENS	O
_:751:53	Definite-T 1:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:751:60	Definite-T 1:Inrush blocks operate	ACT	O
_:751:55	Definite-T 1:Pickup	ACD	O
_:751:56	Definite-T 1:Operate delay expired	ACT	O
_:751:57	Definite-T 1:Operate	ACT	O

6.5.5 Stage with Inverse-Time Characteristic Curve

6.5.5.1 Description

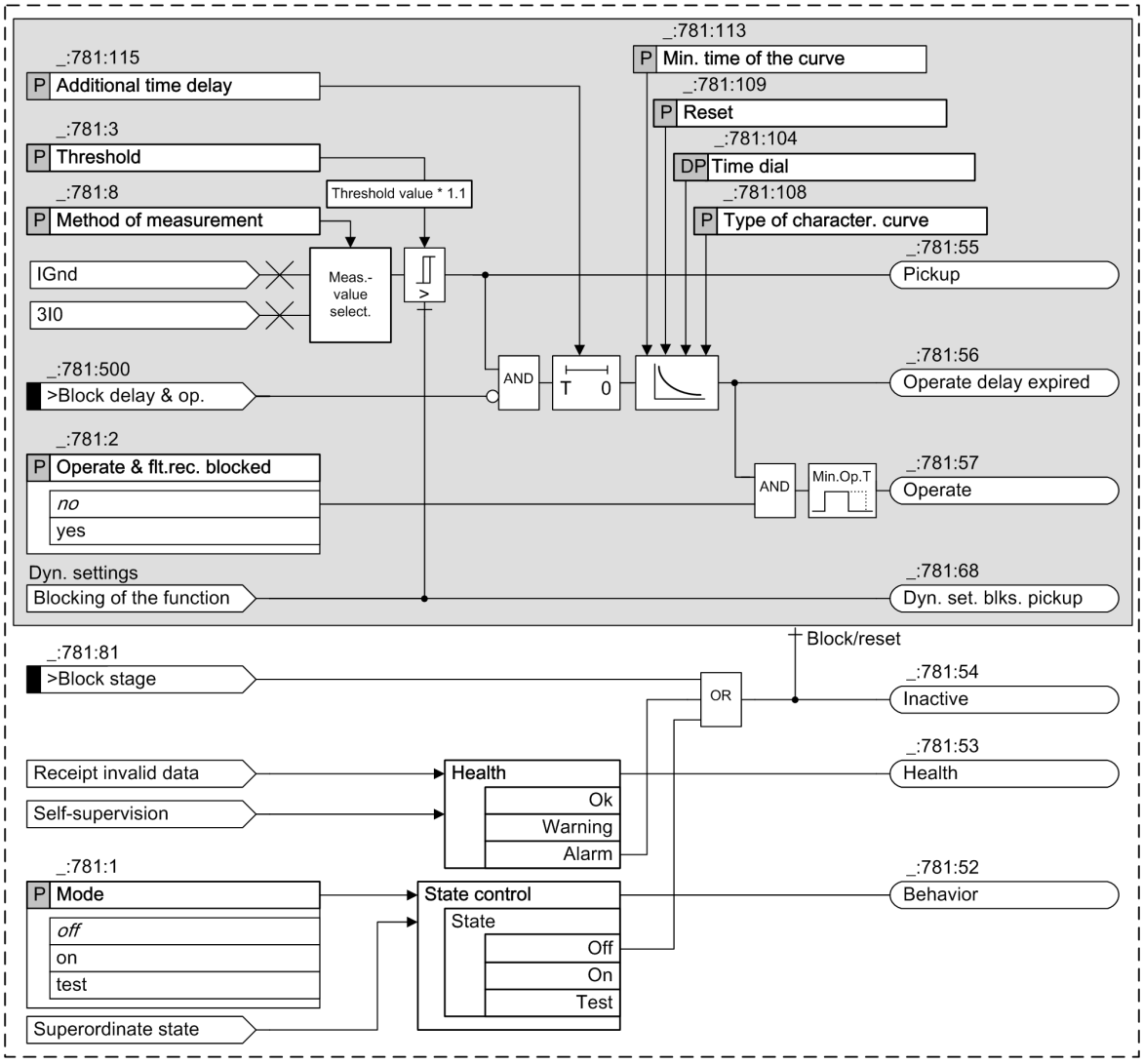
Logic of the Basic Stage



[loocpgr2-070213-01.tif, 3, en_US]

Figure 6-37 Logic Diagram of the Inverse Time-Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[loocpgn2-291112-01.tif, 2, en_US]

Figure 6-38 Logic Diagram of the Inverse Time-Overcurrent Protection (Ground) – Advanced

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

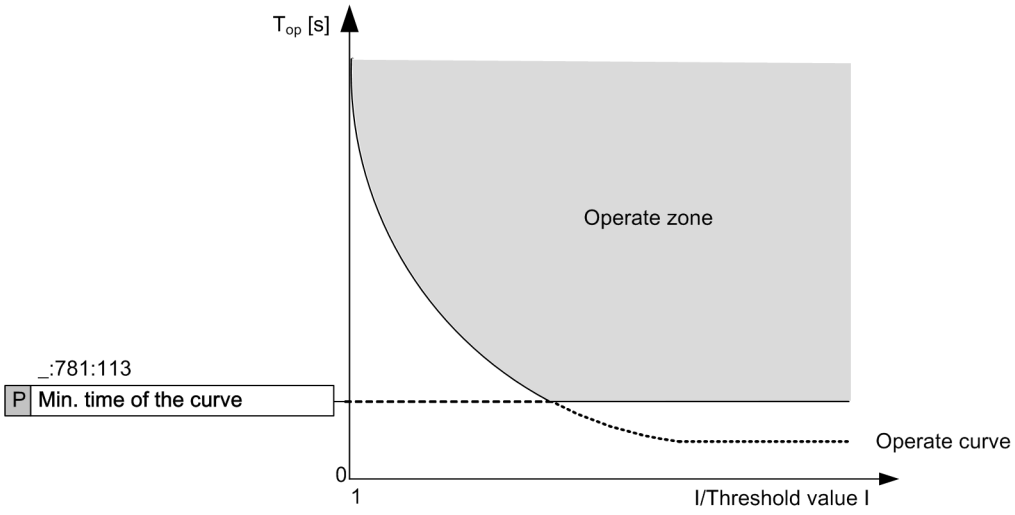
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define the minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[Dwocpgr3Mi_20140716-01, 1, en_US]

Figure 6-39 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (see subtitle **Influence of other functions via dynamic settings** and chapter *6.5.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.5.7.1 Description*.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.5.8.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.5.8.1 Description* .

6.5.5.2 Application and Setting Notes

Parameter: `Method of measurement`

- Recommended setting value **`(_:781:8) Method of measurement`** = ***`fundamental comp.`***

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** (standard method) or the calculated ***`RMS value`***.

Parameter Value	Description
`fundamental comp.`	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
`RMS value`	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **`threshold value`** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Type of character. curve

- Default setting **`(_:781:108) Type of character. curve`** = ***`IEC normal inverse`***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **`Type of character. curve`** required for your specific application. For more information about the parameter **`Type of character. curve`**, refer to chapter*12.7.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: `Min. time of the curve`

- Default setting **`(_:781:113) Min. time of the curve`** = ***`0.00 s`***

This parameter is only available in the advanced stage.

With the parameter **`Min. time of the curve`**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: `Additional time delay`

- Recommended setting value **`(_:781:115) Additional time delay`** = ***`0.00 s`***

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: `Threshold`

- Default setting **`(_:781:3) Threshold`** = ***`1.20 A`***

The setting depends on the minimal occurring ground-fault current. This must be determined.

Parameter: `Time dial`

- Default setting **`(_:781:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`***.

Parameter: `Reset`

- Default setting **`(_:781:109) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.5.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:781:1	Inverse-T 1:Mode		• off • on • test	off
_:781:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:781:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:781:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:781:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:108	Inverse-T 1:Type of character. curve			
_:781:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:781:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:781:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:781:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:781:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:781:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:781:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:781:36	Inverse-T 1:Stage blocked		• no • yes	no
_:781:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:781:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:781:37	Inverse-T 1:Stage blocked		• no • yes	no
_:781:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:781:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:38	Inverse-T 1:Stage blocked		• no • yes	no
_:781:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:781:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:781:39	Inverse-T 1:Stage blocked		• no • yes	no
_:781:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:781:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:781:40	Inverse-T 1:Stage blocked		• no • yes	no
_:781:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:781:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:781:41	Inverse-T 1:Stage blocked		• no • yes	no
_:781:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.5.5.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:781:81	Inverse-T 1:>Block stage	SPS	I
_:781:500	Inverse-T 1:>Block delay & op.	SPS	I
_:781:54	Inverse-T 1:Inactive	SPS	O
_:781:52	Inverse-T 1:Behavior	ENS	O
_:781:53	Inverse-T 1:Health	ENS	O
_:781:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:781:59	Inverse-T 1:Disk emulation running	SPS	O
_:781:55	Inverse-T 1:Pickup	ACD	O
_:781:56	Inverse-T 1:Operate delay expired	ACT	O
_:781:57	Inverse-T 1:Operate	ACT	O

6.5.6 Stage with User-Defined Characteristic Curve

6.5.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.5.5.1 Description*). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

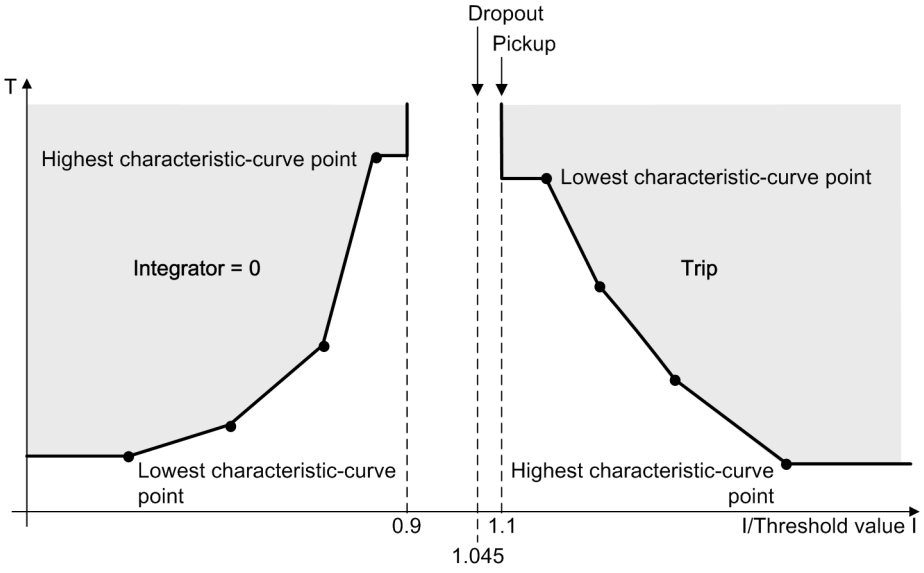
Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The following figure shows the pickup and dropout behavior when a user-defined characteristic curve is used.



[dwocpken-140611-02.tif, 1, en_US]

Figure 6-40 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.5.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage. The only difference is that the user can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves. For guidance on the other parameters of the stage, see chapter *6.5.5.2 Application and Setting Notes* .

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **Time dial** at ***1*** (default setting).

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **Time dial** parameter.



NOTE

The value pairs must be entered in continuous order.

6.5.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation

Addr.	Parameter	C	Setting Options	Default Setting
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

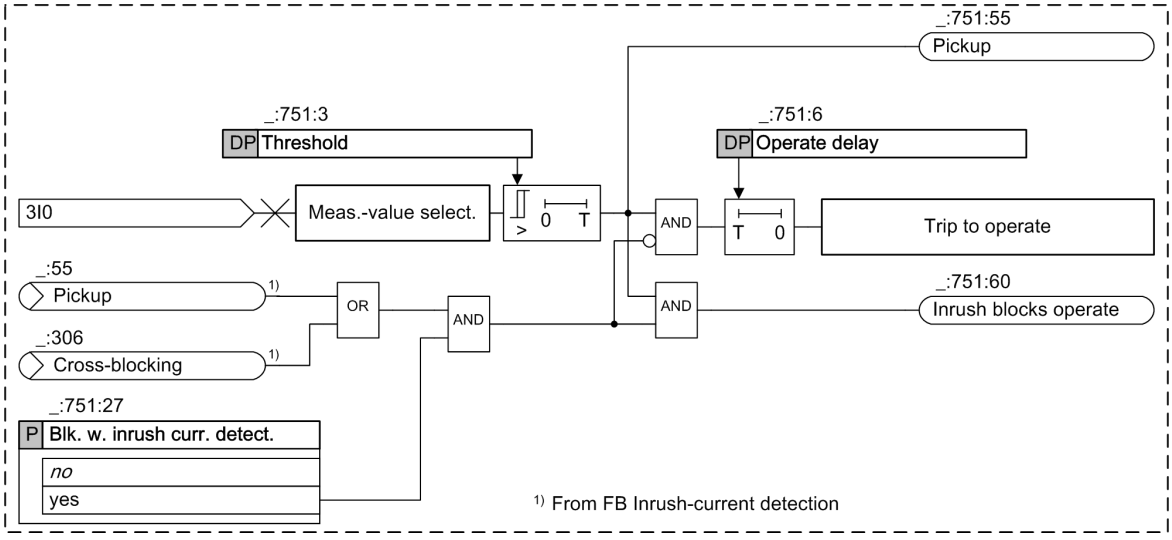
6.5.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.5.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.5.7.1 Description

With the **Blk. w. inrush curr. detect.** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite time-overcurrent protection stage 1) that illustrates the influence of the inrush-current detection. Only if the central function **Inrush-current detection** (see section *12.10 Inrush-Current Detection*) is in effect can the blocking be set.



[loocpgrd-210812-01.tif, 1, en_US]

Figure 6-41 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite Time-Overcurrent Protection Stage

6.5.7.2 Application and Setting Notes

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:751:27) Blk. w. inrush curr. detect.** = ***no***

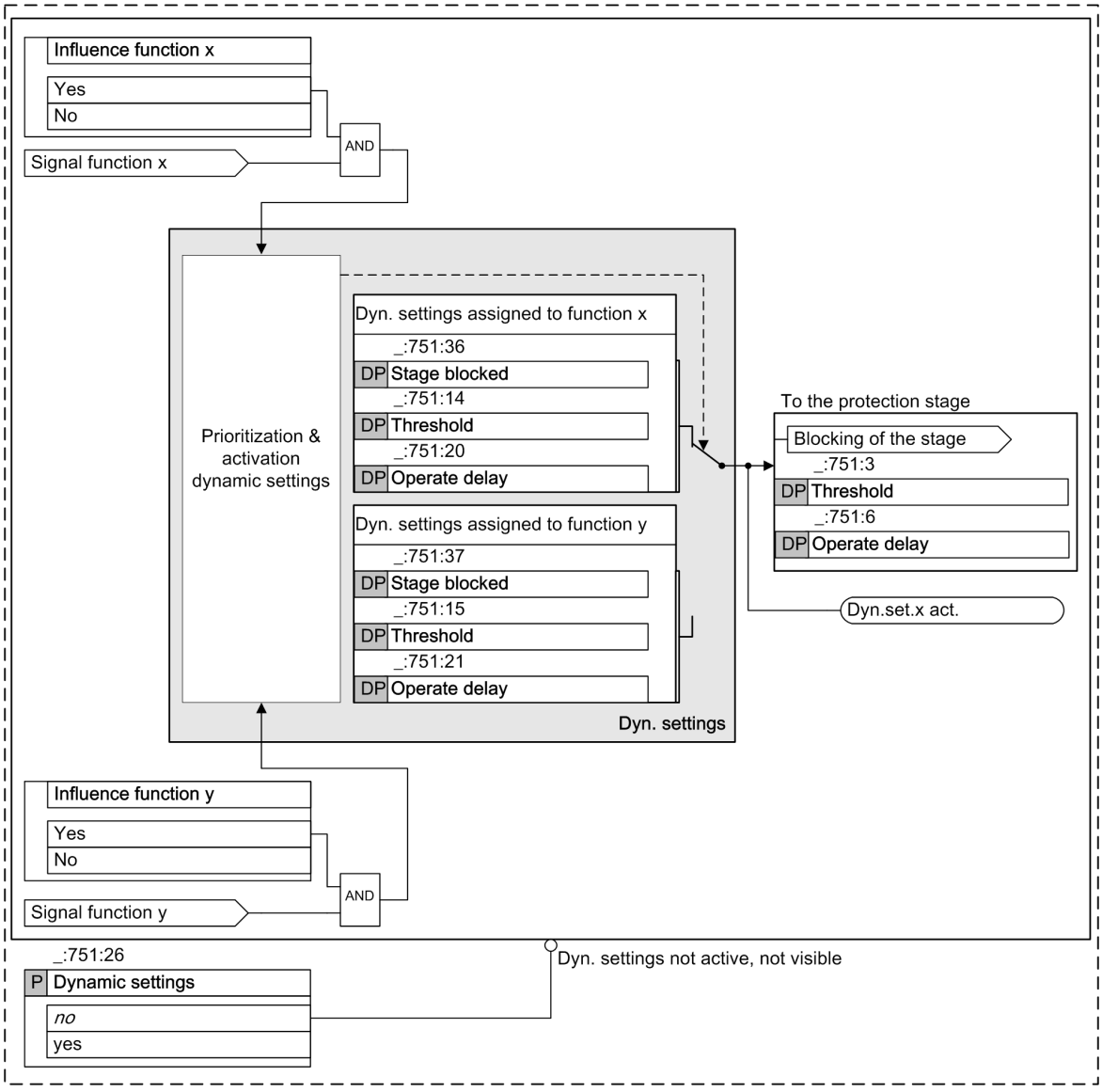
Parameter Value	Description
no	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.

Parameter Value	Description
yes	When the transformer inrush current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.5.8 Influence of Other Functions via Dynamic Settings

6.5.8.1 Description

The **Threshold** and **Operate delay** settings used for tripping are so-called **dynamic settings**. Depending on other functions, the settings of these parameters can be changed dynamically. Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.



[loocpgnd-030311-01.vsd, 1, en_US]

Figure 6-42 Principle of the Dynamic Settings in the Example of 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

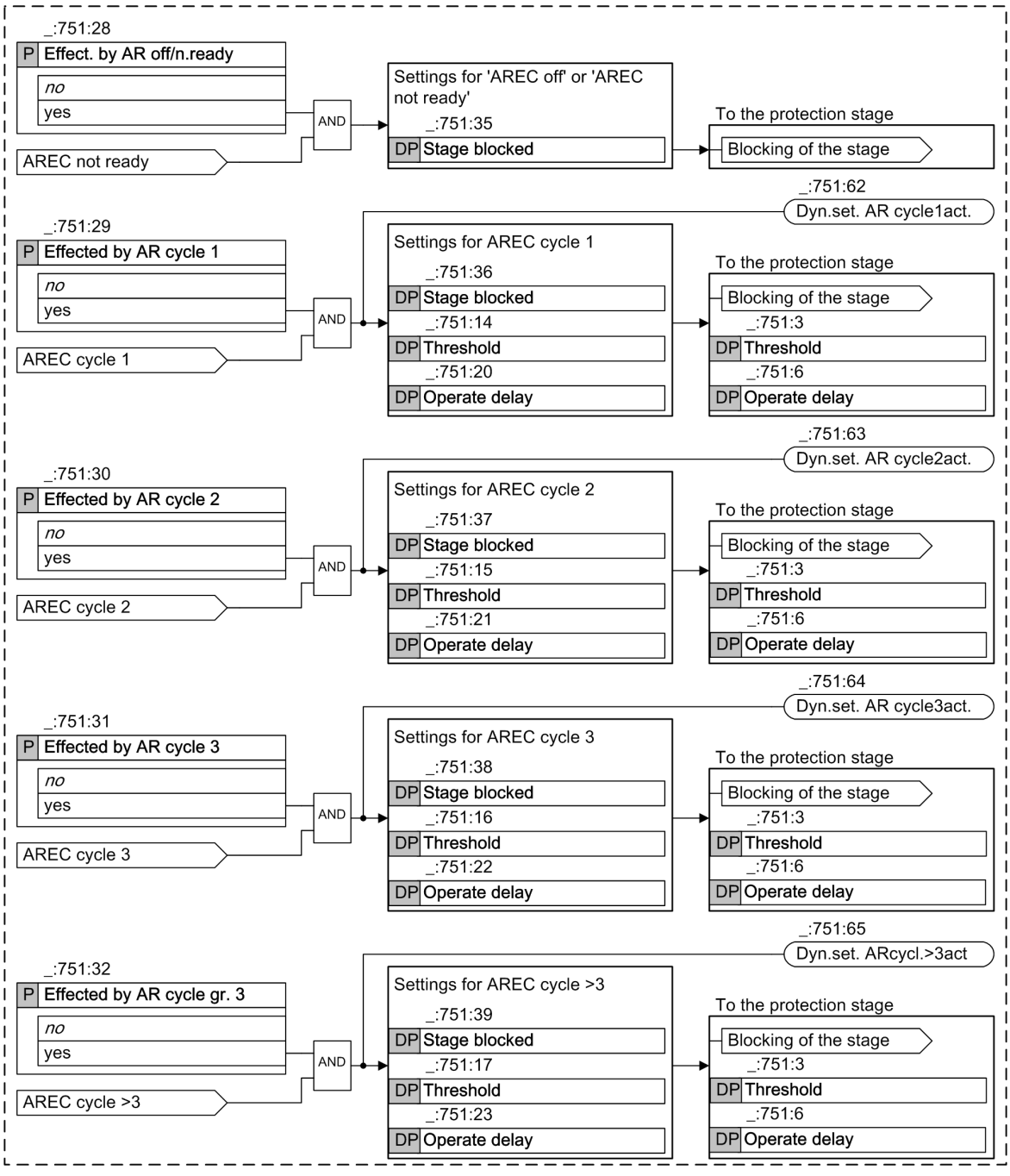
Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings for the **Threshold** and the **Operate delay** are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter **Influence of function ...** and its own dynamic settings (**Operate delay** and **Threshold**). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these parameter settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Automatic Reclosing (Advanced Stage)*



[loocpgrnd-040311-01.vsd, 1, en_US]

Figure 6-43 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several AREC signals can affect the setting for the **Threshold** and the **Operate delay** of the protection stage and its blocking.

- AREC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- AREC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- AREC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- AREC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

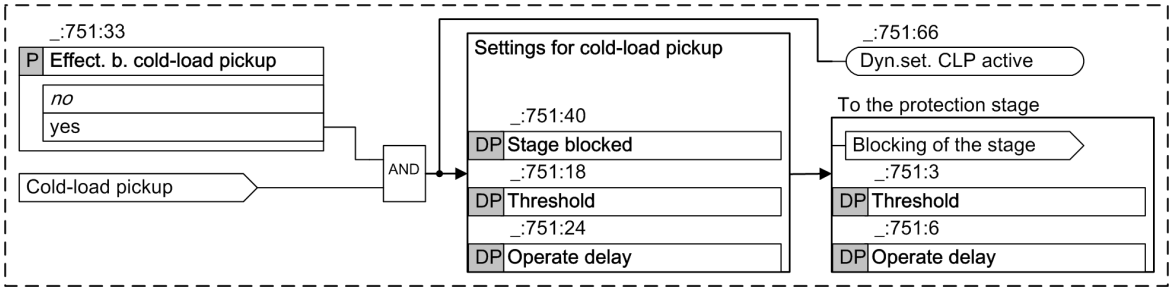
- AREC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the AREC is ready and the protection stage is in the idle state, the settings for **AREC cycle 1** are active and not the standard settings. The standard settings are active in the case of **AREC off/not ready**.

The influence can be activated for each signal individually. You also have to set the **Threshold** and **Operate delay** or **Stage blocked** parameters, which take effect when the signal is active.

The way AREC signals are generated is described in chapter *6.43.1 Overview of Functions*.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*



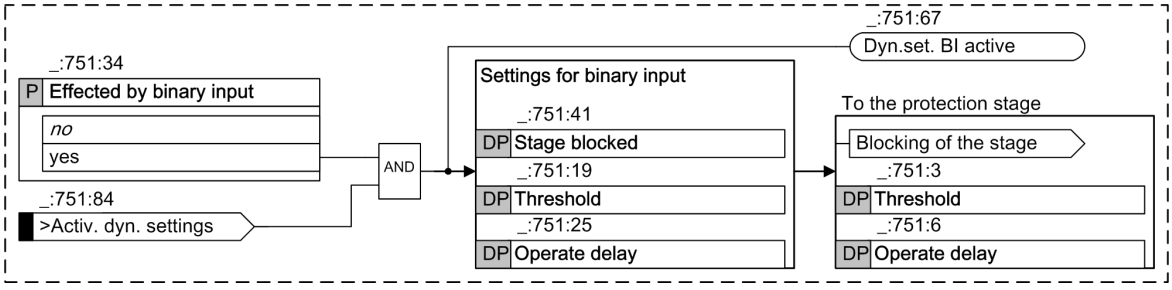
[loocpkalgnd-030311-01.vsd, 1, en_US]

Figure 6-44 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

You have the option of changing the settings for the **Threshold** and the **Operate delay** of the protection stage for a cold-load pick-up. You can also block the stage. To do so, you must activate the influence of the cold-load pickup. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

The way signals are generated **Cold-load pickup** is described in chapter *5.8.8 Cold-Load Pickup Detection (Optional)* .

Link to an External *Function via a Binary Input Signal (Advanced Stage)*



[loocpbingnd-030311-01.vsd, 1, en_US]

Figure 6-45 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal **>Activ. dyn. settings** to change the settings for the **Threshold** and the **Operate delay** of the protection stage. You can also block the stage. To do so, you must activate the influence of the binary input. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

6.5.8.2 Application and Setting Notes (Advanced Stage)

Binary Input Signal: `Dynamic settings`

- Default setting **`(_:751:26) Dynamic settings`** = ***`no`***

Parameter Value	Description
`no`	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
`yes`	If a device-internal function (automatic reclosing function or cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to ***`yes`***. This makes the configuration parameters **`Influence of function...`** as well as the dynamic settings **`Threshold`**, **`Operate delay`** and **`Stage blocked`** of the stage visible and enables the settings to be set for the specific influence.

Influence of AREC

The example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by AREC.

The setting of the overcurrent level (1st level) results from the time-grading schedule. It is to be used as fast stage before an automatic reclosing. Because fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the **`Operate delay`** parameter can be set to ***`0`*** or to a very low value. To achieve the selectivity, the final disconnection must be done with the grading time.

AREC is set to 2 reclosings. A secondary **`Threshold`** of ***`1.5 A`*** and a **`Operate delay`** of ***`600 ms`*** are assumed (according to the time-grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings **`Effected by AR cycle 1`** and **`Effected by AR cycle 2`** are changed in the example to ***`yes`*** (= influenced). This activates the **`AR cycle 1`** and **`AR cycle 2`** input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings **`Operate delay`** assigned to these input signals (sources of influence) are set to the time delay ***`0`*** (instantaneous tripping). The two dynamic settings **`Threshold`** assigned to these input signals are set to the normal threshold value of ***`1.5 A`***.

If the threshold value (***`1.5 A`***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***`600 ms`*** according to the time-grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the AREC function is performed by an external device.

To realize the application, the configuration setting **`Effected by binary input`** must be changed to ***`yes`*** (= influenced). This activates the **`>Activ. dyn. settings`** input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings. The external device must provide the **`Cycle 1`** and **`Cycle 2`** signals or, alternatively, an AREC ready signal. The signals must be connected with the binary input signal **`>Activ. dyn. settings`**.

The dynamic setting **`Operate delay`**, which is assigned to the input signal (source of influence) **`>Activ. dyn. settings`**, is set to the time delay ***`0`*** (instantaneous tripping). The dynamic setting **`Threshold`** assigned to this input signal is set to the normal threshold value of ***`1.5 A`***.

If the threshold value (***`1.5 A`***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***`600 ms`*** according to the time-grading schedule.

6.6 Directional Overcurrent Protection, Phases

6.6.1 Overview of Functions

The **Directional time-overcurrent protection, phases** (ANSI 67):

- Detects short circuits at electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.6.2 Structure of the Function

The **Directional time-overcurrent protection, phases** function is used in protection function groups. 2 function types are offered:

- **Directional time-overcurrent protection, phases - advanced** (67 Dir.OC-3ph-A)
- **Directional time-overcurrent protection, phases - basic** (67 Dir.OC-3ph-B)

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **directional, definite time-overcurrent protection** stages and with 1 **directional inverse time-overcurrent protection** stage.

In the advanced function type **Directional time-overcurrent protection, phases – advanced** the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite time-overcurrent protection – advanced**
- 1 stage **Inverse time-overcurrent protection – advanced**
- 1 stage **User-defined overcurrent protection characteristic curve**

In the Basic function type **Directional time-overcurrent protection, phases – basic** the following stages can be operated simultaneously:

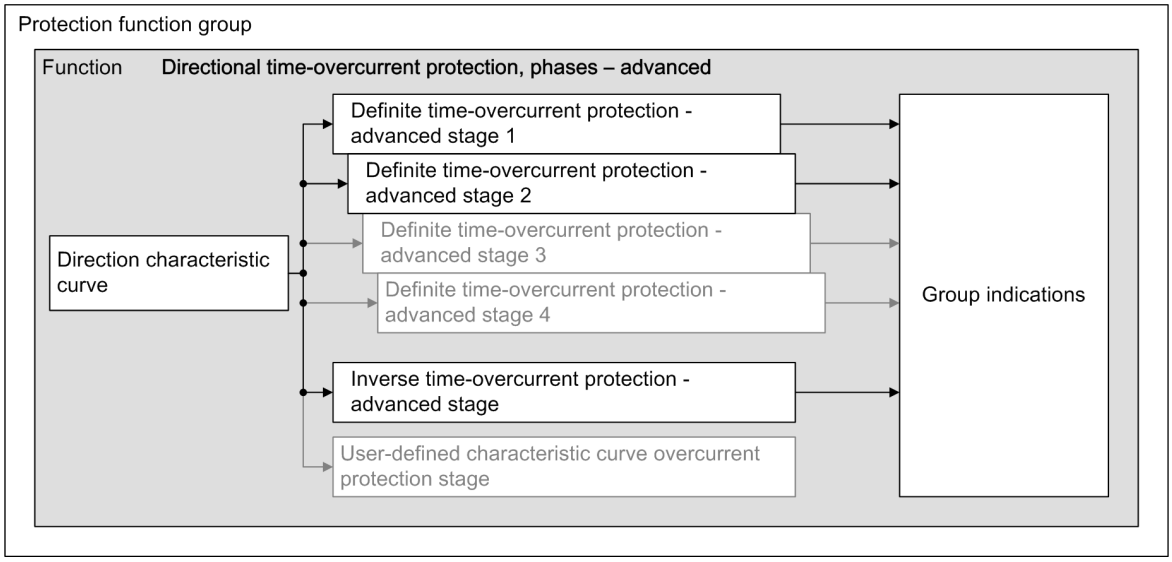
- Maximum of 4 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The direction determination occurs on function level and has the same effects in all stages (see following figure and chapter *6.6.7.1 Description*). In this way, it is ensured that all stages of a function receive the same direction result. Every stage can be set to the forward or reverse direction.

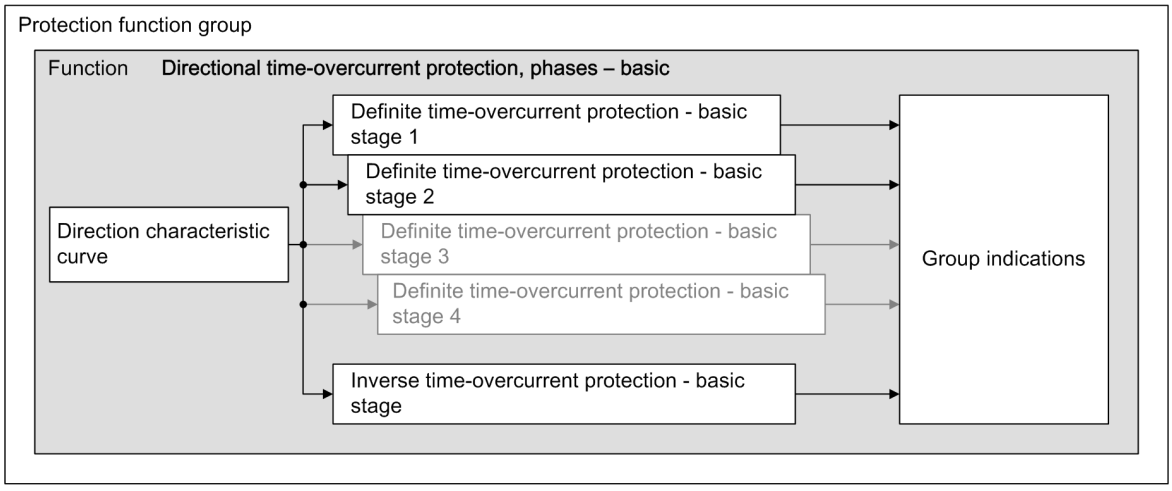
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dwdiocan-050213-01.tif, 3, en_US]

Figure 6-46 Structure/Embedding the Function Directional Time-Overcurrent Protection, Phases – Advanced



[dwdiocba-050213-01.tif, 4, en_US]

Figure 6-47 Structure/Embedding the Function Directional Time-Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

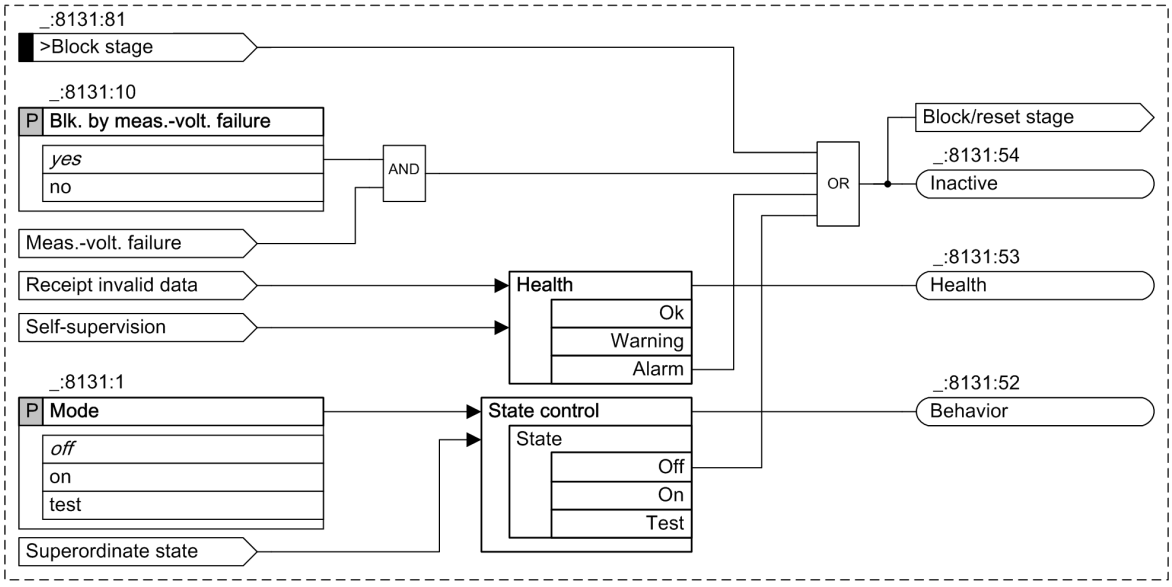
If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents.

6.6.3 Stage Control

6.6.3.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.



[lodocpn2-291112-01.tif, 1, en_US]

Figure 6-48 Stage-Control Logic Diagram

Blocking of the Stage with Measuring-Voltage Failure (Basic and Advanced Stage)

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*)
- From an external source via the binary input signal **>Open** of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.6.3.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:8131:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

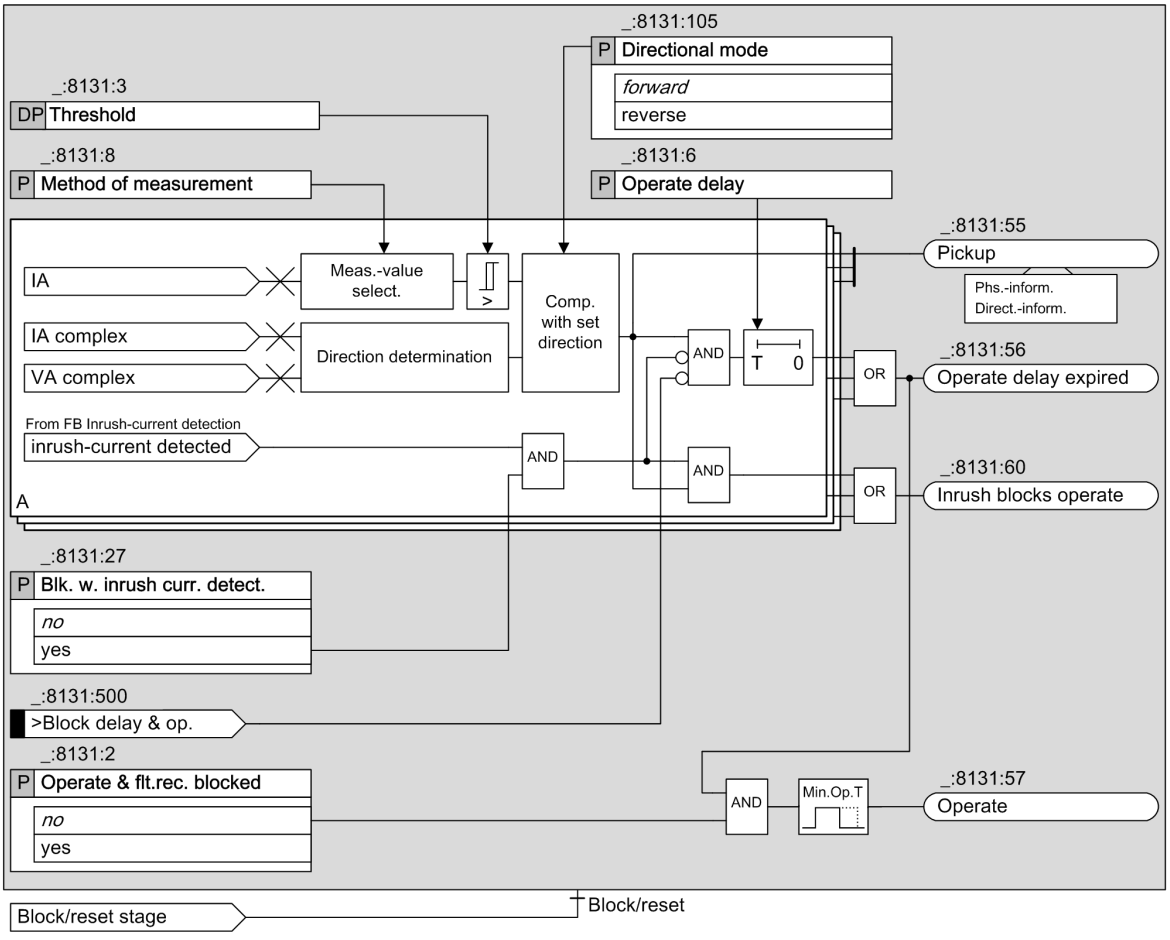
- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The directional overcurrent-protection stage is blocked. Siemens recommends that you retain the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked.

6.6.4 Stage with Definite-Time Characteristic Curve

6.6.4.1 Description

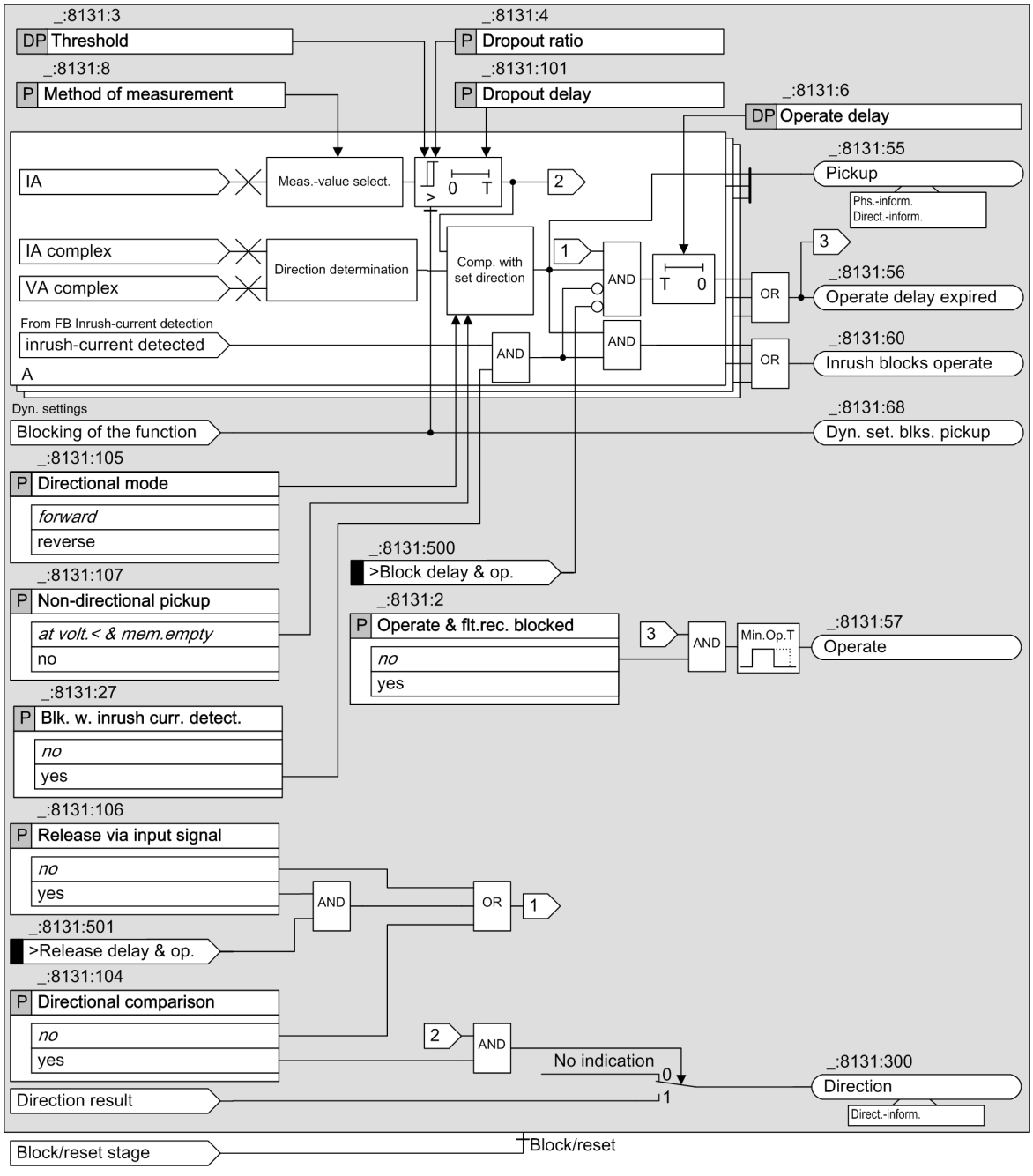
Logic of the Basic Stage



[lodocg6b-060213-01.tif, 2, en_US]

Figure 6-49 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage



[lodocp31-141013, 1, en_US]

Figure 6-50 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction.

Direction determination itself works across stages (see section *6.6.7.1 Description*).

Non-Directional Pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter l *6.6.7.1 Description*). If no voltage measure-

ments which can be used to determine the direction are available in the voltage memory, the basic stage generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the **Non-directional pickup** parameter. With the ***at volt.< & mem.empty*** setting, the function picks up in such a situation without direction determination. With the ***no*** setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication **Direction** . The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** setting and the **>Release delay & op.** input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes*** , the start of the time delay, and therefore the tripping of the stage, are only enabled if the **>Release delay & op.** input signal is active.

Method of measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value*** .

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal **>Block stage** (see chapter *6.6.3.1 Description*)
- Measuring-voltage failure (see chapter *6.6.3.1 Description*)
- Via the dynamic settings function (only provided in the Advanced function type, see chapter **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*)

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.6.4.2 Application and Setting Notes

Parameter: **Directional mode**

- Default setting **(_:8131:105) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: **Method of measurement**

- Recommended setting value **(_:8131:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: **Directional comparison**, **Release via input signal**

- Default setting **(_:8131:104) Directional comparison** = ***no***
- Default setting **(_:8131:106) Release via input signal** = ***no***

These 2 parameters are not visible in the basic stage.
You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the **Direction** and **>Release delay & op.** signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.

Parameter Value	Description
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the **Direction** output signal, and the **>Release delay & op.** input signal become available. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the **>Release delay & op.** input signal is active. The **>Release delay & op.** input signal must be connected to the release information from the opposite end (forward information from the **Direction** output signal); see also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: **Non-directional pickup**

- Recommended setting value **(_:8131:107) Non-directional pickup** = ***at volt.< & mem.empty***

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the circuit breaker (CB) trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: **Threshold**

- Default setting **(_:8131:3) Threshold** = ***1.50 A*** (for the first stage)

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. For further information, refer to section *6.3.4.2 Application and Setting Notes* .

Parameter: **Operate delay**

- Default setting **(_:8131:6) Operate delay** = ***0.300 s*** (for the 1st stage)

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system.

Typical examples of grading times are provided in the chapters *6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends* and *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: **Dropout ratio**

- Recommended setting value **(_:8131:4) Dropout ratio** = ***0.95***

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

For high-precision measurements, the setting value of the **Dropout ratio** parameter can be reduced, for example to 0.98. If you expect heavily fluctuating measurands at the response threshold, you can increase the setting value of the **Dropout ratio** parameter. This avoids chattering of the tripping stage.

Parameter: **Dropout delay**

- Recommended setting value **(_:8131:101) Dropout delay** = ***0 s***

This parameter is not visible in the basic stage.

Siemens recommends using this setting value, since the dropout of a protection stage must be performed as fast as possible.

You can use the **Dropout delay** parameter ≠ *0 s* to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

6.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
Definite 1				
_:8131:1	Definite-T 1:Mode		• off • on • test	off
_:8131:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8131:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:8131:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8131:107	Definite-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8131:104	Definite-T 1:Directional comparison		• no • yes	no
_:8131:106	Definite-T 1:Release via input signal		• no • yes	no
_:8131:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8131:26	Definite-T 1:Dynamic settings		• no • yes	no
_:8131:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8131:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:8131:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:8131:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:8131:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8131:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8131:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8131:36	Definite-T 1:Stage blocked		• no • yes	no
_:8131:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:8131:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:8131:37	Definite-T 1:Stage blocked		• no • yes	no
_:8131:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:8131:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:8131:38	Definite-T 1:Stage blocked		• no • yes	no
_:8131:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:8131:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8131:39	Definite-T 1:Stage blocked		• no • yes	no
_:8131:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: Cold load PU				
_:8131:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8131:40	Definite-T 1:Stage blocked		• no • yes	no
_:8131:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:8131:34	Definite-T 1:Effected by binary input		• no • yes	no
_:8131:41	Definite-T 1:Stage blocked		• no • yes	no
_:8131:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.6.4.4 Information List

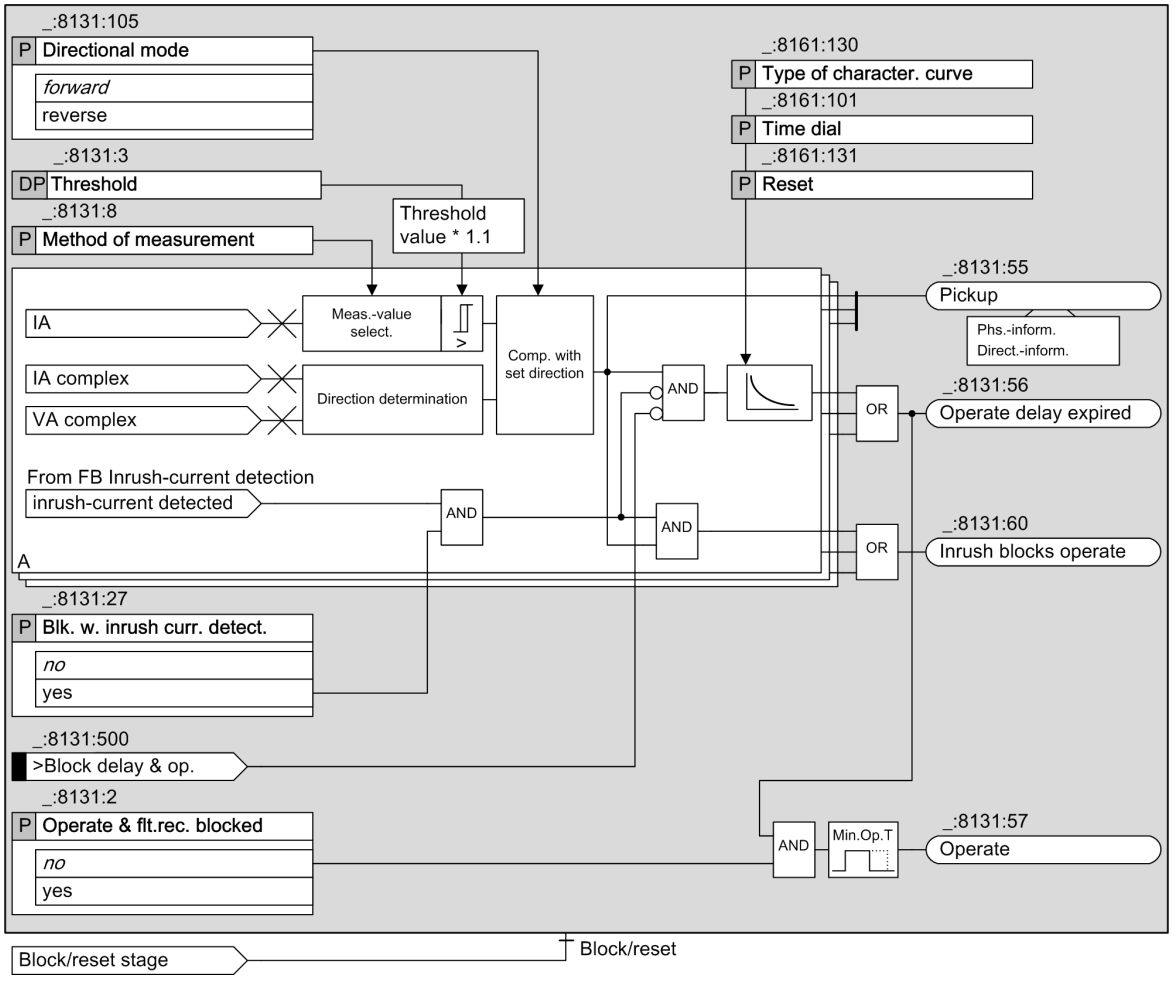
No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:8131:81	Definite-T 1:>Block stage	SPS	I
_:8131:501	Definite-T 1:>Release delay & op.	SPS	I
_:8131:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:8131:500	Definite-T 1:>Block delay & op.	SPS	I
_:8131:54	Definite-T 1:Inactive	SPS	O
_:8131:52	Definite-T 1:Behavior	ENS	O
_:8131:53	Definite-T 1:Health	ENS	O
_:8131:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8131:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8131:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8131:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O

No.	Information	Data Class (Type)	Type
_:8131:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8131:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:8131:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:8131:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:8131:55	Definite-T 1:Pickup	ACD	O
_:8131:300	Definite-T 1:Direction	ACD	O
_:8131:56	Definite-T 1:Operate delay expired	ACT	O
_:8131:57	Definite-T 1:Operate	ACT	O

6.6.5 Stage with Inverse-Time Characteristic Curve

6.6.5.1 Description

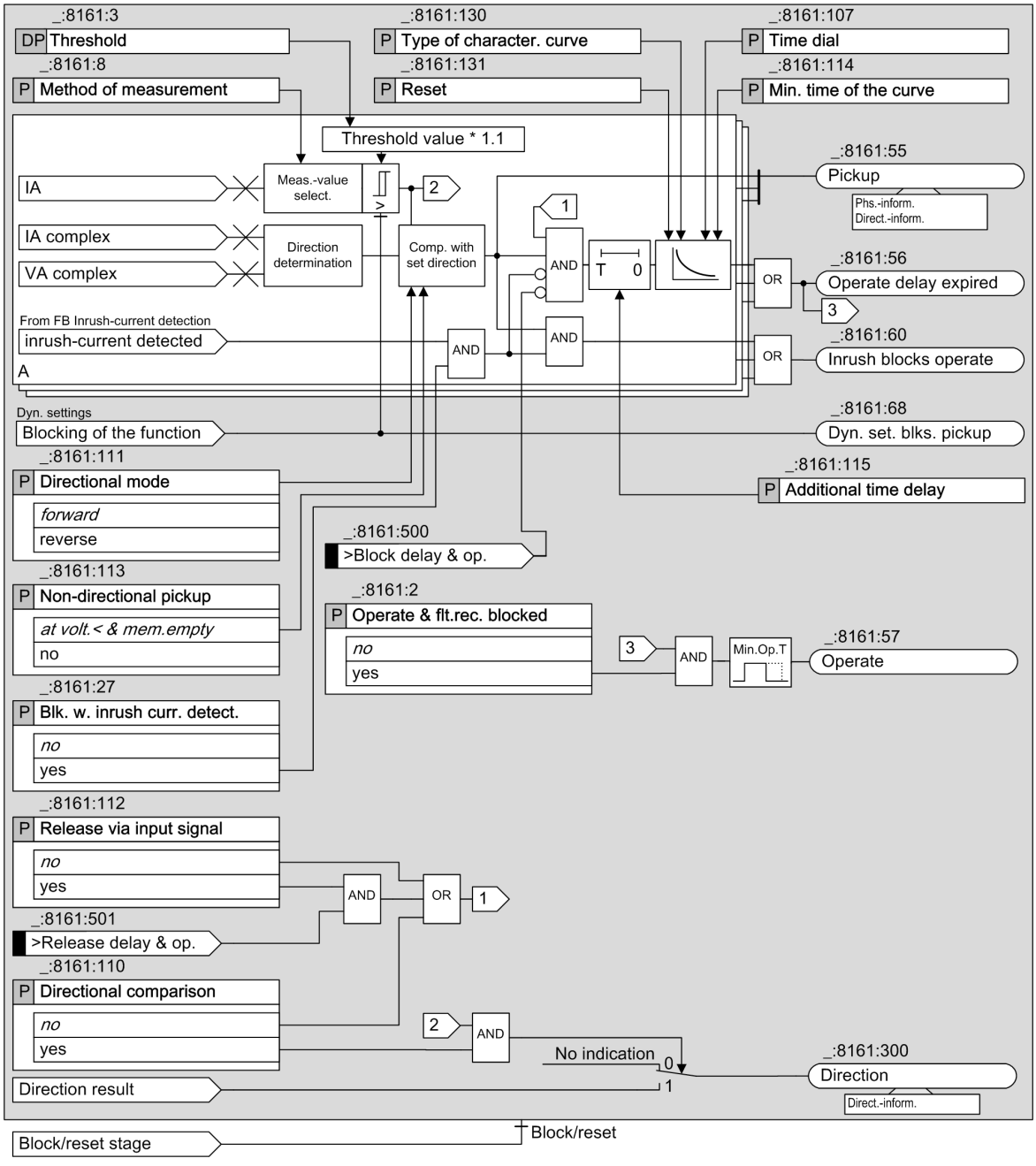
Logic of the Basic Stage



[lodoci6b-060213-01.tif, 2, en_US]

Figure 6-51 Logic Diagram of the Directional, Inverse Time-Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage



[lodocp33-121013, 2, en_US]

Figure 6-52 Logic Diagram of the Directional, Inverse Time-Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across stages (see chapter *6.6.7.1 Description*).

`Non-directional pickup`, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter *6.6.7.1 Description*). If no voltage measurements which can be used to determine the direction are available in the voltage memory, the basic stage

generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the **Non-directional pickup** parameter. With the ***at volt.< & mem.empty*** setting, the function picks up in such a situation without direction determination. With the ***no*** setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication **Direction**. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** setting and the **>Release delay & op.** input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore the tripping of the stage, are only enabled if the **>Release delay & op.** input signal is active.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

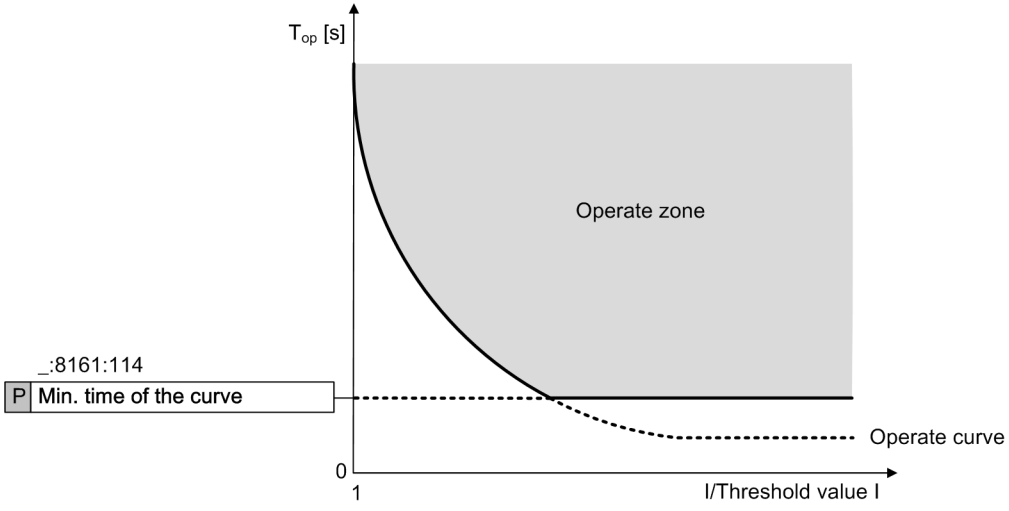
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwDocp01_040715-01.vsd, 1, en_US]

Figure 6-53 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal **>Block stage** (see chapter *6.6.3.1 Description*)
- Measuring-voltage failure (see chapter *6.6.3.1 Description*)
- Via the functionality of the **dynamic settings** (only in the advanced function type, see subtitle **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.6.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:8161:111) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:8161:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: **Directional comparison, Release via input signal**

- Default setting **(_:8161:110) Directional comparison** = ***no***
- Default setting **(_:8161:112) Release via input signal** = ***no***

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the **Direction** and **>Release delay & op.** signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the **Direction** output signal, and the **>Release delay & op.** input signal become available. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the **>Release delay & op.** input signal is active. The **>Release delay & op.** input signal must be connected to the release information from the opposite end (forward information from the **Direction** output signal); see also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: **Non-directional pickup**

- Recommended setting value **(_:8161:113) Non-directional pickup** = ***at volt.< & mem.empty***

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the CB trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: **Type of character. curve**

- Default setting **(_:8161:130) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: **Min. time of the curve**

- Default setting **(_:8161:114) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.



NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: `Additional time delay`

- Default setting **`(_:8161:115) Additional time delay`** = ***`0.00 s`***

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: `Threshold`

- Default setting **`(_:8161:3) Threshold`** = ***`1.50 A`***

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. Therefore, refer to chapter *6.3.5.2 Application and Setting Notes* for further information.

Parameter: `Time dial`

- Default setting **`(_:8161:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`*** (default setting).

Parameter: `Reset`

- Default setting **`(_:8161:131) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.6.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
`Inverse-T 1`				
_:8161:1	Inverse-T 1:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:8161:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8161:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:8161:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8161:113	Inverse-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8161:110	Inverse-T 1:Directional comparison		• no • yes	no
_:8161:112	Inverse-T 1:Release via input signal		• no • yes	no
_:8161:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8161:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:8161:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8161:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:130	Inverse-T 1:Type of character. curve			
_:8161:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:8161:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:8161:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:8161:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:8161:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8161:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8161:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:8161:36	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:8161:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:8161:37	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:8161:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:8161:38	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:8161:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8161:39	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:8161:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8161:40	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: bin.input				
_:8161:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:8161:41	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.6.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:8161:81	Inverse-T 1:>Block stage	SPS	I
_:8161:501	Inverse-T 1:>Release delay & op.	SPS	I
_:8161:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:8161:500	Inverse-T 1:>Block delay & op.	SPS	I
_:8161:54	Inverse-T 1:Inactive	SPS	O
_:8161:52	Inverse-T 1:Behavior	ENS	O
_:8161:53	Inverse-T 1:Health	ENS	O
_:8161:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:8161:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8161:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8161:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:8161:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8161:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:8161:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:8161:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:8161:59	Inverse-T 1:Disk emulation running	SPS	O
_:8161:55	Inverse-T 1:Pickup	ACD	O
_:8161:300	Inverse-T 1:Direction	ACD	O
_:8161:56	Inverse-T 1:Operate delay expired	ACT	O
_:8161:57	Inverse-T 1:Operate	ACT	O

6.6.6 Stage with User-Defined Characteristic Curve

6.6.6.1 Description

The structure of this stage is identical to that of the advanced stage with directional inverse-time characteristic curve (*6.6.4.1 Description*). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

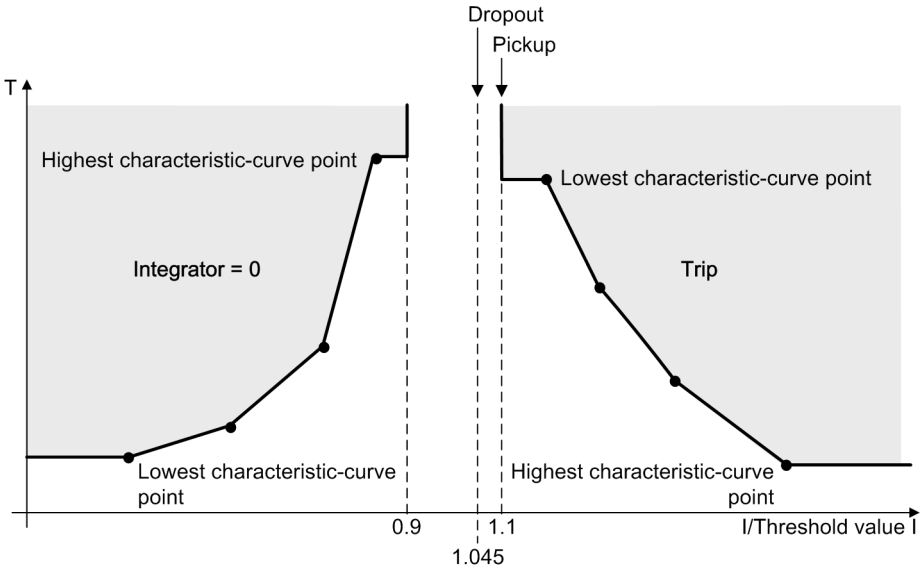
With the directional, user-defined characteristic curve, you can define the tripping curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



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Figure 6-54 Pickup and Dropout Behavior when Using a Directional User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.6.6.2 Application and Setting Notes

This stage is structured in the same way as the stage with a directional inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter set to ***`1`***.

Parameter: `Reset`

- Default setting **`(_:115) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `Current/time value pairs` (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

6.6.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:110	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:109	User curve #:Directional comparison		• no • yes	no
_:111	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:115	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.6.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:309	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.6.7 Direction Determination

6.6.7.1 Description

General

Every phase has a separate direction-measuring element. If the threshold value in a phase is exceeded, the direction determination is started for this phase. If there are multiphase short circuits, all measuring elements involved perform direction determination independently. If one of the determined directions matches the set direction, the stage picks up (see descriptions of the stage logic).

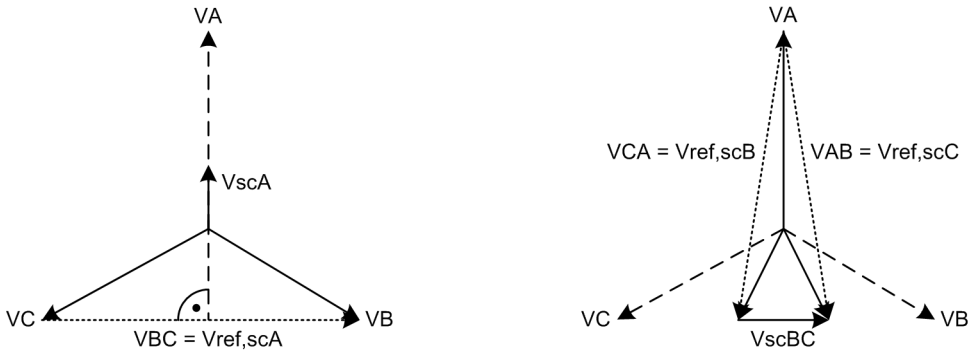
The direction is determined by calculating the phase angle between the short-circuit current and a reference voltage.

Measurands for Direction Determining

The directional measuring element uses the short-circuit current of the phase concerned and the cross-polarized phase-to-phase voltage (as the reference voltage) to determine the direction. This means that the direction can still be determined unambiguously and correctly, even if the short-circuit voltages collapse completely when a 1 or 2-phase fault occurs (close-up fault).

The phase-to-phase voltages are calculated when phase-to-ground voltages are connected.

The cross-polarized voltage (reference voltage) is vertical in relation to the short-circuit voltages for 1-phase-to-ground faults (*Figure 6-55*, left). For 2-phase short circuits, the position of the reference voltages changes up to 30°, depending on the extent to which the short-circuit voltages collapse (*Figure 6-55*, right).



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Figure 6-55 Cross-Polarized Voltages for Direction Determination

The following table shows how measurands are assigned for direction-determination purposes in the event of different types of fault.

Table 6-3 Measurands for Direction Determining

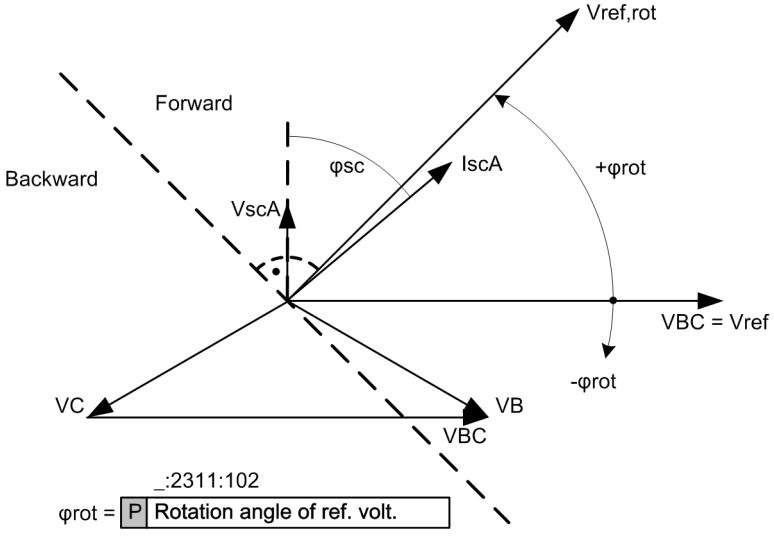
Threshold-Value Exceeding	Measuring Element							
	A		B		C		Ground	
	Current	Voltage	Current	Voltage	Current	Voltage	Current	Voltage
A	I_A	V_{BC}	–	–	–	–	–	–
B	–	–	I_B	V_{CA}	–	–	–	–
C	–	–	–	–	I_C	V_{AB}	–	–
Gnd	–	–	–	–	–	–	I_r	V_0
A, Gnd	–	V_{BC}	–	–	–	–	I_r	V_0
B, Gnd	–	–	I_B	V_{CA}	–	–	I_r	V_0
C, Gnd	–	–	–	–	I_C	V_{AB}	I_r	V_0
A, B	I_A	V_{BC}	I_B	V_{CA}	–	–	–	–
B, C	–	–	I_B	V_{CA}	I_C	V_{AB}	–	–
A, C	I_A	V_{BC}	–	–	I_C	V_{AB}	–	–
A, B, Gnd	I_A	V_{BC}	I_B	V_{CA}	–	–	I_r	V_0
B, C, Gnd	–	–	I_B	V_{CA}	I_C	V_{AB}	I_r	V_0
A, C, Gnd	I_A	V_{BC}	–	–	I_C	V_{AB}	I_r	V_0
A, B, C	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	–	–
A, B, C, Gnd	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	I_r	V_0

Voltage Memory

Saved voltages are used if, when a 3-pole close-up fault occurs, the measuring voltages are not sufficient for reliable direction determination. Insofar as and as long as no sufficient measuring voltage is available after the storage time (2 s) has elapsed, the detected direction is retained. If the memory does not contain any voltages (when closing onto a short circuit, for example), the behavior of the stage is defined using the **Non-directional pickup** parameter.

Direction Determination

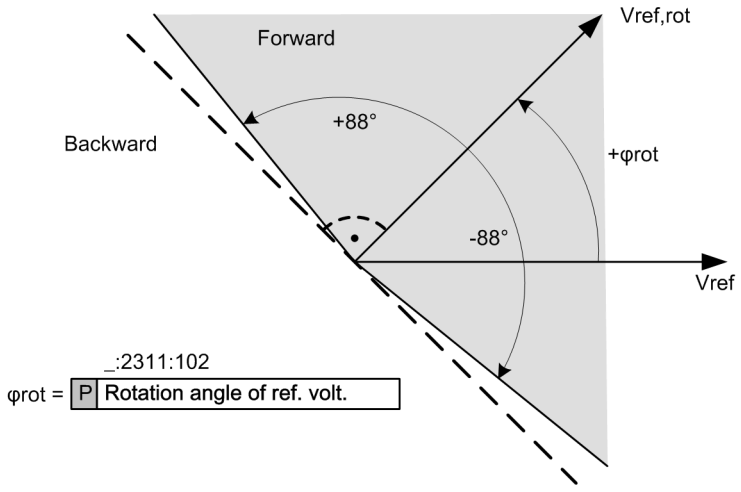
As mentioned in the **General** section, the direction is determined by calculating the phase angle between short-circuit current and reference voltage. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (**Rotation angle of ref. volt.** parameter). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current. Consequently, the result of direction determination is as reliable as possible. *Figure 6-56* illustrates the relationship based on a 1-phase ground fault in phase A. The short-circuit current I_{kL1} lags the short-circuit voltage by the short-circuit angle φ_k. The reference voltage, in this case V_{BC} for measuring element A, is rotated positively (counterclockwise) by the setting value of the **Rotation angle of ref. volt.** parameter. In the scenario illustrated here, the rotation is +45°.



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Figure 6-56 Rotation of the Reference Voltage, Phase-Measuring Element

The rotated reference voltage defines the forward and reverse range; see *Figure 6-57*. The forward range is calculated as ±88° around the rotated reference voltage $V_{ref,rot}$. If the short-circuit current vector is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the backward direction. In the intermediate range, the direction is undetermined.



[dwdocp34-240611-01.tif, 2, en_US]

Figure 6-57 Forward Characteristic of the Directional Function, Phase-Measuring Element

Direction Determination for Test Purposes

If you activate the binary input signal **>Test of direction**, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as current and voltage are greater than approx. 7 % of their secondary rated values.

6.6.7.2 Application and Setting Notes

Parameter: Rotation angle of ref. volt.

- Default setting **(_:2311:102) Rotation angle of ref. volt.** = ***45°***

The directional characteristic, that is, the position of the **forward** and **reverse** ranges, is set with the **Rotation angle of ref. volt.** parameter. The short-circuit angle is typically to be found in a range from 30° to 60° inductive. Therefore, in most cases, the default setting of +45° can be retained to position the reference voltage, as it ensures a reliable directional result.

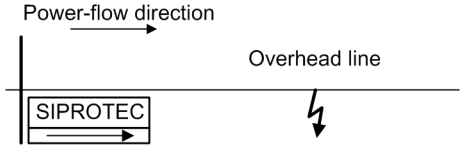
Some example settings for special applications appear in the following (*Table 6-4*). Please note that for phase-to-ground faults (PG faults), the reference voltage (fault-free voltage) is vertical in relation to the short-circuit voltage. This results in the following setting for the rotation angle:

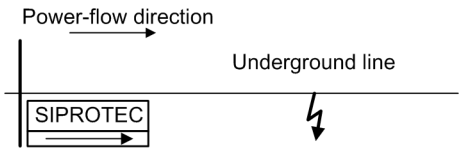
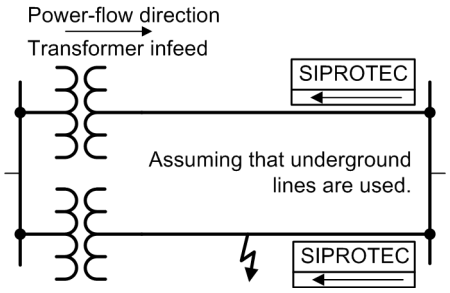
Rotation angle of ref. volt. = 90 - φsh phase-measuring elements (PG faults)

Please also note that for phase-to-phase faults, the reference voltage is rotated between 0° (distant fault) and 30° (close-up fault) dependent upon the collapse of the faulted voltage (see *Figure 6-56*). You can take this into account with an average value of 15°.

Rotation angle of ref. volt. = 90 - φsh - 15° phase-measuring elements (PP faults)

Table 6-4 Example settings

Application	φsh typical	Setting **Rotation angle of ref. volt.**
	60°	Range 30° to 0° for PP faults Selected: 15°

Application	φsh typical	Setting Rotation angle of ref. volt.
	30°	Range 60° to 30° for PP faults Selected: 45°
	30°	Range 60° to 30° for PP faults Selected: 45°

Input signal: >Test of direction

If you activate the binary input signal **>Test of direction**, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.6.8 Influence of Other Functions via Dynamic Settings

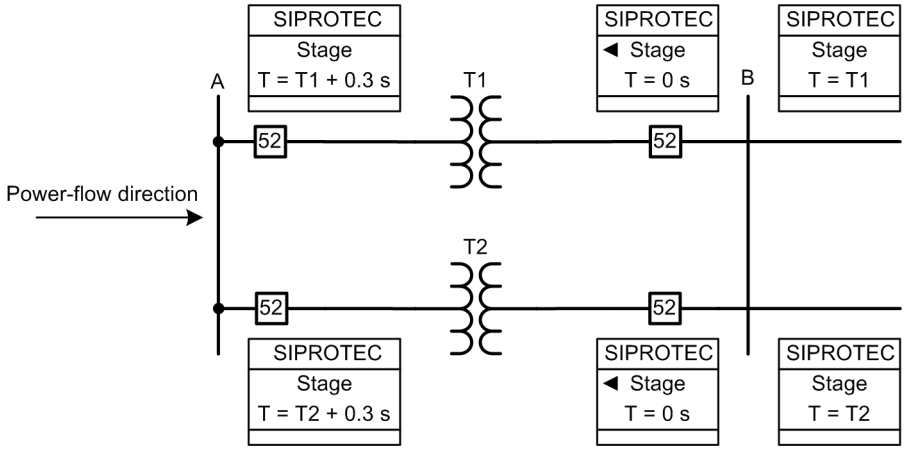
The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* and chapter *6.3.8.2 Application and Setting Notes (Advanced Stage)* .

6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends

Parallel Lines or Transformers

In parallel lines or transformers with infeed at one end (see *Figure 6-58*), if there is no directional measuring element, a fault on feeder T1 will also trip the other feeder T2. In contrast, a directional measuring element in the devices on busbar B prevents the tripping of the circuit-breaker in the parallel feeder. Therefore, in *Figure 6-58*, directional time-overcurrent protection is used in the places marked with direction arrows. Please note that the forward direction of the protection device represents the direction towards the object to be protected. This does not have to be the same as the power direction of normal load flow.

Set time grading in opposition to the load flow with increasing time. As load can only flow in one direction, you can set the directional devices without time delay.



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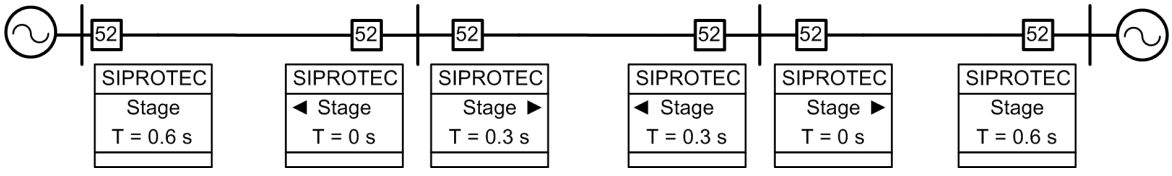
Figure 6-58 Parallel Line with Transformers

Legend for *Figure 6-58*

Stage ►:	Directional stage, **forward** direction set
Stage:	Non-directional stage
T:	Grading time

Cable Runs with Infeed at Both Ends

Cable runs with infeed at both ends and lines connected to form ring topologies also require that you supplement overcurrent protection with the directional criterion. *Figure 6-59* shows a ring system implementation, with the 2 infeeds shown merging in the ring to form a single infeed. For the directional devices whose forward direction matches the power-flow direction, set time grading in opposition to the power flow with increasing time. As power flow from both ends is possible, grading has to be set at both ends.



[dwdocp06-240611-01.tif, 1, en_US]

Figure 6-59 Cable Runs with Infeed at Both Ends

Legend for *Figure 6-59*

Stage ►:	Directional stage, **forward** direction set
Stage:	Non-directional stage
T:	Grading time

6.6.10 Application Notes for Directional Comparison Protection

The direction determination of directional time-overcurrent protection can be used to implement directional comparison protection for cable runs with infeed at both ends. Directional comparison protection is used for the selective isolation of a faulted line section (for example, subsections of closed rings). Sections are isolated in fast time, that is, they do not suffer the disadvantage of long grading times.

This technique requires that directional information can be exchanged between the individual protection stations. You can implement this information exchange using a communication channel (protection interface or IEC 61850 GOOSE) or with pilot wires for signal transmission via an auxiliary voltage loop.

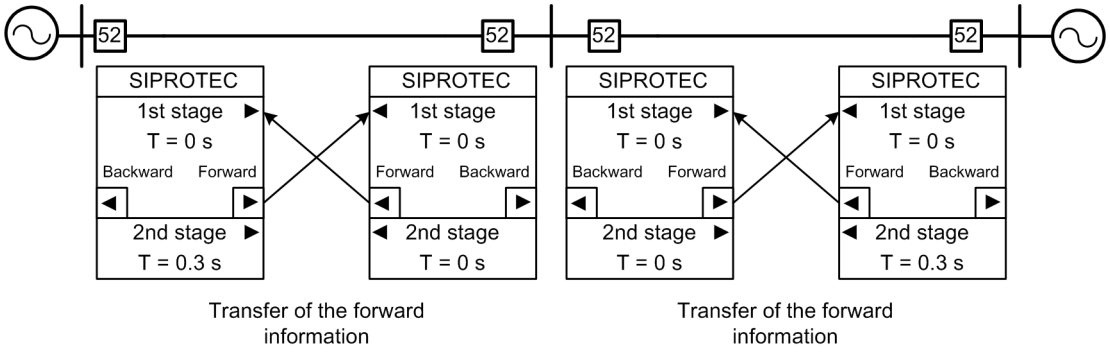
Protection Principle

The protection principle is shown in *Figure 6-60*. 2 devices (one at the start of the line and the other at the end of the line) work together in each line section. The information **fault in forward direction** is transferred between them. A directional definite time-overcurrent protection level is in operation in both devices in the forward direction (1st level). However, this level is not enabled in the idle state. The level is only released when the information **fault in forward direction** is received from the opposite end. If the enabled level also defines the fault in the forward direction, the fault must be on this line section and the level trips immediately. As this protection principle works with an enable procedure (and not with a blocking procedure), there is no need to delay the level.

A second directional definite time-overcurrent protection stage with standard time grading works in parallel with the first stage as a selective backup stage. This ensures full selectivity of protection in the following situations:

- Infeed at one end or weak infeed at one end: In this case, no release signal is generated.
- Failure of the communication route: In this case, the release signal is not transmitted.

To provide selective protection in fast time for busbars between the line sections also, you can combine this protection principle with the principle of reverse interlocking. This principle is not discussed in further detail in this document.



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Figure 6-60 Selectivity through Directional Comparison Protection

Legend for *Figure 6-60*

Stage ►:	Stage is set in the **forward** direction; stage 1 is instantaneous, stage 2 is graded
►, ◄:	If a threshold value is exceeded, the stage indicates the direction (forward or reverse)

If you are using a communication channel, the protocol-transmission methods detect if the channel is interrupted. If you are using pilot wires, we recommend operation based on a closed-circuit connection. The device uses a function chart to check and indicate if the binary input is dead for an unexpectedly long period. In contrast with the blocking procedure, overfunction is not possible if communication is lost. Therefore, a loss of communication is not critical where this procedure is concerned, although it must be detected and indicated.

Directional comparison protection can also be implemented as a blocking procedure. This procedure works under all system switching states, i.e. also with infeed at one end (or weak infeed). However, to use it you must delay the stage (typically by 100 ms) so that the blocking signal is received in time under all circumstances. It is also essential that you monitor the communication channel to avoid overfunction in the event of failure followed by a system incident.

Configuration of the Stage, Function Chart

To configure the stage, proceed as follows:

- The **`Directional mode`** parameter of both stages must be set to ***`forward`***
- The **`Directional comparison`** and **`Release via input signal`** parameters of the first stage must be set to ***`yes`***. This is so that the first stage is only released if the **`>Release delay & op.`** input signal is active. Furthermore, the direction is indicated if a threshold value is exceeded.
- The first stage can be set without a time delay. The second stage has to be graded

- The information ***forward*** from the **Direction** signal in the first stage must be transmitted to the opposite end. The routing is determined by the type of transmission
- A function chart has to be implemented at the receive end to link the received (***forward*** information) and release signals, dependent upon the type of transmission.

6.7 Directional Overcurrent Protection, Ground

6.7.1 Overview of Functions

The **Directional time-overcurrent protection, ground** function (ANSI 67N):

- Detects short circuits to ground affecting electric equipment
- Ensures selective ground fault detection for parallel lines or transformers with infeed at one end
- Ensures selective ground fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.7.2 Structure of the Function

The **Directional time-overcurrent protection, ground** function can be used in protection function groups which provide zero-sequence current and zero-sequence voltage measurements. 2 function types are offered:

- **Directional time-overcurrent protection, ground – advanced** (67N Dir.OC-gnd-A)
- **Directional time-overcurrent protection, ground – basic** (67N Dir.OC-gnd-B)

The basic function type shall be used for standard applications. The advanced function type provides more functionalities and is intended for more sophisticated applications.

Both function types are preconfigured by the manufacturer with 2 **Definite time-overcurrent protection** stages and 1 **Inverse time-overcurrent protection** stage.

In the advanced function type **Directional time-overcurrent protection, ground – advanced**, the following stages can operate simultaneously:

- A maximum of 4 **Definite time-overcurrent protection – advanced** stages
- 1 **Inverse time-overcurrent protection – advanced** stage
- 1 **Logarithmic inverse time-overcurrent protection** stage
- 1 **Logarithmic inverse time with knee-point overcurrent protection** stage
- 1 **User-defined characteristic curve overcurrent protection** stage

In the basic function type **Directional time-overcurrent protection, ground – basic**, the following stages can operate simultaneously:

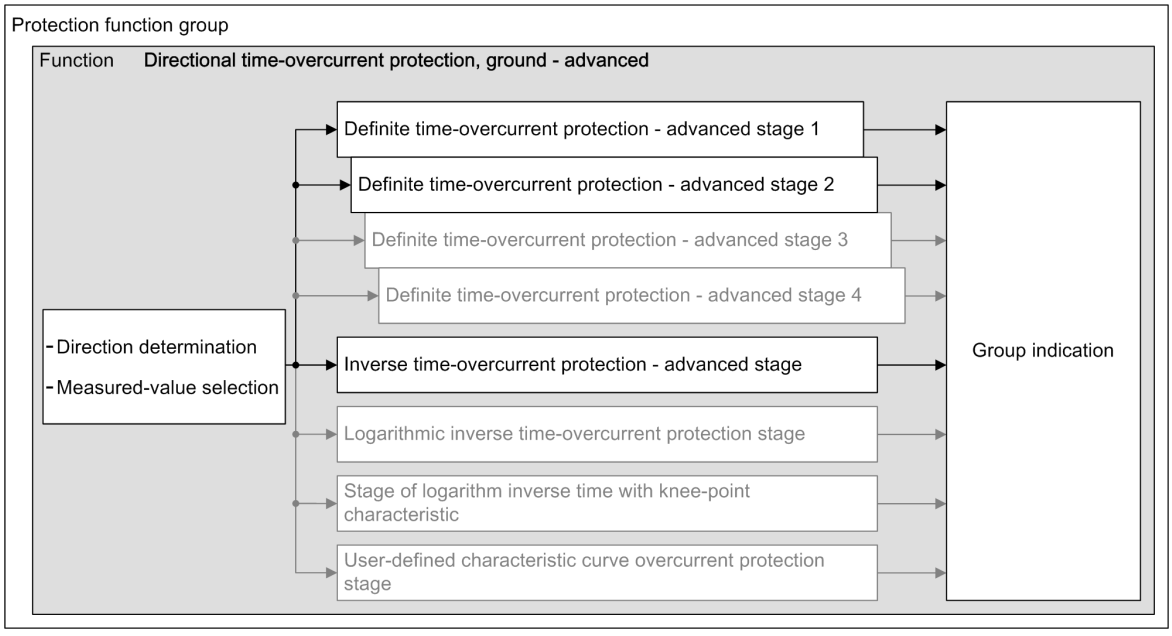
- A maximum of 4 **Definite time-overcurrent protection – basic** stages
- 1 **Inverse time-overcurrent protection – basic** stage

Referring to *Figure 6-61* and *Figure 6-62*, the stages not preconfigured are shown in gray. Apart from the operate-delay characteristic curve, the stages are similar in structure.

The general functionallity includes the direction determination and the measured-value selection (only advanced function). They take place on the functional level and have a uniform effect on the stages (see *Figure 6-61* and chapter General Functionality. This ensures that all stages of the function receive the same measured current value and the same direction result. Each stage can be set to work in forward or reverse direction.

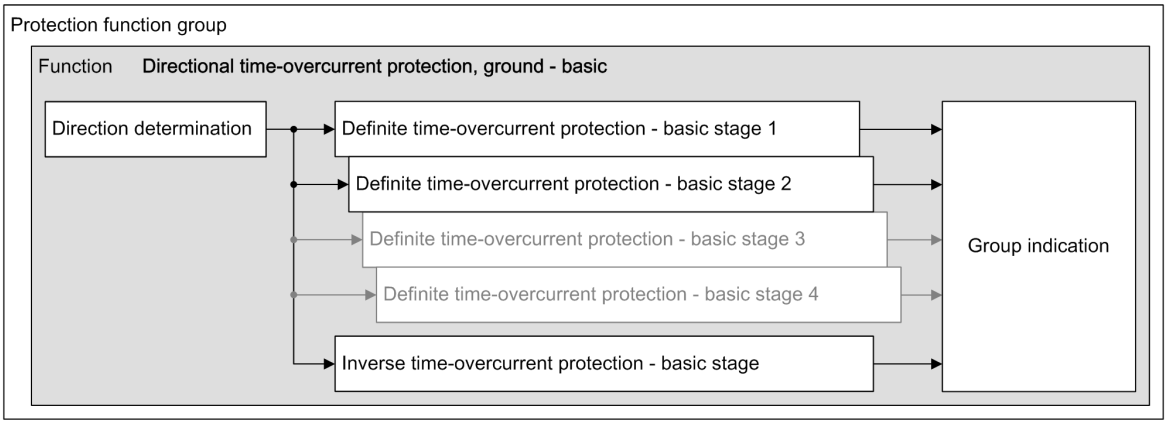
The group indication output logic generates the following group indications for the protection function by the logic OR from the stage-selective indications:

- Pickup
- Operate



[dwrdirad-300913, 2, en_US]

Figure 6-61 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Advanced



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Figure 6-62 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Basic

If the following listed device-internal functions are present in the device, these functions can influence the pickup values and operate delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against operate due to transformer-inrush currents.

6.7.3 General Functionality

6.7.3.1 Measured-Value Selection

Logic

The function provides the option to select between the values ***IN measured*** or ***3I0 calculated***.

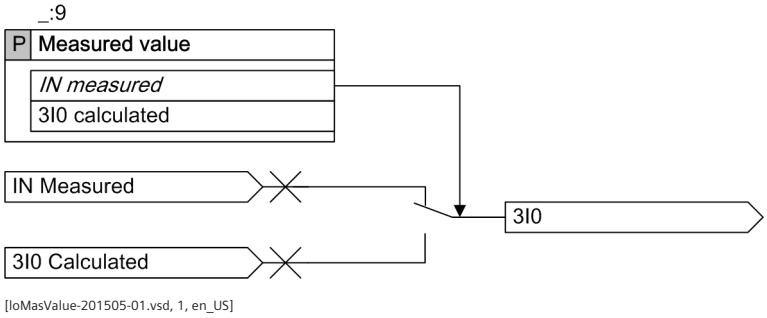


Figure 6-63 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types ***3-phase + IN*** and ***3-phase + IN-separate***. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

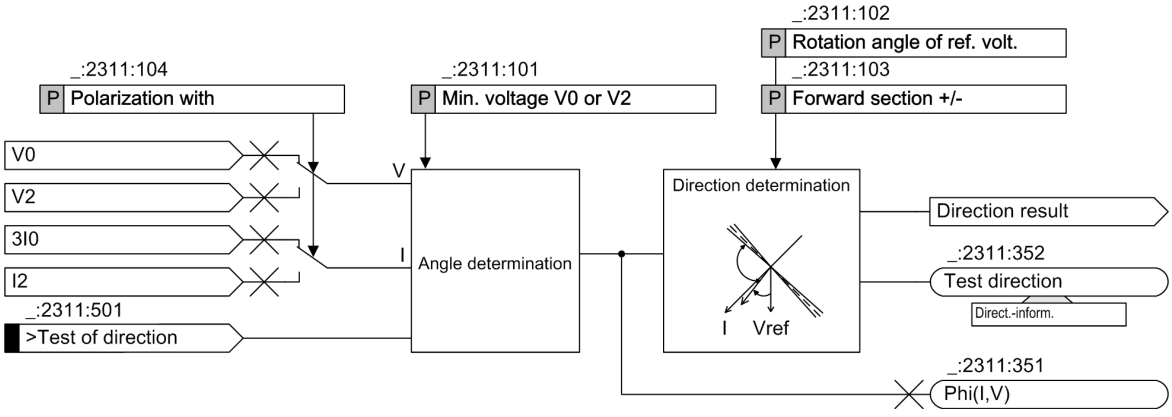
Table 6-5 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	0.15 A to 175.00 A	0.030 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.7.3.2 Direction Determination

Logic of Direction Determination

The following figure represents the logic of the direction determination. It applies to all types of stages.



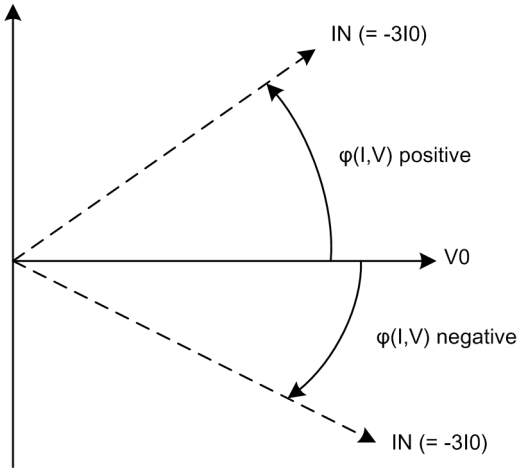
[lodirdet-280812-01.tif, 1, en_US]

Figure 6-64 Logic Diagram of Direction Determination

Measurand for the Direction Determination

With the parameter **`Polarization with`** you define whether the direction determination is calculated with the zero-sequence components 3I0 and V0 or with the negative-sequence components I2 and V2, which are present during faults in the network.

The angle between IN (=-3I0) and V0 (respectively -I2 and V2) in case of using the negative-sequence components is available as a functional measured value. This value is only present during faults in the network.



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Figure 6-65 Measured-Value Definition

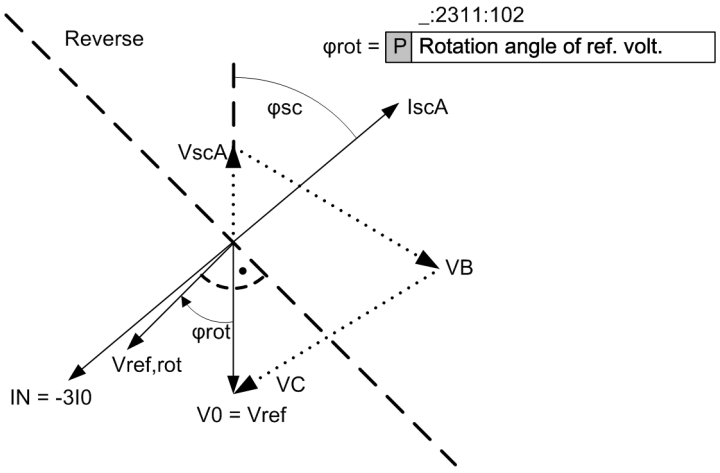
Start of the Direction Determination

If the zero-sequence current 3I0 exceeds the pickup threshold of a stage and the selected voltage (V0 or V2) exceeds the parameter **`Min. voltage V0 or V2`** as well, the direction determination is started.

Direction Determination with Zero-Sequence Values

The direction is determined by calculating the phase angle between the short-circuit current -3I0 and the rotated reference voltage **Vref, rot**. Contrary to the **Directional time-overcurrent protection, phase** function, which works with the healthy voltage as reference voltage, the fault voltage V0 itself is the reference voltage for the **Directional time-overcurrent protection, ground** function. To take different system condi-

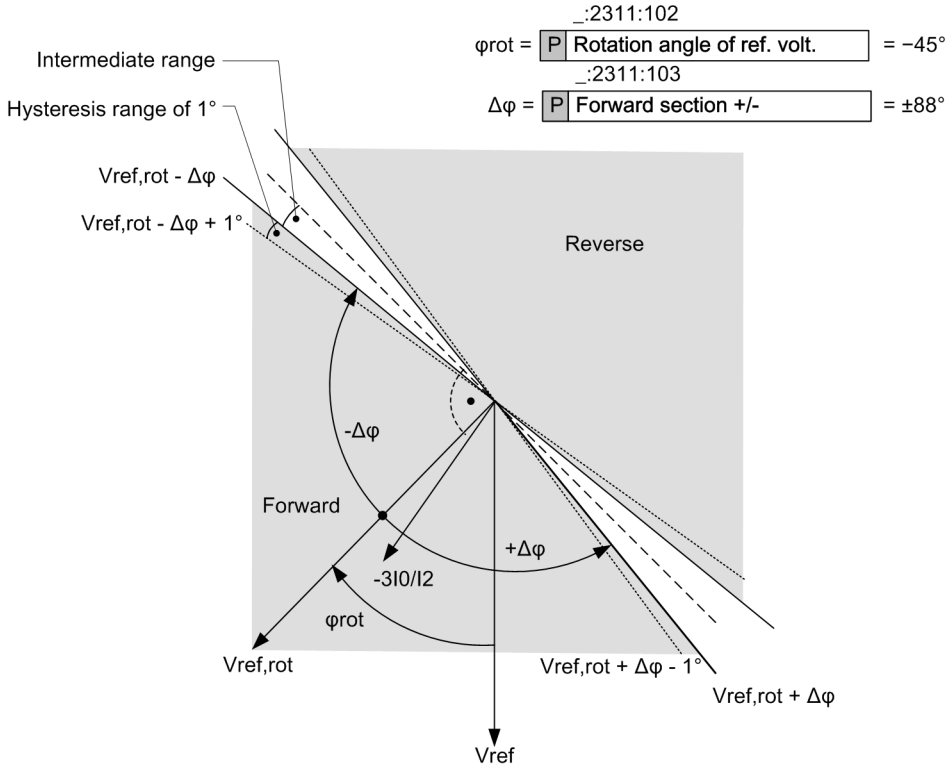
tions and applications into account, the reference voltage V0 can be rotated through an adjustable angle (parameter **Rotation angle of ref. volt.**). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current -3I0. Consequently, the result of direction determination is as reliable as possible. *Figure 6-66* illustrates the relationship based on a 1-phase-to-ground fault in phase A. The fault current has a phase displacement of 180° to the fault current IscA and lags the fault voltage by the fault angle φsc. The reference voltage V0 is rotated by φrot which is -45°.



[dwroreze-300913, 2, en_US]

Figure 6-66 Rotation of the Reference Voltage, Directional Time-Overcurrent Protection, Ground Function with Zero-Sequence Values

The rotated reference voltage **Vref, rot** and the parameter **Forward section +/-** define the forward and reverse ranges, see *Figure 6-67* . The forward range is calculated as ± Δφ° around the rotated reference voltage **Vref, rot**. Δφ is set with the parameter **Forward section +/-** . If the short-circuit current vector -3I0 is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the reverse direction. In the intermediate range, the direction is undetermined.



[dwforrev-281013, 2, en_US]

Figure 6-67 Forward/Reverse Characteristic of the Directional Time-Overcurrent Protection, Ground Function

Direction Determination with Negative-Sequence Values

The method works in the same way as for zero-sequence values. Instead of 3I0 and V0, the negative-sequence values I2 and V2 are used for determining the direction.

Direction Determination for Test Purposes

If you activate the binary input signal *>Test of direction* , the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as the zero-sequence current 3I0 and the zero-sequence voltage V0 exceeds approx. 7 % of the secondary rated values of phase current and voltage.

6.7.3.3 Application and Setting Notes

Parameter: `Measured value`

- Recommended setting value **`(_:9) Measured value`** = ***`IN Measured`***

This parameter is not available in the basic function.

Parameter Value	Description
`IN Measured`	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
`3I0 Calculated`	The function operates with the calculated zero-sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

Parameter: **Min. voltage V0 or V2**

- Recommended setting value **(_:2311:101) Min. voltage V0 or V2** = ***2 V***

This parameter is not available in the basic function. The basic function uses a fixed value of 2 V.

You use the **Min. voltage V0 or V2** parameter to define the minimum zero-sequence voltage or negative-sequence voltage for the direction determination. The minimum voltage must be set greater than the maximum operational unbalance plus the voltage-transformer measuring errors.

As the measuring error of the individual voltage transformer is not added up, the critical measuring-error influence is the unbalance of the primary system.

Siemens recommends observing the operational zero-sequence voltage V0 of the protected object (for example, the line) via the operational measured values of the device and providing the maximum value with a certainty of 50 %.

EXAMPLE

Maximum operational measured value of zero-sequence voltage V0 = 0.5 Vsec

Min. voltage V0 or V2 = 1.5 * 0.5 V = 0.75Vsec

If you have no information about maximum operational unbalance, Siemens recommends using the default setting.

Parameter: **Rotation angle of ref. volt. / Forward section +/-**

- Recommended setting value **(_:2311:102) Rotation angle of ref. volt.** = ***-45°***
- Recommended setting value **(_:2311:103) Forward section +/-** = ***88°***

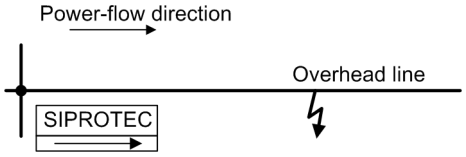
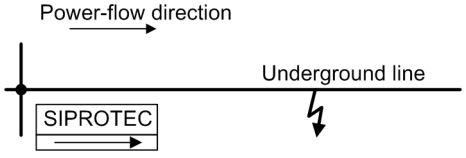
The parameter **Forward section +/-** is not available in the basic function. The basic function uses a fixed value of 88°.

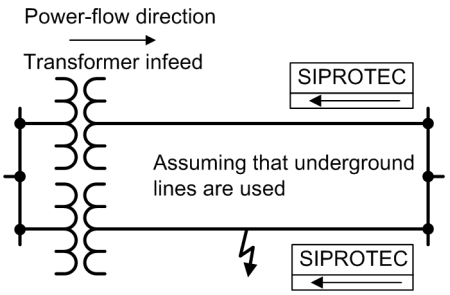
The direction characteristic, that is, the area of the forward and reverse ranges, is set with the **Rotation angle of ref. volt.** and the **Forward section +/-** parameters. The short-circuit angle is typically to be found in a range from -30° to -60° inductively. Therefore, in most cases, the default setting of -45° can be retained to position the reference voltage, as it ensures a reliable directional result.

Some example settings for special applications appear below *Table 6-6*. Note that for 1-phase-to-ground faults (PG faults), the reference voltage is the zero-sequence voltage V0. This results in the following setting for the rotation angle:

Rotation angle of ref. volt. = -φk ground-measuring elements (PG faults)

Table 6-6 Example Settings

Application	φk Typical	Setting **Rotation angle of ref. volt.**
	60°	-60°
	30°	-30°

	30°	-30°

Parameter: **`Polarization with`**

- Recommended setting value **`(_:2311:104) Polarization with`** = ***`zero sequence`***

This parameter is not available in the basic function. The basic function uses always zero-sequence components for the direction determination.

You use the parameter **`Polarization with`** to select the values for the direction determination.

Parameter Value	Description
`zero sequence`	Select ***`zero sequence`*** to determine the direction via the zero-sequence components V0 and 3I0. Siemens recommends using the zero-sequence components for the direction determination.
`negative sequence`	Select ***`negative sequence`*** to determine the direction via the negative-sequence components V2 and I2. The negative-sequence system can be used in case of danger that the zero-sequence voltage is too small due to unfavorable zero-sequence impedance conditions or that a parallel line influences the zero-sequence system.

Input Signal: ***`>Test of direction`***

If you activate the binary input signal ***`>Test of direction`***, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.7.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
_:101	General:Min. voltage V0 or V2		0.150 V to 20.000 V	2.000 V
_:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	General:Forward section +/-		0 ° to 90 °	88 °
_:104	General:Polarization with		• zero sequence • negative sequence	zero sequence

6.7.3.5 Information List

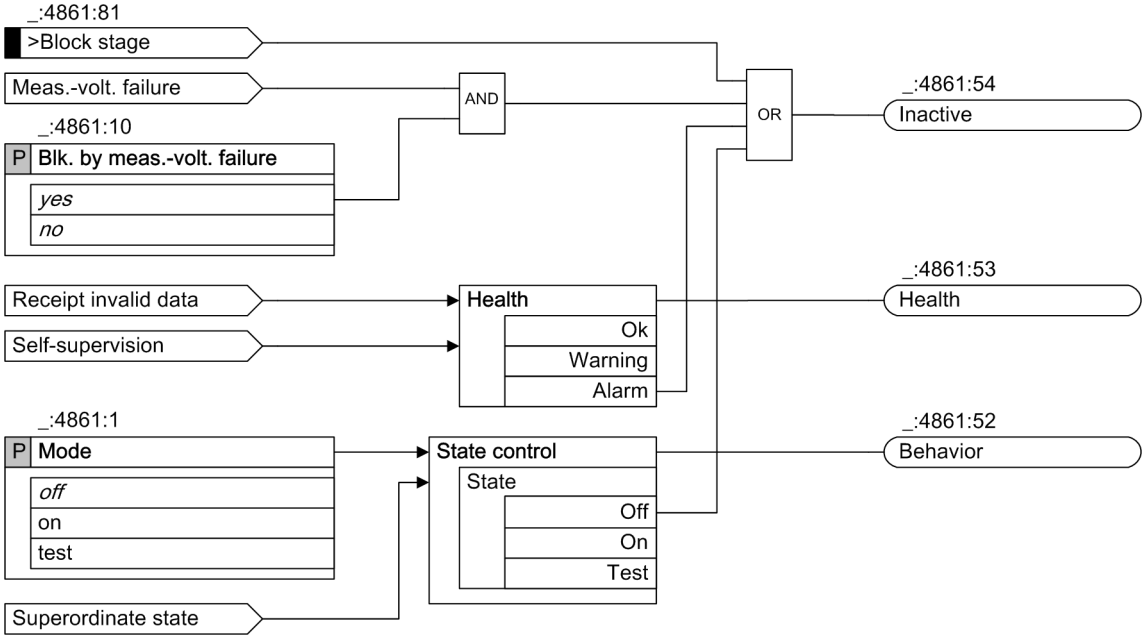
No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction		I
_:2311:352	General:Test direction		O
_:2311:351	General:Phi(I,V)		O

6.7.4 Stage Control

6.7.4.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.



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Figure 6-68 Logic Diagram of the Stage Control

Blocking of Stage in Case of Measuring-Voltage Failure

The stages can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source on the pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage-transformer circuit breaker**, which links to the trip of the voltage-transformer circuit breaker

The **`Blk. by meas.-volt. failure`** parameter can be set to either block or not block the stage when the **Measuring-voltage failure detection** function picks up.

6.7.4.2 Application and Setting Notes

Parameter: **`Blk. by meas.-volt. failure`**

- Recommended setting value **`(_:4861:10) Blk. by meas.-volt. failure`** = ***`yes`***

You can use the **Blk. by meas.-volt. failure** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

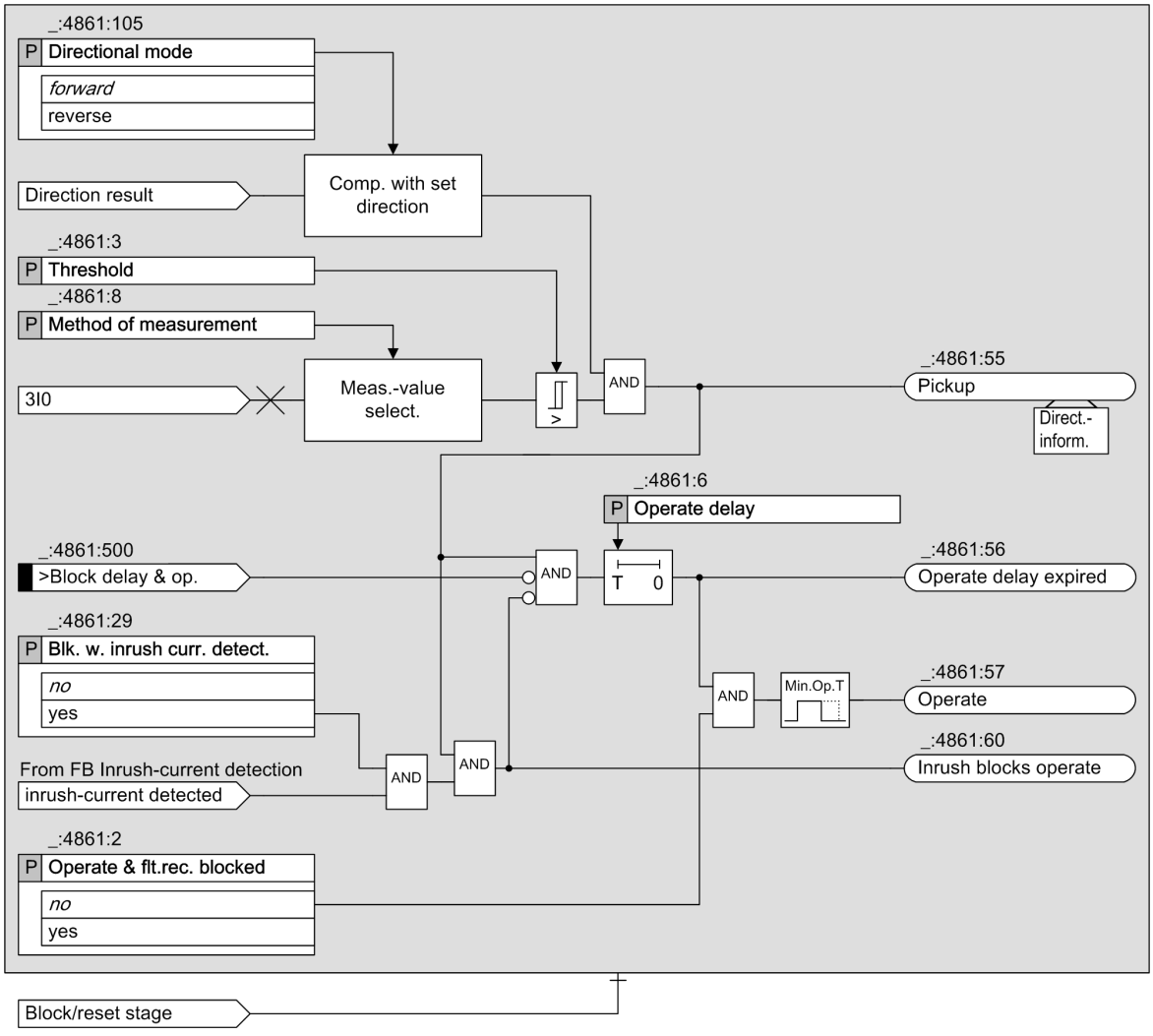
- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The directional overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.

6.7.5 Stage with Definite-Time Characteristic Curve

6.7.5.1 Description

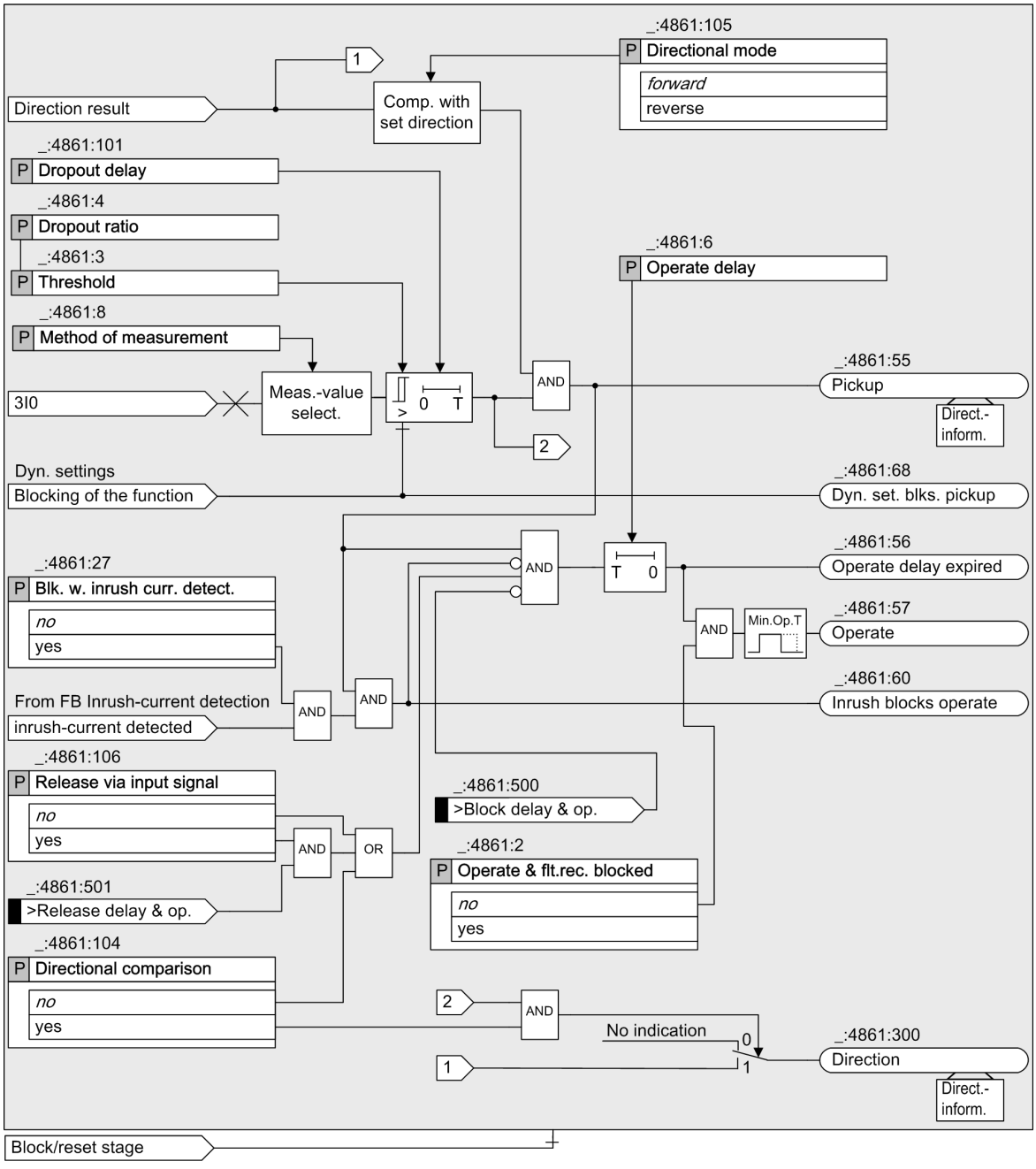
Logic of the Basic Stage



[lodirovb-280812-02.tif, 1, en_US]

Figure 6-69 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage



[lodirova-280812-02.tif, 1, en_US]

Figure 6-70 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the **Measuring point I-3ph**, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 **`Threshold`** range varies according to the following table.

Table 6-7 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This measuring procedure processes the sampled current values and filters out the fundamental components numerically.
- Measurement of the RMS value:
  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter *6.7.3.2 Direction Determination*).

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage* (see chapter *6.7.4.1 Description*)
- Measuring-voltage failure (see chapter *6.7.4.1 Description*)
- Via the dynamic settings functionality (only available in the advanced function type, see **Influence of Other Functions via Dynamic Settings** and chapter *6.7.10 Influence of Other Functions via Dynamic Settings*)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal *>Block delay & op.* to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.5.7.1 Description*

Dropout Delay (Advanced Stage)

In case of undershooting of the dropout threshold, the dropout can be delayed. The pickup is maintained for the specified time. The operate delay continues to run. If the operate delay expires while the pickup is still maintained, the stage operates.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the direction indication *Direction* is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** parameter and the *>Release delay & op.* input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the *>Release delay & op.* input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.7.10 Influence of Other Functions via Dynamic Settings*.

6.7.5.2 Application and Setting Notes

Parameter: **Directional mode**

- Default setting **(_:4861:105) Directional mode** = ***forward***

You can use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: **Method of measurement**

- Recommended setting value **(_:4861:8) Method of measurement** = ***fundamental comp.***

You can use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: **Directional comparison**, **Release via input signal**

- Default setting **(_:4861:104) Directional comparison** = ***no***
- Default setting **(_:4861:106) Release via input signal** = ***no***

The parameters **Directional comparison** and **Release via input signal** are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the *Direction* and *>Release delay & op.* signals.

Parameter Value	Description

no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the *Direction* output signal, and the *>Release delay & op.* input signal become available. If the **Release via input signal** parameter is set to ***yes***, the starts of the operate delay and operate signal are only enabled when the *>Release delay & op.* input signal is active. The *>Release delay & op.* input signal must be connected to the enable information from the opposite end (forward information from the *Direction* output signal). See also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection*

Parameter: **Dynamic settings**

- Default setting **(_:4861:26) Dynamic settings** = ***no***

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (**Automatic reclosing** or **Cold-load pickup detection**) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters effected by **Auto reclosing**/**Cold-load PU**/**Binary input** as well as the dynamic settings **Threshold**, **Operate delay**, and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter *6.5.8.2 Application and Setting Notes (Advanced Stage)* of the function **Overcurrent Protection, Ground**.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:4861:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: `Threshold`

- Default setting **`(_:4861:3) Threshold`** = ***`1.20 A`***

For setting the threshold value, the same considerations apply as for the non-directional time-overcurrent protection function.

For further information, refer to chapter *6.5.4.2 Application and Setting Notes* .

Parameter: `Dropout ratio`

- Recommended setting value **`(_:4861:4) Dropout ratio`** = ***`0.95`***

This parameter is not visible for the basic stage.

The recommended setting value of ***`0.95`*** is appropriate for most applications.

For high-precision measurements, the setting value of the **`Dropout ratio`** parameter can be reduced, for example to 0.98. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the **`Dropout ratio`** parameter. This avoids chattering of the stage.

Parameter: Dropout delay

- Recommended setting value **`(_:4861:101) Dropout delay`** = ***`0 s`***

This parameter is not visible for the basic stage.

Siemens recommends using the dropout delay of 0 s, since the dropout of a protection stage must be performed as fast as possible.

You can use the **`Dropout delay`** parameter ≠ ***`0 s`*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical data) and set the result.

Parameter: `Operate delay`

- Default setting **`(_:4861:6) Operate delay`** = ***`0.300 s`*** (for the 1st stage)

The **`Operate delay`** to be set is derived from the time-grading chart that has been prepared for the system.

Typical examples of grading times are provided in sections *6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends* and *6.6.10 Application Notes for Directional Comparison Protection* .

6.7.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:4861:1	Definite-T 1:Mode		• off • on • test	off
_:4861:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4861:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:4861:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4861:104	Definite-T 1:Directional comparison		• no • yes	no
_:4861:106	Definite-T 1:Release via input signal		• no • yes	no
_:4861:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4861:26	Definite-T 1:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4861:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:4861:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:4861:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:4861:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4861:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4861:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:4861:36	Definite-T 1:Stage blocked		• no • yes	no
_:4861:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:4861:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:4861:37	Definite-T 1:Stage blocked		• no • yes	no
_:4861:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:4861:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:38	Definite-T 1:Stage blocked		• no • yes	no
_:4861:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:4861:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4861:39	Definite-T 1:Stage blocked		• no • yes	no
_:4861:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:4861:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4861:40	Definite-T 1:Stage blocked		• no • yes	no
_:4861:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:4861:34	Definite-T 1:Effected by binary input		• no • yes	no
_:4861:41	Definite-T 1:Stage blocked		• no • yes	no
_:4861:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

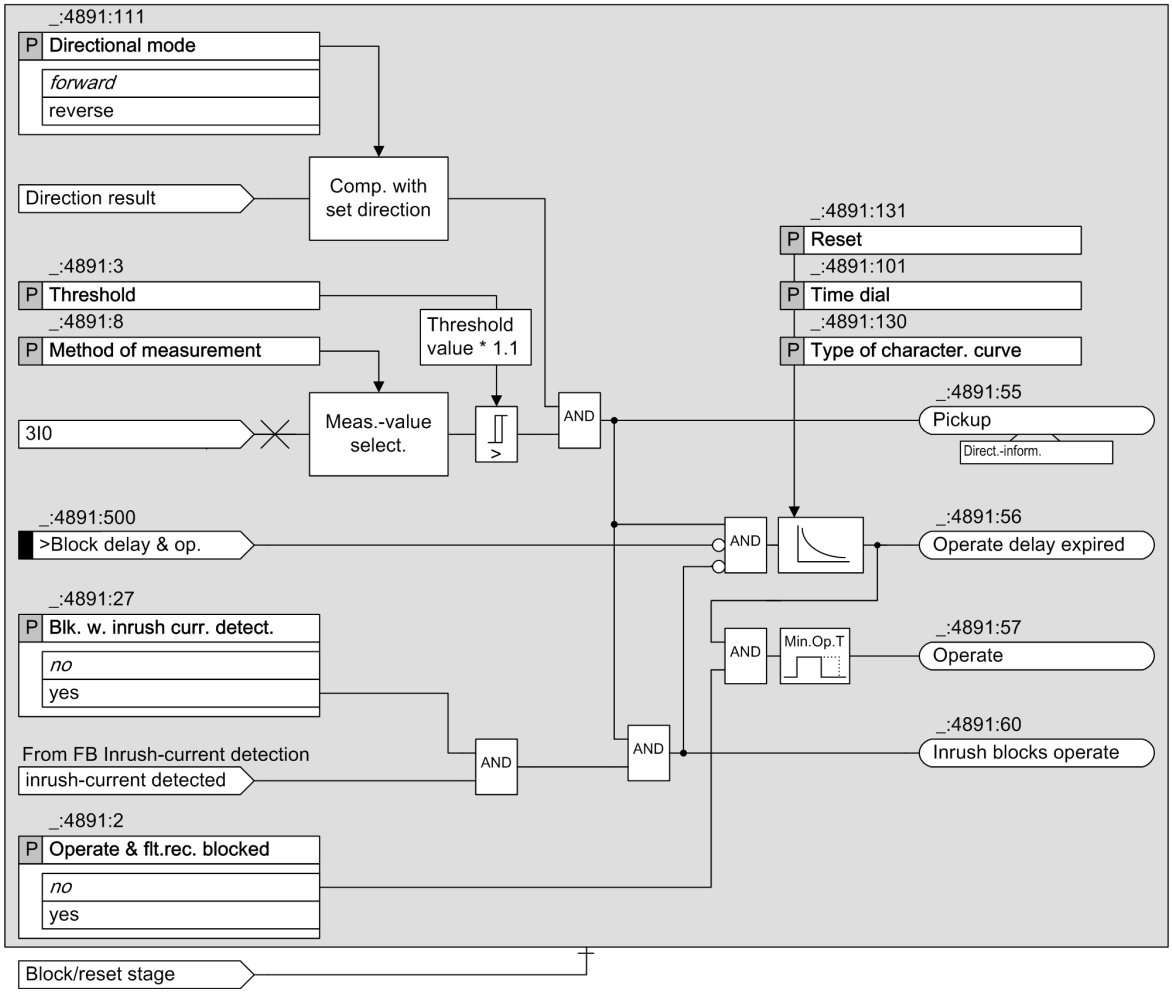
6.7.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:352	General:Test direction	ACD	O
_:2311:351	General:Phi(I,V)	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:4861:81	Definite-T 1:>Block stage	SPS	I
_:4861:501	Definite-T 1:>Release delay & op.	SPS	I
_:4861:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:4861:500	Definite-T 1:>Block delay & op.	SPS	I
_:4861:54	Definite-T 1:Inactive	SPS	O
_:4861:52	Definite-T 1:Behavior	ENS	O
_:4861:53	Definite-T 1:Health	ENS	O
_:4861:60	Definite-T 1:Inrush blocks operate	SPS	O
_:4861:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4861:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4861:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4861:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:4861:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:4861:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:4861:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:4861:55	Definite-T 1:Pickup	ACD	O
_:4861:300	Definite-T 1:Direction	ACD	O
_:4861:56	Definite-T 1:Operate delay expired	ACT	O
_:4861:57	Definite-T 1:Operate	ACT	O

6.7.6 Stage with Inverse-Time Characteristic Curve

6.7.6.1 Description

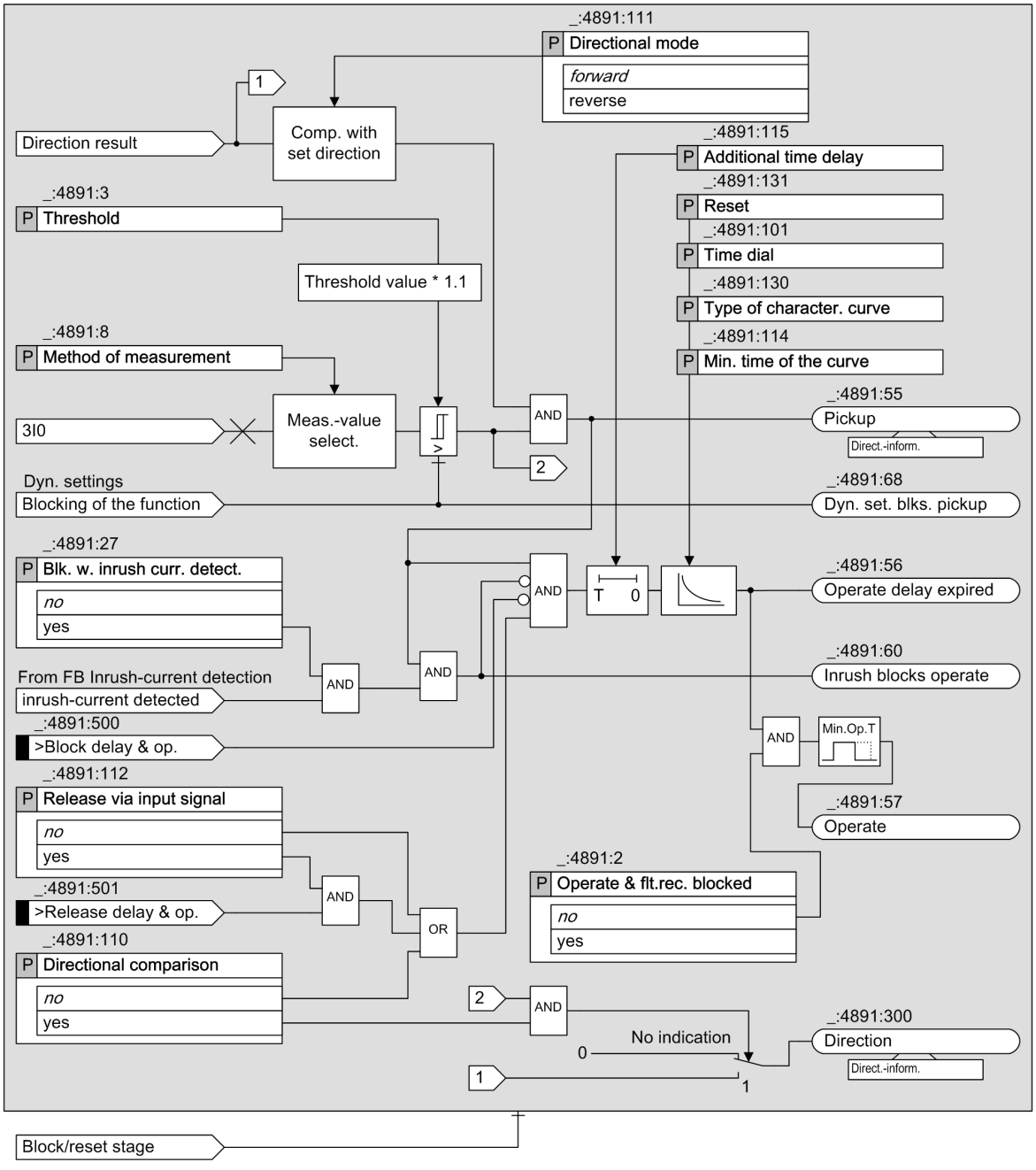
Logic of the Basic Stage



[lodiinvb-280812-02.tif, 2, en_US]

Figure 6-71 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage



[lodiinva-280812-02.tif, 2, en_US]

Figure 6-72 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the **Measuring point I-3ph**, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 **`Threshold`** range varies according to the following table.

Table 6-8 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This measuring procedure processes the sampled current values and filters out the fundamental components numerically.
- Measurement of the RMS value:
  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter *6.7.3.2 Direction Determination*).

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

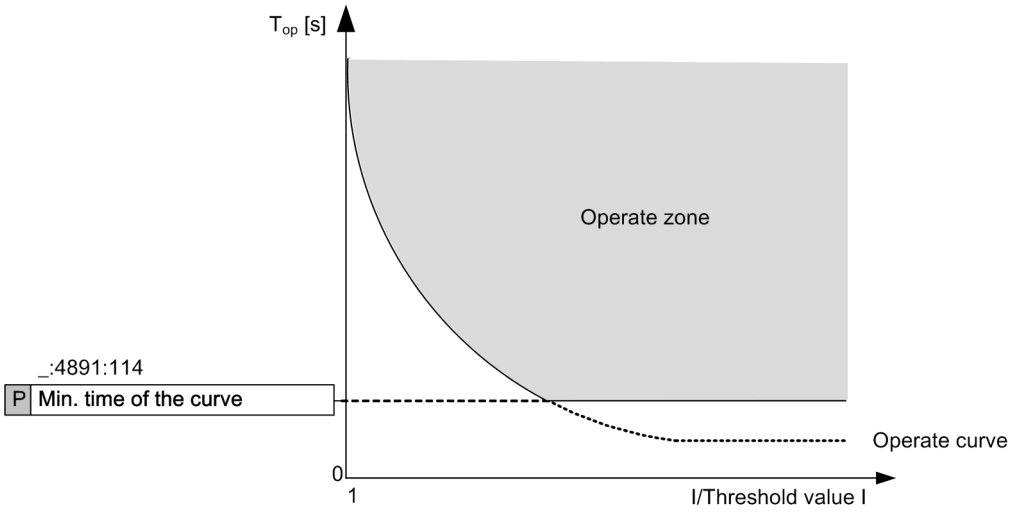
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrated measuring procedure totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the threshold value by a factor of 1.045 (0.95 × 1.1× threshold value), the dropout starts. The pickup will be indicated as clearing. You can influence the dropout behavior via adjustable parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwMinTime_20140708-01.vsd, 1, en_US]

Figure 6-73 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage* (see chapter *6.7.4.1 Description*)
- Measuring-voltage failure (see chapter *6.7.4.1 Description*)
- Via the dynamic settings functionality (only available in the advanced function type, see **Influence of Other Functions via Dynamic Settings** and chapter *6.7.10 Influence of Other Functions via Dynamic Settings*)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal *>Block delay & op.* to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter Blocking of the Tripping by Device-Internal Inrush-Current Detection

For more information, refer to *6.5.7.1 Description*.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the direction indication *Direction* is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** parameter and the *>Release delay & op.* input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the *>Release delay & op.* input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.7.10 Influence of Other Functions via Dynamic Settings*.

6.7.6.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:4891:111) Directional mode** = ***forward***

You can use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:4891:8) Method of measurement** = ***fundamental comp.***

You can use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Directional comparison, Release via input signal

- Default setting **(_:4891:110) Directional comparison** = ***no***
- Default setting **(_:4891:112) Release via input signal** = ***no***

The parameters **Directional comparison** and **Release via input signal** are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the *Direction* and *>Release delay & op.* signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.

Parameter Value	Description
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the *Direction* output signal, and the *>Release delay & op.* input signal become available. If the **Release via input signal** parameter is set to ***yes***, the starts of the operate delay and operate signal are only enabled when the *>Release delay & op.* input signal is active. The *>Release delay & op.* input signal must be connected to the release information from the opposite end (forward information from the *Direction* output signal). See also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: **Dynamic settings**

- Default setting **(_:4891:26) Dynamic settings** = ***no***

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (**Automatic reclosing** or **Cold-load pickup detection**) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters effected by **Auto reclosing**/**Cold-load PU**/**Binary input** as well as the dynamic settings **Threshold**, **Time dial**, and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter *6.5.8.2 Application and Setting Notes (Advanced Stage)* of the function **Overcurrent Protection, Ground**.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:4891:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage V_{sc} of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable shortcircuit current.

Parameter Value	Description
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: **Min. time of the curve**

- Default setting **(_:4891:114) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.



NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: **Additional time delay**

- Default setting **(_:4891:115) Additional time delay** = ***0.00 s***

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: **Threshold**

- Default setting **(_:4891:3) Threshold** = ***1.20 A***

The setting depends on the minimal occurring ground-fault current. This must be detected.

Consider that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

Parameter: **Type of character. curve**

- Default setting **(_:4891:130) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: **Time dial**

- Default setting **(_:4891:101) Time dial** = ***1***

You can use the **Time dial** parameter to displace the characteristic curve in the time direction.

The setting value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1*** (default setting).

Parameter: Reset

- Default setting **(_:4891:131) Reset** = ***disk emulation***

You can use the **Reset** parameter setting to define whether the stage decreases according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

6.7.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4891:1	Inverse-T 1:Mode		• off • on • test	off
_:4891:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4891:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:4891:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4891:110	Inverse-T 1:Directional comparison		• no • yes	no
_:4891:112	Inverse-T 1:Release via input signal		• no • yes	no
_:4891:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4891:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:4891:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4891:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:130	Inverse-T 1:Type of character. curve			
_:4891:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:4891:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:4891:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:4891:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR off/n.rdy				
_:4891:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4891:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4891:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:4891:36	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:4891:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:4891:37	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:4891:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:4891:38	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:4891:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4891:39	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4891:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:4891:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4891:40	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:4891:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:4891:41	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.7.6.4 Information List

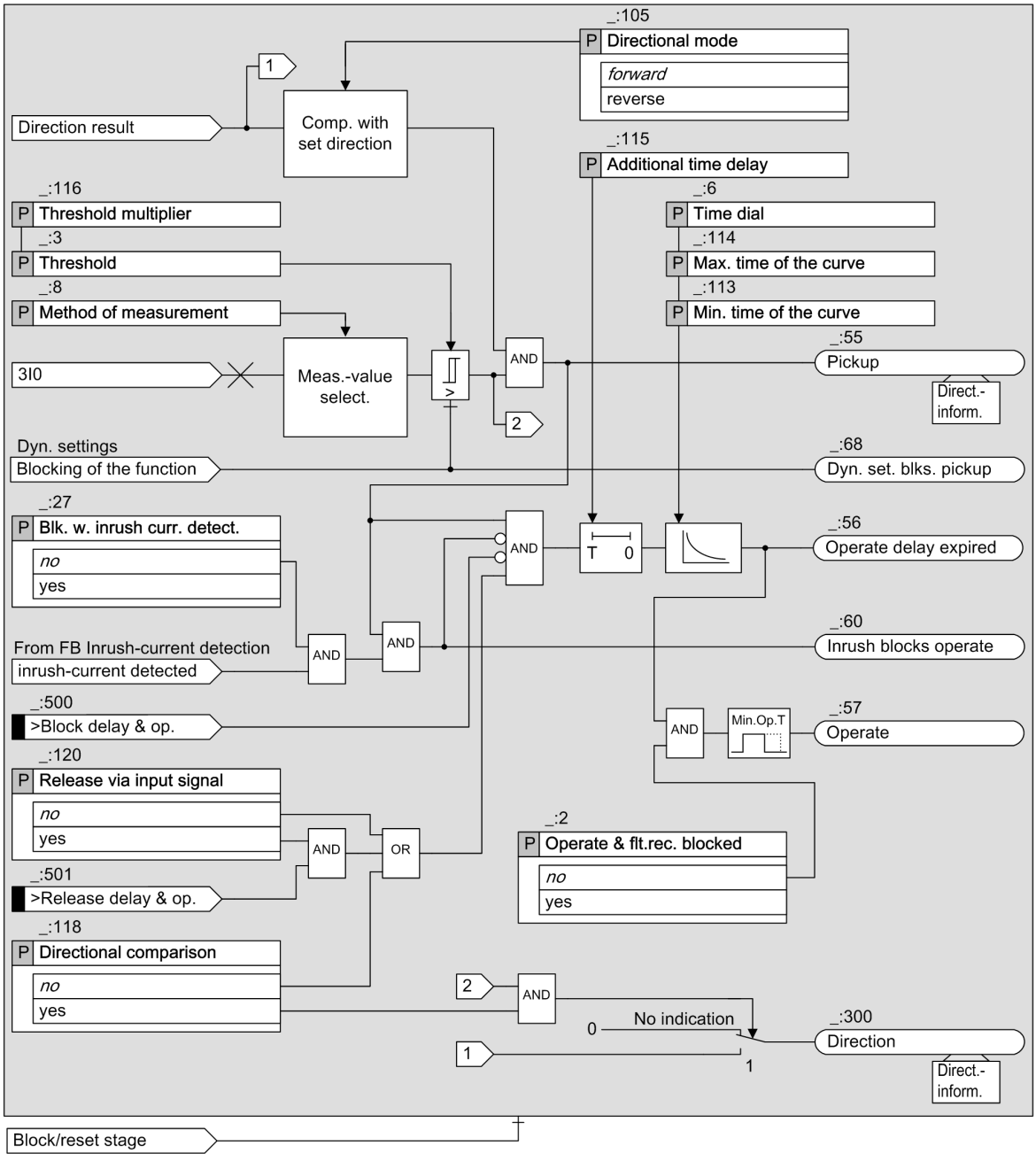
No.	Information	Data Class (Type)	Type
Inverse-T 1			
_:4891:81	Inverse-T 1:>Block stage	SPS	I
_:4891:501	Inverse-T 1:>Release delay & op.	SPS	I
_:4891:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:4891:500	Inverse-T 1:>Block delay & op.	SPS	I
_:4891:54	Inverse-T 1:Inactive	SPS	O
_:4891:52	Inverse-T 1:Behavior	ENS	O
_:4891:53	Inverse-T 1:Health	ENS	O
_:4891:60	Inverse-T 1:Inrush blocks operate	SPS	O
_:4891:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4891:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4891:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4891:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O

No.	Information	Data Class (Type)	Type
_:4891:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:4891:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:4891:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:4891:59	Inverse-T 1:Disk emulation running	SPS	O
_:4891:55	Inverse-T 1:Pickup	ACD	O
_:4891:300	Inverse-T 1:Direction	ACD	O
_:4891:56	Inverse-T 1:Operate delay expired	ACT	O
_:4891:57	Inverse-T 1:Operate	ACT	O

6.7.7 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

6.7.7.1 Description

Logic of the Stage



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Figure 6-74 Logic Diagram of the Directional Logarithmic Inverse Time-Overcurrent Protection, Ground

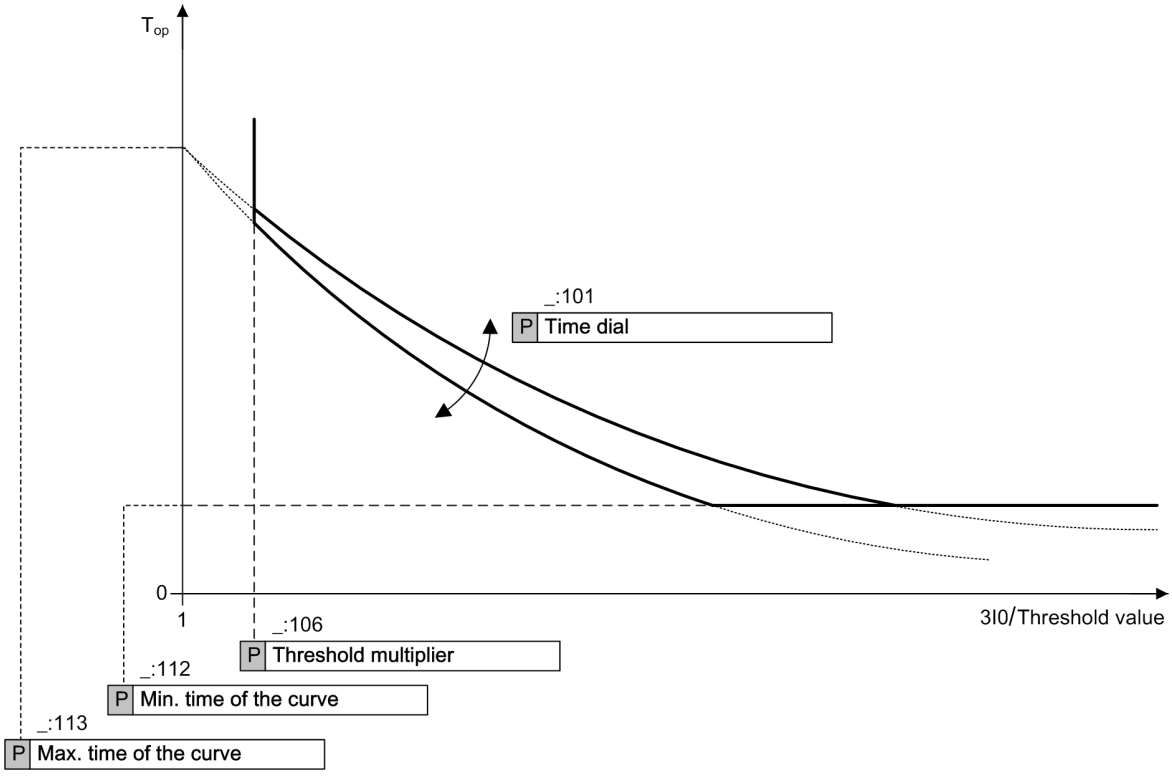
Apart from the operate curve, this type of stage is identical to the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*).

This section will only discuss the nature of the operate curve. For further functionality, refer to chapter *6.7.6.1 Description*.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the pickup value. An integrator accumulates the value 1/ T_{op}. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following figure. The **Threshold multiplier** parameter defines the beginning of the characteristic curve. The **Max. time of the curve** determines the initial value of the characteristic curve. The **Time dial** parameter changes the slope of the characteristic curve. At high currents, the **Min. time of the curve** parameter indicates the lower time limit.



[dwloginv-300913, 2, en_US]

Figure 6-75 Operate Curve of Logarithmic Inverse-Time Characteristic

The time to operate is calculated with the following formula:

$$T_{op} = T_{max} - T_d \ln\left(\frac{3I0}{I_{thresh} \times I_{mul}}\right)$$

[fomula01-240812-01.tif, 1, en_US]

Where

T_{max}	Maximum time of the curve (parameter **Max. time of the curve**)
T_d	Time dial (parameter **Time dial**)
T_{op}	Operate time
3I0	Measured zero-sequence current
I_{thresh}	Threshold value (parameter **Threshold**)
I_{mul}	Threshold multiplier (parameter **Threshold multiplier**)

If the calculated time is less than T_{min} (parameter **Min. time of the curve**), T_{min} is used.

6.7.7.2 Application and Setting Notes

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (advanced function type) (see chapter *6.7.6.1 Description*).

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.2 Application and Setting Notes*.

Stage Type Selection

If the operate delay is to be dependent on the current level according to a logarithmic characteristic curve, select this stage type.

Dynamic Settings: `Threshold`

- Default setting **`(_:3) Threshold`** = ***`1.20 A`***

Define the pickup value corresponding to the application. In doing so, for time-graded stages, the settings of the superordinate and of the subordinate stages in the time-grading chart must be taken into consideration.

Parameter: `Threshold multiplier`

- Default setting **`(_:116) Threshold multiplier`** = ***`1.1`***

You can use the **`Threshold multiplier`** parameter to define the beginning of the characteristic curve on the current axis (in relation to the threshold value).

General information cannot be provided. Define the value corresponding to the application.

EXAMPLE

`Threshold` (Secondary current)	I_{thresh} = 1.2 A
`Threshold multiplier`	I_{mul} = 1.1
Pickup value (Secondary current)	I_{PU} = 1.2 A ×1.1 = 1.32 A

Dynamic Settings: `Time dial`

- Default setting **`(_:6) Time dial`** = ***`1.250 s`***

You can use the **`Time dial`** parameter to change the slope of the characteristic curve.

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Max. time of the curve`

- Default setting **`(_:114) Max. time of the curve`** = ***`5.800 s`***

The parameter **`Max. time of the curve`** determines the initial value of the characteristic curve (for 3I0 = **`Threshold`**).

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Min. time of the curve`

- Default setting **`(_:113) Min. time of the curve`** = ***`1.200 s`***

The parameter **`Min. time of the curve`** determines the lower time limit (at high currents).

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Additional time delay`

- Recommended setting value **`(_:115) Additional time delay`** = ***`0 s`***

You can set an additional current-independent time delay. This additional delay is intended for special applications.

Siemens recommends setting this time to ***0 s*** so that it has no effect.

6.7.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log.-inv.-T #:Mode		• off • on • test	off
_:2	Log.-inv.-T #:Operate & flt.rec. blocked		• no • yes	no
_:119	Log.-inv.-T #:Directional mode		• forward • reverse	forward
_:8	Log.-inv.-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:118	Log.-inv.-T #:Directional comparison		• no • yes	no
_:120	Log.-inv.-T #:Release via input signal		• no • yes	no
_:10	Log.-inv.-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	Log.-inv.-T #:Dynamic settings		• no • yes	no
_:27	Log.-inv.-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:6	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
_:113	Log.-inv.-T #:Min. time of the curve		0.000 s to 60.000 s	1.200 s
_:114	Log.-inv.-T #:Max. time of the curve		0.000 s to 60.000 s	5.800 s
_:116	Log.-inv.-T #:Threshold multiplier		1.00 to 4.00	1.10
_:115	Log.-inv.-T #:Additional time delay		0.000 s to 60.000 s	0.000 s
Dyn.s: AR off/n.rdy				
_:28	Log.-inv.-T #:Effect. by AR off/n.ready		• no • yes	no
_:35	Log.-inv.-T #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	Log.-inv.-T #:Effected by AR cycle 1		• no • yes	no
_:36	Log.-inv.-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:14	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 2				
_:30	Log.-inv.-T #:Effected by AR cycle 2		• no • yes	no
_:37	Log.-inv.-T #:Stage blocked		• no • yes	no
_:15	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:108	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 3				
_:31	Log.-inv.-T #:Effected by AR cycle 3		• no • yes	no
_:38	Log.-inv.-T #:Stage blocked		• no • yes	no
_:16	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:109	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.s: AR cycle>3				
_:32	Log.-inv.-T #:Effected by AR cycle gr. 3		• no • yes	no
_:39	Log.-inv.-T #:Stage blocked		• no • yes	no
_:17	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.s: Cold load PU				
_:33	Log.-inv.-T #:Effect. b. cold-load pickup		• no • yes	no
_:40	Log.-inv.-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:18	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:111	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: bin.input				
_:34	Log.-inv.-T #:Effected by binary input		• no • yes	no
_:41	Log.-inv.-T #:Stage blocked		• no • yes	no
_:19	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:112	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s

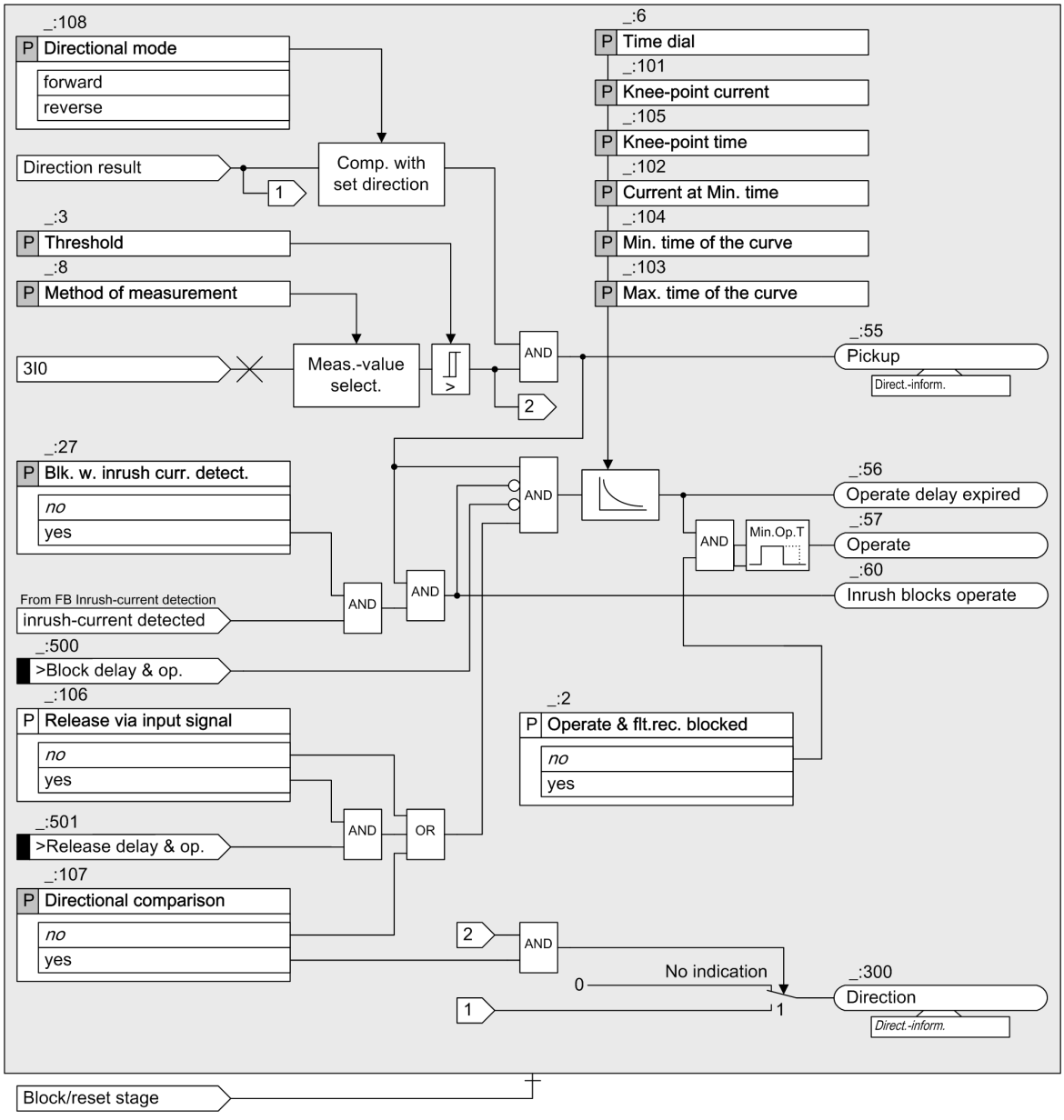
6.7.7.4 Information List

No.	Information	Data Class (Type)	Type
Log.-inv.-T #			
_:81	Log.-inv.-T #:>Block stage		I
_:501	Log.-inv.-T #:>Release delay & op.		I
_:84	Log.-inv.-T #:>Activ. dyn. settings		I
_:500	Log.-inv.-T #:>Block delay & op.		I
_:54	Log.-inv.-T #:Inactive		O
_:52	Log.-inv.-T #:Behavior		O
_:53	Log.-inv.-T #:Health		O
_:60	Log.-inv.-T #:Inrush blocks operate		O
_:62	Log.-inv.-T #:Dyn.set. AR cycle1act.		O
_:63	Log.-inv.-T #:Dyn.set. AR cycle2act.		O
_:64	Log.-inv.-T #:Dyn.set. AR cycle3act.		O
_:65	Log.-inv.-T #:Dyn.set. ARcycl.>3act		O
_:66	Log.-inv.-T #:Dyn.set. CLP active		O
_:67	Log.-inv.-T #:Dyn.set. BI active		O
_:68	Log.-inv.-T #:Dyn. set. blks. pickup		O
_:55	Log.-inv.-T #:Pickup		O
_:300	Log.-inv.-T #:Direction		O
_:56	Log.-inv.-T #:Operate delay expired		O
_:57	Log.-inv.-T #:Operate		O

6.7.8 Stage Description Knee-Point Characteristic Curve

6.7.8.1 Description

Logic of the Stage



[lodilokn-280812-02.tif, 2, en_US]

Figure 6-76 Logic Diagram of the Directional Logarithmic Inverse Time with Knee-Point Overcurrent Protection, Ground

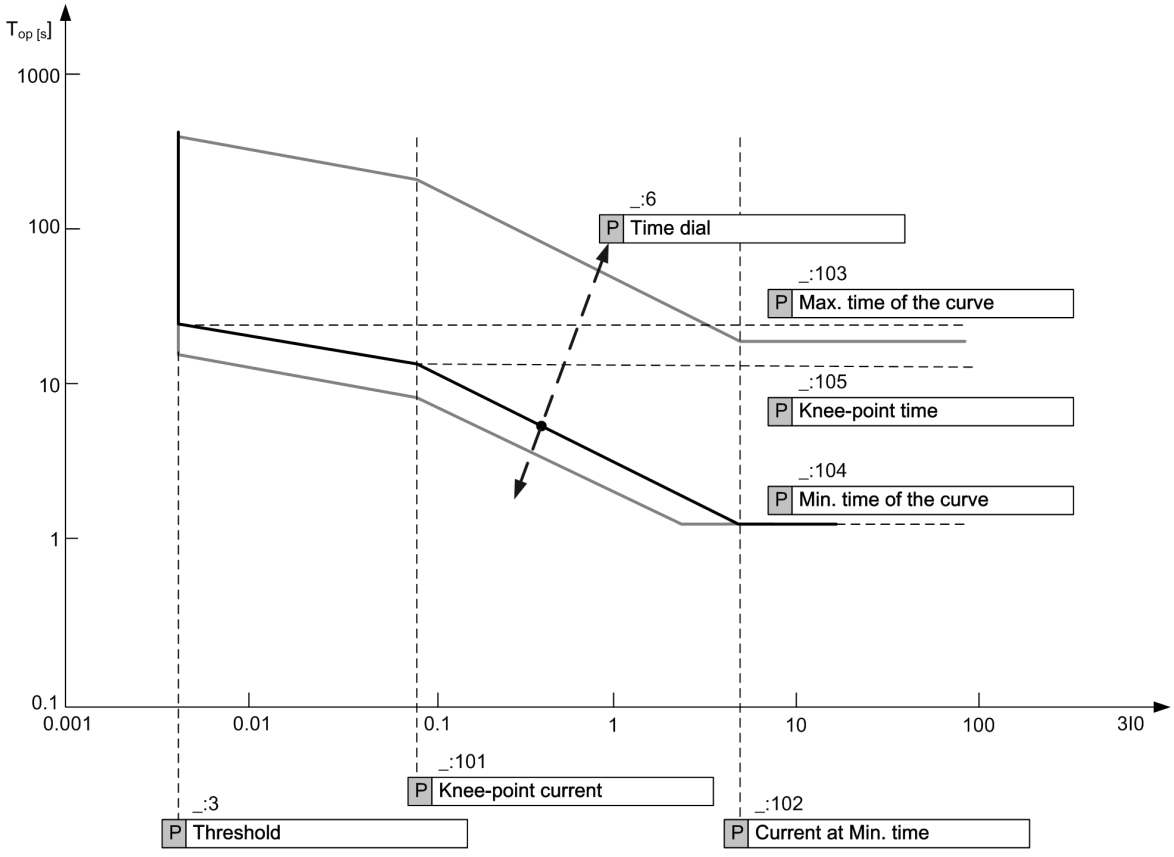
Apart from the operate curve, this type of stage is almost identical to the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.1 Description*.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the threshold value. An integrator accumulates the value $1/T_{op}$. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following graphic. The curve is composed of 2 sections with different slops. 7 parameters are used to define the logarithmic inverse time with knee-point characteristic curve. The parameter **Max. time of the curve** determines the initial time value of the characteristic curve, and relates to the 3I0 **Threshold** value. The transition point is defined by parameter **Knee-point current** and parameter **Knee-point time**. The parameter **Min. time of the curve** indicates the lower time limit, and parameter **Current at Min. time** determines the current value at **Min. time of the curve**. The parameter **Time dial** servers as a time factor to the operate time.



[dwloinkn-300913, 2, en_US]

Figure 6-77 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (In the Example of **Threshold** = ***0.004 A***)

6.7.8.2 Application and Setting Notes

Apart from the operate curve, this type of stage is almost identical to the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.2 Application and Setting Notes*.

Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1.20 A***

You can use the **Threshold** parameter to define the pickup value of the stage corresponding to the specific application.

Parameter: `Time dial`

- Default setting **`(_:6) Time dial`** = ***`0.2`***

You can use the **`Time dial`** parameter to displace the operate curve in the time direction.

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Knee-point`

- Default setting **`(_:101) Knee-point current`** = ***`1.300 A`***
- Default setting **`(_:105) Knee-point time`** = ***`23.60 s`***

You use the **`Knee-point current`** parameter and the **`Knee-point time`** parameter to define the knee-point of the operate curve.

General information cannot be provided. Define the values corresponding to the application.

Parameter: Minimum Time of the Operate Curve

- Default setting **`(_:104) Min. time of the curve`** = ***`0.80 s`***
- Default setting **`(_:102) Current at Min. time`** = ***`1.500 A`***

Via the parameters **`Min. time of the curve`** and **`Current at Min. time`**, the point of the operate curve is defined where higher currents do no longer cause shorter operate times.

General information cannot be provided. Define the value corresponding to the application.

Parameter: Maximum Time of the Operate Curve

- Default setting **`(_:103) Max. time of the curve`** = ***`93.00 s`***

You can use the parameter **`Max. time of the curve`** to determine the initial value of the operate curve (for 3I0 = **`Threshold`**).

General information cannot be provided. Define the value corresponding to the application.

6.7.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	Log.inv.T KP #:Mode		• off • on • test	off
_:2	Log.inv.T KP #:Operate & flt.rec. blocked		• no • yes	no
_:108	Log.inv.T KP #:Direc-tional mode		• forward • reverse	forward
_:8	Log.inv.T KP #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:107	Log.inv.T KP #:Direc-tional comparison		• no • yes	no
_:106	Log.inv.T KP #:Release via input signal		• no • yes	no
_:10	Log.inv.T KP #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Log.inv.T KP #:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3	Log.inv.T KP #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:109	Log.inv.T KP #:Time dial		0.05 to 1.50	0.20
_:101	Log.inv.T KP #:Knee-point current	1 A @ 100 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.300 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.500 A
_:105	Log.inv.T KP #:Knee-point time		0.00 s to 100.00 s	23.60 s
_:102	Log.inv.T KP #:Current at Min. time	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	Log.inv.T KP #:Min. time of the curve		0.00 s to 30.00 s	0.80 s
_:103	Log.inv.T KP #:Max. time of the curve		0.00 s to 200.00 s	93.00 s

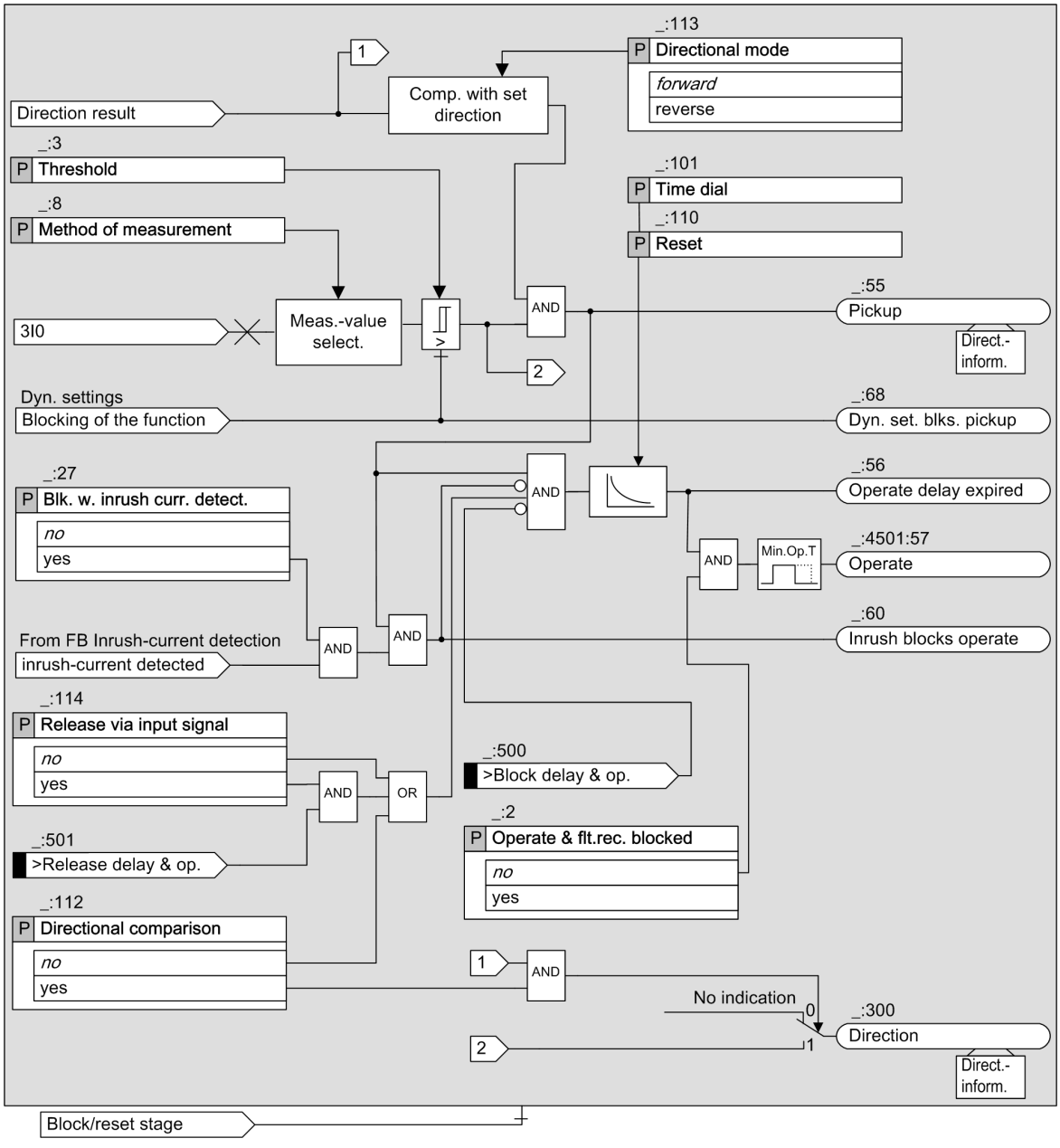
6.7.8.4 Information List

No.	Information	Data Class (Type)	Type
Stage #			
_:81	Log.inv.T KP #:>Block stage	SPS	I
_:501	Log.inv.T KP #:>Release delay & op.	SPS	I
_:500	Log.inv.T KP #:>Block delay & op.	SPS	I
_:54	Log.inv.T KP #:Inactive	SPS	O
_:52	Log.inv.T KP #:Behavior	ENS	O
_:53	Log.inv.T KP #:Health	ENS	O
_:60	Log.inv.T KP #:Inrush blocks operate	SPS	O
_:55	Log.inv.T KP #:Pickup	ACD	O
_:300	Log.inv.T KP #:Direction	ACD	O
_:56	Log.inv.T KP #:Operate delay expired	ACT	O
_:57	Log.inv.T KP #:Operate	ACT	O

6.7.9 Stage with User-Defined Characteristic Curve

6.7.9.1 Description

Logic of the Stage



[lodirusr-280812-02.tif, 1, en_US]

Figure 6-78 Logic Diagram of the Directional User-Defined Characteristic Curve Overcurrent Protection, Ground

This stage is structured in the same way as the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*). The only difference is that you can define the characteristic curve.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.1 Description*.

User-Defined Characteristic Curve

With the directional, user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

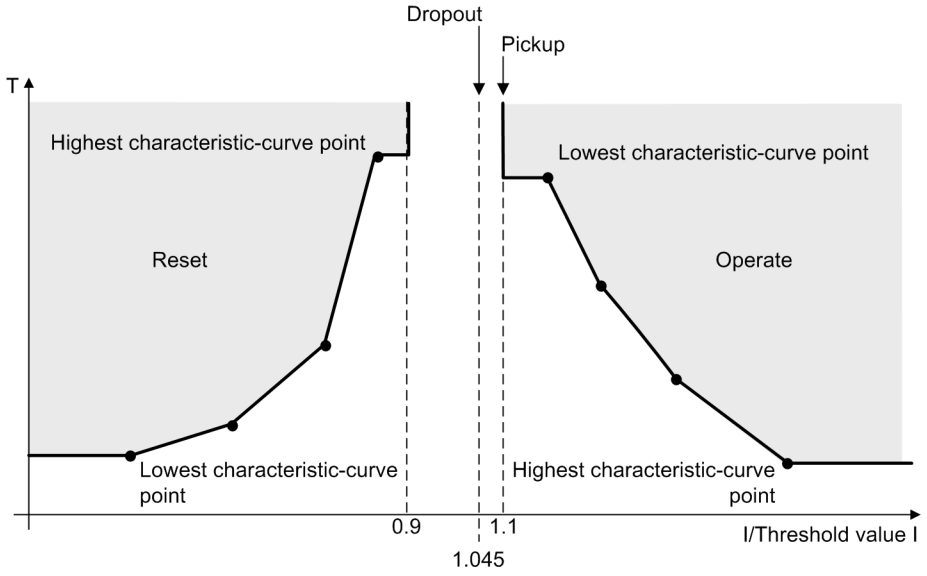
Pickup and Dropout Behavior with User-Defined Characteristic Curves

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the threshold value by a factor of 1.045 (0.95 × 1.1× threshold value), the dropout is started. The pickup will be indicated as outgoing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The following figure shows the pickup behavior and dropout behavior when a directional user-defined characteristic curve is used.



[dwpidrbe-300913, 1, en_US]

Figure 6-79 Pickup and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.7.9.2 Application and Setting Notes

This stage is structured in the same way as the **Inverse time-overcurrent protection – advanced** stage. The only difference is that you can define the characteristic curve as required. This section only provides application and setting notes for setting the characteristic curves. For guidance on the other parameters of the stage, see chapter *6.7.6.2 Application and Setting Notes*.

Parameter: `Current/time value pairs` (of the Operate Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting follows the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

You can use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The setting value for the **`Time dial`**parameter is derived from the time-grading chart that has been prepared for the system. Where no grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** set to ***`1`***.

Parameter: `Reset`

- Default setting **`(_:110) Reset`** = ***`disk emulation`***

The **`Reset`** parameter is used to define whether the stage drops out according to the dropout characteristic curve (behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Both operate curve and a dropout characteristic curve have to be specified with this setting. Use this setting if the device is coordinated with electromechanical devices or other devices performing dropout after disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation, that is, if instantaneous dropout is required.

Parameter: `Current/time value pairs` (of the Dropout Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting is determined by the characteristic curve you want to achieve.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the **`Time dial`**parameter.



NOTE

The value pairs must be entered in continuous order.

6.7.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	User curve #:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:113	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Directional comparison		• no • yes	no
_:114	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.7.9.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	SPS	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:300	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.7.10 Influence of Other Functions via Dynamic Settings

6.5.8.1 Description and *6.5.8.2 Application and Setting Notes (Advanced Stage)* describe the influence of other functions on dynamic settings.

6.8 Inrush-Current Detection

6.8.1 Overview of Functions

The function **Inrush-current detection**

- Recognizes an inrush process on transformers
- Generates a blocking signal for protection functions that protect the transformer (protected object) or for protection functions that are affected in undesirable ways when transformers are switched on
- Allows a sensitive setting of the protection functions

The following protection functions evaluate the blocking signal

- Overcurrent protection with a pickup value below the maximum inrush current
- Negative-sequence protection as sensitive backup protection for transformers

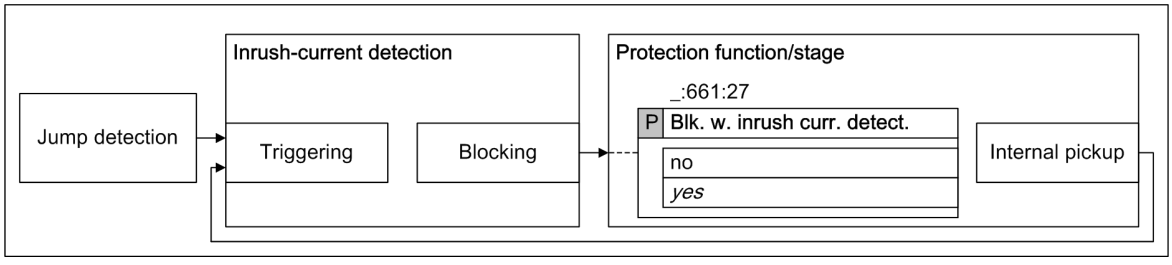
6.8.2 Structure of the Function

The function **Inrush current detection** is not an individual protection function. In the connection process of a transformer, it transmits a blocking signal to other protection functions. For this reason, the inrush-current detection must be in the same function group as the functions that are to be blocked.

The following figure shows the embedding of the function. The setting parameter **`Blk. w. inrush curr. detect.`** establishes the connection between inrush-current detection and the functions that are to be blocked. If the parameter is set to ***`yes`***, the connection is effective.

A jump detection or the threshold value exceeding of the functions to be blocked is used as trigger signal for synchronization of the internal measurement methods.

The jump detection reacts to changes in the current. The threshold value exceeding is recognized due to an internal pickup of the protection function that is to be blocked.



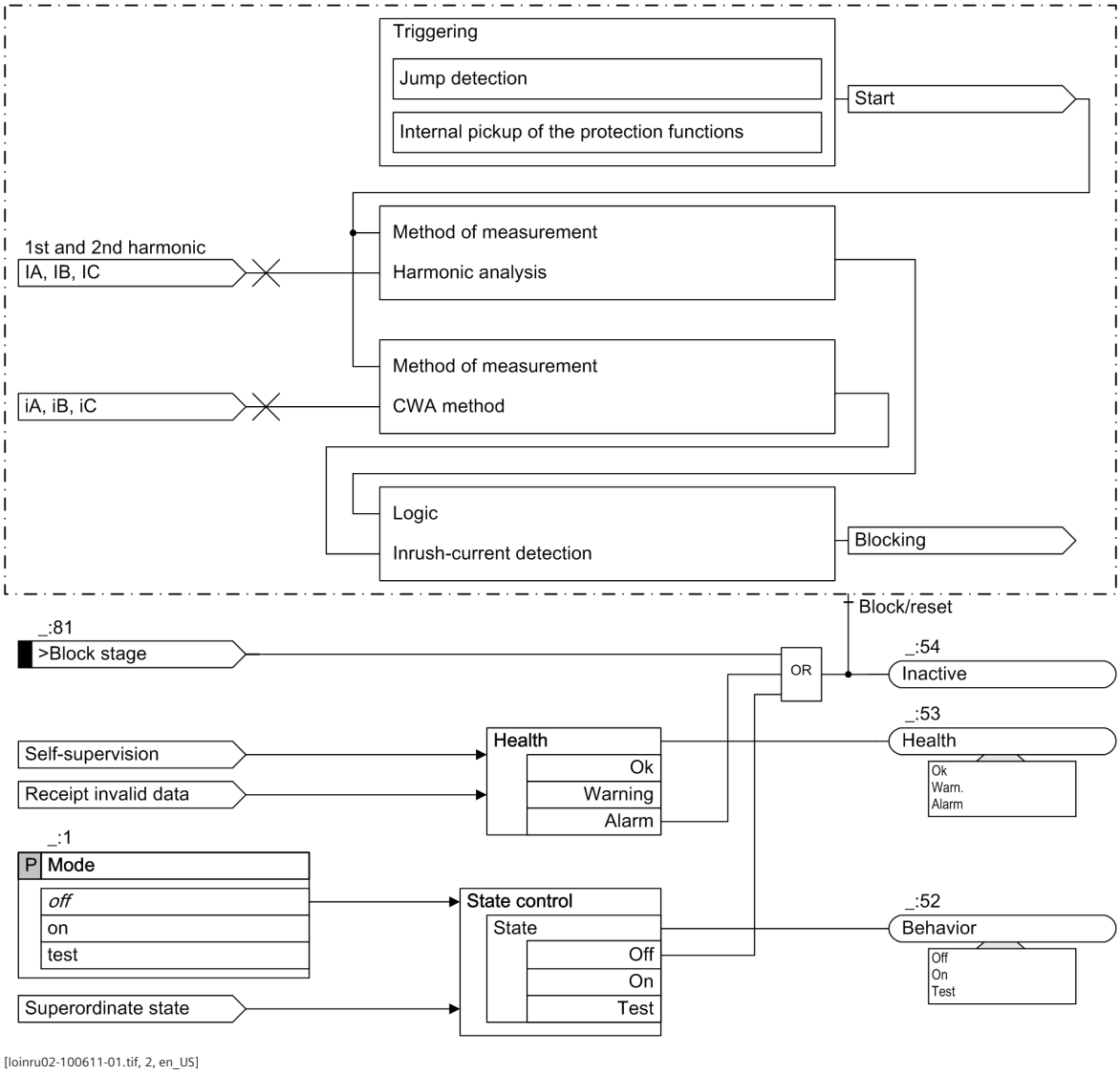
[dwirsh01-070611-01.tif, 1, en_US]

Figure 6-80 Structure/Embedding of the Function

6.8.3 Function Description

The function **Inrush-current detection** analyzes the trigger signal of the jump detection or the threshold-value violation of the function to be blocked in a start logic, and synchronizes the method of measurement. In order to securely record the inrush processes, the function uses the **Harmonic analysis** method of measurement and the **CWA method** (current wave shape analysis). Both methods work in parallel and link the results through a logical OR.

If you wish to work with only one process, deactivate the other method by way of the parameters **`Blocking with 2. harmonic`** or **`Blocking with CWA`** .



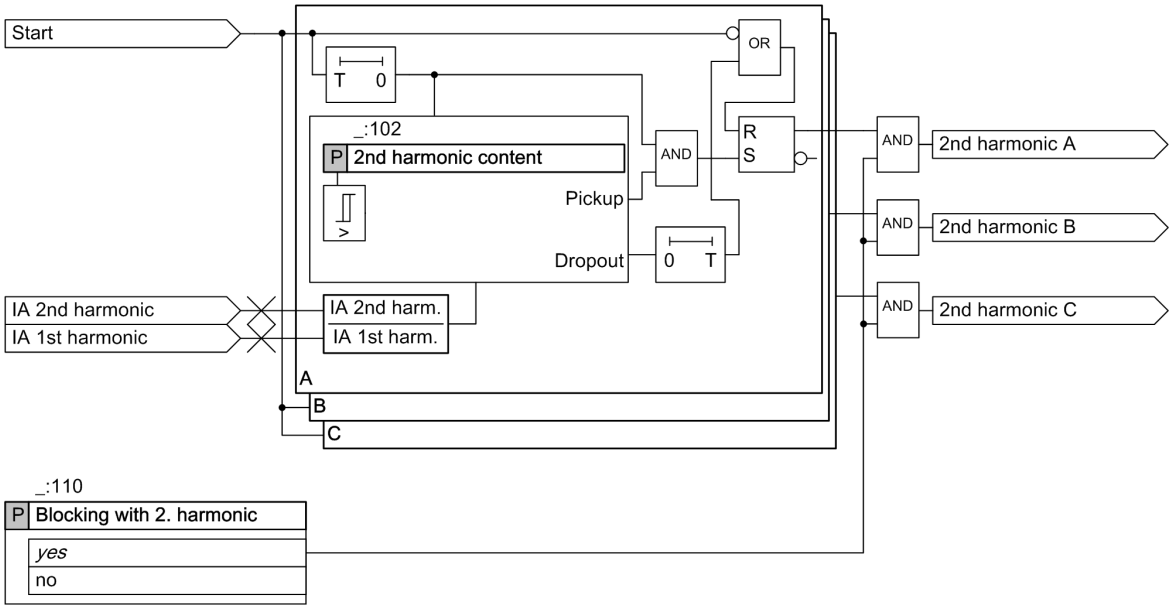
[loinru02-100611-01.tif, 2, en_US]

Figure 6-81 Basic Structure of the Inrush-Current Detection

Harmonic Analysis

For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) are determined for each of the phase currents I_A, I_B, and I_C and the quotient $I_{2nd\ harm} / I_{1st\ harm}$ is formed from this. If this quotient exceeds the set threshold value, a phase-selective signal is issued.

If 95 % of the set threshold value is exceeded, this leads to a pickup reset (dropout ratio = 0.95).

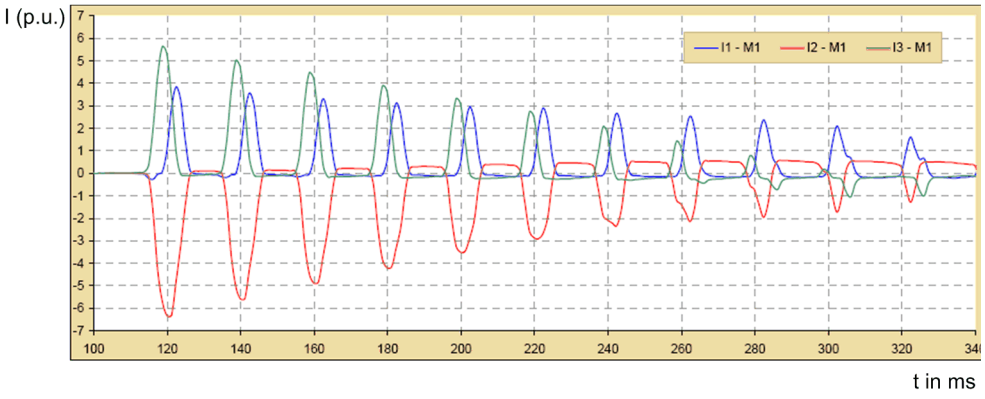


[loinru10-040912-01.tif, 1, en_US]

Figure 6-82 Logic of the Harmonic Analysis Function (T = 1 Period)

CWA Method (Current Wave Shape Analysis)

The CWA method executes a wave shape analysis of the phase currents IA, IB, and IC. If all 3 phase currents show flat areas at the same point in time, the inrush-current detection signal will be issued. This signal applies for all 3 phases simultaneously. The following figure shows a typical inrush-current characteristic, with the simultaneously occurring flat areas clearly recognizable.

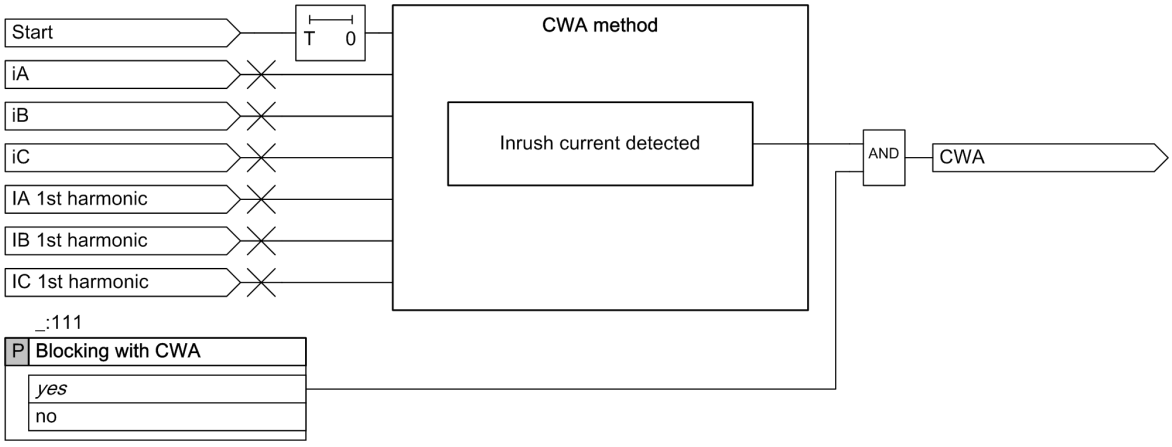


[dwinru03-240211-01.tif, 1, en_US]

Figure 6-83 Inrush-Current Characteristic

The following figure shows the logic diagram of the CWA method.

From the present fundamental-component current (1st harmonic), the threshold value for identification of the flat areas is derived via an internal factor.



[loinru05-240211-01.tif, 1, en_US]

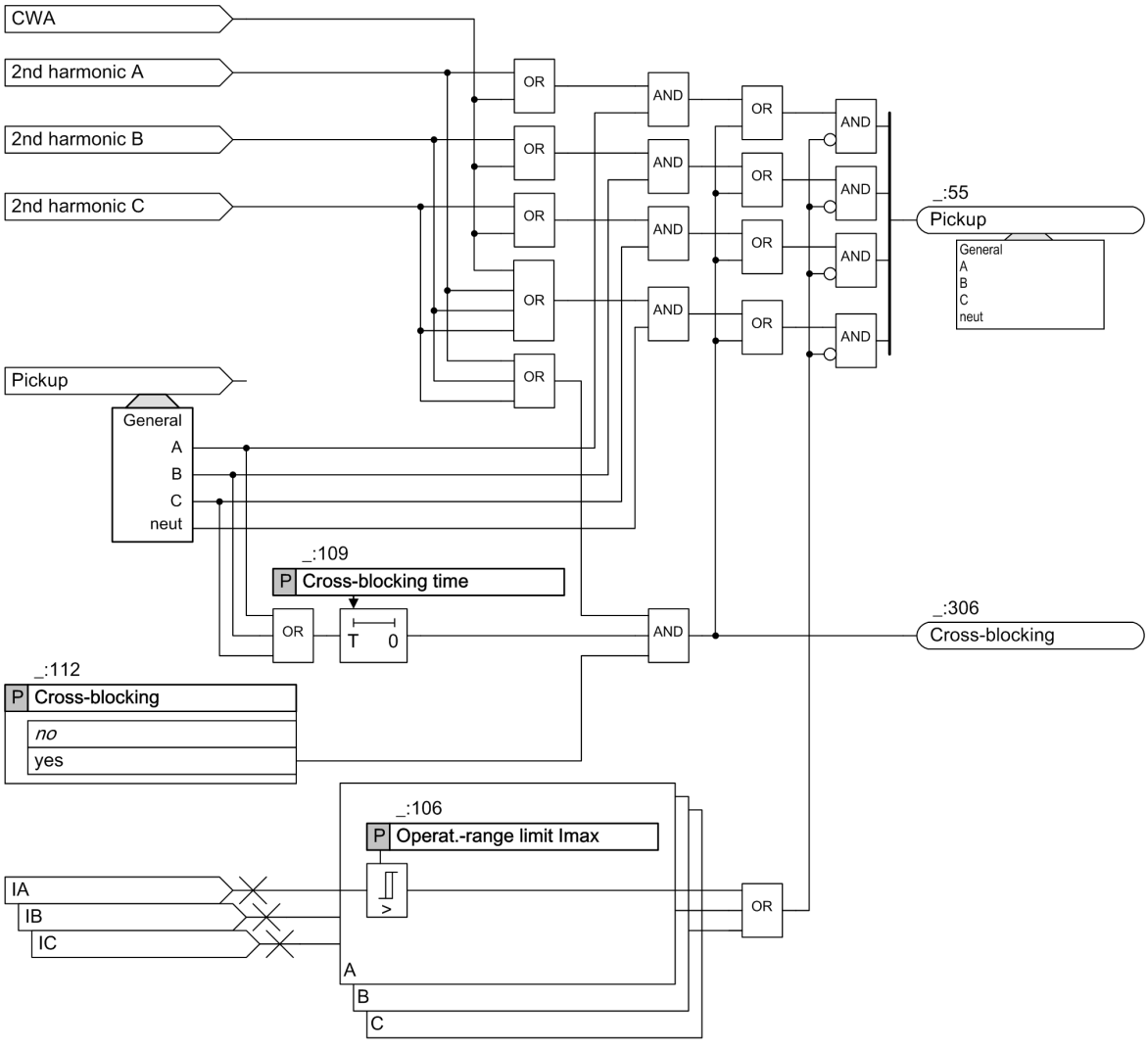
Figure 6-84 Logic of the CWA-Method Function (T = 1 Period)

Logic of the Inrush-Current Detection

The following logic diagram shows the link of the 2 methods of measurement **Harmonic Analysis** and **CWA method**.

The crossblock function influences the **Harmonic Analysis** process. If you have set the parameter **Cross-blocking** to ***yes***, you will receive in the event of threshold-value violation a blocking indication for all 3 phase currents and the measured or calculated zero-sequence current ($I_{2nd\ harm}$ / $I_{1st\ harm}$). The crossblock function works via a timer. Set parameters for the time depending on the expected duration factor via the parameter **Cross-blocking time**.

If the phase current exceeds the maximum permissible current **Operat.-range limit Imax**, the inrush-current detection will be blocked.



[loinru12-060912-01.tif, 1, en_US]

Figure 6-85 Logic Diagram of the Inrush-Current Detection

6.8.4 Application and Setting Notes

Parameter: Operat.-range limit Imax

- Recommended setting value **(_:106) Operat.-range limit Imax** = ***7.5 A***

  With the parameter **Operat.-range limit Imax** , you can specify at which current the inrush-current detection is blocked internally. The setting value must be above the maximum inrush current of the transformer. A practicable value is 7.5 times the transformer rated current.

Parameter: Blocking with CWA

- Recommended setting value = **(_:111) Blocking with CWA** = ***yes***

Parameter Value	Description
yes	**CWA process** activated.
no	**CWA process** deactivated.

Parameter: Blocking with 2. harmonic

- Recommended setting value **(_:110) Blocking with 2. harmonic** = ***yes***

Parameter Value	Description
yes	**Harmonic analysis** process activated.
no	**Harmonic analysis** process deactivated.



NOTE

Make sure that at least one process is activated. Siemens recommends retaining the advised setting values.

Parameter: 2nd harmonic content

- Recommended setting value **(_:102) 2nd harmonic content** = ***15 %***

  With the parameter **2nd harmonic content** , you can specify the pickup value of the harmonic analysis function. The setting value of 15 % is practicable for most transformers.

Parameter: Cross-blocking

- Recommended setting value **(_:112) Cross-blocking** = ***no***

Parameter Value	Description
no	Through the CWA process working in parallel in the inrush-current detection, the function is not activated as standard.
yes	If a subfunction of the inrush-current detection is identified in the course of the closure trials during commissioning, set the parameter **Cross-blocking** to ***yes*** .

Parameter: Cross-blocking time

- Default setting **(_:109) Cross-blocking time** = ***0.06 s***

  You define the duration of this blocking with the **Cross-blocking time** parameter. The default setting of ***0.06 s*** (about 3 periods) has proven practicable. Set the time as short as possible and check the value during the closure trials. The parameter **Cross-blocking time** is inactive at **Cross-blocking** = ***no*** .

Parameter: Start flt.rec

- Default setting **(_:114) Start flt.rec** = ***yes***

  With the **Start flt.rec** parameter, you determine whether a fault record should be started upon pickup of the inrush-current detection. The following settings are possible:

Parameter Value	Description
no	No fault recording starts with pickup.
yes	The fault recording starts with pickup. When the protection function is blocked by the inrush-current detection, a fault recording is started nevertheless.

6.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inrush detect.				
_:1	Inrush detect.:Mode		• off • on • test	on

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Inrush detect.:Operat.-range limit Imax	1 A @ 100 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	7.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	37.500 A
_:111	Inrush detect.:Blocking with CWA		• no • yes	yes
_:110	Inrush detect.:Blocking with 2. harmonic		• no • yes	yes
_:102	Inrush detect.:2nd harmonic content		10 % to 45 %	15 %
_:112	Inrush detect.:Cross-blocking		• no • yes	no
_:109	Inrush detect.:Cross-blocking time		0.03 s to 200.00 s	0.06 s
_:114	Inrush detect.:Start flt.rec		• no • yes	yes

6.8.6 Information List

No.	Information	Data Class (Type)	Type
Inrush detect.			
_:81	Inrush detect.:>Block stage	SPS	I
_:54	Inrush detect.:Inactive	SPS	O
_:52	Inrush detect.:Behavior	ENS	O
_:53	Inrush detect.:Health	ENS	O
_:300	Inrush detect.:2.harmonic phase A	SPS	O
_:301	Inrush detect.:2.harmonic phase B	SPS	O
_:302	Inrush detect.:2.harmonic phase C	SPS	O
_:305	Inrush detect.:CWA	SPS	O
_:306	Inrush detect.:Cross-blocking	SPS	O
_:55	Inrush detect.:Pickup	ACD	O

6.9 Instantaneous High-Current Tripping

6.9.1 Overview of Functions

The **Instantaneous high-current tripping** function has the following tasks:

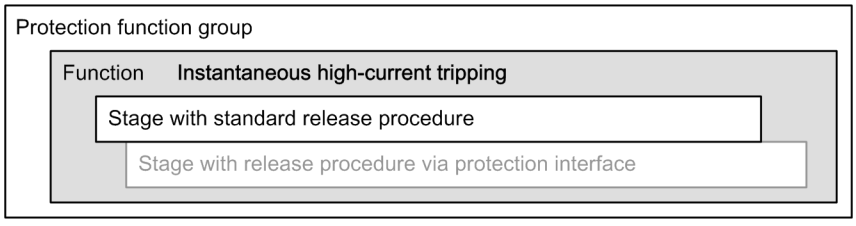
- Instantaneous tripping when switching onto an existing fault, for example, if a grounding switch is closed.
- Instantaneous disconnection of high currents above the highest overcurrent-protection stage.

6.9.2 Structure of the Function

The **Instantaneous high-current tripping** function offers 2 different increment types:

- Stage with standard release method
- Stage with release method via protection interface (only applicable if the device is equipped with a protection interface)

The function with the stage for the standard release procedure is factory-set.

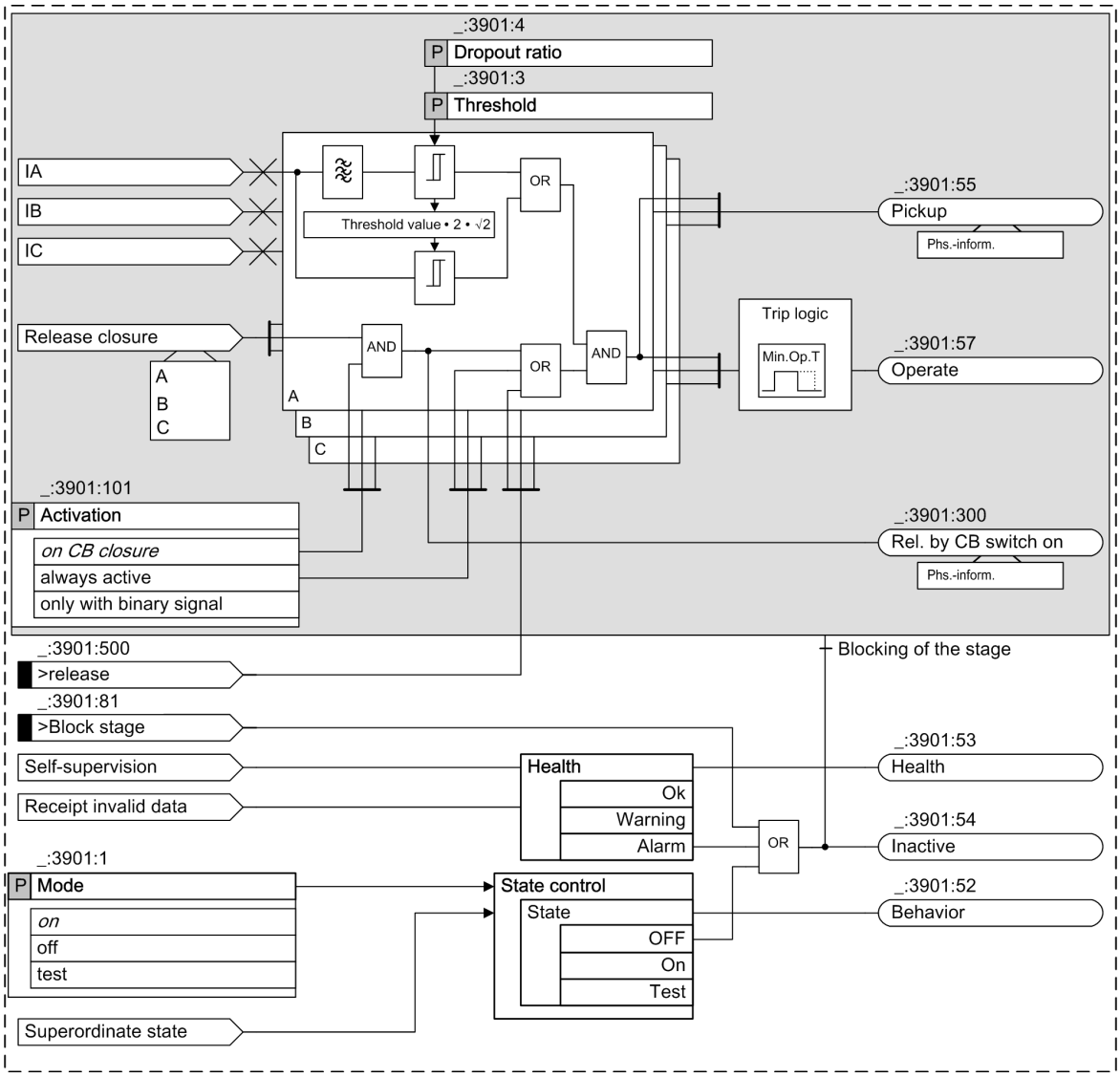


[dwihcstr-230211-01.tif, 1, en_US]

Figure 6-86 Structure/Embedding of the Function

6.9.3 Standard Release Procedure

Logic



[lohlore3-160611-01.tif, 2, en_US]

Figure 6-87 Logic Diagram of Instantaneous High-Current Tripping with Standard Release Method

Activation

Using the **Activation** parameter, you set the conditions under which the stage is released.

- ***on CB closure***

With this procedure, the stage is released only if the circuit breaker is about to be closed (the CB is open) or if the circuit breaker is being closed or if the binary input signal *>release* is active. The way signals are generated *Rel. by CB switch on* is described in section *5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

- ***always active***

The stage is always released and is thus independent of closing of the circuit breaker switch and of the binary input signal *>release*.

- ***only with binary signal***

The stage is released only if the binary input signal *>release* is active.

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds a preset threshold value by
  current ≥ 2·√2·threshold value
  this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

6.9.4 Application and Setting Notes

Parameter: Activation

- Default setting **(_:3901:101) Activation** = ***on CB closure***

Using the parameter **Activation**, you define the conditions under which the stage is released.

Parameter Value	Description
on CB closure	Select this setting to activate the stage only when the circuit breaker is closed.
always active	Select this setting to release the stage statically.
only with binary signal	Select this setting to release the stage via an external signal.

Parameter: Threshold

- Default setting **(_:3901:3) Threshold** = ***10.0 A*** for I_{rated} = 1 A or ***50.0 A*** for I_{rated} = 5 A

The stage works independently of the position of the remote circuit breakers. For this reason, set the **Threshold** so that the fault current flowing through does not trigger the stage. Thus, use this stage only if current grading over the protected object is possible, that is, for transformers, shunt reactors or long lines with low source impedance. In other cases, deactivate the stage.

EXAMPLE

Calculation example for current grading of a 110 kV overhead line measuring 150 mm²

s (length) = 100 km;

R_1/s = 0.21 Ω/km;

X_1/s = 0.43 Ω/km

Since the stage is non-directional, the calculation must consider the maximum short-circuit power at the start of the line or at the opposite end:

Ssc" = 3.5 GVA (subtransient, because the function can respond to the 1st peak value)

Current transformer: 600 A/5 A

The line impedance Z_L and the minimum source impedance Z_S are calculated on this basis:

Line impedance Z_L and Source impedance Z_S:

$$Z_1/s = \sqrt{0.21^2 + 0.43^2}\ \Omega/km = 0.479\ \Omega/km$$

$$Z_L = 0.479\ \Omega/km \cdot 100\ km = 47.9\ \Omega$$

$$Z_S = \frac{110\ kV^2}{3500\ MVA} = 3.46\ \Omega$$

[foglchzv-170309-01.tif, 1, en_US]

The maximum 3-phase short-circuit current I''_{sc} flowing through is (at a source voltage of 1.1 V_N):

$$I''_{sc} = \frac{1.1 \cdot V_{net}}{\sqrt{3} \cdot (Z_S + Z_L)} + \frac{1.1 \cdot 110\,kV}{\sqrt{3} \cdot (3.46\,\Omega + 47.9\,\Omega)} = 1360\,A$$

[foglchik-170309-01.tif, 1, en_US]

With a safety margin of 10 %, the following setting value results:

- **Threshold value** (primary) $= 1.1 \cdot 1360\,A = 1496\,A$
- **Threshold value** (secondary) $= 1.1 \cdot \frac{1360\,A}{600\,A} \cdot 5\,A = 12.5\,A$

[foglnste-170309-01.tif, 1, en_US]

If short-circuit currents exceed 1496 A (primary) or 12.5 A (secondary), there is a short circuit on the line to be protected. It can be disconnected immediately.

NOTE

The calculation was performed with absolute values, which is accurate enough for overhead lines. A complex calculation is required only if the source impedance and the line impedance have extremely different angles.

Parameter: `Dropout ratio`

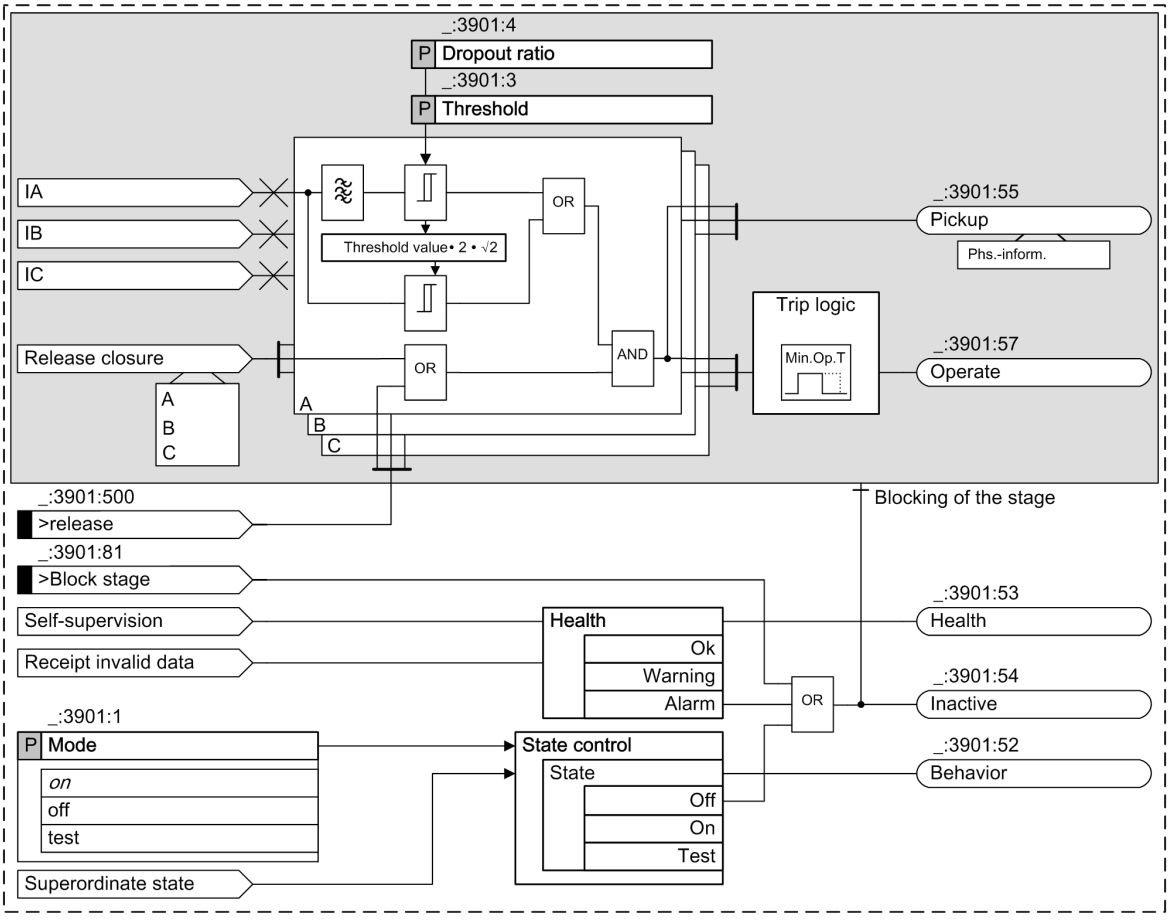
- Recommended setting value **`(_:3901:4) Dropout ratio`** = ***`0.90`***

The recommended setting value of ***`0.90`*** is sufficient for many applications. To obtain high-precision measurements, the **`Dropout ratio`** can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the parameter **`Dropout ratio`**. This avoids chattering of the tripping stage.

6.9.5 Release Procedure via Protection Interface

This stage can be applied only if the device is equipped with a protection interface.

Logic



[lohinre3-160611-01.tif, 1, en_US]

Figure 6-88 Logic Diagram of Instantaneous High-Current Tripping with Release Procedure via Protection Interface

Release

If one of the following conditions is fulfilled, the stage is released (the internal **Release** signal is present) (for further information, see chapter *5.8 Process Monitor*):

- No voltage has yet been applied to the protected object, which means that the remote circuit breakers are open, or
- Switching to the local circuit breaker is immanent.

These conditions are recognized internally if a circuit breaker is open or just closed

Furthermore, the stage can be activated externally via the **`>release`** binary input signal.

NOTE

To enable internal release of the stage, the devices at all ends of the protected object must be informed of the circuit-breaker position (the circuit-breaker auxiliary contacts must be connected to the devices; the respective binary input signals must be jumpered).

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds a preset threshold value by
  current ≥ 2·√2·threshold value
  this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

6.9.6 Application and Setting Notes

Parameter: **Threshold**

- Default setting **(_:3901:3) Threshold** = ***2.5 A*** for I_{rated} = 1 A or ***12.5 A*** for I_{rated} = 5 A

Select the value high enough for the protection not to pick up on the RMS value of the inrush current that occurs when the local circuit breaker is closed. You do not have to consider short-circuit currents flowing through, because the stage is released only if the circuit breakers are opened at all remote ends of the protected object or the release was caused by the binary input *>release*.

Parameter: **Dropout ratio**

- Recommended setting value **(_:3901:4) Dropout ratio** = ***0.90***

The recommended setting value of ***0.90*** is sufficient for many applications. To obtain extremely accurate measurements, the dropout ratio can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the dropout ratio. This avoids chattering of the tripping stage.

6.9.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Standard 1				
_:3901:1	Standard 1:Mode		• off • on • test	on
_:3901:101	Standard 1:Activation		• on CB closure • only with binary signal • always active	on CB closure
_:3901:3	Standard 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:3901:4	Standard 1:Dropout ratio		0.50 to 0.90	0.90

6.9.8 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
Standard 1			
_:3901:500	Standard 1:>release	SPS	I
_:3901:81	Standard 1:>Block stage	SPS	I
_:3901:54	Standard 1:Inactive	SPS	O
_:3901:52	Standard 1:Behavior	ENS	O
_:3901:53	Standard 1:Health	ENS	O
_:3901:300	Standard 1:Rel. by CB switch on	ACT	O
_:3901:55	Standard 1:Pickup	ACD	O
_:3901:57	Standard 1:Operate	ACT	O

6.10 Arc Protection

6.10.1 Overview of Function

The function **Arc protection**:

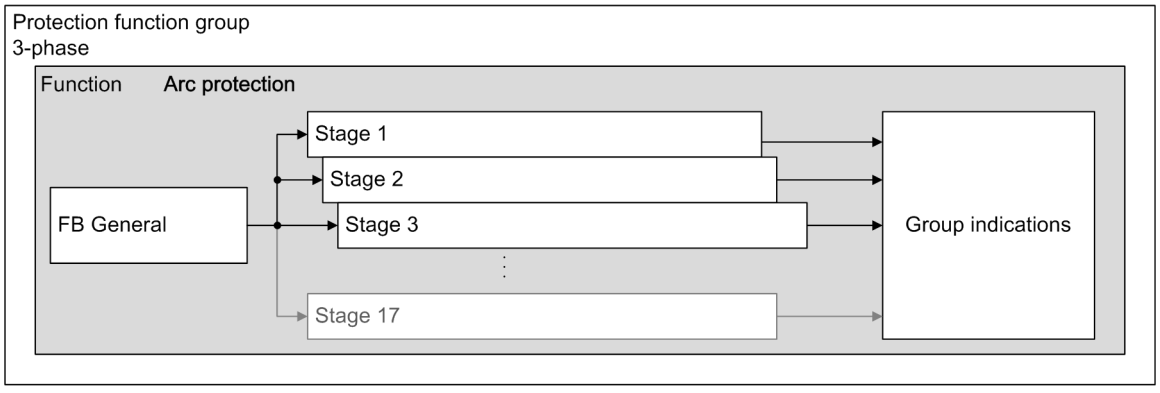
- Detects arcs in air-insulated switchgear parts without delay and in a fail-safe way
- Limits system damage through instantaneous high-speed tripping
- Protect systems from thermal overload
- Increases safety of personnel
- Trips in a 3-pole way
- Is suitable for use in all voltage levels

6.10.2 Structure of the Function

The **Arc protection** function can be added to function groups that provide current measured values.
The **Arc protection** function consists of the following blocks.

- General
- 3 stages
- Output logic 3-phase

The **Arc protection** function is preconfigured with 3 stages. A maximum of 17 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.
The following figure shows the basic structure of the **Arc protection** function.

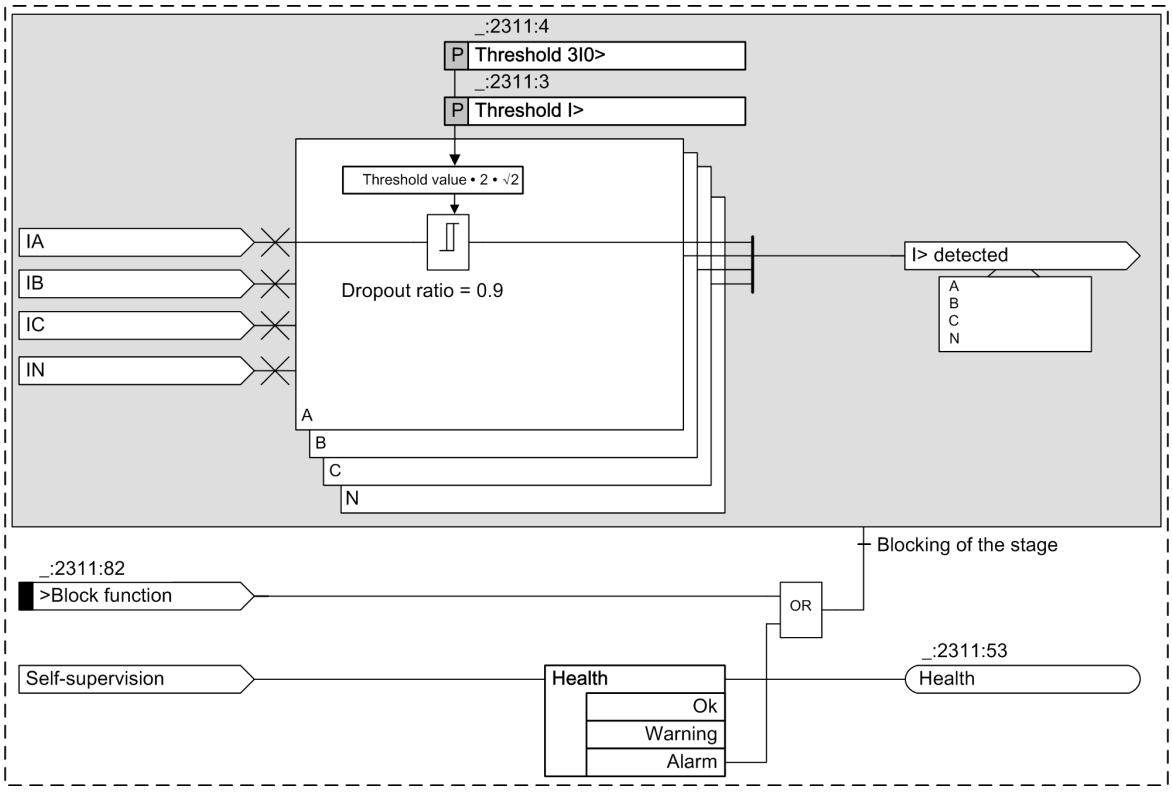


[dw_structure_arcprot, 2, en_US]

Figure 6-89 Structure/Embedding of the Arc Protection Function

6.10.3 Function Description

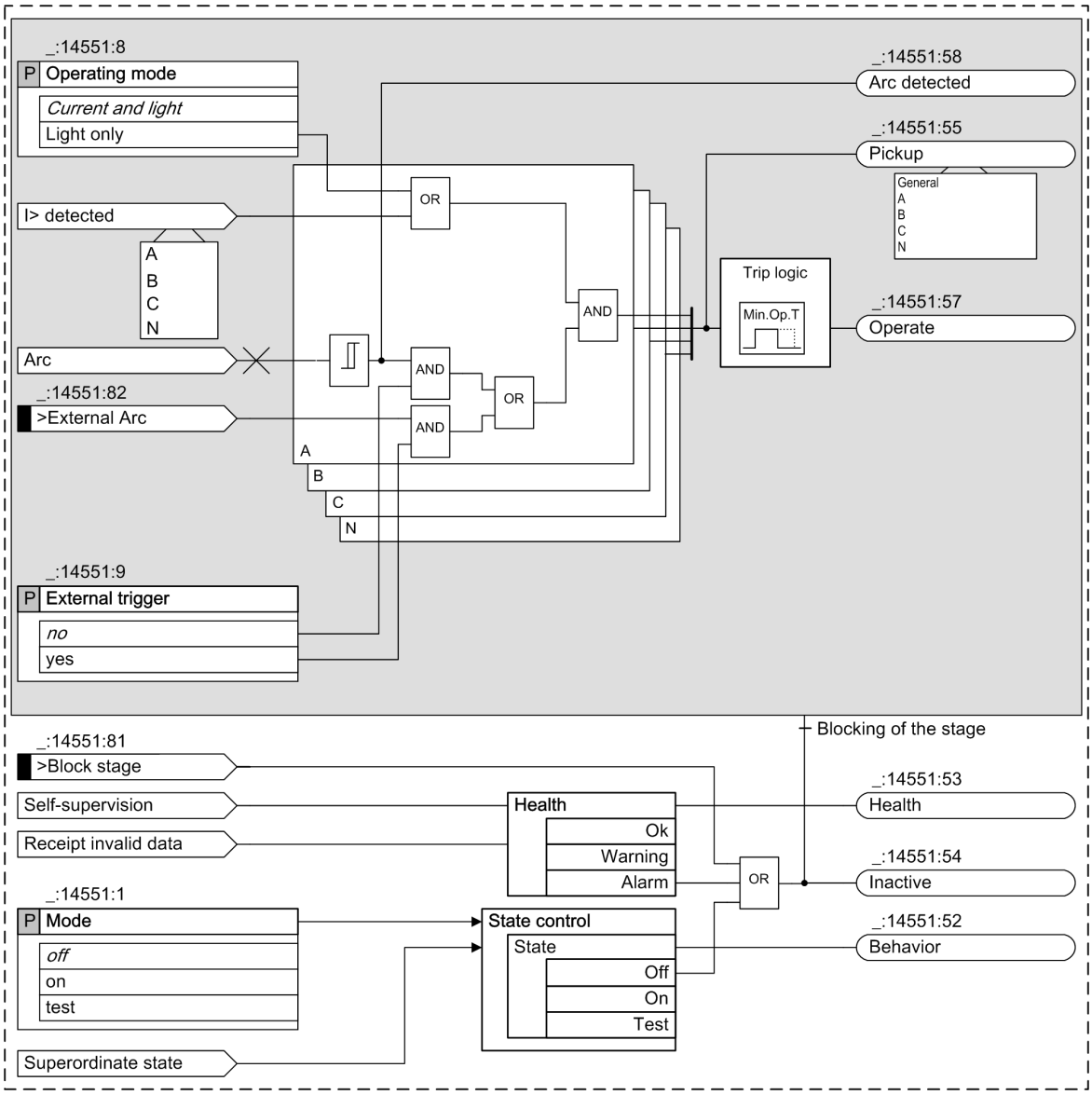
General Logic of the Function Block



[lo_fb0_arcprot, 1, en_US]

Figure 6-90 General Logic Diagram of the Function Block

Logic of the Stage



[lo_stage_arcprot, 1, en_US]

Figure 6-91 Logic Diagram of the Stage

The**Arc protection** function uses a locally connected optical arc sensor or an external trip initiation by other devices in order to detect arcs.

NOTE

Install the arc sensors inside the switchgear in such a way that they are not hidden behind other system components!

Shadowing of the arc sensors must be avoided!

NOTE

Once an optical sensor has detected an arc, you must replace the affected optical sensor!

Within the **Arc protection** function, you can use a fast current-flow criterion as an additional release criterion. The parameters for the current-flow criterion can be found in the **General** block. For each stage, you can select individually whether the current-flow criterion must be evaluated as well.

Method of Measurement, Current-Flow Criterion

The current-flow criterion works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A direct-current component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds the threshold value set by the current amount $\geq 2 \cdot \sqrt{2} \cdot$ threshold value, the stage uses additional unfiltered measurands. Thus, very short operate times are possible.



NOTE

If using the current-flow criterion in addition to the light, prevent a potential overfunction caused by the suddenly occurring light signal.

If you use the current-flow criterion, arcs are typically detected in 4 ms!

Self Monitoring

The **Arc protection** function uses a self-monitoring circuit. This circuit monitors the optical arc sensors and the fiber-optic cables. The arc-protection module uses the fiber-optic cable to send a cyclic test signal (light) to the arc sensors. If the channel is operating properly, the test signal is sent back to the arc protection module. If the test signal is not returned to the arc protection module, the indication *channel # Sensor failure* is generated.

If the self-monitoring function detects a fault, the indication *Health* is set to *Alarm* and the stage/function is blocked.

6.10.4 Application and Setting Notes – General Settings

Go to **General** under the function **Arc protection** and set the following parameters. The setting values apply to all stages.

Parameter: Threshold I>

- Default setting **(_:2311:3) Threshold I>** = *2.000 A*

Use the parameter **Threshold I>** to define the trigger threshold of the phase currents. The **Threshold I>** is relevant for the current-flow criterion of the **arc protection** function.

Set the **Threshold I>** of the function **Arc protection** in such a manner that the RMS value of the inrush current does not exceed the **Threshold I>** when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to *6.3.4.2 Application and Setting Notes*

Parameter: Threshold 3I0>

- Default setting **(_:2311:4) Threshold 3I0>** = *1.000 A*

Use the parameter **Threshold 3I0>** to determine the tripping threshold for the zero-sequence current. The **Threshold 3I0>** is relevant for the current-flow criterion of the **Arc protection function**.

Set the **Threshold 3I0>** of the function **Arc protection** in such a manner that the RMS value of the inrush current does not exceed the **Threshold 3I0>** when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to *6.5.4.2 Application and Setting Notes*

NOTE

If you set the parameter **CT connection** = ***3-phase, 2 primary CT*** for the **3-phase current measuring point**, the parameter **Threshold 3I0>** has no effect.

6.10.5 Application and Setting Notes for the Stage

Parameter: External trip initiation

- Default setting **(_:14551:9) External trip initiation** = ***no***

Use parameter **External trip initiation** to set whether an external input signal is used to trigger the stage.

Parameter Value	Description
no	The stage does not operate with an external input signal.
yes	The stage operates with an external input signal. If the stage operates with an external input signal, the binary input signal *>External Arc* must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal *>External Arc* is only visible in the DIGSI 5 information routing **Note**: When working with external trip initiation, do not select a channel. If an additional channel is selected with this setting value, DIGSI 5 will signal an inconsistency.

Parameter: Operating mode

- Default setting **(_:14551:8) Operating mode** = ***Current and light***

Use the parameter **Operating mode** to define the basic functionality of the stage.

Parameter Value	Description
Current and light	The stage operates with the input variables current and light. The current-flow criterion ensures that the light signal originates from an arc. Siemens recommends using this setting.
Light only	This stage operates only with the input signal 'light' and is triggered even if current is not measured. This operating mode can cause a overfunction if light is detected suddenly. Use this setting value only if the effect caused by external light signals is impossible.

Parameter: Sensor

- Default setting **(_:14551:11) Sensor** = ***Point sensor***

Use the parameter **Sensor** to set which sensor type is connected to the device.

Parameter Value	Description
Point sensor	A point sensor is connected to the device.
Line sensor	A line sensor is connected to the device.
Custom	If you select this setting option, the parameter **Threshold Light** is visible. Siemens recommends the default setting values ***Point sensor*** or ***Line sensor***. This allows arcs to be detected reliably regardless of diffused light.

Parameter: Threshold Light

- Default setting **(_:14551:7) Threshold Light** = ***-20.00 dB***

Use the parameter **Threshold Light** to set the light sensitivity. If you set the **Threshold Light** to a smaller value, the sensitivity increases. If you set the **Threshold Light** to a higher value, the sensitivity decreases. If the sensors even pick up in case of a switching arc of the circuit breaker, set the **Threshold Light** parameter to a higher value.

Siemens recommends the default settings for point or line sensors.

Set the parameter **Threshold Light** manually only if you have special default settings for light sensitivity.

Parameter: Channel

- Default setting **(_:14551:10) Channel** = ***No channel is selected***

Use the parameter **Channel** to select which sensor channel the stage uses.

If the **Arc protection** function has several stages, a different channel must be selected for each stage.

For parameter **Channel**, the selection texts are identical to the name of the arc-protection module and its channels.

6.10.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:3	General:Threshold I>	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:2311:4	General:Threshold 3I0>	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
Stage 1				
_:14551:1	Stage 1:Mode		• off • on • test	off
_:14551:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:14551:9	Stage 1:External trip initiation		• no • yes	no
_:14551:8	Stage 1:Operating mode		• Light only • Current and light	Current and light
_:14551:11	Stage 1:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14551:7	Stage 1:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14551:10	Stage 1:Channel		Setting options depend on configuration	

Addr.	Parameter	C	Setting Options	Default Setting
Stage 2				
_:14552:1	Stage 2:Mode		• off • on • test	off
_:14552:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:14552:9	Stage 2:External trip initiation		• no • yes	no
_:14552:8	Stage 2:Operating mode		• Light only • Current and light	Current and light
_:14552:11	Stage 2:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14552:7	Stage 2:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14552:10	Stage 2:Channel		Setting options depend on configuration	
Stage 3				
_:14553:1	Stage 3:Mode		• off • on • test	off
_:14553:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:14553:9	Stage 3:External trip initiation		• no • yes	no
_:14553:8	Stage 3:Operating mode		• Light only • Current and light	Current and light
_:14553:11	Stage 3:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14553:7	Stage 3:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14553:10	Stage 3:Channel		Setting options depend on configuration	

6.10.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:14551:81	Stage 1:>Block stage	SPS	I
_:14551:82	Stage 1:>External Arc	SPS	I
_:14551:54	Stage 1:Inactive	SPS	O
_:14551:52	Stage 1:Behavior	ENS	O
_:14551:53	Stage 1:Health	ENS	O
_:14551:58	Stage 1:Arc detected	SPS	O

No.	Information	Data Class (Type)	Type
_:14551:55	Stage 1:Pickup	ACD	O
_:14551:57	Stage 1:Operate	ACT	O
Stage 2			
_:14552:81	Stage 2:>Block stage	SPS	I
_:14552:82	Stage 2:>External Arc	SPS	I
_:14552:54	Stage 2:Inactive	SPS	O
_:14552:52	Stage 2:Behavior	ENS	O
_:14552:53	Stage 2:Health	ENS	O
_:14552:58	Stage 2:Arc detected	SPS	O
_:14552:55	Stage 2:Pickup	ACD	O
_:14552:57	Stage 2:Operate	ACT	O
Stage 3			
_:14553:81	Stage 3:>Block stage	SPS	I
_:14553:82	Stage 3:>External Arc	SPS	I
_:14553:54	Stage 3:Inactive	SPS	O
_:14553:52	Stage 3:Behavior	ENS	O
_:14553:53	Stage 3:Health	ENS	O
_:14553:58	Stage 3:Arc detected	SPS	O
_:14553:55	Stage 3:Pickup	ACD	O
_:14553:57	Stage 3:Operate	ACT	O

Informationen der Selbstüberwachung vom Lichtbogenschutz-Modul

No.	Information	Data Class (Type)	Type
channel #			
_:307	channel #:Sensor failure	SPS	O

6.10.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only

6.10.8.1 Description

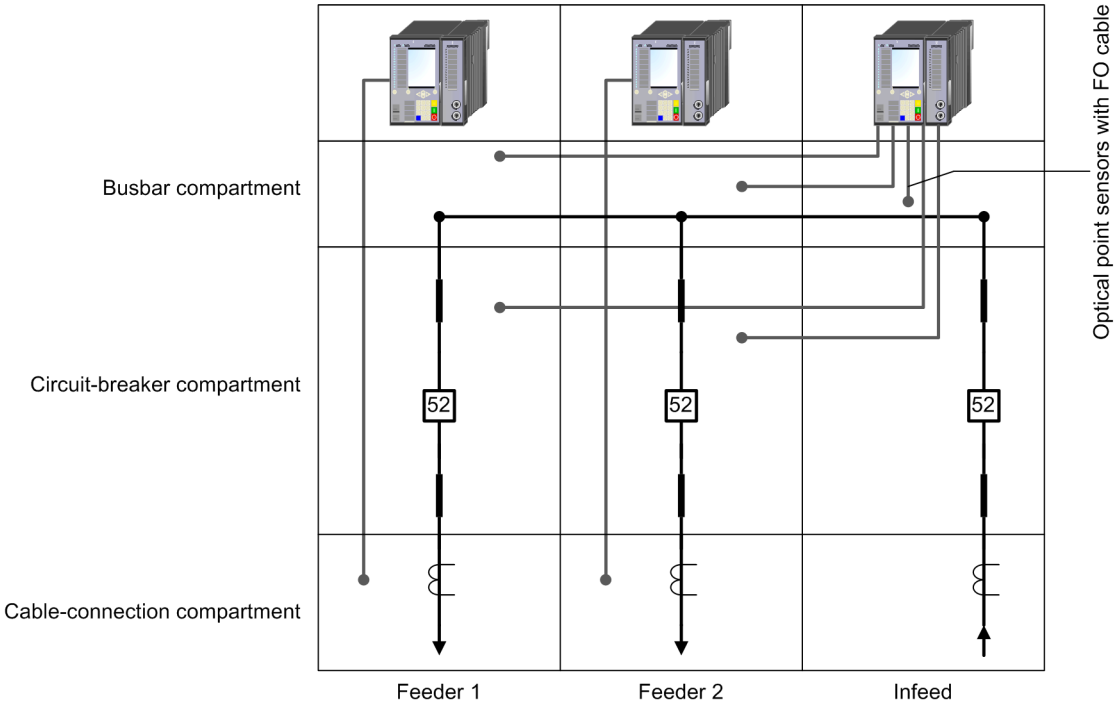
Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***Light only***.

The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function

The following figure shows the arrangement and the connection of the optical point sensors:



[dw_arcprot-light-only, 2, en_US]

Figure 6-92 Layout and Connection of the Optical Point Sensors (Operating Mode = Light only)

For this example, the following is assumed:

- The circuit breaker of the infeed must be switched off. This ensures that the arcs in the busbar compartments of the infeed and the feeders or in the circuit-breaker compartment of the feeders are off.

  Install the optical point sensors in the busbar compartments (BB compartment) of the infeed and feeders. Install additional optical point sensors in the circuit-breaker compartment (CB compartment) of the feeders. Connect all optical point sensors to the protection device of the infeed.

- The optical point sensors in the cable-connection compartment of the feeders detect arcs in this compartment. Install one optical point sensor in the cable-connection compartment of the feeders and connect it to the protection device of the feeder. This allows for the selective clearing of arcs inside the cable-connection compartment.

  Due to the pressure waves that occur during the formation of an arc, partitions can deform and cause undesirable light influences in adjacent compartments. This can result in a non-selective tripping.

- If there is an arc in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must switch off.

NOTE

If the **Arc protection** function operates in **`Operating mode`** = ***`Light only`***, the effects of external light can result in non-selective tripping.

NOTE

It must be considered that the number of arc protection modules connected to the device depends on the hardware configuration of the device.

When using modular devices, a maximum of 15 sensors can be connected. If using non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.10.8.2 Application and Setting Notes

General Notes

- Connect one optical point sensor from the cable-connection compartment in feeder 1 to the protection device in feeder 1. Arcs in the cable-connection compartment are cleared selectively by the circuit breaker in feeder 1.
- Connect one optical point sensor from the cable-connection compartment in feeder 2 to the protection device in feeder 2. Arcs in the cable-connection are cleared selectively by the circuit breaker in feeder 2.
- Connect optical point sensors from all busbar compartments and all circuit-breaker compartments of feeders 1 and 2 to the protection device in the infeed. Arcs in these compartments are detected and cleared by the device in the infeed.

Setting Notes for the Protection Device in Feeder 1

The **Arc protection** function operates with **one** stage.

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***Light only***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 1***

The parameters in block **General** are not relevant since the **Operating mode** = ***Light only***.

Setting Notes for the Protection Device in Feeder 2

The **Arc protection** function operates with **one** stage.

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***Light only***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 1***

The parameters in block **General** are not relevant since the **Operating mode** = ***Light only***.

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **5** stages.

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***Light only*** (applies to all stages)
- Parameter: **Sensor** = ***Point sensor*** (applies to all stages)
- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Busbar compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 1*** (Stage 4) → Circuit-breaker compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 2*** (Stage 5) → Busbar compartment supervision in the infeed

The parameters in block **General** are not relevant since the **Operating mode** = ***Light only***.

6.10.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current

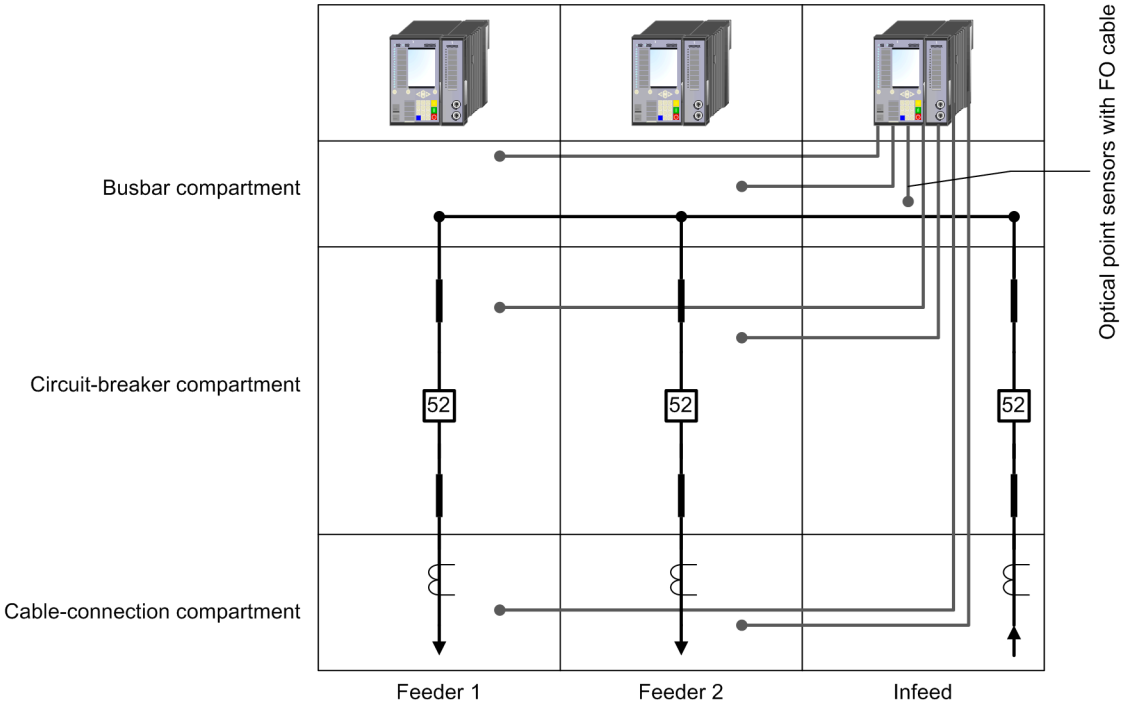
6.10.9.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***Current and light***. In the example, all arcs are detected by the protection device in the infeed.

The following items are considered in the example:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about selected parameters in the stages of the function



[dw_light-and-current, 2, en_US]

Figure 6-93 Layout and Connection of the Optical Point Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional security to prevent unwanted tripping caused by sudden light influences.

  Depending on the arc location in the cable-connection compartment of the feeder, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the feeder, the current will therefore be evaluated in the infeed.

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders as well as the busbar compartment of the infeed. Connect the optical point sensors to the protection device in the infeed.
- The protection device in the infeed clears all arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeder 1 and 2. Furthermore, the protection device clears arcs in the busbar compartment of the infeed.

- If the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders, or in the busbar compartment of the infeed detect an arc, the protection device in the infeed evaluates the current as well.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must trip.



NOTE

If the **Arc protection** function operates with the **Operating mode** = ***Current and light***, the additional current-flow criterion prevents unwanted tripping caused by external light influences.



NOTE

This application example requires the connection of several optical point sensors to a single protection device. It must be considered that the number of arc-protection modules that are connected to the device depends on the hardware configuration of the device.

When using modular devices, a maximum of 15 sensors can be connected. If you use non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.10.9.2 Application and Setting Notes

General Notes

- Connect the optical point sensors from the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeders 1 and 2 to the protection device in the infeed. Arcs in the busbar compartment, the circuit-breaker compartment and the cable-connection compartment of feeders 1 and 2 are detected and cleared by the device in the infeed.
- Connect an optical point sensor from the busbar compartment in the infeed to the protection device in the infeed. Arcs in the busbar compartment of the infeed are cleared selectively by the circuit breaker in the infeed.

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **7** stages.

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***Current and light*** (applies to all stages)
- Parameter: **Sensor** = ***Point sensor*** (applies to all stages)
- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Cable-connection compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 2 channel 1*** (Stage 4) → Busbar compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 2*** (Stage 5) → Circuit-breaker compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 3*** (Stage 6) → Cable-connection compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 3 channel 1*** (Stage 7) → Busbar compartment supervision in the infeed

You can find more information about the settings of the parameters **Threshold I>** and **Threshold 3I0>** in chapter *6.10.4 Application and Setting Notes – General Settings*.

6.10.10 Application Example for Arc Protection with Point Sensors via External Trip Initiation

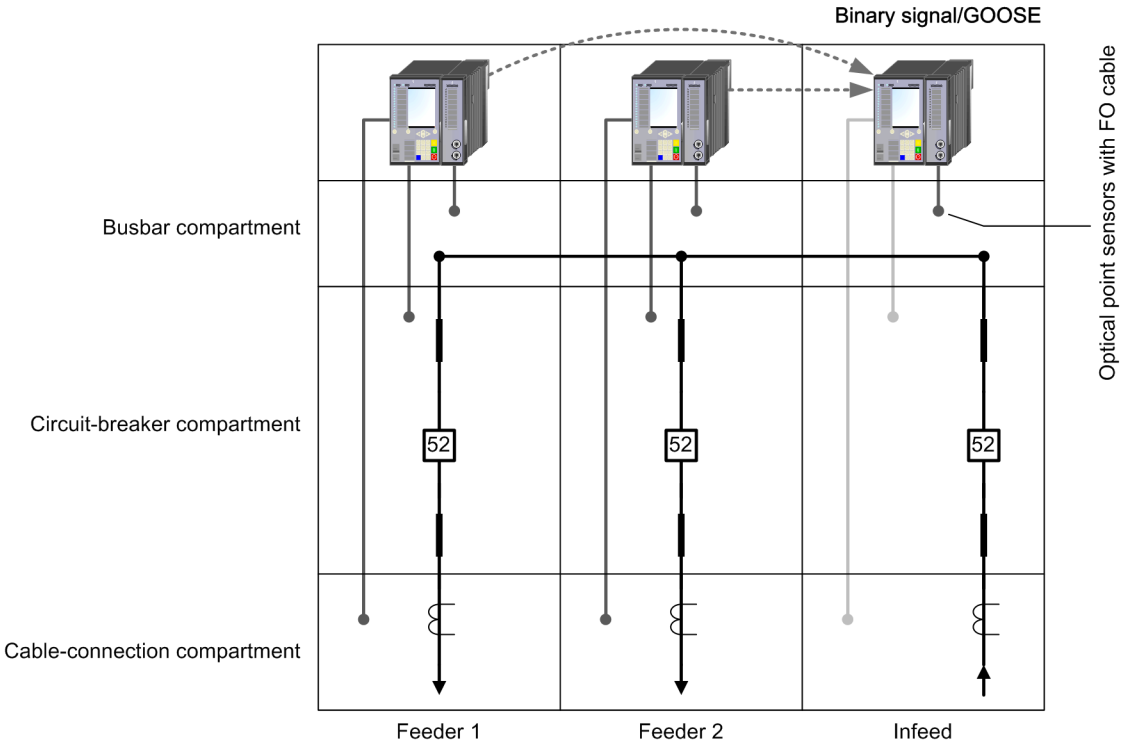
6.10.10.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The stages of the **Arc protection** function are triggered by **External trip initiation**.

The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function



[dw_arcprot-extern-input, 2, en_US]

Figure 6-94 Arc Protection with External Trip Initiation

For this example, the following is assumed:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeder and the infeed. Connect the optical point sensors to the respective protection device in the feeder and infeed.
- If the optical point sensors detect an arc in the busbar compartment, the circuit-breaker compartment, or the cable-connection compartment of the feeders, the *Arc detected* indication is sent via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed. Then, the protection device in the infeed evaluates the current as well. If the measured current exceeds the thresholds **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed clears the malfunction.

  You can find detailed information in chapter *6.10.10.2 Application and Setting Notes*

- Alternatively, arcs in the cable-connection compartment of the feeders can be cleared selectively by the protection device of the affected feeder. To do this, the pickup indication from the infeed unit must be sent back to the appropriate protection device in the feeder.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device trips.



NOTE

If the **Arc protection** function operates via the **External trip initiation**, only 3 optical point sensors are required per feeder protection device in order to detect the arcs (only one arc-protection module).

The signals from the feeder protection devices are sent via binary inputs/outputs, a protection interface or IEC 61850 GOOSE to the protection device of the infeed and processed.

The number of GOOSE messages is not limited. Therefore, the number of feeders is not limited, and the protection of complex systems is feasible.

Siemens recommends using the **Arc protection** function with external trip initiation.

6.10.10.2 Application and Setting Notes

General Notes:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders and the infeed to the respective protection devices.
- Arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders must be cleared by the protection device in the infeed. To do this, the protection devices in the feeder device must send the indication *Arc detected* to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.
- The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed clears the malfunction.

  Connect the signals over 6 stages, using the external trip initiation or a CFC chart.

Setting Notes for the Protection Device in Feeder 1

The **Arc protection** function operates with **3** stages.

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***Light only*** (applies to all stages)
- Parameter: **Sensor** = ***Point sensor*** (applies to all stages)
- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Operate & flt.rec. blocked** = ***yes*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Cable-connection compartment supervision in feeder 1

Setting Notes for the Protection Device in Feeder 2

The **Arc protection** function operates with **3** stages.

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***Light only*** (applies to all stages)
- Parameter: **Sensor** = ***Point sensor*** (applies to all stages)

- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Operate & flt.rec. blocked** = ***yes*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervison in feeder 2

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Cable-connection compartment supervision in feeder 2

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **9** stages.

Stage 1 (busbar compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***no***

  If an arc is detected in the busbar compartment of the infeed and the thresholds **Threshold I>** or **Threshold 3I0>** are exceeded, an operate indication is generated immediately.
- Parameter: **Channel** = ***Arc mod. 1 channel 1***
- Parameter: **Operating mode** = ***Current and light***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 2 (circuit-breaker compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***yes***

  If an arc is detected in the circuit-breaker compartment of the infeed (light-gray point sensors in *Figure 6-94*), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
- Parameter: **Channel** = ***Arc mod. 1 channel 2***
- Parameter: **Operating mode** = ***Current and light***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 3 (cable-connection compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***yes***

  If an arc is detected in the cable-connection compartment of the infeed (light-gray point sensors in *Figure 6-94*), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.

  Depending where the arc is generated in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the infeed, the current must be evaluated by the superordinate protection device.
- Parameter: **Channel** = ***Arc mod. 1 channel 3***
- Parameter: **Operating mode** = ***Light only***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 4 to 9 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Operating mode** = ***Current and light***

- Parameter: **External trip initiation** = ***yes***

  If an arc is detected in the busbar compartment, the circuit-breaker compartment, or the cable-connection compartment of the feeder, the feeder device sends the indication *Arc detected* to the infeed device. Only if the indication in the infeed device *Arc detected* is connected with the signal *>External Arc*, an external trip initiation via these stages is effective.

  The protection device in the infeed evaluates the current. If the measured current exceeds the **Threshold I>** and/or **Threshold 3I0>** threshold values, the protection device in the infeed clears the arc.

6.10.11 Application Example for Arc Protection with a Line Sensor in Operating Mode: Light and Current

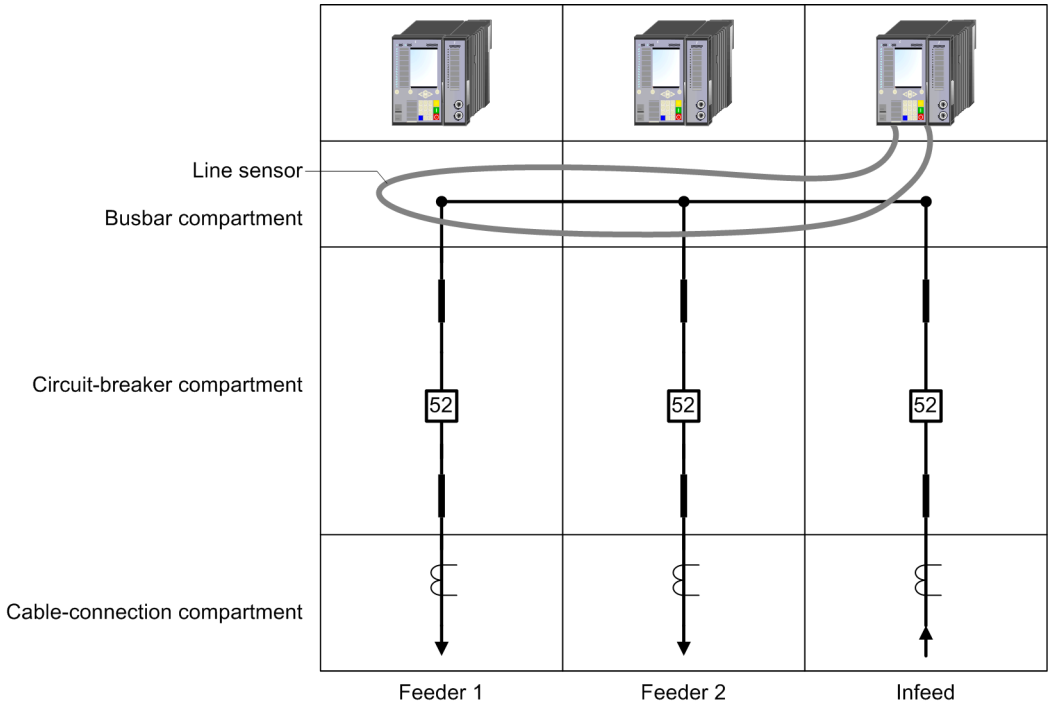
6.10.11.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with 1 infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***Current and light***. In the example, all arcs are detected by the protection device in the infeed.

The following items are considered in the example below:

- Optical line sensor placement in the switchgear
- Optical line sensor connection to the protection device in the infeed
- Number of necessary stages of the functions in the infeed protection device
- Setting notes about the selected parameters in the stages of the function



[dw_Liniensensor, 1, en_US]

Figure 6-95 Layout and Connection of the Optical Line Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional protection to prevent unwanted tripping caused by the sudden effects of light.
- *Figure 6-95* shows how the optical line sensors should be routed. Start in the infeed busbar compartment and route the optical line sensor along the busbar and back again to the protection device in the infeed. Connect the optical line sensor to the protection device in the infeed.
- Depending on the routing options in the control cabinet, you can also route the optical line sensor through the circuit breaker and cable-connection compartments of the feeders.
  If this is not possible, you can detect arcs in these compartments using point sensors. For more detailed information, see chapters *6.10.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only* and *6.10.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current*.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device will shut off.

NOTE

If the **Arc protection** function operates with the **`Operating mode`** = ***`Current and light`***, the additional current-flow criterion will prevent unwanted tripping caused by external light effects.

NOTE

Note that the number of arc protection modules that are connected to the device depend on the hardware configuration of the equipment.

When using modular equipment, a maximum of 15 sensors can be connected. If using non-modular equipment, a maximum of 6 sensors (3 sensors per module) can be connected.

Depending on the use case, you can combine point and line sensors.

6.10.11.2 Application and Setting Notes

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **1** stage.

Set the parameters of the stage as follows:

- Parameter: **`Operating mode`** = ***`Current and light`***
- Parameter: **`Sensor`** = ***`Line sensor`***
- Parameter: **`External trip initiation`** = ***`no`***
- Parameter: **`Channel`** = ***`Arc mod. 1 channel 1`*** (Stage 1) → Busbar compartment supervision (infeed, feeder 1, feeder 2)

You can find more information about the settings of the parameters **`Threshold I>`** and **`Threshold 3I0>`** in chapter *6.10.4 Application and Setting Notes – General Settings*.

6.11 Instantaneous Tripping at Switch onto Fault

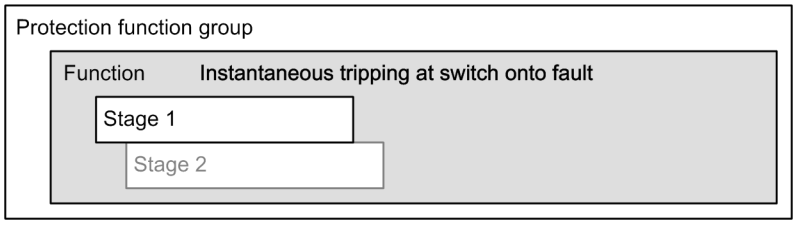
6.11.1 Overview of Functions

The **Instantaneous tripping at switch onto fault** function serves for immediate tripping when switching onto a fault.

The function does not have its own measurement and must be linked to another protection function with the pickup (measurement).

6.11.2 Structure of the Function

The function **Instantaneous tripping at switch onto fault** can be used in all protection function groups.The function is preconfigured with a stage. A maximum of 2 tripping stages can be operated simultaneously in the function. The stages have an identical structure.

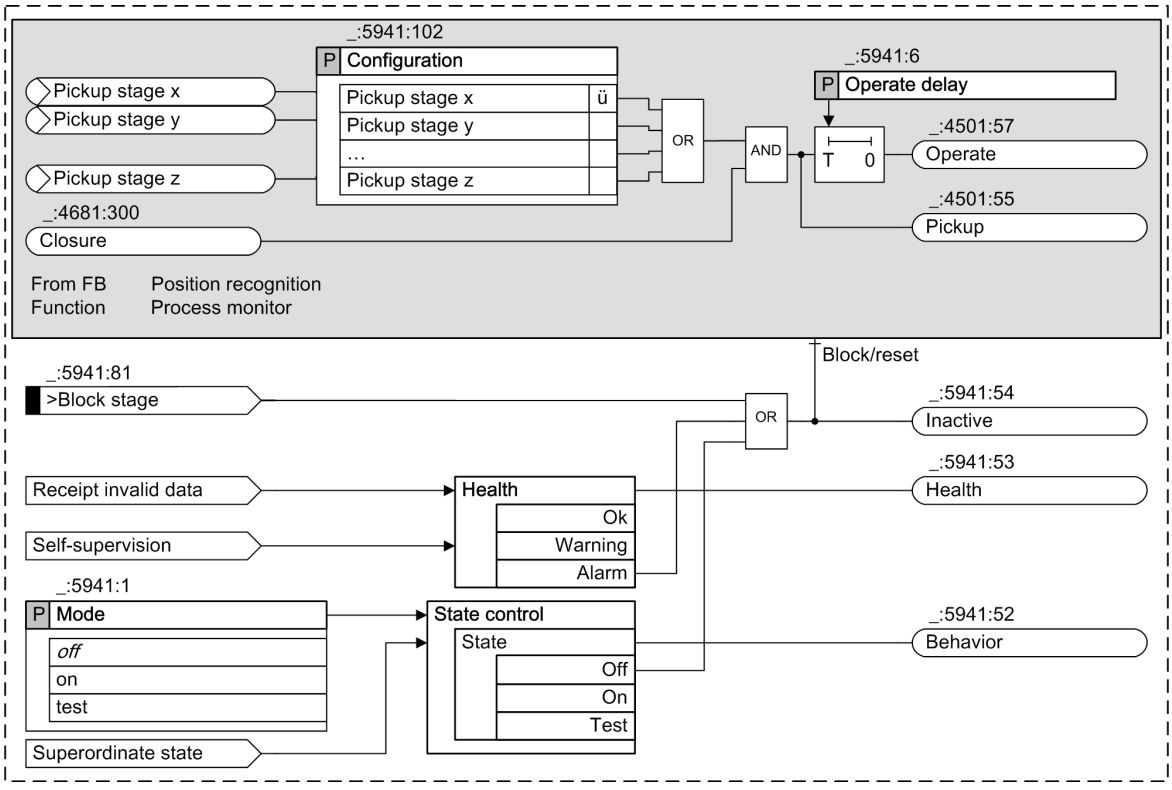


[dwstrsto-030211-01.tif, 1, en_US]

Figure 6-96 Structure/Embedding of the Function

6.11.3 Stage Description

Logic of the Stage



[logisotf-170312-01.tif, 1, en_US]

Figure 6-97 Logic Diagram of the Stage Instantaneous Tripping at Switch onto Fault

Connection of the Stage

The stage is intended to initiate instantaneous tripping when switching onto a fault. To do this, the stage must be connected to one or more pickups from protection functions or protection stages, for example, to pickup of an overcurrent-protection stage . That is, the stage of the **Instantaneous tripping at switch onto fault** function does not have its own measuring function but requires the pickup of another protection function or protection stage to pick up.

The stage is active only if switching is pending or executed (for this, see section *6.3 Overcurrent Protection, Phases*).

NOTE

If the pickup of a protection stage takes place and tripping is blocked by the **Inrush-current detection** function, no pickup of the **Instantaneous tripping at switch onto fault** function takes place. In this case, there is no fault recording neither. Despite this, if a fault recording is necessary, you can activate it with the parameter **(_:114) Start flt.rec** of the **Inrush-current detection** function (see chapter *6.8 Inrush-Current Detection*).

6.11.4 Application and Setting Notes

Parameter: Configuration

- Default setting **(_:5941:102) Configuration** = ***no stage***

The **Configuration** parameter is used to define with which pickup of a protection function or protection stage the **Instantaneous tripping at switch onto fault** function responds.

Normally, the pickups of protection functions and stages with high fault current are selected:

- Distance Protection
- Overcurrent protection (phase and ground)
- Directional time-overcurrent protection (phase and ground)

A specific protection stage is generally used. This can be one of the protection stages provided for the protection application, which itself trips with a delay. An additional protection stage with settings optimized for this use case, for example, increased threshold value and blocking of self-tripping, can also be used.

Parameter: Operate delay

- Recommended setting value **(_:5941:6) Operate delay** = ***0.00 s***

When switching onto a fault, the tripping should usually be instantaneous. The tripping delay is therefore set to 0.

6.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:5941:1	Stage 1:Mode		• off • on • test	off
_:5941:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:5941:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s
_:5941:102	Stage 1:Configuration		Setting options depend on configuration	

6.11.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:5941:81	Stage 1:>Block stage	SPS	I
_:5941:54	Stage 1:Inactive	SPS	O
_:5941:52	Stage 1:Behavior	ENS	O
_:5941:53	Stage 1:Health	ENS	O
_:5941:55	Stage 1:Pickup	ACD	O
_:5941:57	Stage 1:Operate	ACT	O

6.12 Overcurrent Protection, 1-Phase

6.12.1 Function Overview

The **Overcurrent protection, 1-phase** function (ANSI 50N/51N):

- Detects and monitors the current measured in a transformer neutral point grounding
- Can operate as sensitive tank leakage protection
- Detects and monitors the circulating current between the neutral points of 2 capacitor banks
- Switches off high-current faults instantaneously

6.12.2 Structure of the Function

The **Overcurrent protection, 1-phase** function is used in protection function groups with 1-phase current measurement. 2 function types are offered:

- **Overcurrent protection, 1-phase – advanced** (50N/51N OC-1ph-A)
- **Overcurrent protection, 1-phase – basic** (50N/51N OC-1ph-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the function type **Overcurrent protection, 1-phase – advanced** the following stages can be operated simultaneously:

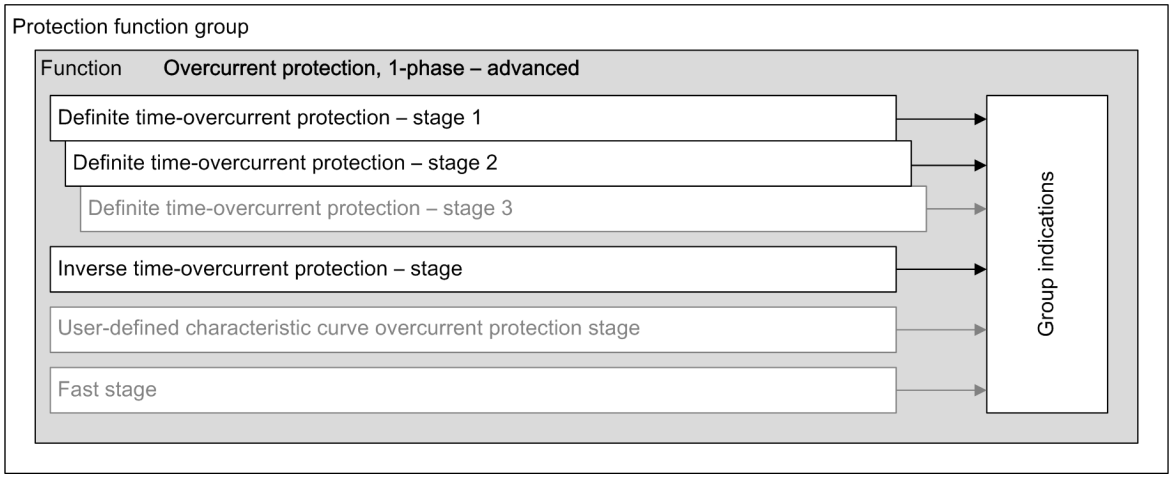
- Maximum of 3 stages **Definite time-overcurrent protection** (UMZ)
- 1 stage **Inverse time-overcurrent protection** (AMZ)
- 1 stage **User-defined characteristic curve overcurrent protection**
- 1 **Fast stage**

In the function type **Time-Overcurrent protection, 1-phase – basic**, the following stages can operate simultaneously:

- Maximum of 3 stages **Definite time-overcurrent protection**
- 1 stage **Inverse time-overcurrent protection**

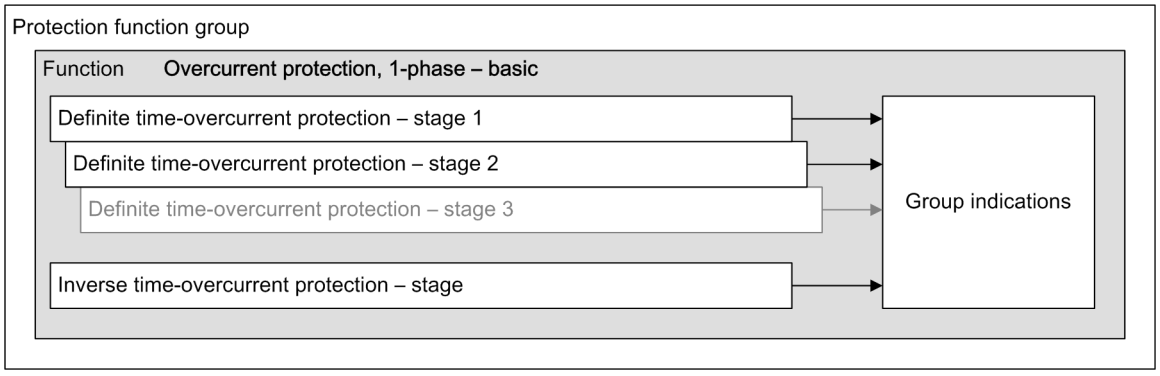
The non-preconfigured stages in *Figure 6-98* and *Figure 6-99* are shown in gray. Apart from the operate-delay characteristic curve, the **Definite time-overcurrent protection** stage, the **Inverse time-overcurrent protection** stage, and the **User-defined characteristic curve time-overcurrent protection** stage are structured identically.

The **Fast stage** uses a fast tripping algorithm. It is therefore suited in particular for sensitive ground-fault detection according to the high-impedance principle.



[dwocp1pa-280113-01.tif, 2, en_US]

Figure 6-98 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Advanced



[dwocp1pb-310113-01.tif, 2, en_US]

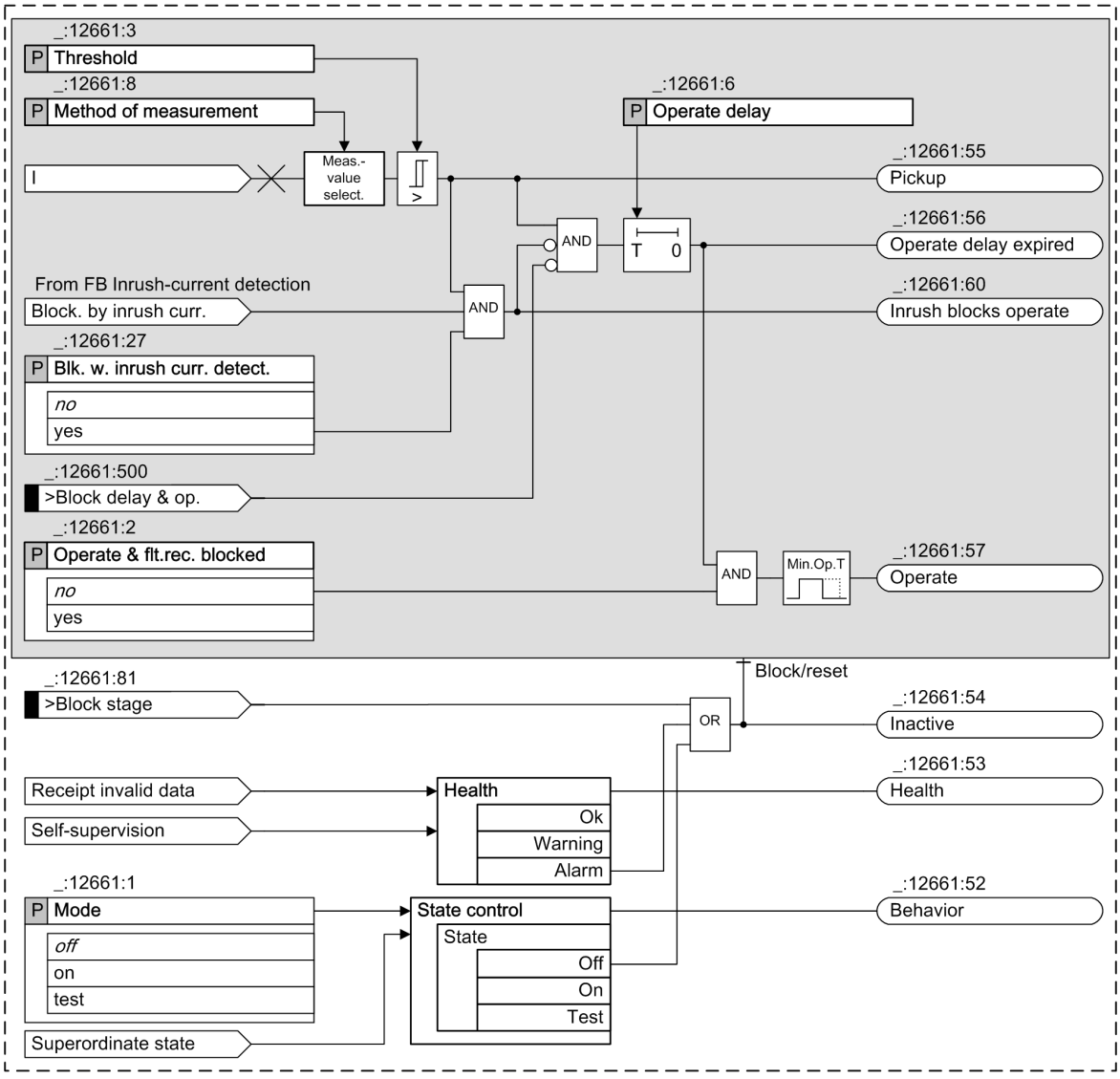
Figure 6-99 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Basic

If the device is equipped with the **Inrush-current detection** function, you can stabilize the stages against issuing of the operate indication due to transformer inrush-currents.

6.12.3 Stage with Definite-Time Characteristic Curve

6.12.3.1 Description

Logic of a Stage



[loinvocp-270612-01.tif, 1, en_US]

Figure 6-100 Logic Diagram of the Definite Time-Overcurrent Protection, 1-Phase

Method of measurement

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **Blk. w. inrush curr. detect.** parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication. The blocking can only be set if the central function **Inrush-current detection** is effective.

Blocking of tripping with the **Inrush-current detection** function is possible only if the following conditions have been met:

- The central **Inrush-current detection** function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project Tree → Name of the device → **Function group connections**.

Related Topics

6.3.7.1 Description

6.12.3.2 Application and Setting Notes

Parameter: **Method of measurement**

- Recommended setting value **(_:12661:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: **Threshold**, **Operate delay**

- Default setting **(_:12661:3) Threshold** = ***1.200 A*** (for the first stage)
- Default setting **(_:12661:6) Operate delay** = ***0.300 s*** (for the first stage)

Set the **Threshold** and **Operate delay** parameters for the specific application.

6.12.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:12661:1	Definite-T 1:Mode		• off • on • test	off
_:12661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

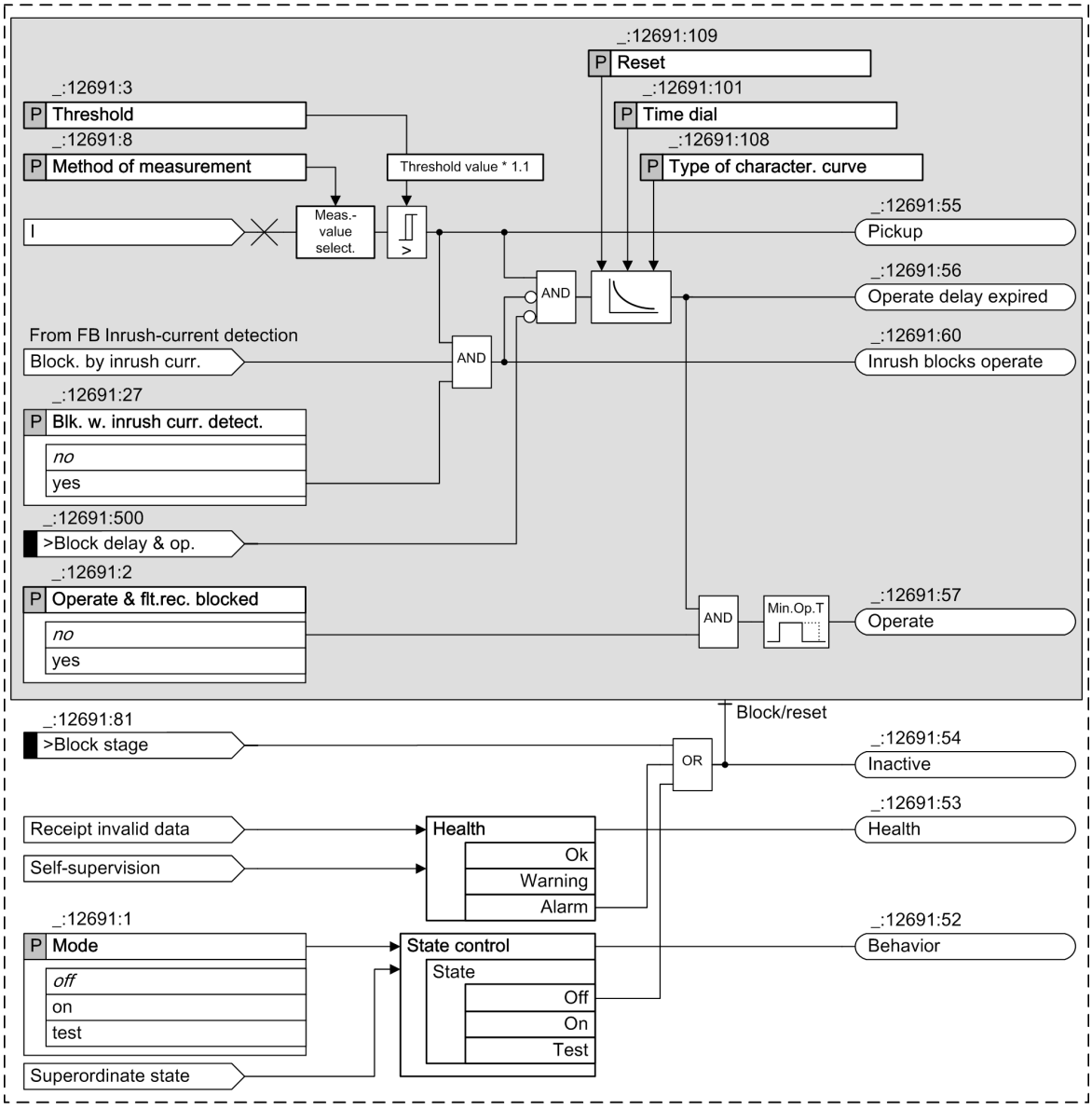
6.12.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:12661:81	Definite-T 1:>Block stage	SPS	I
_:12661:500	Definite-T 1:>Block delay & op.	SPS	I
_:12661:54	Definite-T 1:Inactive	SPS	O
_:12661:52	Definite-T 1:Behavior	ENS	O
_:12661:53	Definite-T 1:Health	ENS	O
_:12661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:12661:55	Definite-T 1:Pickup	ACD	O
_:12661:56	Definite-T 1:Operate delay expired	ACT	O
_:12661:57	Definite-T 1:Operate	ACT	O

6.12.4 Stage with Inverse-Time Characteristic Curve

6.12.4.1 Description

Logic of the Stage



[lodefocp-270612-01.tif, 1, en_US]

Figure 6-101 Logic Diagram of the Inverse Time-Overcurrent Protection (1-Phase)

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The

dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Method of Measurement

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

Blocking of the Time Delay

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **Blk. w. inrush curr. detect.** parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication.

Blocking of tripping with the **Inrush-current detection** function is possible only if the following conditions have been met:

- The central **Inrush-current detection** function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project Tree → Name of the device → **Function group connections**.

6.12.4.2 Application and Setting Notes

Parameter: **Method of measurement**

- Recommended setting value **(_:12691:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Type of character. curve

- Default setting **(_:12691:108) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: Threshold

- Default setting **(_:12691:3) Threshold** = ***1.20 A***

Set the **Threshold** and **Type of character. curve** parameters for the specific application.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

Parameter: Time dial

- Default setting **(_:12691:101) Time dial** = ***1***

Use the **Time dial** parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **Time dial** at ***1*** (default setting).

Parameter: Reset

- Default setting **(_:12691:109) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T 1				
_:12691:1	Inverse-T 1:Mode		• off • on • test	off
_:12691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12691:108	Inverse-T 1:Type of character. curve			

Addr.	Parameter	C	Setting Options	Default Setting
_:12691:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:12691:101	Inverse-T 1:Time dial		0.05 to 15.00	1.00

6.12.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:12691:81	Inverse-T 1:>Block stage	SPS	I
_:12691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:12691:54	Inverse-T 1:Inactive	SPS	O
_:12691:52	Inverse-T 1:Behavior	ENS	O
_:12691:53	Inverse-T 1:Health	ENS	O
_:12691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:12691:59	Inverse-T 1:Disk emulation running	SPS	O
_:12691:55	Inverse-T 1:Pickup	ACD	O
_:12691:56	Inverse-T 1:Operate delay expired	ACT	O
_:12691:57	Inverse-T 1:Operate	ACT	O

6.12.5 Stage with User-Defined Characteristic Curve

6.12.5.1 Description

The **User-defined characteristic curve time-overcurrent protection** stage is only available in the advanced function type.

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

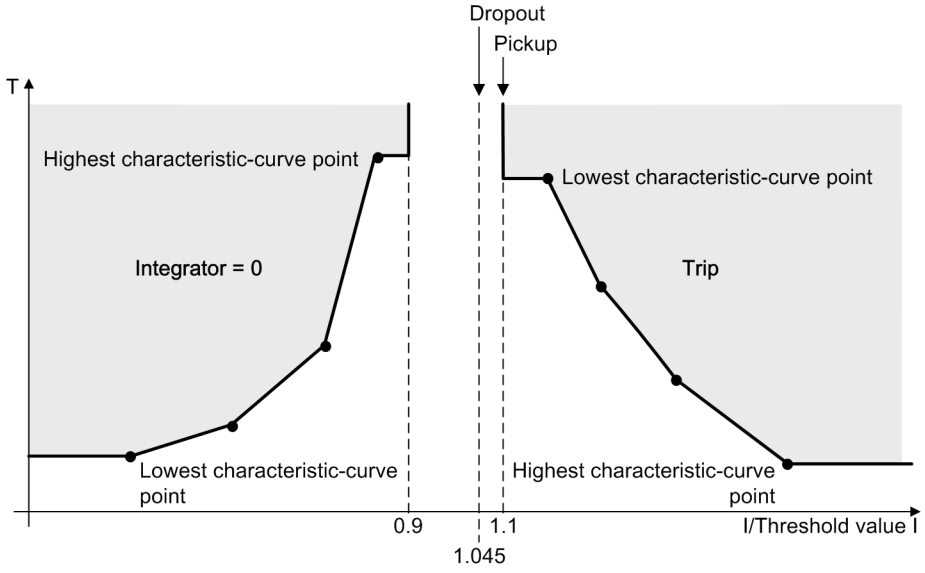
With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dwocpken-140611-02.tif, 1, en_US]

Figure 6-102 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.12.5.2 Application and Setting Notes

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`***.

Parameter: `Reset`

- Default setting **`Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `Current/time value pairs` (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

6.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00

6.12.5.4 Information List

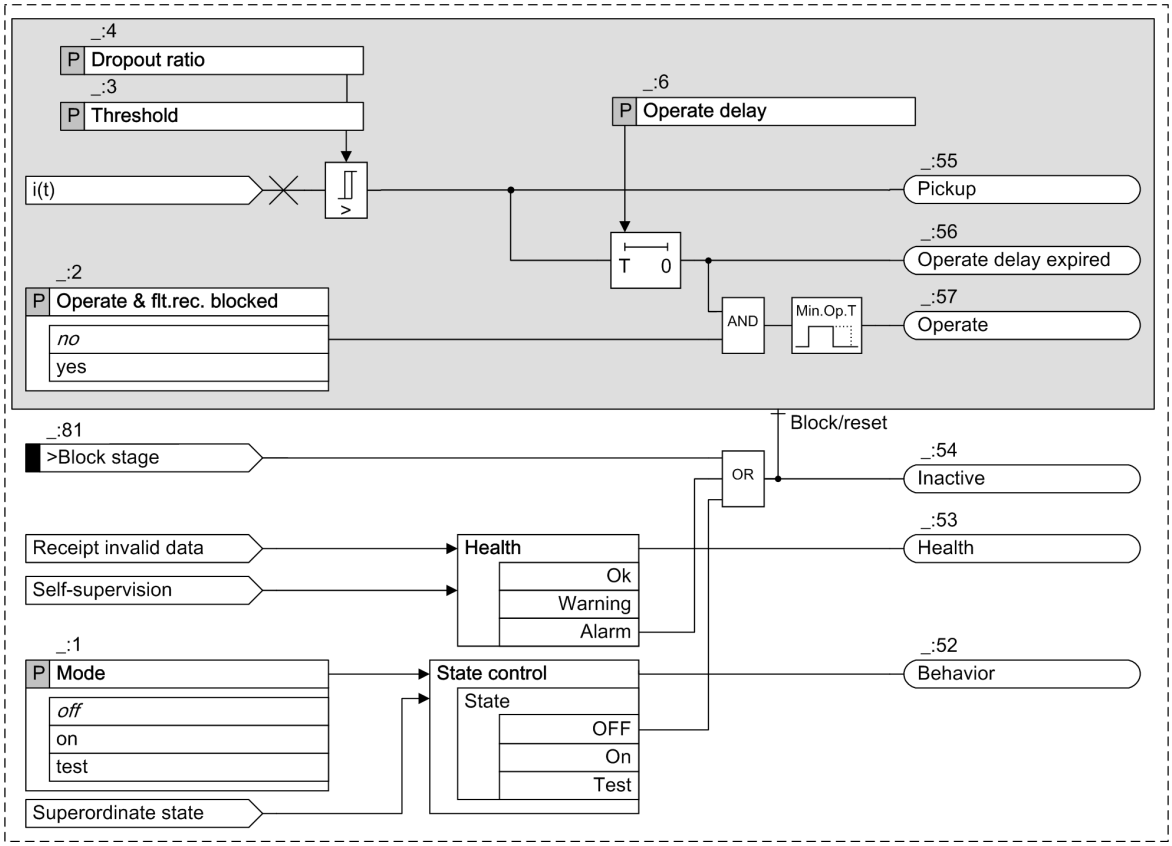
No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.12.6 Fast Stage

6.12.6.1 Description

Logic of a Stage

The fast stage is only available in function type Advanced.



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Figure 6-103 Logic Diagram of the Fast Stage, 1-Phase

Method of Measurement, Pickup and Dropout Behavior of the Fast Stage

This stage evaluates the unfiltered measurands. Thus, very short response times are possible. When the absolute values of 2 consecutive sampled values of the last half period exceed the **Threshold**, the stage picks up. When all sampled values of the previous period are less than the dropout threshold, the stage drops out.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

6.12.6.2 Application and Setting Notes

Parameter: Threshold, Operate delay

- Default setting **(_:3) Threshold** = ***10.00 A***
- Default setting **(_:6) Operate delay** = ***0.00 s***

Set the **Threshold** and **Operate delay** parameters for the specific application.

Ensure that the sampled values are compared directly without an additional factor with the set threshold value.

Parameter: Dropout ratio

- Recommended setting value **(_:4) Dropout ratio** = ***0.90***

The recommended setting value of ***0.90*** is sufficient for many applications. To obtain high-precision measurements, the **Dropout ratio** can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the **Dropout ratio** setting. This avoids chattering of the tripping stage.

6.12.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fast stage #				
_:1	Fast stage #:Mode		• off • on • test	off
_:2	Fast stage #:Operate & flt.rec. blocked		• no • yes	no
_:3	Fast stage #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:4	Fast stage #:Dropout ratio		0.90 to 0.99	0.90
_:6	Fast stage #:Operate delay		0.00 s to 60.00 s	0.00 s

6.12.6.4 Information List

No.	Information	Data Class (Type)	Type
Fast stage #			
_:81	Fast stage #:>Block stage	SPS	I
_:54	Fast stage #:Inactive	SPS	O
_:52	Fast stage #:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:53	Fast stage #:Health	ENS	O
_:55	Fast stage #:Pickup	ACD	O
_:56	Fast stage #:Operate delay expired	ACT	O
_:57	Fast stage #:Operate	ACT	O

6.12.7 Application Example: High-Impedance Restricted Ground-Fault Protection

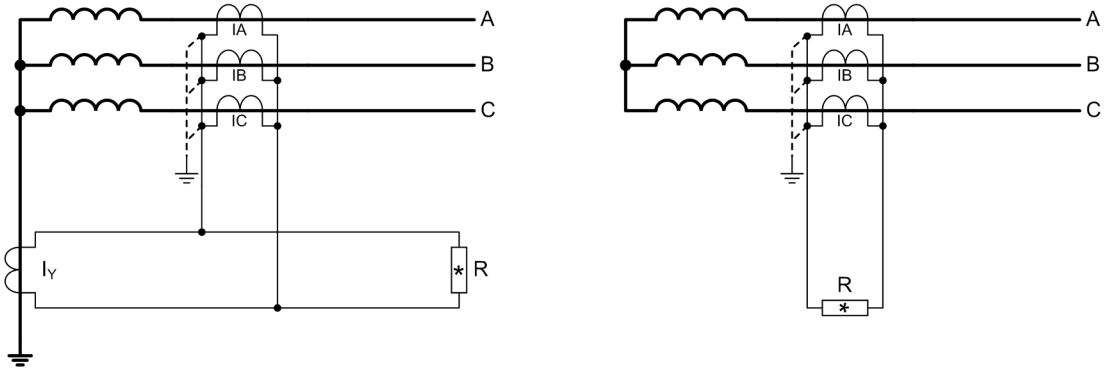
6.12.7.1 Description

With the high-impedance method, all current transformers operate in parallel at the limits of the protection range on a common, relatively high-impedance resistor R, the voltage of which is measured.

The current transformers must be of the same type of construction and have at least one core of their own for the High-impedance restricted ground-fault protection. Furthermore, they must have the same transfer ratio and approximately the same knee-point voltage.

The high-impedance principle is especially suited for ground-fault detection in grounded networks at transformers, generators, motors, and shunt reactors.

The left part of *Figure 6-104* shows an application example for a grounded transformer winding or a grounded motor/generator. The example at the right shows an ungrounded transformer winding or an ungrounded motor/generator. In this example, it is assumed that the network is grounded at a different point.



[dwhimpef-310113-01.tif, 2, en_US]

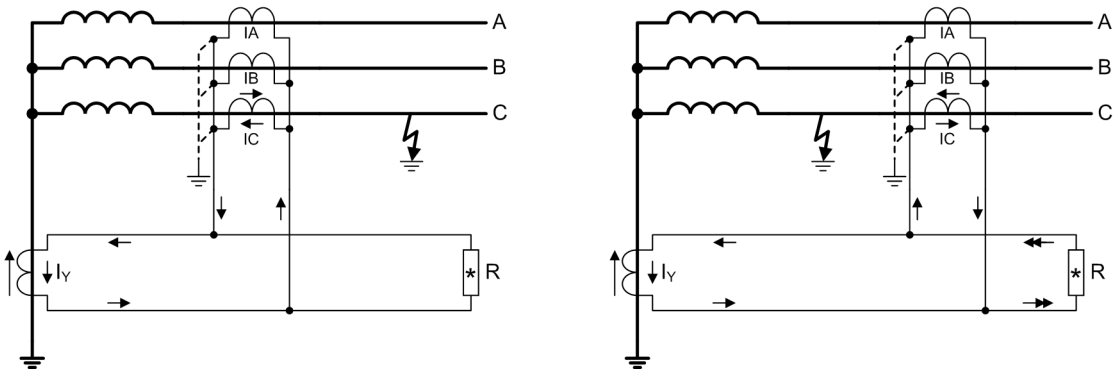
Figure 6-104 Restricted Ground-Fault Protection According to the High-Impedance Principle

Function of the High-Impedance Principle

The high-impedance principle is explained using the example of a grounded transformer winding.

In normal state, no residual currents flow, that is, in the transformer neutral point $I_Y = 0$ and in the phases $3I_0 = I_A + I_B + I_C = 0$.

With an external ground fault (on the left in *Figure 6-105*), the short-circuit current of which is fed via a grounded neutral point, the same current flows in the transformer neutral point and in the phases. The respective secondary currents (with the same transfer ratio of all current transformers) draw each other off. They are connected in series. At the resistor R, only a little voltage arises, which results from the internal resistances of the transformers and those of the transformer connection lines. Even if a current transformer is briefly saturated, it becomes a low-impedance during the time of the saturation and forms a low-impedance shunt to the high-impedance resistor R. The high resistance of the resistor thus has a stabilizing effect (so-called resistor stabilization).



[dwprhimp-310113-01.tif, 2, en_US]

Figure 6-105 Principle of the Restricted Ground-Fault Protection According to the High-Impedance Principle

With a ground-fault in the protection range (on the right in *Figure 6-105*), a neutral-point current I_Y flows in any case. The magnitude of the residual current in the phase currents depends on the grounding conditions in the rest of the network. A secondary current corresponding to the entire short-circuit current attempts to flow via the resistor R. But since this resistor is high-impedance, a high voltage arises there which causes the saturation of the current transformers. The effective voltage at the resistor therefore corresponds approximately to the knee-point voltage of the current transformers.

The resistor R is thus dimensioned in such a way that even the smallest ground-fault current to be detected leads to a secondary voltage that corresponds to half of the knee-point voltage of the current transformers (see chapter 2.5.4).

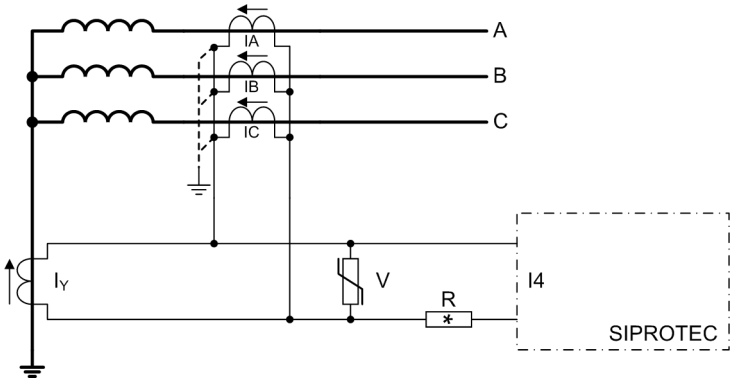
Further information can be found at Sensitivity view for high-impedance ground-fault differential protection in chapter *6.12.7.2 Application and Setting Notes* .

High-Impedance Restricted Ground-Fault Protection with a SIPROTEC 5 Device

Use the I4 measuring input of the SIPROTEC 5 device for the high-impedance restricted ground-fault protection. This input for this application is to be executed as a sensitive measuring input. Since this is a current input, the current is detected by this resistor instead of the voltage at the resistor R.

Figure 6-106 shows the connection diagram. The protection device is connected in series with the resistor R and thus measures its current.

The varistor V limits the voltage in case of an internal fault. The varistor cuts the high instantaneous voltage peaks in the case of transformer saturation. Simultaneously, a smoothing of the voltage arises without any relevant reduction of the average value.



[dwanedif-310113-01.tif, 2, en_US]

Figure 6-106 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

As a protection against overvoltages, it is important that you connect the device directly at the grounded side of the current transformer. The high voltage at the resistor is thus kept away from the device.

In a similar manner, the high-impedance restricted ground-fault protection for generators, motors, and shunt reactors is used. With auto transformers, you must connect the upper-voltage side and low-voltage side current transformers and neutral-point transformer in parallel.

The method can be realized for each protected object. As busbar protection, the device, for example, is connected via the resistor to the parallel connection of the transformers of all feeders.

6.12.7.2 Application and Setting Notes

A prerequisite for the application of the high-impedance restricted ground-fault protection is that neutral-point current detection is possible on the station side (see example in (*Figure 6-106*). Furthermore, a sensitive input transformer must be available at device input I4. Set the pickup value for current at input I4 with the function **Overcurrent protection, 1-phase**.

Observe the interaction between current-transformer characteristic curve, external resistor R, and the voltage at R for the overall function of the high-impedance restricted ground-fault protection. Notes on this follow.

Current Transformer Data for High-Impedance Restricted Ground-Fault Protection

All affected current transformers must have the same ratio and approximately the same knee-point voltage. This is normally the case when the current transformers are of the same type and have the same rated data. You can calculate the knee-point voltage from the rated data as follows:

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated}$$

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V_{KP}	Knee-point voltage
Ri	Internal resistance of the current transformer
P_{rated}	Rated power of the current transformer
I_{rated}	Secondary rated current of the current transformer
n	Rated overcurrent factor

Rated current, rated power, and overcurrent factor are found on the name plate of the transformer.

EXAMPLE

Current transformer with the following data on the name plate: 800/5; 5P10; 30 VA

You can read the following transformer data with this data:

I_{rated}	= 5 A (out of 800/**5**)
n	= 10 (out of 5P**10**)
P_{rated}	= **30** VA

The internal resistance is frequently to be found in the test report of the transformer. If it is not known, it can be approximately determined by a direct current measurement at the secondary winding.

EXAMPLE

Calculation of the knee-point voltage

Current transformer 800/5; 5P10; 30 VA with $R_i = 0.3\ \Omega$

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated} = \left(0.3\ \Omega + \frac{30\ VA}{(5\ A)^2} \right) \cdot 10 \cdot 5\ A = 75\ V$$

[foukp5aw-310113-01.tif, 1, en_US]

Current transformer 800/1; 5P10; 30 VA with $R_i = 5\ \Omega$

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated} = \left(5\,\Omega + \frac{30\ VA}{(1\,A)^2} \right) \cdot 10 \cdot 1\,A = 350\ V$$

[foukp1aw-310113-01.tif, 1, en_US]

Besides the current-transformer data, the resistance of the longest connection line between transformer and device must be known.

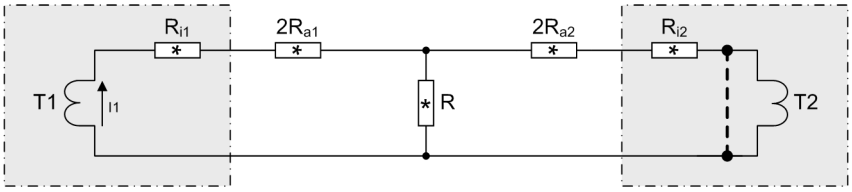
Stability Consideration for High-Impedance Restricted Ground-Fault Protection

The stability condition is based on the simplified assumption that one current transformer is completely saturated and the others transfer their partial currents proportionately in the case of an external fault. This is theoretically the worst case. A safety margin is automatically provided, since, in practice, even the saturated transformer still delivers some current.

Figure 6-107 shows an equivalent circuit of this simplification. CT1 and CT2 are assumed to be ideal transformers with their internal resistances R_{i1} and R_{i2}. R_a are the core resistances of the connection lines between transformer and resistance R; they are used doubled (forward line and return line). R_{a2} is the resistance of the longest connection line.

CT1 transmits the current I1. CT2 is assumed to be saturated. This is indicated by the dotted short-circuit line. The transformer thus represents a low-impedance shunt by its saturation.

A further prerequisite is $R >> (2R_{a2} + R_{i2})$.



[dwvebhdi-310113-01.tif, 2, en_US]

Figure 6-107 Simplified Connection Diagram of a Layout for High-Impedance Restricted Ground-Fault Protection

The voltage at R is, then,

$V_R = I_1 \cdot (2R_{a2} + R_{i2})$

A further assumption is that the pickup value of the SIPROTEC 5 device corresponds to half of the knee-point voltage of the current transformers. In the edge case,

$V_R = V_{KP}/2$

The stability limit I_{SL} results, which means the through-current up to which the arrangement remains stable:

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}}$$

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EXAMPLE

For the 5 A transformer as above with V_{KP} = 75 V and R_i = 0.3 Ω

Longest connection line = 22 m with 4 mm² cross-section; that corresponds to R_a = 0.1 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{37.5\ V}{2 \cdot 0.1\,\Omega + 0.3\,\Omega} = 75\ A$$

[foisl5aw-310113-01.tif, 1, en_US]

In the example, the stability limit is 15 × rated current or 12 kA primary.

For the 1 A transformer as above with V_{KP} = 350 V and R_i = 5 Ω

Longest connection line = 107 m with 2.5 mm^2 cross-section; that corresponds to R_a = 0.75 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{175\ V}{2 \cdot 0.75\ \Omega + 5\ \Omega} = 27\ A$$

[foisl1aw-310113-01.tif, 1, en_US]

In the example, the stability limit is 27 × rated current or 21.6 kA primary.

Sensitivity Consideration for High-Impedance Restricted Ground-Fault Protection

The voltage present at the set of current transformers is supplied to the protection device via a series resistor R as proportional current for evaluation. For dimensioning of the resistor, the following must be taken into account:

The high-impedance restricted ground-fault protection should pick up at approximately half of the knee-point voltage of the current transformers. From this, you can calculate the resistor R.

Since the device measures the current through the resistor, the resistor and measuring input of the device must be connected in series. Since the resistor still should be high-impedance (aforementioned condition R >> $2R_{a2} + R_{i2}$), the inherent resistance of the measuring input can be neglected. The resistance results thus from the pickup current I_{pick} and half of the knee-point voltage:

$$R = \frac{V_{KP}/2}{I_{pick.}}$$

[foberecr-310113-01.tif, 1, en_US]

EXAMPLE

For the 5 A transformer as above

Desired pickup value I_{pick} = 0.1 A (corresponds to 16 A primary)

$$R = \frac{V_{KP}/2}{I_{pick.}} = \frac{75\ V/2}{0.1\ A} = 375\ \Omega$$

[fober5aw-310113-01.tif, 1, en_US]

For the 1 A transformer as above

Desired pickup value I_{pick} = 0.05 A (corresponds to 40 A primary)

$$R = \frac{V_{KP}/2}{I_{pick.}} = \frac{350\ V/2}{0.05\ A} = 3500\ \Omega$$

[fober1aw-310113-01.tif, 1, en_US]

The series resistor R must be designed for a minimum continuous load $P_{continuous}$.

$$P_{continuous} \geq \frac{(V_{KP}/2)^2}{R} = \frac{37.5^2}{375} = 3.75\ W \qquad \text{at the 5-A-transformer}$$

[fopdau5a-310113-01.tif, 1, en_US]

$$P_{continuous} \geq \frac{(V_{KP}/2)^2}{R} = \frac{175^2}{3500} = 8.75\ W \qquad \text{at the 1-A-transformer}$$

[fopdau1a-310113-01.tif, 1, en_US]

Further, the series resistor R must be designed for a fault current lasting approximately 0.5 s. This time is usually sufficient for fault clarification through backup protection.

The thermal stress of the series resistor depends on the voltage $V_{RMS,stab}$ that is present during an internal fault. It is calculated according to the following equations:

$$V_{RMS,rest} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{75^3 \cdot 375 \cdot 250} = 579.7\ V \qquad \text{at the 5–A–transformer}$$

[fousta5a-310113-01.tif, 1, en_US]

$$V_{RMS,rest} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{350^3 \cdot 3500 \cdot 50} = 2151.6\ V \qquad \text{at the 1–A–transformer}$$

[fousta1a-310113-01.tif, 1, en_US]

$I_{K,max,int}$ corresponds to the maximum fault current here in the case of an internal fault.

5-A current transformer 800/5 with 40 kA primary corresponds to $I_{K,max,int}$ = 250 A secondary.

1-A current transformer 800/1 with 40 kA primary corresponds to $I_{K,max,int}$ = 50 A secondary.

This results in a temporary load for the series resistor over 0.5 s of:

$$P_{0.5\,s} = \frac{V_{RMS,rest}^2}{R} = \frac{579.7^2}{375} = 896\ W \qquad \text{at the 5–A–transformer}$$

[fop05s5a-310113-01.tif, 1, en_US]

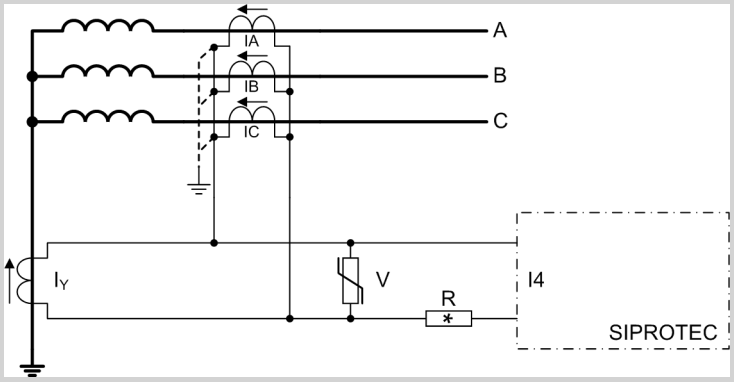
$$P_{0.5\,s} = \frac{V_{RMS,rest}^2}{R} = \frac{2151.6^2}{3500} = 1322.7\ W \qquad \text{at the 1 – A – transformer}$$

[fop05s1a-310113-01.tif, 1, en_US]

Observe that with the selection of a higher pickup value I_{pick}, the resistor value must be lowered and therefore the dissipation rises sharply.

The varistor (see following figure) must be sized such that it remains high impedance up to the knee-point voltage, for example:

- Approx. 100 V with 5 A transformer
- Approx. 500 V with 1 A transformer



[dwanedif-310113-01.tif, 2, en_US]

Figure 6-108 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

Even with unfavorable wiring, the maximum occurring voltage peaks do not exceed 2 kV for safety reasons.

When for performance reasons, several varistors must be connected in parallel, give preference to types with flat characteristic curves, in order to avoid an unbalanced load. Siemens therefore recommends the following types by METROSIL:

600A/S1/S256 (k = 450, β = 0.25)

600A/S1/S1088 (k = 900, β = 0.25)

In the example, set the pickup value of the first Definite time-overcurrent protection stage (setting **`Threshold`**) to 0.1 A for 5-A transformers or 0.05 A for 1-A transformers. No further protection stages are needed. Delete these or switch them off. Set the **`Operate delay`** setting to 0 s.

If several current transformers are connected in series, for example, with use as busbar protection with several feeders, the magnetization currents of the transformers switched in parallel can no longer be neglected. In

this case, add up the magnetization currents at half of the knee-point voltage (corresponds to the set **Threshold**). These magnetization currents reduce the current through the resistor R. Thus, the actual pickup value is correspondingly higher.

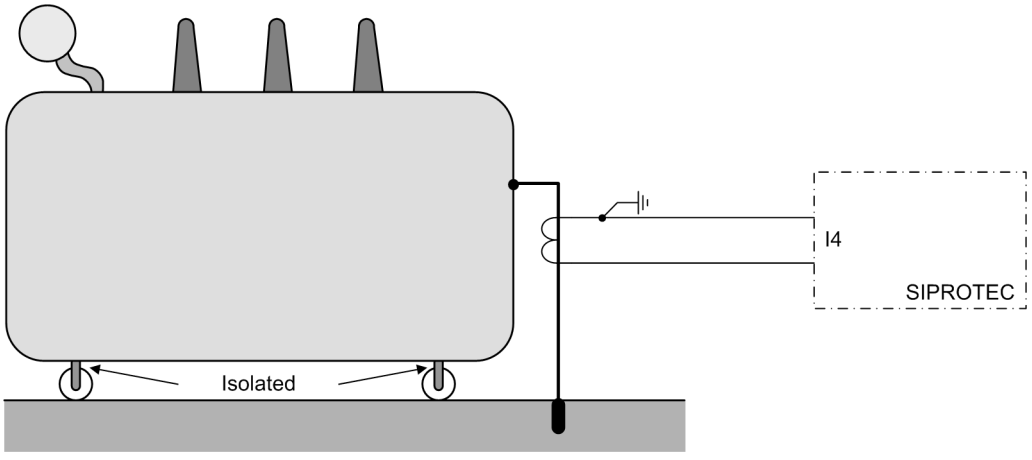
6.12.8 Application Example: Tank Leakage Protection

6.12.8.1 Description

Tank leakage protection records short-circuits to ground – including high-impedance ones – between a phase and the tank of a transformer. The tank is thus insulated, or at least grounded with high impedance. The tank must be connected with a line to ground. The current that flows through this line is fed to the protection device. If a short-circuit to ground occurs in a tank, a fault current (tank current) flows to substation ground via the ground connection.

The function **Overcurrent protection, 1-phase** detects the tank current. If the tank current exceeds the set **Threshold**, the function **Overcurrent protection, 1-phase** generates an operate indication. Depending on the set **Operate delay**, the transformer is tripped immediately or time-delayed on all sides.

For tank protection, a sensitive, 1-phase current measuring input is used.



[dwprkess-310113-01.tif, 2, en_US]

Figure 6-109 Tank-Control Principle

6.12.8.2 Application and Setting Notes

A prerequisite for the application of tank protection is the availability of a sensitive input transformer at device input I4.

If you connect **Measuring point I 1-ph** with the function group **Voltage-current 1-phase**, the function **Overcurrent protection, 1-phase** works with the 1-phase current connected to input I4.

Use only the first definite time-overcurrent protection stage of function **Overcurrent protection, 1-phase**. The **Threshold** setting is used to set the pickup value. No further protection stages are needed. Delete these or switch them off. Set the **Operate delay** setting to 0 s.

6.13 Non-Directional Intermittent Ground-Fault Protection

6.13.1 Overview of Functions

A typical characteristic of intermittent ground faults is that they often extinguish automatically and strike again after some time. The fault duration can last between a few milliseconds and many seconds. Thus, such faults are not detected at all or not selectively by the ordinary overcurrent protection. If pulse durations are extremely short, not all protection devices in a short-circuit path can pick up. Thus, selective tripping is not ensured.

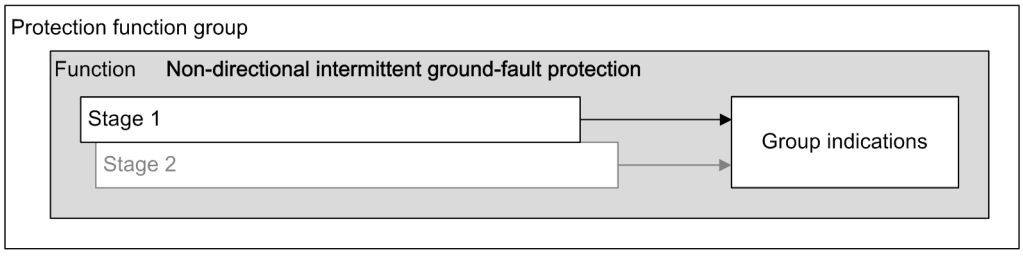
Due to the time delay of the overcurrent protection function, such faults are too short to initiate switching off the faulted cable. The short-circuit protection can clear such ground faults selectively only if the ground faults have become permanent.

But such intermittent ground faults already bear the risk of damaging the equipment thermally. This is why SIPROTEC 5 devices feature a protection function that is able to detect such intermittent ground faults and accumulates their duration. If the sum reaches a configurable value within a certain time, the limit of the thermal rating has been reached. If intermittent ground faults are distributed over a long period or if the ground fault disappears and does not restrike after some time, the equipment under load is expected to cool down. Tripping is not necessary in this case.

The **Non-directional intermittent ground-fault protection** function is used to protect against intermittent ground faults which occur, for example, in cables due to poor insulation or water ingress in cable joints.

6.13.2 Structure of the Function

The **Non-directional intermittent ground-fault protection** function can be used in protection function groups with current measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously. The non-preconfigured stages are shown in gray in the following figure.

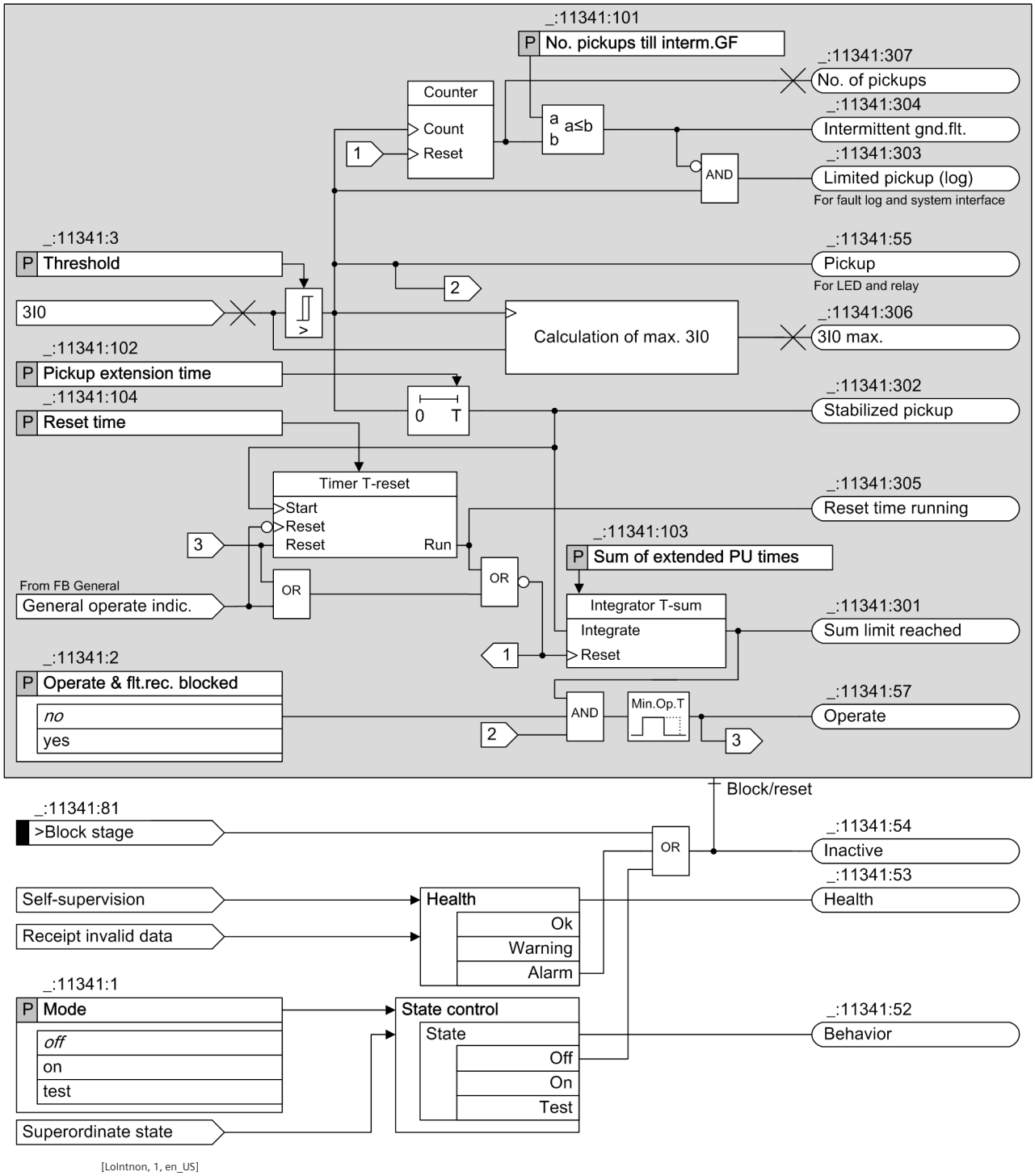


[DwIntGFP, 1, en_US]

Figure 6-110 Structure/Embedding of the Function

6.13.3 Stage Description

Logic



[LoIntnon, 1, en_US]

Figure 6-111 Logic of the Non-Directional Intermittent Ground-Fault Protection

Measured Value 3I0

The intermittent ground-fault current 3I0 can either be detected via the standard ground-current input I_N or via the sensitive ground-current input I_{NS}. It can also be calculated from the sum of the 3-phase currents. The measured value depends on the parameter **Connection type** of the measuring point I-3ph.

Table 6-9 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Method of Measurement

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonics components and the direct component (DC). Both components contribute to the thermal load.

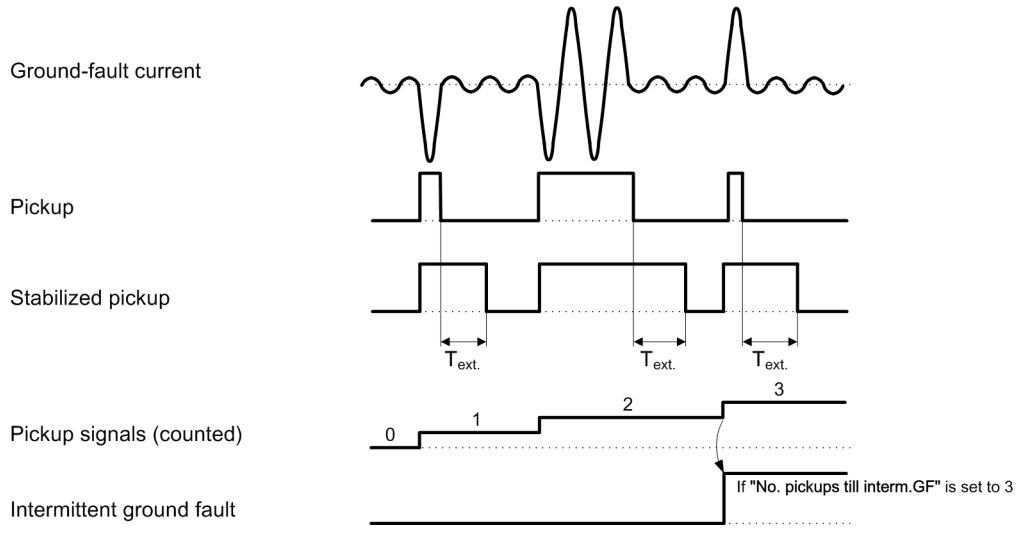
Maximum 3I0 of the Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault. The statistic value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. With the coming operate signal, this value is logged via the information *3I0 max.*.

Pickup and Intermittent Ground-Fault Indication

When 3I0 exceeds the threshold value, the pickup signals *Pickup* and *Limited pickup (log)* are issued. The stage generates the *Stabilized pickup* signal by extending the *Pickup* for a defined time (parameter **Pickup extension time**).

The stage counts the *Pickup* signals. If the counted number reaches the configured **No. pickups till interm.GF**, the *Intermittent gnd.flt.* signal is issued. The signal *Limited pickup (log)* is not issued anymore after the issue of the *Intermittent gnd.flt.* signal.



[DwIntFaD, 1, en_US]

Figure 6-112 Fault Detection of the Intermittent Ground-Fault Protection

$T_{ext.}$ Defined time for extending the *Pickup* signal

Number of Pickups

The stage counts the number of *Pickup* signals during the intermittent ground fault. With the operate of the stage this number is logged via the information *No. of pickups*.

Accumulation of the Intermittent Ground-Fault Current and Issuing the Operate Signal

An intermittent ground fault can result in thermal stress on the protected equipment. The magnitude and the duration of the ground-fault current are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the predefined **Sum of extended PU times**, the limit of the thermal load is reached. The stage issues the signal *Sum limit reached* and operates when the signal *Pickup* is active.

Reset Timer for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if ground fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, an operation is not necessary. The interval between ground faults is monitored with the reset timer. If a ground fault occurs, the **Timer T-reset** with its setting **Reset time** is launched simultaneously with **Integrator T-sum**. Unlike the integrator, each new ground fault restarts the reset timer with its initial value. If **Timer T-reset** expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new fault event.

Reset Conditions

Under one of the following 2 conditions, **Timer T-reset** is reset.

- The Intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, **Integrator T-sum** and **Counter** are reset and the whole stage is reset and returns to its idle state.

- **Timer T-reset** expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter **Operate & flt.rec. blocked** to ***yes***, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start & Stop of Fault Recording, Fault Logging, and General Pickup

The *Stabilized pickup* signal initiates the fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the *Stabilized pickup* signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Signals

Intermittent ground faults may cause other functions, based on overcurrent measurement, to pick up, which may result in a burst of signals. In order to avoid an overflow of the fault log, a special mechanism is applied to the signals of these functions after detection of an intermittent ground fault (signal *Intermittent gnd.flt.*).

The special mechanism is applied for the following listed functions and other functions are not influenced:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Directional overcurrent protection, phases
- Directional overcurrent protection, ground
- Overcurrent protection, 1-phase
- Negative-sequence protection with definite-time characteristic curve
- Directional negative-sequence protection with definite-time delay
- Directional overcurrent-protection stage with cos phi or sin phi measurement
- Directional overcurrent-protection stage with 3I0-phi (V,I) measurement
- Sensitive ground-current protection with 3I0

If a function picks up, normally its output signals are sent directly to the information targets, for example, the pickup signal is written to the fault log. To avoid overflow of logs due to intermittent ground faults, a special log buffer mechanism is used. If one of the preceding functions or stages picks up after an intermittent ground fault has been detected (signal *Intermittent gnd.flt.* has been issued), its output signals are processed as shown in the following 2 tables.

Table 6-10 Processing of the Signal Status Changes

Processing of Signal Status Changes	Description
Special buffering mechanism	The status changes of signals are written to a special buffer. This buffer can store a maximum of 2 status changes (the most recent ones) for each signal. With the pickup signal as example, if one of the preceding protection functions or stages picks up during an active *Intermittent gnd.flt.* signal, the pickup signal is not written in the fault log anymore unless one of the preceding functions operates. After the operation, the buffered signals are written to the information target with the original time stamp. This measure ensures that a pickup signal, although delayed, is always signaled in association with each operate command.
Discard	The signal status changes are discarded.
Pass through	The signal is forwarded to the information target without restriction. Special buffering does not apply for specific information targets as protection measure, for example, reverse interlocking, need these signals for proper operation.

Table 6-11 Information Target with Different Processing of Signal Status Changes

Information Target		Processing of Signal Status Changes
Processing of Signal Status Changes	Operational log Fault log Ground-fault log User-defined log	Special buffering mechanism
Communication interface	IEC 61850-8-1 Client/Server IEC 60870-5-103/104 DNP V3.0	Special buffering mechanism
Protection interface	PDI	Pass through
IEC 61850-8-1 GOOSE		Pass through
CFC		Pass through
LEDs		Pass through
Binary output		Pass through
Fault recorder		Pass through
Automatic reclosing function		Discard
Circuit-breaker failure protection		Discard
Group indications		Discard

6.13.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults as the protection function only operates after repeated detection of a fault or after the integration value reaches the predefined **Sum of extended PU times**. Besides this, its basic design is to prevent thermal overload. For these reasons, the intermittent ground-fault protection function is not intended to start the automatic reclosing function.

Rooting of Pickup Signals

The signal *Pickup* is supposed to be routed to LED and relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface before the signal *Intermittent gnd.flt.* is issued. This scheme prevents a burst of messages.



NOTE

To avoid a burst of messages, do not route the signal *Pickup* to the operational log and fault log.

Parameter: 3I0 Threshold

- Default setting **(_:11341:3) Threshold** = ***1.00 A***

With the **Threshold** parameter, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: No. pickups till interm.GF

- Default setting **(_:11341:101) No. pickups till interm.GF** = ***3***

With the parameter **No. pickups till interm.GF**, you set the number of counted *Pickup* signals after which the ground fault is considered as intermittent.

Parameter: Pickup extension time

- Default setting **(_:11341:102) Pickup extension time** = ***0.10 s***

You can get a stabilized pickup signal with the **Pickup extension time** parameter. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: Sum of extended PU times

- Default setting **(_:11341:103) Sum of extended PU times** = ***20 s***

With the **Sum of extended PU times** parameter, you set the threshold value for the integrator. If the integration reaches **Sum of extended PU times**, the stage operates if the pickup state is present.

This **Sum of extended PU times** represents one of the 4 selectivity criteria (pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on adjacent feeders. It is comparable to the time grading of the overcurrent protection. The protection in the radial system which is closest to the intermittent fault and picks up, has the shortest summation time **Sum of extended PU times**.

Parameter: Reset time

- Default setting **(_:11341:104) Reset time** = ***300 s***

With the parameter **Reset time**, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the **Reset time**, the counter and integrator are reset.

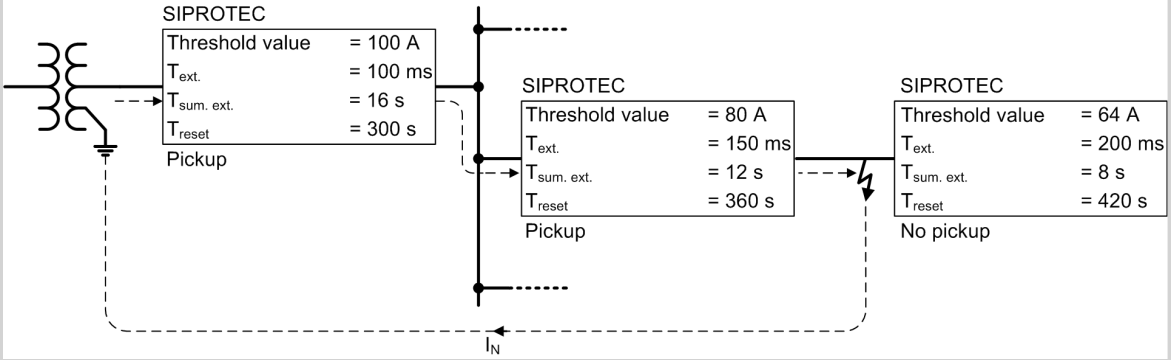
The **Reset time** parameter must be much higher than the operate value of the **Sum of extended PU times**.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:11341:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

EXAMPLE



[TiExaInt, 1, en_US]

Figure 6-113 Example of Selectivity Criteria of the Intermittent Ground-Fault Protection

6.13.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:11341:1	Stage 1:Mode		• off • on • test	off
_:11341:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11341:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:11341:101	Stage 1:No. pickups till interm.GF		2 to 10	3
_:11341:102	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:11341:103	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:11341:104	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s

6.13.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:11341:81	Stage 1:>Block stage	SPS	I
_:11341:54	Stage 1:Inactive	SPS	O
_:11341:52	Stage 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:11341:53	Stage 1:Health	ENS	O
_:11341:55	Stage 1:Pickup	ACD	O
_:11341:302	Stage 1:Stabilized pickup	ACD	O
_:11341:303	Stage 1:Limited pickup (log)	ACD	O
_:11341:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:11341:301	Stage 1:Sum limit reached	SPS	O
_:11341:305	Stage 1:Reset time running	SPS	O
_:11341:57	Stage 1:Operate	ACT	O
_:11341:306	Stage 1:3I0 max.	MV	O
_:11341:307	Stage 1:No. of pickups	MV	O

6.14 Directional Intermittent Ground-Fault Protection

6.14.1 Overview of Functions

The function **Directional intermittent ground-fault protection**:

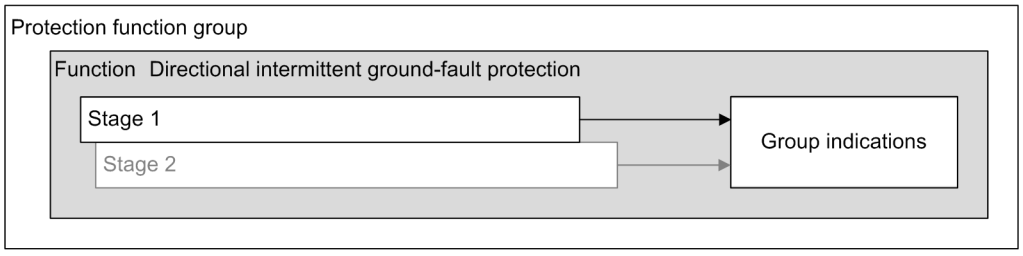
- Detects the intermittent ground faults in grounded, compensated, or isolated cable systems selectively
- Can be operated in 2 different modes:
  - Operate only by counting directional ground-current pulses
  - Operate by integration of the fault current in combination with a directional criterion by counting directional ground-current pulses

The intermittent ground faults in cable systems are frequently caused by weak insulation or water ingress in cable joints. The ground faults are characterized by the following properties:

- Intermittent ground faults show very short high ground-current pulses (up to several hundred amperes) with a duration of less than 1 ms.
- Intermittent ground faults are self-extinguishing and reignite within one half period up to several periods, depending on the power-system conditions and the fault type.
- Intermittent ground faults can persist over longer periods (several seconds to minutes) and develop to static ground faults.

6.14.2 Structure of the Function

The function **Directional intermittent ground-fault protection** can be used in protection function groups with current and voltage measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously.

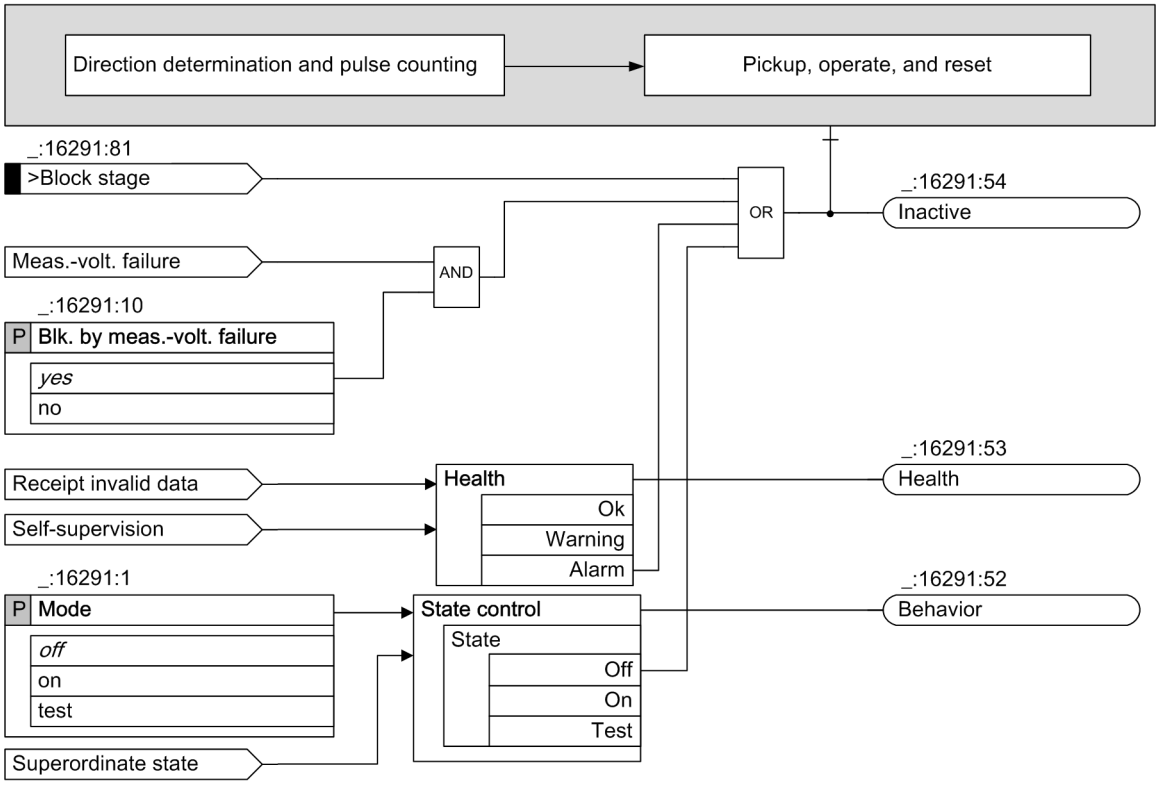


[DwStrDirIGFP_20140618, 1, en_US]

Figure 6-114 Structure/Embedding of the Function

6.14.3 Stage Description

Overview



[LoOverview, 1, en_US]

Figure 6-115 Logic of the Directional Intermittent Ground-Fault Protection

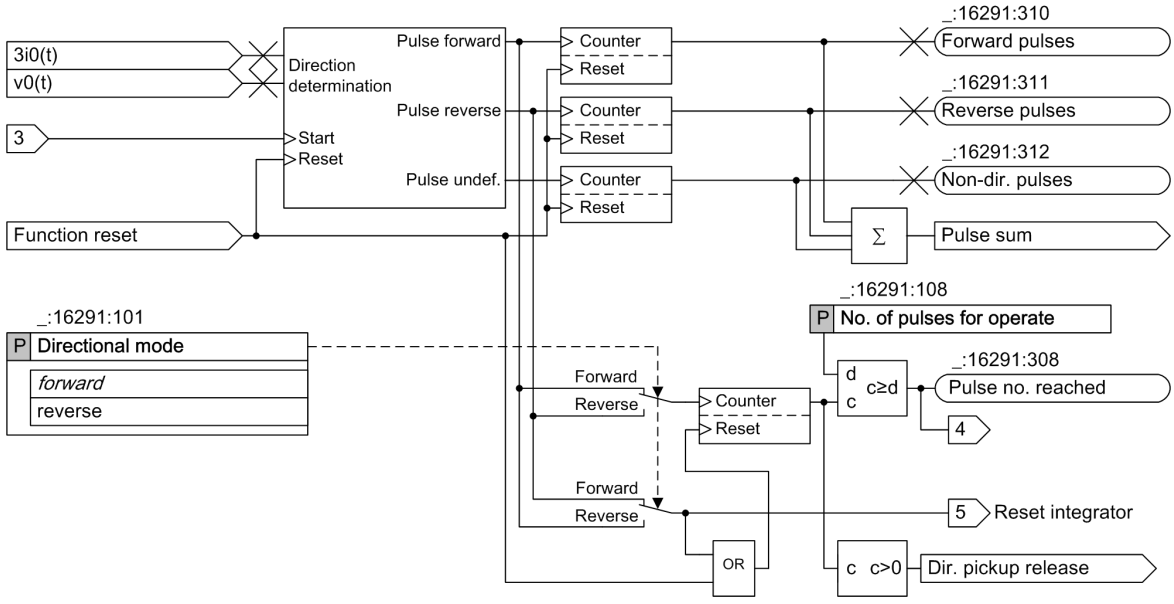
Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **`Volt.-transf. c. b.`**, which links in the tripping of the voltage-transformer circuit breaker

The **`Blk. by meas.-volt. failure`** parameter can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

Logic for Direction Determination and Pulse Counting



[LoIntdir1, 2, en_US]

Figure 6-116 Logic Diagram of Direction Determination and Pulse Counting

(1) The input signal 3 is from *Figure 6-117*.

Measurement Values for Direction Determination

The function **Directional intermittent ground-fault protection** uses the zero-sequence active energy to determine the direction of the ground-current pulse.

The zero-sequence active energy is calculated from v0(t) and 3i0(t). The zero-sequence voltage v0(t) can either be measured via the voltage input VN or can be calculated from the sum of 3 phase-to-ground voltages. The measured value depends on the parameter **Connection type** of the measuring point V-3ph.

The intermittent ground-fault current 3i0(t) can either be measured via the ground-current input IN or via the sensitive ground-current input INS. It can also be calculated from the sum of the 3 phase currents. The measured value and its setting range depend on the parameter **Connection type** of the measuring point I-3ph.

Table 6-12 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Direction Determination and Pulse Counting

When the RMS value of 3I0 exceeds the set threshold value (signal no. 3 in *Figure 6-116*), the direction determination process is started and is continuously carried out until the function resets. At first, the current pulse (current peak) detection takes place. If a current pulse is detected, the direction determination for this pulse is carried out.

The direction is determined by calculating the active zero-sequence energy of the current pulse. The active zero-sequence energy of the pulse is compared to internal threshold values resulting in the directional decision ***forward***, ***reverse***, or ***non-directional***. During the ongoing intermittent ground fault, the directional results for all current pulses are counted.

Directional Mode and Directional Pulse Counter Criterion

The parameter **Directional mode** defines whether the function operates in ***forward*** or in ***reverse*** direction. The pulses in the specified direction are counted. If the pulse counter reaches the threshold value set in the parameter **No. of pulses for operate**, the signal *Pulse no. reached* is issued. Depending on the operating mode (***Counter*** or ***Integrator and counter***) of the function, the signal can immediately cause the operate of the function (***Counter*** mode) or it is processed as directional release criteria (***Integrator and counter*** operating mode). Refer to the further description in the following sections.

The directional pulse counter is reset when a different direction than the set **Directional mode** is detected. An undefined direction result does not reset the counter.

Operating Mode

2 different functional operating modes are available: ***Counter*** and ***Integrator and counter***. You can select the different operating modes using the parameter **Operating mode**.

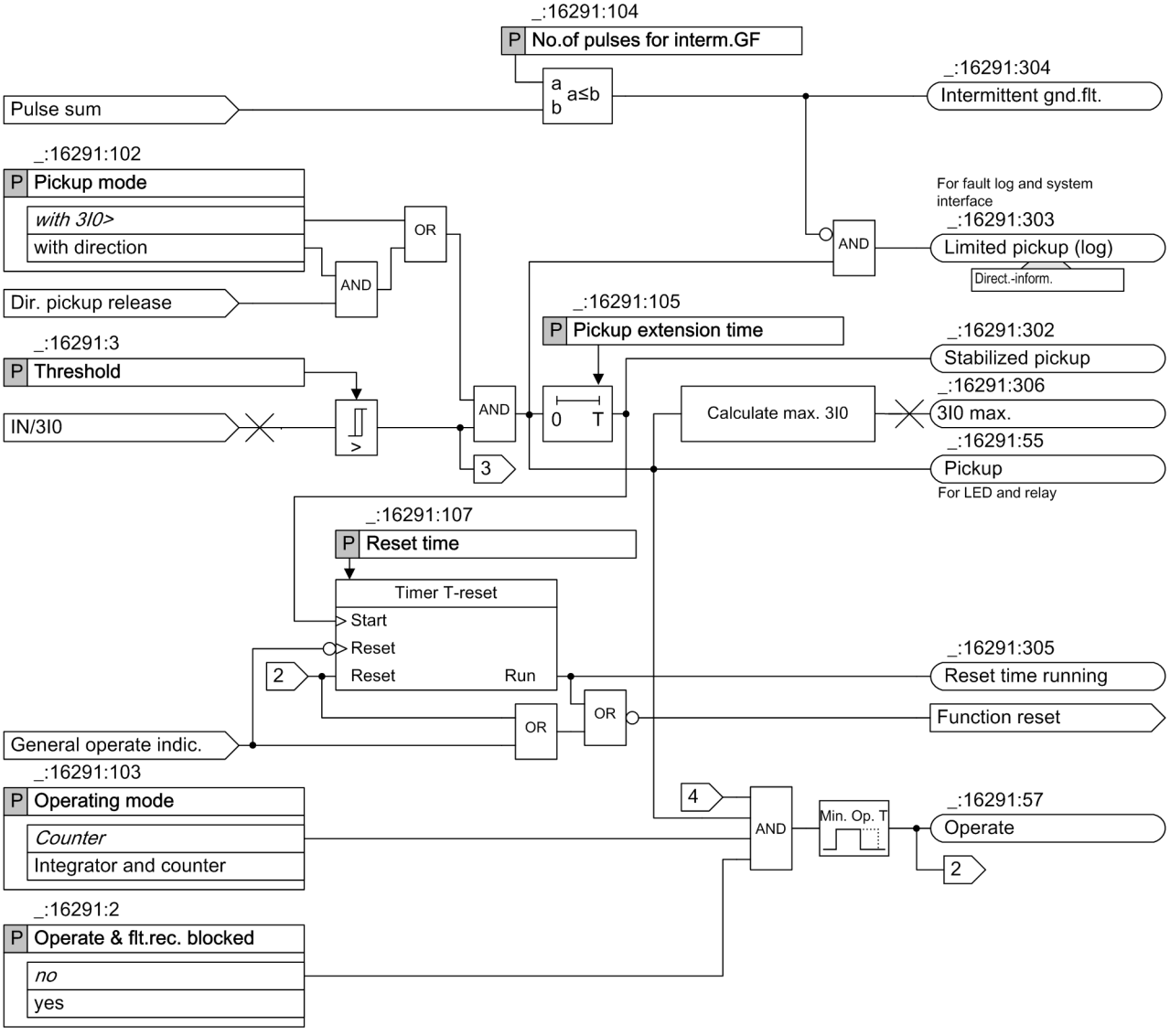
- Operating mode ***Counter***:

  Many ground-current pulses of intermittent ground faults can result in a damage of the protected object. In this mode, the criterion for operate is only the number of directional current pulses. This is similar to the SIPROTEC 4 implementation.

- Operating mode ***Integrator and counter***:

  An intermittent ground fault can result in thermal stress on the protected object. The magnitude and the duration of the ground-current pulses are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the threshold value, one criterion for the operate is fulfilled. The 2nd criterion for the operate is the ground-fault direction. The ground-fault direction is determined by counting the directional ground-current pulses.

Pickup, Operate, and Reset logic for the Counter Mode

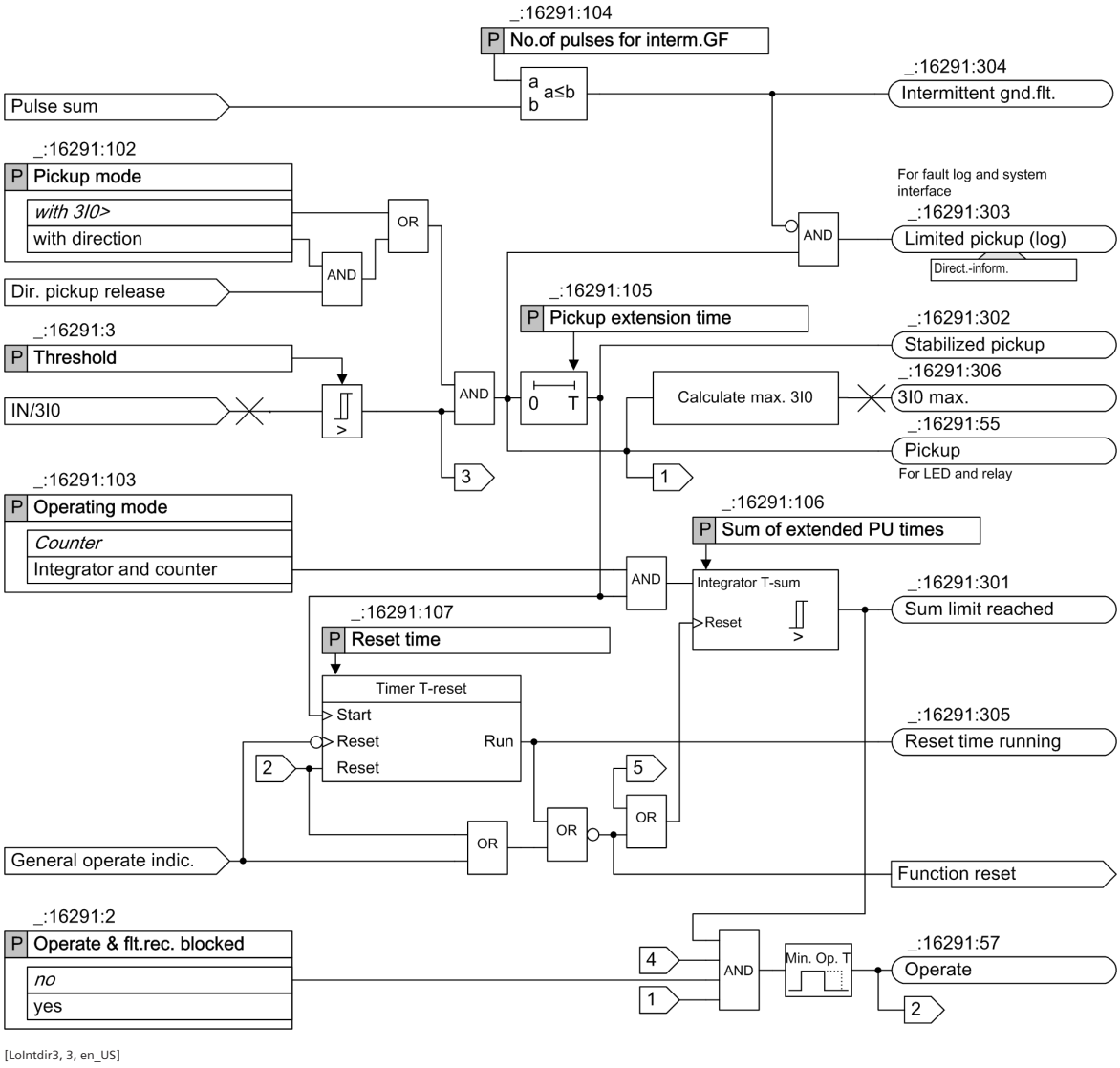


[LoIntdir2, 3, en_US]

Figure 6-117 Pickup, Operate, and Reset Logic in Operating Mode Counter

(1) The internal signal 4 is from *Figure 6-116*.

Pickup, Operate, and Reset logic for the Integrator and Counter Mode



[LoIntdir3, 3, en_US]

Figure 6-118 Pickup, Operate, and Reset Logic in Operating Mode Integrator and Counter

(1) The internal signal 4 and 5 are from *Figure 6-116*.

Measurement Value for Pickup and Integration

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonic components and the direct component (DC). Both components contribute to the thermal load.

Pickup, Limited Pickup, and Stabilized Pickup

Whenever 3I0 exceeds **`Threshold`**, the stage issues the signal *`Pickup`*. The signal is intended to be applied for LED and relay output.

`Stabilized pickup` is formed by prolonging the pickup indication by a settable time **`Pickup extension time`**. This stabilization is especially important for the coordination with the existing static or electromechanical overcurrent protection.

The *`Limited pickup (log)`* signal is intend to be applied for logging and communication interface. The *`Limited pickup (log)`* signal will be entered in the fault log and reported via the system interface unless the *`Intermittent gnd.flt.`* indication is given. This behavior prevents a burst of indications.

Intermittent Ground-Fault Indication

The stage counts the 3I0 pulses. If the sum of forward pulse counts, reverse counts, and directional undefined counts is equal to or greater than **No.of pulses for interm.GF**, the signal *Intermittent gnd.flt.* is issued.

If the signal *Intermittent gnd.flt.* is issued, the pickup indications of some protection functions will be restraint to avoid an indication burst during an intermittent ground fault.

Operate

The conditions for issuing the signal *Operate* depend on the operating mode.

Operating Mode	Conditions for Issuing the Operate Signal
Counter	• The current-pulse counter reached the **No. of pulses for operate**, which is signaled via the *Pulse no. reached* indication. • The pickup is active, which is signaled via the *Pickup* indication.
Integrator and counter	• The 3I0 current integration value reaches the predefined **Sum of extended PU times**, which is signaled via the *Sum limit reached* indication. • The current-pulse counter reached the **No. of pulses for operate**, which is signaled via the *Pulse no. reached* indication. • The pickup is active, which is signaled via the *Pickup* indication.

When an opposite current pulse against the setting **Directional mode** is detected, the **Integrator T-sum** and the **Counter** are reset.

Reset Time for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if the ground fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, no operate is necessary. The interval between ground faults is monitored with the reset time. If a ground fault occurs, the **Timer T-reset** with the setting **Reset time** and the **Integrator T-sum** are launched simultaneously. Unlike the integrator, each new ground-current pulse restarts the reset time with its initial value. If the **Timer T-reset** expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. The **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new ground-fault event.

Reset Conditions

Under one of the following 2 conditions, **Timer T-reset** is reset:

- The intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, **Integrator T-sum** and **Counter** are reset and the whole stage is reset and returns to its idle state:

- The **Timer T-reset** expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Maximum Value 3I0 of the Ground Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault.The statistic value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. If the function resets or operates, this value is logged via the signal *3I0 max.*.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter **Operate & flt.rec. blocked** to *yes*, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start and Stop of Fault Recording, Fault Logging, and General Pickup

The *Stabilized pickup* signal initiates fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the *Stabilized pickup* signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Indications

In this case, the function uses the same mechanism as the **Non-directional intermittent ground-fault protection**. For more information, refer to chapter *Influence on Other Functions to Avoid a Burst of Signals, Page 538*.

6.14.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults. For this reason, the **Directional intermittent ground-fault protection** function is not intended to start the Automatic reclosing function.

Routing of Pickup Signals

The signal *Pickup* is supposed to be routed to an LED and a relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface until the signal *Intermittent gnd.flt.* is issued. This scheme prevents a burst of indications.



NOTE

To avoid a burst of indications, do not route the signal *Pickup* to the operational log and to the fault log.

Parameter: Threshold

- Default setting **(_:16291:3) Threshold** = *1.00 A*

With the parameter **Threshold**, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: Directional mode

- Default setting **(_:16291:101) Directional mode** = *forward*

With the parameter **Directional mode**, you define if the function operates in *forward* or in *reverse* direction.

Parameter: Pickup mode

- Default setting **(_:16291:102) Pickup mode** = *with 3I0>*

With the parameter **Pickup mode**, you define under which conditions pickup is detected and fault logging and recording start:

- When the parameter **Pickup mode** is set to ***with 3I0>***, the signal *Pickup* is released without considering the ground fault direction. The signal *Pickup* is issued once the IN/3I0 exceeds the threshold value.
- When the parameter **Pickup mode** is set to ***with direction***, the signal *Pickup* is issued when at least one pulse direction is the same as the direction specified by the set value of parameter **Directional mode**.

Parameter: **Operating mode**

- Default setting **(_:16291:103) Operating mode** = ***Counter***

With the parameter **Operating mode**, you define if the function operates in ***Counter*** or in ***Integrator and counter*** mode.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. This is a simple method which is similar to the implementation in the 7SJ SIPROTEC 4 devices. Siemens recommends using this method if no time grading or only simple time grading between protection devices (time grading of only 2 or 3 devices) is required. Time grading is then carried out by increasing the parameter value **No. of pulses for operate** towards the infeed.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The integrator works in the same way as for the non-directional intermittent ground fault function. This allows the same time-grading principles as for the non-directional intermittent ground fault function. Refer to this function for more description.

Parameter: **No.of pulses for interm.GF**

- Default setting **(_:16291:104) No.of pulses for interm.GF** = ***3***

With the parameter **No.of pulses for interm.GF**, you set the total number of pulse counts (***forward***, ***reverse*** and ***non-dir. pulses***) at which the ground fault is considered to be intermittent. Siemens recommends using the default setting.

Parameter: **Pickup extension time**

- Default setting **(_:16291:105) Pickup extension time** = ***0.10 s***

With the parameter **Pickup extension time**, you get a prolonged and thus stabilized pickup signal. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: **No. of pulses for operate**

- Default setting **(_:16291:108) No. of pulses for operate** = ***5***

The pulses in the specified direction from **Directional mode** are counted. If the pulse counter reaches the set value of the parameter **No. of pulses for operate**, the directional counter criterion is fulfilled.

The setting of parameter **No. of pulses for operate** depends on the **Operating mode**.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. Thus do not set the value for parameter **No. of pulses for operate** too small. Consider that a permanent intermittent ground fault will cause many current pulses. If no time-grading considerations are required, Siemens recommends using a value in the range of 10 to 20.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The value for parameter **No. of pulses for operate** to fulfill the directional criterion can be set to a rather small value in the range of 3 to 5.

Parameter: **Sum of extended PU times**

- Default setting **(_:16291:106) Sum of extended PU times** = ***20.00 s***

This parameter is only relevant in the operating mode ***Integrator and counter***.

With the parameter **Sum of extended PU times**, you set the threshold value for the integrator. If the integration reaches **Sum of extended PU times**, the stage operates if the *Pulse no. reached* signal and the pickup state is present.

The parameter **Sum of extended PU times** represents one of the 5 selectivity criteria (ground-fault direction, pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on subordinate devices. It is comparable to the time grading of the overcurrent protection.

The **Sum of extended PU times** has the shortest summation time in the radial system for the device that is closest to the intermittent ground fault and that picks up.

Parameter: **Reset time**

- Default setting **(_:16291:107) Reset time** = ***300 s***

With the parameter **Reset time**, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the **Reset time**, the counter and integrator are reset.

The **Reset time** parameter must be much higher than the operate value of the **Sum of extended PU times**.

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:16291:2) Operate & flt.rec. blocked** = ***no***

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log. In this case, a ground-fault log is created instead of the fault log.

6.14.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:16291:1	Stage 1:Mode		• off • on • test	off
_:16291:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:16291:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:16291:101	Stage 1:Directional mode		• forward • reverse	forward

Addr.	Parameter	C	Setting Options	Default Setting
_:16291:102	Stage 1:Pickup mode		• with 3I0> • with direction	with 3I0>
_:16291:103	Stage 1:Operating mode		• Counter • Integrator and counter	Counter
_:16291:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:16291:105	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:16291:104	Stage 1:No.of pulses for interm.GF		2 to 10	3
_:16291:106	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:16291:107	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s
_:16291:108	Stage 1:No. of pulses for operate		2 to 100	5

6.14.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:16291:81	Stage 1:>Block stage	SPS	I
_:16291:54	Stage 1:Inactive	SPS	O
_:16291:52	Stage 1:Behavior	ENS	O
_:16291:53	Stage 1:Health	ENS	O
_:16291:55	Stage 1:Pickup	ACD	O
_:16291:302	Stage 1:Stabilized pickup	ACD	O
_:16291:303	Stage 1:Limited pickup (log)	ACD	O
_:16291:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:16291:301	Stage 1:Sum limit reached	SPS	O
_:16291:308	Stage 1:Pulse no. reached	SPS	O
_:16291:305	Stage 1:Reset time running	SPS	O
_:16291:57	Stage 1:Operate	ACT	O
_:16291:306	Stage 1:3I0 max.	MV	O
_:16291:310	Stage 1:Forward pulses	MV	O
_:16291:311	Stage 1:Reverse pulses	MV	O
_:16291:312	Stage 1:Non-dir. pulses	MV	O

6.15 Sensitive Ground-Fault Detection

6.15.1 Overview of Functions

2 functions are available for ground-fault detection: A directional one that is used if, in addition to the zero-sequence current 3I0, the zero-sequence voltage V0 is also available, and a non-directional one that is used if only the zero-sequence current 3I0 is available.

The **Directional sensitive ground-fault detection** (ANSI 67Ns) serves:

- For directional detection of permanent ground faults in isolated or resonant-grounded systems
- For directional detection of fast extinguishing transient ground faults in isolated or resonant-grounded systems
- For determination of the faulty phase
- For detection of high-resistance ground faults in effectively (solidly) or low-resistance (semi-solidly) grounded systems

The **Non-directional sensitive ground-fault detection** (ANSI 51Ns) serves:

- For ground-fault detection in isolated or resonant-grounded systems
- For detection of high-resistance ground faults in effectively (solidly) or low-resistance (semi-solidly) grounded systems

6.15.2 Structure of the Function

Directional Sensitive Ground-Fault Detection

The **Directional sensitive ground-fault detection** function can be used in protection function groups that make current and voltage zero-sequence systems (3I0 and V0) available. The function is preconfigured at the factory with a **V0> stage**, a directional **3I0> stage with cos φ or sin φ measurement**, and a **transient ground-fault stage**.

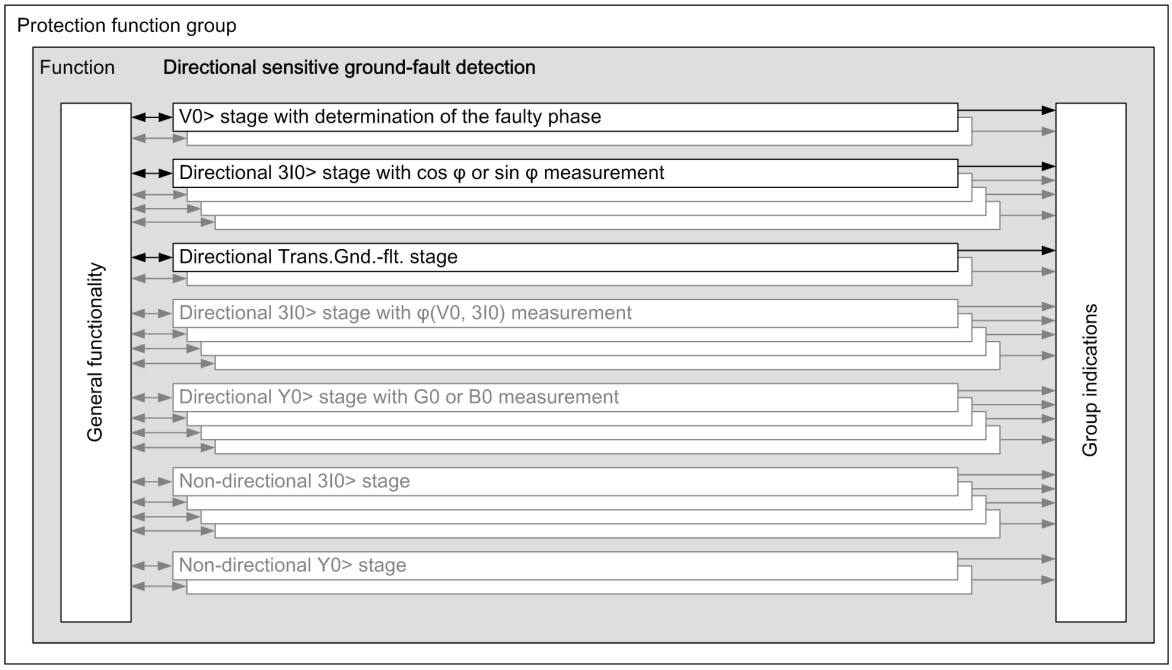
The following stages can be operated simultaneously within the function:

- 2 **V0> stages** with determination of the faulty phase
- 4 directional **3I0> stages with cos φ or sin φ measurement**
- 2 directional **transient ground-fault stages**
- 4 directional **3I0> stages with φ(V0, 3I0) measurement**
- 4 directional **Y0> stages with G0 or B0 measurement** (admittance method)
- 4 non-directional **3I0> stages**
- 2 non-directional **Y0> stages**

The general functionality works across stages on the function level.

The group-indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication



[DwStrGFP-250113-01, 4, en_US]

Figure 6-119 Structure/Embedding of the Directional Function in Protection Function Groups

Non-Directional Sensitive Ground-Fault Detection

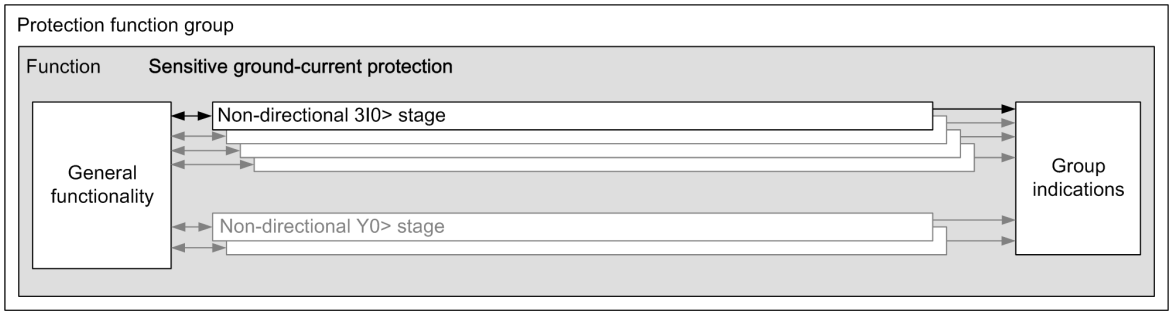
The **Non-directional sensitive ground-fault detection** function can be used in protection function groups that only make the zero-sequence system (3I0) available. The function is preconfigured at the factory with a non-directional **3I0> stage**.

4 non-directional **3I0> stages** and 2 non-directional **Y0> stages** can be operated simultaneously in the function.

The general functionality works across stages on the function level.

The group-indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication



[DwSGFPu4-230113-01, 3, en_US]

Figure 6-120 Structure/Embedding of the Non-Directional Function in Protection Function Groups

6.15.3 General Functionality

6.15.3.1 Description

Logic

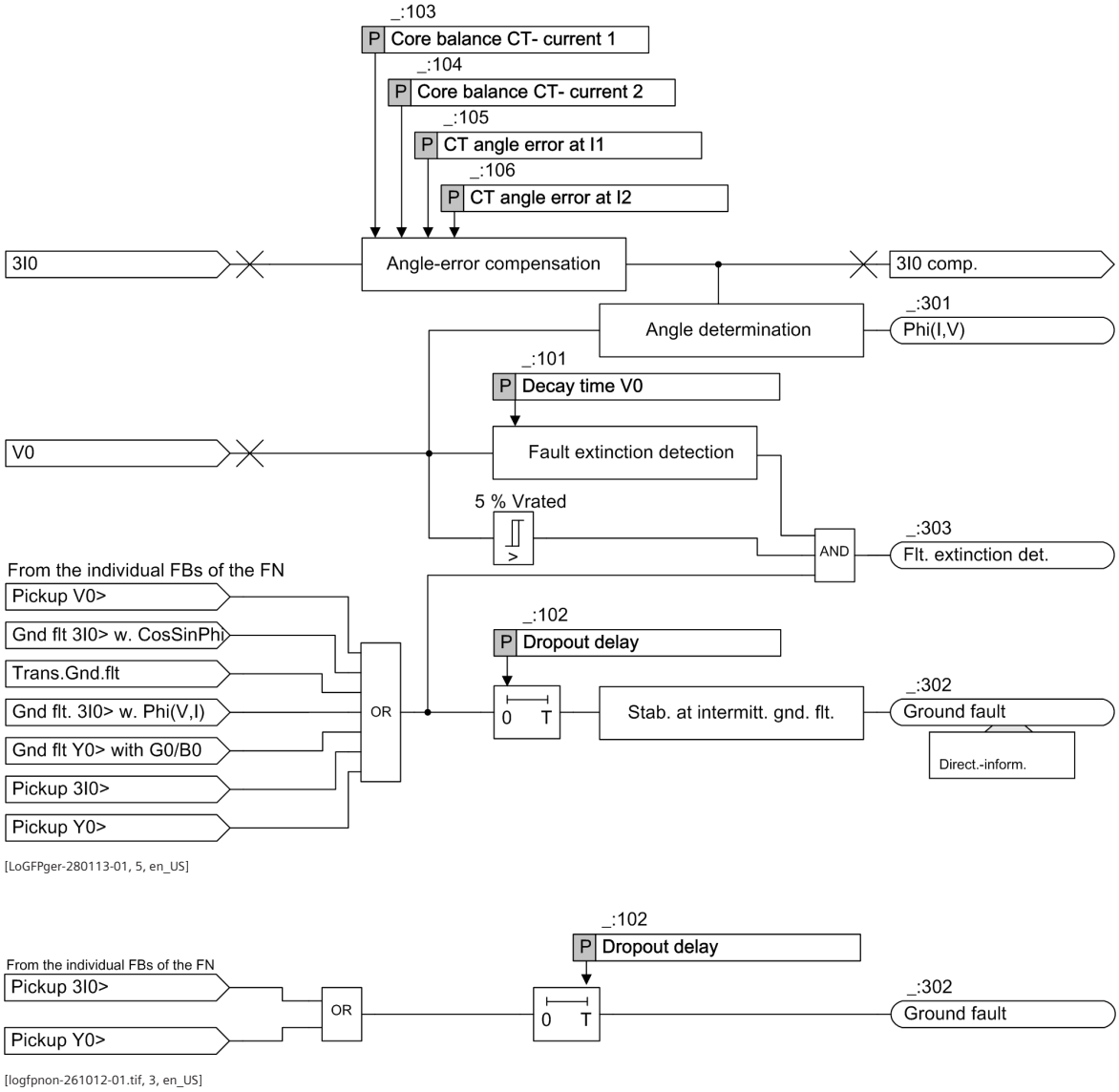
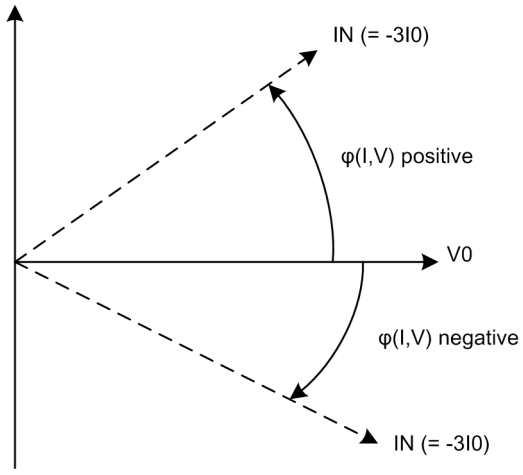


Figure 6-121 Logic Diagram of the Cross-Stage Functionality of the Non-Directional Function

Operational Measured Value φ(I,V)

The function block calculates the angle between IN and V0 and makes the angle available as function measured value *Phi(I,V)* .



[DwPhINU0, 1, en_US]

Figure 6-122 Sign Definition for the Measured Value

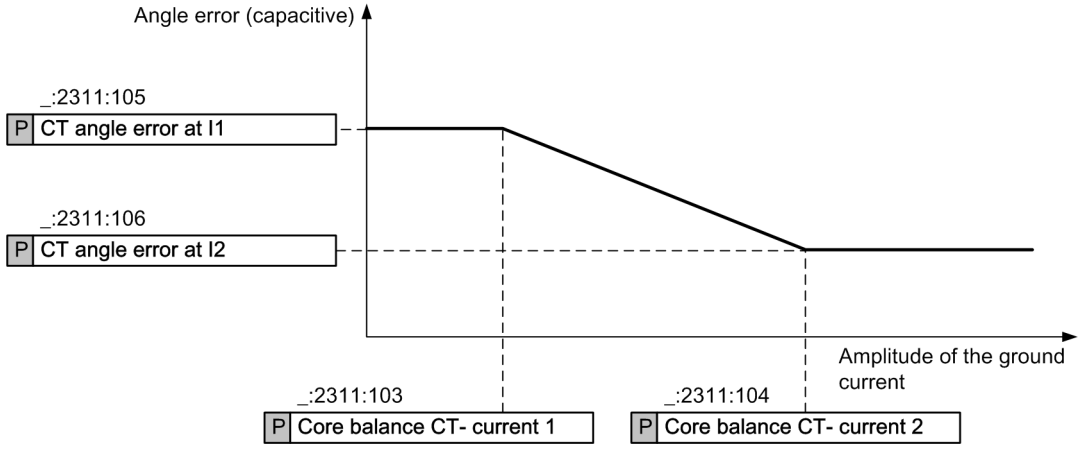
Fault-Extinction Detection

The extinction of the fault is characterized by the fact that the zero-sequence voltage subsides. Depending on the system conditions and fault characteristics, this process can last several 100 ms. If a continuously falling zero-sequence voltage is detected during the set time **`Decay time V0`**, then the fault is considered extinguished. The signal ***`Flt. extinction det.`*** is issued.

Thus, the possibility exists, for example, to block the **3I0> stage with cos φ or sin φ measurement** directly after the fault extinction, in order to avoid an overfunction during the subsiding process with a very sensitive setting of the stage.

Angle-Error Compensation

The high reactive power factor in the arc-suppression-coil-ground system and the unavoidable air-gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. Using the characteristic shown in the following figure, the device approaches the angle error of the core balance current transformer with sufficient precision.



[dwerdwdl-110512-01.tif, 1, en_US]

Figure 6-123 Correction of the Transmission Characteristic Curve of a Core Balance Current Transformer

Ground-Fault Indication, Stabilization at Intermittent Ground Fault

The indication ***`(_:302) Ground fault`*** indicates the ground fault and manages the ground-fault log (see *Ground-Fault Log, Page 558*). The corresponding information of the stages used is accessed for the generation of this indication.

The indication *Ground fault* contains the direction information, independent of the parameterized working direction of a stage. The indication is thus suited for transfer to a station.

To avoid a flood of indications in case of an intermittent ground fault, a maximum of 30 status changes of this indication is logged per ground fault. An intermittent ground fault must be treated as a ground fault so that the stabilization can take action. This is ensured with the parameter **Dropout delay**, by the dropout of the indication *Ground fault* being delayed. If the next ignition of the ground fault takes place during the dropout delay, the indication does not dropout and the log remains open.



NOTE

The *Ground fault* indication in the general stage must be routed to the ground-fault log. If not, you can meet an overflow of the ground-fault log when an intermittent ground fault occurs.

Ground-Fault Log

Ground faults can be recorded in a designated buffer, the ground-fault log. As long as the **Operate & flt.rec. blocked** parameter is set to ***yes***, all indications routed into the ground-fault log are written in the ground-fault log.

The criterion for opening the ground-fault log is the raising of any indication which is routed to the ground-fault log, for example, the indication *Ground fault* . The criterion for closing is the clearing of all routed indications.

Related Topics

You can find general notes on the ground-fault login chapter **Indications** under *3.1.5.4 Ground-Fault Log* .

Value Indications

If the following value indications can be calculated, they are written into the log (ground-fault log or fault log) at the time of the 1st raising ground-fault indication and the 1st operate indication of any stage.

- 3I0 (value)
- 3I0 active component
- 3I0 reactive component
- V0
- φ (IN, V0)

6.15.3.2 Application and Setting Notes

Indication: Ground fault

To indicate the ground fault and its direction via the protocol, Siemens recommends using the indication *(_:302) Ground fault*. The indication contains the direction information, independent of the parameterized working direction of a stage. And this indication is also stabilized against a flood of indications in case of an intermittent ground fault.

Parameter: Decay time V0

- Recommended setting value **(_:101) Decay time V0** = ***0.10 s***

With the **Decay time V0** parameter, you specify the time slot for the detection of a fault extinction. If V0 continuously falls within this time, fault extinction is detected and the indication *Flt. extinction det.* is issued.

Siemens recommends using the default setting.

Parameter: Dropout delay

- Recommended setting value **(_:102) Dropout delay** = ***1.00 s***

To avoid chattering of the indication *Ground fault* during an intermittent ground fault and thus a frequent opening and closing of the ground-fault log, the dropout of the indication *Ground fault* (and thus the closing of the log) can be delayed by the **Dropout delay**.

Siemens recommends using the default setting.

Using the default setting ensures that no flood of indications arises in case of an intermittent ground fault for the indication *Ground fault*. The intermittent ground fault is then treated as a ground fault, and the stabilization of the indication *Ground fault* can thus take action.

Angle-Error Compensation of the Core Balance Current Transformer

- Default setting **(_:103) Core balance CT- current 1** = ***0.050 A***
- Default setting **(_:104) Core balance CT- current 2** = ***1.000 A***
- Default setting **(_:105) CT angle error at I1** = ***0.0°***
- Default setting **(_:106) CT angle error at I2** = ***0.0°***

The high reactive-power factor in the arc-suppression-coil-ground system and the unavoidable air gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. For the burden actually connected, the maximum angle error **CT angle error at I1** and the corresponding secondary current **Core balance CT- current 1** as well as a further operating point **CT angle error at I2**/**Core balance CT- current 2** are entered, from which point the angle error no longer changes appreciably.

In the isolated or grounded system, angle compensation is not necessary.

6.15.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Decay time V0		0.06 s to 0.20 s	0.10 s
_:102	General:Dropout delay		0.00 s to 60.00 s	1.00 s
_:103	General:Core balance CT- current 1	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:104	General:Core balance CT- current 2	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:105	General:CT angle error at I1		0.0 ° to 5.0 °	0.0 °
_:106	General:CT angle error at I2		0.0 ° to 5.0 °	0.0 °

6.15.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:302	General:Ground fault	ACD	O
_:303	General:Flt. extinction det.	SPS	O

No.	Information	Data Class (Type)	Type
_:309	General:Pos. measuring window	SPS	O
_:301	General:Phi(I,V)	MV	O

6.15.4 Directional 3I0 Stage with Cos φ or Sin φ Measurement

6.15.4.1 Description

Logic

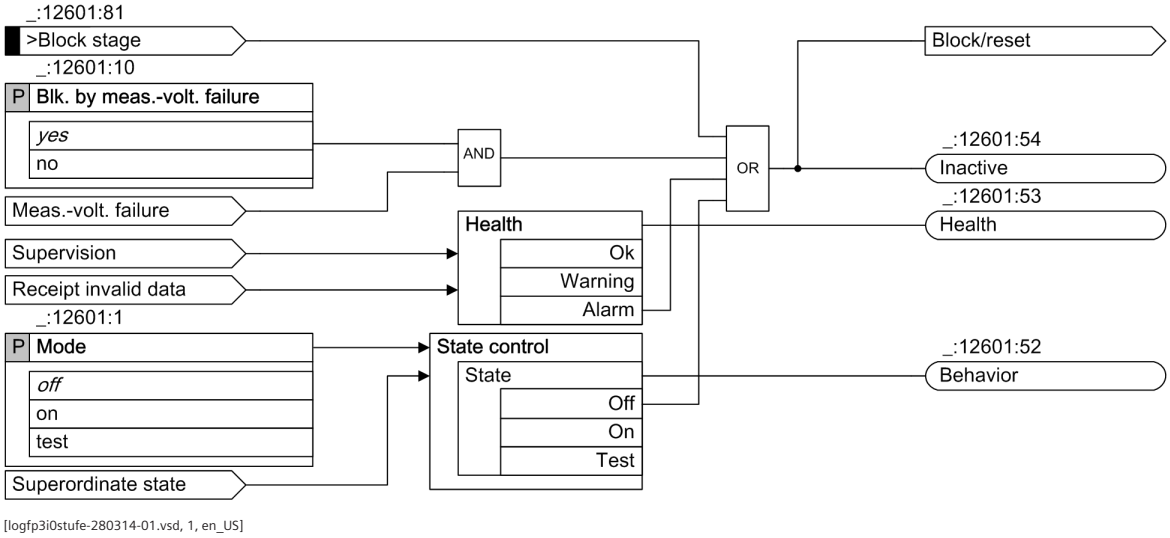
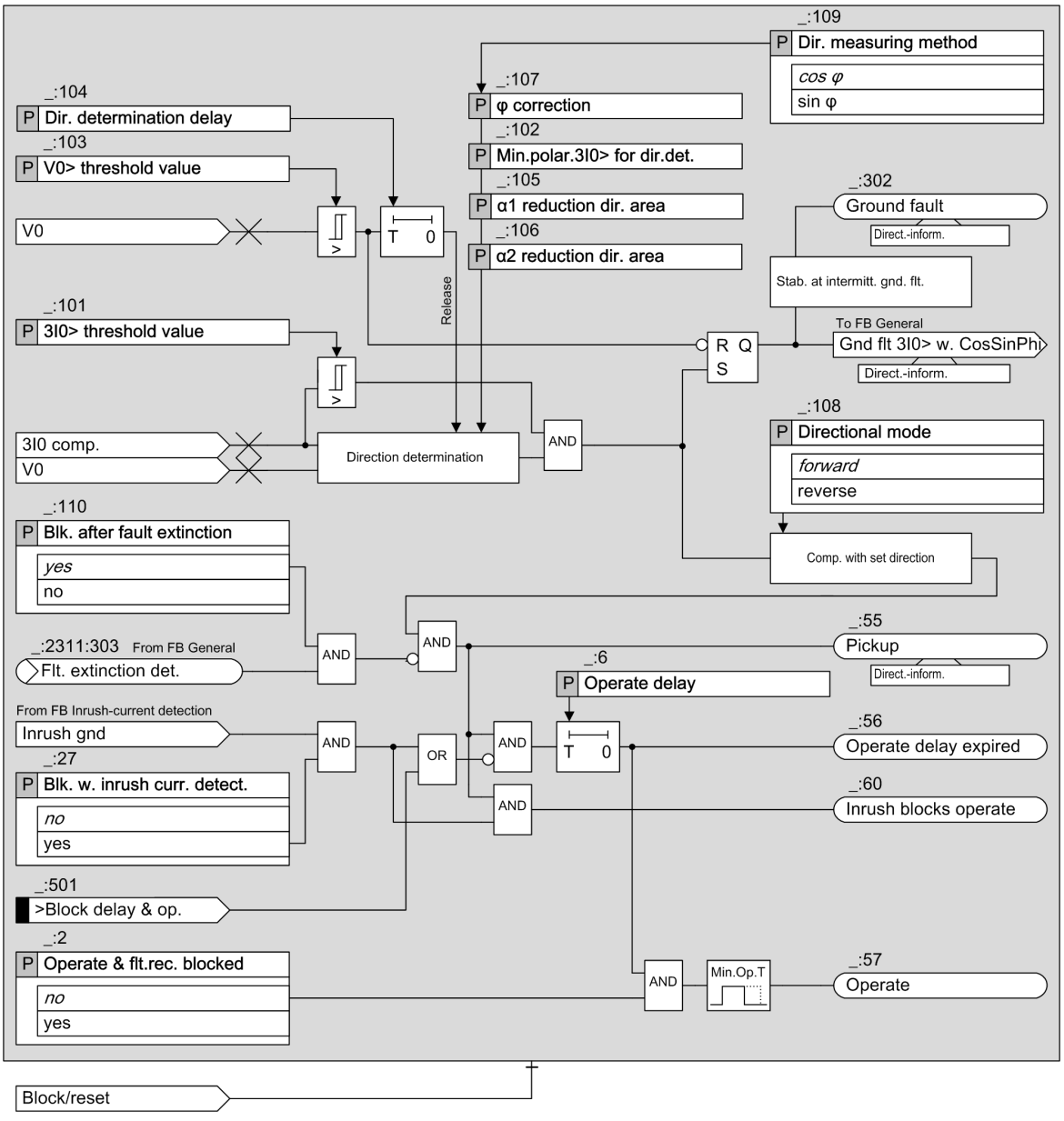


Figure 6-124 Logic Diagram of the Stage Control



[logfp3i0f-280314-01, 3, en_US]

Figure 6-125 Logic Diagram of the Directional 3I0 Stage with Cos φ or Sin φ Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the setting of the parameter Connection type of the measuring point **I-3ph** as well as the current terminal block used, the following different linearity and settings ranges result in addition to the usual application:

Setting Value Connection Type of the Measuring Point I-3ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [10]
3-phase + IN separate [11] 3-phase + IN	Measured	3 x protection, 1 x sensitive	0.001 A to 35.000 A
		4 x protection	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A
3-phase	Calculates	4 x protection	0.030 A to 35.000 A
		3 x protection, 1 x sensitive	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A

With the use of the function within a 1-phase function group and therefore at a 1-phase measuring point **I-1ph**, the following different linearity and settings ranges result:

Measuring Point I-1ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [12]
	Measured	Sensitive	0.001 A to 1.600 A
		Protection	0.030 A to 35.000 A

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

Ground-Fault Detection, Pickup

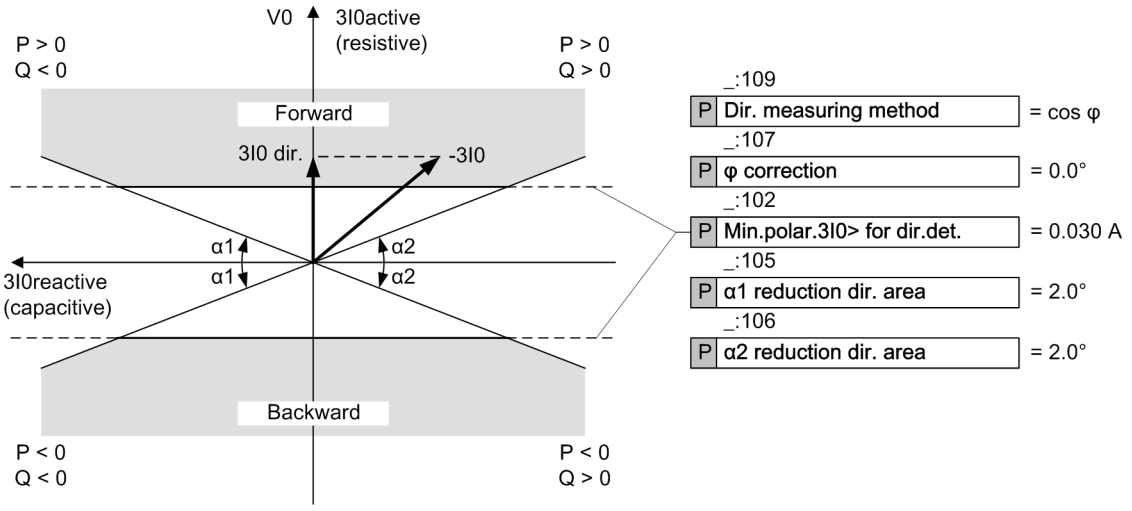
If the absolute value of the ground current 3I0 exceeds the threshold value **3I0> threshold value** and the absolute value of the zero-sequence voltage V0 exceeds the threshold value **V0> threshold value**, the stage recognizes the ground fault. The direction determination (see the next paragraph) is started when the V0 threshold value is exceeded. The direction result is indicated via the *Ground fault* signal (in the general function block). If the direction result equals the parameterized direction (parameter **Directional mode**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The result form the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its threshold value.

The following figure shows an example of the direction determination in the complex phasor diagram for the cos-φ direction measurement method with a correction value of the direction straight lines from 0 (parameter **φ correction**). The example is suitable for the determination of the ground-fault direction in an arc-suppression-coil-ground system where the variable $3I0 \cdot \cos \varphi$ is decisive for the direction determination.

[10] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.
[11] Usual application
[12] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.



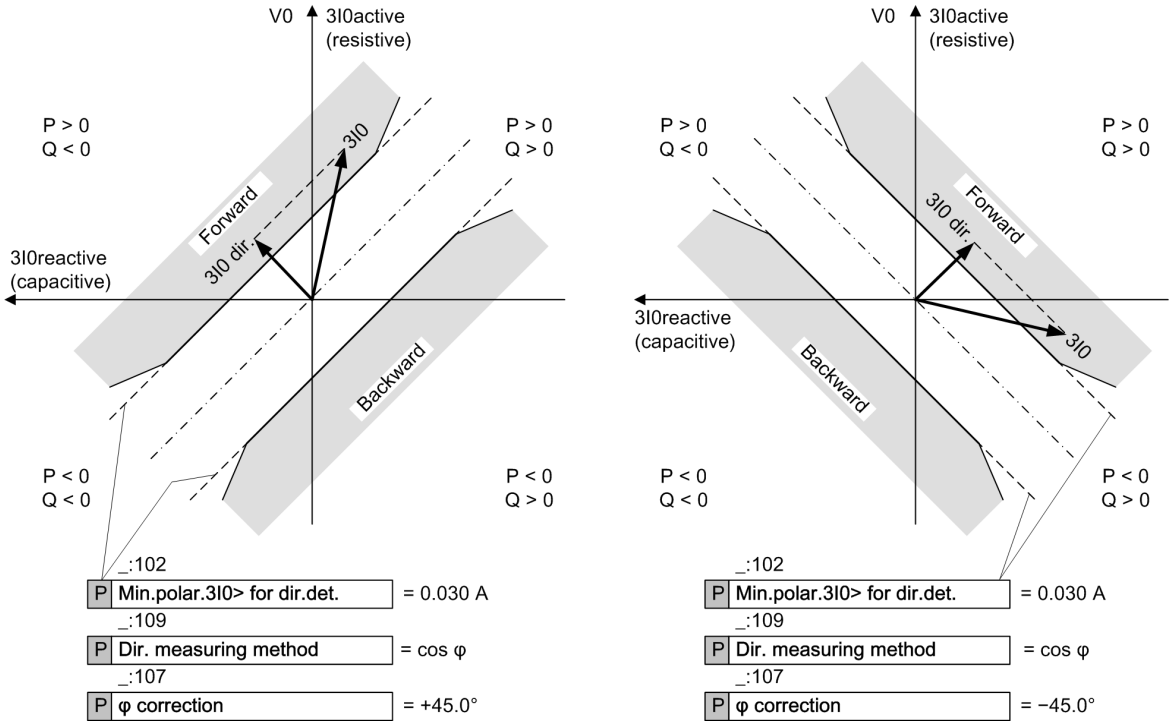
[dwcosphi-171012-01.tif, 2, en_US]

Figure 6-126 Direction-Characteristic Curve with Cos φ Measurement

The zero-sequence voltage V0 is basically the reference value for the real axis. The axis of symmetry of the direction-characteristic curve coincides with the 3I0react axis for this example. For the direction determination, basically the portion of the current vertical to the set direction-characteristic curve (= axis of symmetry) is decisive (3I0 dir.). In this example, this is the active portion 3I0active of the current 3I0. The current 3I0dir. (here = 3I0active) is calculated and compared with the setting value **`Min.polar.3I0> for dir.det.`**. If the current 3I0 dir. exceeds the positive setting value, the direction is forward. If the current 3I0 dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the **`α1 reduction dir. area`** and **`α2 reduction dir. area`** parameters, you can limit the forward and backward ranges as shown in the figure. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle **`φ correction`** parameter) in a range of ±45. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a rotation of +45°.

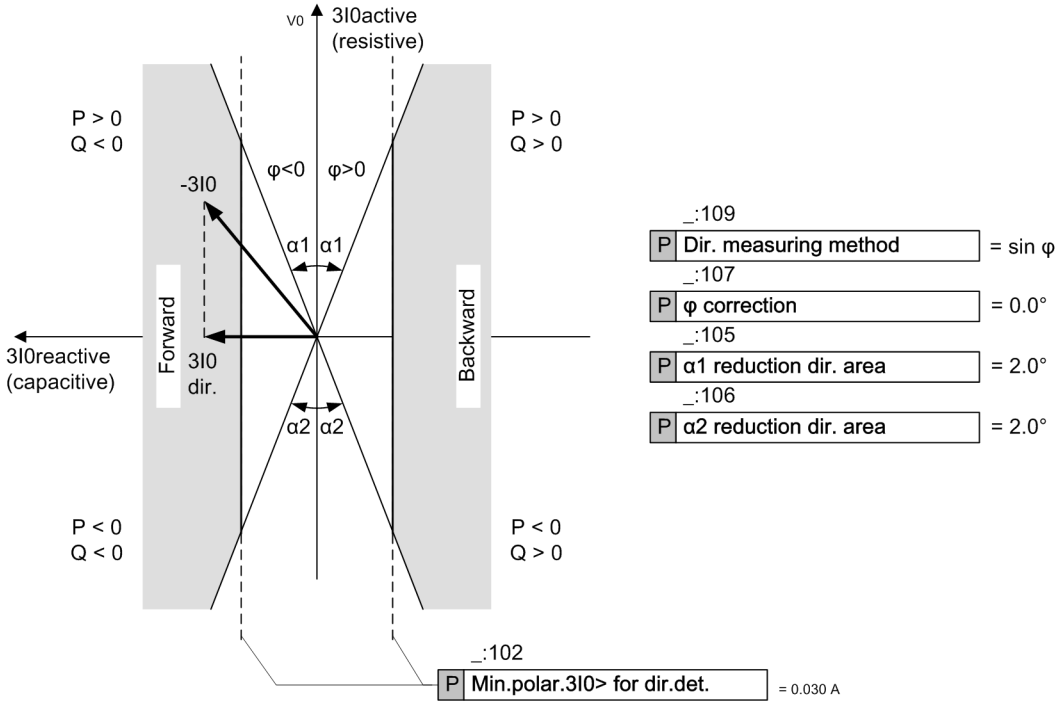


[dwphicor-171012-01.tif, 1, en_US]

Figure 6-127 Turning the Direction-Characteristic Curves with Cos φ Measurement with Angle Correction

If you set the **Dir. measuring method** parameter to ***sin φ*** and the **φ correction** parameter to ***0***, the symmetry axis of the direction-characteristic curve coincides with the 3I0active axis and the V0 axis. Since the portion of the current vertical to the direction-characteristic curve (= axis of symmetry) is decisive (3I0dir.), here, the current 3I0react is included in the direction determination. If the current 3I0dir. (here, =3I0react) exceeds the negative setting value **Min.polar.3I0> for dir.det.**, the direction is forward. If the current 3I0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.



[dwsinphi-011112-01.tif, 3, en_US]

Figure 6-128 Direction-Characteristic Curve with Sin φ Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pick up of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the **Blk. after fault extinction** parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.4.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: **Blk. w. inrush curr. detect.**

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by an enabling procedure.

Parameter: **Blk. after fault extinction**

- Recommended setting value **(_:110) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: **Directional mode**

- Default setting **(_:108) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: **Dir. measuring method, φ correction, Min.polar.3I0> for dir.det., 3I0> threshold value**

- Default setting **(_:109) Dir. measuring method** = ***cos φ***
- Default setting **(_:107) φ correction** = ***0.0°***
- Default setting **(_:102) Min.polar.3I0> for dir.det.** = ***0.030 A***
- Default setting **(_:101) 3I0> threshold value** = ***0.050 A***

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral-point treatment of the system.

Note that, for the direction determination, basically only a portion of the current vertical to the set direction-characteristic curve (3I0dir.) is decisive, refer to *6.15.4.1 Description*. This portion of the current is compared to the threshold value **Min.polar.3I0> for dir.det.**. In contrast, the absolute value of the current 3I0 is compared with the **3I0> threshold value** parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc-suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • **Dir. measuring method** = ***cos φ*** • **φ correction** = ***0.0°*** The direction determination for a ground fault is made more difficult in that a much larger capacitive or inductive reactive current is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground-fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the **Min.polar.3I0> for dir.det.** parameter, the rule of thumb is: Set the pickup value only to half of the expected measuring current as only the watt leakage current can be put into use. The **3I0> threshold value** parameter can also be set to half of the expected measuring current, whereby here the entire zero-sequence current can be put to use.
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • **Dir. measuring method** = ***sin φ*** • **φ correction** = ***0.0°*** In an isolated system, the capacitive ground-fault currents of the entire electrically connected system flow through the measuring point in case of a ground fault. The ground current of the faulty feeder is compensated in the measuring point. As the pickup value of the **Min.polar.3I0> for dir.det.** and **3I0> threshold value** parameters, select about half of this capacitive ground-fault current flowing via the measuring point.

System Type/ Neutral-Point Treatment	Description
Resistance-Grounded	In the resistance-grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • **Dir. measuring method** = ***cos φ*** • **φ correction** = ***-45.0°*** Set the **Min.polar.3I0> for dir.det.** and **3I0> threshold value** parameters to a value below the minimum ground-fault current to be expected.

Parameter: **α1 reduction dir. area, α2 reduction dir. area**

- Recommended setting value **(_:105) α1 reduction dir. area** = ***2°***
- Recommended setting value **(_:106) α2 reduction dir. area** = ***2°***

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: **V0> threshold value**

- Default setting **(_:103) V0> threshold value** = ***30.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence voltage V0 that must still be detected.

Parameter: **Dir. determination delay**

- Default setting **(_:104) Dir. determination delay** = ***0.00 s***

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: **Operate delay**

- Default setting **(_:6) Operate delay** = ***2.0 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> cos/sinφ#				
_:1	3I0> cos/sinφ#:Mode		• off • on • test	off
_:2	3I0> cos/sinφ#:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> cos/sinφ#:Blk. by meas.-volt. failure		• no • yes	yes
_:27	3I0> cos/sinφ#:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:110	3I0> cos/sinφ#:Blk. after fault extinction		• no • yes	yes
_:108	3I0> cos/sinφ#:Directional mode		• forward • reverse	forward
_:109	3I0> cos/sinφ#:Dir. measuring method		• cos φ • sin φ	cos φ
_:107	3I0> cos/sinφ#:φ correction		-45 ° to 45 °	0 °
_:102	3I0> cos/sinφ#:Min.polar.3I0> for dir.det.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A
_:105	3I0> cos/sinφ#:α1 reduction dir. area		1 ° to 15 °	2 °
_:106	3I0> cos/sinφ#:α2 reduction dir. area		1 ° to 15 °	2 °
_:101	3I0> cos/sinφ#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:103	3I0> cos/sinφ#:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	3I0> cos/sinφ#:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> cos/sinφ#:Operate delay		0.00 s to 60.00 s	2.00 s

6.15.4.4 Information List

No.	Information	Data Class (Type)	Type
3I0> cos/sinφ#			
_:81	3I0> cos/sinφ#:>Block stage	SPS	I
_:501	3I0> cos/sinφ#:>Block delay & op.	SPS	I
_:54	3I0> cos/sinφ#:Inactive	SPS	O
_:52	3I0> cos/sinφ#:Behavior	ENS	O
_:53	3I0> cos/sinφ#:Health	ENS	O
_:60	3I0> cos/sinφ#:Inrush blocks operate	ACT	O
_:55	3I0> cos/sinφ#:Pickup	ACD	O
_:56	3I0> cos/sinφ#:Operate delay expired	ACT	O
_:57	3I0> cos/sinφ#:Operate	ACT	O
_:302	3I0> cos/sinφ#:Ground fault	ACD	O

6.15.5 Directional Transient Ground-Fault Stage

6.15.5.1 Description

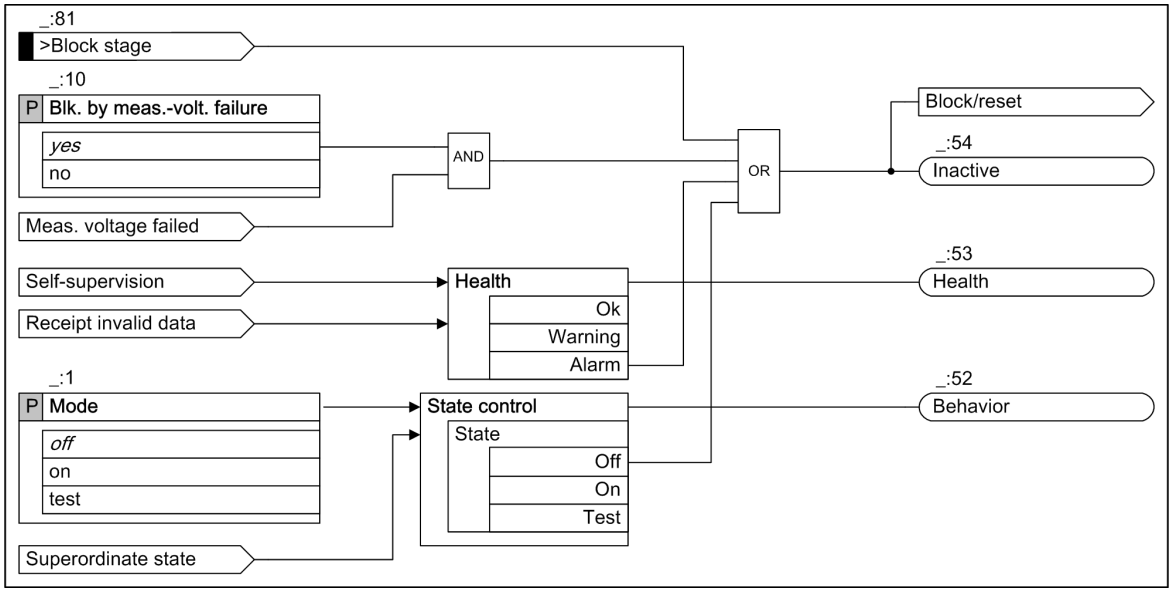
Overview

Ground faults occurring in arc-suppression-coil-ground systems quite often extinguish a short time after the ignition, mostly within a few milliseconds. Such transient occurrences are called transient ground faults. In order to detect the ground-fault direction, based on these transient occurrences, a special method of measurement is required that can also capture high frequencies. Conventional methods based on phasor calculations are not suitable. Even for ground faults lasting for a short time, usually, a high-frequency charging process occurs in healthy phases. The transient charging process is evaluated by the transient ground-fault method of measurement to determine the ground-fault direction. An integrating method of measurement ensures a high degree of sensitivity and a positive stability against parasitic signals in the zero-sequence system.

Since permanent ground faults also start with the transient charging process of flawless wires, those errors will be detected as well.

This process is most suitable for the use in closed loops or meshed systems. Operational, circulating zero-sequence currents are eliminated and therefore, cannot affect the directional result.

Stage-Control Logic



[lostuwis-240113-01.tif, 1, en_US]

Figure 6-129 Logic Diagram of the Stage Control

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage* . In the event of blocking, the picked up stage will be reset.

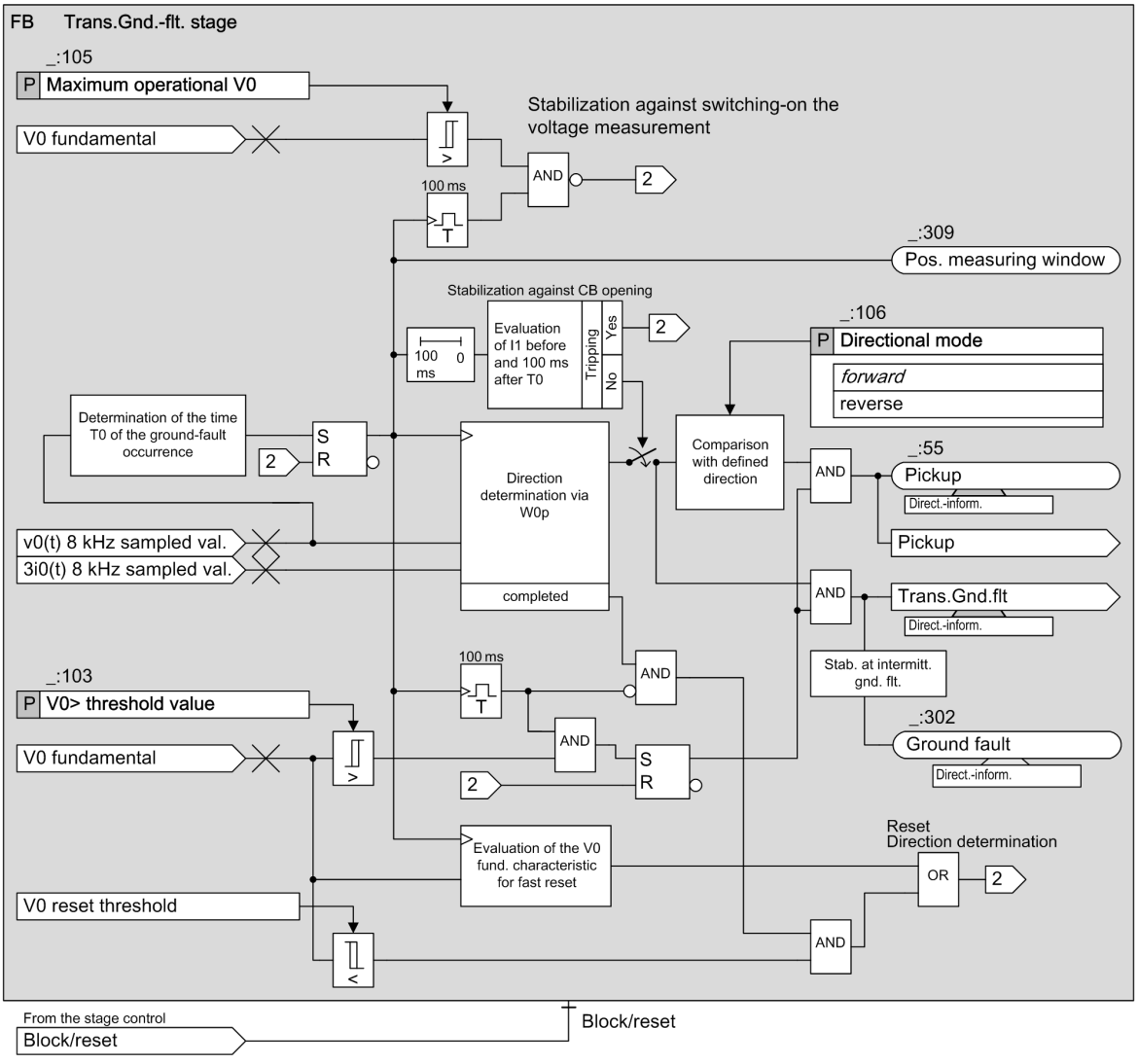
Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The **`Blk. by meas.-volt. failure`** parameter can be set so that **measuring-voltage failure detection** blocks the stage or not.

Logic of the Transient Ground-Fault Functionality



[lowisfut-240113-01.tif, 6, en_US]

Figure 6-130 Logic Diagram of the Directional Transient Ground-Fault Stage

Measured Values, Method of Measurement

The zero-sequence values of zero-sequence voltage and zero-sequence current are measured directly or calculated from the phase variables. When measuring directly, the following is detected:

- Zero-sequence voltage on the broken-delta winding
- Zero-sequence current via Holmgreen connection or via core balance current transformer

The voltage measured on the broken-delta winding will be converted to zero-sequence voltage V_0.

The instantaneous values of the zero-sequence voltage V0(t) that are sampled at a high frequency (8 kHz) serve to determine the point in time of the ground fault occurrence T0.

The instantaneous values of the zero-sequence voltage V0(t) and the ground current 3I0(t), which are sampled at a high frequency (8 kHz), are the basis for direction determination.

The fundamental-component values of the zero-sequence voltage V0 serve to release the directional result and the pickup as well as a criterion for the stabilization against switching operations.

The positive-sequence system (if it exists as a measured value) serves as an additional criterion for the stabilization against switching operations.

The fundamental-component values V0 and 3I0 will be used in the optional trip logic.

Operational, meaning circulating zero-sequence currents, can occur in closed loops or meshed systems. This type of zero-sequence current is also present in case of a failure and can falsify the directional result. Therefore, an operational zero-sequence current is eliminated.

Determining the Time of the Ground-Fault Ignition

The algorithm uses the evaluation of the instantaneous values of the zero-sequence voltage to verify continuously if a ground fault occurred. This takes place regardless of whether the set threshold value for V0 is exceeded. If a ground fault occurred, the measuring window for determining the direction is positioned and the direction determination is performed. The position of the measuring window is logged via the indication *Pos. measuring window* (in FB **General**). The precise identification of the time T0 at which the ground fault occurred is decisive for the correct direction determination.

Determination of Direction, Method of Measurement

The active energy of the zero-sequence system is calculated for the direction determination. Once the ground fault occurrence has been detected, the active energy will be calculated across approximately 1 cycle frequency. If the active energy of the zero-sequence system is negative, a forward fault is present; otherwise it is a backward fault.

Direction Result Message, Pickup

Determining the time of the ground-fault ignition and the direction is always done with maximum sensitivity. With the parameter **V0> threshold value**, you define the sensitivity for the indication of the direction and the pickup of the stage.

If the fundamental-component value of the zero-sequence voltage V0 exceeds the associated threshold value (**V0> threshold value** parameter) within 100 ms after detecting the ground-fault ignition, the direction result will be reported. In this way, high-impedance ground faults are also reported in which the zero-sequence system values rise only slowly, and, for this reason, the occurrence of the ground fault is detected noticeably earlier than the exceedance of the parameterized threshold value.

The direction result will be reported to the function via the *(_:302) Ground fault* of the function block **General information**. This indication is reported irrespective of the parameterized direction of the function.

If the determined direction corresponds with the parameterized direction (parameter **Directional mode**), a pickup occurs.

Reset of the Algorithm

To allow a new directional measurement, the algorithm needs to be reset. The normal reset takes place when the fundamental component of the zero-sequence voltage V0 drops below the V0 reset threshold. This reset threshold is a small device-internal V0 threshold. It is also depending on an operational V0 and is thus a dynamic threshold. The threshold value is 3.0 V secondary without dynamic influence.

Stabilization against Switching Operations

Switching operations in the system to be protected can cause transient signals in the zero-sequence system. The stage is stabilized against possible overfunction due to switching operations.

The following mechanisms are applied:

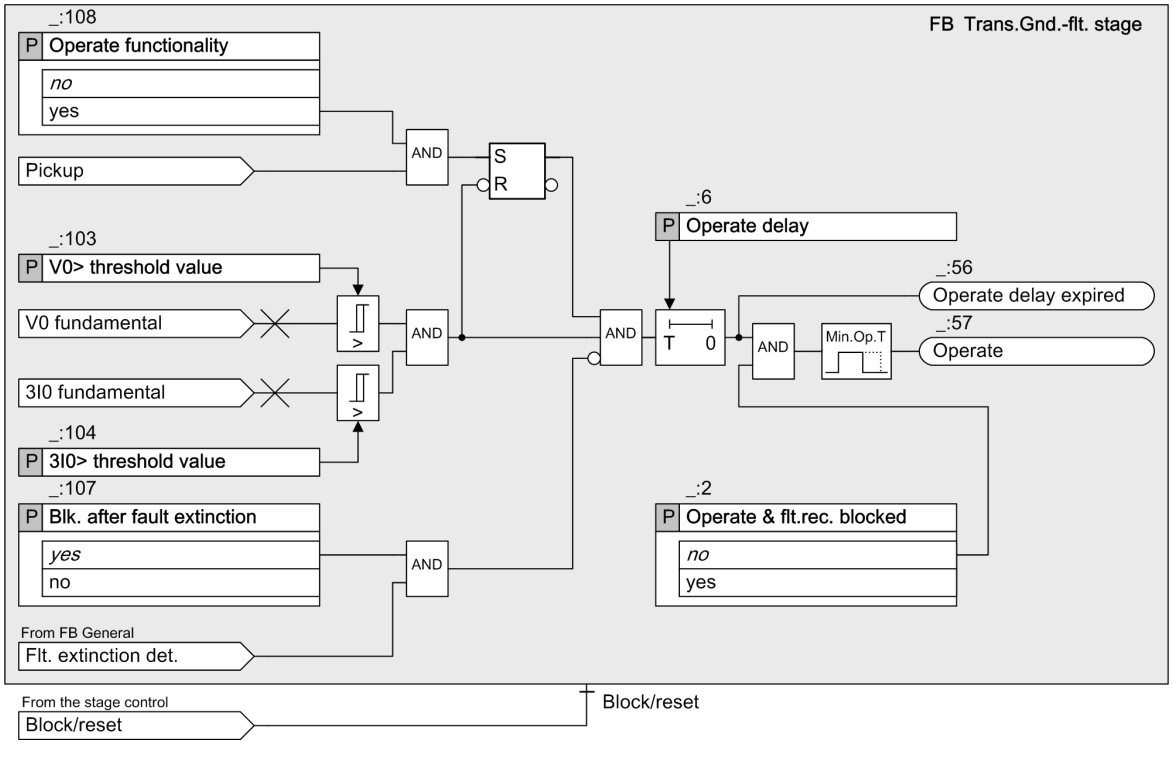
- For reporting the direction result, the fundamental-component value of the zero-sequence voltage must exceed the **V0> threshold value** in a time slot of 100 ms after the ground-fault extinction. This effectively suppresses wrong indications as a result of switching operations.
- The fundamental-component value of the zero-sequence voltage V0 is not influenced by switching operations and is thus a good criterion for distinguishing the ground fault from a switching procedure. The condition that the fundamental-component value must exceed the **V0> threshold value** for reporting the direction result effectively suppresses switching operations.

  For rare cases in which high zero-sequence voltages occur over longer time ranges after switching off the feeder or line, a criterion on the basis of the positive-sequence system current is also effective. This criterion compares the positive-sequence system current before and after the transient event and thus detects a disconnection. In case of disconnection, the direction result is not reported.

  Through stabilization mechanisms, the direction result is reported 100 ms after the ground-fault ignition. Thus a pickup occurs with a 100-ms delay.

  If the stage is used in a 1-phase function group, the additional criterion via the positive-sequence system current is not effective.
- The function detects transient occurrences in the zero-sequence voltage. In systems with operational zero-sequence voltages, if the measuring voltage is switched on, the function can internally be started. If the fundamental-component value of the zero-sequence voltage does not exceed the threshold of the **Maximum operational V0** parameter in a time slot of 100 ms after the function start, the function is reset internally.

Trip Logic



[loauswis-240113-01.tif, 2, en_US]

Figure 6-131 Trip Logic Diagram

In many applications, the transient ground-fault stage is used only to indicate the direction. In this case, the trip logic is not required and remains disabled. However, this stage can also be used to disable a permanent ground fault. For this, you enable the optional trip logic with the **Operate functionality** parameter. If the fundamental-component values V0 and 3I0 exceed the set threshold values, the operate delay (**Operate delay** parameter) starts with the pickup. In order to start the operate delay, the threshold values must be

exceeded during the time delay. The process of the operate delay will be indicated. If the **Operate & flt.rec. blocked** setting is set to ***no***, the pickup indication is sent.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value cycle of the zero-sequence voltage, the fault extinction of the ground fault can be detected faster than via the dropout of the V0 fundamental-component value under the pickup value. The fast detection of the fault extinction (see function block **General information**) blocks the tripping time delay. When using the parameter **Blk. after fault extinction**, this accelerated blocking mechanism can be enabled or disabled.

6.15.5.2 Application and Setting Notes

Parameter: **Operate functionality**

- Default setting **(_:108) Operate functionality** = ***no***

If the transient ground-fault stage is used only to indicate the direction, this optional trip logic is not required and remains disabled. If the transient ground-fault stage is used to disable permanent faults as well, this optional trip logic is enabled. Pickup of the stage will initiate the tripping delay.

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: **Blk. after fault extinction**

- Recommended setting value **(_:107) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the tripping delay is reset after the detection of the fault extinction. Therefore, if the tripping delay is set for a short time, the possibility of an overfunction is avoided. The reason for an overfunction is a slower attenuation in the zero-sequence system following the fault extinction. Siemens recommends keeping this default setting if the stage is used for tripping. If you are using the stage only for reporting or for detecting intermittent faults, you have to disable the blocking.

Parameter: **Directional mode**

- Default setting **(_:106) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: **V0> threshold value**

- Default setting **(_:103) V0> threshold value** = ***15.000 V***

With the parameter **V0> threshold value**, you define the sensitivity for the indication of the direction and the pickup of the stage.

Note that the sensitivity of the direction determination itself is not thereby changed. The direction determination always works with maximum sensitivity.

Should high-resistive ground faults be reported as well, very sensitive settings are possible, for example, **V0> threshold value** = ***5 V*** secondary.

Parameter: **Maximum operational V0**

- Recommended setting value **(_:105) Maximum operational V0** = ***3.000 V***

The setting of the **Maximum operational V0** parameter is in conjunction with the stabilization against switching operations.

The setting is made with reference to the zero-sequence voltage V0 according to its definition.

Network Structure	Description
Radial system	In the primary system, no operational zero-sequence voltages are present. A measured zero-sequence voltage results from tolerances within the voltage measurement, for example, from the voltage transformers. Siemens recommends using the default value of 3.000 V.
Ring network, meshed network	Operational zero-sequence voltages can occur in such networks. The secondary operational zero-sequence voltages can be determined by reading the residual voltage $V_{N\,sec}$ or the zero-sequence voltage $V_{0\,sec}$ under the symmetrical components from the device or via DIGSI. In case you read the secondary residual voltage $V_{N\,sec}$, you convert it to $V_{0\,sec}$ with the **Matching ratio Vph / VN** parameter. You can find more information in chapter *6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)* . If $V_{0\,sec}$ is greater than 2.5 V, the value of **Maximum operational V0** shall be increased to $V_{0\,sec} \cdot 1.2$. Example: $V_{N\,sec}$ = 5.000 V **Matching ratio Vph / VN** = $\sqrt{3}$ $V_{0\,sec}$ = 5.000 V · $\sqrt{3}$ / 3 = 2.887 V **Maximum operational V0** = 2.887 V · 1.2 = 3.464V In most cases, the operational zero-sequence voltages will be smaller than 2.500 V. Siemens recommends using the default value of 3.000 V.

Parameter: **3I0> threshold value**

- Default setting **(_:104) 3I0> threshold value** = ***0.030 A***

The setting is significant only for optional trip logic for switching off permanent ground faults. Select the setting such that the static ground-fault current exceeds the threshold value.

Parameter: **Operate delay**

- Default setting **(_:6) Operate delay** = ***0.50 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

The setting of the **Operate delay** depends on the specific application. Ensure that the pickup is delayed by 100 ms with regard to the time of the ground-fault ignition.

6.15.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trans.Gnd.flt#				
_:1	Trans.Gnd.flt#:Mode		• off • on • test	off
_:2	Trans.Gnd.flt#:Operate & flt.rec. blocked		• no • yes	no
_:10	Trans.Gnd.flt#:Blk. by meas.-volt. failure		• no • yes	yes
_:107	Trans.Gnd.flt#:Blk. after fault extinction		• no • yes	yes
_:108	Trans.Gnd.flt#:Operate functionality		• no • yes	no
_:106	Trans.Gnd.flt#:Direc-tional mode		• forward • reverse	forward
_:103	Trans.Gnd.flt#:V0> threshold value		0.300 V to 200.000 V	25.981 V
_:104	Trans.Gnd.flt#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:6	Trans.Gnd.flt#:Operate delay		0.00 s to 60.00 s	0.50 s
_:105	Trans.Gnd.flt#:Maximum operational V0		0.300 V to 340.000 V	3.000 V

6.15.5.4 Information List

No.	Information	Data Class (Type)	Type
Trans.Gnd.flt#			
_:81	Trans.Gnd.flt#:>Block stage	SPS	I
_:54	Trans.Gnd.flt#:Inactive	SPS	O
_:52	Trans.Gnd.flt#:Behavior	ENS	O
_:53	Trans.Gnd.flt#:Health	ENS	O
_:55	Trans.Gnd.flt#:Pickup	ACD	O
_:56	Trans.Gnd.flt#:Operate delay expired	ACT	O
_:57	Trans.Gnd.flt#:Operate	ACT	O
_:302	Trans.Gnd.flt#:Ground fault	ACD	O

6.15.6 Usage Information for Detection of Intermittent Ground Faults

The stage type **3I0> with cos φ or sin φ measurement** is suited for directional detection of intermittent ground faults. Many years of field experience and field tests have shown that the direction determination of this stage type reliably determines the direction of the current peaks. Between the current peaks, the direction is detected as *unknown*. To generate a tripping or an alarm, you can analyze the individual pickups of a stage (each directional pickup corresponds to a current peak) in a time-based way or count them via an additional user logic (CFC chart).

You can also ensure the result in the user logic via a 2nd directional stage that works in the backward direction, as well as a V0 stage.

You can operate a 3rd directional stage in parallel for detection of permanent ground faults.

In the following, certain settings are explained that are necessary for this application (detection of intermittent ground faults):

- Parameter: **(_:102) Dropout delay**

  The function must treat the intermittent process as one ground fault. For this, it is necessary that the indication *Ground fault* does not drop out between 2 consecutive current peaks. This is ensured via the **Dropout delay** parameter (FB **General**). A dropout delay of 1 s is a feasible value.

- Parameter: **(_:104) Dir. determination delay**

  You must set the delay of the direction determination to 0 s so that the direction of the current peaks can be determined.

- Parameter: **(_:105) α1 reduction dir. area** and **(_:106) α2 reduction dir. area**

  The current peaks show a clear ohmic component. With these parameters, you can limit the direction characteristic and ensure a reliable direction result.

  Siemens recommends setting both parameters to 10°.

- Parameter: **(_:110) Blk. after fault extinction**

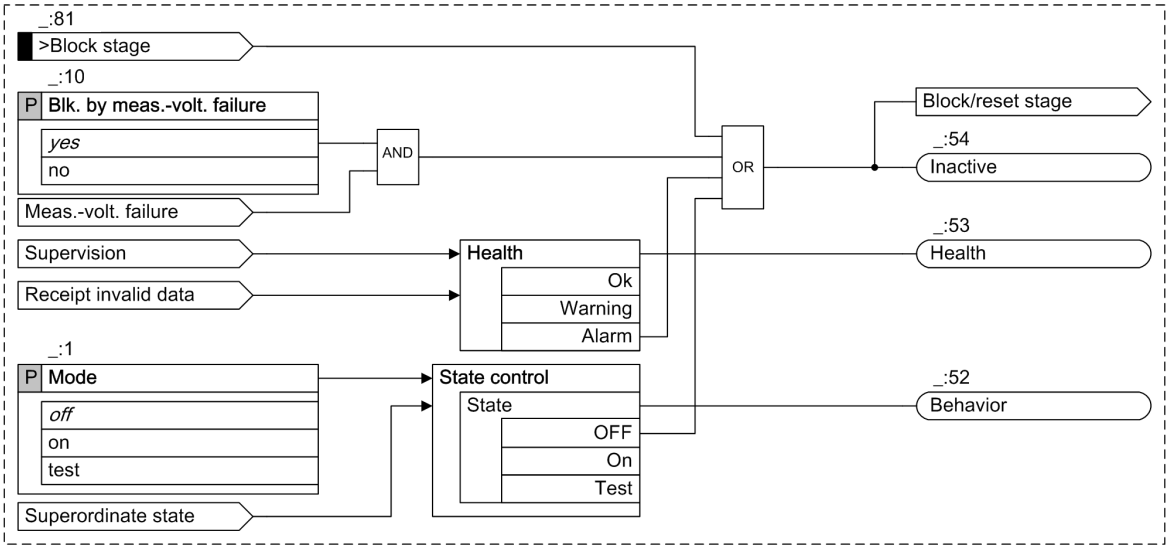
  To make possible a continuous and immediate detection of the current peaks, you must switch off the blocking after fault suppression.

No further parameters need particular consideration with regard to an intermittent ground fault. You can set these as for the detection of permanent ground faults.

6.15.7 Directional 3I0 Stage with φ(V0,3I0) Measurement

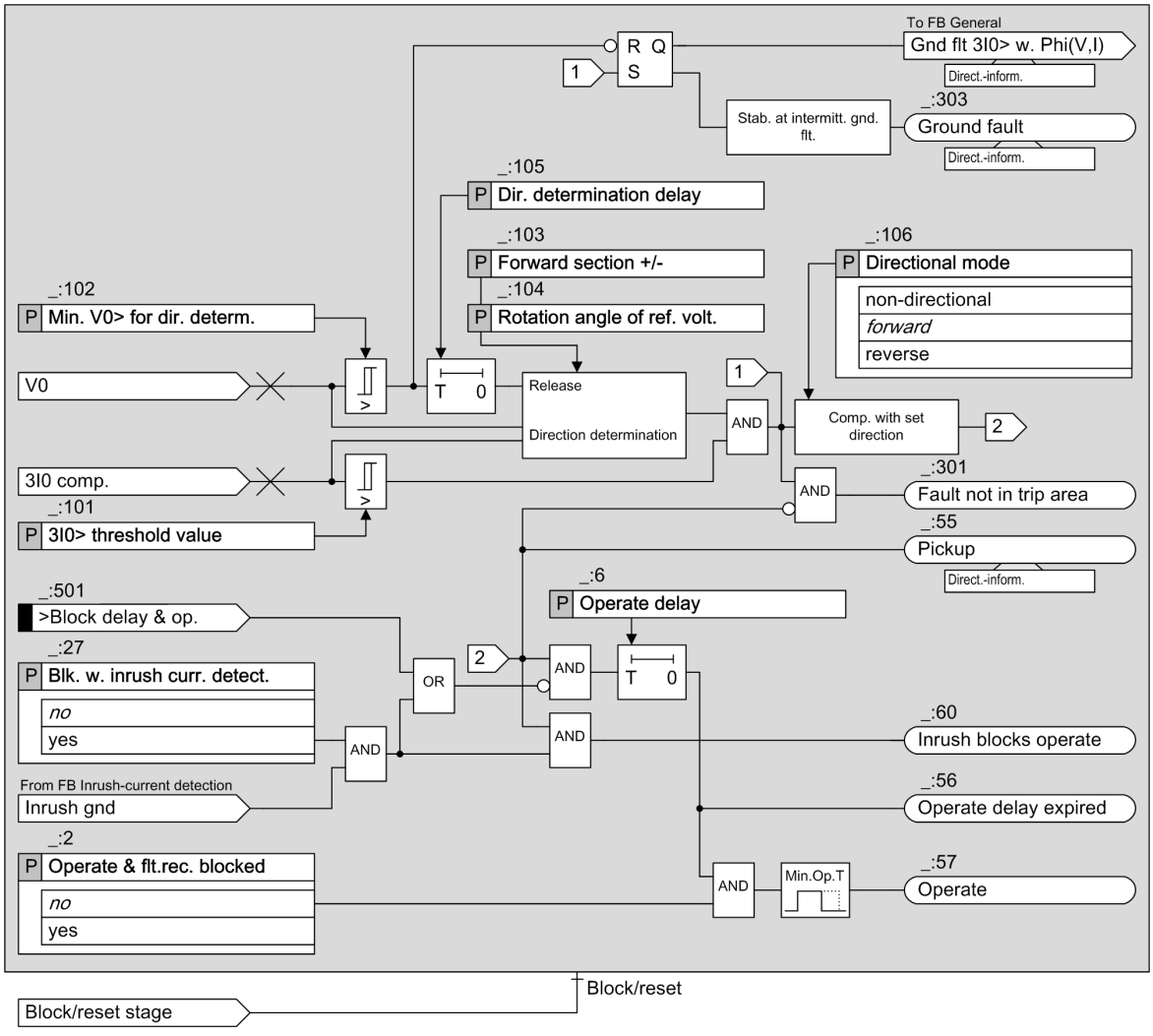
6.15.7.1 Description

Logic



[logfppvi-291112-02.vsd, 1, en_US]

Figure 6-132 Logic Diagram of the Stage Control



[logfppvi-291112-01.tif, 3, en_US]

Figure 6-133 Logic Diagram of the Directional 3I0 Stage with φ(V0,3I0) Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

Depending upon the settings of the **`Connection type`** and **`Measuring point I-3ph`** parameters, as well as the current terminal blocks used, different linearity and setting ranges result, refer for this to chapter *6.15.4.1 Description* , Ground-Fault Detection, Pickup.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 vector exceeds the threshold value **3I0> threshold value** and the absolute value of the zero-sequence voltage V0 vector exceeds the threshold value **Min. V0> for dir. determ.**, the stage detects the ground fault . The direction determination (see in the following paragraph) is started when the zero-sequence voltage exceeds the threshold. The result from the direction determination is only valid if the absolute value of the ground current 3I0 vector has also exceeded its threshold value. The direction result is indicated via the *Ground fault* signal (in the **General** function block).

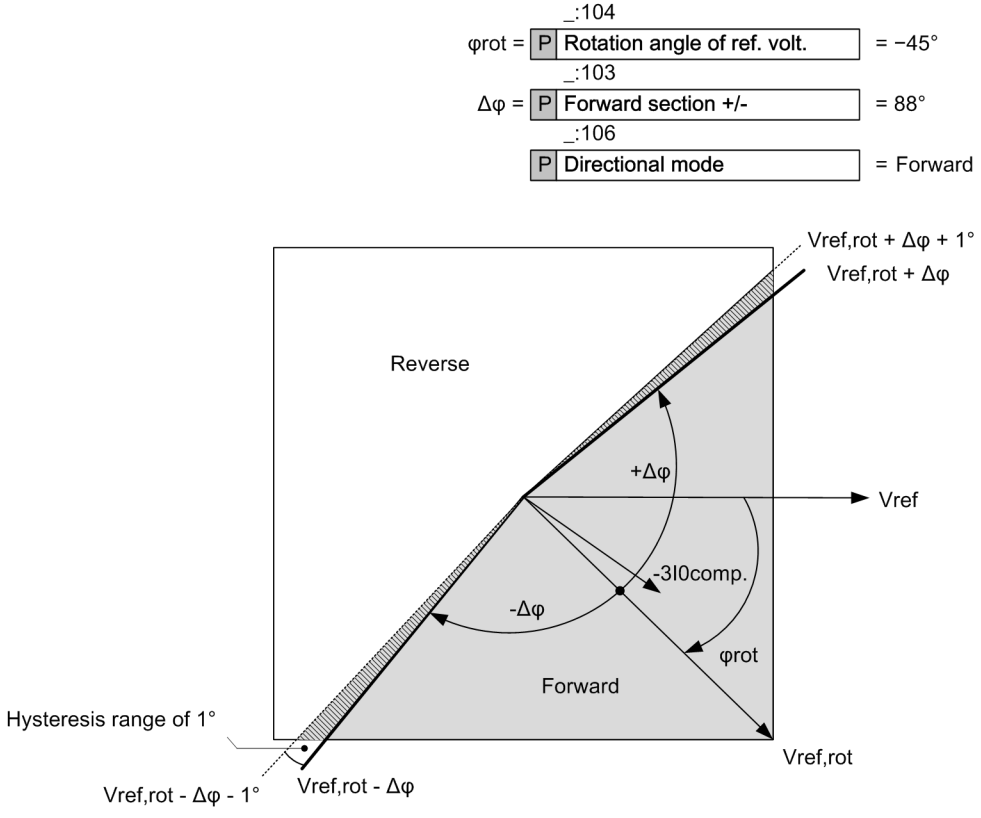
As long as the direction result equals the parameterization direction (parameter **Directional mode**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands.

The direction is determined via the determination of the phase angle between the angle-error compensated ground current 3I0com. and the rotated zero-sequence voltage V0, indicated in the following as reference voltage $V_{ref,rot}$. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (**Rotation angle of ref. volt.** parameter). This moves the vector of the rotated reference voltage close to the vector ground current -3I0com. Consequently, the result of direction determination is as reliable as possible.

The rotated reference voltage $V_{ref,rot}$ and the **Forward section +/-** parameter define the forward and reverse area. The forward area results as range ± Δφ around the rotated reference voltage $V_{ref,rot}$. The value ± Δφ is set with the **Forward section +/-** parameter. The remaining area besides the forward area is the reverse area. Between the forward and reverse area, a hysteresis is defined, refer to *Figure 6-134* .



[dwdirrot-011112-02.vsd, 1, en_US]

Figure 6-134 Directional Characteristic in Forward Mode

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that **measuring-voltage failure detection** blocks the stage or not.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.7.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>open* of the function block **Voltage transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: **Blk. w. inrush curr. detect.**

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by an enabling procedure.

Parameter: Directional mode

- Default setting **(_:106) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or reverse direction.

When the parameter **Directional mode** is set as ***non-directional***, the direction determination is not considered. The pickup condition depends only on the absolute values 3I0 and V0 and the respective thresholds.

Parameter: Rotation angle of ref. volt.,Forward section +/-

- Default setting **(_:104) Rotation angle of ref. volt.** = ***-45°***
- Default setting **(_:103) Forward section +/-** = ***88°***

With the **Rotation angle of ref. volt.** and **Forward section +/-** parameters, you set the direction characteristic, that is, the areas of forward and reverse. With this, you set the direction characteristic according to the system conditions and the neutral-point treatment.

Typical settings for the **Rotation angle of ref. volt.** parameter are:

- Arc-suppression-coil-ground system: 0°
- Isolated system: +45°
- Grounded system: -45°

The **Forward section +/-** parameter can normally be left at its default setting. A reduction of the forward area by a few degrees is practical, for example in an arc-suppression-coil-ground system with long cable feeders, that generate high capacitive fault currents.

Parameter: Min. V0> for dir. determ.

- Default setting **(_:102) Min. V0> for dir. determ.** = ***2.000 V***

With the **Min. V0> for dir. determ.** parameter, you determine the minimum voltage V0 necessary for the release of the direction determination that must be attained within the time delay **Dir. determination delay**.

Parameter: 3I0> threshold value

- Default setting **(_:101) 3I0> threshold value** = ***0.050 A***

The **3I0> threshold value** parameter allows you to set the ground-current sensitivity of the stage. Set the threshold value lower than the minimum absolute value of the ground-fault current 3I0 that must still be detected.

Parameter: Dir. determination delay

- Default setting **(_:105) Dir. determination delay** = ***0.10 s***

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***0.50 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.7.3 Settings

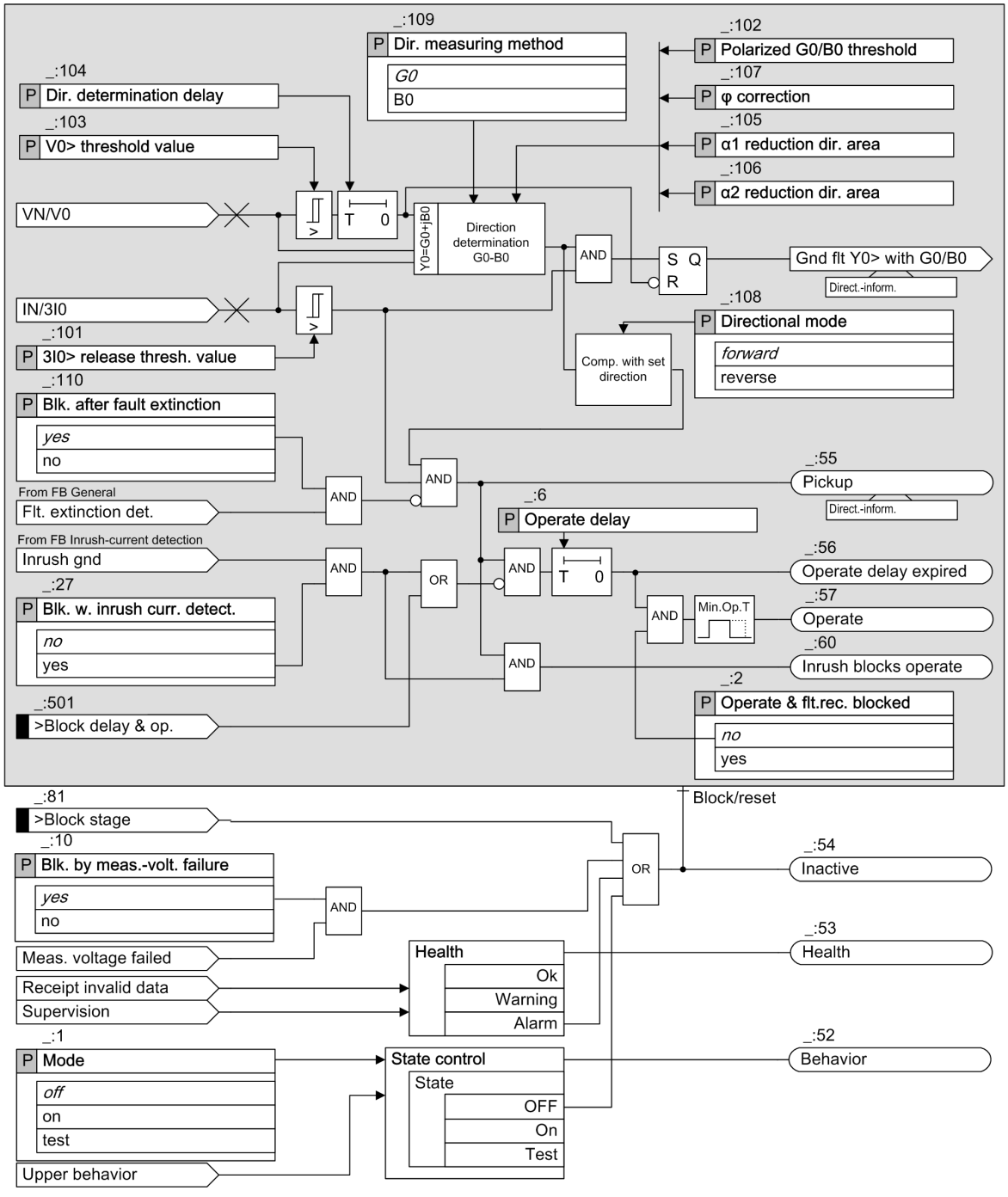
Addr.	Parameter	C	Setting Options	Default Setting
3I0> φ(VI) #				
_:1	3I0> φ(VI) #:Mode		• off • on • test	off
_:2	3I0> φ(VI) #:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> φ(VI) #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	3I0> φ(VI) #:Blk. w. inrush curr. detect.		• no • yes	no
_:106	3I0> φ(VI) #:Directional mode		• non-directional • forward • reverse	forward
_:104	3I0> φ(VI) #:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	3I0> φ(VI) #:Forward section +/-		0 ° to 180 °	88 °
_:102	3I0> φ(VI) #:Min. V0> for dir. determ.		0.300 V to 200.000 V	2.000 V
_:101	3I0> φ(VI) #:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:105	3I0> φ(VI) #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> φ(VI) #:Operate delay		0.00 s to 60.00 s	0.50 s

6.15.7.4 Information List

No.	Information	Data Class (Type)	Type
3I0> φ(VI) #			
_:81	3I0> φ(VI) #:>Block stage	SPS	I
_:501	3I0> φ(VI) #:>Block delay & op.	SPS	I
_:54	3I0> φ(VI) #:Inactive	SPS	O
_:52	3I0> φ(VI) #:Behavior	ENS	O
_:53	3I0> φ(VI) #:Health	ENS	O
_:301	3I0> φ(VI) #:Fault not in trip area	SPS	O
_:60	3I0> φ(VI) #:Inrush blocks operate	ACT	O
_:303	3I0> φ(VI) #:Ground fault	ACD	O
_:55	3I0> φ(VI) #:Pickup	ACD	O
_:56	3I0> φ(VI) #:Operate delay expired	ACT	O
_:57	3I0> φ(VI) #:Operate	ACT	O

6.15.8 Directional Y0 Stage with G0 or B0 Measurement

6.15.8.1 Description



[LoY0G0B0-300713-01, 4, en_US]

Figure 6-135 Logic Diagram of the Directional Y0 Stage with G0 or B0 Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the definition equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, G0, B0, Method of Measurement

The function usually evaluates the ground current 3I0 sensitively measured via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0 = G0 + jB0. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically. The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

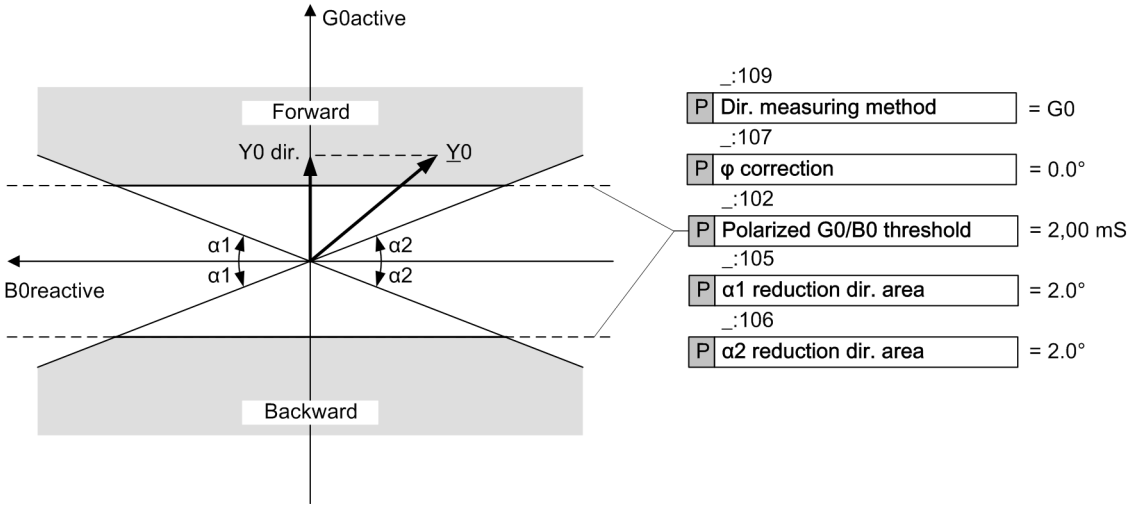
Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value **`3I0> release thresh. value`** and the absolute value of the zero-sequence voltage V0 exceeds the threshold value **`V0> threshold value`**, the stage recognizes the ground fault. The calculation of G0 or B0 is started with exceeding the threshold values and then, the direction determination (see the following) is performed. The direction result is indicated via the *`Ground fault`* signal (in the **General** function block). If the direction result equals the parameterized direction (parameter **`Directional mode`**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **`Dir. determination delay`** parameter to achieve steady-state measurands. The result from the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its release threshold value.

The following figure shows an example of the direction determination in the complex phasor diagram for the G0 direction measurement method with a correction value of the direction straight line from 0 (Parameter **`φ correction`**). The example is suitable for the determination of the ground-fault direction in an arc-suppression-coil-ground system where the value G0 is decisive for the direction determination.



[DwY0Dire-171012-01, 1, en_US]

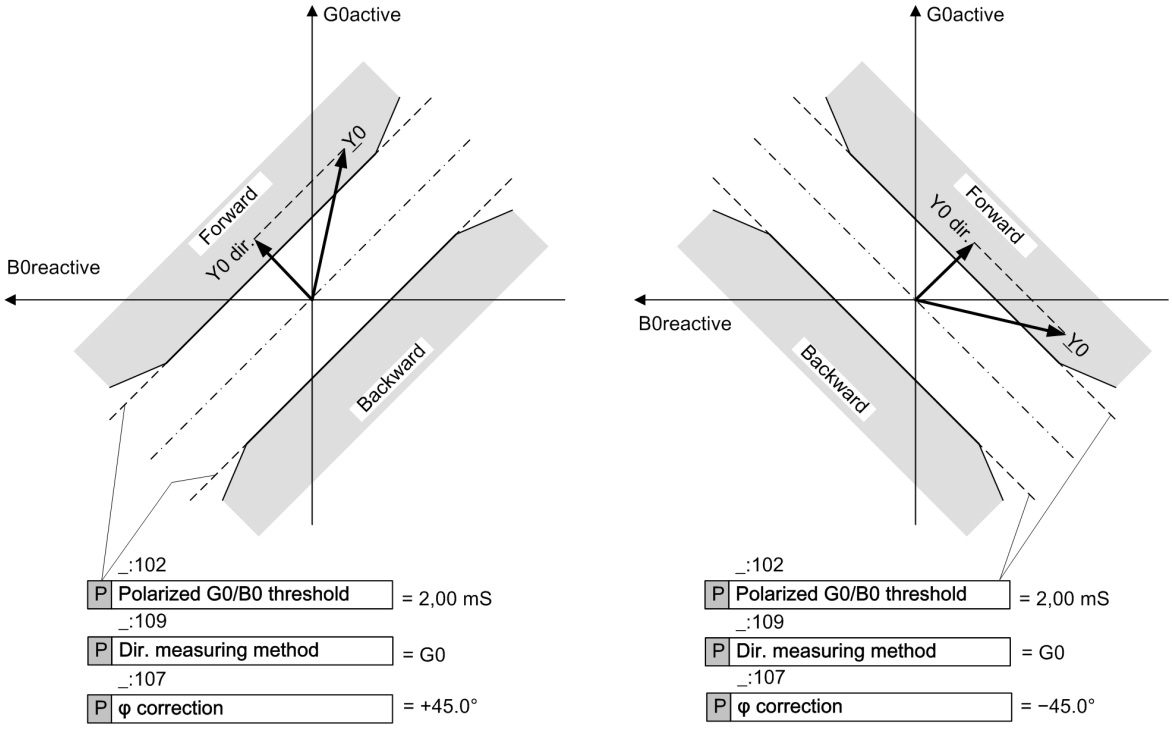
Figure 6-136 Direction-Characteristic Curve for the G0 Measurement

The zero-sequence voltage V0 is generally the reference value for the real axis and is identical to the G0 axis. The axis of symmetry of the direction-characteristic curve coincides with the B0 (reactive) axis for this example. For the direction determination, the component of the admittance perpendicular to the set direction-characteristic curve (= axis of symmetry) is decisive G0dir (=Y0dir). In this example, this is the active component **G0active** of the admittance Y0. The conductance G0dir. (here = G0active) is calculated and

compared with the setting value **Polarized G0/B0 threshold**. If the conductance G0dir. exceeds the positive setting value, the direction is forward. If the conductance G0dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you can limit the forward and backward ranges as shown in *Figure 6-137* . With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle (**φ correction** parameter) in a range of ±45. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a turn of +45° (see following figure).

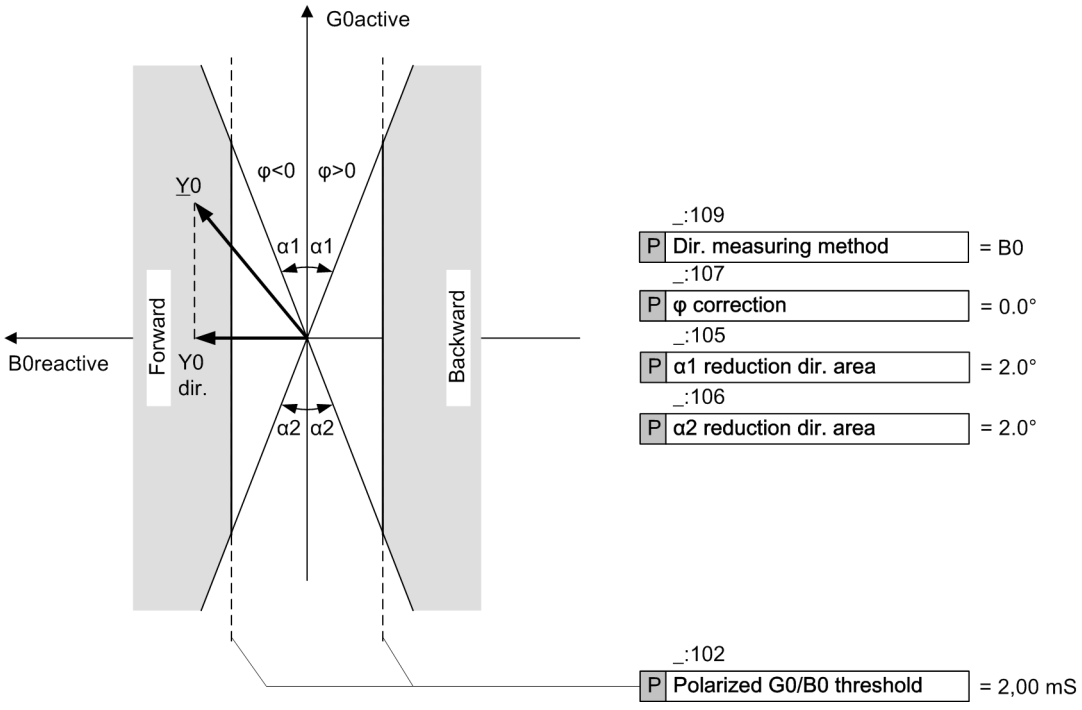


[DwY0meas-171012-01, 1, en_US]

Figure 6-137 Turning the Direction-Characteristic Curves with G0 Measurement with Angle Correction

If you set the **Dir. measuring method** parameter to B0 and the **φ correction** parameter to ***0***, the axis of symmetry of the direction-characteristic curve coincides with the G0 and V0 axes. Since the component of the admittance Y0 perpendicular to the direction-characteristic curve (= axis of symmetry) is decisive (B0dir. (=Y0dir.)), here, the susceptance B0 (reactive) is used in the direction determination. If the susceptance B0dir. (B0reactive) exceeds the negative setting value **Polarized G0/B0 threshold**, the direction is forward. If the susceptance B0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.



[DwSiCoY0-011112-01, 1, en_US]

Figure 6-138 Direction-Characteristic Curve for the B0 Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the **Blk. after fault extinction** parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.8.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: **Blk. w. inrush curr. detect.**

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains untouched by an enabling procedure.

Parameter: **Blk. after fault extinction**

- Recommended setting value **(_:110) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: **Directional mode**

- Default setting **(_:108) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: **Dir. measuring method, φ correction, Polarized G0/B0 threshold, 3I0> release thresh. value**

- Default setting **(_:109) Dir. measuring method** = *G0*
- Default setting **(_:107) φ correction** = *0.0°*
- Default setting **(_:102) Polarized G0/B0 threshold** = *2.00 mS*
- Default setting **(_:101) 3I0> release thresh. value** = *0.002 A*

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral-point treatment of the system.

Note that, for the direction determination, basically only the component of the admittance perpendicular to the set direction-characteristic curve is decisive, see chapter *6.15.8.1 Description* . This admittance component is compared to the threshold value **Polarized G0/B0 threshold**. In contrast, the absolute value of the current 3I0 is compared with the **3I0> release thresh. value** parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc-suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • **Dir. measuring method** = *G0* • **φ correction** = *0.0°* The direction determination for a ground fault is made more difficult in that a much larger reactive current of capacitive or inductive character is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground-fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the **Polarized G0/B0 threshold** parameter, the following formula applies: $G0 > k_s \frac{I_{0active}}{\sqrt{3}V_{rated}} + \frac{I_{0min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{0active}$: Active component of the ground-fault current (watt leakage current) of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{0min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage $\approx 0.1\sqrt{3}V_{rated}$ If a parallel resistor Rp is used on the arc-suppression coil, the threshold value G0 must also be smaller than: $G0 \leq \frac{1}{k_s} \frac{I_{Rp}}{\sqrt{3}V_{rated}}$ where: k_s: Safety margin $\geq$ 1.5 I_{Rp}: Secondary rated current of the parallel resistor V_{rated}: Secondary rated voltage in the healthy case The **3I0> release thresh. value** parameter can be set to half of the expected measuring current and here, the entire zero-sequence current can be put to use.

System Type/ Neutral-Point Treatment	Description
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • **Dir. measuring method** = ***B0*** • **φ correction** = ***0.0°*** In isolated systems, a ground fault allows the capacitive ground-fault currents of the entire electrically connected system, except for the ground current in the faulty cable itself, to flow through the measuring point as the latter flows directly away from the fault location (that is, not via the measuring point). The following formula can be used to determine the pickup value of the **Polarized G0/B0 threshold** parameter. $B0 \geq \frac{I_{0min}}{V0>}$ where: I_{0min}: Ground current in the healthy case V0>: Pickup threshold of the residual voltage $\approx 0.02\sqrt{3}V_{rated}$ In healthy operation, B0 ≤ 0. For the **3I0> release thresh. value** parameter, select around half of this capacitive ground-fault current flowing via the measuring point.
Resistance-Grounded	In the resistance-grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • **Dir. measuring method** = ***G0*** • **φ correction**= ***-45.0°*** For the setting of the **Polarized G0/B0 threshold** parameter, the rule of thumb is: Set the pickup value according to the following formula where only the active ground-fault current can be put into use. $G0 > k_s \frac{I_{0active}}{\sqrt{3}V_{rated}} + \frac{I_{0min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{0active}$: Active component of the ground-fault current of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{0min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage $\approx 0.02\sqrt{3}V_{rated}$ The **3I0> release thresh. value** parameter must be set to a value below the minimum expected ground-fault current.

Parameter: **α1 reduction dir. area, α2 reduction dir. area**

- Recommended setting value **(_:105) α1 reduction dir. area** = ***2°***
- Recommended setting value **(_:106) α2 reduction dir. area** = ***2°***

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting **(_:103) V0> threshold value** = ***30.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: Dir. determination delay

- Default setting **(_:104) Dir. determination delay** = ***0.10 s***

The start of the ground fault normally indicates a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed for this reason from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***2.0 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Y0> G0/B0 #				
_:1	Y0> G0/B0 #:Mode		• off • on • test	off
_:2	Y0> G0/B0 #:Operate & flt.rec. blocked		• no • yes	no
_:10	Y0> G0/B0 #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Y0> G0/B0 #:Blk. w. inrush curr. detect.		• no • yes	no
_:110	Y0> G0/B0 #:Blk. after fault extinction		• no • yes	yes
_:108	Y0> G0/B0 #:Directional mode		• forward • reverse	forward
_:109	Y0> G0/B0 #:Dir. measuring method		• G0 • B0	G0
_:107	Y0> G0/B0 #:φ correction		-45 ° to 45 °	0 °
_:102	Y0> G0/B0 #:Polarized G0/B0 threshold		0.10 mS to 100.00 mS	2.00 mS
_:105	Y0> G0/B0 #:α1 reduction dir. area		1 ° to 15 °	2 °
_:106	Y0> G0/B0 #:α2 reduction dir. area		1 ° to 15 °	2 °

Addr.	Parameter	C	Setting Options	Default Setting
_:101	Y0> G0/B0 #:3I0> release thresh. value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:103	Y0> G0/B0 #:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	Y0> G0/B0 #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	Y0> G0/B0 #:Operate delay		0.00 s to 60.00 s	2.00 s

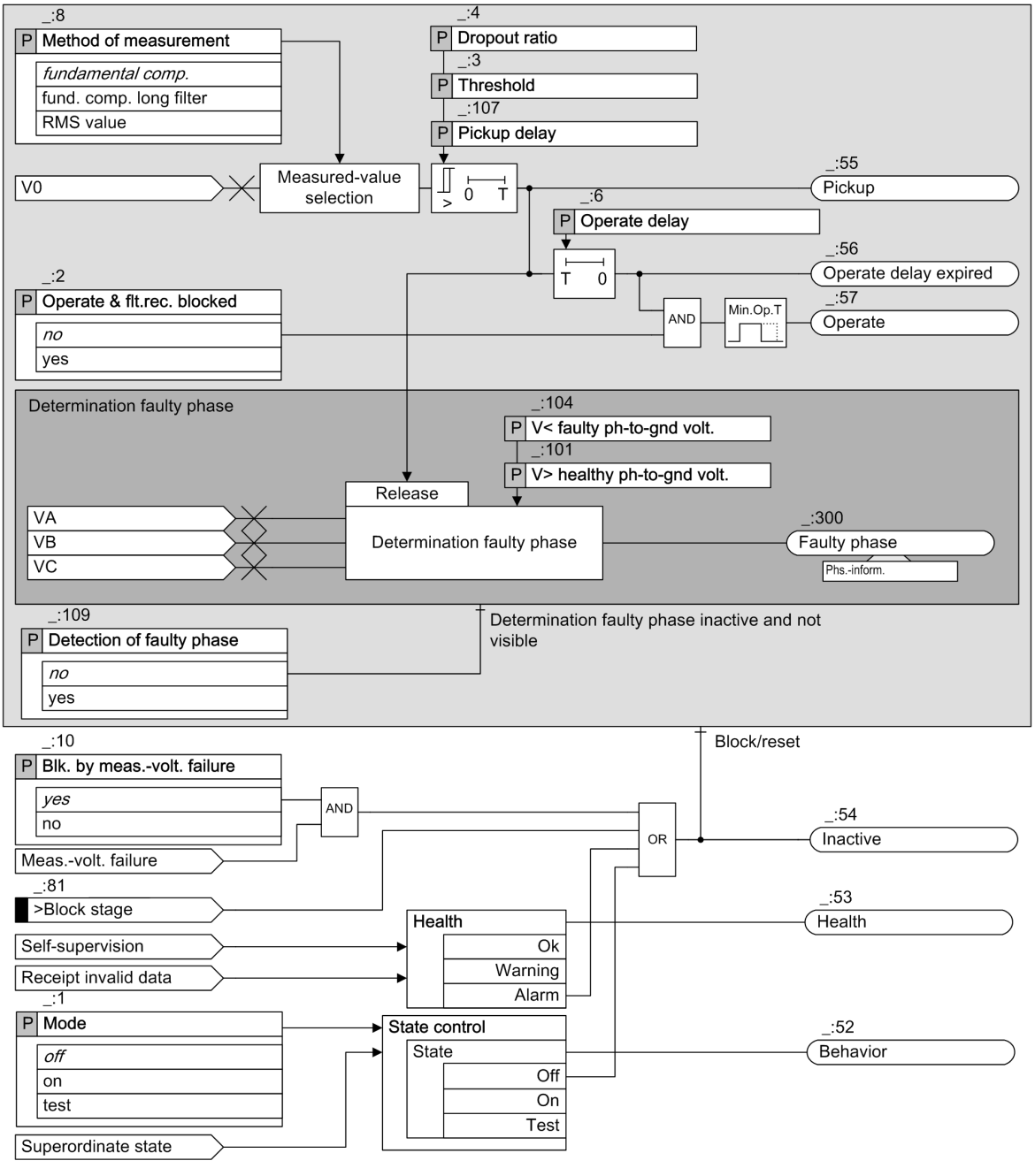
6.15.8.4 Information List

No.	Information	Data Class (Type)	Type
Y0> G0/B0 #			
_:81	Y0> G0/B0 #:>Block stage	SPS	I
_:501	Y0> G0/B0 #:>Block delay & op.	SPS	I
_:54	Y0> G0/B0 #:Inactive	SPS	O
_:52	Y0> G0/B0 #:Behavior	ENS	O
_:53	Y0> G0/B0 #:Health	ENS	O
_:60	Y0> G0/B0 #:Inrush blocks operate	ACT	O
_:55	Y0> G0/B0 #:Pickup	ACD	O
_:56	Y0> G0/B0 #:Operate delay expired	ACT	O
_:57	Y0> G0/B0 #:Operate	ACT	O

6.15.9 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

6.15.9.1 Description

Logic



[logfpsv0-291112-01.tif, 3, en_US]

Figure 6-139 Logic Diagram of the Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

Use the **Method of measurement** parameter to select the relevant method of measurement, depending on the application:

- Measurement of the fundamental component (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- Measurement of the fundamental component over 2 cycle filters with triangular window:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see *12.18.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage*).

Pickup, Dropout

The stage compares the **Threshold** with the zero-sequence voltage V_0. The **Pickup delay** parameter allows you to delay the pickup of the stage depending on the residual voltage.
With the **Dropout ratio** parameter, you can define the ratio of the dropout value to the **Threshold**.

Determination of the Faulty Phase

With the **Detection of faulty phase** parameter, you can enable or disable the determination of the ground-fault phase. Determining is released when the stage picks up. If 2 phases exceed the threshold value **V> healthy ph-to-gnd volt.** and one phase falls below the threshold value **V< faulty ph-to-gnd volt.**, the last phase is determined to be faulty and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal **>Block stage** from an external or internal source
- From inside on pickup of the **measuring-voltage failure detection** function. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or not.

6.15.9.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Method of measurement**

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

The **Method of measurement** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).
fund. comp. long filter	To implement particularly strong damping of harmonics and transient faults, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Note that in this case the pickup time of the stage increases slightly (see *12.18.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage*).

Parameter: `Pickup delay`

- Recommended setting value **`(_:107) Pickup delay`** = ***`0 ms`***

The **`Pickup delay`** parameter allows you to delay the analysis of the measurand (to generate the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.

Siemens recommends using the default setting **`Pickup delay`** = ***`0 ms`***.

Parameter: `Threshold`

- Default setting **`(_:3) Threshold`** = ***`30 V`***

The threshold value of the function is set as the zero-sequence voltage V_0. The device calculates the zero-sequence voltage V_0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.

The setting value depends on the system grounding:

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. Siemens recommends setting the value between 20 V and 40 V. A higher sensitivity (= lower threshold value) can be necessary for high fault resistances.
- Siemens recommends setting a more sensitive (smaller) value in grounded systems. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE

For an isolated system

The residual voltage is measured via the broken-delta winding:

- If the ground fault is fully unbalanced, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/$\sqrt{3}$ = 57.7 V
  Setting value: 0,5 · 57.7 V = 28.9 V ≈ 30 V

Parameter: `Dropout ratio`

- Recommended setting value **`(_:4) Dropout ratio`** = ***`0.95`***

The recommended setting value of ***`0.95`*** is appropriate for most applications. To achieve high measurement precision, the dropout ratio can be reduced to 0.98, for example.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`3.00 s`***

The **`Operate delay`** allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: **Detection of faulty phase**

- Default setting **(_:109) Detection of faulty phase** = ***no***

The **Detection of faulty phase** parameter controls how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults, for example for applications in grounded systems.
yes	After a pickup by the residual voltage, the device tries to determine which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: **V< faulty ph-to-gnd volt.**

- Default setting **(_:104) V< faulty ph-to-gnd volt.** = ***30 V***

Set the threshold value for determining which phase is affected by the ground fault in the **V< faulty ph-to-gnd volt.** parameter. The setting value is a phase-to-ground quantity.

The set value must be smaller than the minimum phase-to-ground voltage occurring during operation. Siemens recommends using the default setting **V< faulty ph-to-gnd volt.** = ***30 V***.

Parameter: **V> healthy ph-to-gnd volt.**

- Default setting **(_:101) V> healthy ph-to-gnd volt.** = ***70 V***

Set the threshold value for the 2 healthy phases in the **V> healthy ph-to-gnd volt.** parameter. The setting value is a phase-to-ground measurand.

The set value must be above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 70 V, for example. Siemens recommends using the default setting **V> healthy ph-to-gnd volt.** = ***70 V***.

Operation as Supervision Function

If you want the stage to have a reporting effect only, the generation of the operate indication and fault logging can be disabled via the **(_:2) Operate & flt.rec. blocked** parameter.

6.15.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0> #				
_:1	V0> #:Mode		• off • on • test	off
_:2	V0> #:Operate & flt.rec. blocked		• no • yes	no
_:10	V0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:109	V0> #:Detection of faulty phase		• no • yes	no
_:8	V0> #:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:3	V0> #:Threshold		0.300 V to 200.000 V	30.000 V
_:4	V0> #:Dropout ratio		0.90 to 0.99	0.95
_:107	V0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	V0> #:Operate delay		0.00 s to 60.00 s	3.00 s
_:101	V0> #:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	70.000 V
_:104	V0> #:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	30.000 V

6.15.9.4 Information List

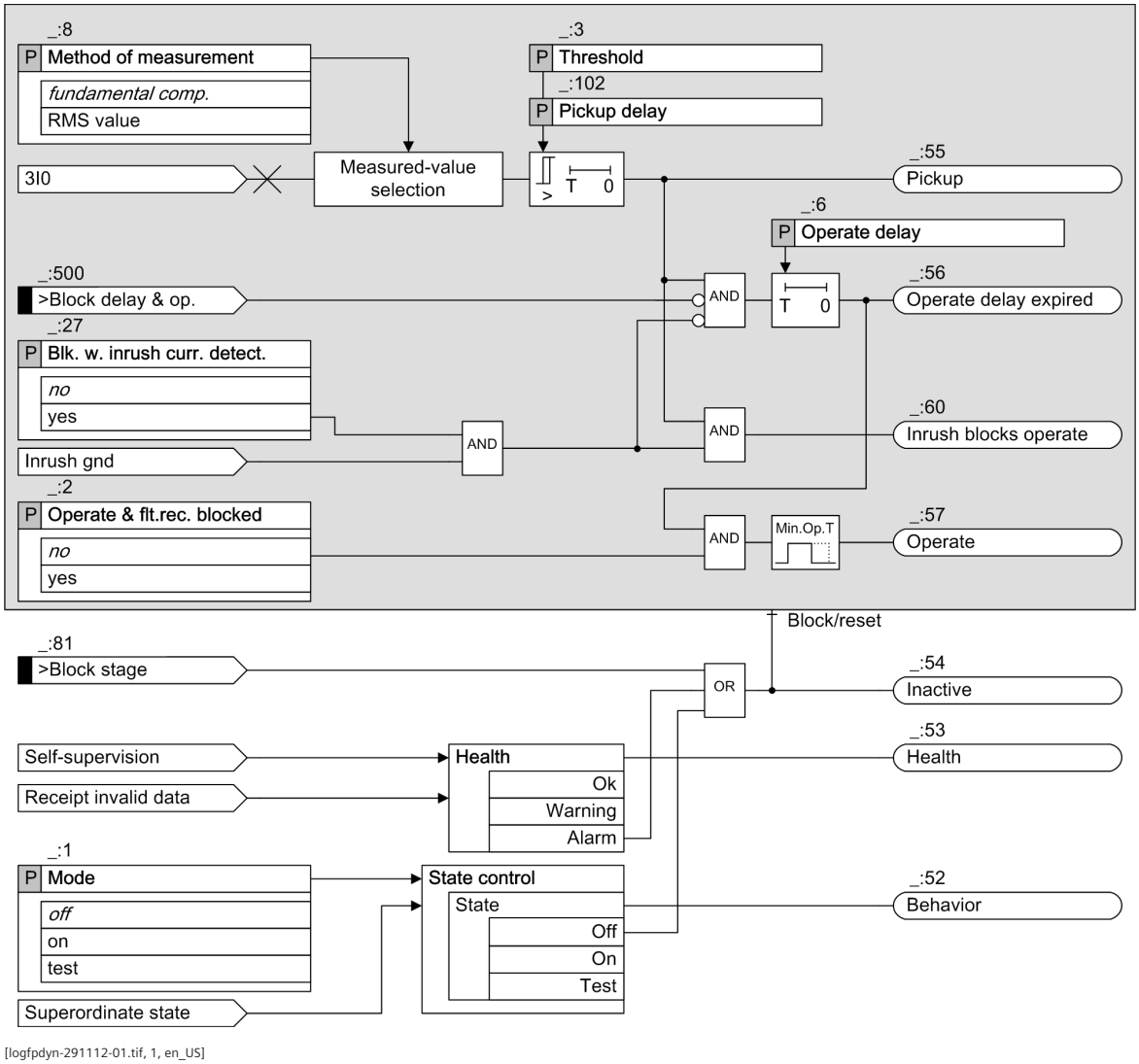
No.	Information	Data Class (Type)	Type
V0> #			
_:81	V0> #:>Block stage	SPS	I
_:54	V0> #:Inactive	SPS	O
_:52	V0> #:Behavior	ENS	O
_:53	V0> #:Health	ENS	O
_:300	V0> #:Faulty phase	ACT	O
_:55	V0> #:Pickup	ACD	O
_:56	V0> #:Operate delay expired	ACT	O
_:57	V0> #:Operate	ACT	O

6.15.10 Non-Directional 3I0 Stage

6.15.10.1 Description

In the **Directional sensitive ground-fault detection** function, the **Non-directional 3I0 stage** also works on demand.

Logic



[logfpdyn-291112-01.tif, 1, en_US]

Figure 6-140 Logic Diagram of the Non-Directional 3I0 Stage

Measured Value 3I0

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending upon the settings of the **`Connection type`** and **Measuring point I-3ph** parameters, as well as the current terminal blocks used, different linearity and setting ranges result, refer for this to chapter *6.15.4.1 Description* , Ground-Fault Detection, Pickup.

Method of Measurement

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.

- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Tripping via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.15.10.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording and the fault log with the **Operate & flt.rec. blocked** parameter. In this case a ground-fault log is created instead of the fault log.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the tripping is blocked during the detection of an inrush current.

Parameter: **Method of measurement**

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: **Threshold**

- Default setting **(_:3) Threshold** = ***0.050 A***

The **Threshold** parameter allows you to set the threshold value of the ground current 3I0.

Parameter: `Pickup delay`

- Default setting **`(_:102) Pickup delay`** = ***`0.00 s`***

With the parameter **`Pickup delay`** you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`0.30 s`***

The parameterized time **`Operate delay`** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> #				
_:1	3I0> #:Mode		• off • on • test	off
_:2	3I0> #:Operate & flt.rec. blocked		• no • yes	no
_:27	3I0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	3I0> #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	3I0> #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:102	3I0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	3I0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.15.10.4 Information List

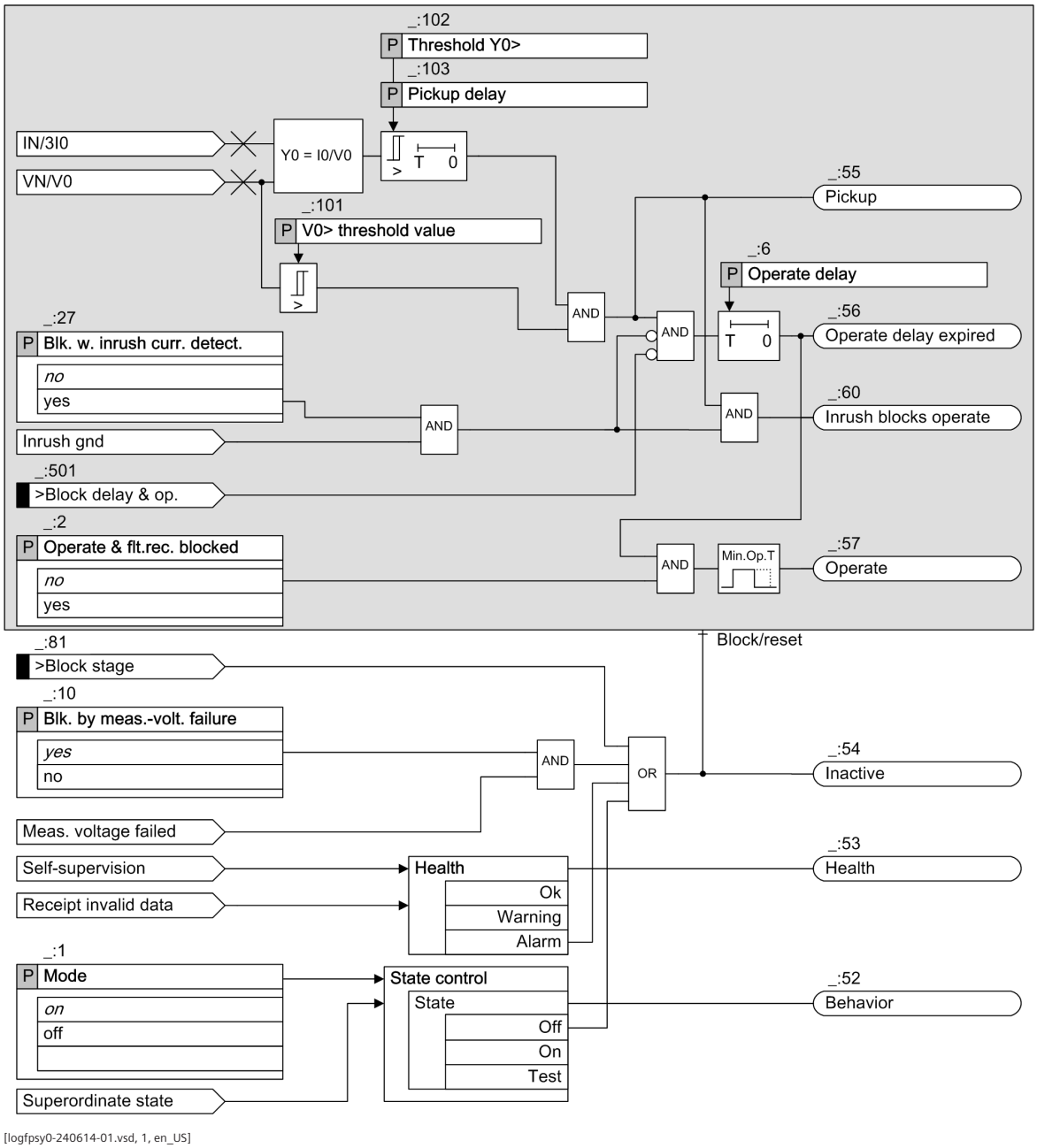
No.	Information	Data Class (Type)	Type
3I0> #			
_:81	3I0> #:>Block stage	SPS	I
_:500	3I0> #:>Block delay & op.	SPS	I
_:54	3I0> #:Inactive	SPS	O
_:52	3I0> #:Behavior	ENS	O
_:53	3I0> #:Health	ENS	O
_:60	3I0> #:Inrush blocks operate	ACT	O
_:55	3I0> #:Pickup	ACD	O
_:56	3I0> #:Operate delay expired	ACT	O
_:57	3I0> #:Operate	ACT	O

6.15.11 Non-Directional Y0 Stage

6.15.11.1 Description

In the **Directional sensitive ground-fault detection** function, the **Non-directional Y0 stage** also works on demand.

Logic



[logfpsy0-240614-01.vsd, 1, en_US]

Figure 6-141 Logic Diagram of the Non-Directional Y0 Stage

Measured Value 3I0, Y0

The function evaluates the sensitively measured ground current 3I0 via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0=I0/V0. Since the linearity range of the

sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the settings of the **Connection type** and **Measuring point I-3ph** parameters, as well as the current terminal block used, different linearity and setting ranges result, refer for this to chapter *6.15.8.1 Description* .

Blocking the Stage via Binary Input Signal

Blocking of the stage is possible externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pick up of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.15.11.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = *no*

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = *yes*

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected. A measuring-voltage failure can only be detected if 1 of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.

Parameter Value	Description
no	The protection stage is not blocked.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the operate is blocked during the detection of an inrush current.

Parameter: **V0> threshold value**

- Default setting **(_:101) V0> threshold value** = ***5.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: **Threshold Y0>**

- Default setting **(_:102) Threshold Y0>** = ***2.00 mS***

With the parameter **Threshold Y0>**, you set the threshold value of the ground admittance Y0. If the ground admittance for the setting value is unknown, you can assume the following relation:

$$Y0 > k_s \frac{I_{c,line}}{3V_{ph-gnd}} + \frac{3I_{0\,min}}{V0>}$$

[fo_SeGfY0-270614-01, 2, en_US]

k_s:	Factor, takes into account the ohmic components of the current (1.2 for overhead lines, 1.0-1.05 for cable systems)
$I_{c,line}$	Secondary capacitive ground-fault current for the protected line
V_{ph-gnd}	Secondary phase-to-ground voltage in the healthy case
$3I_{0min}$	Secondary ground current in the healthy case (resulting from transformer error), 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer)
V0>	Secondary pickup threshold of the residual voltage

Parameter: **Pickup delay**

- Default setting **(_:103) Pickup delay** = ***0.00 s***

With the parameter **Pickup delay**, you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: **Operate delay**

- Default setting **(_:6) Operate delay** = ***0.30 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Y0> #				
_:1	Y0> #:Mode		• off • on • test	off
_:2	Y0> #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:10	Y0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Y0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Y0> #:V0> threshold value		0.300 V to 200.000 V	5.000 V
_:102	Y0> #:Threshold Y0>		0.10 mS to 100.00 mS	2.00 mS
_:103	Y0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	Y0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.15.11.4 Information List

No.	Information	Data Class (Type)	Type
Y0> #			
_:81	Y0> #:>Block stage	SPS	I
_:501	Y0> #:>Block delay & op.	SPS	I
_:54	Y0> #:Inactive	SPS	O
_:52	Y0> #:Behavior	ENS	O
_:53	Y0> #:Health	ENS	O
_:60	Y0> #:Inrush blocks operate	ACT	O
_:55	Y0> #:Pickup	ACD	O
_:56	Y0> #:Operate delay expired	ACT	O
_:57	Y0> #:Operate	ACT	O

6.16 Undercurrent Protection

6.16.1 Overview of Functions

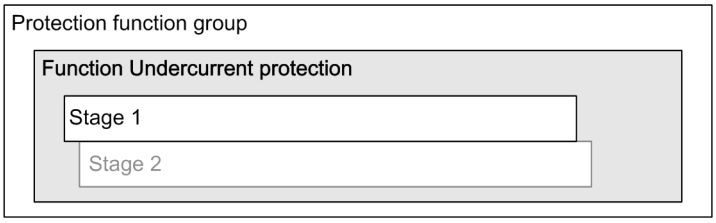
The **Undercurrent protection** function (ANSI 37):

- Detects the going current in a feeder after the opening of the infeed circuit breaker
- Detects the loss of loads
- Detects and protects pumps from running idle

6.16.2 Structure of the Function

The **Undercurrent protection** function is used in protection function groups with current measurement.

The **Undercurrent protection** function comes with 1 protection stage preconfigured at the factory. A maximum of 2 protection stages can be operated simultaneously in this function. The protection stages are structured identically.

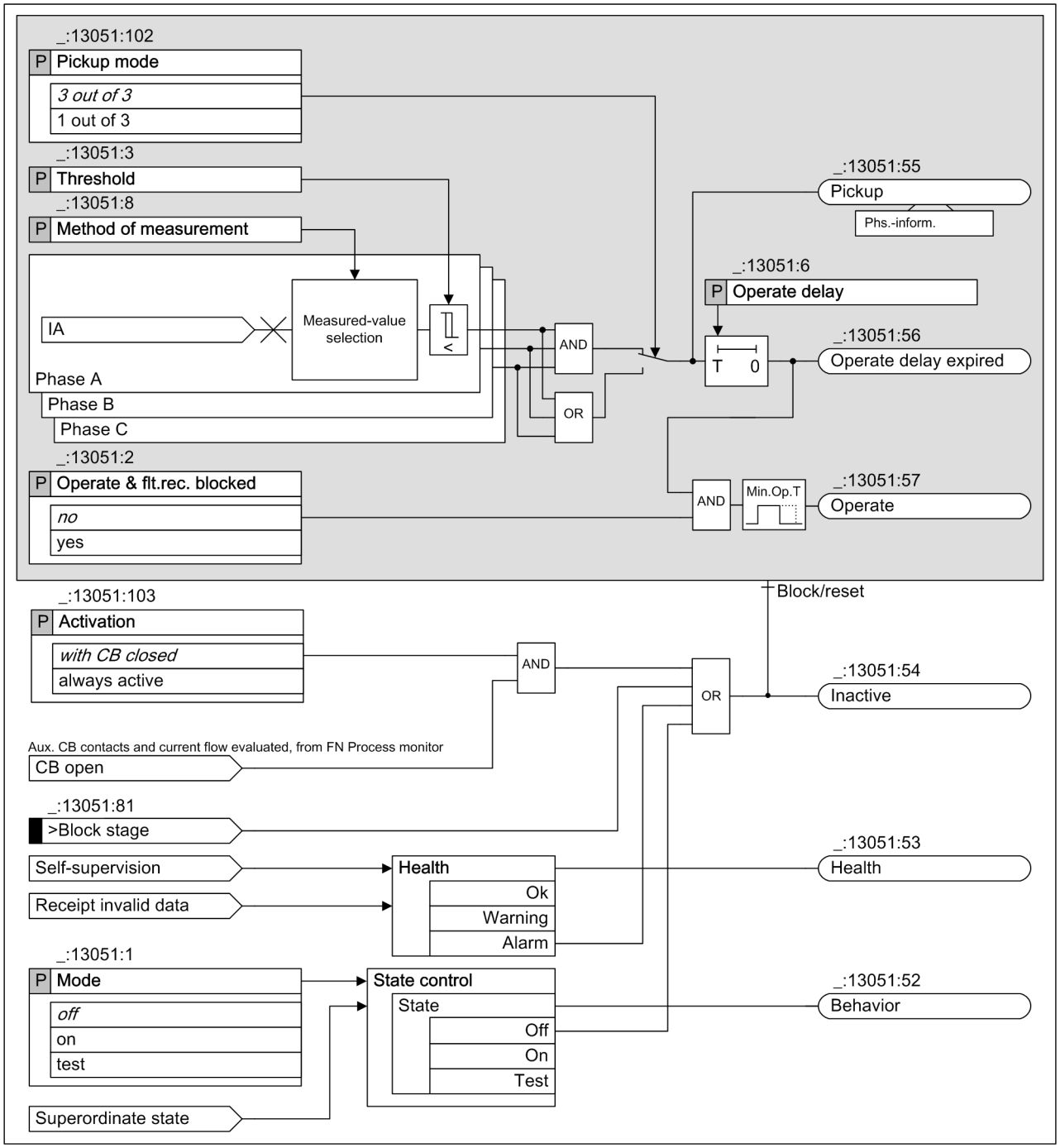


[lostuundcu-150813, 2, en_US]

Figure 6-142 Structure/Embedding of the Function

6.16.3 Stage Description Undercurrent Protection

Logic of the Stage



[loundcur-200713-01.tif, 1, en_US]

Figure 6-143 Logic Diagram of the Undercurrent Protection

Method of Measurement

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental comp.:
  This measurement method processes the sampled current values and numerically filters out the fundamental component.
- Measurement of the parameter value RMS value:
  This measurement method determines the current amplitude from the sampled values according to the definition equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

The **Pickup mode** parameter defines whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (***3 out of 3***) or if only 1 measuring element has to detect the undercurrent condition (***1 out of 3***).

Blocking the Stage

When blocked, the picked-up protection stage will drop out. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

Activation and Blocking of the Stage Depending On the Circuit-Breaker Condition

With the parameter **Activation**, you define if the **Undercurrent protection** stage is always active or only active if the circuit breaker is indicating **closed**.

If the parameter **Activation** is set to ***with CB closed*** and the local circuit breaker is not **closed**, the function **Undercurrent protection** is blocked and no pickup is generated.

The circuit-breaker position is detected as **closed** if one of the following condition is met:

- The binary inputs are connected to the auxiliary contacts of the circuit breaker. The circuit-breaker switch position is detected as **closed** via the related binary inputs of the **Position** indication. This is also true under the condition that no phase current is flowing.
- The current-flow criterion indicates that the circuit breaker is **closed**. This is also true under the condition that the auxiliary contacts indicate the circuit breaker as **open**.

6.16.4 Application and Setting Notes

Parameter: Activation

- Default setting **(_:13051:103) Activation** = ***with CB closed***

Parameter Value	Description
with CB closed	The **Undercurrent protection** is active only when the circuit-breaker position is detected as **closed**. A precondition is, that the **Position** indication is routed to binary inputs to obtain the CB position information via the CB auxiliary contacts. If this is not the case, the function will always be inactive.
always active	The **Undercurrent protection** stage is always active independent of the position of the circuit breaker.

Parameter: Method of measurement

- Recommended setting value **(_:13051:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient current peaks. Siemens recommends using this method as default setting.

Parameter Value	Description
RMS value	Select this measurement method if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: **Pickup mode**

- Default setting **(_:13051:102) Pickup mode** = ***3 out of 3***

Use the **Pickup mode** parameter to define whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (***3 out of 3***) or if only 1 measuring element has to detect the undercurrent condition (***1 out of 3***).

Parameter: **Threshold**

- Default setting **(_:13051:3) Threshold** = ***0.050 A***

Specify the **Threshold** (pickup threshold) for the specific application.

Parameter: **Operate delay**

- Default setting **(_:13051:6) Operate delay** = ***0.05 s***

Operate delay must be set according to the specific application. No general application notes can be given.

6.16.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:13051:1	Stage 1:Mode		• off • on • test	off
_:13051:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13051:103	Stage 1:Activation		• always active • with CB closed	with CB closed
_:13051:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:13051:102	Stage 1:Pickup mode		• 1 out of 3 • 3 out of 3	3 out of 3
_:13051:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:13051:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.50 s

6.16.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:13051:81	Stage 1:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:13051:54	Stage 1:Inactive	SPS	O
_:13051:52	Stage 1:Behavior	ENS	O
_:13051:53	Stage 1:Health	ENS	O
_:13051:55	Stage 1:Pickup	ACD	O
_:13051:56	Stage 1:Operate delay expired	ACT	O
_:13051:57	Stage 1:Operate	ACT	O

6.17 Negative-Sequence Protection

6.17.1 Overview of Functions

The function **Negative-sequence protection** (ANSI 46):

- Detects 1-phase or 2-phase short circuits in the electrical power system with clearly increased sensitivity compared to the classical overcurrent protection
- Protects electric machines during excessive unbalanced load
- Reports unbalanced load conditions in the electricity supply system
- Detects phase interruptions in the primary system
- Locates short circuits or inversions in the connections to the current transformers

6.17.2 Structure of the Function

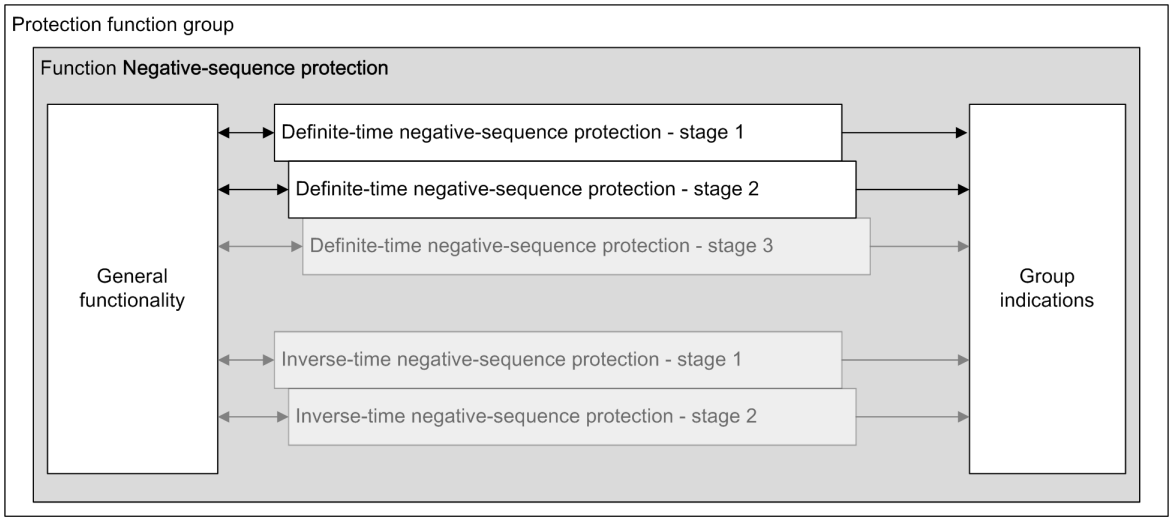
The **Negative-sequence protection** function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 2 **Definite-time negative-sequence protection** stages.

In the function **Negative-sequence protection**, the following stages can be operated simultaneously:

- 3 stages **Definite-time negative-sequence protection**
- 2 stages **Inverse-time negative-sequence protection**

The stages have an identical structure. Stages that are not preconfigured are shown in gray in the following figure.



[dwnspstr-271112-01.tif, 3, en_US]

Figure 6-144 Structure/Embedding of the Function

If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against operate due to transformer-inrush currents.

6.17.3 General Functionality

6.17.3.1 Description

Logic

The following figure represents the logic of the general functionality which applies across all configured stages. It contains:

- Selection of the reference value
- Current-release criterion

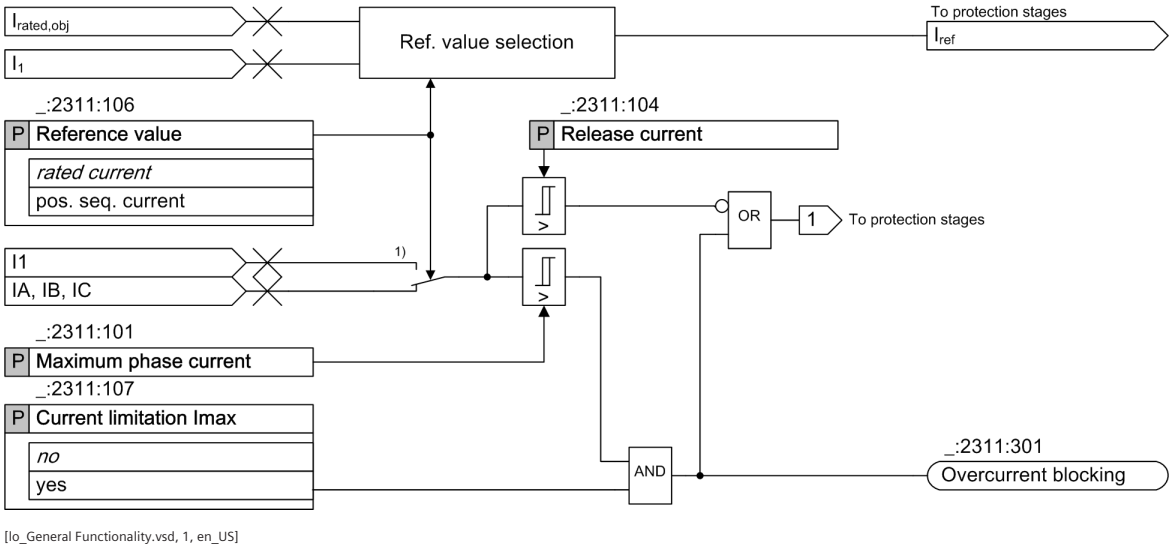


Figure 6-145 Logic Diagram of the General Functionality

(1) Switchover to I_1 with **(_:2311:106) Reference value** = ***pos. seq. current***

Reference Value

With the parameter **Reference value**, the negative-sequence current I_2 is normalized to the rated object current $I_{rated, obj}$ or to the positive-sequence current I_1. When I_2 is normalized to I_1, the sensitivity of the function for low short-circuit currents is increased.

Current Limitation and Maximum Phase Current

With the parameters **Current limitation Imax** and **Maximum phase current**, you restrict the operating range of the function. When the limiting is activated, pickup of the stages is blocked as soon as the maximum phase-current threshold value is exceeded. For more information, refer to the stage description.

Release Current

The threshold value of the **Release current** serves to release the negative-sequence protection.

6.17.3.2 Application and Setting Notes

Parameter: Reference value

- Default setting **(_:2311:106) Reference value** = ***rated current***

With the parameter **Reference value**, you define the normalization of the negative-sequence current I_2 to the rated object current $I_{rated, obj}$ ($I_2/I_{rated, obj}$) or to the positive-sequence current I_1 (I_2/I_1).

Parameter Value	Description
$I_2/I_{rated, obj}$	The negative-sequence current is referred to the rated current of the protected object. This is a preferred normalization for electrical machines, because the permissible limiting values are indicated exclusively referred to the machine rated current. You can also use this normalization for other applications.
I_2/I_1	The normalization of the negative-sequence system to the positive-sequence system yields a higher sensitivity. Use this normalization when detecting interruptions in the primary system.

Set the parameter depending on the application.

Parameter: **Current limitation Imax, Maximum phase current**

- Default setting **(_:2311:107) Current limitation Imax** = ***no***
- Recommended setting value **(_:2311:101) Maximum phase current** = ***10.0 A at 1 A***

If the protection function needs a maximum current limitation, set the value of the **Current limitation Imax** parameter from ***no*** to ***yes***. With the parameter **Maximum phase current**, you set the upper limit of the phase current. CT saturation will cause negative-sequence current in the secondary system. To avoid over-function due to the CT saturation, a suitable phase-current limit value is 10 times of the rated protection-object current.

Parameter: **Release current**

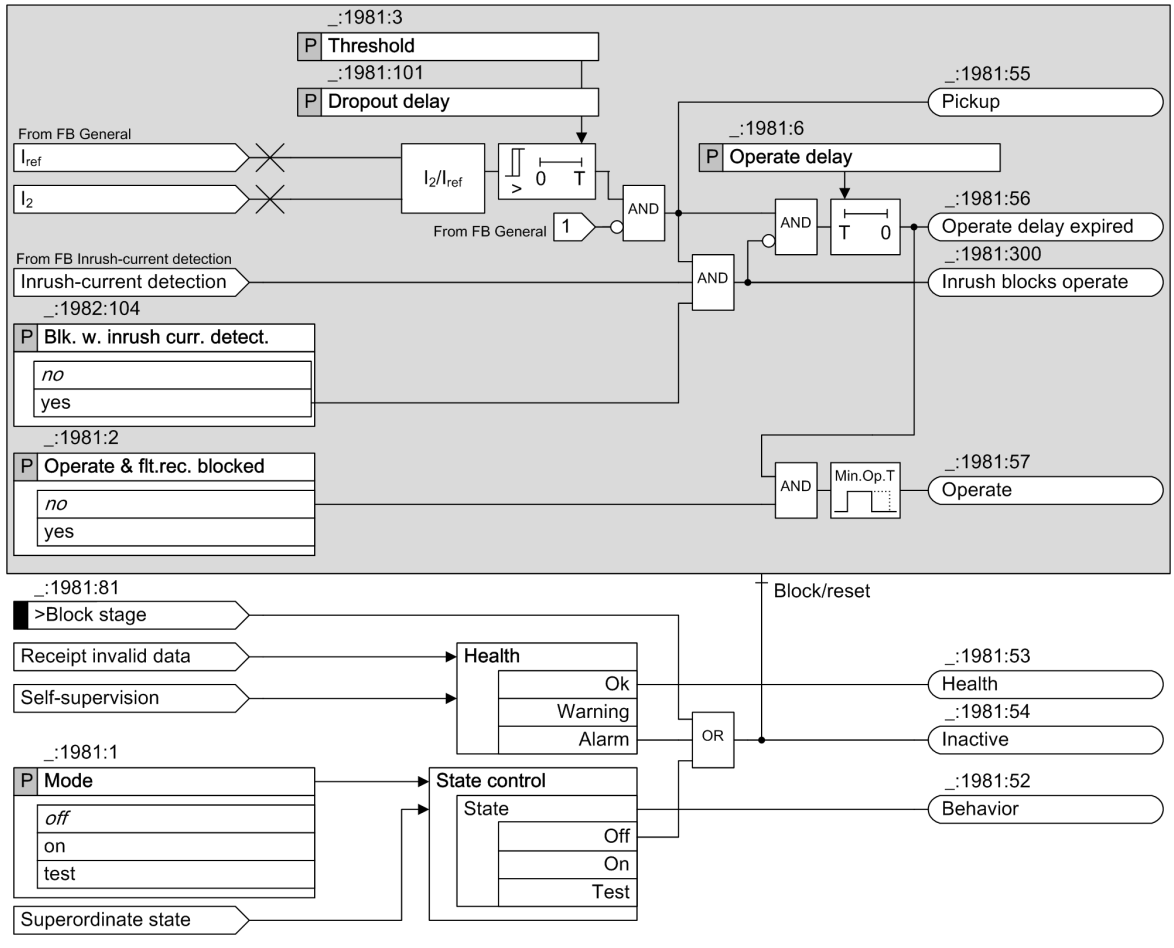
- Recommended setting value **(_:2311:104) Release current** = ***0.05 A at 1 A***

For the safe calculation of negative-sequence currents, the current in at least one phase must be greater than 5 % of the secondary rated device current. For a 1-A device, the value of **Release current** is 0.05 A (0.25 A for a 5-A device).

6.17.4 Stage with Definite-Time Characteristic Curve

6.17.4.1 Stage Description

Logic of a Stage



[logiknsp-070312-01.tif, 2, en_US]

Figure 6-146 Logic Diagram of the Stage Negative-Sequence Protection with Definite-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the **FB General**.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal **`>Block stage`**.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **`Blk. w. inrush curr. detect.`** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a

corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.17.4.2 Application and Setting Notes

Parameter: `Threshold`

- Recommended setting value **`(_:1981:3) Threshold`** = ***`10 %`***

The setting of the parameter **`Threshold`** depends on the respective application. A threshold value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: `Operate delay`

- Recommended setting value **`(_:1981:6) Operate delay`** = ***`1500 ms`***

The setting of the **`Operate delay`** depends on the application. Observe the time grading in the power-system protection and do not set the time for monitoring too short. The default setting is practicable. For motors, the time depends on the permissible time period for the set unbalanced load.

Parameter: `Blk. w. inrush curr. detect.`

- Default setting **`(_:1981:104) Blk. w. inrush curr. detect.`** = ***`no`***

With the parameter **`Blk. w. inrush curr. detect.`**, the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to **`yes`**.

6.17.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:106	General:Reference value		• pos. seq. current • rated current	rated current
_:2311:107	General:Current limitation Imax		• no • yes	no
_:2311:101	General:Maximum phase current	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:2311:104	General:Release current	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
`Definite-T 1`				
_:1981:1	Definite-T 1:Mode		• off • on • test	off
_:1981:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:1981:3	Definite-T 1:Threshold		5.0 % to 999.9 %	10.0 %
_:1981:4	Definite-T 1:Dropout ratio		0.40 to 0.99	0.95

Addr.	Parameter	C	Setting Options	Default Setting
_:1981:104	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:1981:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1981:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.50 s
Definite-T 2				
_:1982:1	Definite-T 2:Mode		• off • on • test	off
_:1982:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:1982:3	Definite-T 2:Threshold		5.0 % to 999.9 %	65.0 %
_:1982:4	Definite-T 2:Dropout ratio		0.40 to 0.99	0.95
_:1982:104	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:1982:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1982:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

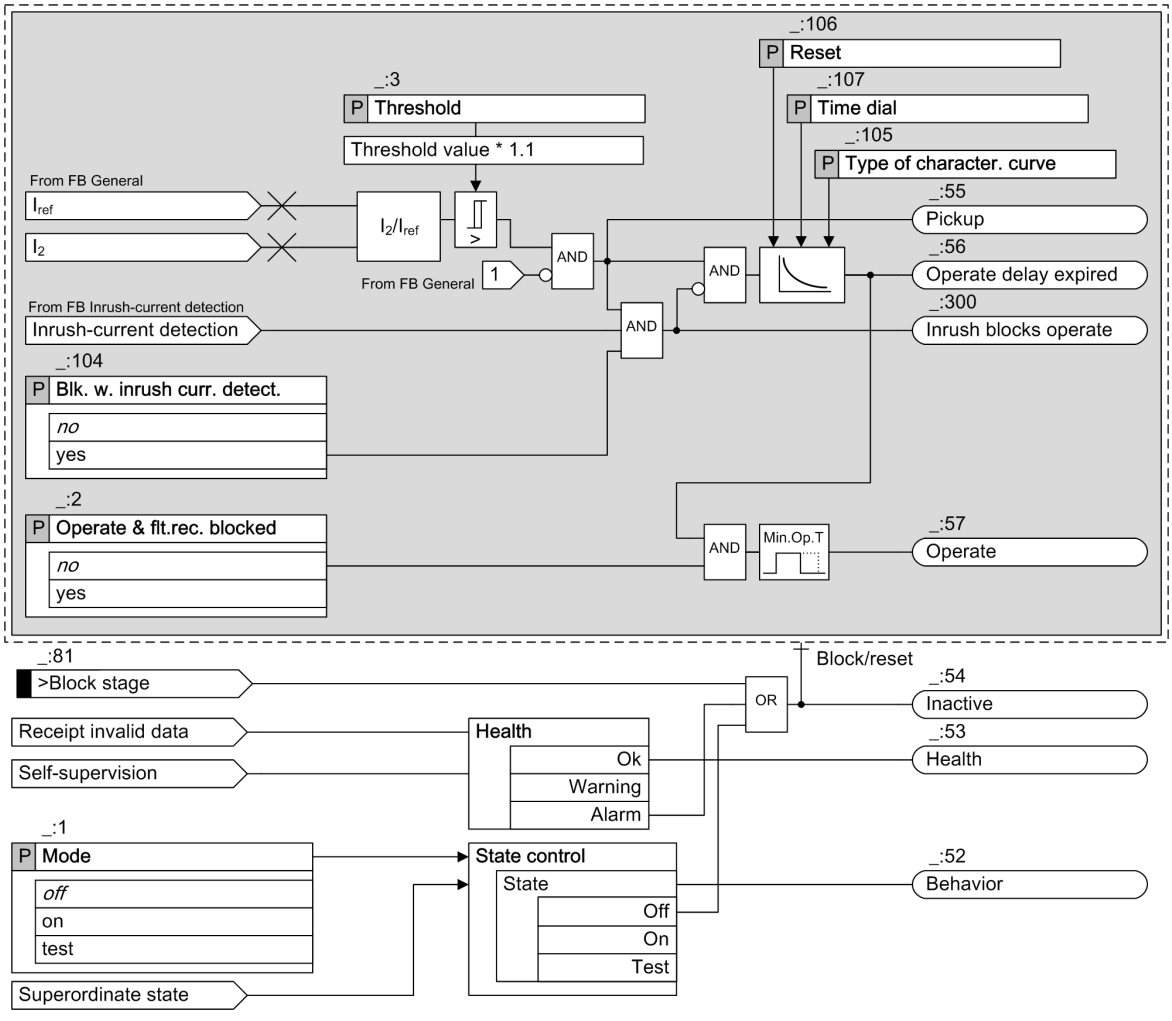
6.17.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Overcurrent blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:1981:81	Definite-T 1:>Block stage	SPS	I
_:1981:52	Definite-T 1:Behavior	ENS	O
_:1981:53	Definite-T 1:Health	ENS	O
_:1981:54	Definite-T 1:Inactive	SPS	O
_:1981:56	Definite-T 1:Operate delay expired	ACT	O
_:1981:300	Definite-T 1:Inrush blocks operate	ACT	O
_:1981:55	Definite-T 1:Pickup	ACD	O
_:1981:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:1982:81	Definite-T 2:>Block stage	SPS	I
_:1982:52	Definite-T 2:Behavior	ENS	O
_:1982:53	Definite-T 2:Health	ENS	O
_:1982:54	Definite-T 2:Inactive	SPS	O
_:1982:56	Definite-T 2:Operate delay expired	ACT	O
_:1982:300	Definite-T 2:Inrush blocks operate	ACT	O
_:1982:55	Definite-T 2:Pickup	ACD	O
_:1982:57	Definite-T 2:Operate	ACT	O

6.17.5 Stage with Inverse-Time Characteristic Curve

6.17.5.1 Description

Logic of a Stage



[lo_NSP_Inverse, 1, en_US]

Figure 6-147 Logic Diagram of the Negative-Sequence Protection with Inverse-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the **FB General**.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the stage picks up, and the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 0.95 (0.95 · 1.1 · threshold value), the dropout is started. The pickup is indicated as clearing. You can influence the dropout behavior via setting

parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal **>Block stage**.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **Blk. w. inrush curr. detect.** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.17.5.2 Application and Settings Notes

Parameter: Type of character. curve

- Default setting **(_:105) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter *12.20.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Threshold

- Recommended setting value **(_:3) Threshold** = ***10.0 %***

The setting of the parameter **Threshold** depends on the respective application. A threshold value of 10 % is a practicable value for fault detection for different applications.

Parameter: Time dial

- Recommended setting value **(_:107) Time dial** = ***1.00***

With the parameter **Time dial**, you displace the characteristic curve in the time direction.

The set value for the parameter **Time dial** is derived from the time-grading schedule that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at 1.00 (default setting).

Parameter: Reset

- Default setting **(_:106) Reset** = ***disk emulation***

With the parameter **Reset**, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:104) Blk. w. inrush curr. detect.** = ***no***

With the parameter **Blk. w. inrush curr. detect.**, the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to ***yes***.

6.17.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:3	Inverse-T #:Threshold		5.0 % to 999.9 %	10.0 %
_:104	Inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:105	Inverse-T #:Type of character. curve			
_:106	Inverse-T #:Reset		• instantaneous • disk emulation	disk emulation
_:107	Inverse-T #:Time dial		0.05 to 15.00	1.00

6.17.5.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:54	Inverse-T #:Inactive	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:300	Inverse-T #:Inrush blocks operate	ACT	O
_:59	Inverse-T #:Disk emulation running	SPS	O
_:55	Inverse-T #:Pickup	ACD	O
_:57	Inverse-T #:Operate	ACT	O

6.18 Directional Negative-Sequence Protection

6.18.1 Overview of Functions

The function **Directional negative-sequence protection with current-independent time delay** (ANSI 46) serves as the backup short-circuit protection for unbalanced faults.

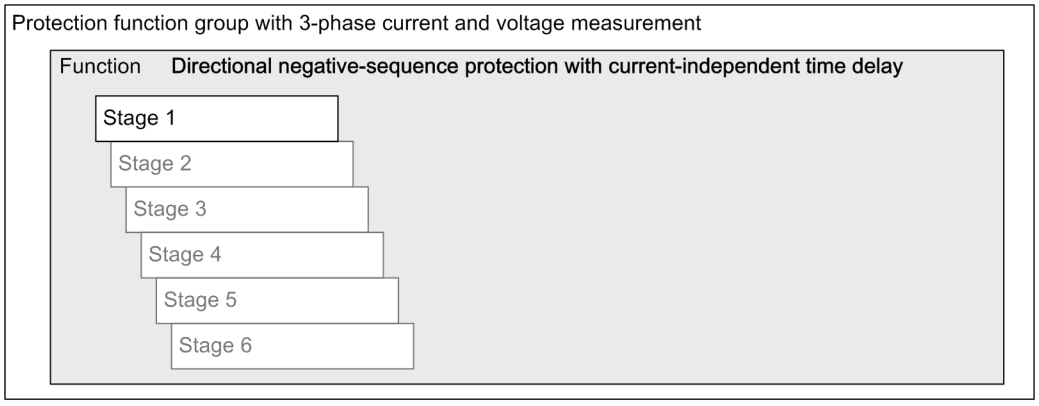
With the negative-sequence system, various supervision and protection tasks can be realized, for example:

- Recording of 1 or 2-phase short circuits in the system with a higher sensitivity than in classic overcurrent protection. The pickup value can be set under the rated object current.
- Recording of phase conductor interruptions in the primary system and in the current-transformer secondary circuits
- Location of short circuits or reversals in the connections to the current transformers
- Indication of unbalanced states in the energy system
- Protection of electrical machines following unbalanced loads that are caused by unbalanced voltages or conductor interruptions (for example, through a defective fuse)

6.18.2 Structure of the Function

The **Directional negative-sequence protection with definite time delay** function can be used in protection function groups with 3-phase current and voltage measurement.

The function comes factory-set with 1 stage. A maximum of 6 tripping stages can be operated simultaneously in the function.



[dwnspdir-271112-01.tif, 1, en_US]

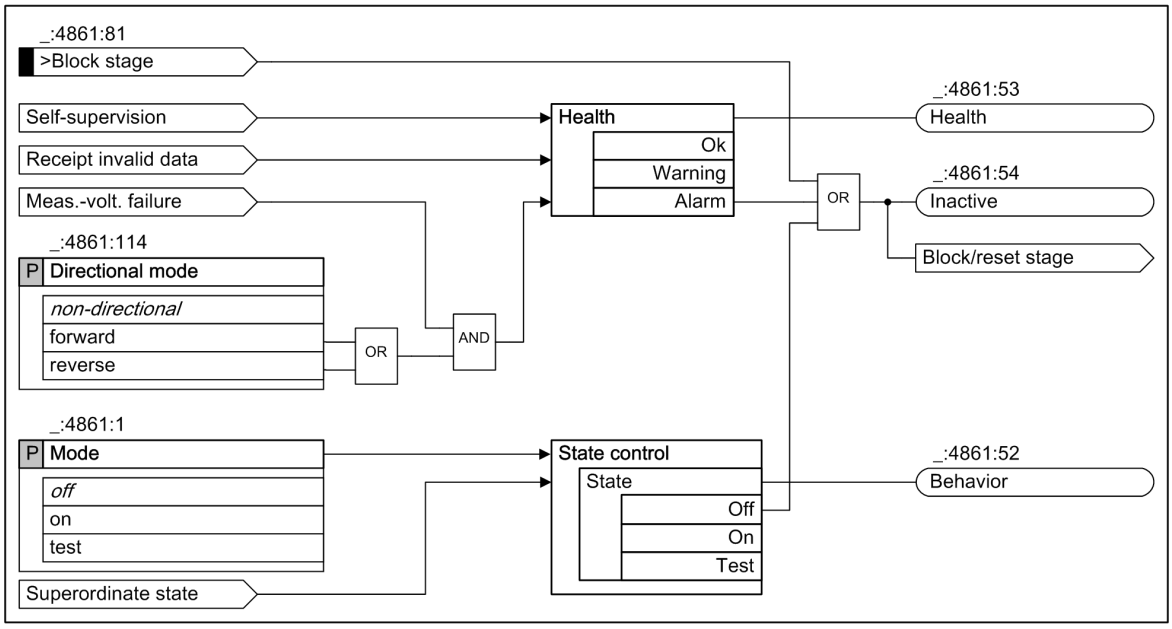
Figure 6-148 Structure/Embedding of the Function

If the device is equipped with the **Inrush-current detection** function, the tripping stages can be stabilized against tripping due to transformer-inrush currents.

6.18.3 Function Description

Stage Control

The following figure shows a stage control. It is available separately for each stage.

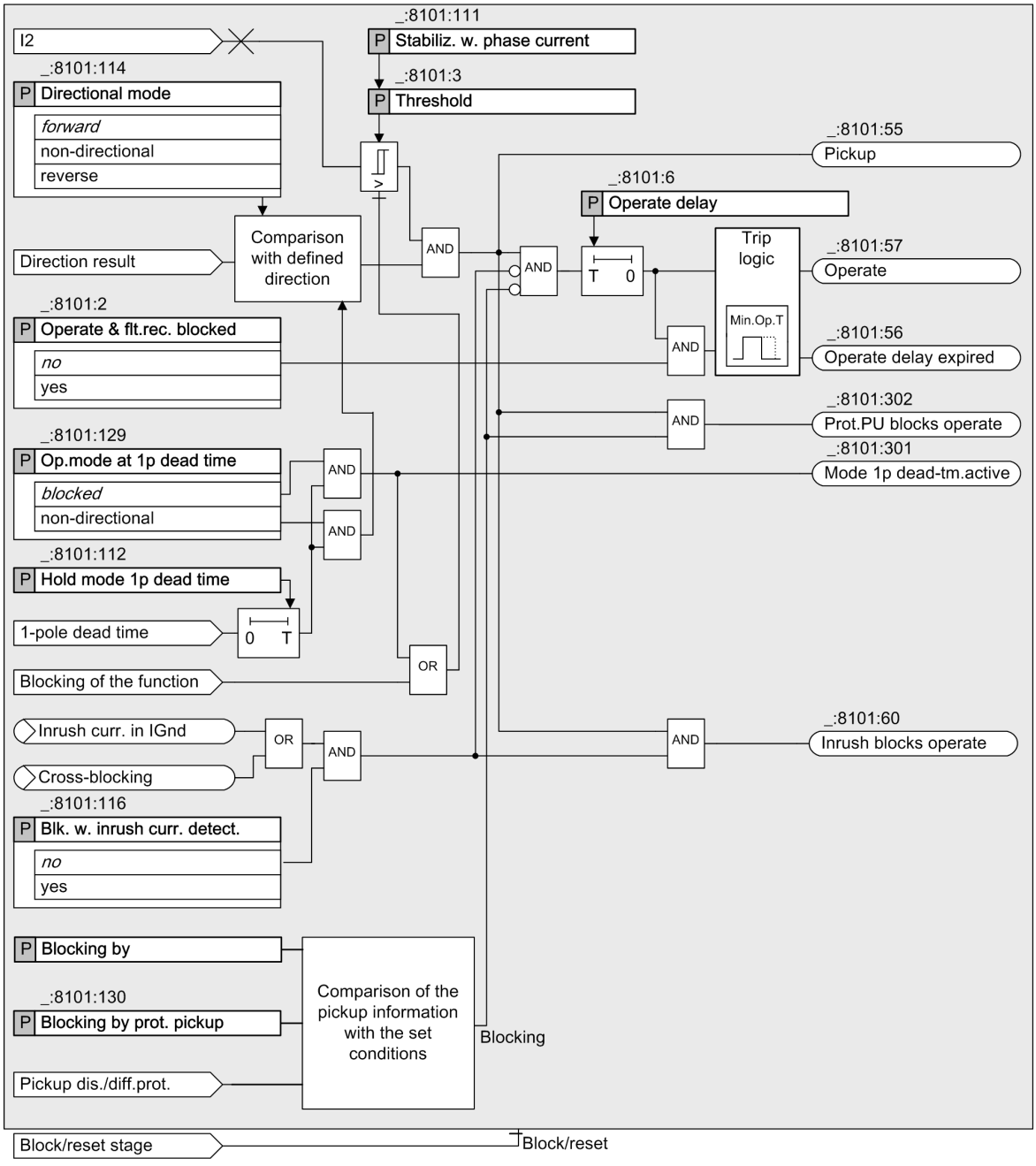


[lostensp-070611-01.tif, 1, en_US]

Figure 6-149 Stage Control of the Directional Negative-Sequence System Protection

In addition to the generally valid stage control, the stage is blocked in the event of a measuring voltage failure, provided the stage is working directionally.

Logic of the Stage



[lonspdir-300112-01.tif, 1, en_US]

Figure 6-150 Logic Diagram of the Function Directional Negative-Sequence System Protection with Current-Independen Time Delay

Measurand

The negative-sequence current I2 is used as a measurand. From the 3-phase currents, the fundamental phasors are determined via a 1-cycle filter and, corresponding with the definition equation of the symmetrical components, the negative-sequence system is calculated from this.

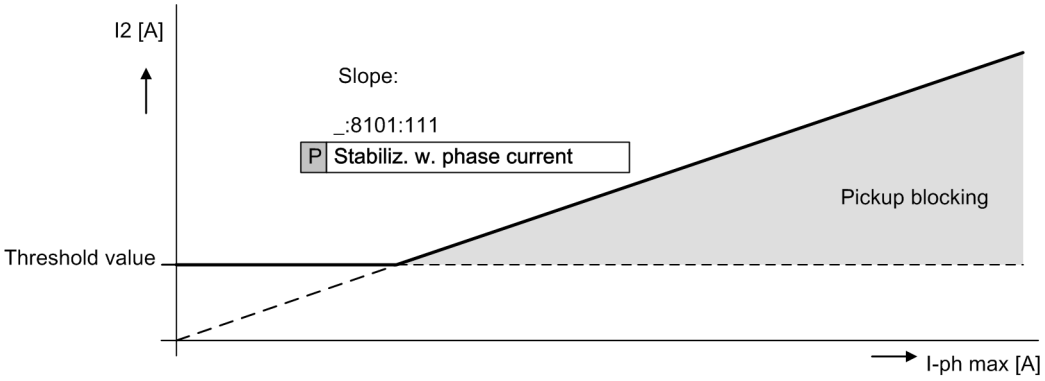
Functioning

The stage picks up if the negative-sequence system current exceeds the set threshold value and the parameterized direction agrees with the measured direction. The pickup drops out if the negative-sequence system current falls below 95 % of the set threshold.

Stabilization with Phase Current

Unbalance in operation and unbalanced transformer ratios can lead to spurious pickups and incorrect tripping. In order to avoid this, the directional negative-sequence system stage is stabilized with the phase currents. The threshold value increases with rising phase currents (see next image).

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.



[dwstabil-300112-01.tif, 1, en_US]

Figure 6-151 Stabilization with Phase Currents

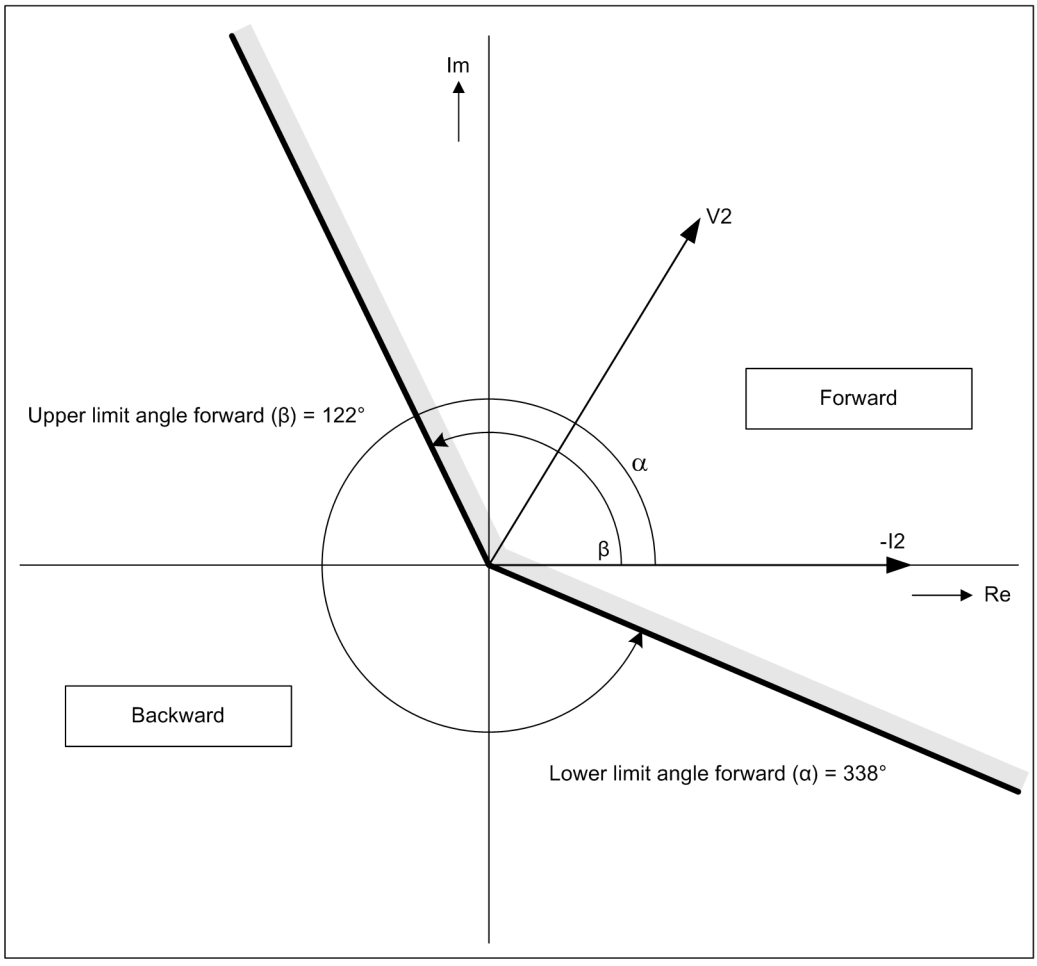
Direction Determination

The direction determination takes place with the negative-sequence system measurements I2 and V2.

The forward and reverse region is defined through the parameters **Angle forward α** and **Angle forward β** (see next figure). The reference for the 2 angles that must be set is the positive real axis. The angles are positively defined in a mathematical sense (counter-clockwise). The region between the limit angle α and the limit angle β - counted from the former in a positive direction - is the forward region. The remaining region is the reverse region.

For determining of the direction, the function places the measuring current I2 on the real axis. If the phasor of the negative-sequence system voltage V2 is located within the defined forward region, the function determines the direction as *forward*. In the other case, the function determines the direction as *reverse*.

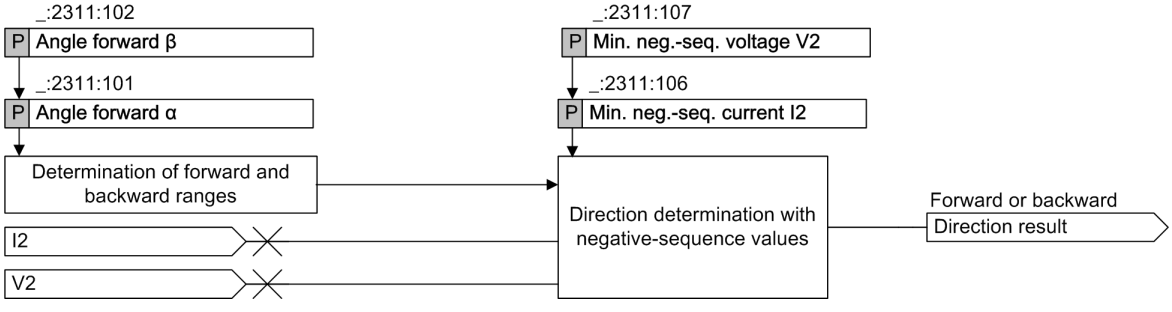
The requirement for determining the direction is that the adjustable minimum variables have been exceeded for the negative-sequence system current and negative-sequence system voltage (parameters **Min. neg.-seq. current I2** and **Min. neg.-seq. voltage V2**).



[dwphasor-140212-01.tif, 1, en_US]

Figure 6-152 Phasor Diagram for Direction Determination with Negative-Sequence System Values

If the device determines a fault in the voltage-transformer secondary circuit (through the binary input *voltage transformer circuit-breaker dropout* or through **measuring-voltage failure detection**), direction determination will be disabled and every directionally set stage will be blocked. Non-directionally set stages become active again if there are faults in the voltage-transformer secondary circuit.



[lorichtu-070611-01.tif, 1, en_US]

Figure 6-153 Logic of Direction Determination

Directional Mode

You use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction. Non-directional operation is also possible.

Blocking the Tripping by Pickup of the Main Protection Functions

The pickup and type of pickup for the main protection functions can block the tripping of the stage. You can perform this setting via 2 parameters:

- **Blocking by**

  This setting is used to select the zone or stage at which blocking is to occur in the event of pickup.

- **Blocking by prot. pickup**

  The pickup type at which the blocking is to occur is defined with this parameter. The blocking can occur at any pickup or only at 1-pole or only at multipole pickups.

  This parameter is also used to set that no blocking should occur when the main protection has picked up.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

If the device is equipped with the additional **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer inrush currents.

With the **Blk. w. inrush curr. detect.** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.18.4 Application and Setting Notes for Direction Determination

Parameter: Limit Angle Region Forward

- Recommended setting value **(_:2311:101) Angle forward α** = ***338°***
- Recommended setting value **(_:2311:102) Angle forward β** = ***122°***

With the parameters **Angle forward α** and **Angle forward β**, you can change the location of the directional characteristic curve.

Siemens recommends using the defaults, because the function with these settings reliably determines the direction.

Parameter: Minimum Negative-Sequence System Variables V2 and I2

- Default setting **(_:2311:107) Min. neg.-seq. voltage V2** = ***0.7 V***
- Default setting **(_:2311:106) Min. neg.-seq. current I2** = ***0.05 A***

With the parameters **Min. neg.-seq. voltage V2** and **Min. neg.-seq. current I2**, you can specify the minimum negative-sequence system values for direction determination with V2 and I2. The set limiting values must not be exceeded by operational unbalances.

6.18.5 Application and Setting Notes for Stages

Parameter: Directional mode

- Default setting **(_:8101:114) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
non-directional	If the stage is to work in the forward and reverse direction (in the direction of the line and busbar), then select this setting. The stage will work with this setting even if no direction measurement is possible, for example due to insufficient polarization voltage (or none at all), or due to failure of the measuring voltage.

Parameter Value	Description
forward	Select these settings if the stage is only to work in a forward direction (in direction of the line).
reverse	Select this setting if the level is only to work in the reverse direction (in the direction of the busbar).

Parameter: Blk. w. inrush curr. detect.

If the device is equipped with the additional **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer inrush currents.

- Default setting **(_:8101:116) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: 1) In cases where the device is not used on transformers. 2) In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer.
yes	When the transformer inrush current detection detects an inrush current that can lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer.

Parameter: Blocking by the main Protection

- Recommended setting value **(_:8101:140) Blocking by** =

If you wish to give selective fault clarification through the main protection function precedence over tripping through the directional negative-sequence protection, you can define this via the 2 parameters **Blocking by** and **Blocking by prot. pickup**. The **Blocking by** parameter is used to select the zones or tripping stages of the main protection function(s), upon whose pickup the negative-sequence protection is to be blocked.

Parameter: Blocking by prot. pickup

- Default setting **(_:8101:130) Blocking by prot. pickup** = ***every pickup***

The **Blocking by prot. pickup** parameter can be used to define the type of pickup, which leads to the blocking.

Parameter Value	Description
every pickup	Blocking at every pickup
1-phase pickup	Blocking only at 1-pole pickup
multi-phase pickup	Blocking only at multipole pickup
no pickup	If the pickup of the main protection function should not lead to blocking of the negative-sequence protection, select this setting.

Parameter: Hold mode 1-p dead time

- Default setting **(_:8101:112) Hold mode 1p dead time** = ***0.040 s***

The **Hold mode 1p dead time** setting is used to define the time by which the device-internal signal for the 1-pole interruption is extended after the end of the 1-pole interruption.

At all line ends, there is no simultaneous switch-in after a 1-pole dead time. Thus, the parameterized operating mode for a 1-pole dead time must be retained for a certain time after the switch-in (end of the 1-pole dead time) until the other end or ends have securely switched in. The time to be set here corresponds to the maximum time between the switch-in of the 1st circuit breaker and the switch-in of the last circuit breaker at all ends of the feeder after a 1-pole dead time.

NOTE

The **Hold mode 1p dead time** setting is only available in devices with 1-/3-pole tripping. In devices with 3-pole tripping, this setting does not apply.

Parameter: Stabiliz. w. phase current

- Recommended setting value **(_:8101:111) Stabiliz. w. phase current** = ***10 %***

In order to avoid unwanted pickups and tripping, the negative-sequence system current stage is stabilized with the phase currents.

More information can be found in chapter *6.18.3 Function Description*.

The threshold value increases as the phase currents increase.

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.

Siemens recommends a default setting of 10 % under normal operations.

Parameter: Threshold

- Default setting **(_:8101:3) Threshold** = ***1.5 A***

Define the pickup value corresponding to the application. In doing so, for the time-graded stages, the setting for the superordinate and subordinate stages must be taken into account in the grading chart.

With a very sensitive setting, you must make sure that the negative-sequence system current does not lead to undesired response of the stage due to unbalance (for example non-twisted line).

Parameter: Operate delay

- Default setting **(_:8101:6) Operate delay** = ***0.30 s***

The tripping delay (time delay) to be set is derived from the time-grading schedule that has been prepared for the system.

When selecting the current and time setting, pay attention to whether the stage must work dependent on the direction.

6.18.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle forward α		0 ° to 360 °	338 °
_:2311:102	General:Angle forward β		0 ° to 360 °	122 °
_:2311:107	General:Min. neg.-seq. voltage V2		0.150 V to 34.000 V	1.213 V
_:2311:106	General:Min. neg.-seq. current I2	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:8101:1	Definite-T 1:Mode		• off • on • test	off
_:8101:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8101:114	Definite-T 1:Directional mode		• non-directional • forward • reverse	forward
_:8101:111	Definite-T 1:Stabiliz. w. phase current		0 % to 30 %	10 %
_:8101:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8101:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
_:8101:116	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8101:130	Definite-T 1:Blocking by prot. pickup		• every pickup • 1-phase pickup • multi-phase pickup • no pickup	every pickup
_:8101:129	Definite-T 1:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:8101:112	Definite-T 1:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:8101:140	Definite-T 1:Blocking by		Setting options depend on configuration	

6.18.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Test of direction	SPS	I
_:2311:300	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:8101:81	Definite-T 1:>Block stage	SPS	I
_:8101:54	Definite-T 1:Inactive	SPS	O
_:8101:52	Definite-T 1:Behavior	ENS	O
_:8101:53	Definite-T 1:Health	ENS	O
_:8101:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8101:302	Definite-T 1:Prot.PU blocks operate	SPS	O
_:8101:301	Definite-T 1:Mode1p dead-tm.active	SPS	O
_:8101:55	Definite-T 1:Pickup	ACD	O
_:8101:56	Definite-T 1:Operate delay expired	ACT	O
_:8101:57	Definite-T 1:Operate	ACT	O

6.19 Thermal Overload Protection, 3-Phase

6.19.1 Overview of Functions

The **Thermal overload protection** function (ANSI 49) is used to:

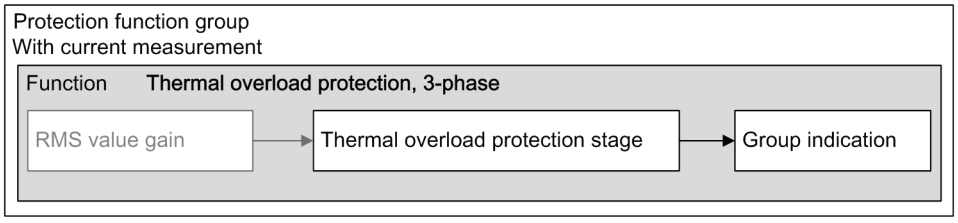
- Protect the equipment (motors, generators, transformers, capacitors, overhead lines, and cables) against thermal overloads
- Monitor the thermal state of motors, generators, transformers, capacitors, overhead lines, and cables

6.19.2 Structure of the Function

The **Thermal overload protection, 3-phase** function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 1 **Thermal overload protection** stage.

The non-preconfigured function block **Filter** can optionally be applied to gain the RMS value used by the **Thermal overload protection** stage.



[dw_TOLP_with Filter stage, 1, en_US]

Figure 6-154 Structure/Embedding of the Function

6.19.3 Filter for RMS Value Gain

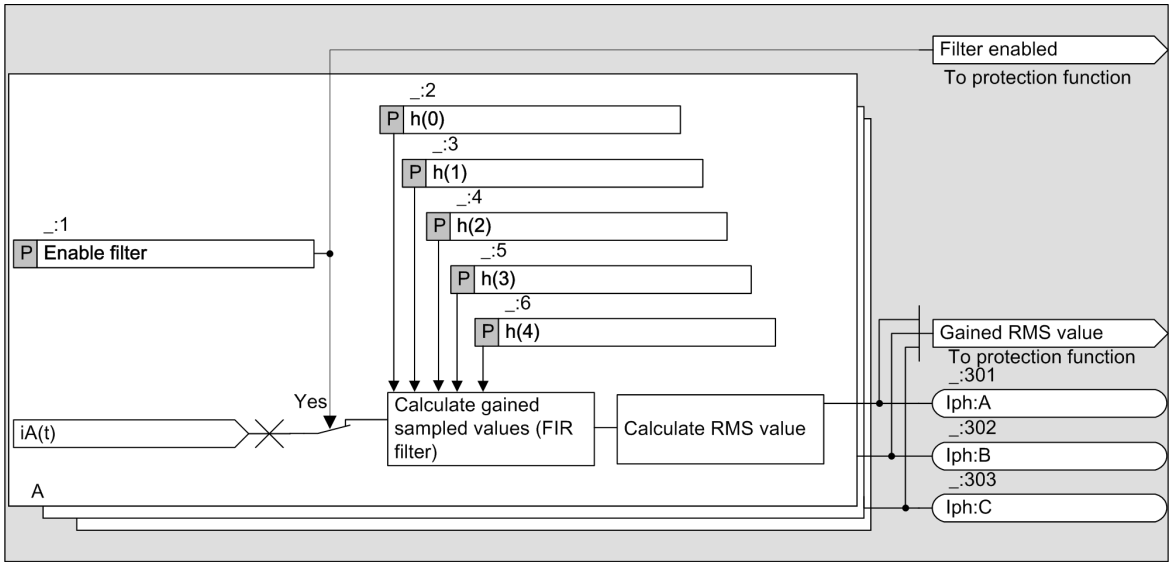
6.19.3.1 Description

The function block **Filter** can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter
- To only compensate the amplitude attenuation of higher frequencies by the device (due to the anti-aliasing filter)

The filter gain (amplitude response) is realized by a 9-order FIR filter.

Logic



[lo_TOLP_FilterStage, 1, en_US]

Figure 6-155 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the respective parameters **h(0)**, **h(1)**, **h(2)**, **h(3)** and **h(4)**.

NOTE

A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block **Filter** is instantiated and the parameter **Enable filter** is set as ***yes*** . Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Filtered RMS measured value of current A	kA	A	Parameter **Rated current**
Iph:B	Filtered RMS measured value of current B	kA	A	Parameter **Rated current**
Iph:C	Filtered RMS measured value of current C	kA	A	Parameter **Rated current**

You can find the parameter **Rated current** in the **FB General** of function groups where the **Thermal overload protection** function is used.

If the parameter **Enable filter** is set to ***no***, the function values are shown as ---.

6.19.3.2 Application and Setting Notes

Parameter: Enable filter

- Default setting **(_:1) Enable filter** = ***no***.

With the parameter **Enable filter**, you set whether the **Filter** is enabled.

Parameter Value	Description
yes	If gained RMS values should be used in one of the protection stages, set parameter **Enable filter** = ***yes***.
no	If no gained RMS values are needed, set the parameter **Enable filter** = ***no***.

Parameter: **h(0),h(1),h(2),h(3),h(4)**

- Default setting **(_:2) h(0)** = ***0.000***
- Default setting **(_:3) h(1)** = ***0.000***
- Default setting **(_:4) h(2)** = ***0.000***
- Default setting **(_:5) h(3)** = ***0.000***
- Default setting **(_:6) h(4)** = ***1.000***

With the default value of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.19.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

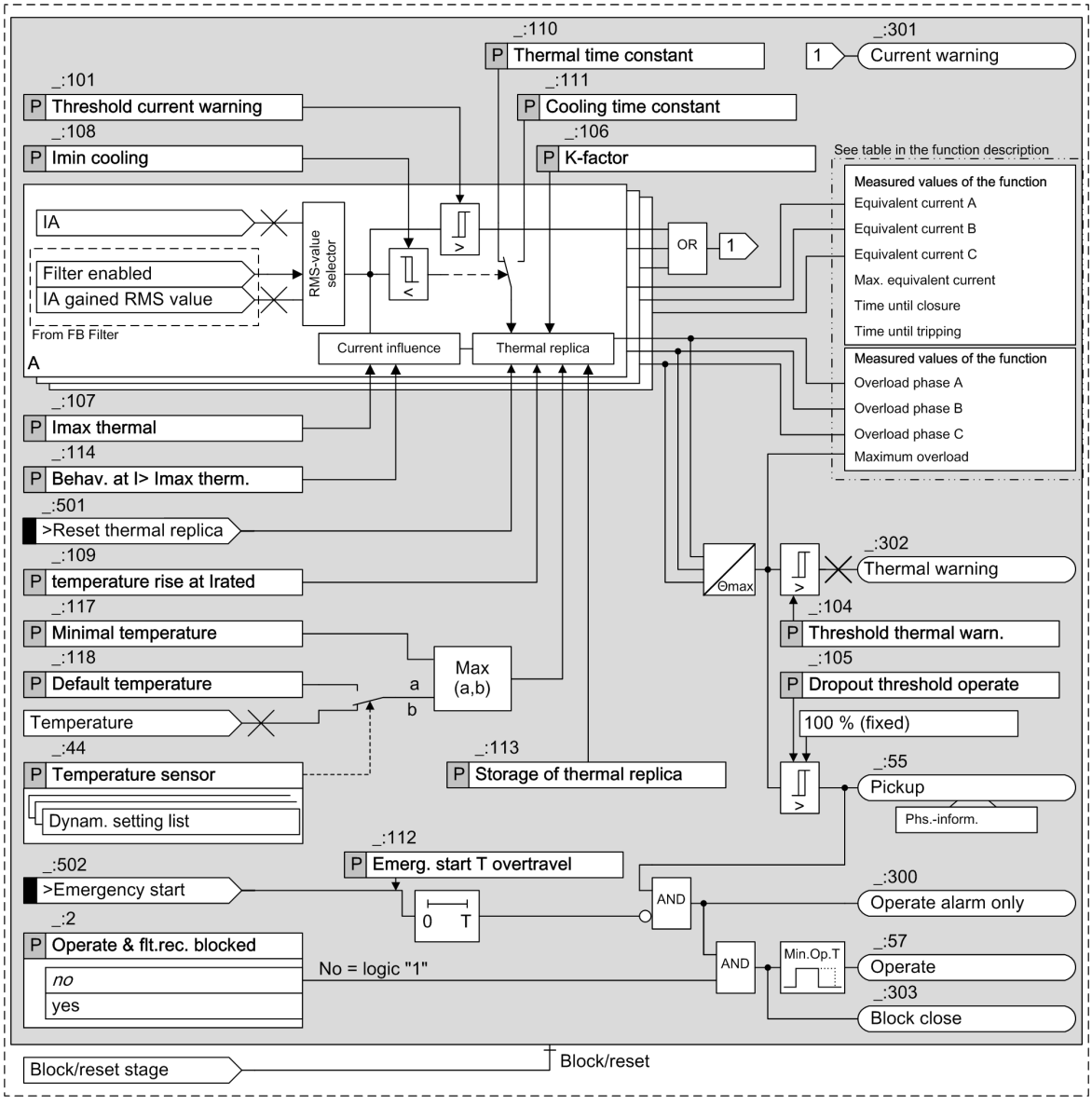
6.19.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O

6.19.4 Stage with Thermal Overload Protection

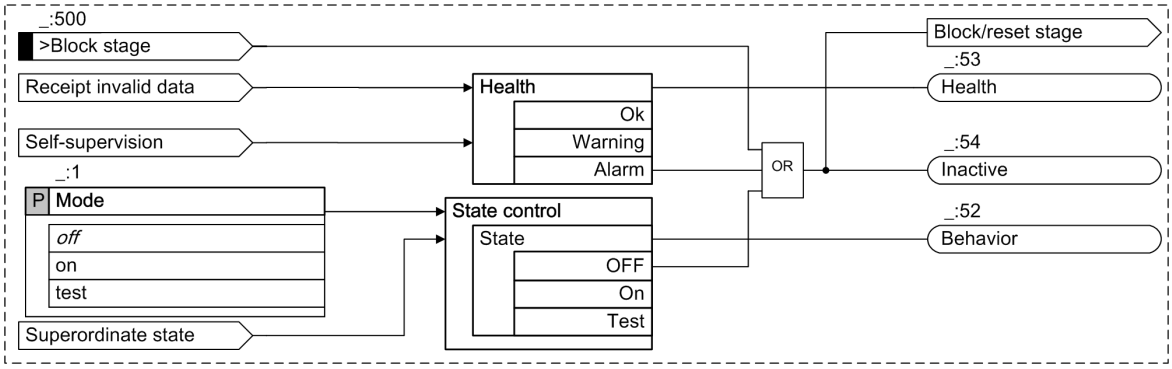
6.19.4.1 Description

Logic



[lo_TOLP_withFilterstage, 1, en_US]

Figure 6-156 Logic Diagram of the Thermal Overload Protection Stage



[lo_Stage Control, 1, en_US]

Figure 6-157 Logic Diagram of the Stage Control

RMS-Value Selection

The protection function supports 2 kinds of RMS measurement:

- Normal RMS value
- Gained RMS value from the function block **Filter**

The gained RMS value is automatically used if the function block **Filter** is configured and the filter has been enabled.

NOTE

When the function block **Filter** is applied, only one current measuring point I-3ph is allowed to be connected to the 3-phase current interface of the function group.

Thermal Replica

The protection function calculates the overtemperature from the phase currents based on a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\theta}{dt} + \theta - \theta_{Amb}$$

[fo_diffgl-170914, 2, en_US]

With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{K \cdot I_{rated\ ,obj.}} \qquad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{K^2 \cdot \Delta\vartheta_{rated\ ,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \theta_{Amb} = \frac{\vartheta_{Amb} - 40\ °C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\ °C}{K^2 \cdot \Delta\vartheta_{Amb\ ,obj.}}$$

[fo_normie-170914, 2, en_US]

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current k $I_{rated, obj}$
Θ_{Amb}	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the **`Default temperature`** parameter.
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object

k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated, obj}$)
$I_{rated, obj}$	Rated current of the protected object

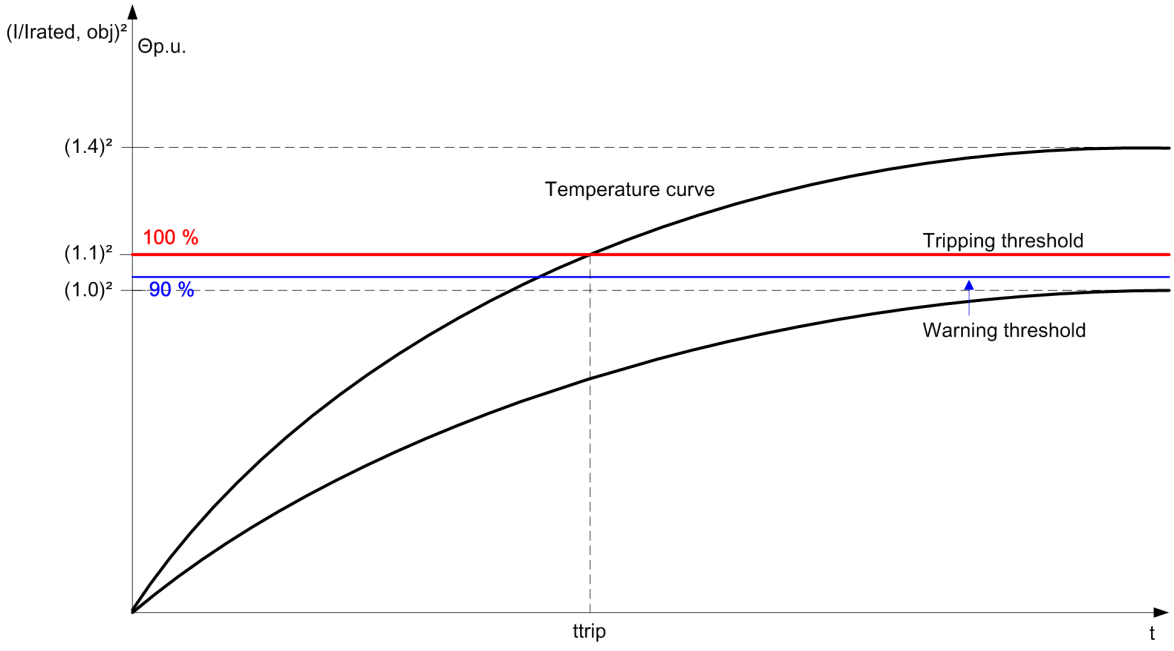
At the same time, $I_{rated, obj}$ is the rated current of the assigned protected object side:

- In the case of transformers, the rated current of the winding to be protected, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- The uncontrolled winding forms the basis in the case of transformers with voltage control
- In the case of generators, motors and reactors, the rated current, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- In the case of lines, nodes and busbars, the rated current of the protected object is set directly

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (**Threshold thermal warn.**), a warning indication is given.

If the overtemperature limit Θ_{Off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-158 shows the temperature rise at different overload currents and the supervision thresholds.



[dwtempve-030211-01.tif, 1, en_US]

Figure 6-158 Temperature History for Different Overload Currents (**K-factor** = ***1.1***)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

If the flowing current falls below an adjustable minimum current **Imin cooling** , the **Cooling time constant** is activated.

Operate Curve

If the ambient temperature is not measured and set to 40°C, you can get the operate curve as following:

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$$

[foauslos-211010-01.tif, 1, en_US]

t	Operate time
τ_{th}	Time constant
I	Measured load current
$I_{preload}$	Preload current
k	Setting factor according to VDE 0435 part 3011 or IEC 60255-8 (K factor)
$I_{rated, obj}$	Rated current of the protected object

Ambient Temperature

This function can take the ambient temperature into consideration. The reference temperature of the thermal model is 40°C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The **`Default temperature`** parameter can be used to fix or measure the ambient temperature. The **`Minimal temperature`** parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter **`Temperature rise at Irated`**).

The measured ambient temperature is measured by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions **RTD unit Ether.** or **RTD unit serial** of the function group **Analog transformer**. When using the **`Temperature sensor`** parameter, the respective temperature sensor can be selected.

If the temperature measurement is faulty, for example, due to an open circuit between the device and the RTD unit, the device reports this. In this case, the process continues with either the temperature measured last or the value set under the **`Default temperature`** parameter, depending on which value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding **`I`** $_{threshold}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal **`K-factor`** of ***`1.1`*** , a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate** , the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see Technical Data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the setting parameter **Storage of thermal replica** . You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication **>Reset thermal replica** . The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal **>Emergency start** , tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input **>Emergency start** disappears, the blocking remains in effect for the set **Emerg. start T overtravel** .

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal **>Block stage** .

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.19.4.2 Application and Setting Notes

Parameter: **Threshold current warning**

- Recommended setting value **(_:101) Threshold current warning** = ***1.1 A*** at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for the **K-factor** .

Parameter: **Threshold thermal warn.**

- Recommended setting value **(_:104) Threshold thermal warn.** = ***90 %***

The default setting can be left at a **K-factor** , of ***1.1***, as the thermal memory results for 83 % at continuously flowing rated current. The calculation uses the rule of three: 100 % corresponds to (**K-factor**)^2 and x % corresponds to 1^2.

$$\frac{\Theta}{\Theta_{off}} = \frac{100\ \%}{k^2} = 83\ \%$$

[fowarnsc-100810-01.tif, 2, en_US]

At a **K-factor** of 1.05, the thermal memory for rated current is already 91 % filled. Increase the **Threshold thermal warn.** to 95 %.

Parameter: **Dropout threshold operate**

- Recommended setting value **(_:105) Dropout threshold operate** = ***90 %***

The **Dropout threshold operate** parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value **Time until close** refers to this value.

Parameter: **Emerg. start T overtravel**

- Default setting **(_:112) Emerg. start T overtravel** = ***6300 s***

This functionality is not required for protection of lines and cables. If the logical binary indication is not routed, the **Emerg. start T overtravel** will be ineffective. The **Emerg. start T overtravel** presetting can therefore be retained.

Parameter: **K-factor**

- Recommended setting value **(_:106) K-factor** = ***1.1***

The **K-factor** parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated, obj}$ of the protected object (for example, cable) is the basic current for overload sensing.

You can determine the **K-factor** on the basis of the thermally permissible continuous current $I_{max, perm.}$:

$$K\text{-factor} = \frac{I_{max,perm.}}{I_{rated,obj.}}$$

[fotolpkf-100810-01.tif, 2, en_US]



NOTE

The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer!

In the case of cables, the permissible continuous current depends on the cross-section, insulation material, design type, and the manner in which the cables have been laid. In the case of overhead lines, an overload of 10 % is permissible.

EXAMPLE

For the Permissible Continuous Current

Cross-linked polyethylene cables (N2XS2Y): 10 kV 150 mm^2 (Cu)

Current-carrying capacity (underground laying): $I_{max, perm}$ = 406 A

Selected **`K factor`** of 1.1

This yields a rated current of $I_{rated, obj}$= 369 A

Parameter: `Thermal time constant`

- Recommended setting value **`(_:110) Thermal time constant`** = ***`2777 s (46.29 min)`***

The **`Thermal time constant`** parameter is used to define the tripping characteristics of the stage. If no data on the **`Thermal time constant`** is available, you can determine this from the short-time current-rating capacity of the cable, for example, from the 1-s current. The 1-s current is the maximum current permissible for 1 s application time. The 1-s current can be found in the cable specifications. Calculate the **`Thermal time constant`** according to the following formula:

$$\tau[\text{min}] = \frac{1}{60}\left(\frac{\text{perm. 1–s–current}}{\text{perm. continuous current}}\right)^2$$

[fodauers-170309-07.tif, 2, en_US]

If the short-term current-rating capacity is specified for an application time other than 1 s, use the short-time current instead of the 1-s current. Multiply the result by the specified application time.

For a given short-term current-carrying capacity of 0.5 s, use the following formula:

$$\tau[\text{min}] = \frac{0.5}{60}\left(\frac{\text{perm. 0.5–s–current}}{\text{perm. continuous current}}\right)^2$$

[fodauers-170309-01.tif, 2, en_US]

EXAMPLE for a Cable

For a cable

Permissible continuous current: $I_{max, perm}$ = 406 A

Maximum short-circuit current for 1 s: I_{1s} = 21.4 kA

Therefore, for the **`Thermal time constant`**, it follows

$$\tau\ [\text{min}] = \frac{1}{60}\left(\frac{21400\ \text{A}}{406\ \text{A}}\right)^2 = \frac{1}{60}52.7^2 = 46.29\ \text{min}$$

[fokonsta-310510-01.tif, 2, en_US]

with 46.29 min = 2777 s

Parameter: `Cooling time constant`

- Recommended setting value **`(_:111) Cooling time constant`** = ***`2777 s`***

The **`Cooling time constant`** parameter is used to define the dropout behavior of the stage. Cables and overhead lines have the same time constant for both heating and cooling. Therefore, set the same value for the **`Cooling time constant`** as for the parameter **`Thermal time constant`**.

Parameter: `Imax thermal`

- Recommended setting value **`(_:107) Imax thermal`** = ***`2.5 A`*** at I_{rated} = 1 A

The **`Imax thermal`** parameter allows you to set the threshold current for the **`Behav. at I> Imax therm.`** parameter. The selected threshold current of 2.5 $I_{rated, obj}$ is a practicable value.

Parameter: `Imin cooling`

- Recommended setting value **`(_:108) Imin cooling`** = ***`0 A`***

If only the thermal time constant (parameter **`Thermal time constant`**) must provide protection, set the current parameter **`Imin cooling`** to 0 A.

Parameter: `Temperature rise at Irated`

- Default setting **`(_:109) Temperature rise at Irated`** = ***`70 K`***

As a value, set the overtemperature that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the technical data of the equipment or measure it. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40°C.

The overtemperature at maximum permissible current (***`ϑmax`***) and the **`Temperature rise at Irated`** (***`ϑrated,obj.`***) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated\ ,obj.}} \right)$$

[fo_ueb_for_Irated, 3, en_US]

EXAMPLE:

Temperature class **B** for continuous operation: permissible overtemperature = 80 K
From this, a temperature for I_{rated} of 120°C (80 K + 40°C) can be derived when using a temperature sensor for the measurement.
Temperature class **F** as thermal limiting value: permissible overtemperature = 105 K.
From this, a maximum temperature of 155°C (105 K + 40°C) derives.

From these values, the K factor can be derived:

$$k^2 = \frac{\Delta\vartheta_{max\ ,Obj.}}{\Delta\vartheta_{rated\ ,Obj.}} = \frac{105\ K}{80\ K} = 1.31 \qquad \rightarrow\ k = 1.146$$

[fo_bsp_kfaktor, 3, en_US]

If you select a setting value of 1.1 for the **`K-factor`**, your selection can be considered as conservative.

NOTE

For electrical machines, the limits can vary depending on the type of coolant.
Consult the machine manufacturer to agree on a setting value for the overtemperature.

Parameter: `Storage of thermal replica`

- Recommended setting value **`(_:113) Storage of thermal replica`** = ***`no`***

If a continuous auxiliary voltage for the bay units is ensured, the bay default setting can be retained.

Parameter: **Behav. at I> Imax therm.**

- Recommended setting value **(_:114) Behav. at I> Imax therm.** = ***freeze therm. rep.***

The **Behav. at I> Imax therm.** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.

The default setting has been selected to be compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the ***current limiting*** procedure is recommended.

Parameter Value	Description
freeze therm. rep.	If input currents exceed the **Imax thermal** parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products!
current limiting	The input currents are limited to the value set in the **Imax thermal** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.

Parameter: **Temperature sensor**

- Default value **(_:44) Temperature sensor** = ***none***

With the **Temperature sensor** parameter, you determine which temperature sensor to use to detect the ambient temperature.

A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and feed it to the device via an RTD unit. The **Thermal overload protection** function receives the measured temperature value via the functions **RTD unit Ether.** or **RTD unit Serial** from the function group **Analog transformer**.

Parameter: **Default temperature**

- Recommended setting value **(_:118) Default temperature** = ***40 °C***

The **Default temperature** is set as ambient temperature under the following conditions:

- No temperature sensor for measuring the ambient temperature is connected.
- The temperature measurement is faulty and the last measured temperature value is less than the **Default temperature**.

Siemens recommends using the default setting.

Parameter: **Minimal temperature**

- Default setting **(_:117) Minimal temperature** = ***-20 °C***

If the measured ambient temperature drops below the set value, the set value is assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the **Minimal temperature** parameter, the **Minimal temperature** is also used.

6.19.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:112	49 Th.overl. #:Emerg. start T overtravel		0 s to 15000 s	300 s
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:111	49 Th.overl. #:Cooling time constant		10 s to 60000 s	3600 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:108	49 Th.overl. #:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Temperature sensor		Setting options depend on configuration	

6.19.4.4 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:502	49 Th.overl. #:>Emergency start	SPS	I

No.	Information	Data Class (Type)	Type
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload phase A	MV	O
_:307	49 Th.overl. #:Overload phase B	MV	O
_:308	49 Th.overl. #:Overload phase C	MV	O
_:309	49 Th.overl. #:Overload maximum	MV	O
_:310	49 Th.overl. #:Equival. current phs A	MV	O
_:311	49 Th.overl. #:Equival. current phs B	MV	O
_:312	49 Th.overl. #:Equival. current phs C	MV	O
_:313	49 Th.overl. #:Equival. current max.	MV	O

6.20 Thermal Overload Protection, User-Defined Characteristic Curve

6.20.1 Overview of Functions

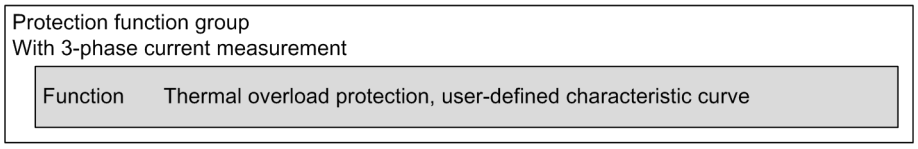
The **Thermal overload protection, user-defined characteristic curve** function (ANSI 49) is used to:

- Protect the equipment (motors, generators, and transformers) against thermal overloads
- Realize a manufacturer specific overload characteristic curve for specific equipment, for example, shunt reactors
- Monitor the thermal state of motors, generators, and transformers

6.20.2 Structure of the Function

The **Thermal overload protection, user-defined characteristic curve** function is used in protection function groups with 3-phase current measurement.

The **Thermal overload protection, user-defined characteristic curve** function is steplessly preconfigured.

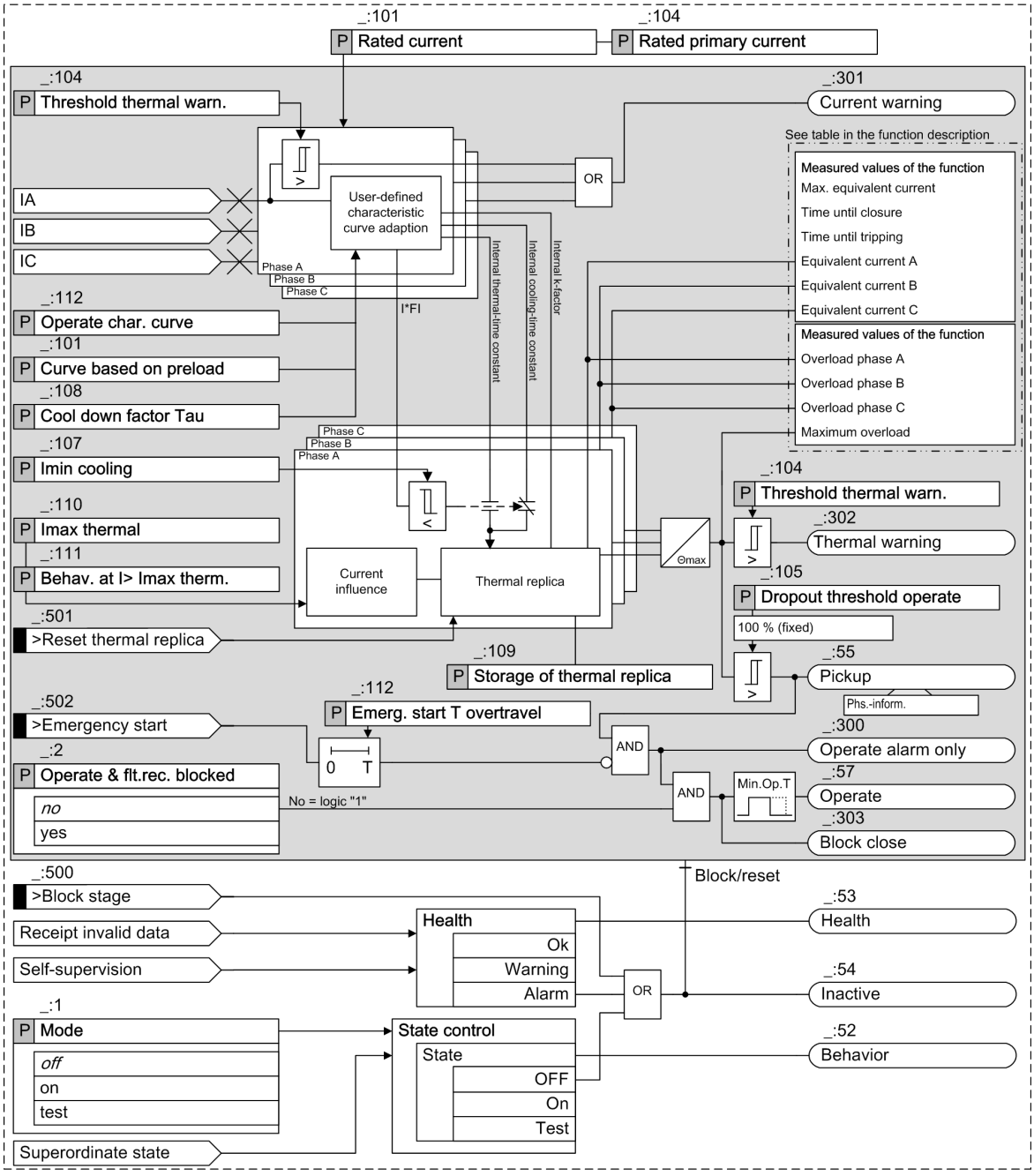


[dw_TOLP_UserCurveStr, 1, en_US]

Figure 6-159 Structure/Embedding of the Function

6.20.3 Function Description

Logic



[lo_TOLP_UserCurve_stage, 1, en_US]

Figure 6-160 Logic Diagram of the Thermal Overload Protection, User-Defined Characteristic Curve Function

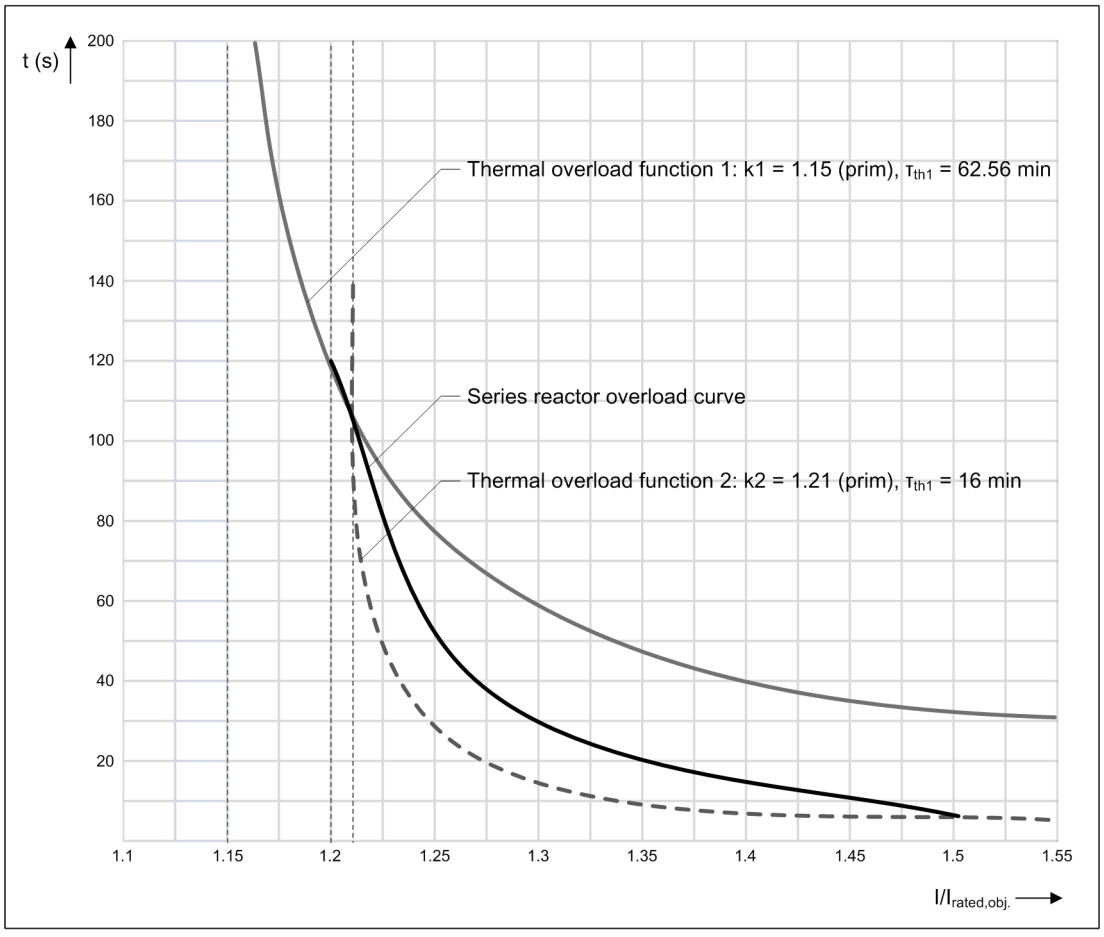
(1) The **(_:101) Rated current** parameter is from the protected object.

(2) The **(_:104) Rated primary current** parameter is from the used current transformer.

User-Defined Characteristic Curve

For specific equipment (for example, shunt reactors and transformers) or for special applications, the manufacturer specifies an overload characteristic curve. This curve cannot be described accurately with a single-

body model so that deviations can occur. The following figure shows an example of a predefined overload characteristic curve and 2 standard characteristic curves based on the single-body model.



[dw_TOLP_UserCurve_characteristic, 1, en_US]

Figure 6-161 User-Defined Characteristic Curve with Replica of Standard Characteristics

The calculation is identical to the realization of the standard **Thermal overload protection, 3-phase** function. You can find more information in the function description **Thermal overload protection, 3-phase** starting from chapter *6.19.1 Overview of Functions* .

The main deviations are as follows:

- The thermal characteristic is set with a flexible characteristic ($t_{trip} = f(I/I_{rated,obj})$).
  - The first point of the characteristic curve is important and is used to calculate the internal k-Factor.
  - The point at $I/I_{rated,obj} = 1.5$ is used to calculate the internal thermal time constant. If there is no point at $I/I_{rated,obj} = 1.5$, the point which is the closest to $I/I_{rated,obj} = 1.5$ from $I/I_{rated,obj} = 1.1$ is used to calculate the internal thermal time.
  - The points are set according to the maximum permissible load current.
- The **`Curve based on preload`** parameter describes for which thermal preload the user-defined characteristic curve is valid. Normally, such a curve is given for protected objects under rated load.
- The **`Cool-down factor Tau`** parameter is used for the determination of the cooling time constant. The set factor is multiplied with the internal calculated time constant.
- The thermal model is based on a constant ambient temperature of 40 °C. It cannot be corrected via the external measurement.

Thermal Replica

The protection function calculates the overtemperature from the phase currents on the basis of a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\theta}{dt} + \theta$$

[fo_TOLP_diffgl, 1, en_US]

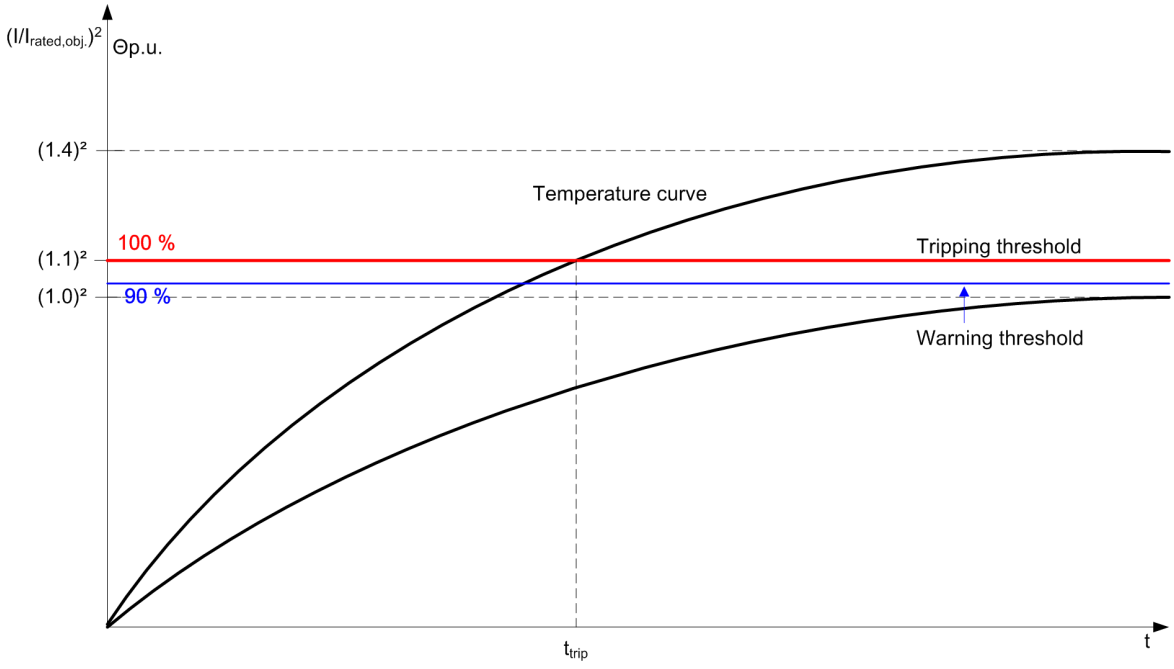
With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{K \cdot I_{rated\ ,obj.}} \quad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{K^2 \cdot \Delta\vartheta_{rated\ ,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th}$$

[fo_TOLP_normie, 1, en_US]

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current k $I_{rated, obj}$
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object. The value is calculated internally.
K	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($K = I_{max}/I_{rated, obj}$) and is calculated internally.
$I_{rated, obj}$	Rated current of the protected object



[dw_TOLP_Temperature, 1, en_US]

Figure 6-162 Temperature History for Different Overload Currents (**K-factor** = ***1.1***)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Current Influence

The thermal replica based on the single-body model applies only with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced in case of overcurrents (exceeding $I_{threshold}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection can be avoided. If the first setting value of the user-defined characteristic curve is set to 1.1 of the rated current, a thermal memory value of 83 % is set to the continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate**, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see Technical Data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the setting parameter **Storage of thermal replica**. You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Memory

You can reset the thermal memory via the binary input indication **>Reset thermal replica**. The thermal memory will then have a 0 value.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal **>Emergency start**, tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input **>Emergency start** disappears, the blocking remains in effect for the set **Emerg. start T overtravel**.

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal **>Block stage**.

All indications then drop out and the thermal memory is not calculated.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.20.4 Application and Setting Notes

Motors and generators as well as transformers are at risk from long-lasting overloads. You can adapt the given overload characteristic curve to the user-defined characteristic curve with the **Thermal overload protection, user-defined characteristic curve** function. You can find the predefined characteristic curve in the chapter *12.23 Thermal Overload Protection, User-Defined Characteristic Curve*.

When setting the parameters, consider the following:

- The settings for the used current transformer (primary values and secondary values) must be set correctly in the power system.
- The rated values for the protected object must be correct in the used function group.

Parameter: `Threshold current warning`

- Recommended setting value **`(_:101) Threshold current warning`** = ***`1.1 A`*** at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for the first value of the user-defined characteristic curve.

Parameter: `Threshold thermal warn.`

- Recommended setting value **`(_:104) Threshold thermal warn.`** = ***`90 %`***

If the first value of the user-defined characteristic curve is 1.1 of the rated current, the default setting can be left. The thermal memory results for 83 % at continuously flowing rated object current.

If the first value of the user-defined characteristic curve is 1.05 of the rated object current, the thermal memory for rated current is already 91 % filled. Increase the **`Threshold thermal warn.`** to 95 %.

Parameter: `Dropout threshold operate`

- Recommended setting value **`(_:105) Dropout threshold operate`** = ***`90 %`***

The **`Dropout threshold operate`** parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value **`Time until close`** refers to this value.

Parameter: **Emerg. start T overtravel**

- Default setting **(_:112) Emerg. start T overtravel** = ***300 s***

The **Emerg. start T overtravel** parameter is used to set the time for which blocking of the tripping has to remain active after an outgoing binary input signal **>Emergency start**. With an outgoing input signal, the load on the protected object is removed. The emergency start T-overtravel must be set long enough to allow the thermal memory to fall below the dropout threshold after cooling. Select a time on the order of magnitude of the **Cooling time constant**. In the example, 5 min (300 s) have been assumed.

Parameter: **Imax thermal**

- Recommended setting value **(_:107) Imax thermal** = ***2.5 A*** at I_{rated} = 1 A

The **Imax thermal** parameter allows you to set the threshold current for the **Behav. at I> Imax therm.** parameter. If you calculate with relatively long start times for motors (longer than 25 s), the current limiting must be reduced to 2 $I/I_{rated, obj}$.

Parameter: **Imin cooling**

- Recommended setting value **(_:108) Imin cooling** = ***0.5 A*** at I_{rated} = 1 A

When defining the minimum current **Imin cooling**, you can use the no-load current for orientation. If no data is available, set 0.5 $I/I_{rated, obj}$. If the current falls below this value, the internal thermal time constant τ automatically switches to the internal cooling time constant with the **Cool-down factor Tau** parameter.

Parameter: **Storage of thermal replica**

- Recommended setting value **(_:113) Storage of thermal replica** = ***no***

If a continuous auxiliary voltage for the bay units is ensured, the default setting can be retained.

Parameter: **Behav. at I> Imax therm.**

- Recommended setting value **(_:114) Behav. at I> Imax therm.** = ***current limiting***

The **Behav. at I> Imax therm.** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified. As overcurrent due to a starting of the motor also leads to a certain heating of the stator winding, limiting the input current is recommended for machines.

Parameter Value	Description
current limiting	The input currents are limited to the value set in the **Imax thermal** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.
freeze therm. rep.	If input currents exceed the **Imax thermal** parameter, the thermal replica will be frozen for the time the parameter is exceeded.

Parameter: **Curve based on preload**

- Default value **(_:101) Curve based on preload** = ***100 %***

The **Curve based on preload** parameter is used for a certain load case. In most cases, it applies for an operation under rated conditions. For that, it is assumed that rated current is flowing permanently. This is referred to as warm condition. In this case, the default setting 100 % is applied.

Thus, the thermal behavior is also correct for different preloads.

For cases without preload or cold condition, set the parameter to 0 %.

Parameter: **Cool-down factor Tau**

- Default value **(_:108) Cool-down factor Tau** = ***7.0***

If the current becomes lower than the setting value of the **Imin cooling** parameter, you can set the **Cool-down factor Tau** parameter to calculate the internal cooling time constant.

Parameter: **Operate char. curve**

- Default value **Operate char. curve** = ***1.1 p.u., 600.00 s***

With the **Operate char. curve** parameter, you define the characteristic curve in a tabular form with ordered normalized current values and associated normalized time values.

When setting the parameter, consider the following:

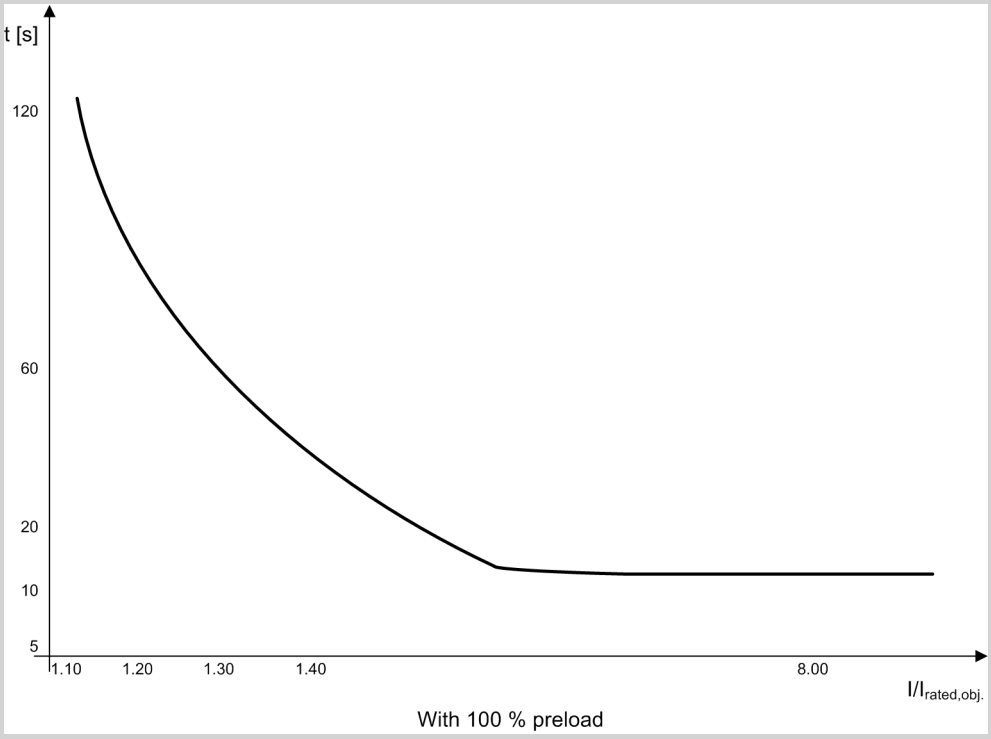
- Set the current value as per-unit value with the rated current of the protected object as reference.
- Set the time value in seconds.
- Enter the values in continuous order.

EXAMPLE

With the following 12 points, you can get a user-defined characteristic curve as shown in the following figure.

Table 6-13 User-Defined Points

I / I_{obj}	t (s)
1.16	120.00
1.21	96.00
1.25	76.00
1.28	62.00
1.35	48.00
1.42	37.50
1.48	33.50
1.58	27.50
1.84	20.50
2.09	14.00
2.25	9.85
8.00	9.85



[dw_TOLP_Predefined curve, 1, en_US]

Figure 6-163 Example of the User-Defined Characteristic Curve

6.20.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User charact.#:Mode		• off • on • test	off
_:2	User charact.#:Operate & flt.rec. blocked		• no • yes	no
_:102	User charact.#:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	User charact.#:Threshold thermal warn.		50 % to 100 %	90 %
_:105	User charact.#:Dropout threshold operate		50 % to 99 %	90 %
_:106	User charact.#:Emerg. start T overtravel		0 s to 15000 s	300 s

Addr.	Parameter	C	Setting Options	Default Setting
_:107	User charact.#:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:108	User charact.#:Cool-down factor Tau		0.5 to 20.0	7.0
_:109	User charact.#:Storage of thermal replica		• no • yes	no
_:110	User charact.#:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:111	User charact.#:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:112	User charact.#:Operate char. curve		Setting options depend on configuration	1.1 p.u., 600 s
_:101	User charact.#:Curve based on preload		0 % to 100 %	100 %

6.20.6 Information List

No.	Information	Data Class (Type)	Type
User charact.#			
_:81	User charact.#:>Block stage	SPS	I
_:500	User charact.#:>Reset thermal replica	SPS	I
_:501	User charact.#:>Emergency start	SPS	I
_:54	User charact.#:Inactive	SPS	O
_:52	User charact.#:Behavior	ENS	O
_:53	User charact.#:Health	ENS	O
_:300	User charact.#:Current warning	SPS	O
_:301	User charact.#:Thermal warning	SPS	O
_:302	User charact.#:Block close	SPS	O
_:55	User charact.#:Pickup	ACD	O
_:303	User charact.#:Operate alarm only	ACT	O
_:57	User charact.#:Operate	ACT	O
_:304	User charact.#:Time until close	MV	O
_:305	User charact.#:Time until trip	MV	O
_:306	User charact.#:Overload phase A	MV	O
_:307	User charact.#:Overload phase B	MV	O
_:308	User charact.#:Overload phase C	MV	O
_:309	User charact.#:Overload maximum	MV	O
_:310	User charact.#:Equival. current phs A	MV	O
_:311	User charact.#:Equival. current phs B	MV	O

No.	Information	Data Class (Type)	Type
_:312	User charact.#:Equival. current phs C	MV	O
_:313	User charact.#:Equival. current max.	MV	O

6.21 Thermal Overload Protection, 1-Phase

6.21.1 Overview of Functions

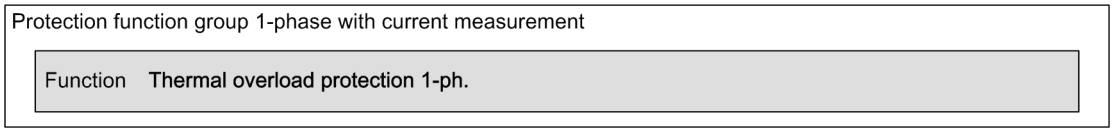
The **Thermal overload protection 1-phase** function (ANSI 49) is used to:

- Protect the equipment (reactors or resistors in the neutral point of a transformer) from thermal overload

6.21.2 Structure of the Function

The **Thermal overload protection 1-phase** function is used in 1-phase protection function groups with current measurement..

The **Thermal overload protection, 1-phase** function is steplessly preconfigured.

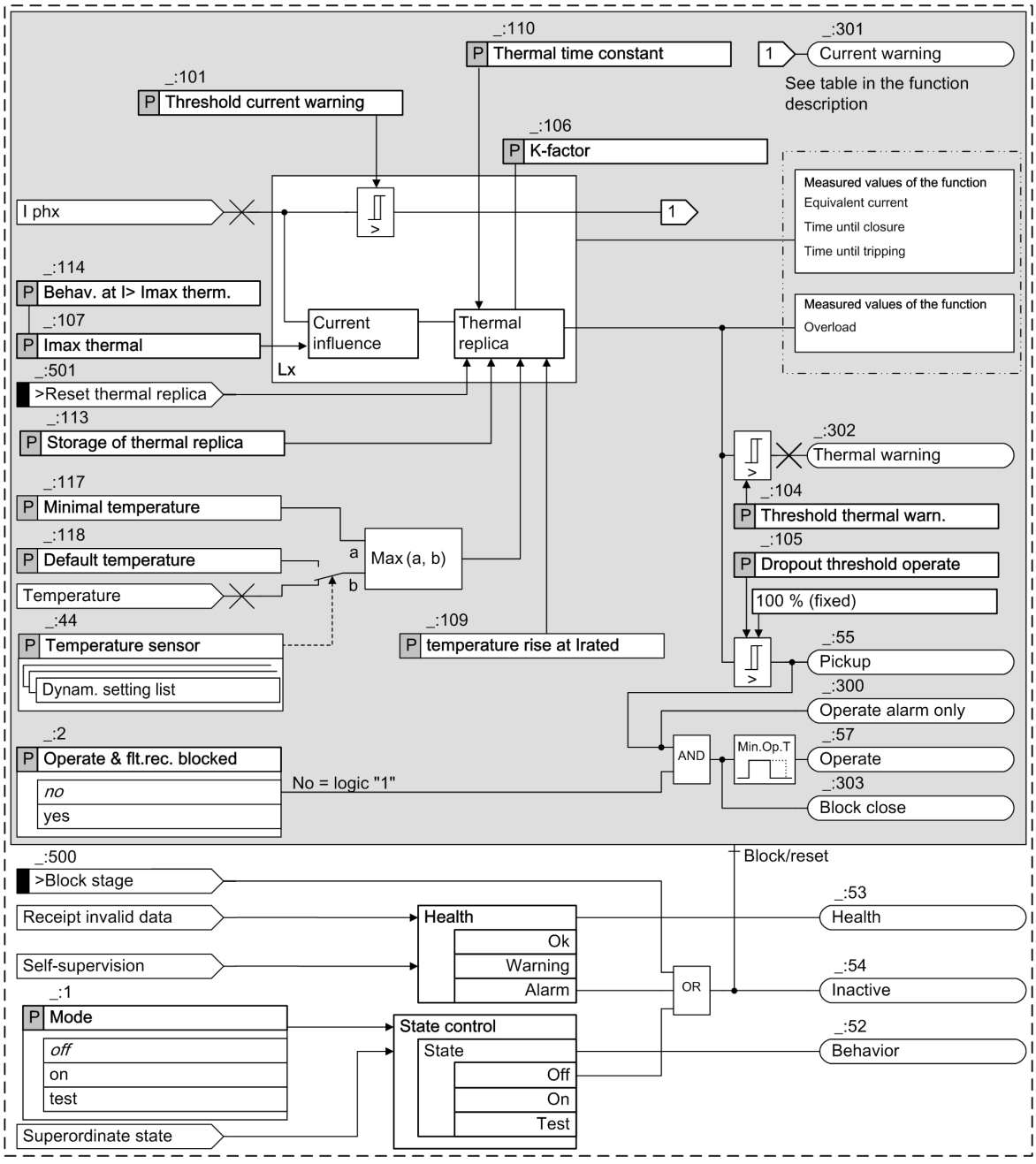


[dwtolp1p-270613-01.tif, 2, en_US]

Figure 6-164 Structure/Embedding of the Function

6.21.3 Function Description

Logic



[lotolp1p-250713-01.tif, 2, en_US]

Figure 6-165 Logic Diagram of the Thermal Overload Protection Function

Thermal Replica

The protection function calculates the overtemperature from the current flowing in the protected object (for example, reactor or resistance in the transformer neutral point) on the basis of a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\Theta}{dt} + \Theta - \Theta_V$$

[fodiffgl-310510-01.tif, 2, en_US]

With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{k \cdot I_{rated,obj.}} \qquad \Theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{k^2 \cdot \Delta\vartheta_{rated,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \Theta_V = \frac{\vartheta_{Amb} - 40\,°C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\,°C}{k^2 \cdot \Delta\vartheta_{rated,obj.}}$$

[fonormie-310510-01.tif, 2, en_US]

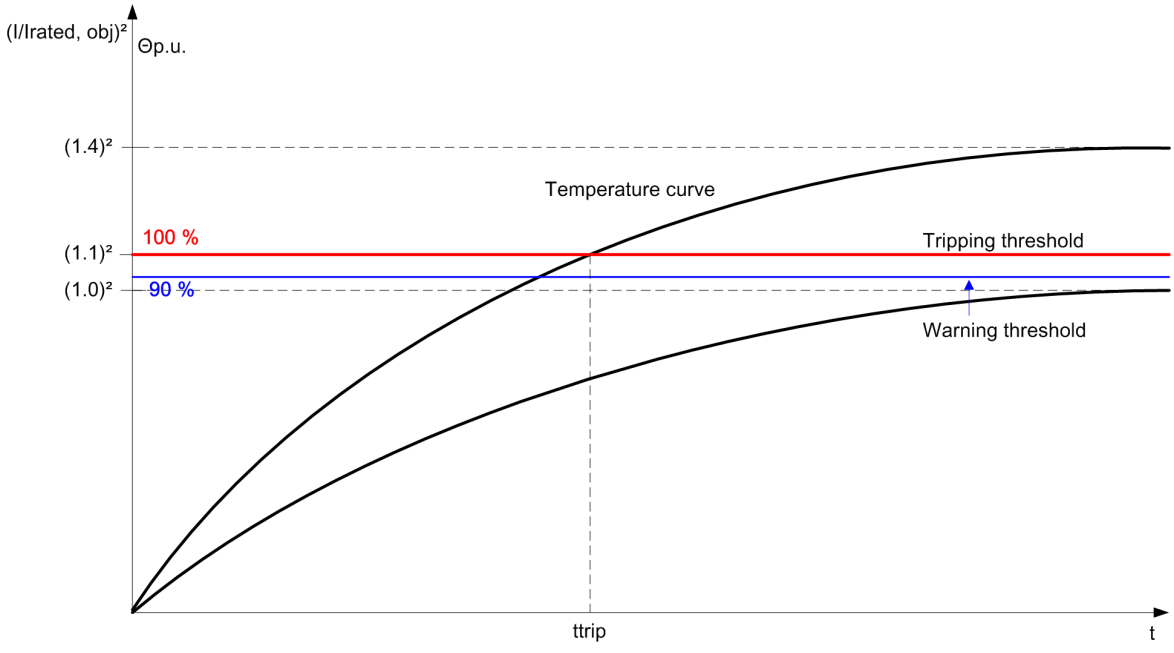
Θ	Current overtemperature, in relation to the final temperature at a maximum permissible current k $I_{rated,\ obj}$
Θ_V	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the **`Default temperature`** parameter.
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object
k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,\ obj}$)
$I_{rated.,\ obj}$	Rated current of the protected object

At the same time, $I_{rated,\ obj}$ is the rated current of the protected object.

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (**`Threshold thermal warn.`**), a warning indication is given.

If the overtemperature limit Θ_{Off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-166 shows the temperature rise at different overload currents and the supervision thresholds.



[dwtempve-030211-01.tif, 1, en_US]

Figure 6-166 Temperature History for Different Overload Currents (**`K-factor`** = ***`1.1`***)

The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached.

The analysis of the RMS value of the current over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Ambient Temperature

This function can take the ambient temperature into consideration The reference temperature of the thermal model is 40 °C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The **Default temperature** parameter can be used to fix or measure the ambient temperature. The **Minimal temperature** parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter **Temperature rise at Irated**).

The measured ambient temperature is recorded by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions **RTD unit Ether.** or **RTD unit serial** of the function group **Analog units**. When using the **Temperature sensor** parameter, the respective temperature sensor can be selected.

If the temperature measurement is disrupted, for example, due to an open circuit between the device and the RTD unit, the device will report it. In this case, the process continues with either the temperature measured last or the value set under the **Default temperature** parameter, whichever value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding $\mathbf{I}_{\text{limit}}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal **K-factor** of ***1.1***, a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate**, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see technical data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the **Storage of thermal replica** parameter. You can save the thermal state for a down time of 500 min. If the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication **>Reset thermal replica**. The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Blocking the Function

Blocking will cause a picked up function to be reset. The function can be blocked externally or internally by the binary input signal **>Block stage**.

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Measured Value	Description
(_:310) Equival. current	Besides the thermal measured values in percent, the equivalent current is also issued as a thermal current-measured value (A or kA). The current equivalent is the primary current, which corresponds to the thermal measured value in percent, assuming steady-state conditions.
(_:304) Time until close	The **Time until close** is the expected time until it is possible for the protected object for reclosure. The calculation of this value is based on the assumption of constant currents. The thermal replica has then fallen below the setting value of the dropout threshold.
(_:305) Time until trip	The **Time until trip** is the expected time until tripping (100 % value exceeded) occurs. The calculation of this value is based on the assumption of constant currents.
(_:306) Overload	The value **Overload** indicates the current temperature of the protected object in percent. Tripping occurs if 100 % is exceeded.

6.21.4 Application and Setting Notes

Parameter: Threshold current warning

- Recommended setting value **(_:101) Threshold current warning** = ***1.1 A*** for I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for **K-factor**.

Parameter: Threshold thermal warn.

- Recommended setting value **(_:104) Threshold thermal warn.** = ***90 %***

The default setting can be left at a **K-factor** of 1.1, because the thermal memory sets itself to 83 % at continuously flowing rated current. The calculation uses the rule of three: 100 % corresponds to (**K-factor**)^2 and x % corresponds to 1^2.

$$\frac{\Theta}{\Theta_{off}} = \frac{100\ \%}{k^2} = 83\ \%$$

[fowarnsc-100810-01.tif, 2, en_US]

At a **K-factor** of 1.05, the thermal memory for rated current is 91% filled. Increase the **Threshold thermal warn.** to 95%.

Parameter: Dropout threshold operate

- Recommended setting value **(_:105) Dropout threshold operate** = ***90 %***

The **Dropout threshold operate** parameter is used to cancel pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling, or longer blocking of switching on.

The calculation of the operational measured value **Time until close** refers to this value.

Parameter: K-factor

- Recommended setting value **(_:106) K-factor** = ***1.1***

The **K-factor** parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated, obj}$ of the protected object (for example, resistance) is the basic current for overload sensing.

You can determine **K-factor** on the basis of the thermally permissible continuous current $I_{max, perm.}$:

$$K\text{-factor} = \frac{I_{max,perm.}}{I_{rated,obj.}}$$

[fotolpkf-100810-01.tif, 2, en_US]

NOTE

The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer!

Siemens recommends using the default value as it is a typical value for many applications.

Parameter: Thermal time constant

- Default value **(_:110) Thermal time constant** = ***900 s (15 min)***

The **Thermal time constant** parameter is used to define the operate curve of the stage. If no time constant is given, you can derive it from other values.

EXAMPLE

Protection of a current-limiting resistance

Rated current of the resistance: I_{rated} = 100 A

Values for the overload capability:

- 1.1 I_{rated} permanent (k-Factor = 1.1; k = 1.1)
- 1.5 I_{rated} for 20 s for charge by cold

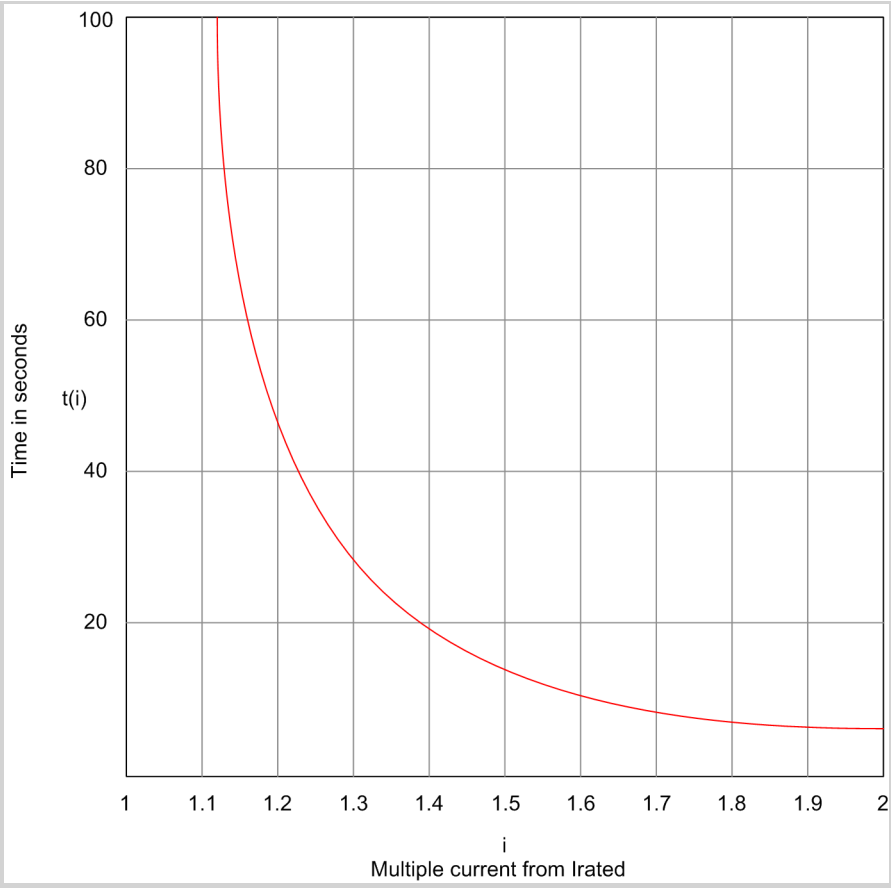
The following time constant results from these assumed values:

$$\tau_{th} = t \times \left[\ln \frac{\left(\frac{I}{k \times I_{rated,obj}}\right)^2}{\left(\frac{I}{k \times I_{rated,obj}}\right)^2 - 1} \right]^{-1} = 20\ s \times \left[\ln \frac{\left(\frac{1.5}{1.1}\right)^2}{\left(\frac{1.5}{1.1}\right)^2 - 1} \right]^{-1} = 20\ s \times \left[\ln \frac{1.86}{0.86} \right]^{-1} \approx 26\ s$$

[fo_time_constance_11082015, 1, en_US]

For **Thermal time constant**, set 26 s.

The following time-dependent characteristic results from the data. In case of a current increase to 1.5 I_{rated}, the tripping occurs in 20 s.



[dwtime-dependent-110815-01.vsd, 1, en_US]

Parameter: Imax thermal

- Recommended setting value **(_:107) Imax thermal**= ***2.5 A*** for I_{rated} = 1 A

The **Imax thermal** parameter allows you to set the threshold current for the **Behav. at I> Imax therm.** parameter. The selected current threshold of 2.5 $I_{rated, obj}$ is a practicable value.

Parameter: Temperature rise at Irated

- Default setting **(_:109) Temperature rise at Irated** = ***70 K***

NOTE

For an application as a 1-phase overload protection, the ambient temperature measured via the temperature sensor is not taken into account. Therefore, the setting has no influence. You can keep the default setting. If you take into account the temperature, note the following descriptions.

Set the overtemperature as the value that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the Technical data of the equipment or you can measure the value. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40 °C.

The overtemperature at maximum permissible current (***ϑmax***) and the **Temperature rise at Irated** (***ϑrated,obj.***) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated\ ,obj.}} \right)$$

[fo_ueb_for_Irated, 3, en_US]

EXAMPLE:

Temperature class **B** for continuous operation: permissible overtemperature = 80 K
From this, a temperature for I_{rated} of 120 °C (80 K + 40 °C) can be derived when using a measuring element for the measurement.
Temperature class **F** as thermal limiting value: permissible overtemperature = 105 K.
From this, a maximum temperature of 155 °C (105 K + 40 °C) derives.
From these values, the magnitude of the K factor can also be derived.

$$k^2 = \frac{\Delta\vartheta_{max\ ,Obj.}}{\Delta\vartheta_{rated\ ,Obj.}} = \frac{105\ K}{80\ K} = 1.31 \qquad \rightarrow\ k = 1.146$$

[fo_bsp_kfaktor, 3, en_US]

If selecting a setting value of 1.1 for the **K-factor**, your selection can be considered as conservative.

Parameter: Storage of thermal replica

- Recommended setting value **(_:113) Storage of thermal replica** = ***no***

If a continuous auxiliary voltage of the bay units is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value **(_:114) Behav. at I> Imax therm.** = ***current limiting***

The **Behav. at I> Imax therm.** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.
The default setting has been selected compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the **current limiting** procedure is recommended.

Parameter Value	Description
current limiting	The input current is limited to the value set in the **Imax thermal** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.
freeze therm. rep.	If the input current exceeds the **Imax thermal** parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products!

Parameter: Temperature sensor

- Default setting **(_:44) Temperature sensor** = ***none***

Use the **Temperature sensor** parameter to determine which temperature sensor to use to detect the ambient temperature.
A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and to feed it to the device via an RTD unit. The function **Thermal overload protection** receives the measured temperature value via the function **RTD unit Ether.** or **RTD unit Serial** from the function group **Analog units**.

Parameter: Default temperature

- Recommended setting value **(_:118) Default temperature** = ***40 °C***

Under the following conditions, the **Default temperature** will be set as ambient temperature:

- A temperature sensor for measuring the ambient temperature is not connected.
- The temperature measurement is interrupted and the measured temperature value is less than the **Default temperature**.

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting **(_:117) Minimal temperature** = ***-20 °C***

If the measured ambient temperature drops below the preset value, the set value will be assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the **Minimal temperature** parameter, the **Minimal temperature** can also be used.

6.21.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C

Addr.	Parameter	C	Setting Options	Default Setting
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Temperature sensor		Setting options depend on configuration	

6.21.6 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload	MV	O
_:310	49 Th.overl. #:Equival. current	MV	O

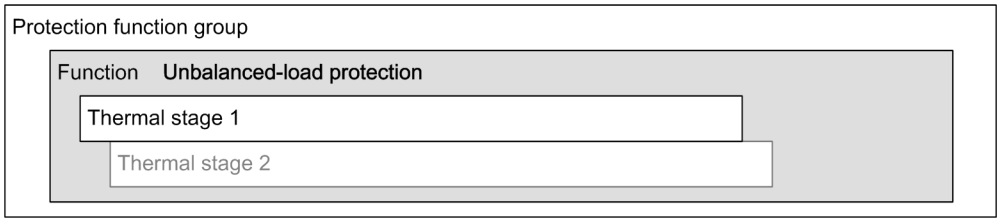
6.22 Unbalanced-Load Protection

6.22.1 Overview of Functions

The **Unbalanced-load protection** function detects unbalanced loads or line interruptions of electrical machines (generators and motors). Unbalanced loads create a counter-rotating magnetic field at double frequency in the rotor. The skin effect leads to local overheating on the surface of the rotor bars in the transition between the slot wedges and the winding bundles. Another effect of unbalanced loads is the overheating of the damper winding.

6.22.2 Structure of the Function

The **Unbalanced-load protection** function is used in the protection function group. The **Unbalanced-load protection** function is preconfigured with 1 stage. A maximum of 2 stages can operate simultaneously in the function.

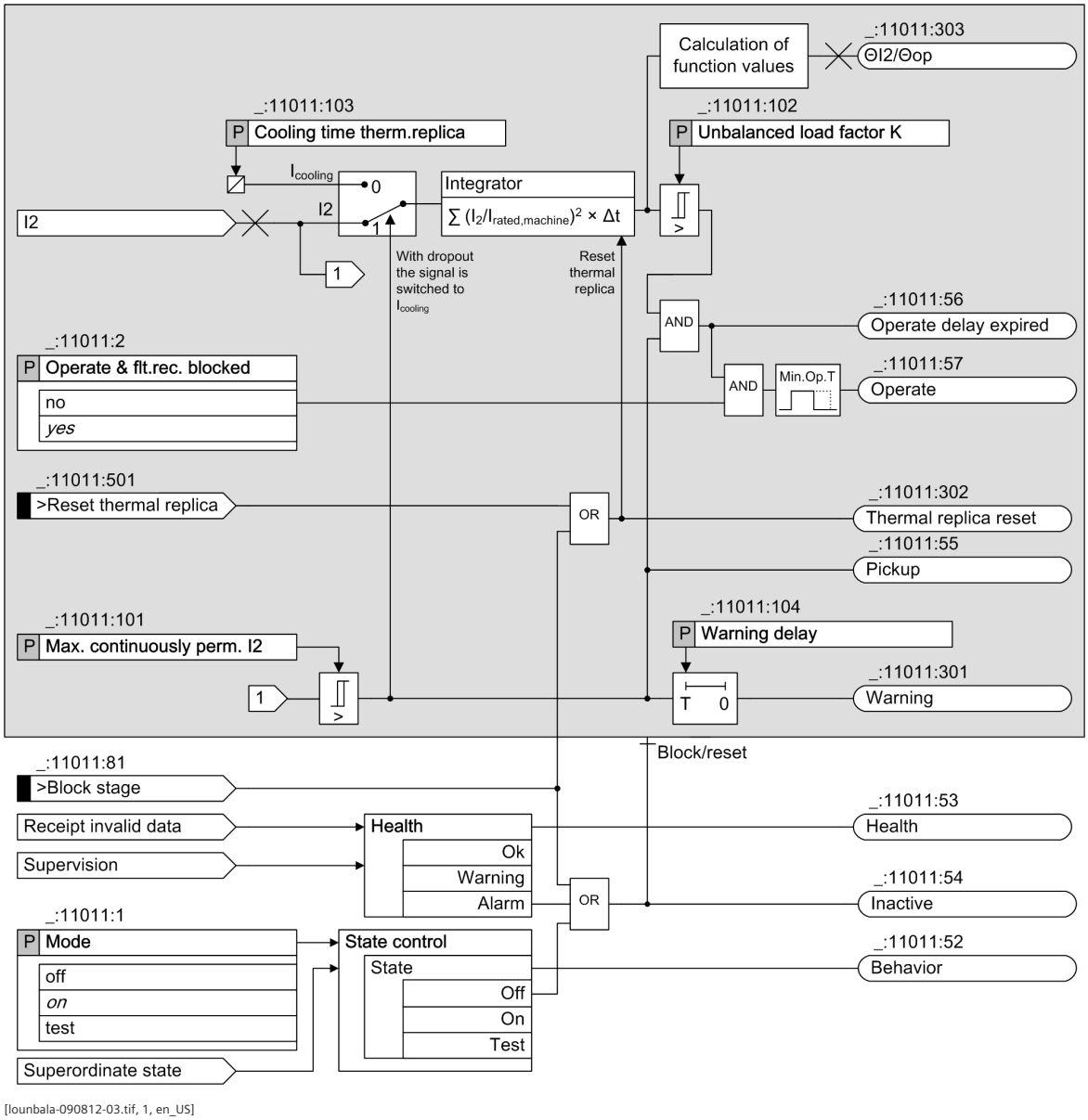


[dwunbla-240913, 1, en_US]

Figure 6-167 Structure/Embedding of the Function

6.22.3 Function Description

Logic of the Stage



[lounbala-090812-03.tif, 1, en_US]

Figure 6-168 Logic Diagram of the Unbalanced-Load Protection Function

Method of Measurement

The stage uses the negative-sequence current I_2 as a measurand. The negative-sequence current is calculated from the measured 3-phase currents according to the defining equation of symmetrical components.

Warning Stage

If the negative-sequence current I_2 continuously exceeds the parameter **`Max. continuously perm. I2`**, the *`warning`* indication is given after expiry of a set time **`Warning delay`**.

Thermal Characteristic Stage

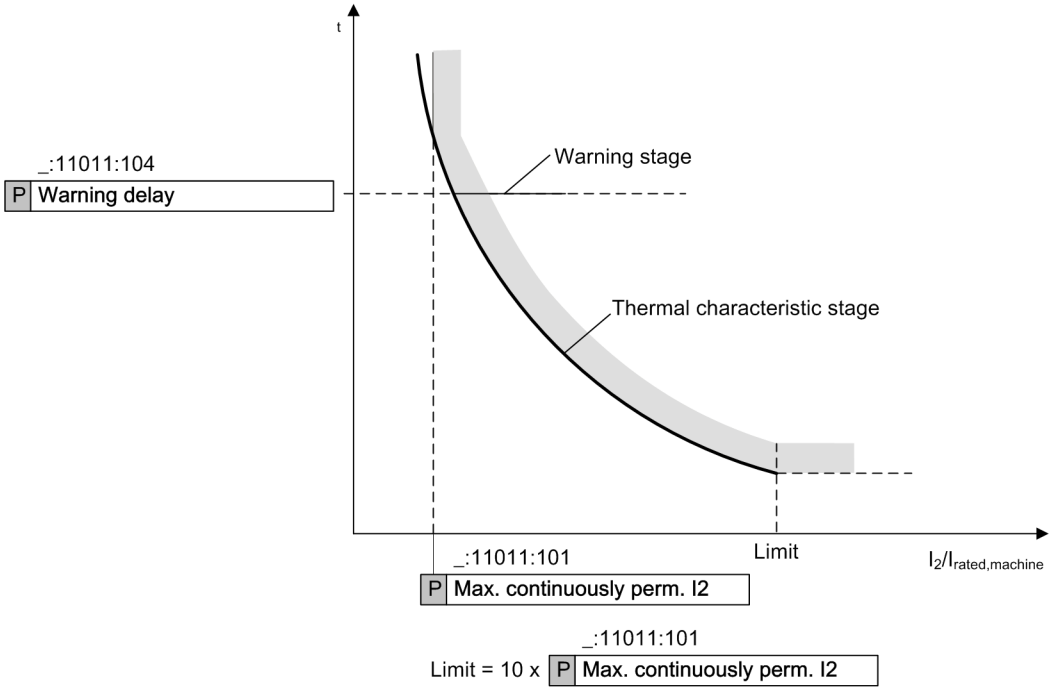
The machine manufacturers indicate the permissible unbalanced load using the following formula:

$$t_{I2\,Perm} = \frac{K}{\left(I_2 / I_{rated,machine}\right)^2}$$

[forbanl1-030812-02.tif, 1, en_US]

With:

t_{I2Perm}	Permissible time of the negative-sequence current
K	Unbalanced-load factor of the machine (parameter **Unbalanced load factor K**)
$I_2/I_{rated,machine}$	Actual unbalanced-load current as a per unit value(negative-sequence current/rated current of the machine)



[dwunbalo-230913, 2, en_US]

Figure 6-169 Operate Curve of the Unbalanced-Load Protection

The parameter **Unbalanced load factor K** depends on the machine. It also represents the time in seconds during which the machine can be loaded with a 100 % unbalanced load. This factor is typical in a range from 5 s to 40 s. The heating of the protected object starts to calculate as soon as the negative-sequence current I_2 exceeds the parameter **Max. continuously perm. I2**. The operate time is calculated from the flowing negative-sequence current I_2 with an integrating method of measurement depending on the thermal characteristic. As soon as the integrate result reaches the parameter **Unbalanced load factor K**, the thermal characteristic stage operates.

Limitation of Operate Curve

To avoid an overfunction of the thermal characteristic stage in the situation of unbalanced short circuits (for example, 2-phase short circuit), the input current I_2 is restricted to an upper limit. The limiting value is 10 times of **Max. continuously perm. I2**. If I_2 exceeds the limit, the operate time of the function is constant.

In addition, the thermal memory is limited to 200 % of **Unbalanced load factor K**. The limitation avoids a too long cooling after a delayed short-circuit tripping (for example, of external power-system faults).

Cooling Time Thermal Replica

The thermal replica starts to cool down as soon as the negative-sequence current I_2 is lower than **Max. continuously perm. I2**. The thermal replica decreases according to the parameter **Cooling time therm.replica**. The parameter **Cooling time therm.replica** is the time required by the thermal replica to cool down from 100 % to 0 %. If the parameter **Cooling time therm.replica** is set to 0, the thermal replica is reset immediately.

The parameter **Cooling time therm.replica** depends on the construction type of the machine, especially of the damper winding. Preloading is considered when unbalanced loading occurs again during the cooling time. The protection device thus operates in a shorter time.

Functional Measured Values

The following formula is used to calculate the functional measured value ΘI2/Θop:

$$\Theta I2/\Theta op = \frac{\sum_{0}^{t}\left(I_2/I_{rated,machine}\right)^2 \cdot \Delta t}{K} 100\ \%$$

[forunbI2-030812-02.tif, 1, en_US]

With

ΘI2/Θop	Functional measured value indicating the thermal replica of the unbalanced load
$\sum_{0}^{t}\left(I_2/I_{rated,\ machine}\right)^2 \cdot \Delta t$	Integrating method of measurement of the thermal replica of the negative-sequence system
K	Unbalanced-load factor of the machine (parameter **Unbalanced load factor K**)
$I_2/I_{rated,machine}$	Unbalanced-load as a per unit value (negative-sequence current/rated current of the machine)

If the functional measured value reaches 100 %, the operate of the function is initiated.

6.22.4 Application and Setting Notes

The function is used in the applications of machines. You can get the necessary settings from the technical data of the synchronous generators and motors. The setting example is applied for a generator application.

Parameter: Max. continuously perm. I2, Warning delay

- Default setting **(_:11011:101) Max. continuously perm. I2** = ***10.0 %***
- Default setting **(_:11011:104) Warning delay** = ***15 s***

If the negative-sequence current I_2 exceeds **Max. continuously perm. I2** , the stage picks up and a warning indication is given after the set time delay **Warning delay** .

The parameter **Max. continuously perm. I2** is given in percentage of the rated current of the protected object.

The setting value of the parameter **Max. continuously perm. I2** depends on following parts:

- Design of the machine (salient pole or non-salient pole rotor synchronous machine)
- Cooling system (directly or indirectly cooled)
- Size of the machine

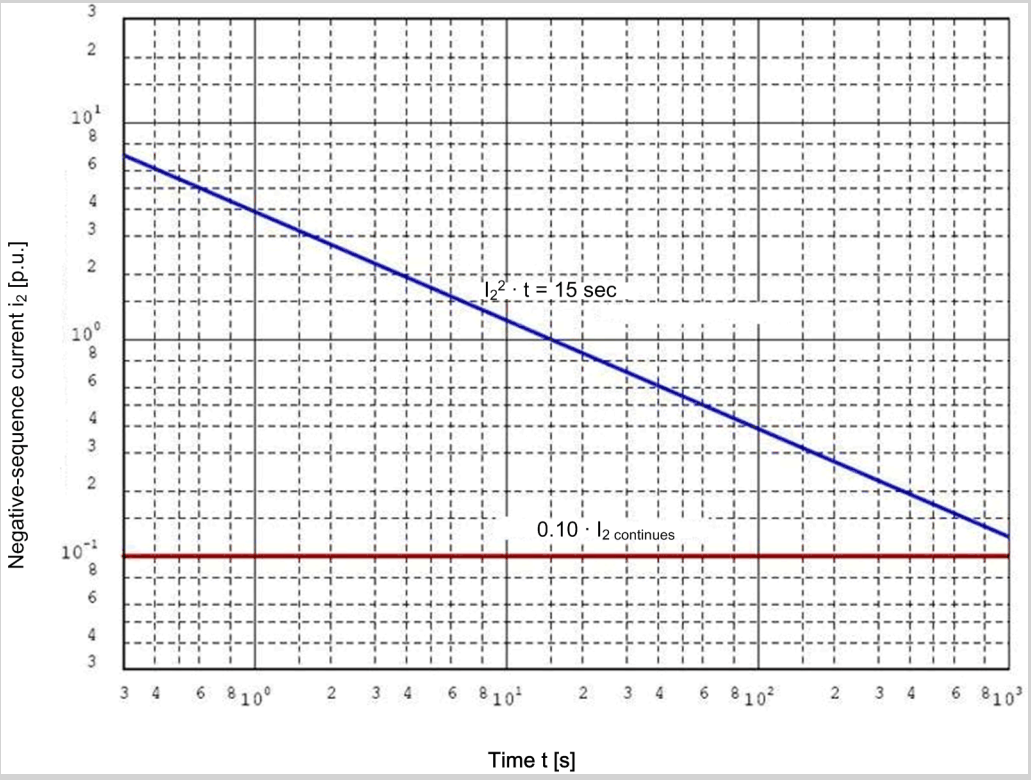
Depending on the standards IEEE C50.12 and IEC 60034-1, the parameter is given in the range between 5 % and 12 %. To set the parameter **Max. continuously perm. I2** , technical data of the machine is

required. The technical data of the machine is provided in the Technical Data Sheet of the machine manufacturer.

EXAMPLE

The following example shows the setting of the parameter **Max. continuously perm. I2** . The value 10 % is selected in the example.

To avoid issuing the *warning* indication too fast, Siemens recommends a longer delay. Setting the parameter **Warning delay** in the range of 10 s to 20 s is practicable. 15 s is selected in the example.



[dwunbloc-030812, 1, en_US]

Figure 6-170 Example of an Unbalanced-Load Characteristic Specified by the Machine Manufacturer

Parameter: **Unbalanced load factor K**

- Default setting **(_:11011:102) Unbalanced load factor K** = ***15 s***

Unbalanced load factor K can be derived from the unbalanced-load characteristic according to *Figure 6-170* . You can read the time corresponding to **Unbalanced load factor K** at the point I_2 / $I_{rated,machine}$= 1. In the example, this is the p.u. value 10° which corresponds to a time of 15 s. As the example shows, the time is often written directly on the characteristic curve.

Parameter: **Cooling time therm.replica**

- Default setting **(_:11011:103) Cooling time therm.replica** = ***1500 s***

The parameter **Cooling time therm.replica** establishes the time required by the protected object to cool down the thermal replica to the initial value. If the machine manufacturer does not provide this information, the setting value of **Cooling time therm.replica** can be calculated from the setting values of **Unbalanced load factor K** and **Max. continuously perm. I2** by the formula in the following example.

EXAMPLE

$$\text{Cooling time therm. replica} = \frac{\text{Unbalanced load factor K}}{(\text{Max. continuously perm. I 2})^2}$$

[forbala2-290812-02.tif, 1, en_US]

Max. continuously perm. I_2	= 10.0 % (corresponds to 0.1)
Unbalanced load factor K	= 15 s
Cooling time therm. replica	= 1500 s

6.22.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Therm. Stage 1				
_:11011:1	Therm. Stage 1:Mode		• off • on • test	off
_:11011:2	Therm. Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11011:101	Therm. Stage 1:Max. continuously perm. I2		3.0 % to 30.0 %	10.0 %
_:11011:102	Therm. Stage 1:Unbalanced load factor K		1.0 s to 100.0 s	15.0 s
_:11011:103	Therm. Stage 1:Cooling time therm.replica		0 s to 50000 s	1500 s
_:11011:104	Therm. Stage 1:Warning delay		0.0 s to 60.0 s;∞	15.0 s

6.22.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Therm. Stage 1			
_:11011:81	Therm. Stage 1:>Block stage	SPS	I
_:11011:501	Therm. Stage 1:>Reset thermal replica	SPS	I
_:11011:53	Therm. Stage 1:Health	ENS	O
_:11011:54	Therm. Stage 1:Inactive	SPS	O
_:11011:52	Therm. Stage 1:Behavior	ENS	O
_:11011:302	Therm. Stage 1:Thermal replica reset	SPS	O
_:11011:301	Therm. Stage 1:Warning	ACD	O
_:11011:55	Therm. Stage 1:Pickup	ACD	O
_:11011:56	Therm. Stage 1:Operate delay expired	ACT	O
_:11011:57	Therm. Stage 1:Operate	ACT	O
_:11011:303	Therm. Stage 1:ΘI2/Θop	MV	O

6.23 Overvoltage Protection with 3-Phase Voltage

6.23.1 Overview of Functions

The function **Overvoltage protection with 3-phase voltage** (ANSI 59) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components, machines, etc.) against damages caused by overvoltage
- Decouple systems (for example, wind power supply)

Abnormally high voltages in power systems are caused by voltage controller failure at the transformer or on long transmission lines under low-load conditions.

When using common-mode reactors in the protected power system, the device must shut down the line quickly if the reactors fail (for example, due to fault clearance). The insulation is endangered by the overvoltage condition.

Overvoltages at capacitor banks can be caused by resonances with line or transformer inductances.

In power plants increased voltage levels can be due to one of these factors:

- Incorrect operation when controlling the excitation system manually
- Failure of the automatic voltage controller
- After full load shedding of a generator
- Generators which are disconnected from the network or in island mode

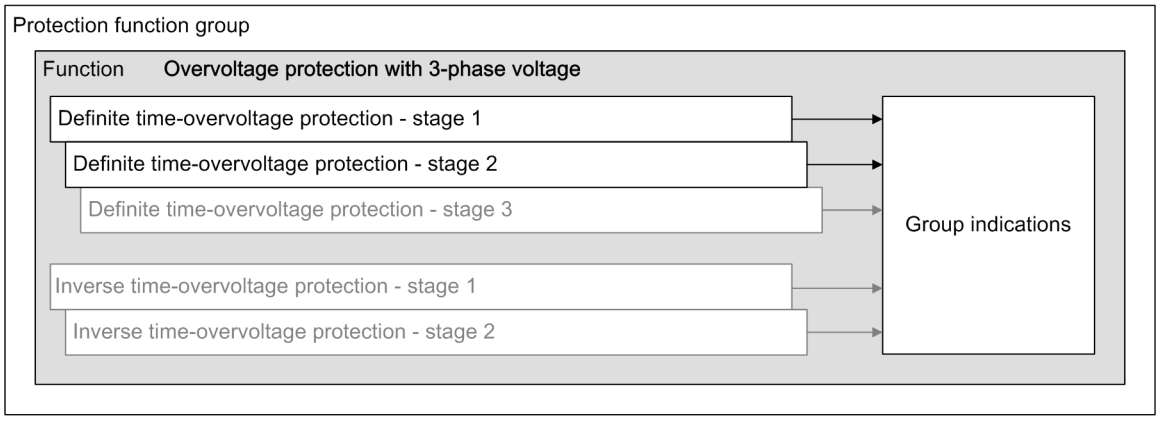
6.23.2 Structure of the Function

The **Overvoltage protection with 3-phase voltage** function is used in protection function groups with voltage measurement.

The **Overvoltage protection with 3-phase voltage** function is preconfigured by the manufacturer with 2 **Definite time-overvoltage protection** stages. In this function, the following stages can operate simultaneously:

- 3 stages **Definite time-overvoltage protection**
- 2 stages **Inverse time-overvoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.



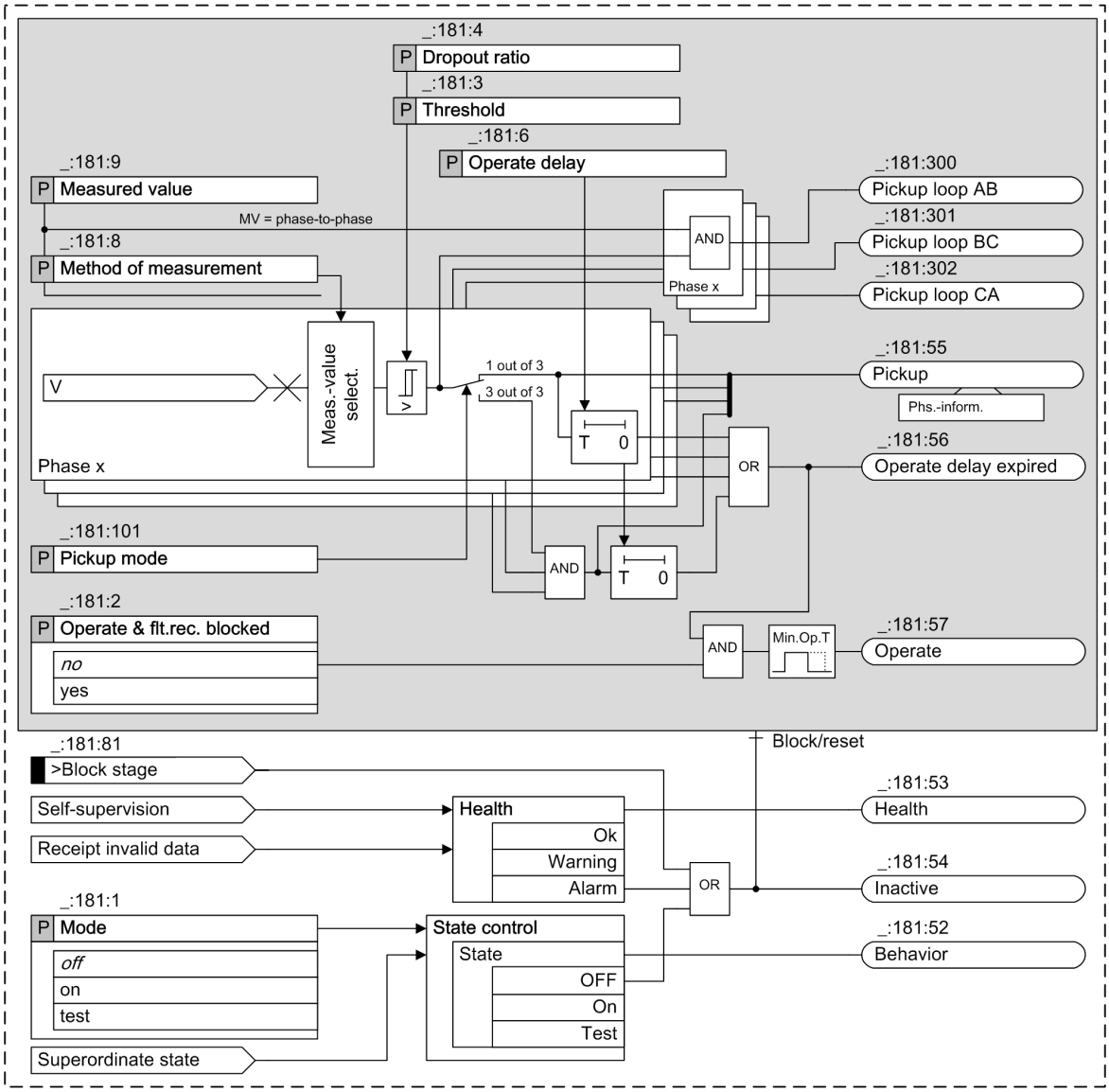
[dw3phovp-030211-01.tif, 3, en_US]

Figure 6-171 Structure/Embedding of the Function

6.23.3 Stage with Definite-Time Characteristic Curve

6.23.3.1 Description

Logic of the Stage



[lo3phasi-090611-01.tif, 3, en_US]

Figure 6-172 Logic Diagram of the Definite Time-Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value***.

- Measurement ***fundamental comp.***:

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement ***RMS value***:

  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

The **Pickup mode** parameter defines whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Measured Value

Use the **Measured value** parameter to define whether the tripping stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

6.23.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:181:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:181:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep ***phase-to-phase*** as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting **(_:181:3) Threshold** = ***110 V***

Depending on the **Measured value** , the **Threshold** is set either as phase-to-phase quantity or as phase-to-ground quantity. The default setting assumes that the voltage range is monitored on long-distance transmission lines under low-load conditions.

Specify the **Threshold** (pickup threshold) for the specific application.

Parameter: `Operate delay`

- Default setting **`(_:181:6) Operate delay`** = ***`3 s`***

The **`Operate delay`** must be set for the specific application.

Parameter: `Dropout ratio`

- Recommended setting value **`(_:181:4) Dropout ratio`** = ***`0.95`***

The recommended set value of ***`0.95`*** is appropriate for most applications. To achieve high measurement precision, the **`Dropout ratio`** can be reduced, to 0.98, for example.

Parameter: `Pickup mode`

- Recommended setting value **`(_:181:101) Pickup mode`** = ***`1 out of 3`***

With the **`Pickup mode`** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***`3 out of 3`***) or if only 1 measuring element detects the overvoltage condition (***`1 out of 3`***).

Parameter Value	Description
`1 out of 3`	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends ***`1 out of 3`*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
`3 out of 3`	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **`Operate & flt.rec. blocked`** parameter.

EXAMPLE

Example for 2-stage overvoltage protection

The example describes the possible settings for a 2-stage overvoltage protection function. We will look at the settings of the parameters **`Threshold`** and **`Operate delay`**.

- 1. Stage:

  To detect stationary overvoltages, set the threshold value of the first overvoltage-protection element at least 10 % above the max. stationary phase-to-phase voltage anticipated during normal operation. When setting the parameter **`Measured value`** to phase-to-phase voltage and a secondary rated voltage of 100 V, the secondary setting value of the first overvoltage-protection element is calculated as follows:

Threshold value: 10 % above V_{rated}

$V_{threshold, sec} = 1.1\ V_{rated, sec} = 1.1 \times 100\ V = 110\ V$

This requires that the primary rated voltages of protected object and voltage transformer are identical. If they are different, you have to adjust the pickup value.

For the **`Operate delay`** set a value of 3 s.

- 2. Stage:

  The second overvoltage-protection stage is intended for high overvoltages with short duration. A high pickup value is selected here, for example, 1.5 times the rated voltage. A time delay setting of 0.1 s to 0.2 s is sufficient then.

Stage	Setting Values	
	Threshold value	Time delay
1	Time delay 1.1 V_{rated}	3 s

Stage	Setting Values	
2	1.5 V_{rated}	0.1 s to 0.2 s

6.23.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:181:1	Definite-T 1:Mode		• off • on • test	off
_:181:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:181:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:181:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:181:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:181:3	Definite-T 1:Threshold		0.300 V to 340.000 V	110.000 V
_:181:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:181:6	Definite-T 1:Operate delay		0.00 s to 300.00 s	3.00 s
Definite-T 2				
_:182:1	Definite-T 2:Mode		• off • on • test	off
_:182:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:182:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:182:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:182:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:182:3	Definite-T 2:Threshold		0.300 V to 340.000 V	130.000 V
_:182:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:182:6	Definite-T 2:Operate delay		0.00 s to 300.00 s	0.50 s

6.23.3.4 Information List

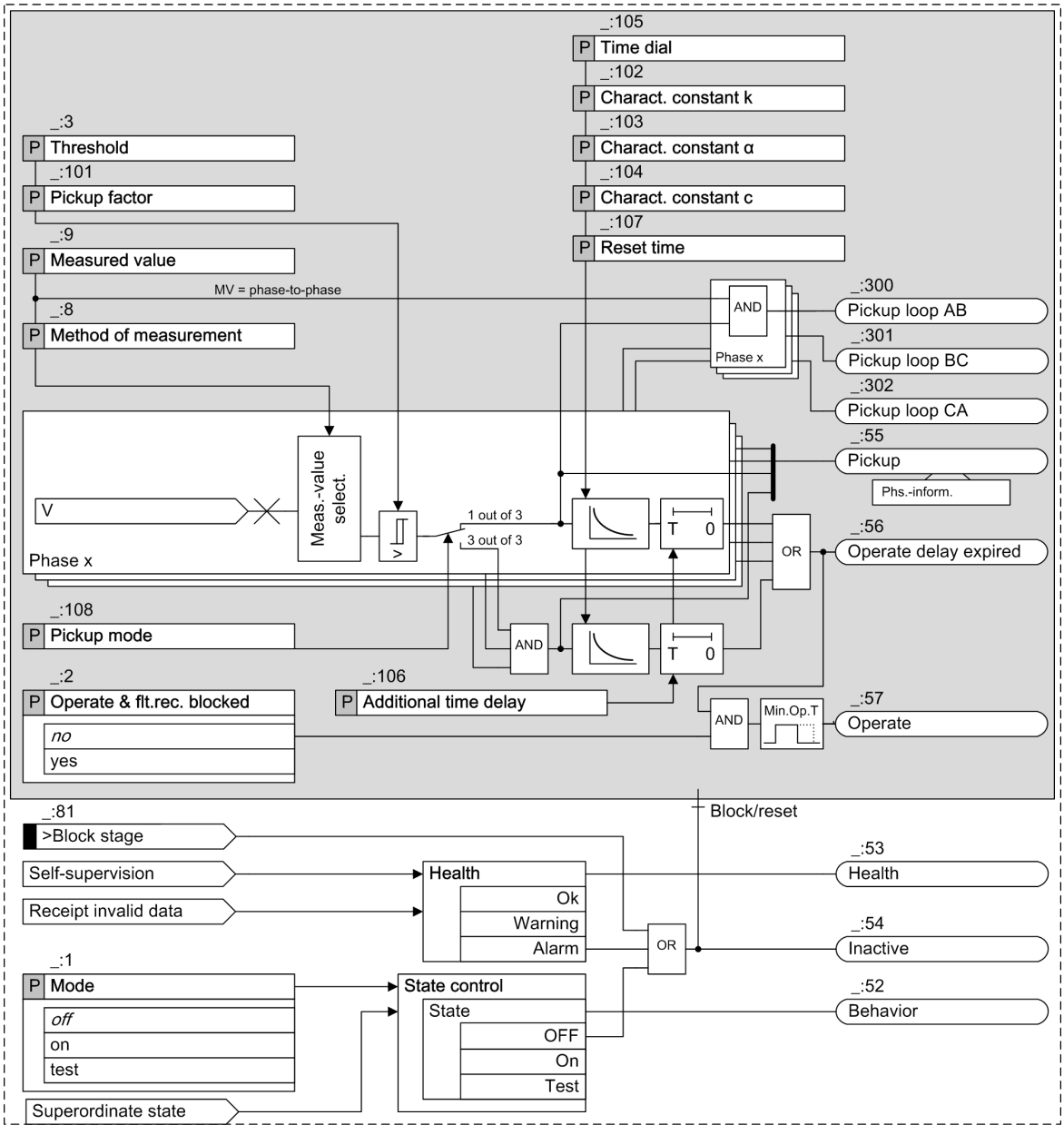
No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:181:81	Definite-T 1:>Block stage	SPS	I
_:181:54	Definite-T 1:Inactive	SPS	O
_:181:52	Definite-T 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:181:53	Definite-T 1:Health	ENS	O
_:181:55	Definite-T 1:Pickup	ACD	O
_:181:300	Definite-T 1:Pickup loop AB	SPS	O
_:181:301	Definite-T 1:Pickup loop BC	SPS	O
_:181:302	Definite-T 1:Pickup loop CA	SPS	O
_:181:56	Definite-T 1:Operate delay expired	ACT	O
_:181:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:182:81	Definite-T 2:>Block stage	SPS	I
_:182:54	Definite-T 2:Inactive	SPS	O
_:182:52	Definite-T 2:Behavior	ENS	O
_:182:53	Definite-T 2:Health	ENS	O
_:182:55	Definite-T 2:Pickup	ACD	O
_:182:300	Definite-T 2:Pickup loop AB	SPS	O
_:182:301	Definite-T 2:Pickup loop BC	SPS	O
_:182:302	Definite-T 2:Pickup loop CA	SPS	O
_:182:56	Definite-T 2:Operate delay expired	ACT	O
_:182:57	Definite-T 2:Operate	ACT	O

6.23.4 Stage with Inverse-Time Characteristic Curve

6.23.4.1 Description

Logic of the Stage



[lo3phinv, 2, en_US]

Figure 6-173 Logic Diagram of the Inverse Time-Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value*** .

- Measurement ***fundamental comp.*** :

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement ***RMS value*** :
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Measured Value

Use the **Measured value** parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup and Operate Curve

When the input voltage exceeds the threshold value by a settable value **Pickup factor** , the stage picks up and the inverse-time characteristic curve is processed. Operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

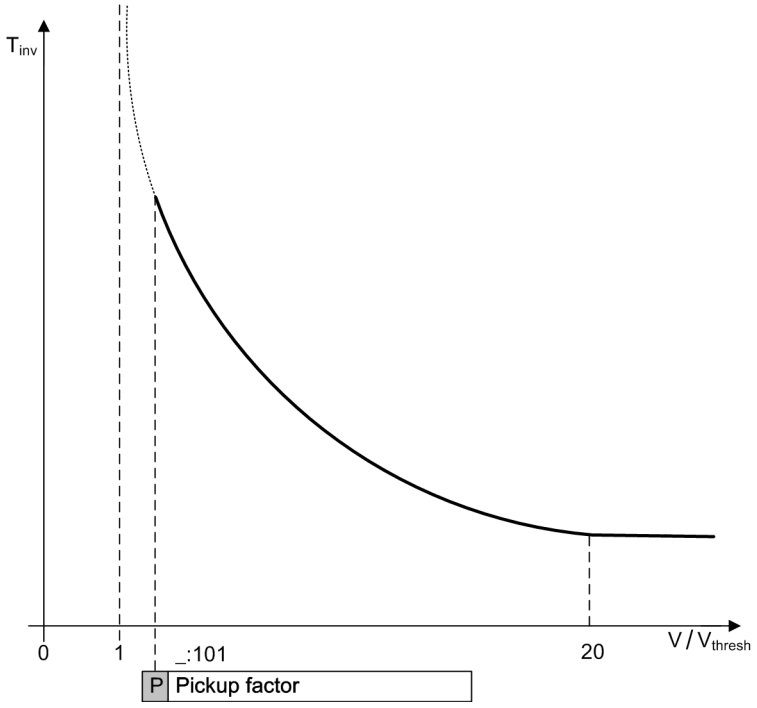
$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op}	Operate delay
T_{inv}	Inverse-time delay
T_{add}	Additional time delay (parameter **Additional time delay**)

After pickup, the time value T_{inv} is calculated for every input voltage that exceeds the threshold. An integrator accumulates the value $1/T_{inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The additional time delay T_{add} starts. The stage operates after the additional time delay expires.

The inverse-time characteristic is shown in the following figure.



[dwovpinv, 2, en_US]

Figure 6-174 Operate Curve of Inverse-Time Characteristic

The inverse-time delay is calculated with the following formula:

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter **`Time dial`**)
V	Measured voltage
V_{thresh}	Threshold value (parameter **`Threshold`**)
k	Curve constant k (parameter **`Charact. constant k`**)
α	Curve constant α (parameter **`Charact. constant α`**)
c	Curve constant c (parameter **`Charact. constant c`**)

When V/V_{thresh} is equal to or greater than 20, the inverse-time delay does not decrease any further.

Dropout Behavior

When the voltage falls below the dropout threshold (0.95 × pickup factor × threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter **`Reset time`** . Instantaneous reset takes place by setting **`Reset time`** to 0 s. A delayed reset takes place by setting the desired delay time.

During the **`Reset time`** (> 0 s), the elapsed operate delay is frozen. If the pickup value is exceeded again within this period, the stage operates when the rest of operate delay expires.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage* .

6.23.4.2 Application and Setting Notes

Parameter: **Method of measurement**

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: **Measured value**

- Default setting **(_:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the tripping stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep ***phase-to-phase*** as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: **Threshold**, **Pickup factor**

- Default setting **(_:3) Threshold** = ***110.000 V***
- Default setting **(_:101) Pickup factor** = ***1.10***

The stage picks up when the measured voltage value exceeds the pickup value **Threshold** × **Pickup factor**.

Depending on the **Measured value**, the **Threshold** is set either as phase-to-phase quantity or as phase-to-ground quantity.

With the **Pickup factor** parameter, you modify the pickup value. To avoid a long-time operate delay after pickup when the measured value is slightly over the threshold, Siemens recommends using the default setting.

Specify the **Threshold** (pickup threshold) and **Pickup factor** for the specific application.

Parameter: **Pickup mode**

- Recommended setting value **(_:182:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: **Charact. constant k**, **Charact. constant α**, **Charact. constant c**

- Default setting **(_:102) Charact. constant k** = ***1.00***
- Default setting **(_:103) Charact. constant α** = ***1.000***
- Default setting **(_:104) Charact. constant c** = ***0.000***

With the parameters **Charact. constant k**, **Charact. constant α**, and **Charact. constant c**, you define the required inverse-time characteristic curve.

Parameter: **Time dial**

- Default setting **(_:105) Time dial** = ***1.00***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the **Time dial** parameter at ***1.00*** (default setting).

Parameter: **Additional time delay**

- Default setting **(_:106) Additional time delay** = ***0.00 s***

With the **Additional time delay** parameter, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

Parameter: **Reset time**

- Default setting **(_:107) Reset time** = ***0.00 s***

With the **Reset time** parameter, you define the reset time delay which is started when the voltage falls below the dropout threshold. Set the parameter **Reset time** to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the **Reset time** to an appropriate value (> 0 s) to ensure the operation. Otherwise Siemens recommends to keep the default value to ensure a fast reset of the function.

6.23.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:108	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3

Addr.	Parameter	C	Setting Options	Default Setting
_:3	Inverse-T #:Threshold		0.300 V to 340.000 V	110.000 V
_:101	Inverse-T #:Pickup factor		1.00 to 1.20	1.10
_:102	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:103	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:104	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:105	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:106	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:107	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.23.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.24 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

6.24.1 Overview of Functions

The **Overvoltage protection with zero-sequence voltage/residual voltage** function (ANSI 59):

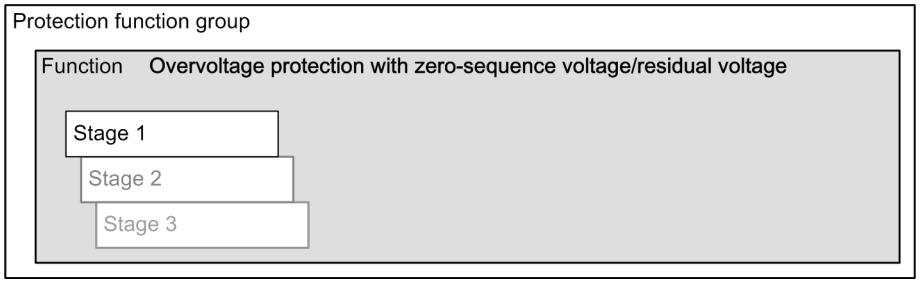
- Is used in isolated or arc-suppression-coil-grounded systems to detect ground faults
- determines the phase affected by the ground fault, if needed
- is used with electrical machines to detect ground faults in the stator winding.

6.24.2 Structure of the Function

The **Overvoltage protection with zero-sequence voltage/residual voltage** function is used in protection function groups, which are based on voltage measurement.

The **Overvoltage protection with zero-sequence voltage/residual voltage** function comes with 1 factory-set tripping stage. A maximum of 3 tripping stages can be operated simultaneously in the function.

The tripping stages have an identical structure.

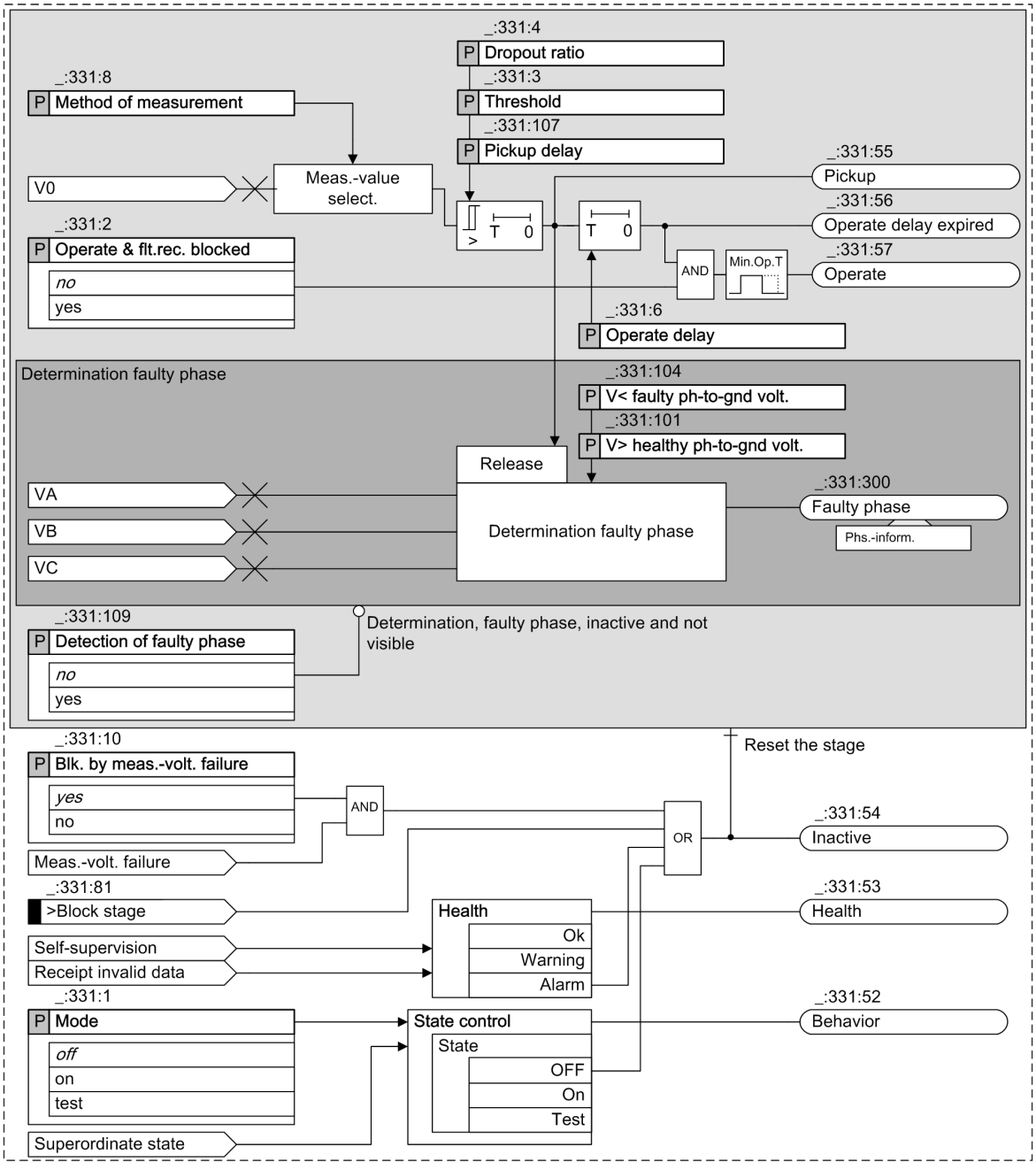


[dwu0ovps-030211-01.tif, 1, en_US]

Figure 6-175 Structure/Embedding of the Function

6.24.3 Stage Description

Logic of a Stage



[loovpu03-090611-01.tif, 2, en_US]

Figure 6-176 Logic Diagram of an Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage Stage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

Use the **Method of measurement** parameter to select the relevant method of measurement, depending on the application.

- Measurement of the ***fundamental comp.*** (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the ***RMS value*** parameter value (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- ***fund. comp. long filter*** (fundamental component over 2 cycle filters with triangular window):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see Technical Data).

Pickup, Dropout

The stage compares the **Threshold** with the zero-sequence voltage V_0. The **Pickup delay** parameter allows you to delay the pickup of the stage depending on the residual voltage.
With the **Dropout ratio** parameter you can define the ratio of the dropout value to the **Threshold**.

Determination of the Faulty Phase

You can use the **Detection of faulty phase** parameter to enable or disable the determining of the phase affected by the ground fault. Determining is released when the stage picks up. If 2 phases exceed the threshold value **V> healthy ph-to-gnd volt.** and 1 phase falls below the threshold value **V< faulty ph-to-gnd volt.**, the last phase is considered to be affected by the ground fault and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal **>Block stage** from an external or internal source
- From inside on pick up of the **measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal **>Open** of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.24.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:331:8) Method of measurement** = ***fundamental comp.***

The **Method of measurement** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.
fund. comp. long filter	To implement particularly strong damping of harmonics and transient disturbances, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Please note that in this case the pickup time of the tripping level increases slightly (see Technical Data).

Parameter: Pickup delay

- Recommended setting value **(_:331:107) Pickup delay** = ***0 ms***

The **Pickup delay** parameter allows you to delay the analysis of the measurand (to generate the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.

Siemens recommends using the default setting **Pickup delay** = ***0 ms***.

Parameter: Threshold

- Default setting **(_:331:3) Threshold** = ***30 V***[13]

The threshold value of the function is set as the zero-sequence voltage V_0. The device calculates the zero-sequence voltage V_0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.

The setting value depends on the system grounding:

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. It should range between 20 V and 40 V. A higher sensitivity (= lower threshold value) can be necessary for high fault resistances.
- You should select a more sensitive (smaller) value in a grounded system. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE

For an isolated system

The residual voltage is measured via the broken-delta winding:

- If the ground fault is fully unbalanced, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/$\sqrt{3}$ = 57.7 V
  Setting value: 0.5 * 57.7 V = 28.9 V ≈ 30 V

Parameter: Dropout ratio

- Recommended setting value **(_:331:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. The dropout ratio can be reduced for example, to 0.98 to achieve a high measurement precision.

Parameter: Operate delay

- Default setting **(_:331:6) Operate delay** = ***3.00 s***

The **Operate delay** allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

[13] The specific setting limits depend on the transformer data and transformer connections set.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:331:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see Chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Detection of faulty phase

- Default setting **(_:331:109) Detection of faulty phase** = ***no***

The **Detection of faulty phase** parameter controls how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults. For example, applications in grounded systems.
yes	After a pickup by the residual voltage the device tries to determine, which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting **(_:331:104) V< faulty ph-to-gnd volt.** = ***30.000 V***[14]

Set the threshold value for determining which phase is affected by the ground fault in the **V< faulty ph-to-gnd volt.** parameter. The setting value is a phase-to-ground quantity.

The set value must be smaller than the minimum phase-to-ground voltage occurring during operation. Siemens recommends using the default setting **V< faulty ph-to-gnd volt.** = ***30.000 V***.

Parameter: V> healthy ph-to-gnd volt.

- Default setting **(_:331:101) V> healthy ph-to-gnd volt.** = ***75.000 V***[15]

Set the threshold value for the two healthy phases in the **V> healthy ph-to-gnd volt.** parameter. The setting value is a phase-to-ground quantity.

The set value must lie above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 75 V, for example. Siemens recommends using the default setting **V> healthy ph-to-gnd volt.** = ***75.000 V***.

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

[14] The specific setting limits depend on the transformer data and transformer connections set.
[15] The specific setting limits depend on the transformer data and transformer connections set.

6.24.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:331:1	Stage 1:Mode		• off • on • test	off
_:331:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:331:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:331:109	Stage 1:Detection of faulty phase		• no • yes	no
_:331:8	Stage 1:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:331:3	Stage 1:Threshold		0.300 V to 340.000 V	30.000 V
_:331:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:331:107	Stage 1:Pickup delay		0.00 s to 320.00 s	0.00 s
_:331:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:331:101	Stage 1:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	75.000 V
_:331:104	Stage 1:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	40.000 V

6.24.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:331:81	Stage 1:>Block stage	SPS	I
_:331:54	Stage 1:Inactive	SPS	O
_:331:52	Stage 1:Behavior	ENS	O
_:331:53	Stage 1:Health	ENS	O
_:331:300	Stage 1:Faulty phase	ACT	O
_:331:55	Stage 1:Pickup	ACD	O
_:331:56	Stage 1:Operate delay expired	ACT	O
_:331:57	Stage 1:Operate	ACT	O

6.25 Overvoltage Protection with Positive-Sequence Voltage

6.25.1 Overview of Functions

The function **Overvoltage protection with positive-sequence voltage** (ANSI 59) is used to:

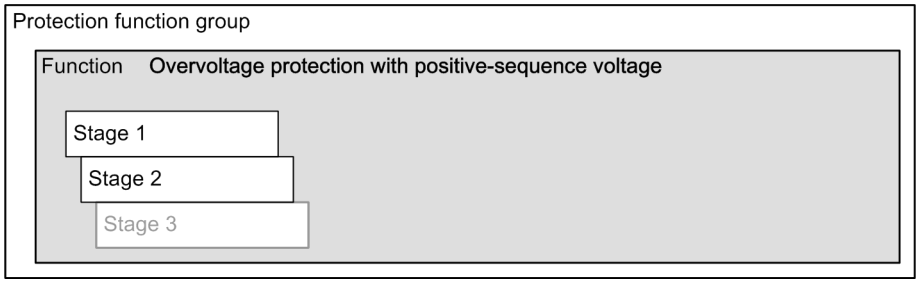
- Detect symmetric stationary overvoltages
- Supervise the voltage range if the positive-sequence voltage is the decisive quantity

Unbalanced overvoltages, for example, caused by ground faults and unbalanced faults, are not detected due to the evaluation of the positive-sequence voltage.

6.25.2 Structure of the Function

The **Overvoltage protection with positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Overvoltage protection with positive-sequence voltage** comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

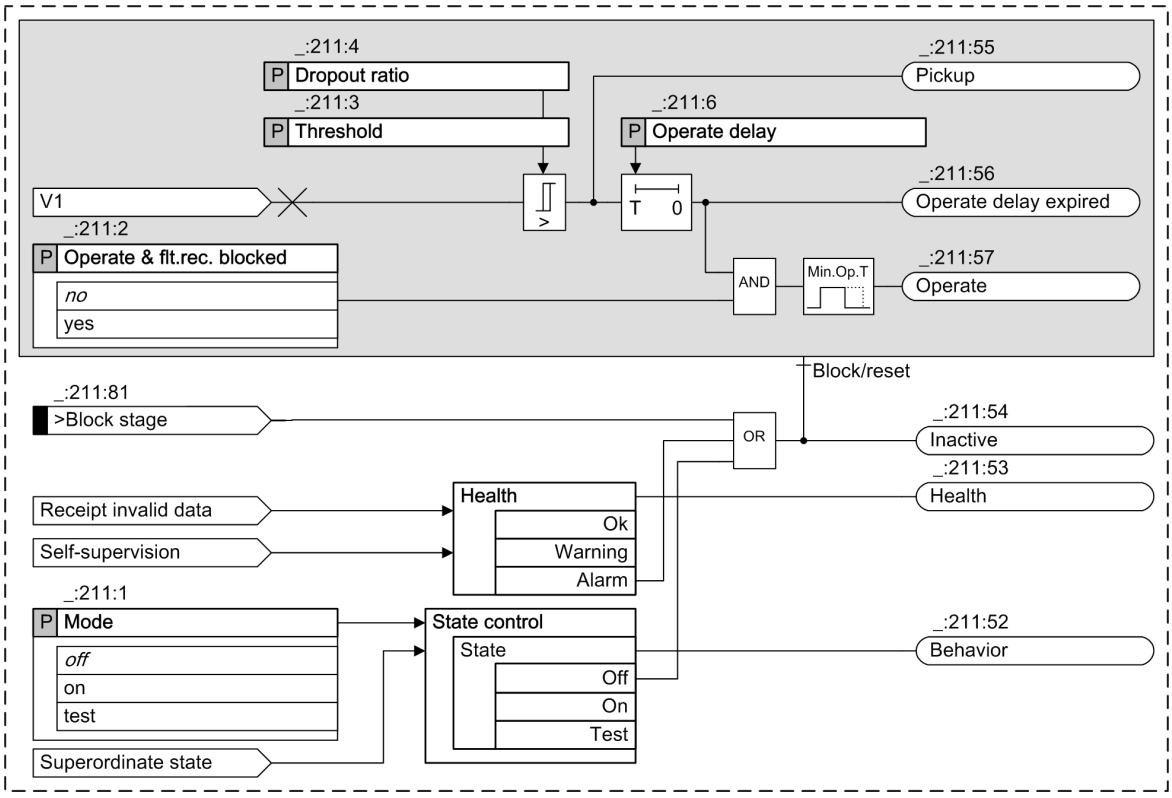


[dwovpu1s-030211-01.tif, 1, en_US]

Figure 6-177 Structure/Embedding of the Function

6.25.3 Stage Description

Logic of a Stage



[logovpu1-090611-01.tif, 1, en_US]

Figure 6-178 Logic Diagram of a Stage: Overvoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal **>Block stage**.

6.25.4 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:211:3) Threshold** = ***65 V***

The Threshold is set according to the definition of the positive-sequence system.
Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default **(_:211:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:211:4) Dropout ratio** = ***0.95***

The default value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

General Notes

If the overvoltage is high, the first stage can trip with a short time delay. If overvoltages are lower, the second stage can either only signal the threshold value violation (see Operation as monitoring function) or trip with a longer delay to allow the voltage controller to regulate the voltage back into the nominal range.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.25.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:211:1	Stage 1:Mode		• off • on • test	off
_:211:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:211:3	Stage 1:Threshold		0.300 V to 200.000 V	65.000 V
_:211:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:211:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:212:1	Stage 2:Mode		• off • on • test	off
_:212:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:212:3	Stage 2:Threshold		0.300 V to 200.000 V	75.000 V
_:212:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:212:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.25.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:211:81	Stage 1:>Block stage	SPS	I
_:211:54	Stage 1:Inactive	SPS	O
_:211:52	Stage 1:Behavior	ENS	O
_:211:53	Stage 1:Health	ENS	O
_:211:55	Stage 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:211:56	Stage 1:Operate delay expired	ACT	O
_:211:57	Stage 1:Operate	ACT	O
Stage 2			
_:212:81	Stage 2:>Block stage	SPS	I
_:212:54	Stage 2:Inactive	SPS	O
_:212:52	Stage 2:Behavior	ENS	O
_:212:53	Stage 2:Health	ENS	O
_:212:55	Stage 2:Pickup	ACD	O
_:212:56	Stage 2:Operate delay expired	ACT	O
_:212:57	Stage 2:Operate	ACT	O

6.26 Overvoltage Protection with Negative-Sequence Voltage

6.26.1 Overview of Functions

The function **Overvoltage protection with negative-sequence voltage** (ANSI 47) is used to:

- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failure, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

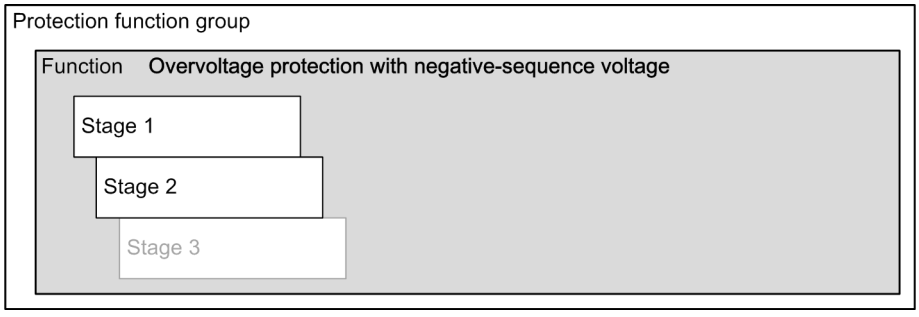
6.26.2 Structure of the Function

The **Overvoltage protection with negative-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Overvoltage protection with negative-sequence voltage** function comes with 2 factory-set stages.

A maximum of 3 stages can be operated simultaneously in the function.

The stages have an identical structure.



[dwu2ovpsExt.vsd, 2, en_US]

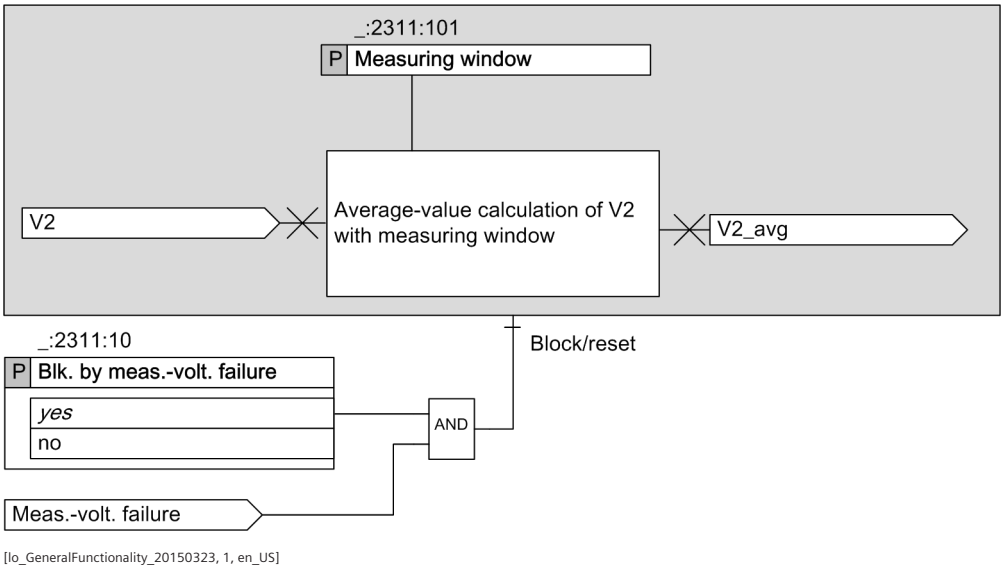
Figure 6-179 Structure/Embedding of the Function

6.26.3 General Functionality

6.26.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the negative-sequence voltage. The average value is forwarded to all subordinate stages.



[lo_GeneralFunctionality_20150323, 1, en_US]

Figure 6-180 Logic Diagram of the General Functionality

Measurand

The average value of negative-sequence voltage is determined by a settable time interval (parameter: **Measuring window**). With the parameter **Measuring window**, you can adapt this function to all power-system conditions.

You can set the parameter **Measuring window** with a large value to get a more accurate calculated result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pick up of the **Measuring-voltage failure detection** function (see section *9.3.2.1 Overview of Functions*).
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.26.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting **(_:2311:101) Measuring window** = ***1 cycle***

  With the parameter **Measuring window**, you can optimize the measuring accuracy or the pickup time of this function.

  For sensitive settings of the parameter **Threshold**, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends ***10 cycles***, and in this case, the pickup time is increased.

  For further information, refer to chapter *12.32 Overvoltage Protection with Negative-Sequence Voltage* .

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:2311:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.26.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:101	General:Measuring window		1 cycles to 10 cycles	1 cycles

6.26.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:V2 average	MV	O

6.26.4 Stage with Negative-Sequence Voltage

6.26.4.1 Description

Logic of a Stage

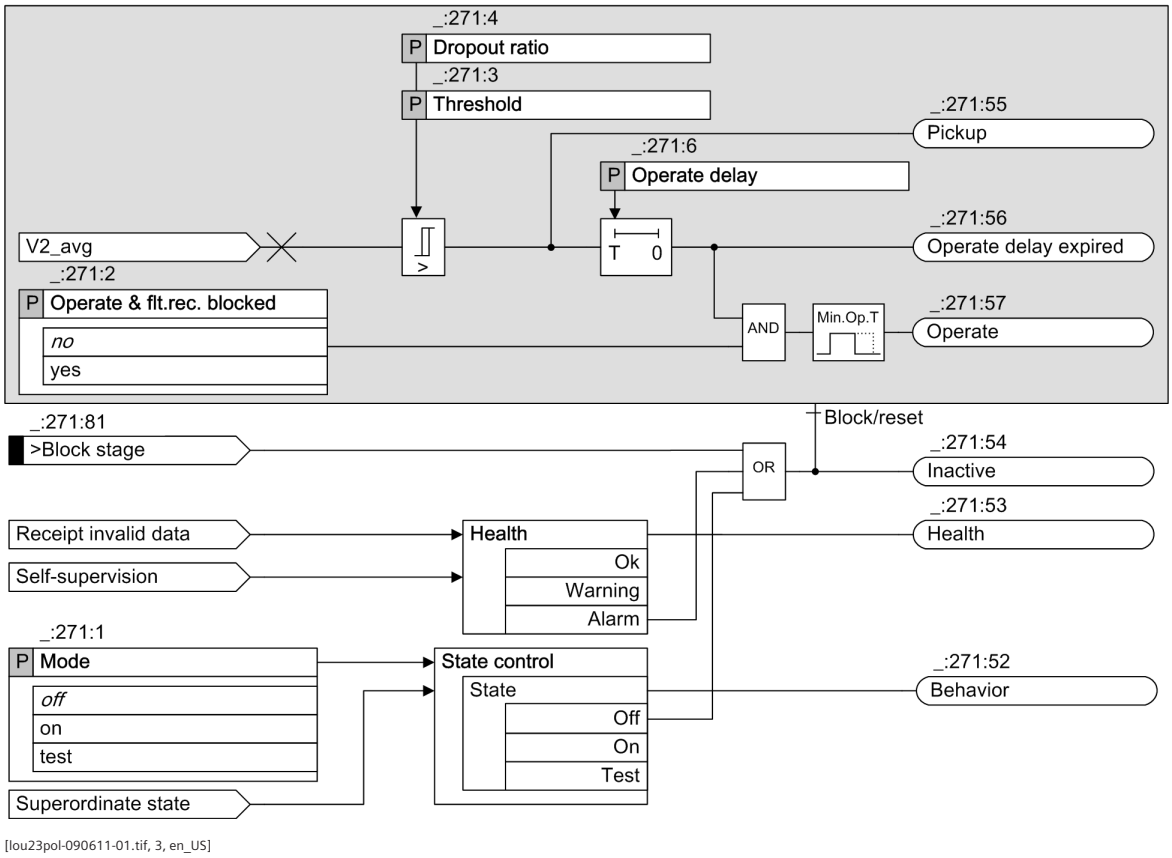


Figure 6-181 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage, which is calculated from the function block **General Functionality**. For more information, refer to chapter *6.26.3.1 Description*.

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal *>Block stage*

6.26.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:271:3) Threshold** = ***5.800 V***

The parameter **Threshold** is set according to the definition of the negative-sequence system.

Specify the **Threshold** (pickup threshold) for the specific application.

The secondary voltage of the voltage transformer can be used if the voltage transformer is adapted to the rated voltage. The value of the 10 % negative-sequence voltage at a 100 V rated secondary voltage is:

100 V / 1.73 * 0.1 = 5.77 V

Parameter: Dropout ratio

- Default setting `(_:271:4) Dropout ratio` = *`0.95`*

The default setting of *`0.95`* is appropriate for most applications.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90.

Parameter: Operate delay

- Default setting `(_:271:6) Operate delay` = *`3.00 s`*

Specify the `Operate delay` for the specific application. 3.00 s is a practicable value.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

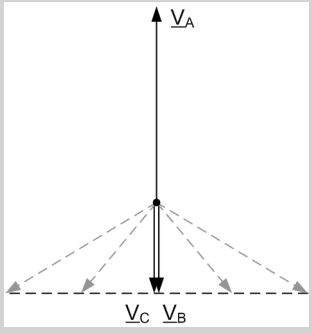
If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the `Operate & flt.rec. blocked` parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an **Overcurrent-protection** stage when unbalanced faults occur. Set the **Overcurrent-protection** stage only slightly higher than the load current, that is very sensitive. To prevent the **Overcurrent-protection** stage from picking up inadvertently, the **Overcurrent-protection** stage is released when the **Negative-sequence voltage** stage picks up. The **Overcurrent-protection** stage remains blocked as long as the **Negative-sequence voltage** stage has not picked up.

Figure 6-182 shows the voltage phasors during a 2-phase local fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.



[dwuazeig-020412-01.tif, 1, en_US]

Figure 6-182 Voltage Phasors during a 2-Phase Local Fault

A 2-phase local fault generates a relatively large negative-sequence voltage of up to 50 % referred to the phase-to-ground voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % negative-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the **Overcurrent-protection** stage when a fault occurs.

For a secondary rated voltage of 100 V, set the following secondary threshold value:

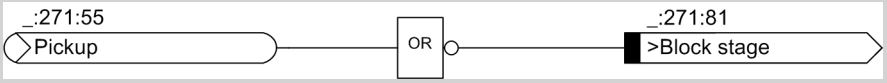
$$V2_{sec} = \frac{V_{rated}\ 100\ V}{\sqrt{3}} \times 10\,\% = \frac{100\ V}{\sqrt{3}} \times 0.1 \approx 5.8\ V$$

[fo_OVP_V2_Secondary Threshold, 1, en_US]

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the **Negative-sequence voltage** stage so that it does not generate a fault when it picks up and does not initiate tripping. The **Overcurrent-protection** stage generates a fault indication. The pickup of the **Negative-sequence voltage** stage is used as the release criterion because the **Short-circuit** function must be released immediately when the **Negative-sequence voltage** stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the **Overcurrent-protection** stage using a logic block chart. An inverter links the pickup of the **Negative-sequence voltage** stage with the **Overcurrent-protection** stage blocking.



[loinvert-020412-01.tif, 1, en_US]

Figure 6-183 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Secondary Threshold Value	Time Delay	Dropout Ratio
1	5.800 V	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents on motors. This leads to a thermal overload of the rotors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, this can, for example, initiate a switching of the infeed in order to prevent a protection trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are discussed.

The first stage has a pickup threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s, see *Table 6-14*. Further, it is assumed that the voltage transformer is well adapted to the rated voltage.

$$V2_{sec} = \frac{100\ V}{1.73} \times \frac{V2\ [\%]}{100\%}$$

[fo_OVP_V2_SecondaryThreshold2, 1, en_US]

Table 6-14 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	5.800 V	1.50 s
Stage 2	1.730 V	8.00 s

6.26.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:271:1	Stage 1:Mode		• off • on • test	off
_:271:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:271:3	Stage 1:Threshold		0.300 V to 200.000 V	5.800 V

Addr.	Parameter	C	Setting Options	Default Setting
_:271:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:271:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:272:1	Stage 2:Mode		• off • on • test	off
_:272:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:272:3	Stage 2:Threshold		0.300 V to 200.000 V	9.000 V
_:272:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:272:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.26.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:271:81	Stage 1:>Block stage	SPS	I
_:271:54	Stage 1:Inactive	SPS	O
_:271:52	Stage 1:Behavior	ENS	O
_:271:53	Stage 1:Health	ENS	O
_:271:55	Stage 1:Pickup	ACD	O
_:271:56	Stage 1:Operate delay expired	ACT	O
_:271:57	Stage 1:Operate	ACT	O
Stage 2			
_:272:81	Stage 2:>Block stage	SPS	I
_:272:54	Stage 2:Inactive	SPS	O
_:272:52	Stage 2:Behavior	ENS	O
_:272:53	Stage 2:Health	ENS	O
_:272:55	Stage 2:Pickup	ACD	O
_:272:56	Stage 2:Operate delay expired	ACT	O
_:272:57	Stage 2:Operate	ACT	O

6.27 Overvoltage Protection with Any Voltage

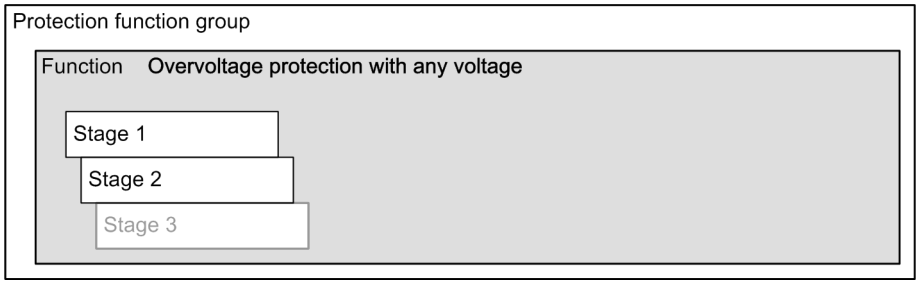
6.27.1 Overview of Functions

The function **Overvoltage protection with any voltage** (ANSI 59) detects any 1-phase overvoltages and is intended for special applications.

6.27.2 Structure of the Function

The **Overvoltage protection with any voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Overvoltage protection with any voltage** comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

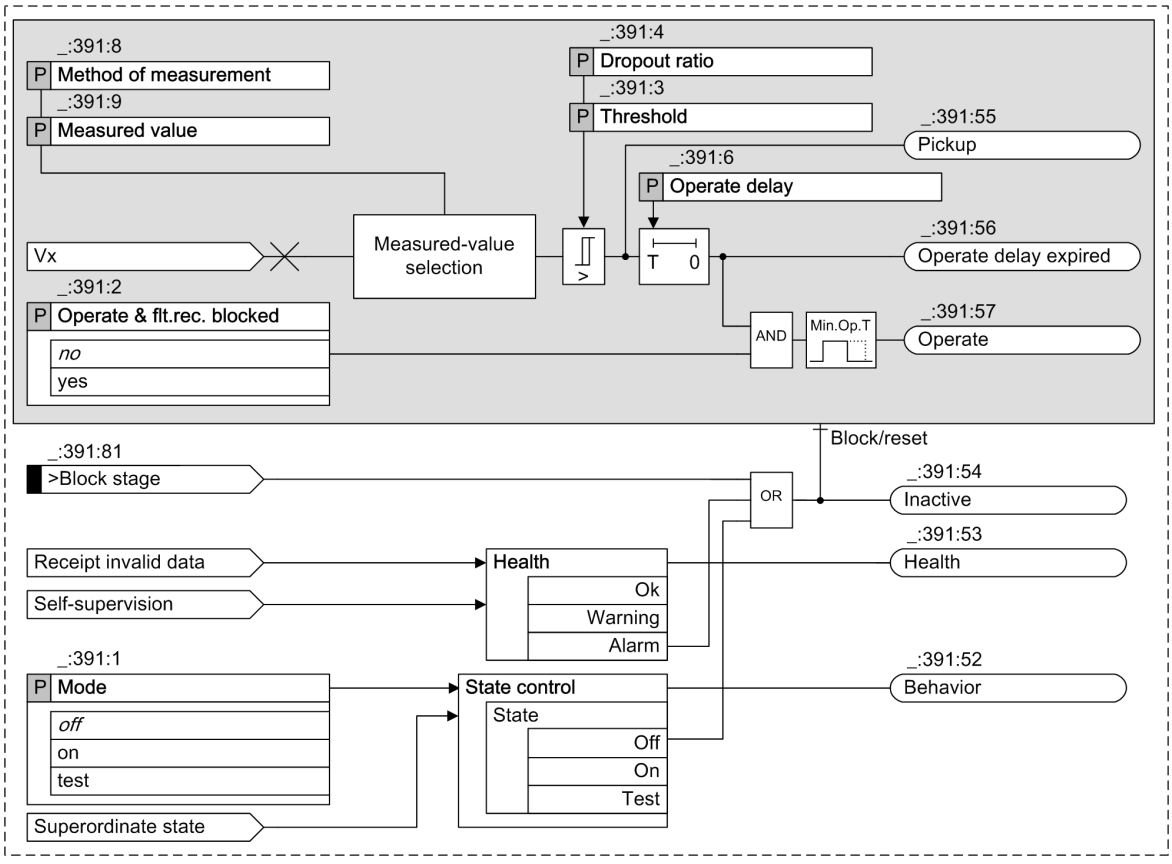


[dwovpuxs-030211-01.tif, 1, en_US]

Figure 6-184 Structure/Embedding of the Function

6.27.3 Stage Description

Logic of a Stage



[louxovpr-211212-01.tif, 1, en_US]

Figure 6-185 Logic Diagram of a Stage: Overvoltage Protection with Any Voltage

NOTE

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **`Measured value`** is not visible.

Method of Measurement

The **`Method of measurement`** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the ***`fundamental comp.`***:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the parameter value ***`RMS value`***:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter **`Measured value`** allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **`Measured value`** is not visible.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

6.27.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:391:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:391:9) Measured value** = ***VA measured***

The **Measured value** parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (***VA measured***)
- Measured phase-to-ground voltage V_B (***VB measured***)
- Measured phase-to-ground voltage V_C (***VC measured***)
- Measured phase-to-phase voltage V_{AB} (***VAB measured***)
- Measured phase-to-phase voltage V_{BC} (***VBC measured***)
- Measured phase-to-phase voltage V_{CA} (***VCA measured***)
- Calculated phase-to-phase voltage V_{AB} (***VAB calculated***)
- Calculated phase-to-phase voltage V_{BC} (***VBC calculated***)
- Calculated phase-to-phase voltage V_{CA} (***VCA calculated***)
- Calculated voltage V0 (***V0 calculated***)

The selection depends on the corresponding application.

NOTE

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

Parameter: Threshold

- Default setting **(_:391:3) Threshold** = ***110 V***

Specify the **Threshold** (pickup threshold) for the specific application.

Depending on the measured value, the **Threshold** is set either as **Measured voltage** or as **Phase-to-phase** quantity.

Parameter: Operate delay

- Default setting **(_:391:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:391:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.27.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:391:1	Stage 1:Mode		• off • on • test	off
_:391:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:391:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:391:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:391:3	Stage 1:Threshold		0.300 V to 340.000 V	110.000 V
_:391:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:391:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:392:1	Stage 2:Mode		• off • on • test	off
_:392:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:392:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:392:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:392:3	Stage 2:Threshold		0.300 V to 340.000 V	130.000 V
_:392:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:392:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.27.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:391:81	Stage 1:>Block stage	SPS	I
_:391:54	Stage 1:Inactive	SPS	O
_:391:52	Stage 1:Behavior	ENS	O
_:391:53	Stage 1:Health	ENS	O
_:391:55	Stage 1:Pickup	ACD	O
_:391:56	Stage 1:Operate delay expired	ACT	O
_:391:57	Stage 1:Operate	ACT	O
Stage 2			
_:392:81	Stage 2:>Block stage	SPS	I
_:392:54	Stage 2:Inactive	SPS	O
_:392:52	Stage 2:Behavior	ENS	O
_:392:53	Stage 2:Health	ENS	O
_:392:55	Stage 2:Pickup	ACD	O
_:392:56	Stage 2:Operate delay expired	ACT	O
_:392:57	Stage 2:Operate	ACT	O

6.28 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

6.28.1 Overview of Functions

The function **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** is used to:

- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

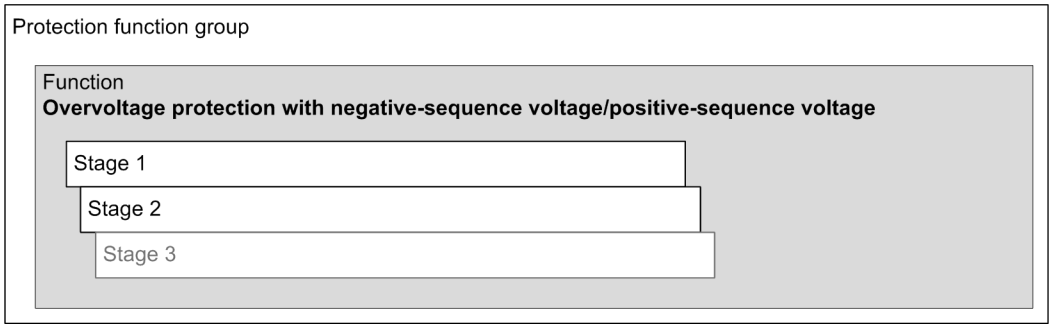
Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failure, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

6.28.2 Structure of the Function

The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function comes with 2 factory-set stages. A maximum of 3 stages can be operated simultaneously in the function. The stages have an identical structure.



[Structure-V2/V1_20150521, 2, en_US]

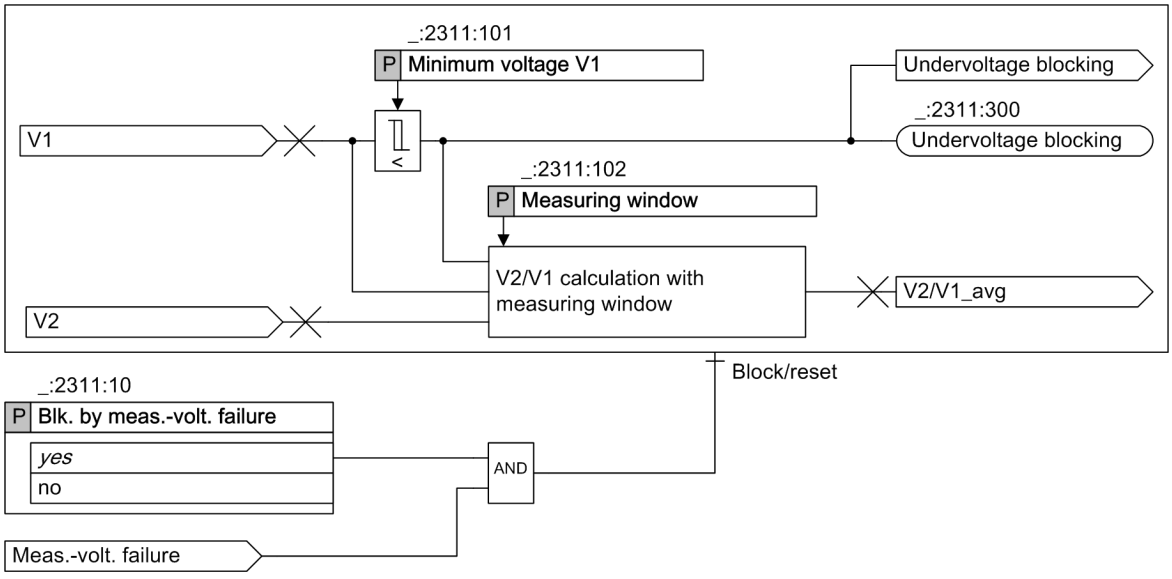
Figure 6-186 Structure/Embedding of the Function

6.28.3 General Functionality

6.28.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the ratio of negative-sequence voltage to positive-sequence voltage. The average value is forwarded to all subordinate stages.



[lo_V2toV1_FB General_20150326, 1, en_US]

Figure 6-187 Logic Diagram of the General Functionality

Measurand

The average value of the ratio of negative-sequence voltage to positive-sequence voltage is determined by a settable time interval (parameter: **Measuring window**). With the parameter **Measuring window**, you can adapt this function to all power-system conditions.

You can set the parameter **Measuring window** with a large value to get a more accurate calculated result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pick up of the **Measuring-voltage failure detection** function (see section *9.3.2.1 Overview of Functions*).
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.28.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting **(_:2311:102) Measuring window** = ***1 cycle***

  With the parameter **Measuring window**, you can optimize the measuring accuracy or the pickup time of this function.

  For sensitive settings of the parameter **Threshold**, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends ***10 cycles***, and in this case, the pickup time is increased.

  For further information, refer to chapter *12.35 Overvoltage Protection with Negative-Sequence Voltage/ Positive-Sequence Voltage* .

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:2311:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.28.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:102	General:Measuring window		1 cycles to 10 cycles	1 cycles
_:2311:101	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

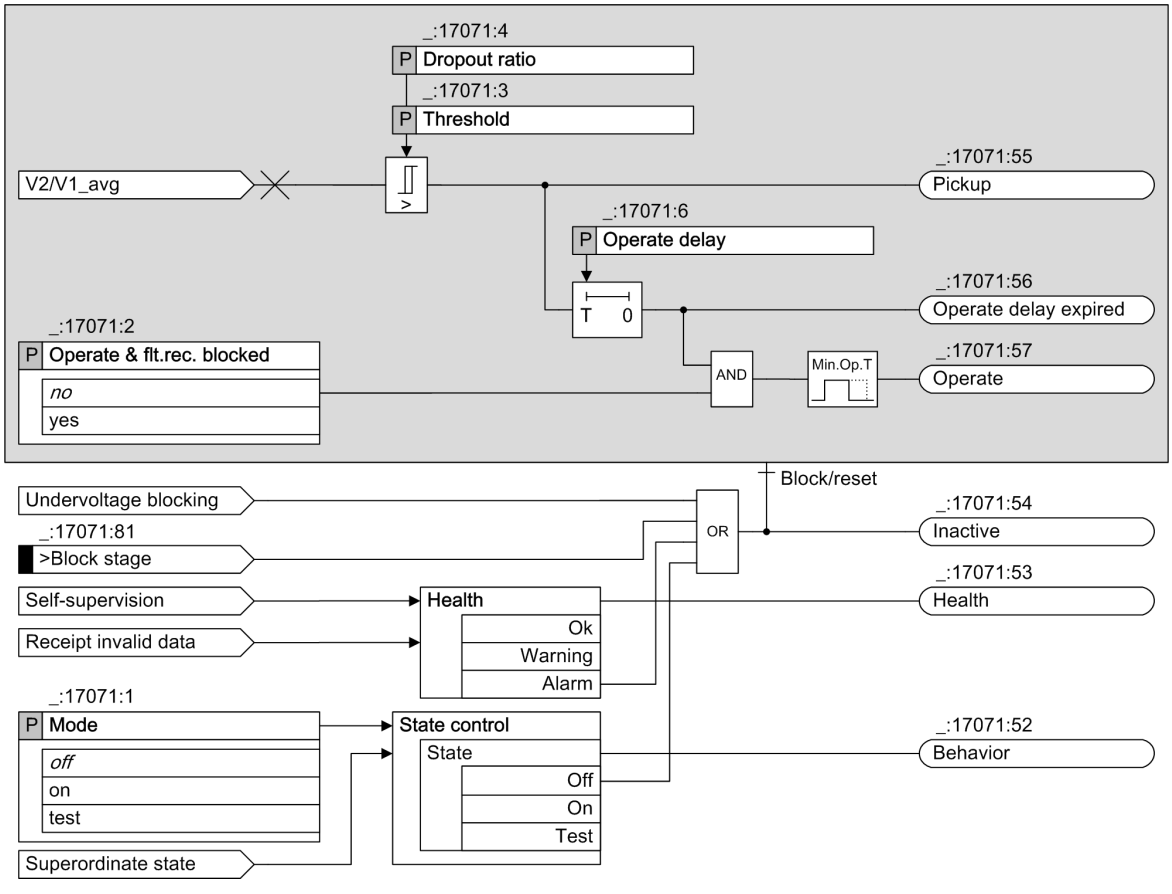
6.28.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:V2/V1	MV	O

6.28.4 Stage with Negative-Sequence Voltage/Positive-Sequence Voltage

6.28.4.1 Description

Logic of a Stage



[lo_V2V1_PROV_20150326, 1, en_US]

Figure 6-188 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage/positive-sequence voltage, which is calculated from the function block **General Functionality**. For more information, refer to chapter *6.28.3.1 Description* .

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal *>Block stage*

6.28.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:17071:3) Threshold** = *10.00 %*

The parameter **Threshold** is set in percentage according to the definition of the symmetrical compents. It is the ratio of the negative-sequence voltage to positive-sequence voltage.

Specify the **Threshold** (pickup threshold) for the specific application.

In the application with a lower threshold setting of about 2.00 %, there is a risk of an overfunction due to the measuring errors with small values as well as an influence via disturbances.

Parameter: Dropout ratio

- Default setting **(_:17071:4) Dropout ratio** = ***0.95***

The default setting of ***0.95*** is appropriate for most applications if a higher threshold is used.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90.

Parameter: Operate delay

- Default setting **(_:17071:6) Operate delay** = ***3.00 s***

Specify the **Operate delay** for the specific application. When using the sensitive setting of the threshold value that is described in this chapter, the function can be delayed by 3.00 s.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

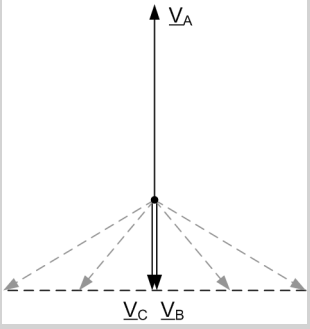
If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an **Overcurrent-protection** stage when unbalanced faults occur. Set the **Overcurrent-protection** stage only slightly higher than the load current, that is very sensitive. To prevent the **Overcurrent-protection** stage from picking up inadvertently, the **Overcurrent-protection** stage is released when the **Negative-sequence voltage** stage picks up. The **Overcurrent-Protection** stage remains blocked as long as the **Negative-sequence voltage** stage has not picked up.

Figure 6-189 shows the voltage phasors during a 2-phase local fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.



[dwuazeig-020412-01.tif, 1, en_US]

Figure 6-189 Voltage Phasors during a 2-Phase Local Fault

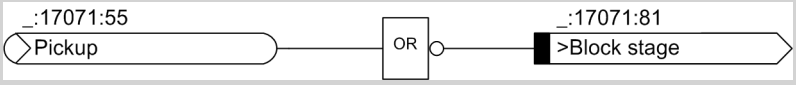
A 2-phase local fault generates a relatively large negative-sequence voltage of up to 100 % referred to the positive-sequence voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % of the negative-sequence voltage to positive-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the **Overcurrent-protection** stage when a fault occurs.

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the **Negative-sequence voltage** stage so that it does not generate a fault when it picks up and does not initiate tripping. The **Overcurrent-protection** stage generates a fault indication. The pickup of the **Negative-sequence voltage** stage is used as the release criterion because the **Short-circuit** function must be released

immediately when the **Negative-sequence voltage** stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the **Overcurrent-protection** stage using a logic block chart. An inverter links the pickup of the **Negative-sequence voltage** stage with the **Overcurrent-protection** stage blocking.



[lo_Pickup of V2_20150507, 1, en_US]

Figure 6-190 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Percentage of the Negative-Sequence Voltage to Positive-Sequence Voltage	Time Delay	Dropout Ratio
1	10.00 %	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents on motors. This leads to a thermal overload of the rotors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, this can, for example, initiate a switching of the infeed in order to prevent a protection trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are discussed.

The first stage has a pickup threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s, see *Table 6-15* .

Table 6-15 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	10.00 %	1.50 s
Stage 2	3.00 %	8.00 s

6.28.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:17071:1	Stage 1:Mode		• off • on • test	off
_:17071:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:17071:3	Stage 1:Threshold		0.50 % to 100.00 %	10.00 %
_:17071:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:17071:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:17072:1	Stage 2:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:17072:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:17072:3	Stage 2:Threshold		0.50 % to 100.00 %	15.00 %
_:17072:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:17072:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.28.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:17071:81	Stage 1:>Block stage	SPS	I
_:17071:54	Stage 1:Inactive	SPS	O
_:17071:52	Stage 1:Behavior	ENS	O
_:17071:53	Stage 1:Health	ENS	O
_:17071:55	Stage 1:Pickup	ACD	O
_:17071:56	Stage 1:Operate delay expired	ACT	O
_:17071:57	Stage 1:Operate	ACT	O
Stage 2			
_:17072:81	Stage 2:>Block stage	SPS	I
_:17072:54	Stage 2:Inactive	SPS	O
_:17072:52	Stage 2:Behavior	ENS	O
_:17072:53	Stage 2:Health	ENS	O
_:17072:55	Stage 2:Pickup	ACD	O
_:17072:56	Stage 2:Operate delay expired	ACT	O
_:17072:57	Stage 2:Operate	ACT	O

6.29 Undervoltage Protection with 3-Phase Voltage

6.29.1 Overview of Functions

The function **Undervoltage protection with 3-phase voltage** (ANSI 27) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components and machines) against damages caused by undervoltage
- Handle disconnection or load shedding tasks in a system

6.29.2 Structure of the Function

The **Undervoltage protection with 3-phase voltage** function is used in protection function groups with voltage measurement.

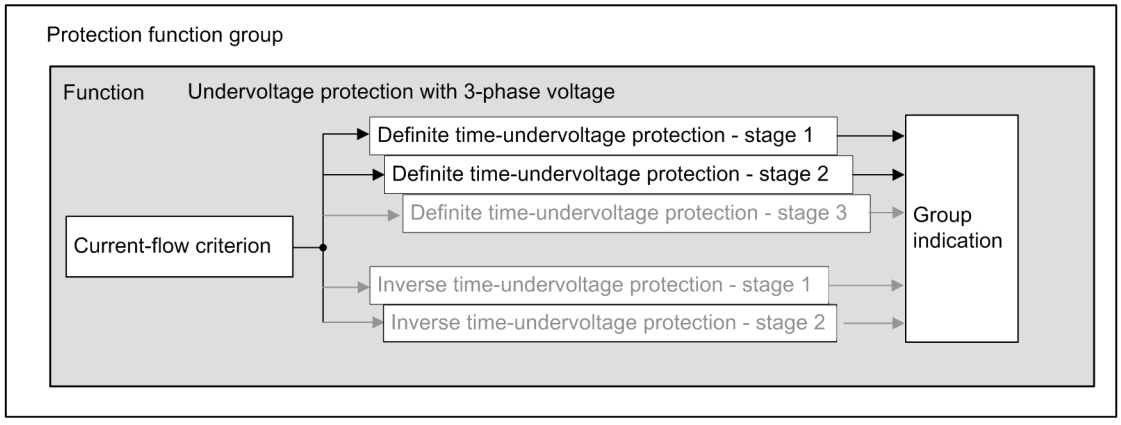
The **Undervoltage protection with 3-phase voltage** function is preconfigured by the manufacturer with 2 **Definite time-undervoltage protection** stages.

In the function **Undervoltage protection with 3-phase voltage**, the following stages can be operated simultaneously:

- 3 stages **Definite time-undervoltage protection**
- 2 stages **Inverse time-undervoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-191*). If the protection function group used has no current measurement, you can only set the current-flow criterion as **fulfilled** via the corresponding binary input signal.



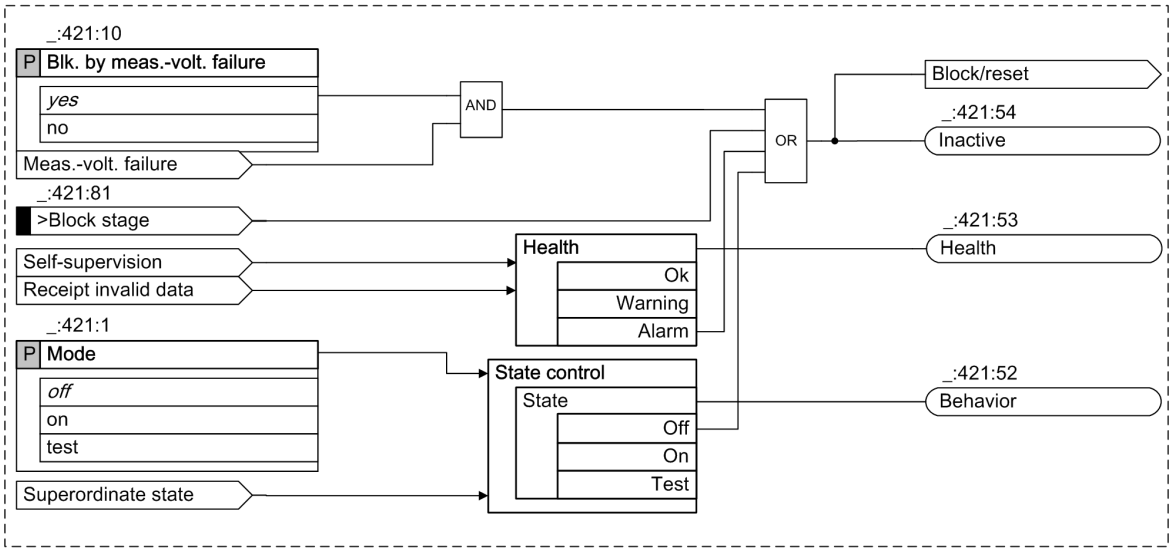
[dwstru3p-110211-01.tif, 3, en_US]

Figure 6-191 Structure/Embedding of the Function

6.29.3 Stage with Definite-Time Characteristic Curve

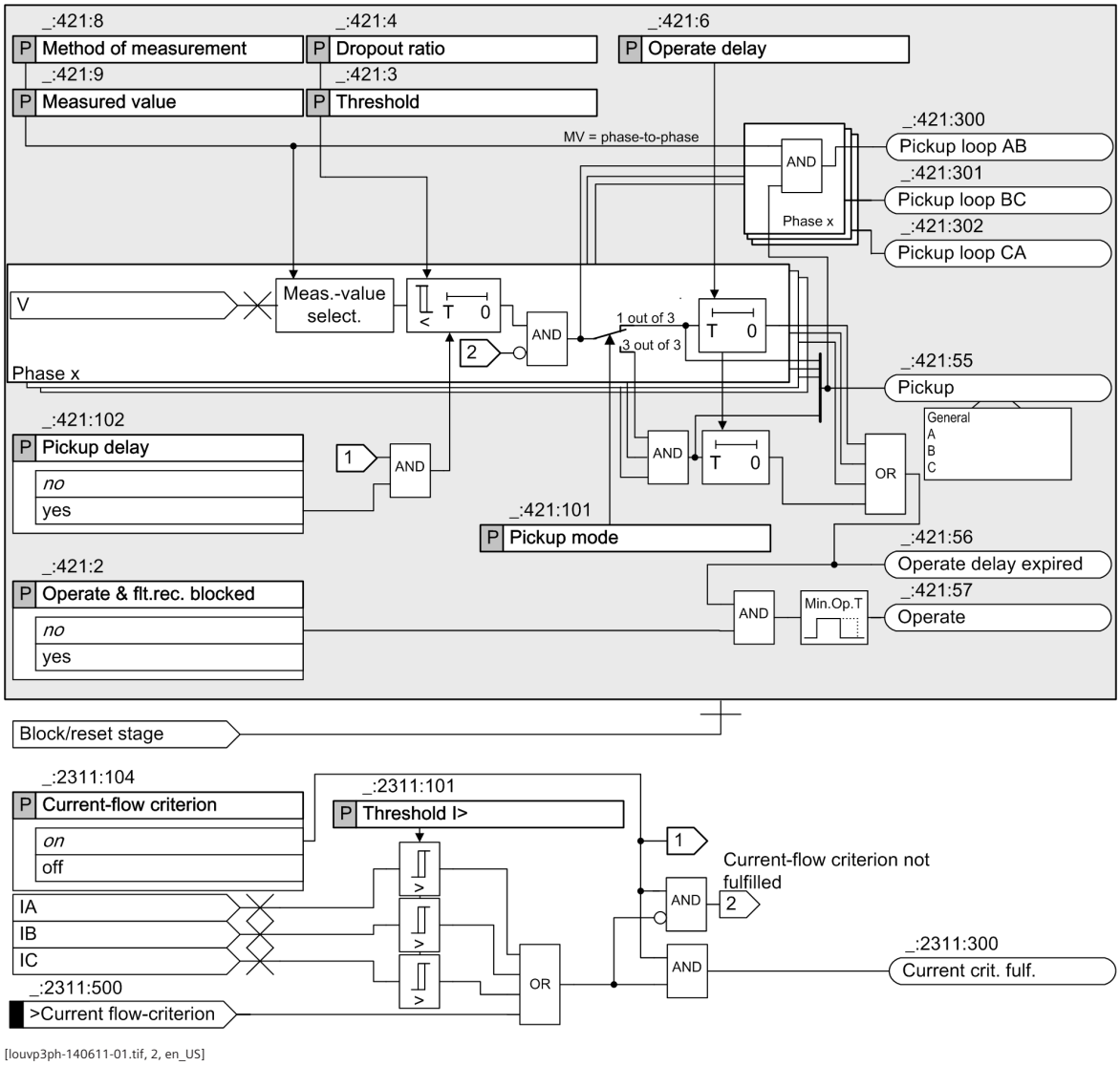
6.29.3.1 Description

Logic of a Stage



[louvp3ph-140611-01_stagecontrol.vsd, 1, en_US]

Figure 6-192 Logic Diagram of the Stage Control



[louvp3ph-140611-01.tif, 2, en_US]

Figure 6-193 Logic Diagram of the Function

Method of Measurement

With the **`Method of measurement`** parameter, you select the relevant method of measurement, depending on the application.

- Measurement fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

With the **`Measured value`** parameter, you define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Mode

With the **Pickup mode** setting, you define whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the **Pickup delay** parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The **Current-flow criterion** works across all tripping stages.

When the **Current-flow criterion** parameter is activated, the undervoltage protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-193 illustrates the influence of the current-flow criterion.



NOTE

If the **(_:2311:104) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pick up of the **measuring-voltage failure detection** function (see section *9.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.29.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:421:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Recommended setting value **(_:421:9) Measured value** = ***phase-to-phase***

Use the **Measured value** parameter to define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C. Parameter Value

Parameter Value	Description
phase-to-phase	If you want to detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. The function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances or overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting **(_:421:3) Threshold** = ***80 V***

The **Threshold** is set in accordance with the **Measured value** as either a ***phase-to-phase*** or ***phase-to-ground*** variable.

Specify the **Threshold** (pickup threshold) for the specific application.

For the default setting, the lower limit of the voltage range to be monitored is assumed to be 80% of the rated voltage of the protected object.

EXAMPLE:

Rated voltage of the protected object: $V_{rated,\ obj.} = 10\ kV$

Voltage transformer:

$$Ratio_V = \frac{10\ kV/\sqrt{3}}{100\ V/\sqrt{3}}$$

Threshold value: 80 % of $V_{rated,\ obj.}$

The secondary setting value is calculated as follows:

$$V_{Threshold\ value,\ sec} = \frac{0.8 \cdot V_{rated,obj.}}{Ratio_V} = \frac{0.8 \cdot 10\ kV \cdot 100\ V}{10\ kV} = 80\ V$$

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Parameter: Pickup mode

- Recommended setting value **(_:421:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting **(_:421:102) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter **Pickup delay** you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Operate delay

- Default **(_:421:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:421:4) Dropout ratio** = ***1.05***

The recommended set value of ***1.05*** is appropriate for most applications. To achieve high-precision measurements, the **Dropout ratio** can be reduced (to 1.02, for example).

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:421:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see Chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.

Parameter Value	Description
no	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:104) Current-flow criterion** = ***on***

Depending on the system, the voltage transformers are arranged either on the supply side or the junction side. These 2 possible voltage transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker:

- If they are located on the supply side, the voltage remains on
- If they are located on the junction side, the voltage is cleared.

Parameter Value	Description
on	If the voltage transformers are located on the junction side, you can use the current-flow criterion to make the pickup fall back when the current falls below a minimum value (parameter **Threshold I>**).
off	Since the voltage is switched off, the pickup of the undervoltage protection stage persists when the current-flow criterion is not used.

Parameter: Threshold I>

- Recommended setting value **(_:2311:101) Threshold I>** = ***0.05 A***

The **Threshold I>** parameter makes it possible to detect when the circuit-breaker is closed. Siemens recommends setting the **Threshold I>** parameter to 5% of the rated current. With a secondary rated transformer current of 1 A, the secondary setting value for **Threshold I>** would be 0.05 A.

If the sensitivity of the **Threshold I>** parameter is set too high, compensation processes in the secondary circuit of the current transformer will extend the dropout time when breaking extremely high currents. To speed up dropout, increase the default setting.

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.29.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:421:1	Definite-T 1:Mode		• off • on • test	off
_:421:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:421:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:421:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:421:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:421:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:421:102	Definite-T 1:Pickup delay		• no • yes	no
_:421:3	Definite-T 1:Threshold		0.300 V to 175.000 V	80.000 V
_:421:4	Definite-T 1:Dropout ratio		1.01 to 1.20	1.05
_:421:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	3.00 s
Definite-T 2				
_:422:1	Definite-T 2:Mode		• off • on • test	off
_:422:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:422:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:422:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:422:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:422:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:422:102	Definite-T 2:Pickup delay		• no • yes	no
_:422:3	Definite-T 2:Threshold		0.300 V to 175.000 V	65.000 V
_:422:4	Definite-T 2:Dropout ratio		1.01 to 1.20	1.05
_:422:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.29.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:421:81	Definite-T 1:>Block stage	SPS	I
_:421:54	Definite-T 1:Inactive	SPS	O
_:421:52	Definite-T 1:Behavior	ENS	O
_:421:53	Definite-T 1:Health	ENS	O
_:421:55	Definite-T 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:421:300	Definite-T 1:Pickup loop AB	SPS	O
_:421:301	Definite-T 1:Pickup loop BC	SPS	O
_:421:302	Definite-T 1:Pickup loop CA	SPS	O
_:421:56	Definite-T 1:Operate delay expired	ACT	O
_:421:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:422:81	Definite-T 2:>Block stage	SPS	I
_:422:54	Definite-T 2:Inactive	SPS	O
_:422:52	Definite-T 2:Behavior	ENS	O
_:422:53	Definite-T 2:Health	ENS	O
_:422:55	Definite-T 2:Pickup	ACD	O
_:422:300	Definite-T 2:Pickup loop AB	SPS	O
_:422:301	Definite-T 2:Pickup loop BC	SPS	O
_:422:302	Definite-T 2:Pickup loop CA	SPS	O
_:422:56	Definite-T 2:Operate delay expired	ACT	O
_:422:57	Definite-T 2:Operate	ACT	O

6.29.4 Stage with Inverse-Time Characteristic Curve

6.29.4.1 Description

Logic

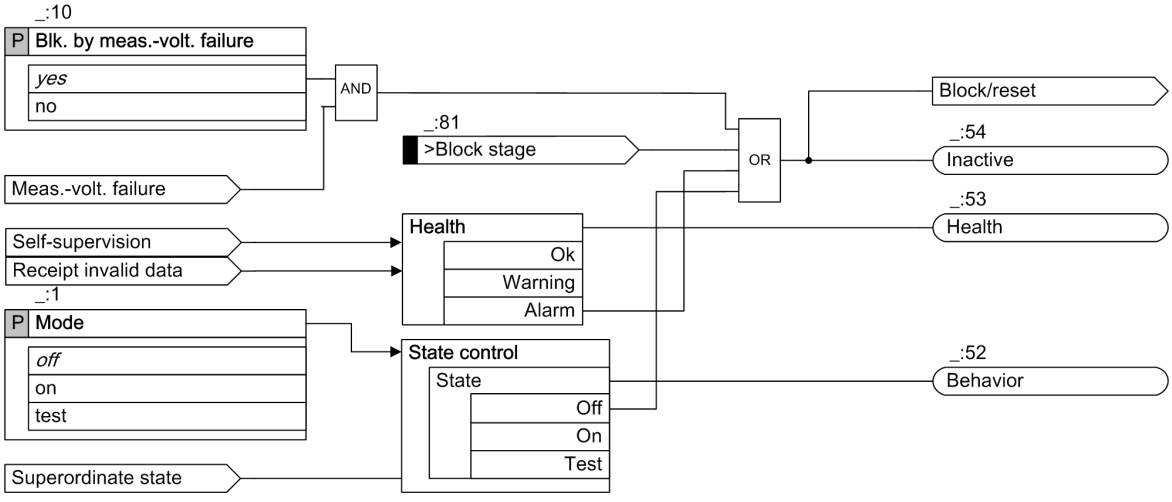
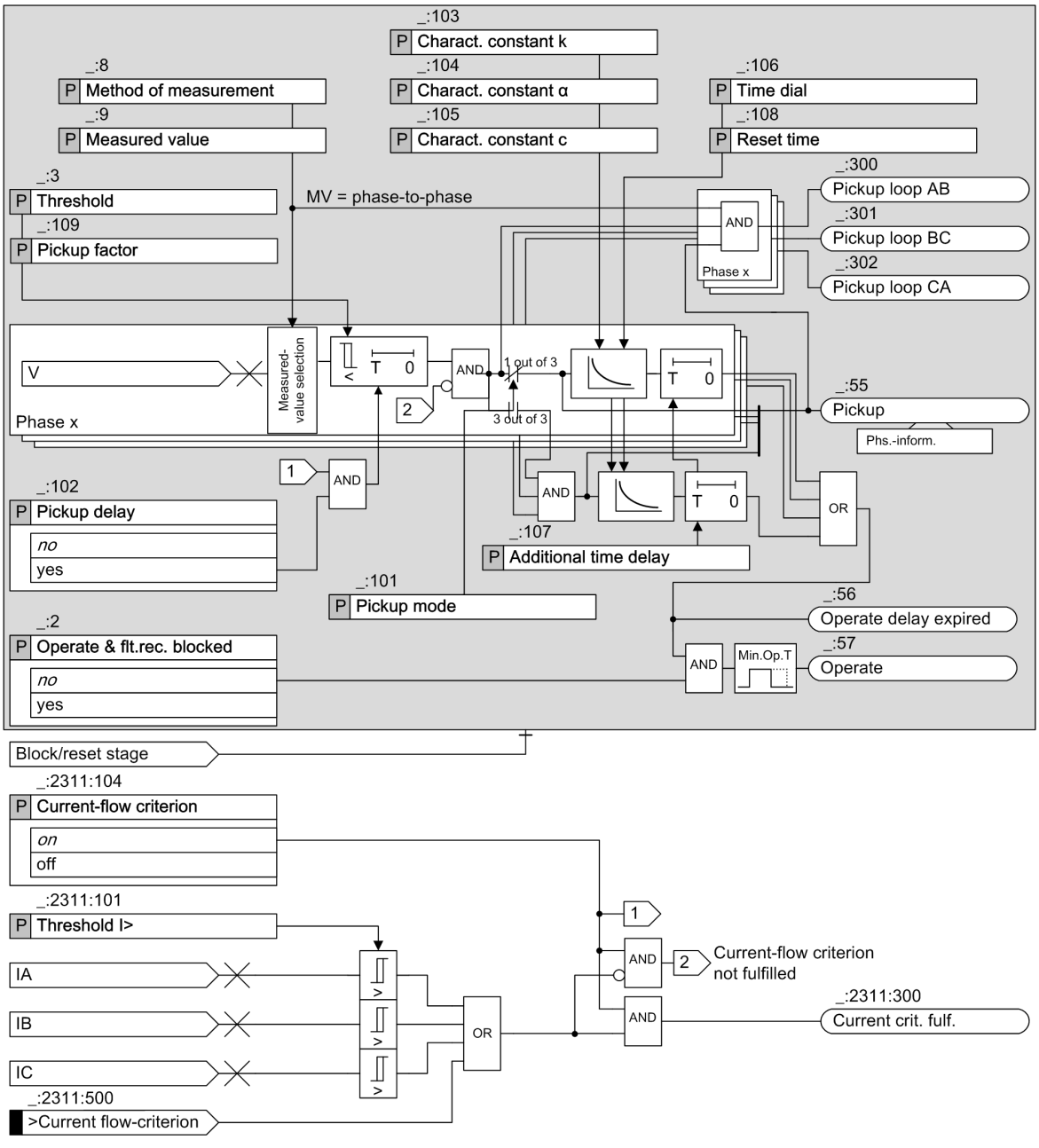


Figure 6-194 Logic Diagram of the Stage Control



[lo_UVP3ph_In, 3, en_US]

Figure 6-195 Logic Diagram of the Function

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value***.

- Measurement ***fundamental comp.***:

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement ***RMS value***:

  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

Use the **Measured value** parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Mode

Use the **Pickup mode** parameter to define whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Pickup and Operate Curve

When the input voltage falls below the threshold value by a settable value **Pickup factor**, the stage picks up and the inverse-time characteristic curve is processed. The operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

$T_{op}=T_{Inv}+T_{add}$

Where:

T_{op}	Operate delay
T_{Inv}	Inverse-time delay
T_{add}	Additional time delay (Parameter **Additional time delay**)

After pickup the time value T_{Inv} is calculated for every input voltage less than the dropout value. An integrator accumulates the value $1/T_{Inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The stage operates after the additional time delay.

The inverse-time delay is calculated with the following formula:

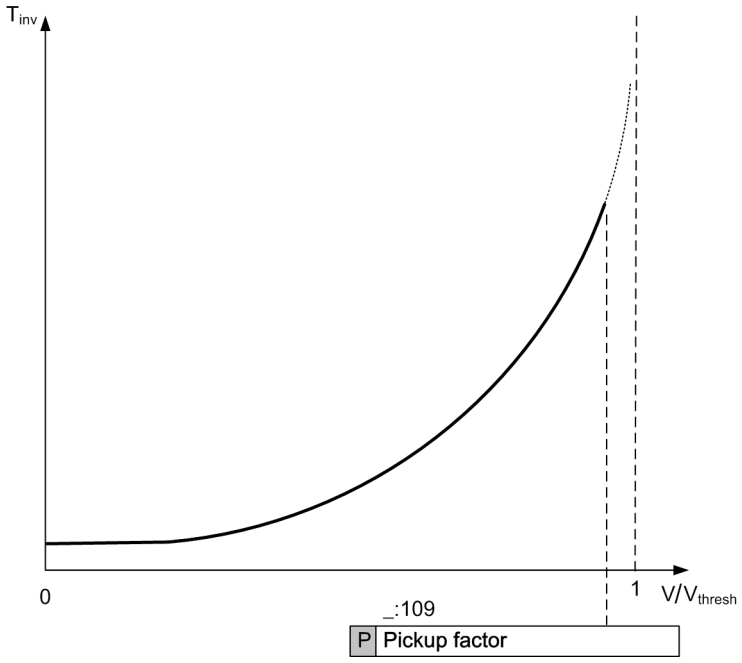
$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_UVP3ph_inverse, 2, en_US]

Where

T_{Inv}	Inverse-time delay
T_p	Time multiplier (Parameter **Time dial**)
V	Measured undervoltage
V_{Thresh}	Threshold value (Parameter **Threshold**)
k	Curve constant k (Parameter **Charact. constant k**)
α	Curve constant α (Parameter **Charact. constant α**)
c	Curve constant c (Parameter **Charact. constant c**)

The inverse-time characteristic is shown in the following figure:



[dwUVP3ph_inverse, 1, en_US]

Figure 6-196 Inverse-Time Characteristics for Undervoltage Protection

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the **Pickup delay** parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Dropout Behavior

When the voltage exceeds the dropout value (1.05 x pickup factor x threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter **Reset time**. Instantaneous reset takes place by setting **Reset time** to 0 s. A delayed reset takes place by setting the desired delay time.

During the Reset time (> 0 s), the elapsed operate delay is frozen. If the stage picks up again within this period, the stage operates when the rest of operate delay expires.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The **Current-flow criterion** works across all tripping stages.

When the **Current-flow criterion** parameter is activated, the undervoltage-protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-193 illustrates the influence of the current-flow criterion.

NOTE

If the **(_:2311:104) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage is reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pick up of the **Measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*) . The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.29.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Recommended setting value **(_:9) Measured value** = ***phase-to-phase***

Use the **Measured value** parameter to define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. The function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances or overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting **(_:3) Threshold** = ***80.000 V***
- Default setting **(_:109) Pickup factor** = ***0.90***

The stage picks up when the measured voltage value falls below the pickup value **Threshold** × **Pickup factor**.

Depending on the **Measured value**, the **Threshold** is set either as ***phase-to-phase*** quantity or as ***phase-to-ground*** quantity.

With the **Pickup factor**, you modify the pickup value. To avoid a long operate delay time after pickup, Siemens recommends using the default value of **Pickup factor** .

Specify the **Threshold** (pickup threshold) and **Pickup factor** for the specific application.

Parameter: Pickup mode

- Recommended setting value **(_:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting **(_:102) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter **Pickup delay**, you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for under-voltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting **(_:103) Charact. constant k** = ***1.00***
- Default setting **(_:104) Charact. constant α** = ***1.000***
- Default setting **(_:105) Charact. constant c** = ***0.000***

With the **Charact. constant k**, **Charact. constant α**, and **Charact. constant c** parameters, you define the required inverse-time characteristic.

Parameter: `Time dial`

- Default setting **`(_:106) Time dial`** = ***`1.00`***

With the **`Time dial`** parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the **`Time dial`** parameter at ***`1.00`*** (default setting).

Parameter: `Reset time`

- Default setting **`(_:108) Reset time`** = ***`0.00 s`***

With the **`Reset time`** parameter, you define the reset time delay which is started when the voltage exceeds the dropout value. Set the parameter **`Reset time`** to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the **`Reset time`** to an appropriate value > 0 s to ensure the operation. Otherwise, Siemens recommends to keep the default value to ensure a fast reset of the function.

Parameter: `Additional time delay`

- Default setting **`(_:107) Additional time delay`** = ***`0.00 s`***

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

Parameter: Blk. by meas.-volt. failure

- Default setting **`(_:10) Blk. by meas.-volt. failure`** = ***`yes`***

You use the **`Blk. by meas.-volt. failure`** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **`>Open`** of the function block **`VTCB`** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
`yes`	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
`no`	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value **`(_:2311:104) Current-flow criterion`** = ***`on`***

Depending on the system, the voltage transformers are arranged either on the supply side or the junction side. These 2 possible voltage-transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker:

- If they are located on the supply side, the voltage remains on.
- If they are located on the junction side, the voltage is cleared.

Parameter Value	Description
`on`	If the voltage transformers are located on the junction side, you can use the current-flow criterion to make the pickup fall back when the current falls below a minimum value (parameter **`Threshold I>`**).
`off`	Since the voltage is switched off, the pickup of the undervoltage protection stage persists when the current-flow criterion is not used.

6.29.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:10	Inverse-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:101	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:102	Inverse-T #:Pickup delay		• no • yes	no
_:3	Inverse-T #:Threshold		0.300 V to 175.000 V	80.000 V
_:109	Inverse-T #:Pickup factor		0.80 to 1.00	0.90
_:103	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:104	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:105	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:106	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:107	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:108	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.29.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.30 Undervoltage Protection with Positive-Sequence Voltage

6.30.1 Overview of Functions

The **Undervoltage protection with positive-sequence voltage** function (ANSI 27) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components and machines) from damage caused by undervoltage
- Protect motors and generators from inadmissible operating states and a possible loss of stability in the event of voltage dips

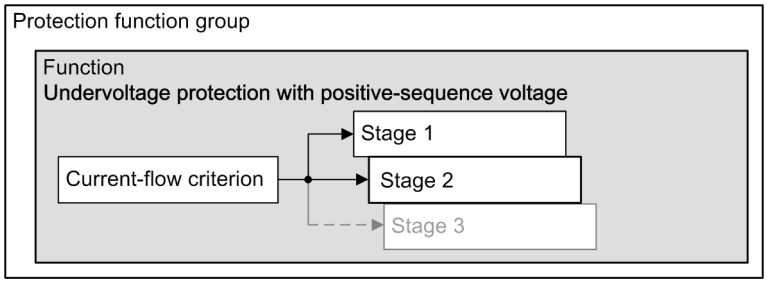
2-phase short circuits or ground faults lead to an unbalanced voltage collapse. In comparison to three 1-phase measuring systems, such events have no noticeable impact on the positive-sequence voltage. This makes this function particularly suitable for the assessment of stability problems.

6.30.2 Structure of the Function

The **Undervoltage protection with positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Undervoltage protection with positive-sequence voltage** function comes with 2 factory-set tripping stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-197*). If the protection function group used has no current measurement, you can only set the current- flow criterion as **fulfilled** via the corresponding binary input signal.

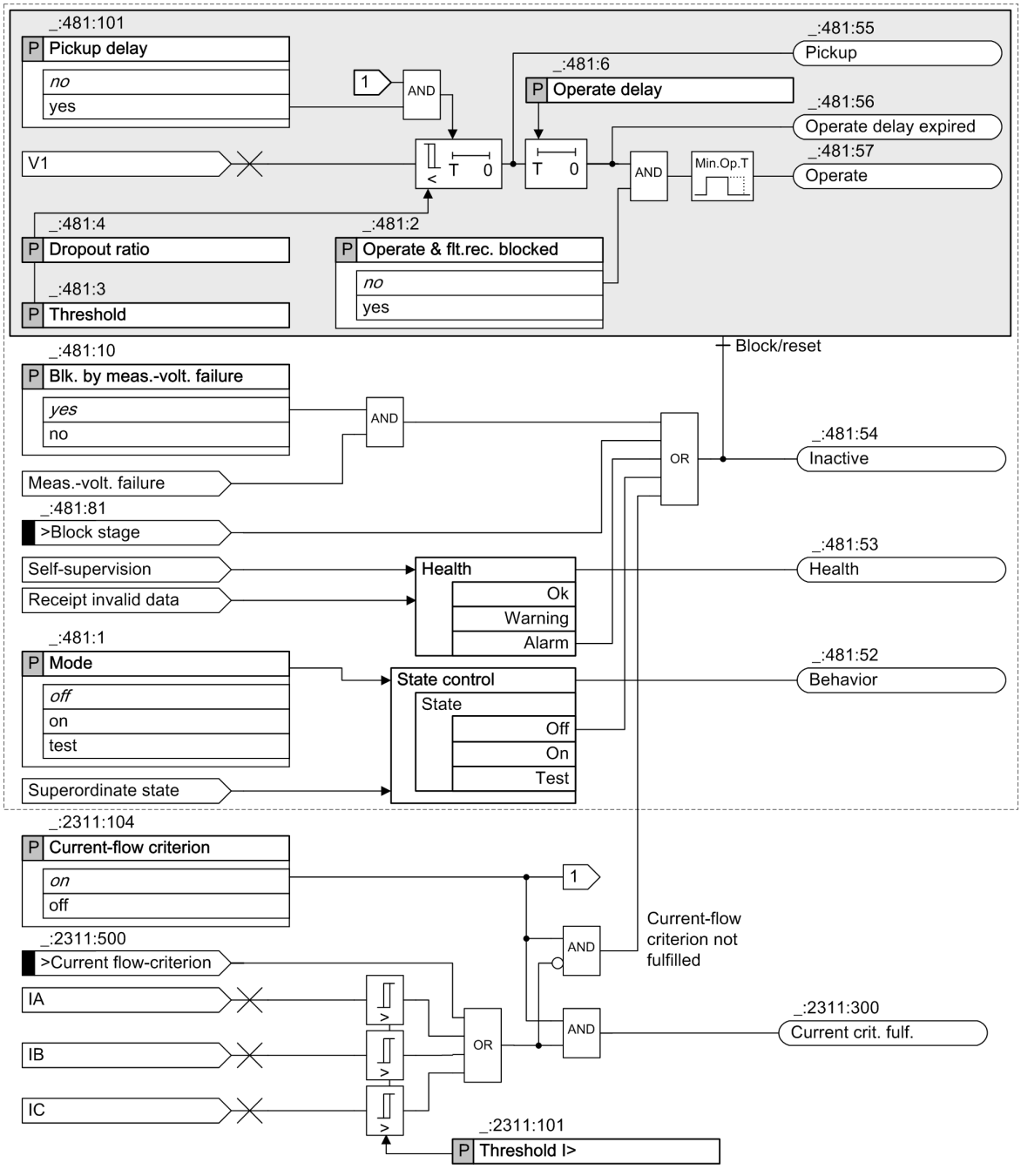


[dwstuvu1-110211-01.tif, 3, en_US]

Figure 6-197 Structure/Embedding of the Function

6.30.3 Stage Description

Logic of a Stage



[louv3pu1-021012-01.tif, 1, en_US]

Figure 6-198 Logic Diagram of a Stage: Undervoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the tripping stage picks up briefly. Use the **Pickup delay** parameter to prevent the tripping stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the **Current-flow criterion** parameter is activated, the undervoltage protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded in at least one phase. A current below the minimum current blocks the tripping stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-198 illustrates the influence of the current-flow criterion.



NOTE

If the **Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pickup of the **Measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set to either block or not block the tripping stage when the measuring-voltage failure detection picks up.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.30.4 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:481:3) Threshold** = ***46 V***

Specify the **Threshold** (pickup threshold) for the specific application. For the default setting, it has been assumed that the lower voltage range, that is, 80 % of the rated voltage of the protected object, is to be monitored.

Parameter: Pickup delay

- Default setting **(_:481:101) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter **Pickup delay** you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want tripping-stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the tripping stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in tripping-stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Operate delay

- Default setting **(_:481:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:481:4) Dropout ratio** = ***1.05***

The recommended setting value of 1.05 is sufficient for many applications. To obtain extremely accurate indications, the **Dropout ratio** can be reduced.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:481:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:104) Current-flow criterion** = ***on***

Depending on the system, the voltage transformers can be located on the supply or the outgoing side. These 2 possible voltage transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker:

- If they are located on the supply side, the voltage remains on
- If they are located on the output side, the voltage is switched off

Parameter Value	Description
on	The current-flow criterion allows to achieve, in the case of voltage transformers located on the output side, that the pickup drops out when the current drops below a minimum value (parameter Threshold value I>).

Parameter Value	Description
off	Since the voltage is switched off, the pickup of the undervoltage-protection stage persists when the current-flow criterion is not used.

Parameter: Threshold I>

- Recommended setting value **(_:2311:101) Threshold I>** = ***0.05 A***

The **Threshold I>** parameter makes it possible to detect when the circuit-breaker is closed. We recommend that you set the **Threshold I>** parameter to 5% of the rated current. With a secondary rated transformer current of 1 A, the secondary setting value for **Threshold I>** would be 0.05 A.

If the sensitivity of the **Threshold I>** parameter is set too high, compensation processes in the secondary circuit of the current transformer can extend the dropout time when breaking extremely high currents. To speed up dropout, increase the default setting.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

EXAMPLE of a 2-stage undervoltage protection

The undervoltage protection can be used for the protection of motors within the power plant's own power system. The example describes the possible settings for a two-stage undervoltage-protection function. We will look at the settings of the parameters **Threshold** and **Operate delay**.

1. Stage:

Set the **Threshold** to approx. 80 % of the rated voltage. In the case of voltage dips down to that value, the motors can still start up. Depending on the machine characteristic, the **Threshold** can also be set somewhat lower.

The following data apply:

Rated motor voltage:	$V_{rated,M} = 6\ kV$
Minimum startup voltage:	80 % of rated motor voltage
Voltage-transformer ratio:	$Ratio_V = \frac{6\ kV/\sqrt{3}}{100\ V/\sqrt{3}}$

When setting the threshold value, make sure that the positive-sequence voltage as defined is equal to the value of one phase-to-ground voltage. Taking into account the rated primary voltage of the motor, the primary setting value of the first stage is calculated as follows:

$$V_{prim} = 0.8 \cdot V_{rated,M} = 0.8 \cdot \frac{6\ kV}{\sqrt{3}} = 2.77\ kV$$

[fobglei1-190309-01.tif, 2, en_US]

When setting secondary values, you calculate the secondary setting value as follows, taking into account the voltage-transformer ratio:

$$V_{sec} = \frac{V_{prim}}{Ratio_V} = \frac{2.77\ kV}{6\ kV/\sqrt{3}} \cdot 100\ V/\sqrt{3} = 46.2\ V$$

[fobglei3-190309-01.tif, 2, en_US]

Set a value of 3 s for the **Operate delay**.

2. Stage:

Undervoltage cause excessive torques and current surges which place inadmissible strains on the motor. The voltage at which motors do no longer start up is in the range of (0.55 ... 0.70) $V_{rated,M}$. If no data are available, use the empirical value of approx. 70% of the rated voltage for setting the parameter **Threshold**. Set the **Operate delay** so that it slightly overlaps the tripping time of the overcurrent protection for the power-plant auxiliary power. Unless otherwise required by the motor manufacturer, set a **Operate delay** between 0.5 s and 3 s. The shorter time should be preferred.

Stage	Setting Values	
	Threshold value	Time delay
1	0.70 to 0.85 $V_{rated,M}$ (for example, 0.80 $V_{rated,M}$)	Approx. 3 to 5 s
2	0.55 to 0.70 $V_{rated,M}$ (for example, 0.70 $V_{rated,M}$)	0.5 s to 3 s

6.30.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Stage 1				
_:481:1	Stage 1:Mode		• off • on • test	off
_:481:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:481:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:481:101	Stage 1:Pickup delay		• no • yes	no
_:481:3	Stage 1:Threshold		0.300 V to 200.000V	46.000V
_:481:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:481:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:482:1	Stage 2:Mode		• off • on • test	off
_:482:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:482:10	Stage 2:Blk. by meas.-volt. failure		• no • yes	yes
_:482:101	Stage 2:Pickup delay		• no • yes	no
_:482:3	Stage 2:Threshold		0.300 V to 200.000 V	40.000V

Addr.	Parameter	C	Setting Options	Default Setting
_:482:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:482:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.30.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:481:81	Stage 1:>Block stage	SPS	I
_:481:54	Stage 1:Inactive	SPS	O
_:481:52	Stage 1:Behavior	ENS	O
_:481:53	Stage 1:Health	ENS	O
_:481:55	Stage 1:Pickup	ACD	O
_:481:56	Stage 1:Operate delay expired	ACT	O
_:481:57	Stage 1:Operate	ACT	O
Stage 2			
_:482:81	Stage 2:>Block stage	SPS	I
_:482:54	Stage 2:Inactive	SPS	O
_:482:52	Stage 2:Behavior	ENS	O
_:482:53	Stage 2:Health	ENS	O
_:482:55	Stage 2:Pickup	ACD	O
_:482:56	Stage 2:Operate delay expired	ACT	O
_:482:57	Stage 2:Operate	ACT	O

6.31 Undervoltage Protection with Any Voltage

6.31.1 Overview of Functions

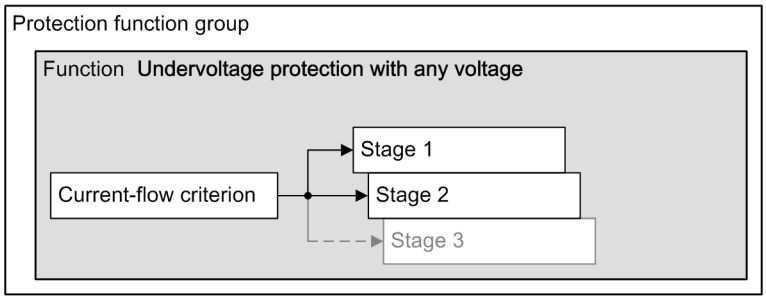
The function **Undervoltage protection with any voltage** (ANSI 27) detects any 1-phase undervoltage and is intended for special applications.

6.31.2 Structure of the Function

The **Undervoltage protection with any voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Undervoltage protection with any voltage** comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-199*).

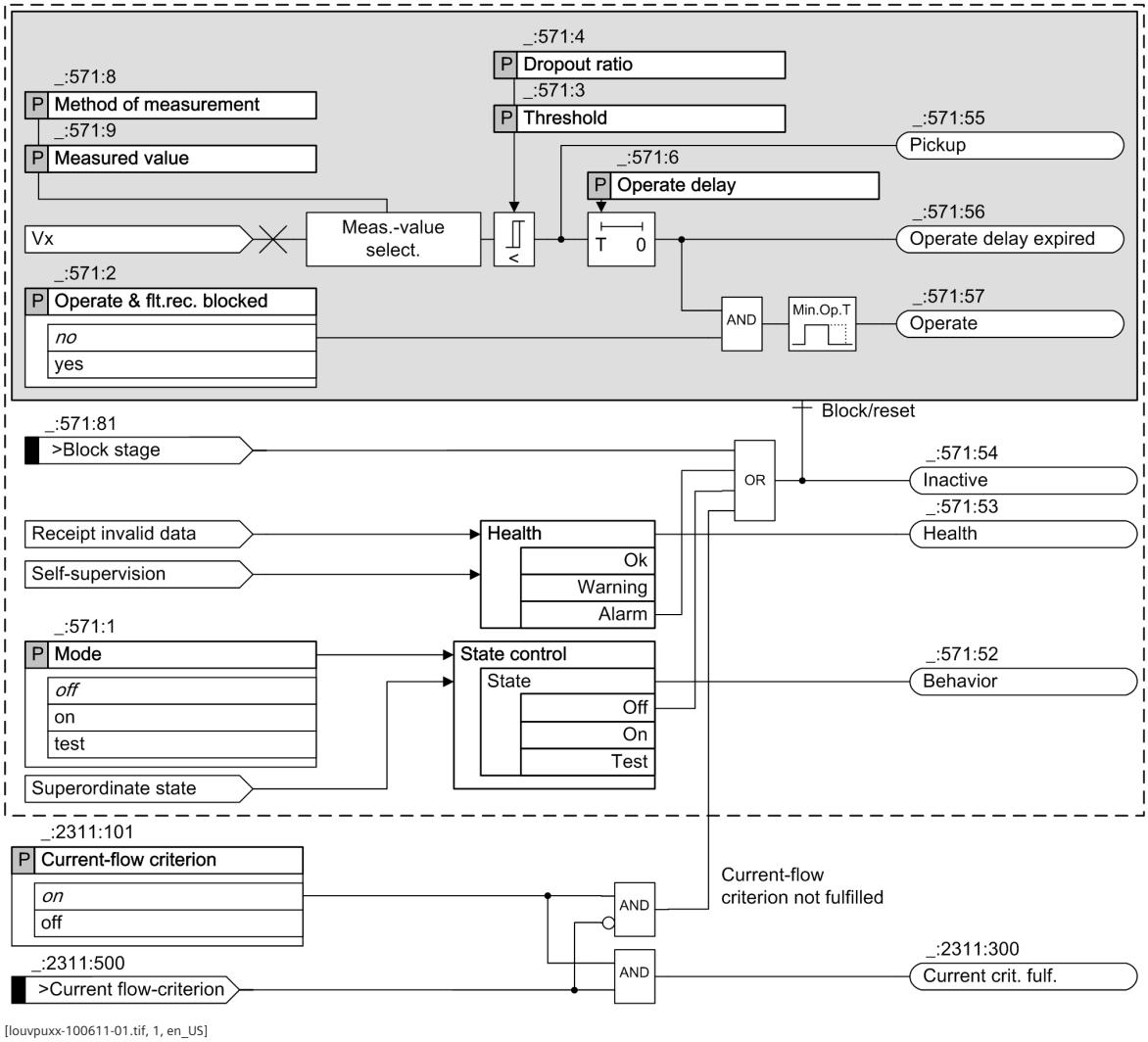


[dwstuvux-110211-01.tif, 1, en_US]

Figure 6-199 Structure/Embedding of the Function

6.31.3 Stage Description

Logic of a Stage



[louvpuxx-100611-01.tif, 1, en_US]

Figure 6-200 Logic Diagram of a Stage: Undervoltage Protection with Any Voltage

NOTE

If the function is used in 1-phase function groups, the parameter **`Measured value`** is not available.

Method of Measurement

The **`Method of measurement`** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter **Measured value** allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function is used in 1-phase function groups, the parameter **Measured value** is not available.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the **Current-flow criterion** parameter is switched on, the undervoltage protection stages only pick up when the current-flow criterion has been set to **fulfilled** via the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-200 illustrates the influence of the current-flow criterion.



NOTE

If the **(_:2311:101) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.31.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:571:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:571:9) Measured value** = ***VA measured***

The **Measured value** parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (***VA measured***)
- Measured phase-to-ground voltage V_B (***VB measured***)
- Measured phase-to-ground voltage V_C ***VC measured***)
- Measured phase-to-phase voltage V_{AB} (***VAB measured***)

- Measured phase-to-phase voltage V_{BC} (***VBC measured***)
- Measured phase-to-phase voltage V_{CA} (***VCA measured***)
- Calculated phase-to-phase voltage V_{AB} (***VAB calculated***)
- Calculated phase-to-phase voltage V_{BC} (***VBC calculated***)
- Calculated phase-to-phase voltage V_{CA} (***VCA calculated***)
- Calculated voltage V0 (***V0 calculated***)

The selection depends on the corresponding application.

NOTE

If the function is used in 1-phase function groups, the parameter **Measured value** is not available.

Parameter: Threshold

- Default setting **(_:571:3) Threshold** = ***80 V***

Specify the **Threshold** (pickup threshold) for the specific application.

Depending on the **Measured value**, the **Threshold** is set either as **measured voltage** or as a **phase-to-phase** variable.

Parameter: Operate delay

- Default setting **(_:571:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:571:4) Dropout ratio** = ***1.05***

The recommended set value of ***1.05*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced to 1.02, for example.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:101) Current-flow criterion** = ***on***

Parameter Value	Description
on	Because of the application, it makes sense that the stage is only active (that is, not blocked) when a certain current flow is present (see note).
off	Current flow monitoring does not make sense for the application.

NOTE

Because of the flexible setting options of the voltage measurand, the function itself does not determine the current associated with the voltage. A suitable current-flow monitoring function must be created by the user with the Continuous Function Chart (CFC), and connected to the binary input signal **>Current flow-criterion**.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.31.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Current-flow criterion		• off • on	on
Stage 1				
_:571:1	Stage 1:Mode		• off • on • test	off
_:571:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:571:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:571:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:571:3	Stage 1:Threshold		0.300 V to 340.000 V	80.000 V
_:571:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:571:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:572:1	Stage 2:Mode		• off • on • test	off
_:572:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:572:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:572:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:572:3	Stage 2:Threshold		0.300 V to 340.000 V	65.000 V
_:572:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:572:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.31.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:571:81	Stage 1:>Block stage	SPS	I
_:571:54	Stage 1:Inactive	SPS	O
_:571:52	Stage 1:Behavior	ENS	O
_:571:53	Stage 1:Health	ENS	O
_:571:55	Stage 1:Pickup	ACD	O
_:571:56	Stage 1:Operate delay expired	ACT	O
_:571:57	Stage 1:Operate	ACT	O
Stage 2			
_:572:81	Stage 2:>Block stage	SPS	I
_:572:54	Stage 2:Inactive	SPS	O
_:572:52	Stage 2:Behavior	ENS	O
_:572:53	Stage 2:Health	ENS	O
_:572:55	Stage 2:Pickup	ACD	O
_:572:56	Stage 2:Operate delay expired	ACT	O
_:572:57	Stage 2:Operate	ACT	O

6.32 Overfrequency Protection

6.32.1 Overview of Functions

The **Overfrequency protection** function (ANSI 81O):

- Detect overfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Disconnect generating units when the power frequency is critical
- Provide additional turbine protection if the speed limiter fails

Frequency deviations are caused by an unbalance between the active power generated and consumed. Overfrequency is caused by load shedding (island network), power system disconnection or disturbances of the frequency controller. Overfrequency implies a risk of self excitation of machines which are connected to long lines without load.

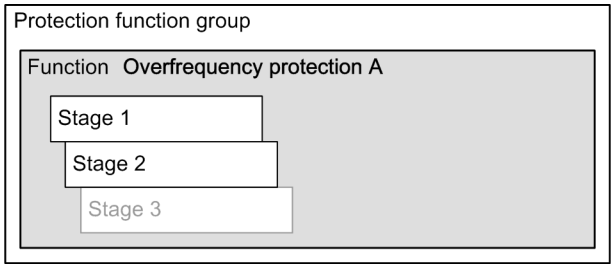
Overfrequency protection is available in two functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.32.2 Structure of the Function

The **Overfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The overfrequency protection function comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters **`Dropout differential`** and **`Minimum voltage`** are set for all stages.

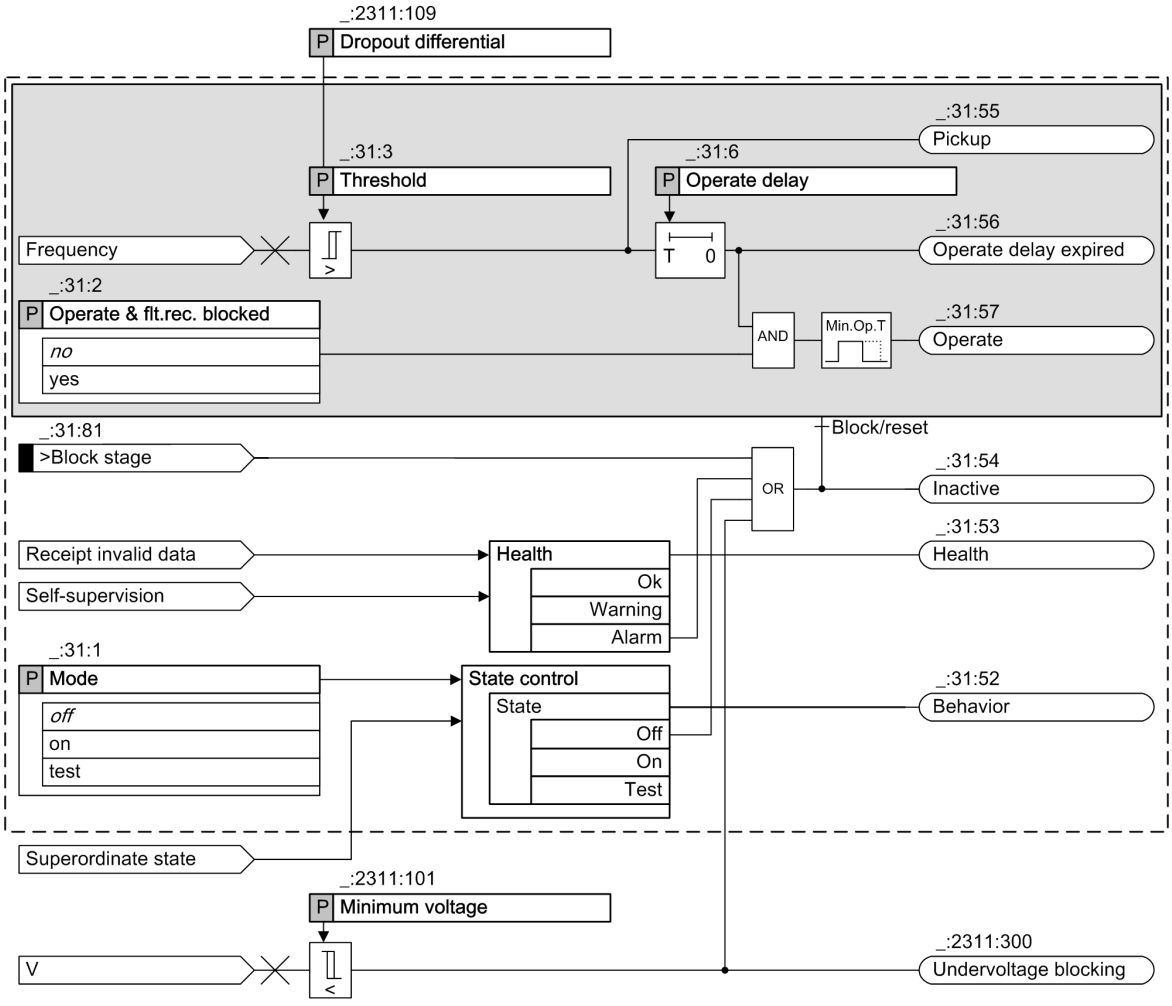


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Figure 6-201 Structure/Embedding of the Function

6.32.3 Overfrequency-Protection Stage

Logic of a Stage



[lostofqp-040411-01.tif, 1, en_US]

Figure 6-202 Logic Diagram of the Overfrequency-Protection Stage

Frequency-Measurement Method

Overfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency-measurement method in dependence of the application.

- Angle-difference method (method A):

  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.

- Filtering method (method B):

  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short pickup time. Disturbance values such as harmonics, high frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.

Functional Measured Value

The angle-difference method provides the following measured value:

Value	Description
f	Calculated frequency with the angle-difference method

Behavior on Leaving the Operating Range

The sampling frequency tracking makes an additional frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to dropout. The following blocking options are available for the stage:

- Externally or internally via the logical binary input *>Block stage*
- Internally when the voltage drops below the **Minimum voltage**

6.32.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a **2-out-of-2 decision** by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Frequency-Measurement Method	Description
Angle difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value **(_:31:3) Threshold** = ***50.20 Hz*** for f_{rated} = 50 Hz

The **Threshold** parameter is used to define the pickup threshold of the overfrequency protection stage in dependence of the application. 50.20 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value **(_:31:6) Operate delay** = ***10 s***

The **Operate delay** parameter is used to set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value **(_:2311:101) Minimum voltage** = **37.5 V**

For the **Undervoltage blocking**, 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value **(_:2311:109) Dropout differential** = ***20 mHz***

Due to the high-precision frequency measurement, the recommended setting value for the **Dropout differential** can remain at 20 mHz. If in your application you wish a subsequent dropout of the tripping stage, then increase the setting value of the dropout differential. For instance, if the pickup value (parameter **Threshold**) of the tripping stage is set to 50.20 Hz and the **Dropout differential** to 100 mHz, the stage will drop out at 50.10 Hz.

Application example of the overfrequency protection

Overfrequency protection can be used for monitoring the frequency range. If the frequency deviates from the rated frequency by for example, 0.2 Hz, a fault indication is generated. The trip command is delayed to avoid overfunction due to disturbing influences (for example, switching operations). A delay of a few seconds (for example, 10 s) is deemed to be a good value. You can leave the **Dropout differential** at the default value of ***20 mHz***. The following table shows a setting recommendation.

For this application, 1 stage of the overfrequency protection is used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1>	Warning	50.20 Hz	60.20 Hz	10.00
f2>	Not used (OFF)	-	-	-

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

6.32.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:31:1	Stage 1:Mode		• off • on • test	off
_:31:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:31:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	51.50 Hz
_:31:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:32:1	Stage 2:Mode		• off • on • test	off
_:32:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:32:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	54.00 Hz

Addr.	Parameter	C	Setting Options	Default Setting
_:32:6	Stage 2:Operate delay		0.00 s to 600.00 s	5.00 s

6.32.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:31:81	Stage 1:>Block stage	SPS	I
_:31:54	Stage 1:Inactive	SPS	O
_:31:52	Stage 1:Behavior	ENS	O
_:31:53	Stage 1:Health	ENS	O
_:31:55	Stage 1:Pickup	ACD	O
_:31:56	Stage 1:Operate delay expired	ACT	O
_:31:57	Stage 1:Operate	ACT	O
Stage 2			
_:32:81	Stage 2:>Block stage	SPS	I
_:32:54	Stage 2:Inactive	SPS	O
_:32:52	Stage 2:Behavior	ENS	O
_:32:53	Stage 2:Health	ENS	O
_:32:55	Stage 2:Pickup	ACD	O
_:32:56	Stage 2:Operate delay expired	ACT	O
_:32:57	Stage 2:Operate	ACT	O

6.33 Underfrequency Protection

6.33.1 Overview of Functions

The **Underfrequency protection** function (ANSI 81U) is used to:

- Detect underfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Decouple power systems
- Load shedding to ensure power system stability and protect motors
- Disconnect generating units when the power system frequency is critical (for example, $f < 0.95\ f_{rated}$)

Frequency deviations are caused by an unbalance between the active power generated and consumed. Underfrequency is caused by an increase of the consumers' active power demand or by a decrease of the power generated. These conditions occur in the case of power system disconnection, generator failure, or disturbances of the power and frequency controller.

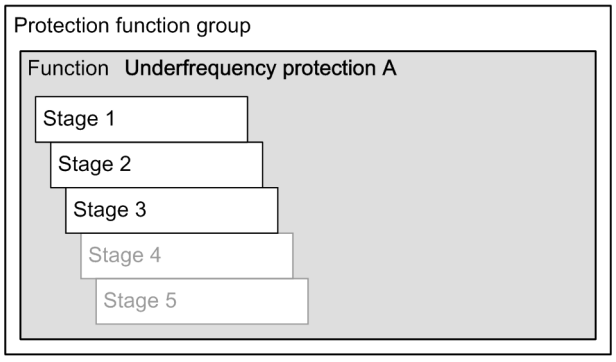
Underfrequency protection is available in 2 functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.33.2 Structure of the Function

The **Underfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The **Underfrequency protection** function comes with 3 factory-set stages. A maximum of 5 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters **`Dropout differential`** and **`Minimum voltage`** are set for all stages.

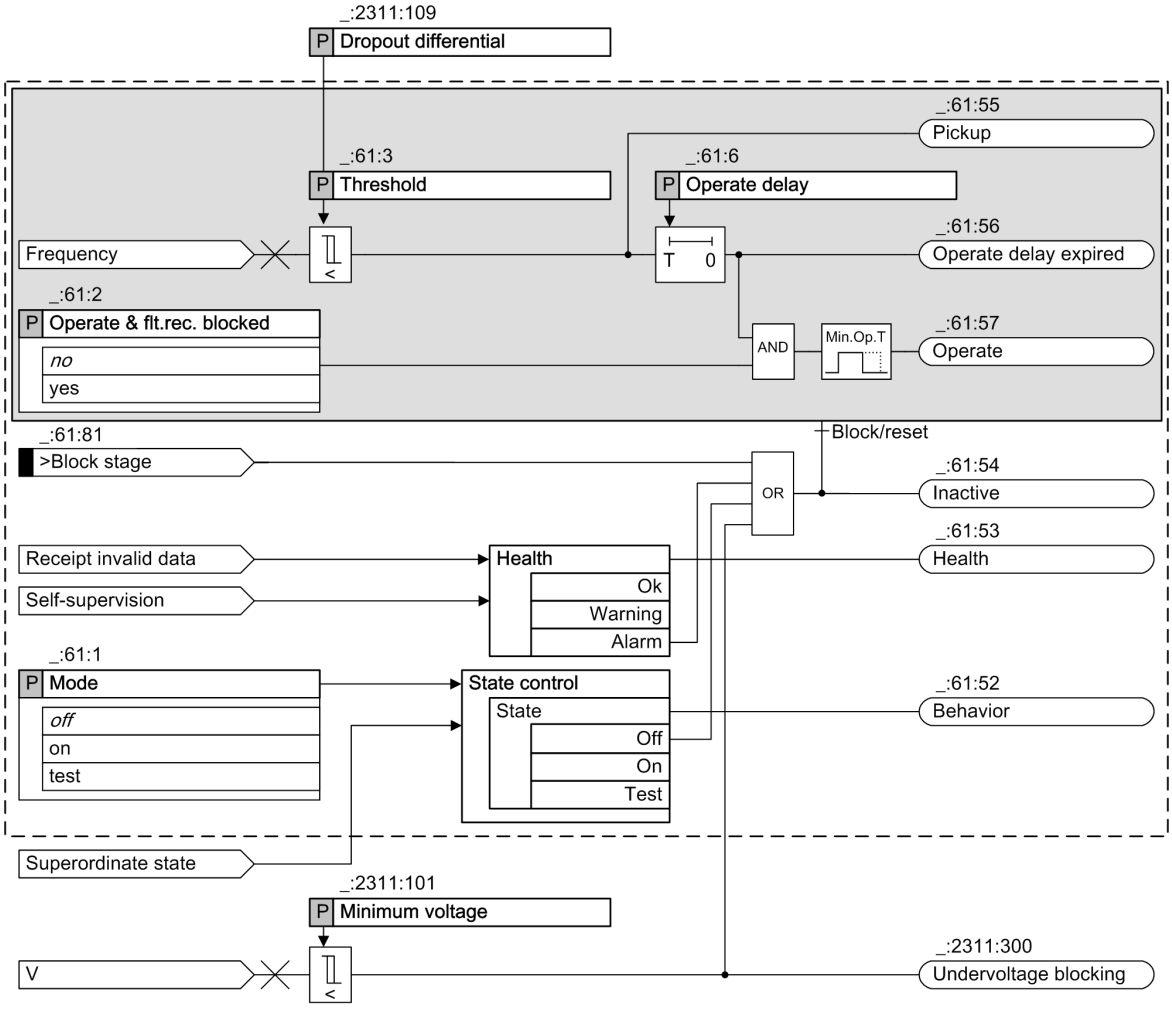


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Figure 6-203 Structure/Embedding of the Function

6.33.3 Underfrequency-Protection Stage

Logic of a Stage



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Figure 6-204 Logic Diagram of the Underfrequency-Protection Stage

Frequency-Measurement Method

Underfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency-measurement method in dependence of the application.

- Angle-difference method (method A):
  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.
- Filtering method (method B):
  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short response time. Disturbance values such as harmonics, high frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.

Behavior on Leaving the Operating Range

The sampling frequency tracking makes an additional frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to dropout. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- Internally when the voltage drops below the **Minimum voltage**

6.33.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a **2-out-of-2 decision** by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Method of Measurement	Description
Angle difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value **(_:61:3) Threshold** = ***49.80 Hz*** for f_{rated} = 50 Hz

The **Threshold** parameter is used to define the pickup threshold of the underfrequency protection stage in dependence of the application. 49.8 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value **(_:61:6) Operate delay** = ***10.00 s***

The **Operate delay** parameter is used to set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value **(_:2311:101) Minimum voltage** = **37 500 V**

For the **Undervoltage blocking**, 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value **(_:2311:109) Dropout differential** = ***20 mHz***

Due to the high-precision frequency measurement, the recommended setting value for the **Dropout differential** can remain at 20 mHz. If in your application you wish a subsequent dropout of the tripping stage, then increase the setting value of the dropout differential. For instance, if the pickup value (parameter **Threshold**) of the tripping stage is set to 49.8 Hz and the **Dropout differential** to 100 mHz, the stage will drop out at 49.9 Hz.

Application example of the underfrequency protection

Frequency protection can be used for load shedding. The UCTE has defined a 5-stage plan for the Western European power grid. The setting values of the stages are based on that plan (see table below).

Table 6-16 Stage Plan

Frequency	Activity
49.80 Hz	Alarm and activation of reserves following an established plan
49.00 Hz	Undelayed disconnection of 10 % to 15 % of the power system load
48.70 Hz	Undelayed disconnection of another 10 % to 15 % of the power system load
48.40 Hz	3rd load shedding stage. Another 15 % to 20 % of the power system load is disconnected.
47.50 Hz	Power plants are decoupled from the electrical power system

For this application, 3 stages of the underfrequency protection are used. 2 of these stages are used for load shedding. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1<	Warning	49.80 Hz	59.80 Hz	10.00
f2<	1st load shedding	49.00 Hz	59.00 Hz	0.00
f3<	2nd load shedding	48.70 Hz	58.70 Hz	0.00

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

6.33.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:61:1	Stage 1:Mode		• off • on • test	off
_:61:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:61:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	49.80 Hz
_:61:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:62:1	Stage 2:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:62:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:62:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	47.50 Hz
_:62:6	Stage 2:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 3				
_:63:1	Stage 3:Mode		• off • on • test	off
_:63:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:63:3	Stage 3:Threshold		40.00 Hz to 70.00 Hz	47.00 Hz
_:63:6	Stage 3:Operate delay		0.00 s to 600.00 s	10.00 s

6.33.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:61:81	Stage 1:>Block stage	SPS	I
_:61:54	Stage 1:Inactive	SPS	O
_:61:52	Stage 1:Behavior	ENS	O
_:61:53	Stage 1:Health	ENS	O
_:61:55	Stage 1:Pickup	ACD	O
_:61:56	Stage 1:Operate delay expired	ACT	O
_:61:57	Stage 1:Operate	ACT	O
Stage 2			
_:62:81	Stage 2:>Block stage	SPS	I
_:62:54	Stage 2:Inactive	SPS	O
_:62:52	Stage 2:Behavior	ENS	O
_:62:53	Stage 2:Health	ENS	O
_:62:55	Stage 2:Pickup	ACD	O
_:62:56	Stage 2:Operate delay expired	ACT	O
_:62:57	Stage 2:Operate	ACT	O
Stage 3			
_:63:81	Stage 3:>Block stage	SPS	I
_:63:54	Stage 3:Inactive	SPS	O
_:63:52	Stage 3:Behavior	ENS	O
_:63:53	Stage 3:Health	ENS	O
_:63:55	Stage 3:Pickup	ACD	O
_:63:56	Stage 3:Operate delay expired	ACT	O
_:63:57	Stage 3:Operate	ACT	O

6.34 Rate of Frequency Change Protection

6.34.1 Overview of Functions

The function **Rate of frequency change protection** is used to:

- Detect a frequency change quickly
- Prevent the system from not secure states caused by unbalance between the generated and consumed active power
- Network decoupling
- Load shedding

6.34.2 Structure of the Function

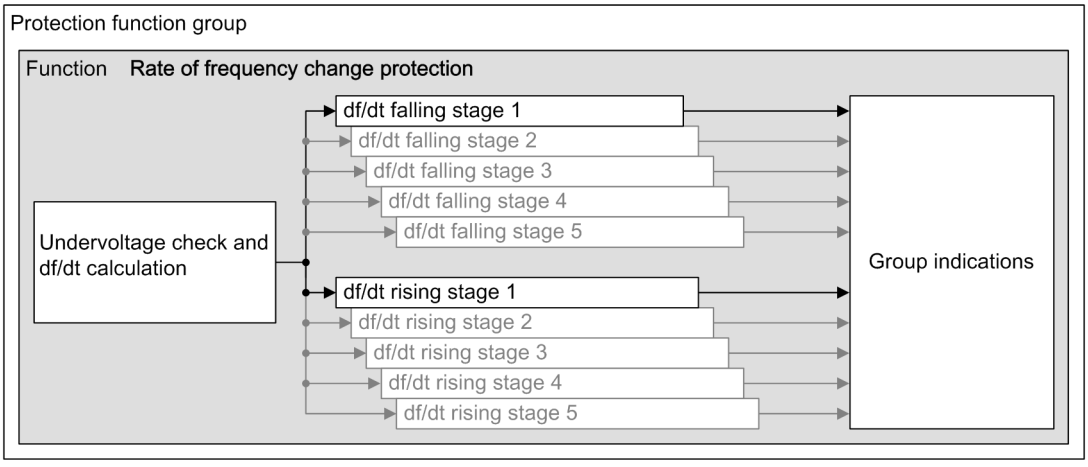
The function **Rate of frequency change protection** can be used in protection function groups containing a 3-phase voltage measurement.

2 function block types are available:

- **df/dt rising**
- **df/dt falling**

The function **Rate of frequency change protection** is preconfigured by the manufacturer with 1 df/dt rising stage and 1 df/dt falling stage. A maximum of 5 df/dt rising stages and 5 df/dt falling stages can operate simultaneously within the function. Both of the function block types are similar in structure.

Undervoltage check and df/dt calculation are general functionalities and take place on the function level. All stages use these general functionalities.



[dwdfdt01-160113-01.tif, 1, en_US]

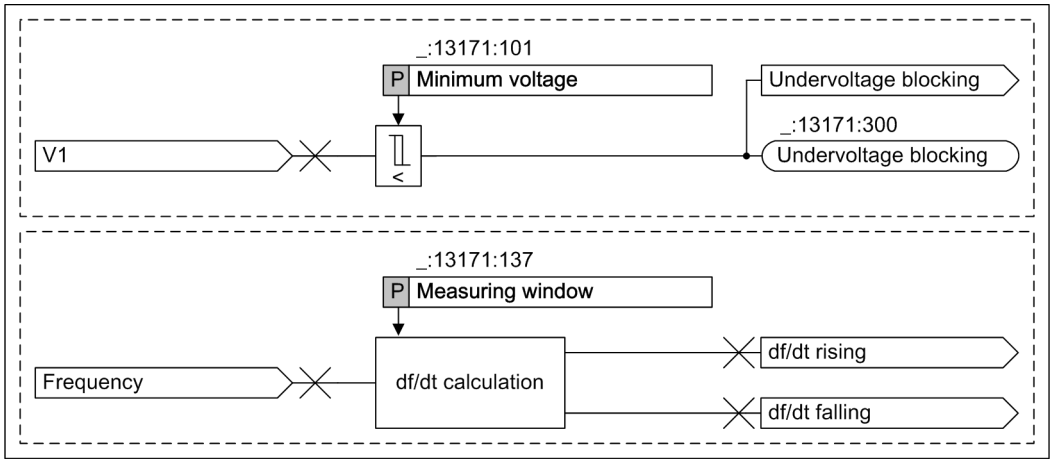
Figure 6-205 Structure/Embedding of the Function

6.34.3 General Functions (Undervoltage Test, df/dt Calculation)

6.34.3.1 Description

Logic

The following figure represents the logic of undervoltage check and df/dt calculation. It applies to all types of stages.



[lodfdtgf-160113-01.tif, 1, en_US]

Figure 6-206 Logic Diagram of General Functionality

Measurand

This function uses the frequency calculated via the angle difference algorithm.

For more information, refer to chapter *6.32.3 Overfrequency-Protection Stage* .

The frequency difference is calculated over a settable time interval (default setting: 5 periods).

The ratio between the frequency difference and the time difference reflects the frequency change which can be positive or negative.

A stabilization counter works to avoid overfunction. This counter is increased if the set threshold value is exceeded. If the value drops below the threshold value, the counter is reset immediately. The counter is set to 8 internally and is activated at each half system cycle.

Undervoltage Blocking

If the measuring voltage drops below the **`Minimum voltage`**, the **Rate of frequency change protection** is blocked because precise frequency values cannot be calculated anymore.

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

6.34.3.2 Application and Setting Notes

Parameter: `Minimum voltage`

- Recommended setting value **`(_:13171:101) Minimum voltage`** = ***`37.500 V`***

For the **Undervoltage blocking**, 65 % of the rated voltage of the protected object is recommended.

The method of measurement uses the phasor of the positive-sequence voltage. When determining the setting value, keep in mind that the absolute value of the sound positive-sequence voltage is equal to the absolute value of the phase-to-ground voltage. The default setting is referred to this value.

Parameter: `Measuring window`

- Default setting **`(_:13171:137) Measuring window`** = ***`5 periods`***

You can use the **`Measuring window`** parameter to optimize the measuring accuracy or the pickup time of the function. For information regarding pickup time and measuring accuracy, refer to the technical data.

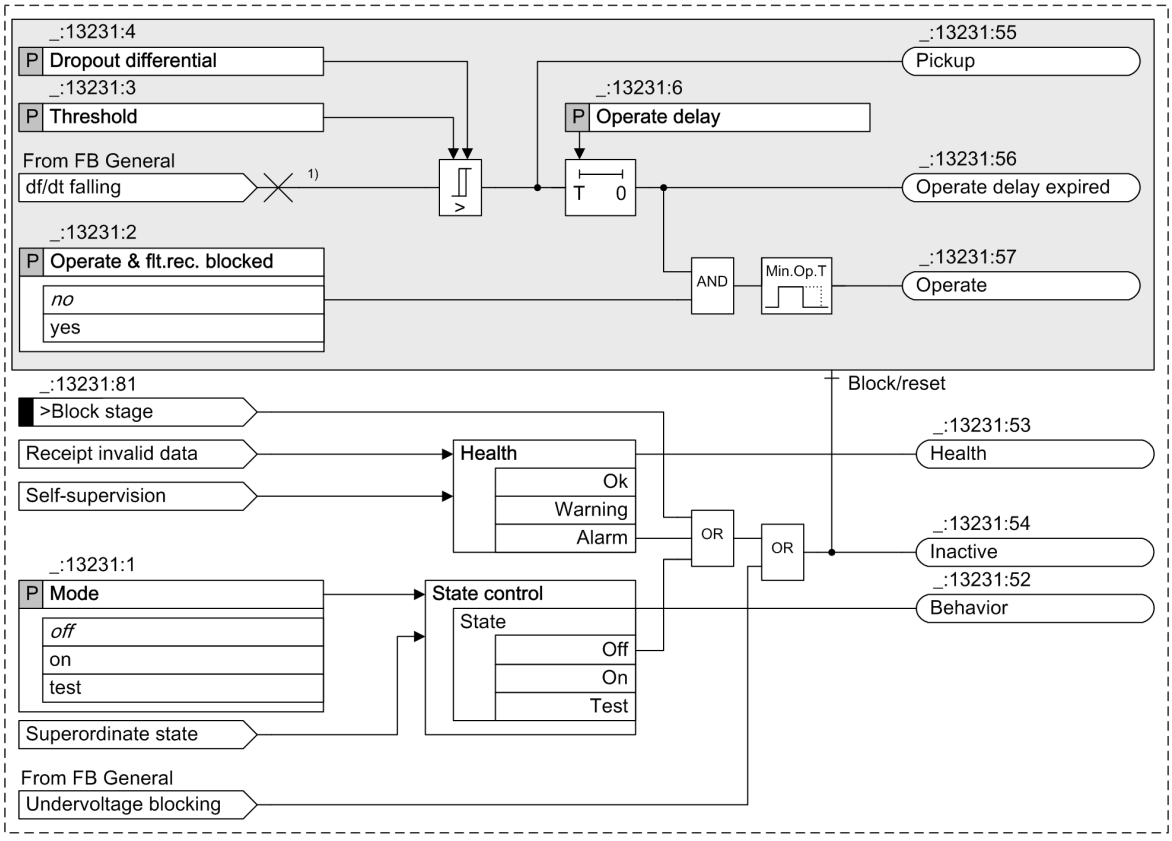
The default setting provides maximum measuring accuracy. If you do not have specific requirements for a decreased pickup time, Siemens recommends using the default setting.

The default setting is a reasonable compromise between measuring accuracy and pickup time. For a non-sensitive setting (high threshold value), you can set the parameter **Measuring window** to a smaller value.

6.34.4 Stage Description

6.34.4.1 Description

Logic of the Stage



[lodfdtst-160113-01.tif, 1, en_US]

Figure 6-207 Logic Diagram of Rate of Frequency Change Protection

(1) For the stage type **df/dt rising**, the value **df/dt rising** is used.

Frequency Rising/Falling

The stage **df/dt falling** is used to detect frequency falling and the stage **df/dt rising** is used to detect frequency rising.

You set the threshold value as an absolute value. You define the frequency-change direction via the selected stage type.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Via the binary input signal *>Block stage*
- Via the undervoltage blocking when the voltage drops below the **Minimum voltage**

6.34.4.2 Application and Setting Notes

Parameter: **Threshold**

- Default setting **(_:13231:3) Threshold** = ***3.0 Hz/s***

The pickup value depends on the application and is determined by power-system conditions. In most cases, a network analysis will be necessary. A sudden disconnection of loads leads to a surplus of active power. The frequency rises and causes a positive frequency change. On the other hand, a failure of generators leads to a deficit of active power. The frequency drops and results in a negative frequency change.

The following relations can be used as an example for estimation. They apply for the change rate at the beginning of a frequency change (approximate 1 s).

$$\frac{df}{dt} = -\frac{f_{rated}}{2H} \cdot \frac{\Delta P}{S_{rated}}$$

Where:

f_{rated}	Rated frequency
ΔP	Active power change $\Delta P = P_{Consumption} - P_{Generation}$
S_{rated}	Rated apparent power of the machines
H	Inertia constant

Typical data for H:

For hydro generators (salient-pole machines)	H = 1.5 s to 6 s
For turbine-driven generators (non-salient pole rotors)	H = 2 s to 10 s
For industrial turbine-driven generators	H = 3 s to 4 s

EXAMPLE

f_{rated} = 50 Hz

H = 3 s

Case 1: $\Delta P/S_{rated}$ = 0.12

Case 2: $\Delta P/S_{rated}$ = 0.48

Case 1: df/dt = -1 Hz/s

Case 2: df/dt = -4 Hz/s

Parameter: **Operate delay**

- Default setting **(_:13231:6) Operate delay** = ***1.00 s***

You can use the **Operate delay** parameter to avoid overfunction due to disturbing influences (for example, switching operations). If the protection function is supposed to respond quickly, set the **Operate delay** parameter to 0 s.

For monitoring small changes (< 1 Hz/s), a small time delay is useful to avoid overfunctioning.

Parameter: **Dropout differential**

- Recommended setting value **(_:13231:4) Dropout differential** = ***0.10 Hz/s***

You can use the **Dropout differential** parameter to define the dropout value. The recommended value is ***0.10 Hz/s***.

NOTE

In case of power-system incidents, especially in case of transmission incidents and influence of voltage-stabilizing measures via power-electronic components (reactive-power compensation through SVC), the magnitude and the phase angle of the voltage can change. Sensitive settings can lead to overfunction. Therefore, it is reasonable to block the **Rate of Frequency Change Protection** if other protection functions, for example, residual voltage or negative-sequence voltage, pick up. To do this, use the blocking input *>Block stage* and connect it via CFC.

6.34.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13171:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:13171:137	General:Measuring window		2 periods to 5 periods	5 periods
df/dt falling1				
_:13231:1	df/dt falling1:Mode		• off • on • test	off
_:13231:2	df/dt falling1:Operate & flt.rec. blocked		• no • yes	no
_:13231:3	df/dt falling1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13231:4	df/dt falling1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13231:6	df/dt falling1:Operate delay		0.00 s to 60.00 s	1.00 s
df/dt rising1				
_:13201:1	df/dt rising1:Mode		• off • on • test	off
_:13201:2	df/dt rising1:Operate & flt.rec. blocked		• no • yes	no
_:13201:3	df/dt rising1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13201:4	df/dt rising1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13201:6	df/dt rising1:Operate delay		0.00 s to 60.00 s	1.00 s

6.34.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:13171:300	General:Undervoltage blocking	SPS	O
_:13171:301	General:df/dt	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
df/dt falling1			
_:13231:81	df/dt falling1:>Block stage	SPS	I
_:13231:54	df/dt falling1:Inactive	SPS	O
_:13231:52	df/dt falling1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:13231:53	df/dt falling1:Health	ENS	O
_:13231:55	df/dt falling1:Pickup	ACD	O
_:13231:56	df/dt falling1:Operate delay expired	ACT	O
_:13231:57	df/dt falling1:Operate	ACT	O
df/dt rising1			
_:13201:81	df/dt rising1:>Block stage	SPS	I
_:13201:54	df/dt rising1:Inactive	SPS	O
_:13201:52	df/dt rising1:Behavior	ENS	O
_:13201:53	df/dt rising1:Health	ENS	O
_:13201:55	df/dt rising1:Pickup	ACD	O
_:13201:56	df/dt rising1:Operate delay expired	ACT	O
_:13201:57	df/dt rising1:Operate	ACT	O

6.35 Power Protection (P,Q), 3-Phase

6.35.1 Overview of Functions

The **3-phase power protection (P, Q)** function (ANSI 32) is used to:

- Detect whether the active or reactive power rises above or drops below a set threshold
- Monitor agreed power limits and output warning indications
- Detect both active and reactive power feedback in the power systems or on electric machines
- Detect machines (motors, generators) running without load and output an indication to shut them down.
- Be integrated into any automation solution, for example, to monitor very specific power limits (further logical processing in CFC)

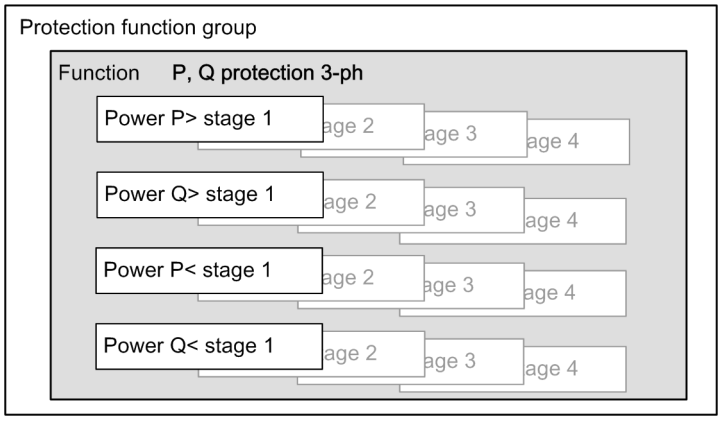
6.35.2 Structure of the Function

The **3-phase power protection (P, Q)** function can be integrated in function groups, which provide measured voltages and currents of the 3-phases for calculation of the power.

The **3-phase power protection (P,Q)** function comes with one factory-set stage each for the active and the reactive power. The following stages are preconfigured:

- Power P>
- Power Q>
- Power P<
- Power Q<

A maximum of 4 active power stages and 4 reactive power stages can be operated simultaneously in the function. The tripping stages have an identical structure.

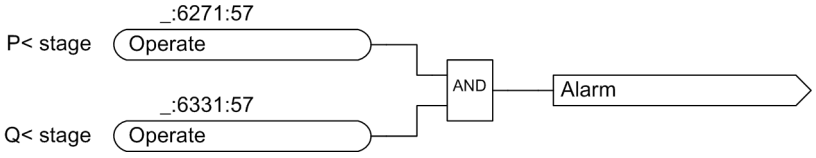


[dwstpq3p-110211-01.tif, 1, en_US]

Figure 6-208 Structure/Embedding of the Function

Logical Combination of Output Signals

The operate indications of the active and reactive power stage(s) can be logically combined in CFC. When an operate indication is present in both the active and the reactive power stage, an alarm indication is generated.

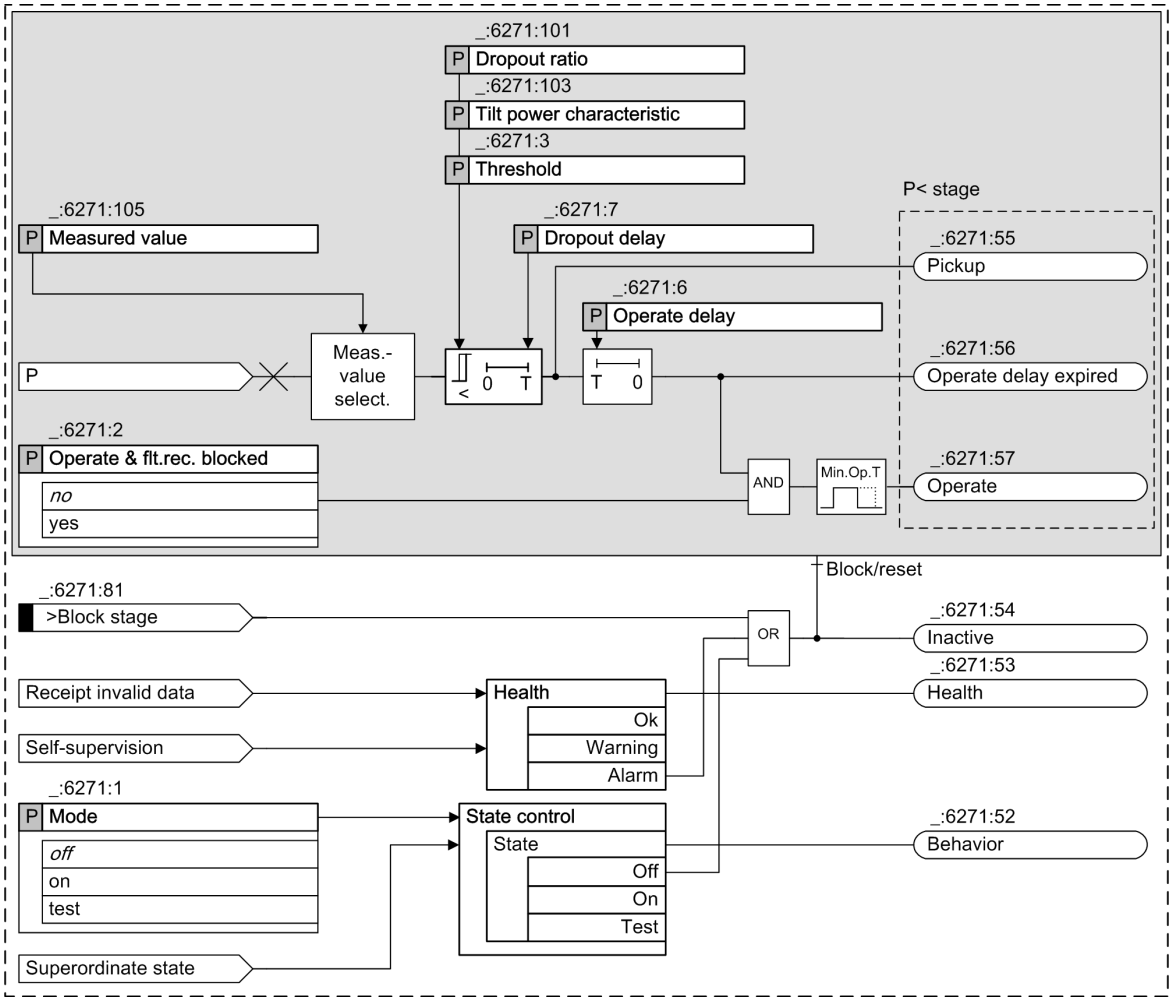


[loausmel-050411-01.tif, 1, en_US]

Figure 6-209 Logical Combination of Operate Indications in CFC

6.35.3 Active Power Stage

Logic of a Stage



[lop3phas-040411-01.tif, 1, en_US]

Figure 6-210 Logic Diagram of the Active Power Stage (Stage Type: Power P<)

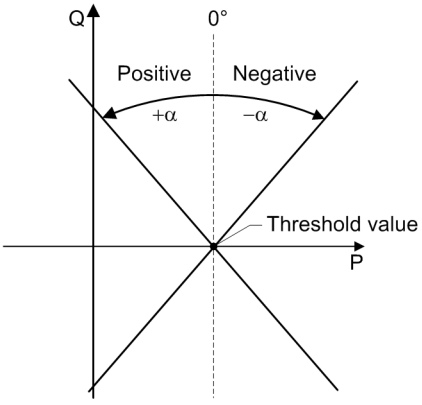
Measured Value

The **`Measured value`** parameter is used to specify which measured power value is analyzed by the tripping stage. Possible settings are ***`positive seq. power`*** and the phase-selective powers ***`power of phase A`***, ***`power of phase B`*** or ***`power of phase C`***.

Pickup Characteristic

With the stage type you specify if the stage work as a **greater stage** (stage type: **Power P>**) or as a **smaller stage** (stage type: **Power P<**).

The **Threshold** parameter is used to define the pickup threshold of the stage. The **Tilt power characteristic** parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.



[dwdvzpgr-100611-01.tif, 1, en_US]

Figure 6-211 Tilt-Power Characteristic

Pickup

The stage compares the selected power value with the set **Threshold**. Depending on the stage type (**Power P>** or **Power P<**) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

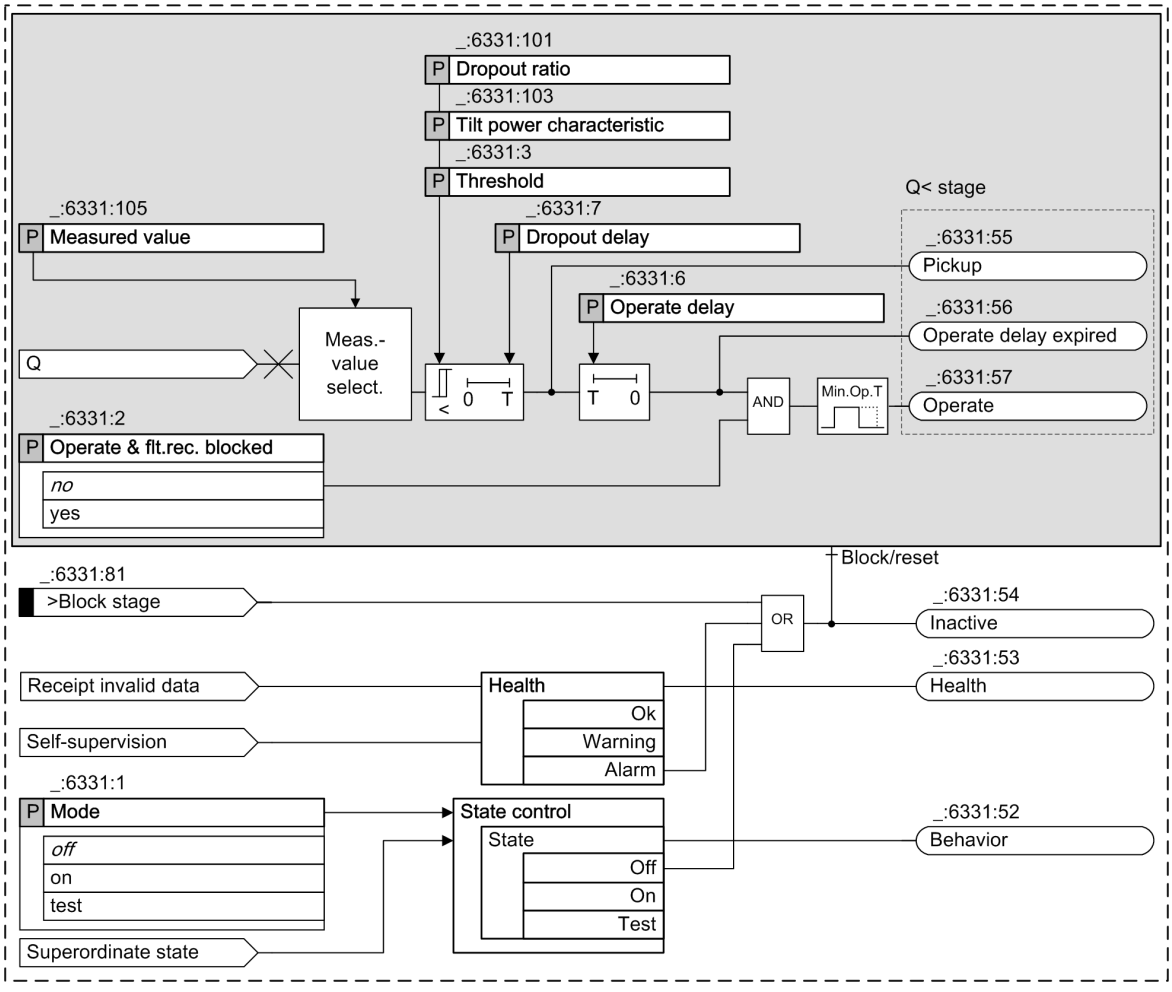
A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter **Operate delay**) continues to run. Once the **Operate delay** has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.35.4 Reactive Power Stage

Logic of a Stage



[loq3phas-040411-01.tif, 1, en_US]

Figure 6-212 Logic Diagram of the Reactive Power Stage (Stage Type: Power Q<)

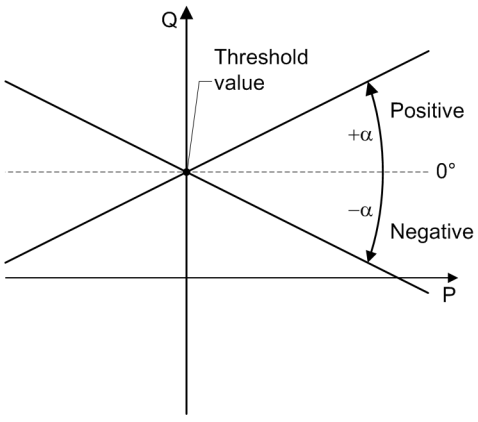
Measured Value

The **Measured value** parameter is used to specify which measured power value is processed by the tripping stage. Possible settings are ***positive seq. power*** and the phase-selective powers ***power of phase A***, ***power of phase B*** or ***power of phase C***.

Pickup Characteristic

With the stage type you specify if the stage work as a **greater stage** (stage type: **Power Q>**) or as a **smaller stage** (stage type: **Power Q<**).

The **Threshold** parameter is used to define the pickup threshold of the stage. The **Tilt power characteristic** parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.



[dwdvzqgr-100611-01.tif, 1, en_US]

Figure 6-213 Tilt-Power Characteristic

Pickup

The stage compares the selected power value with the set **Threshold**. Depending on the stage type (**Power Q>** or **Power Q<**) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

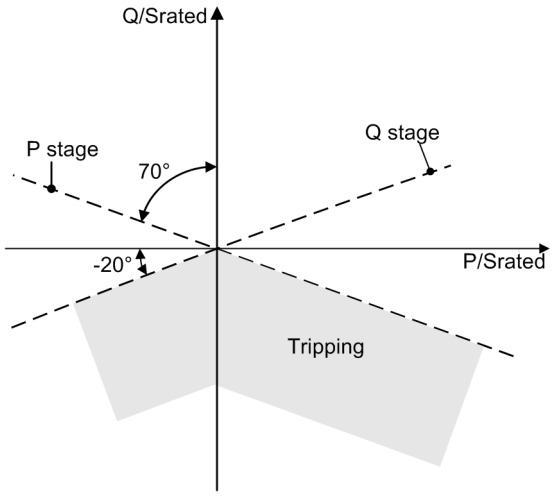
A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter **Operate delay**) continues to run. Once the **Operate delay** has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.35.5 Application Example

The setting of the function will be explained using an active/reactive power range as an example. If the apparent power phasor is within the power range (in *Figure 6-214* tripping zone defined by characteristics), an alarm indication is generated. For this purpose, you have to make an AND operation of the stage indications of the active and reactive power stage in CFC. The function used is 3-phase power measurement. *Figure 6-214* shows the threshold values and the location of the characteristics in the PQ diagram.



[dwpqd7sa-110211-01.tif, 1, en_US]

Figure 6-214 Pickup Values and Characteristic Curves

6.35.6 Setting Notes for the Active Power Stage

Stage Type

In the following example, a drop of the active power below a threshold is to be monitored. In the **3-phase circuit breaker (P, Q)** function, work with the stage type **Power P<**.

Parameter: Measured value

- Recommended setting value **(_:6271:105) Measured value** = ***positive seq. power***

The **Measured value** parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value **(_:6271:3) Threshold** = ***0 %***

The **Threshold** parameter is used to define the pickup threshold of the active power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter **Threshold** to ***0%***.

NOTE

If you use several settings groups, consider the following:

- The dropout value of a stage must have the same sign in all settings groups.
- Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value **(_:6271:101) Dropout ratio** = ***1.05***

A hysteresis of 5 % is sufficient for most applications. The setting value for the **lower stage** is therefore 1.05.

Parameter: Tilt power characteristic

- Recommended setting value **(_:6271:103) Tilt power characteristic** = ***+70°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In the above example, an inclination is required. The setting value is ***+70°*** (for a definition of the sign, see *Figure 6-211*).

Parameter: Dropout delay

- Recommended setting value **(_:6271:7) Dropout delay** = ***20 ms***

The **Dropout delay** parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value **(_:6271:6) Operate delay** = ***100 ms***

The **Operate delay** must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.35.7 Setting Notes for the Reactive Power Stage

Stage Type

In the example, the reactive power is to be monitored if it falls below the threshold. In the **3-phase circuit breaker (P, Q)** function, work with the stage type **Power Q<**.

Parameter: Measured value

- Recommended setting value **(_:6331:105) Measured value** = ***positive seq. power***

The **Measured value** parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value **(_:6331:3) Threshold** = ***0 %***

The **Threshold** parameter is used to define the pickup threshold of the reactive power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter **Threshold** to ***0%***.



NOTE

If you use several settings groups, consider the following:

- The dropout value of a stage must have the same sign in all settings groups.
- Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value **(_:6331:101) Dropout ratio** = ***0.95***

A hysteresis of 5 % is sufficient for most applications. The setting value for the **lower stage** is therefore 0.95.

Parameter: Tilt power characteristic

- Recommended setting value **(_:6331:103) Tilt power characteristic** = ***+20°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In the example (see *Figure 6-214*), the power characteristic has a tilt of 20°. Set the **Tilt power characteristic** parameter to ***+20°*** (for a definition of the sign, see *Figure 6-213*).

Parameter: Dropout delay

- Recommended setting value **(_:6331:7) Dropout delay** = ***20 ms***

The **Dropout delay** parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value **(_:6331:6) Operate delay** = ***100 ms***

The **Operate delay** must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.35.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Power P> 1				
_:6241:1	Power P> 1:Mode		• off • on • test	off
_:6241:2	Power P> 1:Operate & flt.rec. blocked		• no • yes	no
_:6241:104	Power P> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6241:3	Power P> 1:Threshold		-200.0 % to 200.0 %	80.0 %
_:6241:101	Power P> 1:Dropout ratio		0.90 to 0.99	0.95
_:6241:103	Power P> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6241:7	Power P> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6241:6	Power P> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power P< 1				
_:6271:1	Power P< 1:Mode		• off • on • test	off
_:6271:2	Power P< 1:Operate & flt.rec. blocked		• no • yes	no
_:6271:105	Power P< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6271:3	Power P< 1:Threshold		-200.0 % to 200.0 %	5.0 %
_:6271:101	Power P< 1:Dropout ratio		1.01 to 1.10	1.05
_:6271:103	Power P< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °

Addr.	Parameter	C	Setting Options	Default Setting
_:6271:104	Power P< 1:Pickup delay		• no • yes	yes
_:6271:7	Power P< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6271:6	Power P< 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q> 1				
_:6301:1	Power Q> 1:Mode		• off • on • test	off
_:6301:2	Power Q> 1:Operate & flt.rec. blocked		• no • yes	no
_:6301:105	Power Q> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6301:3	Power Q> 1:Threshold		-200.0 % to 200.0 %	70.0 %
_:6301:101	Power Q> 1:Dropout ratio		0.90 to 0.99	0.95
_:6301:103	Power Q> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6301:7	Power Q> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6301:6	Power Q> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q< 1				
_:6331:1	Power Q< 1:Mode		• off • on • test	off
_:6331:2	Power Q< 1:Operate & flt.rec. blocked		• no • yes	no
_:6331:105	Power Q< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6331:3	Power Q< 1:Threshold		-200.0 % to 200.0 %	-30.0 %
_:6331:101	Power Q< 1:Dropout ratio		0.90 to 0.99	0.95
_:6331:103	Power Q< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6331:104	Power Q< 1:Pickup delay		• no • yes	yes
_:6331:7	Power Q< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6331:6	Power Q< 1:Operate delay		0.00 s to 60.00 s	1.00 s

6.35.9 Information List

No.	Information	Data Class (Type)	Type
Power P> 1			
_:6241:81	Power P> 1:>Block stage	SPS	I
_:6241:54	Power P> 1:Inactive	SPS	O
_:6241:52	Power P> 1:Behavior	ENS	O
_:6241:53	Power P> 1:Health	ENS	O
_:6241:55	Power P> 1:Pickup	ACD	O
_:6241:56	Power P> 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:6241:57	Power P> 1:Operate	ACT	O
Power P< 1			
_:6271:81	Power P< 1:>Block stage	SPS	I
_:6271:54	Power P< 1:Inactive	SPS	O
_:6271:52	Power P< 1:Behavior	ENS	O
_:6271:53	Power P< 1:Health	ENS	O
_:6271:55	Power P< 1:Pickup	ACD	O
_:6271:56	Power P< 1:Operate delay expired	ACT	O
_:6271:57	Power P< 1:Operate	ACT	O
Power Q> 1			
_:6301:81	Power Q> 1:>Block stage	SPS	I
_:6301:54	Power Q> 1:Inactive	SPS	O
_:6301:52	Power Q> 1:Behavior	ENS	O
_:6301:53	Power Q> 1:Health	ENS	O
_:6301:55	Power Q> 1:Pickup	ACD	O
_:6301:56	Power Q> 1:Operate delay expired	ACT	O
_:6301:57	Power Q> 1:Operate	ACT	O
Power Q< 1			
_:6331:81	Power Q< 1:>Block stage	SPS	I
_:6331:54	Power Q< 1:Inactive	SPS	O
_:6331:52	Power Q< 1:Behavior	ENS	O
_:6331:53	Power Q< 1:Health	ENS	O
_:6331:55	Power Q< 1:Pickup	ACD	O
_:6331:56	Power Q< 1:Operate delay expired	ACT	O
_:6331:57	Power Q< 1:Operate	ACT	O

6.36 Reverse Power Protection

6.36.1 Overview of Functions

The **Reverse-power protection** function (ANSI 32R):

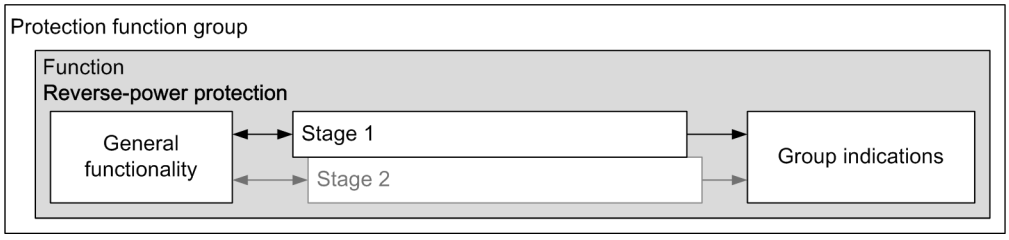
- Monitors the motor operation of generators and thus detects driving-power failure
- Prevents endangering the turbine (e.g. the turbine-blade damage due to overheating) by opening the circuit breaker of the system
- Protects a turbo-generator set

For the generator, there is a danger that the turbo-generator set accelerates and reaches overspeed in case of an incorrect residual-steam passage (quick-stop valves defective) after the circuit breaker has opened. Consequently, disconnecting the system (opening the circuit breaker of the system) shall only occur after reverse power (active-power consumption) has been detected.

6.36.2 Structure of the Function

The **Reverse-power protection** function comes factory-set with 1 stage. A maximum of 2 stages can be operated simultaneously within the function.

In all function groups, the function works with a 3-phase voltage and current interface.



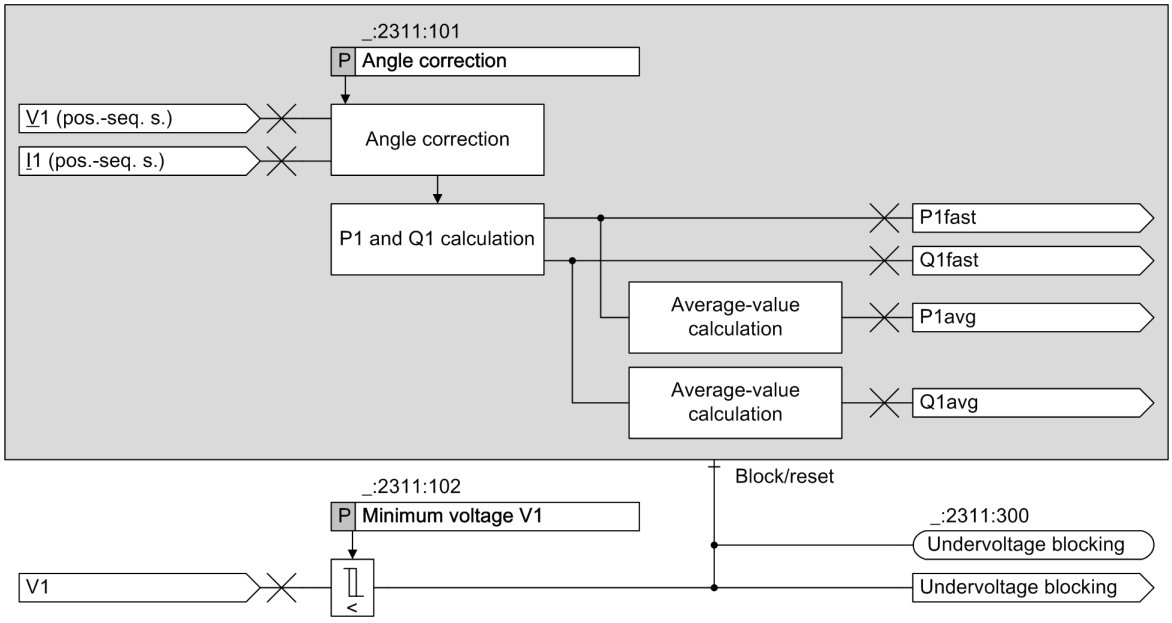
[dwstruct-160410-01.tif, 2, en_US]

Figure 6-215 Structure/Embedding of the Function

6.36.3 General Functionality

6.36.3.1 Description

Logic of the Function



[lo_RPP_01, 1, en_US]

Figure 6-216 Logic Diagram of the Cross-Stage Functionality

Calculating the Reverse Power

The reverse-power protection calculates the active power from the symmetrical components of the fundamental components of the voltages and currents. It generates the average value of the active power over a fixed number of cycles. Since positive-sequence variables are used for evaluation, the reverse power is determined independently of unbalance in currents or voltages. The frequency-tracking sampled values are used for calculation. The determined reverse power corresponds to the load on the driving-power side. The calculated active-power value corresponds to the total active power.

Taking the phase-displacement angle of the voltage and current transformers into account, the function calculates the exact active power even with a high apparent power and a small cos φ. A constant correction angle φ_{corr} makes correction possible. The influence of the current-transformer angle error is predominant here.

Determine this constant correction angle when you commission the protection device in the plant and adjust it as specified in the table (see *Table 11-1*).

Power Calculation and Angle Correction

To satisfy the high measuring-accuracy requirements, the power measured value is additionally averaged over 16 cycles before it is supplied to the protection function. The active power is calculated from the symmetrical-component vectors of voltage V1 and current I1. The total power is evaluated as power. The complex apparent power results from the following relationship. The real component is the active power:

$\underline{S} = 3\underline{V}_1 \cdot \underline{I}_1^{\,*} = 3V_1\, e^{j\varphi V} \cdot I_1\, e^{-j\varphi I} = 3V_1\, I_1\, e^{j(\varphi V - \varphi I)}$

$P = 3V_1\, I_1 \cos(\varphi_V - \varphi_I)$

The angle error between voltage transformer and current transformer has a strong influence on the measuring accuracy. With the parameter **(_:2311:101) Angle correction** , you can correct the angle error. The following 2 methods are possible here:

- Determine the angle error from the transformer test report data. Ask the transformer manufacturer for these values when you order the transformer.
- While the generator is connected to the power system, measure to determine the angle error (see chapter *11.14.2 Primary Test*).

The influence on the power-system voltage makes it very difficult to test high-power generators with a measurement while the generator is connected to the power system. In this case, you must determine the angle error from the transformer test report data (see chapter *6.36.3.2 Application and Setting Notes*). Alternatively, you can use instrument transformers with small angle errors. This is ensured with class 0.2 instrument transformers (voltage and current). The following equation describes the influence of the angle error:

$P = 3V_1 I_1 \cos(\varphi_V + \varphi_{V,F} - (\varphi_I + \varphi_{I,F})) = 3V_1 I_1 \cos(\varphi_U - \varphi_I + (\varphi_{V,F} - \varphi_{I,F}))$

The angle error to be corrected results as:

$\varphi_{Corr} = \varphi_{V,F} - \varphi_{I,F}$

To rotate in the correct direction, the correction angle is considered with inverted sign inside the unit.

Functional Measured Values

You can use the following functional measured values to check the behavior of the protection function and to support commissioning. The total power is represented as the measured value.

Measured Value	Description	
P1fast	Positive-sequence system active power calculated per cycle	Angle correction influences the measured value
Q1fast	Positive-sequence system reactive power calculated per cycle	Angle correction influences the measured value
P1avg	Positive-sequence system active power calculated from **P1fast** over 16 cycles	Input value for Reverse-power protection
Q1avg	Positive-sequence system reactive power calculated from **Q1fast** over 16 cycles	–

6.36.3.2 Application and Setting Notes

In the general functionality, you can adjust the parameter **(_:2311:101) Angle correction** . The parameter results from the angle error of the primary transformer. In SIPROTEC 5, the input transformers are calibrated so that the angle error is negligible. You can assume an error of < 0.1°. There is no difference between a protection input and an instrument-transformer input.



NOTE

If you use class 0.2 instrument transformers on the primary side to avoid the influence of the angle, you can connect a protection device with a protection current transformer without any problems.

Class 0.2 voltage transformers have a maximum admissible angle error of 10 min (0.17°). The angle error of a class 0.2 measuring current transformer at rated current is approximately 10 min, at 0.2 I_{rated} = 15 min, and at 0.05 I_{rated} = 30 min.

Parameter: Angle correction

- Default setting **(_:2311:101) Angle correction** = 0°

To determine the correction angle via measurement with the primary system, follow the instructions in chapter *11.14.2 Primary Test* .

You can use the method that is explained in the following section to derive the necessary correction angle from the transformer measuring reports.

Example

This example uses a class 0.2 voltage transformer with a rated burden of 45 VA. The following data was taken from the measuring report.

Table 6-17 For Phase A

V/Vn	$S_b = S_{br}$		$S_b = S_{br}/4$	
	ε_v [%]	δ_v [min]	ε_v [%]	δ_v [min]
0.8	-0.14	0.31	0.16	-0.34
1	-0.15	0.43	0.15	-0.24
1.2	-0.16	0.68	0.14	-0.06

The values resulting for the phases B and C are almost identical.

Furthermore, a termination with a rated burden (other measuring devices are still connected) is assumed so that an angle error of +0.43 min (rated-voltage value) is used as the calculation variable.

A current transformer of type 5PR is used here. This current transformer features a gap that limits the remanence to 10 %. However, this gap results in larger angle errors. The following tables show excerpts from the test reports.

Table 6-18 Phase A

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ε_i [%]	δ_i [min]
100	0.314	46.40

Table 6-19 Phase B

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ε_i [%]	δ_i [min]
100	0.247	35.10

Table 6-20 Phase C

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ε_i [%]	δ_i [min]
100	0.702	41.10

Since the positive-sequence system power is evaluated in the device, take the sign into account when you add the angle errors per phase, and divide the result by 3.

The following value results in this example:

$$\delta_i[\text{min}] = \frac{1}{3}\left(\delta_{i,A} + \delta_{i,B} + \delta_{i,C}\right) = \frac{1}{3}(46.40 + 35.10 + 41.10) = 40.87 \text{ min}$$

The resulting correction angle is:

$$\varphi_{corr}[\text{min}] = \varphi_{V,F} - \varphi_{I,F} = 0.43 \text{ min} - 40.87 \text{ min} = -40.44 \text{ min}$$

$$\varphi_{corr}[^\circ] = \frac{\varphi_{corr[\text{min}]}}{60} \cdot 1^\circ = \frac{-40.44}{60} \cdot 1^\circ = -0.674^\circ$$

Set the parameter **(_:2311:101) Angle correction = *-0.67*°**.

Parameter: **Minimum voltage V1**

- Default setting **(_:2311:102) Minimum voltage V1** = 5.000 V

With the parameter **Minimum voltage V1** , you can limit the operating range of the reverse-power protection. If the positive-sequence voltage falls below the set value, the reverse-power protection is deactivated. If no other restrictions are known, Siemens recommends using the default setting.

6.36.3.3 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle correction		-10.00 ° to 10.00 °	0.00 °
_:2311:102	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

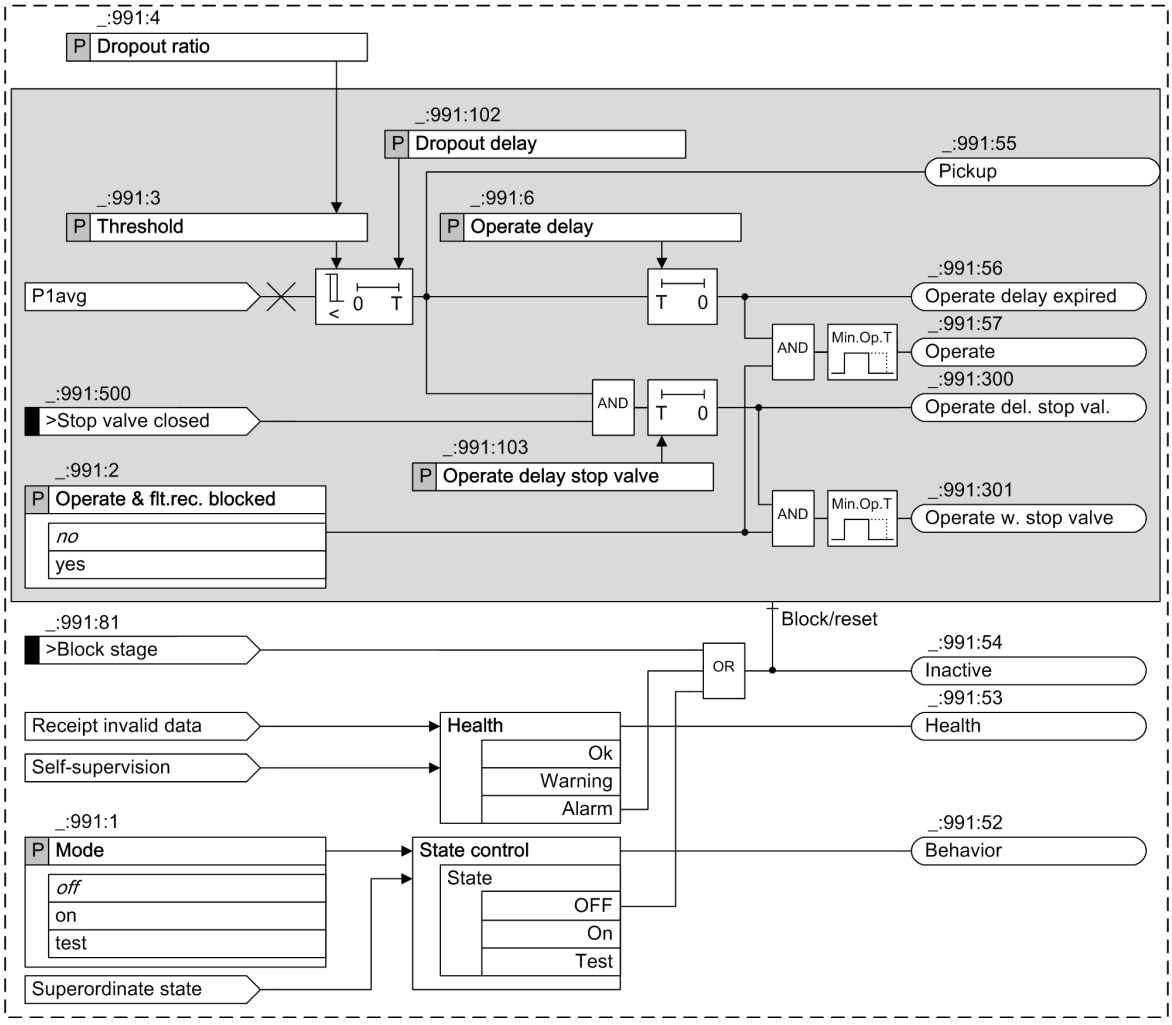
6.36.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:P1avg	MV	O
_:2311:302	General:Q1avg	MV	O
_:2311:303	General:P1fast	MV	O
_:2311:304	General:Q1fast	MV	O

6.36.4 Stage Description

6.36.4.1 Description

Logic of the Stage



[lo_RPP_02, 1, en_US]

Figure 6-217 Logic Diagram of the Reverse-Power Protection Stage

Trip Command

To bridge brief power consumption during synchronization or during power swings caused by system incidents, tripping (shutdown of the generator via reverse power) is delayed by a settable time (for example, 10 s).

A brief delay is enough when the quick-stop valve is closed. Couple the position of the quick-stop valve via the binary input signal **>Stop valve closed** . When quick stop is tripped, the short Operate delay thus becomes effective.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking of the stage is possible externally or internally via the binary input signal **>Block stage** .

6.36.4.2 Application and Setting Notes

If reverse power occurs in a power plant, the turbo-generator set must be disconnected from the electrical power system. Operating the turbine without the minimum steam flow (cooling effect) is dangerous. For a gas turbine cogeneration unit, the motor load can also be too great for the electrical power system.

Parameter: `Threshold`

- Recommended setting value **`(_:991:3) Threshold`** = ***`-1.00 %`***

The friction losses that have to be overcome mainly determine the active power consumed by a turbo-generator set. Depending on the plant, the consumed active power is of the following ranges:

Steam turbines	$P_{reverse}/S_{rated}$ = 1.00 % to 3.00 %
Diesel drives	$P_{reverse}/S_{rated}$ > 5.00 %
Gas turbines	$P_{reverse}/S_{rated}$ = up to 30.00 %

You can measure the reverse power of the turbo-generator set yourself in a primary test by using the protection function. Set the setting value **`P`** $_{reverse}$, for example, to 0.5 times the value of the measured reverse power. This power is shown additionally in the functional measured values in the **Reverse-power protection** function (**`P1avg`**). For large machines with very small reverse power, you must use the angle-error correction option of the current and voltage transformers.



NOTE

In the current-input selection, you can select protection current transformers or instrument transformers on the device side. Since the transformers are calibrated at the factory, there are hardly any differences between the transformers for the **Reverse-power protection** function. You can thus always select device inputs with a protection current transformer.

In contrast, a primary current transformer significantly influences the measuring accuracy via its angle error. The angle error of a class 0.2 instrument transformer is significantly smaller than the angle error of a class 5P protection current transformer. A separate function group is necessary for the connection to an instrument transformer. Use a **Voltage/current 3-phase** function group and load the **Reverse-power protection** function from the library.

Do not connect the **Reverse-power protection** function to a linear core-type transformer (for example, a TPZ type), as these transformers have a large angle error (for example, approx. 180 min).

6.36.4.3 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
`Stage 1`				
_:991:1	Stage 1:Mode		• off • on • test	off
_:991:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:991:3	Stage 1:Threshold		-30.00 % to -0.30 %	-1.00 %
_:991:4	Stage 1:Dropout ratio		0.40 to 0.99	0.60
_:991:102	Stage 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:991:6	Stage 1:Operate delay		0.00 s to 60.00 s	10.00 s
_:991:103	Stage 1:Operate delay stop valve		0.00 s to 60.00 s	1.00 s

6.36.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:991:81	Stage 1:>Block stage	SPS	I
_:991:500	Stage 1:>Stop valve closed	SPS	I
_:991:54	Stage 1:Inactive	SPS	O
_:991:52	Stage 1:Behavior	ENS	O
_:991:53	Stage 1:Health	ENS	O
_:991:55	Stage 1:Pickup	ACD	O
_:991:56	Stage 1:Operate delay expired	ACT	O
_:991:57	Stage 1:Operate	ACT	O
_:991:300	Stage 1:Operate del. stop val.	ACT	O
_:991:301	Stage 1:Operate w. stop valve	ACT	O

6.37 Overexcitation Protection

6.37.1 Overview of Functions

The **Overexcitation protection** (ANSI 24) is used for detecting high induction values in generators and transformers. It protects the equipment from excessive thermal loads.

The induction is recorded indirectly by analyzing the V/f ratio (also referred to as Volt per Hertz protection). Overvoltage leads to excessive magnetizing currents, while underfrequency leads to higher losses when resetting the magnetization.

If the power system is disconnected and the voltage and frequency control function in the remaining system does not react quickly or the power imbalance is excessive, there is a risk of overexcitation.

6.37.2 Structure of the Function

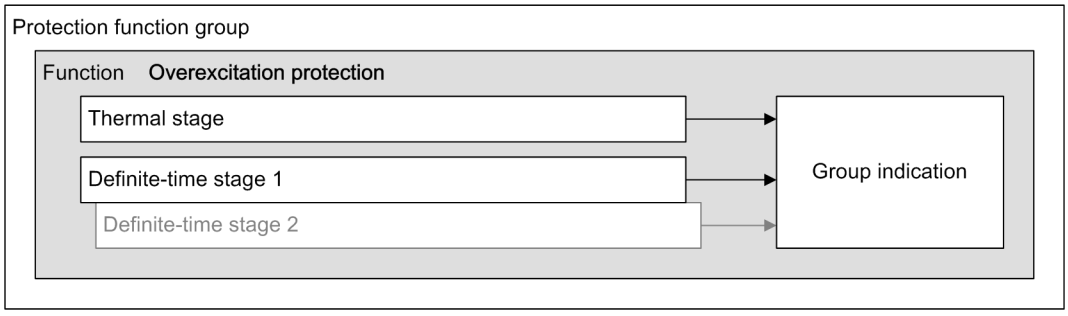
The **Overexcitation protection** function is used within protection function groups that have a 3-phase voltage input. The function comes with the following factory-set stages:

- Thermal stage adjustable with a user-defined characteristic curve
- Definite-time stage which can be delayed using a time component

Within this function, the following maximum number of stages can be operated simultaneously: one stage with a user-defined characteristic curve and 2 definite-time stages.

The group-indication output logic (see following figure) uses the logical OR function from the stage-selective indications to generate the following group indications of the entire **Overexcitation protection** function:

- Pickup
- Operate Indication



[dwovexuf-080513-01.tif, 3, en_US]

Figure 6-218 Structure/Embedding of the Function

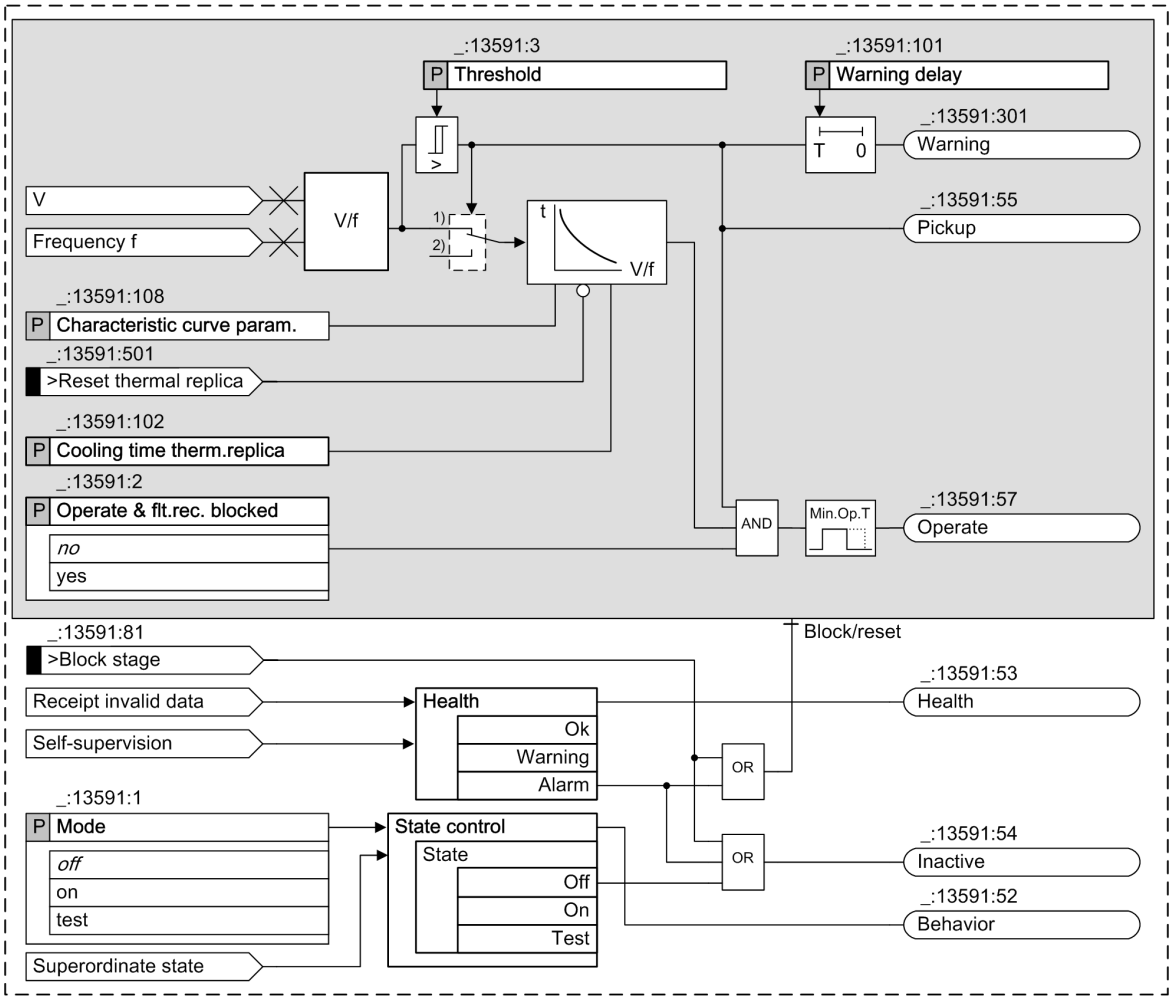
Function Measured Value

Measured Value	Description
(_:2311:322) V/f	Value calculated by the voltage and the frequency

6.37.3 Stage with Dependent Characteristic Curve (Thermal Stage)

6.37.3.1 Function Description

Logic



[lothchuf-080513-01.tif, 1, en_US]

Figure 6-219 Logic of the Overexcitation Protection with Thermal Characteristic Curve

(1) Heating
(2) Cooling

V/f Method of Measurement

The input values of the protection function are the continuously measured voltage and the frequency. The phase-to-phase voltage is used to process the voltage. The angle difference method (see *6.32 Overfrequency Protection*) is used to determine the frequency. Both values form the V/f ratio. In order to arrive at an absolute value, standardized data is applied.

Thus, the ratio is derived from:

$$\frac{V/V_{rated,obj.}}{f/f_{rated}}$$

[foverufn-080523-01.tif, 1, en_US]

with

V	Measured voltage (maximum phase-to-phase voltage)
$V_{rated, obj.}$	Adjusted rated voltage of the protected object
f	Measured frequency
f_{rated}	Adjusted rated frequency

Based on the definition above, the protection function refers exclusively to primary values of the protected object. A deviation between the primary rated voltage of the voltage transformer and the protected object is corrected automatically.

NOTE

This fact must be considered during a secondary test.

More information can be found in chapter *11.16 Functional Test for Overexcitation Protection* .

The function compares the calculated value of the measured V/f ratio with the threshold value and the user-defined thermal characteristic curve.

Depending on the characteristic curve, a **thermal** trip signal is triggered after a pre-determined duration.

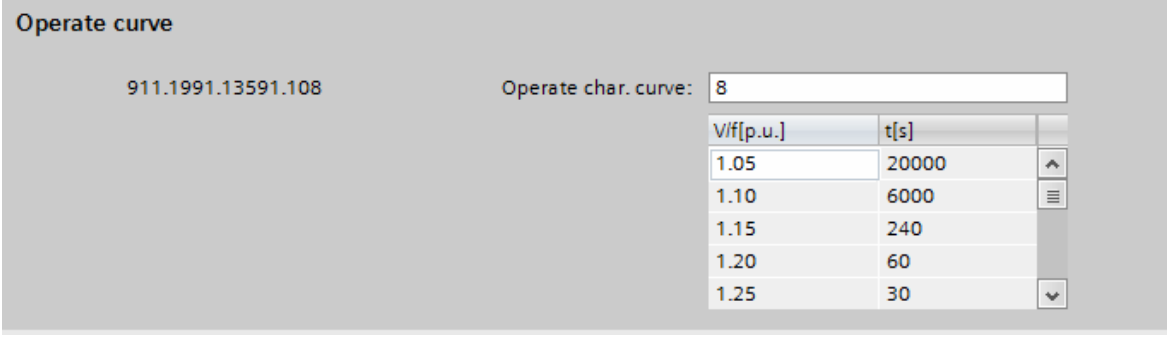
Characteristic Curve

You can freely configure the thermal characteristic curve with the user-defined values. This provides a flexible adjustment to the specified characteristics of the protected object. If the set threshold value (parameter **(_:13591:3) Threshold**) is exceeded, the evaluation of the characteristic curve is initiated. Exceeding the threshold value triggers an indication (*(_:13591:55) Pickup*). In addition, a definite-time stage may be used to generate a delayed indication output as (*(_:13591:301) warning*).

The pickup is used to start the integration process (weighted counting) of the thermal characteristic curve. If the time as a factor of V/f is reached, the pickup is triggered. Based on the replica of the thermal behavior, the trigger value is always 100 % (see *Thermal Behavior, Page 776*).

If the value drops below the pickup threshold, the trip command is rescinded and the **internal counter** of the parameterized cooling time (parameter **(_:13591:102) Cooling time therm.replica**) is reduced. The dropout threshold of the pickup threshold is fixed to 0.98 * **Threshold**.

A maximum of 30 overexcitation value pairs V/f (referring to the rated values) and operate time t can be set. The default characteristic curve refers to a standard transformer.

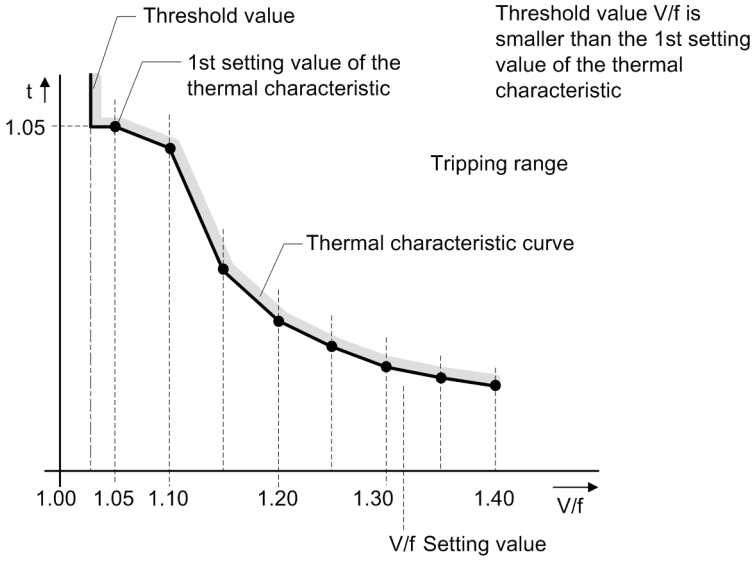


[scaulskn-200214-01, 1, en_US]

Figure 6-220 Data Sheet for Adjustment of Thermal Characteristic Curve

The parameter **Threshold** (pickup threshold) affects the evaluation of the characteristic curve as follows:

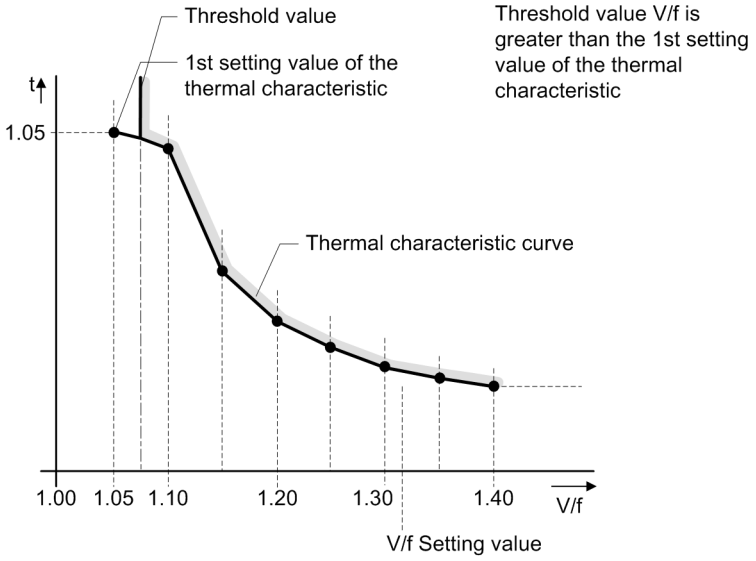
If the **Threshold** is smaller than the first characteristic pair, the set time will be extended (see *Figure 6-221*).



[dwovexak-210313-01.tif, 1, en_US]

Figure 6-221 Tripping Zone of the Thermal Characteristic Curve (I)

If the **Threshold** is greater, then a cutoff occurs (see *Figure 6-222*).



[dwovexab-210313-01.tif, 1, en_US]

Figure 6-222 Tripping Zone of the Thermal Characteristic Curve (II)

Warning Threshold

If the **Threshold** is exceeded, the time delay (parameter **(_:13591:101) Warning delay**) is started. If the time delay has elapsed, the indication (*(_:13591:301) warning*) will be displayed.

Thermal Behavior

The time derived from the characteristic curve and associated with the V/f value is set to 100 %. With each function call, the time will be increased according to the respective weighted invocation interval. If the 100 % value is exceeded, tripping is initiated. If the V/f value is changed, the associated time from the characteristic curve is added as a new 100 % value.

In order to prevent excessive cooling times, the thermal storage has been limited internally to 150 %. The *fill level* of the thermal storage will be provided as functional measured value.

Measured Value	Description
(_:13591:321) V/f th.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, the tripping occurs.

Cooling Time

If the value drops below the threshold (**(_:13591:3) Threshold**), tripping of the thermal characteristic curve (dependent characteristic curve) is reverted. However, the parameterized cooling time (**Cooling time therm.replica**) reduces the thermal storage (counter content) to 0. This parameter is defined as time. It is required by the thermal replica in order to cool down from 100 % to 0 %.

Resetting the Thermal Map

The binary input indication *(_:13591:501) >Reset thermal replica* can be applied to reset the thermal replica. The thermal replica will then have a value of 0. A reparameterization will also lead to resetting the thermal replica.

Blocking the Stage

The function can be blocked externally or internally by the binary input signal *(_:13591:81) >Block stage*. Blocking will cause a picked up function to be reset.

6.37.3.2 Application and Setting Notes

Thermal overloads extended over a longer period will jeopardize electric equipment, for example, synchronous motors, generators, or transformers and may cause damage. When using the thermal, user-defined characteristic curve, the overexcitation protection lends itself perfectly for adjustment to the specified limits of the protection equipment.

The following provides the recommended settings:



NOTE

It must be noted that one requirement for the correct mode of operation of the function is based on the proper setting of the power-system data.

You can find more detailed information on this in chapter *6.1 Power-System Data* .

For additional setting recommendations, verity the following parameter in the power-system data:

- Adjusted rated frequency
- Adjusted rated voltage of the protected object
- Adjusted rated voltage of the voltage transformer of the applicable measuring point

Parameter: Threshold Value

- Default setting **(_:13591:3) Threshold** = *1.10*

  The **Threshold** parameter is used to describe the value for the permissible continuous overexcitation. The default value is a practical value used for transformers. The value may be less for generator applications. These values can be found in the manufacturer's information.

Parameter: Time Delayed Warning

- Default setting **(_:13591:101) Warning delay** = *10.00 s*

  When using the **Warning delay** parameter, the time can be determined by which the warning indication of the stage should be delayed after the pickup. This time delay depends on the specific application. This time must clearly exceed the reaction time of the regulators. 10 seconds is a feasible value.

Parameter: Cooling Time Therm. Replica

- Default setting **(_:13591:102) Cooling time therm.replica** = *3600 s*

The **Cooling time therm.replica** parameter is used to define the cooling characteristics of the thermal replica. If concrete specifications are not given, the default value can be maintained.

Parameter: V/f/time value pairs (operate curve)

With this parameter, the number of potting points along the thermal operate curve are defined. This is required for the calculation. The number of points defines the accuracy of the image of the specified characteristic curve. Adjust the value individually.

Set a V/f/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize. The default settings refer to a Siemens standard transformer.

NOTE

The value pairs must be entered in continuous order.

NOTE

Note that the V/f values that are lower than the V/f values of the smallest characteristic-curve point do not extend the operate time. Up to the smallest characteristic-curve point, the characteristic curves runs parallel to the V/f axis. V/f values that are larger than the V/f value of the largest characteristic-curve point do not reduce the operate time. From the largest characteristic-curve point, the pickup characteristic runs parallel to the V/f axis (see *Characteristic Curve, Page 775*).

6.37.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:13621:1	Definite-T 1:Mode		• off • on • test	off
_:13621:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13621:3	Definite-T 1:Threshold		1.00 to 1.40	1.40
_:13621:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.00 s
General				
_:13591:1	Therm.charact.:Mode		• off • on • test	off
_:13591:2	Therm.charact.:Operate & flt.rec. blocked		• no • yes	no
_:13591:3	Therm.charact.:Threshold		1.00 to 1.20	1.10
_:13591:101	Therm.charact.:Warning delay		0.00 s to 60.00 s	10.00 s
_:13591:102	Therm.charact.:Cooling time therm.replica		0 s to 100000 s	3600 s

6.37.3.4 Information List

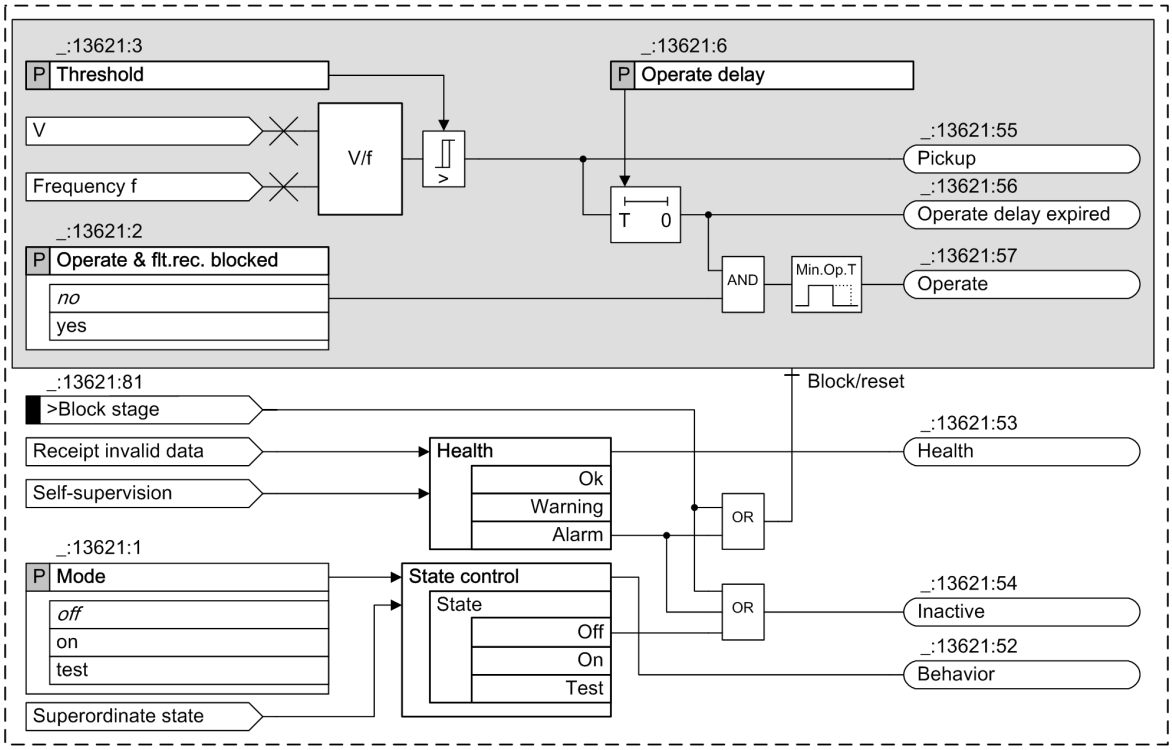
No.	Information	Data Class (Type)	Type
General			
_:2311:322	General:V/f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:13621:81	Definite-T 1:>Block stage	SPS	I
_:13621:54	Definite-T 1:Inactive	SPS	O
_:13621:52	Definite-T 1:Behavior	ENS	O
_:13621:53	Definite-T 1:Health	ENS	O
_:13621:55	Definite-T 1:Pickup	ACD	O
_:13621:56	Definite-T 1:Operate delay expired	ACT	O
_:13621:57	Definite-T 1:Operate	ACT	O
Therm.charact.			
_:13591:81	Therm.charact.:>Block stage	SPS	I
_:13591:501	Therm.charact.:>Reset thermal replica	SPS	I
_:13591:54	Therm.charact.:Inactive	SPS	O
_:13591:52	Therm.charact.:Behavior	ENS	O
_:13591:53	Therm.charact.:Health	ENS	O
_:13591:55	Therm.charact.:Pickup	ACD	O
_:13591:301	Therm.charact.:Warning	ACT	O
_:13591:57	Therm.charact.:Operate	ACT	O
_:13591:321	Therm.charact.:V/f th.	MV	O

6.37.4 Stage with Independent Characteristic Curve

6.37.4.1 Function Description

Logic



[lodtchuf-080513-01.tif, 1, en_US]

Figure 6-223 Logic of the Overexcitation Protection with Inpendent Characteristic Curve (Definite-Time Stage)

Method of Measurement

This stage evaluates also the V/f value that is identical to the input value of the thermal stage.

Measurement-relevant details can be found in chapter *6.37.3 Stage with Dependent Characteristic Curve (Thermal Stage)* .

How the Definite-Time Stage Works

The stage comprises a threshold and a time-delay stage. If the V/f value is greater than the set threshold value (**(_:13621:3) Threshold**), then the stage is tripped after an adjustable time delay has elapsed. You can set the time delay with the parameter **(_:13621:6) Operate delay**.

The dropout ratio for the **Threshold** is fixed to 98 %.

6.37.4.2 Application and Setting Notes

The definite-time stage can be applied when fast tripping is required in the presence of high V/f values. In this case, the stage acts superimposed on the thermal, dependent stage.

Parameter: Threshold Value

- Default setting **(_:13621:3) Threshold** = ***1.40***

  The **Threshold** parameter is used to describe the overexcitation value that causes the tripping function. The default value matches a feasible upper limit.

Parameter: `Tripping delay`

- Default setting `(_:13621:6) Operate delay` = *`1.00 s`*

  The `Operate delay` parameter is used to determine the time by which the stage is delayed after the pickup. This time delay depends on the specific application. The default value is practical for the application described in the previous chapter.

6.37.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:13621:1	Definite-T 1:Mode		• off • on • test	off
_:13621:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13621:3	Definite-T 1:Threshold		1.00 to 1.40	1.40
_:13621:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.00 s
Therm.charact.				
_:13591:1	Therm.charact.:Mode		• off • on • test	off
_:13591:2	Therm.charact.:Operate & flt.rec. blocked		• no • yes	no
_:13591:3	Therm.charact.:Threshold		1.00 to 1.20	1.10
_:13591:101	Therm.charact.:Warning delay		0.00 s to 60.00 s	10.00 s
_:13591:102	Therm.charact.:Cooling time therm.replica		0 s to 100 000 s	3600 s

6.37.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:322	General:V/f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
df/dt falling1			
_:13621:81	Definite-T 1:>Block stage	SPS	I
_:13621:54	Definite-T 1:Inactive	SPS	O
_:13621:52	Definite-T 1:Behavior	ENS	O
_:13621:53	Definite-T 1:Health	ENS	O
_:13621:55	Definite-T 1:Pickup	ACD	O
_:13621:56	Definite-T 1:Operate delay expired	ACT	O
_:13621:57	Definite-T 1:Operate	ACT	O
Therm.charact.			
_:13591:81	Therm.charact.:>Block stage	SPS	I
_:13591:501	Therm.charact.:>Reset thermal replica	SPS	I
_:13591:54	Therm.charact.:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:13591:52	Therm.charact.:Behavior	ENS	O
_:13591:53	Therm.charact.:Health	ENS	O
_:13591:55	Therm.charact.:Pickup	ACD	O
_:13591:301	Therm.charact.:Warning	ACT	O
_:13591:57	Therm.charact.:Operate	ACT	O
_:13591:321	Therm.charact.:V/f th.	MV	O

6.38 Undervoltage-Controlled Reactive-Power Protection

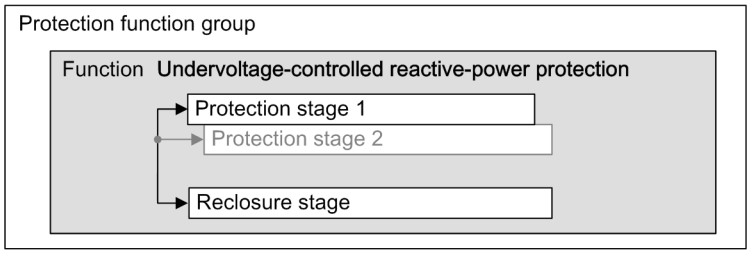
6.38.1 Overview of Functions

The **Undervoltage-controlled reactive-power protection** function (ANSI 27/Q):

- Detects critical power-system situations, mainly in case of regenerative generation
- Prevents a voltage collapse in power system by disconnecting the power-generation facility from the main power systems
- Ensures reconnection under stable power-system conditions

6.38.2 Structure of the Function

The **Undervoltage-controlled reactive-power protection** function can be used in protection function groups containing 3-phase voltage and current measurement. Depending on the device, it is preconfigured by the manufacturer with 1 **Protection stage** and 1 **Reclosure stage**. A maximum of 2 **Protection stages** and 1 **Reclosure stage** can operate simultaneously within the function.



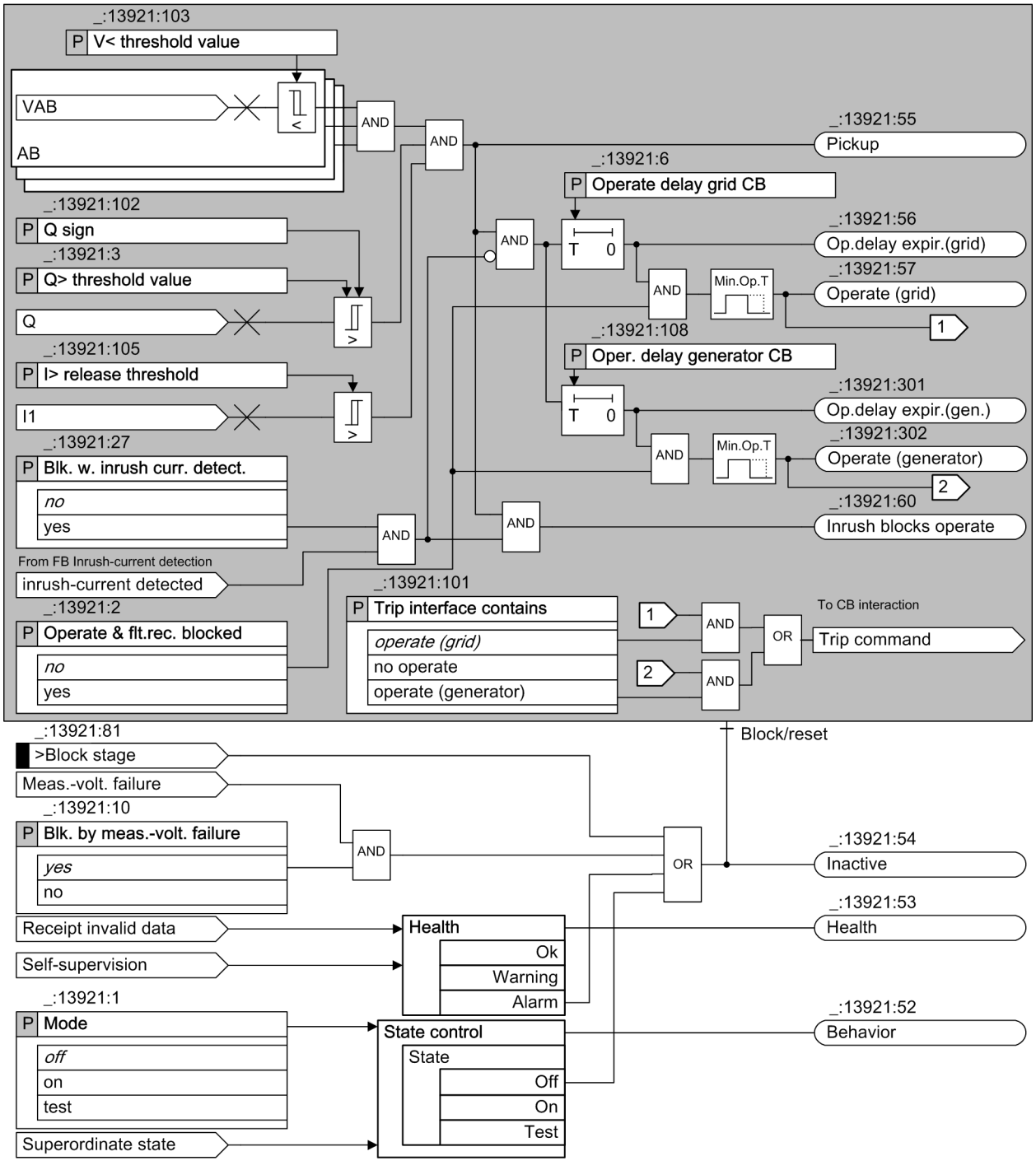
[dwqvprot-110713-01.tif, 1, en_US]

Figure 6-224 Structure/Embedding of the Function

6.38.3 Description Protection Stage

6.38.3.1 Description

Logic of the Stage



[loqvprst-110713-01.tif, 1, en_US]

Figure 6-225 Logic Diagram of the Protection Stage of the Undervoltage-Controlled Reactive-Power Protection

Measurand

To detect critical power-system situations, the **Undervoltage-controlled reactive-power protection** function uses the fundamental values of the phase-to-phase voltages, the positive-sequence current, and the reactive power.

Q-Measurement Direction

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the protected object. Via parameter **Q sign**, the direction of the positive reactive-power flow Q can be changed by inverting the sign of the reactive power Q.

Pickup

The protection stage picks up under the following conditions:

- All 3 phase-to-phase voltages are below the parameterized threshold value.
- The positive-sequence current I_1 is above the parameterized threshold value.
- The power-generation facility requires more than the parameterized reactive power (Q is above the parameterized threshold value).

Trip Interface

The stage provides 2 operate signals, the *Operate (generator)* and the *Operate (grid)*. Depending on the parameter **Trip interface contains**, one or none of them will be forwarded to the trip interface of the circuit-breaker interaction.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage*
- Measuring-voltage failure
  For further information, refer to chapter *6.7.4.1 Description*.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter permits you to define whether the operate delay should be blocked by a threshod-value violation due to an inrush current.

For further information about device-internal **Inrush-current detection** function, refer to chapter *6.3.7.1 Description* .

6.38.3.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:13921:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The **Protection stage** is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as there is no assurance that the **Protection stage** will function correctly if the measuring voltage fails.

no	The **Protection stage** is not blocked when a measuring-voltage failure is detected.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:13921:27) Blk. w. inrush curr. detect.** = ***no***

You use the **Blk. w. inrush curr. detect.** parameter to determine whether the operate delay and operate signal are blocked during the detection of an inrush current.

Parameter: **I> release threshold**

- Recommended setting value **(_:13921:105) I> release threshold** = ***0.100 A***

You use the **I> release threshold** parameter to define a precondition that the stage can pick up. The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: **V< threshold value**

- Recommended setting value **(_:13921:103) V< threshold value** = ***85.000 V***

You use the **V< threshold value** parameter to define one of the 2 pickup criteria. If all 3 phase-to-phase voltages drop below the parameterized undervoltage threshold value, the pickup criterion is fulfilled.

The setting should be set below the lower value of the permissible voltage range, according to the national transmission code. In Germany, the recommended undervoltage threshold is 85 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: **Q> threshold value**

- Default setting **(_:13921:3) Q> threshold value** = ***5 %***

You use the **Q> threshold value** parameter to define the second of the 2 pickup criteria. If the positive reactive power exceeds the parameterized **Q> threshold value**, the pickup criterion is fulfilled.

In the following example, the pickup takes place if Q exceeds 5 % of the power-supply system rated power.

EXAMPLE

The following example is given for settings in secondary values.

Rated voltage: $V_{rated,\ sec}$ = 100 V

Rated current: $I_{rated,\ sec}$ = 1 A

Threshold value: 5 % of the power-supply system rated power

You can calculate the setting value as follows:

$$Q >_{threshold} = 100\ V \cdot 1\ A \cdot \sqrt{3} \cdot 0.05 = 8.7\ VAr$$

[foqvprot-110713-01.tif, 1, en_US]

Parameter: **Operate delay**

- Default setting **(_:13921:6) Operate delay grid CB** = ***1.50 s***
- Default setting **(_:13921:108) Oper. delay generator CB** = ***0.50 s***

You can set the **Operate delay grid CB** for the circuit breaker at the power-supply system connection point, or set the **Oper. delay generator CB** for the circuit breaker of the facility, for example, the generator.

The time of the **Operate delay grid CB** should always be set longer than the time of the **Oper. delay generator CB**.

Parameter: **`Trip interface contains`**

- Default setting **`(_:13921:101) Trip interface contains`** = ***`operate (grid)`***

The stage provides 2 operate signals, the *`Operate (generator)`* and the *`Operate (grid)`*.

You use the **`Trip interface contains`** parameter to define whether one or none of them will be forwarded to the trip interface of the circuit-breaker interaction. The selected operate signal will trip the circuit breaker that has been connected to the protection function group.

The setting depends on the specific application.

Parameter: **`Q sign`**

- Default setting **`(_:13921:102) Q sign`** = ***`not reversed`***

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the main protected object (for example, a feeder). You use the **`Q sign`** parameter to reverse the sign and therefore the direction of the reactive-power flow Q. This reversal may be required for specific application, where the main protected object (for example, a line towards the main power systems) is in different direction to the power-generation facility.

Parameter Value	Description
`not reversed`	The protected object is in the same direction as the power-generation facility.
`reversed`	The protected object is not in the same direction as the power-generation facility.

6.38.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Prot. stage 1`				
_:13921:1	Prot. stage 1:Mode		• off • on • test	off
_:13921:2	Prot. stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13921:10	Prot. stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:13921:27	Prot. stage 1:Blk. w. inrush curr. detect.		• no • yes	no
_:13921:101	Prot. stage 1:Trip interface contains		• no operate • operate (generator) • operate (grid)	operate (grid)
_:13921:102	Prot. stage 1:Q sign		• not reversed • reversed	not reversed
_:13921:3	Prot. stage 1:Q> threshold value		1.00 % to 200.00 %	5.00 %
_:13921:103	Prot. stage 1:V< threshold value		3.000 V to 175.000 V	85.000 V
_:13921:105	Prot. stage 1:I> release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:13921:108	Prot. stage 1:Oper. delay generator CB		0.00 s to 60.00 s	0.50 s

Addr.	Parameter	C	Setting Options	Default Setting
_:13921:6	Prot. stage 1:Operate delay grid CB		0.00 s to 60.00 s	1.50 s

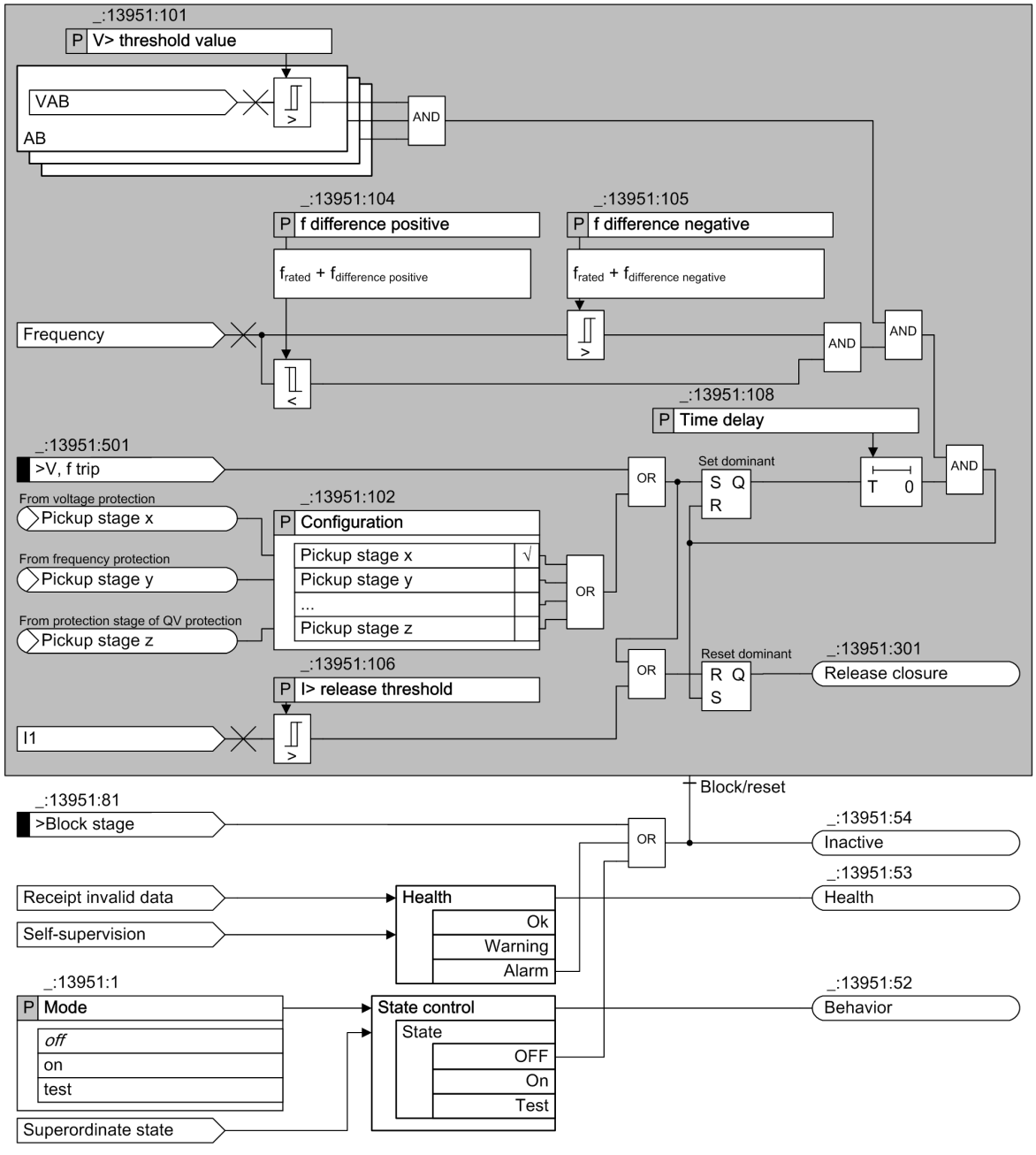
6.38.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Prot. stage 1			
_:13921:81	Prot. stage 1:>Block stage	SPS	I
_:13921:54	Prot. stage 1:Inactive	SPS	O
_:13921:52	Prot. stage 1:Behavior	ENS	O
_:13921:53	Prot. stage 1:Health	ENS	O
_:13921:60	Prot. stage 1:Inrush blocks operate	ACT	O
_:13921:55	Prot. stage 1:Pickup	ACD	O
_:13921:301	Prot. stage 1:Op.delay expir.(gen.)	ACT	O
_:13921:302	Prot. stage 1:Operate (generator)	ACT	O
_:13921:56	Prot. stage 1:Op.delay expir.(grid)	ACT	O
_:13921:57	Prot. stage 1:Operate (grid)	ACT	O

6.38.4 Description Reclosure Stage

6.38.4.1 Description

Logic of the Stage



[loqvclst-110713-01.tif, 3, en_US]

Figure 6-226 Logic Diagram of Reclosure Stage in Undervoltage-Controlled Reactive-Power Protection

Measurand

The stage works with fundamental values of voltage and current.

Release for Reconnecting

The release for reconnecting the power-generation facility is given under the following conditions:

- All 3 phase-to-phase voltages are above the threshold value.
- The power frequency is within a specified range.
- The reclosure time delay, started by the operate of specific protection functions, has elapsed. The time delay is started by the first operate signal of the protection stages configured via the **Configuration** parameter. All protection stages of the voltage protection, the frequency protection, and the QV protection are available for configuration.

External Start of Reclosure Time Delay

Reclosure time delay can be started via the binary input signal *>V, f trip*, which can be connected to external voltage and frequency protection trip signals.

Blocking of the Stage

The stage can be blocked via the binary input signal *>Block stage*.

6.38.4.2 Application and Setting Notes

Parameter: Configuration

- Default setting **(_:13951:102) Configuration** = ***no stage***

You use the **Configuration** parameter to define which operate signal of specific protection functions starts the release time delay of the **Reclosure stage**:

- Overfrequency protection
- Underfrequency protection
- Overvoltage protection
- Undervoltage protection
- Protection stage of undervoltage-controlled reactive-power protection

When the protection stage of undervoltage-controlled reactive-power protection is selected, only the signal *Operate (generator)* can start the release time delay of this stage. The signal *Operate (grid)* cannot start the release time delay.

The configuration depends on the specific application.

Parameter: I> release threshold

- Recommended setting value **(_:13951:106) I> release threshold** = ***0.100 A***

You use the **I> release threshold** parameter to define a precondition that the stage can work.

The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: V> threshold value

- Recommended setting value **(_:13951:101) V> threshold value** = ***95.000 V***

You use the **V> threshold value** parameter to set one of the 2 release criteria. The setting should be set above the lower value of the allowed voltage range, according to the national transmission code. In Germany, the recommended overvoltage threshold is 95 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: Frequency range

- Recommended setting value **(_:13951:104) f difference positive** = ***0.05 Hz***
- Recommended setting value **(_:13951:105) f difference negative** = ***-2.50 Hz***

You use these 2 parameters to define the admitted frequency deviation from the rated frequency. **f difference positive** defines the upper frequency range limit. **f difference negative** defines the lower frequency range limit.

Siemens recommends using the default settings, which reflect common practice in Germany. Other national transmission codes may require a slightly different range.

Parameter: `Time delay`

- Default setting **`(_:13951:108) Time delay`** = ***`0.00 s`***

You use the **`Time delay`** parameter to specify the minimum time delay for releasing the reconnection of the power-generation facility after tripping by protection.

The setting depends on the specific application.

6.38.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Reclos. stage`				
_:13951:1	Reclos. stage:Mode		• off • on • test	off
_:13951:101	Reclos. stage:V> threshold value		3.000 V to 340.000 V	95.000 V
_:13951:104	Reclos. stage:f difference positive		0.01 Hz to 5.00 Hz	0.05 Hz
_:13951:105	Reclos. stage:f difference negative		-5.00 Hz to -0.01 Hz	-2.50 Hz
_:13951:106	Reclos. stage:I> release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:13951:108	Reclos. stage:Time delay		0.00 s to 3600.00 s	0.00 s
_:13951:102	Reclos. stage:Configuration		Setting options depend on configuration	

6.38.4.4 Information List

No.	Information	Data Class (Type)	Type
`Reclos. stage`			
_:13951:81	Reclos. stage:>Block stage	SPS	I
_:13951:501	Reclos. stage:>V, f trip	SPS	I
_:13951:54	Reclos. stage:Inactive	SPS	O
_:13951:52	Reclos. stage:Behavior	ENS	O
_:13951:53	Reclos. stage:Health	ENS	O
_:13951:301	Reclos. stage:Release closure	ACT	O

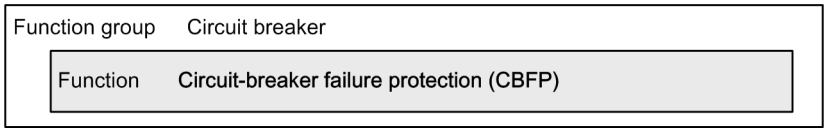
6.39 Circuit-Breaker Failure Protection

6.39.1 Overview of Functions

The **Circuit-breaker failure protection** function (ANSI 50BF) monitors the tripping of the associated circuit-breaker (CB) and generates a backup trip signal if the circuit-breaker fails.

6.39.2 Structure of the Function

The function **Circuit-breaker failure protection** (CBFP) can be used in the **Circuit-breaker** function group.



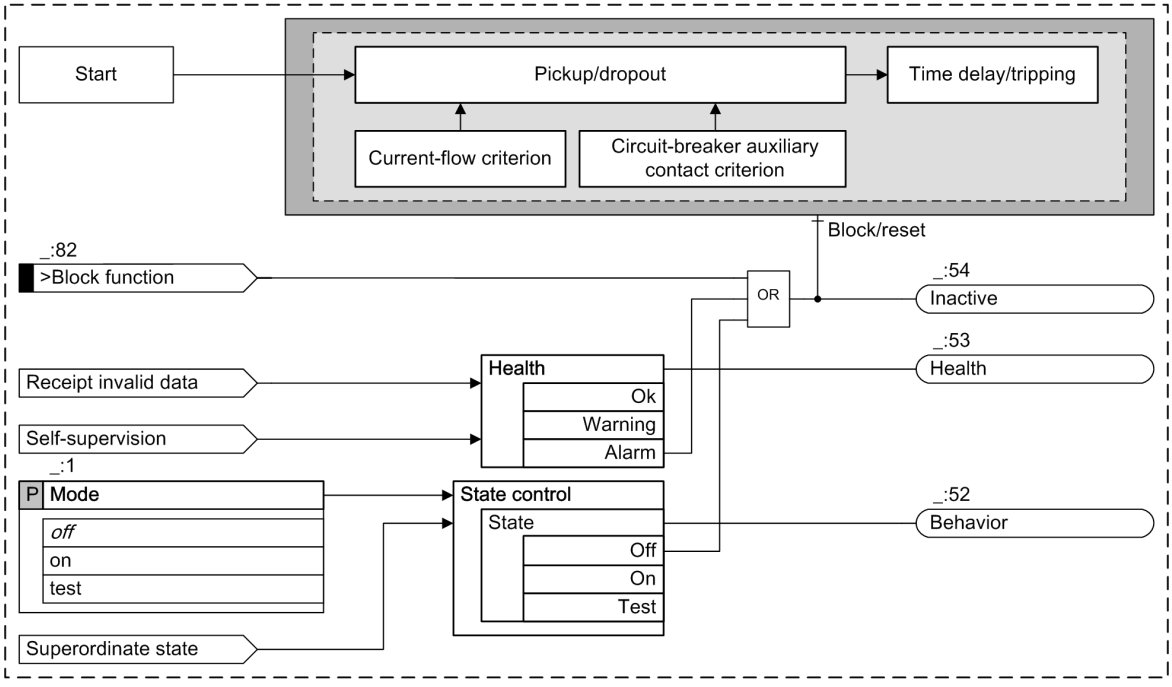
[dwstrbfp-260213-01.tif, 1, en_US]

Figure 6-227 Structure/Embedding of the Function

Figure 6-228 shows the functionalities and the function control of the function.

The start is initiated by the device-internal protection function or by an external protection. Along with the start, the current-flow criterion or the circuit-breaker auxiliary contact criterion is used to check whether the circuit breaker is closed. If the circuit breaker is closed, the function picks up and starts the time delay. During the time delay, the system checks continuously whether the circuit breaker has opened. If this is the case, the function drops out. If the circuit breaker is not opened, the function trips upon expiration of the time delay.

The following description elaborates on the detailed functionality of the individual function blocks.



[losvsbfp-090712-01.tif, 2, en_US]

Figure 6-228 Function Logic Overview

6.39.3 Function Description

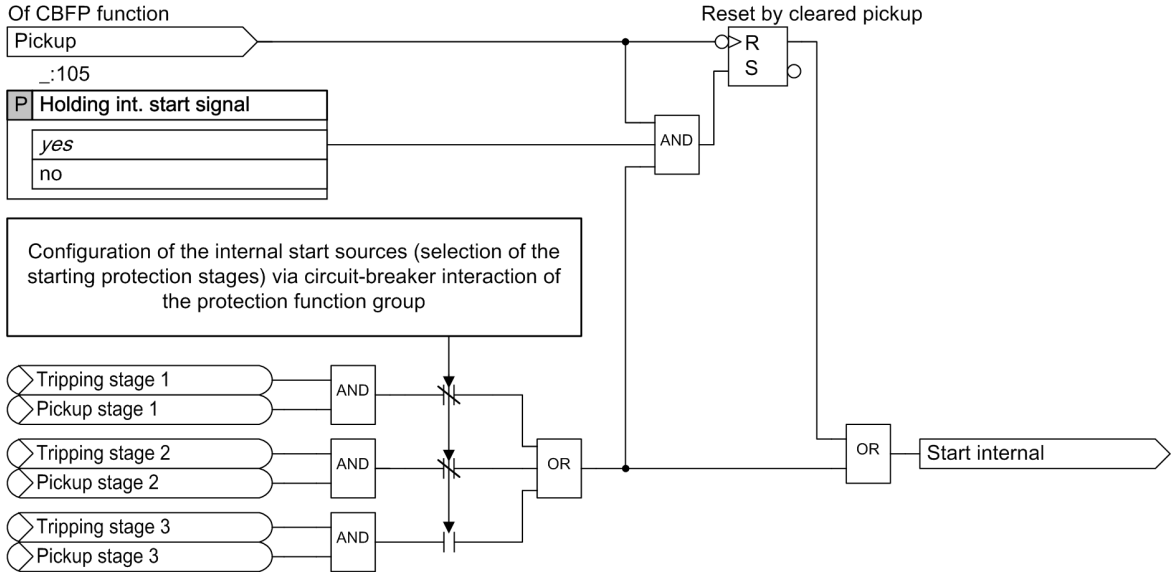
The Circuit-breaker failure protection function is started by device-internal protection functions and/or externally (via a binary input or an interface, such as GOOSE). *Figure 6-229* and *Figure 6-230* show the functionality.

Internal Start

By default, each device-internal protection stage, which has to control the local circuit breaker, starts the circuit-breaker failure protection. The function is started by the tripping of the protection stage. In the default setting, the starting signal **`Internal start`** (see *Figure 6-229*) is held when the pickup signal has a falling edge or the protection function has tripped. The Circuit-breaker failure protection function can in this case only dropout if the circuit breaker is detected to be open. This is detected using the current flow or circuit-breaker auxiliary contact criterion. If necessary, the Circuit-breaker failure protection function can also drop out when the pickup signal has a falling edge or the protection function trips (internal starting signal is not held).

Using routing, you can specify whether individual protection stages or protection functions are to be used as the starting source or whether starting happens only externally.

The internal starting sources are routed in the protection function groups via the **Circuit-breaker interaction** entry (for this, see *2.1 Function Embedding in the Device Figure 2-6*).

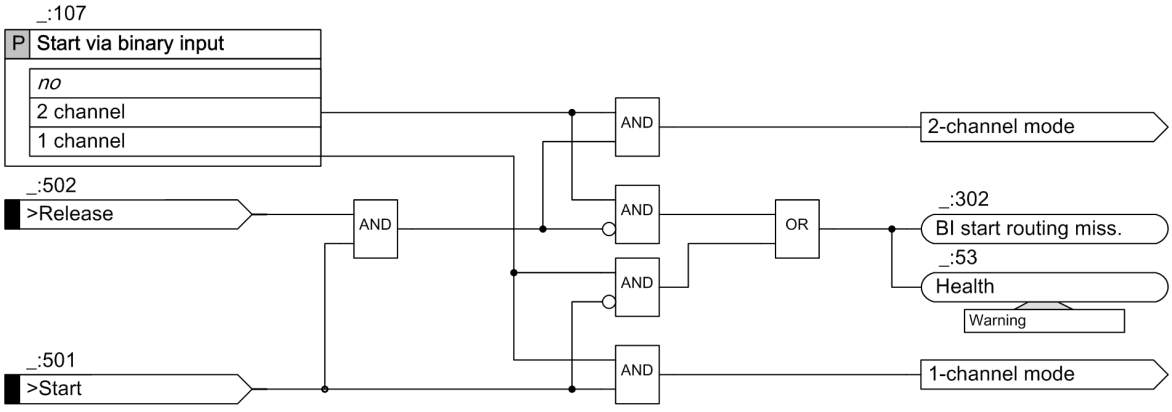


[loanwint-160611-01.tif, 1, en_US]

Figure 6-229 Internal Start of the Circuit-Breaker Failure Protection Function

External Start

The parameter **`Start via binary input`** is used to set whether the external start is initiated by a 1-channel or 2-channel signal. The required routing of the input signals is compared with the setting. If a routing is missing, an error message is generated. The Health signal changes to the state *`warning`*.



[loanwext-030211-01.tif, 1, en_US]

Figure 6-230 Configuration of the External Start of the Circuit-Breaker Failure Protection Function

In 1-channel operation, the start is initiated with the binary input signal **>Start** only.

In 2-channel operation, the binary input signal **>Release** must also be activated to initiate the start. In the default setting, the starting signal **External start** drops out immediately when the input signals have a falling edge (see *Figure 6-231*). If necessary, the starting signal can be held. In this case the start remains active when the binary input signals have a falling edge.

The input signals are monitored to avoid an unwanted pickup of the function.

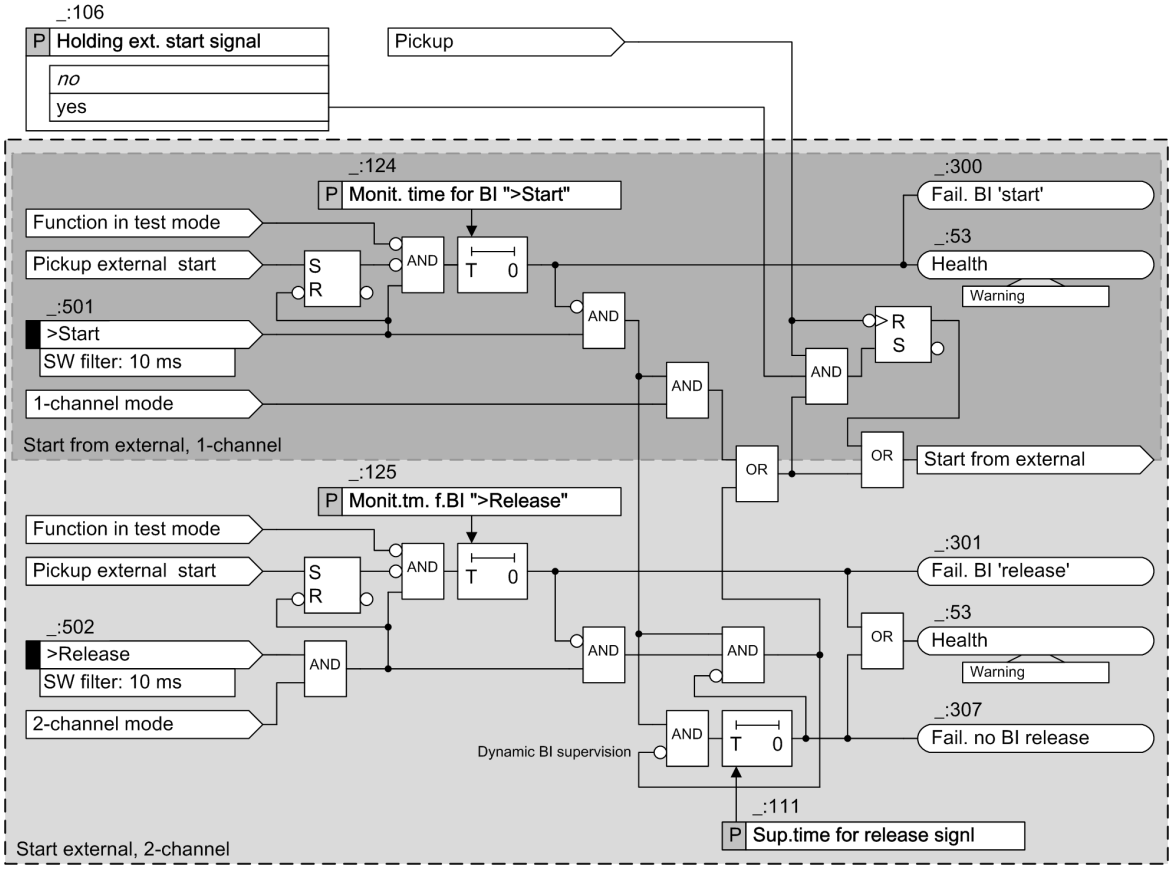
If either of the signals **>Start** or **>Release** is active for more than the set time without the function picking up, an error in the binary input circuit is assumed. The corresponding signal is blocked to exclude an external pickup of the function. An indication to this effect is output, and the Health signal changes to the state *Warning*. The blocking is reset as soon as the binary input signal drops out.

Supervision is disabled in the following cases:

- On pickup of the Circuit-breaker failure protection function (only in the case of an external start). This prevents an unwanted pickup of the supervision if the external protection that starts the Circuit-breaker failure protection function uses a lockout functionality. When the starting signal drops out, the supervision is active again.
- As long as the function or the device is in **test mode**. This allows to check the function without the supervision blocking the function.

If the **>Start** signal is active but no release signal is present after the settable supervision time expires, the pickup is blocked and an indication to this effect is output. The Health signal changes to the state Warning. The blocking is reset with the dropout of the starting signal.

The binary input signals only take effect if the binary inputs are activated for at least 10 ms (SW filter, see *Figure 6-231*).



[logikext-070611-02.tif, 2, en_US]

Figure 6-231 External Start of the Circuit-Breaker Failure Protection Function, Logic

Current-Flow Criterion

The current-flow criterion is the primary criterion for determining the circuit-breaker position. A circuit-breaker pole is supposed to be closed, and the current-flow criterion fulfilled, as soon as one of the phase currents exceeds the phase-current threshold value, and at the same time a plausibility current exceeds the associated threshold value. The plausibility current can be either a 2nd phase current (to compare with the threshold value for phase currents) or the zero-sequence or negative-sequence current (to compare with the sensitive threshold value). The additional evaluation of the plausibility current increases the safety of the criterion.

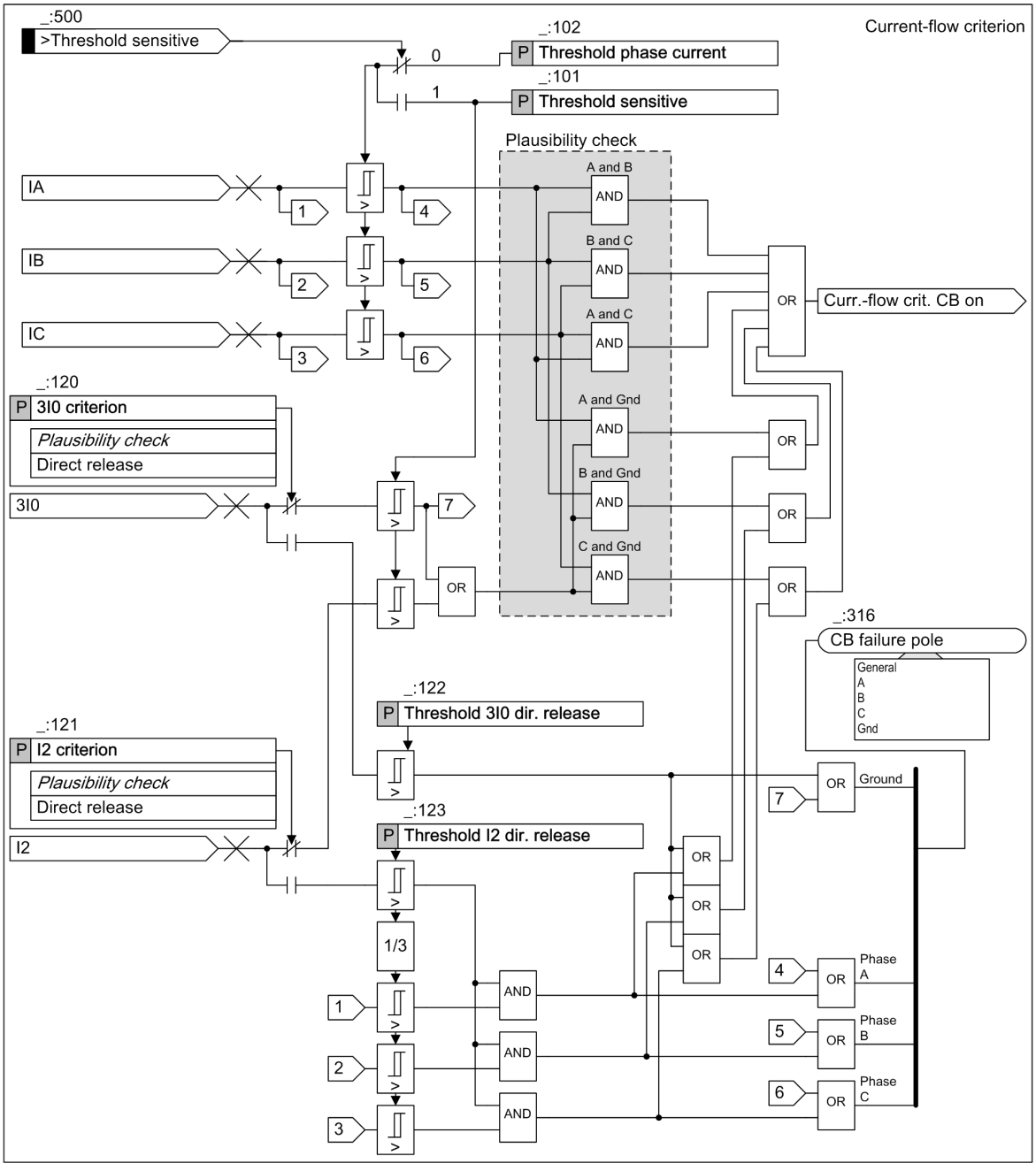
In the case of ground faults, the sensitive threshold value can be dynamically applied to the phase currents as well. The current-flow criterion is fulfilled when the currents exceed the sensitive threshold value. The phase-current threshold value is then ineffective. The binary signal **>Threshold sensitive** is used for the switch-over.

If you set the **3I0 criterion** parameter to ***Direct release***, you prevent the plausibility check of the zero-sequence current. In this way, a pickup only by way of this current can be achieved. Using the **Threshold 3I0 dir. release** parameter, you set the threshold value to be exceeded.

If you set the **I2 criterion** parameter to ***Direct release***, you also switch off the plausibility check of the negative-sequence current. Using the **Threshold I2 dir. release** parameter, you set the threshold value to be exceeded.

If you set the **I2 criterion** parameter to ***Direct release***, a plausibility check is performed via the phase currents with 1/3 * **Threshold I2 dir. release**.

The measuring algorithm is optimized for fast dropout when the value drops below the threshold value.



[lostrom1-030211-01.tif, 3, en_US]

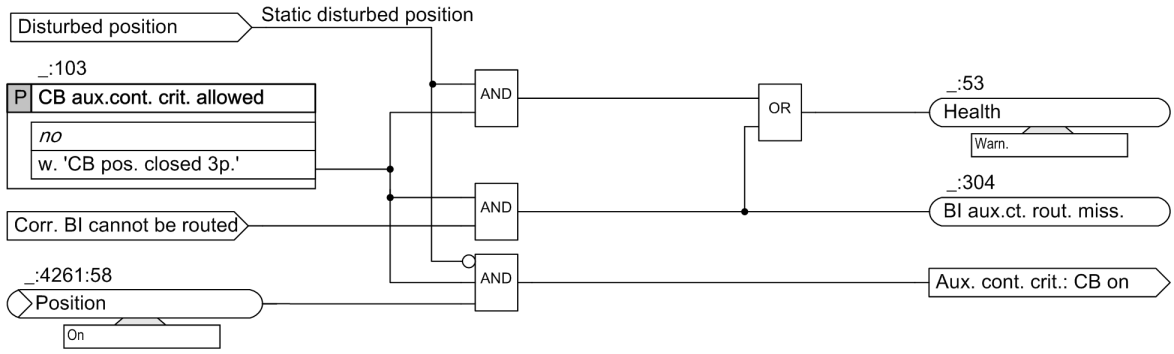
Figure 6-232 Current-Flow Criterion

Circuit-Breaker Auxiliary-Contact Criterion

Settings allow you to specify whether the circuit-breaker auxiliary contacts are permitted for determining the circuit-breaker position.

The double-point indication **`3-pole position`** (from the **Circuit-breaker** function block) is used to determine whether all 3 poles of the circuit breaker are closed. If the double-point indication is not routed, the output is an error message. Furthermore, the Health signal changes to the state *`warning`*.

The detection of a static disturbed position (not an intermediate position) has the effect that the circuit-breaker auxiliary-contact criterion is not used (the internal signal **`Aux.co.crit.: CB Clsd`** is disabled).



[lokriter-140611-01.tif, 1, en_US]

Figure 6-233 Circuit-Breaker Auxiliary-Contact Criterion

Pickup/Dropout

After the start, a check is performed whether the circuit breaker is closed. The current-flow criterion and the circuit-breaker auxiliary-contact criterion are available for this purpose.

Even if the circuit-breaker auxiliary-contact criterion is permitted, preference is given to the fulfilled current-flow criterion because the current-flow criterion is the most reliable criterion for detecting whether the circuit breaker is closed. This means that the circuit breaker is deemed to be closed if it is closed according to the current-flow criterion but at the same time open according to the circuit-breaker auxiliary-contact criterion.

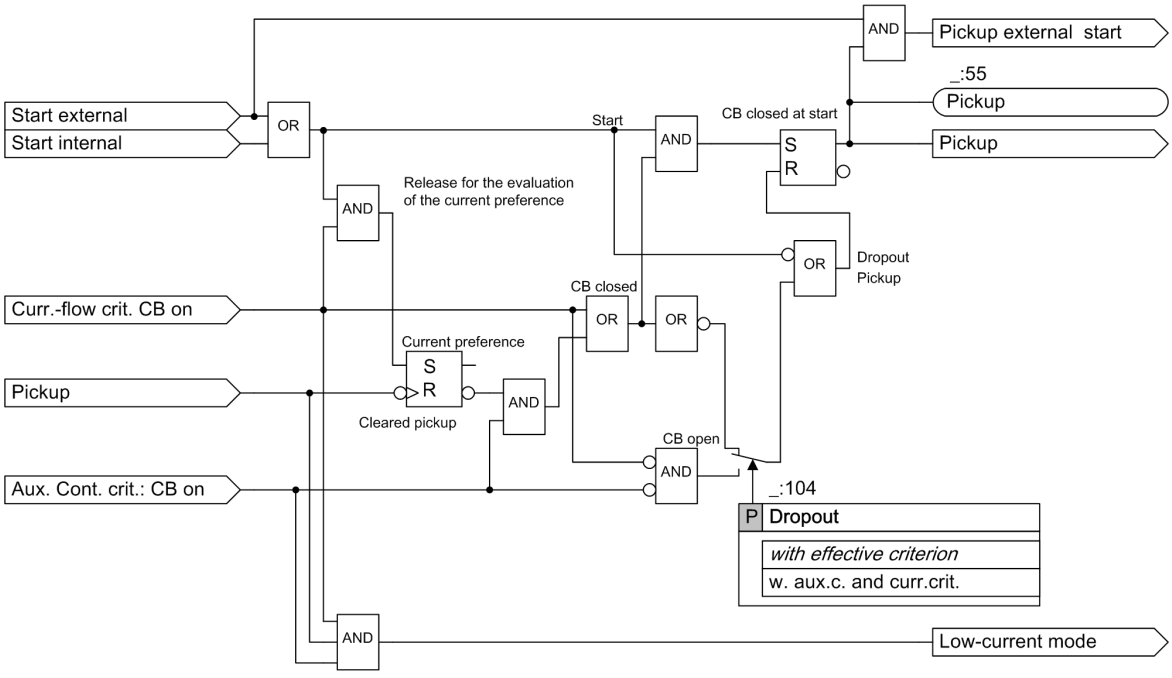
If no current is flowing at the start time, the function can only pick up on the basis of the circuit-breaker auxiliary-contact criterion. For this purpose, the circuit-breaker auxiliary contacts must be permitted as criterion. When the current begins to flow after the start, the function switches over to the current-flow criterion.

If the circuit breaker is detected to be closed, the function picks up.

The pickup starts a time delay (see Delay/Tripping). While the delay is running, the system checks continuously whether the circuit breaker has opened. In the default setting, the opening of the circuit breaker is checked on the basis of the currently valid criterion, which is normally the current-flow criterion because it is preferred. If until expiration of the time delay, no current flow above the set threshold values has been detected, the circuit-breaker auxiliary-contact criterion becomes effective.

The function has also a setting in which dropout is only possible if both criteria in parallel detect the circuit breaker to be open (dropout with auxiliary contact and current-flow criterion).

In the default setting, the internal starting signal is held (see *Figure 6-229* and *Figure 6-231*). This means that dropout is controlled solely by the switch or the circuit-breaker auxiliary-contact criterion. If dropout is also to occur on the falling edge of the starting signal (that is, when the pickup signal has a falling edge or the protection function trips), holding of the start signal must be disabled.



[loanreg1-030211-01.tif, 3, en_US]

Figure 6-234 Pickup/Dropout of the Circuit-Breaker Failure Protection Function

Delay/Tripping

In a first step, tripping at the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. If the local CB was not yet tripped, for example, in the event of an external start of the circuit-breaker failure protection, the trip logic of the circuit breaker itself is activated when the time delay T1 elapses.

Time delay T2 (backup tripping) can commence in parallel either with the start of time T1 or after expiration of time T1.

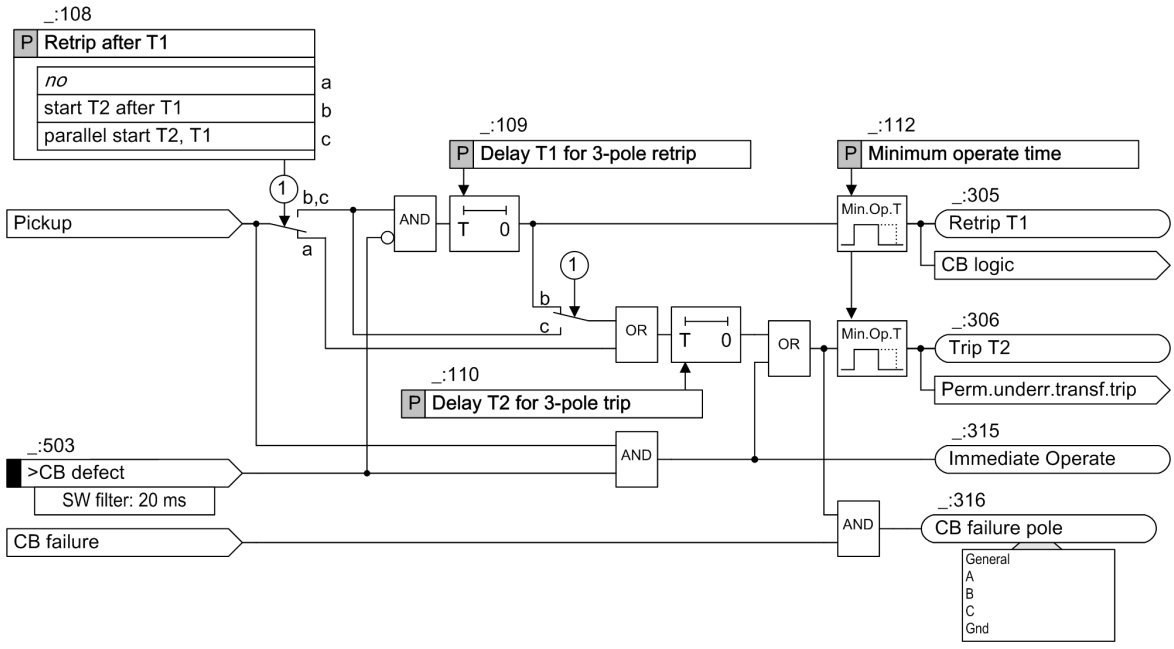
If time delay T2 expires without a dropout of the function, a circuit-breaker failure is assumed and the backup tripping signal **`Tripping T2`** is output. If there is a protection interface in the device, if needed a transfer-trip signal can be sent to the opposite end.

You can find detailed information in the chapter *3.5.3 Protection Interface and Protection Topology*.

If the **`>CB defect`** input signal is valid, any repetition of the trip signal is suppressed, and the backup tripping signal T2 is generated immediately (without delay). The binary input of the **`>CB defect`** input signal must be activated for at least 20 ms before the signal becomes valid.

With help of the *`CB failure pole`* indication, you can determine the phase currents that are above the threshold value at the tripping time T2.

The **`Minimum operate time`** parameter defines the minimum duration for tripping the function. In contrast to other protection functions, the parameter is set within its own function. As a result, the setting is independent of the identically named global parameter that is set in the **Device settings**.

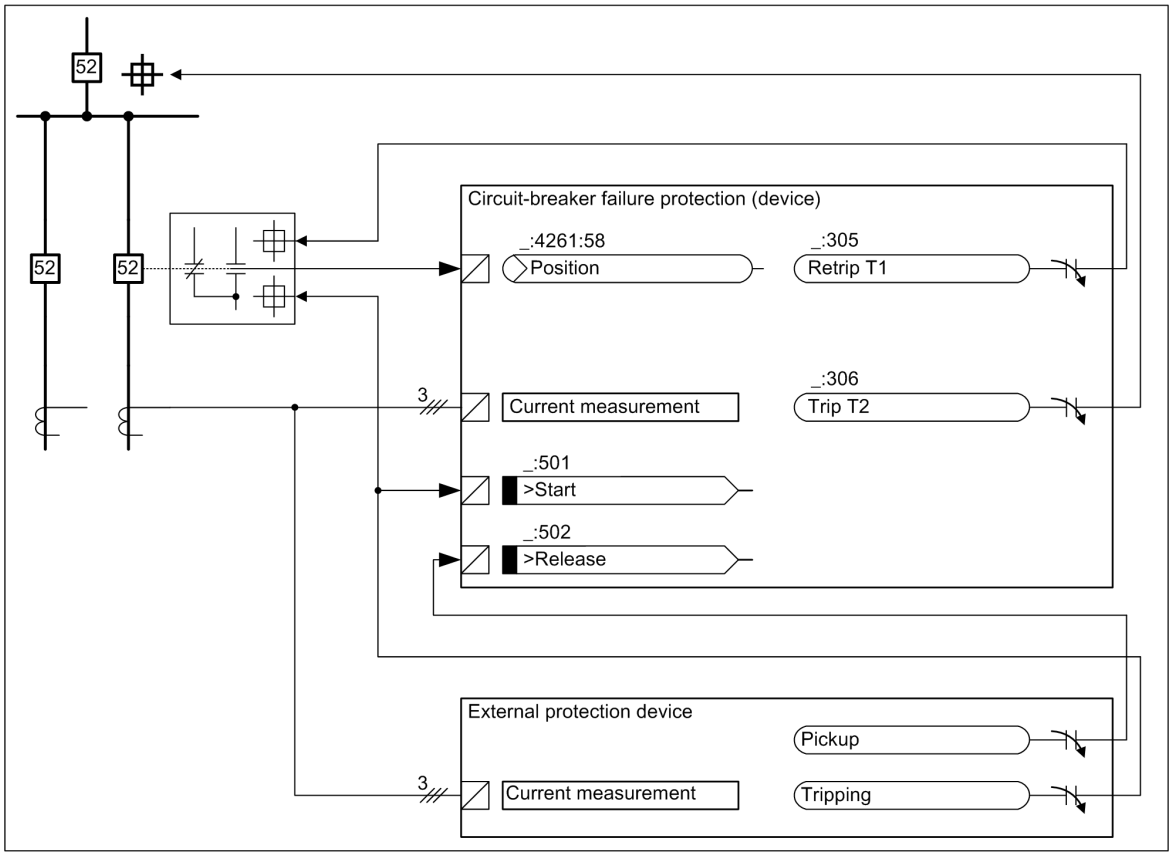


[lo-bbp-verza-3ph.vsd, 4, en_US]

Figure 6-235 Delay/Tripping of the Circuit-Breaker Failure Protection Function

6.39.4 Application and Setting Notes

Figure 6-236 gives an overview of the functions involved in an external start of the CBFP function. In the case of an internal start, there is no external protection device and the protection functionality is located in the CBFP device.



[loextpol-021112-01.tif, 1, en_US]

Figure 6-236 Circuit-Breaker Failure Protection with External Start, Tripping Repetition and 3-Pole Tripping (T2)

Routing: Configuration of Internal Starting Sources (Internal Protection Function)

Configuration of the internal starting sources takes place in the protection function groups via the **Circuit-breaker interaction** entry (for this, see *2.1 Function Embedding in the Device*, *Figure 2-2*).

By default, the function can be started by any tripping of the internal protection functions, which control the local circuit breaker. Depending on the specific application, it can be necessary to exclude certain device-internal protection functions from starting the CBFP. For instance, busbar disconnection following a local circuit-breaker failure can be undesirable in the case of load-shedding applications or ground faults in isolated/resonant-grounded systems.

Where a start exclusively from external sources is required, all internal protection functions must be routed so that they are excluded as a starting source.

Parameter: Start via binary input

- Default setting **(_:107) Start via binary input** = ***no***

Parameter Value	Description
no	If no external start is intended, the parameter is set to ***no***.

Parameter Value	Description
2 channel	2-channel start is used if there is a risk that the circuit-breaker failure protection causes a tripping due to a faulty activation of the start binary input. This is the case in the following situations: a) The CBFP pickup value (threshold value) is set to less than the load current. b) There can be operating conditions under which the current flow is higher than the pickup value. To avoid a possible overfunction, Siemens recommends using the 2-channel start.
1 channel	The 1-channel start must be used where only one control circuit of a binary input is available for starting the CBFP.

Input Signals: >Start, >Release

The start and release input signals have a filtering time of ***10 ms*** as default setting. If a transient control signal to the binary inputs is to be expected due to the design of the external binary-input control circuits and due to environmental conditions, the filtering time can be extended. This delays the start of the CBFP function.

Input Signals	Description
>Start	The start input signal is linked with the tripping of the external protection device (see *Figure 6-236*).
>Release	The enabling input signal is normally linked with the pickup of the external protection device (see *Figure 6-236*). Another common configuration is the parallel wiring of the external trip initiation to both binary inputs (start and release).

Parameter: Supervision time release signal

- Default setting **(_:111) Sup.time for release signl** = ***0.06 s***

The setting depends on the external function which generates the release signal. If the pickup or tripping of the external protection is used as release signal, the default setting can be kept. If it is ensured that the release signal is always present before the starting signal, the time can be set to 0.

Parameter: Holding internal signal

- Recommended setting value **(_:105) Holding int. start signal** = ***yes***

Parameter Value	Description
yes	For an internal start, the starting signal is hold by default. The dropout of the CBFP depends exclusively on the determination of the CB position. This setting must be selected if it is not ensured that all 3 poles of the CB have opened when the pickup signal of the protection function has a falling edge. Siemens recommends using this method as the standard method.
no	Holding of the starting signal can be disabled if it is ensured by the application that the CB has reliably opened when the starting signal has a falling edge, or if the CBFP is explicitly required to dropout when the starting signal has a falling edge.

EXAMPLE

Holding internal starting signal (setting value: yes)

In the event of a 2-pole fault, only one contact of the CB opens. The fault current is thus reduced, and the starting phase short-circuit protection drops out.

Parameter: Holding ext. start signal

- Recommended setting value **(_:106) Holding ext. start signal** = ***no***

Parameter Value	Description
no	The CBFP drops out when the external starting signal has a falling edge. This setting prevents the CBFP from generating a tripping signal when an unwanted pulse is received at the binary input and the current flow is high enough. Siemens recommends using this method as the standard method.
yes	You can hold the starting signal if it is not ensured that the circuit breaker is open when the external starting signal has a falling edge.

EXAMPLE

Holding external starting signal (setting value: yes)

The function is started from the opposite end via an auxiliary device for command transmission. This device generates only a signal pulse.

NOTE

Siemens would like to point out that, with a hold signal, the CBFP generates a trip signal each time a starting pulse is received and the current flow is high enough. Remember this particularly in the case of an external start.

Parameter: Threshold phase current/Threshold sensitive

- Recommended setting value **(_:102) Threshold phase current** = ***approx. 0.50 $I_{sc,min}$***
- Recommended setting value **(_:101) Threshold sensitive** = ***approx. 0.50 $I_{sc,min}$***

In order to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly, Siemens recommends setting both thresholds to half the minimum short-circuit current ($I_{sc, min}$).

If – depending on the neutral-point treatment and/or load conditions – ground faults lead to relatively low fault currents, a sensitive setting of the parameter **Threshold sensitive** must be selected according to the rule (0.5 $I_{sc,min}$). There can also be values which are noticeably below the rated or load current.

Input Signal: >Threshold sensitive

In order to ensure that the function picks up reliably in all switch positions of the power-supply system (examples: opposite end of line open, switching onto a ground fault), the setting of the parameter **Threshold sensitive** can be applied dynamically to all currents – including phase currents – in the presence of ground faults. For this purpose, the binary signal **>Threshold sensitive** must be activated. This can be done via a device-internal function for ground-fault detection (if provided in the device), for example, using **Overvoltage protection with zero-sequence voltage**. In this case, the pickup of the V0> function must be linked with the binary signal. Alternatively, the signal can be coupled from a separate device for sensitive ground-fault detection via a binary input.

Parameter: Circuit-breaker auxiliary-contact criterion allowed for protection

- Recommended setting value **(_:103) CB aux.cont. crit. allowed** = ***no***

Parameter Value	Description
no	If sufficient current flow is ensured under all conditions with the CB closed, Siemens recommends not to permit the auxiliary contacts as a further criterion for determining the CB position, because measurement based on the current flow is the most reliable criterion.

Parameter Value	Description
w. 'CB pos. closed 3p.'	The auxiliary contacts are permitted as a further criterion in applications (see the following examples) where the current is no reliable criterion for determining the circuit-breaker position.

Parameter: 3I0 criterion

- Recommended setting value (_:120) **3I0 criterion** = ***Plausibility check***

Parameter Value	Description
Plausibility check	The ground current serves only for the plausibility check of the phase currents. The threshold for the ground current uses the value set in the **Threshold sensitive** parameter.
Direct release	The current-flow criterion can be satisfied only by the ground current without the phase currents exceeding the set threshold value. The threshold for the ground current uses the value set in the **Threshold 3I0 dir. release** parameter in this case.

Parameter: I2 criterion

- Recommended setting value (_:121) **I2 criterion** = ***Plausibility check***

Parameter Value	Description
Plausibility check	The negative-sequence current serves only for the plausibility check of the phase currents. The threshold for the negative-sequence current uses the value set in the **Threshold sensitive** parameter.
Direct release	If one phase current exceeds 1/3 of the **Threshold I2 dir. release**, the current-flow criterion can be satisfied just by the negative-sequence current without the phase currents exceeding their set threshold value. The threshold for the negative-sequence current uses the value set in the **Threshold I2 dir. release** parameter in this case.

EXAMPLES

Applications which require you to permit the circuit-breaker auxiliary-contact criterion:

- Tripping of the high and low-voltage side CB on the transformer. If only one of the 2 CBs trips, there is no more current flow.
- Tripping of protection functions whose tripping decision is not based on current measurement, in combination with low-load situations.
- Injection of the tripping signal from Buchholz protection

Parameter: Dropout

- Recommended setting value **(_:104) Dropout** = ***with effective criterion***

The parameter **Dropout** is available if the circuit-breaker auxiliary-contact criterion is permitted (see parameter **CB aux.cont. crit. allowed**).

Parameter Value	Description
with effective criterion	Siemens recommends keeping the default setting, because it prefers the current as a reliable criterion for detection of an open CB and thus for dropout of the CBFP function.
w. aux.c. and curr.crit.	Select this setting for applications on transformers or generators (see the preceding examples) in which the current flow is such that the current is no longer a reliable criterion for detecting the opening of the CB.

Parameter: Retrip

- Default setting **(_:108) Retrip after T1** = ***no***

Parameter Value	Description
no	Where no redundant CB control is provided, a repetition of the trip signal to the local CB is not required.
start T2 after T1	Where a redundant CB control (2nd trip coil with 2 trip circuits) is provided, a repetition of the trip signal to the local CB makes sense. Siemens recommends the setting ***start T2 after T1*** because it provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember here that the overall fault-clearance time in case of a failure of the local CB is the sum of T1 and T2.
parallel start T2, T1	As an alternative to the setting ***start T2 after T1***, the user can start T2 and T1 in parallel.

Parameter: Delay T1 for 3-pole retrip

- Default setting **(_:109) Delay T1 for 3-pole retrip** = ***0.05 s***

The parameter is visible only when retripping is set.

The setting depends on the user's philosophy.

The following settings make sense:

- If the minimum fault-clarification time has top priority, Siemens recommends setting the time to 0. This setting causes initiation of the retrip immediately upon the start. The drawback is that a defect of the 1st trip circuit is not detected.
- With a small time delay of, for instance, 50 ms, the defect of the 1st trip circuit can be detected based on the evaluation of the fault record.
- With a long time delay which reliably ensures the dropout of the CBFP with the CB open, the rising edge indication of the trip repeat **Retrip T1** is a sure signal for a fault in the 1st trip circuit. The following example shows how this time is determined.

EXAMPLE

Determining the T1 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by the device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T1)	130 ms

Parameter: Delay T2 for 3-Pole Trip

- Default setting **(_:110) Delay T2 for 3-pole trip** = ***0.13 s***

This setting has to ensure that after opening of the local CB the function drops out reliably and that backup tripping is avoided under all circumstances. The setting depends on the parameter **Retrip after T1**.

If T2 is started afterT1, there is no need to consider the time T1 for the setting of T2.

EXAMPLE

Determining the T2 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by the device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T2)	130 ms

If T1 and T2 are started in parallel, take into account the time T1 for the setting of T2.

EXAMPLE

Simultaneous start of T2 and T1

Time for a reliable dropout after the local CB has opened	130 ms
Setting of T1	50 ms
Total (= T2)	180 ms

Parameter: Minimum operate time

- Default setting **(_:112) Minimum operate time** = **-**

The **Minimum operate time** parameter is used to set the minimum duration for tripping the function.



CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

✧ Set a duration that is long enough to ensure that the circuit breaker reaches its final position **open** reliably after a control operation.

Input Signal: >CB defect

The input signal **>CB defect** has a default filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the CB opens.

This time can be set to 0 if such a transient pickup of the physical binary input can be excluded due to the CB design.

Output Signal: Retrip T1

If only one control circuit is available for the local CB, it is not mandatory to route the output signal because the signal also controls the CB trip logic.

If a 2nd control circuit is present, the output signal **Retrip T1** must be routed to the associated binary output.

Output Signal: Trip T2

In order to operate the adjacent circuit breakers, the backup tripping (indication **Trip T2**) must be routed to a binary output; andif necessary, to an interface (intertripping to opposite end).

6.39.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
50BF CB fail.#				
_:1	50BF CB fail.#:Mode		• off • on • test	on
_:105	50BF CB fail.#:Holding int. start signal		• no • yes	yes
_:107	50BF CB fail.#:Start via binary input		• no • 2 channel • 1 channel	no
_:106	50BF CB fail.#:Holding ext. start signal		• no • yes	no
_:111	50BF CB fail.#:Sup.time for release signl		0.06 s to 1.00 s	0.06 s
_:103	50BF CB fail.#:CB aux.cont. crit. allowed		• no • w. 'CB pos. closed 3p.'	no
_:104	50BF CB fail.#:Dropout		• with effective criterion • w. aux.c. and curr.crit.	with effective criterion
_:108	50BF CB fail.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	no
_:102	50BF CB fail.#:Threshold phase current	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:101	50BF CB fail.#:Threshold sensitive	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:109	50BF CB fail.#:Delay T1 for 3-pole retrip		0.000 s to 60.000 s	0.050 s
_:110	50BF CB fail.#:Delay T2 for 3-pole trip		0.050 s to 60.000 s	0.130 s
_:112	50BF CB fail.#:Minimum operate time		0.00 s to 60.00 s	0.10 s
_:120	50BF CB fail.#:3I0 criterion		• Direct release • Plausibility check	Plausibility check
_:121	50BF CB fail.#:I2 criterion		• Direct release • Plausibility check	Plausibility check
_:122	50BF CB fail.#:Threshold 3I0 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A

Addr.	Parameter	C	Setting Options	Default Setting
_:123	50BF CB fail.#:Threshold I2 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:124	50BF CB fail.#:Monit. time for BI ">Start"		0.05 s to 60.00 s	15.00 s
_:125	50BF CB fail.#:Monit.tm. f.BI ">Release"		0.05 s to 60.00 s	15.00 s

6.39.6 Information List

No.	Information	Data Class (Type)	Type
50BF CB fail.#			
_:501	50BF CB fail.#:>Start	SPS	I
_:502	50BF CB fail.#:>Release	SPS	I
_:82	50BF CB fail.#:>Block function	SPS	I
_:503	50BF CB fail.#:>CB defect	SPS	I
_:500	50BF CB fail.#:>Thresh. ground curr.	SPS	I
_:54	50BF CB fail.#:Inactive	SPS	O
_:52	50BF CB fail.#:Behavior	ENS	O
_:53	50BF CB fail.#:Health	ENS	O
_:55	50BF CB fail.#:Pickup	ACD	O
_:305	50BF CB fail.#:Retrip T1	ACT	O
_:306	50BF CB fail.#:Trip T2	ACT	O
_:302	50BF CB fail.#:BI start routing miss.	SPS	O
_:304	50BF CB fail.#:BI aux.ct. rout. miss.	SPS	O
_:300	50BF CB fail.#:Fail. BI 'start'	SPS	O
_:307	50BF CB fail.#:Fail. no BI release	SPS	O
_:301	50BF CB fail.#:Fail. BI 'release'	SPS	O

6.40 Circuit-Breaker Restrike Protection

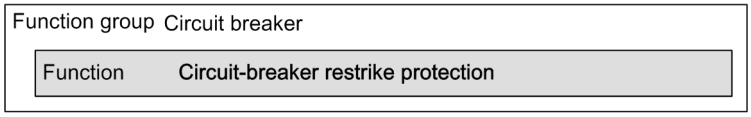
6.40.1 Overview of Function

The **Circuit-breaker restrike protection** function:

- Monitors the circuit breaker against restriking, for example, caused by an overvoltage over the circuit-breaker poles after switching off a capacitor bank
- Generates a backup operate signal in case of a circuit-breaker restriking

6.40.2 Structure of the Function

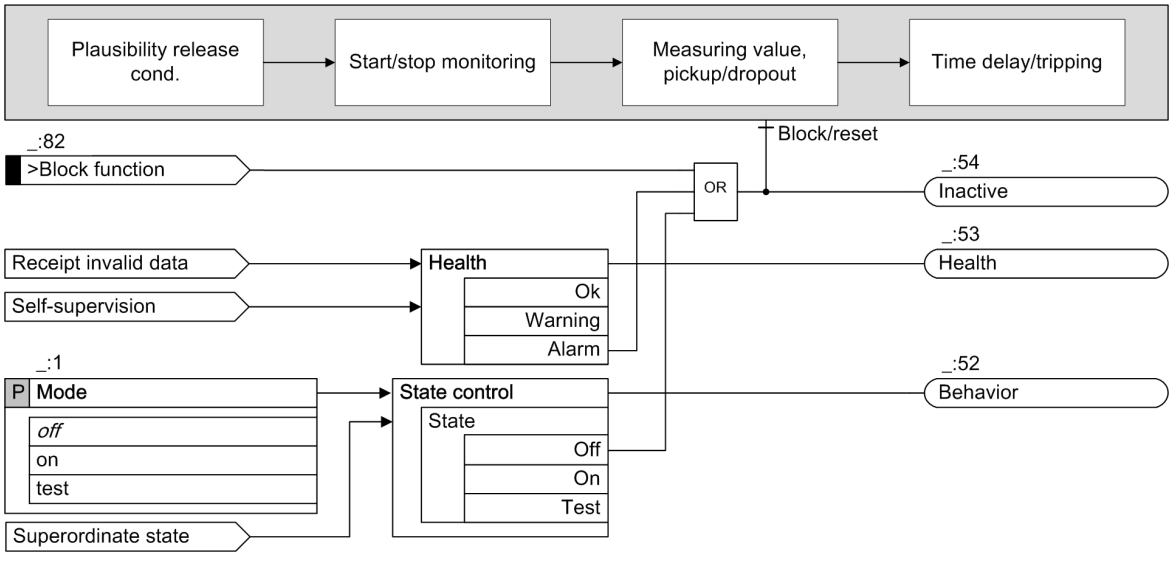
The **Circuit-breaker restrike protection** function is used in the **Circuit-breaker** function group. A maximum of 2 functions can operate simultaneously within the function group.



[lo_strrestrike_2014-03-05.vsd, 2, en_US]

Figure 6-237 Structure/Embedding of the Function

The function logic is grouped into the parts shown in *Figure 6-238*. In the following chapter, these logic parts are described in detail.



[lo_respro-210113-01.vsd, 1, en_US]

Figure 6-238 Logic Overview of the Function

6.40.3 Function Description

Plausibility Release

The function **Circuit-breaker restrike protection** issues a trip command to a superordinated circuit breaker, usually the infeed circuit breaker of a busbar. Overfunction of this protection can cause extreme problems for the whole application.

The logic of plausibility release strongly reduces the risk of a false start of the function by adding an extra release criteria for a function start.

Each criterion can be switched on or off individually.

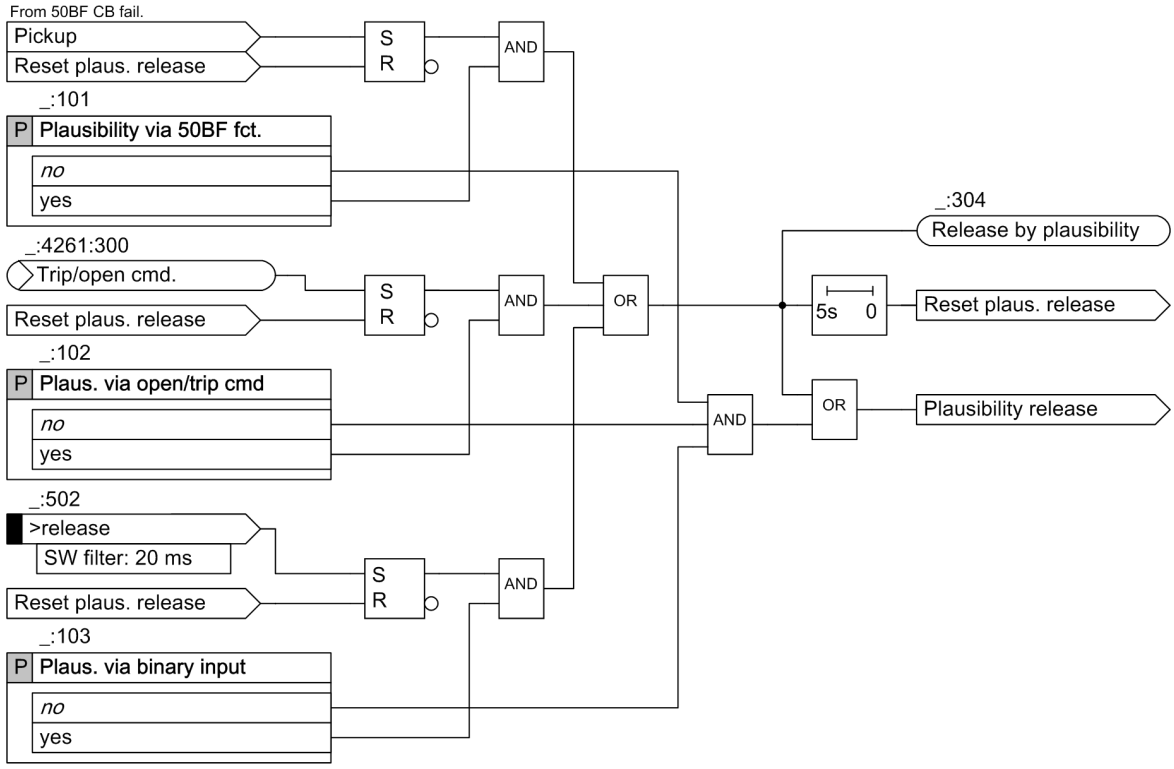


Figure 6-239 Logic Diagram for the Plausibility Release of the Circuit-Breaker Restrike Protection

The plausibility-release logic checks the following conditions:

- When the parameter **Plausibility via 50BF fct.** is set to ***yes***, the pickup signal of the **Circuit-breaker failure protection** is monitored. The plausibility release is given if the **Circuit-breaker failure protection** has picked up.
- When the parameter **Plaus. via open/trip cmd** is set to ***yes***, the trip/open command is monitored. The plausibility release is given if the trip/open command has been generated.
- When the parameter **Plaus. via binary input** is set to ***yes***, the *>release* signal is monitored. The plausibility release is given if the *>release* signal has been received.

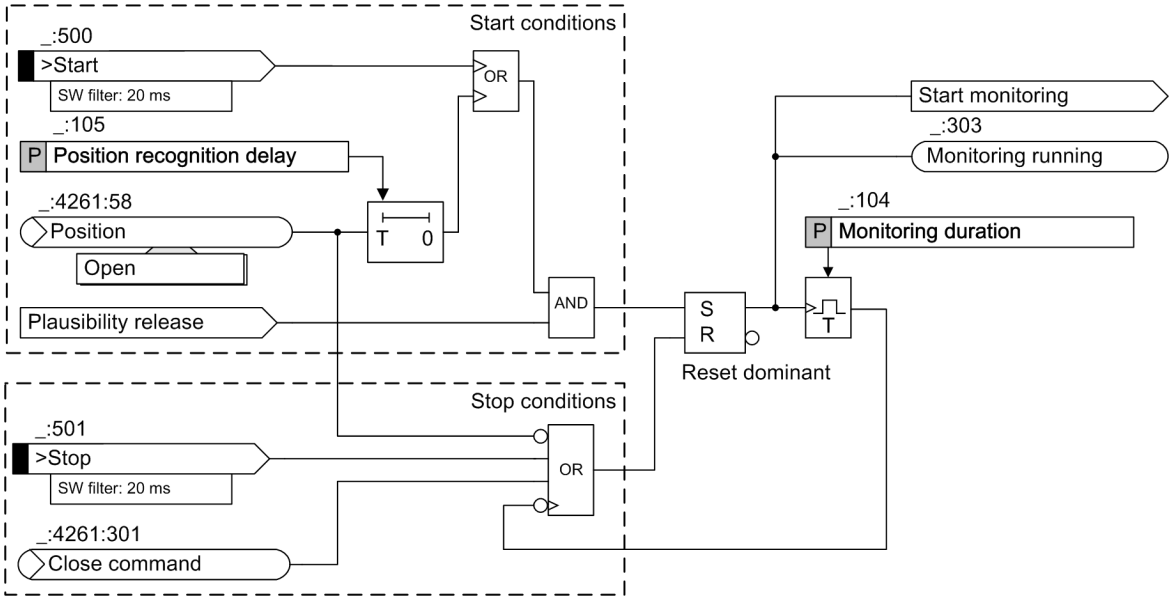
If one of the conditions is fulfilled, the plausibility release is given for 5 s. The 5-s timer ensures that the release criterion and start condition relate to the same circuit-breaker opening/tripping process.

If all the 3 plausibility settings are set to ***no***, the start/stop-monitoring logic considers the release as fulfilled.

For safety reasons, the input signal *>release* has a preset software filtering time of 20 ms.

Start/Stop Monitoring

Via the start/stop monitoring logic, the monitoring duration of the current signal regarding restriking is determined.



[lo_starstop-210113-01.vsd, 2, en_US]

Figure 6-240 Logic Diagram for Start/Stop Monitoring of the Circuit-Breaker Restrike Protection

The monitoring is started if one of the following conditions is met:

- The circuit-breaker position is detected as **open** via the circuit-breaker auxiliary contacts during the time set with the parameter **`Position recognition delay`**.

  The **`Position recognition delay`** time is used for safety means to ensure that the circuit breaker is definitely open when the monitoring starts. This parameter allows to adapt this start criterion to all kinds of auxiliary-contact configurations.

- The binary input signal *`>Start`* is activated.

For safety reasons, the input signal has a preset software filtering time of 20 ms.

In addition to the active start criterion, the plausibility release (refer to the *Plausibility Release, Page 808*) must be present to start the monitoring duration.

With the fulfilled start condition, the **`Monitoring duration`** timer is started. This timer defines how long the current signal is monitored regarding restriking. If the time expires, the monitoring is terminated.

The monitoring is also terminated immediately if one of the following conditions is met:

- The circuit-breaker position is detected no longer as **open**.
- A close command is given by the device.
- The binary input signal *`>Stop`* is activated.

  For safety reasons, the input signal has a preset software filtering time of 20 ms.

Measuring Value, Pickup/Dropout

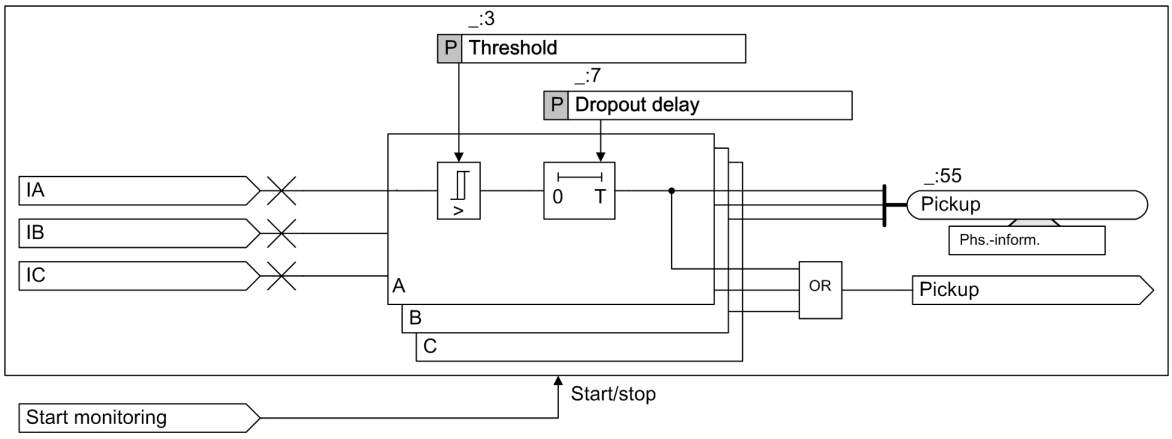
During the **`Monitoring duration`**, the current signal is monitored phase-selectively regarding restriking.

As a measuring value, the fundamental component of the current is used.

- On one hand, current peaks are damped but still detected reliably by the fundamental-component value.
- On the other hand, a DC (Direct Current) component is suppressed. A DC component can occur after switching off the circuit breaker.

Thus, the fundamental-component value is a good choice for a reliable restrike detection.

If any phase current exceeds the set current threshold value, the function picks up. The coming pickup indicates the first restrike current pulse. With the pickup, the operate delay timers are started, see also the following description *Delay/Tripping, Page 811*.



[lo_pickdrop-210113-01.vsd, 1, en_US]

Figure 6-241 Logic Diagram for Measuring Value, Pickup/Dropout of the Circuit-Breaker Restrike Protection

If restriking occurs, the current signal drops below the current threshold if the time between restrike pulses is long enough. In this case, the operate delay must not be reset. During the dropout delay, the pickup is extended to ensure that the operate delay timers are not reset. However, if the dropout delay time expires (no new current peak occurred), the function drops out and the operate delay timers are reset.

Delay/Tripping

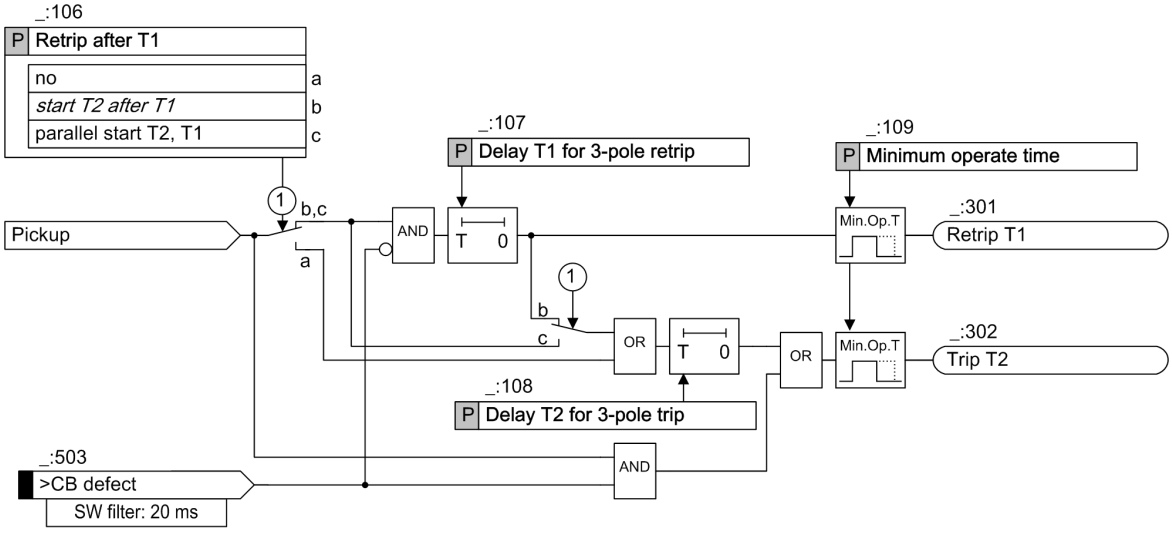
In the first step, tripping of the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. The retrip on the local circuit breaker is as a safety mechanism as well. In the event of a wrong start and pickup, only the local circuit breaker is opened instead of the superordinated circuit breaker.

Time delay T2 (backup tripping) can start in parallel either with the start of time T1 or after expiration of time T1.

If time delay T2 expires, circuit-breaker restriking takes place and the backup-tripping signal *Trip T2* is generated.

If the *>CB defect* input signal is valid, any repetition of the trip signal is suppressed and the backup-tripping signal *Trip T2* is generated immediately (without delay). For safety reasons, a default software filter time of 20 ms is preset (configurable in DIGSI) for the binary input signal *>CB defect*.

The **Minimum operate time** parameter defines the minimum duration for the trip command of the function. In contrast to other protection functions, the parameter is set within its own function. As a result, the setting is independent of the identically named comprehensive parameter that is set in the **Device settings**.



[lo_deltrip-030211-01.vsd, 2, en_US]

Figure 6-242 Logic Diagram for Delay/Tripping of the Circuit-Breaker Restrike Protection

6.40.4 Application and Setting Notes

Parameter: Switch On or Off Additional Plausibility Release Criteria

- Default setting **(_:101) Plausibility via 50BF fct.** = ***no***
- Default setting **(_:102) Plaus. via open/trip cmd** = ***no***
- Default setting **(_:103) Plaus. via binary input** = ***no***

When using the plausibility release, the start condition and the release condition instead of only the start condition must be present to start the current monitoring regarding restriking. Since the current threshold value is set below the operating current, a false start would directly cause tripping. Thus, the plausibility release strongly reduces the risk that a falsely given start criterion leads to a wrong tripping of the superordinated circuit breaker.

3 different release criteria are available. You can use one or more than one or none of them. The selection depends on the application.

NOTE

When using release criteria, it must be ensured that the criteria are given under all the conditions where the **Circuit-breaker restrike protection** shall be started. If you choose no release criteria, the release is permanently given.

- **Open/trip command by the device**

Use this criterion in case that all control or trip commands are given by the protection device.

NOTE

Opening the circuit breaker manually without using the device will not release the start of the **Circuit-breaker restrike protection**.

- **Pickup of the Circuit-breaker failure protection**

Use this criterion if the **Circuit-breaker restrike protection** should only be started in case that the **Circuit-breaker failure protection** was started (picked up) before.

NOTE

Opening the circuit breaker by control or manually will not trigger the circuit breaker failure protection. Consequently the **Circuit-breaker restrike protection** cannot be released either.

- **Binary input signal**

Use this option if neither of the above 2 release criteria fit the application and you want to define your own release criterion.

Input signals: *>Start, >release, >Stop*

Input Signals	Description
>Start	This input signal allows to start the monitoring, for example, via protocol commands from a master (by use of a CFC chart) or by other specific conditions.
>release	This input signal allows to define specific release conditions by use of a CFC chart. Also refer to *Parameter: Switch On or Off Additional Plausibility Release Criteria , Page 812*.
>Stop	This input signal allows to stop the monitoring, for example, via protocol commands from a master (by use of a CFC chart) or by other specific conditions.

The input signals *>Start* , *>release* , and *>Stop* have a filtering time of *20 ms* as default setting. If a transient spurious signal to the binary inputs is expected due to the design of the external binary-input control circuits and environmental conditions, the filtering time can be extended.

Parameter: Position recognition delay

- Default setting **(_:105) Position recognition delay** = *0.02 s*

With the parameter **Position recognition delay**, you define how long the circuit breaker must be detected as **open** (via the circuit-breaker auxiliary contacts) before the monitoring time is started. This definition is a safety feature to ensure that the monitoring is not started too early. For example, in case that due to a non-standard auxiliary-contacts configuration, the circuit-breaker is already detected as **open** while current flow is still present.

The setting depends on the circuit-breaker auxiliary-contacts configuration. If it can be ensured that the auxiliary contacts announce the circuit breaker as **open** after the current flow is interrupted, the time can be set to zero.

Parameter: Monitoring duration

- Default setting **(_:104) Monitoring duration** = *200.00 s*

With the parameter **Monitoring duration** , you define how long the current signal is monitored regarding restriking after the circuit breaker has been opened.

With ongoing discharging of the capacitor bank, the probability of restriking is decreasing. There is no need to set the monitoring time longer than the discharging time. Siemens recommends setting the monitoring time in the range of 0.5 * discharging time to 1 * discharging time.

Parameter: Threshold

- Default setting **(_:3) Threshold** = *0.250 A*

After opening of the circuit breaker, the phase currents are compared with the threshold value. If no restriking takes place, the current is zero. Consequently the threshold for detecting restriking can be set much smaller than the operating current. A typical value is 25 % of the operating current.

With a threshold below the operating current, a falsely-given start directly cause tripping. For minimizing this risk, Siemens recommends applying a release criterion additionally. Refer to *Parameter: Switch On or Off Additional Plausibility Release Criteria , Page 812*.

Parameter: Dropout delay

- Default setting **(_:7) Dropout delay** = *0.05 s*

The parameter **Dropout delay** ensures that a short dropping below the current threshold does not cause the operate delay timers to be reset.

Since restriking is normally a periodical effect, the dropout delay can be set to a rather small time. Siemens recommends applying the default value of 50 ms.

Input signal: *>CB defect*

The input signal *>CB defect* has a preset filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the circuit breaker opens.

This time can be set to 0 if such a transient response of the physical binary input can be excluded due to the circuit-breaker design.

Parameter: Retrip after T1

- Default setting **(_:106) Retrip after T1** = *start T2 after T1*

Parameter Value	Description
start T2 after T1	The retrip on the local circuit breaker is a safety mechanism to avoid false tripping of the superordinated circuit breaker. With generating a retrip, only the local circuit breaker is tripped in the event of a false start. Afterwards the **Circuit-breaker restrike protection** function drops out during the T2 delay time. Siemens recommends applying a retrip on the local circuit breaker. Siemens also recommends applying the parameter value ***start T2 after T1***. The parameter value provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember that the overall fault-clearance time in case of circuit-breaker restriking is the sum of T1 and T2.
no	No retrip is given
parallel start T2, T1	As an alternative to the setting ***parallel start T2, T1*** the customer can start T2 and T1 in parallel.

Parameter: **Delay T1 for 3-pole retrip**

- Default setting (_:109) **Delay T1 for 3-pole retrip** = ***0.00 s***

The parameter is visible only when the parameter **Retrip after T1** is set to ***start T2 after T1*** or ***parallel start T2, T1*** .

The retrip on the local circuit breaker is as a safety mechanism to avoid false tripping of the superordinated circuit breaker. In the event of a false start, only the local circuit breaker is tripped by the retrip. Afterwards the **Circuit-breaker restrike protection function** will drop out during the T2 delay time.

Siemens recommends applying a retrip on the local circuit breaker. Since the retrip is a safety mechanism, it can be given without a delay time. Siemens recommends setting the delay time to 0 s.

Parameter: **Delay T2 for 3-pole trip**

- Default setting (_:110) **Delay T2 for 3-pole trip** = ***0.15 s***

This parameter defines the duration of restriking after the backup tripping is sent. The following should be considered:

- When using the retrip functionality, this delay time must ensure a safe function dropout after giving the retrip on the local circuit breaker.

Siemens recommends applying a delay time of 150 ms which is the default setting.

Parameter: **Minimum operate time**

- Default setting **(_:109) Minimum operate time** = ***0.15 s***

The **Minimum operate time** parameter is used to set the minimum duration for the trip command of the function.



CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts interrupt the control circuit. If this happens, the device contacts burn out.

✧ Set a duration that is long enough to ensure that the circuit breaker reliably reaches its final position (**open**) after a control operation.

Output signal: *Retrip T1*

The output signal *Retrip T1* must be routed to a binary output.

If only one control circuit is available for the local circuit breaker, the output signal must be routed to the binary output to which the general circuit breaker trip command (command *Position*) is routed.

If a second control circuit is present, the *Retrip T1* output signal can be routed to the associated binary output.

Output signal: *Trip T2*

In order to trip the adjacent circuit breakers, the backup tripping (indication *Trip T2*) must be routed to a binary output and if necessary, to an interface (intertripping to the opposite end). Thus, the circuit breaker on the opposite end can be tripped without delay.

6.40.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Restrike prt.#				
_:1	Restrike prt.#:Mode		• off • on • test	off
_:101	Restrike prt.#:Plausibility via 50BF fct.		• no • yes	no
_:102	Restrike prt.#:Plaus. via open/trip cmd		• no • yes	no
_:103	Restrike prt.#:Plaus. via binary input		• no • yes	no
_:106	Restrike prt.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	start T2 after T1
_:104	Restrike prt.#:Monitoring duration		1.00 s to 600.00 s	200.00 s
_:105	Restrike prt.#:Position recognition delay		0.00 s to 60.00 s	0.02 s
_:3	Restrike prt.#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:7	Restrike prt.#:Dropout delay		0.00 s to 60.00 s	0.05 s
_:107	Restrike prt.#:Delay T1 for 3-pole retrip		0.00 s to 60.00 s	0.00 s
_:108	Restrike prt.#:Delay T2 for 3-pole trip		0.05 s to 60.00 s	0.15 s
_:109	Restrike prt.#:Minimum operate time		0.00 s to 60.00 s	0.15 s

6.40.6 Information List

No.	Information	Data Class (Type)	Type
Restrike prt.#			
_:500	Restrike prt.#:>Start	SPS	I
_:501	Restrike prt.#:>Stop	SPS	I
_:502	Restrike prt.#:>release	SPS	I
_:82	Restrike prt.#:>Block function	SPS	I
_:503	Restrike prt.#:>CB defect	SPS	I
_:54	Restrike prt.#:Inactive	SPS	O
_:52	Restrike prt.#:Behavior	ENS	O
_:53	Restrike prt.#:Health	ENS	O
_:304	Restrike prt.#:Release by plausibility	SPS	O
_:303	Restrike prt.#:Monitoring running	SPS	O
_:55	Restrike prt.#:Pickup	ACD	O
_:301	Restrike prt.#:Retrip T1	ACT	O
_:302	Restrike prt.#:Trip T2	ACT	O

6.41 Restricted Ground-Fault Protection

6.41.1 Overview of Functions

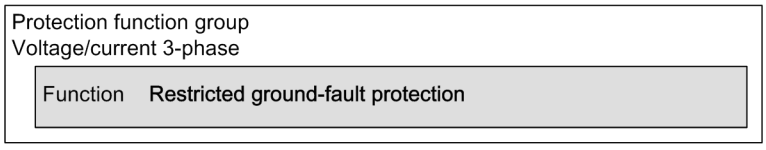
The **Restricted ground-fault protection** function (ANSI 87N):

- Detects ground faults in transformers, shunt reactors, neutral reactors or rotating machinery in which the neutral point is grounded.
- Has high sensitivity to ground faults near the neutral point.
- Is supplemental main protection to longitudinal differential protection.
- Protects grounding transformers in the protection range. It is required that a current transformer be used in the case of neutral point feed, that is, between neutral point and grounding conductor. The neutral point transformer and the phase current transformer define the protection range.
- Adapts itself to the highest-amperage side with auto transformers and thereby prevents overfunction in the event of external ground faults.

6.41.2 Structure of the Function

The **Restricted ground-fault protection** function is used in the **Transformer side** or **Auto transformer** protection function group. Furthermore, you can use the function in the stabilizing winding of the auto transformer or also in the **Standard UI** function. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The **Restricted ground-fault protection** function is stepless.

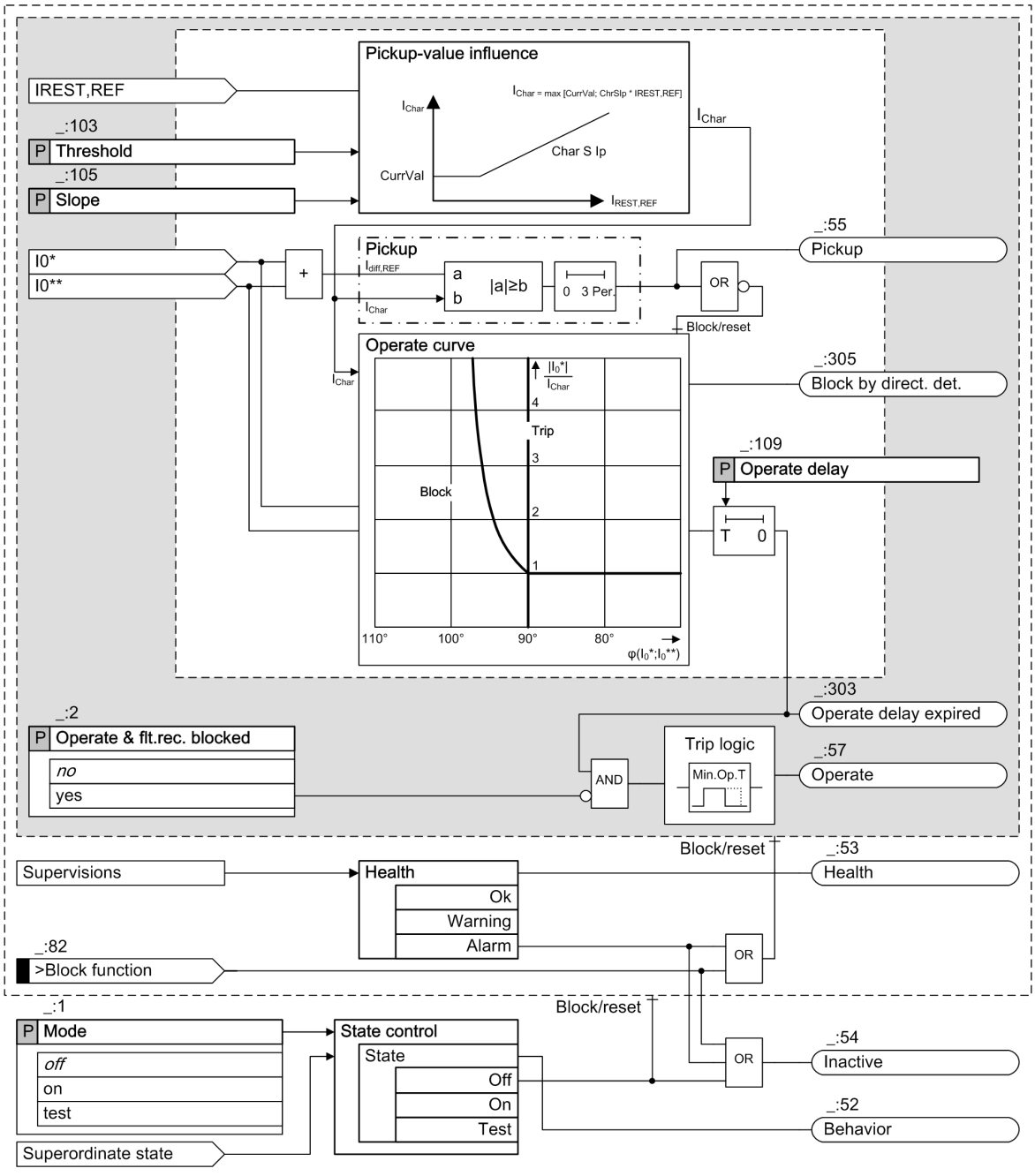


[dwstrupt-170712-01.tif, 2, en_US]

Figure 6-243 Structure/Embedding of the Function

6.41.3 Function Description

Logic of the Function

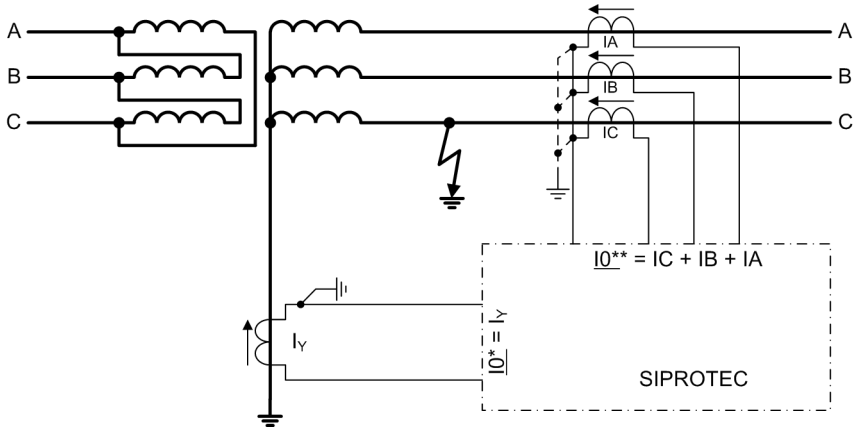


[loreffkt-170712-01.tif, 1, en_US]

Figure 6-244 Logic Diagram of the Restricted Ground-Fault Protection Function

The protection function processes the neutral-point current I_0* (exactly $3I_0$) and the calculated zero-sequence current I_0** (exactly $3I_0$) from the phase currents (see following figure). The protection range extends exclusively over the transformer winding, including current transformer. The amount-adapted (compensated) currents are described by the * icon. They are normalized to the rated object current of the respective side.

In case of an internal ground fault, the residual currents flow to the fault location. With an external ground fault, the fault current inverts itself in the phase current transformers. In this way, the direction of current flow serves as the decisive criterion for an internal fault.



[dwgrdpri-170712-01.tif, 1, en_US]

Figure 6-245 Basic Principle of the Function

In accordance with the logic diagram, *Figure 6-244* the protection function consists of 3 parts:

Effect of Pickup Value

The differential current and the restraint current are calculated from the residual currents. The reference arrows are defined as positive when pointing to the protected object (see *Figure 6-245*). Consider that the ground current in the fault record and in the DIGSI 5 Test Suite are displayed as positive if the current flows to ground from the protected object.

NOTE

The following calculation applies to the configurations with a current transformer for the side. In a special case of several current transformers per side, the calculation of the restraint current must be performed in greater detail.

$\underline{I}_0^* = k_m \cdot 3\underline{I}_0'$

$\underline{I}_0^{**} = k_m \cdot 3\underline{I}_0'' \rightarrow 3\underline{I}_0'' = \underline{I}_A + \underline{I}_B + \underline{I}_C$

with $k_m = I_{N,transformer}/I_{N,side}$

$I_{Diff,REF} = |\underline{I}_0^* + \underline{I}_0^{**}|$

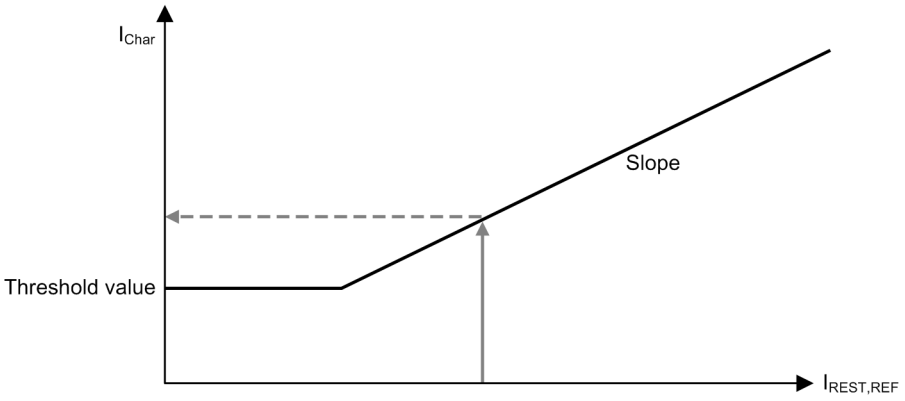
$I_{rest,REF} = |\underline{I}_0^*| + |\underline{I}_A| + |\underline{I}_B| + |\underline{I}_C|$

where:

$3\underline{I}_0'$	Measured zero-sequence current at neutral point
$3\underline{I}_0''$	Zero-sequence current calculated from the phase currents
k_m	Factor for amount adaptation (compensation)
$I_{rated,trans-former}$	Primary transformer rated current
$I_{rated,side}$	Primary rated current of the transformer side
$I_{Diff,REF}$	Differential current
$I_{Rest.,REF}$	Restraint current

Using the calculated restraint current, a current $I_{char.\ curve}$ which represents the pickup value for the tripping is determined from the characteristic curve (*Figure 6-246*). In this way, the protection function is stabilized in the event of external, multiphase ground faults, for example, a 2-pole ground fault. This means that the protection function becomes less sensitive.

If the **`Slope = 0`** is set here, the set **`Threshold`** of the operate curve is delivered independent of the restraint current.

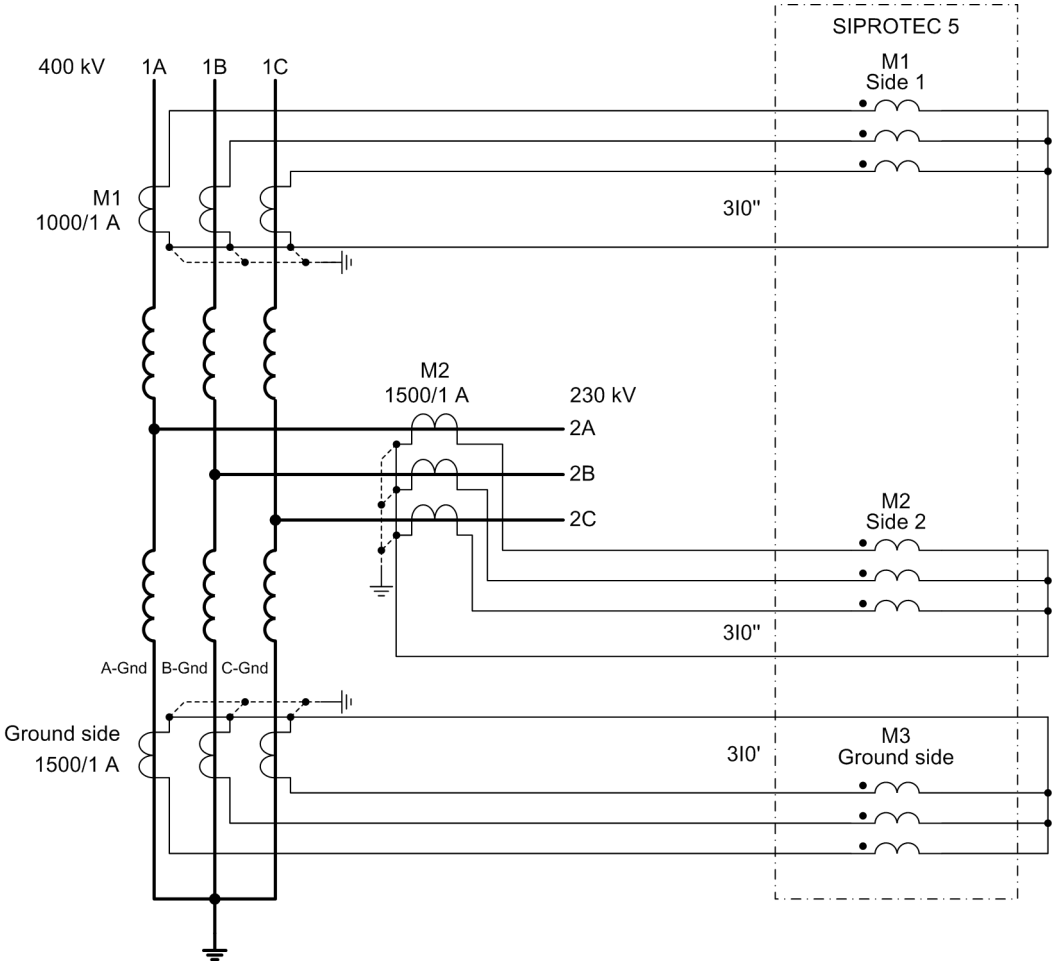


[dwstabke-170712-01.tif, 1, en_US]

Figure 6-246 Stabilized Characteristic Curve

Processing a Ground Side for Auto Transformer

Instead of a 1-phase neutral point, with an auto transformer a 3-phase ground side can also be used.



[dwautraf-201112-01.tif, 1, en_US]

Figure 6-247 Connecting a Ground Side on the Auto Transformer

In this case the neutral-point current calculates as sum of the phase currents of the ground side:

$I_0^* = k_m \cdot 3I_0' \rightarrow 3I_0' = I_{gnd,A} + I_{gnd,B} + I_{gnd,C}$

with $k_m = I_{N,transformer}/I_{N,side}$

The following applies for the restraint current:

The following applies for the restraint current: $I_{rest.,REF} = |I_{gnd,A}| + |I_{gnd,B}| + |I_{gnd,C}| + |I_A| + |I_B| + |I_C|$

NOTE

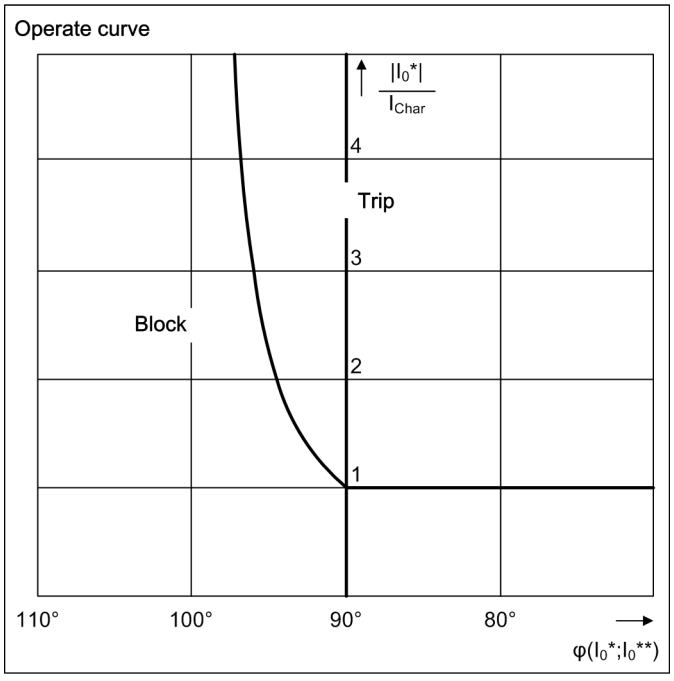
If both 1-phase neutral point and 3-phase ground side are connected, only the 1-phase neutral point is used by the restricted ground-fault protection. The 3-phase ground side is not considered.

Pickup

If the $I_{Diff,REF}$ calculated differential current exceeds the $I_{char.\ curve}$ calculated current (see *Figure 6-244*), pickup occurs and the internal processing is enabled. The pickup is indicated.

Operate Curve

The operate curve represented in the following figure consists of 2 parts. In the right part of the characteristic curve, you will find a case of an **internal ground fault**. Under ideal conditions, the angle between the two residual currents ($\angle(\underline{I}_0^*, \underline{I}_0^{**})$) equals 0. With current-transformer saturation, angle errors can result. The right part of the characteristic curve is valid for angles ≤ 90°. The tripping current is the current flowing at the neutral point ($\underline{I}_0^*$). It is compared to the set or increased threshold value.



[dwausken-170712-01.tif, 1, en_US]

Figure 6-248 Operate Curve Depending on the Phase Angle between $\underline{I}_0^*$ and $\underline{I}_0^{**}$ at $|\underline{I}_0^*| = |\underline{I}_0^{**}|$ (180° = External Fault)

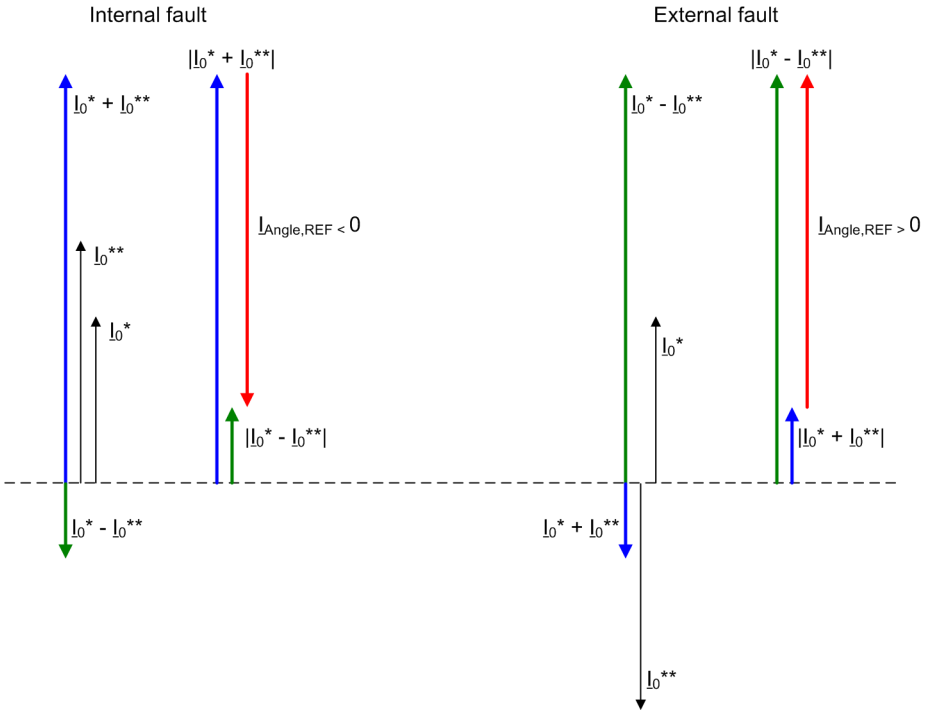
In case of an **external ground fault** the zero-sequence current calculated from the phase currents reverses by 180°. The phase angle between the residual currents thus ($\angle(\underline{I}_0^*, \underline{I}_0^{**})$) equals 180°. They are located in the left part of the operate curve and recognize a clearly increased pickup value. Angle deviations of 180° are caused by transformer saturation in conjunction with external short-circuits.

The current $I_{angle,REF}$ for the **Angle Decision** is determined from the following subtraction and summation:

$I_{angle,REF} = |\underline{I}_0^* - \underline{I}_0^{**}| - |\underline{I}_0^* + \underline{I}_0^{**}|$

The resulting current $I_{angle,REF}$ results from the respective fault conditions, which are illustrated in the following figure. With an internal fault (angle = 0°) a current results that has a negative sign. If angle errors occur, the sign remains negative. The amount of the current decreases.

In an external short-circuit (180°), the current becomes positive. At a smaller angle (<180°) due to transformer saturation, the angle remains positive. The amount also decreases.



[dwwinken-011112-01.tif, 1, en_US]

Figure 6-249 Angle Decision in Internal and External Faults

For tripping to occur, the neutral-point current $\underline{I}_0$* must reach the value $\underline{I}_{REF,off}$. The characteristic curve in the left part of the figure can be determined from the following relationship:

$\underline{I}_{REF,off} = I_{char.\ curve} + k \cdot I_{angle,REF}$

where:

$I_{char.\ curve}$	Pickup value resulting from the pickup value increase
k	Factor (permanently set to 4.05657. With this value, the limit angle at $\lvert\underline{I}_0^*\rvert = \lvert\underline{I}_0^{**}\rvert$ is precisely 100°. No tripping is possible from this angle on.)

Processing of Several Measuring Points on One Side

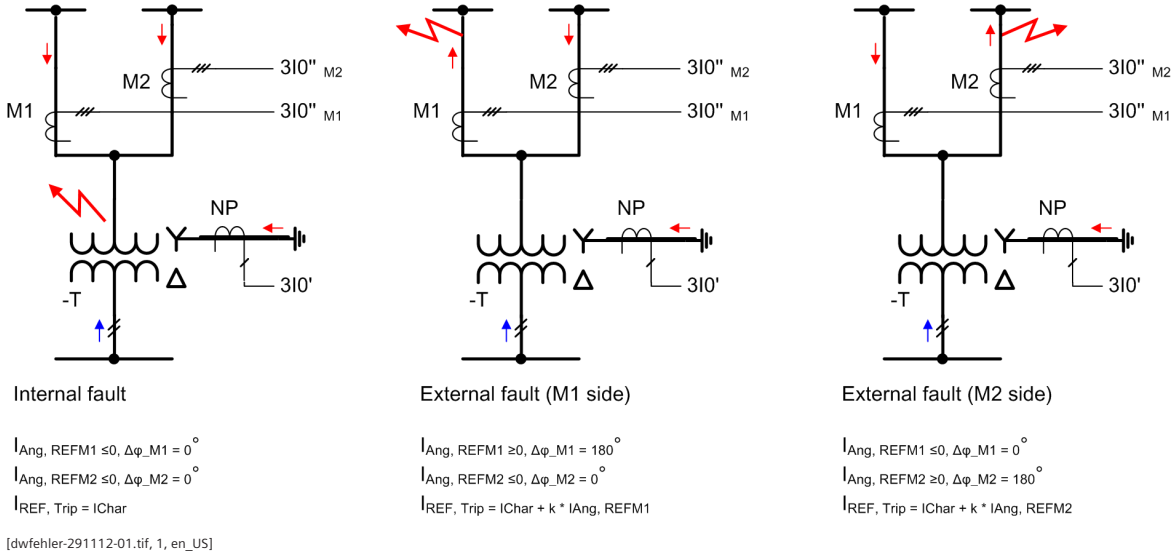
If several measuring points are present on one side of a star winding, as with a 1 1/2 circuit-breaker application, the angle decision occurs separately for each measuring point. The maximum current $I_{angle,REF}$ is used to establish the tripping decision.

NOTE

With an external fault, the current $\underline{I}_{angle,REF}$ is always > 0.

The following figure shows the behavior under different fault conditions.

Also observe that the restraint current ($I_{rest.,REF}$) always results from the sum of all currents (phase currents of the measuring points and the neutral-point current). For pickup, the differential current $I_{Diff,REF}$ is necessary. This differential current results from the geometric sum of all adapted residual currents. The residual currents of the measuring points on the outgoing side and of the neutral-point current are meant here.



[dwfehler-291112-01.tif, 1, en_US]

Figure 6-250 Behavior under Different Fault Conditions

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF
(_:301) I diff.	Differential current
(_:302) I restr.	Restraint current

You will find the measured values for the **Restricted ground-fault protection** under the following device menu entries:

- Main menu → Measurements → function → Function values → 87N REF

6.41.4 Application and Setting Notes

NOTE

The following conditions must be observed when setting the threshold values:

Threshold value ≥ max { *0.05 I/Irated,S* ; *0.05 I/Irated,S* * $I_{prim\ transf.\ max}$ / $I_{rated,\ protected\ object}$ }

Threshold value ≤ min { *2.00 I/Irated,S* ; *100.00 I/Irated,S* * $I_{prim\ transf.\ max}$ / $I_{rated,\ protected\ object}$ }

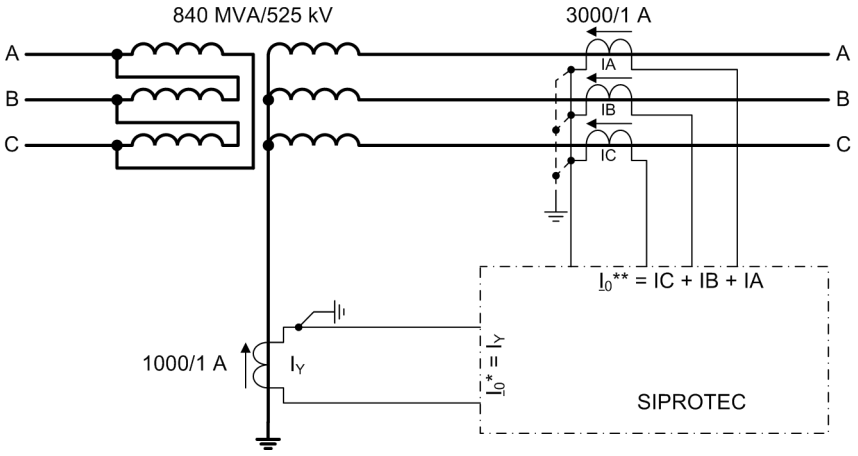
The value ***0.05 I/Irated,S*** is the minimum possible setting value and ***2.00 I/Irated,S*** the maximum possible. $I_{prim,transf.\ max}$ is the largest transformer current and $I_{rated,protected\ object}$ the protected object rated current. ***100.00 I/Irated,S*** is the upper measurement limit.

If otherwise it could happen that there is chattering of the pickup indication, the minimum threshold limit is lifted. The maximum limit on the other hand is corrected downward, if the exceeding current otherwise through the magnitude scaling must be so large, that it would already be outside of the measuring range of the transformer.

The adaptation of the setting limits is done automatically. In addition a setting is prevented outside of these limits.

In the following, typical applications are described for the restricted ground-fault protection.

Protection of a Solidly Grounded Star Winding (Y Side)



[dwanster-170712-01.tif, 1, en_US]

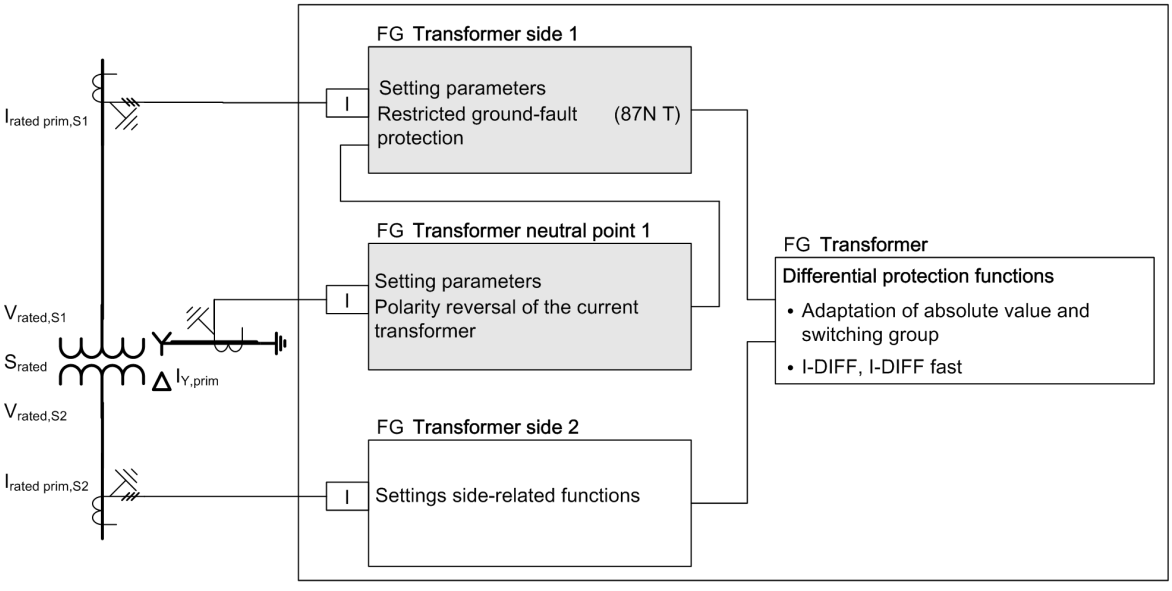
Figure 6-251 Application Star Side

This application is a standard application. Here the phase currents of one side and the neutral-point current are processed. The function is located in the **Transformer Side** function group.

The following figure show the structural division of the function. The restricted ground-fault protection gets its measurands from the current transformers, which are connected to the **Transformer side** function group. The neutral-point current is guided via the **Transformer neutral point** function group to the **Transformer side** function group. To be compatible with SIPROTEC 4 (including reference arrow definition of the restricted ground-fault protection), in addition to the magnitude scaling of the neutral-point current, a rotation of the polarity (phase rotation by 180°) is also done in the **Transformer neutral point** function group.

NOTE

The fault record indicates the analog traces according to the connection. For this reason the neutral-point current is shown rotated by 180° in comparison to SIPROTEC 4.



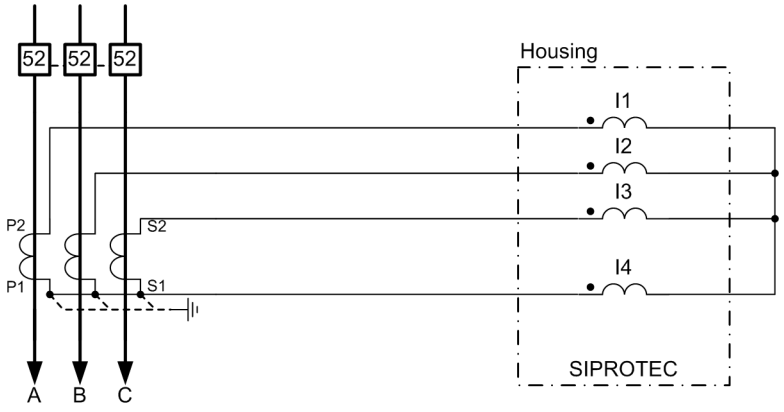
[dw2wtyde-201112-01.tif, 2, en_US]

Figure 6-252 Function Group Structure of the Restricted Ground-Fault Protection

Explanations on the Connection and Current-Direction Definition

Uniform reference arrows and transformer burdens are defined for the SIPROTEC 5 device series. These agreements also apply to the transformer protection devices. The special handling of the neutral-point current described previously is a result of this.

The current definition states that the sum of the currents flowing into the protected object is equal to 0 ($\underline{I}_A + \underline{I}_B + \underline{I}_C + \underline{I}_N = 0$ or $\underline{I}_A + \underline{I}_B + \underline{I}_C = -\underline{I}_N$). The protected object is located to the right or left of the transformer set. The following basic connections result from this.

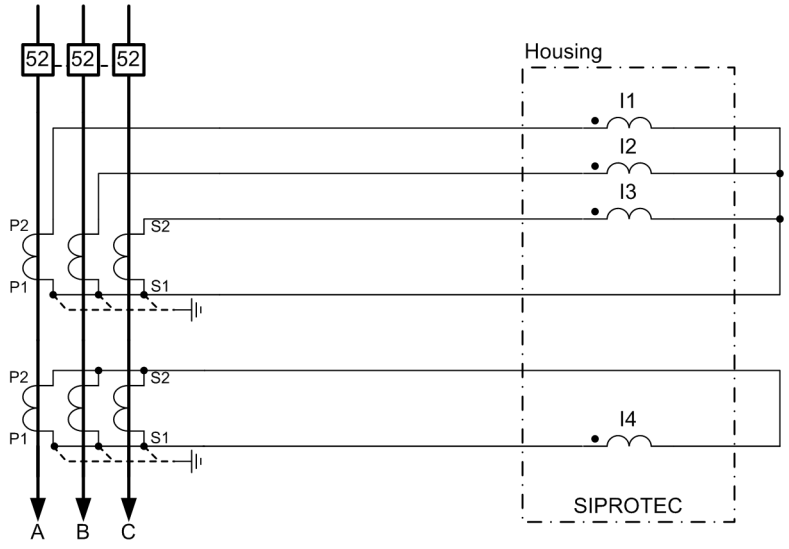


Current transformer 3-phase: connection = **3-phase + IN**

[tileite2-070211-01.tif, 1, en_US]

Figure 6-253 Current Transformer Connection (1) According to Definition

or



Current transformer 3-phase: connection = **3-phase + IN-separate**

[tileite4-260313-01.tif, 1, en_US]

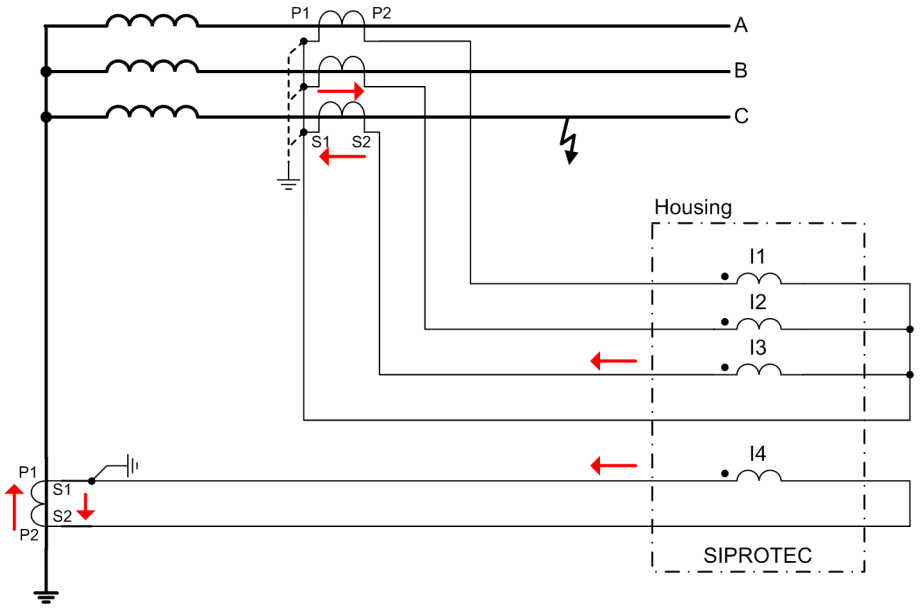
Figure 6-254 Current-Transformer Connection (2) According to Definition

The following connection is defined for the transformer according to *Figure 6-255*. The current flow for an external ground fault is entered at the same time. It is recognized that the secondary currents each flow from the device. From this, a differential current ($I_{diff,REF} = |\underline{I}_Y + \underline{I}_A + \underline{I}_B + \underline{I}_C| = |-\underline{I}_4 - \underline{I}_3|$) results, according to the reference arrow definition for the restricted ground-fault protection (positive to the protected object) with an

external ground fault. To prevent that, the neutral-point current is rotated in the **Transformer neutral-point** function group. It follows that: $I_{Diff, REF} = |\underline{I}_4 - \underline{I}_3| = 0$.

NOTE

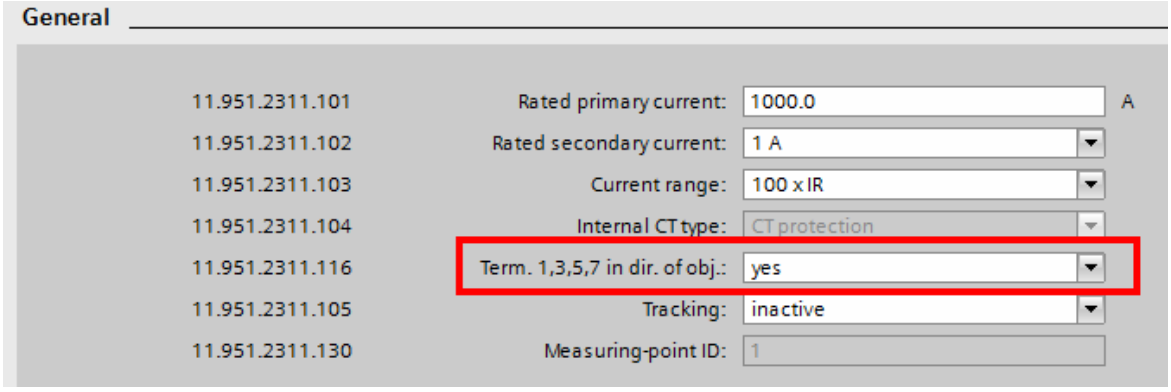
If the neutral-point current is included in the protection function (zero-sequence current correction), this rotation also has an effect for the differential protection.



[dwstwnas-281112-01.tif, 1, en_US]

Figure 6-255 Current Transformer Connection on the Transformer

The setting of the 1-phase measuring point based on the definition is done as follows:



[scedsall-200214-01, 1, en_US]

Figure 6-256 DIGSI 5 Setting

The point in *Figure 6-255* describes the polarity of the current transformer. At the same time the current terminal is designed so that this side is fed out on an odd number terminal point. Since in the SIPROTEC 5 system each current transformer can be assigned a 1-phase measuring point, the odd number terminal points are named in the setting parameters. According to *Figure 6-255* the setting must be ***yes***.

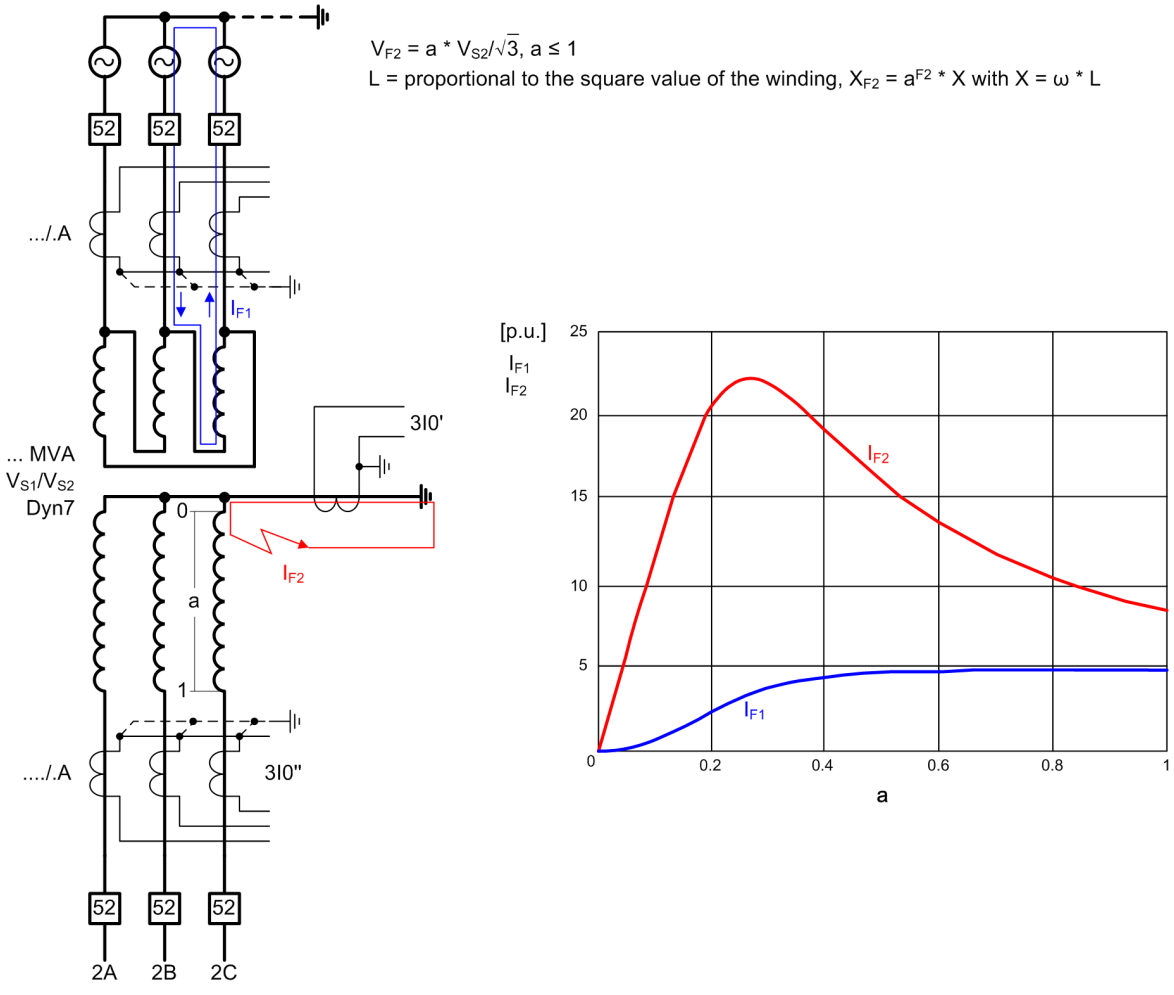
- Default setting **(_:115) terminal 1,3,5,7 in dir.obj.** = ***yes***

The following view can be used to derive the threshold value. The transformer is supplied, for example, via the delta winding and a 1-pole ground fault occurs on the star side.

NOTE

For estimation of the short-circuit current, note that the inductance changes quadratically with the winding and the linearly with the voltage.

The right part in the following figure represents the fault current as a function of the fault location. The fault current curve $_{F1}$ shows that the longitudinal differential protection with faults near the neutral point has sensitivity problems due to the sinking current. On the other hand, the neutral-point current $_{F2}$ is sufficiently large. There is therefore no need to set the **Threshold** (current through the neutral point transformer) to sensitive.



[dwf1pole-170712-01.tif, 1, en_US]

Figure 6-257 Principal Fault Current Curves with a 1-Pole Ground Fault

- Recommended setting value **(_:103) Threshold** = ***0.2 I/Irated,S***

The previously mentioned condition must be maintained during the setting.

$$\text{Threshold value} \geq 0.05\ \text{I/Irated, S} \cdot \frac{I_{CT\,max,prim}}{I_{rated,side}}$$

[foschwe1-170712-01.tif, 1, en_US]

The following lower limiting value results from the data from *Figure 6-251*:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{3000\,\text{A}}{924\,\text{A}} = 0.162\ \text{I/Irated,S}$$

$$\text{with } I_{\text{object,side}} = \frac{S_{\text{rated}}}{\sqrt{3}\,V_{\text{rated}}} = \frac{840\,\text{MVA}}{\sqrt{3}\,525\text{kV}} = 924\,\text{A}$$

[foschwe2-041012-01.tif, 1, en_US]

The recommended setting value of ***0.2 I/Irated,S*** lies above it.

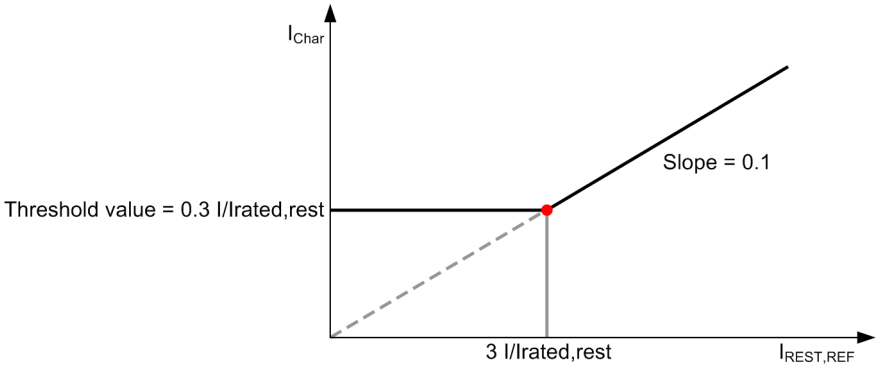
- Recommended setting value **(_:105) Slope** = ***0.07***

You can stabilize the protection function (less sensitive setting) with external multiphase short-circuits to ground with the parameter **Slope**. To determine the setting value, no pickup value increase can occur up to the rated current. After this, the gradient must be active. To derive the gradient, it is assumed that continuation of the straight line must go through the coordinate origin (see *Figure 6-258*). Determine the intersection from the threshold value and the restraint current at rated current. Calculate the gradient as follows:

$$I_{\text{rest,REF}} = \left|I_{!0}{}^{*}\right| + \left|I_{!A}\right| + \left|I_{!B}\right| + \left|I_{!C}\right| = 0 + 3\ \text{I/Irated, S} = 3\ \text{I/Irated, S}$$

$$\text{Slope} = \frac{\text{Threshold value}}{I_{\text{rest,REF}}} = \frac{0.2\ \text{I/Irated, S}}{3\ \text{I/Irated, S}} = 0.07$$

[fostbref-231012-01.tif, 1, en_US]



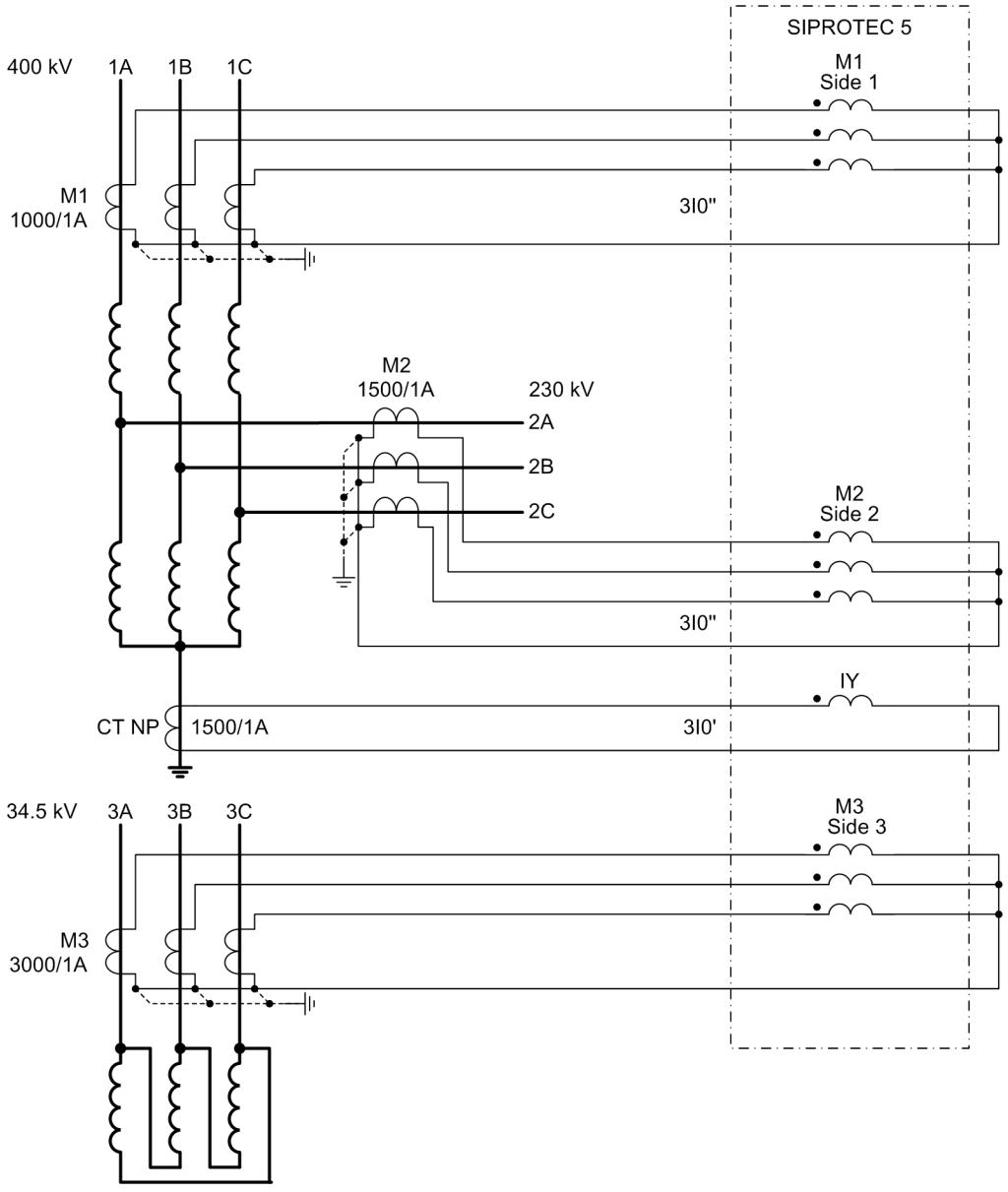
[dwsteiga-221012-01.tif, 1, en_US]

Figure 6-258 Derivation of the Setting Value for the Gradient

If you have several measuring points on an outgoing side (see *Figure 6-250*), Siemens recommends using the value **3 I/Irated,S** in the intersection calculation for the restraint current. In the load case, the maximum transformer rated current flows on one side.

If, however, several measuring points are on the supply side (for example, breaker-and-a-half layout), Siemens recommends including all phase currents in the intersection calculation, in order to avoid too strong of a stabilization. With 2 measuring points, a value of **6 I/Irated,S** results as intersection with the threshold value. The slope becomes flatter (**0.2 I/Irated,S/6 I/Irated,S = 0.03**).

Protection of an Auto Transformer



[dwsptran-170712-01.tif, 1, en_US]

Figure 6-259 Activation and Application Example of an Auto Transformer (500 MVA: 400 kV, 230 kV; 125 MVA: 34.5 kV)

Use the highest side rated current with the auto transformer for normalization. In the example (*Figure 6-259*), the measuring point is M2 (230 kV side). For this side, a rated current of 500 MVA/(√(3) · 230 kV) = 1255 A results. The primary transformer rated current is 1500 A. With this, you can estimate the minimum permissible pickup value.

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{I_{\text{CT max,prim}}}{I_{\text{object,side}}} = 0.05\ \text{I/Irated,S} \cdot \frac{1500\text{A}}{1255\text{A}} = 0.06\ \text{I/rated,S}$$

[foscwe01-170712-01.tif, 1, en_US]

Siemens recommends a setting value of **0.2 I/Irated,S**.

- Recommended setting value **(_:103) Threshold** = ***0.2 I/Irated,S***

To determine the **Slope**, the restraint current of both sides (400 kV and 230 kV) must be used. The rated current is used as starting value for the gradient. Since side 2 (230 kV) is the reference side for the normalization, the value of the 400 kV side must be adapted to this rated current. The adaptation factor results from the inverse ratio (230 kV/400 kV). The following restraint current goes into the calculation:

$$I_{rest,REF} = 3\ I/Irated,S2 + 3\frac{230\,kV}{400\,kV}\ I/Irated,S2 = 3\ I/Irated,S2 + 1.725\ I/Irated,S2 = 4.73\ I/Irated,S$$

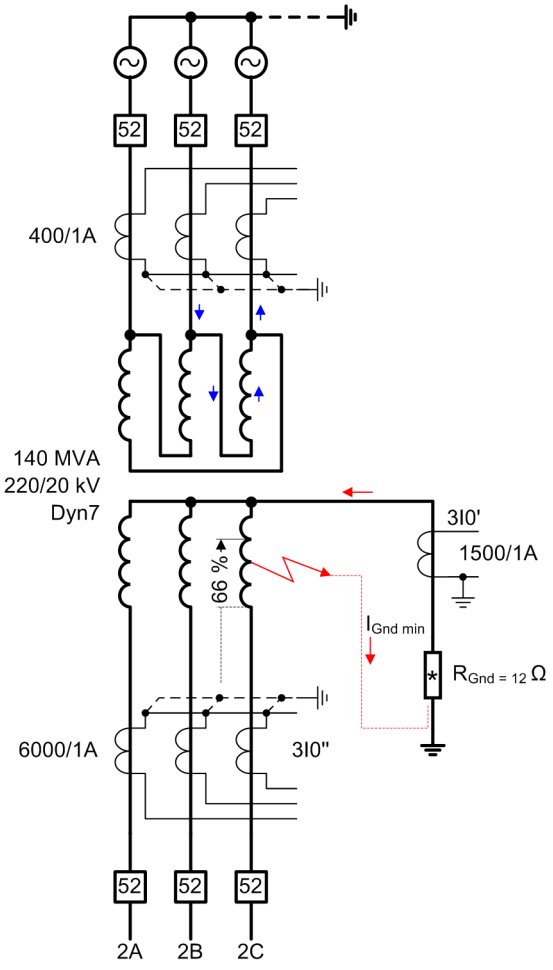
$$Slope = \frac{Threshold\ value}{I_{rest,REF}} = \frac{0.2\ I/Irated,S}{4.73\ I/Irated,S} \approx 0.042$$

[fostbrst-231012-01.tif, 1, en_US]

Siemens recommends using the setting 0.07.

- Recommended setting value **(_:105) Slope** = ***0.07***

Protection of a Resistance-Grounded Star Winding (Y Side)



[dwrefspa-170712-01.tif, 1, en_US]

Figure 6-260 Application with Resistance-Grounded Neutral Point

To also capture faults in the resistance to ground, a current transformer must be installed at the neutral point of the protected object (see *Figure 6-260*). The pickup values can be derived from the data in the example. As side rated value, the following results:

140 MVA/(√3 · 20 kV) = 4042 A

The following threshold value results as lower limit:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{6000\,\text{A}}{4042\,\text{A}} = 0.07422\ \text{I/Irated,S}$$

$$\text{with } I_{\text{object,side}} = \frac{S_{\text{rated}}}{\sqrt{3} \cdot V_{\text{rated}}} = \frac{840\text{MVA}}{\sqrt{3} \cdot 525\text{kV}} = 924\text{A}$$

[foschwe3-170712-01.tif, 1, en_US]

So that the function is responsive, select a setting value of 0.08 I/Irated,S.

- Recommended setting value **(_:103) Threshold** = ***0.08 I/Irated,S***

As gradient, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{\text{rest,REF}}} = \frac{0.08\ \text{I/Irated,S}}{3\ \text{I/Irated,S}} \approx 0.03$$

[fosteig1-170712-01.tif, 1, en_US]

- Recommended setting value **(_:105) Slope** = ***0.03***

Because of the grounding resistance R_E reduced protection range results. This can be estimated as follows: The grounding resistance is much larger than the winding reactance, thus the following maximum ground current results:

$I_{\text{Gnd max}} = 20\ \text{kV}/(\sqrt{3} \cdot 12\ \Omega) = 962\ \text{A}$

You can determine the minimum tripping current from the setting value:

$I_{\text{Gnd min}}$ = side rated current * threshold value = 4042 A · 0.08 = 323 A

Thus, the following protection range results:

$$\text{Protection range} = 1 - \frac{I_{\text{gnd min}}}{I_{\text{gnd max}}} = 1 - \frac{323\,\text{A}}{962\,\text{A}} = 0.664$$

[foschwe4-170712-01.tif, 1, en_US]

The attainable protection range amounts to approx. 66.4 %. In order to capture ground faults near the neutral point, it is also recommended to connect a sensitive ground current protection to the neutral point transformer. You must coordinate its operate time with the line protection.



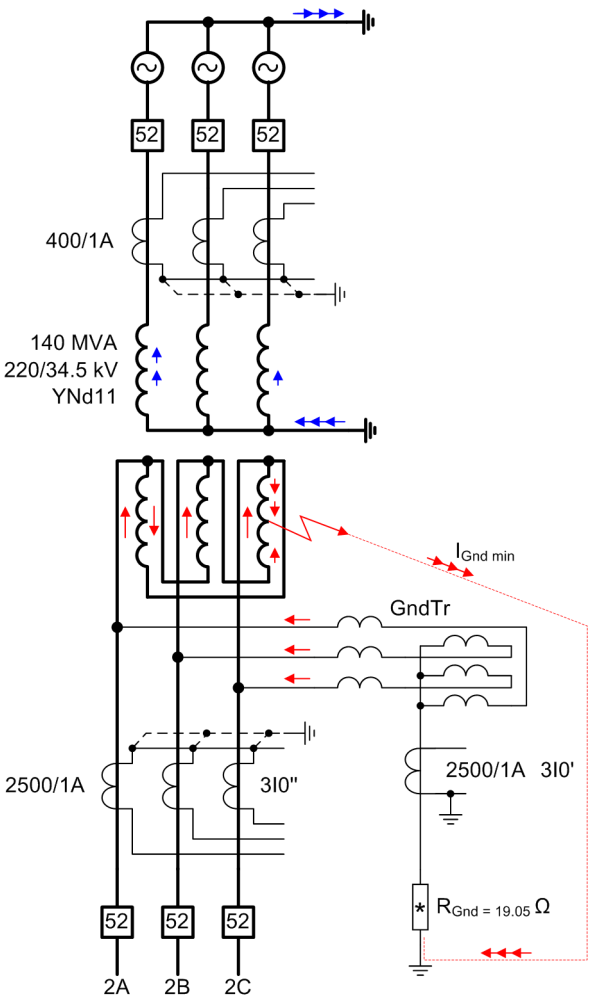
NOTE

Ensure that the protection range further limits itself with larger neutral-point resistances, or the restricted ground-fault protection can no longer be used.

Protection with Neutral Reactors on the Delta Side

To produce ground currents on the delta side of a transformer, neutral reactors (zigzag reactors) are used. A resistance for ground current limitation can also be present. In this case, the resistance is much greater than the reactor and delta reactance of the transformer. The following figure shows a typical implementation. The restricted ground-fault protection works between output-sided phase current transformers and the current transformer in the neutral point of the neutral reactor.

In the example, the fault current curve with the ground fault in a delta winding is also represented. The fault location in which the lowest fault current flows can also be seen. This current influences the protection setting set close.



[dwstrpkt-170712-01.tif, 1, en_US]

Figure 6-261 Application with Neutral Reactor

As side rated value, the following results:

140 MVA/($\sqrt{3}$ · 34.4 kV) = 2343 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{2500\ \text{A}}{2343\ \text{A}} = 0.06\ \text{I/Irated,S}$$

[foschwe5-170712-01.tif, 1, en_US]

If the fault is in the middle of the winding, the minimum ground current will arise, as shown in *Figure 6-261*. The driving voltage is:

$V_{Gnd\ min} = V_{rated,S2}/(2\sqrt{3}) = 34.5\ kV/(2\sqrt{3}) = 9.96\ kV$

The following minimum ground current results:

$I_{Gnd\ min} = V_{Gnd\ min}/R_{Gnd} = 9.96\ kV/19.05\ \Omega = 523\ A$

With reference to the side rated current, the relationship is:

$I_{Gnd\ min}/I_{rated,S} = 523\ A/2343\ A = 0.223$

With a safety margin of 2, 0.223/2 = 0.1115 results. Select this value as threshold value (rounded: 0.12 I/Irated,S).

- Recommended setting value **(_:103) Threshold** = ***0.12 I/Irated,S***

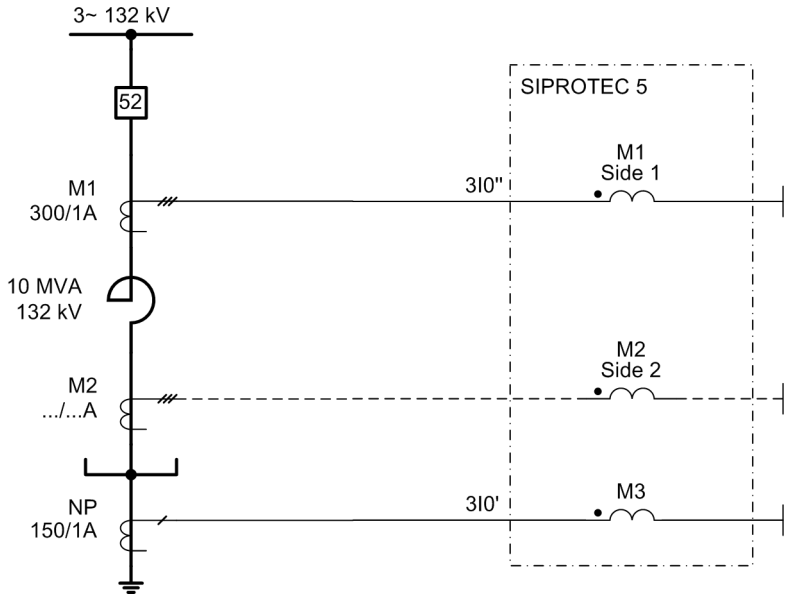
As gradient, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{rest,REF}} = \frac{0.12\ I/I_{rated,S}}{3\ I/I_{rated,S}} \approx 0.04$$

[fosteig2-170712-01.tif, 1, en_US]

- Recommended setting value **(_:105) Slope** = ***0.04***

Protection of a Shunt Reactor



[dwanquer-170712-01.tif, 1, en_US]

Figure 6-262 Application with Neutral Reactor

As side rated value, the following results:

10 MVA/($\sqrt{3}$ · 132 kV) = 43.7 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{300\ A}{43.7\ A} = 0.343\ I/I_{rated,S}$$

[foschwe6-170712-01.tif, 1, en_US]

Select 0.35 I/Irated,S as threshold value.

- Recommended setting value **(_:103) Threshold** = ***0.35 I/Irated,S***

For the shunt reactor, there is no external fault that can lead to overfunction. Siemens recommends a minimum rise (0.05).

- Recommended setting value **(_:105) Slope** = ***0.05***

6.41.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
87N REF #				
_:1	87N REF #:Mode		• off • on • test	off
_:2	87N REF #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:103	87N REF #:Threshold		0.05 I/IrObjto 2.00 I/IrObj	0.20 I/IrObj
_:105	87N REF #:Slope		0.00 to 0.95	0.07
_:109	87N REF #:Operate delay		0.00 s to 60.00 s; ∞	0.00 s
_:191	87N REF #:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned

6.41.6 Information List

No.	Information	Data Class (Type)	Type
87N REF #			
_:82	87N REF #:>Block function	SPS	I
_:54	87N REF #:Inactive	SPS	O
_:52	87N REF #:Behavior	ENS	O
_:53	87N REF #:Health	ENS	O
_:55	87N REF #:Pickup	ACD	O
_:57	87N REF #:Operate	ACT	O
_:303	87N REF #:Operate delay expired	ACT	O
_:305	87N REF #:Block by direct. det.	SPS	O
_:306	87N REF #:I REF,operate	MV	O
_:307	87N REF #:I Angle,REF	MV	O
_:311	87N REF #:I REF,Trip operate	MV	O
_:312	87N REF #:I angle,REF operate	MV	O
_:301	87N REF #:I diff.	MV	O
_:302	87N REF #:I restr.	MV	O

6.42 External Trip Initiation 3-Pole

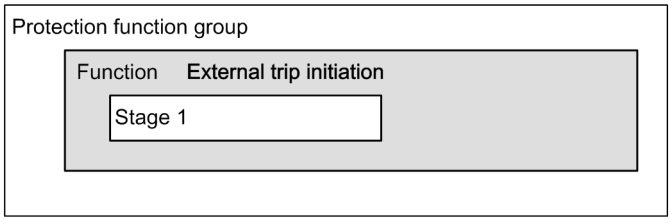
6.42.1 Overview of Functions

The **External trip initiation** function:

- Processes any signals from external protection or supervision devices
- Enables the integration of any signals from external protection equipment in the indication and tripping processing, for example from transient ground-fault relays or Buchholz protection
- Enables direct tripping of the circuit breaker in conjunction with busbar-protection applications
- Enables direct tripping of the circuit-breaker in the case of circuit-breaker failure at the other line end

6.42.2 Structure of the Function

The **External trip initiation** function contains one step. The **External trip initiation** function can be instantiated in DIGSI 5 multiple times.

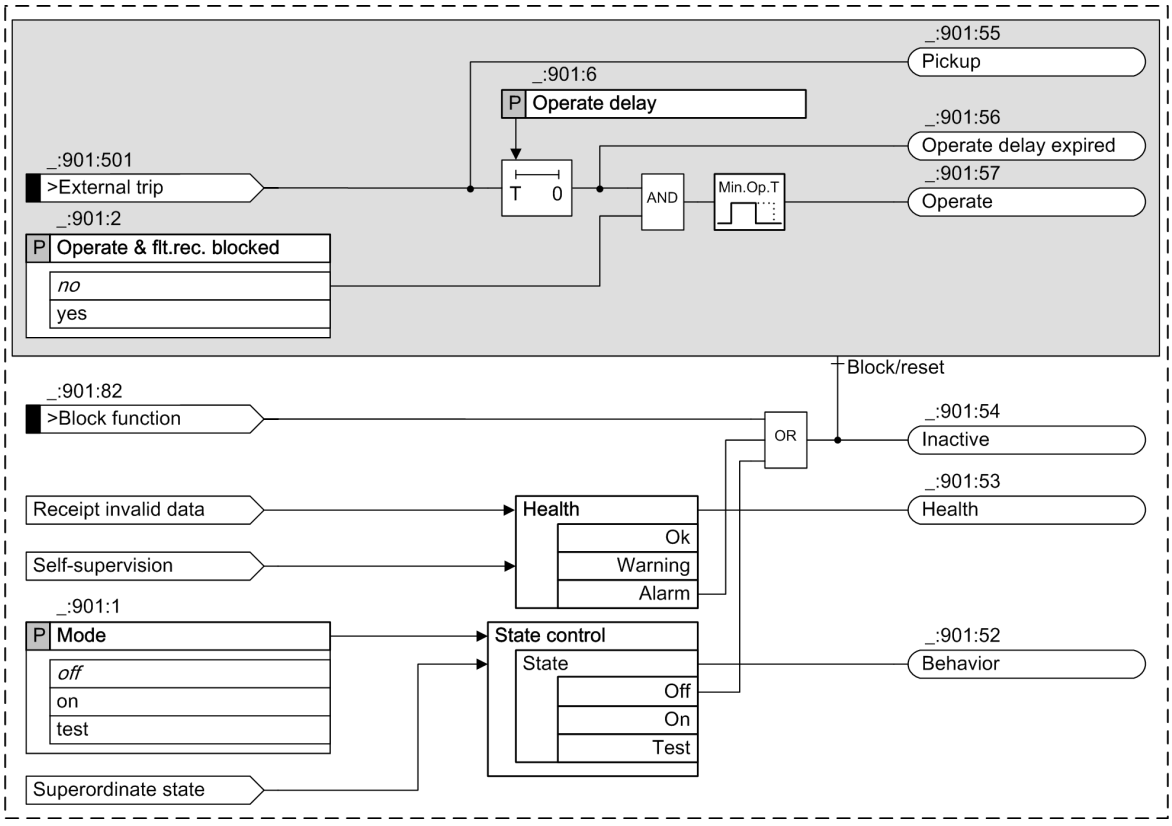


[dwstrext-030211-01.tif, 1, en_US]

Figure 6-263 Structure/Embedding of the Function

6.42.3 Stage Description

Logic of the Stage



[lotrip3p-070611-01.tif, 1, en_US]

Figure 6-264 Logic Diagram for the External Trip-Initiation Stage

Binary Input Signal >External Trip

The binary input signal **>External trip** starts the **Pickup** and the **Operate delay**.

Blocking the Stage

The stage can be switched to ineffective via a number of signals. If the stage is in the pickup state at the time of blocking, it will be immediately reset. However, the operate indication remains stopped for the minimum operating time **(_:102) Minimum operate time**.

6.42.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:901:6) Operate delay** = ***0.05 s***

The **Operate delay** parameter must be set for the specific application. After expiry of the **Operate delay** the time expiry and tripping are signaled. The duration of the initiation signal as well as the adjustable minimum command time determine the signal duration of the **Operate**.

6.42.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	off
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.05 s

6.42.6 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:901:82	Stage 1:>Block function	SPS	I
_:901:501	Stage 1:>External trip	SPS	I
_:901:54	Stage 1:Inactive	SPS	O
_:901:52	Stage 1:Behavior	ENS	O
_:901:53	Stage 1:Health	ENS	O
_:901:55	Stage 1:Pickup	ACD	O
_:901:56	Stage 1:Operate delay expired	ACT	O
_:901:57	Stage 1:Operate	ACT	O

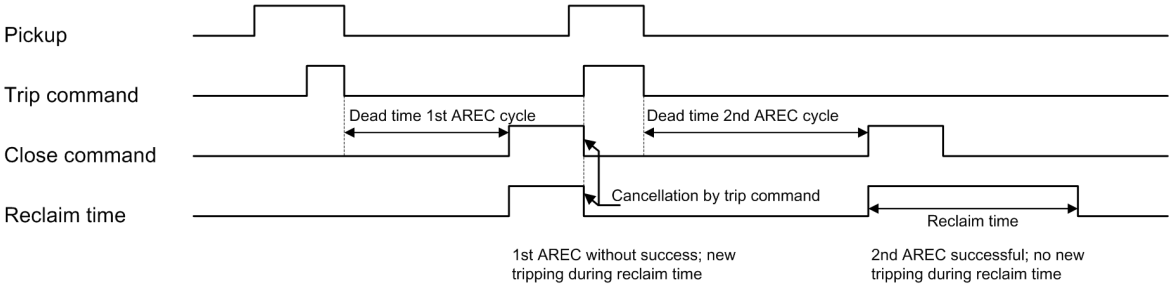
6.43 Automatic Reclosing Function

6.43.1 Overview of Functions

The Automatic reclosing function:

- Automatically closes overhead lines after arc short-circuits
- Is only permissible for overhead lines, because only the possibility of self-activated extinguishing of an arc short-circuit exists here
- Can be controlled by integrated protection functions and by external protection devices
- The automatic reclosing can occur through an external automatic reclosing function via binary inputs.

The automatic reclosing after switching off through a short-circuit protection is taken over by the automatic reclosing function (AREC). The following figure shows an example for the normal procedure with a two-time automatic reclosing where the second automatic reclosing attempt is successful.



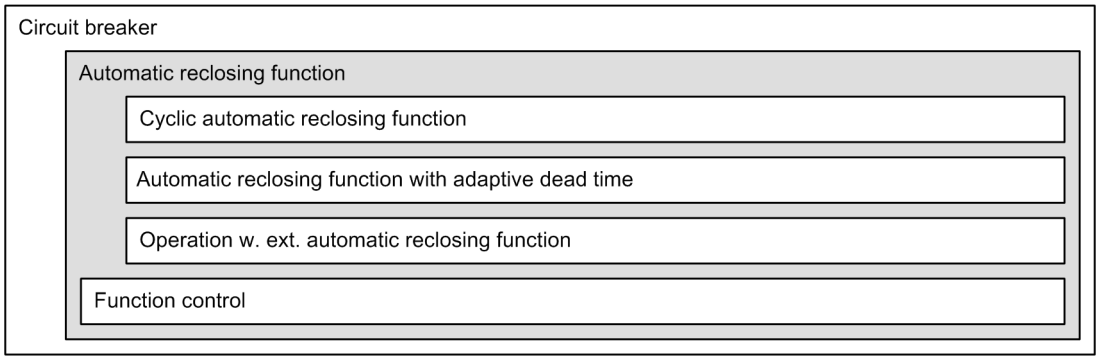
[dw2awewz-090210-01.tif, 1, en_US]

Figure 6-265 Process Diagram of a Two-Time Reclosing With Action Time (2nd Reclosing Successful)

The integrated Automatic reclosing function allows for up to 8 reclosing attempts. Each of the 8 disruption cycles can work with different parameters.

6.43.2 Structure of the Function

The automatic reclosing function is used in function groups for circuit breakers. In a function group for circuit breakers, one of the 3 types of functions illustrated in the following figures can be used. The Automatic reclosing function has a central function control.



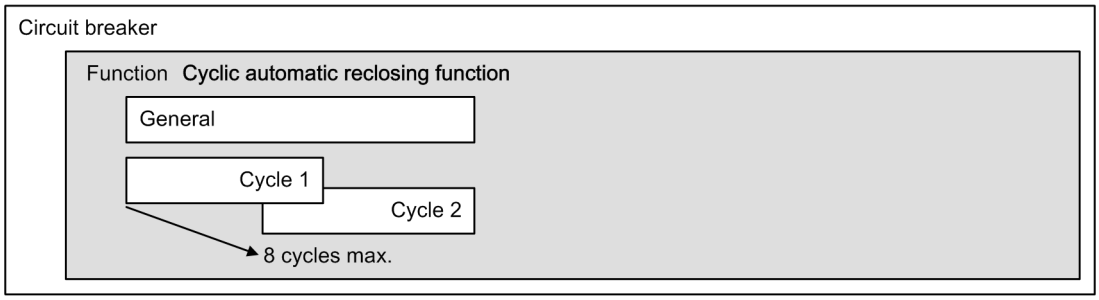
[dwfktawe-100611-01.tif, 1, en_US]

Figure 6-266 Structure/Embedding of the Function

Cyclic Automatic Reclosing Function

The Cyclic automatic reclosing function (*Figure 6-267*) allows for up to 8 reclosing attempts. Here each disruption cycle may work with different settings.

For the Cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete additional cycles from the function library in DIGSI 5.

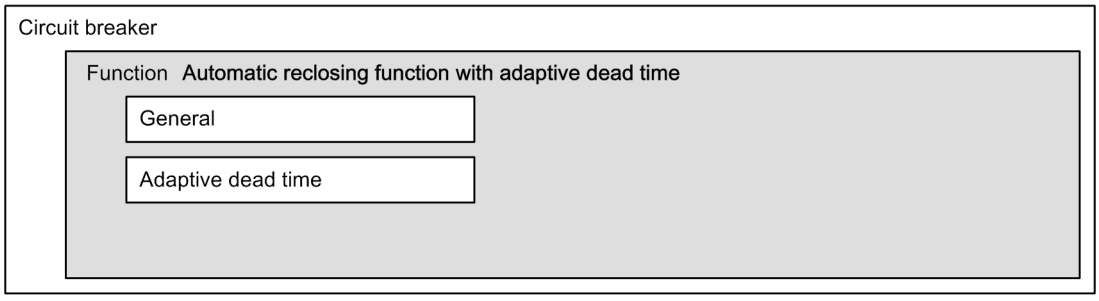


[dwzykawe-100611-01.tif, 1, en_US]

Figure 6-267 Structure/Embedding of the Cyclic Automatic Reclosing Function

Automatic Reclosing Function with Adaptive Dead Time

The Automatic reclosing function with adaptive dead time (ADT) works without fixed disruption cycles (*Figure 6-268*). The requirement for the usage of ADT is that voltage transformers on the line-side are connected or there is a possibility to transfer a close command to a remote line end. With the ADT, the Automatic reclosing function decides independently if and when an automatic reclosing is reasonable and permissible and when it is not. The criteria is the phase-to-ground voltage, which is switched through after reclosing from the opposite line end. The Automatic reclosing function with ADT occurs as soon as it is known that the line from the opposite end has been placed back under voltage.

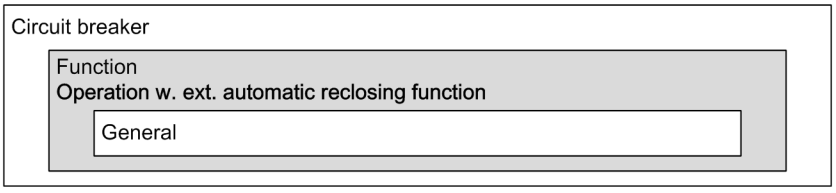


[dwaweasp-100611-01.tif, 1, en_US]

Figure 6-268 Structure/Embedding of the Automatic Reclosing Function With Adaptive Dead Time (ADT)

Operation with External Automatic Reclosing Function

The cooperation of an external reclosing device with the SIPROTEC protection device occurs through the function mode **Operation with external automatic reclosing function** (*Figure 6-269*). The function only provides binary inputs for the influence of the protection functions in the SIPROTEC protection device. The external automatic reclosing device delivers the close command. The SIPROTEC protection functions then provide for the trip commands.

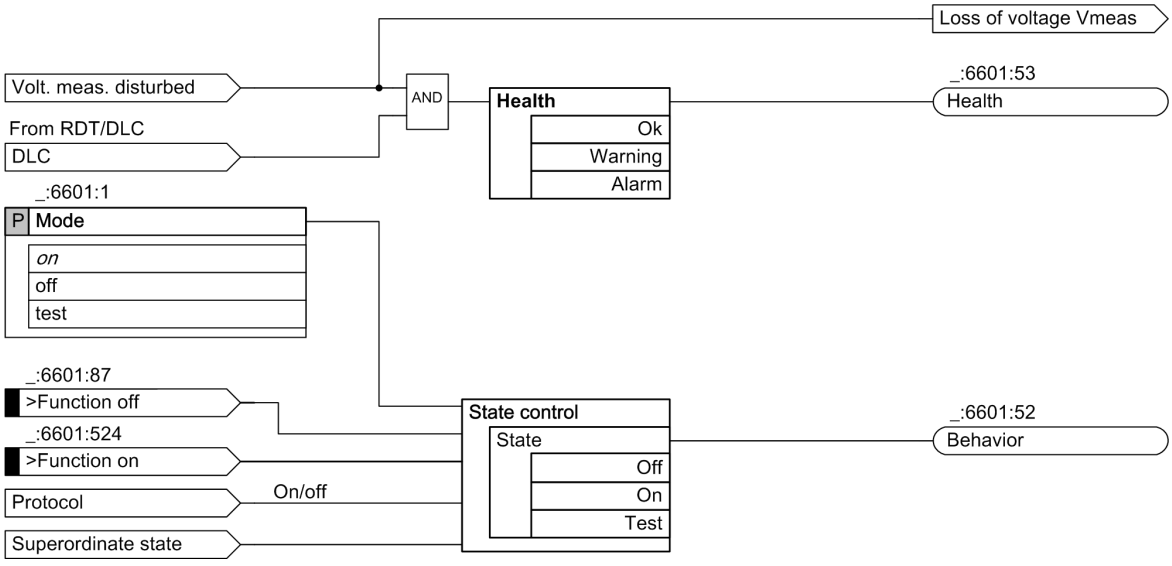


[dwextawe-100611-01.tif, 1, en_US]

Figure 6-269 Structure/Embedding of the Operating Function With External Automatic Reclosing Function

Function Control

The automatic reclosing function contains a central function control, see the following figure. You can find detailed information on the function control in the section **Function/Stage Control**.



[loarcfkt-090211-01.tif, 1, en_US]

Figure 6-270 Function Control for the Automatic Reclosing Function

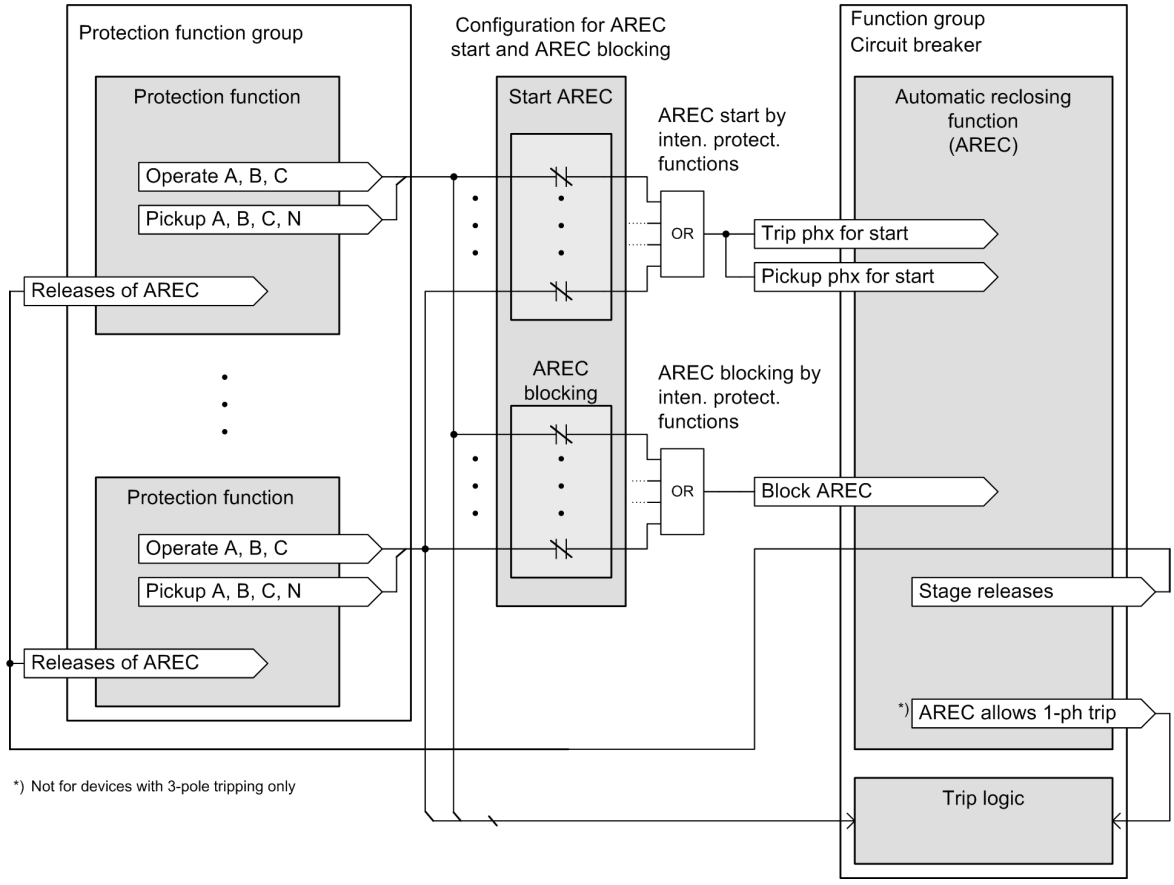
6.43.3 Cooperation of the Automatic Reclosing Function and Protection Functions

The Automatic reclosing function (AREC) can be influenced by the protection functions in the following way:

- The AREC is started through pickup indications and operate indications by the selected protection functions or protection stages. The start is independent of the set operating mode for the AREC.
- Individual protection functions or protection stages can be configured so that their operate indication blocks the AREC. If such a blocking exists, the AREC cannot be started. If the AREC is already started, the blocking will lead to the cancellation of the AREC.

The automatic reclosing device can thus have an influence on the effects of the protection functions. The following influence possibilities exist:

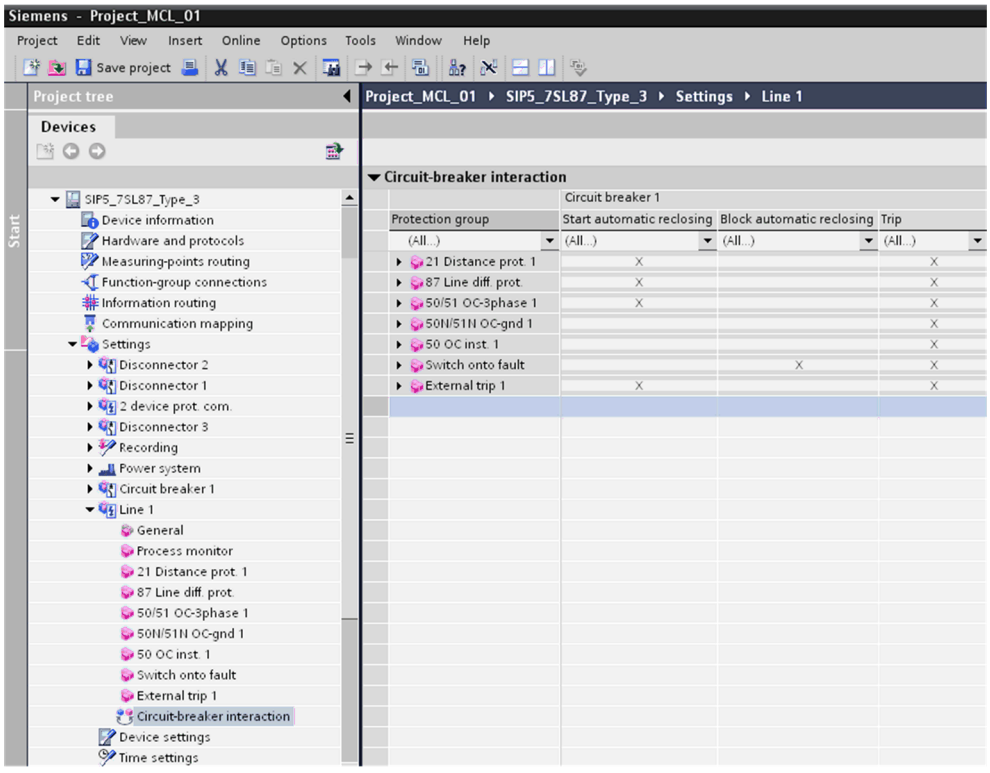
- The AREC provides signals that can be used by protection functions for the blocking or release of special stages or zones. An example is the release of overreaching zones with distance protection.



[loawesig-190912-01.tif, 1, en_US]

Figure 6-271 Signals between Protection Functions and Automatic Reclosing Functions

The configuration of the interaction between internal protection functions and automatic reclosing functions can be set separately for each protection function, see *Figure 6-271*. The configuration occurs in a matrix view in DIGSI, see the following figure..



[scdigsia-080311-01.tif, 1, en_US]

Figure 6-272 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI 5

If a protection function or the stage of a protection function is connected with the AREC through the matrix, this means that the respective pickup and operate indications are forwarded to the AREC.

The links can be conducted separately

- For starting the automatic reclosing function and
- For the blocking of the automatic reclosing function

The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

6.43.4 Cyclic Automatic Reclosing Function

6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function

For the cyclic automatic reclosing function, there are 4 operating modes, from which one can be selected for the parameterization (parameter **(_:6601:101) 79 operating mode**).

The selection of the operating mode is dependent on the tripping behavior of the protection functions and the circuit breaker.

For applications with 3-pole tripping, all 4 operating modes are available.

- Operating mode 1: ***with op., with act. time***
- Operating mode 2: ***w.pickup, w. action time***
- Operating mode 3: ***with op., w/o act. time***
- Operating mode 4: ***w.pickup, w/o act. time***

Operating Mode 1: with op., with act. time

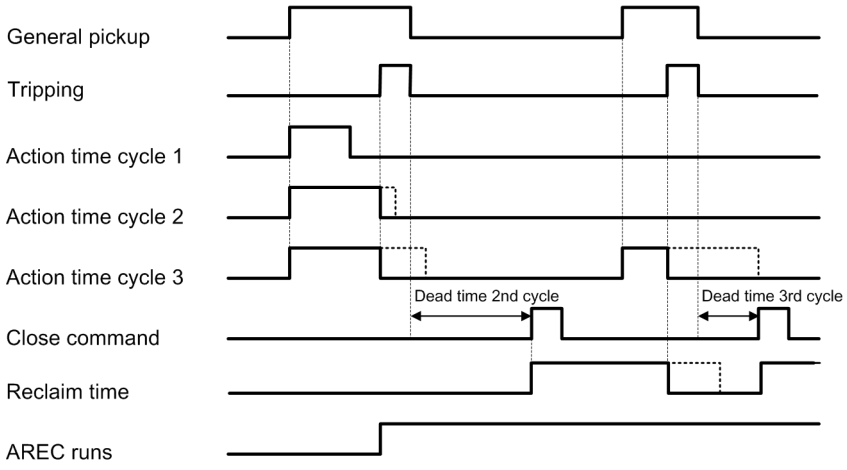
The operating mode ***with op., with act. time*** allows different automatic reclosing cycles depending on the tripping type and operate time of the protection function(s). With this operating mode, the automatic reclosing must be started with the operate indications. Additionally, the general pickup must also be considered.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup *>Gen. pickup for start*.

Through the time between the raising general pickup and clearing operate indication, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example in *Figure 6-273* shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Cycle 2 is now active.

Within the following reclaim time, there will be another pickup and tripping. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The 2nd operate indication comes during the running action time of cycle 3. Thus, cycle 3 is now active.



[dwarce1d-190912-01.tif, 1, en_US]

Figure 6-273 Operating-Mode Signal Examples: With Tripping/With Action Time

Through the action time, there is a direct influence on the dead time behavior of the automatic reclosing function. With faults with short operate times, other dead times can be realized than for removed faults with longer tripping time. With faults with short operate time, an automatic reclosing is executed, with removed faults this does not occur with longer operate time. The operating mode ***with op., with act. time*** allows for different automatic reclosing cycles depending on the operate time of the protection function(s).

Operating Mode 2: w.pickup, w. action time

The operating mode ***w.pickup, w. action time*** allows different automatic reclosing cycles depending on the operate time and type of fault. It is only suitable and applicable for applications with 3-pole tripping.

With this operating mode, the automatic reclosing must be started with the operate indications from the protection functions. Additionally, the pickup sample from the conductor pickups and the general pickup are considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples **phase-to-ground** and **only grounding**.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

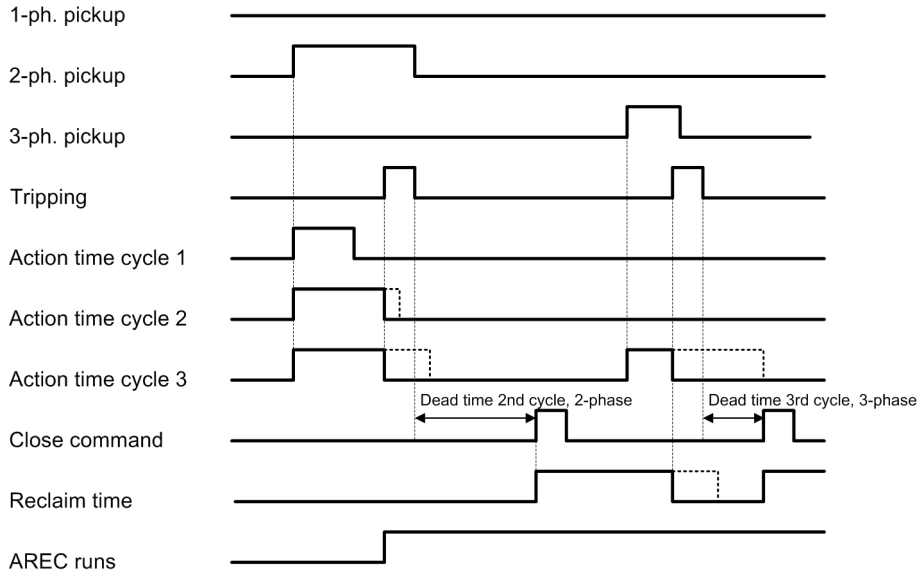
With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup *>Gen. pickup for start*.

Through the time between the raising general pickup and raising trip command, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Since it is a 2-phase pickup, cycle 2 is active with the dead-time setting for 2-phase faults.

After reclosing, there will be another, this time 3-phase, pickup and tripping within the following reclaim time. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The trip command comes during the current action time of cycle 3. Thus, cycle 3 is active, with the dead time setting for 3-phase faults.

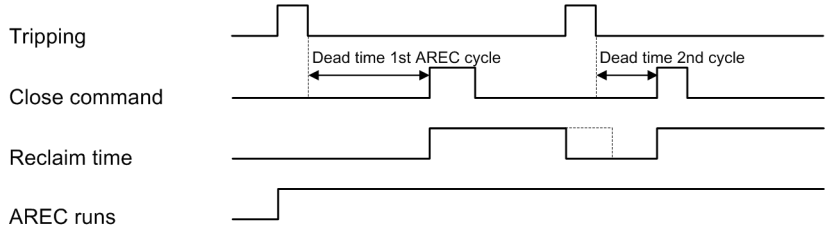


[dwarcbm2-190912-01.tif, 1, en_US]

Figure 6-274 Operating-Mode Signal Examples: With Pickup/With Action Time

Operating Mode 3: with op., w/o act. time

With the operating mode ***with op., w/o act. time***, the respective dead time is started after each trip command. The pickups are not considered. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, and 3.).



[dwaweb3d-240810-01.tif, 1, en_US]

Figure 6-275 Operating-Mode Signal Examples: With Tripping/Without Action Time

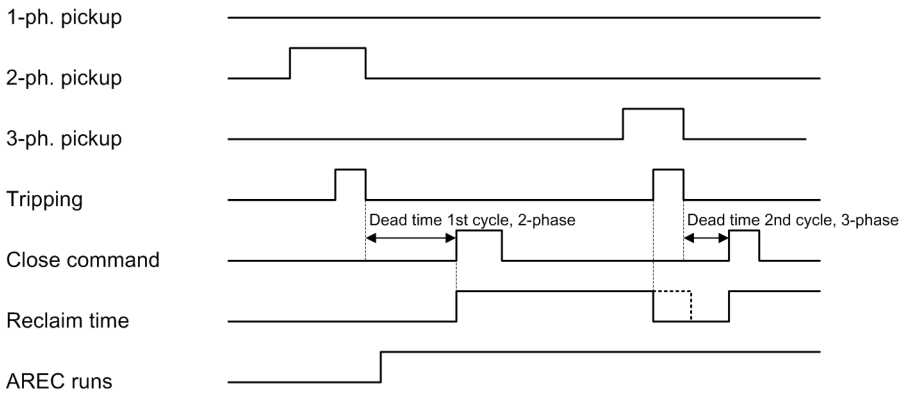
Operating Mode 4: w.pickup, w/o act. time

With the operating mode ***w.pickup, w/o act. time***, the automatic reclosing must be started with the operate indications from the protection functions. It is only suitable and applicable for applications with 3-pole tripping.

The start of the dead time occurs after each trip command. Additionally, the pickup sample from the conductor pickups is considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples **phase-to-ground** and **only grounding**.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, 3, etc.).



[dwarcbs4-170311-01.tif, 1, en_US]

Figure 6-276 Operating-Mode Signal Examples: With Pickup/Without Action Time

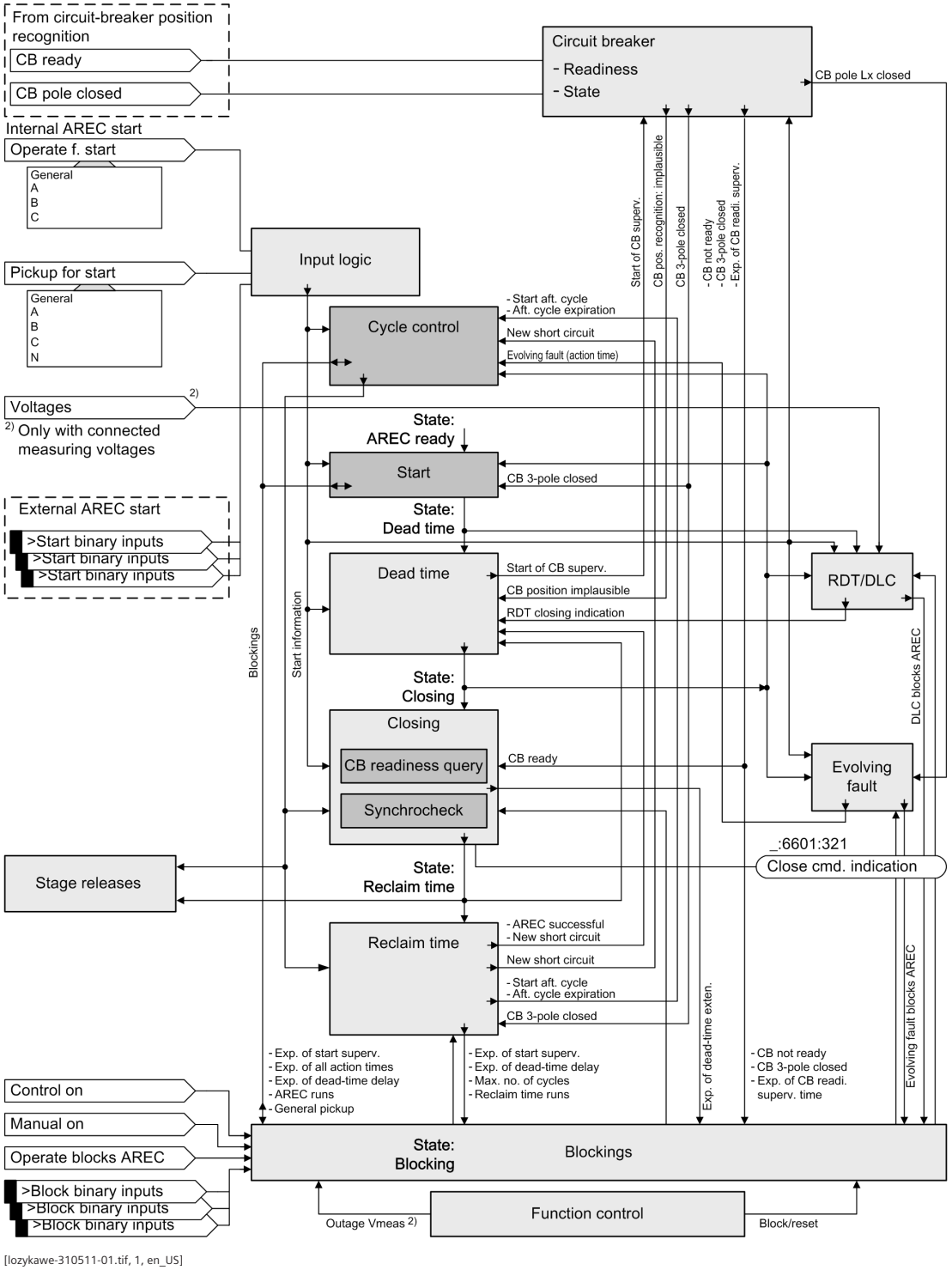
6.43.4.2 Structure of the Cyclic Automatic Reclosing Function

In *Figure 6-277*, the functional structure of the cyclic automatic reclosing function is illustrated as a block diagram. The figure displays the important signals, coming from outside of the cyclic automatic reclosing function, and the most important signals between the individual function blocks.

The automatic reclosing function works as a state machine. From the idle state **AREC ready**, the automatic reclosing function gets through the tripping or pickup indications of the protection functions to the **Dead time** state. After expiration of the dead time, the subsequent state is reached with the closing indication. The reclaim time is also started together with the closing indication. If the reclaim time can expire without further operate or pickup indications, the automatic reclosing is successful and the automatic reclosing function turns back to idle state.

If the automatic reclosing function is restarted during the current reclaim time, there will be either a dynamic blocking or other reclosing cycles will be executed. If other reclosing cycles are possible, there will be a dead time start and the described process starts again.

After the end of a dynamic blocking, the automatic reclosing function switches back to idle state or it goes into the state **Static Blocking** if the blocking condition is permanently present. In the following sections, the individual function blocks are described in detail.



[lozykawe-310511-01.tif, 1, en_US]

Figure 6-277 Cyclic Reclosing Function: Block Diagram of Automatic Reclosing

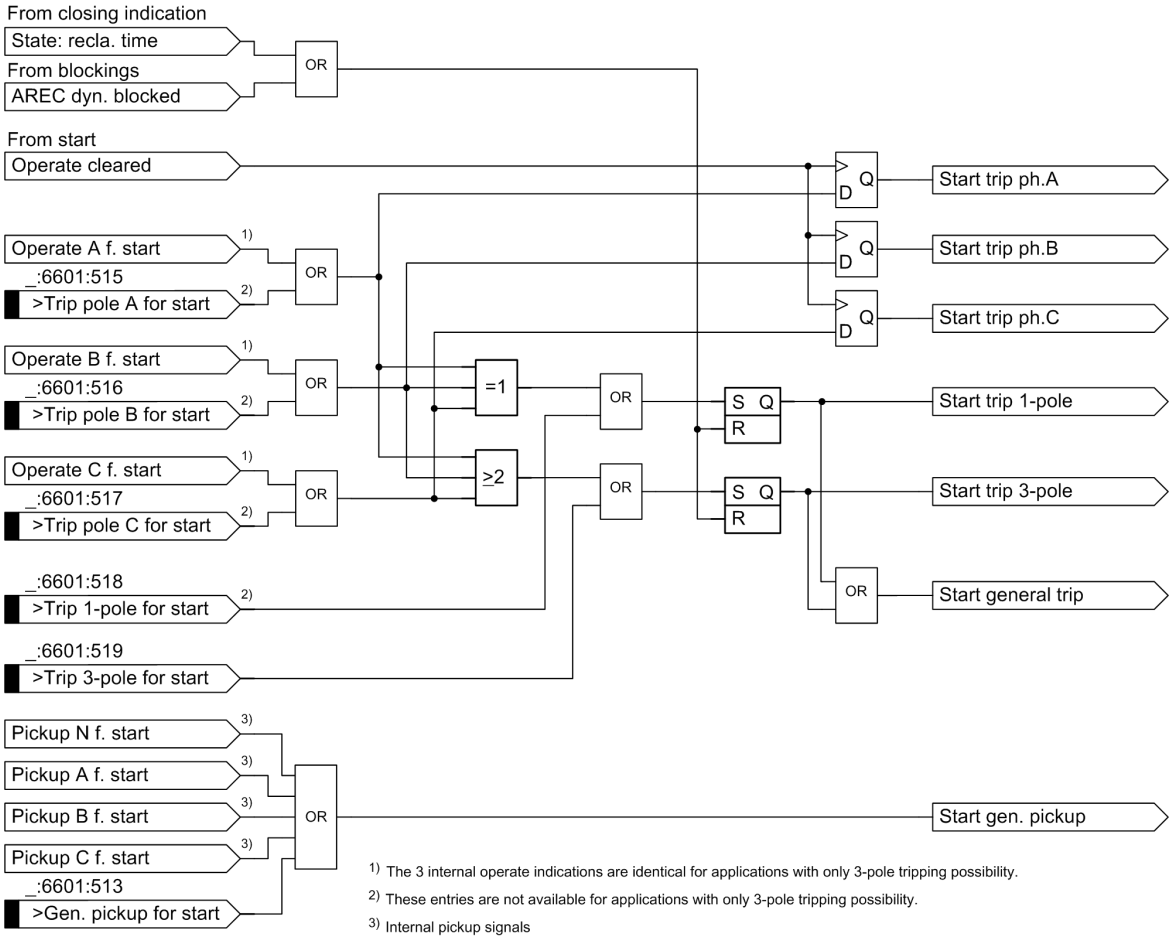
6.43.4.3 Input Logic for Operating Modes with Tripping

The operate indications are used as starting signals. For operating modes **with action time**, the start of the action time(s) occurs with the pickup messages. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

Applications with 3-Pole Tripping

For applications with only 3-pole tripping options, the internal operate indications are always 3-pole. For external starts, there is a binary input, which signalizes a 3-pole tripping of the external protection device.

The outputs of the input logic signalize that the reclosing start has occurred through a 3-pole operate indication.



[lobtaaus-100611-01.tif, 2, en_US]

Figure 6-278 Input Logic for Operating Modes: With Tripping

6.43.4.4 Input Logic for Operating Modes with Pickup

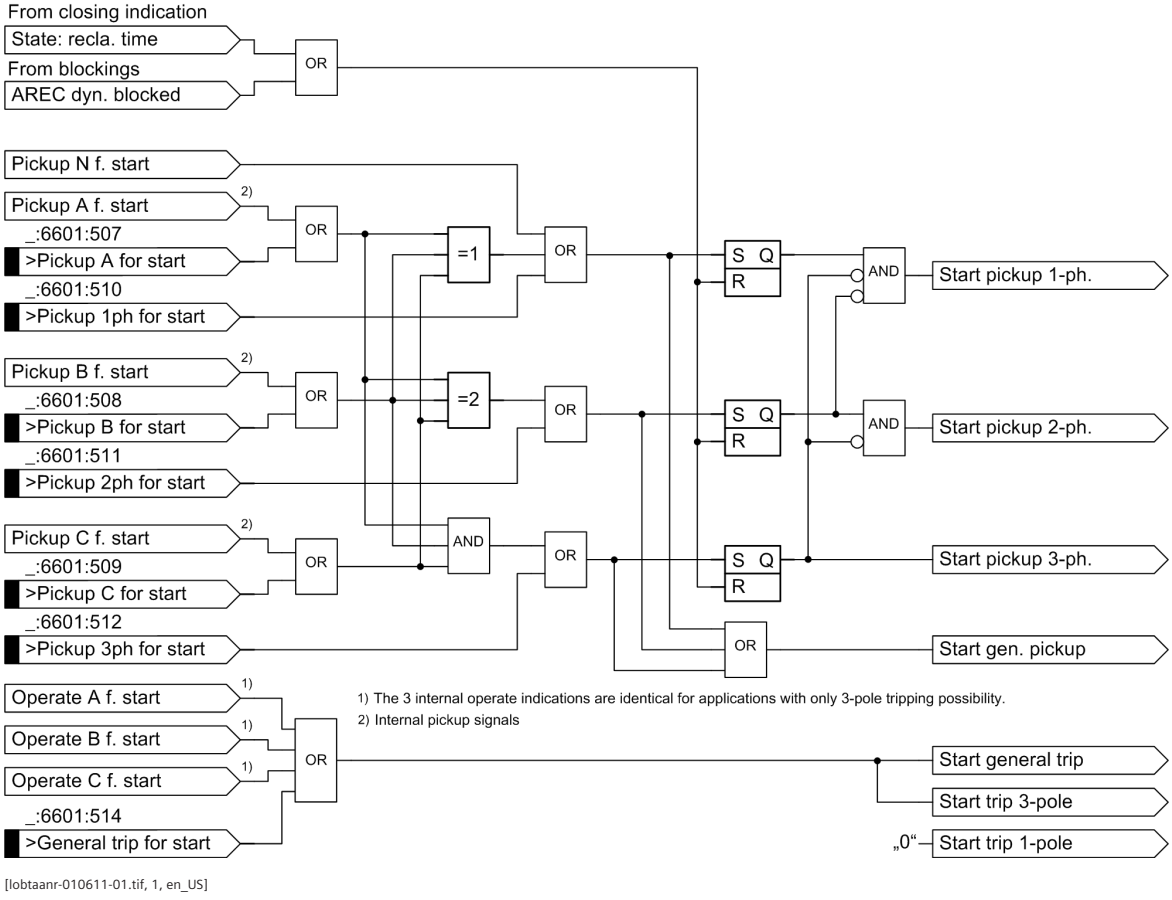
The operate indications and the pickup indications are used as starting signals. The internal pickup indications are processed selective to the phase. Through binary inputs, the pickup information can also be coupled by external protection devices (*>Pickup A for start*, *>Pickup B for start* and *>Pickup C for start*). Optionally, the pickup information can be externally captured as a pickup sample, thus, as a 1-phase, 2-phase and 3-phase pickup.

The outputs of the input logic signalize if the automatic reclosing start occurs through a 1-phase, 2-phase, or 3-phase pickup:

- On **Start with 3-phase pickup**, it is recognized if all 3 phases were picked up in the period from the first raising pickup indication up to the last clearing outgoing pickup indication.
- On **Start with 2-phase pickup**, it is recognized if all 2 phases were picked up in the period from the first raising pickup indication up to the last clearing pickup indication and at no time 3 phases.
- On **Start with 1-phase pickup**, it is recognized if only 1 phase was picked up in the period from the first raising pickup indication up to the last clearing pickup indication.

For operating modes **with action time**, the start of the action time(s) occurs with the pickup indications. During operating modes **with pickup**, the pickup indications affect the selection of the dead times. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

The automatic reclosing operating modes **with pickup** are only ideal for applications with 3-pole tripping. Therefore, the outputs of the input logic always signal 3-pole operate indications.



[lobtaanr-010611-01.tif, 1, en_US]

Figure 6-279 Input Logic for Operating Modes: With Pickup

6.43.4.5 Start

In the **Start** function block, the automatic reclosing function is switched from the idle state **AREC ready** to the state **Dead time**, see *Figure 6-280*. The length of the starting signals is controlled with a supervision time.

Start-Signal Supervision Time

The start-signal supervision stops the automatic reclosing if the short circuit is not switched off within the normal time; for example, in the case of a circuit-breaker failure.

With the first raising operate indication, the start-signal supervision time is initiated, parameter **`Start signal supervis.time`**. The time is stopped as soon as no operate indications are active or if the circuit breaker is recognized as being no longer 3-pole closed.

The automatic reclosing function is blocked if there is an expiration of the start-signal supervision time through a long operate indication. The blocking lasts until the operate indication stops, extended by a further 0.5 s.

Transition to the Dead-Time State

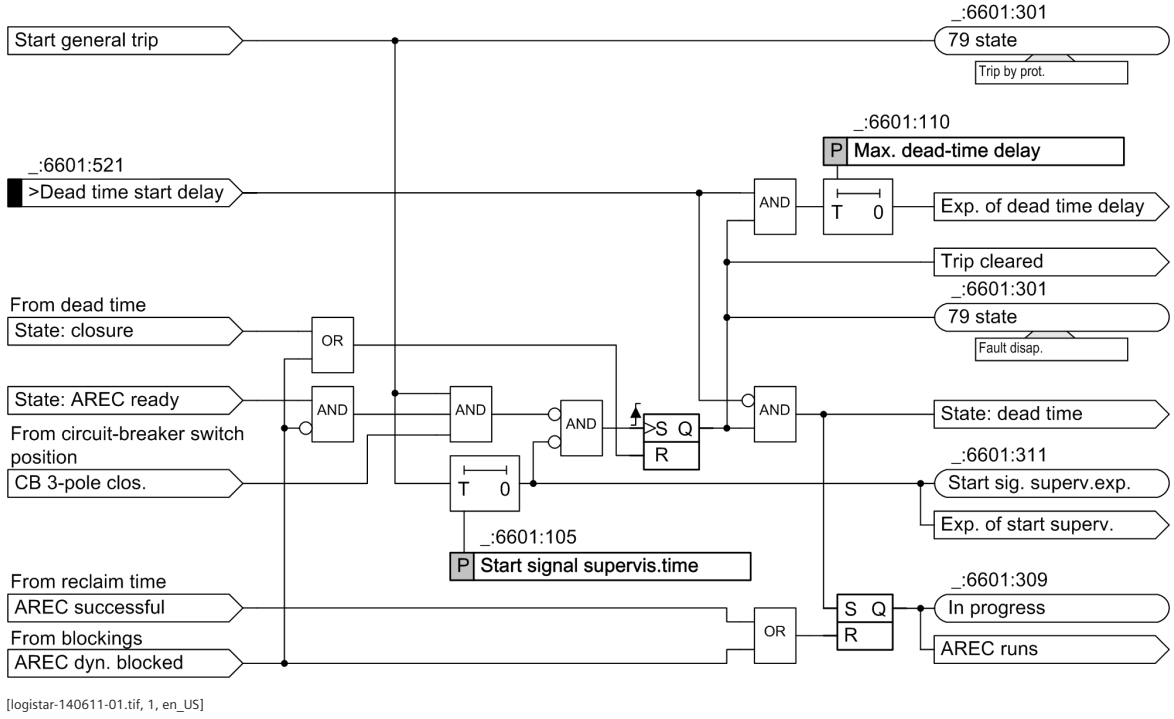
The transition of the automatic reclosing function to the **dead-time** state occurs for:

- Clearing operate indications if none of the signal inputs for operate indications are active
- or if the circuit breaker can no longer be recognized as 3-pole
- and the start-signal supervision time is not expired

Additionally, the following conditions must be fulfilled:

- The circuit breaker signalizes the readiness for automatic reclosing typically through a binary input. If the circuit breaker is not ready, the automatic reclosing function can be statically blocked. In this situation, the automatic closing function is not in idle state **automatic closing function ready**. The control of the circuit-breaker readiness is optional and can be turned off through settings, see also chapter *6.43.4.16 Circuit-Breaker Readiness* and *6.43.4.17 Blockings*.
- The circuit breaker must be closed before the 3-pole trip command. This condition is not considered if the circuit-breaker auxiliary contacts are not connected to the protection device.

You can delay the transition to the **dead time** state through the binary input *>Dead time start delay*. As long the corresponding binary signal is present, the dead time of the automatic reclosing function will not be started. The maximum duration of this binary signal is monitored through a time stage that can be set, parameter **Max. dead-time delay**. Upon expiration of this time stage, that is, if the binary signal is present longer than permitted, the automatic reclosing function will be blocked until the end of the binary signal, additionally extended by another 0.5 s. See also chapter *6.43.4.17 Blockings*.



[logistar-140611-01.tif, 1, en_US]

Figure 6-280 Logic for Function Block Start

6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In *Figure 6-281*, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft. 3-pole trip** to ***invalid*** avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function if the **Dead time**

aft. 1-pole trip [16] is set to ***invalid***. If both dead times are set to ***invalid***, the respective automatic reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (*AR only after 1p. trip*). The approval or switch over of special protection stages only occurs for types of fauts that lead to 1-pole tripping.

Action Time

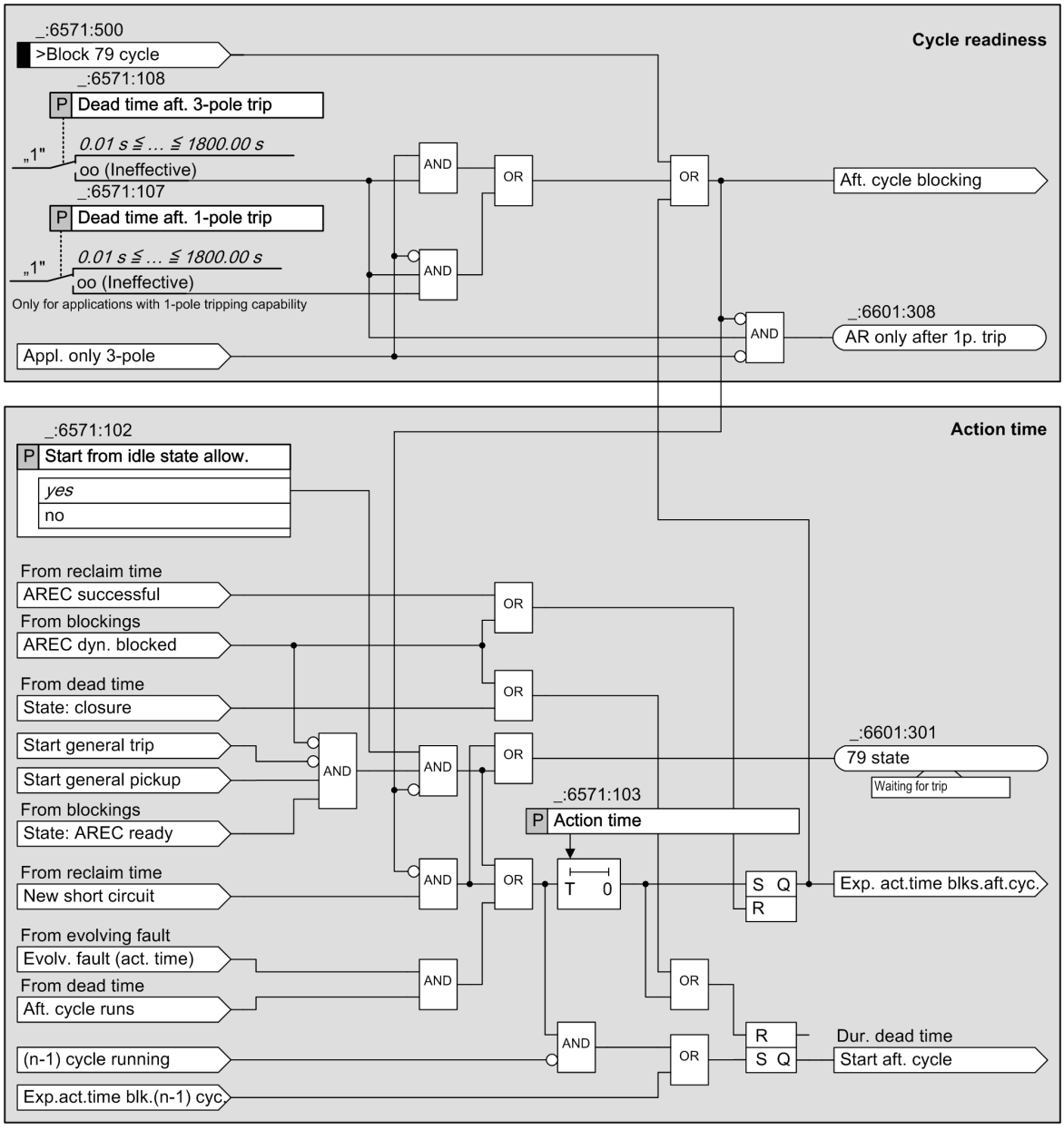
If the automatic reclosing function is in the idle state **automatic reclosing function ready**, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter **Start from idle state allow.** and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.

[16] is not available for devices with only 3-pole tripping



[loauswir-140611-01.tif, 1, en_US]

Figure 6-281 Cycle Control with Operating Mode: With Tripping/With Action Time

6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In *Figure 6-282*, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft.1ph. pickup** to ***invalid*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **Dead time aft.2ph. pickup** and **Dead time aft.3ph. pickup**. If all 3 dead times are set to ***invalid***, the respective reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

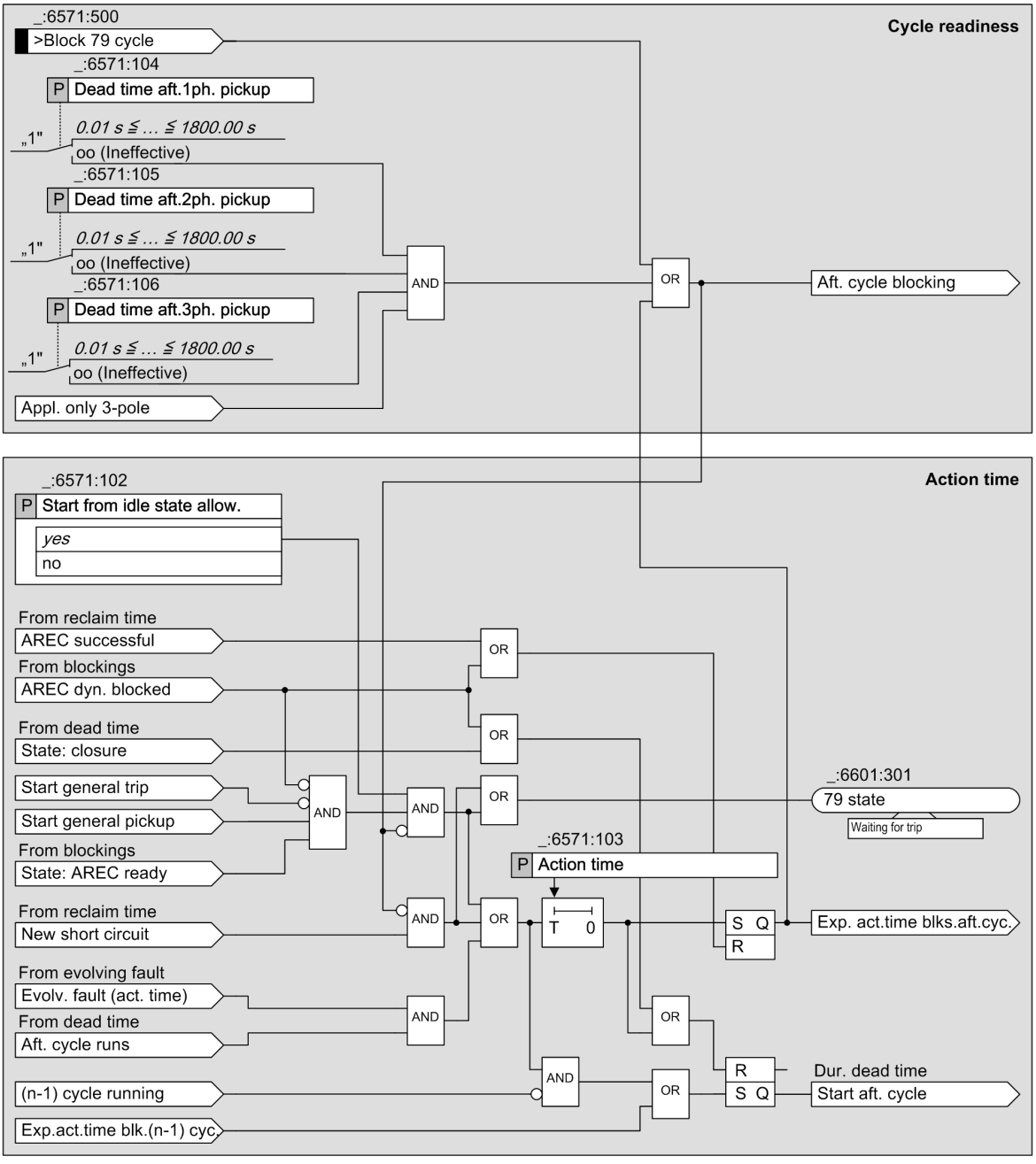
Action Time

If the automatic reclosing function is in the idle state **automatic reclosing function ready**, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter **`Start from idle state allow.`** and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.



[loanrwir-140611-01.tif, 1, en_US]

Figure 6-282 Cycle Control with Operating Mode: With Pickup/With Action Time

6.43.4.8 Cycle Control with Operating Mode 3: With Tripping/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In *Figure 6-283*, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number **n** and apply for all other configured automatic reclosing cycles.

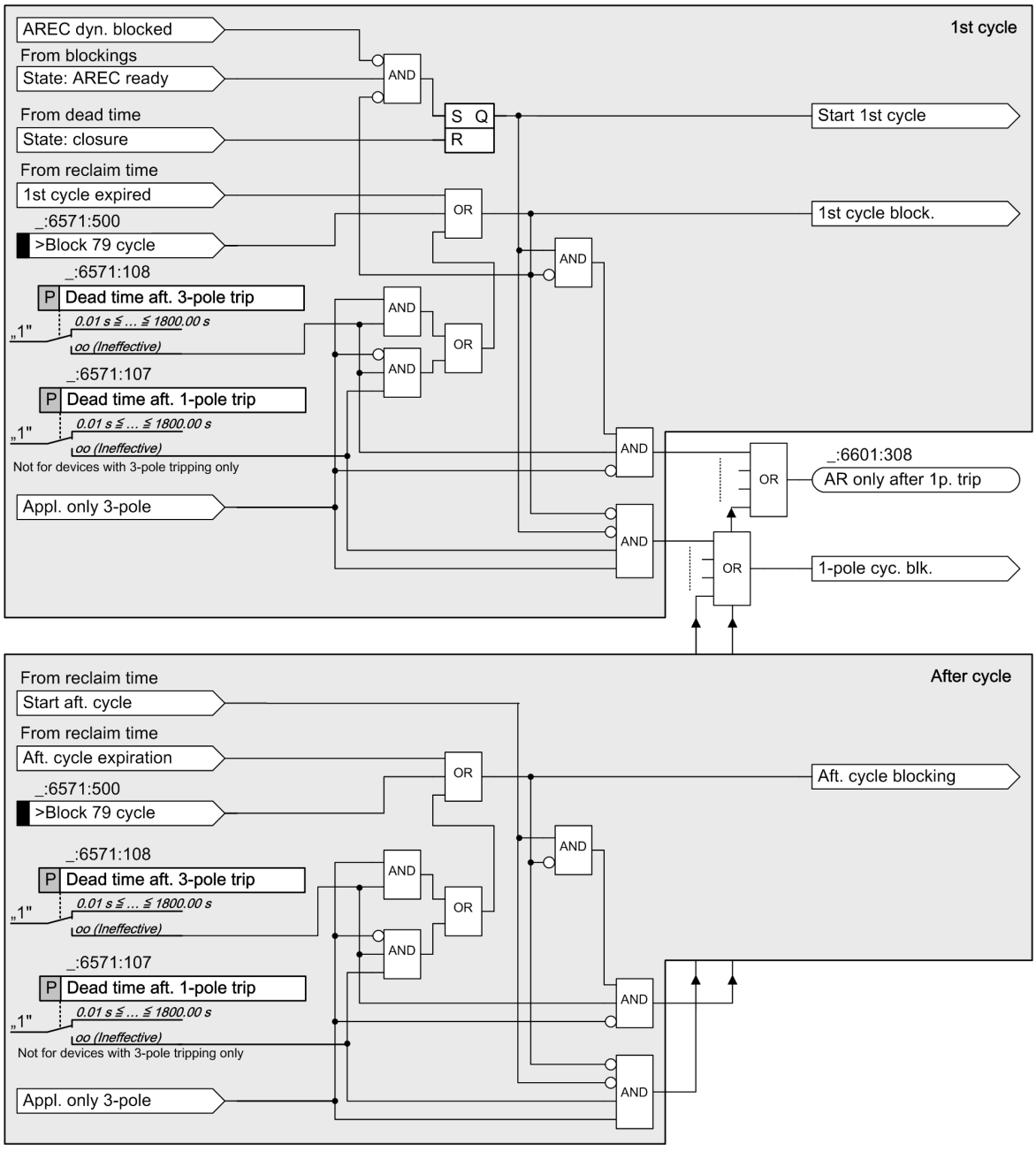
The cycle availability is influenced through the parameterization of the dead time and through a binary input.

In this way, setting the parameter **`Dead time aft. 3-pole trip`** to ***`invalid`*** avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function after 1-pole tripping if the **`Dead time aft. 1-pole trip`** [17] to ***`invalid`***. If both dead times are set to ***`invalid`***, the respec-

[17] is not available for devices with only 3-pole tripping

tive automatic reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (*AR only after 1p. trip*). The approval or switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.



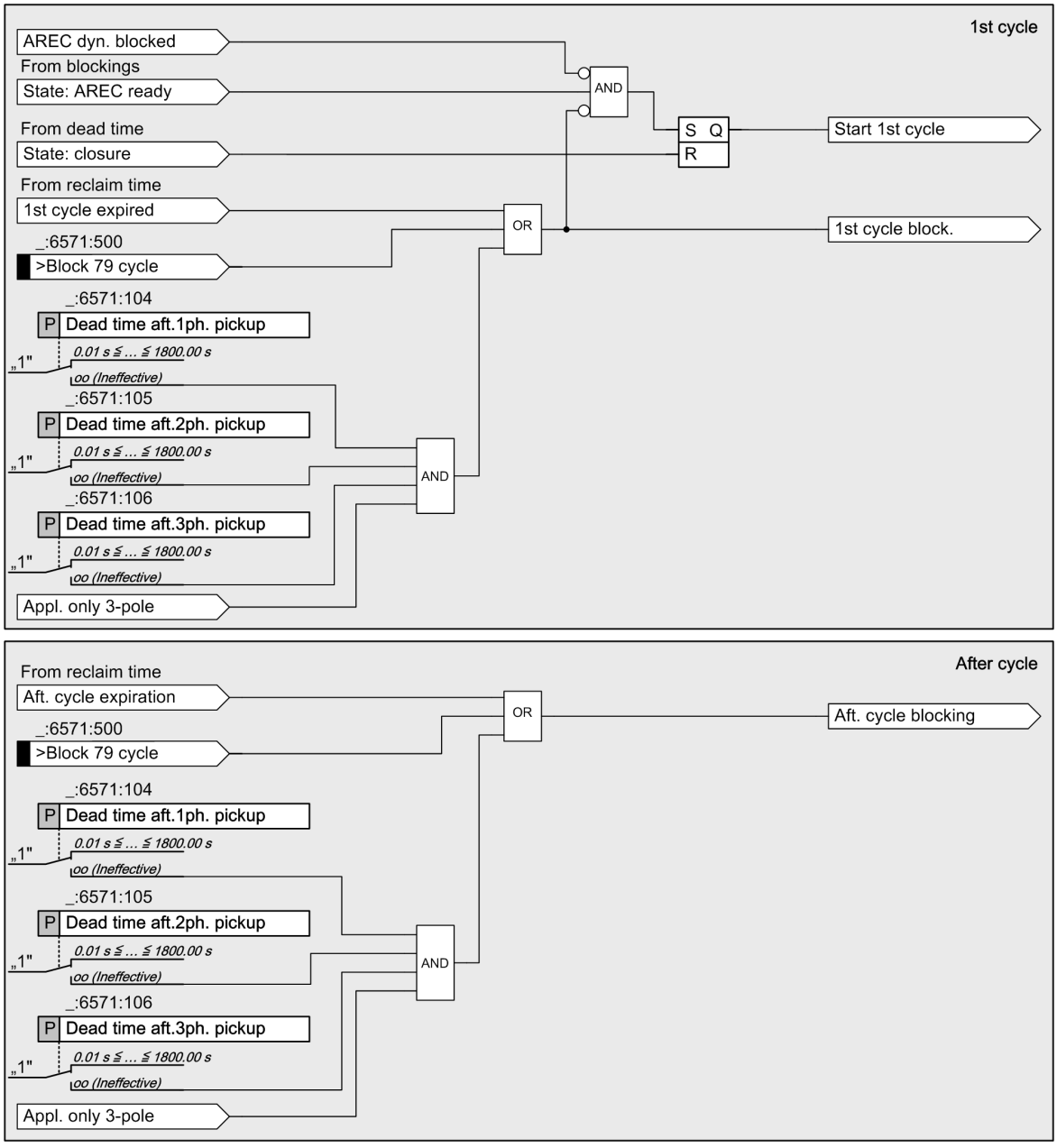
[loauowrk-210311-01.tif, 1, en_US]

Figure 6-283 Cycle Control with Operating Mode: With Tripping/Without Action Time

6.43.4.9 Cycle Control with Operating Mode 4: With Pickup/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In *Figure 6-284*, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number **n** and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft.1ph. pickup** to ***invalid*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **Dead time aft.2ph. pickup** and **Dead time aft.3ph. pickup**. If all 3 dead times are set to ***invalid***, the respective reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.



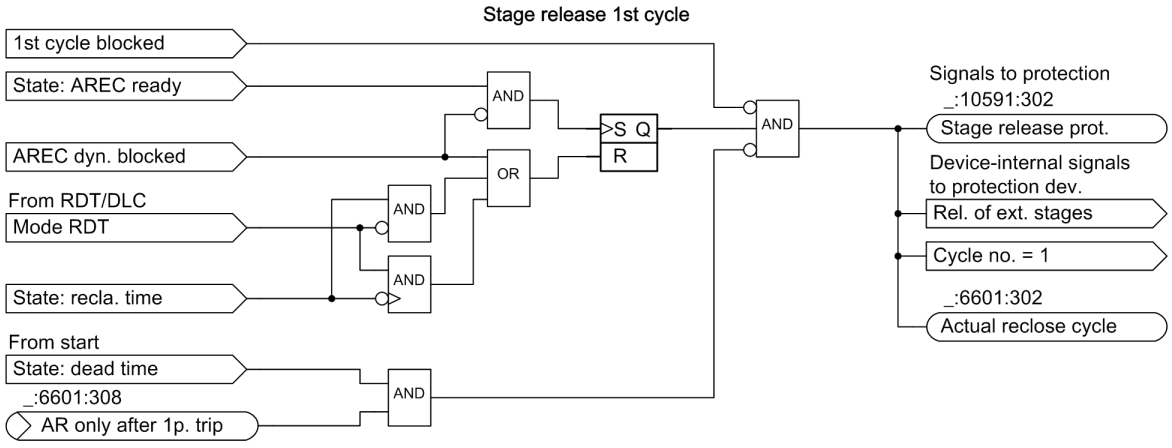
[loanowrk-100611-01.tif, 1, en_US]

Figure 6-284 Cycle Control with Operating Mode: With Pickup/Without Action Time

6.43.4.10 Stage Release

The function block **Stage release** creates output indications for the release or switching over of special stages for protection functions (stage release in the 1st cycle or stage release in the n. cycle). Examples for this are the release of overreaching zones with distance protection and the dynamic adjustment of delays or threshold values with overcurrent protection.

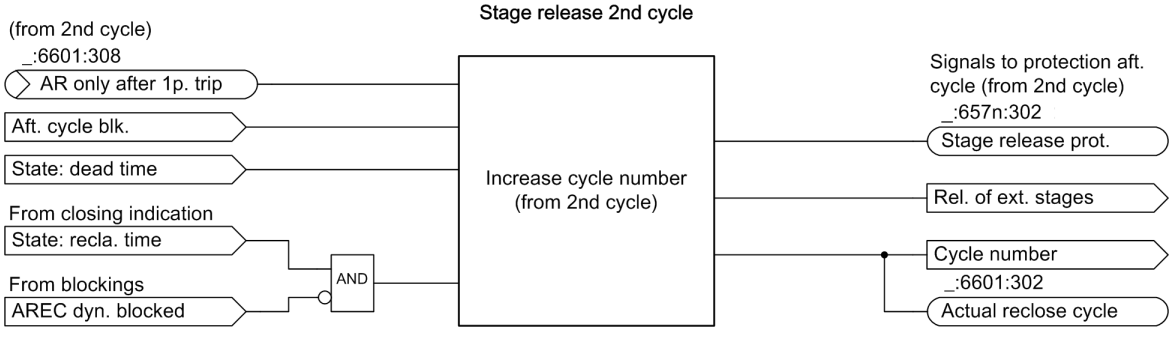
Figure 6-285 shows the tripping stage release for the 1st automatic reclosing cycle. With available automatic reclosing functions, the tripping stage release typically occurs up to the expiration of the dead time. The cycle number in this state is on 1. However, if the automatic reclosing cycle is set only for 1-phase [18], the tripping stage release will be reset to the beginning of the 1-phase dead time. This is necessary, since every additional evolving fault that occurs within the dead time causes a 3-pole cut-off, and subsequently, the automatic reclosing function can no longer take place.



[lo1awezk-170912-01.tif, 1, en_US]

Figure 6-285 Stage Release for Protection Functions in the 1st Automatic Reclosing Cycle

The tripping stage release for higher automatic reclosing cycles is set to the beginning of the reclaim time for rising edge close commands. Simultaneously, the cycle number is increased. The reset condition is identical to the condition for the 1st automatic reclosing cycle. If the reduced dead time (RDT) mode is selected and no additional reduced dead time occurs, the release of the 2nd cycle will be maintained, since it can be assumed that the opposite end is open.



[lo2awezk-170912-01.tif, 1, en_US]

Figure 6-286 Stage Release for Protection Functions Starting With the 2nd Automatic Reclosing Cycle

6.43.4.11 Dead Time for Operating Modes With Tripping

In the **Dead time** function block, that dead time which corresponds with the previous trip command is started. After expiration of the dead time, the automatic reclosing function changes to the status **Switch on**.
Figure 6-287 shows the dead time logic.

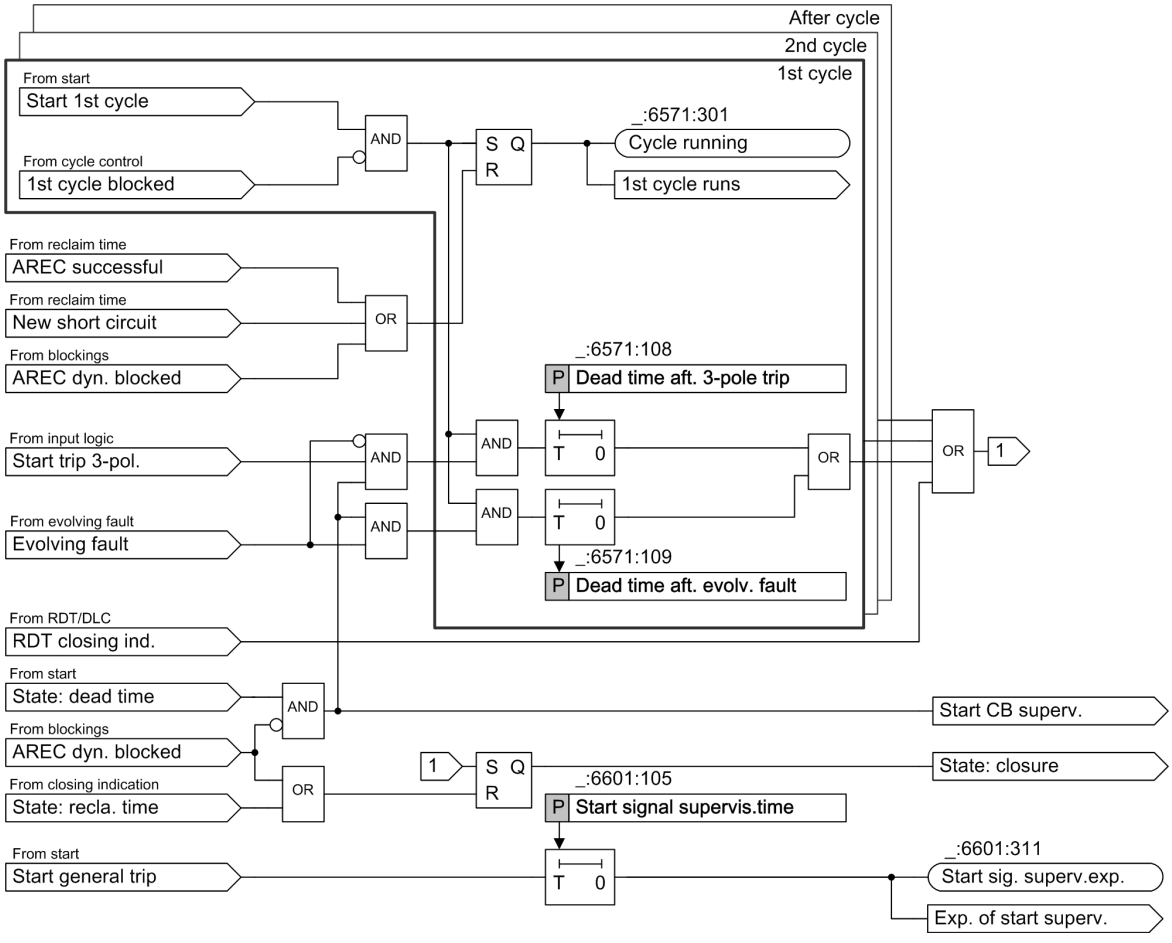
There are the following time stages that can be set differently:

- Dead time after 3-pole tripping
- Dead time after evolving fault

Setting the parameter **`Dead time aft. 3-pole trip`** to ∞ (= invalid) avoids an automatic reclosing after 3-pole tripping.

[18] not for devices with only 3-phase tripping

As soon as an evolving fault is recognized (see chapter *6.43.4.13 Evolving-Fault Detection During Dead Time*), switching to an automatic reclosing cycle for 3-pole interruption occurs. With the 3-pole cut-off of the evolving fault, a separate adjustable dead time for the evolving fault begins. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the first disruption plus the dead time for the evolving fault. With the setting of the parameter **`Dead time aft. evolv. fault`** to ∞ (= invalid), no other automatic reclosing cycle is executed after tripping by the evolving fault. The tripping through evolving faults is then finished.



[lopausjk-021212-01.tif, 1, en_US]

Figure 6-287 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: With Tripping

6.43.4.12 Dead Time for Operating Modes with Pickup

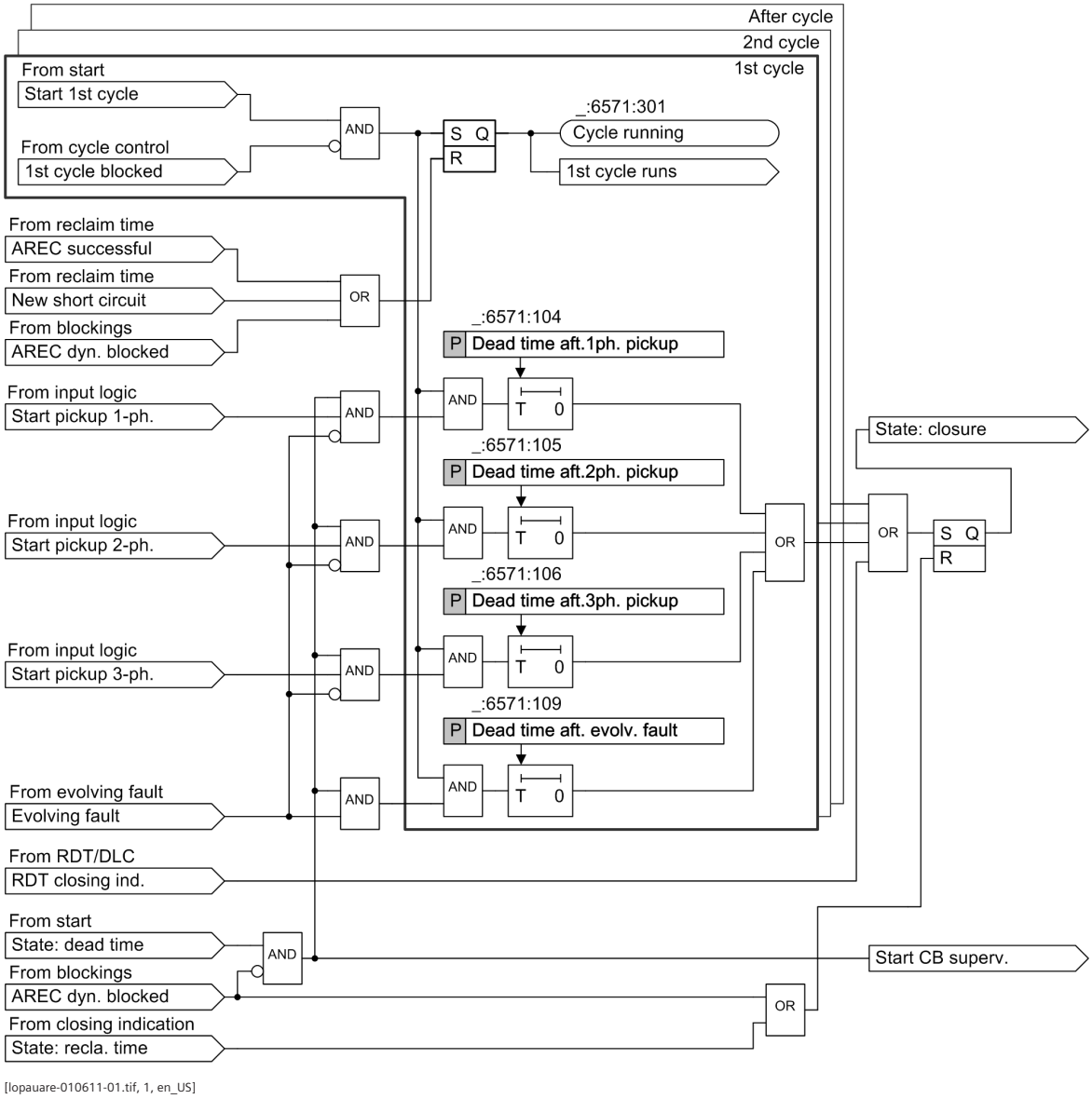
In the **dead time** function block, the dead time corresponding to the type of short circuit that led to the trip command is started. The automatic reclosing operating modes **with pickup** are only ideal for applications with 3-pole tripping. After expiration of the dead time, the automatic reclosing function changes to the status **Switch on**. *Figure 6-288* shows the dead time logic.

There are 4 time stages that can be set differently:

- Dead time after 1-phase short circuits
- Dead time after 2-phase short circuits
- Dead time after 3-phase short circuits
- Dead time for evolving faults

In this way, setting the parameter **`Dead time aft.1ph. pickup`** to ***`invalid`*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **`Dead time aft.2ph. pickup`** and **`Dead time aft.3ph. pickup`** .

As soon as an evolving fault is recognized (see chapter *6.43.4.13 Evolving-Fault Detection During Dead Time*), a separate dead time for faults begins with the stopping of the fault. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the 1st disruption plus the dead time for the evolving fault. With the setting of the **`Dead time aft. evolv. fault`** to ***invalid***, no other automatic reclosing cycle is executed after tripping through the evolving fault. The tripping through evolving faults is then finished.



[lopauare-010611-01.tif, 1, en_US]

Figure 6-288 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: With Pickup

6.43.4.13 Evolving-Fault Detection During Dead Time

Evolving faults are short circuits, which occur after switching off a short circuit during dead time. This may be the case during 1-pole tripping and there is a short circuit in the non-switched conductors after this.

After 3-pole tripping there may also be evolving faults if the line is fed through a second (non-3-pole) opened circuit breaker, for example, for systems with a 1 1/2 circuit breaker layout.

The evolving-fault detection is divided into components:

- Detection of Evolving Faults
- Evolving-Faults Processing
- 3-pole circuit-breaker intertripping during evolving faults

The procedure during evolving faults is illustrated in *Figure 6-289*.

Detection of Evolving Faults

For the detection of an evolving fault, the following criteria can be selected through parameters:

- Parameter **Evolving-fault detection** = ***with trip***

  For this setting, **any tripping** during the dead time leads to evolving-fault detection. At **any tripping** it is decided if an internal protection function is tripped or if the tripping is signaled through a binary input. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not.

- Parameter **Evolving-fault detection** = ***with pickup***

  Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is recognized through a binary input.

- Binary input *>Evolving fault start*

  The evolving-fault detection can also be introduced through a binary input without an internal protection pickup being available.

Reaction to Evolving Faults

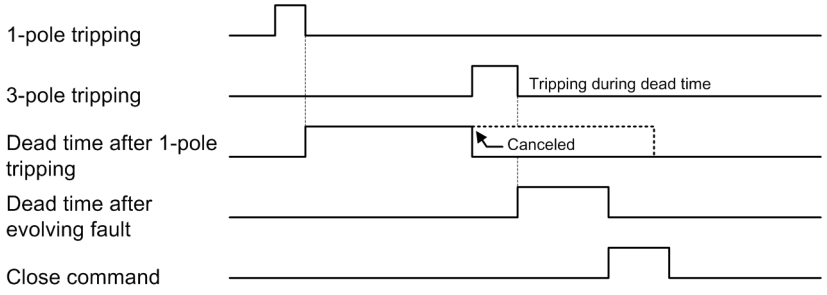
After a recognized evolving fault, the automatic reclosing function can be influenced in 2 ways.

- Parameter **Response to evolv. faults** = ***blocks 79***

  As soon as an evolving fault is recognized, the reclosing function will be blocked. There are no other reclosing attempts and the automatic reclosing function is blocked until the pickup and operate indications causing the evolving fault disappear.

- Parameter **Response to evolv. faults** = ***strt. evol.flt.dead time***

  As soon as an evolving fault is recognized, an automatic reclosing cycle for 3-pole interruption is switched to. The automatic reclosing function does not allow any 1-pole tripping until the fault is solved or there is a final switch off; thus, every following trip command will be 3-pole. When the evolving fault is fixed, the separate dead time for faults will start, see also chapter **Dead time**. The further process is as by 3-pole cycles.

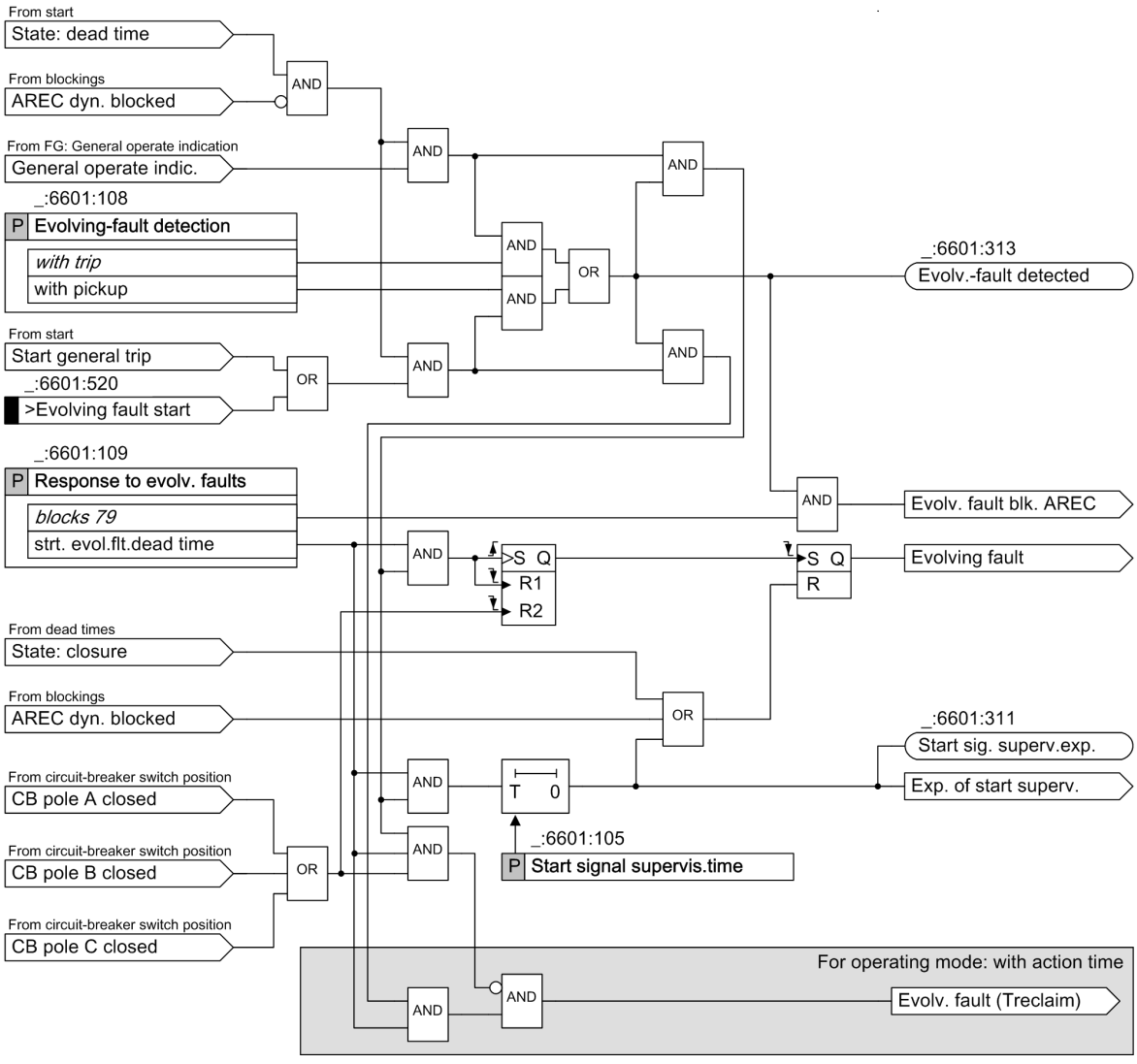


[dwbspffe-100611-01.tif, 1, en_US]

Figure 6-289 Cyclic Automatic Reclosing Function - Example for an Evolving Fault

For tripping through evolving faults, the entire dead time consists of the part of the dead time expired until disconnecting the evolving fault for the 1-pole interruption plus the dead time for the fault together, see *Figure 6-290*.

The dead time for evolving faults is started with the return of the operate indication or with the opening of all 3 circuit-breaker poles, provided the circuit-breaker auxiliary contacts are connected.



[lofolsjk-021212-01.tif, 1, en_US]

Figure 6-290 Cyclic Automatic Reclosing Function - Logic of Evolving-Fault Detection

6.43.4.14 Closing Indication and Close Command

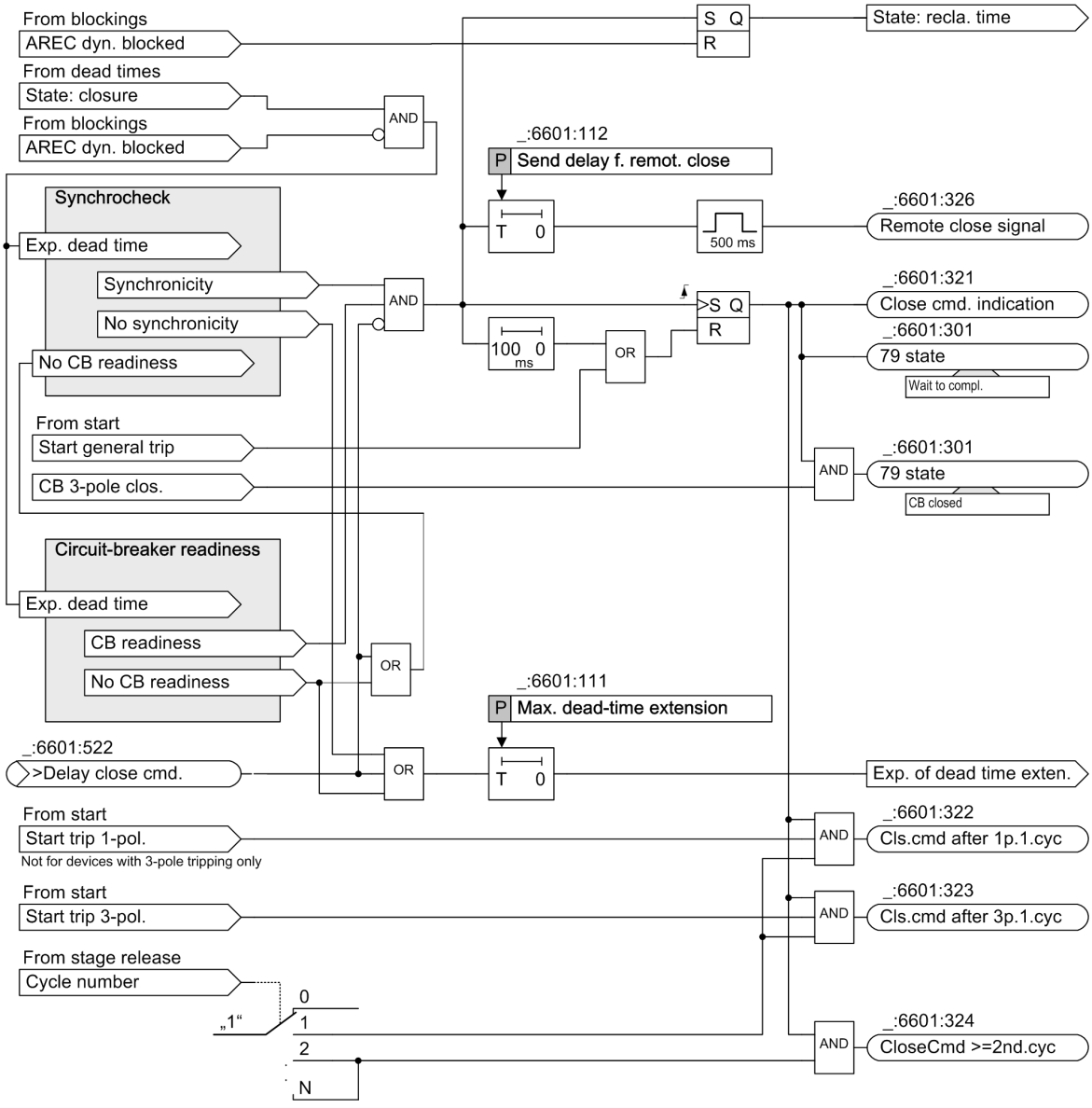
After the expiration of the dead time, the Automatic reclosing function will be in the **closing** state.

The **closing** state can depend on the following influences, see *Figure 6-291*:

- through a synchrocheck if the circuit breaker was opened during the 3-pole dead time
- Through the readiness of the circuit breaker signaled through the binary input
- Through a binary input for delaying the close command (*>Delay close cmd.*)

The *Close cmd. indication* is a requirement for the assignment of the actual close command to the circuit breaker.

The mentioned criteria must not be fulfilled directly after expiration of the dead time. If a dead-time prolongation is set, the mentioned criteria will be checked during the prolongation. With the release of the closing indication, the automatic reclosing function will switch to the **reclaim time** state.

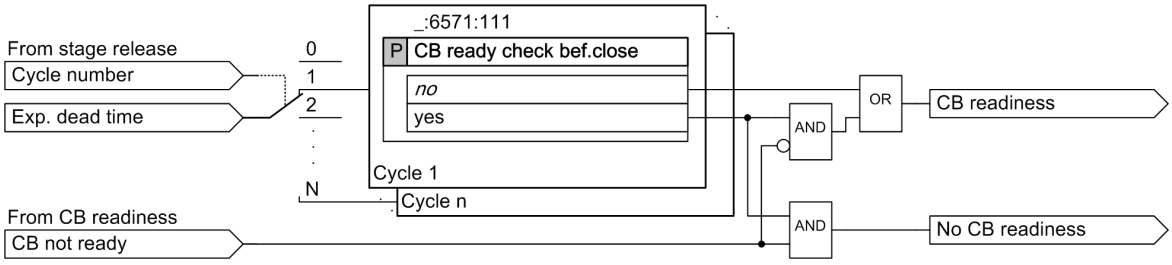


[loeinsha-141111-01.tif, 1, en_US]

Figure 6-291 Cyclic Reclosing Function: Logic for the Closing Indication

Testing the Circuit-Breaker Readiness Directly before Closing

For each of the automatic reclosing cycles, you can set if a test of the circuit-breaker readiness should occur directly before closing (parameters **`CB ready check bef.close`**, *Figure 6-292*). Independent of this, a test of the circuit-breaker readiness before the start of the 1st automatic reclosing cycle can be set, see Chapter *6.43.4.5 Start* and chapter *6.43.4.16 Circuit-Breaker Readiness* .



[lolsvoei-130511-01.tif, 1, en_US]

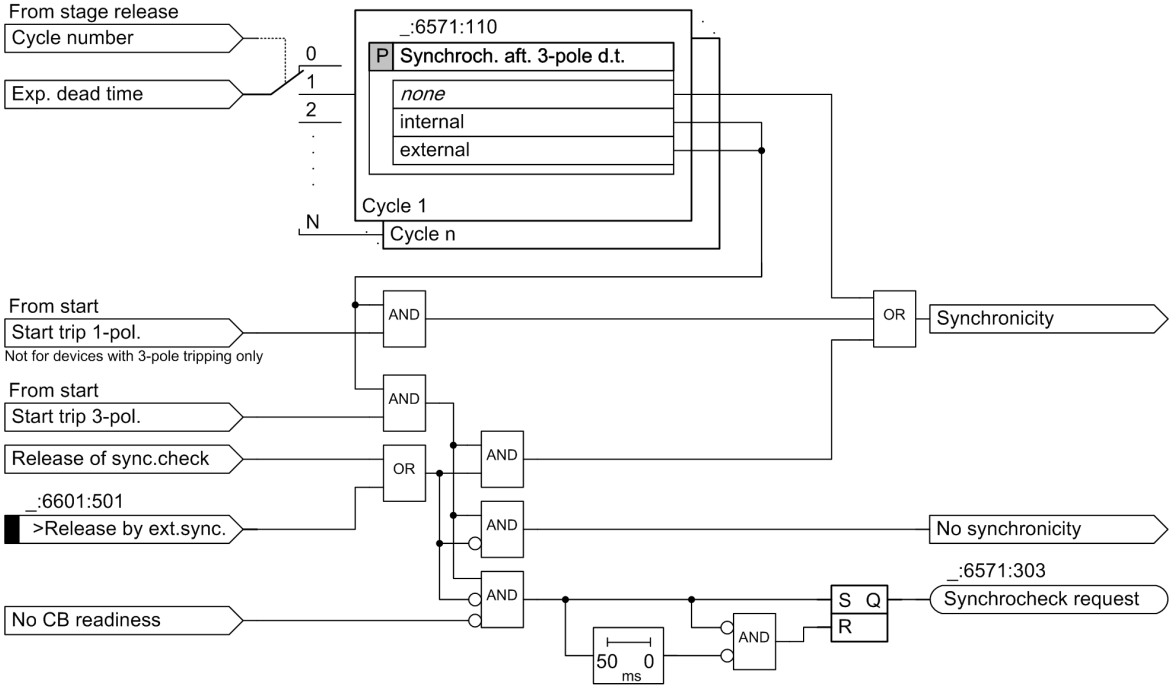
Figure 6-292 Cyclic Reclosing Function: Logic for the Query of the Circuit-Breaker Readiness Directly before Closing

Synchrocheck

For each of the configured automatic reclosing cycles, you can set if a synchrocheck should be executed and which functionality should be used here, see *Figure 6-293*. You may only use the internal synchrocheck if the device is connected to a voltage transformer.

Alternatively, you can also connect an external device with synchrocheck through a binary input.

The measuring request for the synchrocheck is placed if the optional test of the circuit-breaker readiness was positive. The measuring request for the synchrocheck exists until the synchrocheck assigns the allowance for the closure. If the allowance is not given within the set maximum dead time extension, the closure will be cancelled through the blocking of the automatic reclosing function. The minimum duration of the measuring request is 50 ms.



[losyncro-130511-01.tif, 1, en_US]

Figure 6-293 Cyclic Reclosing Function: Logic for the Inquiry of the Synchronism

Close Command

As soon as the test of the circuit-breaker readiness and the synchrocheck deliver a positive result, the closing indication will be created. It will be assigned for 100 ms. The actual close command is not created by the automatic reclosing function, but rather from the circuit-breaker function block outside of the automatic reclosing function. Here the set maximum duration of the close command is also considered.

In addition to the closing indication, additional indications will be created that describe the type of closure. These include:

- Close command after 3-pole tripping in the first cycle (*Cls.cmd after 3p.1.cyc*)
- Close command after 1-pole or 3-pole tripping starting with the second cycle (*CloseCmd >=2nd.cyc*)

Creation of the Signal Remote close signal

The cyclic automatic reclosing function can create information *Remote close signal*. This information can be transferred to the protection device as a binary signal on the line that is to be protected on the opposite end. From the reclosing function, it can be processed in the operating mode **adaptive dead time (ASP)**. Furthermore, the binary signal may be arranged as data for transmission via an existing protection interface.

The information *Remote close signal* is created by the closing logic. It can be delayed by a set time over the local close indication. With this delay, you can make sure that information is only set if the automatic reclosing was successful and there was no further tripping. The pulse duration of the inter-close signal has a fixed length of 500 ms.

6.43.4.15 Reclaim Time

With the assignment of the close command, the automatic reclosing function goes into the **reclaim time** state. During this time, it is decided if the current reclosing cycle was successful or not.

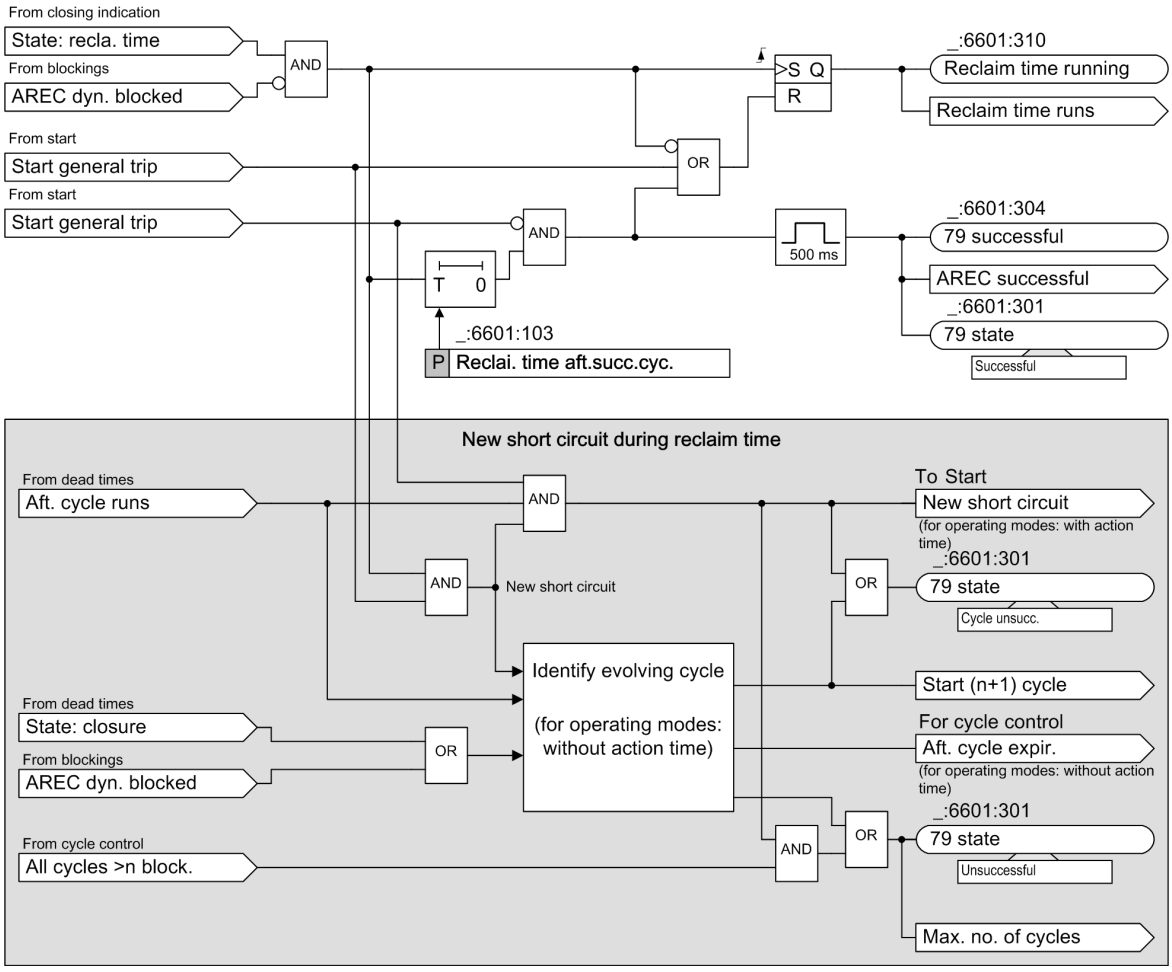
- If during the reclaim time no further tripping occurs, the currently running automatic reclosing cycle, and thus the entire automatic reclosing, was successful.
- If during the reclaim time another tripping occurred, the currently running automatic reclosing cycle was not successful. If other automatic reclosing cycles are permitted, one of these cycles will be used to continue the process. If, in contrast, the currently executed cycle was the last permissible cycle, the automatic reclosing process will end and be reported as unsuccessful.

In both cases, the automatic reclosing function switches back to the idle state **automatic reclosing function ready**.

Short Circuits during Running Reclaim Time

A trip command that occurs during a reclaim time leads to a cancellation of the reclaim time. If further automatic reclosing cycles are allowed, the regulation of the cycle depends on if the automatic reclosing function is executed in an operating mode **with action times** or **without action times**, see *Figure 6-294*.

- With operating modes **with action time**, the action times of all higher cycles are started with the beginning of the new general pickup if these are not blocked. The cycle with the lowest cycle number is selected, whose action time is not yet expired with the incoming trip indication. If no further cycles are possible or if the action times of all possible cycles are expired before the operate indication, there will be no further reclosing.
- With the operating modes **without action time**, the cycle following the current cycle will always be selected in the set cycle. If this is blocked, the cycle following this one will be selected, etc. If no higher cycles exist or if they are all blocked, there will be no further automatic reclosing.



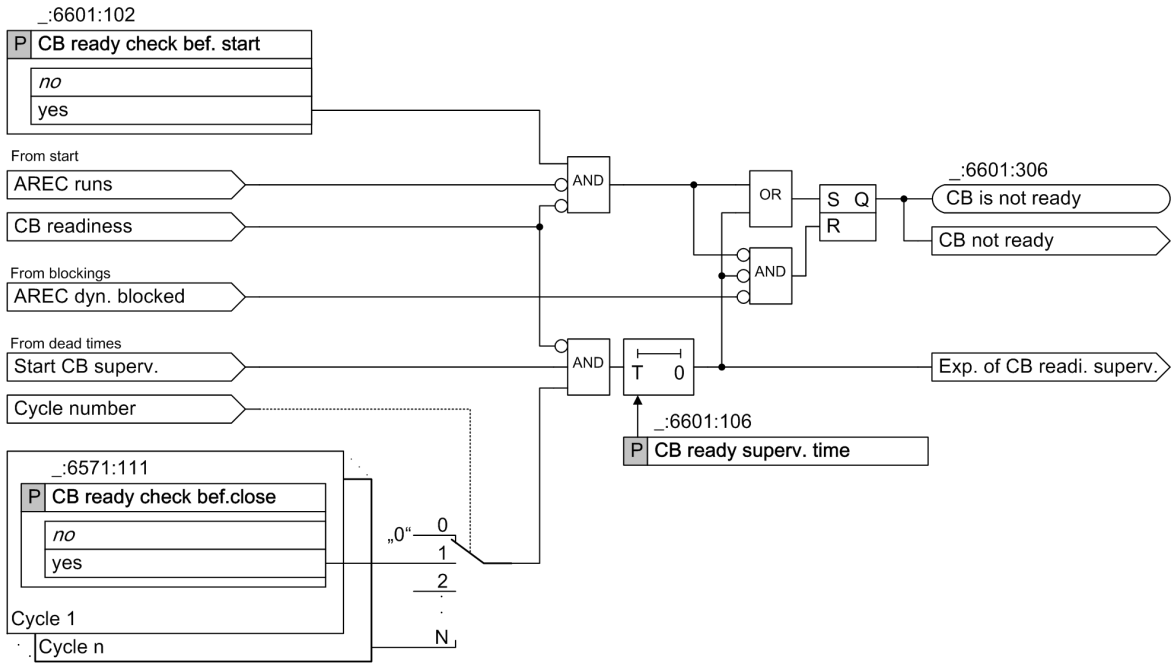
[losperre-140611-01.tif, 1, en_US]

Figure 6-294 Cyclic Reclosing Function: Logic for the reclaim time

6.43.4.16 Circuit-Breaker Readiness

The automatic reclosing function requires the readiness of the circuit breaker for the following purposes, see *Figure 6-295*:

- Recognition of the circuit-breaker readiness from the beginning:
  In idle state of the automatic reclosing function, an unavailable circuit breaker leads to the blocking of the automatic reclosing function. This monitoring is optional and must be switched off through settings if the readiness signal is not available for the protection device.
- Analysis of the circuit-breaker readiness directly before the close command:
  For each of the configured automatic reclosing cycles, it can be set whether the circuit-breaker readiness is a requirement for the assignment of the close command. This monitoring is also optional.



[lolsbere-130511-01.tif, 1, en_US]

Figure 6-295 Cyclic Reclosing Function: Logic for the Circuit-Breaker Readiness

6.43.4.17 Blockings

The Automatic reclosing function differentiates between 2 types of blockings, see *Figure 6-296*:

- Static blocking
- Dynamic blocking

Static Blocking

The Automatic reclosing function is statically blocked if the function is switched on, but is not ready for reclosing and also cannot be started as long as this blocking is present. The dynamic blocking is signaled with the indication *Inactive*.

The following conditions lead to the static blocking:

Condition	Indication
Manual closing of the circuit breaker, recognition through binary input or internal device control. The blocking is temporary, the duration can be set with the parameter **Block. time aft. man.close**.	Inactive
Circuit breaker not available for automatic reclosing function, recognition through binary input. This cause can be switched on or off through the parameter **CB ready check bef.close**.	Inactive
Circuit breaker of non-closed 3-pole, recognition through binary input. This criteria is used if the circuit-breaker auxiliary contacts are connected.	Inactive

Condition	Indication
No reclosing cycle possible Recognition due to the following causes: • Automatic reclosing cycle is not set. • Automatic reclosing cycles are set, but all are blocked, for example, via binary input. • There is no internal device function and no binary input configured for starting the automatic reclosing function. • With operating modes **with tripping**: – both 1-pole and 3-pole cycles are blocked via binary inputs • With operating modes **with pickup**: – 1-phase, 2-phase and 3-phase automatic reclosing cycles, the blocking is done through binary inputs. • With operating modes **without action time**: – the first automatic reclosing cycle is blocked via binary input. • With the **dead-line check** functionality: – if the voltage measurement is not available or is disrupted.	Inactive

Dynamic Blocking

The automatic reclosing function is **blocked dynamically** if a blocking condition occurs while an automatic reclosing function is running. The dynamic blocking is signalized with the indication *Not ready*.

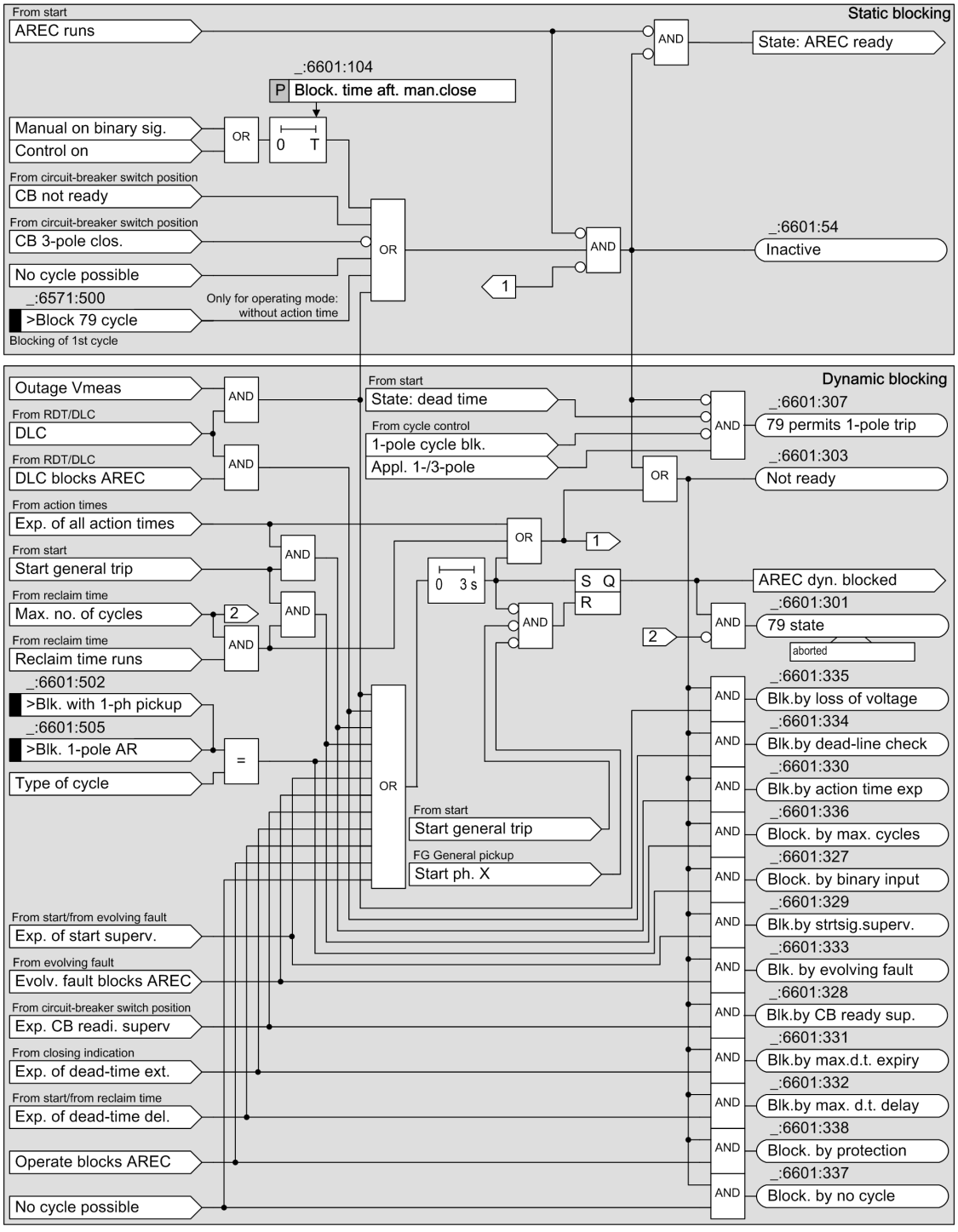
After the occurrence of a dynamic blocking, it is checked in intervals of 0.5 s to see if the blocking can be removed. If the blocking condition remains or if a different blocking condition occurs in the meantime, the blocking will remain. If, in contrast, the cause of the blocking disappears, the dynamic blocking will be removed if no general pickup or no tripping configured for the automatic reclosing function start is available.

A separate indication for logging exists for each individual blocking cause.

The following conditions lead to the dynamic blocking:

Condition	Indication
If no reclosing cycle fitting the fault type is released: • With operating modes **with tripping**: If a 1-pole or 3-pole operate indication occurs during the automatic reclosing function start input, however, the automatic reclosing function does not start in accordance with the parameterization for this type of tripping, the respective dead time will be set to ***invalid***. • With operating modes **with pickup**: If a 1-phase, 2-phase or 3-phase pickup indication occurs during the automatic reclosing function starting process, but the automatic reclosing function may not be started in accordance with the parameterization for this type of pickup.	*Not ready* Block. by no cycle
If a protection function causes the automatic reclosing function to be blocked in accordance with the configuration	*Not ready* Block. by protection
If the maximum set waiting time for the delay of the start of the dead time through the binary input *>Dead time start delay* expires without the binary input becoming inactive during this time lapse	*Not ready* Blk.by max. d.t. delay
If the synchrocheck is set and the synchronism conditions after the expiration of the maximum dead-time prolongation are not fulfilled before the assignment of the close command	*Not ready* *Blk.by max.d.t. expiry*

Condition	Indication
If the inquiry of the circuit-breaker readiness is switched on directly before the close command through the parameter and the maximum dead-time prolongation expires	*Not ready* *Blk.by CB ready sup.* *Blk.by max.d.t. expiry*
If the closing indication is delayed through the binary input *>Delay close cmd.* for so long until the maximum dead time extension is exceeded before the assignment of the close command	*Not ready* *Blk.by max.d.t. expiry*
If an evolving fault occurs and the parameter **Response to evolv. faults** is set to ***blocks 79***	*Not ready* *Blk. by evolving fault*
If the start-signal supervision time for the operate indication starting from the automatic reclosing function or the starting binary input expires. In this case, a circuit-breaker failure is assumed.	*Not ready* *Blk.by strtsig.superv.*
If after the start of the automatic reclosing function a dead time is already running and a blocking binary input is active, with the following binary inputs: *>Blk. 1-pole AR*, *>Blk. 3-pole AR*, *>Blk. with 1-ph pickup*, *>Blk. with 2-ph pickup*, >Blk. with 3-ph pickup	*Not ready* *Block. by binary input*
If the maximum number of automatic reclosing attempts is reached and there is a trip command within the reclaim time	*Not ready* *Block. by max. cycles*
With operating modes **with action time**: If the action times of all released automatic reclosing cycles expire without a trip command	*Not ready* *Blk.by action time exp*
For applications with voltage measurement and switched on functionalities with **dead-line check**: If during the dead time the required voltage criteria is not fulfilled	*Not ready* *Blk.by dead-line check*
For applications with voltage measurement and switched on functionalities with **dead-line check**: If during a running automatic reclosing cycle a failure of the measuring voltage is determined. After the completion of the automatic reclosing cycle, the dynamic blocking becomes static blocking if there is a continued failure of the measuring voltage.	*Not ready* *Blk.by loss of voltage*



[lobloawe-100611-01.tif, 3, en_US]

Figure 6-296 Cyclic Reclosing Function: Blocking Logic in the Example for a 1-Pole Cycle (Static and Dynamic Blocking)

6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)

The additional functions **Dead-line check (DLC)** and **Reduced dead time (RDT)**, are only possible for applications with a voltage-transformer connection. Another requirement is that the voltage of the line being switched on can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line-side - seen from the circuit breaker.

Both additional functions DLC and RDT are mutually exclusive, because the DLC checks if the value falls below a voltage threshold, while the RDT checks if the value exceeds the voltage threshold.

The respectively selected additional function runs in the automatic reclosing state **dead time**.

Reduced Dead Time (RDT)

With the **Reduced dead time**, a close command can be assigned before the expiration of the set dead times if the line to switch on is recognized as fault-free through the measurement of the line voltage.

The voltage measurement occurs with the 3 phase-to-phase-voltages.

In systems with a grounded neutral point, the 3 phase-to-ground voltages are additionally observed.

In systems with compensated or with isolated neutral points, the largest 2 of the 3 phase-to-ground voltages are additionally considered. Through this, a RDT can also be executed with 1-phase ground connections.

For the approval of the close command with RDT, the following conditions apply:

- The automatic reclosing function is in the state **dead time**.
- Each measured voltage is above the set threshold values **`Volt. thres.f. live line/bus`**

  The phase-to-phase voltages are divided by √3 prior to comparing the threshold value. Thus, the phase-to-ground voltage $U_N\sqrt{3}$ applies as the reference size for the parameterization.
- Exceeding the threshold is fulfilled for the set duration **`Voltage supervision time`**.

Dead-Line Check (DLC)

If after switching off a short-circuit the voltage on the switched off line does not disappear, the automatic reclosing function can be avoided with the **dead-line check (DLC)**.

The voltage measurement occurs with the 3 phase-to-ground voltages.

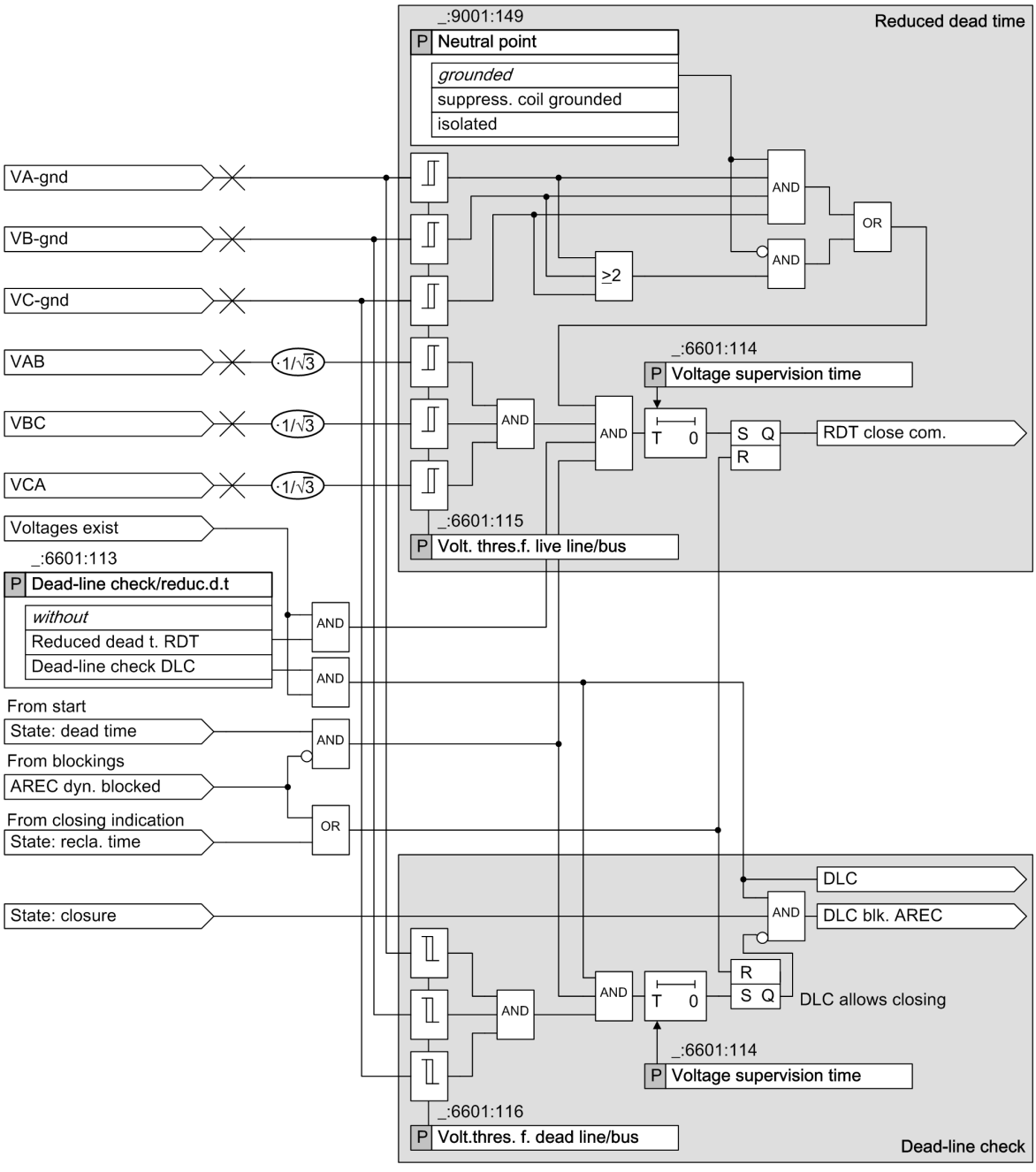
For the release of the close command with DLC, the following conditions apply:

- The automatic reclosing function is in the state **dead time**.
- All measured voltages for the set duration **`Voltage supervision time`** are below the set threshold **`Volt. thres.f. live line/bus`**.
- The set dead time is expired.

As soon as the voltages fall below the threshold value for the set duration, the allowance for automatic reclosing with DLC is assigned. This also applies if the values are not below the voltage threshold until the expiration of the set dead time. In this way, an automatic reclosing is executed if the automatic reclosing function is first switched to at the end of the protected line and thus, the line is exposed to voltage again.

The automatic reclosing function is blocked by the DLC under the following conditions:

- The automatic reclosing function is in the **Closure** state, the dead time has expired
- All measured voltages were not simultaneously below the set threshold values **`Volt.thres. f. dead line/bus`** for the set duration **`Voltage supervision time`** during the dead time.



[lovrkarc-130511-01.tif, 1, en_US]

Figure 6-297 Cyclic Reclosing Function: Logic for the Functions of Reduced Dead Time and Dead-Line Check

6.43.4.19 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time

Addr.	Parameter	C	Setting Options	Default Setting
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:108	General:Evolving-fault detection		• with trip • with pickup	with trip
_:6601:109	General:Response to evolv. faults		• strt. evol.flt.dead time • blocks 79	blocks 79
_:6601:110	General:Max. dead-time delay		0.01 s to 300.00 s	0.50 s
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:112	General:Send delay f. remot. close		0.00 s to 300.00 s; ∞	∞
DLC, RDT				
_:6601:113	General:Dead-line check/ reduc.d.t		• without • Reduced dead t. RDT • Dead-line check DLC	without
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
_:6601:116	General:Volt.thres. f. dead line/bus		0.300 V to 340.000 V	30.000 V
Cycle 1				
_:6571:102	Cycle 1:Start from idle state allow.		• no • yes	yes
_:6571:103	Cycle 1:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6571:108	Cycle 1:Dead time aft. 3-pole trip		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:107	Cycle 1:Dead time aft. 1-pole trip		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:104	Cycle 1:Dead time aft. 1ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:105	Cycle 1:Dead time aft. 2ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:106	Cycle 1:Dead time aft. 3ph. pickup		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:109	Cycle 1:Dead time aft. evolv. fault		0.01 s to 1800.00 s	1.20 s
_:6571:111	Cycle 1:CB ready check bef.close		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:6571:110	Cycle 1:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6571:112	Cycle 1:Intern. synchro-check with		Setting options depend on configuration	

6.43.4.20 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:520	General:>Evolving fault start	SPS	I
_:6601:521	General:>Dead time start delay	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O

No.	Information	Data Class (Type)	Type
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:313	General:Evolv.-fault detected	SPS	O
_:6601:314	General:RDT CloseCmd indicat.	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:320	General:Dead t. aft.evolv.flt.	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:324	General:CloseCmd >=2nd.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:326	General:Remote close signal	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:332	General:Blk.by max. d.t. delay	SPS	O
_:6601:333	General:Blk. by evolving fault	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:334	General:Blk.by dead-line check	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
_:6601:341	General:Cyc2+ 1p AR	INS	O
_:6601:342	General:Cyc2+ 3p AR	INS	O
Cycle 1			
_:6571:51	Cycle 1:Mode (controllable)	ENC	C
_:6571:500	Cycle 1:>Block 79 cycle	SPS	I
_:6571:52	Cycle 1:Behavior	ENS	O
_:6571:53	Cycle 1:Health	ENS	O
_:6571:301	Cycle 1:Cycle running	SPS	O
_:6571:302	Cycle 1:Stage release prot.	SPS	O
_:6571:303	Cycle 1:Synchrocheck request	SPS	O

6.43.5 Automatic Reclosing Function with Adaptive Dead Time (ADT)

6.43.5.1 Description

Considering the cyclic automatic reclosing function, it is assumed that defined and similar dead times were set at both line ends and, if applicable, they are set for different types of faults and/or disruption cycles.

It is also possible to set the dead times only at one line end and to configure the adaptive dead time at the other end or ends. The requirements for this is that the voltage transformer aligned on the line side or a possibility to transfer a close command to a remote line end exists.

Figure 6-298 shows an example with a voltage measurement. It is assumed that device I works with defined dead times, while the adaptive dead time is configured in device II. It is important that the line is at least fed from the busbar A, so from the side with the defined dead times.

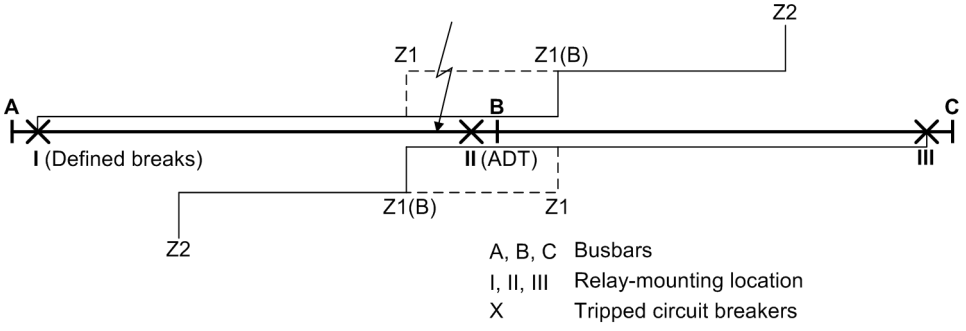
With the adaptive dead time, the automatic reclosing function at the line end II decides independently if and when a reclosing is reasonable and permissible and when it is not. The criteria is the voltage of the line at the end II, which is switched through after reclosing from end I. The reclosing at end II occurs, as soon as it exists, so that the line from end I is set back under voltage. Basically, all phase-to-phase and phase-to-ground voltages are monitored.

With an implied short-circuit, the lines at the positions I, II, and III in the example are switched off. Position I is switched on again after the dead time set there. At position III the reduced dead time (RDT) can be executed with the appropriate configuration (see chapter *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)*) if an infeed is also available on busbar B.

If the short circuit has been cleared after successful reclosing, the line A-B from the busbar A will be set under voltage through the position I. Device II recognizes this voltage and switches on to warrant adequate voltage measurement time after a short delay The system incident is thus successfully cleared.

If the short circuit is not cleared after closure at position I, I will be switched to the fault again. At line end II, now no healthy voltage will appear. The device here recognizes this and does not close again.

With multiple reclosing, the process may repeat if the reclosing is unsuccessful until one of the reclosings is successful or a final closing occurs.



[dwarcasp-100611-01.tif, 1, en_US]

Figure 6-298 Example for Adaptive Dead Time (ADT)

As the example shows, the adaptive dead time brings along the following advantages:

- The circuit breaker at position II does not switch off again with a remaining fault and is protected through this.
- With a non-selective tripping through flashing over to position III, no more disruption cycles may exist here, because the short-circuit path through busbar B and the position II remains disrupted even with multiple reclosing.
- At position I, with multiple reclosing and even with a final tripping, an overlapping is allowed, because the line at position II remains open and thus, no actual overreaching can occur at position I.

The adaptive dead time also contains the reduced dead time (VWE), because the criteria are the same. A special setting of the reduced dead time (VWE) is unnecessary if the automatic reclosing function is used with adaptive dead time (ASP).

6.43.5.2 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
ADT				
_:6631:101	ADT:1-pole trip allowed		• no • yes	no
_:6631:104	ADT:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6631:105	ADT:Maximum dead time		0.50 s to 3000.00 s	5.00 s
_:6631:102	ADT:CB ready check bef.close		• no • yes	no
_:6631:103	ADT:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6631:106	ADT:Intern. synchrocheck with		Setting options depend on configuration	

6.43.5.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I

No.	Information	Data Class (Type)	Type
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:312	General:Max. dead time expired	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O

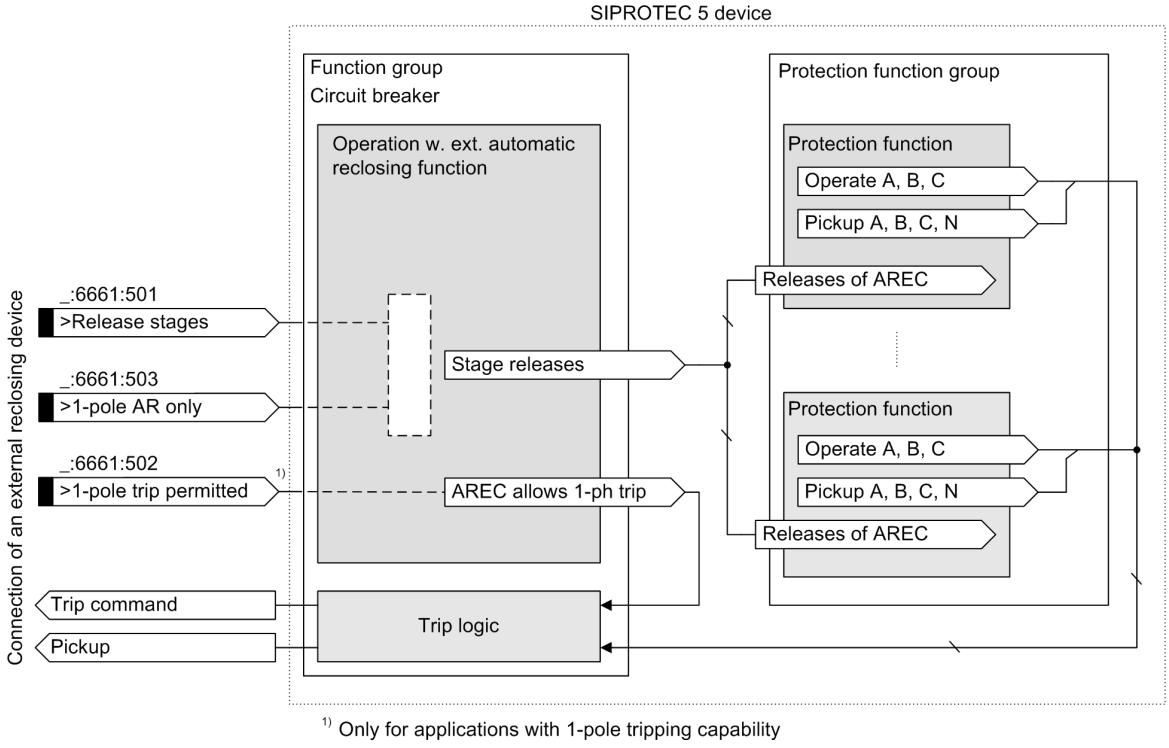
No.	Information	Data Class (Type)	Type
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
ADT			
_:6631:51	ADT:Mode (controllable)	ENC	C
_:6631:501	ADT:>Remote close signal	SPS	I
_:6631:52	ADT:Behavior	ENS	O
_:6631:53	ADT:Health	ENS	O
_:6631:301	ADT:ADT is running	SPS	O
_:6631:302	ADT:Stage release prot.	SPS	O
_:6631:303	ADT:Synchrocheck request	SPS	O

6.43.6 Cooperation with External Automatic Reclosing Function

6.43.6.1 Description

The operation of an external reclosing device with the SIPROTEC protection device occurs through the function mode **Operation with external automatic reclosing function**. In this function mode, the SIPROTEC protection functions create the trip command and the external reclosing device creates the close command.

The following figure shows the interaction of an external reclosing device with the functions of the SIPROTEC 5 device.



[loaweext-140212-01.tif, 1, en_US]

Figure 6-299 Connection of an External Automatic Reclosing Function

There are no setting parameters for operation with external automatic reclosing functions. The function provides exclusively the following described binary inputs. The external reclosing device can thus have an influence on the effects of the internal protection functions.

The following connection possibilities exist:

- From the external reclosing function, the signal *>Release stages* can be coupled so that the protection functions use special stages or zones for release. An example is the release of an overreaching zone with a distance protection or the non-delayed tripping of an overcurrent protection stage in the 1st reclosing cycle.
- For applications with 1-pole tripping, the external reclosing can provide the signal *>1-pole trip permitted*, based on which the protection functions can switch off the 1-pole circuit breaker.
- For applications with reclosing functions only with 1-pole faults and stage or zone releases through the reclosing function can the signal *>1-pole AR only* be connected. The protection functions use this information to allow the stage or zone release only affect 1-pole faults.

6.43.6.2 Information List

No.	Information	Data Class (Type)	Type
Ext			
_:6661:51	Ext:Mode (controllable)		C
_:6661:501	Ext:>Release stages		I
_:6661:502	Ext:>1-pole trip permitted		I
_:6661:503	Ext:>1-pole AR only		I
_:6661:52	Ext:Behavior		O
_:6661:53	Ext:Health		O
_:6661:54	Ext:Inactive		O

6.43.7 Application and Setting Notes for General Settings

For the automatic reclosing function, there are 3 functions available in the function library. In each circuit-breaker function group, a function from the automatic reclosing function can be used.

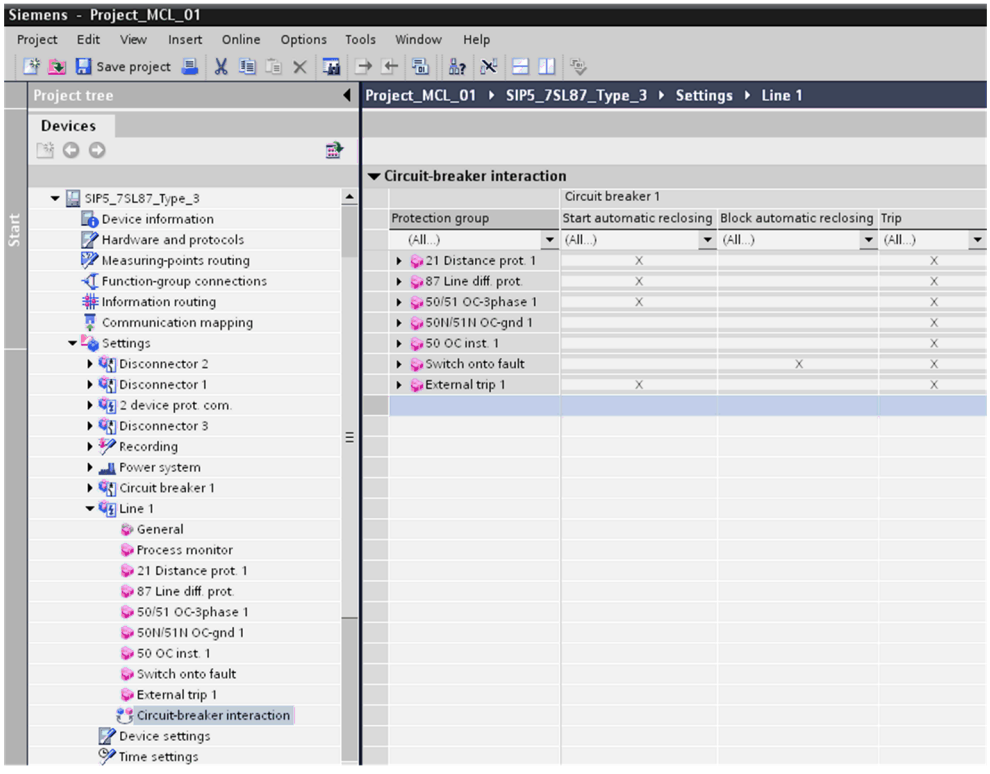
Configure one of the 3 following function specifications:

- Cyclic Automatic reclosing function
- Automatic reclosing function with adaptive dead time (ADT)
- Operation with External Automatic Reclosing Function

Starting the Automatic Reclosing Function

The configuration of the interaction between internal protection functions and the automatic reclosing function can be set separately for each protection function. The configuration occurs in a matrix view in DIGSI. The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

Configure the starting and blocking condition for the automatic reclosing function at the position shown in *Figure 6-300* in DIGSI (for example, a protection function group **Line** is shown here) or route the corresponding binary inputs.



[scdigsia-080311-01.tif, 1, en_US]

Figure 6-300 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI

General Settings

If you use the **Cyclic automatic reclosing function** or **Automatic reclosing function with adaptive dead time** function, set the following settings under **General**.

There are no settings for the function **Operation with external automatic reclosing function**. The control occurs exclusively through binary inputs and binary outputs.

Parameter: 79 operating mode

- Default setting **(_:6601:101) 79 operating mode** = ***with op., with act. time***

You can use the **79 operating mode** parameter to determine which start criteria the automatic reclosing function works with.

Parameter Value	Description
with op., with act. time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s). The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. Siemens generally recommends this setting for applications with 1/3-pole tripping and for applications with 3-pole tripping if a single dead time, independent of the type of connection working, is required in the automatic reclosing function cycle. Detailed information can be found in Chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating mode 1**
w.pickup, w. action time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s) and the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. For applications with 3-pole tripping and dead time dependent on the circuit type, Siemens recommends this setting. Detailed information can be found in the chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 2**
with op., w/o act. time	Each operate indication starts the automatic reclosing function. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 3**
w.pickup, w/o act. time	Each operate indication starts the automatic reclosing function. The automatic reclosing function cycles are dependent on the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 4**

Parameter: CB ready check bef. start

- Default setting **(_:6601:102) CB ready check bef. start** = ***no***

With the **CB ready check bef. start** parameter, you can determine if the readiness of the circuit breaker should be tested **before starting** the automatic reclosing function.

Additionally or alternatively, it is possible to check the readiness of the circuit breaker after the expiration of the dead time, directly before the assignment of the close command. There is another parameter described in the chapter *6.43.8 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function* for this function.

Parameter Value	Description
yes	The automatic reclosing function checks the readiness of the circuit breaker for a switching cycle, consisting of a tripping-reclosing-switching. If the circuit breaker is ready - signaled through a binary input - the startup of the automatic reclosing function can occur. If the circuit breaker is not ready, the automatic reclosing function reports the static blocking. Siemens recommends using this setting. **Note:** The presetting of this parameter does not correspond with the recommended setting for operation. The automatic reclosing function would otherwise be blocked with a non-available circuit breaker-ready-signal. Please set the parameter as recommended.
no	The readiness of the circuit breaker is not checked before starting the automatic reclosing function. The test also does not occur if the readiness signal from the circuit breaker is connected to a binary input on the device.

Parameter: Reclai. time aft.succ.cyc.

- Default setting **(_:6601:103) Reclai. time aft.succ.cyc.** = ***3.00 s***

With the **Reclai. time aft.succ.cyc.** parameter, set the time used to decide if the currently running reclosing cycle was successful or not. Detailed information about the function of the reclaim time can be found in the chapter *6.43.4.15 Reclaim Time* .

The presetting for the reclaim time can be frequently maintained. In regions where thunderstorms and storms often occur, a shorter reclaim time makes sense in order to minimize the danger of the final disconnection due to sequential lightning strikes or cable spark over.

Select a long reclaim time if there is no possibility for circuit-breaker supervision with multiple automatic reclosing, for example, due to missing auxiliary contacts or lacking circuit-breaker-ready-information. In this case, the reclaim time must be longer than the recovery time of the circuit breaker.

Parameter: Block. time aft. man.close

- Default setting **(_:6601:104) Block. time aft. man.close** = ***1.00 s***

With the **Block. time aft. man.close** parameter, the time is determined for which the automatic reclosing should be blocked after a manual connection.

Set the time so that the circuit breaker can be safely switched on and off during connection to a short circuit without the automatic reclosing function being automatically closed.

Parameter: Start signal supervis.time

- Default setting **(_:6601:105) Start signal supervis.time** = ***0.25 s***

With the **Start signal supervis.time** parameter, set the maximum time after which a circuit breaker must be opened after a trip command. If the time expires, a failure of the circuit breaker is assumed and the automatic reclosing function is dynamically blocked.

Detailed information about the function of the start supervision time can be found in the chapter *6.43.4.5 Start* .



NOTE

With the use of an internal or external circuit-breaker failure protection at the same line branch, observe the following:

The start supervision time should be the same as the circuit-breaker failure protection time delay. With this, you can make sure that in the case of a circuit-breaker failure followed by the tripping of the busbar, no automatic reclosing will be executed.

(Note: An exception to this recommendation is described below.)

Parameter: CB ready superv. time

The setting of this parameter is only important if the cycle-specific parameter **CB ready check bef.close** is set to ***yes*** . Otherwise, this parameter has no effect.

- Default setting **(_:6601:106) CB ready superv. time** = ***3.00 s***

With the **CB ready superv. time** parameter, you can determine after which maximum time after the tripping the circuit breaker must be ready for the reclosing function.

Set the time somewhat longer than the regeneration time of the circuit breaker after an OFF-ON-OFF cycle.

Detailed information about the function can be found in Chapters *6.43.4.16 Circuit-Breaker Readiness* and *6.43.4.14 Closing Indication and Close Command* .

Parameter: Evolving-fault detection

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:108) Evolving-fault detection** = ***with trip***

With the **Evolving-fault detection** parameter, you can determine which criteria is used to recognize an evolving fault. The actual effect of the recognized evolving fault on the automatic reclosing function can be set with the parameter described below **Response to evolv. faults** .

Evolving faults are short circuits, which occur after switching off a short circuit during dead time.

You can find detailed information about evolving-fault detection in the chapter *6.43.4.13 Evolving-Fault Detection During Dead Time* .

Parameter Value	Description
with trip	Evolving faults are recognized if an operate indication occurs during the dead time. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not. The pickup of a protection function without an operate indication does not lead to evolving-fault detection.
with pickup	Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is detected through a binary input.

For applications with 1-/3-pole tripping, Siemens recommends the setting ***with trip*** if the system is adequately interconnected.

If multiple individual lines in a row form a total transmission path, the setting ***with pickup*** may be better suitable. With this setting, you can prevent 2 lines following each other from switching to 1-pole in different conductors during evolving faults. The consequence of this fault would be the remainder of a single conductor in the dead time for the overall transmission path. This is particularly important if power plants are coupled through the overall transmission path.

Parameter: Response to evolv. faults

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:109) Response to evolv. faults** = ***blocks 79***

With the **Response to evolv. faults** parameter, you can determine how the automatic reclosing function reacts to recognized faults.

You can find detailed information about the automatic reclosing function for faults in the chapter *6.43.4.13 Evolving-Fault Detection During Dead Time* .

Parameter Value	Description
blocks 79	The automatic reclosing function is immediately blocked until the disconnection of the fault. For blockings through faults during the 1-pole dead times, you can force a 3-pole trip command through the automatic reclosing function if the you set the parameter **3-pole operate by 79** to ***yes*** .
strt. evol.flt.dead time	After the 3-pole trip command to clear up the fault, the automatic reclosing function starts a new 3-pole automatic reclosing function cycle with the set **Dead time aft. evolv. fault** .

Parameter: Max. dead-time delay

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:110) Max. dead-time delay** = ***0.5 s***

With the **Max. dead-time delay** parameter, you determine at which time the starting of the dead time may be delayed before the automatic reclosing function is dynamically blocked.

The delay of the start of the dead time is possible with the binary input **>Dead time start delay** .

You can find detailed information about the functionality in the chapter *6.43.4.5 Start* .

Parameter: Max. dead-time extension

- Default setting **(_:6601:111) Max. dead-time extension** = ***1.2 s***

With the **Max. dead-time extension** parameter, you determine the time by which the dead time may be extended before the automatic reclosing function is dynamically blocked.

With the setting ***oo (invalid)***, the extension is unlimited.

An extension of the dead time can be required under the following conditions:

- Waiting for the readiness of the circuit breaker
- Inquiry of a synchronous test
- Delay through binary input in order e.g. to give the leading automatic reclosing function priority in a system with 1 1/2 circuit breaker layout.

Remember that longer dead times after 3-pole disconnection are only permissible if no stability problems occur or if a synchronous test occurs before the reclosing.

You can find detailed information about the functionality in the chapter *6.43.4.14 Closing Indication and Close Command* .

Parameter: Voltage supervision time

This parameter is only important if you use the subfunctions RDT, DLC, or the ADT function. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting **(_:6601:114) Voltage supervision time** = ***0.1 s***

With the **Voltage supervision time** parameter, you can determine the measuring time that is available as a criteria for the voltage decision. It should be longer than all transient oscillations through switching operations.

For the subfunctions **Reduced dead time** and **Reclosing function with adaptive dead time**, this measuring time applies for the determination of the surpassing of a voltage threshold. For the subfunction **Dead-line check**, the surpassing of a voltage threshold is checked.

Siemens recommends the setting 0.10 s.

Detailed information about the functionality can be found in the following parameters and in the chapters *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* and *6.43.5.1 Description* .

Parameter: Volt. thres.f. live line/bus

This parameter is only important if you use the subfunction **RDT** or the function **ADT**. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting **(_:6601:115) Volt. thres.f. live line/bus** = ***48 V***

With the **Volt. thres.f. live line/bus** parameter, you can determine the limit voltage above which the line should be seen as fault-free. It must be lower than the smallest expected operating voltage. The phase-to-ground voltage applies as the reference value.

Detailed information about the functionality can be found in the following settings and in the chapters *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* and *6.43.5.1 Description* .

Parameter: Dead-line check/reduc.d.t

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:113) Dead-line check/reduc.d.t** = ***without***

With the **Dead-line check/reduc.d.t** parameter, you can determine if the automatic reclosing function should work with one of the additional functions ***Dead-line check DLC*** or ***Reduced dead t. RDT*** .

Parameter Value	Description
without	The automatic reclosing function occurs after the expiration of the parameterized dead times. DLC or RDT are not activated.
Reduced dead t. RDT	The automatic reclosing function works with a reduced dead time (RDT).
Dead-line check DLC	The automatic reclosing functions works with dead-line check. The closing indication is only assigned if the line was really de-energized during the dead time.

You can find detailed information about the functionality in the chapter *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* .



NOTE

Use RDT or DLC only if the voltages of the line can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line-side - seen from the circuit breaker.

Parameter: Volt.thres. f. dead line/bus

This parameter is only important if you use the Dead-line check subfunction. If you do not use any of this subfunction, the setting of this parameter is free to select.

- Default setting **(_:6601:116) Volt.thres. f. dead line/bus** = ***30 V***

With the **Volt.thres. f. dead line/bus** parameter, you can determine the limit voltage below which the line should be seen with certainty as idle or switched off. The threshold value is used by the Dead-line check subfunction (dead-line check). The reference size is the phase-to-ground voltage.

You can find detailed information about the functionality in the chapter *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* .

Parameter: Send delay f. remot. close

With the **Send delay f. remot. close** parameter, you can determine after which time after the automatic reclosing function the information is sent to the remote closing.

- Default setting **(_:6601:112) Send delay f. remot. close** = ***oo (invalid)***

The transmission delay prevents the device operating in the adaptive dead time mode on the opposite side from closing unnecessarily if the local reclosing function remains unsuccessful. On the other hand, it must be remembered that the line is not available for transporting energy as long as the opposite end is also closed. Thus, the **Send delay f. remot. close** must be added to the dead time in order to determine the system stability.

You can find detailed information about this functionality in the chapter *6.43.4.14 Closing Indication and Close Command* .

6.43.8 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function

For the function of the cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete more cycles from the function library in **DIGSI 5**.

Parameter: Start from idle state allow.

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with action time***.

- Default setting **(_:6571:102) Start from idle state allow.** = ***yes***

With the parameter **Start from idle state allow.** you can determine whether the action time of this automatic reclosing cycle is started, if the automatic reclosing function is in idle state during with incoming general pickup. Please set the parameter always to ***yes*** , if the automatic reclosing function is configured for only 1 cycle. If several cycles are configured, you can control the effectiveness of the automatic reclosing cycles with this parameter and various action times.

Detailed information about the functionality can be found in Chapters *6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time* und *6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time* .

Parameter: Action time

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with action time***.

- Default setting **(_:6571:103) Action time** = ***0.2 s***

With this parameter **Action time** you can determine, within which time frame the trip command must appear, in order to start the automatic reclosing function. If the trip command occurs only after the action time has expired, automatic reclosing does not occur within the active automatic reclosing cycle.

You can find detailed information about the functionality in

Chapters *6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time* and *6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time* .

Parameter: Dead time aft. 3-pole trip

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with tripping***.

- Default setting **(_:6571:108) Dead time aft. 3-pole trip** = ***0.5 s***

With this parameter **Dead time aft. 3-pole trip** , you can determine after which dead time the automatic reclosing function will be executed. After a 3-pole trip of the circuit breaker, the system stability is priority. Since the switched off line cannot develop synchronizing forces, only a short dead time is permitted in most cases. The usual duration is 0.3 s to 0.6 s. A longer period can be tolerated if a synchrocheck is carried out prior to reclosing. Longer 3-pole dead times are also possible in radial systems.

Parameter: Dead time aft.1ph. pickup, Dead time aft.2ph. pickup, Dead time aft.3ph. pickup

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with pickup***.

- Default setting **(_:6571:104) Dead time aft.1ph. pickup** = ***1.2 s***
- Default setting **(_:6571:105) Dead time aft.2ph. pickup** = ***1.2 s***
- Default setting **(_:6571:106) Dead time aft.3ph. pickup** = ***0.5 s***

With the 3 dead-time parameters, you can determine after which dead time the automatic reclosing function will be executed. Please set the times as desired for the respective type of short circuit.

- The parameter **Dead time aft.1ph. pickup** applies to dead times after 1-phase short circuits and the following protection tripping: A, B, C, or A-Gnd, B-Gnd, C-Gnd
- The parameter **Dead time aft.2ph. pickup** applies to dead times after 2-phase short circuits and the following protection tripping: A-B, B-C, C-A, or A-B-gnd, B-C-gnd, C-A-gnd
- The parameter **Dead time aft.3ph. pickup** applies to dead times after 3-phase short circuits and the following protection tripping: A-B-C or A-B-C-Gnd



NOTE

If you would like to avoid automatic reclosing during individual short-circuit types, please set the respective dead times to ***oo (invalid)***.

Example:

After 1-phase short-circuits, the automatic reclosing function should occur after 1.2 s. The automatic reclosing function should not occur for 2-phase and 3-phase short circuits.

For this application, the parameters should be set as follows:

- **Dead time aft.1ph. pickup** = ***1.2 s***
- **Dead time aft.2ph. pickup** = ***oo (invalid)***
- **Dead time aft.3ph. pickup** = ***oo (invalid)***

Parameter: Dead time aft. evolv. fault

These parameters are only significant if the parameter **(_:6601:109) Response to evolv. faults** is set to ***strt. evol.flt.dead time*** .

- Default setting **(_:6571:109) Dead time aft. evolv. fault** = ***1.2 s***

With the parameter **Dead time aft. evolv. fault** , you can determine after which dead time the automatic reclosing function should be executed, if based on an evolving fault during the current dead time, a 3-pole trip has occurred. For this 3-pole dead time, stability concerns for the system are also important. Often, this dead time as well as the parameter **(_:6571:108) Dead time aft. 3-pole trip** can be set.

Detailed information about the function during evolving faults during dead time are described in Chapter *6.43.4.13 Evolving-Fault Detection During Dead Time* .

Parameter: CB ready check bef.close

- Default setting **(_:6571:111) CB ready check bef.close** = ***no***

With the parameter **CB ready check bef.close** you can determine if after the expiration of the dead time (meaning, directly prior to assigning the close command) readiness of the circuit breaker should be queried.

Parameter Value	Description
no	With the setting ***no*** , the automatic reclosing function does not check again the readiness of the circuit breaker prior to assigning the close demand. Siemens recommends this setting, if it is sufficient to check the readiness of the circuit breaker for the entire switching cycle once before the start of a reclosing function, consisting of tripping-reclosing-tripping. The setting for checking the readiness of the circuit breaker prior to the start of the automatic reclosing function is done using the parameter **(_:6601:102) CB ready check bef. start** .

Parameter Value	Description
yes	With the setting ***yes*** , the dead time can be extended if after the expiration of the dead time the circuit breaker is not ready for the next ON-OFF cycle. The maximum delay of the dead time can be set with the parameter **(_:6601:111) Max. dead-time extension** . Siemens recommends this setting, if it can be assumed that the circuit breaker becomes available to switch on the reclosing function only after an additional waiting period.

Detailed information about the function can be found in Chapters *6.43.4.16 Circuit-Breaker Readiness* and *6.43.4.14 Closing Indication and Close Command* .

Parameter: Synchroch. aft. 3-pole d.t.

- Default setting **(_:6571:110) Synchroch. aft. 3-pole d.t.** = ***none***

With the parameter **Synchroch. aft. 3-pole d.t.** you can determine if a synchrocheck must be carried out for the configured automatic reclosing cycle.

If during a 3-pole interruption in the system stability problems may be a concern, the synchrocheck should be carried out. If only 1-pole reclosure cycles are possible or stability problems are not to be expected during the 3-pole dead time, for example, due to a highly intermeshed system or radial system, please select the parameter ***none*** .

Parameter Value	Description
none	During the automatic reclosing cycle a synchrocheck is not executed.
internal	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. For the synchrocheck a synchrocheck stage of the internal synchronization function is used, which is contained in the same function group as the circuit breaker and the automatic reclosing function. The selection of the synchrocheck stage that is used in the automatic reclosing cycle occurs through the following described parameter **Internal synchrocheck**.
external	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. An external synchrocheck device initiates the synchrocheck. The external synchrocheck device is connected with the binary signals *Synchrocheck request* and *>Release by ext.sync.* . Detailed information about the function can be found in Chapter *6.43.4.14 Closing Indication and Close Command* under the section **Synchrocheck**.

Parameter: Internal Synchrocheck

These parameters are only significant if the previously described parameter **(_:6571:110) Synchroch. aft. 3-pole d.t.** is set to ***internal*** .

With the parameter **Internal Synchrocheck**, you can determine which function block of the synchronization function for the automatic reclosing function is used after a 3-pole dead time. This selection is only possible for function blocks of the synchronization function, and which are included in the same circuit-breaker function group as the automatic reclosing function. The setting options of the parameter will be generated dynamically, according to the actual parameterization.

6.44 Fault Locator

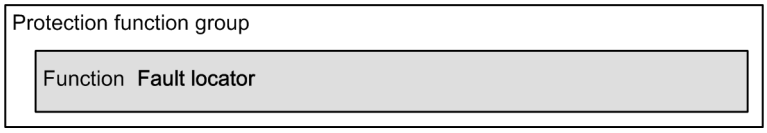
6.44.1 Overview of Functions

The **Fault locator** function serves for measuring the fault distance in the event of a short circuit.

Quick determination of fault location and the associated rapid troubleshooting increase the availability of the line for the power transmission in the electrical power system. Determining the fault location is based on the loop-impedance calculation of short-circuited measuring loops.

6.44.2 Structure of the Function

The **Fault locator** function can be used in protection function groups with 3-phase current and voltage measurement.



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Figure 6-301 Structure/Embedding of the Function

The recording of phase currents and voltages is a prerequisite for calculation of fault locations. The **Fault locator** function contains all necessary control parameters.

The fault location is calculated based on the line parameter. The fault-location calculation starts ***with operate indication*** or ***for dropout*** of the short-circuit protection.

The following functions can start the fault locator:

- Overcurrent protection, phases or ground
- Directional overcurrent protection, phases or ground
- Instantaneous high-current tripping



NOTE

The **Fault locator** function does not work with all possible current and voltage transformer connection types. An error message is displayed in DIGSI 5 if the **Fault locator** function cannot work with the set connection types. In this case check the current and voltage transformer connection type. You will find the **`current transformer connection`** or **`voltage transformer connection`** settings in DIGSI 5 under **Power-system data** → **Measuring point I-3ph** or **Power-system data** → **Measuring point V-3ph**.

The **Fault locator** function only works with the following current and voltage transformer connection types (see parameter value).

Parameter	Parameter Value
`CT connection`	***`3-phase + IN-separate`***
	`3-phase + IN`
	`3-phase`
`VT connection`	***`3 ph-to-gnd volt. + VN`***
	`3 ph-to-gnd voltages`

6.44.3 Function Description

Starting Conditions

The fault location is an independent function with its own measurand memory and its own filter algorithms. To define the valid measuring loop and the most favorable time interval for the measured variable saving, only a start command is required by the short-circuit protection. The fault location can be started by tripping of the short-circuit protection or also at each pickup. If another protection device causes the disconnection of a short-circuit, a fault-location calculation is then also possible for each pickup. In the event of a fault outside the line to be protected, the fault-location indication cannot always be relevant, however, because the measurands can be falsified by the center infeed for example.

Determining the Fault Location

The recorded sampled values of the short-circuit voltage and voltage are frozen shortly after tripping of the protection. No error in the measured value has then occurred through the switch-off process, even in the case of very fast circuit-breakers. The measurands and the impedance calculations are automatically filtered and only indicate a steady-state measured value in the determined data window.

After disconnection of the short-circuit, the measured values are analyzed and the fault location calculated from the short-circuit loops. If no fault location can be calculated, the indication *FO invalid* is output.

Output of the Fault Location

The following results for the fault location are output:

- Short-circuit loop determined from the fault reactance
- Fault reactance X in Ω primary
- Fault resistance R in Ω primary
- Fault impedance in polar coordinates (amount in Ω, angle in degrees)
- Fault distance *d* of the line proportional to the reactance in kilometers or miles, converted on the basis of the parameterized reactance per unit length of the line
- Fault distance *d* as a percentage of the line length, calculated on the basis of the parameterized reactance per unit length and the parameterized line length
- Selected fault loop for calculation of the fault location



NOTE

Specification of distance in kilometers, miles, or percent is relevant only for homogenous line sections. If the line comprises parts which exhibit different reactances per unit of length (for example, overhead-line-cable sections), you can then analyze the reactance determined from the fault location for separate calculation of the fault distance.

Measured-Value Correction for Parallel Lines

In the event of ground faults on double lines, the values determined for the impedance calculation are influenced by the coupling of the ground impedances of both line systems. Without special measures, this leads to measuring errors in the impedance-calculation result. The device is therefore equipped with parallel-line compensation. This parallel-line compensation takes into account the ground current of the parallel line in the line equation and consequently compensates the coupling influence, similar to determining of the distance in distance protection. The ground current of the parallel line must be connected to the device and configured for this. The parallel-line compensation applies only to faults on the line to be protected. Compensation is not possible for faults located externally including those on the parallel line.

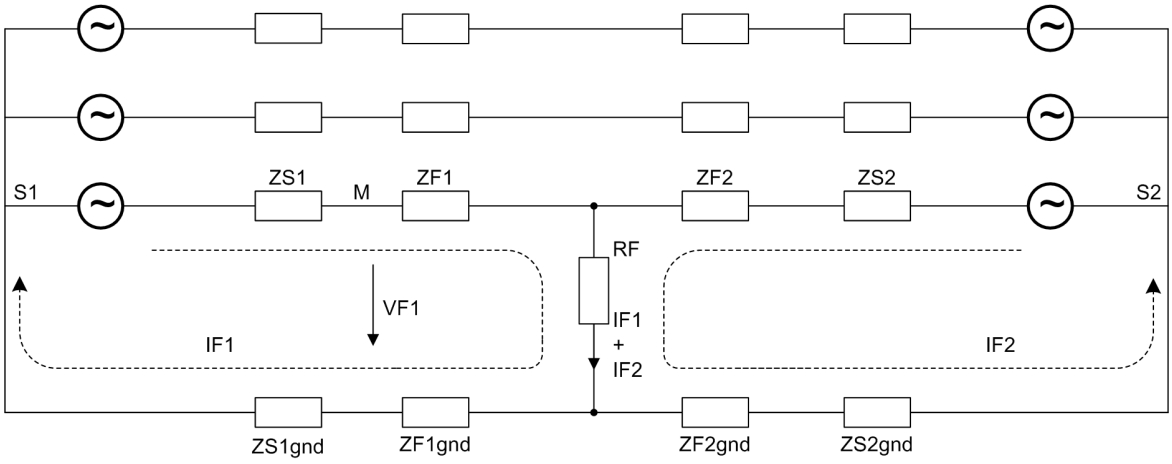
You can activate and deactivate the parallel-line compensation with the **Parallel-line compensat.** parameter.

Measured-Value Correction at Load Current on Lines Fed on Both Sides

In the case of faults on lines fed on both sides and with load transport (see next figure), the fault voltage Y_{F1} is not only influenced by the source voltage E_1, but also by the source voltage E_2, if both voltage sources feed to the common fault resistance R_F. Without special measures, this leads to measuring errors in the impedance-calculation result, since the current component I_{F2} cannot record at the measuring point M. For long lines and lines subject to high loads, this measuring error can be considerable in the crucial X component of the fault impedance (for the distance calculation).

The fault location has a load compensation, which corrects this measuring error in 1-pole short-circuits. A correction is not possible for the R component of the fault impedance. However, the measuring error is not critical here, as only the X component is decisive for the fault distance.

The load compensation acts in 1-phase short circuits. In doing so, both the positive-sequence and zero-sequence system of the balanced components are analyzed for the correction. You can activate and deactivate the load compensation via the **`Load compensation`** parameter.



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Figure 6-302 Fault Currents and Voltages in a Line Fed on Both Sides

M	Measuring point
S1, S2	Source voltage (EMF)
IF1, IF2	Partial fault currents
IF1 + IF2	Total fault current
VF1	Fault voltage at the measuring point
RF	Common fault resistance
ZF1, ZF2	Fault impedances
ZF1gnd, ZF2gnd	Ground fault impedances
ZS1, ZS2	External impedances
ZS1gnd, ZS2gnd	Ground external impedances

6.44.4 Application and Setting Notes

The function requires the following key line data to calculate fault distance:

- Reactance per unit length of the line per kilometer or per mile
- Line length for the correct output of the fault distance as a percentage of the line length
- The residual compensation factors in setting format **`Kr`** and **`Kx`**

Parameter: Start

- Default setting **(_:101) Start** = ***with dropout***

The **Start** parameter is used to define the criterion for starting the fault location. The following functions can start the fault locator:

- Overcurrent protection, phases or ground
- Directional overcurrent protection, phases or ground
- Instantaneous high-current tripping

Parameter Value	Description
with dropout	The fault-location calculation starts with the dropout of one of the protection functions listed previously.
with operate indication	If one of the protection functions listed previously generates an operate indication, calculation of the fault location starts.

As an alternative, the fault locator can be started using external binary input.

Parameter: Load compensation

- Default setting **(_:103) Load compensation** = ***no***

The **Load compensation** parameter can be used to correct measuring errors for 1-pole short circuits on lines fed on both sides. This is the case for overhead lines without grounding cable or with unfavorable grounding conditions of the towers, if high transition resistances can occur in the event of 1-pole short circuits.

Parameter Value	Description
no	The load compensation is deactivated with this setting.
yes	The load compensation becomes effective with this setting.

Parameter: X per length unit

- Default setting **(_:113) X per length unit** = ***0.210 Ω/km***

With the **X per length unit** parameter you set the reactance per unit length for the line to be protected. You set the **X per length unit** parameter as a relative value in Ω/km or Ω/miles.

Parameter: Line length

- Default setting **(_:114) Line length** = ***60 km***

With the **Line length** parameter, you can set the length of the line to be protected as unit of length in km or miles.

Parameter: Line angle

- Default setting **(_:108) Line angle** = ***85.00°***

Calculate the setting value for the parameter **Line angle** from the line constants for the line to be protected as follows:

$$\tan\varphi = \frac{X_L}{R_L} \qquad \text{or} \qquad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

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where:

R_L	Resistance of the line to be protected
X_L	Reactance of the line to be protected

EXAMPLE

110-kV overhead line, 150 mm² with the data

$R'_1 = 0.19\ \Omega/km$

$X'_1 = 0.42\ \Omega/km$

You calculate the setting value for the line angle as follows:

$$\tan\varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.42\ \Omega/km}{0.19\ \Omega/km} = 2.21$$

$$\arctan(2.21) = 65.7°$$

[folwibsp-050912-01.tif, 1, en_US]

Parameter: Kr and Kx

- Default setting **(_:104) Kr** = ***1.00***
- Default setting **(_:105) Kx** = ***1.00***

The **Kr** and **Kx** parameters are used to set the residual compensation factors as scalar values. The **Kr** and **Kx** parameters are relevant for the **Fault locator** function.

Calculate the setting values for the parameters **Kr** and **Kx** from the line data as follows:

Resistance ratio

$$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right)$$

Reactance ratio

$$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right)$$

where:

R_0	Zero-sequence system resistance of the line
X_0	Zero-sequence system reactance of the line
R_1	Positive-sequence system resistance of the line
X_1	Positive-sequence system reactance of the line

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

EXAMPLE

110-kV overhead line, 150 mm² with the data:

R_1/s	0.19 Ω/km positive-sequence system resistance
X_1/s	0.42 Ω/km positive-sequence system reactance
R_0/s	0.53 Ω/km zero-sequence system resistance
X_0/s	1.19 Ω/km zero-sequence system reactance
s	Line length

You receive the following setting values for the parameters **Kr** and **Kx** :

$$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right) = \frac{1}{3} \cdot \left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1 \right) = 0.60$$

$$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right) = \frac{1}{3} \cdot \left(\frac{0.19\ \Omega/km}{0.42\ \Omega/km} - 1 \right) = 0.61$$

[forerlx1-050912-01.tif, 1, en_US]

Parameter: K0 and Angle (K0)

- Default setting **K0** = ***1.000***
- Default setting **Angle (K0)** = ***0.00°***

NOTE

The visibility of the **K0** and **Angle (K0)** parameters depends on the selected setting format of the residual compensation factors. The parameters **K0** and **Angle (K0)** only become visible after you have set the parameter **Set. format residu. comp.** = ***K0*** for the device. The **Set. format residu. comp.** parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Parameter** → **Device settings**.

The **K0** and **Angle (K0)** parameters are used to set the complex residual compensation factor.

Make sure that the line angle is set correctly because the device needs the line angle for calculation of the compensation components from the K0 factor. The complex residual compensation factor is defined by the value and the angle. You can calculate the complex residual compensation factor from the line data as follows:

$$\underline{K}_0 = \left| \frac{\underline{Z}_{gnd}}{\underline{Z}_L} = \frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1 \right) \right|$$

[foforlk0-180912-01.tif, 1, en_US]

where:

$\underline{Z}_0$	(complex) zero-sequence impedance
$\underline{Z}_1$	(complex) positive-sequence impedance

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. The data can be calculated both from the primary values and from the secondary values.

For overhead lines, you can use the values for the calculation because the angles of the zero-sequence system and the positive-sequence system differ only slightly. For cables, however, significant angular differences can occur, as the following example illustrates.

EXAMPLE

110-kV single-conductor liquid-filled cable 3 · 185 mm² Cu with the data:

$\underline{Z}_1/s$	$0.408 \cdot e^{j73°}$ Ω/km positive-sequence impedance
$\underline{Z}_0/s$	$0.632 \cdot e^{j18.4°}$ Ω/km zero-sequence impedance
s	Line length

The values for calculation of the residual compensation factor **K0** are:

$$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408} \cdot e^{j(18.4° - 73°)} = 1.55 \cdot e^{-j54.6°} = 1.55 \cdot (0.579 - j0.815)$$
$$= 0.898 - j1.263$$

[fofork02-180912-01.tif, 1, en_US]

$$K_0 = \left| \frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1 \right) \right| = \left| \frac{1}{3} \cdot (0.898 - j1.263 - 1) \right| = \left| \frac{1}{3} \cdot (-0.102 - j1.263) \right|$$

[fofork03-180912-01.tif, 1, en_US]

The setting value of the parameter **K0** is calculated from:

$$K_0 = \left| \frac{1}{3} \cdot \sqrt{(-0.102^2) + (-1.263^2)} \right| = 0.42$$

[foforк04-180912-01.tif, 1, en_US]

When determining the angle, take note of the quadrant of the result. The following table lists the quadrants and the angle range obtained from the operational signs of the real and imaginary parts of **K0** .

Real Part	Imaginary Part	tan Phi (K0)	Quadrant/Range		Calculation Method
+	+	+	I	0° to 90°	arc tan (|Im| / |Re|)
+	-	-	IV	-90° to 0°	–arc tan (|Im| / |Re|)
-	-	+	III	-90° to -180°	arc tan (|Im| / |Re|) –180°
-	+	-	II	+90° to +180°	–arc tan (|Im| / |Re|) +180°

In this example, the following setting value for the **Angle (K0)** parameter is obtained:

$$\varphi(k_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180° = -94.6°$$

[foforк05-050509-01.tif, 1, en_US]

6.44.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fault locator				
_:1	Fault locator:Mode		• off • on • test	off
_:101	Fault locator:Start		• with operate • with going pickup	with going pickup
_:103	Fault locator:Load compensation		• no • yes	no
_:113	Fault locator:X per length unit	1 A	0.0001 Ω/km to 9.5000 Ω/km	Ω/km
		5 A	0.0000 Ω/km to 1.9000 Ω/km	0.0000 Ω/km
_:114	Fault locator:Line length		0.10 km to 1000.00 km	60.00 km
_:108	Fault locator:Line angle		10.00 ° to 89.00 °	85.00 °
_:104	Fault locator:Kr		-0.33 to 11.00	1.00
_:105	Fault locator:Kx		-0.33 to 11.00	1.00
_:118	Fault locator:K0		0.000 to 11.000	1.000
_:150	Fault locator:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

6.44.6 Information List

No.	Information	Data Class (Type)	Type
Fault locator			
_:54	Fault locator:Inactive	SPS	O
_:52	Fault locator:Behavior	ENS	O
_:53	Fault locator:Health	ENS	O
_:302	Fault locator:Fault resistance prim.	MV	O
_:303	Fault locator:Fault reactance prim.	MV	O

No.	Information	Data Class (Type)	Type
_:308	Fault locator:Fault resistance sec.	MV	O
_:309	Fault locator:Fault reactance sec.	MV	O
_:304	Fault locator:Fault distance	MV	O
_:305	Fault locator:Fault distance in %	MV	O
_:306	Fault locator:Fault loop	ENS	O
_:307	Fault locator:FLO invalid	ENS	O

6.45 Temperature Supervision

6.45.1 Overview of Functions

The **Temperature supervision** function checks the thermal state of:

- Motors
- Generators
- Transformers

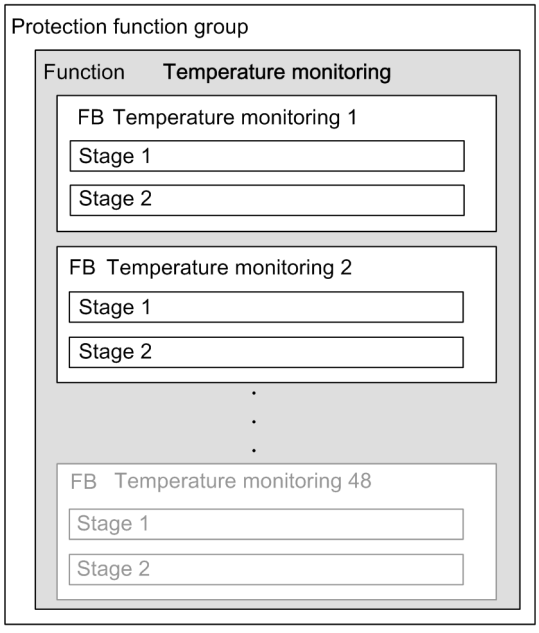
In rotating machines, it also checks bearing temperatures for a limit violation.

The temperatures are measured at various locations of the protected object using temperature sensors (RTD = Resistance Temperature Detector) and are sent to the device via one or more RTD units.

The **Temperature supervision** function receives its measured temperature values via the **RTD unit Ether.** or **Serial RTD unit** functions from the **Analog units** function group.

6.45.2 Structure of the Function

The Temperature supervision function can work in all protection function groups. A maximum of 48 temperature supervision locations can operate simultaneously in the **Temperature supervision function** function. Each temperature supervision location has 2 threshold stages.

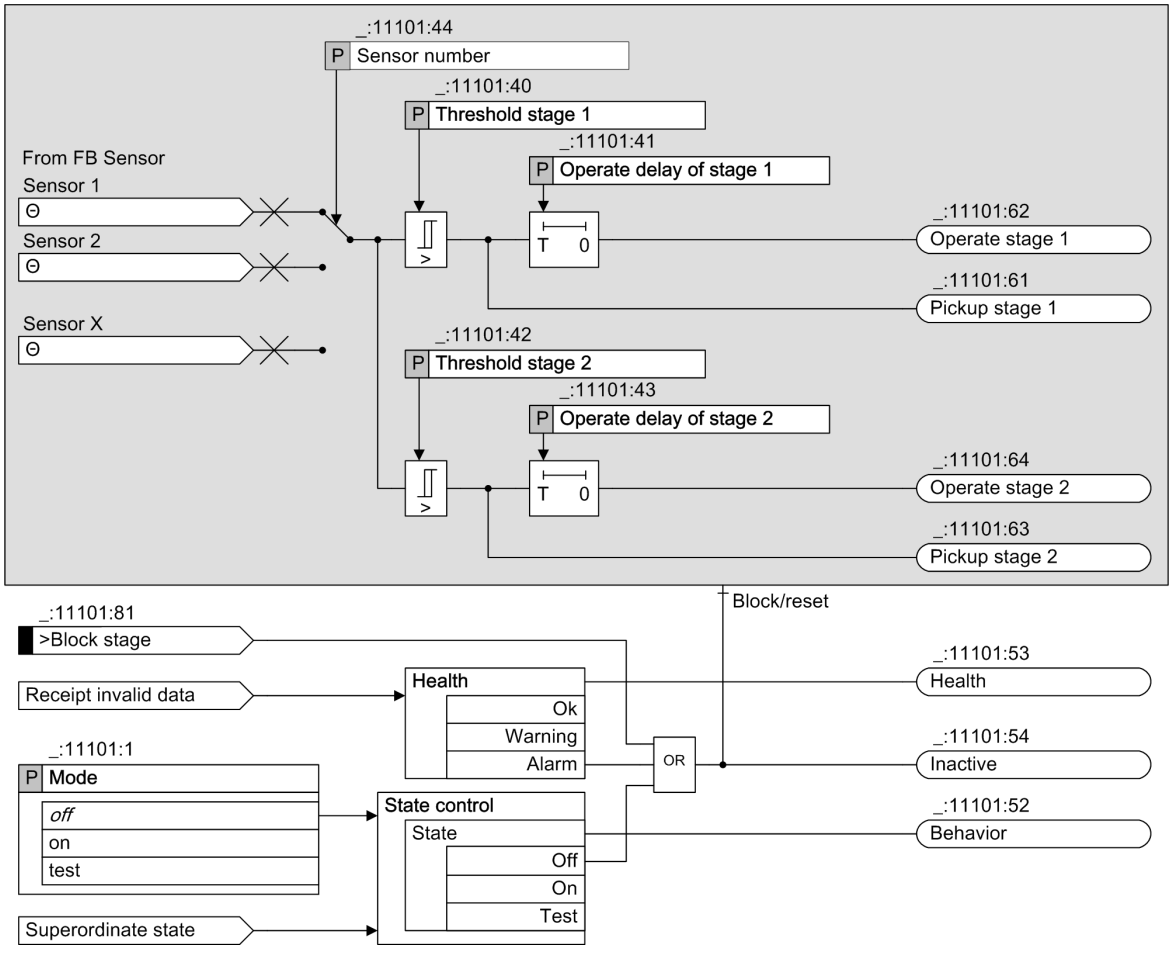


[dwstrtmp-170712-01.tif, 1, en_US]

Figure 6-303 Structure/Embedding of the Function

6.45.3 Function Description

Logic



[lotmpsup-170712-01.tif, 1, en_US]

Figure 6-304 Logic Diagram for a Temperature Supervision Location

The **Temperature supervision location** function block (**Location** FB) receives a measured temperature value in °C or °F as an input variable delivered from the temperature sensor function blocks of the **Analog units** function group. The **Sensor number** parameter is used to select the temperature sensor.

2 threshold value decisions can be performed for each measuring point. If the measured temperature value is greater than or equal to the set threshold values, the stages generate a pickup indication independent of one another and, after a set tripping time delay, an operate indication.

The indications from the supervision locations remain available for further processing.

NOTE

The pickup of the stages does not result in fault logging. The operate indications of the stages do not go into the trip logic of the device.

6.45.4 Application and Setting Notes

If you use an external RTD unit, connect the RTD unit via an interface (Ethernet or serial) to the SIPROTEC 5 device. Observe the setting notes for configuration of the interfaces in chapter Analog Transformer Function Group Type under *5.6.7.3 Communication with an RTD Unit* .

Parameter: `Sensor location`

- Default setting **`(_:11101:46) Sensor location`** = ***`Other`***

You inform the device of the sensor installation location using the **`Sensor location`** parameter. ***`Oil`***, ***`Ambient`***, ***`Turn`***, ***`Bearing`*** and ***`Other`*** are available for selection. The selection is not evaluated in the device, it only serves an informational purpose in the medium in which the temperature measurement takes place.

Parameter: `Sensor number`

- Default setting **`(_:11101:44) sensor number`** = ***`no function block selected`***

With the **`sensor number`** parameter, you assign a specific sensor whose temperature is to be monitored to the **Location** function block. You perform the assignment in DIGSI using a list box that contains all connected RTD units and their sensors.

Parameter: `Threshold stage 1`

- Default setting **`(_:11101:40) Threshold stage 1`** = ***`100 °C`***

With the **`Threshold stage 1`** parameter you establish the temperature value whose exceedance causes a pickup of the 1st tripping stage.

Parameter: `Operate delay of stage 1`

- Default setting **`(_:11101:41) Operate delay of stage 1`** = ***`5 s`***

With the **`Operate delay of stage 1`** parameter you establish the time the operate indication of the 1st tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Parameter: `Threshold stage 2`

- Default setting **`(_:11101:42) Threshold stage 2`** = ***`120 °C`***

With the **`Threshold stage 2`** parameter you establish the temperature value whose exceedance causes a pickup of the 2nd tripping stage.

Parameter: `Operate delay of stage 2`

- Default setting **`(_:11101:43) Operate delay of stage 2`** = ***`0 s`***

With the **`Operate delay of stage 2`** parameter you establish the time the operate indication of the 2nd tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Temperature Unit

Temperature Unit To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly (see *5.6.7.5 Temperature Sensor*).

6.45.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Point 1`				
_:11101:46	Point 1:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11101:1	Point 1:Mode		• off • on • test	off
_:11101:40	Point 1:Threshold stage 1		-50°C to 250°C	100°C
_:11101:41	Point 1:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11101:42	Point 1:Threshold stage 2		-50°C to 250°C	120°C
_:11101:43	Point 1:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11101:44	Point 1:Sensor		Setting options depend on configuration	
Point 2				
_:11102:46	Point 2:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11102:1	Point 2:Mode		• off • on • test	off
_:11102:40	Point 2:Threshold stage 1		-50°C to 250°C	100°C
_:11102:41	Point 2:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11102:42	Point 2:Threshold stage 2		-50°C to 250°C	120°C
_:11102:43	Point 2:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11102:44	Point 2:Sensor		Setting options depend on configuration	
Point 3				
_:11103:46	Point 3:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11103:1	Point 3:Mode		• off • on • test	off
_:11103:40	Point 3:Threshold stage 1		-50°C to 250°C	100°C
_:11103:41	Point 3:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11103:42	Point 3:Threshold stage 2		-50°C to 250°C	120°C
_:11103:43	Point 3:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11103:44	Point 3:Sensor		Setting options depend on configuration	
Point 4				
_:11104:46	Point 4:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11104:1	Point 4:Mode		• off • on • test	off
_:11104:40	Point 4:Threshold stage 1		-50°C to 250°C	100°C
_:11104:41	Point 4:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11104:42	Point 4:Threshold stage 2		-50°C to 250°C	120°C
_:11104:43	Point 4:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11104:44	Point 4:Sensor		Setting options depend on configuration	
Point 5				
_:11105:46	Point 5:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11105:1	Point 5:Mode		• off • on • test	off
_:11105:40	Point 5:Threshold stage 1		-50°C to 250°C	100°C
_:11105:41	Point 5:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11105:42	Point 5:Threshold stage 2		-50°C to 250°C	120°C
_:11105:43	Point 5:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11105:44	Point 5:Sensor		Setting options depend on configuration	
Point 6				
_:11106:46	Point 6:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11106:1	Point 6:Mode		• off • on • test	off
_:11106:40	Point 6:Threshold stage 1		-50°C to 250°C	100°C
_:11106:41	Point 6:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11106:42	Point 6:Threshold stage 2		-50°C to 250°C	120°C
_:11106:43	Point 6:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11106:44	Point 6:Sensor		Setting options depend on configuration	
Point 7				
_:11107:46	Point 7:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11107:1	Point 7:Mode		• off • on • test	off
_:11107:40	Point 7:Threshold stage 1		-50°C to 250°C	100°C
_:11107:41	Point 7:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11107:42	Point 7:Threshold stage 2		-50°C to 250°C	120°C
_:11107:43	Point 7:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11107:44	Point 7:Sensor		Setting options depend on configuration	
Point 8				
_:11108:46	Point 8:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11108:1	Point 8:Mode		• off • on • test	off
_:11108:40	Point 8:Threshold stage 1		-50°C to 250°C	100°C
_:11108:41	Point 8:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11108:42	Point 8:Threshold stage 2		-50°C to 250°C	120°C
_:11108:43	Point 8:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11108:44	Point 8:Sensor		Setting options depend on configuration	
Point 9				
_:11109:46	Point 9:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11109:1	Point 9:Mode		• off • on • test	off
_:11109:40	Point 9:Threshold stage 1		-50°C to 250°C	100°C
_:11109:41	Point 9:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11109:42	Point 9:Threshold stage 2		-50°C to 250°C	120°C
_:11109:43	Point 9:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11109:44	Point 9:Sensor		Setting options depend on configuration	
Point 10				
_:11110:46	Point 10:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11110:1	Point 10:Mode		• off • on • test	off
_:11110:40	Point 10:Threshold stage 1		-50°C to 250°C	100°C
_:11110:41	Point 10:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11110:42	Point 10:Threshold stage 2		-50°C to 250°C	120°C
_:11110:43	Point 10:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11110:44	Point 10:Sensor		Setting options depend on configuration	
Point 11				
_:11111:46	Point 11:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11111:1	Point 11:Mode		• off • on • test	off
_:11111:40	Point 11:Threshold stage 1		-50°C to 250°C	100°C
_:11111:41	Point 11:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11111:42	Point 11:Threshold stage 2		-50°C to 250°C	120°C
_:11111:43	Point 11:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11111:44	Point 11:Sensor		Setting options depend on configuration	
Point 12				
_:11112:46	Point 12:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11112:1	Point 12:Mode		• off • on • test	off
_:11112:40	Point 12:Threshold stage 1		-50°C to 250°C	100°C
_:11112:41	Point 12:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11112:42	Point 12:Threshold stage 2		-50°C to 250°C	120°C
_:11112:43	Point 12:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11112:44	Point 12:Sensor		Setting options depend on configuration	

6.45.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
Point 1			
_:11101:81	Point 1:>Block stage	SPS	I
_:11101:54	Point 1:Inactive	SPS	O
_:11101:52	Point 1:Behavior	ENS	O
_:11101:53	Point 1:Health	ENS	O
_:11101:61	Point 1:Pickup stage 1	SPS	O
_:11101:62	Point 1:Operate stage 1	SPS	O
_:11101:63	Point 1:Pickup stage 2	SPS	O
_:11101:64	Point 1:Operate stage 2	SPS	O
Point 2			
_:11102:81	Point 2:>Block stage	SPS	I
_:11102:54	Point 2:Inactive	SPS	O
_:11102:52	Point 2:Behavior	ENS	O
_:11102:53	Point 2:Health	ENS	O
_:11102:61	Point 2:Pickup stage 1	SPS	O
_:11102:62	Point 2:Operate stage 1	SPS	O
_:11102:63	Point 2:Pickup stage 2	SPS	O
_:11102:64	Point 2:Operate stage 2	SPS	O
Point 3			
_:11103:81	Point 3:>Block stage	SPS	I
_:11103:54	Point 3:Inactive	SPS	O
_:11103:52	Point 3:Behavior	ENS	O
_:11103:53	Point 3:Health	ENS	O
_:11103:61	Point 3:Pickup stage 1	SPS	O
_:11103:62	Point 3:Operate stage 1	SPS	O
_:11103:63	Point 3:Pickup stage 2	SPS	O
_:11103:64	Point 3:Operate stage 2	SPS	O
Point 4			
_:11104:81	Point 4:>Block stage	SPS	I
_:11104:54	Point 4:Inactive	SPS	O
_:11104:52	Point 4:Behavior	ENS	O
_:11104:53	Point 4:Health	ENS	O
_:11104:61	Point 4:Pickup stage 1	SPS	O
_:11104:62	Point 4:Operate stage 1	SPS	O
_:11104:63	Point 4:Pickup stage 2	SPS	O
_:11104:64	Point 4:Operate stage 2	SPS	O
Point 5			
_:11105:81	Point 5:>Block stage	SPS	I
_:11105:54	Point 5:Inactive	SPS	O
_:11105:52	Point 5:Behavior	ENS	O
_:11105:53	Point 5:Health	ENS	O
_:11105:61	Point 5:Pickup stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11105:62	Point 5:Operate stage 1	SPS	O
_:11105:63	Point 5:Pickup stage 2	SPS	O
_:11105:64	Point 5:Operate stage 2	SPS	O
Point 6			
_:11106:81	Point 6:>Block stage	SPS	I
_:11106:54	Point 6:Inactive	SPS	O
_:11106:52	Point 6:Behavior	ENS	O
_:11106:53	Point 6:Health	ENS	O
_:11106:61	Point 6:Pickup stage 1	SPS	O
_:11106:62	Point 6:Operate stage 1	SPS	O
_:11106:63	Point 6:Pickup stage 2	SPS	O
_:11106:64	Point 6:Operate stage 2	SPS	O
Point 7			
_:11107:81	Point 7:>Block stage	SPS	I
_:11107:54	Point 7:Inactive	SPS	O
_:11107:52	Point 7:Behavior	ENS	O
_:11107:53	Point 7:Health	ENS	O
_:11107:61	Point 7:Pickup stage 1	SPS	O
_:11107:62	Point 7:Operate stage 1	SPS	O
_:11107:63	Point 7:Pickup stage 2	SPS	O
_:11107:64	Point 7:Operate stage 2	SPS	O
Point 8			
_:11108:81	Point 8:>Block stage	SPS	I
_:11108:54	Point 8:Inactive	SPS	O
_:11108:52	Point 8:Behavior	ENS	O
_:11108:53	Point 8:Health	ENS	O
_:11108:61	Point 8:Pickup stage 1	SPS	O
_:11108:62	Point 8:Operate stage 1	SPS	O
_:11108:63	Point 8:Pickup stage 2	SPS	O
_:11108:64	Point 8:Operate stage 2	SPS	O
Point 9			
_:11109:81	Point 9:>Block stage	SPS	I
_:11109:54	Point 9:Inactive	SPS	O
_:11109:52	Point 9:Behavior	ENS	O
_:11109:53	Point 9:Health	ENS	O
_:11109:61	Point 9:Pickup stage 1	SPS	O
_:11109:62	Point 9:Operate stage 1	SPS	O
_:11109:63	Point 9:Pickup stage 2	SPS	O
_:11109:64	Point 9:Operate stage 2	SPS	O
Point 10			
_:11110:81	Point 10:>Block stage	SPS	I
_:11110:54	Point 10:Inactive	SPS	O
_:11110:52	Point 10:Behavior	ENS	O
_:11110:53	Point 10:Health	ENS	O
_:11110:61	Point 10:Pickup stage 1	SPS	O
_:11110:62	Point 10:Operate stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11110:63	Point 10:Pickup stage 2	SPS	O
_:11110:64	Point 10:Operate stage 2	SPS	O
Point 11			
_:11111:81	Point 11:>Block stage	SPS	I
_:11111:54	Point 11:Inactive	SPS	O
_:11111:52	Point 11:Behavior	ENS	O
_:11111:53	Point 11:Health	ENS	O
_:11111:61	Point 11:Pickup stage 1	SPS	O
_:11111:62	Point 11:Operate stage 1	SPS	O
_:11111:63	Point 11:Pickup stage 2	SPS	O
_:11111:64	Point 11:Operate stage 2	SPS	O
Point 12			
_:11112:81	Point 12:>Block stage	SPS	I
_:11112:54	Point 12:Inactive	SPS	O
_:11112:52	Point 12:Behavior	ENS	O
_:11112:53	Point 12:Health	ENS	O
_:11112:61	Point 12:Pickup stage 1	SPS	O
_:11112:62	Point 12:Operate stage 1	SPS	O
_:11112:63	Point 12:Pickup stage 2	SPS	O
_:11112:64	Point 12:Operate stage 2	SPS	O

6.46 Current-Jump Detection

6.46.1 Overview of Functions

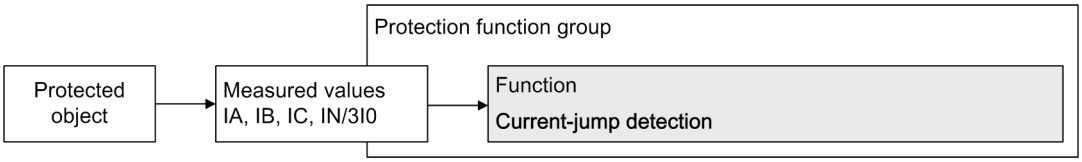
The **Current jump detection** function has the following tasks:

- Detection of jumps in the phase or zero-sequence current (ΔI)
- Generation of an indication when the measurands change by more than a configured threshold value from one system period to the next.

The function for detecting jumps in the phase or zero-sequence current is an additional function used for indication purposes or for further processing in user-specific CFC logics. Pick up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.46.2 Structure of the Function

The **Current-jump detection** function is used in protection function groups based on current measurement. It can be instantiated multiple times.



[dwstruki-111026-01.tif, 1, en_US]

Figure 6-305 Structure/Embedding of the Function

6.46.3 Function Description

Current-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the current. The method used is not sensitive to slow changes of amplitude or frequency.

Using a configurable selection of measured values, you can select from 3 line currents or the residual current. Current-jump detection is phase-selective for the line current A, B and C.

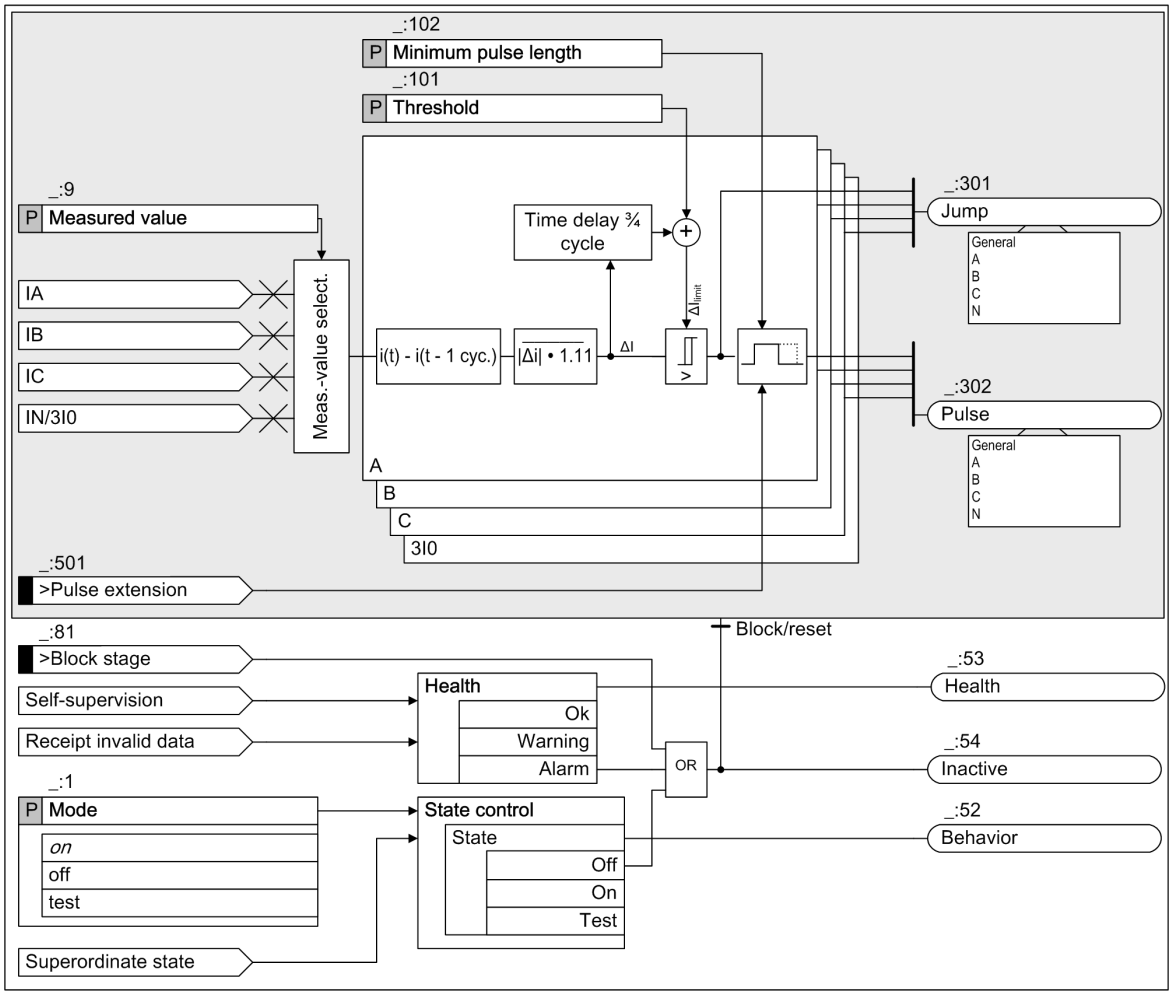
The difference from the previous sampled value of the first system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δi(t). The rectified average for sinusoidal measurands is then converted to a RMS value ΔI by subsequent multiplication by 1.11. The resultant measurand ΔI is then compared with the threshold value.

If the parameter **(_:101) Threshold** is exceeded, the output indication *Jump* is generated. If you have selected the phase currents for measurement, the output indication data type used includes the separate phase information. If you have selected the residual current for measurement, the output indication data type used includes the NI information. If the current-jump detection responds (ΔI_{Limit}), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value (ΔI_{Limit}) in accordance with the logic in *Figure 6-306*. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

The output indication *Pulse* is formed with the configurable timer **(_:102) Minimum pulse length**. As a consequence this output indication has a consistent minimum size. If you activate the binary input *>Pulse extension*, you can prolong the pulse duration even further. If the binary input *>Pulse extension* has been activated, the indication *Pulse* drops off when the configured time has elapsed and the falling edge of the binary input is detected.

Logic



[lojumpii-271011-01.tif, 1, en_US]

Figure 6-306 Current-Jump Detection Logic

6.46.4 Application and Setting Notes

Parameter: `Measured value`

- Default setting **`(_:9) Measured value`** = ***`phase currents`***

With the parameter **`Measured value`**, you set whether the line current(s) or the residual current is to be used for jump detection.

Parameter Value	Description
`phase currents`	The tripping stage evaluates the line currents IL1, IL2 and IL3 phase-selectively to detect a jump.
`zero-sequence current`	The tripping stage evaluates the residual current IN/3I0 to detect a jump.

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***`0.10 A`*** for I_{rated} = 1A or ***`0.50 A`*** for I_{rated} = 5 A

With the parameter **`Threshold`**, you set the threshold value for the measurand which, when exceeded, generates the output indication *`Jump`*.

Parameter: **Minimum pulse length**

- Default setting **(_:102) Minimum pulse length** = ***0.10 s***

With the parameter **Minimum pulse length**, you specify a consistent minimum size for the output indication ***Pulse***.

6.46.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I-jump det. #				
_:1	I-jump det. #:Mode		• off • on • test	off
_:9	I-jump det. #:Measured value		• phase currents • zero-sequence current	phase currents
_:101	I-jump det. #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	I-jump det. #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:102	I-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.46.6 Information List

No.	Information	Data Class (Type)	Type
I-jump det. #			
_:81	I-jump det. #:>Block stage	SPS	I
_:501	I-jump det. #:>Pulse extension	SPS	I
_:54	I-jump det. #:Inactive	SPS	O
_:52	I-jump det. #:Behavior	ENS	O
_:53	I-jump det. #:Health	ENS	O
_:301	I-jump det. #:Jump	ACT	O
_:302	I-jump det. #:Pulse	ACT	O

6.47 Voltage-Jump Detection

6.47.1 Overview of Functions

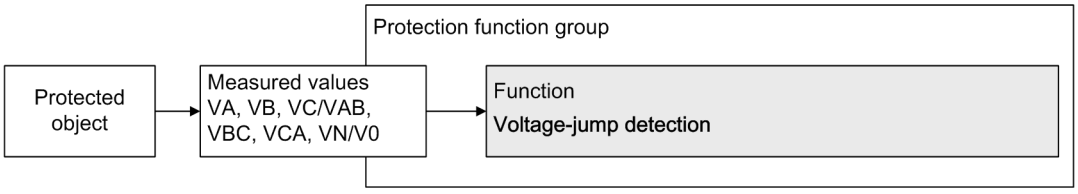
The **Voltage-jump detection** function has the following tasks:

- Recognition of jumps in the phase or zero-sequence voltage (ΔV)
- Generation of an indication when the measurands change by more than a configured threshold value from one system cycle to the next.

The function for detecting jumps in the phase or zero-sequence voltage is an additional function used for indication purposes or for further processing in user-specific CFC logics. Pick up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.47.2 Structure of the Function

The **Voltage-jump detection** function is used in protection function groups based on voltage measurement. It can be instantiated multiple times.



[dwstruku-011211-01.tif, 1, en_US]

Figure 6-307 Structure/Embedding of the Function

6.47.3 Function Description

Voltage-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the voltage. The method used is not sensitive to slow changes of amplitude or frequency.

By using a configurable selection of measured values, you can select from phase-to-ground voltages, phase-to-phase voltages or the zero-sequence voltage. Voltage-jump detection is phase-selective.

The difference from the previous sampled value of 1 system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δv(t). The rectified average for sinusoidal measurands is then converted to a RMS value ΔV by subsequent multiplication by 1.11. The resultant measurand ΔV is then compared with the threshold value.

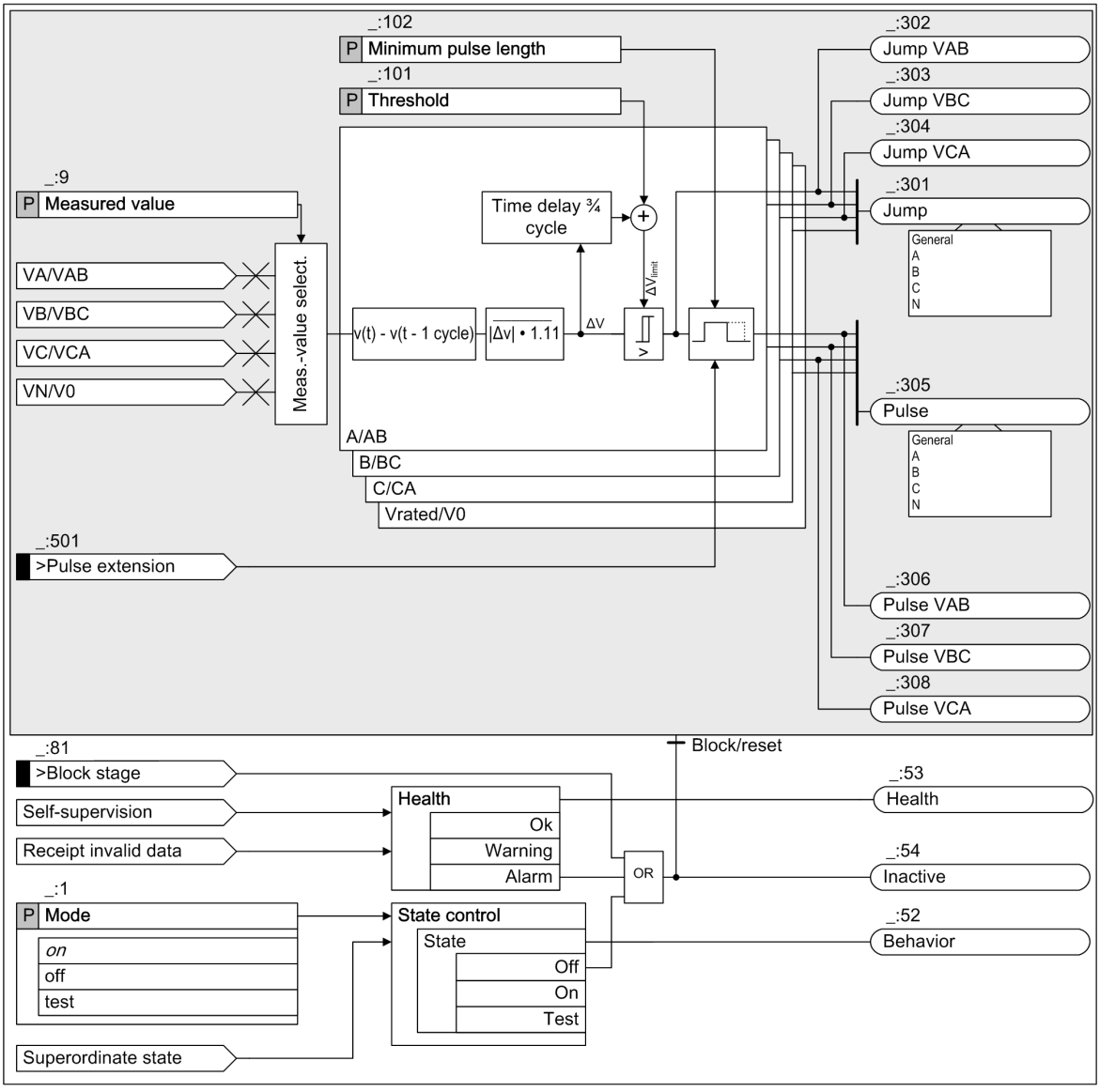
If the parameter **(_:101) Threshold** is exceeded, the output indication *Jump* is generated. If the measured value is set to phase-to-phase, the sudden change in voltage is signaled selectively for the individual measuring elements that have picked up (*Jump VAB*, *Jump VBC* or *Jump VCA*). If you have selected the phase-to-phase or phase-to-ground voltages for measurement, the output indication data type used included the separate phase information. If you have selected the zero-sequence voltage for measurement, the output indication data type used includes the N information. If the voltage-jump detection responds (ΔV_{Limit}), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value ΔU_{Limit} in accordance with the information in *Figure 6-308*. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

A timing element is added to the indication *Jump*. The element generates a pulse from this. The length of this pulse can be set using the parameter **(_:102) Minimum pulse length**. This gives the output indication *Pulse* a reliable minimum size. If you activate the binary input *>Pulse extension*, you can prolong the pulse duration even further. If the binary input *>Pulse extension* has been activated, the indication *Pulse* drops off when the configured time has elapsed and the falling edge of the binary input is detected. If

the measured value is set to phase-to-phase, the pulse duration is signaled selectively for the individual measuring elements that have picked up (*Pulse VAB*, *Pulse VBC* or *Pulse VCA*).

Logic



[lojumpuu-011211-01.tif, 1, en_US]

Figure 6-308 Voltage-Jump Detection Logic

6.47.4 Application and Setting Notes

Parameter: `Measured value`

- Default setting **`(_:9) Measured value`** = ***`phase-to-ground`***

With the parameter **`Measured value`** , you specify which measured values of voltage are to be used for determining the voltage jumps.

Parameter Value	Description
`phase-to-ground`	The tripping stage evaluates the phase-to-ground voltages VA, VB and VC.

Parameter Value	Description
phase-to-phase	The tripping stage evaluates the phase-to-phase voltages VAB, VBC and VCA.
zero-sequence voltage	The tripping stage evaluates the zero-sequence voltage VN/V0.

Parameter: **Threshold**

- Default setting **(_:101) Threshold** = ***5.000 V***

With the parameter **Threshold** , you set the threshold value for the measurand which, when exceeded, generates the output indication *Jump* .

Parameter: **Minimum pulse length**

- Default setting **(_:102) Minimum pulse length** = ***0.10 s***

With the parameter **Minimum pulse length** , you specify a consistent minimum size for the output indication *Pulse* .

6.47.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-jump det. #				
_:1	V-jump det. #:Mode		• off • on • test	off
_:9	V-jump det. #:Measured value		• phase-to-ground • phase-to-phase • zero-sequence voltage	phase-to-ground
_:101	V-jump det. #:Threshold		0.300 V to 340.000 V	5.000 V
_:102	V-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.47.6 Information List

No.	Information	Data Class (Type)	Type
V-jump det. #			
_:81	V-jump det. #:>Block stage	SPS	I
_:501	V-jump det. #:>Pulse extension	SPS	I
_:54	V-jump det. #:Inactive	SPS	O
_:52	V-jump det. #:Behavior	ENS	O
_:53	V-jump det. #:Health	ENS	O
_:301	V-jump det. #:Jump	ACT	O
_:302	V-jump det. #:Jump VAB	SPS	O
_:303	V-jump det. #:Jump VBC	SPS	O
_:304	V-jump det. #:Jump VCA	SPS	O
_:305	V-jump det. #:Pulse	ACT	O
_:306	V-jump det. #:Pulse VAB	SPS	O
_:307	V-jump det. #:Pulse VBC	SPS	O
_:308	V-jump det. #:Pulse VCA	SPS	O

6.48 Voltage Measuring-Point Selection

6.48.1 Overview of Functions

The function block **Voltage measuring-point selection** can:

- Provide the ability to switchover the voltage measuring points to be applied, if various voltage measuring points are connected to the voltage interface of the function group
- Select the correct voltage based on the switch position of the plant

If more than one voltage measuring points are connected to the same voltage interface of the function group, use the **Voltage measuring-point selection** function block in the function group to select the correct voltage based on the switch position of the plant.

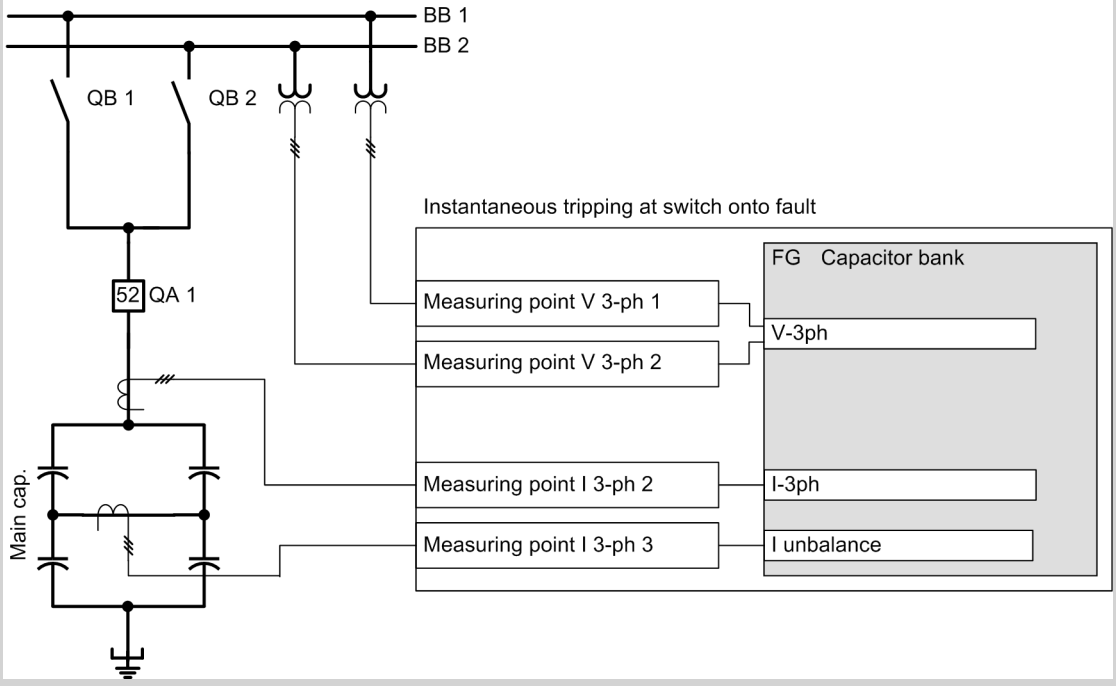
The **Voltage measuring-point selection** is a common functionality for the function groups of the protected objects.

6.48.2 Function Description

The **Voltage measuring-point selection** function block realizes the selection of voltage measuring points by a logic block chart. The logic block chart controls the input *>MP-ID selection* depending on the switch positions of disconnectors.

Example

Figure 6-309 shows an example of voltage measuring points selection for the function group **Capacitor bank** in a double busbar application.

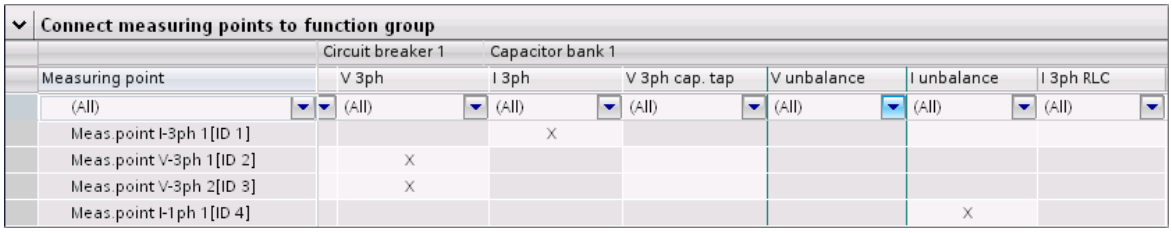


[dwbusbardouble.vsd, 2, en_US]

Figure 6-309 Double Busbar with Capacitor Bank

Connecting Measuring Points to Capacitor Bank Function Group

Figure 6-310 shows the connection of the function group **Capacitor bank** with several measuring points in DIGSI. The ID of each measuring point appears in the bracket after the name.



[scconnection, 1, en_US]

Figure 6-310 Connecting the Measuring Points with the Capacitor Bank Function Group

There are consistency checks that validate the connections of voltage measuring points to the function group:

- The connection type must be identical for all measuring points connected to the same interface of the function group.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to one voltage interface, a function block must be added to enable the selection of the voltage measuring points.

6.48.3 Application and Setting Notes

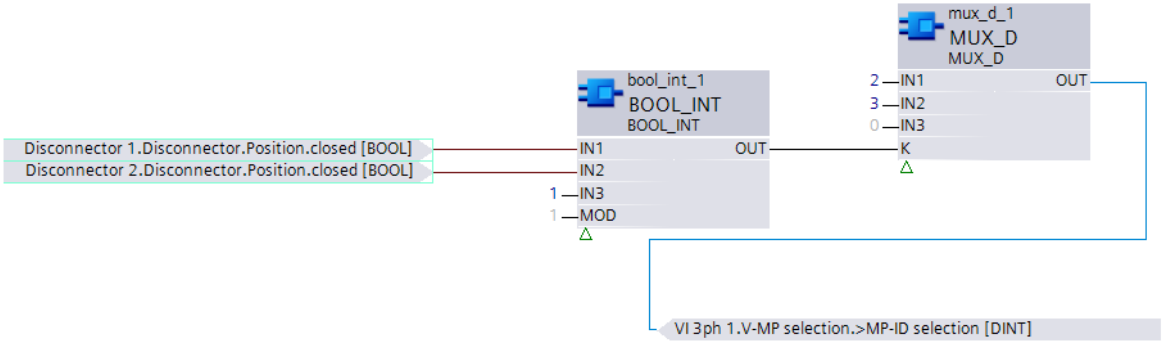
CFC Control

The voltage measuring point is selected by logic block chart on basis of the measuring point IDs. If more than one measuring point is connected to the interface of the function group, instantiate the function block **Voltage measuring-point selection** from the library in the corresponding function group.

In order to ensure the correct measuring-point connection for the function group, a logic block chart has to define the actual valid IDs for the input *>MP-ID selection* of the function block.

The following logic block chart implementation is based on the example given in *Figure 6-309*.

If the Disconnector 1 (QB1) is closed and no matter what the position the Disconnector 2 (QB2) is, the value 2 is the output of CFC block **mux_d_1** and transferred to the input *>MP-ID selection*. Then, the **Meas.point V-3ph** with ID 2 is selected as the reference voltage. Similarly, the **Meas.point V-3ph** with ID 3 is selected as the reference voltage if the Disconnector 1 (QB1) is not closed (open or in intermediate position) while Disconnector 2 (QB2) is closed.



[SclocfcVP, 1, --_--]

Figure 6-311 Logic Block Chart: Voltage Selection Using Measuring Point ID

However, the disconnectors might be both open or in a transient state. In this case, the input IN3 of the block **bool_int_1** becomes true, the value 0 is used as the ID for voltage selection input (*>MP-ID selection*). If ID 0 is selected, then all voltage values of the respective function-group interface are set to 0 V immediately. An alarm indication *Selection invalid* is issued and the indication *Health* is issued as *OK*. In case you want to supply the function group with voltage values under the condition that both disconnectors are open or in transient state from one or the other busbar, you can alter the CFC chart respectively.

NOTE

An invalid measuring-point selection (ID < 0 or an ID of a unconnected measuring point) for input *>MP-ID selection* results in the following:

- The voltage measured values are displayed as **failure**.
- The validity of the voltage measured values is set to **invalid**.
- The indication *Health* is set to ***Alarm***.
- The indication *Selection invalid* becomes true.

6.48.4 Information List

No.	Information	Data Class (Type)	Type
V-MP selection			
_:501	V-MP selection:>MP-ID selection	INS	I
_:53	V-MP selection:Health	ENS	O
_:301	V-MP selection:Selection invalid	SPS	O

7 Capacitor Bank Protection

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7.1 Introduction

Capacitors and capacitor banks are used for various applications. Examples are:

- Reactive-power compensation for voltage stabilization
- Fast voltage- and reactive-power control
- Filter circuits for the elimination of certain frequencies

Capacitor banks for transmission systems are complex systems customized for the special application. The design depends much on the used switching technology (for example, mechanically or via thyristor). In detail hardly one capacitor bank resembles another. However, a capacitor bank consists always of the same components (C, R, L, and switches). A capacitor bank often consists of several subcomponents which are connected to the capacitor-bank busbar via the circuit breakers.

The modularity of hardware and protection functionality allows to tailor the protection device exactly to the needs of the capacitor bank or the subcomponent of the capacitor bank and to realize the complete protection of the whole capacitor bank or the capacitor- bank subcomponent with only one 7SJ8 device.

Capacitor banks require the use of extensive protection functionality. The protection consists of standard protection functions and specific capacitor protection functions. The following topics are described in the next chapters:

- Extensions on standard protection functions for optimal utilization in a capacitor bank
- Specific capacitor protection functions
- Application of standard protection functions for specific protection tasks within a capacitor bank

7.2 Overcurrent Protection for Capacitor Banks

7.2.1 Overview

You can use the following overcurrent protection function types in the **Capacitor Bank** function group:

- **Overcurrent protection, phases** with phase-segregated operate indications for short-circuit protection in the area between the busbar and the capacitor and for protecting against overload of a subbank.
- **Overcurrent protection, phases** for protection against overload of RLC filter circuit elements (**Overcurrent -3ph RLC**)
- **Overcurrent protection, ground** as protection or backup protection in the event of ground faults

Figure 5-15 in Chapter *5.4.2 Structure of the Function Group* shows

- The standard protection functions that you can use in the **Capacitor Bank** function group.
- The specific protection functions that are available for protecting a capacitor bank.
- The assignment of protection functions to the interfaces of the function group.

Figure 5-13 in Chapter *5.4.2 Structure of the Function Group* shows the assignment of the interfaces in the **Capacitor Bank** function group to the measuring points of the device with reference to an example.



NOTE

The structure of the function **Overcurrent protection, Phases for protecting RLC elements of a filter circuit** differs only slightly from the standard function **Overcurrent protection, Phases – Advanced**.

In this chapter, only the differences between this and the standard function are described.

For more information, please refer to the function description **Overcurrent protection, Phases** starting from Chapter *6.3.1 Overview of Functions* .



NOTE

Starting from V07.30, the function type **50/51 OC-3ph 1p** is no longer offered in the DIGSI 5 global library in the function group **Capacitor bank**. Instead you can use now the standard advanced overcurrent function **Overcurrent protection, phases – advanced** to apply phase-segregated operate indications.

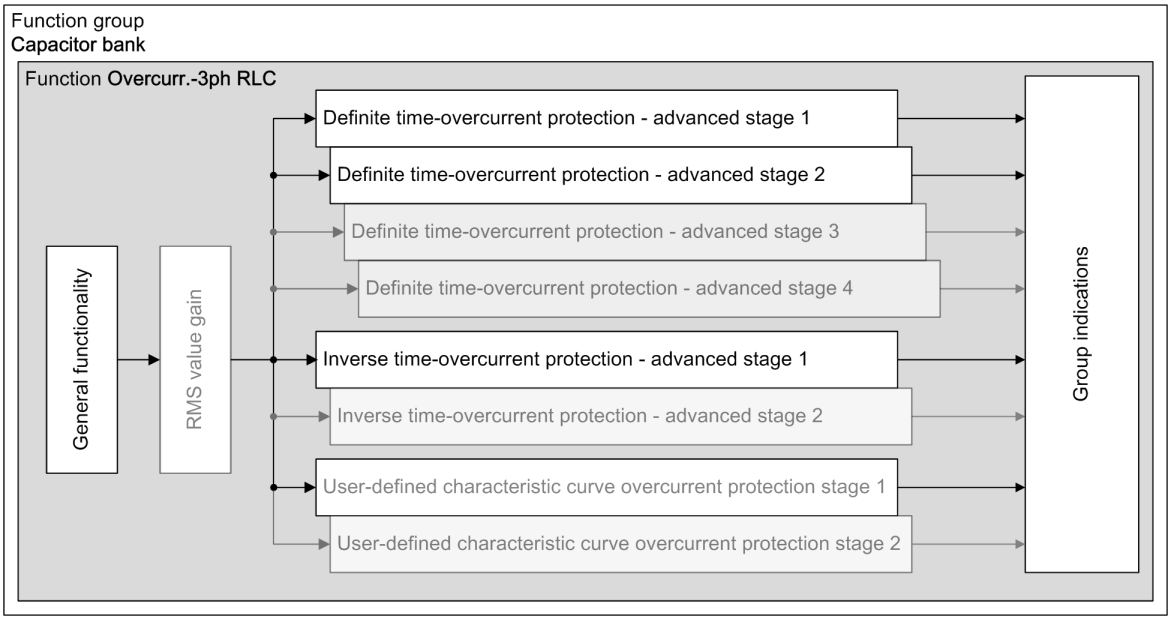
7.2.2 Overcurrent Protection, Phases for Protection of RLC Filter-Circuit Elements

7.2.2.1 Structure of the Function

In the **Capacitor Bank** function group, the **Overcurrent protection, Phases for protecting RLC filter circuit elements** function (**Overcurr. -3ph RLC**) is based on the standard protection function **Overcurrent protection, Phases – Advanced**.

The **Overcurrent protection, Phases for protecting RLC filter circuit elements** function differs from the standard protection function as follows:

- Superordinate measuring point selection
- Setting the rated current of the protected object (for example, reactor or resistor) within the function
- Measured function values of connected phase currents



[dwocpRLC-190813-01.vsd, 2, en_US]

Figure 7-1 Structure/Embedding of the Overc. -3-Ph RLC Function

7.2.2.2 Description

A feature of the **Overcurrent -3ph RLC** function is the **selection of measuring points**. A capacitor bank can include multiple filter circuits. Each filter can include, for example, a 3-phase current measurement device, each of which is assigned a measuring point. In order to protect the filter circuits, multiple instances of the **Overcurrent -3ph RLC** function can be created. Each instance of the function is assigned to a measuring point via **Measuring point selection**.

The function is structured such that the **Measuring point selection** is superordinate to the advanced overcurrent-protection stages.

Measuring-Point Selection

With the **`MP selection`** parameter, you can select from a list of measuring points a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor Bank** function group. The **Overcurrent -3ph RLC** function processes the current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor Bank** function group starting from chapter *5.4.1 Overview*.

Rated Current of the Protected Object

The rated current for the whole capacitor bank is set in the **Capacitor Bank** function group. However, the capacitor bank rated current does not apply for individual reactors or resistors used within a capacitor-bank installation. Such reactors or resistors require an individual rated current setting.

Functional Measured Values

The function provides the connected phase currents as measured function values for display, further processing or transmission to a station.

Values	Description	Primary	Secondary	% Referenced to
Iph:A Iph:B Iph:C	Phase current of measuring point	kA	A	% referenced to parameter **RLC rated current**

You can find the parameter **RLC Rated current** in the function block **General** of the **Overcurrent -3ph RLC** function.

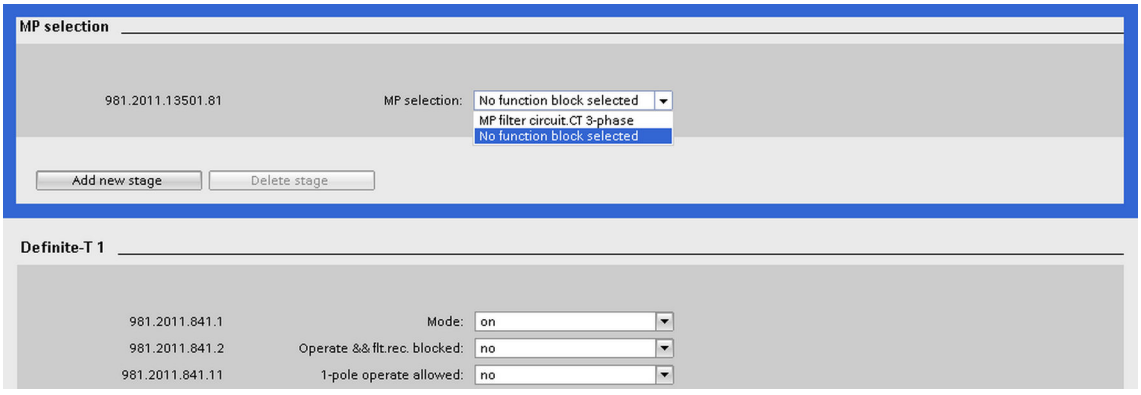
7.2.2.3 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501) MP selection** = ***No meas. point config.***

With the **MP selection** parameter, you can select a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor Bank** function group.

The selection list displays the measuring points that are connected to the **I 3ph RLC** interface of the **Capacitor Bank** function group:

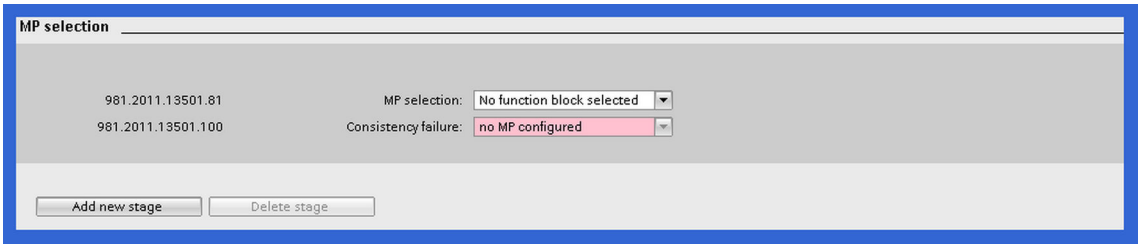


[scmpselection_ocp_rlc-150813, 2, en_US]

Figure 7-2 Example of Measuring-Point Selection

The **MP selection** parameter is set for all stages. The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure**:



[scinconsistency_ocp_rlc-150813, 2, en_US]

Figure 7-3 Function Inconsistency Indication

Parameter: RLC Rated Current

- Default setting **(_:2311:101) RLC rated current** = ***1000 A***

The parameter **RLC rated current** is used to set the primary rated current of the respective protected object which is usually a reactor or resistor branch within the capacitor bank installation. The **RLC rated current** specified here is the reference value for the percentage-measured values and setting values made in percentages.

7.3 Thermal Overload Protection for Capacitor Banks

7.3.1 Overview of Functions

The function **Overload RLC** protects RLC filter circuit elements in a capacitor bank from thermal overload.

NOTE

The structure of the function **Overload RLC** differs only slightly from that of the standard **Thermal overload protection, 3-phase** function. In this chapter, only the differences between these and the standard function are described.

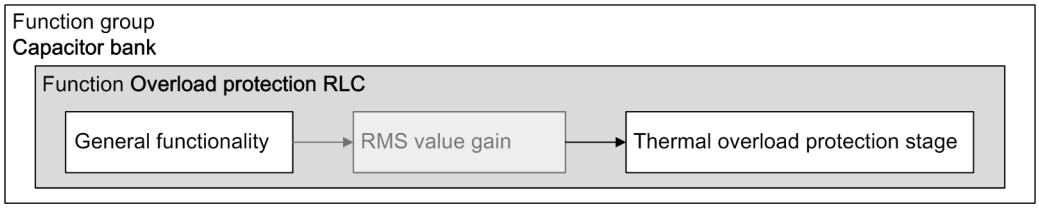
For more information, refer to the function description **Thermal overload protection, 3-phase** starting from chapter *6.19.1 Overview of Functions* .

7.3.2 Structure of the Function

The function **Overload protection RLC** is used in the **Capacitor bank** function group.

The **General functionality** differs from the standard **Thermal overload protection** function and consists of:

- Measuring-point selection
- Setting the rated current of the protected object (for example, reactor or resistor) within the function



[dwtolp_rlc-200813, 2, en_US]

Figure 7-4 Structure/Embedding of the Function

7.3.3 Description

A feature of the function **Overload RLC** is the **measuring-point selection**. A capacitor bank can include multiple filter circuits. Each filter can include, for example, a 3-phase current measurement device, each of which is assigned a measuring point. In order to protect all filter circuits, multiple instances of the function **Overload RLC** can be created. Each instance of the function is assigned to a measuring point via **measuring-point selection**.

The function is structured such that the **measuring-point selection** is superordinate to the **Thermal overload protection**.

Measuring-Point Selection

With the parameter **`MP selection`**, you can select from a list of measuring points a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor bank** function group. The function **Overload RLC** processes the current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor bank** function group starting from Chapter *5.4.1 Overview* .

Rated Current of the Protected Object

The rated current for the whole capacitor bank is set in the **Capacitor Bank** function group. However, the capacitor bank rated current does not apply for individual reactors or resistors used within a capacitor bank installation. Such reactors or resistors require an individual rated current setting.

Function Values

Measured Values	Description	Primary	Secondary	% Referred to
(_:601:304) Time until close	Time until close	s	s	s
(_:601:305) Time until trip	Estimated time until trip	s	s	s
(_:601:306) Overload phase A	Thermal measured values of phases	%	%	Trip temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured values of overload protection	%	%	Trip temperature
(_:601:310) Equival. current phs A	Current measured value as base for overload measured value	A	A	Parameter **RLC rated current**
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value as base for overload value	A	A	Parameter **RLC rated current**

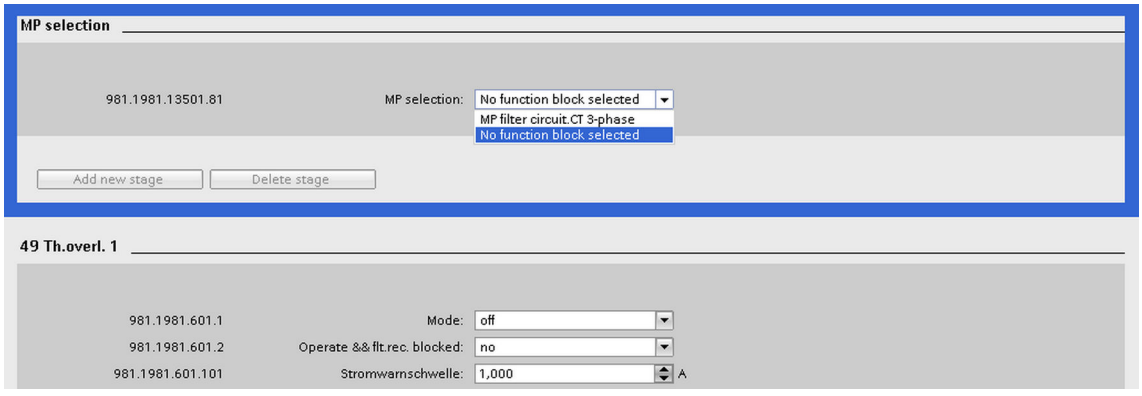
7.3.4 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501) MP selection** = ***no MP configured***

With the **MP selection** parameter, you can select a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor bank** function group.

The selection list displays the measuring points that are connected to the **I 3ph RLC** interface of the **Capacitor bank** function group:

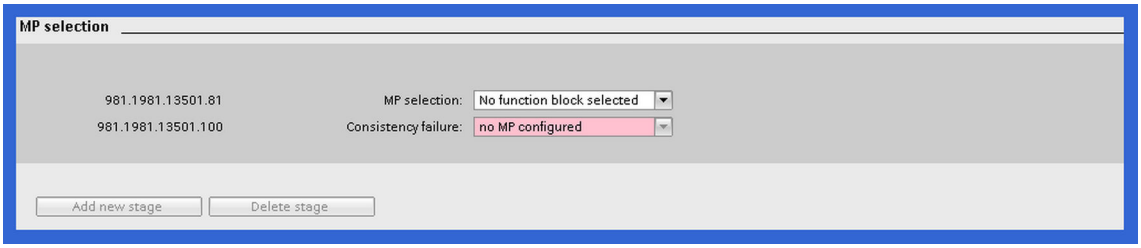


[scmpselection_tolp_rlc-150813, 2, en_US]

Figure 7-5 Example of Measuring-Point Selection

The **MP selection** parameter is set for all stages. The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure** :



[scinconsistency_tolp_rlc-150813, 2, en_US]

Figure 7-6 Function Inconsistency Indication

Parameter: RLC rated current

- Default setting **`RLC rated current`** = ***`1000 A`***

The parameter **`RLC rated current`** is used to set the primary rated current of the respective protected object which is usually a reactor or resistor branch within the capacitor bank installation. The setting is used as $I_{rated, obj}$ for the nominalization calculation within the thermal model.

7.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:101	General:RLC rated current		1 A to 100000 A	1000 A
`MP selection`				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP config-ured
_:13501:81	MP selection:MP selec-tion		Setting options depend on configuration	

7.3.6 Information List

No.	Information	Data Class (Type)	Type
`MP selection`			
_:13501:301	MP selection:Iph	WYE	O

7.4 Current-Unbalance Protection for Capacitors, 3-Phase

7.4.1 Overview of Functions

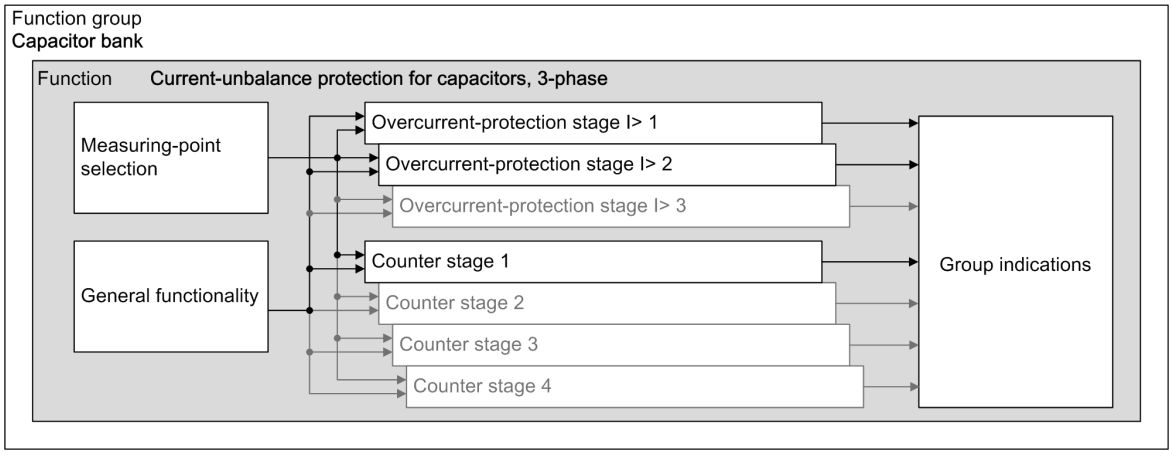
The **Current-unbalance protection for capacitors, 3-phase** function (ANSI 60C):

- Protects in case of capacitor elements (C-elements) faults of a capacitor bank in H connection
- Provides very sensitive supervision of the unbalanced current between the 2-star points
- Allows counting of individual faulty C-elements

7.4.2 Structure of the Function

The **Current-unbalance protection for capacitors, 3-phase** function is used in the **Capacitor bank** function group. It is preconfigured at the factory with 2 overcurrent-protection stages **I>** and one stage of the type **Counter**. A maximum of 3 overcurrent-protection stages and 4 counter stages can be operated simultaneously in the function.

The function is designed so that the **General functionality** (including compensation) and the **Measuring-point selection** can work across the stages.



[dwocplunbalanced-300813, 4, en_US]

Figure 7-7 Structure/Embedding of the Function

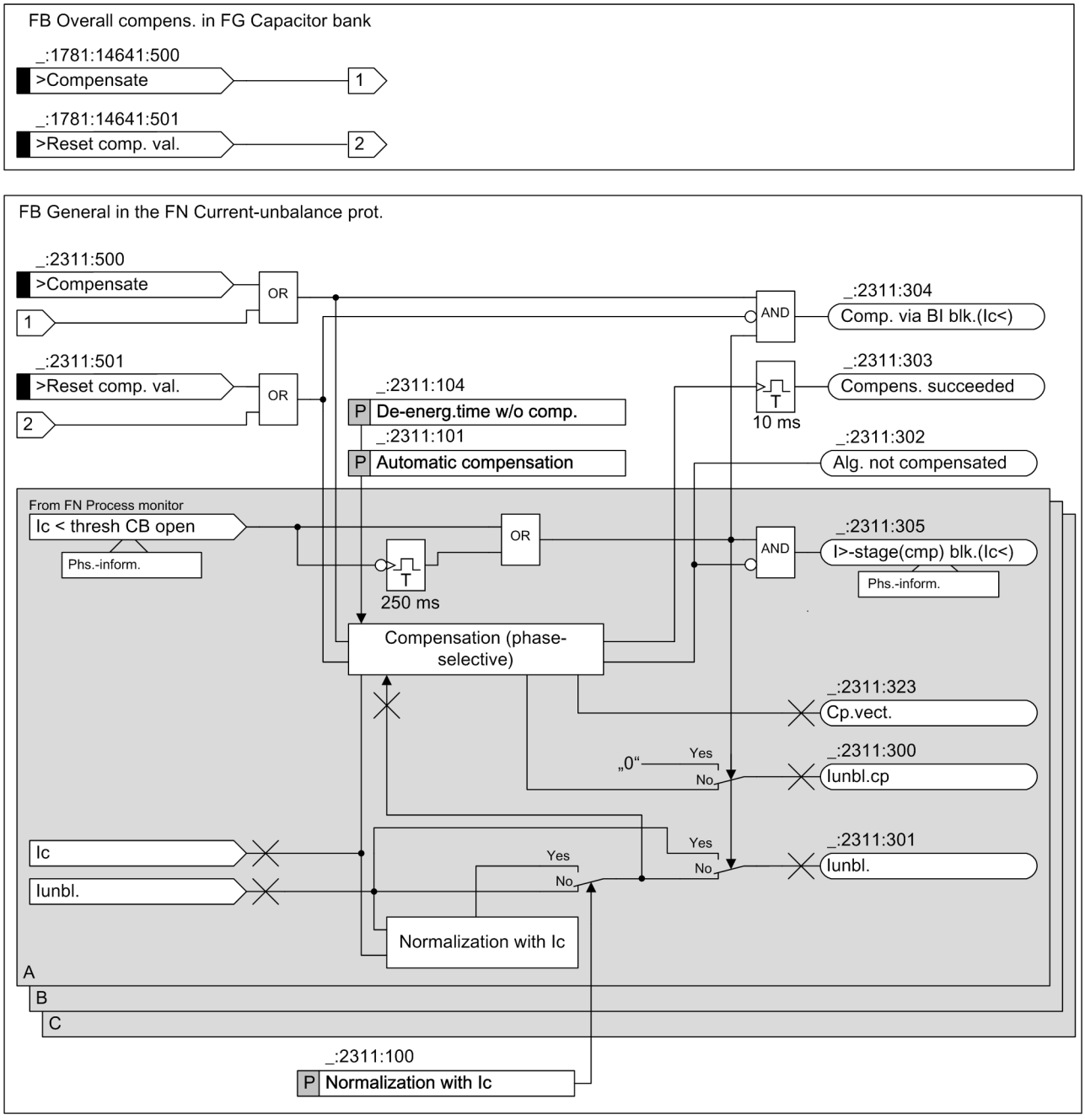
7.4.3 General Functions and Measuring-Point Selection

7.4.3.1 Description

The General functionality is structured in the following functional parts:

- Compensation of the unbalance
- Normalization of the unbalanced current with the current I_c
- Counting faulty C-elements (the stage type **Counter** is used to monitor the counter status)

Logic for Compensation and Normalization



[lo_FBallg_iunbal-020913.tif, 3, en_US]

Figure 7-8 Cross-Stage Functionality

Measuring-Point Selection

With the **`MP selection`** parameter, you can select from a list of measuring points a measuring point that is connected to the **I Unbalanced** interface in the **Capacitor bank** function group. The **Current-unbalance protection for capacitors, 3-phase** function processes the current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor bank** function group starting from chapter *5.4.1 Overview* .

Measurands, Method of Measurement

The function receives its measurands via the **I Unbalanced** interface of the **Capacitor bank** function group.

The compensated and non-compensated unbalanced currents are provided for the overcurrent-protection stage. Within the protection stage, one of the 2 values is selected in the protection stage via the parameter **Measured value**. Both values are available as functional measured values (see *Figure 7-8*).

Configure across the stages whether the unbalanced current must be normalized with the current I_c that flows into the capacitor bank. You can find more information in this chapter under *Normalization with I_c , Page 926* .

The method of measurement used processes the sampled unbalanced-current values and filters out the fundamental component numerically. The protection stages evaluate the fundamental component of the unbalanced current.

General Notes on the Compensation

An operational unbalanced current is added to an unbalanced current resulting from faulty capacitor elements. This corrupts the measuring result.

Operational unbalanced currents can result from the following causes:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates operational unbalanced currents by calculation. For this purpose, the phasor of the operational unbalanced current $\underline{I}_{unbal.,op.}$ is stored at specific times. The stored phasor (compensation phasor), is subtracted from the actually measured unbalanced-current phasor:

$$\underline{I}_{unbal.,comp.} = \underline{I}_{unbal.} - \underline{I}_{unbal.,op.}$$

[fo_compensatied unbal., 1, en_US]

The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. The compensated values are not available under the following conditions: • After initial startup of the device before any compensation is carried out • After activating the binary input *>Reset comp. val.* • After change of $I_{rated,obj}$ Protection stages that are working with compensated values are inactive.
Compens. succeeded	This indication is issued (as transient indication with a pulse duration of 10 ms) if the existing unbalance has been compensated manually or automatically. In case of automatic compensation, the signal is issued at each event-based situation where full compensation is carried out.
Comp. via BI blk.(Ic<)	If a manual compensation has been initiated and the current I_c (current flowing into the capacitor bank) at this time is less than the threshold **Current threshold CB open**, the manual compensation is not executed. This is signaled via the *Comp. via BI blk.(Ic<)* indication.

2 different methods are available for the compensation:

- Manual compensation via binary input signals
- Automatic compensation

Manual Compensation via Binary Input Signal

If the binary input signal *>Compensate* is activated, the manual compensation starts. This will fully compensate any unbalance that exists at this time. This means the value $\underline{I}_{unbal.,comp.}$ will then become 0. You can also use the manual compensation in parallel with the automatic compensation.

Automatic Compensation

When using the parameter **Automatic compensation** , this automatic compensation function can be enabled or disabled.

The automatic compensation consists of 2 different mechanisms:

- The event-based compensation of any existing unbalance.
  This compensation is performed in the following situations:
  - After energizing the capacitor bank or a phase of the bank (phase-selective compensation)
  - After counting a faulty C-element (phase-selective compensation)
  - After each startup of the device
  - After specific parameter changes:
    - Switching on the automatic compensation
    - Changing the rated current of the capacitor bank

  In order to avoid transient inrush-current effects, the compensation is delayed by 250 ms after energizing has been detected.
  Full compensation after bank energization can be avoided in case of only short de-energization by means of parameter **De-energ.time w/o comp.**. If the de-energized duration is less than the setting of parameter **De-energ.time w/o comp.**, the full compensation is not carried out after energizing a phase or the whole bank.
- Cyclic, slow and thus gradual compensation of an existing unbalance in small increments.
  This permits, for example, the automatic compensation of environmental influences.

Resetting the Compensation

The algorithm can be reset to the non-compensated status. Compensated values are not available in this case. Protection stages that work with compensated values are rendered inactive. The binary input signal *>Reset comp. val.* of the function or function group resets the compensation (see also *Figure 7-8*).



NOTE

When operating with manual compensation, changing the value of parameter **capacitor reference current** will reset the compensation values.

Normalization with I_c

The threshold for the unbalanced current is usually set by assuming the rated capacitor current $I_{c,rated}$. The current I_c flowing into the capacitor bank determines the amount of the unbalanced current. A lower I_c also means a lower unbalanced current. If $I_c < I_{c,rated}$, the protection becomes less sensitive. This influence can be compensated via the normalization. Normalization keeps the sensitivity of the protection function constant by normalizing the unbalance value with the current I_c. When using the parameter **Normalization with Ic** , normalization is enabled or disabled.

I_c Lower than Current Thresh.CB Open

If the current I_c is lower than the threshold **Current Thresh.CB Open**, the compensated value can no longer be computed with sufficient accuracy. To avoid a malfunction, the compensated unbalanced value $\underline{I}_{unbal.,comp.}$ is set to 0 A in a phase-segregated way (see *Figure 7-8*). This deactivates the affected phase measuring components of the protection stages that work with compensated values.

This condition will be indicated in a phase-segregated manner (indication *I>-stage(cmp) blk.(Ic<)*). In this case, normalization with current I_c will no longer work properly either. The normalization is canceled in a phase-segregated manner. This means that the non-normalized value is used in place of the normalized value (see *Figure 7-8*).

Charging/Energizing the Capacitor Bank or a Phase of the Bank

Charging of the bank takes place when the discharged bank is switched on to the network. Charging of a phase can occur in case of network faults. If a phase-to-ground voltage drops to 0 V due to a network fault, the respective phase is discharged and the return of the phase-to-ground (after the fault has been cleared) will charge the phase.

Charging the bank or a phase of the bank causes inrush currents in the respective phases. To avoid overfunction in case of sensitive threshold settings, the stages using compensated unbalanced values are blocked in a phase-selective way by setting $\underline{I}_{unbal.,comp.}$ to 0 A. These stages are:

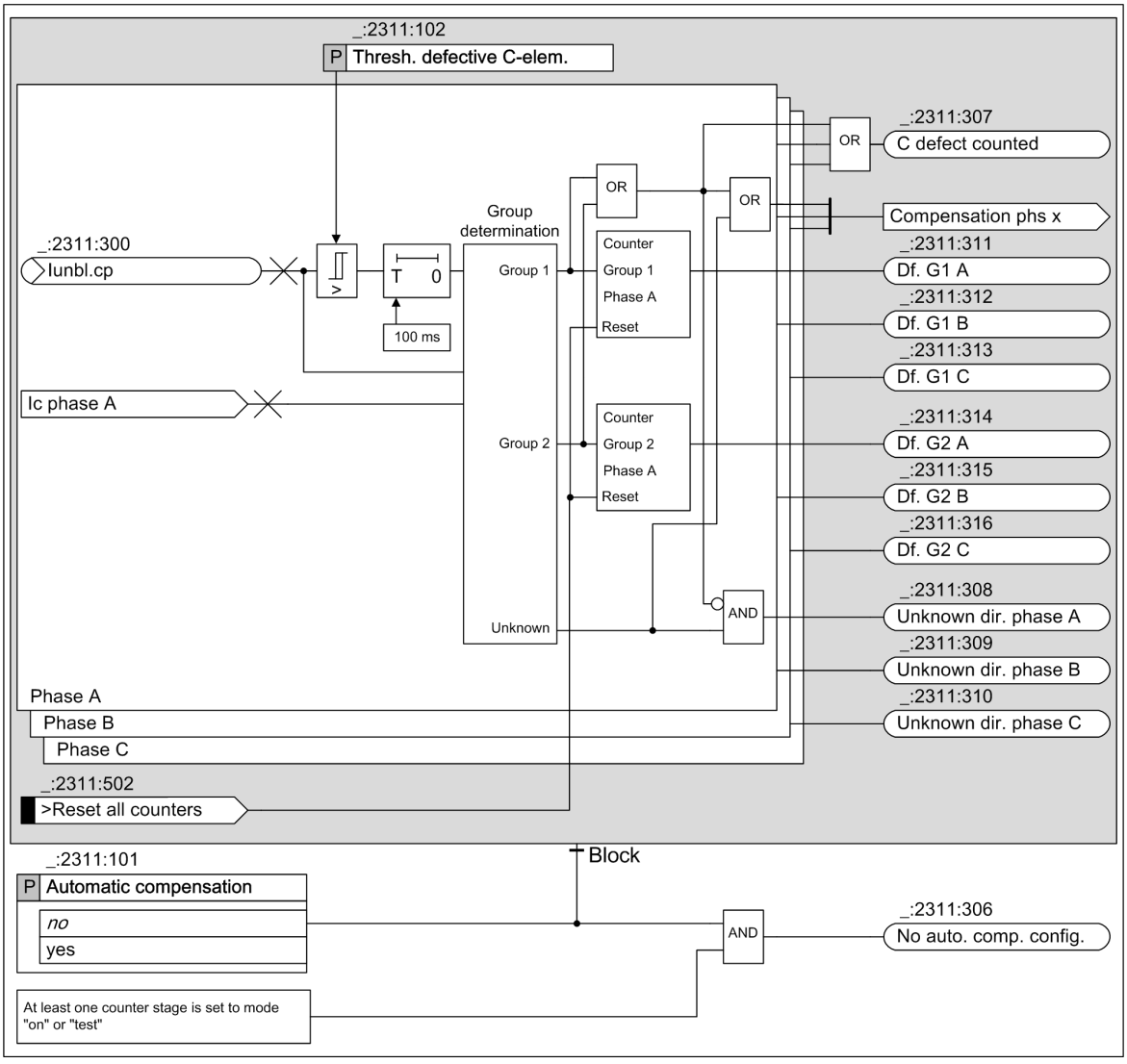
- Counter stage
- I> stage, if set to operate with compensated unbalanced values

The blocking ($\underline{I}_{unbal.,comp.}$ set to 0 A) lasts for 250 ms after energizing detection. Afterwards, the calculated $\underline{I}_{unbal.,comp.}$ is processed again.

Energizing detection takes place in a phase-selective way by monitoring the phase current I_c flowing into the bank. If a phase current exceeds the threshold **`Current Thresh.CB Open`**, energizing in this phase is detected.

Logic for Counting Faulty C-Elements

This part of the General functionality is only important if counter stages are used.



[lo-cnt-EF-260314-01, 3, en_US]

Figure 7-9 Counting Faulty C-Elements

Activation/Blocking Counting

If at least one counter stage is enabled, the counter function is active. Furthermore, the counter function works only if the automatic compensation is enabled.

In order to prevent counting as a consequence of the charging process, the counter function is implicitly blocked for 250 ms by setting $I_{unbal.,comp.}$ to 0 A, after the capacitor energizing has been detected.

Measurands, Counting

The measurand is the phase-selective compensated unbalanced current $I_{unbal.,comp.}$. If a single C-element is faulty, an unbalance occurs in the H connection. This unbalance causes an unbalanced current; this means, a small current jump is generated in the unbalanced current. Set the parameter **`Thresh. defective C-elem.`**, so that the current jump can be detected (refer also to *7.4.3.2 Application and Setting Notes*). The unbalanced current that was caused by the fault must exceed the threshold for 100 ms before the affected group is determined and counting (incrementing the counter) takes place. There is one counter for each phase and group. After the counting, the existing unbalance is compensated; this means, the unbalance is reset to 0 A. If the faulty group cannot be determined, the unbalance is also compensated.

Resetting/Setting the Counters

You can reset or set the counters of group 1 and group 2 via:

- On-site operation panel directly on the device
- Online DIGSI connection to the device
- Binary input *>Reset all counters* (only reset of all counters)
- Communication connection with the control center

You can directly set or reset the counters via IEC 61850 by setting the counter values to the desired value. If you want to reset the counters via DNP3, IEC 60870-5-103, Modbus, or IEC 60870-5-104, an additional configuration with CFC is necessary. For more information, refer to chapter *7.4.3.2 Application and Setting Notes*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:300) Iunbl.cp	Compensated unbalanced current $\underline{I}_{unbal.,comp.}$	kA	A	Parameter **Rated primary current**
(_:2311:301) Iunbl.	Non-compensated unbalanced current $\underline{I}_{unbal.}$	kA	A	Parameter **Rated primary current**
(_:2311:323) Cp.vect.	Compensation vector $\underline{I}_{comp.,vect.}$	kA	A	Parameter **Rated primary current**

You can find the value of the parameter **Rated primary current** of the preceding table in the chapter *6.1.6 Settings* according to the specified parameter **MP selection**.

$\underline{I}_{comp.,vect.}$ is normalized with I_c. The normalization is carried out no matter if the parameter **Normalization with Ic** is set to ***yes*** or ***no***. $\underline{I}_{comp.,vect.}$ keeps its value unchanged until the next compensation occurs.

$$\underline{I}_{comp.,\,vect} = \underline{I}_{unbal.\,op.}\frac{I_{c,rated}}{I_c}$$

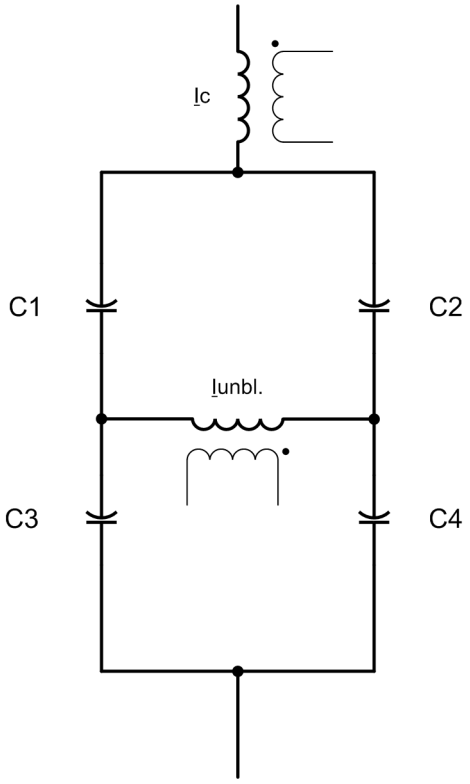
[fo_compensation vector, 1, en_US]

Where:

$\underline{I}_{unbal.op.}$	Operational unbalanced current at the moment the compensation is carried out
$I_{c,rated}$	Rated current of the capacitor bank
I_c	Current of the capacitor bank at the moment the compensation is carried out

Definition of the Group and Fault Location with the Capacitor in H Connection

If the capacitor is designed in an H connection, the following definition is assumed:



[dwfehlerortinf_iunsy-020913, 1, en_US]

Figure 7-10 Definition of the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1 and C4
- Group 2: C2 and C3

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

The angle reference of the unbalanced-current phasor to the reference current I_c is used to determine the direction of the unbalanced current and, thus, the affected group is determined. If the direction cannot be determined with confidence, an appropriate indication will be generated.

7.4.3.2 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501:81) MP selection** = ***None***

With the **MP selection** parameter, you can select from a list the measuring point that is connected to the **I Unbalanced** interface of the **Capacitor bank** function group.

The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure**.

Parameter: Automatic compensation

- Default setting **(_:2311:101) Automatic compensation** = ***no***

The parameter applies equally to all stages of the function that work with compensated measurands.

If no counter stages are applied, Siemens recommends switching the automatic compensation off and using the manual compensation. You can find more information on this recommendation in chapter *7.4.4.2 Application and Setting Notes* (setting notes for the operate delay of the **I>** stage).

If the counter stages are applied, the automatic compensation must be switched on, otherwise the counting function will not work.

Parameter: `De-energ.time w/o comp.`

- Default setting `(_:2311:104) De-energ.time w/o comp.` = ***2.00 s***

In case of networks faults, the faulty phases are discharged. With the returning voltage after fault clearance, charging takes place. For such conditions, Siemens recommends that no automatic full compensation takes place in the affected phases. Otherwise, C-element defects occurring in this period (for example, because of discharging stress due to network-fault inception) will not be detected.

With the parameter `De-energ.time w/o comp.`, you define the duration of short de-energization after which no automatic compensation takes place. The parameter must be set to a value larger than the slowest fault-clearing time in your network plus a safety margin.

If the setting is set to 0 s, an automatic full compensation is carried out after each energizing detection.

Parameter: `Normalization with Ic`

- Default setting `(_:2311:100) Normalization with Ic` = ***no***

This parameter applies equally to all stages of the function.

Parameter Value	Description
no	Select this setting if you can safely assume that I_c will not change for operational reasons or if you do not desire normalization of the unbalanced current with I_c. Please consider that the protection sensitivity will decrease with decreasing I_c.
yes	Select this setting if you want to keep the sensitivity of the protection stages constant during changes of I_c.

Parameter: `Thresh. defective C-elem.`

- Default `(_:2311:102) Thresh. defective C-elem.` = ***0.030 A***

Set the parameter `Thresh. defective C-elem.` to ensure that the jump in the unbalanced current caused by the faulty C-element is detected. Information about occurring unbalanced current as a consequence of single faulty C-elements will be provided by the manufacturer of the capacitor bank. Siemens recommends to set the threshold value to approx. 75 % of the unbalanced current that occurs after the fault of the 1st C-element.

Example 1: Information about the Unbalanced Current Available from the Manufacturer of the Capacitor Bank

Table 7-1 Unbalanced Current, Depending on the Number of Faulty C-Elements

Number of Faulty C-Elements	Primary Unbalanced Current
0	0.00 A
1	0.71 A
2	1.47 A
3	2.29 A
...	...

Assumed current transformer ratio: 10 A/1 A

Primary unbalanced current if 1st C-element fails: 0.71 A

Secondary unbalanced current if 1st C-element fails: 0.071 A

Secondary setting value: 0.75 · 0.071 A = 0.053 A

NOTE

Use sensitive device current inputs in order to apply secondary thresholds of < 30 mA.

If no information is provided by the manufacturer of the capacitor bank, the following example can be used as a basis in order to determine the value.

Example 2 (a to h): Unbalanced-Current Information Not Available from the Manufacturer of the Capacitor Bank, External Capacitor-Bank Structure with Cross-Linked Cans

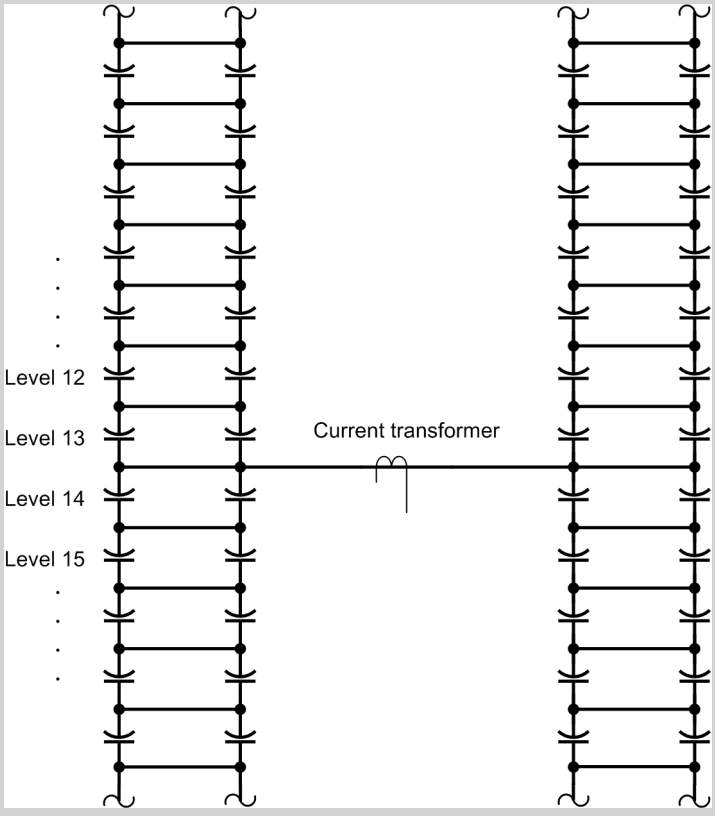
The following consideration applies to one phase.

2a) External Structure of the Capacitor Bank

The external structure of the capacitor bank must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following external structure of the capacitor bank:

- 28 levels (cans) in series
- 4 cans per level
- H transformer between levels 13 and 14, counting from top to bottom
- 2 parallel cans are always cross-linked, refer to the following diagram



[dwexaufbcb-120314-01, 1, en_US]

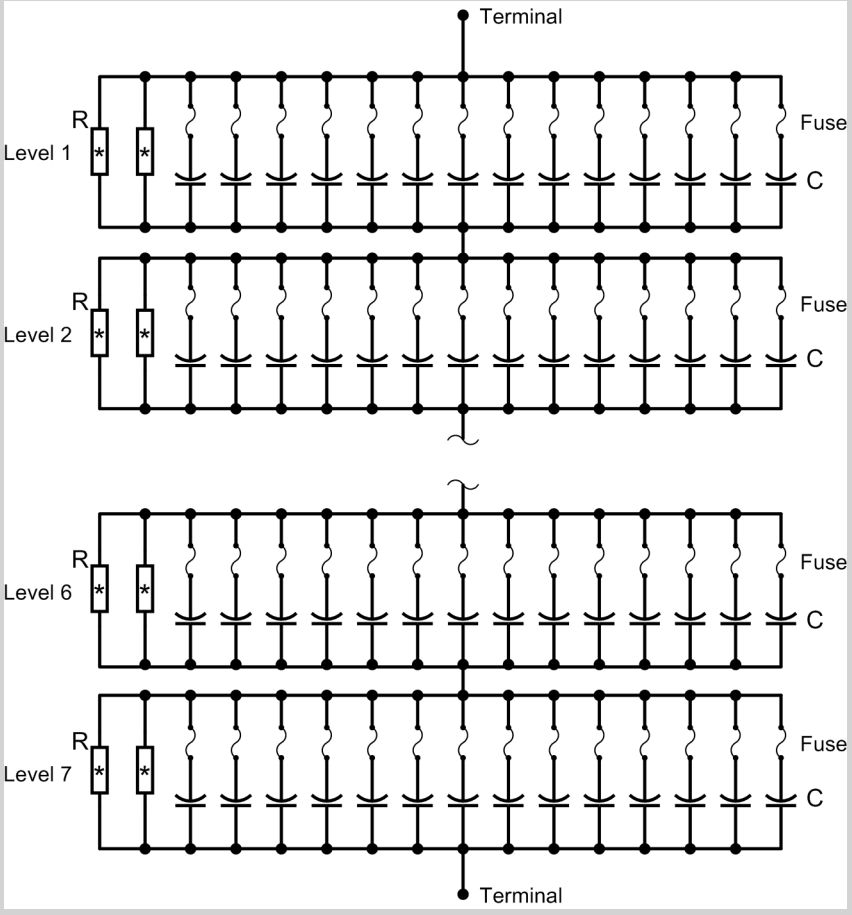
Figure 7-11 External Structure of the Capacitor Bank

2b) Internal Structure of a Can

The internal structure of a can must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following internal structure of the can:

- 14 parallel capacitances
- Internal fuses (one internal fuse per capacitance)
- 7 capacitance levels in series



[dwintauka-120314-01, 2, en_US]

Figure 7-12 Internal Structure of a Can

2c) Capacitance of a Can

The capacitance of a can must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

- Capacitance per can: $C_K = 19.67\ \mu F$

2d) Current per Phase

The unbalanced current is derived under the assumption of a certain phase current.

In this example, the phase current is determined using the following assumptions and data:

- 1-phase rated capacitance of the capacitor bank: 2.81 µF
- Phase-to-ground voltage of the fundamental component of the capacitor bank: 249.1 kV
- Current per phase: $I_C = V_{Ph.\ fund.} \cdot \omega C = 249.1\ kV \cdot 2\pi \cdot 50\ Hz \cdot 2.81\ \mu F = 219.9\ A$

2e) Capacitance of a Can during an Element Fault

To do this, the capacitance of an individual C-element will be determined first:

- Capacitance of a C-element:

$$C_E = \frac{C_K}{\text{No. C in parallel}} \cdot \text{No. C in series} = \frac{19.67\ \mu F}{14} \cdot 7 = 9.835\ \mu F$$

- Capacitance of a can during an element fault:

$$\frac{1}{C_{K,1EF}} = \frac{\text{No. C in series without a fault}}{\text{No. C in parallel} \cdot C_E} + \frac{1}{(\text{No. C in parallel} - 1) \cdot C_E}$$

$$\frac{1}{C_{K,1EF}} = \frac{6}{14 \cdot C_E} + \frac{1}{13 \cdot C_E} = \frac{1}{0.051397\ \mu F}$$

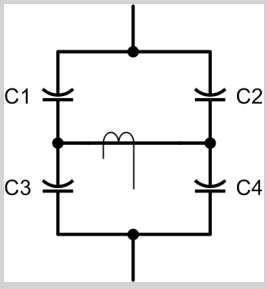
$C_{K,1EF} = 19.456\ \mu F$

2f) Capacitance in the Quarter of the H Connection during an Element Fault

Consider 2 special conditions:

- Cross-linking and therefore the parallel connection of 2 cans, refer to *Figure 7-11*
- Current transformer is not in the center of the levels

Therefore, the following calculation must be performed for the upper (C1) and lower quarter (C3).



[dw4tlkbnk-120314-01, 1, en_US]

Figure 7-13 Quarters of the Capacitor Bank

Based on the cross-linking of the cans, in case of an element fault, the capacitance of the parallel cans must be determined first:

- Capacitance of 2 parallel cans in case of an element fault:

  $C_{2K,1EF} = 19.456\ \mu F + 19.67\ \mu F = 39.126\ \mu F$

  Capacitance in the quarter of C1 in case of an element fault:

$$\frac{1}{C1_{1EF}} = \frac{\text{No. cans in series without a fault}}{2 \cdot C_K} + \frac{1}{C_{2K,1EF}}$$

$$\frac{1}{C1_{1EF}} = \frac{12}{2 \cdot 19.67\ \mu F} + \frac{1}{39.126\ \mu F} = \frac{1}{0.3306\ \mu F}$$

$C1_{1EF} = 3.0249\ \mu F$

- Capacitance in the quarter of C3 in case of an element fault:

$$\frac{1}{C3_{1EF}} = \frac{14}{2 \cdot 19.67\ \mu F} + \frac{1}{39.126\ \mu F} = \frac{1}{0.3814\ \mu F}$$

$C3_{1EF} = 2.6217\ \mu F$

2g) Capacitance in the Quarters of the H Connection without Element Fault

- Capacitance in the quarters of C1 and C3 without element fault:

$$C1 = \frac{2 \cdot C_K}{\text{No. cans in series}} = \frac{2 \cdot 19.67\ \mu F}{13} = 3.026\ \mu F$$

$$C3 = \frac{2 \cdot C_K}{\text{No. cans in series}} = \frac{2 \cdot 19.67\ \mu F}{15} = 2.623\ \mu F$$

2h) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault

- Unbalanced current:

$$I_{unbl.} = I_C \left| \frac{C1}{(C1 + C2)} - \frac{C3}{(C3 + C4)} \right|$$

- Unbalanced current in case of an element fault in C1:

$$I_{unbl.} = 219.9\ A \left| \frac{3.0249\ \mu F}{(3.0249\ \mu F + 3.026\ \mu F)} - \frac{3.623\ \mu F}{(3.623\ \mu F + 3.623\ \mu F)} \right| = 20.0\ mA$$

- Unbalanced current in case of an element fault in C3:

$$I_{unbl.} = 219.9\ A \left| \frac{3.026\ \mu F}{(3.026\ \mu F + 3.026\ \mu F)} - \frac{3.6217\ \mu F}{(3.6217\ \mu F + 3.623\ \mu F)} \right| = 27.3\ mA$$

The lesser of both values is relevant for the setting of the threshold value. For instance, set the threshold to 75 % of this value:

- Threshold value (primary): 0.75 · 20.0 mA = 15.0 mA

The threshold is a primary value. In order to detect this, a 1:1 transformer is required. Under this assumption, the secondary setting value is equal to the primary value.

NOTE

Use sensitive device current inputs in order to apply secondary thresholds of < 30 mA.

Example 3 (a to d): Unbalanced-Current Information Not Available from the Manufacturer of the Capacitor Bank, External Capacitor-Bank Structure without Cross-Linked Cans

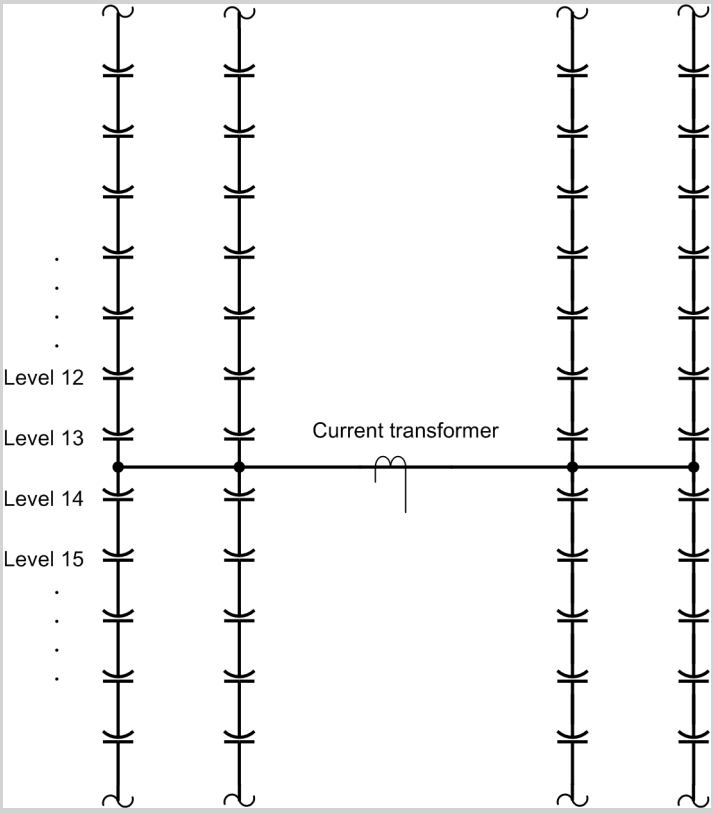
Example 3 is almost identical to example 2. The only difference is that the cans are not cross-linked. Here, only the calculation part is discussed that is a result of the different external structure. Information for additional calculations can be found in example 2.

3a) External Structure of the Capacitor Bank

The external structure of the capacitor bank must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following external structure of the capacitor bank:

- 28 levels (cans) in series
- 4 cans per level
- H transformer between levels 13 and 14, counting from top to bottom
- Parallel cans are not cross-linked, refer to the following diagram

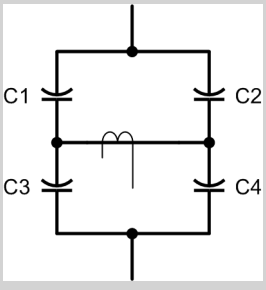


[dwexafbocb-260314-01, 1, en_US]

Figure 7-14 External Structure of the Capacitor Bank

3b) Capacitance in the Quarter of the H Connection during an Element Fault

The current transformer is not located in the center of the levels; therefore, the following calculation for the upper (C1) and the lower quarter (C3) must be performed.



[dw4tlkbnk-120314-01, 1, en_US]

Figure 7-15 Quarters of the Capacitor Bank

- Capacitance in the quarter of C1 in case of an element fault ($C1_{1EF}$):

  Capacitance in the row without element fault:

  $$\frac{1}{C1_{Ro\,EF}} = \frac{\text{No. cans in series}}{C_K} = \frac{13}{19.67\ \mu F}$$

  $C1_{RoEF} = 1.5130\ \mu F$

- Capacitance in the row with element fault:

  $$\frac{1}{C1_{Rm\,EF}} = \frac{\text{No. cans in series without a fault}}{C_K} + \frac{1}{C_{k,1EF}} = \frac{12}{19.67\ \mu F} + \frac{1}{19.456\ \mu F}$$

  $C1_{RmEF} = 1.5118\ \mu F$

  $C1_{1EF} = C1_{RoEF} + C1_{RmEF} = 1.5130\ \mu F + 1.5118\ \mu F = 3.0248\ \mu F$

- Capacitance in the quarter of C3 in case of an element fault ($C3_{1EF}$):

  Capacitance in the row without element fault:

  $$\frac{1}{C3_{Ro\,EF}} = \frac{\text{No. cans in series}}{C_K} = \frac{15}{19.67\ \mu F}$$

  $C3_{RoEF} = 1.3113\ \mu F$

- Capacitance in the row with element fault:

  $$\frac{1}{C3_{Rm\,EF}} = \frac{\text{No. cans in series without a fault}}{C_K} + \frac{1}{C_{k,1EF}} = \frac{14}{19.67\ \mu F} + \frac{1}{19.456\ \mu F}$$

  $C3_{RmEF} = 1.3104\ \mu F$

  $C3_{1EF} = C3_{RoEF} + C3_{RmEF} = 1.3113\ \mu F + 1.3104\ \mu F = 2.6217\ \mu F$

3c) Capacitance in the Quarters of the H Connection without Element Fault

The values are identical to those values in the example *2g) Capacitance in the Quarters of the H Connection without Element Fault, Page 935* .

3d) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault

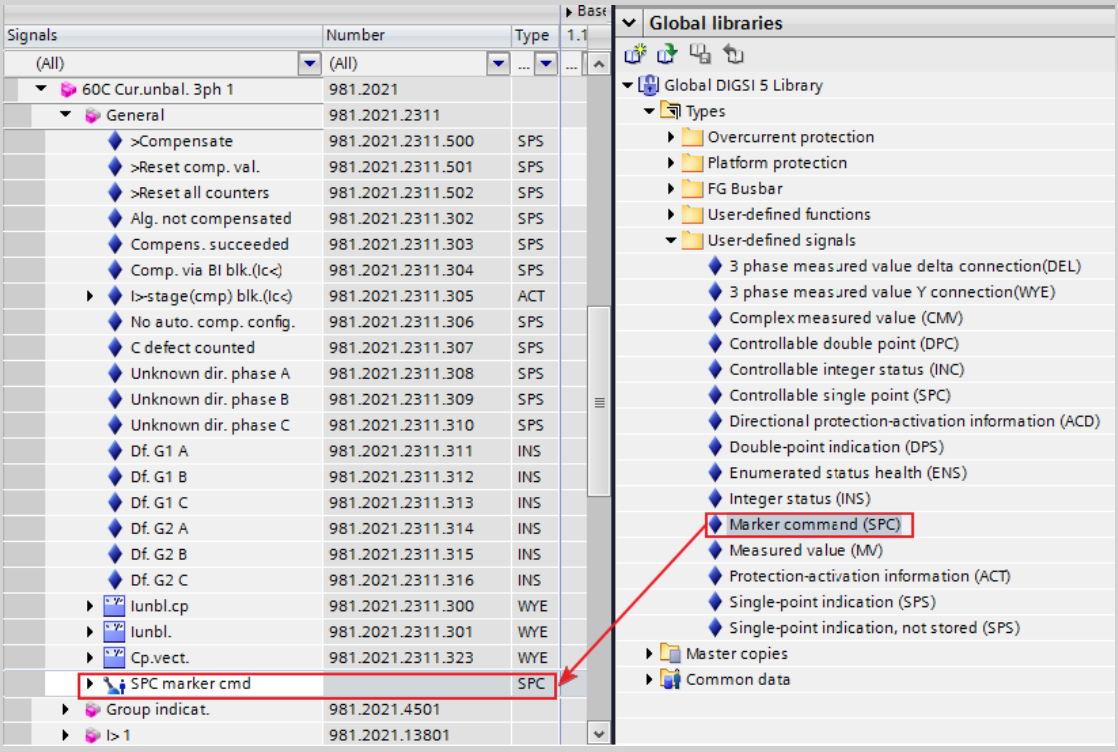
Use the values determined under 3b) for those formula listed in example *2h) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault, Page 935* .

Resetting the Counters via Protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus

The following example shows how to use a function chart (CFC) to reset the counters with the protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus.

EXAMPLE

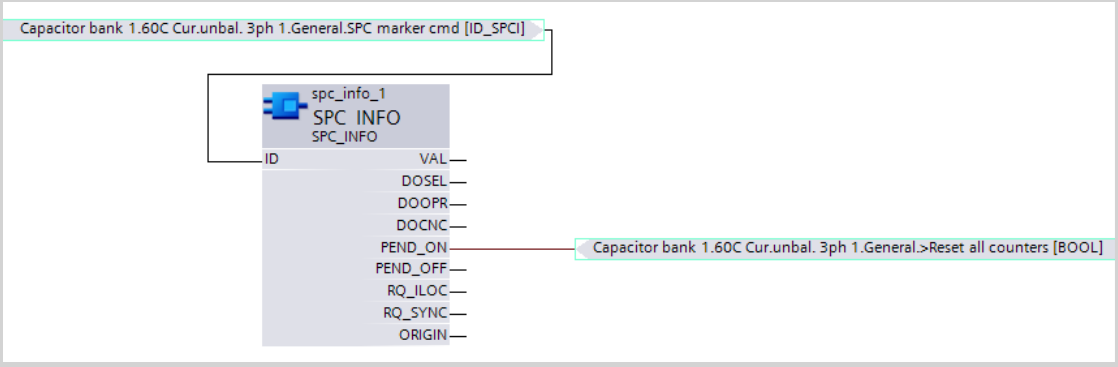
- Add a **Marker command (SPC)** signal to the information list.



[sc_add_SPC_signal, 1, en_US]

Figure 7-16 Adding Marker Command (SPC) Signal to Information List

- Set up the following CFC. Connect the SPC signal as input, and the signal *>Reset all counters* as output.



[sc_CFC_60C_3ph, 1, en_US]

Figure 7-17 Function Chart (CFC): Activating the Binary Input Signal

- Send a single-point control command from the control center to the SPC signal to activate the signal *>Reset all counters*. Then the counters are reset.

7.4.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP selection				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP configured

Addr.	Parameter	C	Setting Options	Default Setting
_:13501:81	MP selection:MP selection		Setting options depend on configuration	
General				
_:2311:101	General:Automatic compensation		• no • yes	no
_:2311:100	General:Normalization with Ic		• no • yes	no
_:2311:102	General:Thresh. defective C-elem.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:2311:104	General:De-energ.time w/o comp.		0.00 s to 60.00 s	2.00 s

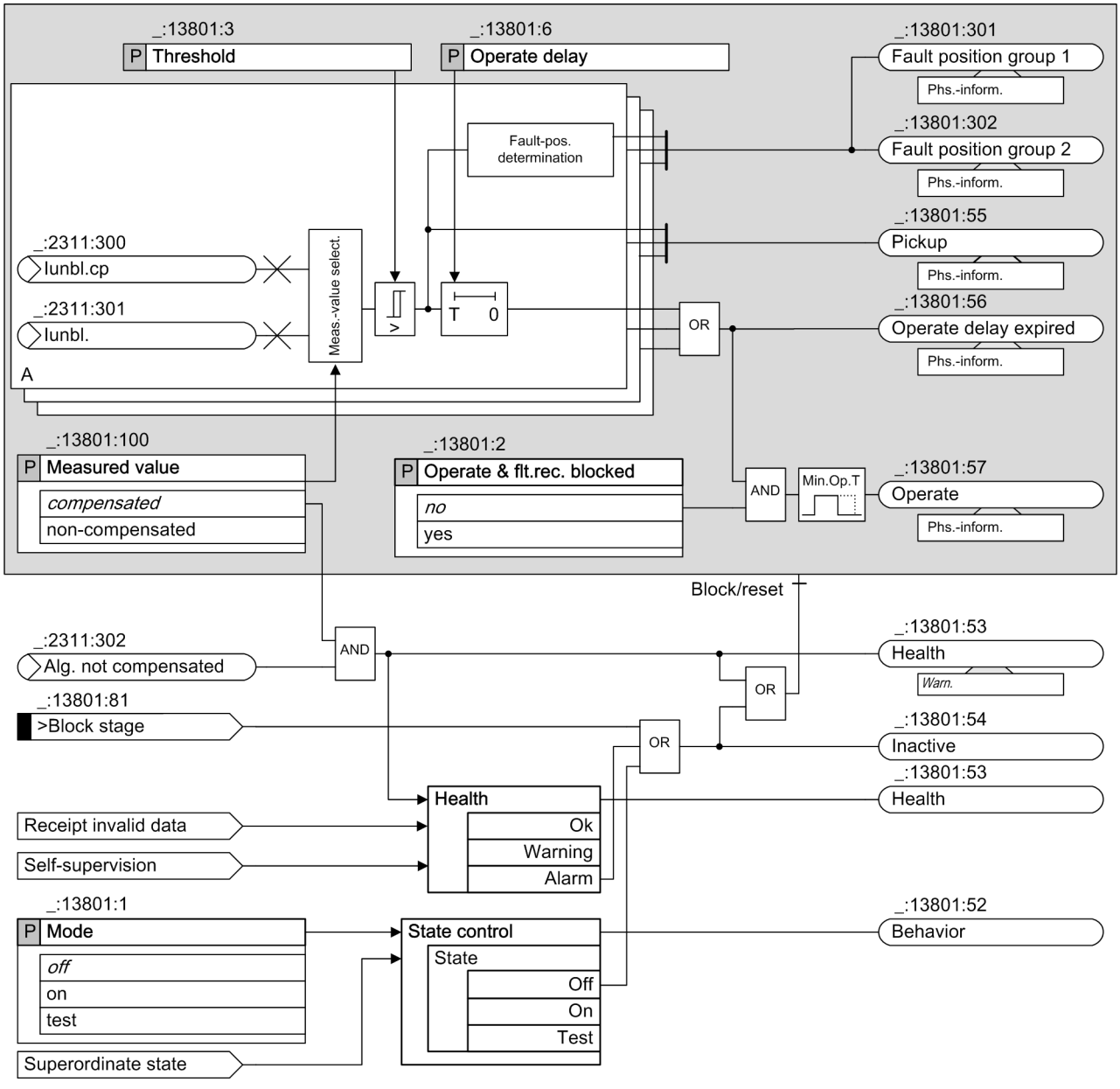
7.4.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
General			
_:2311:500	General:>Compensate	SPS	I
_:2311:501	General:>Reset comp. val.	SPS	I
_:2311:502	General:>Reset all counters	SPS	I
_:2311:302	General:Alg. not compensated	SPS	O
_:2311:303	General:Compens. succeeded	SPS	O
_:2311:304	General:Comp. via BI blk.(Ic<)	SPS	O
_:2311:305	General:I>-stage(cmp) blk.(Ic<)	ACT	O
_:2311:306	General:No auto. comp. config.	SPS	O
_:2311:307	General:C defect counted	SPS	O
_:2311:308	General:Unknown dir. phase A	SPS	O
_:2311:309	General:Unknown dir. phase B	SPS	O
_:2311:310	General:Unknown dir. phase C	SPS	O
_:2311:311	General:Df. G1 A	INS	O
_:2311:312	General:Df. G1 B	INS	O
_:2311:313	General:Df. G1 C	INS	O
_:2311:314	General:Df. G2 A	INS	O
_:2311:315	General:Df. G2 B	INS	O
_:2311:316	General:Df. G2 C	INS	O
_:2311:300	General:Iunbl.cp	WYE	O
_:2311:301	General:Iunbl.	WYE	O
_:2311:323	General:Cp.vect.	WYE	O

7.4.4 Overcurrent-Protection Stage I>

7.4.4.1 Description

Logic of a Stage



[lounbalstufe-020913, 1, en_US]

Figure 7-18 Logic Diagram of the Overcurrent-Protection Stage I>

Measurands

Within the protection stage, the compensated and the non-compensated unbalanced currents are available. Use the parameter **`Measured value`** to select one of the 2 values. Both values are displayed as measured values of the function at the function stage.

Pickup, Tripping Delay

If the selected measurand in one of the phase measuring element exceeds the threshold, the stage picks up. The pickup starts a tripping time delay, and a fault-location information is issued. More information can be found in this chapter under *Fault-Location Information, Page 941* . If the threshold is exceeded during the entire tripping delay, a phase-selective operate indication is issued.

Please note that, when using the compensated measurands as well as the automatic compensation, the currently measured current unbalance (that resulted in the threshold being exceeded) is gradually compensated. This means that even in case of a constantly existing unbalance in the primary system, the compensated measurand becomes gradually lower and may therefore fall below the threshold again at some time. The timing depends on by how much the threshold is exceeded.

For this reason and under those conditions, long time delays must not be set, see also chapter *7.4.4.2 Application and Setting Notes* .

This effect does not occur if manual compensation or the non-compensated measurand is used.

Blocking While Charging

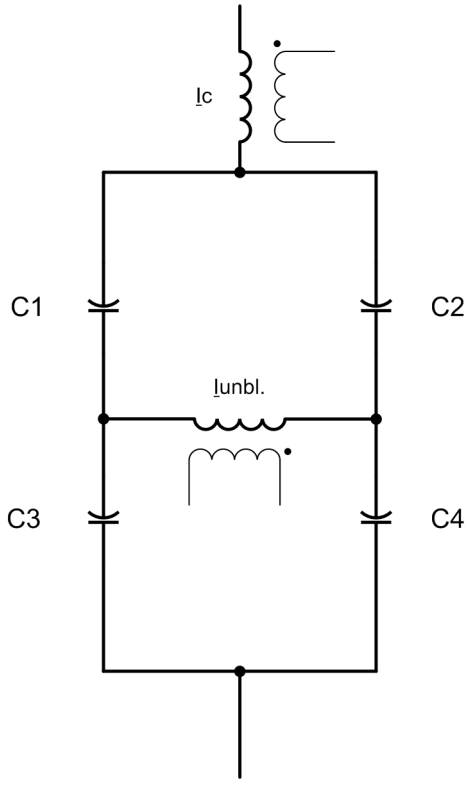
In order to prevent pickup as a consequence of the charging process, the **I>** stage is implicitly blocked in a phase-selective way for 250 ms by setting $I_{unbal.,comp.}$ to 0 A, after capacitor energizing has been detected.

Blocking only takes place if the stage operates with compensated unbalanced values.

Fault-Location Information

When picking up, the stage provides information about the faulty group of the capacitor bank. If the location can be safely determined, the corresponding indication *Fault position group 1* or *Fault position group 2* is issued.

Both indications also contain the information about the faulty phase. If the capacitor is implemented as an H connection, the following definition is assumed:



[dwfehlerortinf_iunsy-020913, 1, en_US]

Figure 7-19 Definition for the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1 and C4
- Group 2: C2 and C3

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

Non-Compensated Status

If no compensated values are available and the stage has been set to use such values, the stage will be blocked. The readiness of the stage turns to *warning*. This condition will be reported on the function stage (indication *Alg. not compensated*).

7.4.4.2 Application and Setting Notes

Parameter: Measured value

- Default setting **(_:13801:100) Measured value** = *no*

With the parameter, you set the **Measured value**.

Parameter Value	Description
compensated	The stage uses compensated unbalanced values. This means an operational current unbalance will be eliminated. This allows you to significantly increase the sensitivity of the measurement. Note the following: If the current I_c is lower than the threshold **Current threshold CB open**, the affected phase measuring elements are rendered inactive by setting $I_{unbal.,comp.}$ to 0 A. This condition is held for 250 ms after energizing has been detected in order to avoid a pickup as a consequence of the charging process. Siemens recommends using compensated unbalanced values. In case that automatic compensation is applied, please consider the setting notes for the operate delay.
non-compensated	The stage works with non-compensated unbalanced values. This means the measurand may contain an existing operational current unbalance.

Parameter: Threshold

- Default setting **(_:13801:3) Threshold** = *0.2 A*

Set the parameter **Threshold** for the specific application.

When using compensated unbalanced values, very sensitive settings are possible. When using non-compensated unbalanced values, the threshold must be higher than the maximum operational unbalanced current.

Parameter: Operate delay

- Default setting **(_:13801:6) Operate delay** = *0.08 s* (for the 1st stage)

Set the parameter **Operate delay** for the specific application.



NOTE

If the function has been set to automatic compensation and the stage works with compensated values, the maximum permitted operate delay is 80 ms. If the operate delay is set to longer than 80 ms, the automatic compensation might cause dropout of the picked-up stage. This risk does not exist when manual compensation or non-compensated values are used.

7.4.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I> 1				
_:13801:1	I> 1:Mode		• off • on • test	off
_:13801:2	I> 1:Operate & flt.rec. blocked		• no • yes	no
_:13801:100	I> 1:Measured value		• compensated • non-compensated	compensated
_:13801:3	I> 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.000 A
_:13801:6	I> 1:Operate delay		0.00 s to 60.00 s	0.08 s

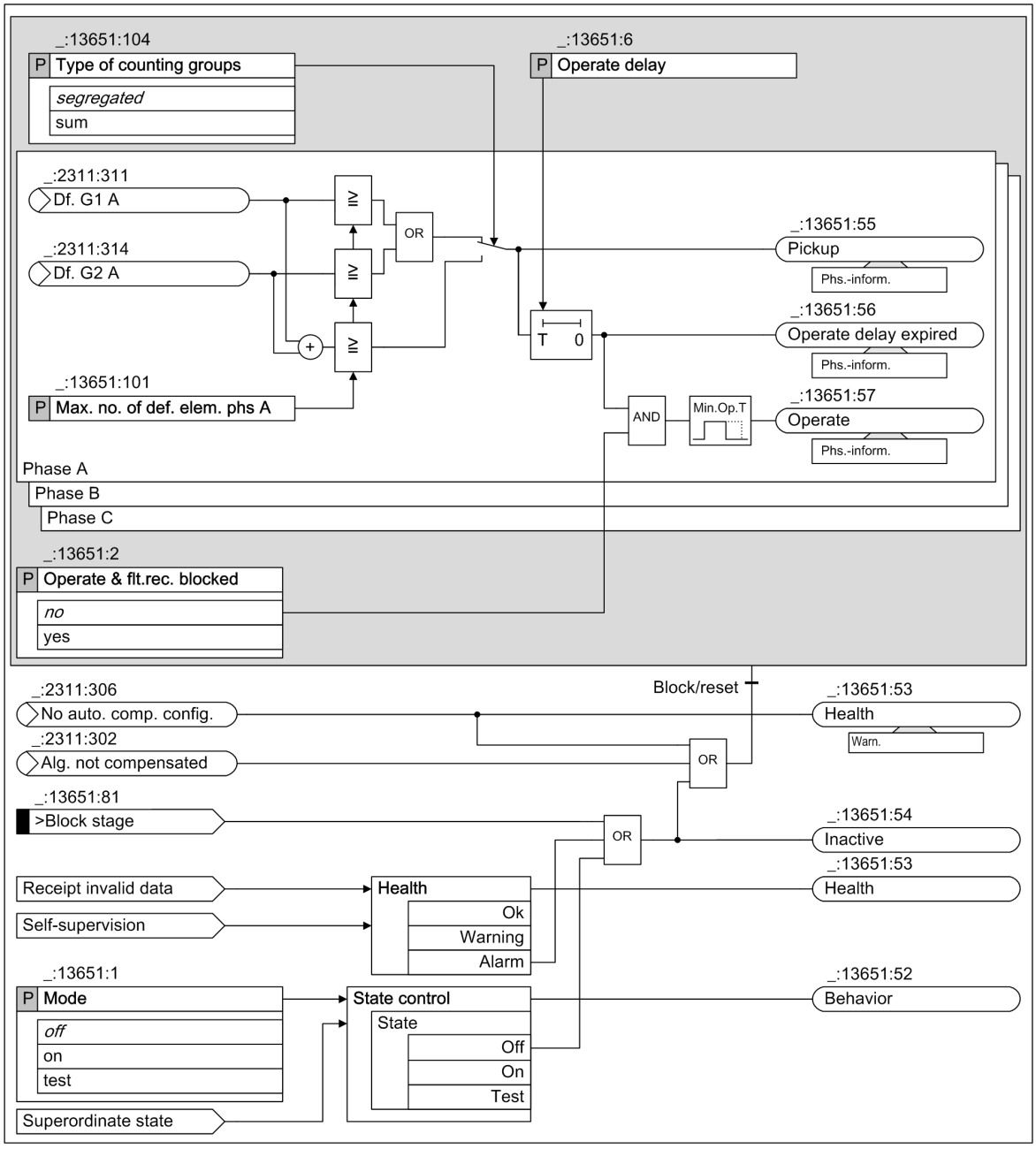
7.4.4.4 Information List

No.	Information	Data Class (Type)	Type
I> 1			
_:13801:81	I> 1:>Block stage	SPS	I
_:13801:54	I> 1:Inactive	SPS	O
_:13801:52	I> 1:Behavior	ENS	O
_:13801:53	I> 1:Health	ENS	O
_:13801:55	I> 1:Pickup	ACD	O
_:13801:56	I> 1:Operate delay expired	ACT	O
_:13801:57	I> 1:Operate	ACT	O
_:13801:301	I> 1:Fault position group 1	ACT	O
_:13801:302	I> 1:Fault position group 2	ACT	O
I> 2			
_:13802:81	I> 2:>Block stage	SPS	I
_:13802:54	I> 2:Inactive	SPS	O
_:13802:52	I> 2:Behavior	ENS	O
_:13802:53	I> 2:Health	ENS	O
_:13802:60	I> 2:Inrush blocks operate	ACT	O
_:13802:55	I> 2:Pickup	ACD	O
_:13802:56	I> 2:Operate delay expired	ACT	O
_:13802:57	I> 2:Operate	ACT	O
_:13802:301	I> 2:Fault position group 1	ACT	O
_:13802:302	I> 2:Fault position group 2	ACT	O

7.4.5 Counter Stage

7.4.5.1 Description

Logic of a Stage



[lo-cnt-stage-260314-01, 2, en_US]

Figure 7-20 Logic Diagram of the Counter Stage

Measurands/Input Values

The measurand/input values of the counter stage are the phase- and group-segregated counter contents that are determined in the **General** FB.

Pickup, Tripping Delay

Supervision of the counter contents is phase-segregated. If a counter reaches the preset threshold (parameter **Max. no. of def. elem. phs A** , **Max. no. of def. elem. phs B** , **Max. no. of def. elem. phs C**), the stage picks up. When using the parameter **Type of counting groups** , a selection is made whether the supervision function occurs group-segregated or with the sum value of both groups. The pickup starts the time delay. If the time delay has elapsed, the operate indication will be issued.

Automatic Compensation

If the automatic compensation function is enabled, the counter stage is working. If this is not the case, the readiness status of the stage changes to the state *warning.*

7.4.5.2 Application and Setting Notes

General Notes

- The setting notes for the current-threshold value for counting faulty C-elements are provided in chapter *7.4.3.2 Application and Setting Notes* as you must set this parameter across all stages.
- In order to react quickly to the simultaneous fault of many C-elements, always use an overcurrent-protection stage I> with a short tripping delay (< 100 ms) in addition to the counter stage. This is necessary as the counter function counts each current jump only once, regardless of its height.

Parameter: Type of counting groups

- Default setting **(_:13651:104) Type of counting groups** = ***segregated***

When using the parameter **Type of counting groups**, you specify whether the group-segregated counter status or the sum of both group counters are compared to the threshold.

Parameter: Maximum Number of Faulty Elements, Operate delay

- Default setting **(_:13651:101) Max. no. of def. elem. phs A** = *10*
- Default setting **(_:13651:102) Max. no. of def. elem. phs B** = *10*
- Default setting **(_:13651:103) Max. no. of def. elem. phs C** = *10*
- Default setting **(_:13651:6) Operate delay** = *0.00 s*

Set the parameters for the specific application.

It is possible to configure several stages for different tasks:

- Reporting only (with or without fault record)

  Use this stage to report 1 or 2 faulty C-elements. To do this, set the 3 parameters **Max. no. of def. elem. phs A**, **Max. no. of def. elem. phs B** and **Max. no. of def. elem. phs C** to a small value (1 or 2). The parameter **Operate delay** can be set to 0.

  If you would like to prevent the operate (tripping) and fault logging (fault log and fault record), set the parameter **Operate & flt.rec. blocked** to ***yes***.

  If you would like to prevent only the operate (tripping) and the fault logging must occur, remove this stage from the interface **Trip** to the circuit breaker (see also *5.4.2 Structure of the Function Group*, **Interfaces with Circuit-Breaker Function Group**).

- Indication with delayed operate

  Use this stage to report in case of some faulty C-elements and set a relatively long time delay of the operate, for example, 2 hours. During this time, the fault of the C-elements can be clarified. If it is possible to find a solution, the counter status can be reset manually. This way, the stage drops out. If a solution cannot be found within 2 hours, the stage trips and disconnects the capacitor bank.

- Immediate operate

  The stage is used to initiate the operate immediately after a larger number of C-elements became faulty.

7.4.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Counter 1				
_:13651:1	Counter 1:Mode		• off • on • test	off
_:13651:2	Counter 1:Operate & flt.rec. blocked		• no • yes	no
_:13651:104	Counter 1:Type of counting groups		• segregated • sum	segregated
_:13651:101	Counter 1:Max. no. of def. elem. phs A		1 to 1000	10
_:13651:102	Counter 1:Max. no. of def. elem. phs B		1 to 1000	10
_:13651:103	Counter 1:Max. no. of def. elem. phs C		1 to 1000	10
_:13651:6	Counter 1:Operate delay		0.00 s to 10000.00 s	0.00 s

7.4.5.4 Information List

No.	Information	Data Class (Type)	Type
Counter 1			
_:13651:81	Counter 1:>Block stage	SPS	I
_:13651:54	Counter 1:Inactive	SPS	O
_:13651:52	Counter 1:Behavior	ENS	O
_:13651:53	Counter 1:Health	ENS	O
_:13651:55	Counter 1:Pickup	ACD	O
_:13651:56	Counter 1:Operate delay expired	ACT	O
_:13651:57	Counter 1:Operate	ACT	O

7.5 Current-Unbalance Protection for Capacitors, 1-Phase

7.5.1 Overview of Functions

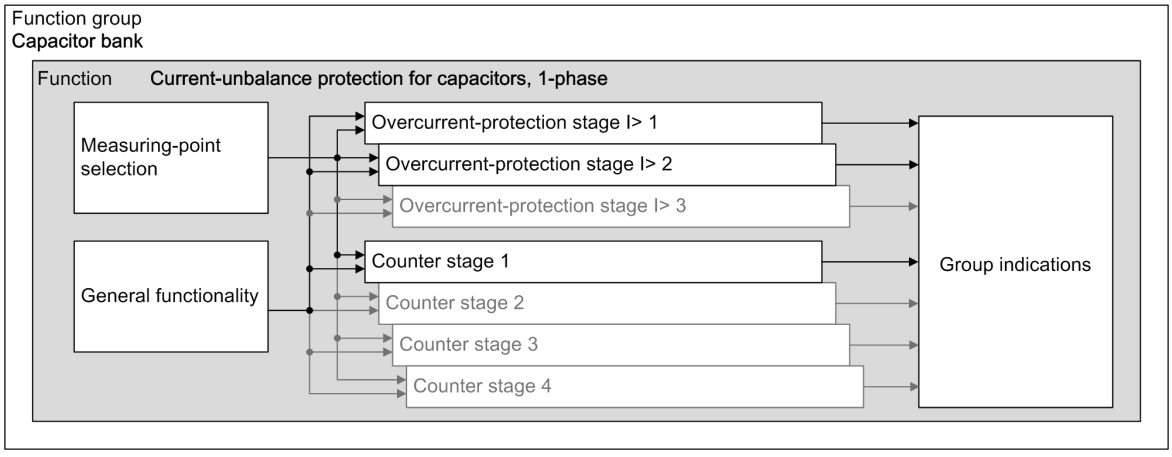
The **Current-unbalance protection for capacitors, 1-phase** function (ANSI 60C):

- Protects in case of faults in capacitor elements (C-elements) of a double neutral point capacitor bank
- Provides very sensitive supervision of the unbalanced current between the 2 neutral points
- Allows counting individual faulty C-elements

7.5.2 Structure of the Function

The **Current-unbalance protection for capacitors, 1-phase** function is used in the **Capacitor bank** function group. It is preconfigured at the factory with 2 overcurrent-protection stages **I>** and 1 stage of the type **Counter**. A maximum of 3 overcurrent-protection stages and 4 counter stages can be operated simultaneously in the function.

The function is designed so that the **General functionality** (including adjustment) and the **Measuring-point selection** can work across the stages.



[dwocplunb1ph-020714, 3, en_US]

Figure 7-21 Structure/Embedding of the Function

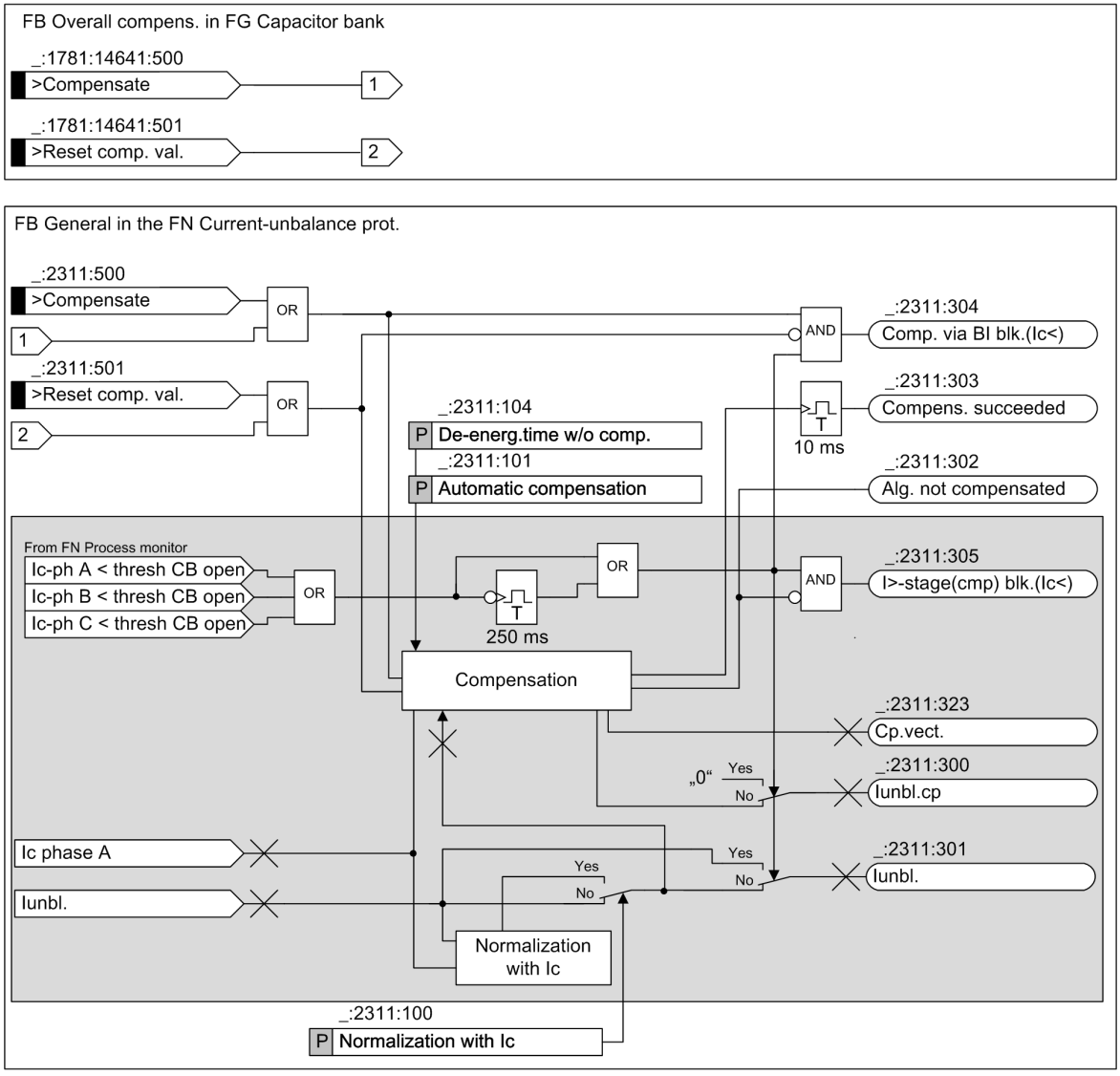
7.5.3 General Functions and Measuring-Point Selection

7.5.3.1 Description

The General functionality is structured in the following functional parts:

- Compensation of the unbalance
- Normalization of the unbalanced current with the current I_c
- Counting faulty C-elements (the stage type **Counter** is used to monitor the counter status)

Logic for Compensation and Normalization



[lo_FBallgiunb1ph-070714-01, 3, en_US]

Figure 7-22 Cross-Stage Functionality

Measuring-Point Selection

With the **`MP selection`** parameter, you can select from a list of measuring points a 1-phase measuring point that is connected to the **I Unbalanced** interface in the **Capacitor bank** function group. The **Current-unbalance protection for capacitors, 1-phase** function processes the 1-phase current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor bank** function group starting from chapter *5.4.1 Overview* .

Measurands, Method of Measurement

The function receives its measurands via the **I Unbalanced** interface of the **Capacitor bank** function group.

The compensated and non-compensated unbalanced currents are provided for the overcurrent-protection stage. Within the protection stage, one of the 2 values is selected in the protection stage via the parameter **`Measured value`**. Both values are available as functional measured values (see *Figure 7-22*).

Configure across the stages whether the unbalanced current must be normalized with the current I_c that flows into the capacitor bank. Phase A component of the current I_c flowing into the capacitor bank is used as the reference for the normalization. You can find more information in this chapter under *Normalization with I_c*, *Page 950* .

The method of measurement used processes the sampled unbalanced-current values and filters out the fundamental component numerically. The protection stages evaluate the fundamental component of the unbalanced current.

General Notes on the Compensation

An operational unbalanced current is added to an unbalanced current resulting from faulty capacitor elements. This corrupts the measuring result.

Operational unbalanced currents can result from the following causes:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates operational unbalanced currents by calculation. For this purpose, the phasor of the operational unbalanced current $\underline{I}_{unbal.,op.}$ is stored at specific times. The stored phasor (compensation phasor), is subtracted from the actually measured unbalanced-current phasor:

$$\underline{I}_{unbal.,comp.} = \underline{I}_{unbal.} - \underline{I}_{unbal.,op.}$$

[fo_compensatied unbal., 1, en_US]

The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. The compensated values are not available under the following conditions: • After initial startup of the device before any compensation is carried out • After activating the binary input *>Reset comp. val.* • After change of $I_{rated,obj}$ Protection stages that are working with compensated values are inactive.
Compens. succeeded	This indication is issued (as transient indication with a pulse duration of 10 ms) if the existing unbalance has been compensated manually or automatically. In case of automatic compensation, the signal is issued at each event-based situation where full compensation is carried out.
Comp. via BI blk.(Ic<)	If a manual compensation has been initiated and the current I_c (current flowing into the capacitor bank) at this time is less than the threshold **Current threshold CB open**, the manual compensation is not executed. This is signaled via the *Comp. via BI blk.(Ic<)* indication.

2 different methods are available for the compensation:

- Manual compensation via binary input signals
- Automatic compensation

Manual Compensation via Binary Input Signal

If the binary input signal *>Compensate* is activated, the manual compensation starts. This will fully compensate any unbalance that exists at this time. This means, the value $\underline{I}_{unbal.,comp.}$ will then become 0. You can also use the manual compensation in parallel with the automatic compensation.

Automatic Compensation

When using the parameter **Automatic compensation**, this automatic compensation function can be enabled or disabled.

The automatic compensation consists of 2 different mechanisms:

- Event-based compensation of any existing unbalance
  This compensation is performed in the following situations:
  - After energizing the capacitor bank or a phase of the bank
  - After counting a faulty C-element
  - After each startup of the device
  - After specific parameter changes:
    - Switching on the automatic compensation
    - Changing the rated current of the capacitor bank

  In order to avoid transient inrush-current effects, the compensation is delayed by 250 ms after energizing has been detected.
  Full compensation after bank energization can be avoided in case of only short de-energization by means of parameter **De-energ.time w/o comp.**. If the de-energized duration is less than the setting of parameter **De-energ.time w/o comp.**, the full compensation is not carried out after energizing a phase or the whole bank.
- Cyclic, slow and thus gradual compensation of an existing unbalance in small increments
  This permits, for example, the automatic compensation of environmental influences.

Resetting the Compensation

The algorithm can be reset to the non-compensated status. Compensated values are not available in this case. Protection stages that work with compensated values are rendered inactive. The binary input signal *>Reset comp. val.* of the function or function group resets the compensation (see also *Figure 7-22*).

Normalization with I_c

The threshold for the unbalanced current is usually set by assuming the rated capacitor current $I_{c,rated}$. The current I_c flowing into the capacitor bank determines the amount of the unbalanced current. A lower I_c also means a lower unbalanced current. If $I_c < I_{c,rated}$, the protection becomes less sensitive. This influence can be compensated via the normalization. Normalization keeps the sensitivity of the protection function constant by normalizing the unbalance value with the current I_c. Phase A component of the current I_c flowing into the capacitor bank is used as the reference for the normalization. When using the parameter **Normalization with Ic**, normalization is enabled or disabled.

I_c Lower than Current Thresh. CB Open

If any phase current of I_c is lower than the threshold **Current thresh. CB open**, the compensated value can no longer be computed with sufficient accuracy. To avoid a malfunction, the compensated unbalanced value $I_{unbal.,comp.}$ is set to 0 A (see *Figure 7-22*). This deactivates the protection stages that work with compensated values.
This condition will be indicated (indication *I>-stage(cmp) blk.(Ic<)*).
In this case, normalization with current I_c will no longer work properly either. Normalization is canceled. This means that the non-normalized value will be used instead of the normalized value (see *Figure 7-22*).

Charging/Energizing the Capacitor Bank or a Phase of the Bank

Charging of the bank takes place when the discharged bank is switched on to the network. Charging of a phase can occur in case of network faults. If a phase-to-ground voltage drops to 0 V due to a network fault, the respective phase is discharged and the return of the phase-to-ground voltage (after the fault has been cleared) will charge the phase.

Charging the bank causes inrush currents in the respective phases. To avoid overfunction in case of sensitive threshold settings, the stages using compensated unbalanced values are blocked by setting $I_{unbal.,comp.}$ to 0 A. These stages are:

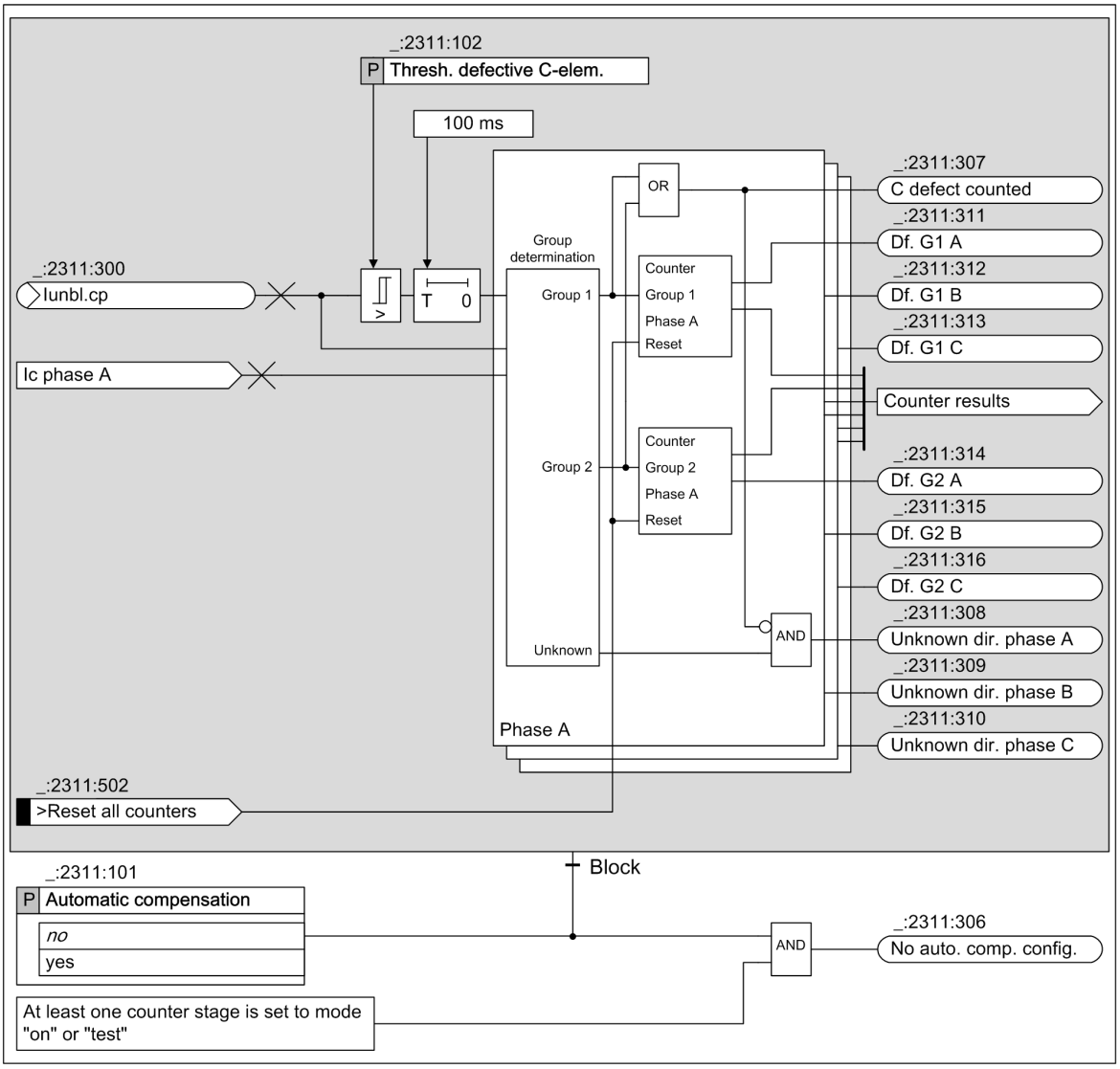
- Counter stage
- I> stage, if set to operate with compensated unbalanced values

The blocking ($I_{unbal.,comp.}$ set to 0 A) lasts for 250 ms after energizing detection. Afterwards, the calculated $I_{unbal.,comp.}$ is processed again.

Energizing detection takes place by monitoring the phases currents I_c flowing into the bank. If all three phase currents exceed the threshold **`Current Thresh.CB Open`**, energizing is detected.

Logic for Counting Faulty C-Elements

This part of the General functionality is only important if counter stages are used.



[locntEF1ph-070714-01, 3, en_US]

Figure 7-23 Counting Faulty C-Elements

Activation/Blocking Counting

If at least one counter stage is enabled, the counting function is active. Furthermore, the counting function works only if the automatic compensation is enabled.

In order to prevent counting as a consequence of the charging process, the counter function is implicitly blocked for 250 ms by setting $\underline{I}_{unbal.,comp.}$ to 0 A, after the capacitor energizing has been detected.

Measurands, Counting

The measurand is the 1-phase compensated unbalanced current $\underline{I}_{unbal.,comp.}$. If a single C-element is faulty, an unbalance occurs between the neutral points of the 2 capacitor banks. This unbalance causes an unbalanced current; this means, a small current jump occurs in the unbalanced current. Set the parameter **Thresh. defective C-elem.**, so that this current jump can be detected (see also *7.5.3.2 Application and Setting Notes*). The unbalanced current that was caused by the fault must exceed the threshold for 100 ms before the affected phase and the affected group are determined and counting (incrementing the counter) takes place. The angle reference of the unbalanced-current phasor to the reference current $I_{c,A}$ is used to determine the phase of the faulty C element. Thus, phase-segregated counting is possible. There is one counter for each phase and group. After the counting, the existing unbalance is compensated; this means, the unbalance is reset to 0 A. If the faulty group cannot be determined, the unbalance is also compensated.

Resetting/Setting the Counters

You can reset or set the counters of group 1 and group 2 via:

- On-site operation panel directly on the device
- Online DIGSI connection to the device
- Binary input *>Reset all counters* (only reset of all counters)
- Communication connection with the control center

You can directly set or reset the counters via IEC 61850 by setting the counter values to the desired value. If you want to reset the counters via DNP3, IEC 60870-5-103, Modbus, or IEC 60870-5-104, an additional configuration with CFC is necessary. For more information, refer to chapter *7.5.3.2 Application and Setting Notes*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:300) Iunbl.cp	Compensated unbalanced current $\underline{I}_{unbal.,comp.}$	kA	A	Parameter **Rated primary current**
(_:2311:301) Iunbl.	Non-compensated unbalanced current $\underline{I}_{unbal.}$	kA	A	Parameter **Rated primary current**
(_:2311:323) Cp.vect.	Compensation vector $\underline{I}_{comp.,vect.}$	kA	A	Parameter **Rated primary current**

You can find the value of the parameter **Rated primary current** of the preceding table in the chapter *6.1.6 Settings* according to the specified parameter **MP selection**.

$\underline{I}_{comp.,vect.}$ is normalized with I_c. The normalization is carried out no matter if the parameter **Normalization with Ic** is set to ***yes*** or ***no***. $\underline{I}_{comp.,vect.}$ keeps its value unchanged until the next compensation occurs.

$$\underline{I}_{comp.,\,vect} = \underline{I}_{unbal.\,op.}\frac{I_{c,rated}}{I_c}$$

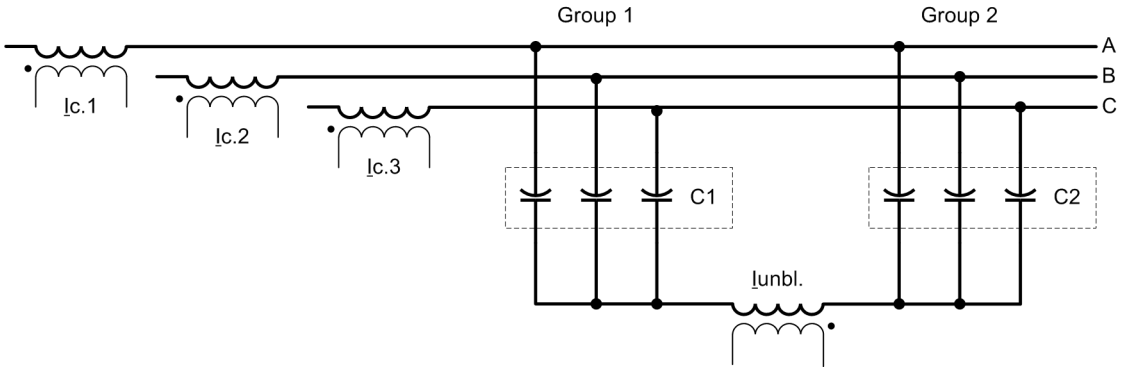
[fo_compensation vector, 1, en_US]

Where:

$\underline{I}_{unbal.op.}$	Operational unbalanced current at the moment the compensation is carried out
$I_{c,rated}$	Rated current of the capacitor bank
I_c	Current of the capacitor bank at the moment the compensation is carried out

Definition of the Group and Fault Location in Case of a Capacitor Dual Switching

If the capacitor is designed with dual switching function, the following definition is assumed:



[dwfehlerortinf_iunsy1ph-070714-01, 1, en_US]

Figure 7-24 Definition of the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1
- Group 2: C2

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

The angle reference of the unbalanced-current phasor to the reference current I_c is used to determine the direction of the unbalanced current and, thus, the affected group is determined. If the direction cannot be determined with confidence, an appropriate indication will be generated.

7.5.3.2 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501:81) MP selection** = ***None***

With the **MP selection** parameter, you can select from a list the measuring point that is connected to the **I Unbalanced** interface of the **Capacitor bank** function group.

The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure**.

Parameter: Automatic compensation

- Default setting **(_:2311:101) Automatic compensation** = ***no***

The parameter applies equally to all stages of the function that work with compensated measurands.

If no counter stages are applied, Siemens recommends to switch the automatic compensation off and use the manual compensation. You can find more information on this recommendation in chapter *7.5.4.2 Application and Setting Notes* (setting notes for the operate delay of the **I>** stage).

If the counter stages are applied, the automatic compensation must be switched on, otherwise the counting function will not work.

Parameter: De-energ.time w/o comp.

- Default setting **(_:2311:104) De-energ.time w/o comp.** = ***2.00 s***

In case of networks faults, the faulty phases are discharged. With the returning voltage after fault clearance, charging takes place. For such conditions, Siemens recommends that no automatic full compensation takes place in the affected phases. Otherwise, C-element defects occurring in this period (for example, because of discharging stress due to network-fault inception) will not be detected.

With the parameter **De-energ.time w/o comp.**, you define the duration of short de-energization after which no automatic compensation takes place. The parameter must be set to a value larger than the slowest fault clearing time in your network plus a safety margin.

If the setting is set to 0 s, an automatic full compensation is carried out after each energizing detection.

Parameter: Normalization with Ic

- Default setting **(_:2311:100) Normalization with Ic** = ***no***

This parameter applies equally to all stages of the function.

Parameter Value	Description
no	Select this setting if you can safely assume that I_c will not change for operational reasons or if you do not desire normalization of the unbalanced current with I_c. Please consider that the protection sensitivity will decrease with decreasing I_c.
yes	Select this setting if you want to keep the sensitivity of the protection stages constant during changes of I_c.

Parameter: Thresh. defective C-elem.

- Default setting **(_:2311:102) Thresh. defective C-elem.** = ***0.030 A***

Set the parameter **Thresh. defective C-elem.** to ensure that the jump in the unbalanced current caused by the faulty C-element is detected. Information about occurring unbalanced current as a consequence of single faulty C-elements will be provided by the manufacturer of the capacitor bank. Siemens recommends to set the threshold value to approx. 75 % of the unbalanced current that occurs after the fault of the 1st C-element.

Example 1: Information about the Unbalanced Current Available from the Manufacturer of the Capacitor Bank

Table 7-2 Unbalanced Current, Depending on the Number of Faulty C-Elements

Number of Faulty C-Elements	Primary Unbalanced Current
0	0.00 A
1	0.71 A
2	1.47 A
3	2.29 A
...	...

Assumed current transformer ratio: 10 A/1 A

Primary unbalanced current if 1st C-element fails: 0.71 A

Secondary unbalanced current if 1st C-element fails: 0.071 A

Secondary setting value: 0.75 · 0.071 A = 0.053 A



NOTE

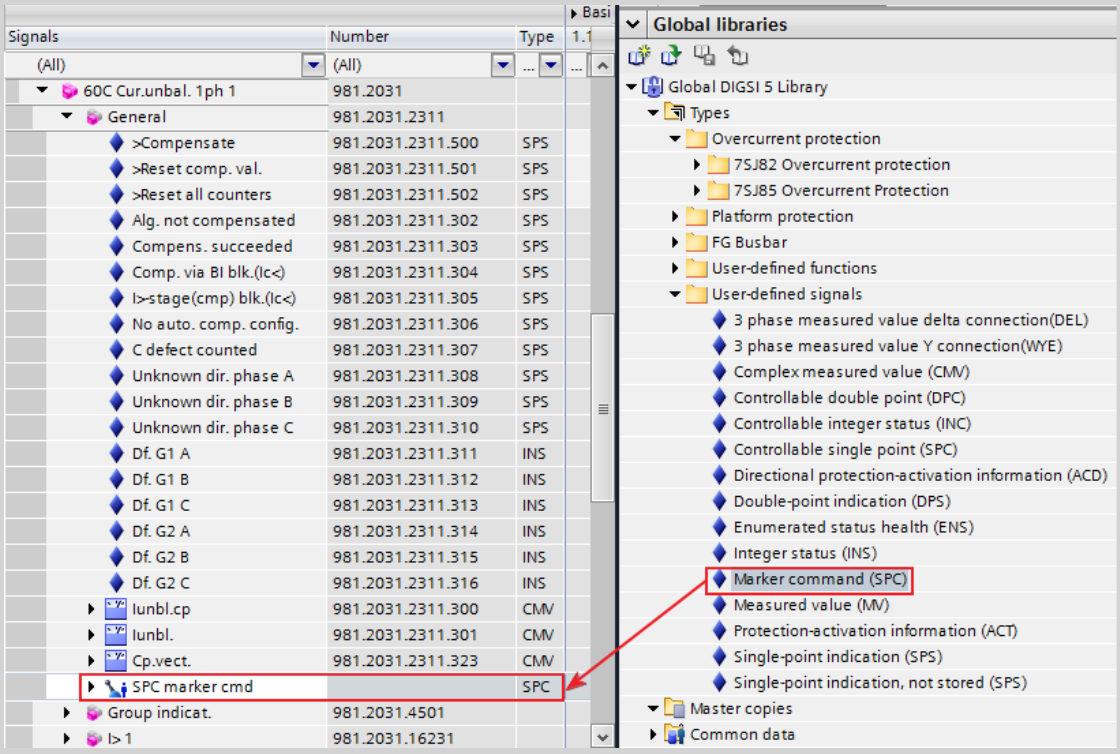
Use senstive device current inputs in order to apply secondary thresholds of < 30 mA.

Resetting the Counters via Protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus

The following example shows how to use a function chart (CFC) to reset the counters with the protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus.

EXAMPLE

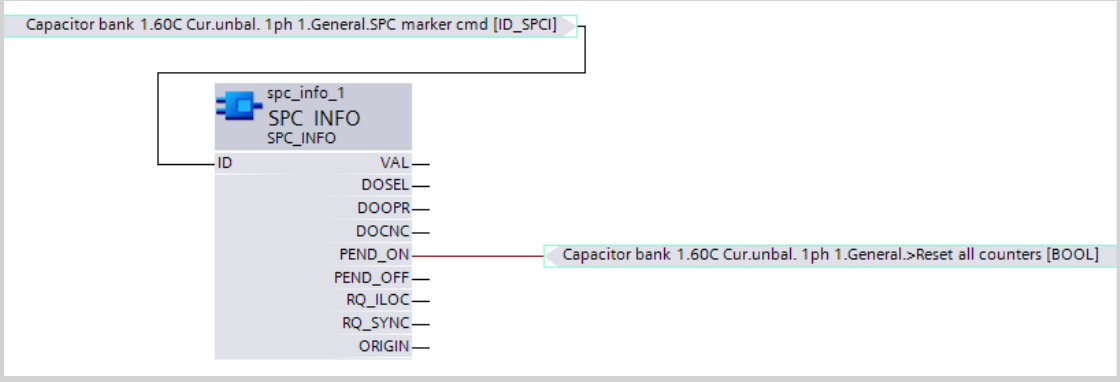
- Add a **Marker command (SPC)** signal to the information list.



[sc_add_SPC_signal_1ph, 1, en_US]

Figure 7-25 Adding Marker Command (SPC) Signal to Information List

- Set up the following CFC. Connect the SPC signal as input, and the signal *>Reset all counters* as output.



[sc_CFC_60C_1ph, 1, en_US]

Figure 7-26 Function Chart (CFC): Activating the Binary Input Signal

- Send a single-point control command from the control center to the SPC signal to activate the signal *>Reset all counters*. Then the counters are reset.

7.5.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP selection				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP configured

Addr.	Parameter	C	Setting Options	Default Setting
_:13501:81	MP selection:MP selection		Setting options depend on configuration	
General				
_:2311:101	General:Automatic compensation		• no • yes	no
_:2311:100	General:Normalization with Ic		• no • yes	no
_:2311:102	General:Thresh. defective C-elem.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:2311:104	General:De-energ.time w/o comp.		0.00 s to 60.00 s	2.00 s

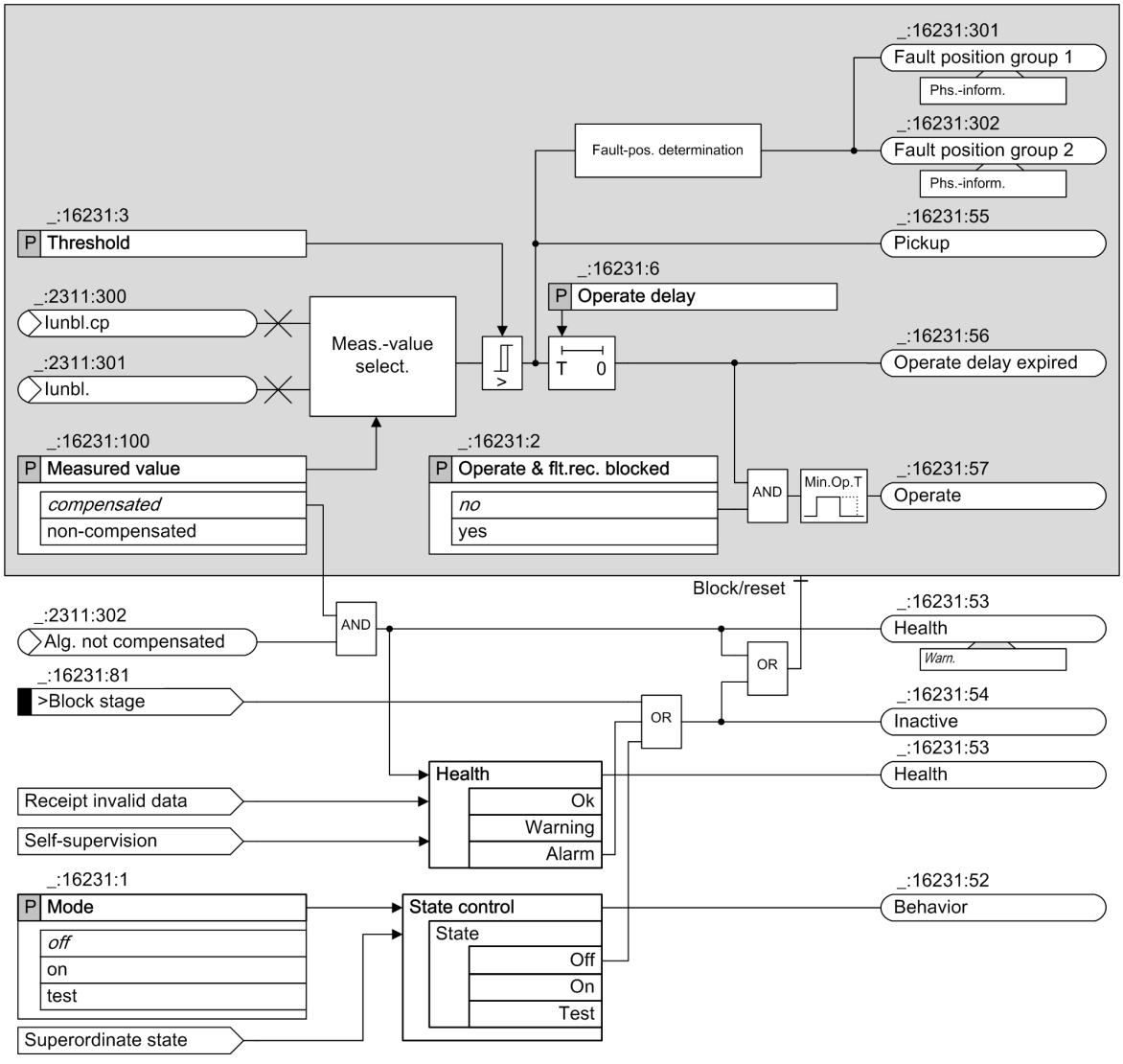
7.5.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
General			
_:2311:500	General:>Compensate	SPS	I
_:2311:501	General:>Reset comp. val.	SPS	I
_:2311:502	General:>Reset all counters	SPS	I
_:2311:302	General:Alg. not compensated	SPS	O
_:2311:303	General:Compens. succeeded	SPS	O
_:2311:304	General:Comp. via BI blk.(Ic<)	SPS	O
_:2311:305	General:I>-stage(cmp) blk.(Ic<)	SPS	O
_:2311:306	General:No auto. comp. config.	SPS	O
_:2311:307	General:C defect counted	SPS	O
_:2311:308	General:Unknown dir. phase A	SPS	O
_:2311:309	General:Unknown dir. phase B	SPS	O
_:2311:310	General:Unknown dir. phase C	SPS	O
_:2311:311	General:Df. G1 A	INS	O
_:2311:312	General:Df. G1 B	INS	O
_:2311:313	General:Df. G1 C	INS	O
_:2311:314	General:Df. G2 A	INS	O
_:2311:315	General:Df. G2 B	INS	O
_:2311:316	General:Df. G2 C	INS	O
_:2311:300	General:Iunbl.cp	CMV	O
_:2311:301	General:Iunbl.	CMV	O
_:2311:323	General:Cp.vect.	CMV	O

7.5.4 Overcurrent-Protection Stage I>

7.5.4.1 Description

Logic of a Stage



[lounbalstu1ph-080714-01, 1, en_US]

Figure 7-27 Logic Diagram of the Overcurrent-Protection Stage I>

Measurands

Within the protection stage, the compensated and the non-compensated unbalanced currents are available. Use parameter **`Measured value`** to select one of the 2 values. Both values are displayed as measured values of the function at the function stage.

Pickup, Operate Delay

If the selected measurand exceeds the threshold, the stage picks up. The pickup starts the operate delay, and a fault-location information is issued. More information can be found in this chapter under *Fault-Location Information, Page 958* . If the threshold is exceeded during the entire operate delay, the operate indication is issued.

Please note that, when using the compensated measurands as well as the automatic compensation, the currently measured current unbalance (that resulted in the threshold being exceeded) is gradually compensated. This means that even in case of a constantly existing unbalance in the primary system, the compensated measurand becomes gradually lower and may therefore fall below the threshold again at some time. The timing depends on by how much the threshold is exceeded.

For this reason and under those conditions, long time delays must not be set, see also chapter *7.5.4.2 Application and Setting Notes* .

This effect does not occur if manual compensation or the non-compensated measurand is used.

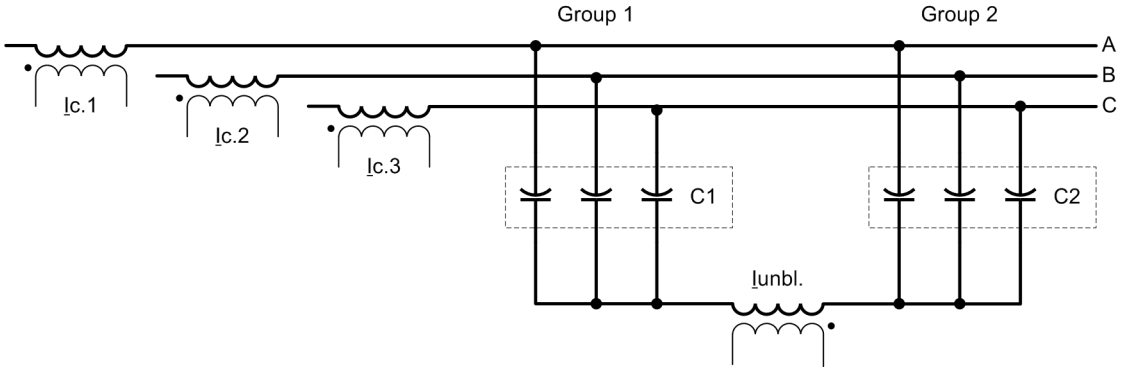
Blocking While Charging

In order to prevent pickup as a consequence of the charging process, the **I>** stage is implicitly blocked for 250 ms by setting $I_{unbal.,comp.}$ to 0 A, after capacitor energizing has been detected. Blocking only takes place if the stage operates with compensated unbalanced values.

Fault-Location Information

When picking up, the stage provides information about the faulty group of the capacitor bank. If the location can be safely determined, the corresponding indication *Fault position group 1* or *Fault position group 2* is issued.

Both indications also contain the information about the faulty phase. If the capacitor is implemented with 2 neutral points, the following definition is assumed:



[dwfehlerortinf_iunsy1ph-070714-01, 1, en_US]

Figure 7-28 Definition for the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1
- Group 2: C2

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

Non-Compensated Status

If no compensated values are available and the stage has been set to use such values, the stage will be blocked. The readiness of the stage turns to *Warning*. This condition will be reported on the function stage (indication *Alg. not compensated*).

7.5.4.2 Application and Setting Notes

Parameter: Measured value

- Default setting **(_:16231:100) Measured value** = ***compensated***

With this parameter you set the **Measured value** .

Parameter Value	Description
compensated	The stage uses compensated unbalanced values. This means an operational current unbalance will be eliminated. This allows you to increase significantly the sensitivity of the measurement. Note: If any phase current I_c is lower than the threshold **Current threshold CB open**, the stage is rendered inactive by setting $I_{unbal.,comp.}$ to 0 A. This condition is held for 250 ms after energizing has been detected in order to avoid a pickup as a consequence of the charging process. Siemens recommends using compensated unbalanced values. In case that automatic compensation is applied, consider the setting notes for the operate delay.
non-compensated	The stage works with non-compensated unbalanced values. This means the measurand may contain an existing operational current unbalance.

Parameter: Threshold

- Default setting **(_:16231:3) Threshold** = ***1.500 A***

Set the parameter **Threshold** for the specific application.

When using compensated unbalanced values, very sensitive settings are possible. When using non-compensated unbalanced values, the threshold must be higher than the maximum operational unbalanced current.

Parameter: Operate delay

- Default setting **(_:16231:6) Operate delay** = ***0.30 s*** (for the 1st stage)

Set the parameter **Operate delay** for the specific application.



NOTE

If the function has been set to automatic compensation and the stage works with compensated values, the maximum permitted operate delay is 80 ms. If the operate delay is set to longer than 80 ms the automatic compensation might cause dropout of the picked-up stage. This risk does not exist when manual compensation or non-compensated values are used.

7.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I> 1				
_:16231:1	I> 1:Mode		• off • on • test	off
_:16231:2	I> 1:Operate & flt.rec. blocked		• no • yes	no
_:16231:100	I> 1:Measured value		• compensated • non-compensated	compensated
_:16231:3	I> 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.000 A
_:16231:6	I> 1:Operate delay		0.00 s to 60.00 s	0.08 s

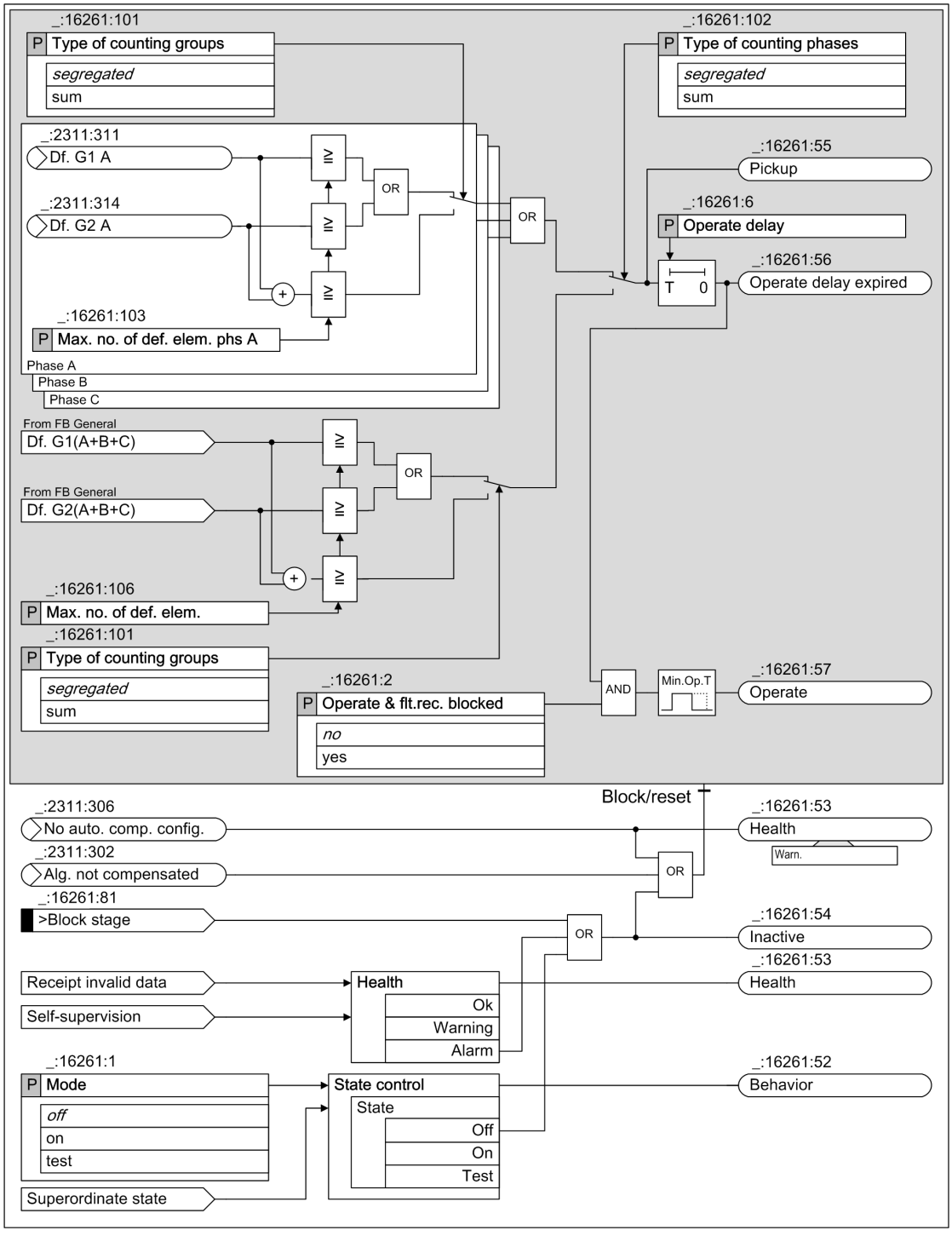
7.5.4.4 Information List

No.	Information	Data Class (Type)	Type
I> 1			
_:16231:81	I> 1:>Block stage	SPS	I
_:16231:54	I> 1:Inactive	SPS	O
_:16231:52	I> 1:Behavior	ENS	O
_:16231:53	I> 1:Health	ENS	O
_:16231:55	I> 1:Pickup	ACD	O
_:16231:56	I> 1:Operate delay expired	ACT	O
_:16231:57	I> 1:Operate	ACT	O
_:16231:301	I> 1:Fault position group 1	ACT	O
_:16231:302	I> 1:Fault position group 2	ACT	O

7.5.5 Counter Stage

7.5.5.1 Description

Logic of a Stage



[lo-cnt-stage1ph-080714-01, 2, en_US]

Figure 7-29 Logic Diagram of the Counter Stage

Measurands/Input Values

The measurand/input values of the counter stage are phase-segregated and group-segregated counter contents that are determined in the **General** FB.

Pickup, Operate Delay

With the parameter **Type of counting phases**, a selection is made whether the supervision function occurs in a phase-segregated way or with the sum value of the phases. With the parameter **Type of counting groups**, a selection is made whether the supervision function occurs in a group-segregated way or with the sum value of both groups. If a counter reaches the set threshold, the stage picks up. The pickup starts the time delay. If the time delay has elapsed, the operate indication will be issued.

Automatic Compensation

If the automatic compensation function is enabled, the counter stage is working. If this is not the case, the readiness status of the stage changes to the state *warning*.

7.5.5.2 Application and Setting Notes

General Notes

- The setting notes for the current-threshold value for counting faulty C-elements are provided in chapter *7.5.3.2 Application and Setting Notes* as you must set this parameter across all stages.
- In order to react quickly to the simultaneous fault of many C-elements, always use an overcurrent-protection stage I> with a short operate delay (< 100 ms) in addition to the counter stage. This is necessary as the counter function counts each current jump only once, regardless of its height.

Parameter: Type of counting groups

- Default setting **(_:16261:101) Type of counting groups** = ***segregated***

With the parameter **Type of counting groups**, you specify whether the group-segregated counter status or the sum value of both group counters are compared to the threshold.

Parameter: Type of counting phases

- Default setting **(_:16261:102) Type of counting phases** = ***segregated***

With the parameter **Type of counting phases**, you specify whether the supervision function occurs in a phase-segregated way or with the sum value of the phases.

Parameter: Maximum Number of Faulty Elements, Operate delay

- Default setting **(_:16261:103) Max. no. of def. elem. phs A** = *10*
- Default setting **(_:16261:104) Max. no. of def. elem. phs B** = *10*
- Default setting **(_:16261:105) Max. no. of def. elem. phs C** = *10*
- Default setting **(_:16261:106) Max. no. of def. elem.** = *10*
- Default setting **(_:16261:6) Operate delay** = *0.00 s*

Set the parameters for the specific application.

It is possible to configure several stages for different tasks:

- Reporting only (with or without fault record)

  Use this stage to report 1 or 2 faulty C-elements. To do this, set the parameters **Max. no. of def. elem. phs A**, **Max. no. of def. elem. phs B** , **Max. no. of def. elem. phs C** , or **Max. no. of def. elem.** to a small value (1 or 2). The parameter **Operate delay** can be set to 0.

  If you would like to prevent the operate (tripping) and fault logging (fault log and fault record), set the parameter **Operate & flt.rec. blocked** to ***yes***.

  If you would like to prevent only the operate (tripping) and the fault logging must occur, remove this stage from the interface **Trip** to the circuit breaker (see also *5.4.2 Structure of the Function Group* **Interfaces with Circuit-Breaker Function Group**).

- Indication with delayed operate

  Use this stage to report in case of some faulty C-elements and to set a relatively long time delay of the operate, for example, 2 hours. During this time, the fault of the C-elements can be clarified. If it is possible to find a solution, the counter status can be reset manually. This way, the stage drops out. If a solution cannot be found within 2 hours, the stage trips and disconnects the capacitor bank.

- Immediate operate

  The stage is used to initiate the operate immediately after a larger number of C-elements became faulty.

7.5.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Counter 1				
_:16261:1	Counter 1:Mode		• off • on • test	off
_:16261:2	Counter 1:Operate & flt.rec. blocked		• no • yes	no
_:16261:101	Counter 1:Type of counting groups		• segregated • sum	segregated
_:16261:102	Counter 1:Type of counting phases		• segregated • sum	segregated
_:16261:103	Counter 1:Max. no. of def. elem. phs A		1 to 1000	10
_:16261:104	Counter 1:Max. no. of def. elem. phs B		1 to 1000	10
_:16261:105	Counter 1:Max. no. of def. elem. phs C		1 to 1000	10
_:16261:106	Counter 1:Max. no. of def. elem.		1 to 1000	10
_:16261:6	Counter 1:Operate delay		0.00 s to 10000.00 s	0.00 s

7.5.5.4 Information List

No.	Information	Data Class (Type)	Type
Counter 1			
_:16261:81	Counter 1:>Block stage	SPS	I
_:16261:54	Counter 1:Inactive	SPS	O
_:16261:52	Counter 1:Behavior	ENS	O
_:16261:53	Counter 1:Health	ENS	O
_:16261:55	Counter 1:Pickup	ACD	O
_:16261:56	Counter 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:16261:57	Counter 1:Operate	ACT	O

7.6 Peak Overvoltage Protection for Capacitors

7.6.1 Overview of Functions

The **Peak overvoltage protection for capacitors (ANSI 59C)** function protects capacitors against:

- Peak overvoltages that stress the dielectric medium in the capacitor causing accelerated aging
- Peak overvoltages that in extreme cases can destroy the dielectric medium in the capacitor

7.6.2 Structure of the Function

The **Peak overvoltage protection for capacitors** function can be applied in the **Capacitor bank** function group.

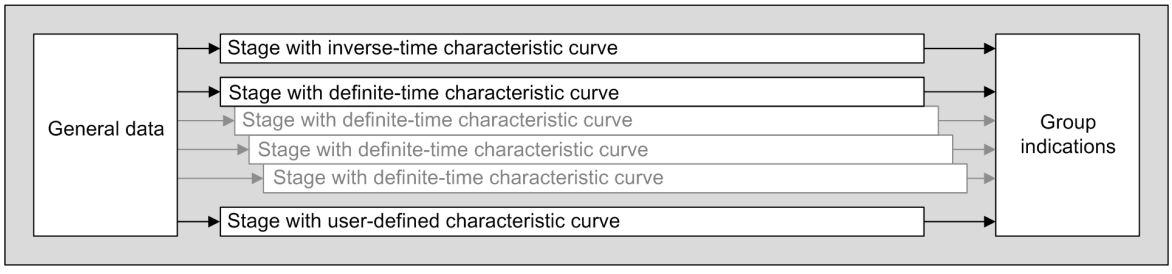
3 types of stages are available:

- Stage with inverse-time characteristic curve according to IEC and IEEE Standards
- Stage with definite-time characteristic curve
- Stage with user-defined characteristic curve

The function is preconfigured at the factory with a stage having an inverse-time characteristic curve and a stage having a definite-time characteristic curve.

Within the function, the following maximum number of stages can be operated simultaneously:

- 1 stage with an inverse-time characteristic curve
- 4 stages with a definite-time characteristic curve
- 1 stage with a user-defined characteristic curve



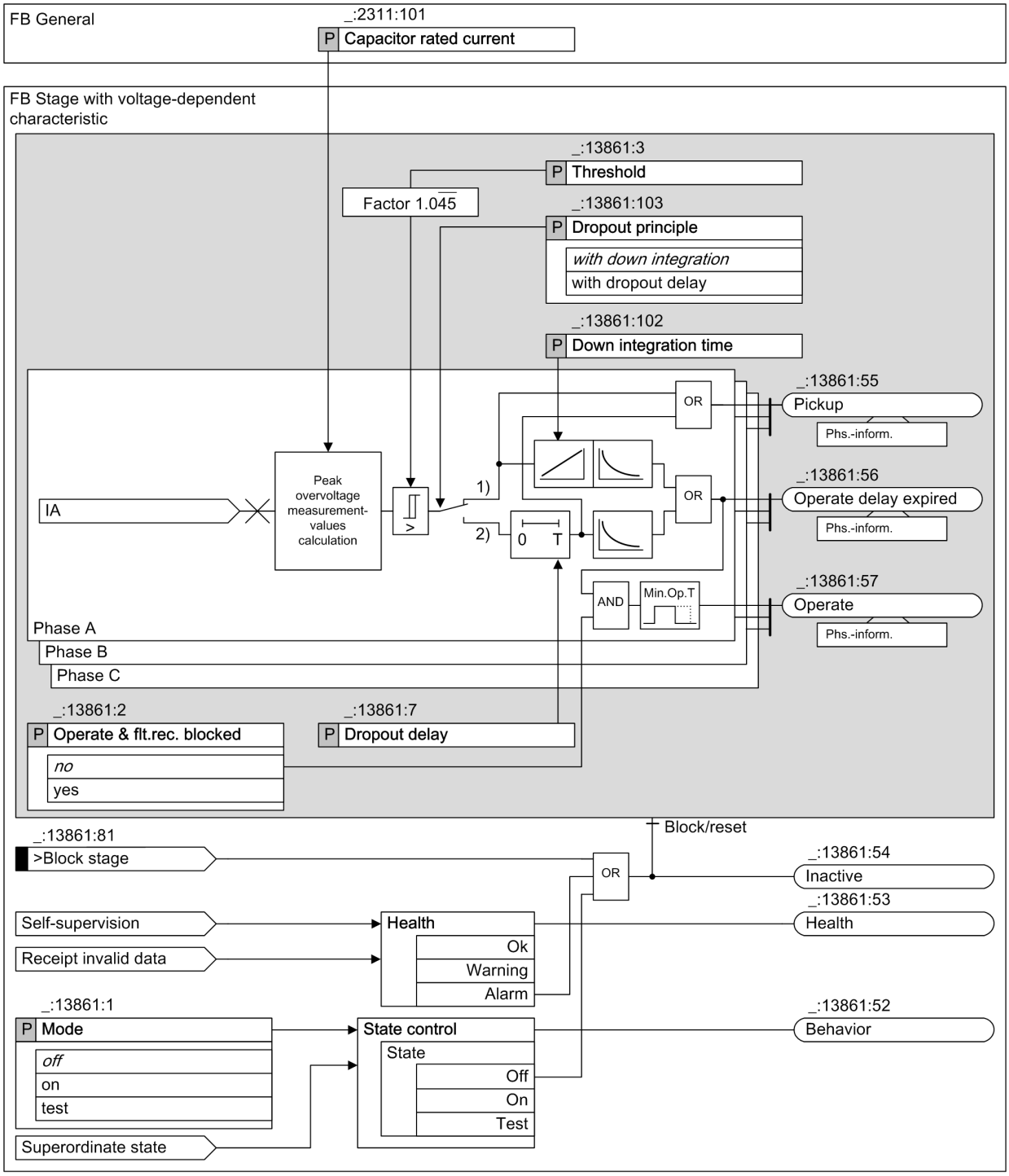
[dw_strpea-230813, 2, en_US]

Figure 7-30 Structure/Embedding of the Function

7.6.3 Stage with Inverse-Time Characteristic Curve

7.6.3.1 Description

Logic of the Stage



[lo_peainv-230813, 2, en_US]

Figure 7-31 Logic Diagram of the Stage with Inverse-Time Characteristic Curve

(1) With down integration time

(2) With dropout delay

Measurand, Method of Measurement

The function calculates the peak voltage in a phase-segregated way from the fundamental component and superimposed harmonics. Integration of the phase currents then yields the voltage. This approach captures the higher harmonics considerably better since they are transferred better by current transformers than by voltage transformers.

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The resulting measurand is $\hat{U}/V_{C\text{-}rated}(t)$. The threshold value for the stage is thus set as a referenced quantity.

The phase-selective peak overvoltages $\hat{U}/V_{C\text{-}rated}(t)$ are available as measured values for display or further processing.

Pickup, Tripping and Dropout Behavior with the Inverse-Time Characteristic Curve

If the measurand $\hat{U}/V_{C\text{-}rated}(t)$ exceeds $1.0\overline{45}$ times the set threshold value (for example, $1.0\overline{45} \times 1.1 \approx 1.15$), pickup occurs and the inverse-time characteristic curve is then followed. For each input value that exceeds the pickup value ($1.0\overline{45}$ × threshold value), the time value T_{trip} is calculated. An integrator accumulates the value $1/T_{trip}$. When the accumulated integral reaches the fixed value of 1, the stage trips.

If the measurand falls below $1.0\overline{45}$ times the set threshold value (pickup value), processing of the characteristic (accumulation of the time values) stops. In the hysteresis region between the pickup value and dropout value (95 % of the pickup value, for example, 0.95 × 1.15 = 1.0925), the integral value remains unchanged. The stage, however, remains in the picked-up state.

Use the parameter **`Dropout principle`** to select the method for the dropout of the stage:

- Method **with down integration time**:

  If the measurand falls below the dropout threshold, the pickup drops out immediately. If the value drops below the pickup threshold, the internal integral value that depends on the selected **`Down integration time`** is slowly reduced. The **`Down integration time`** defines the duration in order to reduce the internal integral value linear from 100 % to 0 %. The internal integral value is limited to 100 % and is reached with the tripping function.

- Method **with dropout delay**:

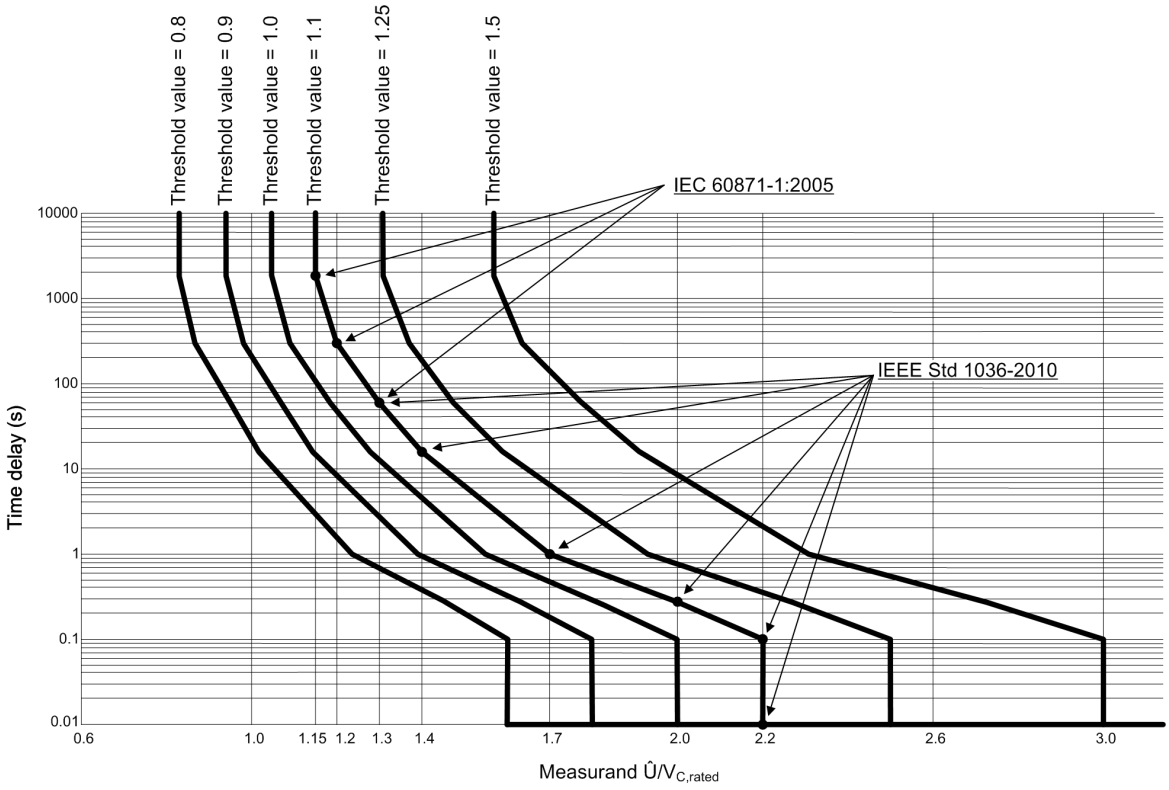
  If the measurand falls below the dropout threshold, the pickup drops not out immediately. The pickup remains for the duration of the set **`Dropout principle`** . The integral value remains frozen during this time. If the pickup value is not exceeded again during this time, a dropout occurs and the integral value is reset to 0. If the pickup value is exceeded during this time again, the integrator continues with the integration of frozen values. The pickup remains active and the **`Dropout principle`** is reset.

Inverse-Time Characteristic Curve

The characteristic curve is defined by the Standards IEC 60871-1:2005 and IEEE Std 1036-2010, see *Figure 7-32* .

The points on the characteristic curve defined in the standards result from a threshold setting of 1.1. Threshold values differing from this value shift the characteristic as shown in *Figure 7-32* .

Straight-line segments are implemented between the defined points on semi-logarithmic coordinates.



[dw_pecinv-230813, 2, en_US]

Figure 7-32 Inverse-Time Characteristic Curve

Phase-Segregated Operate Indications

In contrast to what normally occurs in a 3-phase protection device, the function generates phase-segregated operate indications. These indications are needed for supervision applications.

Function Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:301) VpeakA	Peak voltage phase A	kV	V	Parameter **Capacitor reference volt.**/√3
(_:2311:302) VpeakB	Peak voltage phase B	kV	V	Parameter **Capacitor reference volt.**/√3
(_:2311:303) VpeakC	Peak voltage phase C	kV	V	Parameter **Capacitor reference volt.**/√3

You can find the parameter **Capacitor reference volt.** of the preceding table in the function block **General** of the function group **Capacitor bank**.

7.6.3.2 Application and Setting Notes

Parameter: Capacitor rated current

- Default setting **(_:2311:101) Capacitor rated current** = ***1000.0 A***

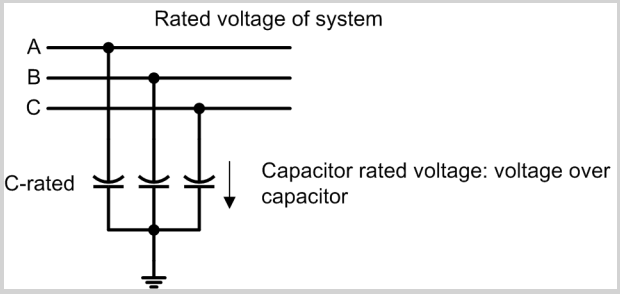
With the **Capacitor rated current** parameter, you set the primary rated current $I_{C\text{-rated}}$ of the capacitor or the capacitor bank.

Keep in mind that the rated current of the capacitor considers harmonics in addition to the fundamental component.

The rated current $I_{C\text{-rated}}$ is determined from the rated capacity and the rated voltage across the bank. Both values are listed in the Technical Data for the capacitor. Take note of the following:

- The rated voltage for the capacitor also takes harmonics into account. This is not the rated voltage of the system.
- The rated voltage to be used is the voltage applied across the capacitor; depending on the application, this can be a phase-to-phase or phase-to-ground voltage.

Example: Determining the Capacitor Rated Current for a Capacitor in a Star Connection



[dw_UC-Y-Schalt-110813, 1, en_US]

Figure 7-33 Capacitor in Star Connection

Rated voltage of the system	220 kV
Rated capacity per phase	5.233 µF
Capacitor rated voltage $V_{C\text{-rated}}$	192.30 kVrms
Rated frequency f	50 Hz

$I_{C\text{-rated}} = \omega C \times U_{C\text{-rated}} = 2\pi f \times C \times U_{C\text{-rated}} = 2\ \pi\ 50 \times 5.233\ 10^{-6} \times 192.3\ 10^{3}$ [Hz × F × U] = 316.1 [A]

Parameter: `Threshold`

- Default setting **`(_:13861:3) Threshold`** = ***`1.10`***

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The threshold value is thus set as a referenced quantity.

The points on the characteristic curve defined in the Standards IEC 60871-1:2005 and IEEE Std 1036-2010 result from a threshold setting of ***`1.10`*** (see *Figure 7-32*). Threshold values differing from this shift the characteristic as shown in *Figure 7-32*.

Siemens recommends using the default setting.

Parameter: `Dropout principle`

- Default setting **`(_:13861:103) Dropout principle`** = ***`with down integration`***

Use the parameter **`Dropout principle`** to select the method for the dropout of the stage:

Parameter Value	Description
`with down integration`	If the measurand for the dropout threshold falls below the limit, the pickup drops out immediately. If the value drops below the pickup threshold, the internal integral value that depends on the selected down integration time is reduced from 100 % to 0 %
`with dropout delay`	If the measurand falls below the dropout threshold, the measurand remains active for the duration of the preset dropout delay. The integral value remains frozen during this time.

Parameter: **Down integration time**

- Default setting **(_:13861:102) Down integration time** = ***3.00 min***

Use the parameter **Down integration time** in order to determine the duration until the internal integration value is linearly reduced from 100 % to 0 %.

For example, if the integration value is 52 %, a duration of 52 % × down integration time is required until the integration value 0 % is reached. When using this parameter, the preloading of a capacitor can be considered and therefore released quicker.

If you are knowledgeable about recovery time of stressed capacitors, they can be considered with this parameter.

Parameter: **Dropout delay**

- Default setting **(_:13861:7) Dropout delay** = ***1.00 s***

The parameter **Dropout delay** can be used to prevent resetting of the integral value in the event that the measured value briefly falls below the dropout threshold.

7.6.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Capacitor rated current		1.0 A to 100000.0 A	1000.0 A
Inverse-T 1				
_:13861:1	Inverse-T 1:Mode		• off • on • test	off
_:13861:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13861:103	Inverse-T 1:Dropout principle		• with dropout delay • with down integration	with down integration
_:13861:3	Inverse-T 1:Threshold		0.80 p.u. to 3.00 p.u.	1.10 p.u.
_:13861:102	Inverse-T 1:Down integration time		1 min to 1500 min	3 min
_:13861:7	Inverse-T 1:Dropout delay		0.00 s to 3600.00 s	1.00 s

7.6.3.4 Information List

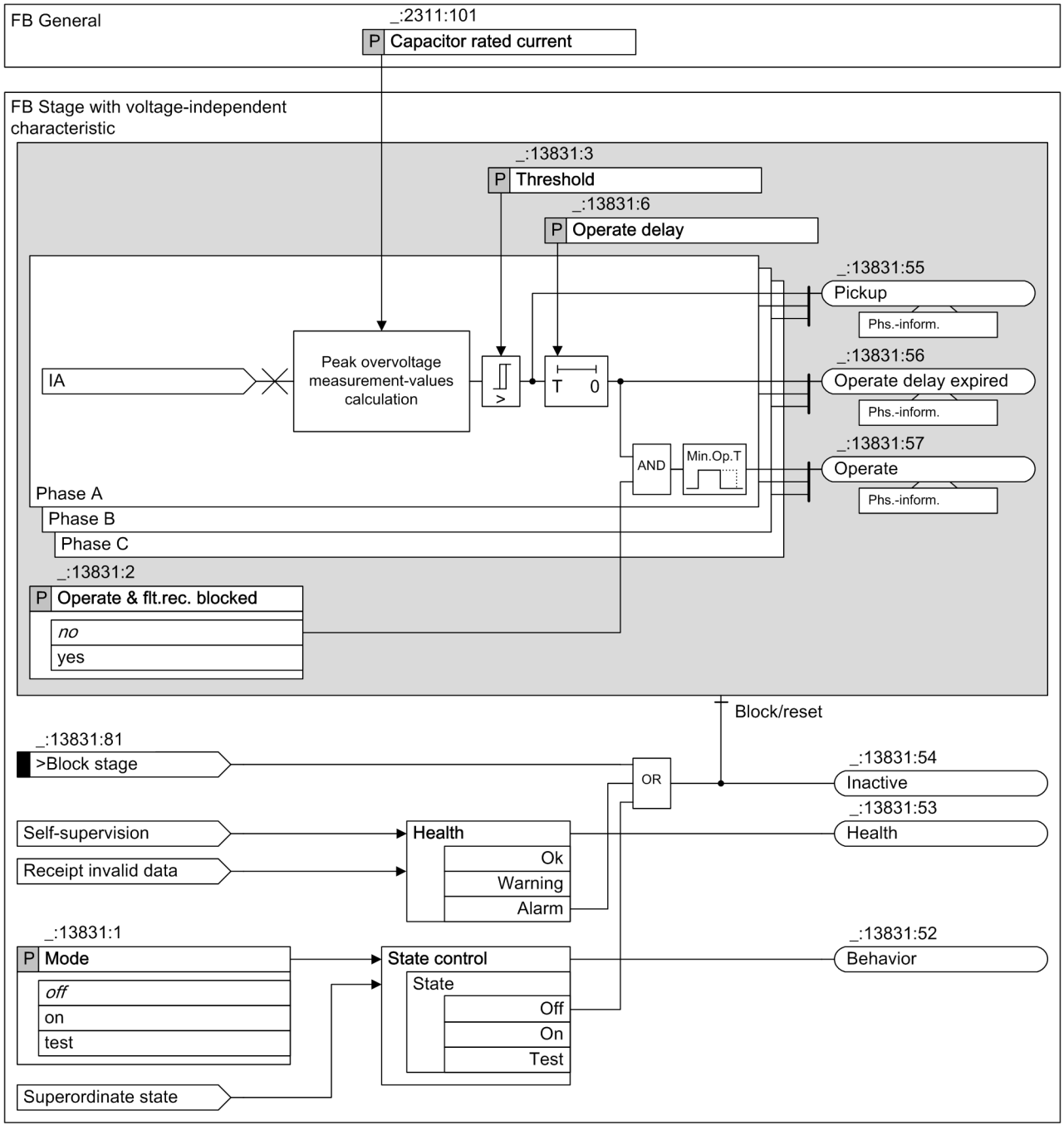
No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:VpeakA	MV	O
_:2311:302	General:VpeakB	MV	O
_:2311:303	General:VpeakC	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:13861:81	Inverse-T 1:>Block stage	SPS	I
_:13861:54	Inverse-T 1:Inactive	SPS	O
_:13861:52	Inverse-T 1:Behavior	ENS	O
_:13861:53	Inverse-T 1:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:13861:55	Inverse-T 1:Pickup	ACD	O
_:13861:301	Inverse-T 1:Down integr. running	SPS	O
_:13861:56	Inverse-T 1:Operate delay expired	ACT	O
_:13861:57	Inverse-T 1:Operate	ACT	O

7.6.4 Stage with Definite-Time Characteristic Curve

7.6.4.1 Description

Logic of the Stage



[lo_peadef-230813, 1, en_US]

Figure 7-34 Logic Diagram of the Stage with Definite-Time Characteristic Curve

Measurand, Method of Measurement

The function calculates the peak voltage in a phase-segregated way from the fundamental component and superimposed harmonics. Integration of the phase currents then yields the voltage. This approach captures

the higher harmonics considerably better since they are transferred better by current transformers than by voltage transformers.

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The resulting measurand is $\hat{U}/V_{C\text{-}rated}(t)$. The threshold value for the stage is thus set as a referenced quantity.

The phase-segregated peak overvoltages $\hat{U}/V_{C\text{-}rated}(t)$ are available as measured values for display or further processing.

Pickup, Tripping and Dropout Behavior with the Definite-Time Characteristic Curve

If the measurand $\hat{U}/V_{C\text{-}rated}(t)$ exceeds the set threshold value, pickup occurs and the tripping delay starts. If the measurand remains above the dropout value (95 % of the threshold value) during the tripping delay, the stage trips.

Phase-Segregated Operate Indications

In contrast to what normally occurs in a 3-phase protection device, the function generates phase-segregated operate indications. These indications are needed for supervision applications.

Function Values

For the detailed information of the function values, refer to *Function Values, Page 968*.

7.6.4.2 Application and Setting Notes

Parameter: `Capacitor rated current`

- Default setting **`(_:2311:101) Capacitor rated current`** = ***`1000.0 A`***

You can find the setting notes for the parameter **`Capacitor rated current`** under *Parameter: **`Capacitor rated current`**, Page 968*.

Parameter: `Threshold`

- Default setting **`(_:13831:3) Threshold`** = ***`1.10`***

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The **`Threshold`** is thus set as a referenced quantity.

The setting depends on the application of the stage. If this stage is intended to operate as a warning stage, a very sensitive setting of approx. ***`1.05`*** can be selected. If the stage is used for instantaneous tripping in addition to the stage with inverse-time characteristic curve, Siemens recommends a setting of ≥ ***`3.00`***.

Parameter: `Operate delay`

- Default setting **`(_:13831:6) Operate delay`** = ***`3.00 s`***

The setting depends on the application of the stage. If this stage is intended to operate as a warning stage, the time delay can be selected in a range of seconds. If the stage is used for instantaneous tripping in addition to the stage with inverse-time characteristic curve, the **`Operate delay`** can be set to ***`0.00 s`***.

7.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:101	General:Capacitor rated current		1.0 A to 100000.0 A	1000.0 A
`Definite-T 1`				
_:13831:1	Definite-T 1:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:13831:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13831:3	Definite-T 1:Threshold		0.80 p.u. to 10.00 p.u.	5.00 p.u.
_:13831:6	Definite-T 1:Operate delay		0.01 s to 3600.00 s	0.03 s

7.6.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:VpeakA	MV	O
_:2311:302	General:VpeakB	MV	O
_:2311:303	General:VpeakC	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:13831:81	Definite-T 1:>Block stage	SPS	I
_:13831:54	Definite-T 1:Inactive	SPS	O
_:13831:52	Definite-T 1:Behavior	ENS	O
_:13831:53	Definite-T 1:Health	ENS	O
_:13831:55	Definite-T 1:Pickup	ACD	O
_:13831:56	Definite-T 1:Operate delay expired	ACT	O
_:13831:57	Definite-T 1:Operate	ACT	O

7.6.5 Stage with User-Defined Characteristic Curve

7.6.5.1 Description

This stage is structured the same way as the stage with a **voltage-dependent** characteristic (see chapter *7.6.3.1 Description*). The only difference is that you can define the characteristic curve as desired. This means that you can also define a dropout characteristic curve. This makes the **dropout delay** parameter superfluous and unneeded.

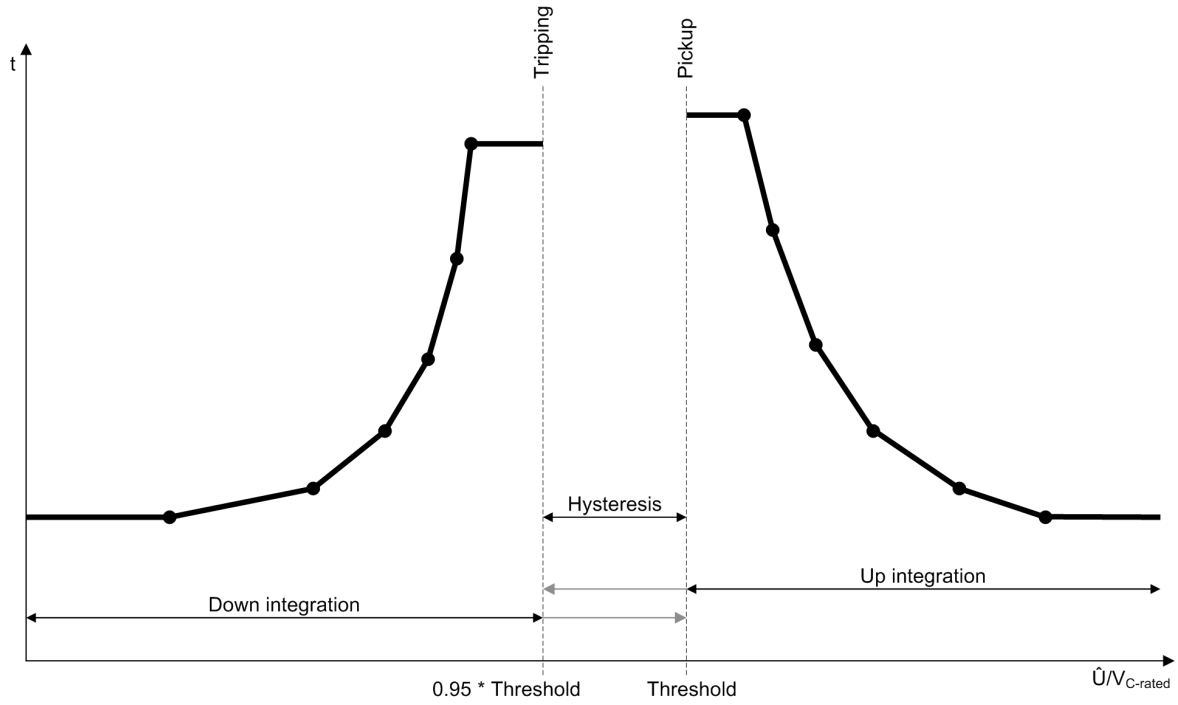
User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of voltage and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

If the measurand $\hat{U}/V_{C\text{-rated}}(t)$ exceeds the threshold value, the characteristic is followed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. This means that the time associated with the present measured value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

If the measured value falls below 95 % of the set threshold value, the dropout is initiated. The pickup will be indicated as clearing. The weighted time results from the dropout characteristic curve. The integral value is reduced until it reaches 0.



[dw_pecuse-230813, 1, en_US]

Figure 7-35 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

7.6.5.2 Application and Setting Notes

This stage is structured the same way as the stage with a **inverse-time** characteristic (see chapter *7.6.3.2 Application and Setting Notes*). The only difference is that you can define the characteristic curve as desired. This chapter provides only application and setting notes for setting characteristic curves.

Parameter: `Voltage/Time Value Pairs` (from the Operate Curve)

Use these settings to define the characteristic curve. Set a voltage/time value pair for each point on the characteristic curve. The setting depends on the characteristic curve you want to realize.

Set the voltage to a multiple of the threshold value. In order to obtain a simple relation, Siemens recommends setting the **`Threshold`** parameter to ***`1.00`***. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **`Time dial`** parameter.

Set the number of value pairs to be used with DIGSI. You can define a maximum of 30 value pairs.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

Where no time grading of tripping and thus no shifting of the characteristic curve is required, leave the parameter **`Time dial`** at 1.

Parameter: `Voltage/Time Value Pairs` (from the Dropout Characteristic Curve)

Use these settings to define the characteristic curve. Set a voltage/time value pair for each point on the characteristic curve. The setting depends on the characteristic curve you want to realize.

Set the voltage to a multiple of the threshold value. Siemens recommends setting the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

Set the number of value pairs to be used with DIGSI. You can define a maximum of 30 value pairs.



NOTE

The value pairs must be entered in continuous order.

7.6.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:3	User curve #:Threshold		0.80 p.u. to 3.00 p.u.	1.10 p.u.
_:101	User curve #:Time dial		0.05 to 15.00	1.00

7.6.5.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O
_:301	User curve #:Down integr. running	SPS	O

7.7 Voltage Differential Protection for Capacitors

7.7.1 Overview of the Functions

The function **Voltage-differential protection** (ANSI 87V) can be applied if the capacitor offers a voltage tap to measure the 3-phase voltage within the capacitor installation. The function:

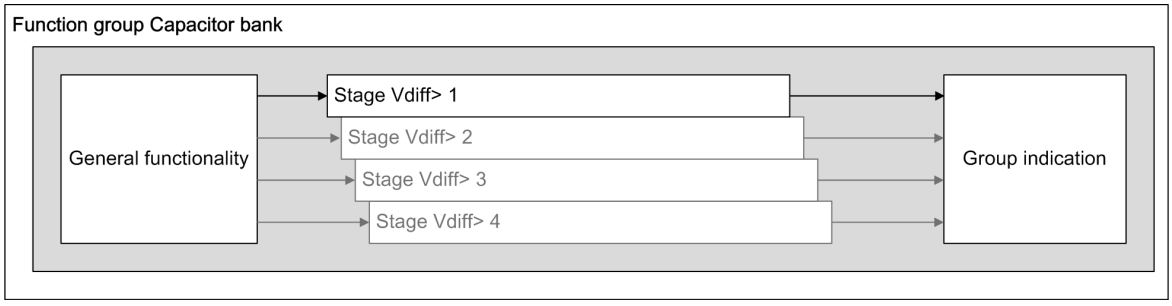
- Calculates the differential voltage between bus and tap voltage by applying a matching factor
- Works as a capacitor unbalance function for protection of faults in capacitor elements (C elements)

7.7.2 Structure of the Function

The function **Voltage-differential protection** is used in the function group **Capacitor bank**. The function is preconfigured at the factory with one protection stage **V_{diff} >**.

A maximum of 4 protection stages **V_{diff} >** can be operated simultaneously in the function.

The **General functionality** (including compensation) works across all stages.



[dw_strucVoldi-060213-01.vsd, 1, en_US]

Figure 7-36 Structure of the Function Voltage-Differential Protection

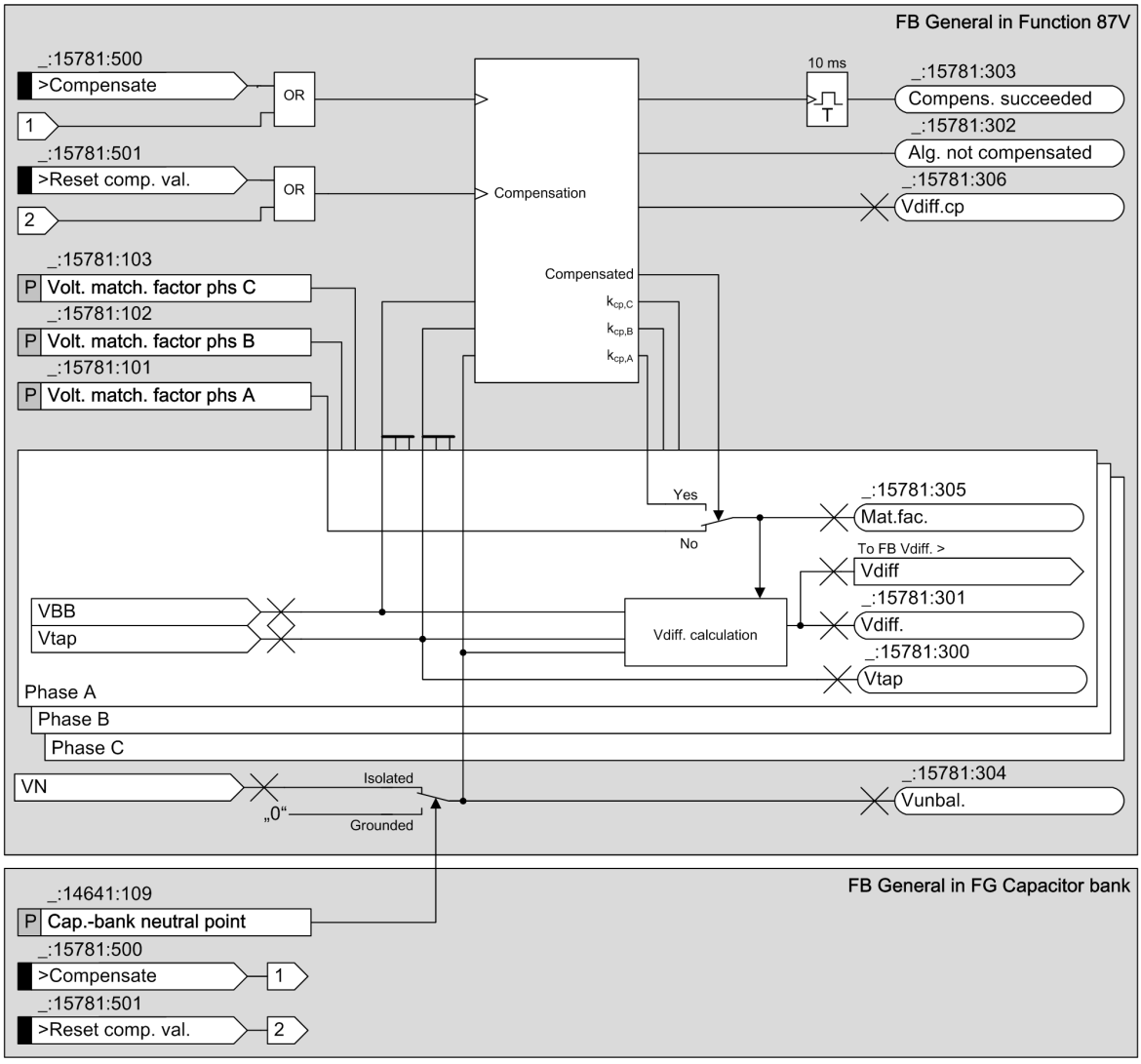
7.7.3 General Functionality

7.7.3.1 Description

The **General functionality** is structured in the following parts:

- Calculation of the differential voltage $V_{diff.}$
- Compensation of an operational differential voltage $V_{diff.}$

Logic for Calculation and Compensation



[Lo_voltdiffgeneral_20140714.vsd, 2, en_US]

Figure 7-37 Logic Diagram of the General Functionality

Measurands, Method of Measurement

The function receives the 3-phase bus and tap voltage measurands (see also V_{BB} and V_{tap} in *Figure 7-37*) via the **3-phase voltage** and **3-phase voltage CB tap** interfaces of the function group **Capacitor bank**. For an isolated capacitor-bank system, the function receives the capacitor-bank neutral-point voltage V_N via the **Voltage unbalance** interface. The method of measurement used processes the sampled voltage values and filters out the fundamental component numerically.

The compensated or not compensated differential voltage is provided to the protection stage for evaluation.

Voltage Matching Factor

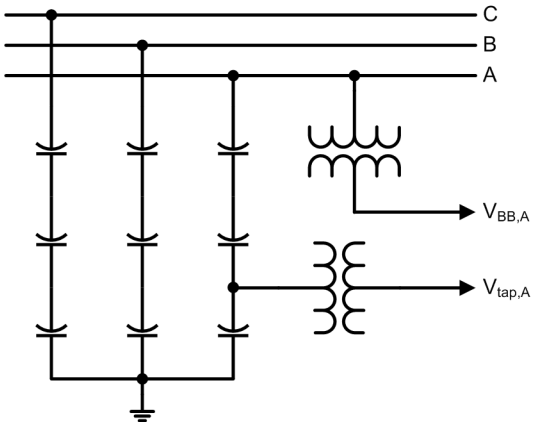
The phase-selective voltage matching factor k is used as a multiplier for the tap voltage to obtain an equivalent voltage value compared to the bus voltage. The voltage matching factor k is obtained either from the parameter **`Volt. match. factor phs A`**, **`Volt. match. factor phs B`**, and **`Volt. match. factor phs C`** or from the compensation functionality. If the compensation is carried out, the function calculates the voltage matching factor k through dividing the measured bus voltage by the measured tap voltage.

Calculation of the Differential Voltage

The calculation of the differential voltage depends on the capacitor-bank neutral-point grounding. With the parameter **`Cap. bank neutral point`**, you can set the grounding type.

2 capacitor-bank neutral-point grounding types are as follows:

- **Grounded capacitor-bank system**



[dw_voltage_measurement_grounded, 1, en_US]

Figure 7-38 Voltage Measurement for a Grounded Capacitor-Bank System

The following formula is used to calculate the differential voltage $V_{diff.}$ of phase A:

$$V_{diff,A} = |\underline{V}_{BB,A} - \underline{k}_A \cdot \underline{V}_{tap,A}|$$

$V_{BB,A}$	Voltage from the busbar, phase A
$V_{tap,A}$	Voltage from the tap, phase A
k_A	Voltage matching factor, phase A

This calculation also applies to the calculation of the $V_{diff.}$ of phase B and phase C.

The voltage measuring-points are connected with the corresponding function-group interfaces.

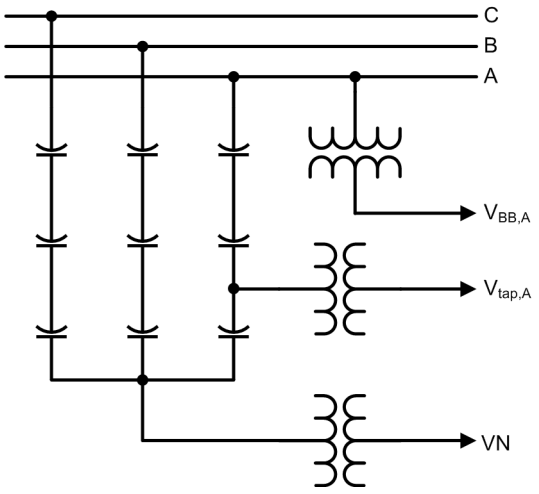
Connect measuring points to function group

	Capacitor bank 1				
Measuring point	V 3ph	I 3ph	V 3ph cap. tap	I unbalance	I 3ph RLC
(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]		X			
Meas.point V-3ph 1[ID 2]	X				
Meas.point V-3ph 2[ID 3]			X		

[Sc_grounded_ground, 1, en_US]

Figure 7-39 Connecting Measuring Points to the Function Group Capacitor Bank for the Grounded Capacitor-Bank System

- **Isolated capacitor-bank system**



[dw_voltage_measurement_isolated, 1, en_US]

Figure 7-40 Voltage Measurement for an Isolated Capacitor-Bank System

The following formula is used to calculate the differential voltage $V_{diff.}$ of phase A:

$$V_{diff,A} = |(\underline{V}_{BB,A} - \underline{V}_N) - \underline{k}_A \cdot (\underline{V}_{tap,A} - \underline{V}_N)|$$

$V_{BB,A}$	Bus voltage, phase A
$V_{tap,A}$	Tap voltage, phase A
k_A	Voltage matching factor, phase A
V_N	Neutral-point-to-ground voltage

This calculation also applies to the calculation of the $V_{diff.}$ of phase B and phase C.

The voltage V_N is obtained by connecting the measuring point **V-1ph** to the interface $\mathbf{V}_{\mathbf{unbalance}}$. **V-1ph** is used for measuring V_N.

Connect measuring points to function group

	Capacitor bank 1					
Measuring point	V 3ph	I 3ph	V 3ph cap. tap	V unbalance	I unbalance	I 3ph RLC
(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]		X				
Meas.point V-3ph 1[ID 2]	X					
Meas.point V-3ph 2[ID 3]			X			
Meas.point V-1ph 1[ID 4]				X		

[Sc_isolate_ground, 1, en_US]

Figure 7-41 Connecting Measuring Points to the Function Group Capacitor Bank for the Isolated Capacitor-Bank System

Both the capacitor-bank tap voltage and the calculated differential voltage are displayed as measured values of the function.

General Notes on the Compensation

An operational differential voltage is added to a differential voltage resulting from faulty capacitor elements. This corrupts the measuring result.

The operational differential voltages can result from the following factors:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates the operational differential voltage by adjusting the voltage matching factors. The adjusted phasors of the matching factor are calculated at the compensation moment, with the following formula (for phase A):

- **Grounded capacitor-bank system**
  $\underline{k}_{cp,A} = \underline{V}_{BB,A} / \underline{V}_{tap,A}$
- **Isolated capacitor-bank system**
  $\underline{k}_{cp,A} = (\underline{V}_{BB,A} - \underline{V}_{N}) / (\underline{V}_{tap,A} - \underline{V}_{N})$

With

$V_{BB,A}$	Bus voltage, phase A
$V_{tap,A}$	Tap voltage, phase A
$k_{cp,A}$	Calculated matching factor at the compensation moment, phase A
V_{N}	Neutral-point-to-ground voltage

The calculation also applies to the calculation of the voltage matching factors of phase B and phase C.
The phasors of the calculated voltage matching factors k_{cp} are stored and used for calculation of the differential voltage until the next compensation is applied or until the compensation is reset.
The phasors of the calculated voltage matching factors k_{cp} are displayed as functional measured values after the compensation is applied. In addition, the compensated differential voltage **Vdiff.cp** is available as functional measured value. **Vdiff.cp** is the differential voltage at the moment of the compensation compared to the uncompensated status. The compensated differential voltage **Vdiff.cp** is calculated with the following formula (for phase A):

- **Grounded capacitor-bank system**
  $V_{diff.cp,A} = | (\underline{V}_{BB,A} - \underline{V}_{N}) - k_{A} \cdot (\underline{V}_{tap,A} - \underline{V}_{N})|$
- **Isolated capacitor-bank system**
  $V_{diff.cp,A} = | \underline{V}_{BB,A} - k_{A} \cdot \underline{V}_{tap,A}|$

With

k_{A}	Parameter **Volt. match. factor phs A**
$V_{BB,A}$	Voltage from the busbar, phase A
$V_{tap,A}$	Voltage from the tap, phase A
V_{N}	Neutral-point-to-ground voltage

This calculation also applies to the calculation of the compensated differential voltage of phase B and phase C.

Manual Compensation via Binary Input Signal

Manual compensation via binary input signals is available.
The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. Compensated values are not available.
Compens. succeeded	If the existing unbalance has been compensated manually, this indication is issued (as transient indication).

By activation of the binary input signal *>Compensate* , the manual compensation is started and the differential voltage that exists at that moment is compensated to 0. The value of $V_{diff.}$ becomes 0.

NOTE

If the measured bus voltage or tap voltage is too low, the manual compensation cannot be performed. No manual compensation is carried out under the following conditions:

- In the **grounded** system:
  $V_{BB} < 10\% * V_{BB,rated}$ or $V_{tap,sec} < 1$ V
- In the **isolated** system:

$$\left| \underline{V}_{BB,prim} - \underline{V}_{N,prim} \right| < 10\% * V_{BB,rated,prim} \text{ or}$$

$$\left| \underline{V}_{tap,prim} - \underline{V}_{N,prim} \right| * \frac{V_{tap,rated,sec}}{V_{tap,rated,prim}} < 1\,V$$

[fo_isolated-system, 1, en_US]

Resetting the Compensation

If one of the following conditions is met, the function works in the not compensated status:

- Initial startup of the device before any compensation has been carried out
- Activation of the binary input *>Reset comp. val.*
- Change of the parameter **Capacitor-bank neutral point** in the function group **Capacitor bank** (refer to chapter *5.4.3 Application and Setting Notes*)

The not compensated status is indicated via the signal *Alg. not compensated*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:15781:300) Vtap	Tap voltage	kV	V	Parameter **Capacitor reference volt.**/√3
(_:15781:304) Vunbal.	Neutral-point voltage	kV	V	Parameter **Capacitor reference volt.**
(_:15781:301) Vdiff.	Differential voltage	kV	V	Parameter **Capacitor reference volt.**/√3
(_:15781:306) Vdiff.cp	The compensated differential voltage at the compensation moment	kV	V	Parameter **Capacitor reference volt.**/√3
(_:15781:101) Volt. match. factor phs A	Voltage matching factor of phase A	-	-	-
(_:15781:102) Volt. match. factor phs B	Voltage matching factor of phase B	-	-	-
(_:15781:103) Volt. match. factor phs C	Voltage matching factor of phase C	-	-	-

You can find the parameter **Capacitor reference volt.** in the function block **General** of the function group **Capacitor bank**.

NOTE

If the function works in the uncompensated status, the values of parameter **Volt. match. factor phs A**, **Volt. match. factor phs B** and **Volt. match. factor phs C** are displayed as functional measured values of the voltage matching factors. And the functional measured values of **Vdiff.cp** are shown as **---**.

7.7.3.2 Application and Setting Notes

Parameter: **Volt. match. factor phs A**, **Volt. match. factor phs B** and **Volt. match. factor phs C**

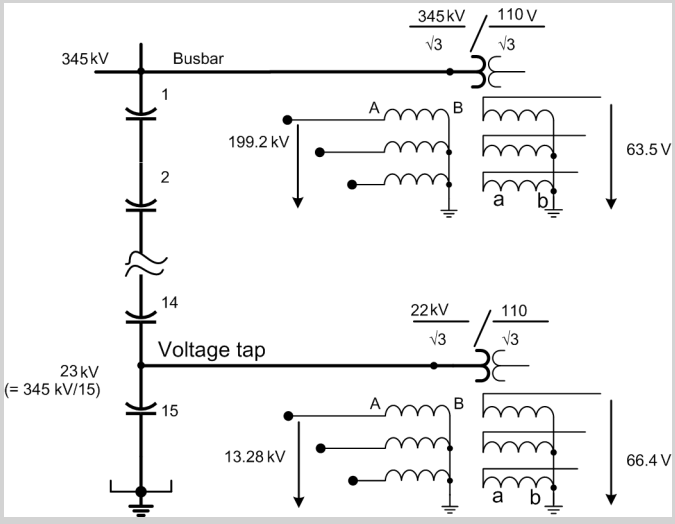
- Default setting **(_:15781:101) Volt. match. factor phs A** = *2.0000*
- Default setting **(_:15781:102) Volt. match. factor phs B** = *2.0000*
- Default setting **(_:15781:103) Volt. match. factor phs C** = *2.0000*

The phase-selective parameters **Volt. match. factor phs A**, **Volt. match. factor phs B** and **Volt. match. factor phs C** are applied as multiplier for the primary tap voltage to calculate the differential voltage. It depends on the position of the tap-voltage measurement in the specific capacitor installation. The setting is defined as the ratio of the capacitor-bank reference voltage to the tap voltage.

EXAMPLE

The application consists of:

- Capacitor-bank busbar, with a rated voltage of 345 kV
- Capacitor bank, consisting of 15 can levels in series
- Capacitor-bank tap-voltage measurement between level 14 and 15



[lo_application example, 2, en_US]

Figure 7-42 Application Example for Setting the Voltage Matching Factor

Capacitor-bank bus voltage as phase-to-phase voltage (it equals to a phase-to-ground voltage of 199.2 kV)	345 kV
Capacitor-bank tap voltage as phase-to-phase voltage (it equals a phase-to-ground voltage of 13.28 kV)	23 kV
Voltage matching factors are set as: (including parameters **Volt. match. factor phs A**, **Volt. match. factor phs B**, and **Volt. match. factor phs C**)	345 kV/23 kV = 15

The voltage measuring points must be set as indicated in the figure:

Busbar transformer, rated primary voltage:	345 kV
Busbar transformer, rated secondary voltage:	110 V
Tap transformer, rated primary voltage:	22 kV
Tap transformer, rated secondary voltage:	110 V

Under normal operation, these settings result in a differential voltage of approximately 0 V and in the primary and secondary measured voltage values as indicated in the *7.7.3.2 Application and Setting Notes*.

NOTE

The sound secondary tap voltage must not be smaller than 1 V. Otherwise the function cannot work properly. Fulfill this condition by applying an appropriate voltage transformer for the tap voltage. Siemens recommends applying a tap voltage transformer which provides under normal operation a secondary voltage in the area of the rated secondary voltage.

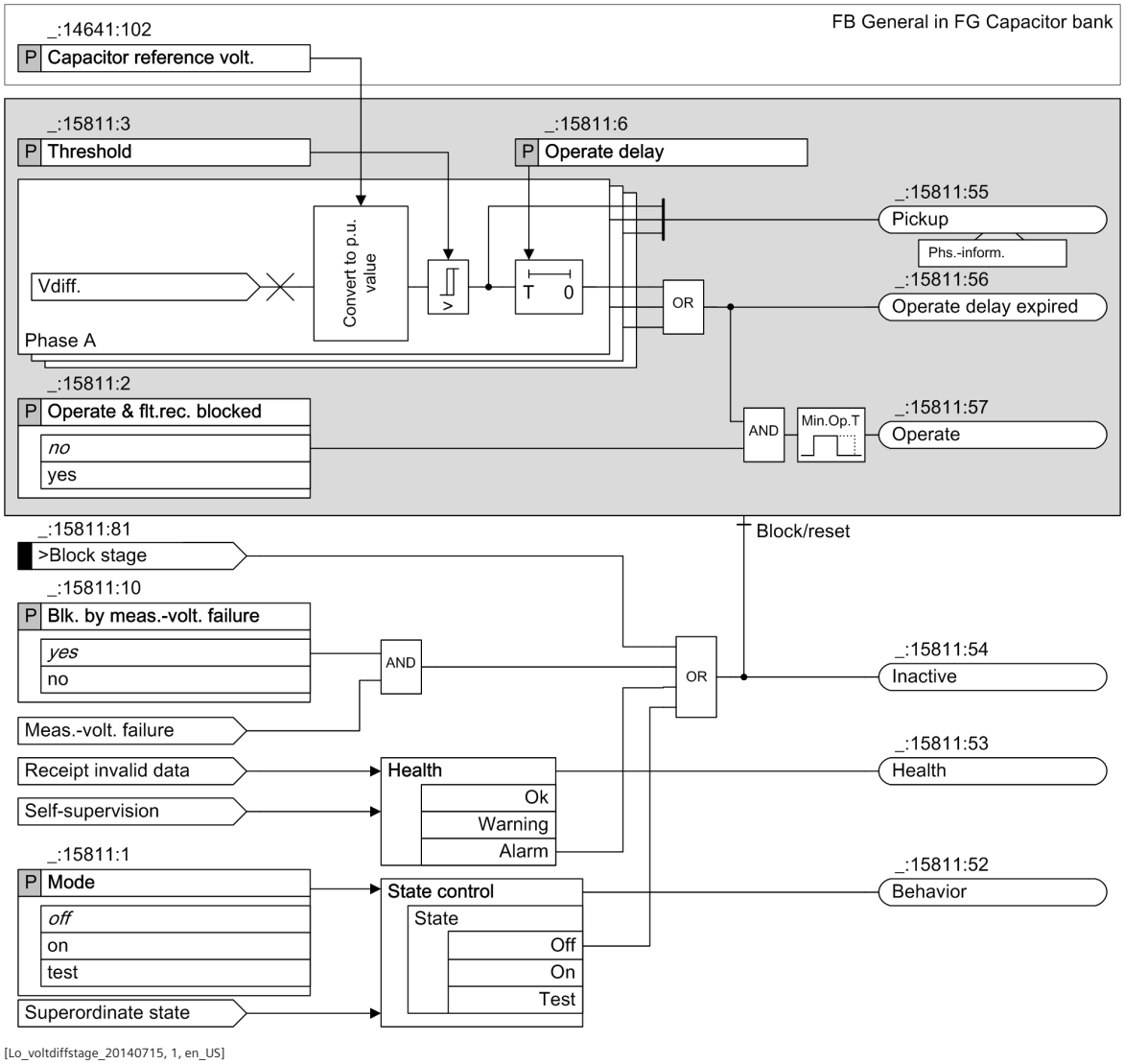
EXAMPLE

In the **grounded** system:
Ratio of the capacitor-bank bus voltage to the tap voltage: matching factor k = 400 kV/400 V = 1000
Busbar transformer, rated primary voltage: 400 kV
Busbar transformer, rated secondary voltage: 100 V
To ensure an optimal tap-voltage measurement, the following transformer ratio is recommended:
Tap transformer, rated primary voltage: 400 V
Tap transformer, rated secondary voltage: 100 V

7.7.4 Description Protection Stage

7.7.4.1 Description

Logic of the Stage V_{diff}



[Lo_voltdiffstage_20140715, 1, en_US]

Figure 7-43 Logic of the Protection Stage V_{diff}

Measurand, Pickup and Operate

In the protection stage, the differential-voltage value is converted to a p.u. value in relation to the capacitor-bank reference voltage.

If the converted value exceeds the **`Threshold`** value, a *`Pickup`* indication is issued. If the threshold is exceeded continuously during the operate delay, an *`Operate`* signal is issued.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source.
- From inside on pickup of the function **Measuring-voltage failure detection** (see section *9.3.2.1 Overview of Functions*). The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

7.7.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:15811:3) Threshold** = *0.200 p.u.*

The parameter **Threshold** is set as a p.u. value related to the parameter **Capacitor bank reference voltage** in the function group **Capacitor bank**.

The setting of the parameter **Threshold** depends on the differential voltage that occurs with the number of defective C elements for which a warning indication or a trip command shall be generated. Determine this differential voltage and set the **Threshold** slightly lower, for example, to 80 % of the value.

Parameter: Operate delay

- Default setting **(_:15811:6) Operate delay** = *1.00 s*

Set the parameter **Operate delay** for the specific application.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:15811:10) Blk. by meas.-volt. failure** = *yes*

You can use the parameter **Blk. by meas.-volt. failure** to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker. This binary input is available in the voltage transformers connected to the bus voltage and capacitor-bank tap voltage. The binary input is also available in the voltage transformer connected to the VN voltage in case of an isolated capacitor bank.

Parameter Value	Description
no	The stage Vdiff > is not blocked when a measuring-voltage failure is detected.
yes	The stage Vdiff > is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

7.7.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:15781:101	General:Volt. match. factor phs A		0.5000 to 2000.0000	2.0000
_:15781:102	General:Volt. match. factor phs B		0.5000 to 2000.0000	2.0000

Addr.	Parameter	C	Setting Options	Default Setting
_:15781:103	General:Volt. match. factor phs C		0.5000 to 2000.0000	2.0000
Vdiff> 1				
_:15811:1	Vdiff> 1:Mode		• off • on • test	off
_:15811:2	Vdiff> 1:Operate & flt.rec. blocked		• no • yes	no
_:15811:10	Vdiff> 1:Blk. by meas.-volt. failure		• no • yes	yes
_:15811:3	Vdiff> 1:Threshold		0.005 p.u. to 1.000 p.u.	0.200 p.u.
_:15811:6	Vdiff> 1:Operate delay		0.00 s to 60.00 s	1.00 s

7.7.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:15781:500	General:>Compensate	SPS	I
_:15781:501	General:>Reset comp. val.	SPS	I
_:15781:302	General:Alg. not compensated	SPS	O
_:15781:303	General:Compens. succeeded	SPS	O
_:15781:300	General:Vtap	WYE	O
_:15781:301	General:Vdiff.	WYE	O
_:15781:304	General:Vunbal.	CMV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Vdiff> 1			
_:15811:81	Vdiff> 1:>Block stage	SPS	I
_:15811:54	Vdiff> 1:Inactive	SPS	O
_:15811:52	Vdiff> 1:Behavior	ENS	O
_:15811:53	Vdiff> 1:Health	ENS	O
_:15811:55	Vdiff> 1:Pickup	ACD	O
_:15811:56	Vdiff> 1:Operate delay expired	ACT	O
_:15811:57	Vdiff> 1:Operate	ACT	O

7.8 Differential Protection for Capacitor Banks

7.8.1 Function Overview

The function **Differential protection for capacitor banks** (ANSI 87C):

- Detects ground faults and multiphase short circuits at capacitor banks
- Detects ground faults during the operation of capacitors in systems with a grounded neutral point
- Uses the necessary stabilization procedures during energizing operations
- Trips safely and very fast in the case of internal high-current faults through an additional high-current stage

7.8.2 Structure of the Function

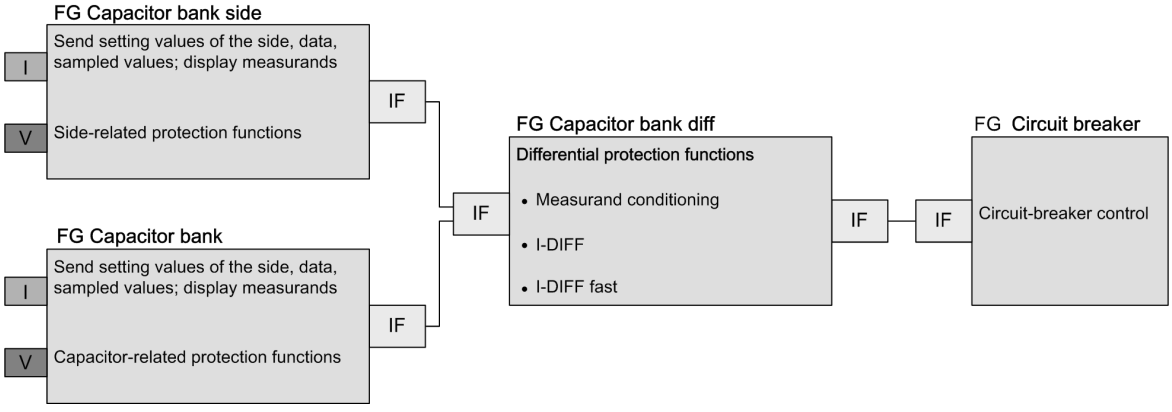
The **Differential capacitor bank protection** function is used in the **Capacitor Bank diff** protection function group. The function is preconfigured by the manufacturer in the corresponding application template depending on the application and can be copied during the engineering into the corresponding function group.

The **Differential capacitor bank protection** function consists of the stages IDiff and IDiff fast. The stages can be blocked, in addition you can switch the stages on and off.

The function group **Capacitor bank side** has the following characteristics:

- The side-related protection settings are performed
- The side-related calculations are performed
- All data (setting values, detected currents) are relayed to the **Capacitor bank Diff** function group

The side-related protection functions can run in the **Capacitor bank side** function group, for example overload protection, overcurrent protection, etc.



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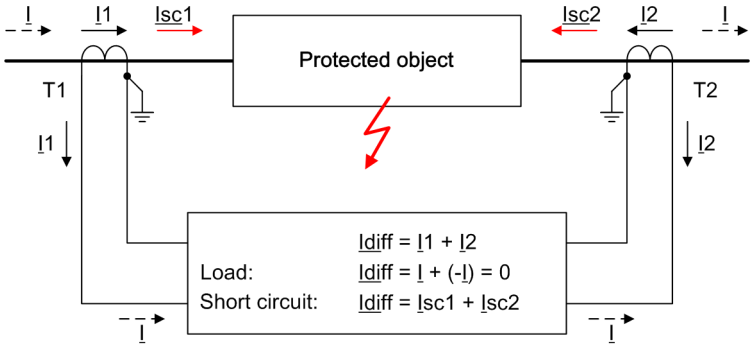
Figure 7-44 Structure/Embedding of the Function

7.8.3 Function Description

Basic Principle of Differential Protection

Differential protection is based on a comparison of currents (Kirchhoff current law). When comparing the current, use is made of the fact that a protected object uses the same current I in a non-faulty operating state on both sides (dotted in *Figure 7-45*). This current flows into the range being observed on one side and leaves it again on the other side. A current differential is a sure indication of a fault within the protected object. The calculation of the difference is determined through the current-direction definition. The current direction is

defined as positive to the protected object. The current difference results from the vector addition of the currents.



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Figure 7-45 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in chapter *Differential Protection Function (Idiff), Page 993*.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers **W1** and **W2** (*Figure 7-45*), a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = (\underline{I}_1 + \underline{I}_2)$

as well as a restraint current of

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|)$

For more than 2 measuring points, this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2| ; \ldots |\underline{I}_n|)$

To clarify the effect, 3 important operating states are observed with ideal and adapted measurands.

- Through fault current in healthy operation or externally caused error:

  $\underline{I}_1$ flows into the protection range, $\underline{I}_2$ flows out of the protection range, that is, negative compared with the prefix definition, thus $\underline{I}_2 = -\underline{I}_1$;

  in addition $|\underline{I}_2| = |\underline{I}_1|$

  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$

  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$

  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.

- Internal short circuit, feed from both sides with equal amount of currents, for example:

  Then $\underline{I}_2 = \underline{I}_1$; In addition $|\underline{I}_2| = |\underline{I}_1|$;

  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$

  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$

  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity (I_{rest}).

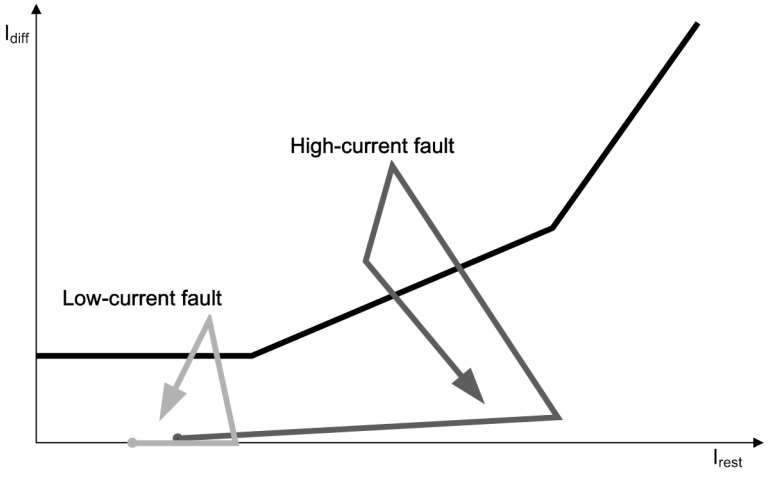
- Internal short circuit, feed only from one side:
  Then $\underline{I}_2 = 0$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + 0| = |\underline{I}_1|$
  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1|$
  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are of the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current-transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with *Figure 7-46*, there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transferred and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct-current time constant (switching of transformers, motors), but small currents flowing through. This manifests itself as a phase-angle rotation of the current. Exceeding the characteristic curve in a non-stabilized area is possible.

Intelligent saturation-detection methods capture this state and lead to a temporally limited blocking of the Differential protection function.



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Figure 7-46 Principle Current Course in External Short Circuit and Temporary Current-Transformer Saturation on One Side

Inrush-Current Detection

The inrush-current detection evaluates the calculated instantaneous values of the differential current. The inrush current develops with Sympathetic Inrush – connection of a parallel transformer or Recovery Inrush – inrush current subsequent to returning voltage after fault in the system considerably higher than in the side currents. An assignment to the corresponding blocking phases is possible only in the differential current due to the vector-group correction.

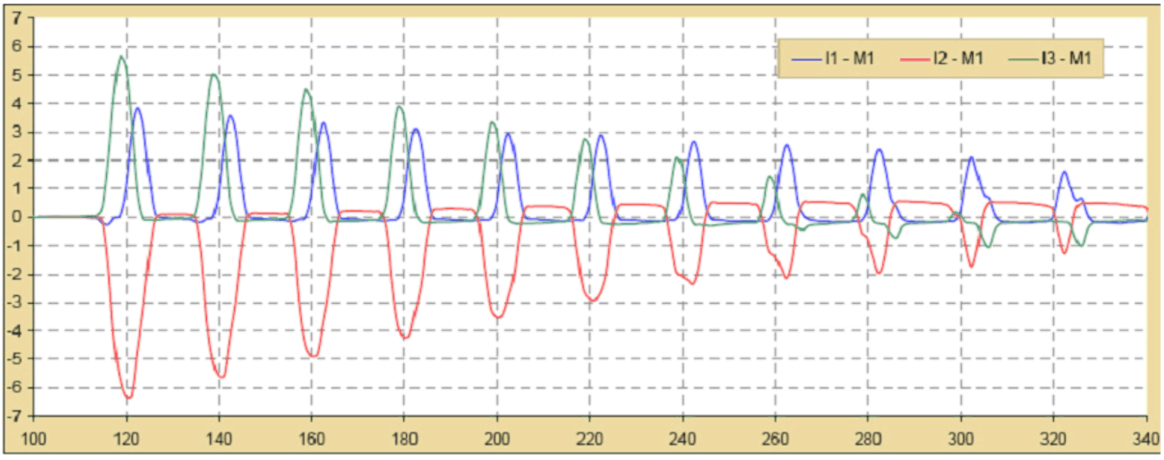
The inrush-current detection is activated when the pickup characteristic is exceeded. It is deactivated when it is blocked by an external fault.

For inrush-current detection, 2 methods working in parallel are used:

- **Share of the 2nd harmonic relative to the fundamental component in the differential current ($I_{2nd\ harm}/I_{1st\ harm}$)**

  As *Figure 7-47* also shows, the 2nd harmonic is clearly pronounced in the inrush current. If the share of the 2nd harmonic exceeds the set threshold value (parameter: **`2nd harmonic content`**), a phase-segregated blocking occurs. The harmonics develop differently in the different phases. If exceeding of the 2nd harmonic is detected in a phase, it may be necessary to block all phases simultaneously. This blocking must be limited with regard to time and is controlled by the parameter **`Crossblock. time 2nd har.`**. The correct positioning of the filter windows is controlled by the internal pickup.

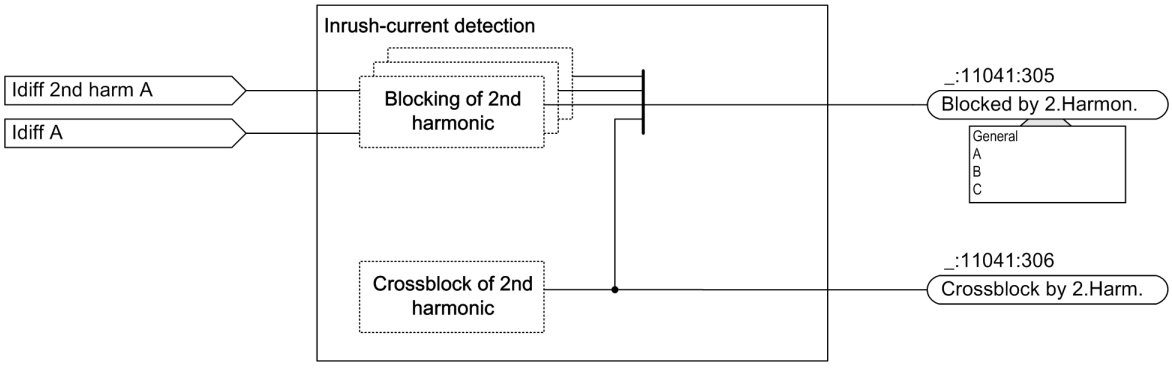
If you want only one method to be active, the other method can be changed to inactive. For this, parameter **`Blocking with 2. harmonic`** = ***no*** is used.



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Figure 7-47 Inrush Current with Pronounced Flat Areas

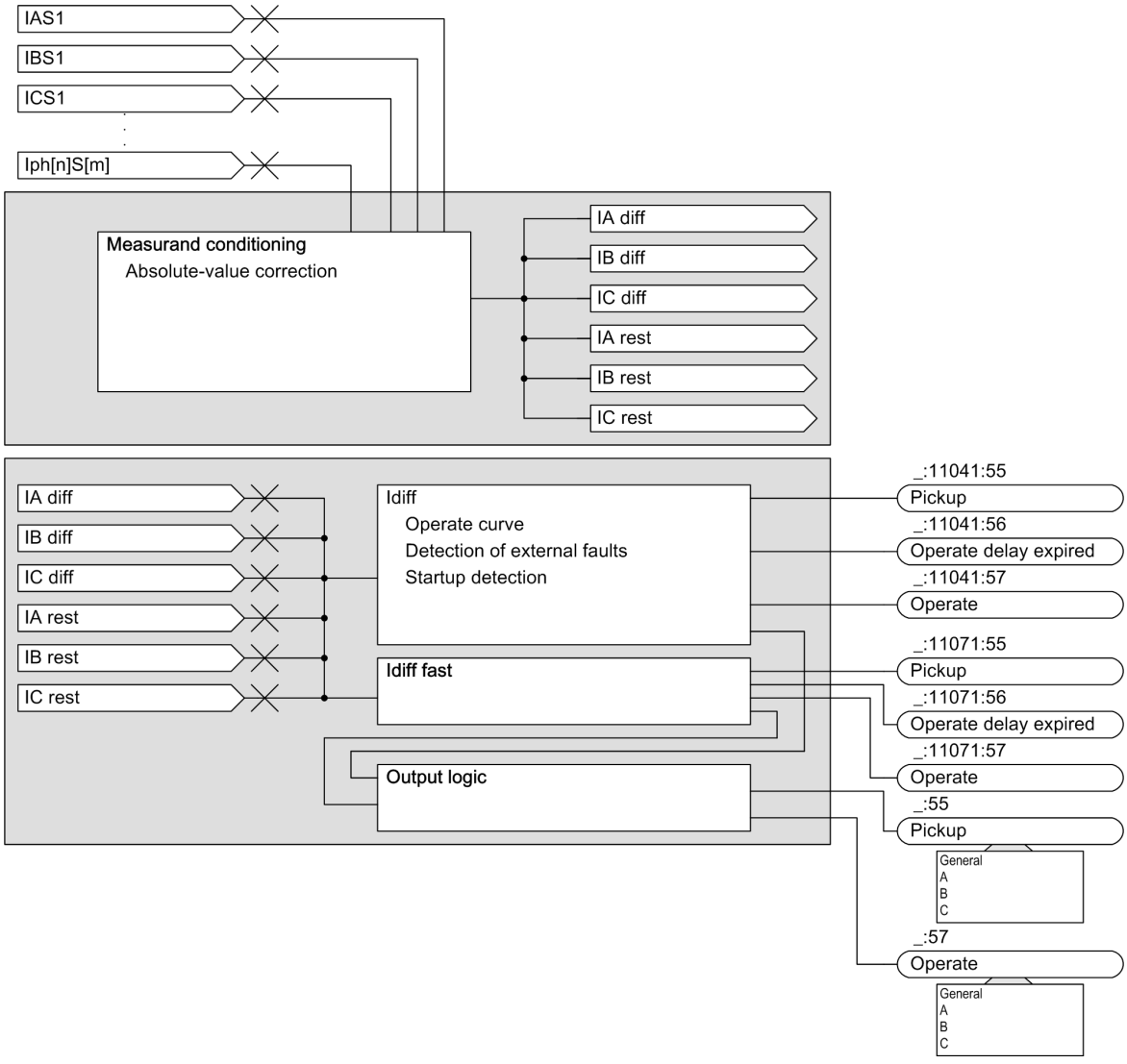
Figure 7-48 shows the logical input and output signals.



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Figure 7-48 Logic Inrush-Current Detection

Logic of the Function



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Figure 7-49 Logic Diagram of the Capacitor Bank Differential Protection Function

Measurand Processing

Absolute-Value Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 80 Hz).

The Idiff-fast stage works on non-frequency tracked values and thus, implements fast operate times with low frequencies.

The absolute value is adapted via the following formula:

$$i^*_{phsx} = k\, i_{phsx}$$

$$\text{with } k = \frac{I_{rated\,prim,\,Sx}}{I_{rated\,obj,\,Sx}} = \frac{I_{rated\,prim,\,Sx}}{\frac{S_{rated,\,ref}}{V_{rated,\,Sx}\sqrt{3}}}$$

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i_{phsx}*	Adapted instantaneous value per phase (x = A, B, C)
i_{phsx}	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated\ prim,Sx}$	Primary transformer rated current per measuring point
$I_{rated\ obj,Sx}$	Primary rated current of the protected object
$S_{rated,ref}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated,Sx}$	Rated voltage of the respective side (measuring point) of the protected object

NOTE

For more than 2 capacitor bank sides (teed feeder), , the winding with the highest power is used as the reference winding. If several sides have the same highest amount of power, then the highest current side is selected as reference side. The absolute value of the neutral-point transformer is also adapted according to the previous formula. In this case, the absolute value should be adapted to the side with the greatest power.

Vector-Group Correction

The vector groups of the capacitor bank sides occur due to couplings that are different on each side. Therefore, the measured currents cannot be used directly for summation. The vector-group correction replicates the coupling of the capacitors and makes the measured currents comparable. The correction occurs such that each side is converted to vector group 0. Since you are in the 3-phase system, the conversion occurs via matrices which are stored for the respective vector-group type. The general description is given in the following formula. In the same calculation step, the absolute value is corrected:

$$\begin{bmatrix} i^*_A \\ i^*_B \\ i^*_C \end{bmatrix} = k * M_{SG} * \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix}$$

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with

i_{phsx}*	Adapted instantaneous value per phase (x = A, B, C)
i_{phsx}	Instantaneous value per phase (x = A, B, C)
k	Absolute-value correction per measuring point
M_{SG}	Correction matrix

Differential Protection Function (Idiff)

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section Measurand Processing). The direction of current flow is defined as to the **protected object as positive**. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length = 1 period (20 sampled values)).

The currents of that measuring point whose RMS value is the largest are used as restraint current. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation, the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

NOTE

Differential protection does not work with sensitive ground-current transformers. Since sensitive transformers can go into saturation too quickly, false differential currents arise.

$$i_{diff,phsx} = \sum_{m=1}^{N} i^{*}_{phsx,Mm} \rightarrow I_{diff,phsx} = FIR(i_{diff,phsx})$$

$$I_{phsx,Mm} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^{*2}_{phsx,Mm}(k)}$$

$$I_{rest,phsx} = \underset{m=1}{\overset{N}{MAX}}\, I_{phsx,Mm}$$

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with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum-value determination

Pickup Characteristic

Figure 7-50 shows the pickup characteristic of the differential protection. The characteristic curve branch **a** represents the sensitivity threshold of the differential protection (parameter **`Threshold`**) and considers constant fault currents like magnetizing currents.

The characteristic branch **b** (parameter **`Intersection 1 Irest`** and **`Slope 1`**) considers current-proportional faults under normal operating conditions.

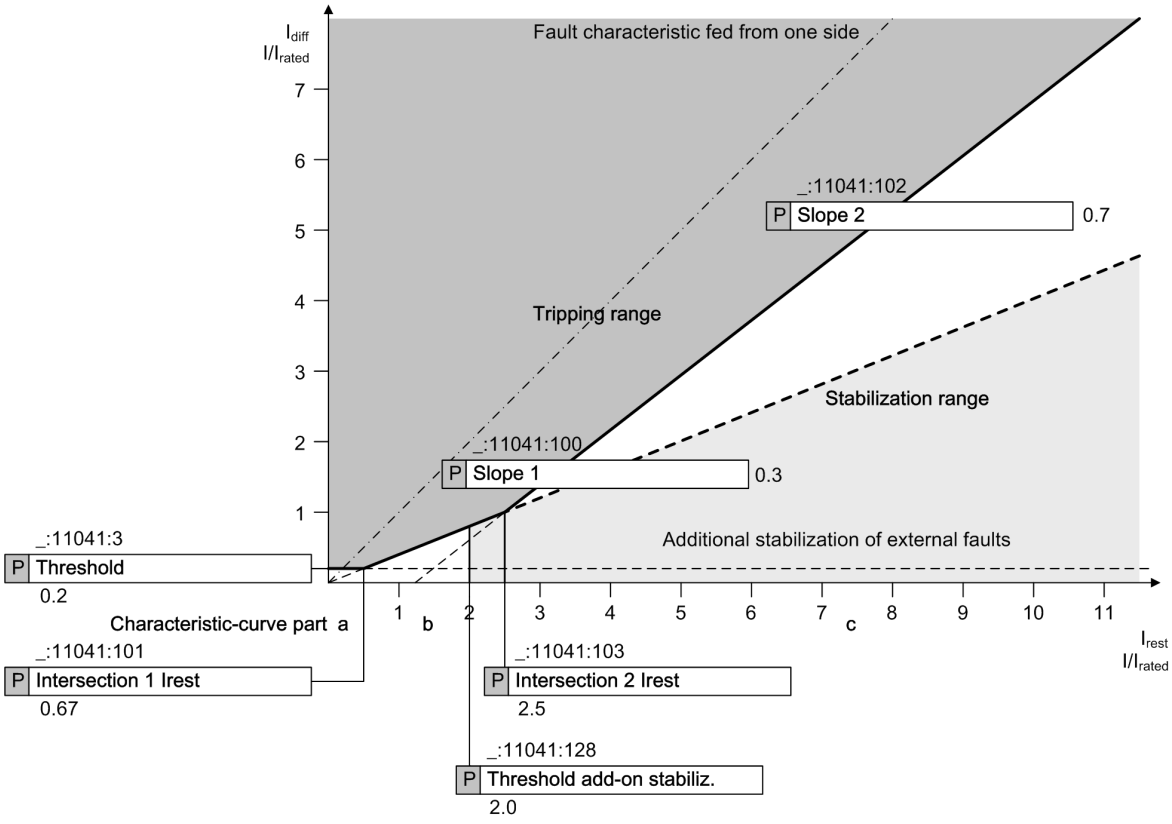
These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations

The characteristic curve branch **c** (parameter **`Intersection 2 Irest`** and **`Slope 2`**) protects the differential protection against overfunction in case of high-current external faults and transformer saturation. In this area, transformer saturation can arise due to high short-circuit currents, and because of this, a higher differential current results.

In order to avoid overfunction in the event of external faults with transformer saturation, a logic is implemented that uses the characteristic curve **Additional stabilization of external faults**. If the operating point is located in the additional stabilization area and exceeds the operate curve from there, then the logic becomes active and blocks the differential protection.

The additional stabilization range is derived from the **`Threshold add-on stabiliz.`** and **`Slope 1`** parameters.



[dwdifaus-030912-01.tif, 1, en_US]

Figure 7-50 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Detection of External Faults

To detect external faults with transformer saturation in a reliable way, the measurand curve is evaluated in the Diff.-Rest level by means of a detector. The detector has 2 essential tasks:

- **Blocking in the case of a definite high-current external fault**

  The differential current and the restraint current are monitored on a phase basis in the Diff/Restr level immediately after fault inception. To ensure the stability of the saturation detection for low saturation-free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.

  If the estimated restraint current exceeds the **`Threshold add-on stabiliz.`** parameter and the expected value of the differential current of all phases is in the additional stabilization range (parameter **`Slope 1`**) (*Figure 7-50*) at the same time, the detector is active and the indication ***`Blocked by ext. fault phsx`*** appears. The tripping of the Differential protection function is blocked.

  If an external fault arises and is cleared by the protection responsible for it, the additional stabilization drops out. If the dropout ratio (0.7) of the RMS value of the restraint current does not reach the **`Threshold add-on stabiliz.`** parameter (*Figure 7-50*), the additional stabilization drops out. The indication ***`Blocked by ext. fault phsx`*** is reset.

  If the differential current exceeds **`Slope 1`** as a result of transformer saturation, that is, there is a pickup phsx, the blocking is limited in time (parameter: **`Time of add-on stabiliz.`**).

  Starting with the indication ***`Blocked by ext. fault phsx`***, the other phases can be blocked with it via the **`Cross-blk. time add-on st.`** parameter. If differential currents due to transformer saturation spread to the other phases through the vector-group correction or residual current elimination, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**

  An internal fault can arise as a consequence of an external fault. This fault change must be recognized and the blocking must be removed. The critical case is a short-circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation, the instantaneous values fall below an internal threshold in the saturation-free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with cross block.

  The blocking of the tripping is removed and the indication ***Blocked by ext. fault phsx*** is reset.

DC-Component Detection

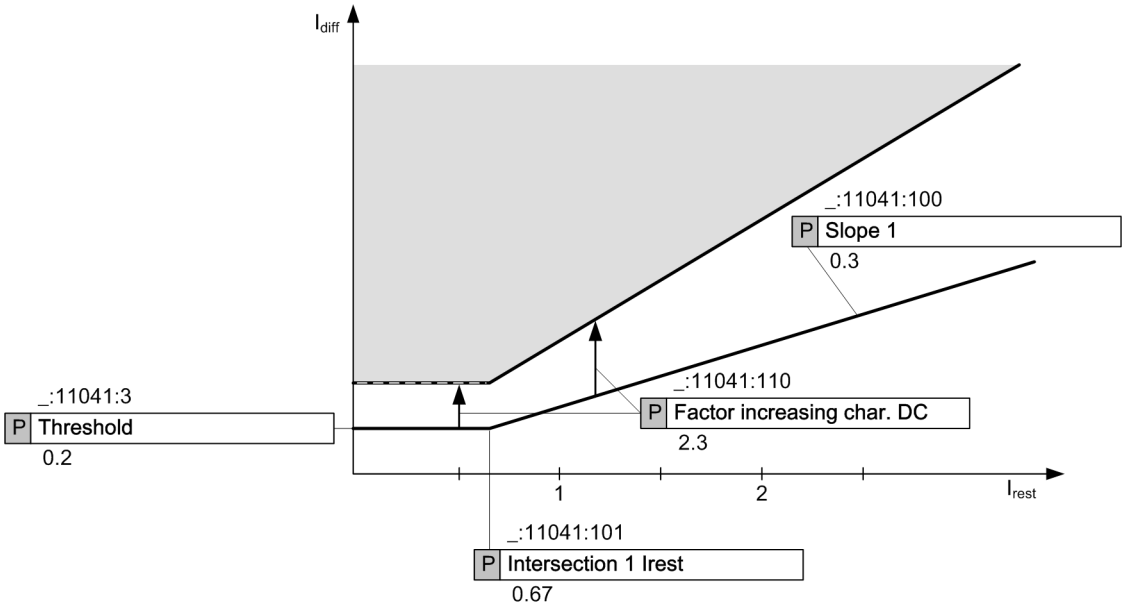
Low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization area is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest.;phsx}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $i_{rest.,phsx} = i_{phsx,Mm}$. The result is $I_{rest.DC,phsx}$. This current is compared to the restraint current $I_{rest.,\ phsx}$ and is checked for exceeding of the internal threshold.
- The differential current $I_{diff,phsx}$ must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter **Factor increasing char.** with a default setting of ***2.3***. Here, only the threshold value and the gradient 1 are raised (see *Figure 7-51*). The indication ***Increase of char. (DC)*** is output. If the product of parameter **Factor increasing char.** and **Slope 1** exceeds **0.85**, the maximum increase of the raised **Slope 1** is limited to 0.85.
- As additional criterion, the pickup indication ***Pickup*** (internal fault is present) or the indication of the additional stabilization ***Blocked by ext. fault phsx*** (high-current external fault) is sampled. If one of the 2 conditions is present, the characteristic-curve increase is stopped. A retroactive pickup no longer resets the characteristic-curve increase. A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

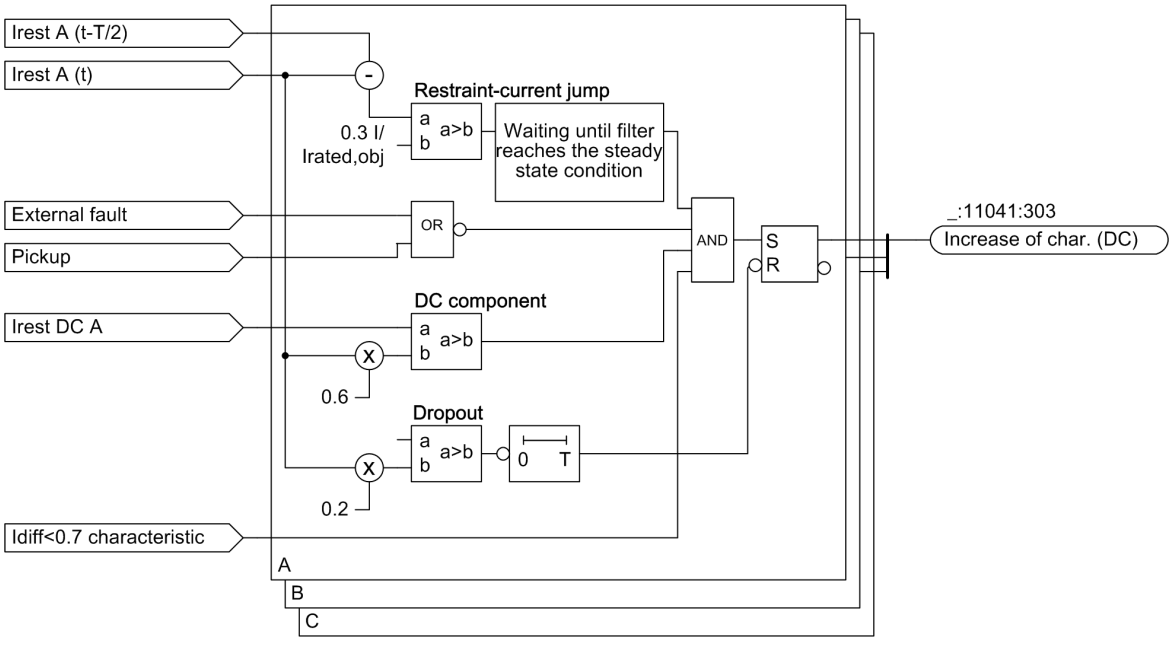
If the DC component $I_{rest.DC,phsx}$ falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the de- and remagnetization of the transformer last equally long. The magnetization is at the highest at the point in time in which the internal dropout threshold is attained. The time is measured from the start of the DC-component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic-curve increase is reset to the original value. *Figure 7-52* shows the overall logic.



[dwdcerkn-201112-01.tif, 2, en_US]

Figure 7-51 Increasing the Characteristic Curve after DC Detection



[lodcerkn-170712-01.tif, 1, en_US]

Figure 7-52 Logic DC Detection

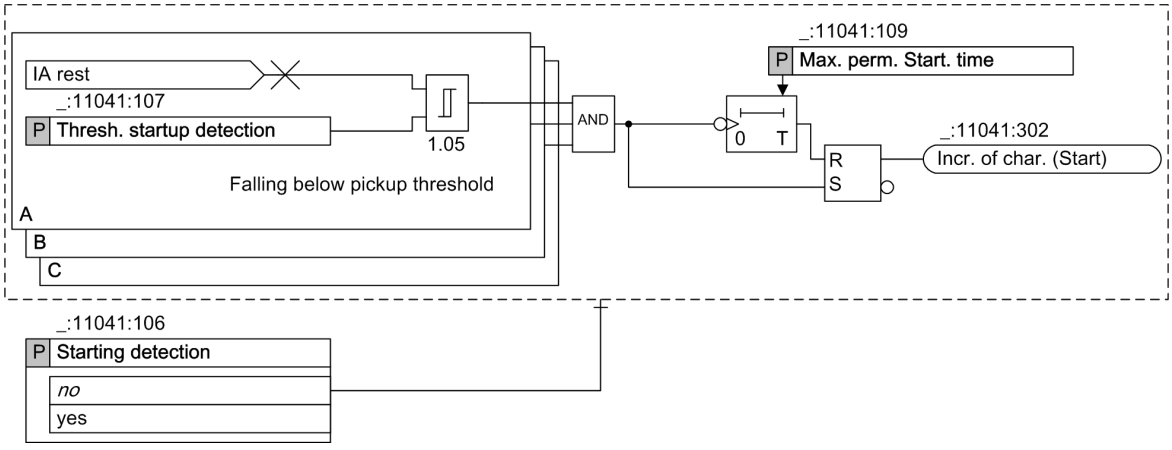
Startup Detection

The pickup-value increase is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current at different operating points of their hysteresis. These differential currents are low in fact, but they can lead to overfunction with sensitive setting of the differential protection.

You can use the pickup-value increase at startup as an additional security against overfunction when switching in a previously currentless protected object. If the restraint current falls below a settable value **`Thresh. startup detection`** in all phases, the pickup-value increase is activated. The pickup value **`Threshold`**

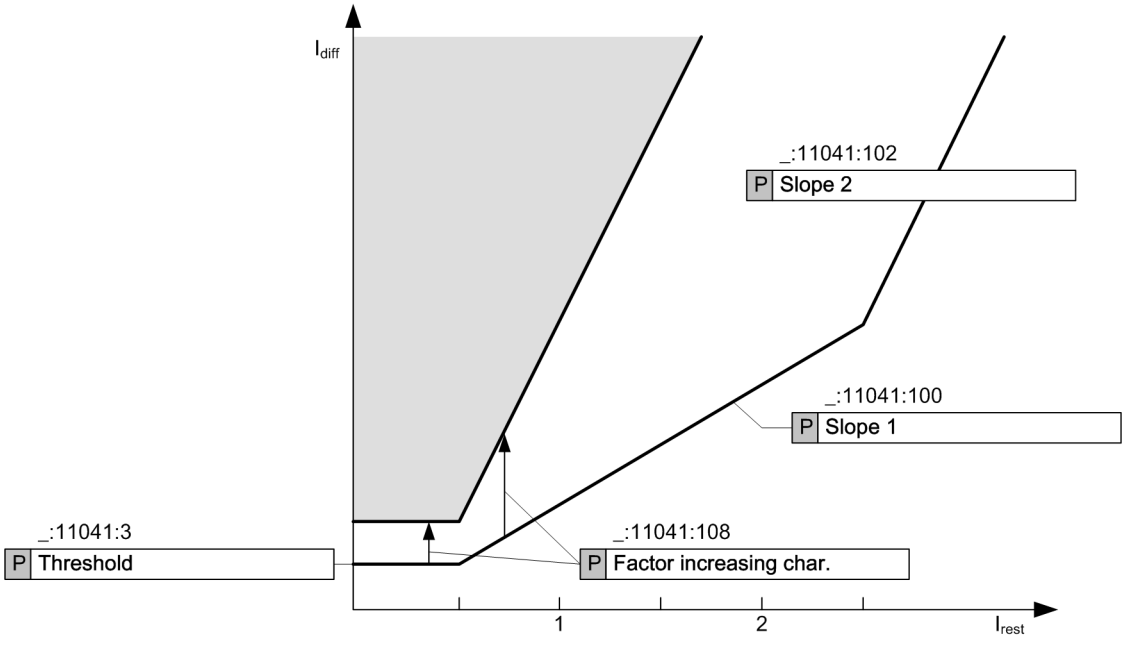
and **Slope 1** are raised by the set value in accordance with parameter **Factor increasing char.** . As a rule here, **Slope 1** cannot exceed a value of 0.85.

If the parameter **Thresh. startup detection** is exceeded, dropout occurs and a timing element (parameter **Max. perm. Start. time**) is started. Once this time has elapsed, the characteristics curve that was raised in all phases is reset to its original value. *Figure 7-53* shows the logic diagram of the pickup recognition and *Figure 7-54* the increased characteristic curve.



[loanlauf-170712-01.tif, 2, en_US]

Figure 7-53 Logic Pickup Recognition



[dwanlken-201112-01.tif, 1, en_US]

Figure 7-54 Characteristic-Curve Increase at Startup

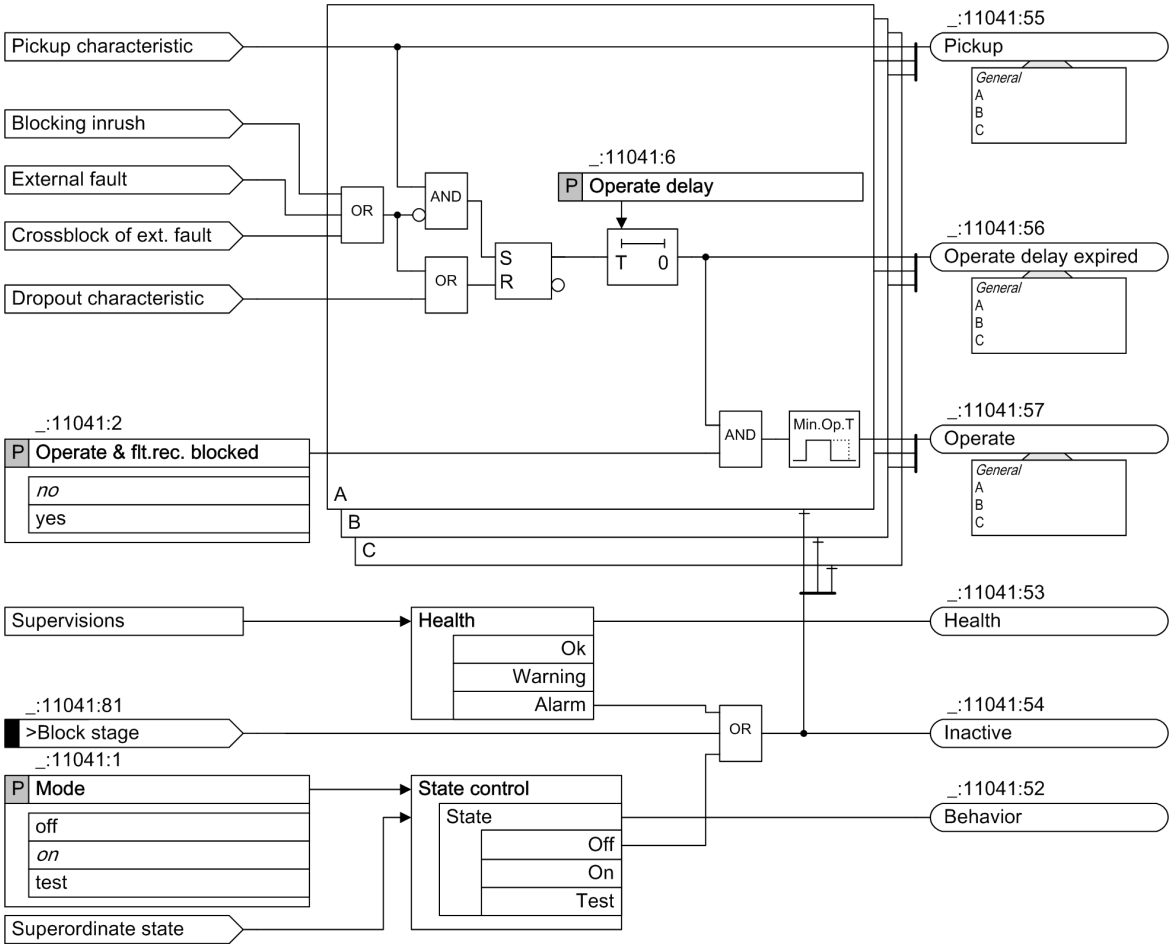
Trip Logic of the Differential Function Idiff

Figure 7-55 shows the trip logic. If the characteristic curve is exceeded (see *Figure 7-50*), a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following variables:

- Recognition of external faults that can simulate an internal fault through transformer saturation
- Recognition of the connection process (2nd harmonic)

In addition, in case of blocking due to an *external error*, a **Crossblock** mechanism comes into effect.



[loauscod-290414-01, 1, en_US]

Figure 7-55 Trip Logic of Idiff

Differential Protection Function (Idiff Fast)

As a supplement to the differential protection function (Idiff), the Idiff fast function is available. The main task consists in switching off high-current internal faults in the shortest amount of time. The method controls current-transformer saturation and is stable in the event of external transverse faults (integration in breaker-and-a-half arrangements).

Metrologically, 2 methods are combined:

- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

Through the instantaneous-values method, an immediate evaluation of the sampled values of the differential $i_{Diff}(t)$ and restraint current $i_{rest}(t)$ occurs. The absolute-value adapted and vector-group adapted currents (i*) are also the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points.

$$i_{diff,phsx}(t) = \left| \sum_{m=1}^{N} i^{*}_{phsx,Mm}(t) \right|$$

$$i_{rest,phsx}(t) = \max_{m=1}^{N} \left| i^{*}_{phsx,Mm}(t) \right|$$

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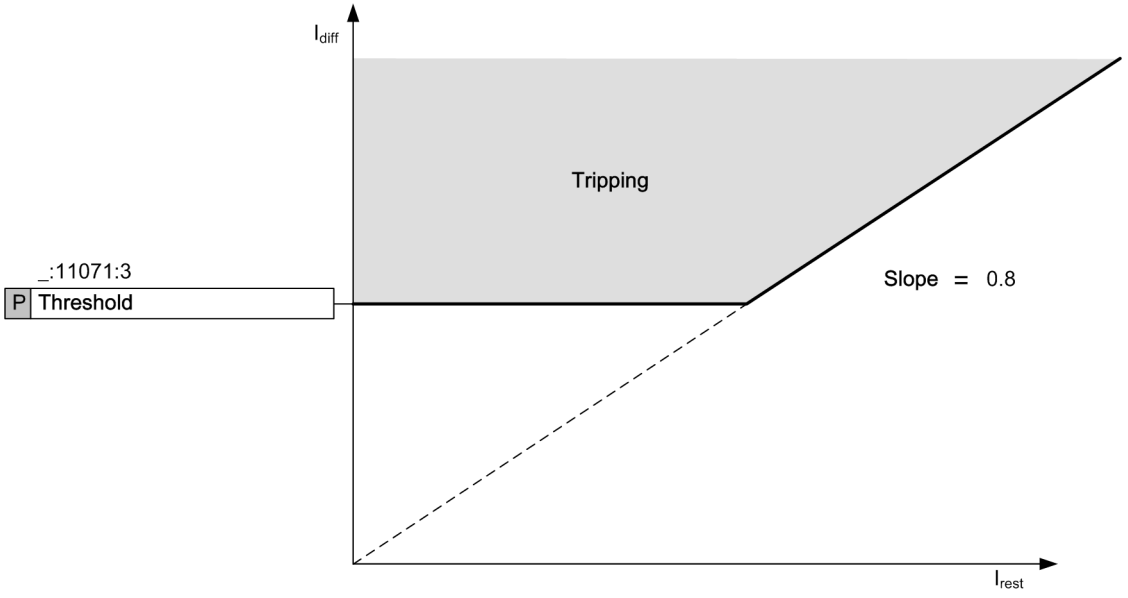
with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points

The evaluation of the restraint current is used to recognize saturated, high-current external faults.
Figure 7-56 shows the operate curve. The parameter **Threshold** is set here such that it lies over the maximum fault current flowing. The gradient of the characteristic curve is fixed at 0.8.
In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $di_{rest}(t)/dt$ is determined continuously and compared with an internal threshold.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve **Gradient** in *Figure 7-56*): $i_{diff}(t) > 0.8 \cdot i_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter **Threshold**.

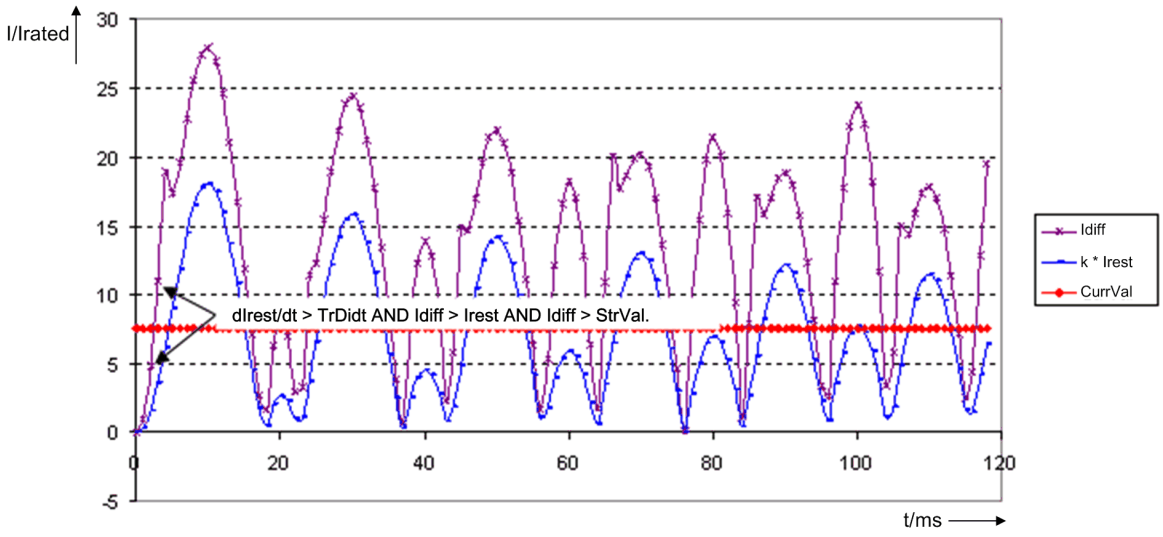
When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.



[dwidfast-300114-01.tif, 1, en_US]

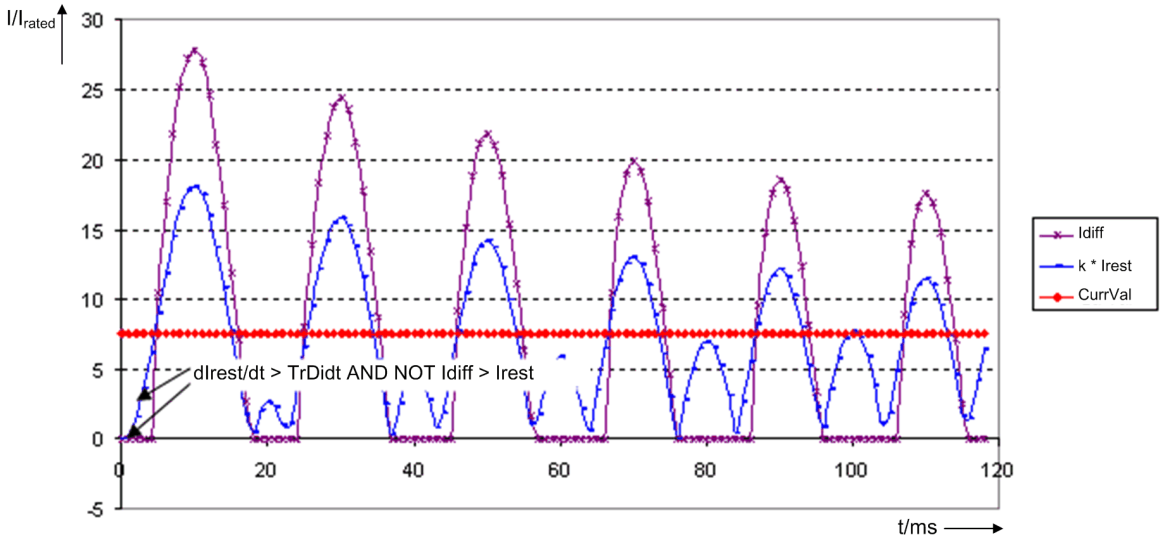
Figure 7-56 Characteristic Curve of Idiff fast

The 2 following figures show the behavior during an internal and an external fault. It is typical for the internal fault (*Figure 7-57*) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external fault, a differential current arises only after transformer saturation occurs. You can always assume, however, that the current is transferred a few milliseconds after occurrence of the fault. In accordance with *Figure 7-59*, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.



[dwinnfel-201112-01.tif, 1, en_US]

Figure 7-57 Curve Plot for Internal Fault with Transformer Saturation (k= 0.65)



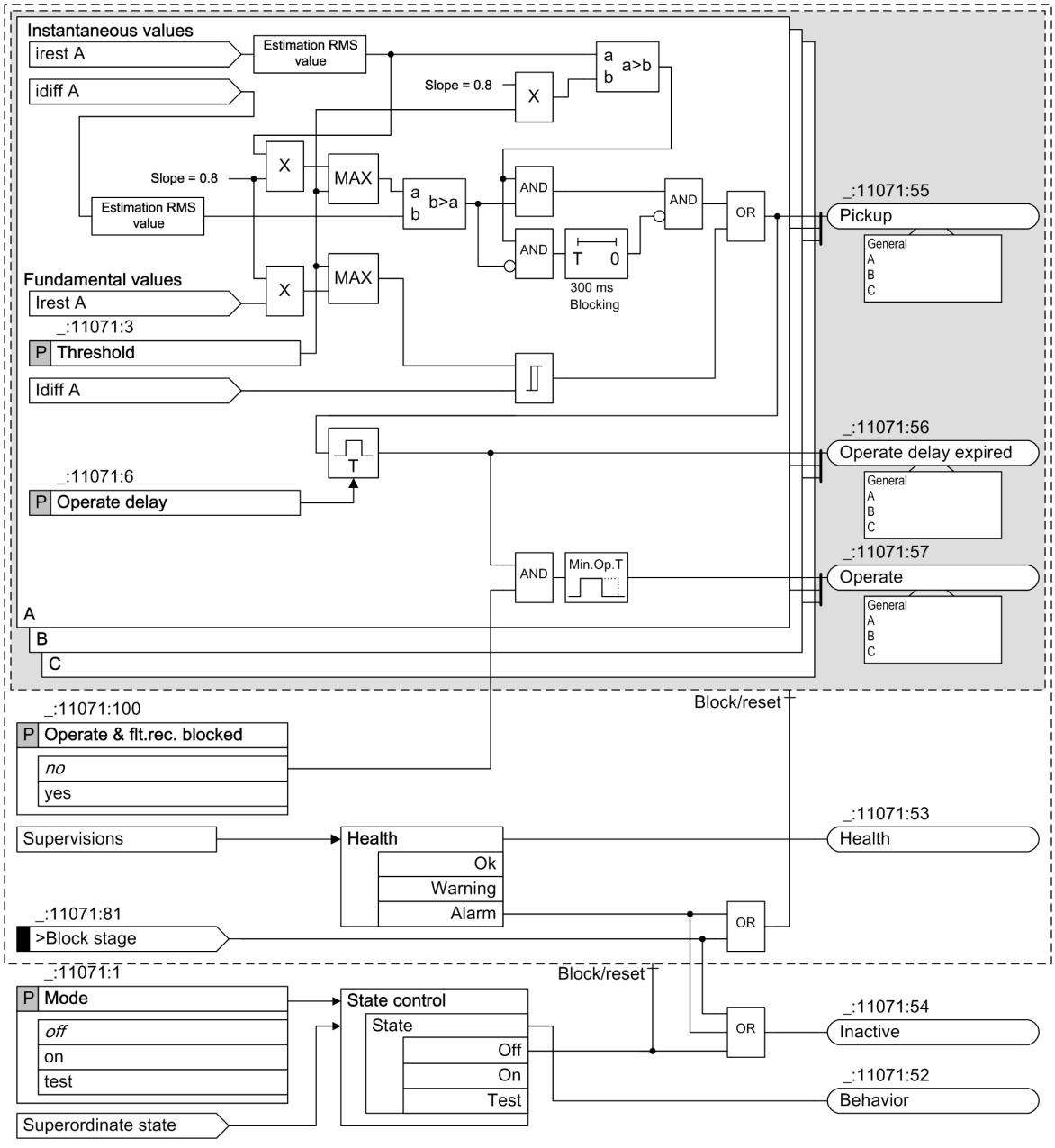
[dwextfel-170712-01.tif, 1, en_US]

Figure 7-58 Curve Plot for External Fault with Transformer Saturation (k= 0.65)

Fundamental-Component Method

Parallel to the instantaneous-value method, the fundamental-component method works with a temporal delay. Here, the same measured values are processed as with the Idiff method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) $I_{rest.}$ are ordered in the operate curve according to *Figure 7-56* and the trip decision is made.

Figure 7-59 shows the overall logic.

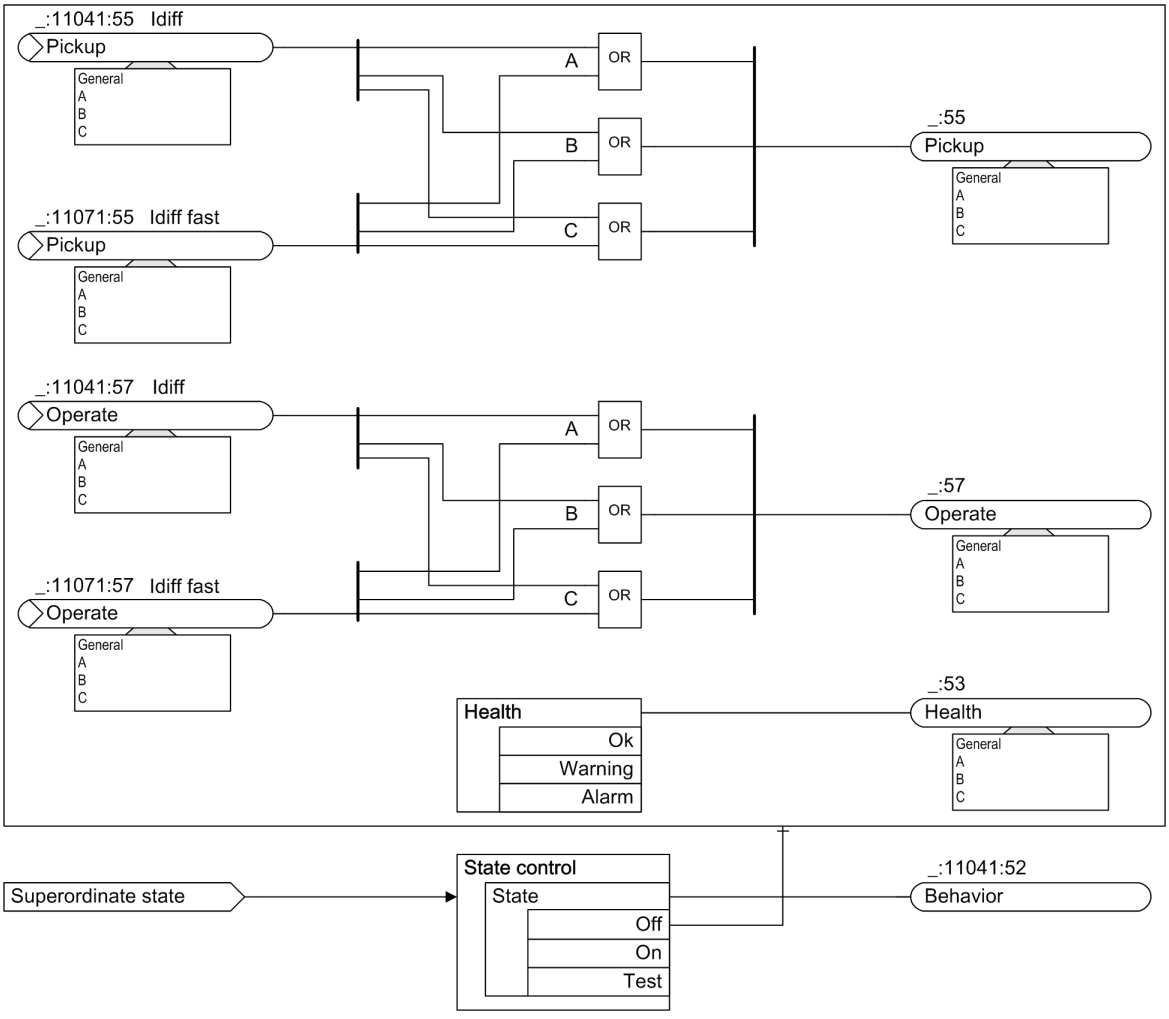


[loidfast-151012-01.tif, 2, en_US]

Figure 7-59 Logic of the Differential Protection Function Idiff Fast

Trip Logic of the Differential Protection

A common trip signal is formed from both subfunctions Idiff and Idiff fast. *Figure 7-60* shows the respective logic.



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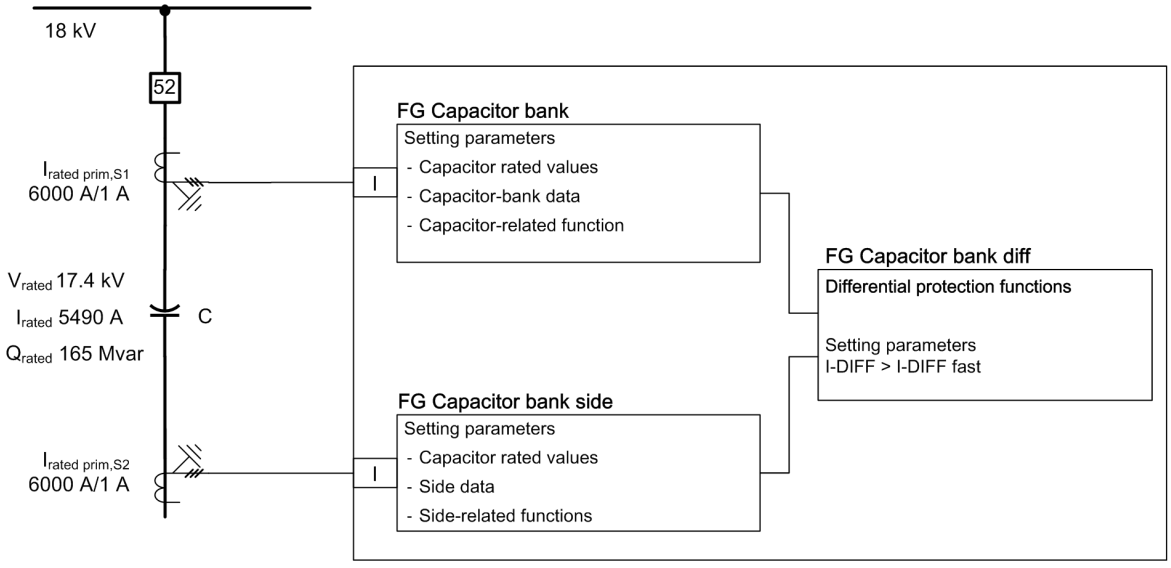
Figure 7-60 Overall Trip Logic

Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Saving of the fault record depends on the setting (see *3.4.3 Function Description*). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with external errors, along with the exceedance of the characteristic curve, a fault record is opened in case of a blocking by an external error or in case of a characteristic-curve increase through component recognition. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

7.8.4 Application and Setting Notes

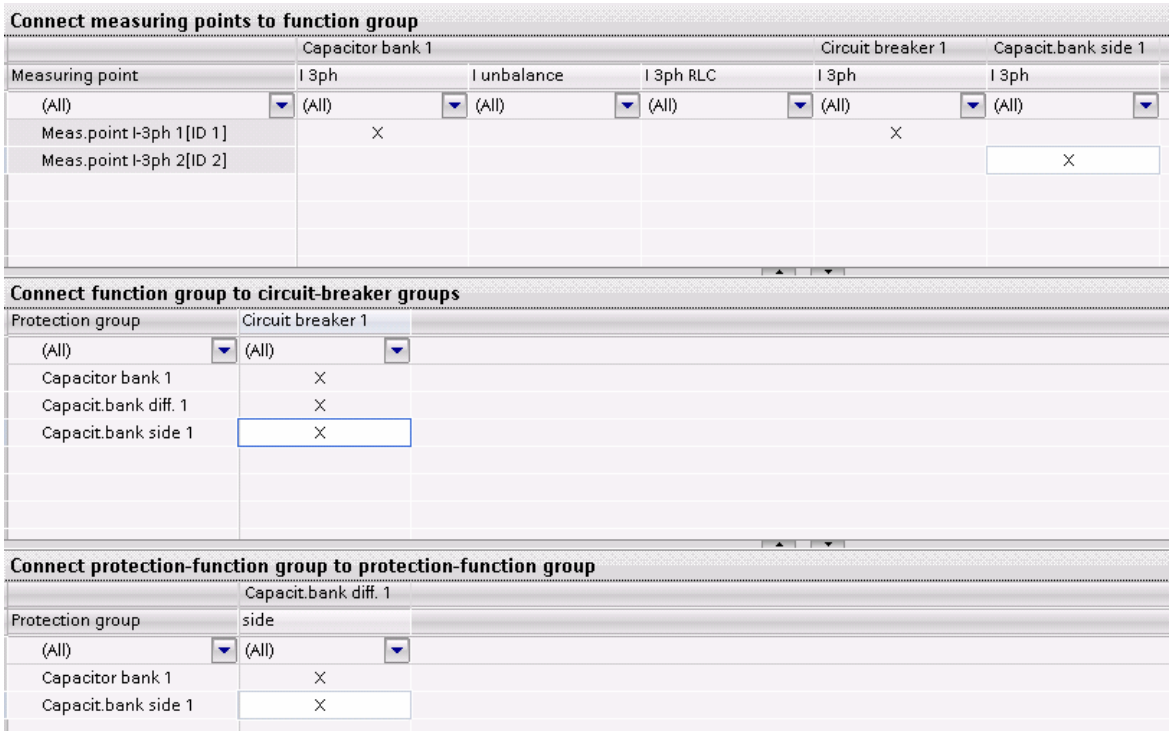
Figure 7-61 shows the application of a differential protection via a capacitor bank in a simplified way.



[dwanslbca-130514-01, 2, en_US]

Figure 7-61 Connection Example

The measuring points must be interconnected with the corresponding function groups.
Figure 7-62 shows the corresponding screenshot from DIGSI 5.



[sccapbak-130514-01, 1, en_US]

Figure 7-62 Internal Interconnection in DIGSI 5

Function Group Capacitor Bank

This chapter only refers to parameters that are important for the differential protection function application. You can find more information on further parameters in chapter *5.4.3 Application and Setting Notes* (**Capacitor bank** function group).

Parameter: **Capacitor reference curr.**

- Default setting **(_:14641:101) Capacitor reference curr.** = ***1000 A***

With the parameter **Capacitor reference curr.**, you set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and for setting values in percent.

For the Differential protection, these values are used for absolute-value correction (rated current of the protected object).

Depending on the application, you can use the capacitor-bank rated current including the harmonics or the capacitor-bank fundamental-component current as a reference value.

Function Group Capacitor Bank Side

Proceed with the following settings in the **Capacitor bank side** function group:

Parameter: **Capacitor reference curr.**

- Default setting **(_:1781:15571:101) Capacitor reference curr.** = ***1000 A***

With the parameter **Capacitor reference curr.**, you set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and for setting values in percent.

For the Differential protection, these values are used for absolute-value correction (rated current of the protected object).

If the capacitor bank is part of a delta connection, the value to be set here can differ from the capacitor reference current set in the **Capacitor bank** function group (by factor √3). Otherwise, set always the same values.

Depending on the application, you can use the capacitor-bank rated current including the harmonics or the capacitor-bank fundamental-component current as a reference value.

Parameter: **Capacitor reference volt.**

- Default setting **(_:1781:15571:102) Capacitor reference volt.** = ***400.00 kV***

With the parameter **Capacitor reference volt.**, you set the reference voltage of the capacitor bank to be protected. The reference voltage set here is the reference value for the percentage measured values and for setting values in percent.

Depending on the application, you can use the system rated voltage (busbar voltage) or the capacitor rated voltage as a reference value.

Parameter: **Neutral point**

- Default setting **(_:1781:15571:149) Neutral point** = ***isolated***

With the parameter **Neutral point**, you specify whether the neutral point in the protection range of the differential protection is ***grounded*** or ***isolated***. As this is not the case for the described application example, use the default setting ***isolated***.

You can find further information in the 7UT8 Device Manual in chapter 6.2.3 Function Description Neutral-Point Current Treatment .



NOTE

For the described application example, you do not need to change the parameters **Winding configuration** and **Vector group numeral**. If the capacitor bank is part of a delta connection, create the phase reference via the vector group.

You can find further information in the 7UT8 Device Manual in chapter 6.2.3 Function Description Vector-Group Correction .

Parameter: **Winding configuration**

- Default setting **(_:1781:15571:104) Winding configuration** = ***Y (Wye)***

With the parameter **Winding configuration**, you set ***D (Delta)*** for a delta connection. Another setting option is ***Y (Wye)*** for a star connection. The parameter **Winding configuration** is relevant for the differential protection function. You do not need to change this setting for the described application example.

Parameter: Vector group numeral

- Default setting **(_:1781:15571:100) Vector group numeral** = ***0***

This parameter is used to account for phase-angle rotation, which is expressed by a number.

Phase-angle rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Adaptation factor for the 3-phase measuring point (with reference to the side)

Each **Vector group numeral** from 0 to 11 can be set to the extent possible. Thus, for example, only even numbers are possible for the vector group Yy and Dd and only odd numbers are possible for Yd and Dy.

You do not need to change this setting for the described application example.

Function Group Capacitor Bank Diff

Proceed with the following settings in the **Capacitor bank Diff** function group for the IDiff function:

Parameter: Threshold (Setting of the Characteristic-Curve Parameters)

- Default setting **(_:11041:3) Threshold** = ***0.20 I/Irated,obj***

You set the pickup threshold for the differential current with this parameter. This is the total current flowing into the protection range during a short-circuit, regardless of how it is distributed on the sides of the protected object. The pickup value is relative to the rated current of the protected object. The default setting of ***0.20 I/Irated,obj*** is a practical value between sensitivity and possible disturbing influence.

Parameter: Intersection 1 Irest

- Default setting **(_:11041:101) Intersection 1 Irest** = ***0.67 I/Irated,obj***

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission errors of the current transformer even with small currents, half of the rated current is an appropriate setting value.

Parameter: Slope 1

- Default setting **(_:11041:100) Slope 1** = ***0.30***

With the **Slope 1**, you avoid an overfunction of the differential protection with low-current external faults as a consequence of current-transformer transmission errors (stationary and dynamic faults). The default setting of ***0.30*** is sufficient for many applications.

Parameter: Intersection 2 Irest

- Default setting **(_:11041:103) Intersection 2 Irest** = ***2.50 I/Irated,obj***



NOTE

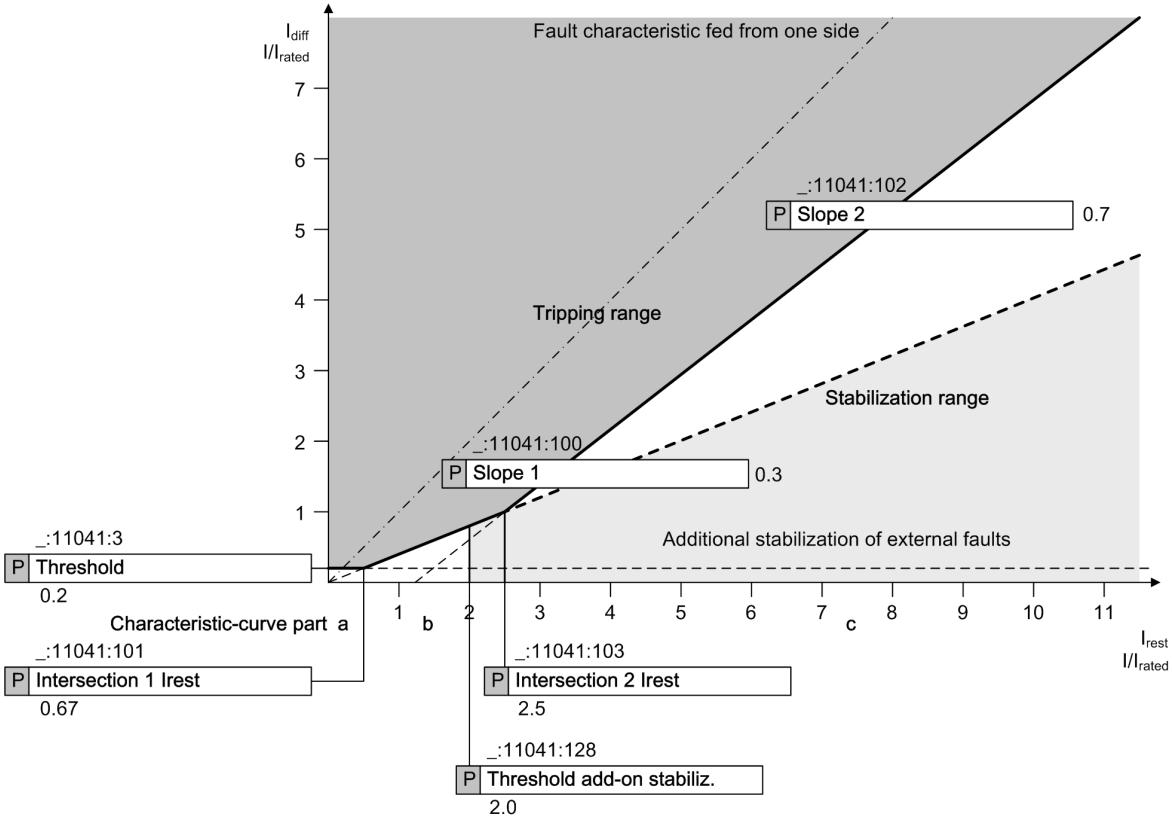
If you expect transmission problems for the current transformer in case of excessive current flows, set the **Slope 2** to a higher value.

The parameter **Intersection 2 Irest** determines from which restraint current the **Slope 2** begins. The default setting ***2.50 I/Irated,obj*** is a practical value.

Parameter: Slope 2

- Default setting **(_:11041:102) Slope 2** = ***0.70***

With the parameter **Slope 2**, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current-transformer transmission errors (for example, due to saturation). A value greater than or equal to double the value of **Slope 1** is practical. As the default setting, ***0.70*** was selected.



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Figure 7-63 Characteristic Curve with the Default Settings

Parameter: Starting detection

- Default setting **(_:11041:106) Starting detection** = ***yes***

To avoid an overfunction when switching on capacitor banks, you can set the parameter **Starting detection** = ***yes***. Siemens recommends the setting **Starting detection** = ***yes***.

Parameter: Thresh. startup detection

- Default setting **(_:11041:107) Thresh. startup detection** = ***0.1 I/Irated,Obj***

If the restraint current falls below this threshold value, the subsequently set characteristic-curve increase becomes effective with activated function. The default setting value of ***0.1 I/Irated,obj*** is recommended for the application.

Parameter: Factor increasing char.

- Default setting **(_:11041:108) Factor increasing char.** = ***2.0***

An increase to the value 2.0 has proven itself to be sufficient for many applications.

Parameter: Max. perm. Start. time

- Default setting **(_:11041:109) Max. perm. Start. time** = *5.0 s*

The setting value must lie above the maximum inrush time of the connected capacitor bank. To guarantee tripping through the capacitor-bank protection (inrush/starting time supervision) and avoid overfunctions, select a somewhat longer time (factor 1.2 or higher).

Parameter: Factor increasing char. DC (DC-Component Recognition)

- Default setting **(_:11041:110) Factor increasing char. DC** = *2.3*

The DC-component recognition is always active. As a result of the DC components, transmission problems can arise (for example, phase-angle rotations) in current transformers with small currents flowing. For this reason, the **Threshold** and the **Slope 1** are raised by the set factor. The default setting of 2.3 has proven itself with numerous applications.

Parameter: Blocking with 2. harmonic (Inrush-Current Detection)

- Default setting **(_:11041:115) Blocking with 2. harmonic** = *no*

The inrush-current detection is not necessary for capacitor-bank applications.

Parameter: 2nd harmonic content

- Default setting **(_:11041:116) 2nd harmonic content** = *15 %*

For many practical applications, the default setting value of *15 %* has proven useful. In exceptional cases, the setting value can be decreased with a small proportion of 2nd harmonic. Avoid a setting below 10 %, however. With an internal fault and current-transformer saturation, some proportion of 2nd harmonic also arises. A setting that is too sensitive leads to a blocking of the protection function.

Parameter: Crossblock. time 2nd har.

- Default setting **(_:11041:117) Crossblock. time 2nd har.** = *0.00 s*

Since the inrush currents develop differently in the 3 phases, the pickup value, for example, is not attained in a phase, but the differential current exceeds the characteristic curve. Corrective action creates a mutual blocking. If a time unequal to 0 s is set, the crossblock function works. If an overfunction arises, the setting cannot be made until commissioning takes place. Do not set the duration for an excessive amount of time. Practical values showed a setting between 3 and 5 periods.

Recognition of External Faults

In *Figure 7-63* the range **Additional stabilization with external fault** is represented. The range is described by the parameters **Threshold add-on stabiliz.** and **Slope 1**. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: Threshold add-on stabiliz.

- Default setting **(_:11041:128) Threshold add-on stabiliz.** = *2.00*

With the **Threshold add-on stabiliz.** parameter, you set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2.00 is practical. The additional stabilization range is limited by the parameters **Threshold add-on stabiliz.** and **Slope 1**.

Parameter: Time of add-on stabiliz.

- Default setting **(_:11041:129) Time of add-on stabiliz.** = *0.30 s*

You can use the operate time of the external feeder protection as an orientation for the setting value. Additionally, take into account the circuit-breaker opening time. Thus, the following calculation rule results:

$t_{Z\ rest.} \geq t_{off,ext\ protection} + t_{off,circuit\ breaker}$

The default value is a practical value. You must adapt the value according to the use case. The value 0 deactivates the recognition of external errors.

Parameter: **Cross-blk. time add-on st.**

- Default setting **(_:11041:130) Cross-blk. time add-on st.** = ***0.30 s***

The additional stabilization acts separately on each phase. However, it can be extended to block all phases. Siemens recommends the activation of the crossblock function by means of a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection Stage Idiff Fast

The task of this protection stage is the fast detection of high-current internal short circuits (see also *Differential Protection Function (Idiff Fast), Page 999*). For this reason, the protection stage must always be activated.

Parameter: **Threshold**

- Default setting **(_:11071:3) Threshold** = ***7.5 I/Irated,obj***

Siemens recommends setting the threshold value greater than or equal to the starting current.

7.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	no
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	2.0
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Inrush blocking				
_:11041:115	I-DIFF:Blocking with 2. harmonic		• no • yes	no
_:11041:116	I-DIFF:2nd harmonic content		10 % to 45 %	15 %

Addr.	Parameter	C	Setting Options	Default Setting
_:11041:117	I-DIFF:Crossblock. time 2nd har.		0.00 s to 200.00 s; ∞	0.00 s
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s; ∞	0.30 s
_:11041:130	I-DIFF:Cross-blk. time add-on st.		0.00 s to 2.00 s; ∞	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no

7.8.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
_:2311:317	General:Adapt. adjustm. inact.	SPS	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:304	I-DIFF:Blocked by inrush	SPS	O
_:11041:305	I-DIFF:Blocked by 2.Harmon.	ACT	O
_:11041:306	I-DIFF:Crossblock by 2.Harm.	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O

No.	Information	Data Class (Type)	Type
_:11041:316	I-DIFF:CWA int. fault detected	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

7.9 Detuning Supervision for Capacitor Banks

7.9.1 AC-Filter Detuning Supervision

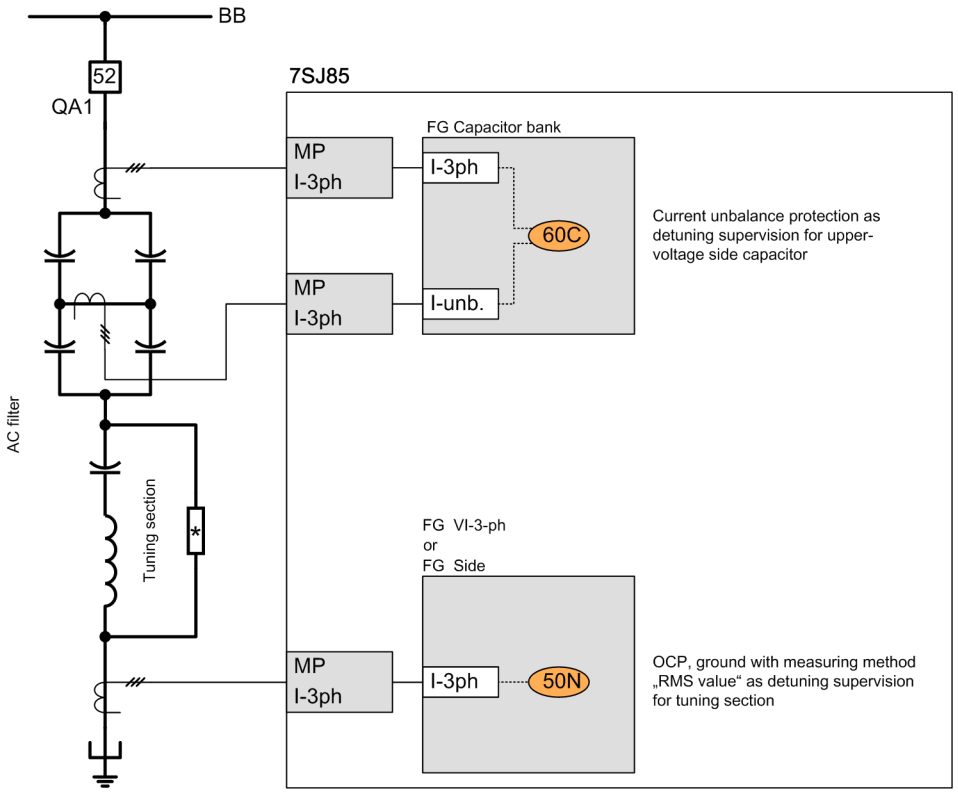
Tuned AC filters serve to provide reactive power and to absorb specific frequencies from the busbar. They usually consist of the upper-voltage side capacitor (for providing reactive power) and the tuning section (for tuning to the frequencies to be absorbed). The tuning section consists of primary C, L and, if required, R elements, refer also to *Figure 7-64*.

Under normal operation, the RLC characteristics of the filter – the impedances – are identical per phase. A change in the impedance of one phase indicates that the filter characteristic of this phase has changed. This situation (a detuned filter) is not wanted and shall be detected.

The primary elements of the AC filter shall be subject of regular maintenance intervals where the compliance with the tolerances of the rated values specified in the design need to be checked. For the detection of detuning between the maintenance intervals, the protection device can be applied. Detuning supervision for the upper-voltage side voltage capacitor can be achieved by applying the phase-selective **Current unbalance** function (ANSI 60C), especially by using the counter function.

A criterion for the supervision of the primary elements of the tuning section is the ground or zero-sequence current (3I0) of the AC filter. The fundamental phase current of the AC filter is determined by the phase capacitance of the upper-voltage side capacitor. Consequently, a difference in the phase capacitances of the upper-voltage side capacitor will cause a fundamental ground current. Therefore it is not sufficient for the tuning-section supervision to evaluate only the fundamental ground current. Under normal operation and symmetrical network conditions, the fundamental ground current will be **0**. An unbalance in the phase impedances (detuning) will cause a ground current. A detuning of the tuning section will mainly cause harmonics in the ground current. Thus, the RMS value of the ground current needs to be evaluated. For a detuning supervision of the tuning section, the function OCP, ground (ANSI 50N) with the measuring method **RMS value** is applied. This allows detecting harmonics up to the 50th harmonic with high precision (refer also to Technical data).

When selecting the settings (pickup value, operate delay and function mode) for the function OCP, ground (ANSI 50N) the present network connecting conditions must be considered! Otherwise short-term power-system unbalances (for example, 1-pole fast auto reclosing) or statically present harmonics in the zero-sequence system may cause an overfunction. Since the primary elements of the AC filter are directly or inherently protected by other protection functions and due to the possible influence of the network conditions on the function OCP, ground (ANSI 50N), this function should be configured only as alarm function and not as tripping function.



[dw_AC-Filter_detuning-supervision, 1, en_US]

Figure 7-64 Application Overview

8 Control Functions

8.1	Introduction	1016
8.2	Switching Devices	1019
8.3	Control Functionality	1046
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8.5	Switching Sequences	1106
8.6	User-Defined Function Block [Control]	1113
8.7	CFC-Chart Settings	1115
8.8	Transformer Tap Changers	1117
8.9	Voltage Controller	1128

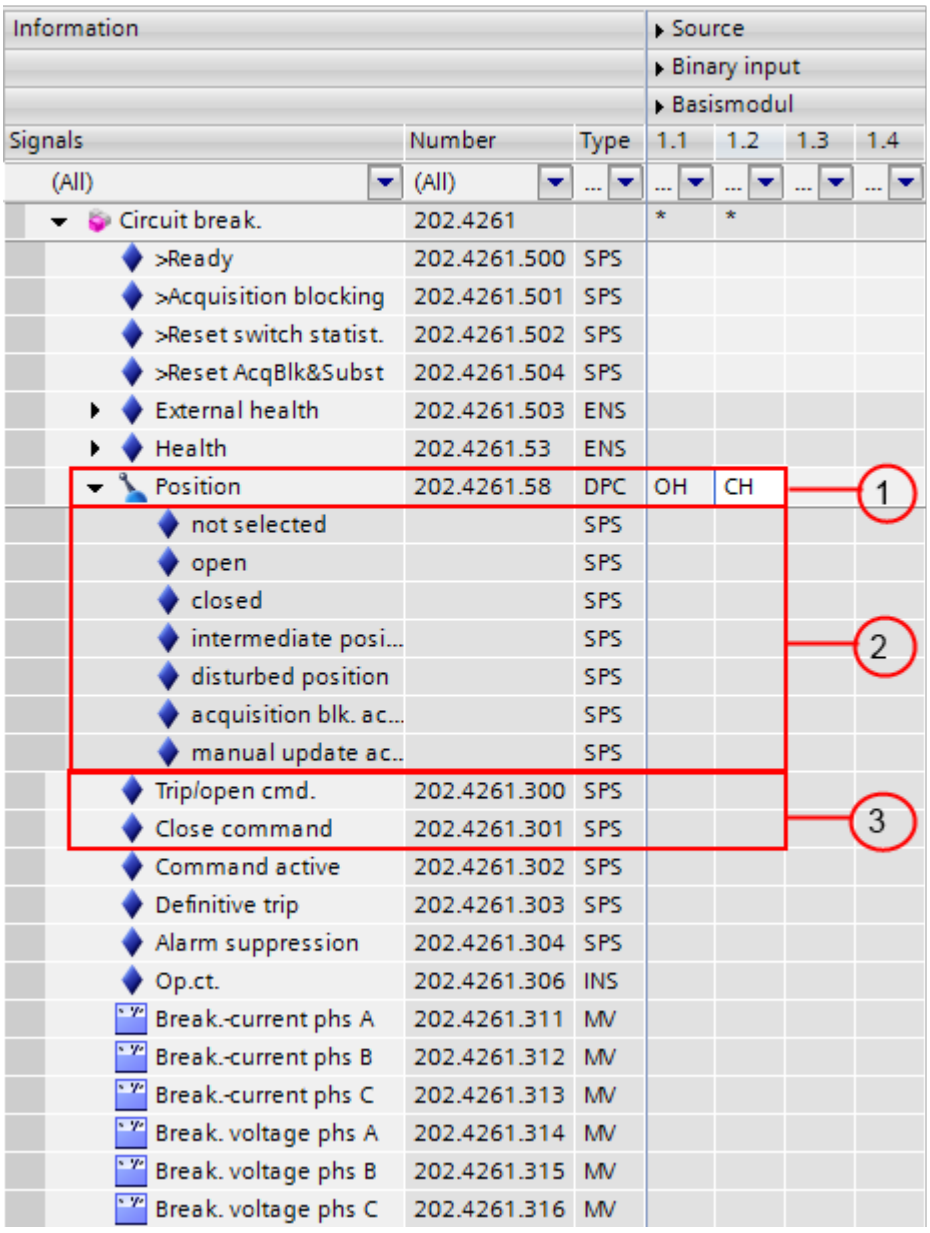
8.1 Introduction

8.1.1 Overview

The SIPROTEC 5 series of devices offers powerful command processing capability as well as additional functions that are needed when serving as bay controllers for the substation automation technology or when providing combi-protection. The object model for the devices is based on the IEC 61850 standard, making the SIPROTEC 5 series of devices ideally suited for use in systems employing the IEC 61850 communication protocol. In view of the function blocks necessary for the control functions, other logs are also used.

8.1.2 Concept of Controllables

The concept of so-called controllables is based on the data model described in IEC 61850. Controllables are objects that can be controlled, such as a switch with feedback. The model of a transformer tap changer , for example, contains controllables. The controllables are identifiable by their last letter **C** of the data type (for example, DPC = Double Point Controllable/Double Command with feedback or BSC = Binary-Controlled Step Position Indication / transformer tap command with feedback).



[sc_contrl, 1, en_US]

(1) Position (connect with binary inputs)
(2) Signalization of the current condition
(3) Command output (connect with relay)

The trip, opening and the close commands are connected to the relays. For the trip command, a choice between saved and unsaved output is possible. The position is connected with 2 binary inputs (double-point indication). In addition, signals are available that display the current state of the switch (**not selected**, **off**, **on**, **intermediate position**, **disturbed position**). These signals can be queried in CFC for example, in order to build interlocking conditions.

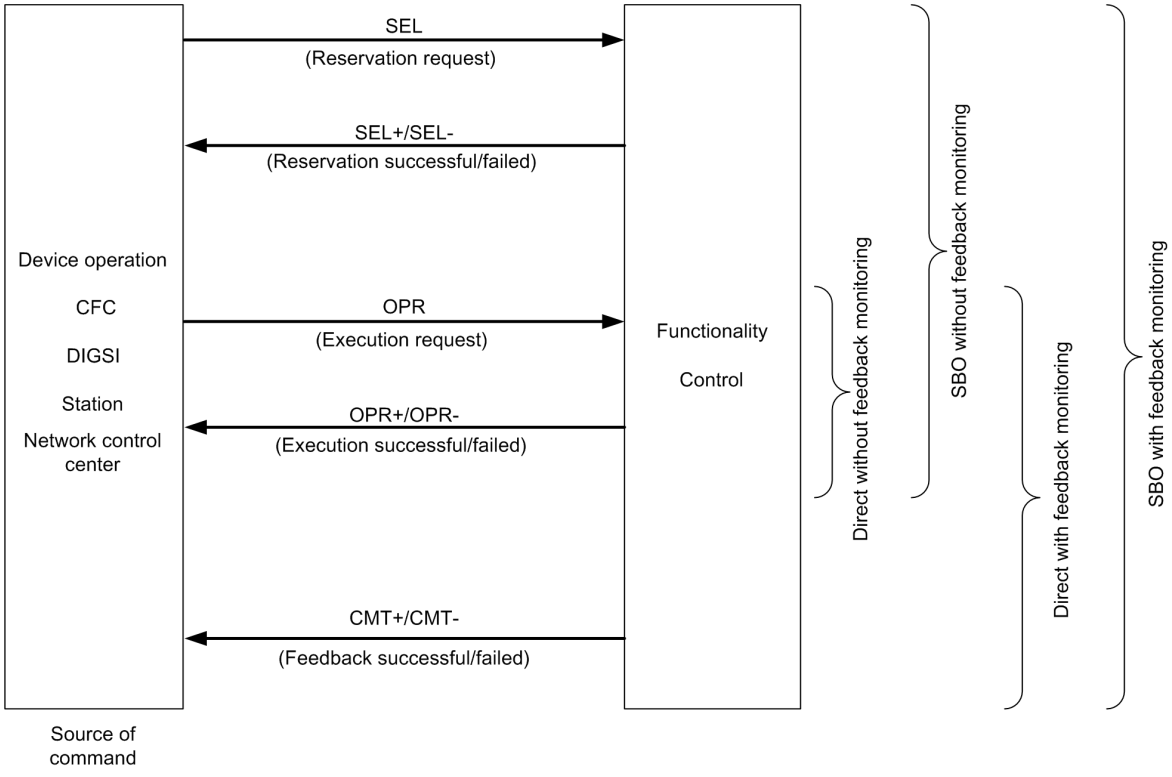
Control Models

You can set the operating mode of the controllables by selecting the control model.

4 different control models are available:

- Direct without feedback monitoring (**`direct w. normal secur.`**)
- With reservation (SBO)[19] without feedback monitoring (**`SBO w. normal secur.`**)
- Direct with feedback monitoring (**`direct w. enh. security`**)
- With SBO with feedback monitoring (**`SBO w. enh. security`**)

The next figure shows the command sources, command types, and control models.



[dwsteuer-190912-01.tif, 1, en_US]

Figure 8-1 Command Sources, Command Types and Control Models

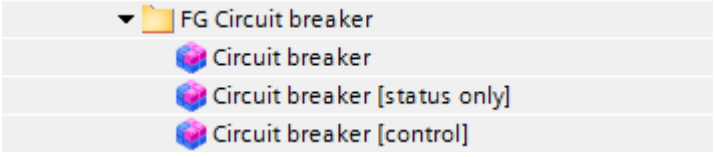
The figure shows the control models (right) with the respective control mechanisms (center). The standard control model for a switching command in an IEC 61850 compliant system is **SBO with feedback monitoring** (**`SBO w. enh. security`**). This control model is the default setting for newly created switching devices.

[19] SBO: Select Before Operate

8.2 Switching Devices

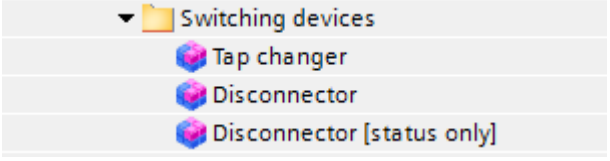
8.2.1 General Overview

The following switching devices can be found in the DIGSI 5 library in the **Circuit-breaker** and **Switching-devices** function groups (see the following images).



[sccbausw, 1, en_US]

Figure 8-2 Selecting the Circuit-Breaker Switching Device Using the DIGSI Circuit-Breaker Function Group Menu



[scswausw, 1, en_US]

Figure 8-3 Selecting the Remaining Switching Devices Using the DIGSI Switching-Devices Menu

8.2.2 Switching Device Circuit Breaker

8.2.2.1 Structure of the Circuit-Breaker Switching Device

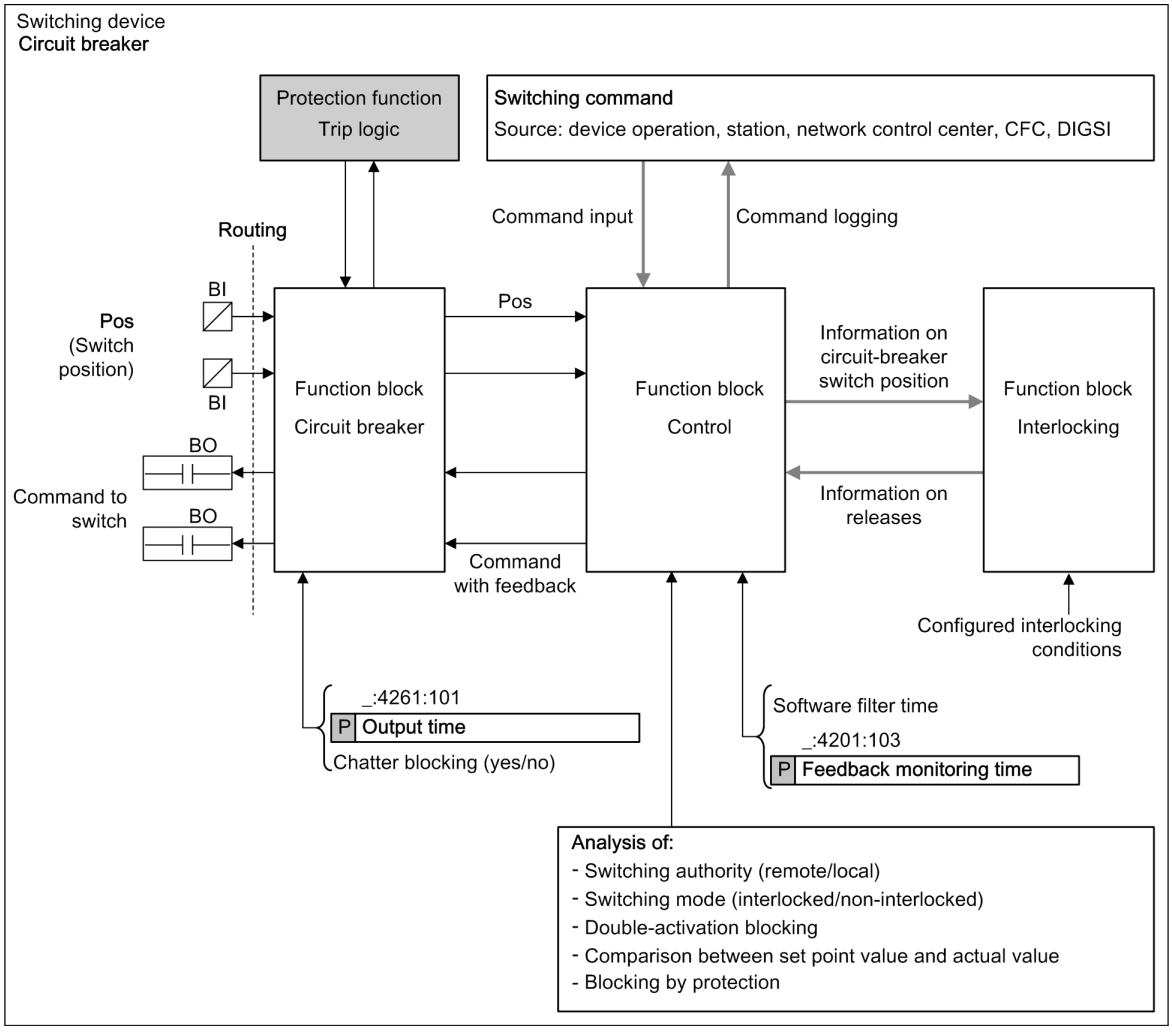
This chapter describes the control properties of the **Circuit breaker** switching device.

The **Circuit breaker** switching device contains the following function blocks that are needed for control:

- Function block **Circuit breaker**
- Function block **Control**
- Function block **Interlocking**

This corresponds to the logical nodes XCBR, CSWI, and CILO in IEC 61850.

In the case of protection devices or combined protection and control devices, additional functions can be contained in the **circuit breaker** switching device, for example, **synchrocheck**, the **automatic reclosing (AREC)**, the **trip logic** or **manual On function**. However, these are not relevant for the control function. The description of these functions is in the chapter Protection and Automatic Functions..



[dwbreake-220512-01.tif, 1, en_US]

Figure 8-4 Control Function Blocks of the Circuit-Breaker Switching Device

The circuit breaker in DIGSI 5 is linked with the binary inputs that acquire the switch position via information routing. The circuit breaker in DIGSI 5 is also linked with the binary outputs that issue the switching commands.

NOTE

When setting the parameters of a device, you will find 2 circuit-breaker types in the DIGSI 5 library:

- **3-pole circuit breaker** or **1-pole circuit breaker**, depending on the device type selected (3-pole or 1-pole tripping)
- **Circuit breaker (status only)**

Function Blocks of the Circuit Breaker

Table 8-1 Function Blocks of the Circuit-Breaker Function Group

Function Block	Description	Parameters	Function
Circuit breaker	The Circuit breaker function block in the SIPROTEC 5 device represents the physical switch.	**Output time**	The circuit breaker forms the switch position from the positions of the binary inputs and also outputs the command via the binary outputs.
Control	Command processing	**Control model** **SBO time-out** **Feedback monitoring time** **Check switching authority** **Check if pos. is reached** **Check double activat. blk.** **Check blk. by protection**	Command check, communication with the command source and with the function block **Circuit breaker**
Interlocking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The **Interlocking** functionality generates the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter *8.2.2.2 Application and Setting Notes*.

Additional Setting Options of the Circuit-Breaker Switching Element

The setting options of the circuit breaker are assigned to the function blocks on the basis of their relevance. Additional setting options of the circuit breakers that cannot be directly assigned to one of the 3 function blocks are nevertheless available:

Table 8-2 Setting Options of the Controllable **Command with Feedback** in the **Control** Function Block of the Circuit Breaker.

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the **Control**(1) function block
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the **Control**(1) function block
Message time before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the **Control**(1) function block
Suppress intermediate position (yes/no)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

Properties	Function	To Be Found in
Treatment of spontaneous position changes (Gen. software filt./Spont. software filt.)	If the ***General software filter*** setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting ***Spontaneous software filter***, a separate filtering is activated for spontaneous position changes.	Position of the **Control**(1) function block
Spontaneous software filtering time	Software filtering time for spontaneous position changes	Position of the **Control**(1) function block
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the **Control**(1) function block
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp in case of a spontaneous change	Position of the **Control**(1) function block
Inhibit intermediate position for a spontaneous chng. (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

(1) First click **Position** and then click the **Details** button in the **Properties** window (below).

Table 8-3 Setting Options of the Controllable **Position** in the Circuit Breaker Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the **Circuit breaker** (1) function block

(1) First click **Position** and then click the **Details** button in the **Properties** window (below).

Table 8-4 Additional Settings in the Device Settings having Effects on the Circuit Breaker

Properties	Function	To Be Found in
Number of permissible status changes	Chatter-blocking setting value: Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter idle time		
Chatter check time		

The inputs and outputs as well as the setting options of the **Circuit-breaker** and **Control** function blocks are described in the next section (see *8.2.2.3 Connection Variants of the Circuit Breaker*).

Interlocking

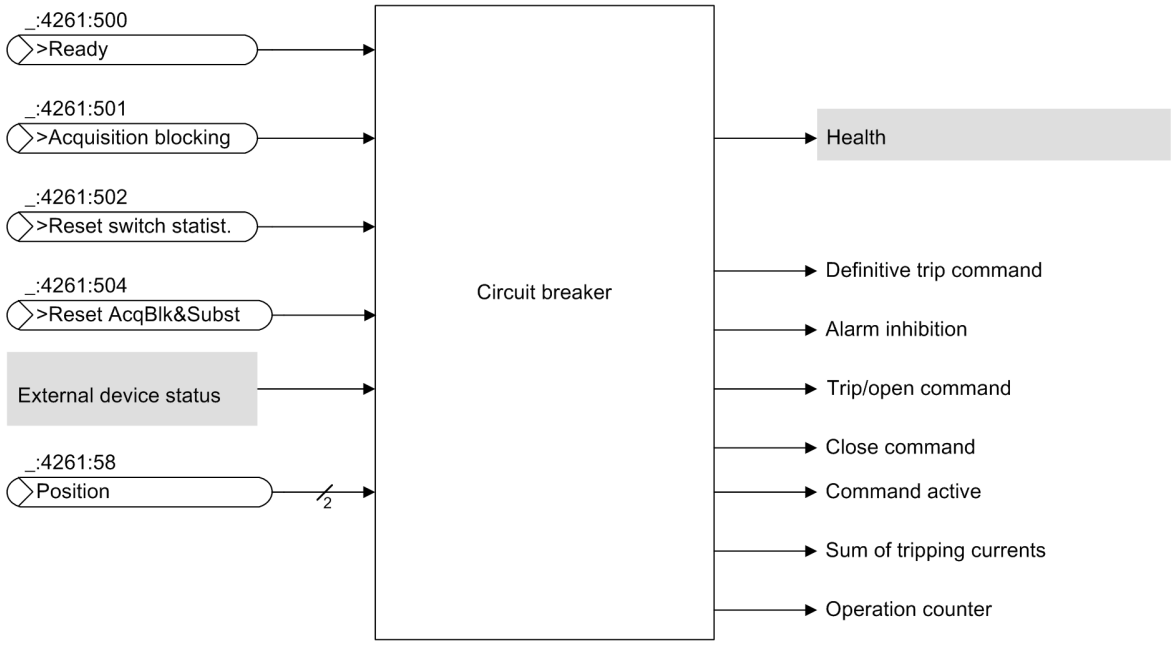
The **Interlocking** function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, see chapter *8.3.1 Command Checks and Switchgear Interlocking Protection*.

8.2.2.2 Application and Setting Notes

Circuit Breaker

The Circuit breaker function block in the SIPROTEC 5 device represents the physical switch device. The task of the circuit breaker is to replicate the switch position from the status of the binary inputs.

The following figure shows the logical inputs and outputs of the **Circuit-breaker** function block.



[dwfuncls-140212-01.tif, 2, en_US]

Figure 8-5 Logical Inputs and Outputs of the Circuit-Breaker Function Blocks

Table 8-5 and *Table 8-6* list the inputs and outputs with a description of their function and type. For inputs, the effect of **Quality = invalid** on the value of the signal is described.

EXAMPLE

If the signal **>Ready** has the **Quality = invalid**, then the value is set to **cleared**. In problematic operating states, the circuit breaker should signal that it is not ready for an **Off-On-Off cycle**.

Table 8-5 Inputs of the Circuit-Breaker Function Block

Signal Name	Description	Type	Default Value if Signal Quality = invalid
>Ready	The signal **>Ready** indicates that the OFF-ON-OFF cycle is possible with the circuit breaker. This signal is used for the AREC standby status.	SPS	Going
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting the acquisition blocking and the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	Among other things, the binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged

Signal Name	Description	Type	Default Value if Signal Quality = invalid
External health	The binary input **External health** reflects the circuit-breaker status (EHealth). This input will be set by the CFC using the BUILD_ENS block. In turn, BUILD_ENS can query binary inputs that represent the conditions ***OK***, ***Warning***, ***Alarm*** (as a result of the function **Trip-circuit supervision**).	ENS	Unchanged
Position	The signal **Position** can be used to read the circuit-breaker position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (EHealth) of the **Circuit-breaker** function block is set to *Warning*.

Table 8-6 Outputs of the Circuit-Breaker Function Block

Signal Name	Description	Type
Definitive trip	Protection has finally been tripped.	SPS
Alarm suppression	The signaling contact for external alarm suppression is suppressed during the runtime of automatic reclosing (optional) as well as during the command output of switching commands.	SPS
Op.ct.	The information counts the number of switching cycles of the circuit breaker.	INS
Trip/open cmd.	This logic output is responsible for the command output **Off**.	SPS
Close command	This logic output is responsible for the command output **On**.	SPS
Command active	The binary output **Command active** is responsible for signaling a running command (relay active or selected switching device (SEL)).	SPS
CB open hours	The statistic value counts the hours the circuit breaker is open.	INS
Operating hours	The statistic value counts the hours where at least one phase current is greater than the **Current thresh. CB open** parameter.	INS

Control

It is the task of the controls to execute command checks and establish communication between the command source and the circuit breaker. Using the control settings, you specify how the commands are to be processed.

Through the function SBO (Select Before Operate, reservation[20]) reserves the switching device prior to the actual switching operation, thus it remains locked for additional commands. Feedback monitoring provides information about the initiator of the command while the command is in process, that means, informing whether or not the command was implemented successfully. These two options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The control makes the following settings available (see next table).

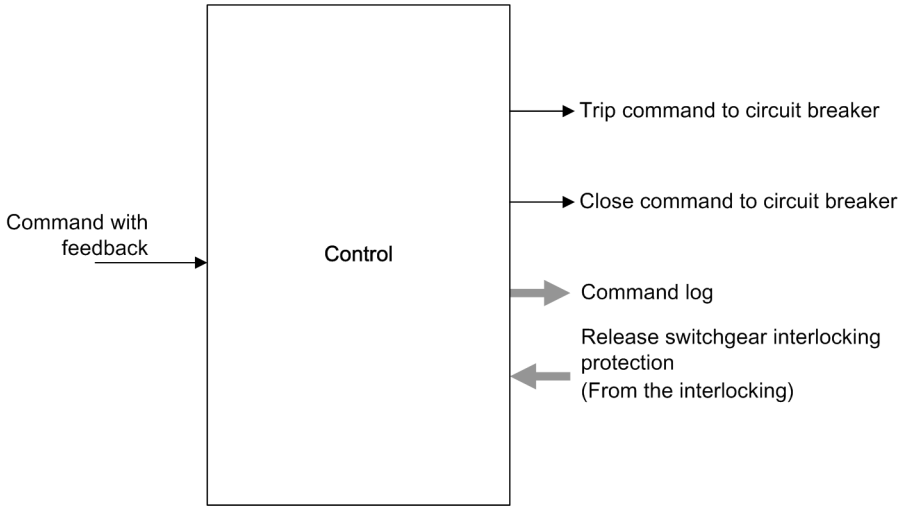
Parameters	Default Setting	Possible Parameter Values
(_:4201:101) Control model	***SBO w. enh. security***[21]	***direct w. normal secur.*** ***SBO w. normal secur.*** ***direct w. enh. security*** ***SBO w. enh. security***
(_:4201:102) SBO time-out	***30.00 s***	0.01 s to 1800 s (Increment: 0.01 s)
(_:4201:103) Feedback monitoring time	***1.00 s***	0.01 s to 1800 s (Increment: 0.01 s)

[20] In the IEC 61850 standard, reservation is described as **Select before Operate (SBO)**.

[21] This default setting is the standard control model for a switching command in an IEC 61850-compliant system.

Parameters	Default Setting	Possible Parameter Values
(_:4201:104) Check switching authority	*yes*	*no* *yes* *advanced*
(_:4201:105) Check if pos. is reached	*yes*	*no* *yes*
(_:4201:106) Check double activat. blk.	*yes*	*no* *yes*
(_:4201:107) Check blk. by protection	*yes*	*no* *yes*

The following figure shows the logical inputs and outputs of the **Control** function block.



[dwsteue1-100611-01.tif, 1, en_US]

Figure 8-6 Logical Inputs and Outputs of the Control Function Block

Table 8-7 Control Function Block Input and Output

Signal Name	Description	Type	Value if Signal Quality=Invalid
Cmd. with feedback	With the **Cmd. with feedback** signal, the circuit-breaker position is accepted via the double-point indication of the **Circuit breaker** function block and the command is submitted.	Controllable (DPC) Unchanged	Unchanged

In the information routing of DIGSI 5, you may select a function key as a possible command source. In addition, it is displayed here if the command is activated by CFC. The logging is routed here.

8.2.2.3 Connection Variants of the Circuit Breaker

For each switching device, you can establish the number of poles (for example, 1-pole, 1.5-pole or 2-pole) that are switched with or without feedback. This results in the necessary amount of information to be processed, thus establishing the command type.

Whether the circuit breaker is triggered 1-, 1.5-, or 2-phase, depends on the design of the auxiliary and control-voltage system. In most cases, the activation of the opening coil of the circuit breaker is 1-pole.

Table 8-8 Meaning of the Abbreviations of the Connection Variants

Abbreviation	Meaning of the Abbreviations of the Connection Variants
BO	Binary output

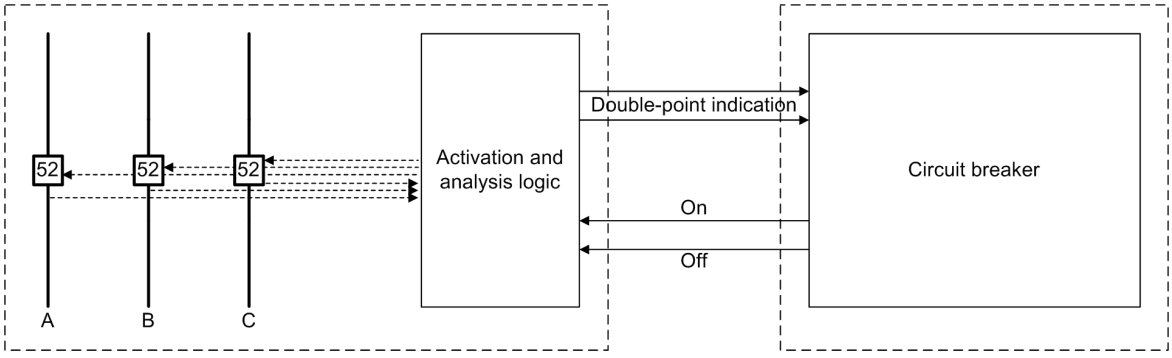
Abbreviation	Meaning of the Abbreviations of the Connection Variants
L+; L-	Control voltage
A	Trip command
Gnd	Close command

Table 8-9 Meaning of the Abbreviations in DIGSI

Abbreviation	Description of the Input in DIGSI
U	Unsaved trip command Click the right mouse button and enter **U**.
X	Close Command Click the right mouse button and enter **X** for the respective binary output.
OH	The switching-device feedback is in the position **OFF**, if there is voltage at the routed binary input (H). Click the right mouse button and enter **OH**.
OL	The switching-device feedback is in the position **OFF**, if there is no voltage at the routed binary input (L). Click the right mouse button and enter **OL**.
GH	The switching-device feedback is in the position **ON**, if there is voltage at the routed binary input (H). Click the right mouse button and enter **CH**.
CL	The switching-device feedback is in the position **ON**, if there is no voltage at the routed binary input (H). Click the right mouse button and enter **CL**.
TL	Trip command stored Click the right mouse button and enter **TL**.

Connection Variant: 3-Pole Circuit Breaker

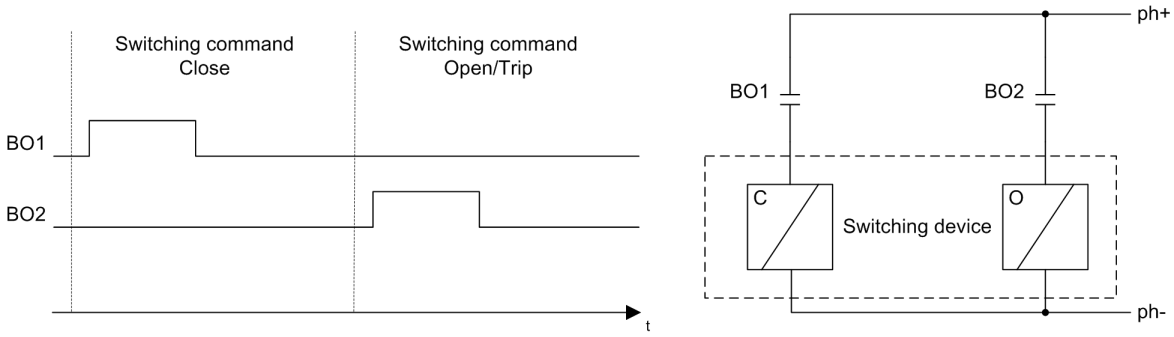
This is the standard type for the control function. All 3 individual poles of the circuit breaker are triggered together by a double command.



[dw3polls-070611-01.tif, 1, en_US]

Figure 8-7 3-Pole Circuit Breaker

1-Pole Triggering



[dw1polig-020211-01.tif, 1, en_US]

Figure 8-8 1-Pole Triggering

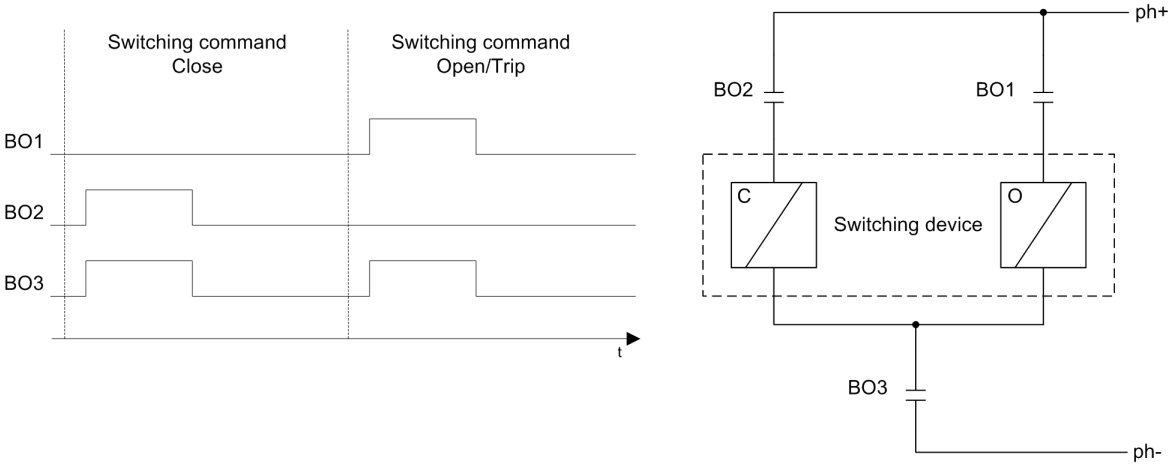
Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*			
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS			U			
Trip only pole A	301.4261.401	SPS						
Trip only pole B	301.4261.402	SPS						
Trip only pole C	301.4261.403	SPS						
Close command	301.4261.301	SPS		X				

[scrang1pLS1p, 1, en_US]

Figure 8-9 1-Pole Triggering, Routing in DIGSI

You can select the contacts for ***On*** and ***Off*** as desired. They need not necessarily be next to one another. The letter **U** represents an unlatched command. Alternatively, **TL** (latched tripping) may be selected.

1.5-Pole Triggering



[dw5polig-020211-01.tif, 1, en_US]

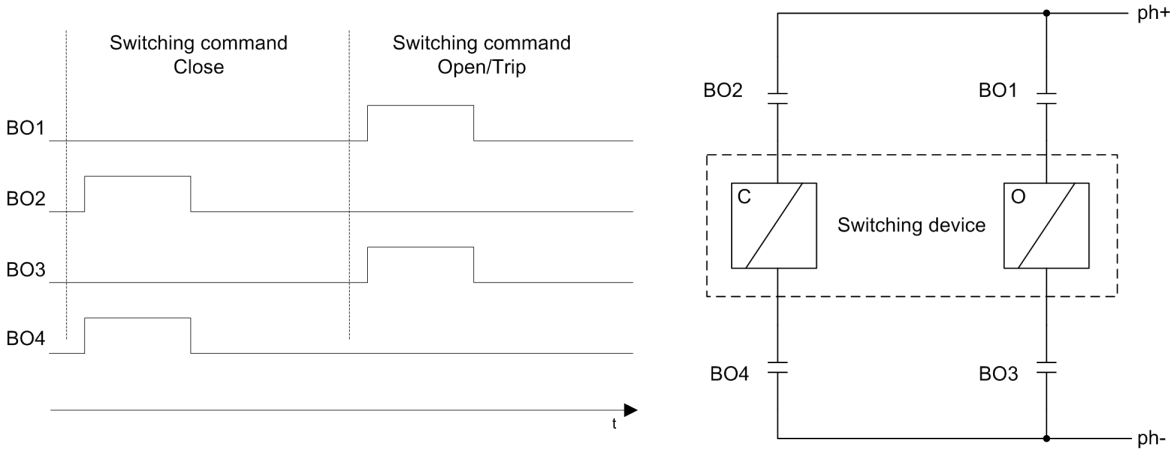
Figure 8-10 1.5-Pole Triggering

Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*	*		
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS		U		U		
Trip only pole A	301.4261.401	SPS						
Trip only pole B	301.4261.402	SPS						
Trip only pole C	301.4261.403	SPS						
Close command	301.4261.301	SPS			X	X		

[scrang1pLS15p, 1, en_US]

Figure 8-11 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw2polan-020211-01.tif, 1, en_US]

Figure 8-12 2-Pole Triggering

Information			Source								Destination			
			Binary input							CF	Binary output			
			Base module							Er	Base module			
Signals	Number	Type	1.1	1.2	1.3	1.4	2.1	2.2	2.3		1.1	1.2	1.3	1.4
(All)	(All)	...	...	...	...	...	...	...	...		...	...	...	...
Line 1	21													
Circuit breaker 1	301		*	*	*	*	*				*	*	*	*
Trip logic	301.5341													
Circuit break.	301.4261		*	*	*	*	*				*	*	*	*
>Ready	301.4261.500	SPS					H							
>Acquisition blocking	301.4261.501	SPS												
>Reset switch statist.	301.4261.502	SPS												
>Reset AcqBlk&Subst	301.4261.504	SPS												
External health	301.4261.503	ENS												
Health	301.4261.53	ENS												
Position 3-pole	301.4261.58	DPC	OH											
Position 1-pole phsA	301.4261.459	DPC		CH										
Position 1-pole phsB	301.4261.460	DPC			CH									
Position 1-pole phsC	301.4261.461	DPC				CH								
Trip/open cmd. 3-pole	301.4261.300	SPS									U	U	U	
Trip only pole A	301.4261.401	SPS									X			
Trip only pole B	301.4261.402	SPS										X		
Trip only pole C	301.4261.403	SPS											X	
Close command	301.4261.301	SPS												X
Command active	301.4261.302	SPS												

[scrang1pLS13p, 1, en_US]

Figure 8-13 2-Pole Triggering, Routing in DIGSI

Connection Variant: 1-Pole Circuit Breaker

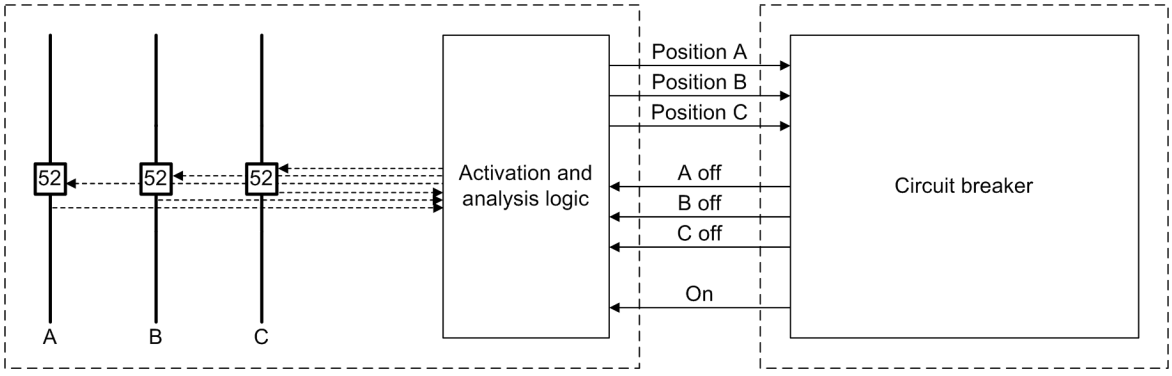
The 1-pole circuit breaker is used for separate activation and acquisition of the individual poles of a circuit breaker. It is intended for common use by 1-pole working protection and control functions.

NOTE

The wiring of the **Circuit-breaker** function group with binary inputs and binary outputs occurs once per device .

The control function in this type switches all 3 poles on or off simultaneously.

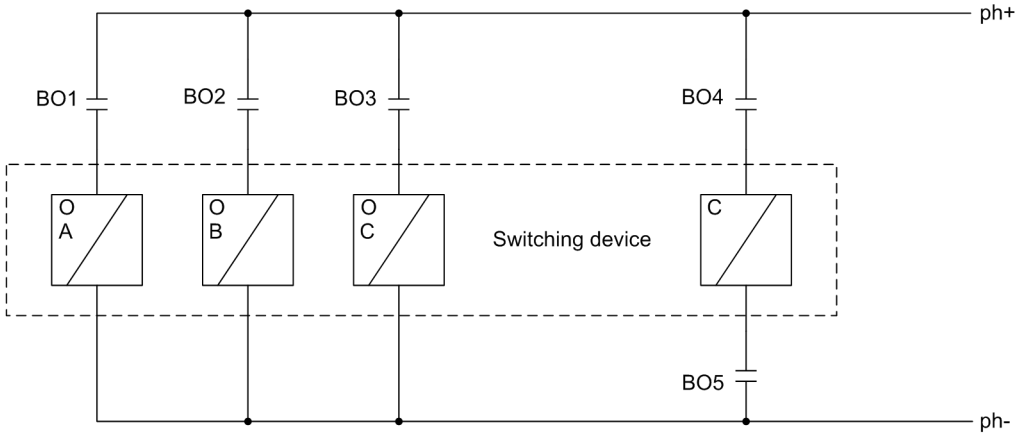
The protection functions can switch off 1-pole. The close command is always 3-pole. Optionally, only the open poles close.



[dw1polls-020211-01.tif, 1, en_US]

Figure 8-14 Circuit Breaker with 1-Pole Triggering

For the circuit breaker with 1-pole triggering, triggering takes place via one relay per phase for the trip command and via a 4th relay for the close command (see next figure).



[dw1panls-020211-01.tif, 1, en_US]

Figure 8-15 1-Pole Connection of a Circuit Breaker

Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*	*	*	*
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS		U	U	U		
Trip only pole A	301.4261.401	SPS		X				
Trip only pole B	301.4261.402	SPS			X			
Trip only pole C	301.4261.403	SPS				X		
Close command	301.4261.301	SPS					X	X

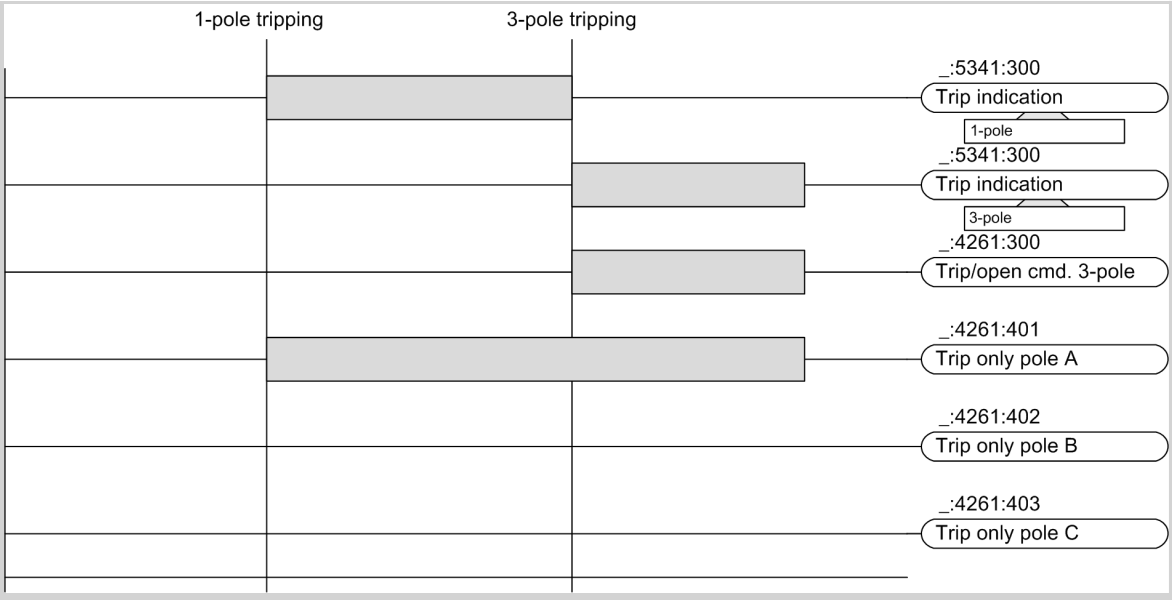
[scrang1pLS13pz, 1, en_US]

Figure 8-16 Routing in DIGSI

In the previous figure, the switch is connected 1-pole. The protection trip command is routed individually for the 3 phases (**`Trip only pole A`** to **`Trip only pole C`**). The protection trip command is routed for the 3 phases (**`Trip/open cmd. 3-pole`**). The control will always switch off the 3 poles of the switch. In addition, the 3 **U** (Unsaved) allocations of the activation and trip command are set to 3-pole. This routing is also used by protection functions that trip 3 poles. The close command is issued simultaneously for all 3 phases.

Example: Trip Command during Transition from 1-Pole to 3-Pole

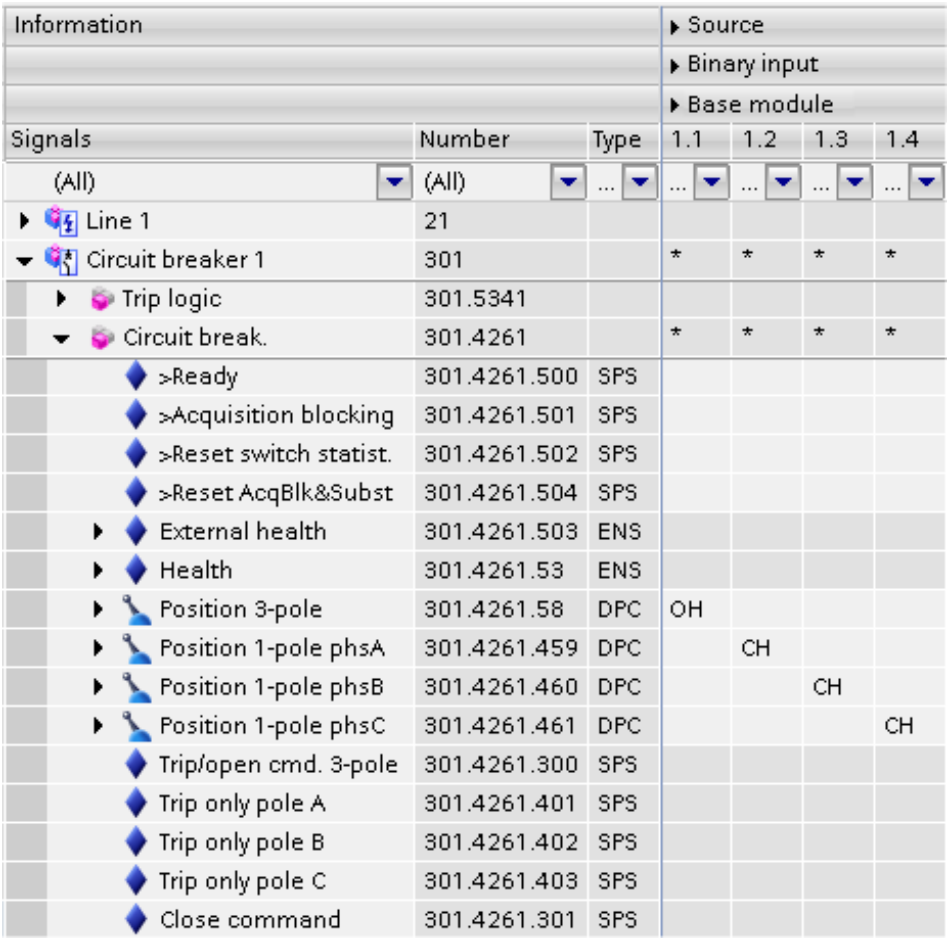
During a transition from 1-pole to 3-pole tripping, **`Trip only pole A`** remains active. To inform, for example, an external AREC whether it is a 1-pole or 3-pole trip, you can use the indications *`Trip logic:Trip indication:1-pole`* and *`Trip logic:Trip indication:3-pole`*.



[dw_trip-command_between_1p-3p, 1, en_US]

Acquisition of the Circuit-Breaker Position

The routing of the binary inputs for feedback of the switch position is done as shown in the previous figure (also see Chapter *5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).



Information			Source			
			Binary input			
			Base module			
Signals	Number	Type	1.1	1.2	1.3	1.4
(All)	(All)	...	...	...	...	...
Line 1	21					
Circuit breaker 1	301		*	*	*	*
Trip logic	301.5341					
Circuit break.	301.4261		*	*	*	*
>Ready	301.4261.500	SPS				
>Acquisition blocking	301.4261.501	SPS				
>Reset switch statist.	301.4261.502	SPS				
>Reset AcqBlk&Subst	301.4261.504	SPS				
External health	301.4261.503	ENS				
Health	301.4261.53	ENS				
Position 3-pole	301.4261.58	DPC	OH			
Position 1-pole phsA	301.4261.459	DPC		CH		
Position 1-pole phsB	301.4261.460	DPC			CH	
Position 1-pole phsC	301.4261.461	DPC				CH
Trip/open cmd. 3-pole	301.4261.300	SPS				
Trip only pole A	301.4261.401	SPS				
Trip only pole B	301.4261.402	SPS				
Trip only pole C	301.4261.403	SPS				
Close command	301.4261.301	SPS				

[scrang1pLSHk, 1, en_US]

Figure 8-17 Routing of the 1-Pole in DIGSI

The meaning of abbreviations can be found in *Table 8-8* and *Table 8-9* .

The indication **`Command active`** can also be routed to a binary output. This binary output is always active if either an On or trip command is pending, or the switching device was selected by the command control.

8.2.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:5341:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<
Circuit break.				
_:4261:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:4201:104	Control:Check switching authority		• no • yes • advanced	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
_:4201:107	Control:Check blk. by protection		• no • yes	yes
Switching authority				
_:4201:151	Control:Swi.dev. related sw.auth.		• 0 • 1	false
_:4201:152	Control:Specific sw. authorities		• 0 • 1	true
_:4201:115	Control:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:4201:153	Control:Num. of specific sw.auth.		2 to 5	2
_:4201:155	Control:Ident. sw.auth. 1		Freely editable text	
_:4201:156	Control:Ident. sw.auth. 2		Freely editable text	
_:4201:157	Control:Ident. sw.auth. 3		Freely editable text	
_:4201:158	Control:Ident. sw.auth. 4		Freely editable text	
_:4201:159	Control:Ident. sw.auth. 5		Freely editable text	
_:4201:154	Control:Multiple specific sw.auth.		• 0 • 1	false
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

8.2.2.5 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:5341:300	Trip logic:Trip indication	ACT	O
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch statist.	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position 3-pole	DPC	C
_:4261:459	Circuit break.:Position 1-pole phsA	DPC	C
_:4261:460	Circuit break.:Position 1-pole phsB	DPC	C
_:4261:461	Circuit break.:Position 1-pole phsC	DPC	C
_:4261:300	Circuit break.:Trip/open cmd. 3-pole	SPS	O
_:4261:401	Circuit break.:Trip only pole A	SPS	O
_:4261:402	Circuit break.:Trip only pole B	SPS	O
_:4261:403	Circuit break.:Trip only pole C	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:407	Circuit break.:Op.ct. A	INS	O
_:4261:408	Circuit break.:Op.ct. B	INS	O
_:4261:409	Circuit break.:Op.ct. C	INS	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	INS	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	BCR	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C	MV	O
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O
Control			
_:4201:53	Control:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:4201:58	Control:Cmd. with feedback	DPC	C
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:53	Interlocking:Health	ENS	O
CB test			
_:6151:53	CB test:Health	ENS	O
_:6151:301	CB test:Test execution	ENS	O
_:6151:302	CB test:Trip command issued	ENS	O
_:6151:303	CB test:Close command issued	ENS	O
_:6151:304	CB test:Test canceled	ENS	O
_:6151:311	CB test:3-pole open-close	SPC	C
_:6151:312	CB test:Pole A open-close	SPC	C
_:6151:313	CB test:Pole B open-close	SPC	C
_:6151:314	CB test:Pole C open-close	SPC	C

8.2.3 Disconnector Switching Device

8.2.3.1 Structure of the Disconnector Switching Device

Like the circuit breaker, the **Disconnector** switching device contains the following 3 function blocks:

- Function block **Disconnector**
- Function block **Control**
- Function block **Interlocking**

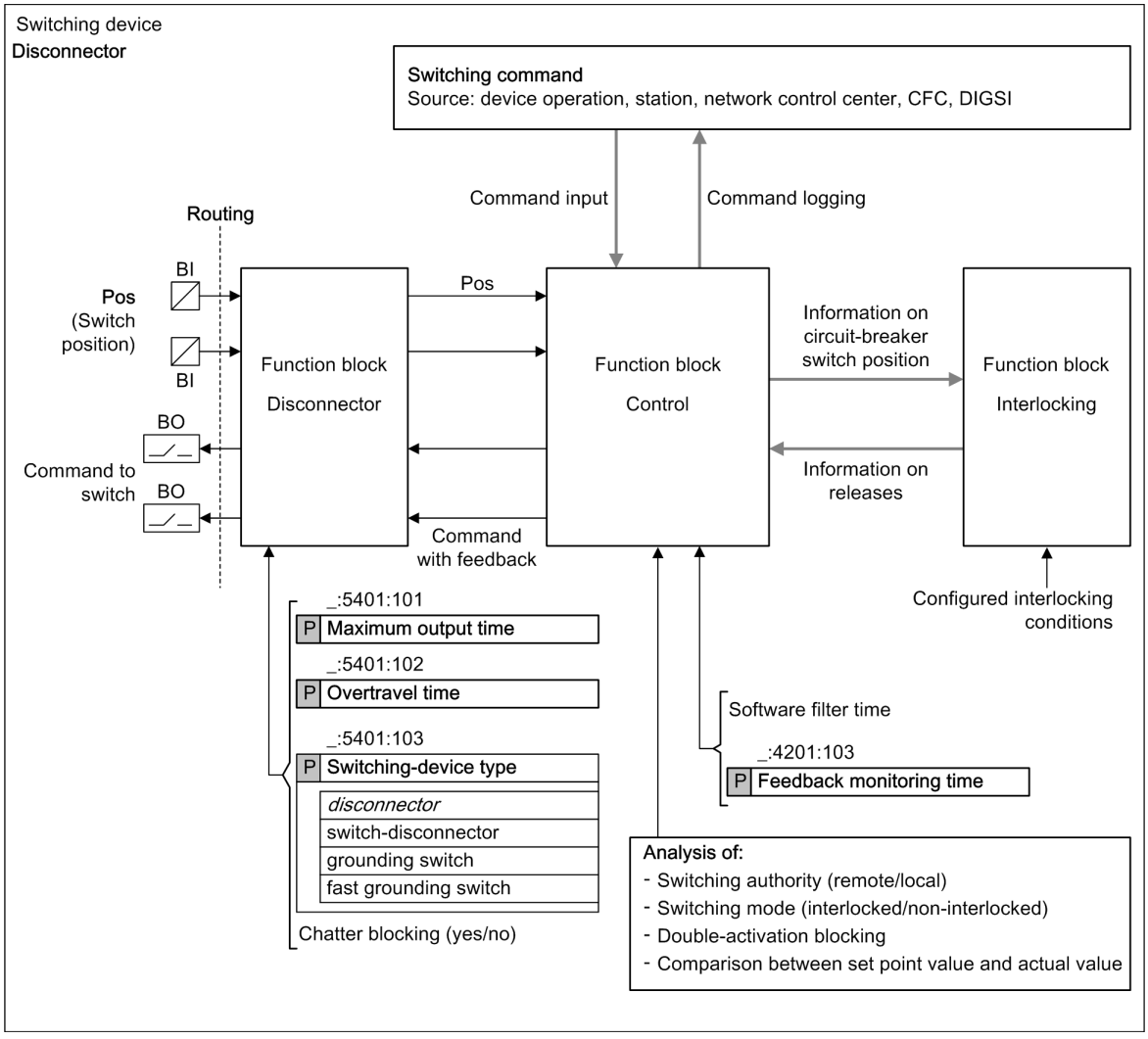
This corresponds to the logical nodes XSWI, CSWI und CILO in IEC 61850.



NOTE

In contrast to the **Circuit-breaker** switching device, the **Disconnector** switching device cannot contain any additional functions because protection functions or synchronization can have no effect on the disconnector.

The following figure shows the structure of the **Disconnector** switching element:



[dwdiscon-190612-01.tif, 1, en_US]

Figure 8-18 Control-Relevant Function Blocks of the Disconnector Switching Device

The **Disconnector** switching device behaves like the **Circuit-breaker** switching device. The only difference is the designation of the function block that the physical switch provides (disconnector instead of circuit breaker). Blocking by protection is not provided in the analysis of the **Control** function block.

The **Disconnector** switching device is available in the DIGSI 5 library in 2 different variants:

- **Disconnector with 3-pole connection**
  The device switches all 3 poles of the disconnector on or off simultaneously.
- **Disconnector without triggering (only status detection, no control)**
  This variant is rarely encountered. It is encountered with grounding switches that frequently cannot be controlled, but only provide their current position. In addition, the position of a disconnector in a neighboring bay can be acquired.

Function Blocks of the Disconnector

Table 8-10 Function Blocks of the Disconnector Function Group

Function Block	Description	Settings	Function
Discon-nector	The disconnector represents the physical switch in the SIPROTEC 5 device.	**Maximum output time** **Overtravel time** **Switching-device type**	The disconnector replicates the switch position from the status of the binary inputs and also transmits the command via the binary outputs.
Control	Command processing	**Control model** **SBO time-out** **Feedback monitoring time** **Check switching authority** **Check if pos. is reached** **Check double activat. blk.**	Command checks, communication with the command source and with the function block **disconnector**
Inter-locking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The **Interlocking** functionality generates the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter *8.2.3.2 Application and Setting Notes*.

Additional Settings of Disconnector Switching Element

The settings of the disconnector are assigned to the function blocks on the basis of their relevance. Additional disconnector settings that cannot be directly assigned to one of the 3 function blocks and are identical to the circuit-breaker settings are available:

Table 8-11 Setting positions of the Controllable **Command with Feedback** in the **Control** Function Block of the Circuit Breaker

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the **Control**(1) function block
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the **Control**(1) function block
Message time before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the **Control**(1) function block
Suppress intermediate position (yes/no)	When activated,only the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

Properties	Function	To Be Found in
Spontaneous position changes filtered by (Gen. software filt./Spont. software filt.	If the ***General software filter*** setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting ***Spontaneous software filter***, a separate filtering is activated for spontaneous position changes.	Position of the **Control**(1) function block
Spontaneous software filter time	Software filtering time for spontaneous position changes	Position of the **Control**(1) function block
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the **Control**(1) function block
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp in case of a spontaneous change	Position of the **Control**(1) function block
Spontaneous suppress intermediate position (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

(1) First click **Position** and then the **Details** key in the **Properties** window (below).

Table 8-12 Setting Options of the Controllable **Position** in the Disconnector Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the **Disconnector** (1) function block

(1) First click **Position** and then the **Details** key in the **Properties** window (below).

Table 8-13 Additional Settings in the Device Settings with effect on the Disconnector

Properties	Function	To Be Found in
Number of permissible state changes	Chatter-blocking setting value: Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter dead time		
Chatter test time		

The inputs and outputs as well as the setting options of the **Disconnector switch** function block are described in the next chapter (see *8.2.3.3 Trigger Variants of the Disconnector*. The **Control** function block is described identically as the **Circuit-breaker** function block, with the exception that the command check blocking is available through protection only with the circuit breaker.

More information on this is can be found in chapter *8.2.2.2 Application and Setting Notes*

Interlocking

The **Interlocking** function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, see section *8.3.1 Command Checks and Switchgear Interlocking Protection*.

8.2.3.2 Application and Setting Notes

Disconnector

The disconnector represents the physical switch in the SIPROTEC 5 device. The task of the disconnector is to replicate the switch position from the status of the binary inputs.

The **Disconnector** function block is linked automatically via the information matrix with the binary inputs that register the switch position and with the binary outputs that issue the switching commands.

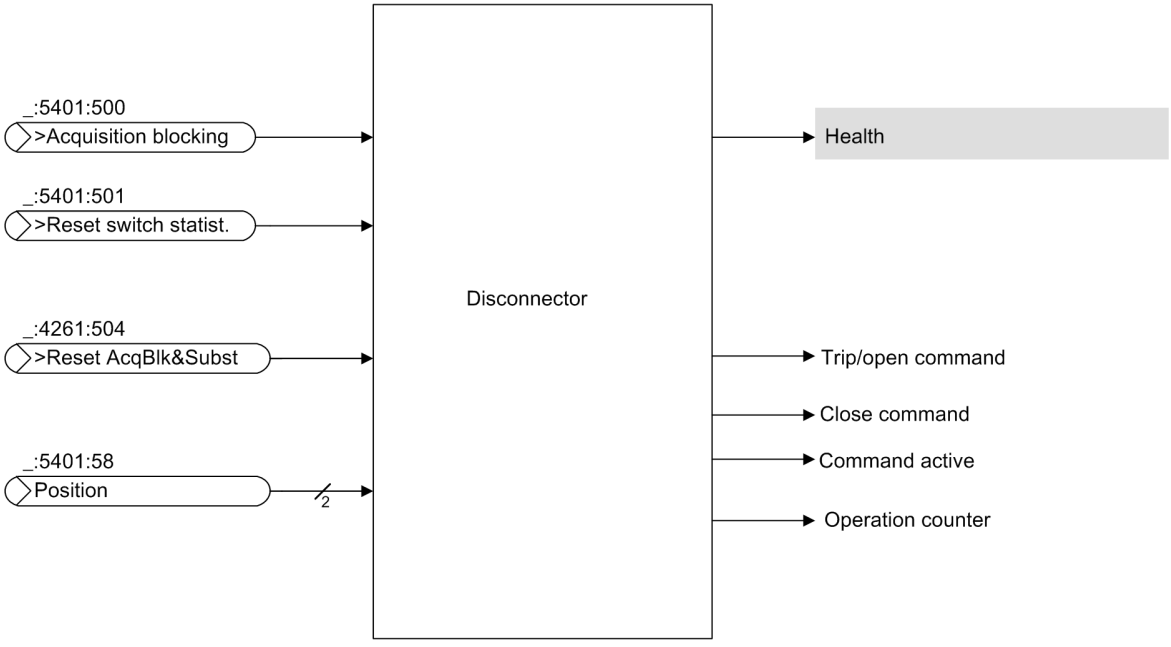
The **Disconnector** function block makes the following settings available (see next table).

Settings	Default Setting	Possible Parameter Values
(_:5401:101) Maximum output time	***10.00 s***	0.01 s to 1800 s (Increment: 0.01 s)
(_:5401:102) Overtravel time	***0.00 s***	0 s to 60 s
(_:5401:103) Switching-device type	***disconnector***	***switch-disconnector*** ***disconnector*** ***grounding switch*** ***fast grounding switch***

NOTE

The parameter **Switching-device type** is effective only on the IEC 61850 interface. This parameter is used to set the disconnector type for communication via an IEC 61850 interface. It is a mandatory data object in the IEC 61850 standard.

The following figure shows the logical inputs and outputs of the **Disconnector** function block.



[dwoutinp-150212-01.tif, 2, en_US]

Figure 8-19 Logical Inputs and Outputs of the Disconnector Function Block

Table 8-14 and *Table 8-15* list the inputs and outputs with a description of their function and type. For inputs, the effect on **Quality = invalid** on the value of the signal is described.

Table 8-14 Inputs of the Disconnector Function Block

Signal Name	Description	Type	Value if Signal Quality=Invalid
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting of the acquisition blocking and of the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	The binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged
Position	The binary input **Position** can be used to read the disconnector position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (Health) of the **Disconnector** function block is set to *warning*.

Table 8-15 Outputs of the Disconnector Function Block

Signal Name	Description	Type
Open command	This binary output is responsible for the command output **Off**.	SPS
Close command	This binary output is responsible for the command output **On**.	SPS
Command active	The binary output **Command active** is a running command for the signalization (command active or selected switching device). During Command active either an On or Off command is active.	SPS
Op.ct.	The information counts the number of disconnector switching cycles.	INS

Control

It is the task of the controls to execute command checks and establish communication between the command source and the disconnector. Using the control settings, you specify how the commands are to be processed.

Through the function SBO (Select Before Operate, reservation[22]) selects the switching device prior to the actual switching function, thus it remains locked for additional commands. Feedback monitoring provides information about the initiator of the command while the command is in process, that means, informing whether or not the command was implemented successfully. These two options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The control makes the following settings available (see next table).

Settings	Default Setting	Possible Parameter Values
(_:4201:101) Control model	***SBO w. enh. security***[23]	***direct w. normal secur.*** ***SBO w. normal secur.*** ***direct w. enh. security*** ***SBO w. enh. security***
(_:4201:102) SBO time-out	***30.00 s***	-
(_:4201:103) Feedback monitoring time	***10.00 s***	-

[22] in standard IEC 61850, Reservation is described as **Select before Operate (SBO)**.

[23] The default setting is the standard control model for a switching command in an IEC 61850-compliant system.

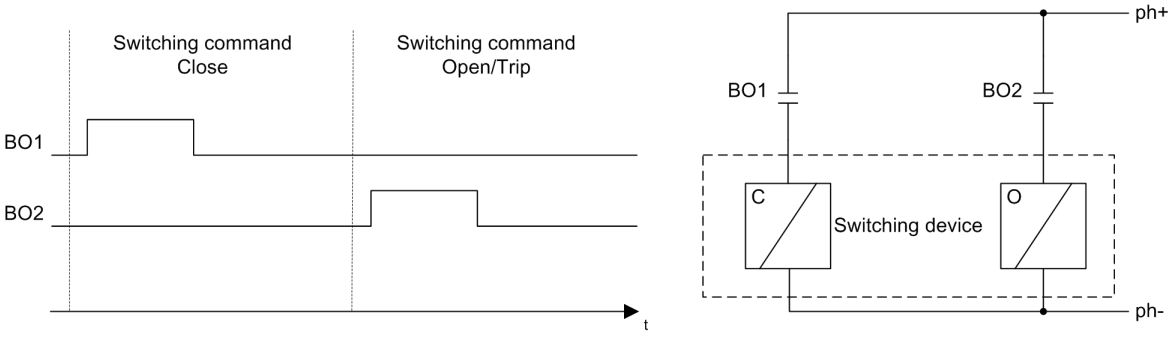
Settings	Default Setting	Possible Parameter Values
(_:4201:104) Check switching authority	*yes*	*no* *yes* *advanced*
(_:4201:105) Check if pos. is reached	*yes*	*no* *yes*
(_:4201:106) Check double activat. blk.	*yes*	*no* *yes*

8.2.3.3 Trigger Variants of the Disconnector

The activation types are identical to those for the circuit breaker. The meaning of abbreviations can be found in *8.2.2.3 Connection Variants of the Circuit Breaker* and *8.2.2.3 Connection Variants of the Circuit Breaker*.

Whether the disconnector is triggered for 1-, 1.5-, or 2-phases depends on the design of the auxiliary and control voltage system.

1-Pole Triggering



[dw1ptren-030211-01.tif, 1, en_US]

Figure 8-20 1-Pole Triggering

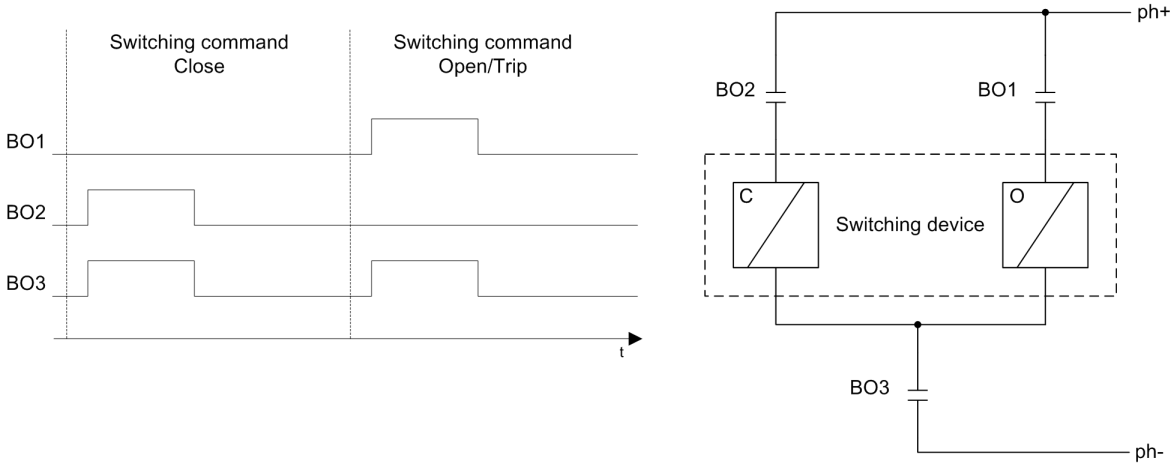
Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*		
Disconnector	601.5401			*	*		
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS			X		
Close command	601.5401.301	SPS		X			

[scrangtrenn1p, 1, en_US]

Figure 8-21 1-Pole Triggering, Routing in DIGSI

You can select the contacts for ***On*** and ***Off*** as desired. They need not necessarily be next to one another.

1.5-Pole Triggering



[dw5polig-020211-01.tif, 1, en_US]

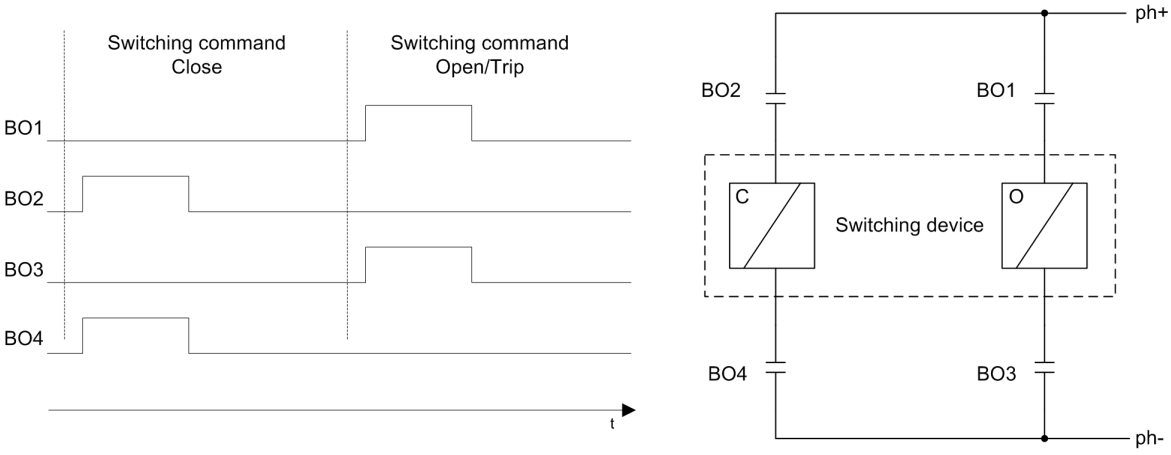
Figure 8-22 1.5-Pole Triggering

Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*	*	
Disconnector	601.5401			*	*	*	
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS		X		X	
Close command	601.5401.301	SPS			X	X	

[scrangtrenn15p, 1, en_US]

Figure 8-23 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw2polan-020211-01.tif, 1, en_US]

Figure 8-24 2-Pole Triggering

Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*	*	*
Disconnector	601.5401			*	*	*	*
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS		X		X	
Close command	601.5401.301	SPS			X		X

[scrangtrenn2p, 1, en_US]

Figure 8-25 2-Pole Triggering, Routing in DIGSI

The feedback is routed via the position with the disconnector.

8.2.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
_:4201:104	Control:Check switching authority		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
Disconnector				
_:5401:101	Disconnector:Maximum output time		0.01 s to 1800.00 s	10.00 s
_:5401:102	Disconnector:Overtravel time		0.00 s to 60.00 s	0.00 s
_:5401:103	Disconnector:Switching-device type		• switch-disconnector • disconnector • grounding switch • fast grounding switch	disconnector

8.2.3.5 Information List

No.	Information	Data Class (Type)	Type
Control			
_:4201:503	Control:>Sw. authority local	SPS	I
_:4201:504	Control:>Sw. authority remote	SPS	I
_:4201:505	Control:>Sw. mode interlocked	SPS	I
_:4201:506	Control:>Sw. mode non-interl.	SPS	I
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
_:4201:302	Control:Switching auth. station	SPC	C
_:4201:308	Control:Enable sw. auth. 1	SPC	C
_:4201:309	Control:Enable sw. auth. 2	SPC	C
_:4201:310	Control:Enable sw. auth. 3	SPC	C
_:4201:311	Control:Enable sw. auth. 4	SPC	C
_:4201:312	Control:Enable sw. auth. 5	SPC	C
_:4201:313	Control:Switching authority	ENS	O
_:4201:314	Control:Switching mode	ENS	O
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:53	Interlocking:Health	ENS	O
Disconnector			
_:5401:500	Disconnector:>Acquisition blocking	SPS	I
_:5401:501	Disconnector:>Reset switch statist.	SPS	I
_:5401:53	Disconnector:Health	ENS	O
_:5401:58	Disconnector:Position	DPC	C
_:5401:300	Disconnector:Open command	SPS	O
_:5401:301	Disconnector:Close command	SPS	O
_:5401:302	Disconnector:Command active	SPS	O
_:5401:305	Disconnector:Op.ct.	INS	O

8.3 Control Functionality

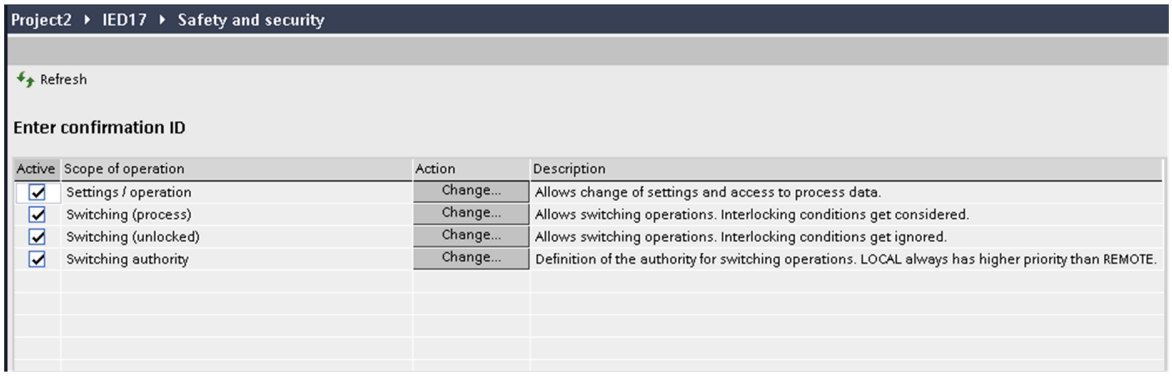
8.3.1 Command Checks and Switchgear Interlocking Protection

Before switching commands can be issued by the SIPROTEC 5 device, several steps are used to check the command:

- Switching mode (interlocked/non-interlocked)
- Switching authority (local/DIGSI/station/remote)
- Switching direction (set=actual)
- Bay interlocking and substation interlocking
- 1-out-of-n check (double-activation blocking)
- Blocking by protection function

Confirmation IDs

SIPROTEC 5 devices offer the ability to safeguard various operations with **confirmation IDs**. The following **confirmation IDs** from the **Safety** menu apply to the control functions:



[scconfir-291110-01.tif, 1, en_US]

Figure 8-26 Confirmation IDs in DIGSI 5: Settings Menu

The following table identifies the meanings of the confirmation IDs:

Table 8-16 Relevant Confirmation IDs for Controls

Confirmation ID	Meaning	Description
Set/operate	Changing settings	The confirmation ID is requested before device parameters can be changed.
Control (process)	General release for control of switching devices	The confirmation ID is usually not needed for bay controllers. In the case of protection devices, this confirmation ID can be used to safeguard control of switching devices.
Control (non-interlocked)	Switching non-interlocked	Switching mode: Release for switching without querying the interlocking conditions (***S1 operation***). The fixed interlocking conditions (for example, **>Enable opening (fixed)** and **>Enable closing (fixed)**) are still queried if this is set in the parameters. The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.

Confirmation ID	Meaning	Description
Switching Authority	Release for switching authority **Local**	The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.

The confirmation IDs are preset with the following values:

- Set/operate 222222
- Control (process, interlocked) 333333
- Control (not-interlocked) 444444
- Switching authority local 666666

If you have configured a device with key switches, the confirmation IDs for non-interlocked switching and switching authority are not displayed or editable in DIGSI; the function is handled by the position of the key switch.

To increase security, change these codes with DIGSI.

Switching Mode (Interlocked/Non-Interlocked)

The switching mode determines whether or not the switchgear interlocking that has been configured in the CFC is checked before the command is output.

You can change the switching mode with the key switch **S1** (interlocking off/normal). For devices without a key switch, you can change the switching mode with a corresponding menu item on the display (after entering a confirmation ID). You can also set the switching mode for switching commands from the sources DIGSI, station or remote.



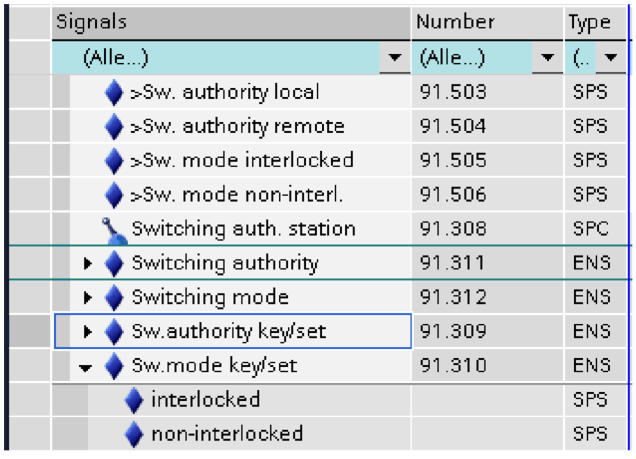
DANGER

If the switching mode = non-interlocked, the switchgear interlocking protection is shut off

Erroneous switching operations can lead to severe or fatal injuries.

✧ Ensure manually that all checks have been implemented.

In addition, you can set the switching mode directly with a binary input or CFC. Use the **General** function block (see next figure).



[scmoscha-260511-01.tif, 1, en_US]

Figure 8-27 Switching Mode in Function Block General

The following table shows the effects of changing the switching mode to use command checks.

Table 8-17 Relationship Between Switching Mode and Command Checks

Command Check	Switching Mode	
	Interlocked	Non-Interlocked
Switching authority	Checked	Checked
Switching direction (set=actual)	Checked	Checked
Fixed interlocking conditions	Checked	Checked
Interlocking conditions	Checked	Not checked
1-out-of-n check (double-activation blocking)	Checked	Not checked
Blocking by protection function	Checked	Not checked

Switching Authority

The switching authority determines which command source is allowed. The following command sources are possible:

- **Local**:

  A switching command from the local control (cause-of-error source **Location**) is possible only if the switching authority is set to **Local** and the device is capable of local operation. Setting the switching authority to **Local** is typically accomplished with key switch **S5** (Local/Remote). In this case, commands from all other sources are rejected. If the switching authority is set to **Local**, the setting cannot be changed **remotely**.

- **DIGSI**:

  A switching command from DIGSI (connected via USB or Ethernet, cause-of-error source **Maintenance**) is accepted only if the switching authority in the device is set to **Remote**. Once DIGSI has signed on the device for command output, no commands from other command sources or a different DIGSI PC will be executed.

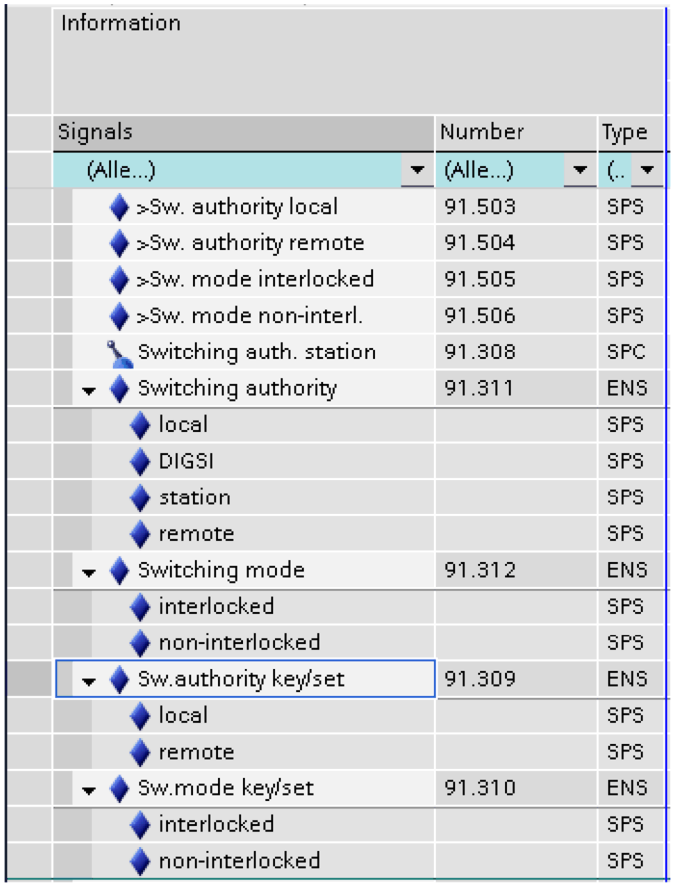
- **Station**:

  This switching authority level can be activated via a parameter in the **General** function block. A switching command from the station level (cause-of-error source **Station** or **Automatic station**) is accepted if the switching authority is set to **Remote** and the controllable **Station switching authority** is set. This is accomplished by a command from the substation automation technology. Switching commands from the device or from outside the station (cause-of-error source **Local**, **Remote** or **Automatic remote**) are rejected.

  Full support of the this switching authority level is assured only when using the IEC 61850 protocol.

- **Remote**:

  This switching authority level stands from remote control directly from the network control center or (if the switching authority level **Station** is not activated) generally for **Remote** control. The cause-of-error source is **Automatic remote**. Commands from this level are accepted if the switching authority is set to **Remote** and the controllable **Station switching authority** is not set. Switching commands from the device or from the station (cause-of-error source **Local**, **Station** or **Automatic station**) are rejected.



[schoheit-260511-01.tif, 1, en_US]

Figure 8-28 Display of Switching Authority and Switching Mode in Information Routing (in Function Block General)

Sw. authority key/set and **Sw.mode key/set** indicate the current state of the key switch or parameter for switching authority or switching mode and provide this information for further processing in the CFC. In the CFC, for example, it is possible to set up an automatic routine to ensure that the switching authority is automatically set to ***Local*** when the key switch is set to ***not interlocked***.

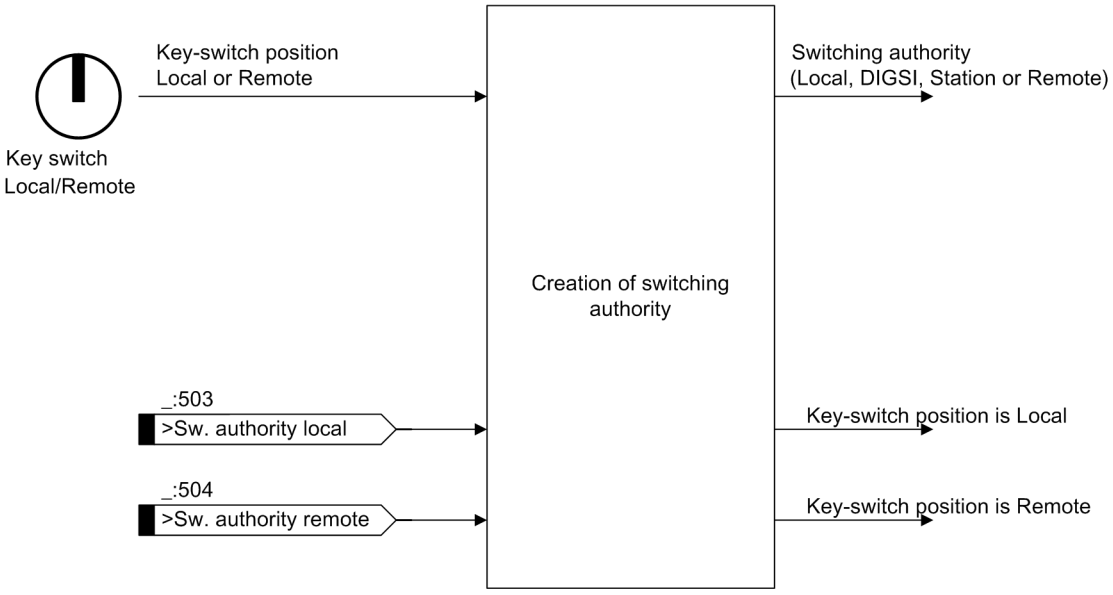
The following table shows the dependency of the switching mode on the key-switch position and the switching authority. In the case of switching commands from **Remote**, the information on whether a locked or non-interlocked switching should take place is also sent. For this reason, the position of the key switch is irrelevant for the switching mode in these cases. The information in the table assumes that, in the case of **remote** switching commands or those from the **station**, the switching mode is *interlocked* in each case.

Table 8-18 Dependency of the Switching Mode on the Key Switch Position and Switching Authority

	Switching Authority		
Key switch for switching mode	**Local**	**Remote**	**Station**
Interlocked	Interlocked	Interlocked	Interlocked
Non-Interlocked	Non-Interlocked	Interlocked	Interlocked

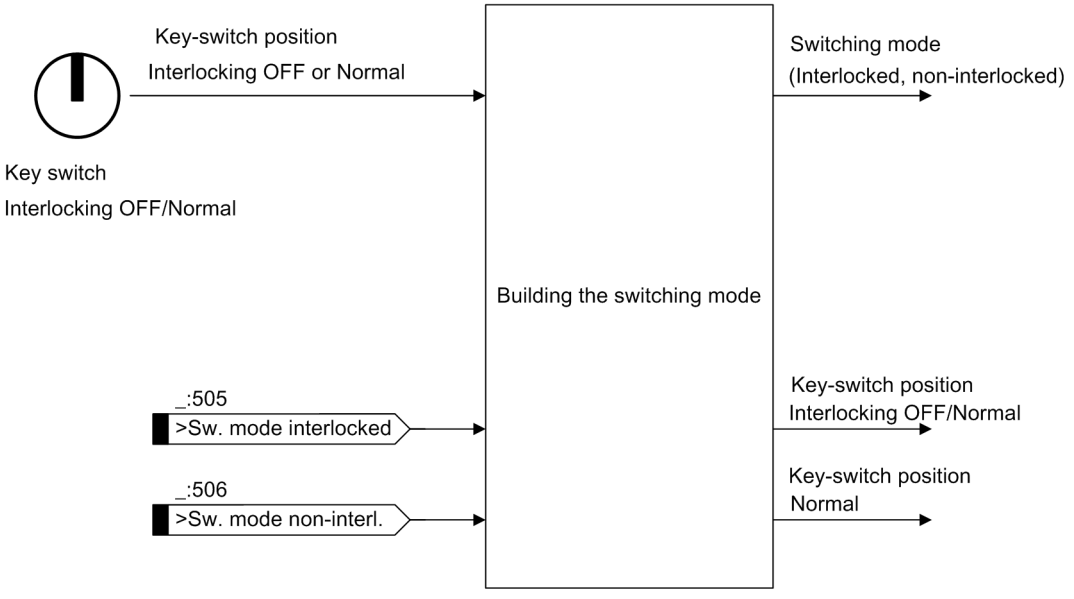
The signals shown in *Figure 8-28* in DIGSI 5 information routing have the following relationship:

- In terms of switching authority and switching mode, the respective key switch position serves as the input signal and the input signals in the matrix.
- The state of the switching authority and switching mode is indicated by corresponding output signals.
- The **Switching authority** and **Switching mode** functions link the input signals and in this way establish the output signals (see *Figure 8-29* and *Figure 8-30*).



[dwhoheit-260511-01.tif, 1, en_US]

Figure 8-29 Establishing Switching Authority



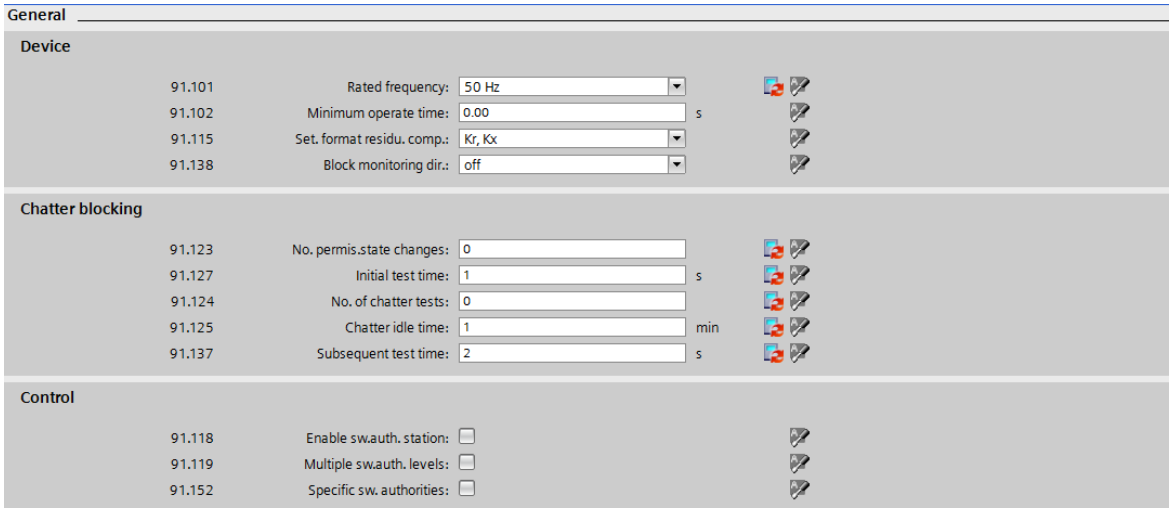
[dwmodsch-020513-01.tif, 1, en_US]

Figure 8-30 Establishing Switching Mode

In the case of both functions, the input signals overwrite the state of the key switch. This allows external inputs to also set the switching authority or switching mode, if desired (for instance, by querying an external key switch).

The following additional settings are available for the switching authority:

- **`Activation of Switching Authority Station`** (defined in IEC 61850 Edition 2):
  If you would like to use this switching authority, set the check mark **General/Control**.
- **`Multiple Switching Authority Levels`**:
  This option permits switching commands from several command sources in the device if the switching authority **Remote** is selected. Subsequently, a distinction between these command sources can also be made. You can find more details in the following table. Activate this option by setting the check mark **General/Control**.
- **`Specific sw. authorities`**:
  You can enable additional options for the switching authority check. You can find more information about these options in chapter *Specific Switching Authority, Page 1052*. By default, these are not used.



[scakthoh-161014, 1, en_US]

Figure 8-31 How to Activate the Station Switching Authority and to Enable Several Switching-Authority Levels

Table 8-19 Effect on Switching Authority when Several Switching-Authority Levels Are Enabled with/without Activation of the Station Switching Authority

Release Several Switching Authority Levels	Switching Authority in the Device	Status of DIGSI in the Device	Station Switching Authority Activated	State of the Station Switching Authority	Resulting Switching Authority
No	Local	-	-	-	Local
	Remote	Signed on	-	-	DIGSI
		Not signed on	No	-	Station and Remote
			Yes	Set	Station
				Not set	Remote
Yes	Local	-	-	-	Local
	Remote	Signed on	-	-	DIGSI
		Not signed on	No	-	Local and station and remote
			Yes	Set	Local and station
				Not set	Local and station and remote

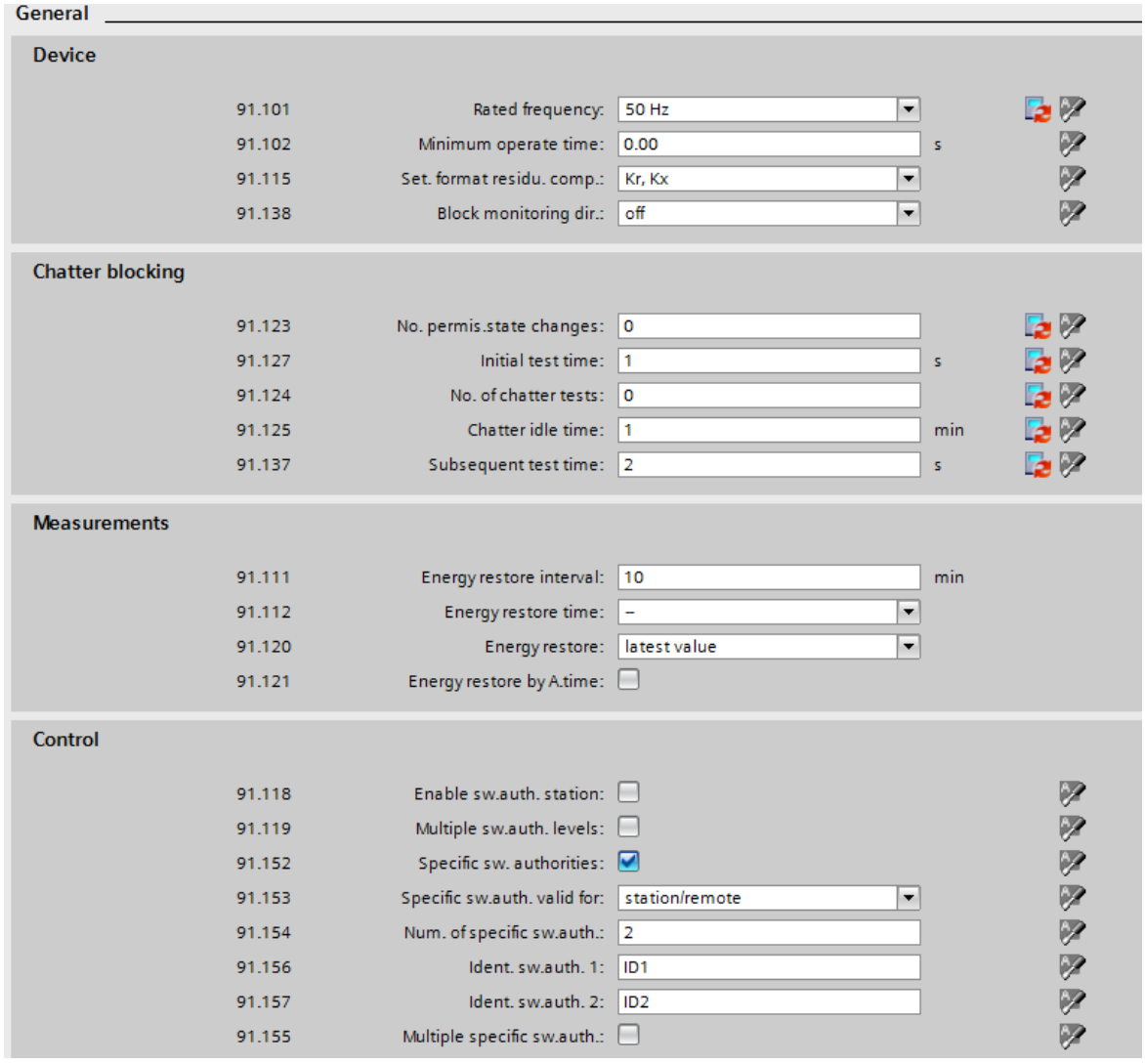
The following table shows the result of the switching-authority check, based on the set switching authority and the cause of the command. This overview represents a simplified normal case (no multiple command sources when using Station and Remote).

Table 8-20 Result of a Switching-Authority Check

Cause Source	Switching Authority			
	Local	**DIGSI**	**Station**	**Remote**
Local	Release	Blocked	Blocked	Blocked
Station	Blocked	Blocked	Release	Blocked
Remote	Blocked	Blocked	Blocked	Release
Local automatic operation	Release	Release	Release	Release
Station automatic operation	Blocked	Blocked	Release	Blocked
Remote automatic operation	Blocked	Blocked	Blocked	Release
DIGSI	Blocked	Release	Blocked	Blocked

Specific Switching Authority

Special switching authorities can be configured as extension of the switching-authority check. This makes it possible to differentiate the **Remote** command sources at the bay level. Switching authorities can be routed to or revoked from different control centers that can, for example, belong to different companies. Thus, precisely one of these command sources can switch at a certain time. This function is based on extending the switching-authority check by verifying the identifier of the command source (field **Originator/orIdent** of switching command). In order to turn on the function, go to **General/Control** and set the check mark for the parameter **`Specific sw. authorities`**. More settings for the configuration of the identifiers and the behavior of the function as well as additional signals appear (see *Figure 8-33*). In order to permit an additional command source to switch, you must activate this specific switching authority. In order to do this, set the controllable **`Enable sw. auth. 1`** to **`Enable sw. auth. 5`**.



[sc_act additional options sw authority, 3, en_US]

Figure 8-32 Activating Additional Options of the Switching Authority

The additional parameters allow you to set the following options:

- **`Specific sw.auth. valid for`** (for ***`station/remote`***, only ***`remote`*** or only ***`station`***):
  With this parameter, you determine for which command source the extended switching-authority check is used.

Table 8-21 Result Derived from the Combination of the Parameter Value **`Specific sw.auth. valid for`** and the Level of the Command Source (Field **`Originator/orCat`** of the Switching Command)

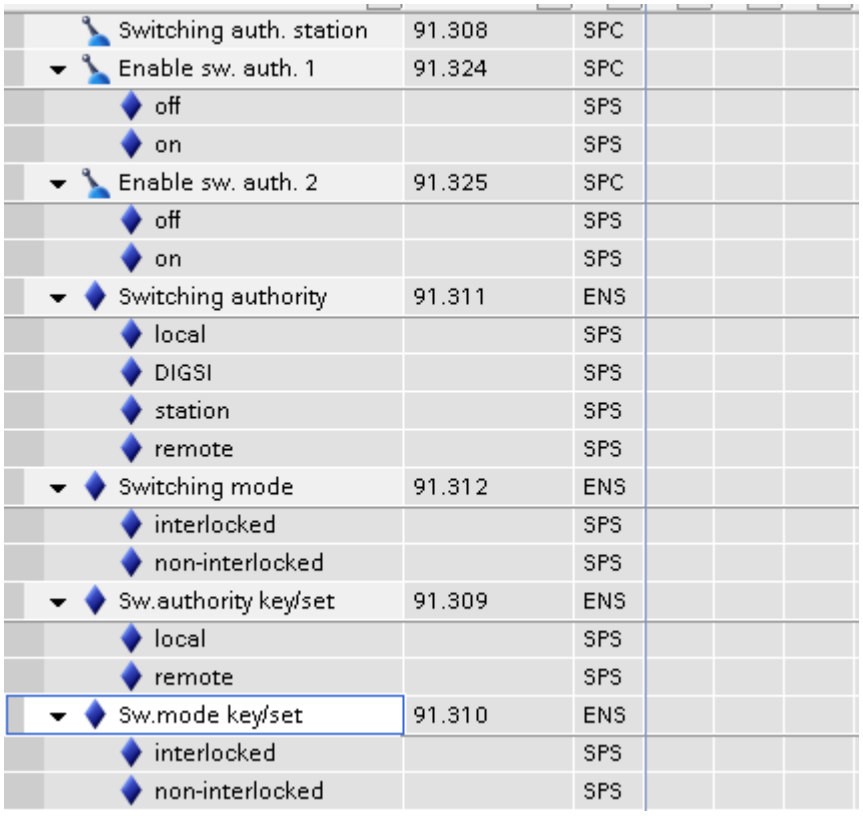
Command Source	`Specific sw.auth. valid for`		
	`station`	***`station/remote`***	***`remote`***
Local, local automatic	No check	No check	No check
Station, station automatic	Check	Check	No check
Remote, remote automatic	No check	Check	Check
DIGSI	No check	No check	No check

- **Num. of specific sw.auth.**:
  With this parameter, you determine how many specific switching authorities are available. This determines the number of parameters **Identifier switching authority** as well as the controllable **Active. Sw. auth.**.
- **Identifier switching authority 1** to **Identifier switching authority 5**:
  The number of names that appear corresponds to the number set in the previous parameter. You can select the names as you wish, 1 to 64 characters are allowed. The command check verifies whether these titles correspond with those sent by the command source. This applies to the switching commands as well as to the activation of a specific switching authority. The requirement for this is the system interface IEC 61850. The field **Originator/orIdent** is used.
- **Multiple specific sw.auth.** ensures the simultaneous validity of the various command sources. The following table shows how to determine the resulting specific switching authority when activating the command sources of Remote or Station. If this parameter is activated, all parameterized command sources get permissible automatically (see last row in the table) and they cannot be deactivated via the controllable **Enable sw. auth. 1** to **Enable sw. auth. 5**. Otherwise, the enabled command source with the lowest number has always the highest priority and prevails against the other numbers.

Table 8-22 Determining Switching Authority if Multiple Command Sources Are Available

Multiple specific sw.auth.	Enable sw. auth. 1	Enable sw. auth. 2	Enable sw. auth. 3	Enable sw. auth. 4	Enable sw. auth. 5	Resulting Specific Switching Authority
No	on	*	*	*	*	Switch. auth. 1
No	off	on	*	*	*	Switch. auth. 2
No	off	off	on	*	*	Switch. auth. 3
No	off	off	off	on	*	Switch. auth. 4
No	off	off	off	off	on	Switch. auth. 5
No	off	off	off	off	off	None
Yes	on	on	on	on	on	All

The * symbol in the previous table refers to any value.



[sc_sw authority and mode in info routing, 1, en_US]

Figure 8-33 Display of Switching Authority and Switching Mode in the Information Routing (in Function Block General), Example of 2 Activated Remote Switching Authorities

Individual Switching Authority and Switching Mode for the Switching Devices

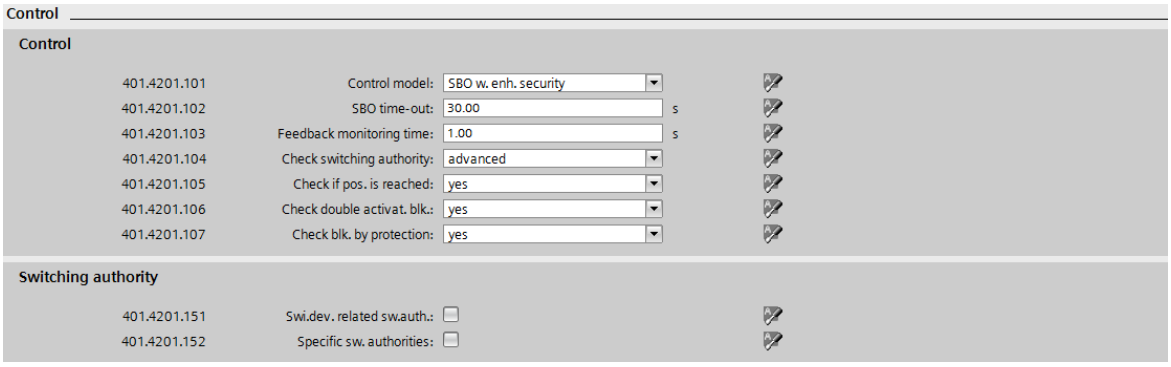
In a standard case, the functionalities switching authority, switching mode, and specific switching authority as described in the previous sections, are applicable to the entire bay unit and, therefore, are valid for all switching devices that are controlled by this bay unit. In addition, you can configure an individual switching authority and specific switching authority as well as individual switching modes for single switching devices. Therefore, individual switching devices can accept various switching authorities and switching modes simultaneously.

This is offered for the following function groups and function blocks:

- **Circuit-breaker** function group
- **Disconnector** function group
- **Transformer tap changer** function group
- **Switching sequence** function block

This allows to select individual settings for each switching device. This is useful if, for example, switching devices of different utilities are managed within a single bay.

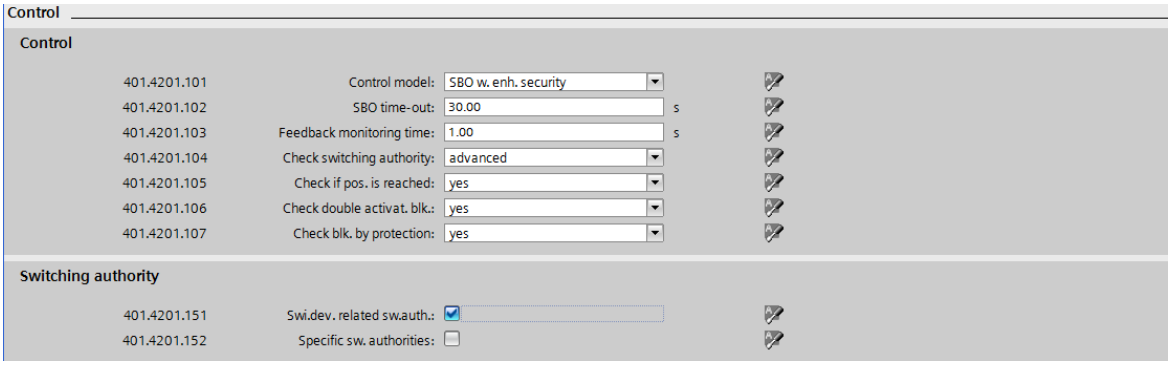
In order to activate this option, go to the function block **Control** of a switching device and set the parameter **`Check switching authority`** to ***`advanced`***. An additional table containing initially 2 parameters is displayed.



[sc_add parameters sw authority sw device, 1, en_US]

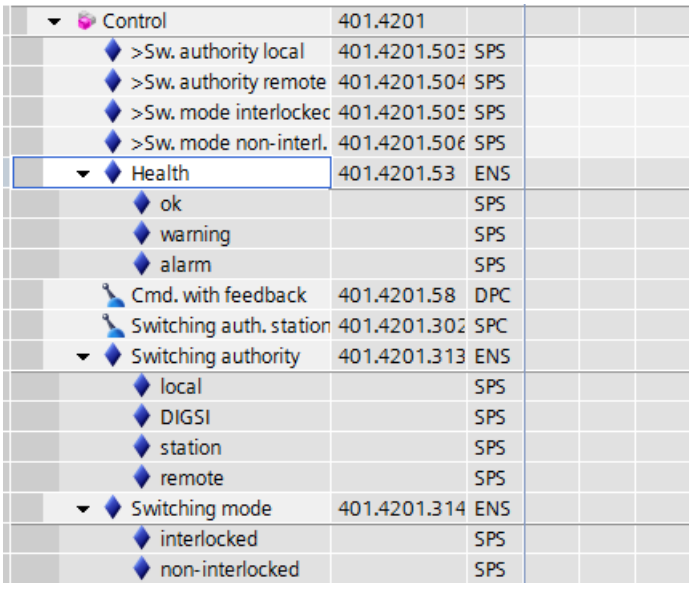
Figure 8-34 Additional Parameters for Switching Authorities in the Parameters of a Switching Device

When activating the parameter **`Swi.dev. related sw.auth.`**, an individual switching authority as well as an individual switching mode for this switching device are configured. Additional signals are displayed in the **Control** function block of the corresponding switching device.



[sc_extended parameters sw authority sw device, 1, en_US]

Figure 8-35 Expanded Parameters for the Switching Authority in the Switching Device



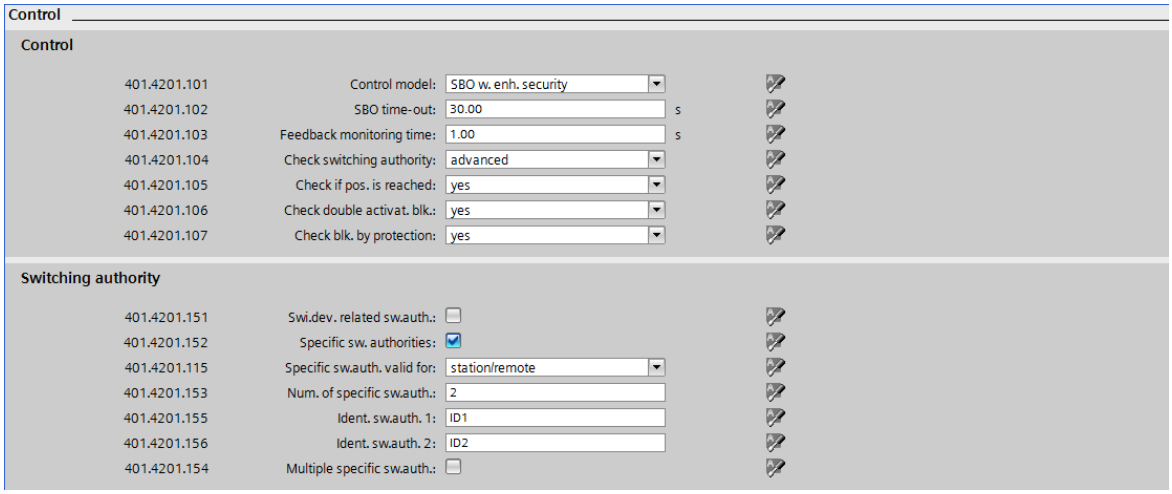
[sc_switching auth sw mode changeable, 1, en_US]

Figure 8-36 Individually Modifiable Switching Authority and Switching Mode for Switching Devices

The new input signals that are displayed allow you to set the individual switching authority and switching mode for the switching devices. For this switching device, these inputs overwrite the central switching

authority and the switching mode. The outputs ***Switching authority*** and ***Switching mode*** indicate the states only for this switching device.

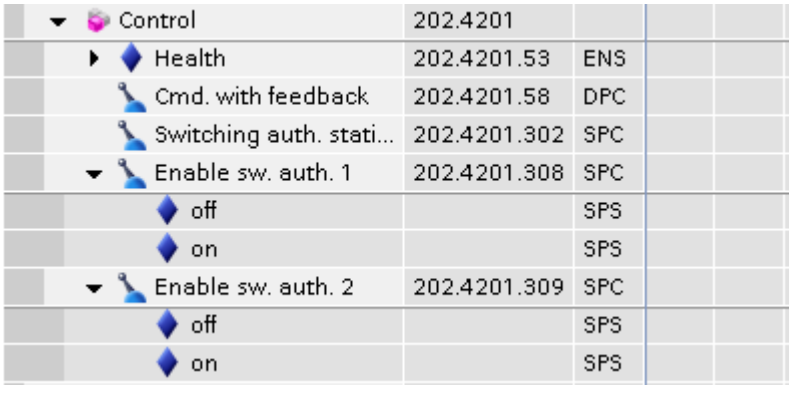
When activating **Specific sw. authorities**, an individual specific switching authority for this switching device is configured. Additional parameters are displayed.



[sc_Parameters FB control all additional options, 1, en_US]

Figure 8-37 Parameters of the FB Control with all Additional Options

The functionality of the specific switching authority for the individual switching device and the significance of the additional parameters is identical to the operating mode of the central specific switching authority. Additional signals are displayed in the **Control** function block.



[sc_Specific sw authority changeable per sw device, 1, en_US]

Figure 8-38 Specific Switching Authority, Modifiable for each Switching Device

Switching Direction (Set = Actual)

With this check, you avoid switching a switching device into a state that has already been achieved. For instance, before a trip command is issued to a circuit breaker, its current position is determined. If this circuit breaker is already in the ***Off*** position, no command is issued. This is logged accordingly.

Switchgear Interlocking Protection

Switchgear interlocking protection means avoiding maloperation by checking the bay and substation interlocking and thus preventing equipment damage and personal injury. The interlocking conditions are always system-specific and for this reason are stored as CFC charts in the devices.

SIPROTEC 5 devices recognize 2 different types of interlocking conditions:

- Normal interlocking conditions:

  These can be revoked by changing the switching mode to **non-interlocked**.

- Non-revocable (fixed) interlocking conditions:
  These are still checked even if the switching mode is set to **non-interlocked**.
  Application: Replacing mechanical interlocking, for example, that prevent actuation of a medium-voltage switch.

Each of the two categories has 2 release signals (for the ***On*** and ***Off*** switching directions) that represent the result of the interlocking plan, so that interlocking is in effect during the command check (see the figure below). The default setting for all release signals is ***TRUE***, so that no switchgear interlocking checks take place if no CFC charts have been prepared.

Information			Source							
			Binary input							
			Base module							
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
(All)	(All)	...	...	...	...	...	...	...	...	...
Circuit breaker 1	201									
Trip logic	201.5341									
Circuit break.	201.4261									
Manual close	201.6541									
Control	201.4201									
Interlocking	201.4231									
>Enable opening	201.4231.500	SPS								
>Enable closing	201.4231.501	SPS								
>Enable opening (fixed)	201.4231.502	SPS								
>Enable closing (fixed)	201.4231.503	SPS								
Health	201.4231.53	ENS								

[scverrie-260912-01.tif, 1, en_US]

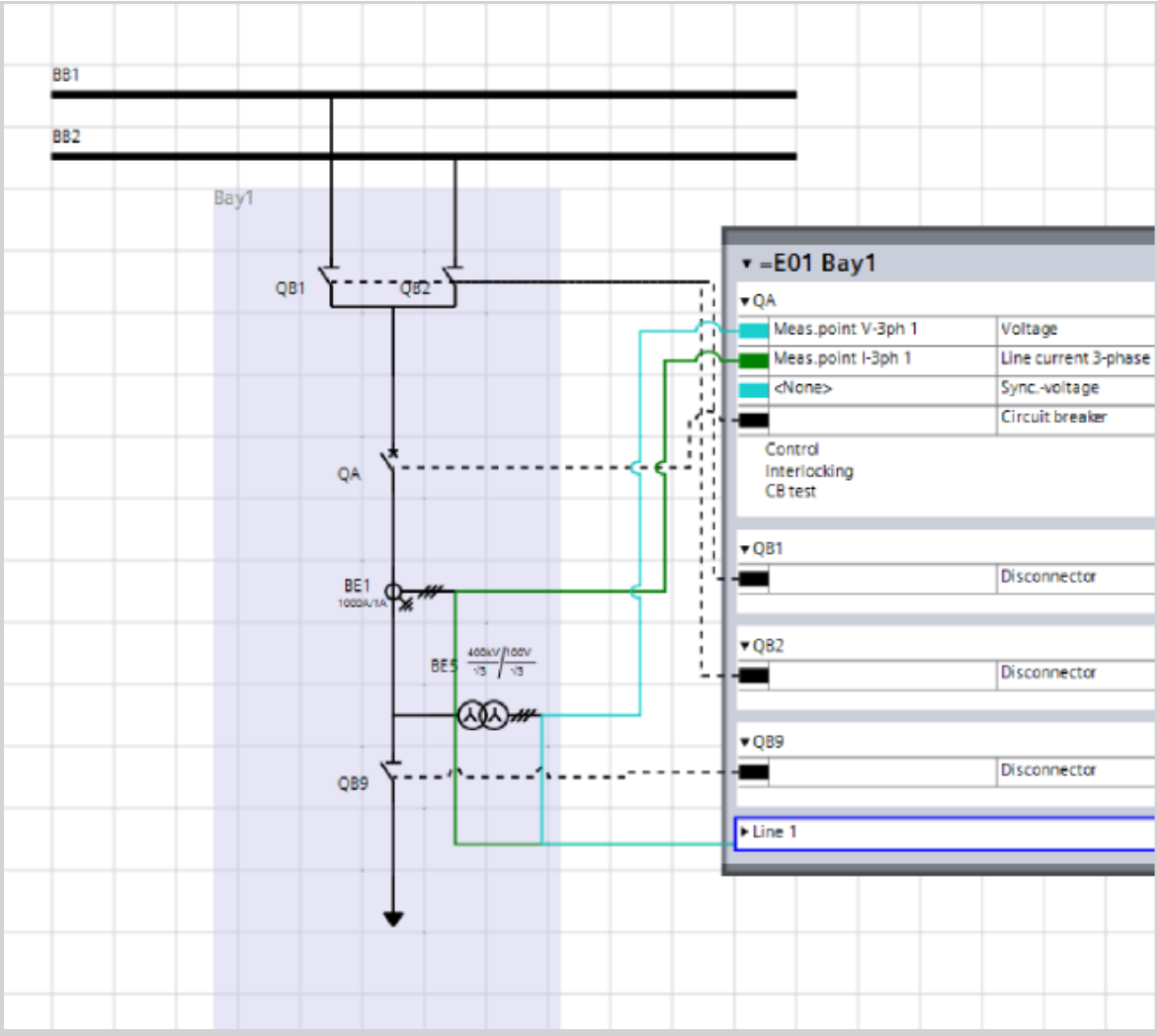
Figure 8-39 Interlocking Signals in Function Block Interlocking

EXAMPLE

For interlocking

For the making direction of the circuit breaker QA in bay E01 (see the figure below), it is necessary to check whether the disconnectors QB1, QB2, and QB9 are in the defined position, that is, either **On** or ***Off***. Opening the circuit breaker QA should be possible at any time.

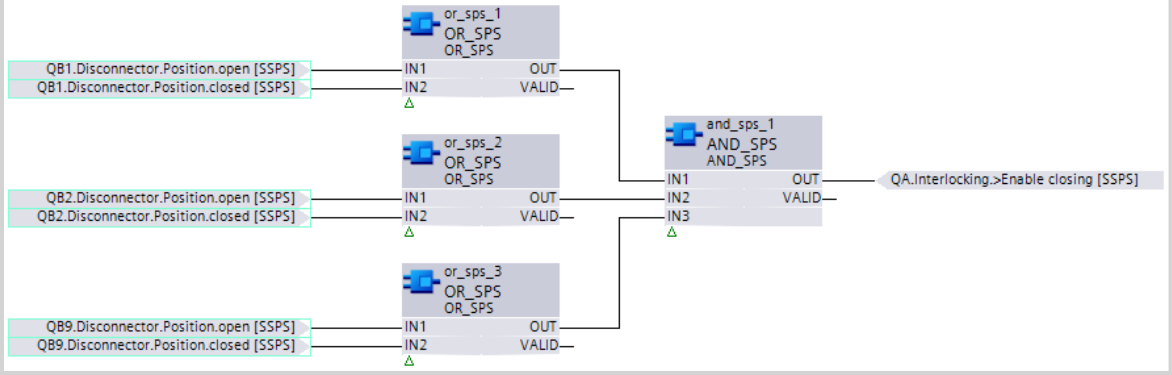
The interlocking equations are: QA_On = ((QB1 = On) or (QB1 = Off)) and ((QB2 = On) or (QB2 = Off)) and ((QB9 = On) or (QB9 = Off)). There is no condition for opening.



[ScAbgang-270410-deDE-01, 1, en_US]

Figure 8-40 Feeder Bay for a Double Busbar System

The CFC chart that is required to implement the interlocking equation is shown in the next figure.



[scverpla-270511-01.tif, 1, en_US]

Figure 8-41 Interlocking Chart for Bay Interlocking

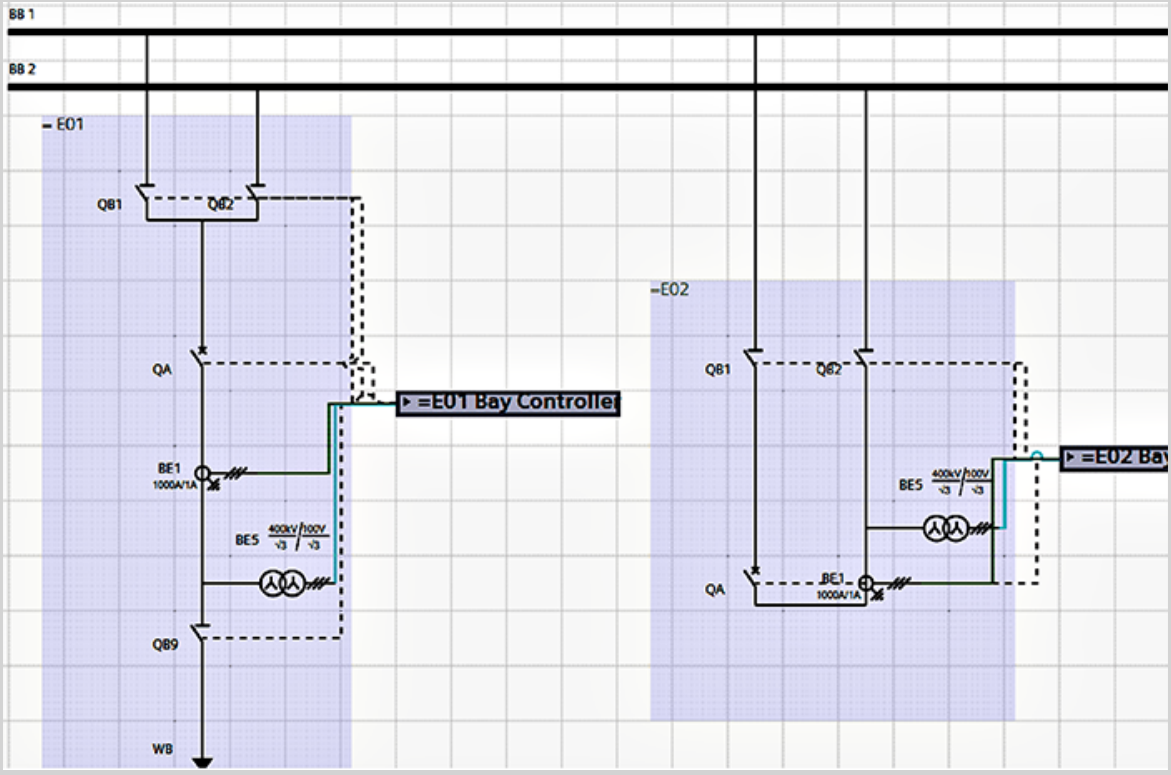
Since the **Disconnector** function block provides the defined position ***On*** or ***Off***, the exclusive OR gate XOR is not necessary for interlocking. A simple OR suffices.

As can be seen in the CFC chart, the result of the check is connected to the **>Release on** signal in the **Interlocking** function block in the **Circuit breaker QA** function group (see *Figure 8-41*).

EXAMPLE

For system interlocking

This example considers the feeder = E01 from the previous example (bay interlocking) and additionally the coupler bay = E02 (see the figure below).



[ScAnlage-270410-deDE-01, 1, en_US]

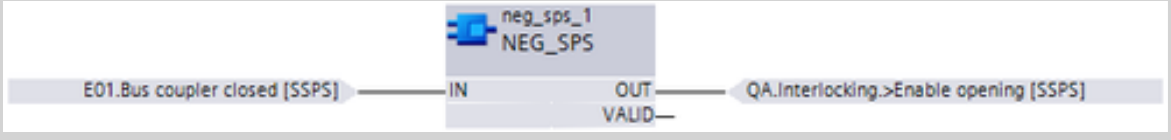
Figure 8-42 System with Feeder and Coupler Bays

The circuit breaker QA in coupler bay = E02 will be considered next. As the multibay interlocking condition, you must provide the bus-coupler command block at the end:

If the 2 busbars in bay = E01 are connected, that is, if the 2 disconnectors QB1 and QB2 in bay =E01 are closed, the circuit breaker QA in bay = E02 is not allowed to be switched off. Accordingly, bay = E01 in the CFC of the device generates the indication *Bus coupler closed* from the positions of the switches QB1 and QB2 and, using IEC 61850-GOOSE, transmits it to bay = E02 in the device. You must then store the following interlocking condition in bay = E02:

QA_Off = NOT (= E01/Bus coupler closed)

In the CFC chart for the coupling device = E02, you must create the following CFC chart (see the figure below).

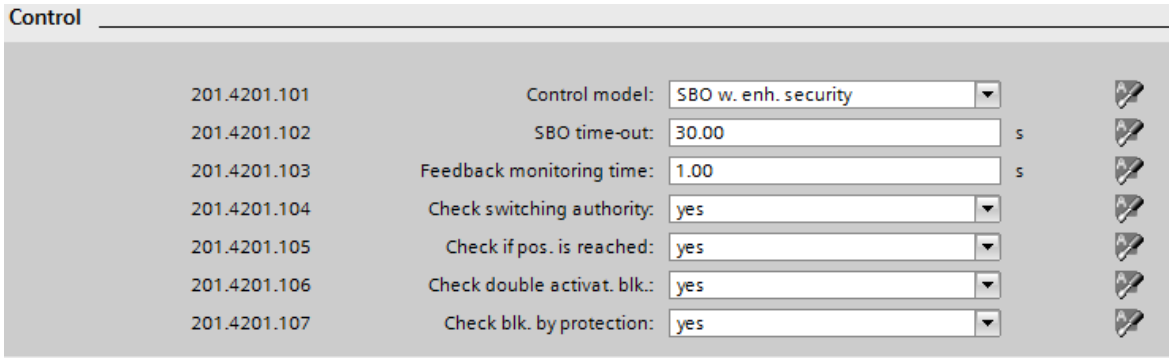


[scplanve-241013, 1, en_US]

Figure 8-43 Interlocking Chart for Substation Interlocking

1-Out-of-n Check (Double-Activation Blocking)

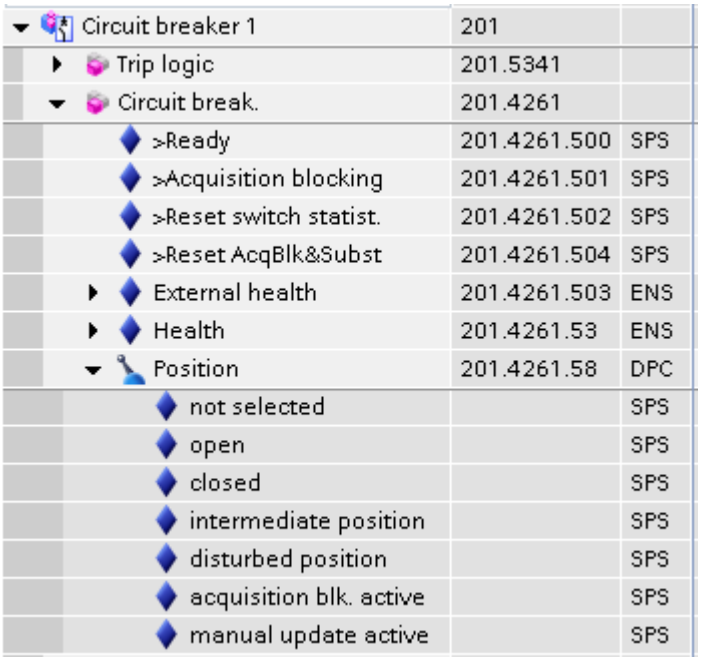
The double-activation blocking prevents 2 commands from being executed in the device simultaneously. You can set the device-internal check for each switching device as a parameter in the **Control** function block.
The default setting is ***Yes***, that is, double-activation blocking is active (see the figure below).



[scdoppel-260912-01.tif, 1, en_US]

Figure 8-44 Activating the Double-Activation Blocking

With SIPROTEC 5, it is also possible to achieve multibay double-activation blocking.
In this case, send the signal **`not selected`** to other devices for analysis using IEC 61850-GOOSE. This signal is available under **Position** in every **Circuit breaker** or **Disconnector** function block in the switching device function groups (see figure below).



[scnotselected-090315_de, 1, en_US]

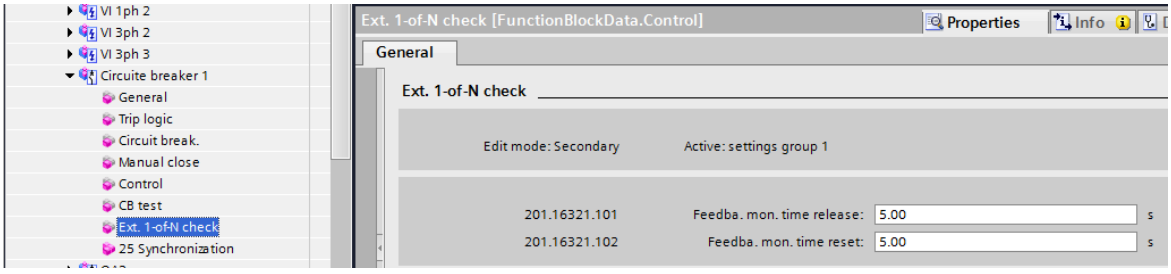
Figure 8-45 Signal *`Not selected`* in the Circuit-Breaker Function Block

The signal is then queried in the CFC interlocking conditions for the associated switching devices and is used to generate the release signal (for example, **`>Release on`**).

External 1-of-N Check (Cross-Bay Double-Activation Blocking)

The function block **Ext. 1-of-N check** offers another option to implement a cross-bay 1-out-of-n check. You can select this function block in the FG **Circuit breaker** – **Control** in the DIGSI library. This function makes it possible to interlock other switching devices across all bays before the allocation of the switching device takes place in its own assigned bay or before the switching operation can be executed.

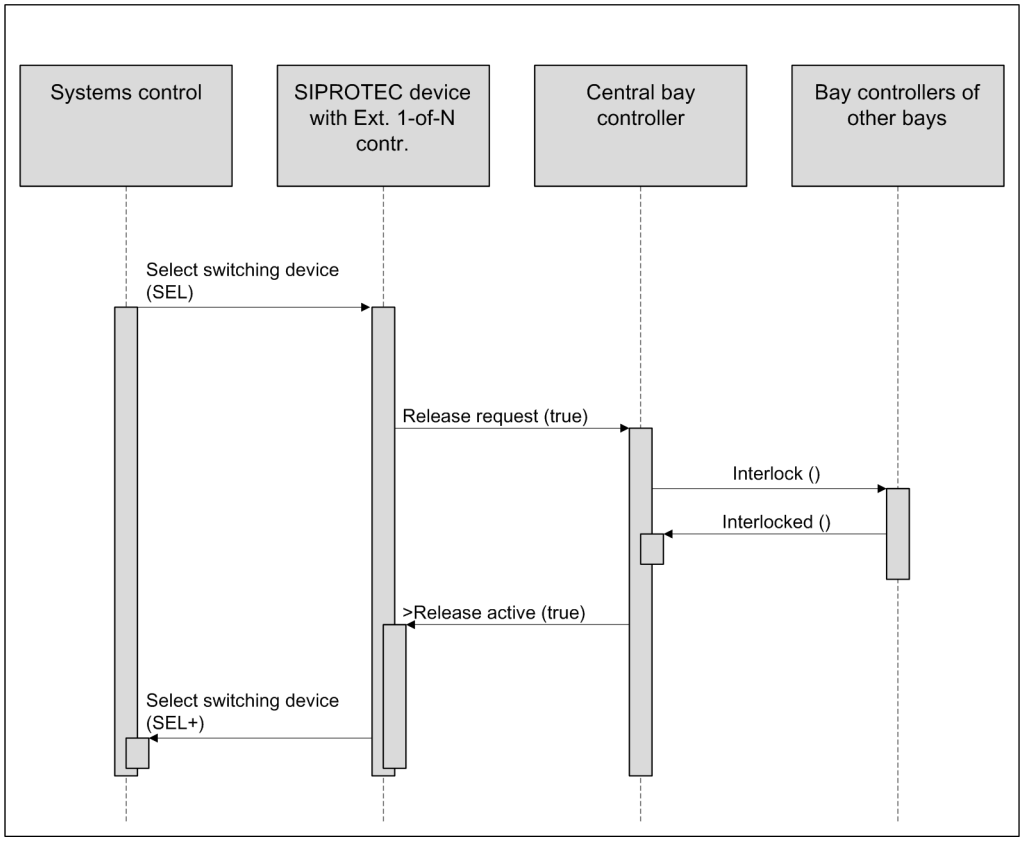
You can use the function block **Ext. 1-of-N check** in the **Circuit breaker** and **Disconnector** function groups. In order to use the function, a control model **with feedback monitoring** must be configured in the circuit-breaker control.



[sc_library properties info routing Ext 1-out-of-n control, 1, en_US]

Figure 8-46 Command Execution

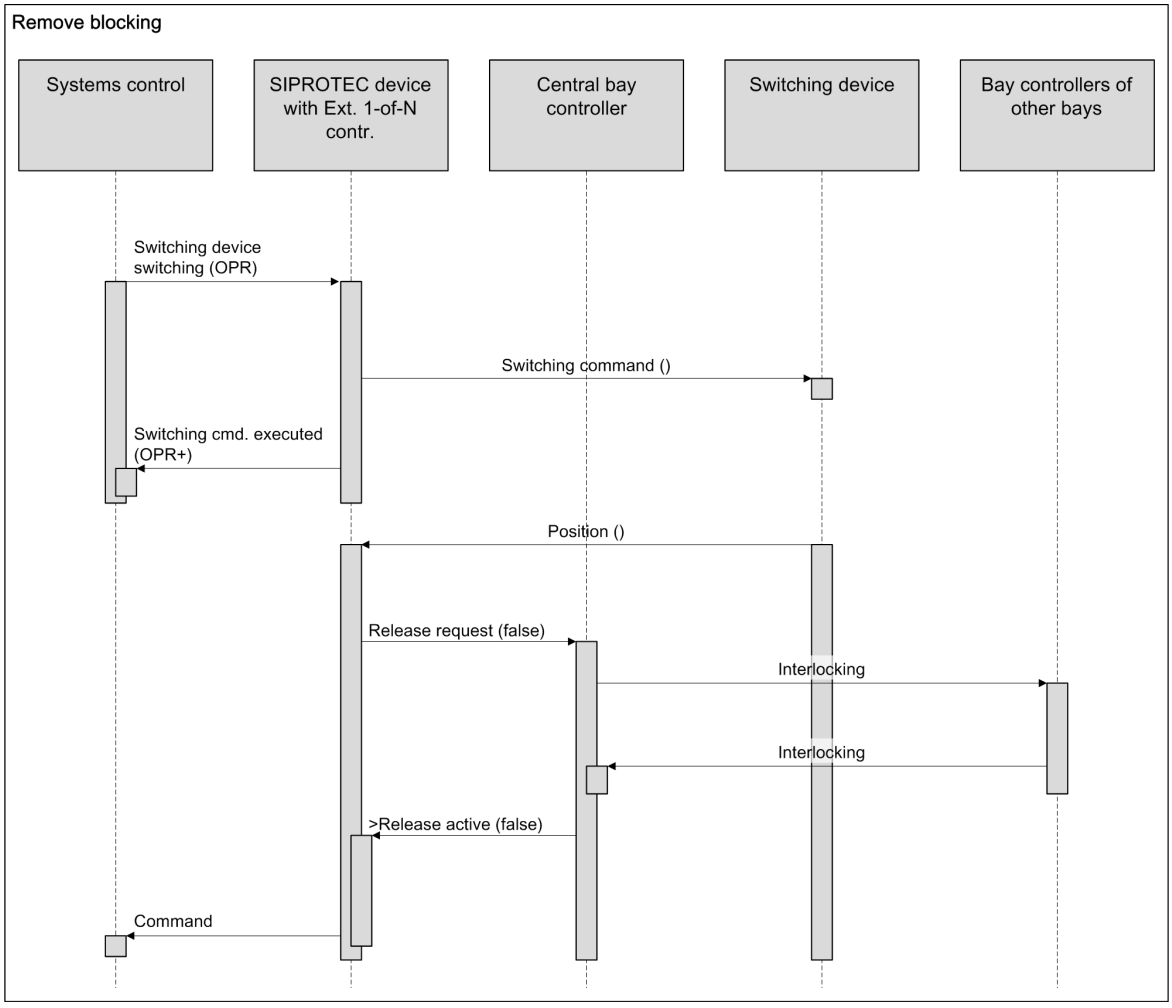
If the external 1-of-N check is instantiated, the output ***Release request*** prompts a central bay controller before executing a switching command. This bay controller must permit the switching operation (see the following figure). If the allocated switching devices were locked in another bay, the release is issued. Only when the release was issued via the input ***>Release active*** the allocations (**Control model**: ***SBO w. enh. security***) or the switching command (**Control model**: ***direct w. enh. security***) are executed and confirmed. The central bay controller is parameterized to reject a 2nd switching request.



[dw_block-ext-setzen, 1, en_US]

Figure 8-47 Setting the Blocking

Once the switch position has been reached, interlocking of the switching devices is canceled via the output ***Release request***. The switching command is completed and acknowledged with CMT (see the following figure) only when interlocking termination has been acknowledged positively via the input ***>Release active***.



[dw_block-aufheben-1, 2, en_US]

Figure 8-48 Terminating the Blocking

User I/O Objects of the External 1-of-N Check Function Block

Name	I/O	Description	Range
Release request	O	This output remains active from the time of the switching prompt until the new position is reached.	true/false
>Release active	I	If this input is set, the switching device is released for switching operation. As long as this input is set, this switching device is blocked for additional switching operations.	true/false

Blocking by Protection Function

- Default setting **(_:107) Check blk. by protection** = ***yes***

In devices with protection and control functions, Siemens recommends that no switching commands can be issued while protection functions have picked up.

This applies to automatic reclosing as well. Switching commands must be prevented as long as automatic reclosing is active.

The default setting for blocking by the protection function is therefore ***yes***. If necessary, you can disable this blocking. You can find the settings on the same page as the double-activation blocking (see *Figure 8-44*).

NOTE

Remember, for instance, that pickup of the thermal overload protection can create a fault as well and thus prevent switching commands.

NOTE

Note that the command check **Blocking by protection function** is only available for controlling circuit breakers, because in this case a unique relationship with protection functions and automatic reclosing has been configured. In disconnectors, this relationship is not always unique, precisely with regard to the 1 1/2 circuit-breaker layout, and it must be mapped for each system using CFC charts.

To carry out the command check **Blocking by protection function** for disconnectors, use the following indications (if present) in your interlocking conditions:

- Group indication: **`Pickup`** (Function group **Line**)
- Circuit-breaker failure protection: **`Pickup`** (**Circuit-breaker failure protection**)
- General: **`In progress`** (**Automatic reclosing function**)

8.3.2 Command Logging

All commands in the sequence are logged. The command log contains:

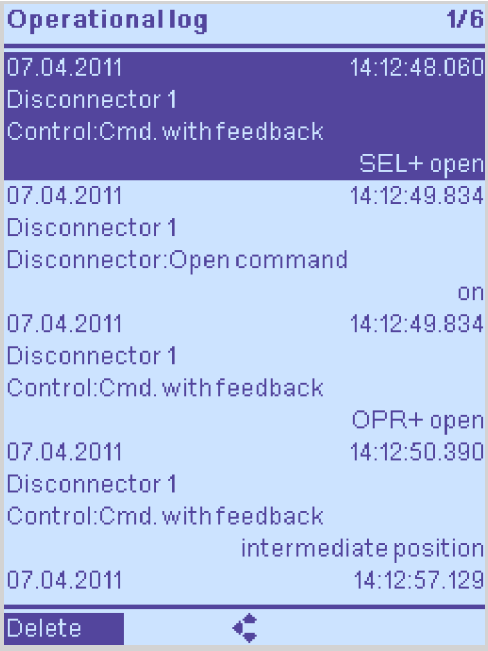
- Date and time
- Name of the switching device (or function group)
- Reason for the transmission (SEL = Selected, OPR = Operate, CMT = Command execution end, SPN = Spontaneous)
- Status or switching direction

EXAMPLE

The following example illustrates control of a disconnector QB1 for various cases.

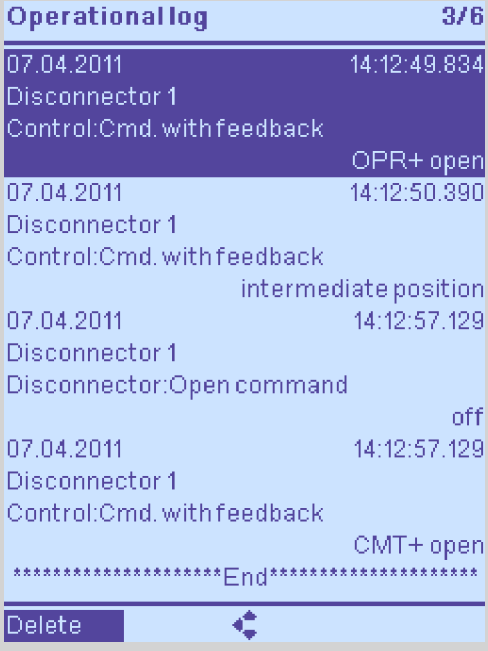
- Successful command output
- Interrupted command
- Command interrupted by switchgear interlocking
- Command ended due to missing feedback
- Spontaneous change of switch position without command output

Figure 8-49 to *Figure 8-55* indicates command logging for various scenarios of the standard control model SBO with feedback monitoring.



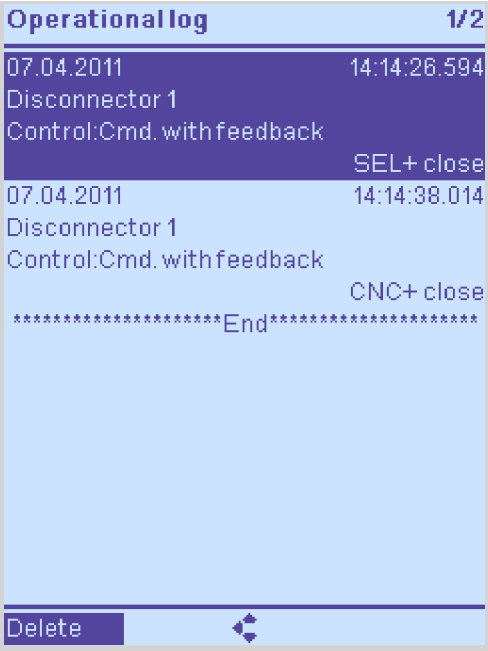
[scposcas-070411-01.tif, 1, en_US]

Figure 8-49 Positive Case (Display 1)



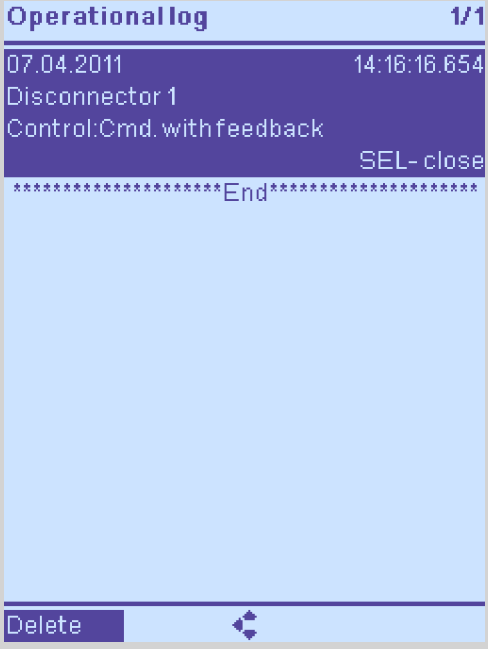
[scposca2-070411-01.tif, 1, en_US]

Figure 8-50 Positive Case (Display 2)



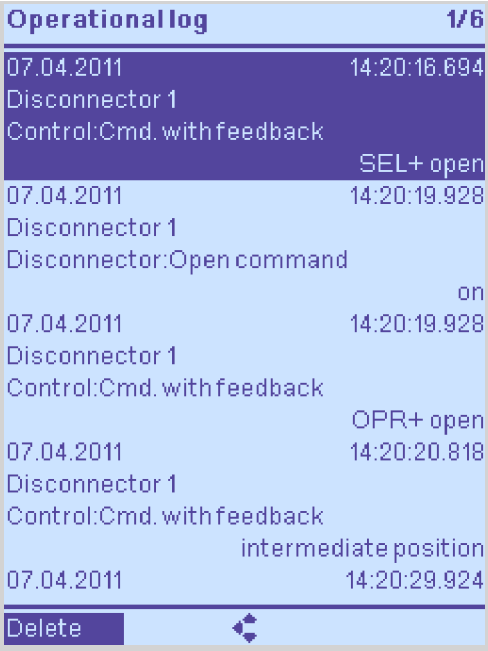
[scposcan-070411-01.tif, 1, en_US]

Figure 8-51 Positive Case with Command Cancellation



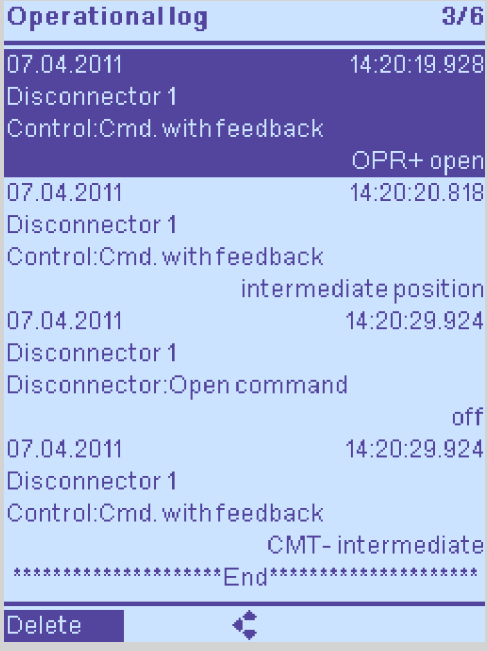
[scnegint-070411-01.tif, 1, en_US]

Figure 8-52 Negative Case (Blocked by Switchgear Interlocking)



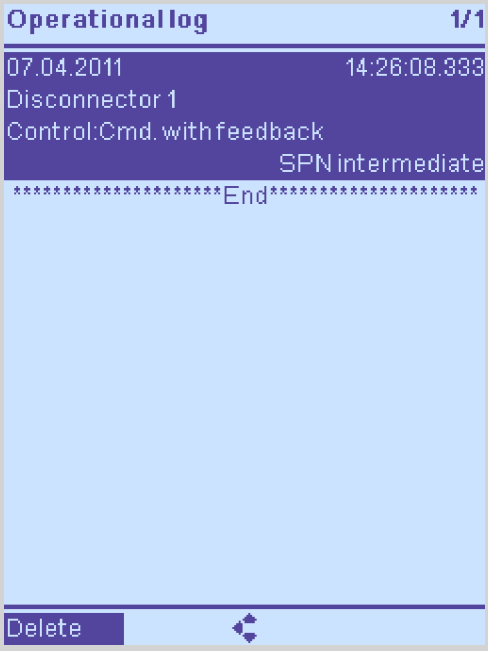
[scnegtim-070411-01.tif, 1, en_US]

Figure 8-53 Negative Case (Expiration of Feedback Supervision Time) (Display 1)



[scnegti2-070411-01.tif, 1, en_US]

Figure 8-54 Negative Case (Expiration of Feedback Supervision Time) (Display 2)



[scsponta-070411-01.tif, 1, en_US]

Figure 8-55 Spontaneous Status Change

Depending on the transmission reason, the desired control value or the actual state value of the controllable and the switching device can be contained in the log.

The following table shows the relationship.

Table 8-23 Relationship between the Reason for Transmission and the Value Logged

Reason for Transmission	Value
Selected (SEL)	Desired value
Operate (OPR)	Desired value
Command cancellation (CNC)	Desired value
Command execution and termination (CMT)	Actual value
Spontaneous change (SPN)	Actual value

8.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:104	Control:Check switching authority		• no • yes	yes
_:105	Control:Check if pos. is reached		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Control:Check double activat. blk.		• no • yes	yes
_:107	Control:Check blk. by protection		• no • yes	yes

8.3.4 Information List

No.	Information	Data Class (Type)	Type
Control			
_:53	Control:Health	ENS	O
_:58	Control:Cmd. with feedback	DPC	C

8.4 Synchronization Function

8.4.1 Overview of Functions

The **Synchronization function** (ANSI 25) checks whether the activation is permissible without a risk to the stability of the system when interconnecting 2 parts of an electrical power system. Typical applications are the synchronization of a line and a busbar or the synchronization of 2 busbars via a cross-coupling. A power transformer between the 2 measuring points can also be taken into consideration.

The following operating modes are covered:

- Synchrocheck
- Switching synchronous power systems
- Switching asynchronous power systems
- Switching to dead line line/busbar

8.4.2 Structure of the Function

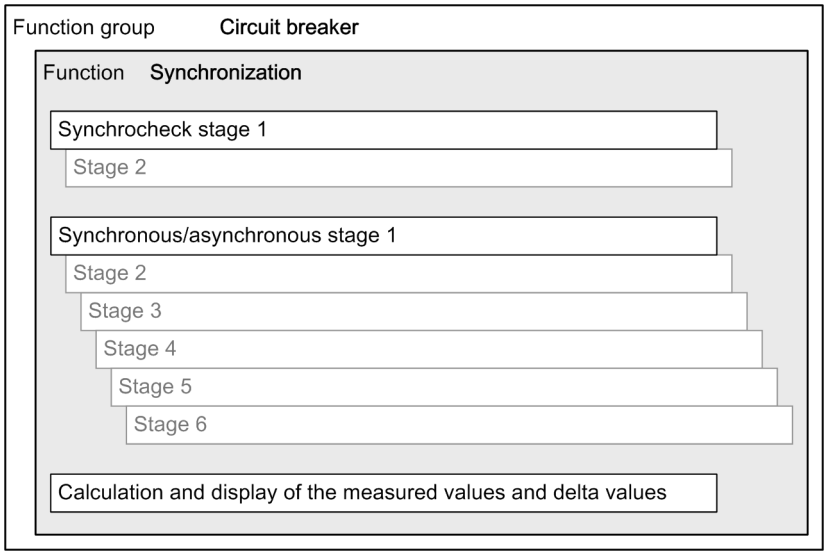
The **Synchronization** function is used in the **Circuit-breaker** function group.

2 different types of stage can be used within the function:

- Synchrocheck stage
- Synchronous/asynchronous stage

Each of the stage types is preconfigured at the factory. You can operate maximum 2 stages of the synchrocheck stage type and maximum 6 stages of the synchronous/asynchronous type in parallel. In addition, the **Expanded delta-f options** stage type is available in the function library. It is not preconfigured.

As soon as the device is functional, the function measuring points are calculated and displayed.



[dwsynfn1-270213-01.tif, 1, en_US]

Figure 8-56 Structure/Embedding of the Function

8.4.3 Connection and Definition

Connection

You can find examples for the synchronization of line and busbar in the following 2 figures. *Figure 8-59* shows an example for the synchronization of 2 busbars via bus coupler.

The synchronization function uses 2 voltages to check the connecting conditions: a voltage of the reference side 1 (V1) as well as a voltage to be used as a reference on side 2 (V2). The reference voltage of side 1 is designated in the synchronization function as V1[24]. This is always the voltage of the measuring point that is connected to the **Sync. voltage 1** interface of the Circuit-breaker function group. The voltage to be set as reference is designated with V2[1]. This is always the voltage of the measuring point that is connected to the **Sync. voltage 2** interface of the Circuit-breaker function group. The assignment of the measuring points to the interfaces of the circuit-breaker function group can be configured, see chapter *2.1 Function Embedding in the Device*.

The selection of the voltages used for the synchronization depends on the device connection to the primary system:

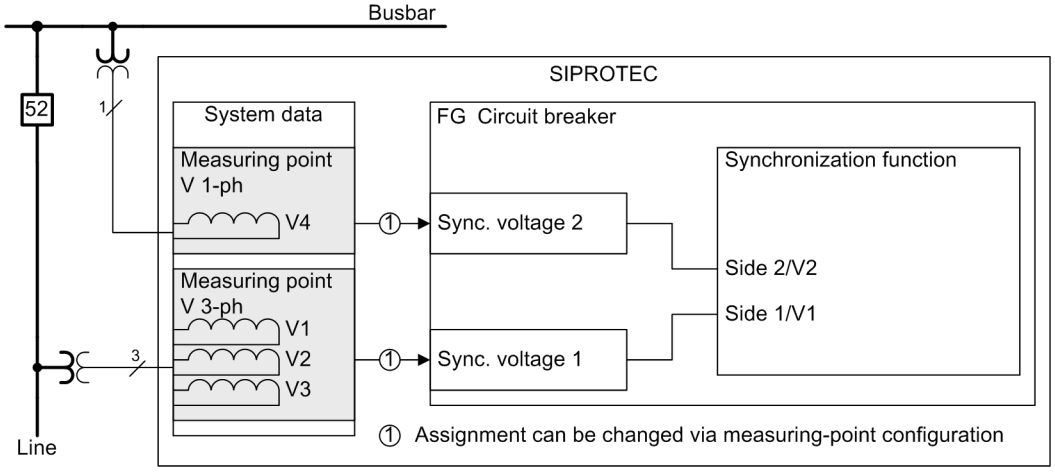
- Connection of the primary system via 4 voltage inputs and hence use of a 1-phase and a 3-phase measuring point (*Figure 8-57* and *Figure 8-59*):

  The voltage connected to the 1-phase measuring point is definitive here. If. for example, this is the phase-to-ground voltage V_A, the voltage V_A is also used by the other side of the 3-phase measuring point.

- Connection of the primary system via 6 voltage inputs and hence use of two 3-phase measuring points (*Figure 8-58*):

  The phase-to-phase voltage V_{AB} of both sides is always used for the test.

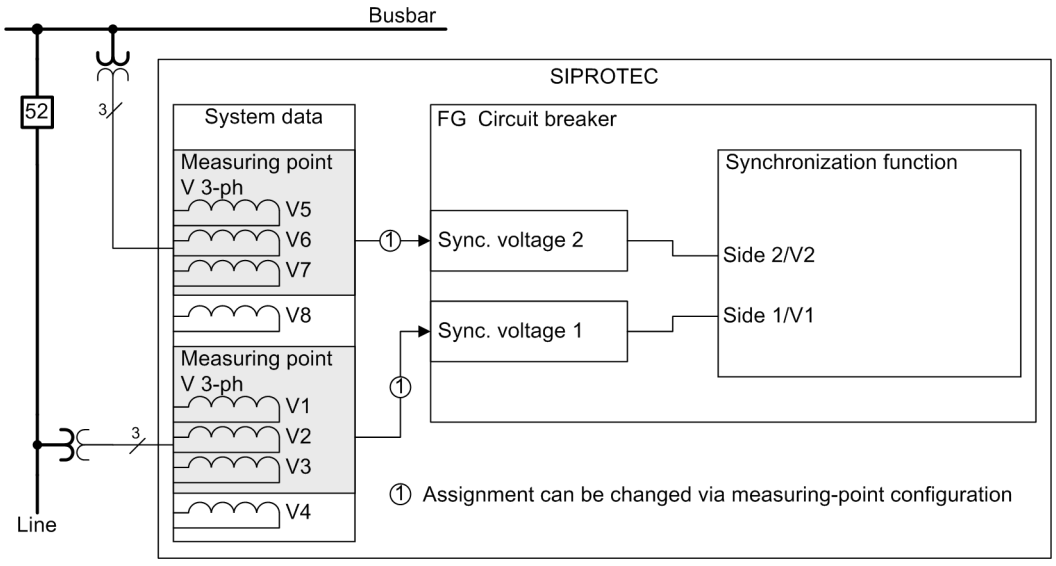
You can connect both the phase-to-ground voltages and the phase-to-phase voltages to the device. The possible interface connections are listed in the Appendix.



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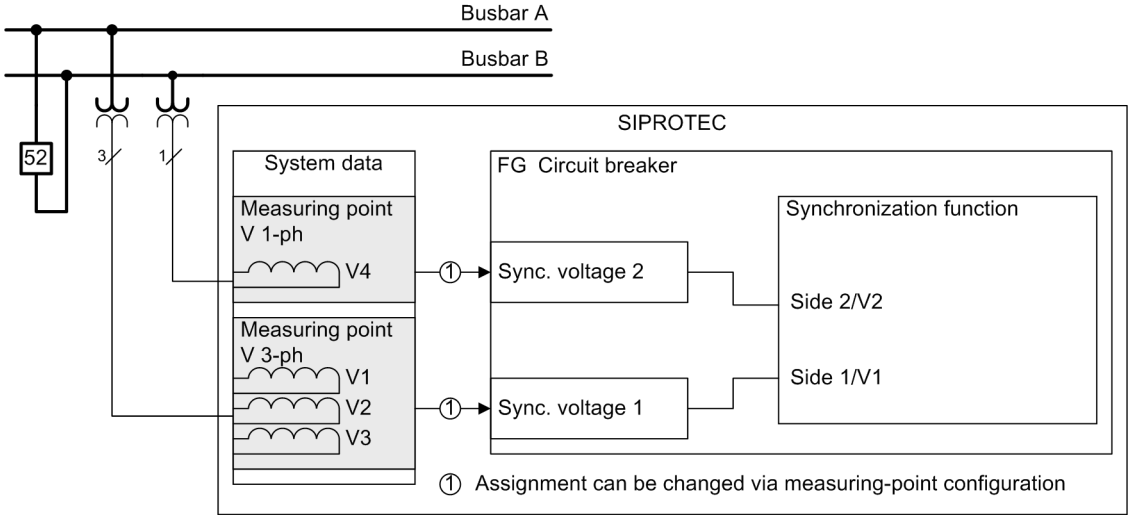
Figure 8-57 Synchronization of Line and Busbar, Connection via 4 Voltage Inputs

[24] Do not confuse the designations V1 and V2 with the numbering of the voltage inputs V1 to V4 (*Figure 8-57*) and V1 to V8 (*Figure 8-58*)



[dwsyns02-210912-01.tif, 1, en_US]

Figure 8-58 Synchronization of Line and Busbar, Connection via 6 Voltage Inputs



[dwsyns03-210912-01.tif, 1, en_US]

Figure 8-59 Synchronization of 2 Busbars via Cross-Coupling, Connection via 4 Voltage Inputs

Definition of the Variables

The definition of the variables is important for understanding the following implementation. The reference side 1 indicates the function with 1. This yields the reference values voltageV1, frequencyf1, and phase angle α1. The side to be synchronized indicates the function with 2. The electrical variables of side 2 are then the voltageV2, frequencyf2, and phase angle α2.

When forming the differential variables, the function is oriented to the definition of the absolute measuring error (Δ x = measured value – real value). The reference value and hence the real value is side 1. This results in the following calculation specifications:

Differential voltage dV = V2 – V1

A positive sign means that the voltage V2 is greater than the voltage V1. In other cases, the sign is negative.

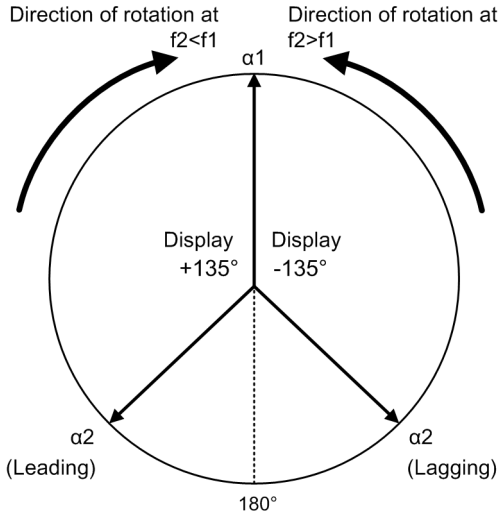
Differential frequency df = f2 – f1

A positive result means that according to the example from *Figure 8-57* the busbar frequency is greater than the line frequency.

Phase-angle difference dα = α2 – α1

The representation is limited to ±180°. A positive result means that α2 **leads** by a maximum of 180°. In the case of a negative value, α2 **lags** by a maximum of 180°. *Figure 8-60* shows the circumstances. The phase angle α1 was added to the zero axis as a reference system.

If asynchronous systems are present and the frequency f2 is greater than f1, the angle dα then changes from the negative value to 0 and then to the positive value. As shown in *Figure 8-60*, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.



[dwsynp04-100611-01.tif, 1, en_US]

Figure 8-60 Phase-Angle Difference Representation dα

Only positive values are permissible for the setting parameters. Inequalities are used to characterize the setting parameters uniquely. The representation is explained with the example of differential voltage. 2 setting values are necessary to allow unbalanced settings.

The inequality V2 > V1 yields a positive value for dV. The associated parameter is **`Max. voltage diff. V2>V1`**. For the 2nd setting parameter **`Max. voltage diff. V2<V1`**, the inequality V2 < V1 applies. It corresponds to a negative dV.

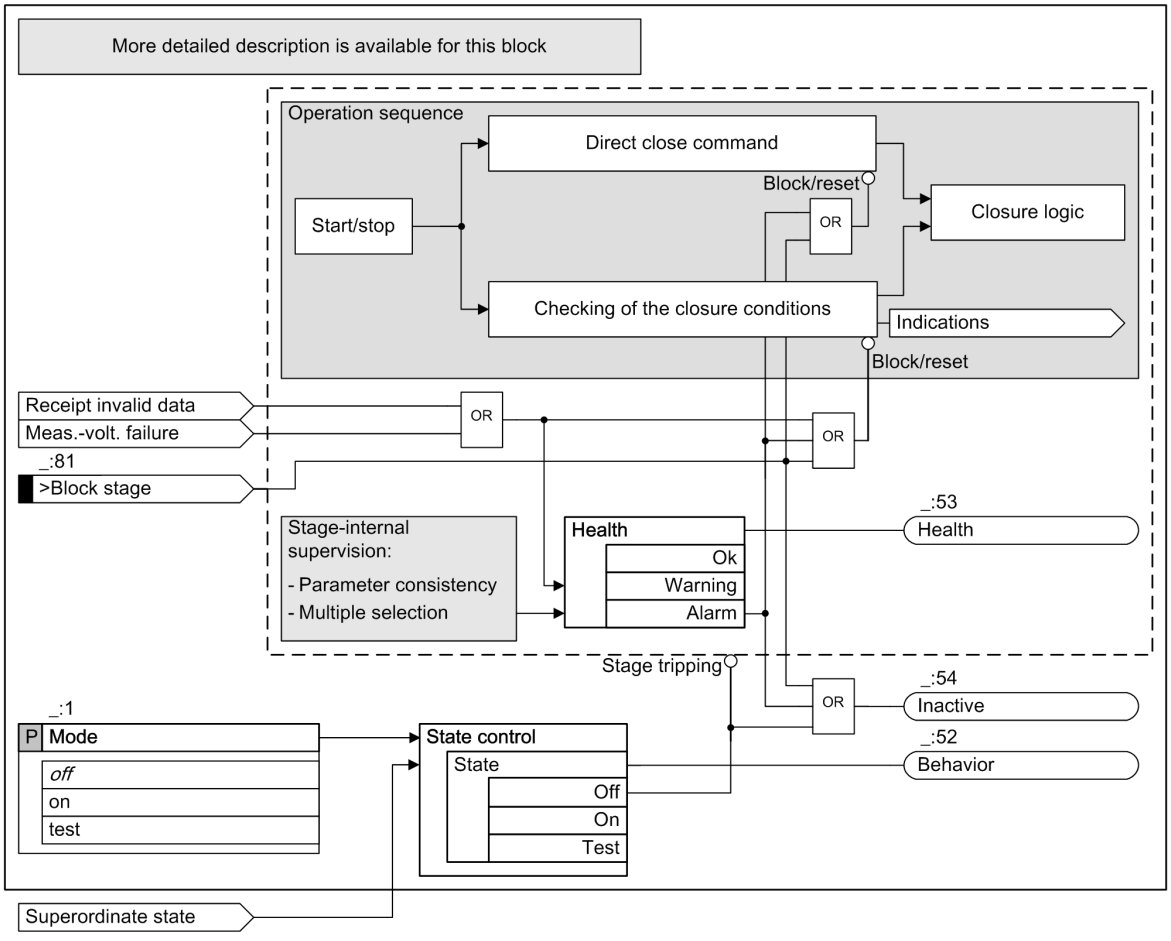
The procedure is the same for the differential frequency and differential phase angle.

8.4.4 General Functionality

Overview of a Synchronization Stage (Sync Stage)

A synchronization stage can be integrated in the following blocks (see *Figure 8-61*):

- Stage control with mode, state control, standby and blocking (description in this chapter)
- Supervision (description in this chapter)
- Functional sequence for issuing the closing release (see chapter *8.4.6 Sequence of Functions*)



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Figure 8-61 Overview of the Stage Logic

Stage Control

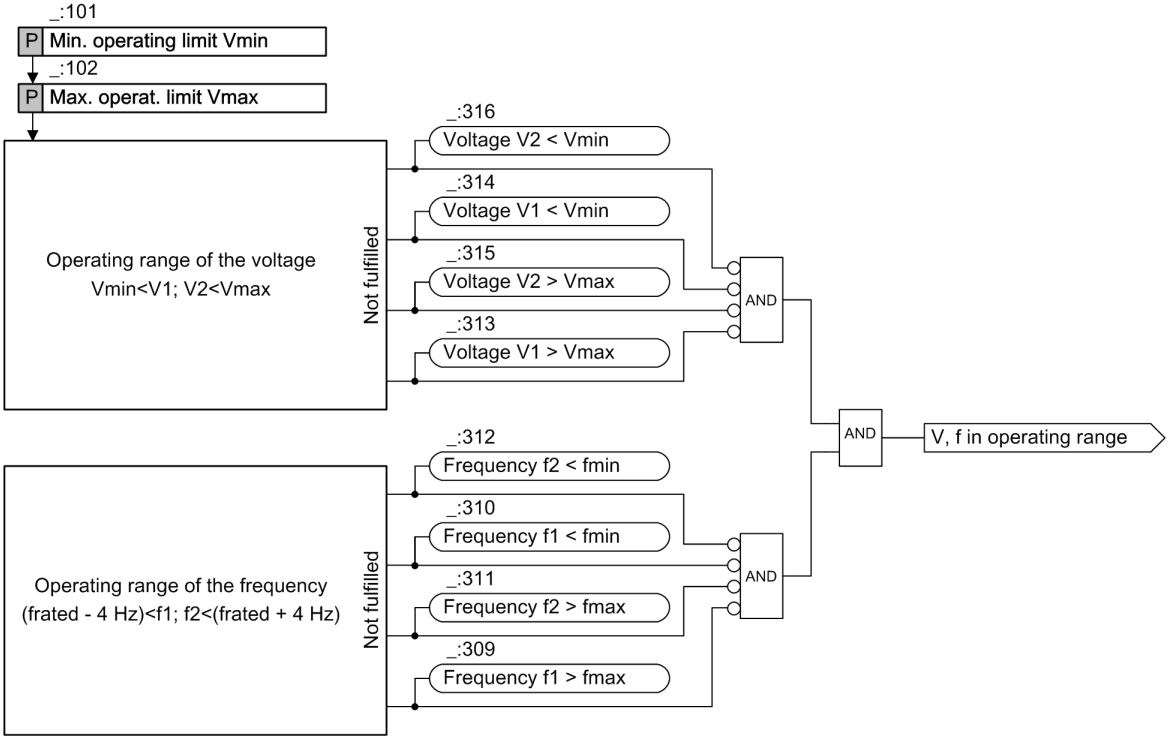
The normal stage control is used for a synchronization stage (see *Figure 8-61*).

Note the following special features:

- As soon as there is a synchronization function available in the device, the measured values are calculated and displayed. One stage must be activated for calculating all Delta settings. It is not necessary to start the stage for this purpose.
- If all synchronization stages are deactivated within the function, closure via the control will no longer be possible, as none of the stages can generate an closing release. If the synchronization function is deleted, the circuit breaker is no longer regarded as subject to compulsory synchronization. In this case, it is possible to activate via the control without synchronization.
- If more than one synchronization stage is switched on, then the **>Selection** signal must be active for exactly one stage, so that it can be activated via the controls.

You can block the entire synchronization stage via the binary signal **>Block stage**. A started process is completed and the entire stage reset after blocking. The stage must be restarted to initiate a new switching procedure. The blocking only affects the test process for the closing conditions. The measured values are still calculated and displayed.

Operating Range



[losyn002-160311-01.tif, 1, en_US]

Figure 8-62 Logic of the Operating Ranges

The operating range of the synchronization function is defined by the configurable voltage limits **Min. operating limit Vmin** and **Max. operat. limit Vmax** as well as by the specified frequency band f_{rated} ±4 Hz.

If one or both voltages are outside the permitted operating range when the measurement is started or a voltage leaves the range, this is displayed via corresponding indications **Frequency f1 > fmax**, **Frequency f1 < fmin**, **Voltage V1 > Vmax**, **Voltage V1 < Vmin** etc. The closing conditions are then not checked.

Supervision

The supervisions listed below are executed in a function-specific manner. If one of the monitors picks up, the Health goes to ***alarm***. The stage is indicated as **Inactive**. A closing release or direct close command is not possible in this case.

- For consistency of settings of specific parameters

  Definite threshold-value settings are checked after a parameter change. If there is an inconsistency, the error message **Setting error** is set.

- For multiple selection of the stage at the start time of the synchronization

  If there is a simultaneous selection of multiple closed synchronization stages at the start time, the error message **Multiple selection** is set.

Measuring-Voltage Failure

If a voltage-transformer fault (measuring-voltage failure) is recorded via the binary input signal **>Open** of one of the voltage-measuring points, then the closing commands of the synchronization stage are no longer tested. In other words, a release of the closure based on the measurement is no longer possible. The readiness of the stage turns to ***warning***. Direct close command is still possible.

The device-internal supervision function measuring-voltage failure detection (Fuse Failure Monitor) does not have any effect on the synchronization stage.

Function Measured Values

The function measured values for the Synchronization function are displayed in their own primary, secondary and percentage measured-value windows. Voltage measurements are always displayed as ph-ph voltages, even if the associated measuring point records phase-to-ground voltages. The function measured values are determined and displayed as soon as the device is functional. The difference values are calculated as soon as the stage is activated.

Table 8-24 Protection-Specific Values of the Synchronization

Values		Primary	Secon-dary	% Referenced to
V_1	Reference voltage V_1	kV	V	Rated operating voltage of the primary values
V_2	Voltage to be synchronized V_2	kV	V	Rated operating voltage of the primary values
f_1	Frequency of the voltage V_1	Hz	Hz	Rated frequency
f_2	Frequency of the voltage V_2	Hz	Hz	Rated frequency
dV	Voltage difference V_2-V_1	kV	V	–
df	Frequency difference f_2-f_1	Hz	Hz	–
dα	Angle difference α_2-α_1	°	–	–

Multiple Synchronization Points

The synchronization function can only be used within a Circuit-breaker function group. It always operates on the circuit breaker that is linked to the Circuit-breaker function group. The reference to the circuit breaker is therefore unique. If you wish to switch several circuit breakers (synchronization points) with the device, you must create several Circuit-breaker function groups.

Different Synchronization Conditions per Synchronization Point

Within the synchronization function, you can operate maximum 2 stages of the stage type **Synchrocheck** and maximum 6 stages of the type **Synchronous/asynchronous** in parallel. All setting parameters for a synchronization point are included in each synchronization stage.

If you have to synchronize with different synchronization conditions (parameter settings), several synchronization stages are used for a synchronization point/circuit breaker. In this case, you must define which of the synchronization stages is currently active via the binary signal **>Selection** (synchronization stage x). The closing conditions are checked if the respective stage is activated via the **>Selection** binary signal and the stage is activated.

The fault indication **Multiple selection** is issued upon simultaneous selection of different synchronization stages. If several synchronization stages are activated and the input signal **>Selection** (synchronization stage x) is missing at the starting time, a valid selection is awaited during the supervision time **Max.durat. sync.process**. If this does not come, the process is terminated.

Different Voltage-Transformer Ratios of Both Parts of the Electrical Power System

The settings of the rated parameters of the transformer for the measuring points automatically takes the different voltage-transformer transformation ratios of both parts of the electrical power system into account. The **Voltage adjustment** parameter is not needed for this purpose.

Synchronization via a Transformer

There are systems in which a power transformer is located between the voltage measuring points of the circuit breaker to be synchronized. The device automatically considers the different voltage stages by setting the transformer ratios (within the measuring points).

A phase displacement must be taken into account based on the transformer vector group, via the **Angle adjust. (transform.)** parameter.

The parameter is defined as -Δα = –(α2 – α1).

To calculate the Delta parameters, the voltage of side 2 is converted to the voltage of side 1 using to the settings of both parameters.

In the Application and Setting Notes, several examples are provided for using both parameters.

Different Connection Types on Both Sides

If both of the measuring points used by the synchronization functions record different voltages of the 3-phase system, the calculation of the phase displacement angle is automatically taken into consideration.

EXAMPLE:

The 1-phase measuring point connected with **Sync-voltage 1** records the phase-to-phase voltage V_{AB}. The 1-phase measuring point connected with **Sync-voltage 2** records V_A. In this case the phase angle between V_{AB} and V_A takes into consideration the delta variable Δα during calculation..

This automation guarantees that several voltage sources can be switched between during running operation, each of which records different voltages.

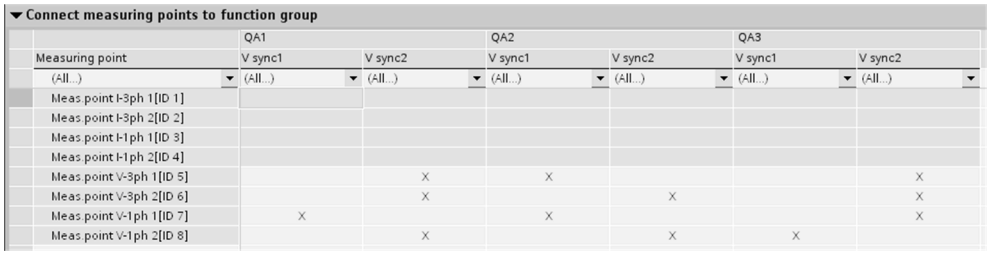
8.4.5 Dynamic Measuring-Point Switching

Dynamic measuring-point switching provides the capability to connect the voltages used in the Synchro-check function to various measuring points. In this way, for example, it is possible to use the correct voltage on the basis of the switch position on the switching devices. If more than 1 measuring point is connected to *V sync1* or *V sync2* , you must create the **V sync select.** function block in the **Circuit breakers** function group.

Selection of the desired voltage measuring points (*V sync1* and *V sync2*) for the **Circuit breakers** function group is controlled via Continuous Function Chart.

Connecting Measuring Points to Circuit-Breaker Function Group

The following figure shows the connection of the **Circuit-breaker** function group with several measuring points in DIGSI. The ID of each measuring point appears in parentheses after the name.



[scdynms2-211212-01.tif, 1, en_US]

Figure 8-63 Connecting the Measuring Points with the Circuit-Breaker Function Group

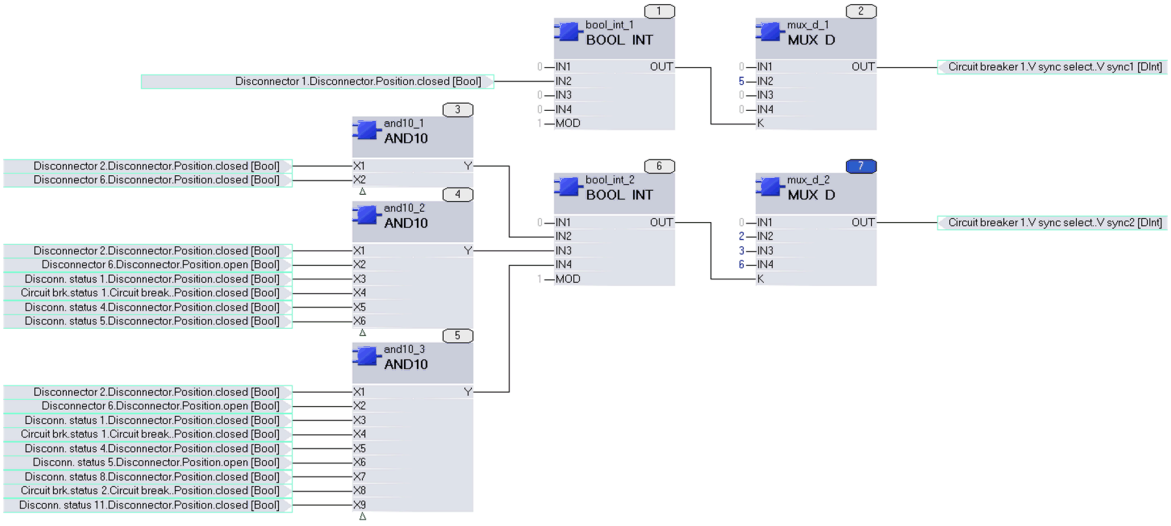
There are consistency checks that validate the connections of voltage measuring points to the function group:

- The connection type must be identical for all measuring points connected to the same interface.
- It is not permitted to route a measuring point to the function group using the option VN.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to 1 voltage interface, a function block must be expanded to enable selection of the synchronization voltage.

CFC Control

The voltages are selected by CFC logic on the basis of the measuring point IDs. If more than one measuring point is connected to interfaces V_{sync1} or V_{sync2} of the **Circuit-breaker** function group, the **V sync select.**

function block has to be removed from the library in the **Circuit-breaker** function group. A CFC logic (see following example) has to define IDs for the *V sync1* or *V sync2* inputs of this function block in order to ensure the correct measuring point connection for the Synchrocheck function.

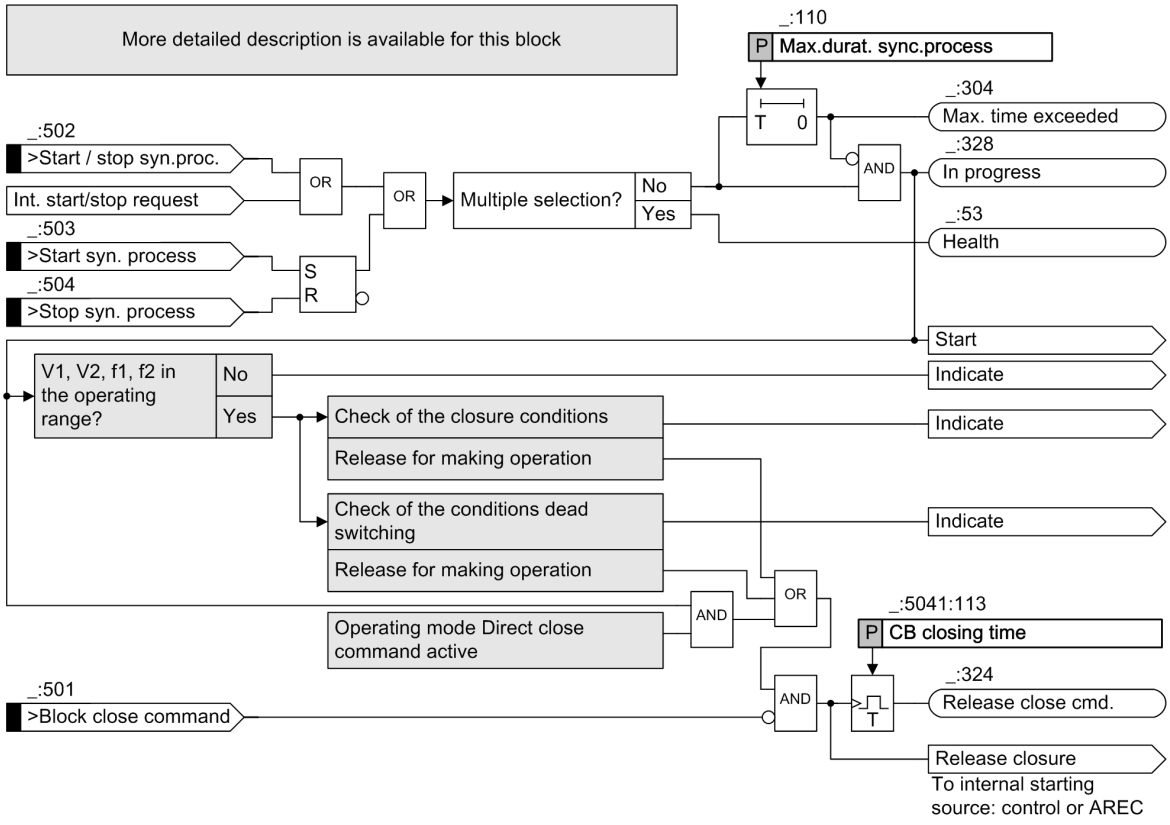


[scdynmsx-160212-01.tif, 1, en_US]

Figure 8-64 CFC Logic: Voltage Selection Using Measuring Point ID

If no measuring point can be selected because of the switch or disconnector positions, the ID0 is used. If ID0 is selected, the indication *(_:2311:304) Blocked no V selected* is set. The synchrocheck is blocked. If you have activated the parameter **(_:5071:108) Direct close command** , unsynchronized switching is still possible.

8.4.6 Sequence of Functions



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Figure 8-65 Sequence of Functions

Start

The synchronization stage must be started to check the closing conditions. The synchronization stage can be started device-internally by the controller and the reclosing, or externally, via binary input signals, for example by an external automatic reclosing (AREC), (see section *8.4.12 Interaction with Control, Automatic Reclosing (AREC), and External Triggering*).

At the start, the system checks whether there is a multiple selection by the synchronization stage (see section **Monitoring** in chapter *8.4.4 General Functionality*). If this is the case, the process is terminated. After a successful start, the indication **`In progress`** is cleared and the supervision time for the maximum duration of the synchronization process (parameter **`Max.durat. sync.process`** is started. The system also checks whether the voltages and frequencies are in the operating range (see section *8.4.4 General Functionality*). If this is not the case, the closing conditions are not checked.

Checking the Closing Conditions, Closure

After starting, the parameterized closing conditions are checked depending on the operating mode selected (see Chapter *8.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type* to *8.4.11 Direct Close Command*). Every condition fulfilled is explicitly indicated here. Conditions not fulfilled are also indicated. If all conditions are fulfilled, the synchronization stage sets the indication **`All sync. conditio. OK`**. The indication is active until all conditions are fulfilled. The further behavior for issuing the release for closing depends on the type of the stage (see Chapters *8.4.7 Closing Conditions for the Synchrocheck Stage Type* and *8.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type*). The release is signaled via the **`Release close cmd.`** indication. This indication is active for 100 ms. With an internal start, the controller or the AREC executes the actual closure, depending on the starting source.

Switching to Dead Line/Busbar

If operating modes for switching to dead parts of an electrical power system are configured, the associated conditions are also checked after the start (see chapter *8.4.10 Closing at De-Energized Line/Busbar*). The fulfilled conditions are signaled. An adjustable supervision time is started after the closure conditions are fulfilled (parameter **CB make time**). If the conditions remain valid until expiry of the time, the function gives the release for closure after expiry of the time.

Direct Closing Command

If the **Direct close command** operation is active, the function instantaneously initiates the release for closure after the successful start (see chapter *8.4.11 Direct Close Command*). A combination of direct close command with other release conditions is not advisable, as these conditions are bypassed by the direct close command.

End of the Process

If the function is started via the device-internal controller or AREC, these functions also terminate the synchronization process upon closure. The process is terminated via the corresponding binary signals in case of external starting.

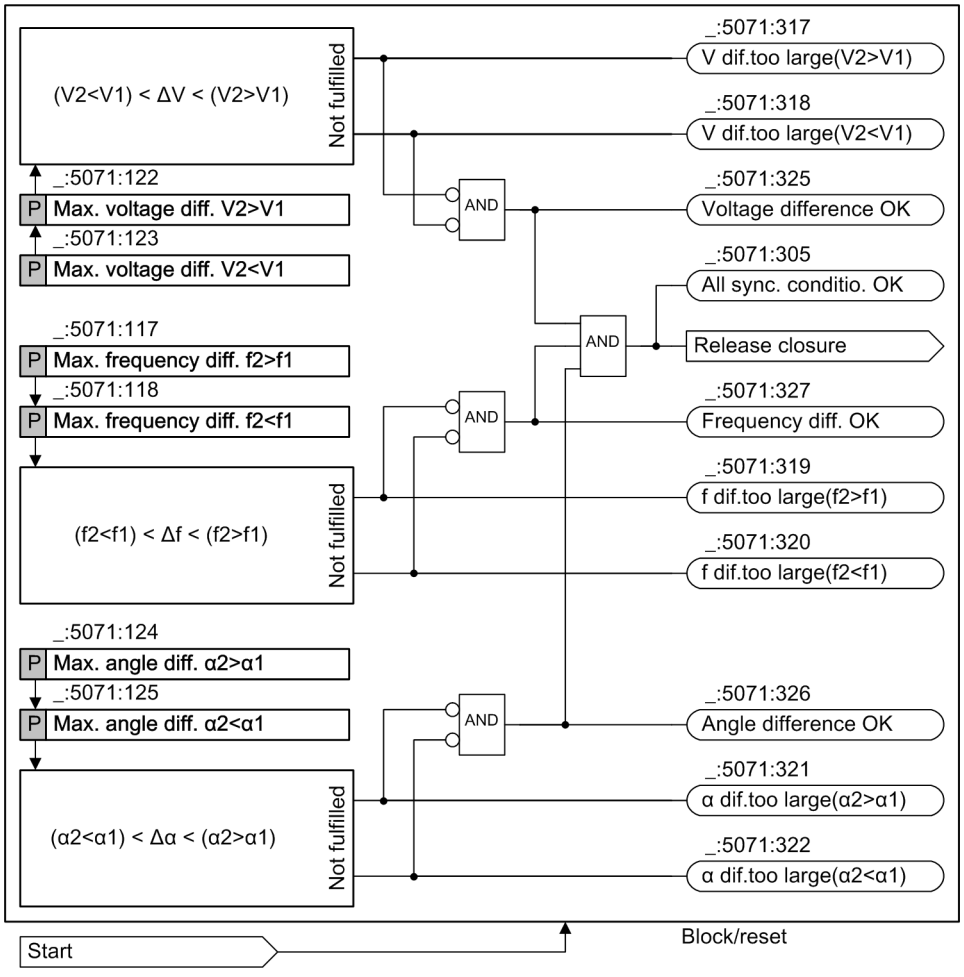
If the supervision time (**Max.durat. sync.process** parameter) has expired, the process is also completed and the indication **Max. time exceeded** is issued. A renewed synchronization is only possible if the stage is restarted.

Blocking Closure

You can use the input signal *>Block close command* to block the release signal for the closure (signal **Release close cmd.**) as well as the closure itself. The measurement continues to operate during the blocking. If the blocking is revoked and the release conditions are still fulfilled, the release is given for closure.

8.4.7 Closing Conditions for the Synchrocheck Stage Type

Checking Closing Conditions



[losynche-160311-01.tif, 1, en_US]

Figure 8-66 Closing Conditions for the Synchrocheck Function

With this operating mode, the values ΔV, Δf, and Δα are checked before connecting the 2 parts of the electrical power system. The indication **`All sync. conditio. OK`** signals that the setting values (conditions) have been reached and that the release for closure has been given (see **Checking the Closing Conditions, Closure** in section *8.4.6 Sequence of Functions*).

Every fulfilled condition is signaled individually via the indications **`Voltage difference OK`**, **`Frequency diff. OK`**, and **`Angle difference OK`**.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication **`V dif.too large(V2<V1)`** is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

With the **Expanded delta-f options** stage type configured and an activated **`(_:140) Limit dfdiff/dt for sync. op`** parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter **`(_:141) Max. value dfdiff/dt syn`**) is exceeded, the indication **`(_:329) d fdiff/dt too large`** is issued.

8.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type

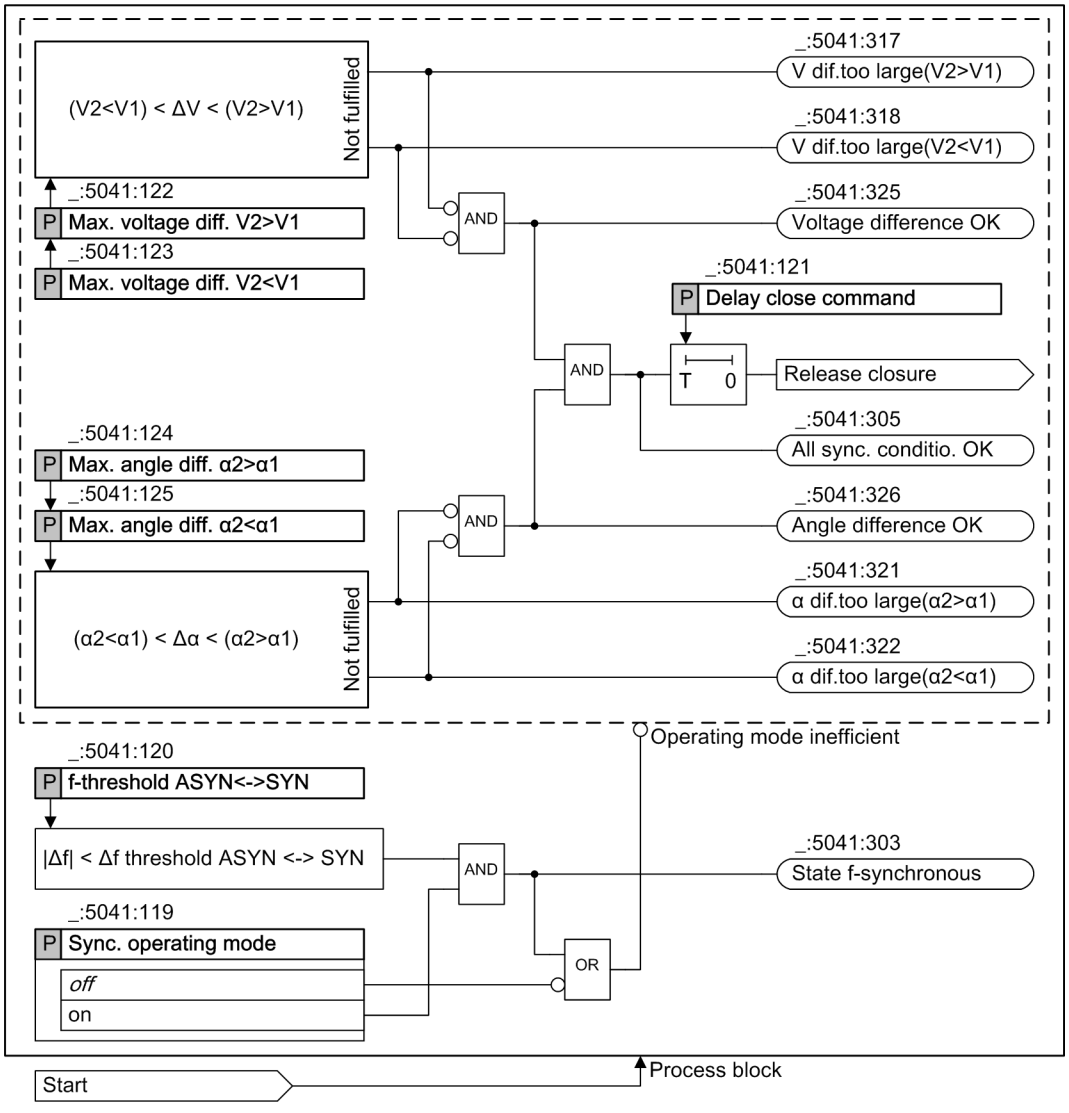
A distinction according to synchronous and asynchronous systems can be made with this type of stage.

If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency (Δf ≈ 0). If the frequency difference falls below the setting value of the **f-threshold ASYN<->SYN** parameter, synchronous systems are to be assumed. If the frequency difference exceeds the setting value of the **f-threshold ASYN<->SYN** parameter, asynchronous systems are to be assumed. This status occurs in galvanically isolated systems, for example.

Both states have their own operating mode with its own closing conditions. Both operating modes can be switched on and off separately (parameter **Sync. operating mode** and **Async. operating mode**). The following combinations result from this:

Sync. operating mode	**Async. operating mode**	Functionality
on	***on***	If the frequency difference is below the threshold value set **f-threshold ASYN<->SYN**, the operating mode synchronous is active. In other cases, the operating mode asynchronous is active.
off	***on***	Regardless of the frequency difference and the threshold value **f-threshold ASYN<->SYN**, the operating mode is exclusively active asynchronously.
on	***off***	If the frequency difference is below the threshold value set **f-threshold ASYN<->SYN**, the operating mode synchronous is active. In other cases, the stage is inactive, i.e. a switching release cannot be issued.
off	***off***	Both operating modes are deactivated. No activation release can be be given via these operating modes either.

Checking the Closing Conditions in Synchronous Systems



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Figure 8-67 Closing Conditions when Switching Synchronous Systems

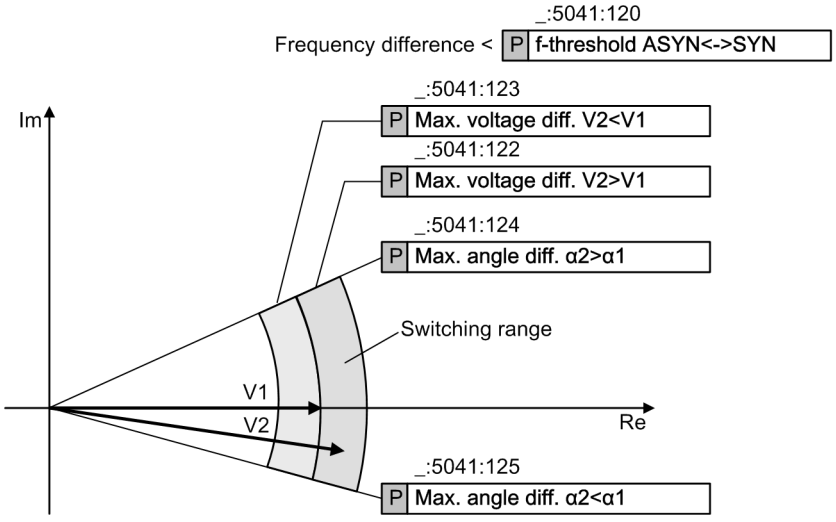
The frequency difference is very low in the synchronous systems operating mode. It is below the threshold value **f-threshold ASYN<->SYN**. The status is signaled via the **State f-synchronous** indication.

The parameters ΔV and Δα are checked for issuing an activation release (see *Figure 8-68*). The indication **All sync. conditio. OK** signals that both setting values (conditions) are reached. If the conditions remain fulfilled over the set time delay (parameter **Delay close command**), the release for closing is given (see also chapter *8.4.7 Closing Conditions for the Synchrocheck Stage Type*).

Every condition fulfilled is signaled individually via the indications **Voltage difference OK** and **Angle difference OK**.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication **V dif.too large(V2<V1)** is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

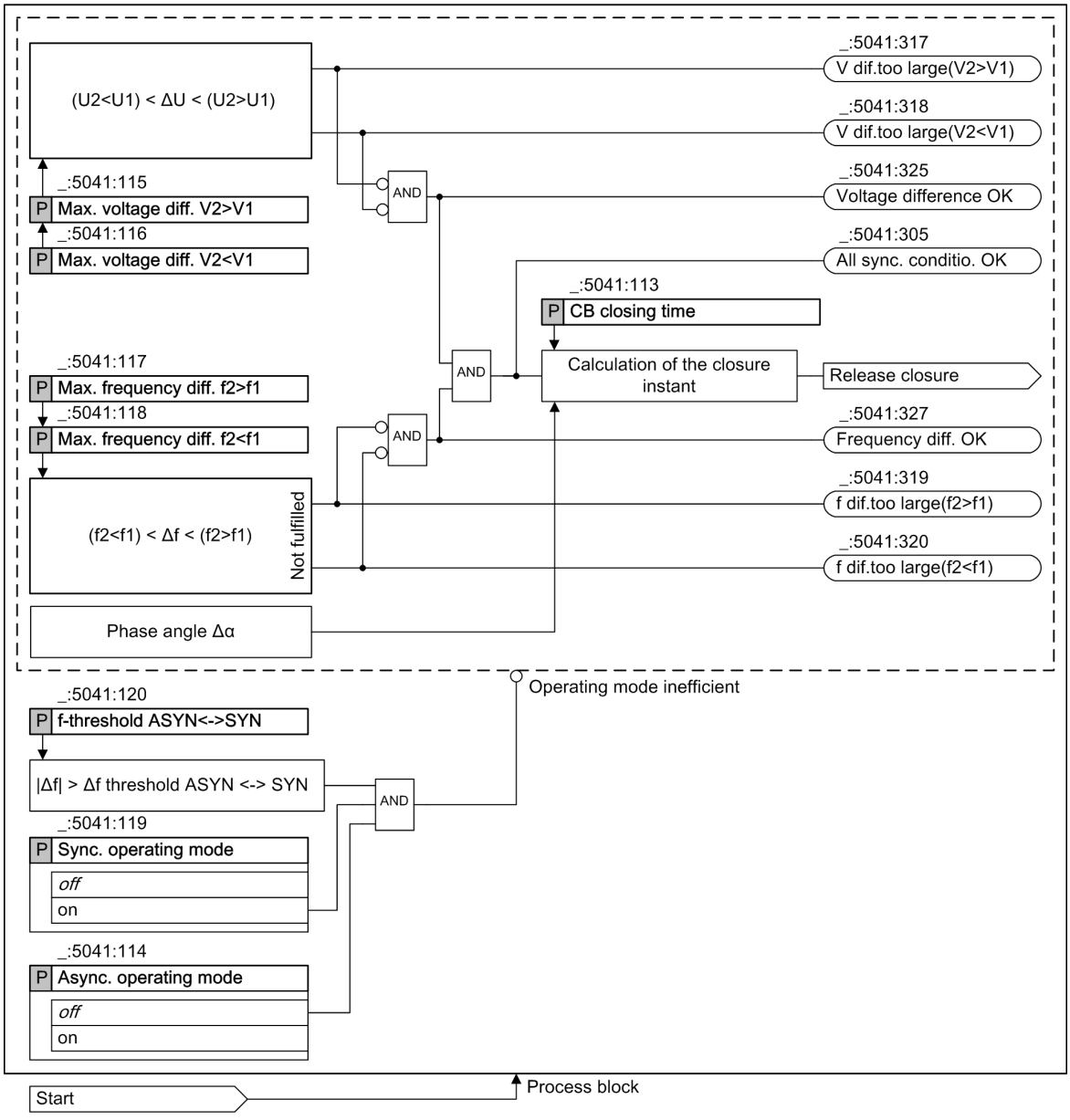
With the **Expanded delta-f options** stage type configured and an activated **(_:142) Limit dfdiff/dt for asyn. op** parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter **(_:143) Max. value dfdiff/dt asyn**) is exceeded, the indication **(_:329) d fdiff/dt too large** is generated.



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Figure 8-68 Connecting Under Synchronous System Conditions

Checking Closing Conditions in Asynchronous Systems



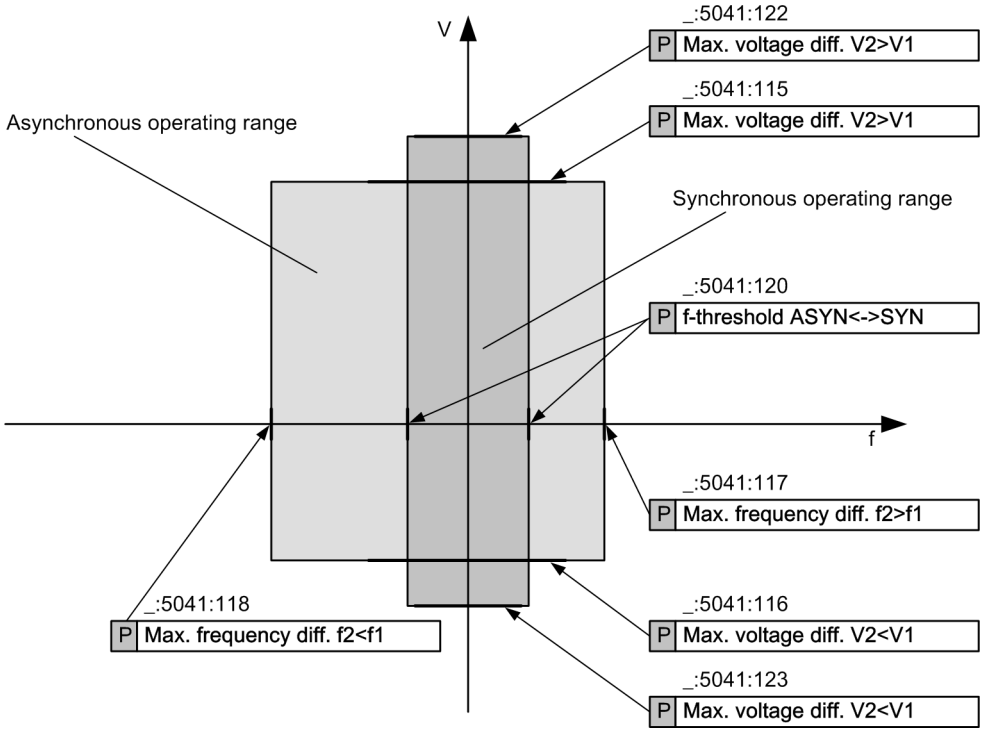
[losynasy-210912-01.tif, 1, en_US]

Figure 8-69 Closing Conditions when Switching Asynchronous Systems

In this operating mode, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The function calculates the time point of the close command taking into account the angular difference Δα and the closing time of the circuit breaker. This is calculated so that the voltage phasors are equal at the moment of pole contact by the circuit breaker ($\Delta V \approx 0$, $\Delta\alpha \approx 0$).

Ranges in the Voltage-Frequency Diagram (V-f Diagram)

Figure 8-70 shows the setting parameters for synchronous and asynchronous conditions in the V-f diagram. The frequency range is very narrow owing to the functional principle in the case of synchronous systems.



[losynarb-080211-01.tif, 1, en_US]

Figure 8-70 Operating Range Under Synchronous and Asynchronous Conditions for Voltage (V) and Frequency (f)

8.4.9 Expanded Checks (df/dt and Smoothing of Oscillations)

When configuring the **Expanded delta-f options** function block, you can expand the synchronization checks to include the following aspects:

- Limitation of the frequency change rate

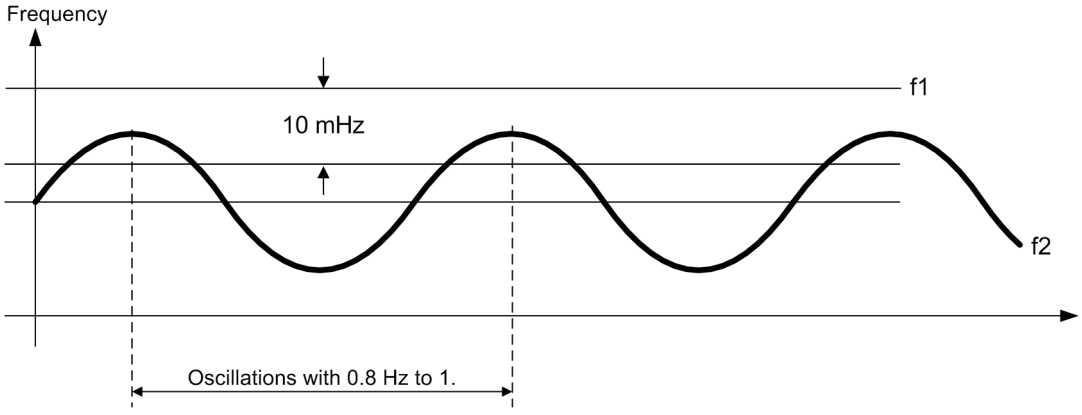
  With this option, you can define additional upper limits for the rate of permissible requency difference change. The release checks for both stage types take these additional upper limits into consideration. Both activation (parameters **(_:140) Limit dfdiff/dt for sync. op** and **(_:142) Limit dfdiff/dt for asyn. op**) and the upper limits (parameters **(_:141) Max. value dfdiff/dt syn** and **(_:143) Max. value dfdiff/dt asyn**) for the frequency change rate are adjustable selectively for synchronous and asynchronous conditions. Both stage types consider the frequency change rate when issuing the release for switching and indicate when the rate is exceeded.

  If you also activate the option to compensate for low-frequency oscillations (parameter **(_:150) Suppr. frequ. oscillations**), the frequency change rate is stabilized in the presence of such oscillations. Stabilization is in effect for asynchronous as well as synchronous operating modes.

- Compensation for low-frequency oscillations

  If you activate this option (parameter **(_:150) Suppr. frequ. oscillations**), low-frequency oscillations, for example, as a consequence of power swings in the range of 0.8 Hz to 1.6 Hz are detected and smoothed. This stabilizes the release checks in the presence of frequently changing violations of upper and lower limits for the specified frequency threshold values. The option affects the frequency check of the **Synchrocheck** stage types and the synchronous operating mode of the **Synchronous/Asynchronous** stage type. It does not affect the asynchronous operating mode.

  In the example of the following figure, the synchrocheck function would initiate energization, if the allowed frequency difference was set to 10 mHz without the parameter **Suppr. frequ. oscillations** as soon as the frequency f2 enters the 10-mHz band. If the parameter **Suppr. frequ. oscillations** is activated, energization is not initiated, since the average value of f2 is outside the band.



[dwsynfre-101013-01.vsd, 1, en_US]

Figure 8-71 Example: Frequency Difference between the Constant Frequency f1 and the Sinusoidal Oscillating Frequency f2

With this option active, the range of function measured values is expanded by the smoothed frequency. Release of switching in synchronous networks occurs after one second at the earliest. This time is needed to smooth the frequency measured values.

The actual frequency can be larger or smaller than the smoothed value at any instant. The **Max. diff. "f threshold"** parameter makes it possible to limit the increase in instantaneous frequency value in relation to the respective frequency threshold value.

8.4.10 Closing at De-Energized Line/Busbar

If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes.

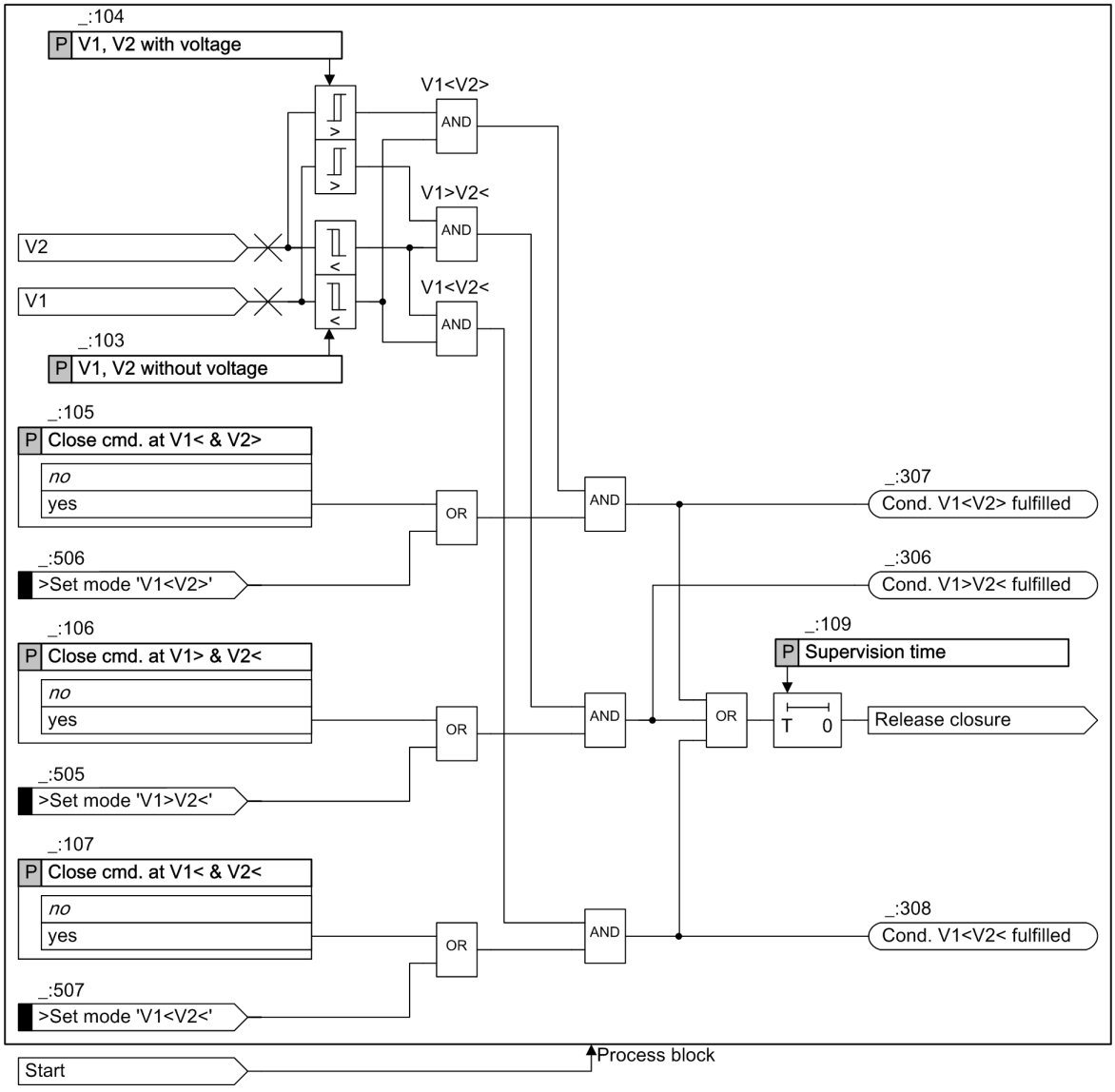
If the measured voltage is less than the threshold **V1, V2 without voltage**, the zero potential of the part of the electrical power system is detected. In this case, all phases are compared to the parameter **V1, V2 without voltage**. The energized side must be in the defined operating range with respect to voltage and frequency (see chapter *8.4.4 General Functionality*) and all phases must exceed the threshold **V1, V2 with voltage**.

The following additional closing conditions can be selected, which are then applied next to the closing conditions for the synchronism:

Settings	Description
Close cmd. at V1> & V2<	Closing release under the condition that the part V_1 of the power system is energized and the part of the electrical power system U_2 is de-energized.
Close cmd. at V1< & V2>	Closing release under the condition that the part V_1 of the power system is de-energized and the part of the electrical power system U_2 is energized.

Settings	Description
Close cmd. at V1< & V2<	Closing release provided mains adapters V_1 and V_2 are de-energized.

Each of these conditions can be made effective individually via parameters or binary input. You can also set parameters for combinations, for example a release for closure, if **Close cmd. at V1> & V2<** or **Close cmd. at V1< & V2>** has been fulfilled.



[losyn003-160311-01.tif, 1, en_US]

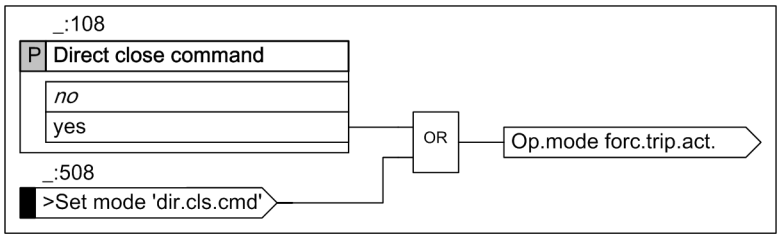
Figure 8-72 Release Conditions for Switching to De-Energized Line/Busbar

The indications **Cond. V1>V2< fulfilled**, **Cond. V1<V2> fulfilled** and **Cond. V1<V2< fulfilled** indicate that the relevant conditions are fulfilled.

You can use the **Supervision time** parameter to set a supervision time for which the closing conditions must at least be fulfilled with de-energized connection, before closing is allowed.

8.4.11 Direct Close Command

You can activate the operating mode direct close command statically via the **`Direct close command`** parameter or dynamically with the binary input signal **`>Op. mode 'dir.cls.cmd'`** (see *Figure 8-73*).



[losyndir-140611-01.tif, 1, en_US]

Figure 8-73 Activation of the Operating Mode Direct Close Command

The operating mode **Direct close command** function initiates a closure release without any testing upon start of the synchronization stage. The closure occurs immediately.

The combination **Direct close command** with other operating modes is not recommended, as the other operating data is bypassed.

If the synchronization function is defective (standby of the sync stage = alarm or warning), a direct close command is executed or not executed, depending on the type of fault (see also supervisions in chapter *8.4.4 General Functionality*).

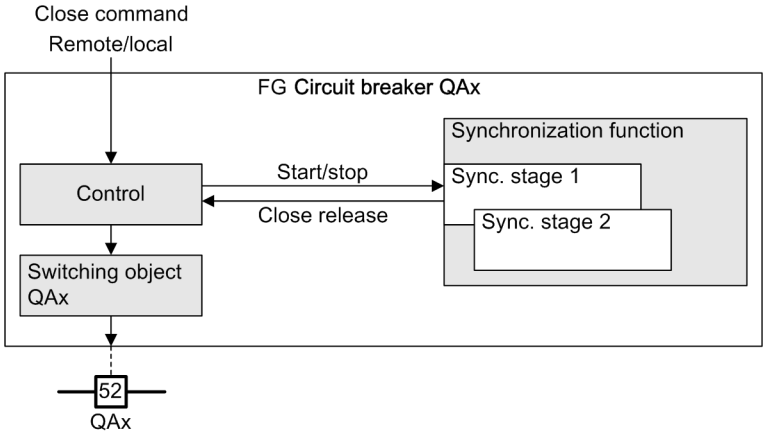
8.4.12 Interaction with Control, Automatic Reclosing (AREC), and External Triggering

With Control

The control and synchronization function are always located in a function group **Circuit breaker**. The control and also the synchronization function always operate with the circuit breaker, which is linked to the function group **Circuit breaker**.

As soon as the synchronization function is in the function group **Circuit breaker**, the circuit breaker is subject to compulsory synchronization. If all synchronization stages are deactivated, the circuit breaker cannot be activated via the control, as no release can be generated for the closure. The circuit breaker is no longer subject to compulsory synchronization after deletion of the synchronization function. Closure without synchronization is then possible via the control.

If closure is to be synchronized via the control, the control automatically generates an internal signal which starts the synchronization function. The functional sequence is described in chapter *8.4.6 Sequence of Functions*. After fulfilling all closing conditions, the synchronization sends a release signal to the control, which closes the circuit breaker and then stops and synchronization function.



[losynaw1-310111-01.tif, 1, en_US]

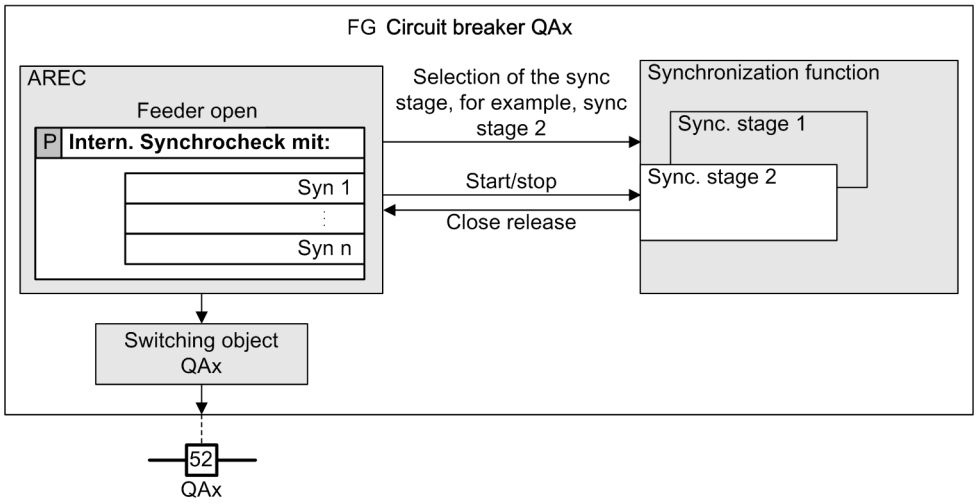
Figure 8-74 Interaction of the Control with the Synchronization Function

With Automatic Reclosing

The automatic reclosing mechanism (AREC) can also work with the synchronization function. Both functions are always located in a function group **Circuit breaker**. Consequently the AREC and synchronization function always work with the circuit.breaker that is linked to the function group **Circuit breaker**.

You must select a synchronization stage via settings within the AREC so that closure is synchronized by the AREC. The tests for the synchronization stage are used for the closure by the AREC. If no synchronization stage is selected, the AREC then activates without synchronization.

If closure is to be synchronized via the AREC, the AREC automatically generates an internal signal which starts the synchronization function. The functional sequence is described in chapter *8.4.6 Sequence of Functions*. After fulfilling all closing conditions, the synchronization sends a release signal to the AREC, which closes the circuit breaker and then stops and synchronization function.



[losynaw2-100611-01.tif, 1, en_US]

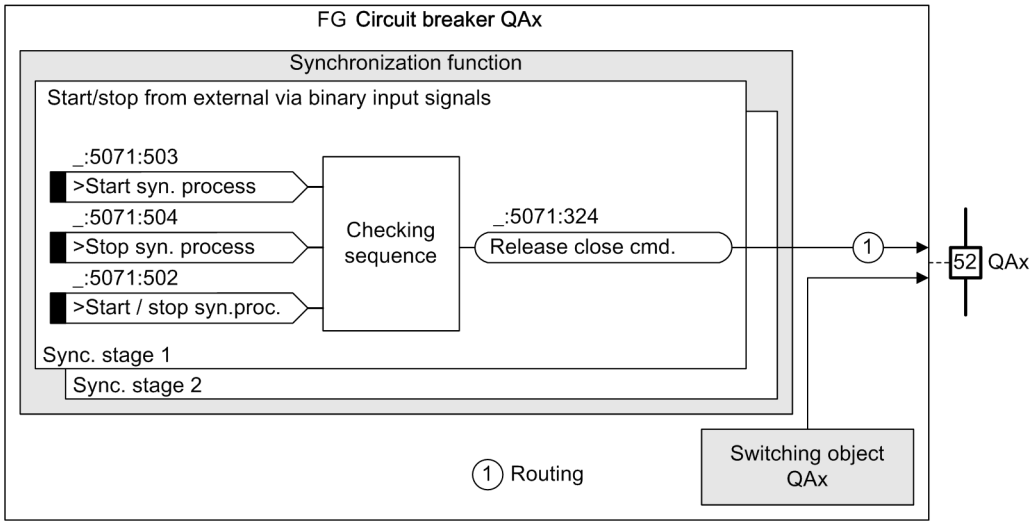
Figure 8-75 Connection of the AREC to the Synchronization Function

With External Control

You have the option of controlling the synchronization function externally via binary input signals. This can be done as follows:

- Edge-controlled
- Via the signals **>Start syn. process** and **>Stop syn. process**
- State-controlled, via the signal **>Start / stop syn.proc.** (see also chapter *8.4.6 Sequence of Functions*).

The start is followed by the functional sequence (see chapter *8.4.6 Sequence of Functions*). If the conditions are fulfilled, the output signal **Release close cmd.** is issued. The switched object QAx of the function group **Circuit breaker** is not closed. The output signal **Release close cmd.** must be explicitly assigned to the binary output in order to close the circuit breaker.



[losynaw3-160311-01.tif, 1, en_US]

Figure 8-76 Interaction of the Synchronization Function with External Control

8.4.13 Application and Setting Notes (General)

Stage-Type Selection

The following 2 types of stage are available:

Stage Type	Application
Synchrocheck stage	Select this type of stage to issue, for example, an additional release during an automatic reclosing or a manual reclosing for safety reasons. With this type, the variables ΔV, Δf and $\Delta\alpha$ are checked before connecting the 2 parts of the power system.
Synchronous/asynchronous stage	Select this type of stage if it is necessary to differentiate between synchronous and asynchronous systems, depending on the switch position. If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency ($\Delta f \approx 0$). In this state, the conditions $\Delta\alpha$ and ΔV are checked. If the systems are galvanically isolated, asynchronous systems can be present. At the same time, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The time of the direct close command is calculated taking into account the angle difference $\Delta\alpha$ and the closing time of the circuit breaker. The time of the direct close command is calculated so that the voltages are equal at the moment of pole contact of the circuit breaker ($\Delta V \approx 0$, $\Delta\alpha \approx 0$).

Configuration of the Voltages V1 (Reference Side) and V2

The voltages V1 and V2 are established via the connection of the measuring points to the interface of the function groups (refer to chapter *8.4.3 Connection and Definition*). The measuring point connected to the interface **Voltage** is the reference side 1 with the reference voltage V1. The measuring point connected to the interface **Sync. voltage** is the side 2 with V2. The definition of the Delta parameters that can be derived from this is also described in chapter *8.4.3 Connection and Definition* .

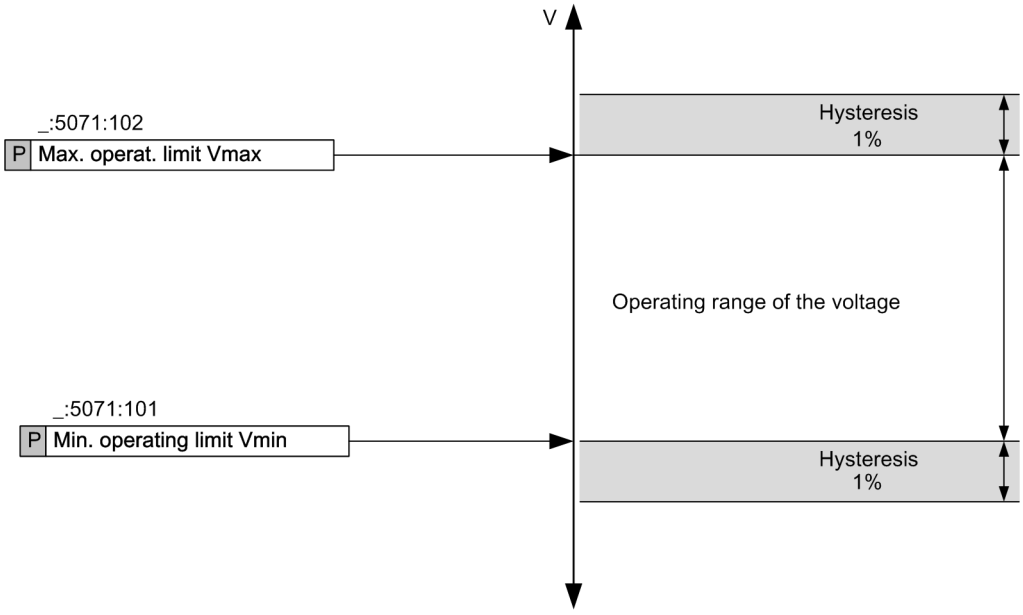
Parameter: **Min. operating limit Vmin ,Max. operat. limit Vmax**

- Recommended setting value **(_:5071:101) Min. operating limit Vmin** = ***90 V***
- Recommended setting value **(_:5071:102) Max. operat. limit Vmax** = ***110 V***

The values define the voltage operating range of the synchronization stage. A normal setting is approx. ±10 % of the rated voltage.

NOTE

All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test. Therefore, connected phase-to-ground voltages are multiplied by √3 as the threshold values with reference to the rated voltage (phase-to-phase voltage) must be set.



[lohyster-010415-01.vsd, 1, en_US]

If the Synchronization function is started within the hysteresis, no switching is performed as a result of the minimum and maximum operating limit (parameters **Min. operating limit Vmin** and **Max. operat. limit Vmax**). If the Synchronization function is started within the voltage operating range and the voltage exceeds the minimum or maximum operating limit during the synchronization process, selecting can occur in the area of the hysteresis.

Parameter: **Max.durat. sync.process**

- Default setting **(_:5071:110) Max.durat. sync.process** = ***30 s***

The parameterized conditions must be fulfilled within this time. If the conditions are not fulfilled, no further closing release takes place and the synchronization stage is stopped. If this time is set to ∞, the conditions are checked until they are fulfilled. This is also the default setting. Observe the operating conditions when defining the time limitation. This must be defined specifically for each system. If 0 or 0.01 s is set, then all conditions are checked once at the starting time point. Thereafter the process is stopped immediately.

Parameter: **Voltage adjustment**

- Default setting **(_:5071:126) Voltage adjustment** = ***1.00***

The parameter can be used for correction of amplitude errors, for example, due to indirect measurement (for example, tap changer).

To apply a transformer between measuring points, the **Voltage adjustment** parameter is not needed. The transformer ratios are set for the measuring points and the function will take them into account automatically.

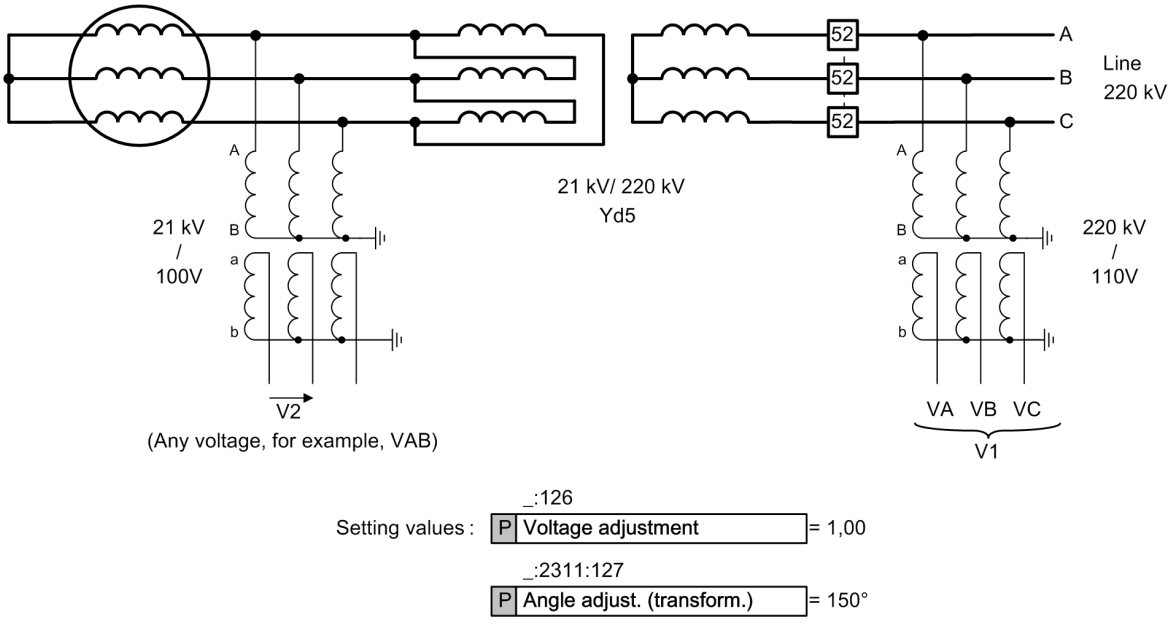
Parameter: **`Angle adjust. (transform.)`**

- Default setting **`(_:2311:127) Angle adjust. (transform.)`** = *0* °

The parameter can be applied under the following conditions:

- 1. Phase-angle rotation by power transformer between the measuring points
- 2. Correction of phase-angle errors

1. Phase-angle rotation by power transformer between the measuring points:



[losynae1-160311-01.tif, 1, en_US]

Figure 8-77 Transformer Between the Measuring Points

If there is a power transformer between the voltage transformers of the circuit breaker to be synchronized, you then have to correct the phase-angle rotation for a vector group deviating from 0. *Figure 8-77* shows such an application. The **`Angle adjust. (transform.)`** parameter is used to save the phase-angle rotation.

The vector group of the transformer is defined by the upper voltage side to the lower voltage side. If the reference voltage transformer V1 is connected on the upper voltage side of the transformer (as in *Figure 8-77*), enter the phase-angle rotation directly according to the vector group. A vector-group figure of 5, for example, means an angular rotation of 5 · 30° = 150°. Set this value for the **`Angle adjust. (transform.)`** parameter.

If the voltage connection V1 is on the lower voltage side due to the system, you then have to apply the extension angle with 360°. A transformer with vector group 5 yields an angular adjustment of 360° – (5 · 30°) = 210°

2. Correction of phase-angle errors: You can correct a phase-angle error between the voltage transformers in increments. Ascertain a possible correction value during commissioning.

Parameter: CB make time

- Default setting **`(_:5041:113) CB make time`** = *0.06 s*

If you are to interconnect under asynchronous system conditions with the device as well, the closing time of the circuit breaker must be taken into account. The device uses this to calculate the time of the direct close command, so that the voltages are in phase at the moment of closure of the switch poles. Note that apart from the operating time of the switch, this also includes the pickup time of an auxiliary relay that may be upstream. You can determine the closing time using the protection device (see commissioning notes in chapter *11.12 Primary and Secondary Testing of the Synchronization Function*).

This parameter only occurs for the stage type **Synchronous/asynchronous**.

8.4.14 Application and Setting Notes (Synchrocheck)

Parameter: Maximum Differential Values of Voltage, Frequency and Angle

- Default setting **(_:5071:122) Max. voltage diff. V2>V1** = ***5.0 V***
- Default setting **(_:5071:123) Max. voltage diff. V2<V1** = ***5.0 V***
- Default setting **(_:5071:117) Max. frequency diff. f2>f1** = ***0.10 Hz***
- Default setting **(_:5071:118) Max. frequency diff. f2<f1** = ***0.10 Hz***
- Default setting **(_:5071:124) Max. angle diff. α2>α1**= ***10***°
- Default setting **(_:5071:125) Max. angle diff. α2<α1**= ***10***°

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

8.4.15 Application and Setting Notes (Synchronous/Asynchronous Closure)

Parameter: **Synchronous operating mode**, **Asynchronous operating mode**

- Default setting **(_:5041:119) Sync. operating mode** = ***off***
- Default setting **(_:5041:114) Async. operating mode** = ***off***

The operating modes of the stages can be activated or deactivated via the parameters. The operating modes are deactivated in the default setting for safety reasons.

The following combination options are possible:

Sync. operating mode	Async. operating mode	Description
on	***on***	If the frequency difference is below the threshold value set **f-threshold ASYN<->SYN**, the operating mode **synchronous** is active. In other cases, the operating mode **asynchronous** is active. If you wish to interconnect galvanically isolated systems, then select this operating mode.
off	***on***	Regardless of the frequency difference and the threshold value **f-threshold ASYN<->SYN**, the operating mode active is exclusively **asynchronous**. The closing time of the circuit breaker is this always taken into account for determining the connecting point. Select this operating mode if you wish to activate machines, for example generators or asynchronous motors. If the same frequency is present on the sides to be interconnected, then this operating mode is not possible. Since, in the case of dependency on the phase angle position (Δα), release of the closure may not be issued.

Sync. operating mode	Async. operating mode	Description
on	***off***	Use this operating mode for galvanically connected systems. Closure is only possible with synchronous systems (with low Δf).
off	***off***	Both operating modes are deactivated. No closing release can be therefore be given via this operating mode. This configuration is only advisable for special applications. Select this operating mode if you only wish to switch, for example de-energized parts of the power system.

Parameter for asynchronous operation: Max. voltage diff. of voltage and frequency

- Default setting **(_:5041:115) Max. voltage diff. V2>V1** = ***2.0 V***
- Default setting **(_:5041:116) Max. voltage diff. V2<V1** = ***2.0 V***
- Default setting **(_:5041:117) Max. frequency diff. f2>f1** = ***0.10 Hz***
- Default setting **(_:5041:118) Max. frequency diff. f2<f1** = ***0.10 Hz***

For information, see **Parameter for synchronous operation**

Parameter for synchronous operation: Maximum voltage diff. of voltage and angle

- Default setting **(_:5041:122) Max. voltage diff. V2>V1** = ***5.0 V***
- Default setting **(_:5041:123) Max. voltage diff. V2<V1** = ***5.0 V***
- Default setting **(_:5041:124) Max. angle diff. α2>α1**= ***10***°
- Default setting **(_:5041:125) Max. angle diff. α2<α1**= ***10***°

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

Parameter: Switchover between synchronous and asynchronous operation

- Recommended setting value **(_:5041:120) f-threshold ASYN<->SYN** = ***0.01 Hz***

This parameter is used to set the frequency difference for switching over between synchronous and asynchronous operation.

Siemens recommends using the default setting of ***0.01 Hz***.

8.4.16 Application and Setting Notes (De-Energized Switching/Direct Close Command)

If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes. The above potential release conditions are independent of one another and can also be combined.

NOTE

For reasons of safety, the releases have been deactivated in the default setting and are therefore at ***no***. Even if you wish to apply one of these operating modes, Siemens recommends leaving the setting at ***no*** for reasons of safety. Set the operating mode only dynamically via the assigned binary input signal (for example **>Operating mode 'U1>U2<'**) (see also *Figure 8-72*). This prevents one of these operating modes from being incorrectly activated statically thereby resulting in an incorrect switching.

Parameter: **Close cmd. at V1< & V2>**

- Recommended setting value **(_:5071:105) Close cmd. at V1< & V2>** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1 of the power system is de-energized and part V2 of the power system is energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **Close cmd. at V1> & V2<**

- Recommended setting value **(_:5071:106) Close cmd. at V1> & V2<** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1 of the power system is energized and part V2 of the power system is de-energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **Close cmd. at V1< & V2<**

- Recommended setting value **(_:5071:107) Close cmd. at V1< & V2<** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If the parts V1 and V2 of the power system are de-energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **V1, V2 with voltage**

- Recommended setting value **(_:5071:104) V1, V2 with voltage** = ***80 V***

The setting value indicates the voltage above which a part of the power system (feeder or busbar) can be regarded as activated with certainty.

You must set the value below the minimum expected operational undervoltage. Siemens therefore recommends a setting value of approx. 80 % of the rated voltage. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: **V1, V2 without voltage**

- Recommended setting value **(_:5071:103) V1, V2 without voltage** = ***5 V***

The setting value indicates the voltage below which a part of the power system (feeder or busbar) can be regarded as deactivated with certainty.

Siemens recommends a setting value of approx. 5 % of the rated voltage for this. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: `Supervision time`

- Recommended setting value **`(_:5071:109) Supervision time`** = ***`0.1 s`***

The parameter defines a supervision time for which the above additional closing conditions have to be at least fulfilled at de-energized switching, before the release for closing is given. In order to include transient phenomena, Siemens recommends a value of ***`0.1 s`***.

Parameter: `Direct close command`

- Recommended setting value **`(_:5071:108) Direct close command`** = ***`no`***

In this operating mode, the function initiates a closing release without any testing upon start of the synchronization stage. The closure occurs immediately.



NOTE

For safety reasons, Siemens recommends leaving the setting at ***`no`***. If a direct close command is necessary, Siemens recommends only using this operating mode dynamically via the binary input signal **`>Op. mode 'dir.cls.cmd'`** (see also *Figure 8-74*). This prevents this operating mode from being incorrectly activated statically thereby resulting in an incorrect switching.

8.4.17 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:127	General:Angle adjust. (transform.)		-179.0 ° to 180.0 °	0.0 °
`General`				
_:5071:1	Synchrocheck 1:Mode		• off • on • test	off
_:5071:101	Synchrocheck 1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5071:102	Synchrocheck 1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5071:110	Synchrocheck 1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5071:108	Synchrocheck 1:Direct close command		• no • yes	no
_:5071:126	Synchrocheck 1:Voltage adjustment		0.500 to 2.000	1.000
`De-en.gized switch.`				
_:5071:105	Synchrocheck 1:Close cmd. at V1< & V2>		• no • yes	no
_:5071:106	Synchrocheck 1:Close cmd. at V1> & V2<		• no • yes	no
_:5071:107	Synchrocheck 1:Close cmd. at V1< & V2<		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:5071:103	Synchrocheck 1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5071:104	Synchrocheck 1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5071:109	Synchrocheck 1:Supervision time		0.00 s to 60.00 s	0.1 s
Synchr. conditions				
_:5071:122	Synchrocheck 1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5071:123	Synchrocheck 1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5071:117	Synchrocheck 1:Max. frequency diff. f2>f1		0.000 Hzto 2.000 Hz	0.100 Hz
_:5071:118	Synchrocheck 1:Max. frequency diff. f2<f1		0.000 Hzto 2.000 Hz	0.100 Hz
_:5071:124	Synchrocheck 1:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:5071:125	Synchrocheck 1:Max. angle diff. α2<α1		0 ° to 90 °	10 °
General				
_:5041:1	Sychr./Asycr.1:Mode		• off • on • test	off
_:5041:101	Sychr./Asycr.1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5041:102	Sychr./Asycr.1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5041:110	Sychr./Asycr.1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5041:108	Sychr./Asycr.1:Direct close command		• no • yes	no
_:5041:126	Sychr./Asycr.1:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:5041:105	Sychr./Asycr.1:Close cmd. at V1< & V2>		• no • yes	no
_:5041:106	Sychr./Asycr.1:Close cmd. at V1> & V2<		• no • yes	no
_:5041:107	Sychr./Asycr.1:Close cmd. at V1< & V2<		• no • yes	no
_:5041:103	Sychr./Asycr.1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5041:104	Sychr./Asycr.1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5041:109	Sychr./Asycr.1:Supervision time		0.00 s to 60.00 s	0.1 s
Asynchr. op.mode				
_:5041:114	Sychr./Asycr.1:Async. operating mode		• off • on	on
_:5041:113	Sychr./Asycr.1:CB make time		0.01 sto 0.60 s	0.06 s

Addr.	Parameter	C	Setting Options	Default Setting
_:5041:115	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:116	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:117	Sychr./Asycr.1:Max. frequency diff. f2>f1		0.000 Hzto 4.000 Hz	0.100 Hz
_:5041:118	Sychr./Asycr.1:Max. frequency diff. f2<f1		0.000 Hzto 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:5041:119	Sychr./Asycr.1:Sync. operating mode		• off • on	on
_:5041:120	Sychr./Asycr.1:f-threshold ASYN<->SYN		0.010 Hzto 0.200 Hz	0.010 Hz
_:5041:122	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:123	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:124	Sychr./Asycr.1:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:5041:125	Sychr./Asycr.1:Max. angle diff. α2<α1		0 ° to 90 °	10 °
_:5041:121	Sychr./Asycr.1:Delay close command		0.00 s to 60.00 s	0.00 s
dfdiff/dt limitation				
_:140	Adv. options:Limit dfdiff/dt for sync. op		• 0 • 1	false
_:141	Adv. options:Max. value dfdiff/dt syn		0.010 Hz/sto 0.025 Hz/s	0.010 Hz/s
_:142	Adv. options:Limit dfdiff/dt for asyn. op		• 0 • 1	false
_:143	Adv. options:Max. value dfdiff/dt asyn		0.050 Hz/sto 0.500 Hz/s	0.050 Hz/s
Frequ. oscillations				
_:150	Adv. options:Suppr. frequ. oscillations		• 0 • 1	false
_:151	Adv. options:Max. diff. "f threshold"		0.000 Hzto 0.100 Hz	0.000 Hz

8.4.18 Information List

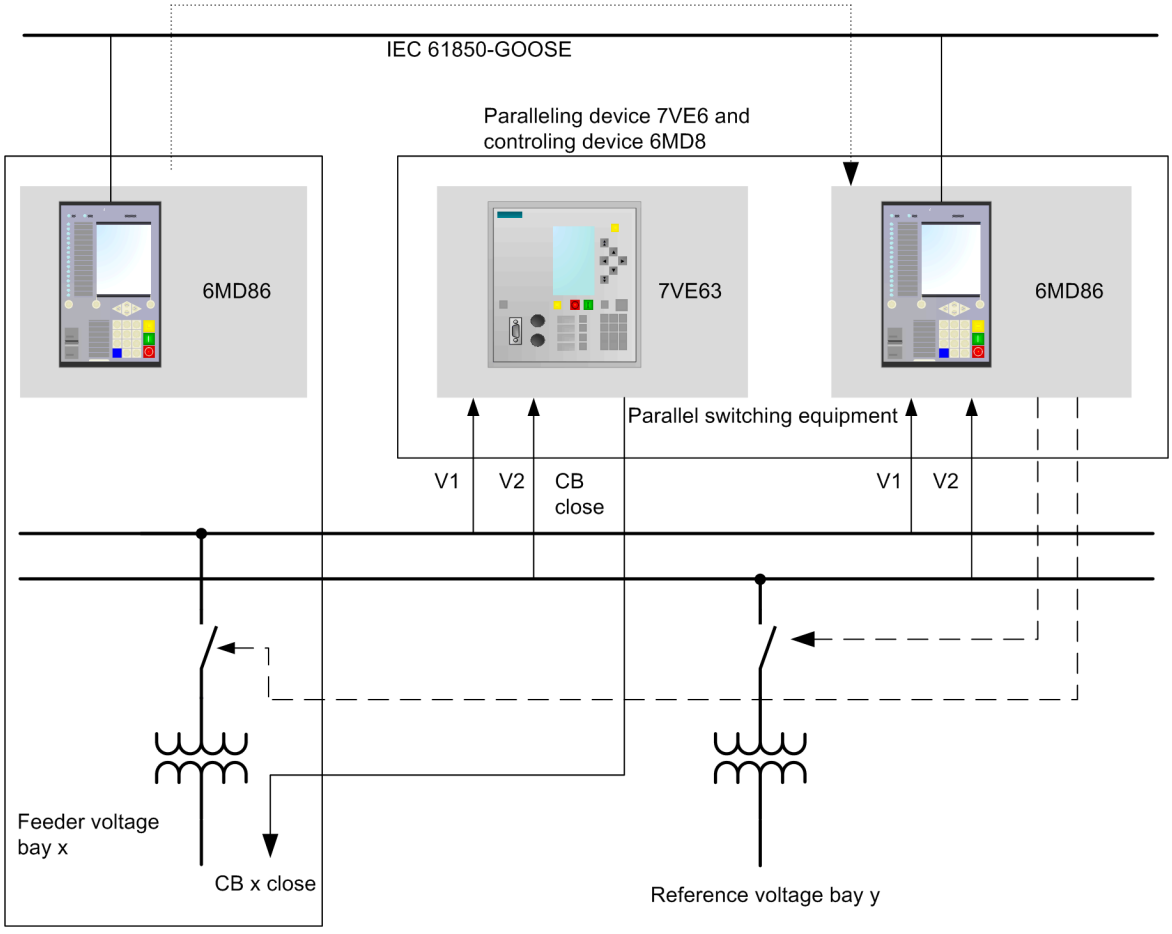
No.	Information	Data Class (Type)	Type
Measurements			
_:2311:303	General:Multiple selection	SPS	O
_:2311:304	General:Blocked no V selected	SPS	O
_:2311:329	General:V1	MV	O
_:2311:330	General:f1	MV	O
_:2311:331	General:V2	MV	O
_:2311:332	General:f2	MV	O
_:2311:300	General:dV	MV	O

No.	Information	Data Class (Type)	Type
_:2311:301	General:df	MV	O
_:2311:302	General:dα	MV	O
Synchrocheck 1			
_:5071:81	Synchrocheck 1:>Block stage	SPS	I
_:5071:500	Synchrocheck 1:>Selection	SPS	I
_:5071:502	Synchrocheck 1:>Start / stop syn.proc.	SPS	I
_:5071:503	Synchrocheck 1:>Start syn. process	SPS	I
_:5071:504	Synchrocheck 1:>Stop syn. process	SPS	I
_:5071:506	Synchrocheck 1:>Op. mode 'V1<V2>'	SPS	I
_:5071:505	Synchrocheck 1:>Op. mode 'V1>V2<'	SPS	I
_:5071:507	Synchrocheck 1:>Op. mode 'V1<V2<'	SPS	I
_:5071:508	Synchrocheck 1:>Op. mode 'dir.cls.cmd'	SPS	I
_:5071:501	Synchrocheck 1:>Block close command	SPS	I
_:5071:54	Synchrocheck 1:Inactive	SPS	O
_:5071:52	Synchrocheck 1:Behavior	ENS	O
_:5071:53	Synchrocheck 1:Health	ENS	O
_:5071:328	Synchrocheck 1:In progress	SPS	O
_:5071:324	Synchrocheck 1:Release close cmd.	SPS	O
_:5071:305	Synchrocheck 1:All sync. conditio. OK	SPS	O
_:5071:325	Synchrocheck 1:Voltage difference OK	SPS	O
_:5071:326	Synchrocheck 1:Angle difference OK	SPS	O
_:5071:327	Synchrocheck 1:Frequency diff. OK	SPS	O
_:5071:307	Synchrocheck 1:Cond. V1<V2> fulfilled	SPS	O
_:5071:306	Synchrocheck 1:Cond. V1>V2< fulfilled	SPS	O
_:5071:308	Synchrocheck 1:Cond. V1<V2< fulfilled	SPS	O
_:5071:309	Synchrocheck 1:Frequency f1 > fmax	SPS	O
_:5071:310	Synchrocheck 1:Frequency f1 < fmin	SPS	O
_:5071:311	Synchrocheck 1:Frequency f2 > fmax	SPS	O
_:5071:312	Synchrocheck 1:Frequency f2 < fmin	SPS	O
_:5071:313	Synchrocheck 1:Voltage V1 > Vmax	SPS	O
_:5071:314	Synchrocheck 1:Voltage V1 < Vmin	SPS	O
_:5071:315	Synchrocheck 1:Voltage V2 > Vmax	SPS	O
_:5071:316	Synchrocheck 1:Voltage V2 < Vmin	SPS	O
_:5071:317	Synchrocheck 1:V dif.too large(V2>V1)	SPS	O
_:5071:318	Synchrocheck 1:V dif.too large(V2<V1)	SPS	O
_:5071:319	Synchrocheck 1:f dif.too large(f2>f1)	SPS	O
_:5071:320	Synchrocheck 1:f dif.too large(f2<f1)	SPS	O
_:5071:321	Synchrocheck 1:α dif.too large(α2>α1)	SPS	O
_:5071:322	Synchrocheck 1:α dif.too large(α2<α1)	SPS	O
_:5071:304	Synchrocheck 1:Max. time exceeded	SPS	O
_:5071:323	Synchrocheck 1:Setting error	SPS	O
Sychr./Asycr.1			
_:5041:81	Sychr./Asycr.1:>Block stage	SPS	I
_:5041:500	Sychr./Asycr.1:>Selection	SPS	I
_:5041:502	Sychr./Asycr.1:>Start / stop syn.proc.	SPS	I
_:5041:503	Sychr./Asycr.1:>Start syn. process	SPS	I

No.	Information	Data Class (Type)	Type
_:5041:504	Sychr./Asycr.1:>Stop syn. process	SPS	I
_:5041:506	Sychr./Asycr.1:>Op. mode 'V1<V2>'	SPS	I
_:5041:505	Sychr./Asycr.1:>Op. mode 'V1>V2<'	SPS	I
_:5041:507	Sychr./Asycr.1:>Op. mode 'V1<V2<'	SPS	I
_:5041:508	Sychr./Asycr.1:>Op. mode 'dir.cls.cmd'	SPS	I
_:5041:501	Sychr./Asycr.1:>Block close command	SPS	I
_:5041:54	Sychr./Asycr.1:Inactive	SPS	O
_:5041:52	Sychr./Asycr.1:Behavior	ENS	O
_:5041:53	Sychr./Asycr.1:Health	ENS	O
_:5041:328	Sychr./Asycr.1:In progress	SPS	O
_:5041:324	Sychr./Asycr.1:Release close cmd.	SPS	O
_:5041:305	Sychr./Asycr.1:All sync. conditio. OK	SPS	O
_:5041:303	Sychr./Asycr.1:State f-synchronous	SPS	O
_:5041:325	Sychr./Asycr.1:Voltage difference OK	SPS	O
_:5041:326	Sychr./Asycr.1:Angle difference OK	SPS	O
_:5041:327	Sychr./Asycr.1:Frequency diff. OK	SPS	O
_:5041:307	Sychr./Asycr.1:Cond. V1<V2> fulfilled	SPS	O
_:5041:306	Sychr./Asycr.1:Cond. V1>V2< fulfilled	SPS	O
_:5041:308	Sychr./Asycr.1:Cond. V1<V2< fulfilled	SPS	O
_:5041:309	Sychr./Asycr.1:Frequency f1 > fmax	SPS	O
_:5041:310	Sychr./Asycr.1:Frequency f1 < fmin	SPS	O
_:5041:311	Sychr./Asycr.1:Frequency f2 > fmax	SPS	O
_:5041:312	Sychr./Asycr.1:Frequency f2 < fmin	SPS	O
_:5041:313	Sychr./Asycr.1:Voltage V1 > Vmax	SPS	O
_:5041:314	Sychr./Asycr.1:Voltage V1 < Vmin	SPS	O
_:5041:315	Sychr./Asycr.1:Voltage V2 > Vmax	SPS	O
_:5041:316	Sychr./Asycr.1:Voltage V2 < Vmin	SPS	O
_:5041:317	Sychr./Asycr.1:V dif.too large(V2>V1)	SPS	O
_:5041:318	Sychr./Asycr.1:V dif.too large(V2<V1)	SPS	O
_:5041:319	Sychr./Asycr.1:f dif.too large(f2>f1)	SPS	O
_:5041:320	Sychr./Asycr.1:f dif.too large(f2<f1)	SPS	O
_:5041:321	Sychr./Asycr.1:α dif.too large(α2>α1)	SPS	O
_:5041:322	Sychr./Asycr.1:α dif.too large(α2<α1)	SPS	O
_:5041:304	Sychr./Asycr.1:Max. time exceeded	SPS	O
_:5041:323	Sychr./Asycr.1:Setting error	SPS	O

8.4.19 External Synchronization

The purpose of the **External synchronization** function is to control an external synchronization device.



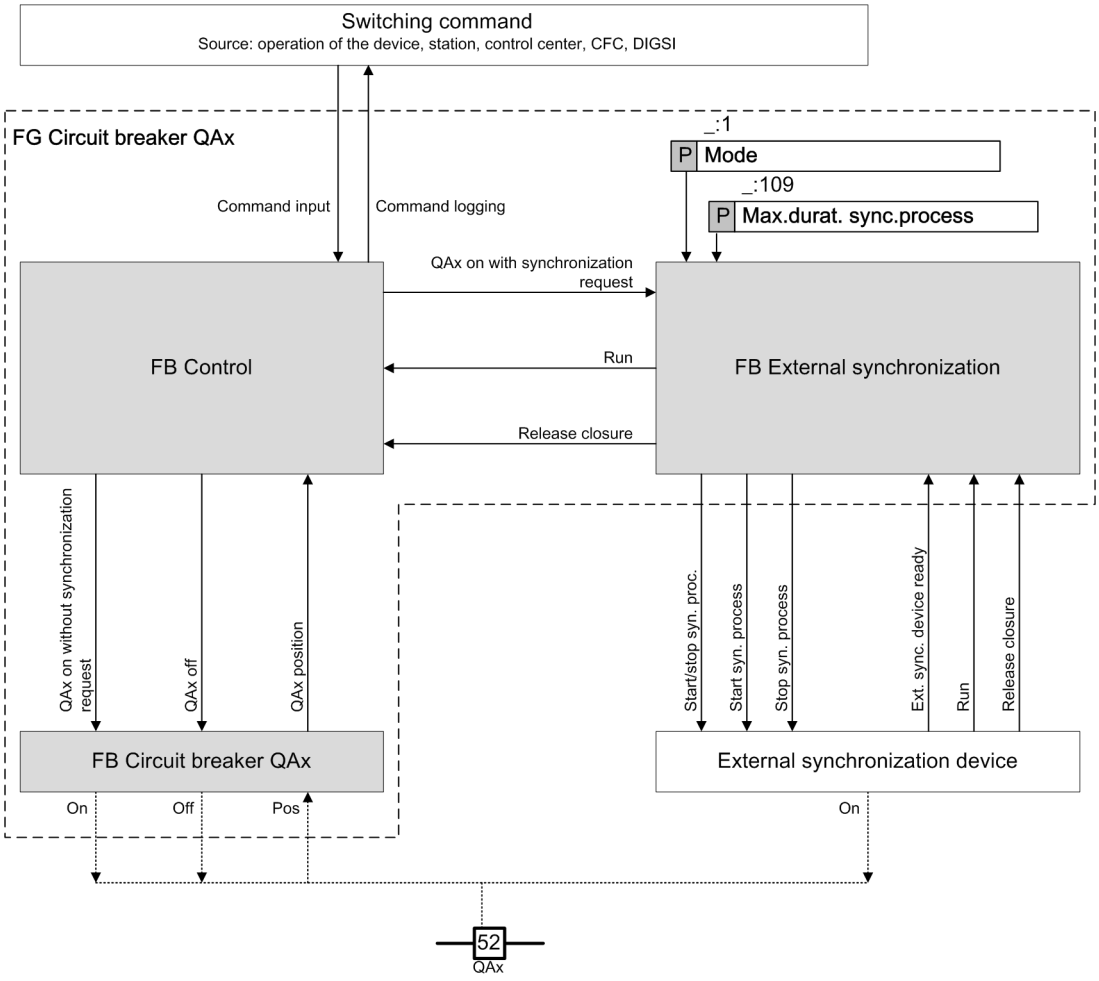
[dw_ctrl_ext_sync_device, 1, en_US]

Figure 8-78 Triggering an External Synchronization Device

The bay controller in bay x should switch the circuit breaker in bay x in synchrony. The synchronization check is carried out in the central paralleling device 7VE6. In addition to the paralleling device, another central bay controller ensures the switching of the correct measuring voltages and the routing of the CB close command from the 7VE6 to the correct circuit breaker in bay x. The bay controller x provides the information to the central bay controller via IEC61850-GOOSE.

The **External synchronization** is designed as a function block which can be used in the Circuit-breaker function group. The additional **External synchronization** function block integrates the external synchronization into command processing, so that the corresponding feedback can be forwarded to the command source.

If a circuit-breaker close command with a synchronization requirement is present, the external synchronization device is started. After successfully checking the synchronization conditions, the close command is issued from the external synchronization device to the circuit breaker. If a circuit-breaker close command without synchronization requirement is present, the circuit-breaker close command is issued directly from the **Circuit-breaker** function group to the circuit breaker. Also, each circuit-breaker trip command is issued directly to the circuit breaker.

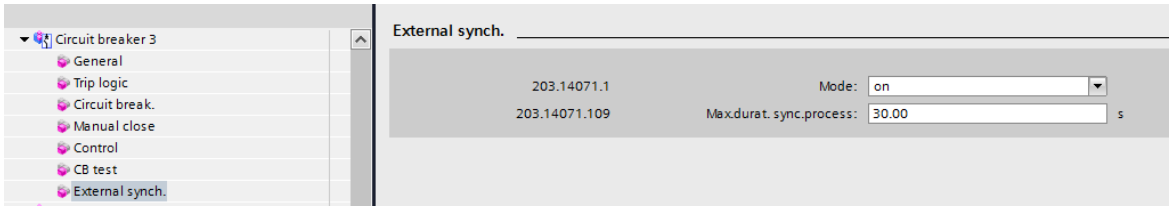


[dwextsyn-01, 1, en_US]

Figure 8-79 Interaction between Control and External Synchronization

Parameterization with DIGSI

In the DIGSI library, the function is visible inside the **Circuit-breaker** function group as the **External synchronization** function block. You can instantiate the function block in the **Circuit-breaker** function group and the **Circuit-breaker (control)** function group. You can instantiate only 1 **External synchronization** function block within these function groups at a time.



[scextsyn, 1, 1, en_US]

Figure 8-80 Instantiating the **External Synchronization** Function Block in the **Circuit-Breaker** Function Group

It is not possible to jointly instantiate the **External synchronization** function block with the **25 synchronization** function in the same **Circuit-breaker** function group.

Notes for Optional Input Interconnections

You have the option of connecting the input signals *>Close cmd. released* and *>In progress* . If you omit these interconnections, observe the following instructions:

Input *>Close cmd. released* :

If you do not interconnect the input signal *>Close cmd. released* , the execution of a circuit-breaker close command with synchronization requirement is confirmed directly (execution successful: OPR+), as soon as the output signal *Start syn. process* is set. In this case, the **(_:109) Max.durat. sync.process** setting has no meaning. If you use a control model with feedback monitoring, consider that the feedback monitoring will start immediately when the *Start syn. process* signal is tripped. The **(_:4201:103) Feedback monitoring time** setting must therefore be set higher than the maximum synchronization time of the external synchronization device plus the circuit-breaker closing time. If *>Close cmd. released* is not routed, the output *Start/stop syn. proc.* is not set.

Input *>In progress* :

The interconnection of the input signal *>In progress* is intended to check whether the synchronization device has received the *Start syn. process* signal. If you do not interconnect this input signal and the external synchronization device rejects a start command, the negative acknowledgment of the circuit-breaker close command does not occur until the maximum synchronization time (parameter **(_:109) Max.durat. sync.process**) has expired.

8.4.20 Application and Setting Notes (External Synchronization)

Parameter: Mode

- Default setting **(_:1) Mode** = *on*

With the **Mode** setting, you switch the external synchronization function on or off. If you set the **Mode** setting to *off*, a circuit-breaker close command with synchronization requirement is rejected.

Parameter: Max.durat. sync.process

- Default setting **(_:109) Max.durat. sync.process** = *30 s*

The **Max.durat. sync.process** setting defines the maximum synchronization time. The time starts when the **External synchronization** function block sends a close command to the external synchronization device. The command must be executed within this time. If the close command is not executed within this time, the **External synchronization** function block sends a command to cancel closing to the external synchronization device.

8.4.21 Settings

Addr.	Parameter	C	Setting Options	Default Setting
External synch.				
_:1	External synch.:Mode		• off • on • test	on
_:109	External synch.:Max.durat. sync.process		0.00 s to 3600.00 s	30.00 s

8.4.22 Information List

No.	Information	Data Class (Type)	Type
External synch.			
_:52	External synch.:Behavior	ENS	O
_:54	External synch.:Health	ENS	O
_:55	External synch.:Start syn. process	SPS	O
_:56	External synch.:Stop syn. process	SPS	O
_:57	External synch.:Start/stop syn. proc.	SPS	O
_:506	External synch.:>Synch. device ready	SPS	I
_:507	External synch.:>Close cmd. released	SPS	I
_:508	External synch.:>In progress	SPS	I

8.5 Switching Sequences

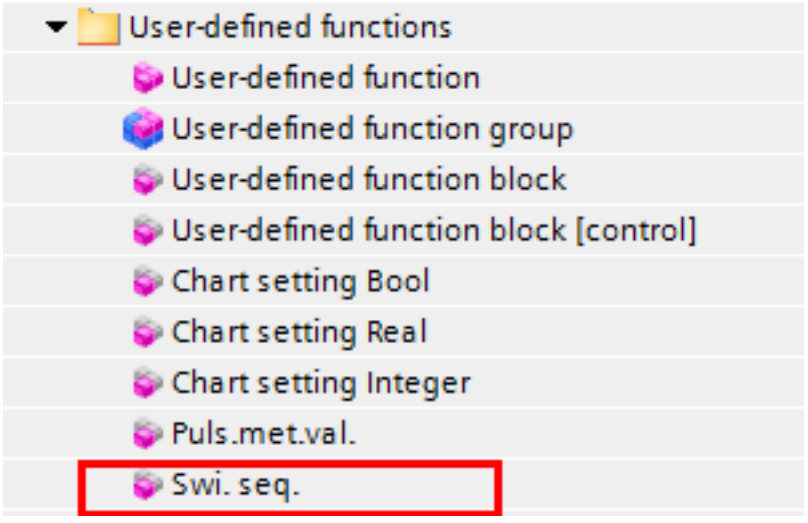
8.5.1 Overview of Functions

Switching sequences may be running inside the device that switch the switchgear automatically in a prespecified sequence.

A switching sequence consists of a special function block **Switching sequence** (Swi. seq.) from the DIGSI 5 Library and the project-specific list of the switching commands that are generated in the CFC.

8.5.2 Function Description

The function block **Switching sequence** is located in folder **User-defined functions** in the DIGSI 5 Library.

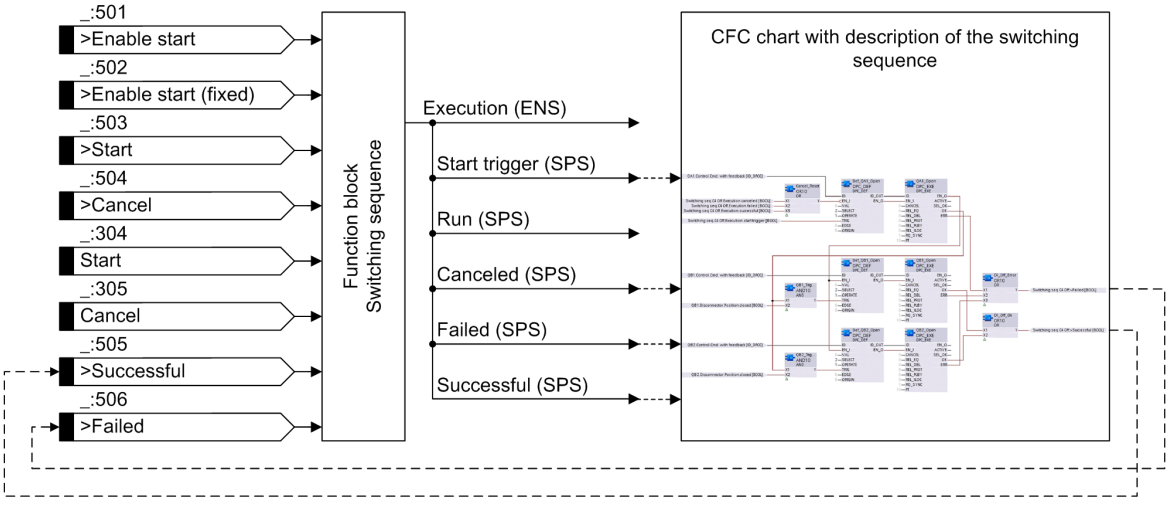


[scudeffb, 1, en_US]

Figure 8-81 Function block **Switching Sequence** in the Library

These function blocks can be used in the information matrix on the highest level (level of the function groups) or in a user-defined function group.

One **Switching sequence** function block is used per switching sequence. The function block is the interface for controlling and monitoring the condition of the CFC switching sequence. The task of the function block is to verify the relative conditions for control commands, for example, switching authority, interlocking conditions, etc. You can connect the signals of the function block with the CFC chart. They start and stop the switching sequence and provide data about the status of the switching sequence (see *Figure 8-82*). The CFC chart is used to activate the switching device that must be switched. The CFC blocks define, among other things, the switching devices that must be switched.



[dwswseq1-110913-01.vsd, 1, en_US]

Figure 8-82 **Switching Sequence** Function Block

Starting and Canceling a Switching Sequence

One of the following methods can be used to start a switching sequence:

- On-site operation: menu or display page
- Input *>Start* during rising edge, for example, via binary input
- Controllable *Start* for the start via a communication protocol, for example, IEC 61850, T103, or DNP
- Input *>Start* via a function key
- Controllable *Start* via a function key

One of the following methods can be used to cancel a switching sequence:

- On-site operation: menu or display page
- Input *>Cancel* during rising edge, for example, via binary input
- Controllable *Cancel* for the cancelation via a communication protocol, for example, IEC 61850, T103, or DNP
- Input *>Cancel* via a function key
- Controllable *Cancel* via a function key

On-Site Operation

If at least one **Switching sequence** function block is used in the device, a new **Switching sequences** entry is shown in the first line of the **Control** menu. If this menu item is selected, an overview of all switching sequences and the current status will be displayed (see *Figure 8-83* , example with 2 switching sequences). You can start or cancel the switching sequences from this menu.

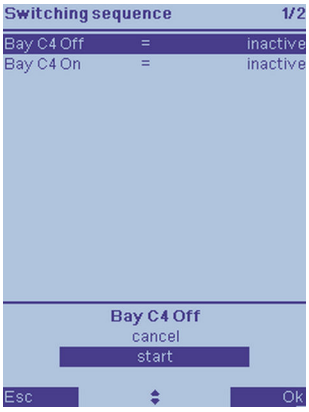
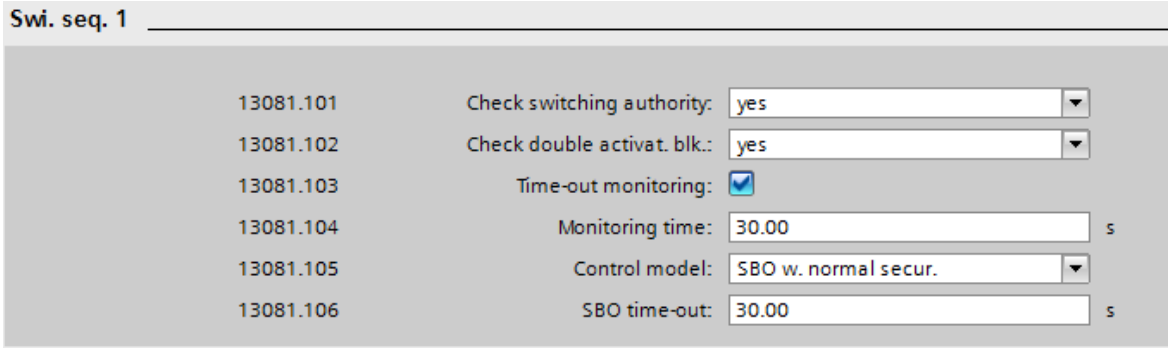


Figure 8-83
Overview of the Switching Sequences on the Device Display

8.5.3 Application and Setting Notes

This function block offers similar settings as the **Control** function block of a circuit breaker or disconnector (see chapter *8.2.1 General Overview*).



[scccs4pa-13112014_DE, 1, en_US]

Figure 8-84 Settings of the **Switching Sequence** Function Block

Parameter: **`Check switching authority`**

- Default setting **`(_:101) Check switching authority`** = ***`yes`***

With the **`Check switching authority`** parameter, you can determine whether the switching authority should be checked before the execution of the switching sequence.

Parameter: **`Check double activat. blk.`**

- Default setting **`(_:102) Check double activat. blk.`** = ***`yes`***

With the **`Check double activat. blk.`** parameter, you can determine whether the double activation of switching devices should be checked. The setting value ***`yes`*** indicates that a switching sequence will be started only if no switching commands for a circuit breaker and disconnector are activated, provided that double-activation blocking was activated for those switching devices.

Parameter: **`Time-out monitoring`**

With the **`Time-out monitoring`** parameter, you can determine whether the feedback from the process should be evaluated. The feedback is gathered via the inputs *`>Successful`* and *`>Failed`*.

Parameter: **`Monitoring time`**

- Default setting **`(_:104) Monitoring time`** = ***`30.00 s`***

With the **`Monitoring time`** parameter, you can determine the duration of the monitoring time.

Parameter: **`Control model`**

- Default setting **`(_:105) Control model`** = ***`SBO w. normal secur.`***

With the **`Control model`** parameter, you select between ***`direct w. normal secur.`*** or ***`SBO w. normal secur.`*** to start the switching sequence.

It is not possible to set a control model for cancelation of the switching sequence. The control model ***`direct w. normal secur.`*** is always used to cancel the function.

Information

The **Switching sequence** function block provides the following data:

Swi. seq. 1	13081	
>Enable start	13081.501	SPS
>Enable start (fixed)	13081.502	SPS
>Start	13081.503	SPS
>Cancel	13081.504	SPS
>Successful	13081.505	SPS
>Failed	13081.506	SPS
Health	13081.53	ENS
Execution	13081.302	ENS
start trigger		SPS
running		SPS
canceled		SPS
failed		SPS
successful		SPS
Start	13081.304	SPC
Cancel	13081.305	SPC
Switching auth. station	13081.303	SPC

[scinfof1-13112014, 1, en_US]

Figure 8-85 Data Provided by the **Switching Sequence** Function Block

In the **Switching sequence** function block, the interlocking is analog to the **Interlocking** function block and it is possible to use it in the switching sequence:

- *`>Enable start`*: Connection to interlocking conditions (CFC) for the start of the entire switching sequence. Not in effect in the **non-interlocked** switching mode.
- *`>Enable start (fixed)`*: Non-revocable interlocking conditions for the start of the entire switching sequence. In effect regardless of the switching mode.

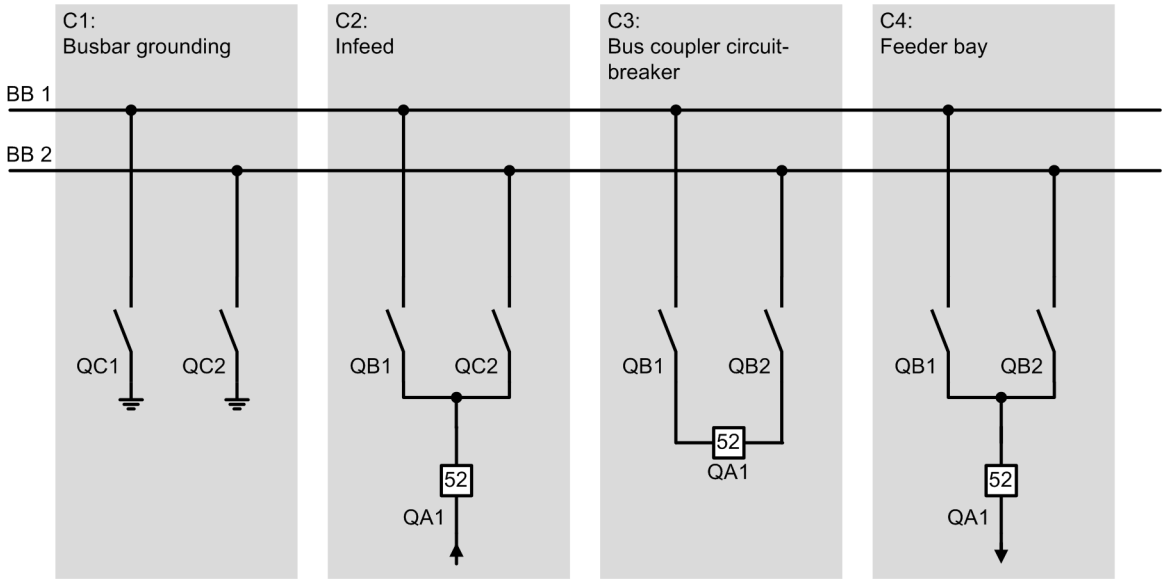
If the time-out monitoring is activated (parameter **`Time-out monitoring`**), the process feedback must take place via the inputs *`>Successful`* and *`>Failed`*. If the last switching command of the switching sequence was executed successfully, the input *`>Successful`* usually is set. To do this, connect the feedback of the last switching command from the CFC with this input of the function block during the device parameterization.

If a switching command fails, this feedback can be captured by the input *`>Failed`*. The active switching sequence will be ended immediately and does not have to wait for a time-out.

The indication *`Execution`* signals the current condition of the switching sequence. The events *`running`*, *`canceled`*, *`failed`*, and *`successful`* are generated only while the time-out monitoring is activated. The event *`Start Trigger`* is used to start the switching sequence in the CFC chart.

Example for a Switching Sequence with CFC

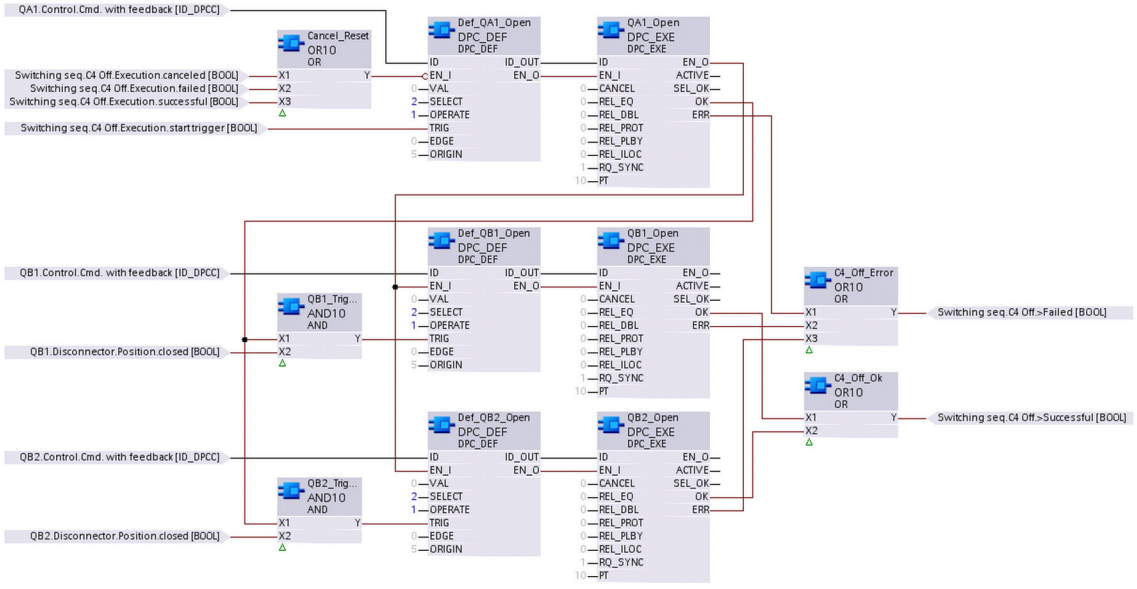
The following figure shows a single-line diagram for a substation with 4 bays: Busbar grounding, infeed, bus coupler, and feeder bay.



[dwbspunt-120913-01.vsd, 1, en_US]

Figure 8-86 Example of a Substation

The switching sequence **C4 Off** (*Figure 8-87*) should switch off feeder bay C4. The circuit breaker is opened; followed by opening of one of the 2 busbar disconnectors.



[Scssc4as-110913-01, 1, en_US]

Figure 8-87 CFC Switching Sequence **C4 Off**

Command Execution

As described in section *Starting and Canceling a Switching Sequence, Page 1107*, the display page or the **Control** menu can be used to start the switching sequence. The *Start Trigger* signal for indication *Execution* is used to recognize the start and initiates the switching sequence by pickup of **TRIG** in the DPC-DEF building block of circuit breaker QA1. Building blocks DPC-DEF and DPC-EXE are always used in pairs. The DEF building block controls the type and nature of the command

- **VAL** = Switching direction (0 = Off, 1 = On)
- **SELECT** = Select switching device (2 = Select with a value suitable for the preset control model ***SBO w. enh. security***)
- **OPERATE** = Switch switching device (1 = Switching device is switched on or off)

Using the connected DPC-EXE building block, the command checks can be deactivated (**REL_**...). In the application example, all inputs are set to 0 and therefore, all checks are activated.

After the open command of circuit breaker QA1 is acknowledged via the auxiliary contacts, the **OK** output of the CFC block DPC_EXE becomes active and triggers the next switching object. With the input **PT** the signal for the **OK** output is time-delayed (in the example by 10 ms) and creates a dead time between individual switching commands and the switching sequence. This dead time is important for the updating of the interlocking conditions.

If QB1 is closed, QB1 will be opened. If QB2 is closed, QB2 will be opened. In order to implement this logic, the **OK** output signal of QA1 is linked with the respective positions of circuit breakers QB1 and QB2 via the logical AND function. This signal serves as a trigger for the trip command of QB1 or QB2.

Because in this example the time-out monitoring is activated, the feedback about the successful or unsuccessful execution of the switching sequence must be parameterized. The **Switching sequence** function block provides the inputs *>Successful* and *>Failed*. In order to acknowledge the entire switching sequence positively, the OR operation of the **OK** outputs for the disconnectors QB1 and QB2 is sufficient. The feedback of all failed executions takes place via the OR operation of all **ERR** outputs of the switching devices. The benefit of such assessment is the fact that, in case of a failure, waiting for the time-out is not necessary, but the active switching sequence can be ended immediately.

In this example, the use of the **EN_I** input of building block DPC-DEF fulfills 2 tasks:

- Cancelation of the entire switching sequence
- Resetting of the outputs **OK** and **ERR** on building block DPC-EXE

By linking all **EN_I** inputs and **EN_O** outputs of building blocks DPC-DEF and DPC-EXE, the execution of the switching sequence can be controlled centrally since the value is transmitted between the building blocks. Only if input **EN_I** on the DPC-EXE is set to 1, a switching command is issued. If the input drops back to 0 while a command is being processed, this command will be canceled. With this behavior, cancelation of an entire switching sequence can be achieved. As recognition of a cancelation, the *canceled* signal of the indication *Execution* is used in the CFC chart and connected with the input **EN_I** of the first switching device, in this example, with the DPC-DEF building block of circuit breaker QA1.

Since the **OK** and **ERR** outputs of the DPC-EXE building block maintain their value until execution of the next command, it is necessary to reset the continuous output after each execution of the switching sequence for correct execution of the entire CFC switching sequence multiple times. In this case, the use of the **EN_I** input is also helpful. In the input drops back to 0, the **OK** and **ERR** outputs are also reset to 0. The triggers for ending the switching sequence are the events *failed* and *successful*. For this reason, in the above example, the signals *failed* and *successful* of the indication *Execution* were connected with **EN_I** of the DPC-DEF building block.

8.5.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Swi. seq. #				
_:101	Swi. seq. #:Check switching authority		• no • yes • advanced	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:102	Swi. seq. #:Check double activat. blk.		• no • yes	yes
_:103	Swi. seq. #:Time-out monitoring		• 0 • 1	true
_:104	Swi. seq. #:Monitoring time		0.02 s to 3600.00 s	30.00 s
_:105	Swi. seq. #:Control model		• direct w. normal secur. • SBO w. normal secur.	SBO w. normal secur.
_:106	Swi. seq. #:SBO time-out		0.01 s to 1800.00 s	30.00 s
Switching authority				
_:151	Swi. seq. #:Swi.dev. related sw.auth.		• 0 • 1	false
_:152	Swi. seq. #:Specific sw. authorities		• 0 • 1	true
_:115	Swi. seq. #:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:153	Swi. seq. #:Num. of specific sw.auth.		2 to 5	2
_:154	Swi. seq. #:Multiple specific sw.auth.		• 0 • 1	false

8.5.5 Information List

No.	Information	Data Class (Type)	Type
Swi. seq. #			
_:501	Swi. seq. #:>Enable start	SPS	I
_:502	Swi. seq. #:>Enable start (fixed)	SPS	I
_:503	Swi. seq. #:>Start	SPS	I
_:504	Swi. seq. #:>Cancel	SPS	I
_:505	Swi. seq. #:>Successful	SPS	I
_:506	Swi. seq. #:>Failed	SPS	I
_:53	Swi. seq. #:Health	ENS	O
_:302	Swi. seq. #:Execution	ENS	O
_:304	Swi. seq. #:Start	SPC	C
_:305	Swi. seq. #:Cancel	SPC	C

8.6 User-Defined Function Block [Control]

8.6.1 Overview of Functions

The **User-defined function block [control]** allows the switching-authority check of a control command and the check of whether the circuit breaker has reached the position for user-defined controllables.

8.6.2 Function Description

The **User-defined function block [control]** is located in the folder **User-defined functions** in the DIGSI 5 Library.

You can instantiate the user-defined function blocks on the top level (in parallel to other function groups) as well as within function groups and functions.

The task of the function block is to check the switching authority. For control commands, the function block checks whether the switching direction is the same as the current switch position. You can instantiate every user-defined signal (for example, SPS, DPC, INC) in the function block and route the corresponding indications (see following figure).

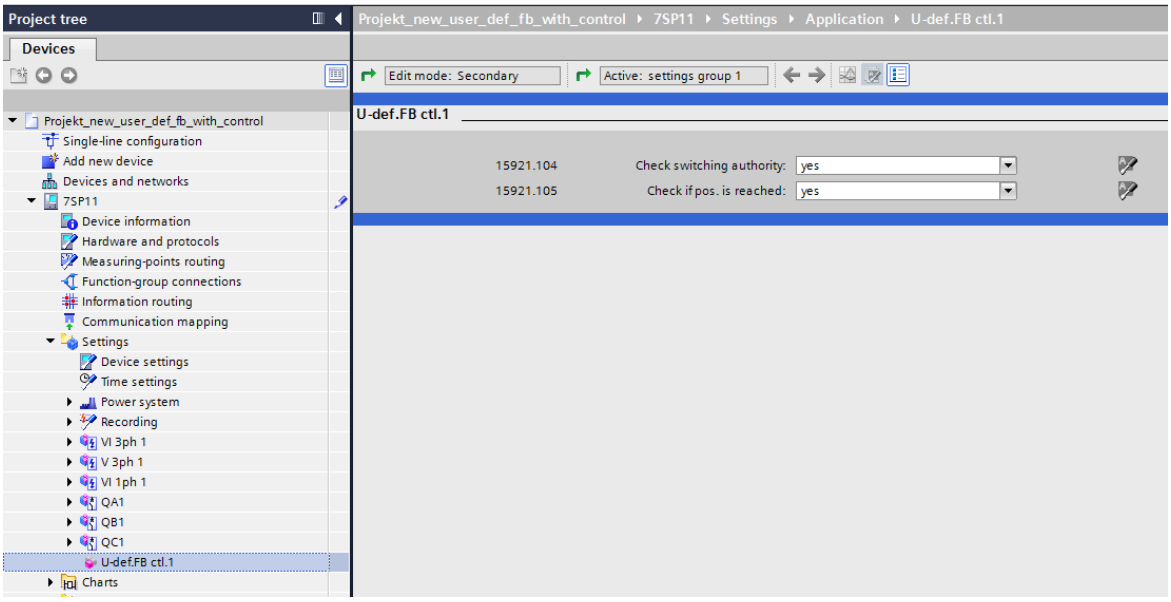
Information			Source					
			Binary input					
			Basismodul					
Signals	Number	Type	1.1	1.2	1.3	1.4	2.1	2.2
(All)	(All)	...	...	...	...	...	...	...
U-def.FB ctl.1	15921				*	*		
Mode (controllable)	15921.51	ENC						
Behavior	15921.52	ENS						
Health	15921.53	ENS						
Switching auth. local	15921.300	SPS						
Switching auth. station	15921.302	SPC						
SPC		SPC			H			
DPC		DPC				CH		
INC		INC						

[scbenutz, 1, en_US]

Figure 8-88 Information Routing with Inserted User-Defined Function Block [Control]: Process Indications and Some Individual Indications

8.6.3 Application and Setting Notes

The function block contains the parameters **(_:104) Check switching authority** and **(_:105) Check if pos. is reached** as shown in the following figure. The parameter settings affect all controllables instantiated in the function block. Other signal types are not affected by these parameters and objects.



[user-def2, 1, en_US]

Figure 8-89 Parameterization Options of the User-Defined Function Block [Control]

Parameter: `Check switching authority`

- Default setting **`(_:104) Check switching authority`** = ***yes***

With the **`Check switching authority`** parameter, you determine whether the command source of switching commands must be checked (see chapter *8.3.1 Command Checks and Switchgear Interlocking Protection*).

Parameter: `Check if pos. is reached`

- Default setting **`(_:105) Check if pos. is reached`** = ***yes***

With the **`Check if pos. is reached`** parameter, you check at a switching command whether the switching direction equals the current position.

8.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
U-def.FB ctl.#				
_:104	U-def.FB ctl.#:Check switching authority		• no • yes	yes
_:105	U-def.FB ctl.#:Check if pos. is reached		• no • yes	yes

8.6.5 Information List

No.	Information	Data Class (Type)	Type
U-def.FB ctl.#			
_:51	U-def.FB ctl.#:Mode (controllable)	ENC	C
_:52	U-def.FB ctl.#:Behavior	ENS	O
_:53	U-def.FB ctl.#:Health	ENS	O
_:300	U-def.FB ctl.#:Switching auth. local	SPS	O
_:302	U-def.FB ctl.#:Switching auth. station	SPC	C

8.7 CFC-Chart Settings

8.7.1 Overview of Functions

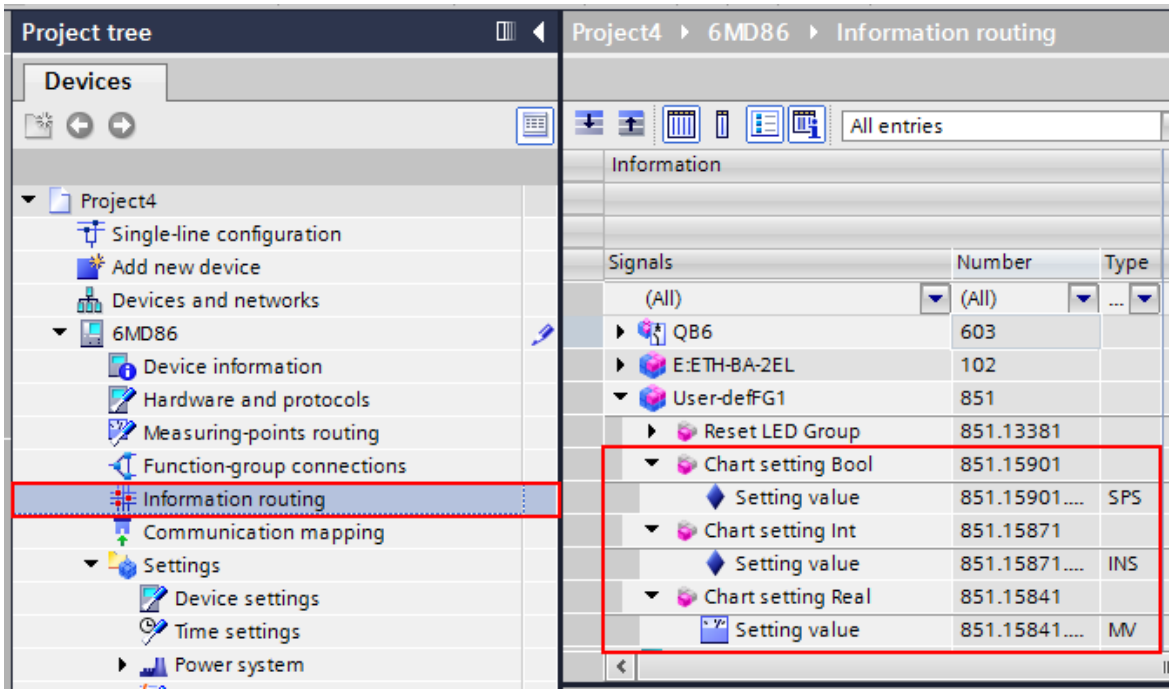
If you want to process a parameter in a CFC chart and this parameter is to be changeable via DIGSI or HMI during runtime, you can use the function blocks **Chart setting Bool**, **Chart setting Integer**, and **Chart setting Real**. Instantiate the appropriate function block depending on the needed parameter value (logical, integer, or floating point).

8.7.2 Function Description

You can find the CFC-chart parameters **`Chart setting Bool`** , **`Chart setting Int`** , and **`Chart setting Real`** in the DIGSI library in the **User-defined functions** folder. Drag and drop the desired function block into a function group or a function. Set the appropriate parameter value of the function block in DIGSI using the parameter editor or via HMI under the **Settings** menu item. You can then use the parameter as an input signal in CFC charts.

NOTE

The user-defined function groups and the user-defined functions can be used to group the CFC-chart parameters. You can rename for the function block and change the parameter value in the DIGSI Information routing matrix to suit your specific application.



[sccfcparam, 1, en_US]

Figure 8-90 CFC-Chart Parameters within Information Routing

8.7.3 Application and Setting Notes

Parameter: **`Chart setting Bool`**

- Default setting **`Chart setting Bool`** = ***`False`***

You can use the parameter **Chart setting Bool** in a CFC chart as an input signal with a Boolean value. This input value can then be changed during the runtime of the CFC chart.

Parameter: **Chart setting Int**

- Default setting **Chart setting Int** = ***10***

You can use the parameter **Chart setting Int** in a CFC chart as an input signal with an integer value. This input value can then be changed during the runtime of the CFC chart.

Parameter: **Chart setting Real**

- Default setting **Chart setting Real** = ***100.000***

You can use the parameter **Chart setting Real** in a CFC chart as an input signal with a floating-point number. This input value can then be changed during the runtime of the CFC chart.

8.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Bool				
_:105	Chart setting Bool:Value		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Int				
_:105	Chart setting Int:Value		-2147483648 to 2147483647	10

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Real				
_:105	Chart setting Real:Value		-10000000000.000 % to 10000000000.000 %	100.000 %

8.7.5 Information List

No.	Information	Data Class (Type)	Type
Chart setting Bool			
_:305	Chart setting Bool:Setting value	SPS	O

No.	Information	Data Class (Type)	Type
Chart setting Int			
_:305	Chart setting Int:Setting value	INS	O

No.	Information	Data Class (Type)	Type
Chart setting Real			
_:305	Chart setting Real:Setting value	MV	O

8.8 Transformer Tap Changers

8.8.1 Function Description

With the device control function, you can change a transformer tap by moving it higher or lower and monitor the proper execution of the adjusting commands.

The function has built-in comprehensive options for measuring the tap changer position as well as supervision functions. The supervision functions are used to check the voltage and supply information about the tap position for adaptive matching of the transformer differential protection.

The following options are provided for control:

- Direct user commands via the device keypad or routed binary inputs
- User-defined conditions via the CFC

If the tap changer reaches the end positions, the control function issues the *(_:301) End higher pos.reached* or *(_:302) End lower pos.reached* indication.

The transformer tap controller is controlled by the function group **Tap changer**, which you can select from the DIGSI library (group **Switching devices**).

Tap changer 1	161		*	*	*	*
Tap changer	161.5461		*	*	*	*
>Acquisition blocking	161.5461.500	SPS				
>Enable	161.5461.501	SPS				
>Reset AcqBlk&Subst	161.5461.504	SPS				
Health	161.5461.53	ENS				
End higher pos.reached	161.5461.301	SPS				
End lower pos.reached	161.5461.302	SPS				
Position	161.5461.308	BSC	X	X	X	X
acquisition blk. active		SPS				
manual update active		SPS				
Higher command	161.5461.305	SPS				
Lower command	161.5461.306	SPS				
Command active	161.5461.307	SPS				
Motor sup. time expired	161.5461.309	SPS				
Trigger motor prot. sw.	161.5461.310	SPS				
Position failure	161.5461.311	SPS				
Op.ct.	161.5461.312	INS				
Reset failure	161.5461.319	SPC				
Switching auth. station	161.5461.317	SPC				

[sc_tssdig, 1, en_US]

Figure 8-91 Tap Changer Functionality in the DIGSI Information Matrix

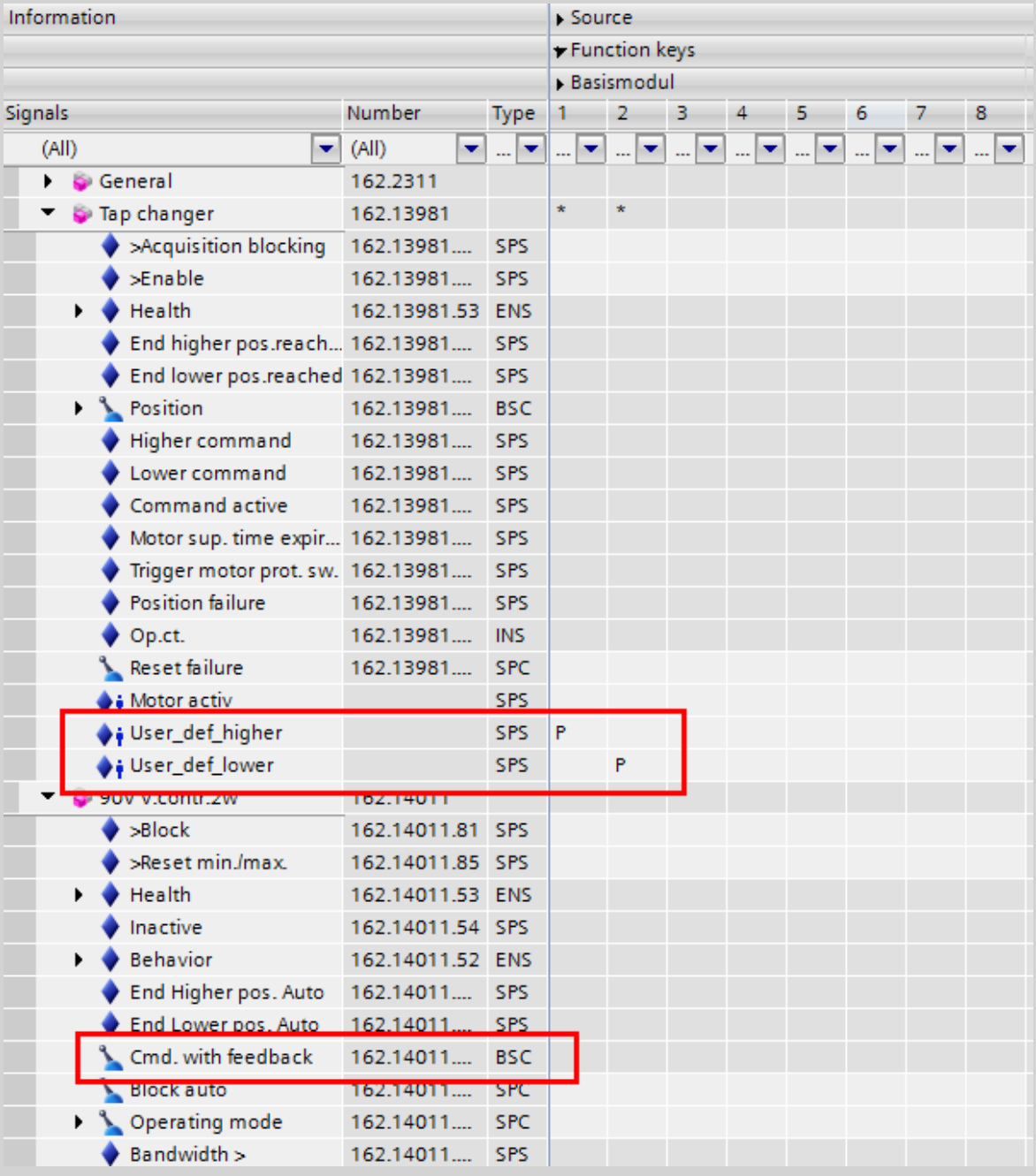
The central element is the Controllable **Position** of type BSC (Binary Controlled Step Position Information, based on IEC 61850). You connect this Controllable in the matrix to the desired number of binary inputs that indicate the current tap position.

You can find more information in chapter *8.8.2 Application and Setting Notes* .

The **Position** Controllable also contains settings. If you wish to change the settings, you must select the Controllable in the DIGSI information matrix and change the settings by way of the Properties dialog. The taps are controlled via the commands **Higher command** and **Lower command**, each of which must be connected to one binary output.

Example

The following 2 figures show a CFC chart as an example for transformer tap control with the routing of the function keys for stepping up or stepping down.



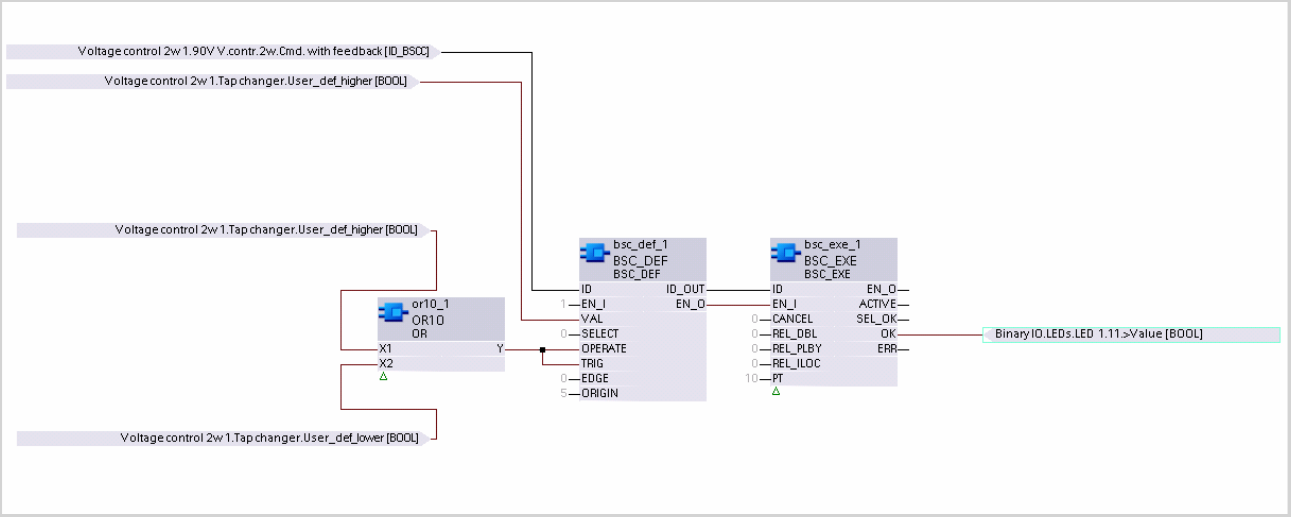
[schilocd-280316-01, 2, en_US]

Figure 8-92 Routing of the Function Keys and CFC Signals

To use the function keys, you create 2 user-defined single-point indications (SPS). These are used for the function keys (for example, <F1>, Higher function key and <F2>, Lower function key) and as the input signals for the appropriate CFC blocks. In addition, you must use the controllable **`Cmd. with feedback`** for the CFC chart.

You can select the control direction using the following values at the **Val** input of the BSC_DEF block.

- 1 means **step up**
- 0 means **step down**



[scbivctv-280715-01, 2, en_US]

Figure 8-93 CFC Chart

Using this simple CFC chart, pressing the function keys to step up or down incrementally can be displayed.

Motor Supervision Time

The runtime of the motor drive can be monitored from the device. This function is used to identify failures of the motor drive during switching and to trip actions if necessary. To use the **Motor supervision time** , you must route the motor sliding contact (highest binary input) and set the proper motor runtime.

The motor sliding contact is active until the tap changer has reached the new position. This time is compared to the **Motor supervision time** . If the new tap position is not reached within the motor runtime, the *Motor sup. time expired* indication is set. The *Trigger motor prot. sw.* indication with which the motor can be switched off is output after 1.5 s.

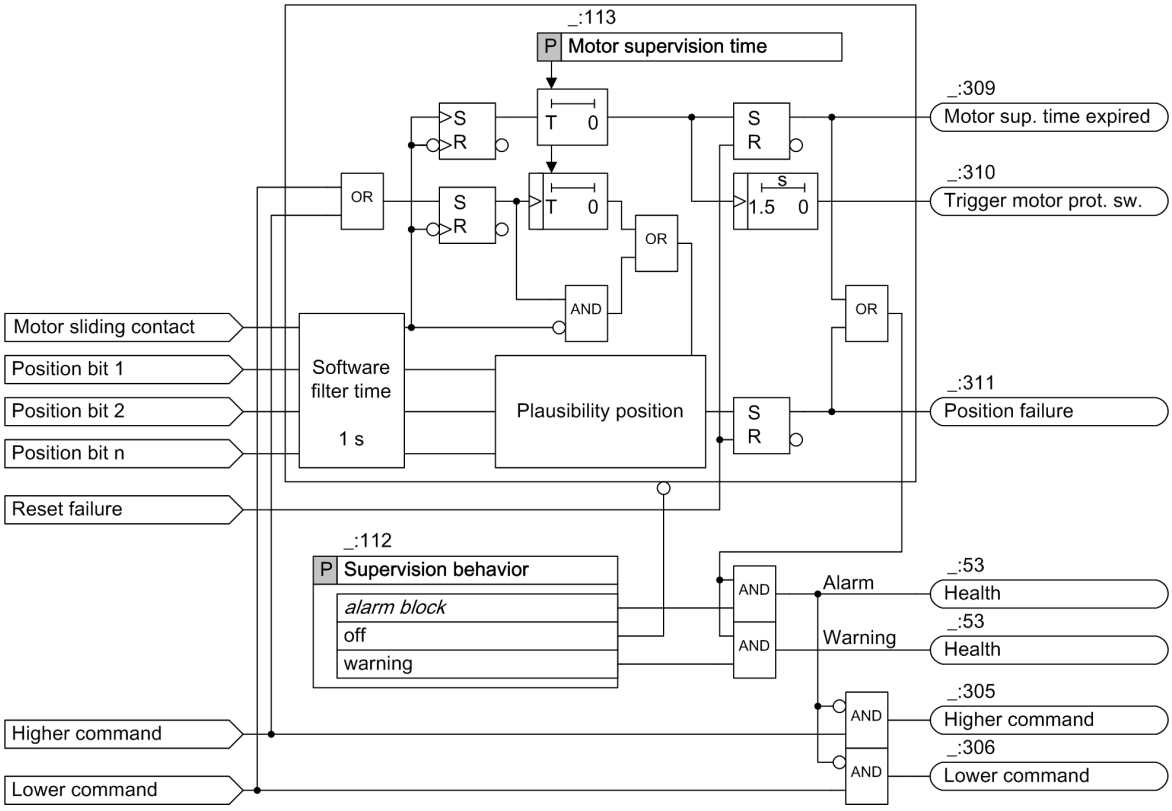
Adjusting-Command Monitoring

The adjusting-command monitoring is used for checking the proper operation of the tap-changer mechanism. The **Tap changer** function calculates the next logical tap position as a result of the higher/lower command. The time of position detection is determined as a function of the availability of the motor sliding contact. After resetting the active motor sliding contact, the **Tap changer** function reads the new tap position value. If the value for the next tap position could not be received within the parameterized time **Motor supervision time** , the error message *Position failure* is issued.

The following position errors of the tap changer considered during this:

- Invalid tap position: The tap position is outside the predefined range of **minimum value** and **maximum value**
- Position command in the wrong direction (for example, if a higher tap was commanded and the tap changer responds with a lower position or vice versa)
- No operation of the tap changer (for example, if the tap-changer motor is defective or the position indication is not functioning)
- Illogical tap-change operation (for example, if no logical tap position following the previous position is indicated)

The value of 0 during an unexpected interruption of the auxiliary voltage represents a special case. An invalid tap-changer position without a corresponding adjusting command is signaled only as an invalid tap position in the **Position** controllable.



[lotcmoue-090713-01.tif, 3, en_US]

Figure 8-94 Position and Motor Supervision Logic

Supervision Behavior

Depending on the setting of the **Supervision behavior** parameter, the function reaches a health state of **Alarm** or **Warning**. You can set the **Supervision behavior** parameter to ***off*** , ***alarm block*** , or ***warning*** .

In the ***alarm block*** mode, the function is set to the health state **Alarm**. All tap-changer commands are blocked.

In the ***warning*** mode, the function is set to the health state **Warning**. Executing tap-changer commands is still possible.

You can reset the health state of ***alarm block*** or ***warning*** manually using the controllable **Reset errors** (Main menu → Device functions → Reset functions → Tap changer). As an alternative to this, you can also switch off the supervision function and then switch it on again.

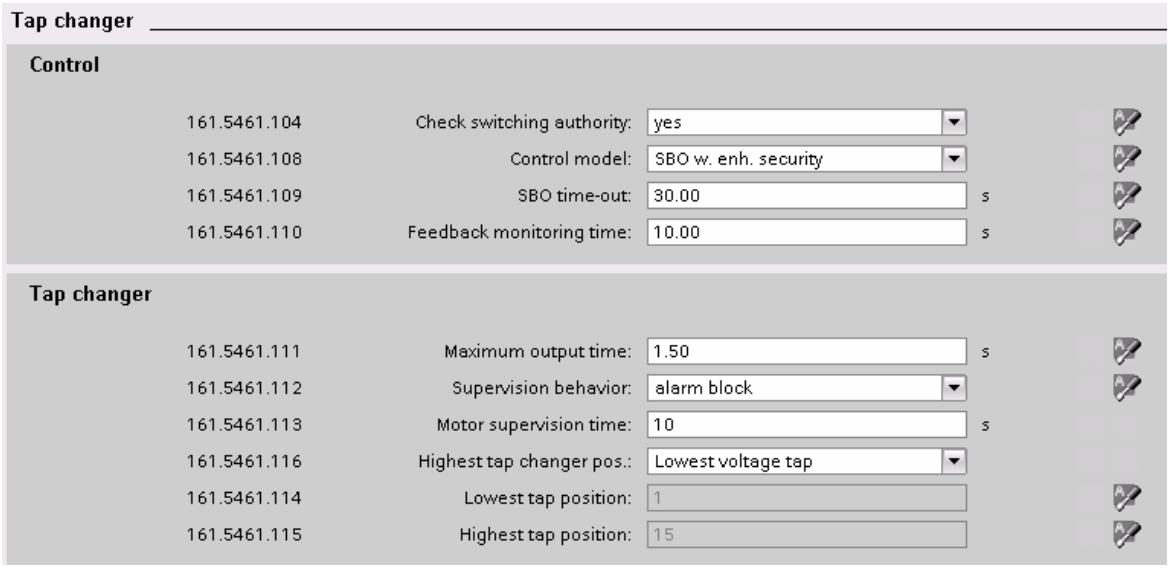
Operating Meter

The device counts the number of successfully completed adjusting commands with the ***Op.Ct.*** switching cycle metered value. The meter and memory levels are protected against an auxiliary-voltage failure. The switching cycle metered value can be preconfigured to 0 or to any other starting value.

You can access the statistical values via the operation panel on the device (measured values/statistics), via DIGSI, or using various communication protocols.

8.8.2 Application and Setting Notes

Parameters of the Transformer Tap Changer Function Group



[scstuslt-100713-01.tif, 2, en_US]

Figure 8-95 Parameters of the Tap Changer

NOTE

If run positions, this means internal tap changer positions without voltage changes, are available, the following must be observed:

If these tap changer positions contain a suffix a and c or + and -, and additional switching pulses are not required, adjust the parameter for the feedback and motor supervision time to the actual motor runtime when passing through a run position. Siemens recommends parameterization with capturing the motor sliding contact.

Parameter: **`Check switching authority`**

- Default setting **`(_:104) Check switching authority`** = ***`yes`***

Parameter: **`Control model`**

- Default setting **`(_:108) Control model`** = ***`SBO w. enh. security`***

Use the **`Control model`** parameter to specify the control model according to IEC 61850-7-2. The following selection options are available:

- ***`direct w. normal secur.`***
- ***`SBO w. normal secur.`***
- ***`direct w. enh. security`***
- ***`SBO w. enh. security`***
- ***`status only`***

Parameter: **`SBO time-out`**

- Default setting **`(_:109) SBO time-out`** = ***`30 s`***

With this setting, you specify the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850-7-2).

Parameter: Feedback monitoring time

- Default setting **(_:110) Feedback monitoring time** = ***10 s***

Reaching a new tap position after the switching command is monitored. If a new tap position is not reached, you specify with this setting the time when the command is canceled. The range of values extends from 0.01 s to 1800.00 s.

Parameter: Maximum output time

- Default setting **(_:111) Maximum output time** = ***1.50 s***

This parameter specifies the maximum output time. The range of values extends from 0.01 s to 1800.00 s. For activating motors to change the tap position, a time of 1.50 s is practical.

Parameter: Supervision behavior

- Default setting **(_:112) Supervision behavior** = ***alarm block***

You can select whether the supervision is switched off (***off***) or if only a warning is indicated (***warning***). With the ***alarm block*** setting, an alarm indication is generated and the function is blocked.

Parameter: Motor supervision time

- Default setting **(_:113) Motor supervision time** = ***10 s***

After the motor supervision time has elapsed, the indication *Motor sup. time expired* is displayed. Additional information can be found in the margin title *Motor Supervision Time, Page 1119* . The range of values extends from 5 s to 100 s.

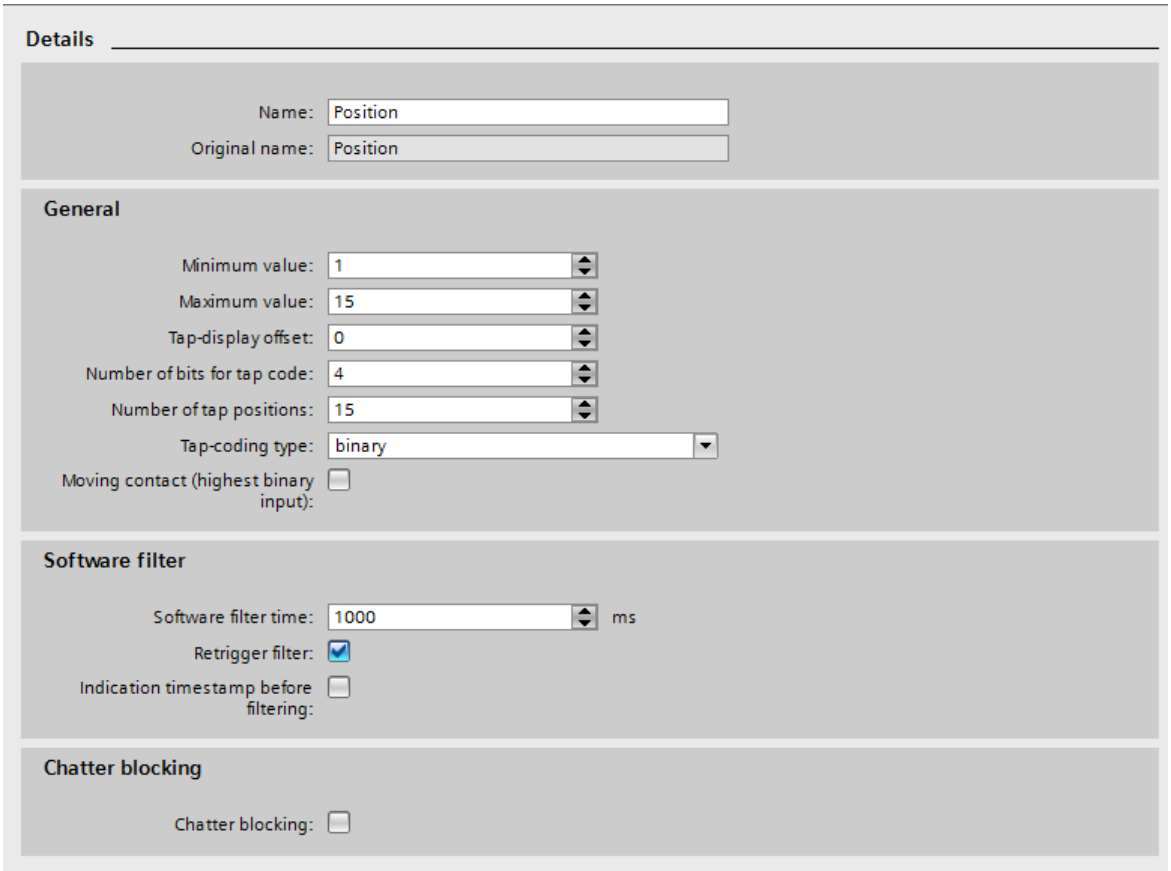
Parameter: Highest tap changer pos.

- Default setting **(_:116) Highest tap changer pos.** = ***Lowest voltage tap***

With the parameter **Highest tap changer pos.**, indicate whether the lowest or highest voltage is present at the highest tap changer position.

Additional Settings (Properties Dialog Position)

Additional settings are assigned to the controllable *Position*. To display and adjust the settings, select *Position* in the DIGSI information matrix and select the Properties dialog. To do this, click the **Properties** tab.



[scdeegts-170216-01, 1, en_US]

Figure 8-96 Properties Dialog

Parameter: `Minimum value`

- Default setting **`Minimum value`** = *1*

Parameter: `Maximum value`

- Default setting **`Maximum value`** = *15*

The **`Minimum value`** and **`Maximum value`** settings are initially calculated by DIGSI 5 based on the tap coding, the **`Number of tap positions`**, and the **`Tap-display offset`**. They represent the allowed control area of the position value. Positions outside this area are defined as invalid. This control area can be further restricted within the initially set physical range (see the **`Number of tap positions`** and the **`Tap-display offset`**).

Parameter: `Tap-display offset`

- Default setting **`Tap-display offset`** = *0*

If you want to move the height of the displayed value in a positive or the negative direction with respect to the height of the actual value, enter the value for this in the **`Tap-display offset`** field.

Parameter: `Number of bits f. tap code`

- Default setting **`Number of bits f. tap code`** = *4*

With the **`Number of bits f. tap code`** parameter, set the number of bits you need for coding the transformer taps. The number is dependent on the selected **Encoding** and on the **Moving contact**. For example, you need 3 bits for 7 binary-encoded transformer taps. The range of values extends from 2 to 32.

Parameter: `Number of tap positions`

- Default setting **`Number of tap positions`** = ***`15`***

With the **`Number of tap positions`** parameter, you set the number of transformer taps. The range of values extends from 2 to 127. The output of the tap position is limited from -63 to +63. If the number of taps is > 63, set the parameter **`Tap-display offset`** so that the tap position is within the range of -63 to +63.

Parameter: `Tap-coding type`

- Default setting **`Tap-coding type`** = ***`binary`***

In the **`Tap-coding type`** list box, select the interpretation type of the indication pending at the binary input.

You can select from the following options:

- ***`binary`***
- ***`1-of-n`***
- ***`BCD`***
- ***`table`***
- ***`BCD signed`***
- ***`gray`***

If you want to specify an individual **`Tap-coding type`**, select ***`table`***.

In the **`Representation of encoding`** section, select the numbering system in which your code table entries will take place, alternatively:

- ***`Binary (2 characters)`***
- ***`Octal (8 characters)`***
- ***`Decimal (10 characters)`***
- ***`Hexadecimal (16 characters)`***

The selected option is valid for all inputs in the **`Encoding`** column.

If you change the number system and there are already entries in this column these will be converted to the new number system. The selection area becomes visible as soon as you have selected the setting ***`table`*** in the list box **`Tap-coding type`**.



NOTE

If the binary inputs used for encoding are all inactive, this indicates an invalid tap position (regardless of the display offset). For an invalid tap position, the display shows the position **---** or **-64** with quality **invalid**; the exception is BCD with sign, see *Routing of the Binary Inputs (Tap Coding Type: BCD with Sign), Page 1125* .

Enter the encoding for the tap in the **Encoding** column in the **Code table**. Enter the value according to the numbering system previously selected. Select the desired number of taps and number of bits for tap coding. Taps with the same encoding and taps with 0 coding are not permitted.

Routing of the Binary Inputs (Tap Coding Type: Binary)

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 4 transformer tap positions designated 3 to 6. BI4 is the moving contact. The encoding is in binary.

Table 8-25 Routing of the Binary Inputs (Tap Coding Type: Binary)

	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	X		

	Example					
Meaning	Bit 1	Bit 2	Bit 3	Moving contact		
Tap = 1	1	0	0			

With 3 binary inputs, a maximum of 2^3 -1 = 7 tap positions can be mapped in binary code. If all routed binary inputs indicate 0, this is interpreted as a connection error and is reported by Position **---** or **-64** with quality **invalid**. The representation of transformer taps should start with the numerical value 3. The information properties must be configured as follows for the example:

Tap-coding type:	Binary
Number of tap positions:	4
Number of bits f. tap code:	4
Tap-display offset:	2
Moving contact (highest binary input):	Yes

The 3 binary inputs must be numbered sequentially, for example, BI 1, BI 2, BI 3 and BI 4 for the moving contact.

Routing of the Binary Inputs (Tap Coding Type: BCD with Sign)

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 7 transformer tap positions designated -3 to 3. The encoding uses BCD with sign.

Table 8-26 Routing of the Binary Inputs (Tap Coding Type: BCD with Sign)

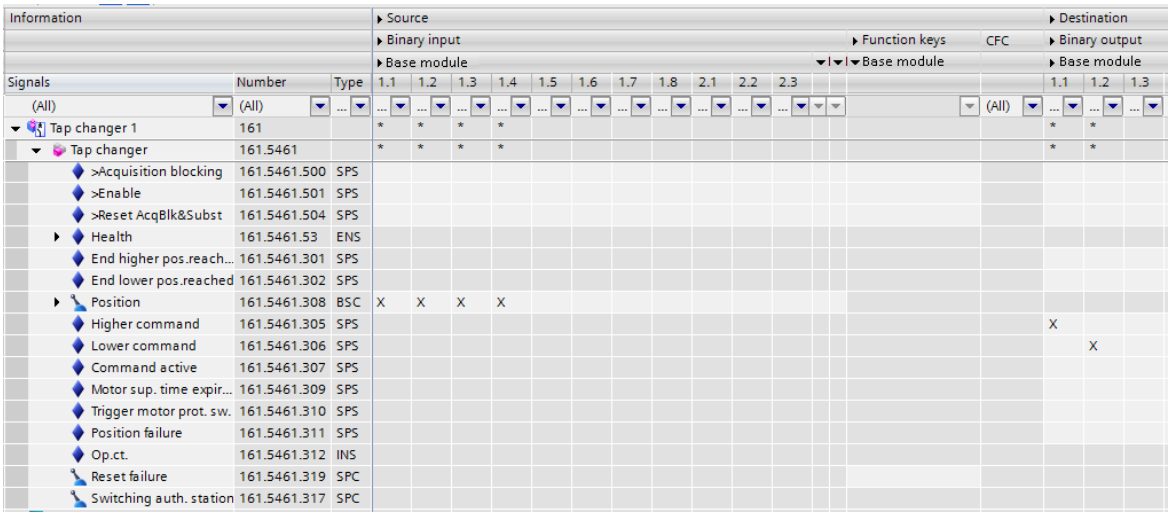
	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X			
Meaning	Bit 1	Bit 2	Sign			
Tap = 1	1	0	1			

Using 3 binary inputs, a maximum of 7 tap positions can be mapped with the tap coding type of BCD with sign. This yields the number of tap positions from -3 to 3. If all routed binary inputs indicate 0, this is recognized as tap 0. The 3 binary inputs must be numbered sequentially.

Tap-coding type:	BCD with sign
Number of tap positions :	7
Number of bits f. tap code:	3
Tap-display offset:	0
Moving contact (highest binary input):	No

Routing the Tap Position to Binary Outputs

For the output of the adjusting commands, route the information **step up** and **step down** on one relay each, see following figure.



[sc_trass7, 1, en_US]

Figure 8-97 Routing the Tap Setting Commands

Parameter: `Moving contact (highest binary input)`

- Default setting **`Moving contact (highest binary input)`** = ***no***

If the tap position is not to be recognized as valid and accepted until the motor sliding contact signals that it has reached the taps, then activate the **`Moving contact (highest binary input)`** option. If this parameter is set, the new positions are shown and labeled with an *****.

Parameter: `Software filter time`

- Default setting **`Software filter time`** = ***1000 ms***

With this parameter, you specify the **`Software filter time`** for capturing the tap position. The range of values extends from 0 ms to 86400000 ms. Within this time, brief changes on the binary inputs are suppressed.

Parameter: `Retrigger filter`

- Default setting **`Retrigger filter`** = ***yes***

With this parameter, you switch retriggering of the filtering time by a position change on or off.

Parameter: `Indication timestamp before filtering`

- Default setting **`Indication timestamp before filtering`** = ***no***

With this parameter, you specify whether the hardware filtering time is accounted for in the time stamp of position capture.

Parameter: `Chatter blocking`

- Default setting **`Chatter blocking`** = ***no***

With this parameter, you switch **`Chatter blocking`** on or off.

8.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Tap changer				
_:104	Tap changer:Check switching authority		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:108	Tap changer:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:109	Tap changer:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:110	Tap changer:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Tap changer				
_:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:113	Tap changer:Motor supervision time		5 s to 100 s	10 s

8.8.4 Information List

No.	Information	Data Class (Type)	Type
Tap changer			
_:500	Tap changer:>Acquisition blocking	SPS	I
_:501	Tap changer:>Enable	SPS	I
_:53	Tap changer:Health	ENS	O
_:301	Tap changer:End higher pos.reached	SPS	O
_:302	Tap changer:End lower pos.reached	SPS	O
_:308	Tap changer:Position	BSC	C
_:305	Tap changer:Higher command	SPS	O
_:306	Tap changer:Lower command	SPS	O
_:307	Tap changer:Command active	SPS	O
_:309	Tap changer:Motor sup. time expired	SPS	O
_:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:311	Tap changer:Position failure	SPS	O
_:312	Tap changer:Op.ct.	INS	O
_:319	Tap changer:Reset failure	SPC	C

8.9 Voltage Controller

8.9.1 Overview of Functions

The transformer voltage controller functionality (ANSI 90V) is used to control power transformers (two-winding transformers, three-winding transformers, grid coupling transformers) and auto transformers using a motor-operated tap changer. The function provides automatic voltage control within a specified voltage range on the secondary side of the transformers or, as an alternative, at a remote load point (Z compensation or R/X compensation) in the network. In order to compensate for the voltage variations in the meshed system, use the ***LDC-Z*** procedure (Z compensation). For voltage drops on the line, use the ***LDC-XandR*** procedure (R/X compensation).

The control principle is based on the fact that a higher or lower command to the tap changer, as a function of the voltage change (ΔV) per tap, causes a voltage increase or decrease.

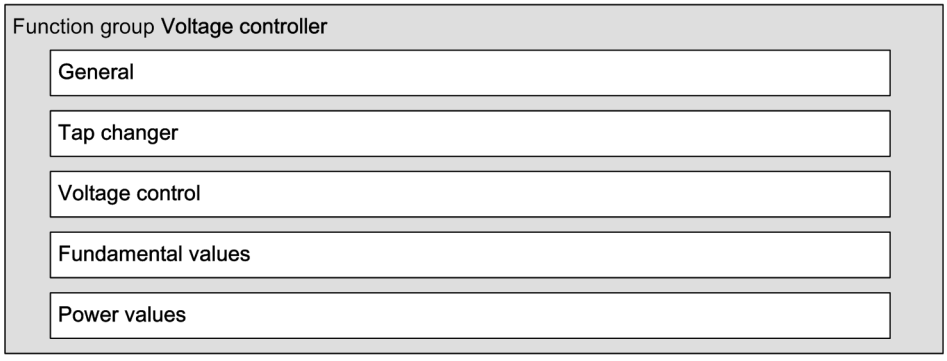
The voltage control operates on a tap-for-tap basis and compares the measured actual voltage (Vact) to the specified target voltage (Vtarget). If the voltage difference is greater than the set bandwidth (B), a higher or lower command is sent to the tap changer once the set time delay (T1) has elapsed. Specifying the time delay (T1) depends on the set controller response (inverse or linear), to avoid unnecessary adjusting commands during brief voltage deviations from the target value and for coordination with other automatic voltage controllers in the system.

The voltage controller function also monitors the currents on the upper-voltage side and the low-voltage side of the transformer to block the controller during impermissible operating states (overcurrent/undercurrent/undervoltage). The voltage controller function also has limiting values that, in special operating cases, suppress higher commands in the case of overvoltage and lower commands in the case of undervoltage.

8.9.2 Structure of the Function

The **Two-winding transformer voltage controller**, **Three-winding transformer voltage controller**, and **Grid coupling transformer voltage controller** function groups consist of 5 function blocks. Depending on the application, the function groups are preconfigured in the relevant application template by the manufacturer or can be copied into the corresponding device project during engineering.

The following figure shows, for example, the functional scope of the **Two-winding transformer voltage controller** function group.



[dwvolctl-060913-01.vsd, 2, en_US]

Figure 8-98 Structure/Embedding of the Function Group

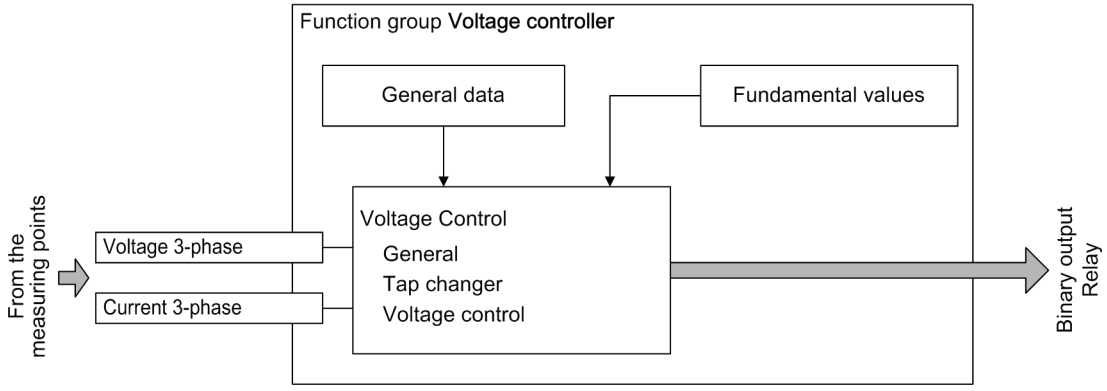
The functions **General** (GAPC), **Tap changer** (YLTC), and **Voltage controller** (ATCC) are logical node points in IEC 61850-8-1.

The tap changer (YLTC) is the interface between the voltage controller (ATCC) and the motor-operated tap changer of the transformer (OLTC). This means that the voltage controller (ATCC) sends higher and lower commands to the tap changer. This tap changer issues command pulses to the motor-operated tap changer of the transformer (OLTC). The tap changer (YLTC) measures the tap positions and monitors the action of the motor-operated tap changer (OLTC).

The function group has interfaces to the following measuring points:

- **Two-winding transformer**:
  - Voltage, 3-phase
  - Current, 3-phase (optional)
- **Three-winding transformer**:
  - 2 x voltage, 3-phase
  - 2 x current, 3-phase (optional)
- **Grid coupling transformer**:
  - 2 x 3-phase voltage
  - 2 x 3-phase current

Figure 8-99 shows these interfaces as a block structure.



[dwvocnti-060913-01.vsd, 2, en_US]

Figure 8-99 Structure of the Voltage Control Function Group

You can find the information and function measured values of the voltage controller in the DIGSI routing matrix.

8.9.3 Function Description

If the load is increased in an electricity-supply system, the voltage is reduced and vice versa. The power transformers are usually equipped with transformer tap changers (OLTC) so as to keep the power-system voltage at a constant level.

As a result, the transformer ratio is changed in predefined steps. Changing the transformer taps causes the voltage to change.

The Voltage control function is intended to control transformers with motor-operated transformer tap changers.

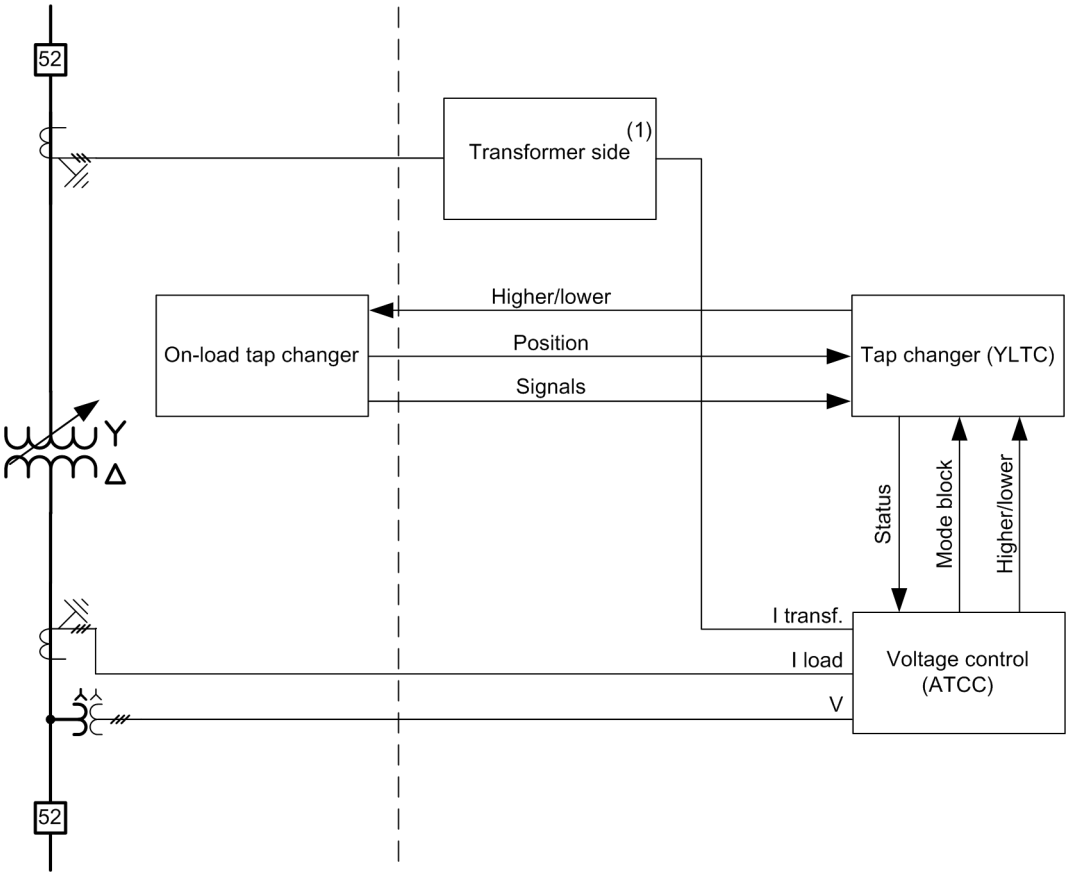
This function is designed to control the following:

- For two-winding transformers (2W): the voltage on the secondary circuit of the power transformer
- For three-winding transformers (3W): the voltage of the secondary winding 1 or winding 2
- For grid coupling transformers (GC): voltage of winding 1 or winding 2, selectively depending on the power direction

The control operation is based on a step-by-step principle. To move the tap changer one position higher or lower, a single control pulse is issued to the motor-drive mechanism of the tap changer. The length of the control pulse can be set over a large range so as to handle the very different types of tap-changer drives. The control pulse is issued if the measured voltage deviates from the set reference value by more than the preset voltage range for more than a given time period.

The voltage can be controlled at the voltage measuring point or at the load point in the electrical power system. In this case, the load-point voltage is calculated on the basis of the measured load current and the known impedance between the voltage measuring point and the load point.

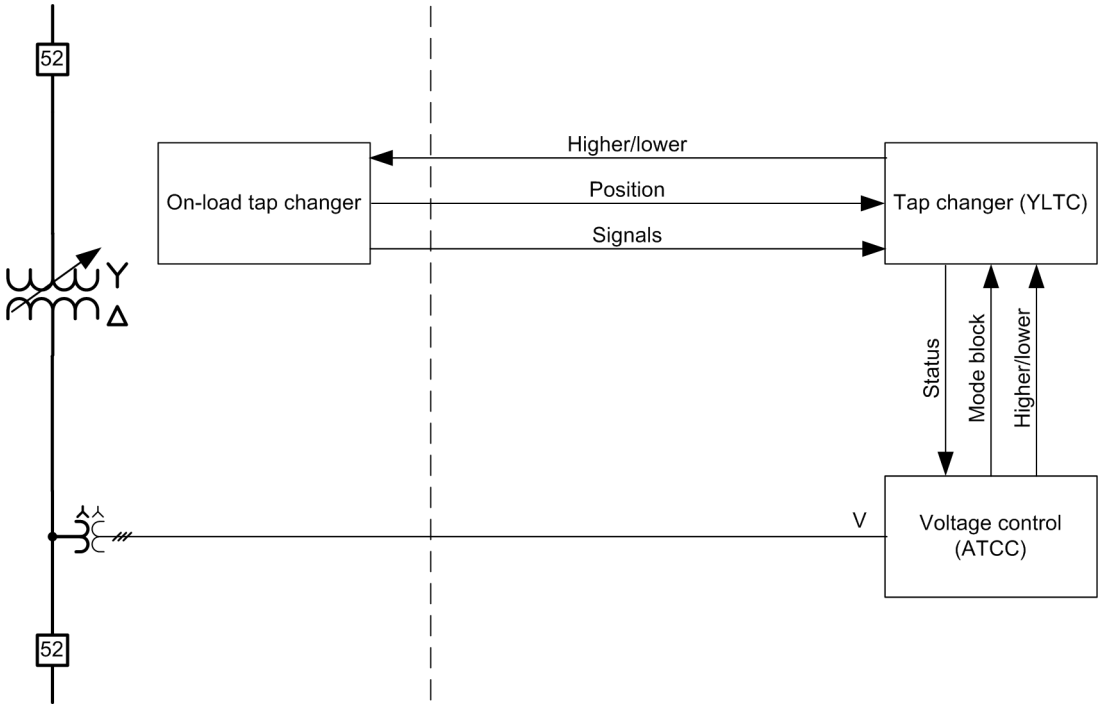
The following figures show possible configurations of the voltage controller for two-winding transformers with and without current measurement.



[dwkonlst-060913.vsd, 1, en_US]

Figure 8-100 Voltage-Controller Constellation for Two-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

(1) Only if a transformer side is present



[dwkonlsK-060913.vsd, 1, en_US]

Figure 8-101 Voltage-Controller Constellation for Two-Winding Transformers without Current Measurement

Three-Winding Transformers

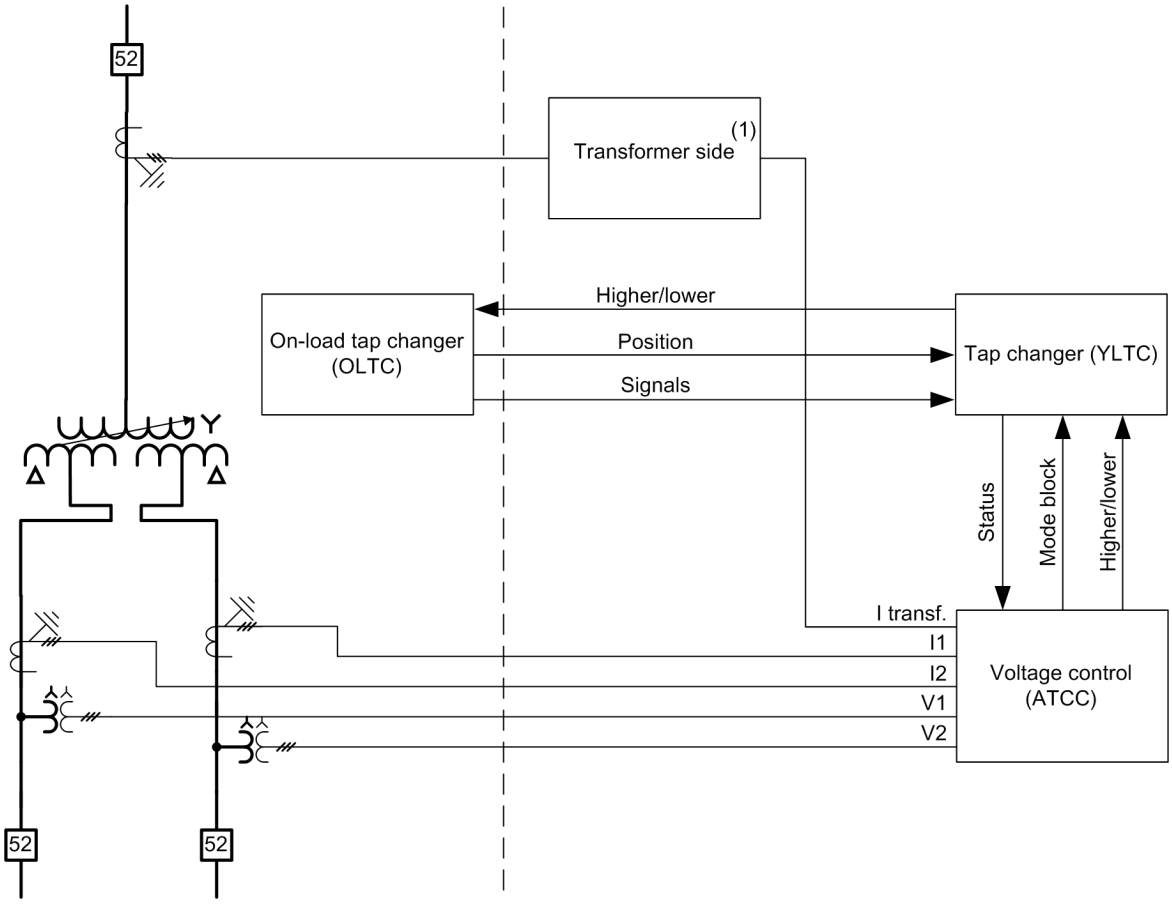
Three-winding transformers are special power transformers that have 2 separate windings on the secondary circuit and typically supply 2 different busbars. The voltage levels on the secondary circuit of the power transformers can either be the same or different. In addition to designs with 2 tap changers on the secondary circuits, in most cases, three-winding transformers are equipped with only one tap changer or on-load tap changer on the primary side. It is therefore necessary to feed both voltages of the secondary windings to the voltage measuring inputs (V1, V2) and to specify one of them, depending on the busbar situation, to the voltage controller as the control variable.

The voltages of side 1 and 2 of the three-winding transformer are simultaneously monitored. In the process, the voltage to be monitored can be automatically selected via the load current of both sides or by using one parameter. This parameter is the settings group switching via binary input, protocol or function keys. The uncontrolled voltage can be monitored in parallel to ensure that it remains within the defined voltage limits.

If a current measuring point is assigned to a function group, the voltage to be controlled can be automatically selected dependent on the load.

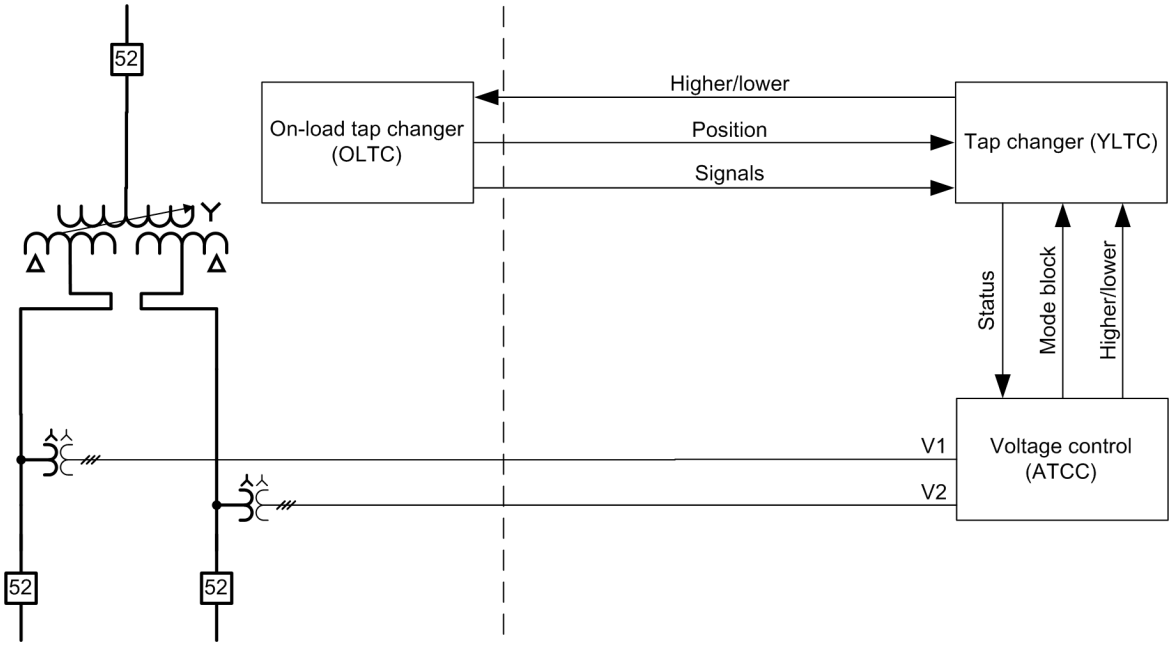
For automatic load change, the voltage of the transformer side into which the larger load current flows is controlled. The respective uncontrolled voltage is monitored for undervoltage and overvoltage.

In contrast to overvoltage on the controlled side, for overvoltage on the uncontrolled side, the higher impulse is blocked and no fast step down to a lower tap occurs. In case of undervoltage on the uncontrolled side, the lower commands are blocked if this behavior is activated for undervoltage supervision.



[dw_V-constell-3wind-with-imeas.vsd, 2, en_US]

Figure 8-102 Voltage-Controller Constellation for Three-Winding Transformers with Current Measurement for Load Compensation at the End of the Line



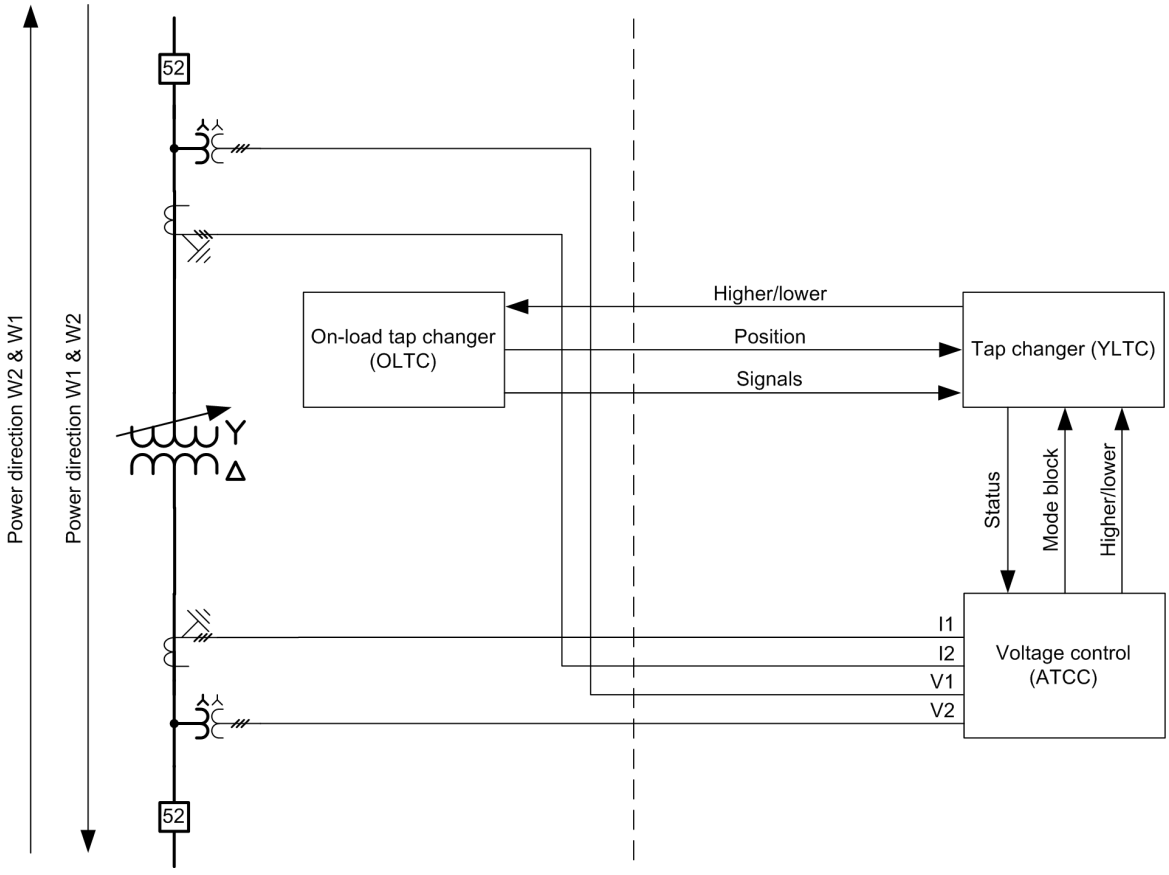
[dw_V-constell-3wind-without-imeas-091014.vsd, 2, en_US]

Figure 8-103 Voltage-Controller Constellation for Three-Winding Transformers without Current Measurement

Grid Coupling Transformers

Grid coupling transformers are special power transformers that connect 2 electrical power systems to one another. The load-side voltage is controlled. The power flow can change during operation. That is why both voltages and currents, winding 1 and winding 2, voltage measuring inputs (V1, V2) and current measuring inputs (I1 and I2) must be fed. A voltage must be specified as a function of the load situation to the voltage controller as the control variable.

The voltages of the windings 1 and 2 of the grid coupling transformers are simultaneously monitored. In the process, you can select the voltage to be controlled using one parameter. This parameter can be changed using the settings group switching via the binary input, protocol, or function keys.



[dw_V-constell-2wind-coupl-transf.vsd, 1, en_US]

Figure 8-104 Voltage-Controller Constellation for Grid Coupling Transformers

On-Load Tap Changer

On-load tap changers are used to set the desired tap of a stepped winding of the transformer while under load. During switchover, the desired tap of the stepped winding is first selected by means of the tap selector. Next, the on-load tap changer switches over from the current-carrying tap to the selected tap. During this switchover, one tap of the stepped winding is briefly bridged by an ohmic resistor so that the load switchover takes place without power interruption. Physically, the tap changer is installed in the transformer tank or in a separate tank.

Tap Changer

The **Tap changer** function issues the adjusting commands to the on-load tap changer and receives the corresponding feedback. The function of the tap changer inside the voltage controller corresponds to that of the separate tap changer. The higher and lower tap commands are generated by the voltage controller. The **`Check switching authority`**, **`Control model`**, **`SBO time-out`** and **`Feedback monitoring time`** parameters are set only in the voltage controller.

You can find more information in chapter *8.9.4 Application and Setting Notes* .

Voltage Controller

The Voltage controller function controls the voltage within the bandwidth and within the set voltage limits. Using the **Mode** parameter, you can turn the voltage controller on or off or set it for test mode.

With the parameter **Number of target voltage**, you can specify up to 4 target voltages. You can only activate one of these target voltages at a time using function key, communication, or a binary input. With the **Set point mode active** parameter, you can specify a valid target voltage via a communication network.

If the voltage controller is switched off, adjusting commands cannot be given to the tap changer in automatic operation or in manual operation. The set on-site or remote switching authority is independent of this.

You can set the controller operating mode via the **Operating mode** parameter or the **Operating mode** command to automatic operation or manual operation. In automatic operation, the voltage is controlled automatically in accordance with the set parameters.

Three-Winding Transformer Voltage Controller

For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the three-winding transformer voltage controller, these measurands can be specified using one parameter (parameter **Winding selection** = ***Winding 1*** or ***Winding 2***) or they can be automatically selected (**Winding selection** = ***WithMaxLoad***).

The winding is automatically selected by evaluating the load current in the windings. If the load current in one of the two windings is greater than the load current in the other winding by 5 % of the rated current for 10 s, then the winding voltage is controlled using the larger load current.

Grid Coupling Transformer Voltage Controller

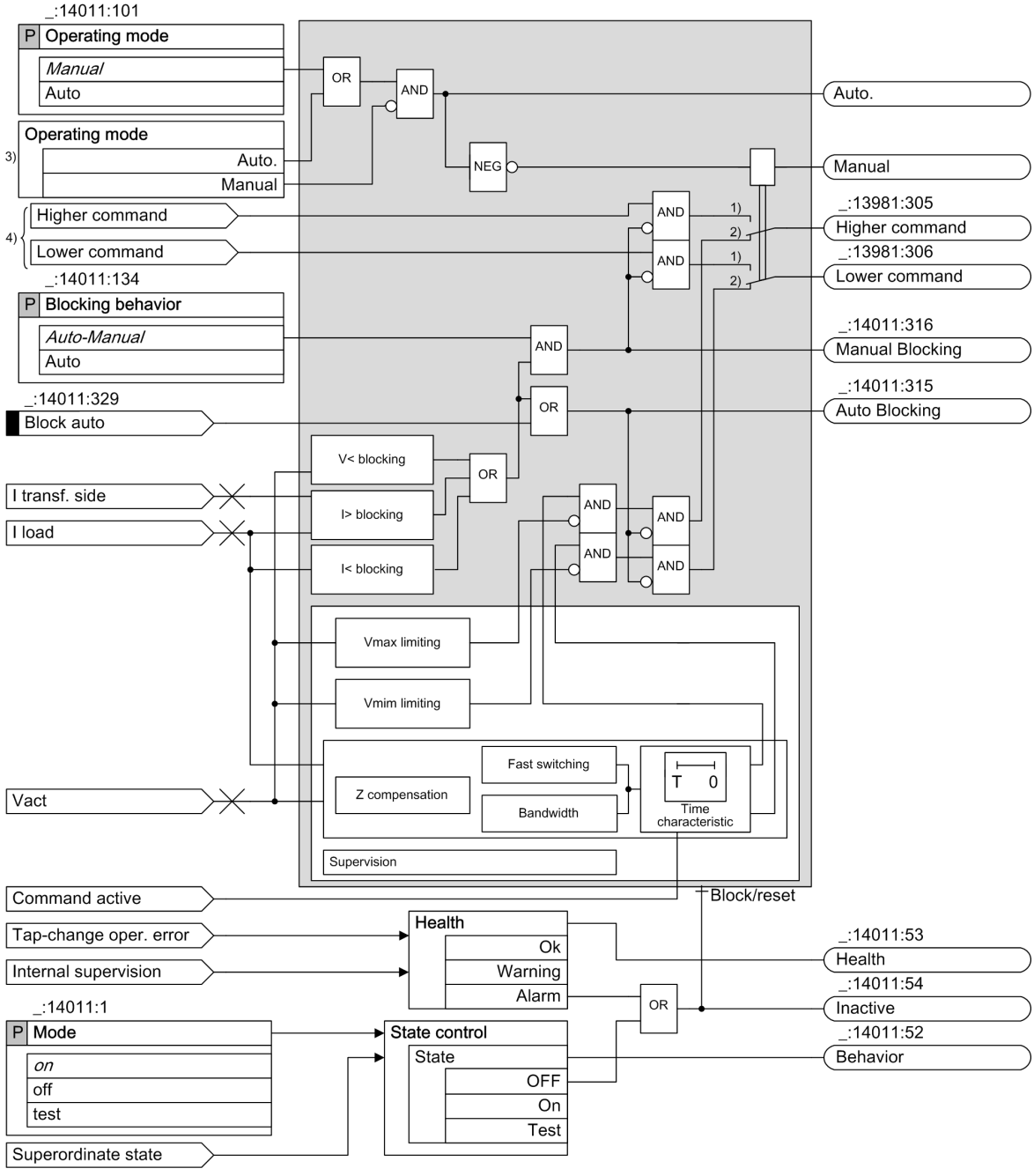
For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the grid coupling transformer voltage controller, these measurands can be selected using a parameter (parameter **Winding selection** = ***Winding 1*** or ***Winding 2***).

You can change the winding selection during operation using the settings group switching.

You can monitor the power-flow direction. If the difference in the power of ***Winding 1*** and ***Winding 2*** is greater than 10 % of the rated power on the control side, the *Power-flow superv.* indication appears and the function switches to the alarm state.

Logic of the Function



[lovoltco-060913-01.vsd, 2, en_US]

Figure 8-105 Higher-Level Logic of the Voltage Controller

(1) Manual operation
(2) Automatic operation
(3) Controllable
(4) Command

In accordance with the IEC 61850 standard, DOI LTCBlk (**Block automatic operation** command), automatic control can be blocked with a command.

The voltage controller measures the actual voltage (Vact) and compares it to the target voltage (Vtarget). If the difference between the measured voltage (control deviation D) is greater than the set bandwidth (B), a higher or lower command is sent to the tap changer once the set time delay (T1) has elapsed.

You can change the settings for control during operation with the settings group switching.

You can switchover the settings groups via the following alternatives:

- Via the on-site operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to a substation automation technology (IEC 60870-5-103, IEC 61850)

You can find more information in chapter *3.10.2 Settings-Group Switching* .

Control Deviation

The control deviation is calculated from the current actual voltage and the target voltage in relation to the rated voltage.

$$D = \frac{V_{act} - V_{target}}{V_{rated}} 100\ \%$$

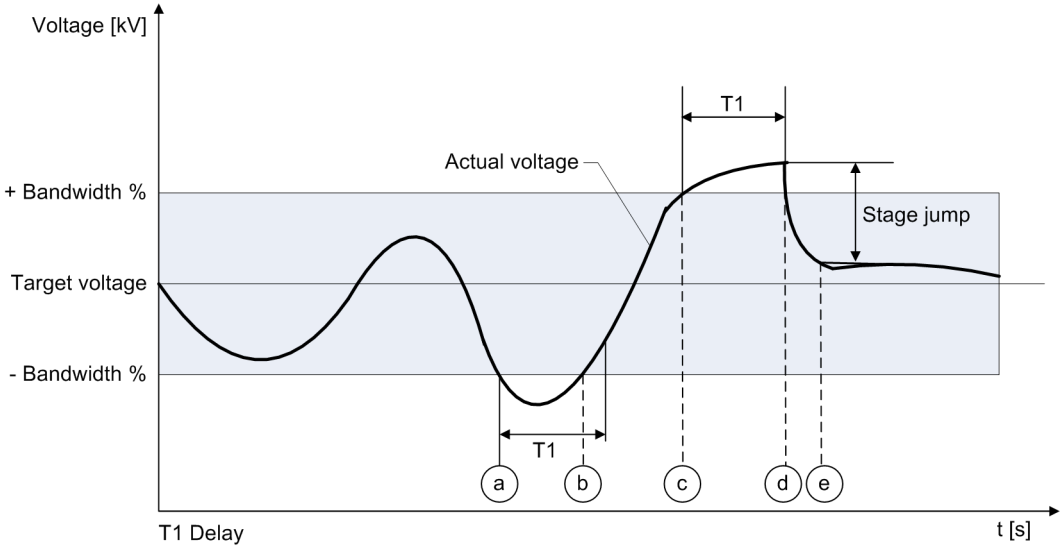
[fokonisk-211013, 2, en_US]

D = Control deviation

Bandwidth

To minimize the number of switching operations by the tap changer, a permitted bandwidth is defined. If the actual voltage is within the bandwidth, no adjusting control commands are issued to the tap changer. If the actual voltage exceeds the defined bandwidth, an adjusting command is issued after the set time delay **`T1 delay`**. If the actual voltage returns to the voltage range of the bandwidth before **`T1 delay`** elapses, no adjusting control command is issued.

If the actual voltage returns to the voltage range of the bandwidth within the time delay T1, the running time delay T1 continues to count down, starting at the already elapsed time. If the actual voltage returns again to the set bandwidth while the time is counting down, the time delay T1 is started at the remaining time. In this way, the time delay is reduced in the event of frequent violations of the lower limit of the bandwidth.



[dwistspn-060913-01.vsd, 1, en_US]

Figure 8-106 Actual Voltage Curve during Control Deviation

(a) Actual voltage outside the bandwidth
(b) Actual voltage before T1 elapses within the bandwidth - no switching
(c) Actual voltage outside the bandwidth, T1 begins to elapse
(d) Actual voltage outside the bandwidth after T1, switching procedure initiated
(e) Switching procedure concluded, actual voltage within the bandwidth

Linear, Inverse Control Response

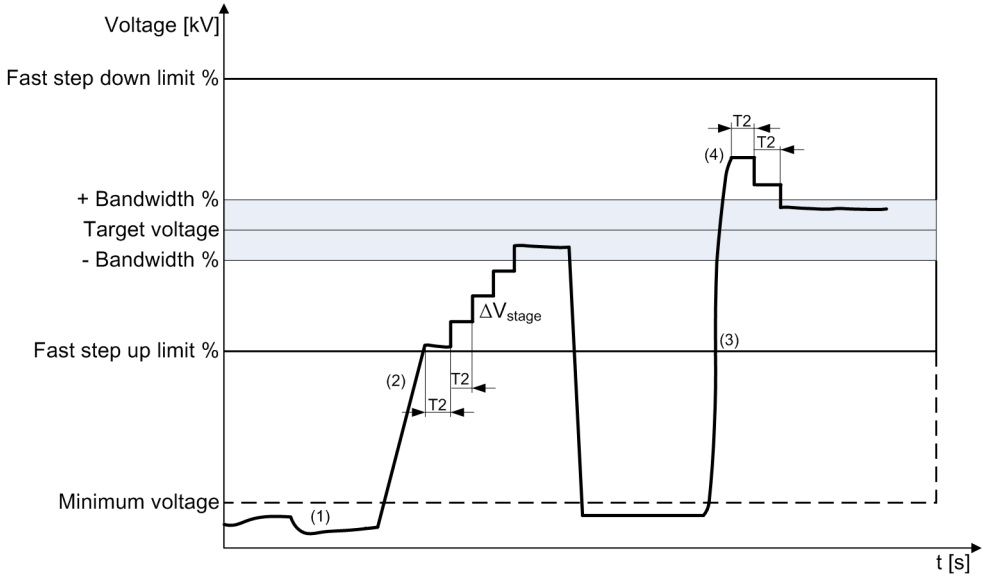
With **linear** control response, the controller reacts independently of the control deviation after the set time **`T1 delay`**. If more than one tap-position change is required to bring the actual voltage back within the bandwidth, the set time **`T2 delay`** takes effect.

With **inverse** control response, the time **`T1 delay`** depends on the magnitude of the control deviation. Small deviations are tolerated for longer than larger ones. If the time delay is very small in accordance with the set characteristic curve, the time **`T1 Inverse Min`** takes effect.

The set **inverse** characteristic curve is a function of the parameter **`T1 delay`**. The characteristic curves arising for different settings of the time **`T1 delay`** are shown in chapter *8.9.4 Application and Setting Notes* , margin title Parameter: **`T1 characteristic`**.

Control Response with Zero Potential or Voltage Recovery

If the actual voltage is not within the defined bandwidth after a voltage recovery, it can be necessary for the voltage controller to send the 1st adjusting command with the T2 time. For this purpose, the parameter **`Regulate with T2 at start`** must be switched on.

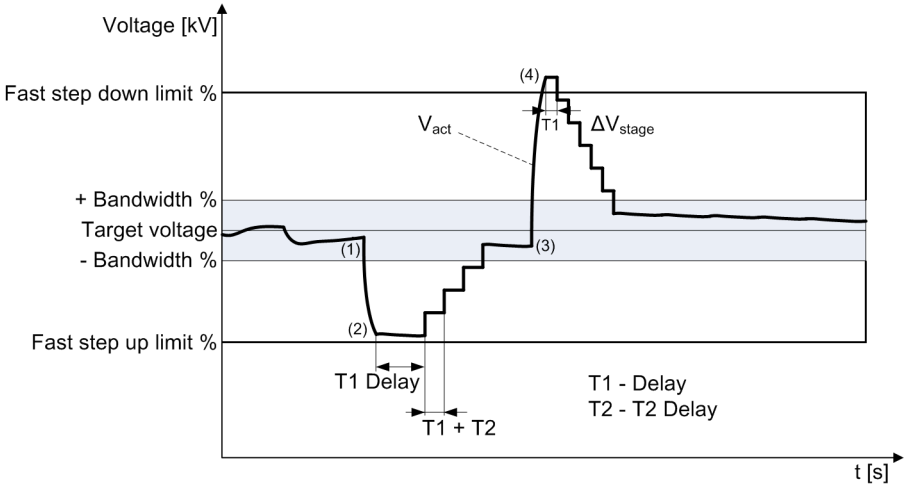


[dw_istgro-130215, 1, en_US]

Figure 8-107 Actual Voltage Curve during Control with T2

(1) Actual voltage below the minimum voltage
(2) After switching on, the change to a higher tap occurs with time T2
(3) After the voltage recovery, the actual voltage is above the bandwidth
(4) Actual voltage outside the bandwidth. A fast step down is made with the time T2 until the bandwidth is reached.

Control Response in the Event of Larger Voltage Deviations



[dwistgro-060913-01.vsd, 2, en_US]

Figure 8-108 Actual Voltage Curve During Larger Control Deviations

(1) Actual voltage outside the bandwidth

(2) The change to a higher tap occurs after T1 and then T2

(3) Actual voltage inside the bandwidth

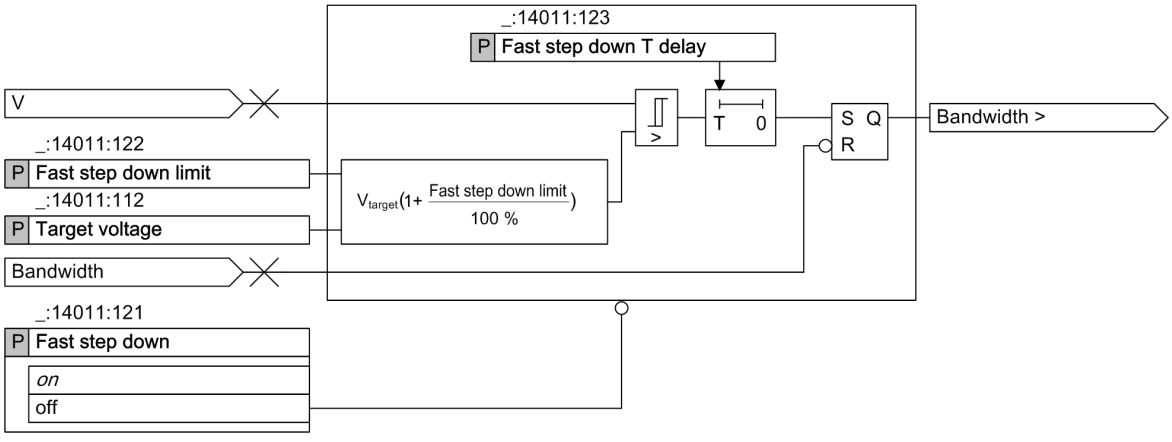
(4) Actual voltage outside the limit for a fast step down. A fast step down occurs until the bandwidth is reached.

Fast Step Up Mode and Fast Step Down Mode

The fast step down mode and the fast step up mode allow a fast reaction to abnormal voltage situations. *Figure 8-108* shows such a situation at point (4). A fast step down mode occurs until the bandwidth has been reached. The step time between 2 consecutive lower commands results from the following 2 conditions:

- The completion of a tap change command after the new valid position was detected
- The measurement time for capturing the new actual voltage

The activity of the fast step down mode and the fast step up mode is displayed with the indications *(_:14011:308) Fast Step Down active* and *(_:14011:307) Fast Step Up active*.



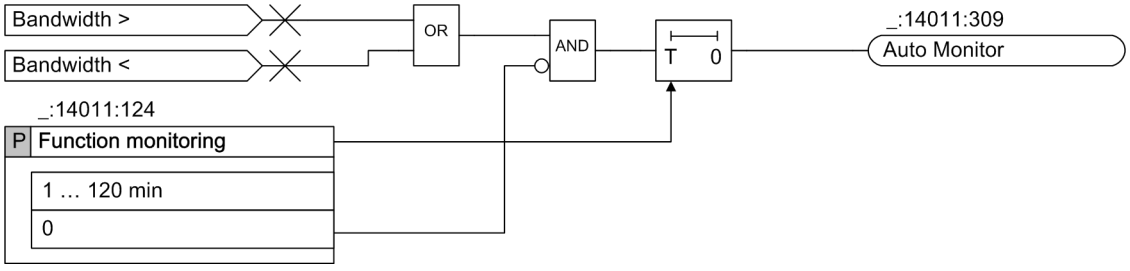
[losnlruk-090913-01.vsd, 2, en_US]

Figure 8-109 Logic of the Fast Step Down Mode

The fast step up mode operates in a similar fashion.

Function Supervision for Automatic Operation

If the actual voltage exceeds or falls below the set bandwidth for longer than the set time delay, this situation is shown by the indication *(_:14011:309) Auto Monitor*. If the actual voltage returns to the voltage range, the indication is reset. You can switch off the function monitor with a time delay = 0 min.



[lofktueb-090913-01.vsd, 1, en_US]

Figure 8-110 Logic of the Function Supervision for Automatic Operation

Phase Compensation

When using phase compensation, the voltage drop of a phase that is connected to a transformer can be included. In this case, 2 processes are available:

- Z compensation (LDC-Z)
- X and R compensation (LDC-XandR)

NOTE

The phase compensation is only active if power is flowing in the direction of the phase.

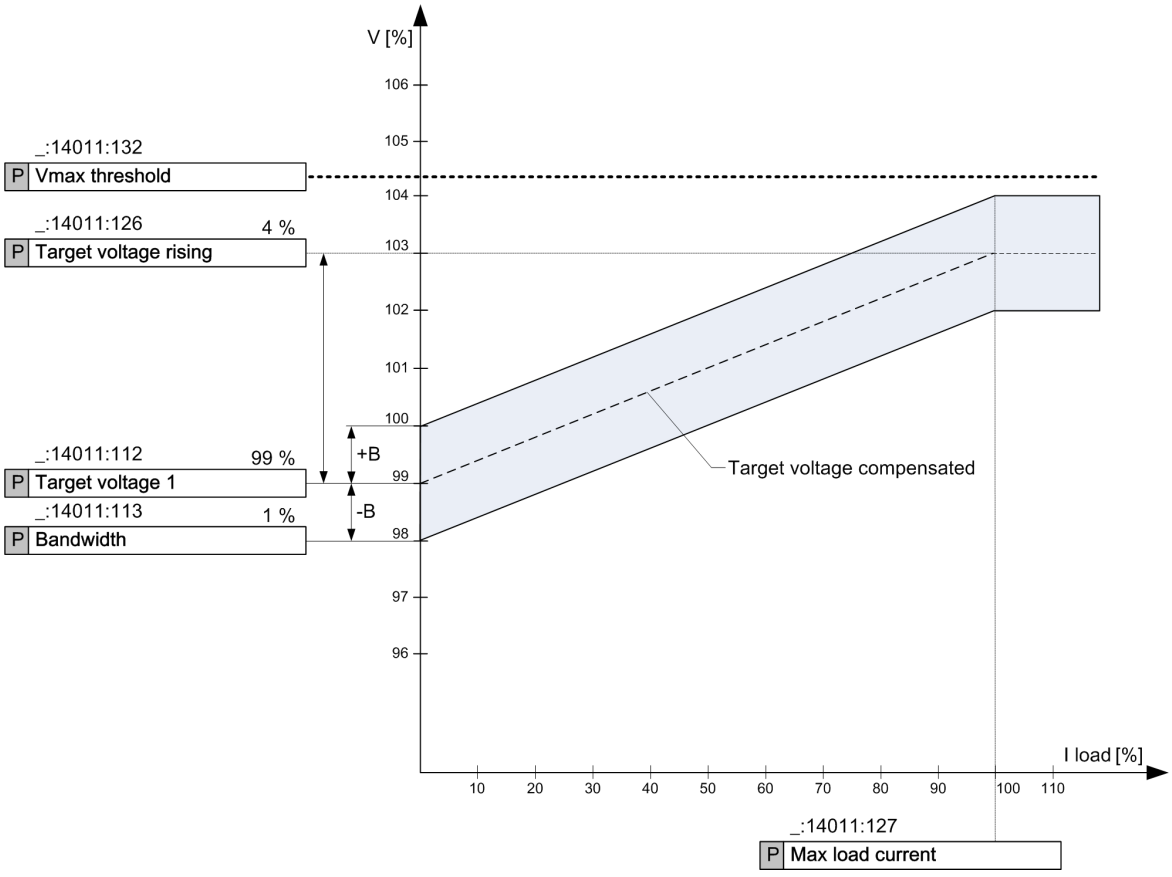
Z Compensation (LDC-Z)

Z compensation allows you to include the voltage drop of a line connected to the transformer. You can switch Z compensation on or off. If cosφ is roughly constant, you can use Z compensation. Setting the parameters requires the calculation of the voltage increase (**`Target voltage rising`**) taking into consideration the load current (**`Max load current`**).

The parameter **`Target voltage rising`** represents the voltage drop across the line as a % under rated load.

You can find more information and the calculation in chapter *8.9.4 Application and Setting Notes* .

In case of active Z compensation, you must limit the maximum permitted voltage increase in relation to the target voltage to avoid a voltage at the transformer that is too high. To do this, set the parameter **`Max load current`**. In addition, the parameter **`Vmax threshold`** is active. If the actual voltage exceeds this threshold value, no more higher tap change commands are issued.

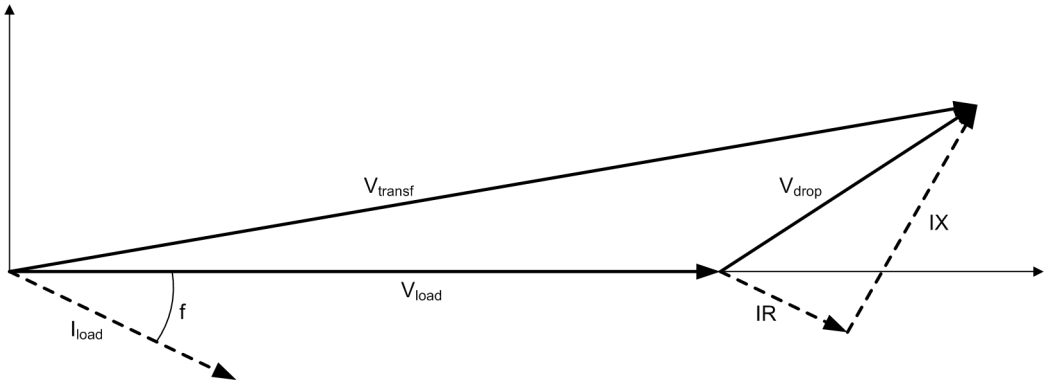


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Figure 8-111 Control Characteristic with Z Compensation

X and R Compensation (LDC-XandR)

When using the X and R compensation, you need the phase data. With this data, it is possible to precisely compensate the voltage drop of the transmission lines. The following figure shows the effect of this compensation type.



[dw-line-drop-kompensation-250214-01.vsd, 1, en_US]

Figure 8-112 Phasor Diagram of the X and R Compensation

You can also use the X and R compensation for the parallel control of transformers. If the X value is positive, the loss of voltage of the phase is compensated. If you are implementing parallel control with X and R compensation, then the X value is negative and considers the voltage increase from the busbar to the transformer.

V_{transf} Voltage on the transformer, voltage to be controlled

V_{load}	Voltage of load point (target voltage, $V_{load} = V_{transf} - V_{drop}$)
V_{drop}	Voltage drop of the phase
IR, IX	Voltage drop through R and X of the power line
I_{load}	Load current
φ	Load angle

If the X and R compensation is active, you must limit the maximum permitted voltage increase in relation to the target voltage to avoid a voltage at the transformer that is too high. To do this, set the parameter **Vmax threshold**. If the actual voltage exceeds this threshold value, no more higher tap change commands are issued.

Limiting Values

The limiting values cause no higher or lower adjusting commands to be given to the tap changer in the event of an upper limit violation (**Vmax threshold**) or lower limit violation (**Vmin threshold**). In this way, changing taps under abnormal voltage conditions and changing taps in the incorrect direction (for example, in the event of wiring errors) is prevented.

The lower and upper tap changer limits are included in the limiting values. The parameters **Lower tap-position limit** and **Higher tap-position limit** cause an additional restriction of the control range.

Blockings

The blockings prevent tap positions under abnormal network conditions. The following blocking functions are available:

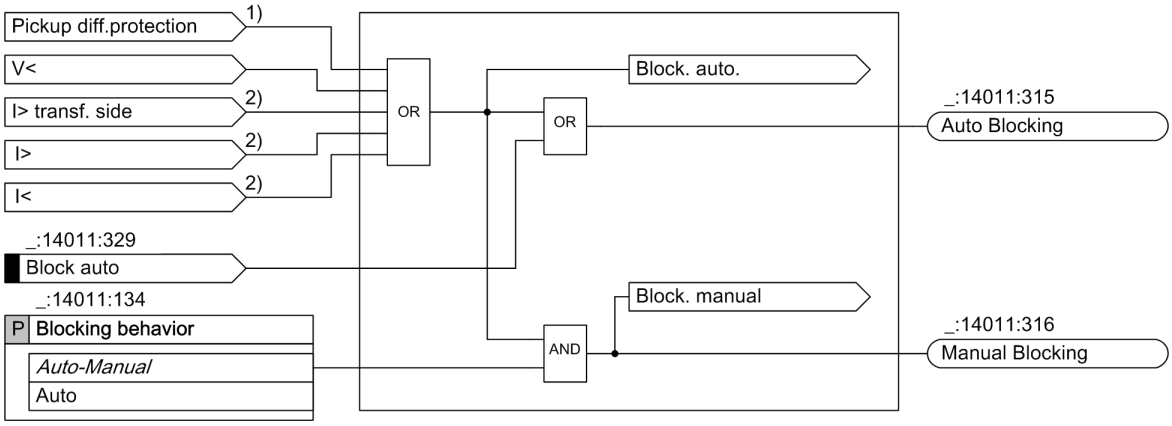
- Undervoltage
- Overcurrent, load current
- Undercurrent
- External blocking (binary input)
- Blocking command LTCBlock IEC 61850
- Blocking in the event of pickup of the transformer differential protection

Using the parameter **Blocking behavior**, you specify whether the blockings are to take effect only in automatic operation (***Auto***) or in both automatic and manual operation (***Auto-Manual***).

Overcurrent blocking prevents tap changes in the event of an overload. For the current blockings, the positive-sequence system of the load current and of the current on the upper-voltage side of transformers is calculated.

By assigning the tap changer to the transformer side, you also arrange the current of the upper-voltage side. Perform this assignment in the appropriate **Transformer side** . Here, you must use the tap changer of the voltage controller.

Undervoltage blocking prevents tap changes in the event of a network collapse. The output signals of the voltage controller are blocked and, depending on the operating mode, the indication *Auto Blocking* and/or *Manual Blocking* is issued.



[loblokir-090913-01.vsd, 1, en_US]

Figure 8-113 Logic Blockings

(1) If transformer differential protection is available

(2) If a current measurement is available

If the tap changer is assigned to the transformer side, is available, the current of the upper-voltage side is also monitored and the differential-protection pickup blocks the voltage controller automatically.

Additional Blockings for the Three-Winding Transformer Voltage Controller

The blockings described in the above sections also apply to the controlled winding of the three-winding transformer. In addition, the blockings for undervoltage, minimum voltage, and overcurrent are used for the measurands of the uncontrolled side.

Additional Blockings for the Grid-Coupling Transformer Voltage Controller

For voltage control in grid coupling transformers, the voltages and currents of both windings are always used for the blockings.

Functional Measured Values

You can read the current status of the measured values for the two-winding, three-winding, and grid-coupling transformers at any time. The following 3 tables show you the available measured values.

Measured Values, Two-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Current, measured positive-sequence voltage (referenced to phase-to-phase)	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load	Current measured load current (positive-sequence system)	A	A	Load current referenced to the rated current of the winding
V max	Maximum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive-sequence voltage ever measured (reference to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding

Measured Value	Description	Primary	Secondary	% Referenced to
V target	Calculated target voltage with consideration of Z compensation	kV	V	Target voltage of the winding referenced to the rated voltage of the winding

The functional measured values V max and V min can be reset with the input indication *>Reset min./max.*.

For the **two-winding transformer**, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control 2w → 90V V.contr.2w
- Main menu → Measurements → Voltage control 2w → Statistics → 90V V.contr.2w

Measured Values, Three-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to the rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to the rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The functional measured values Vmax 1, Vmax 2, Vmin 1 and Vmin 2 can be reset with the input indication *>Reset min./max.*.

For the **three-winding transformer**, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control 3w → 90V V.contr.3w
- Main menu → Measurements → Voltage control 3w → Statistics → 90V V.contr.3w

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The functional measured values Vmax 1, Vmax 2, Vmin 1 and Vmin 2 can be reset with the input indication *>Reset min./max.*.

For the **grid coupling transformer**, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control gc → 90V V.contr.gc
- Main menu → Measurements → Voltage control gc → Statistics → 90V V.contr.gc

Fundamental Values and Power Measured Values

The fundamental values and power measured values are always present in the **Two-winding transformer voltage controller**, **Three-winding transformer voltage controller**, and the **Grid coupling transformer voltage controller** function groups. Furthermore, you can find the fundamental values and power measured values for winding 1 and winding 2 in the **Three-winding transformer voltage controller** and in the **Grid coupling transformer voltage controller** function groups. These values cannot be deleted.

Table 8-27 and *Table 8-28* show the total scope in case a 3-phase voltage measuring point is also connected.

Table 8-27 Possible Fundamental Values for the Voltage Controller Function Group

Fundamental Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B,V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3

Table 8-28 Possible Power Measured Values of the Voltage Controller Function Group

Power Measured Value		Primary	Secondary	% Referenced to
P_{total}	Active power (total power)	MW	W	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1

8.9.4 Application and Setting Notes

Two-Winding Transformer: General

Parameter: Rated current

- Default setting **(_:2311:101) Rated current** = ***1000.00 A***

Parameter: Rated voltage

- Default setting **(_:2311:102) Rated voltage** = ***400.00 kV***

The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the **Rated current** and **Rated voltage** parameters, you set the reference value for the percentage values.

Three-Winding Transformer and Grid Coupling Transformer: General

Winding 1

Parameter: Rated current

- Default setting **(_:2311:101) Rated current** = ***1000.00 A***

Parameter: Rated voltage

- Default setting **(_:2311:103) Rated voltage** = ***400.00 kV***

Winding 2

Parameter: Rated current

- Default setting **(_:2311:102) Rated current** = ***1000.00 A***

Parameter: Rated voltage

- Default setting **(_:2311:104) Rated voltage** = ***400.00 kV***

The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the **Rated current** and **Rated voltage** parameters, you set the reference value for the percentage values.

Tap Changer

The parameters of the tap changer inside the voltage controller correspond to those of the tap changer in chapter *8.8.2 Application and Setting Notes* .

For the tap changer inside the voltage controller, the parameters for the control model are copies of those from the voltage controller. This concerns the parameters:

- Checking the switching authority
- Control model
- SBO[25] Time-out
- Feedback.monitor.time

Voltage Controller

Parameter: Mode

- Default setting **(_:14011:1) Mode** = ***on***

With the **Mode** parameter, you switch the voltage controller in ***on***, ***off***, or in ***test*** operation.

Parameter: Operating mode

- Default setting **(_:14011:101) Operating mode** = ***Manual***

With the **Operating mode** parameter, you specify whether the controller is operating in ***Auto*** mode or in ***Manual***.

Only Three-Winding Transformer:

Parameter: Winding selection

- Default setting **(_:15601:157) Winding selection** = ***Winding 1***

With the **Winding selection** parameter, you specify whether the controller controls the voltage of ***Winding 1*** or ***Winding 2***. With the ***WithMaxLoad*** setting, the voltage to be controlled is selected automatically as a function of the load current. You can switch to this method using the parameter **Winding selection** or the controllable *Automatic winding selection*.

If the controllable *Automatic winding selection* is set to **Off** or is not set, you can influence the winding to be controlled using the following 2 options:

- Via the **Winding selection** parameter
- Via the *Manual winding selection* controllable

The function value *Active winding* shows the winding selection.

Only Grid Coupling Transformer:

Parameter: Winding selection

- Default setting **(_:16351:161) Winding selection** = ***Winding 1***

With the **Winding selection** parameter, you specify whether the controller controls the voltage of ***Winding 1*** or ***Winding 2***.

You may select the winding to be controlled via the **Winding selection** parameter or the *Manual winding selection* controllable. The function value *Active winding* shows the winding selection.

[25] In the IEC 61850 standard, reservation is known as Select Before Operate (SBO).

Controlling

Parameter: Check switching authority

- Default setting **(_:107) Check switching authority** = ***yes***

With the **Check switching authority** parameter, you specify whether the switching authority (**On-site**, **Remote**) is checked during an adjusting command.

Parameter: Control model

- Default setting **(_:109) Control model** = ***SBO w. enh. security***

This parameter **Control model** specifies the control model according to IEC 61850-7-2 that corresponds to the behavior of the data (SBO – Select Before Operate).

You can select one of the following settings:

- ***direct w. normal secur.***
- ***SBO w. normal secur.***
- ***direct w. enh. security***
- ***SBO w. enh. security***

Parameter: SBO time-out

- Default setting **(_:110) SBO time-out** = ***30.00 s***

This parameter specifies the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850-7-2).

Parameter: Feedback monitoring time

- Default setting **(_:111) Feedback monitoring time** = ***10.00 s***

Reaching a new tap position after the adjusting command is monitored via the feedback-monitoring time. If a new tap position is not reached, the command is canceled after this time.

Parameter: Set point mode active

- Default setting **(_:14011:160) Set point mode active** = ***on***

With the parameter **Set point mode active** = ***on***, you can send a target voltage to the controller via a communication network. The controller uses the specified voltage value as target voltage. If the controller does not receive any valid voltage values, it uses the original target voltage. You can switch the parameter on or off.

For the three-winding transformer, the address of the **Set point mode active** parameter is _:15601:171 while the address is _:16351:171 for the grid coupling transformer.

Only Two-Winding Transformer:

Parameter: Number of target voltage

- Default setting **(_:14011:156) Number of target voltage** = ***1***

With this parameter, you specify the number of available **target voltages** (**1** to **4**). You can select a target voltage from the available ones using the function key, the communication, or a binary input.



NOTE

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1** to **4**) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1

- Default setting **(_:14011:112) Target voltage 1** = ***110.000 V***

With the **Target voltage 1** parameter, you specify the voltage that the controller is supposed to reach.

Parameter: Target voltage 2

- Default setting **(_:14011:157) Target voltage 2** = ***110.000 V***

With the **Target voltage 2** parameter, you specify the 2nd voltage that the controller is supposed to reach.

Parameter: Target voltage 3

- Default setting **(_:14011:158) Target voltage 3** = ***110.000 V***

With the **Target voltage 3** parameter, you specify the 3rd voltage that the controller is supposed to reach.

Parameter: Target voltage 4

- Default setting **(_:14011:159) Target voltage 4** = ***110.000 V***

With the **Target voltage 4** parameter, you specify the 4th voltage that the controller is supposed to reach.

Only Three-Winding Transformer:

Parameter: Number of target voltage

- Default setting **(_:15601:164) Number of target voltage** = ***1***

With this parameter, you specify the number of available **target voltages** (**1 W1/2** to **4 W1/2**). You can select a target voltage from the available ones via the function key, the communication, or a binary input.



NOTE

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1 W1/2** to **4 W1/2**) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting **(_:15601:112) Target voltage 1 w1** = ***110.000 V***

Parameter: Target voltage 1 w2

- Default setting **(_:15601:146) Target voltage 1 w2** = ***110.000 V***

Parameter: Target voltage 2 w1

- Default setting **(_:15601:165) Target voltage 2 w1** = ***110.000 V***

Parameter: Target voltage 2 w2

- Default setting **(_:15601:168) Target voltage 2 w2** = ***110.000 V***

Parameter: Target voltage 3 w1

- Default setting **(_:15601:166) Target voltage 3 w1** = ***110.000 V***

Parameter: Target voltage 3 w2

- Default setting **(_:15601:169) Target voltage 3 w2** = ***110.000 V***

Parameter: Target voltage 4 w1

- Default setting **(_:15601:167) Target voltage 4 w1** = ***110.000 V***

Parameter: Target voltage 4 w2

- Default setting **(_:15601:170) Target voltage 4 w2** = ***110.000 V***

Only Grid Coupling Transformer:

Parameter: Number of target voltage

- Default setting **(_:16351:164) Number of target voltage** = ***1***

With this parameter, you specify the number of available **target voltages** (**1 W1/2** to **4 W1/2**). You can select a target voltage from the available ones via the function key, the communication, or a binary input.

NOTE

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1 W1/2** to **4 W1/2**) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting **(_:16351:112) Target voltage 1 w1** = ***110.000 V***

Parameter: Target voltage 1 w2

- Default setting **(_:16351:146) Target voltage 1 w2** = ***110.000 V***

Parameter: Target voltage 2 w1

- Default setting **(_:16351:165) Target voltage 2 w1** = ***110.000 V***

Parameter: Target voltage 2 w2

- Default setting **(_:16351:168) Target voltage 2 w2** = ***110.000 V***

Parameter: Target voltage 3 w1

- Default setting **(_:16351:166) Target voltage 3 w1** = ***110.000 V***

Parameter: Target voltage 3 w2

- Default setting **(_:16351:169) Target voltage 3 w2** = ***110.000 V***

Parameter: Target voltage 4 w1

- Default setting **(_:16351:167) Target voltage 4 w1** = ***110.000 V***

Parameter: Target voltage 4 w2

- Default setting **(_:16351:170) Target voltage 4 w2** = ***110.000 V***

Voltage Controller

Parameter: Bandwidth

- Default setting **(_:113) Bandwidth** = ***1.0%***

With the **Bandwidth** parameter, you specify the voltage range where no control action higher or lower is to occur about the **Target voltage 1**. If the actual voltage is outside the bandwidth referenced to the **Target voltage 1**, no correction takes place.

Calculation of the **Bandwidth**:

NOTE

When calculating the **Bandwidth** B, keep the maximum accepted voltage deviation in the electrical power system and the tap voltage of the tap changer on the secondary side of the transformer in mind.

Calculation of the minimum bandwidth:

$$B[\%] \geq 0{,}6 \cdot \left(\frac{V_{rated,sec}}{V_{Nprim}} - \frac{V_{rated,sec}}{V_{(N-1)prim}} \right) \cdot V_{rated,sec} \cdot 100\,\% \cdot \frac{V_{max,prim}}{V_{rated,prim}}$$

[fospnvrz-211013, 1, en_US]

$V_{rated,sec}$	Secondary rated voltage of the transformer
V_{Nprim}	Primary tap voltage of the transformer of tap N
$V_{(N-1)prim}$	Primary tap voltage of the transformer of tap N-1
$V_{max,prim}$	Maximum primary voltage of the transformer

Parameter: T1 characteristic

- Default setting **(_:114) T1 characteristic** = ***Linear***

Parameter: T1 delay

- Default setting **(_:115) T1 delay** = ***40 s***

You can adjust the control action so that the smallest number of adjusting commands possible is necessary. To do this, using **T1 characteristic**, you set the control response and, using **T1 delay**, you set a time delay.

In the ***Linear*** setting (linear control response), the control response is independent of the voltage deviation. A constant time delay applies here.

In the ***Inverse*** setting (inverse control response), the time delay is a function of the voltage deviation referenced to **Target voltage 1**. The greater the control deviation, the faster the control response. The control quality improves, but the switching frequency increases. The effective time delay results from:

$$t_{1_delay} = \frac{T_1 \cdot B}{|D|}$$

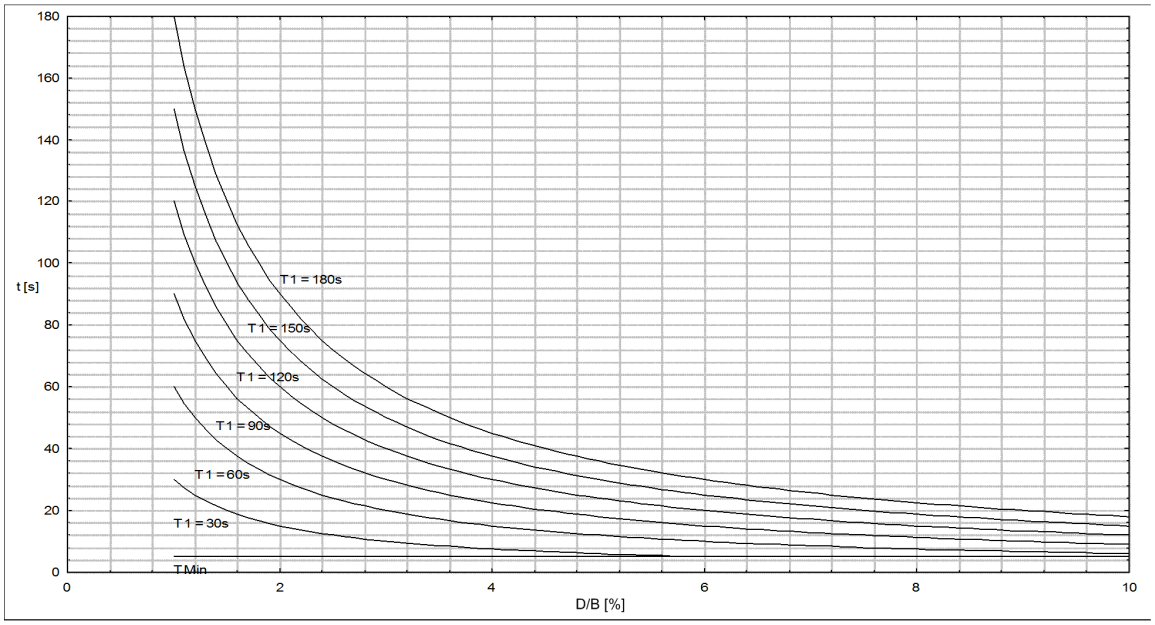
[fovrzzet-211013, 2, en_US]

T_1 – Parameter **T1 delay**

$$D = \frac{V_{act} - V_{target}}{V_{rated}} 100\ \%$$

[fokonisk-211013, 2, en_US]

D = Control deviation



[dwrglchr-160913-01.vsd, 2, en_US]

Figure 8-114 Inverse Control Characteristic

Parameter: T1 Inverse Min

- Default setting **(_:116) T1 Inverse Min** = ***5 s***

The **T1 Inverse Min** parameter is used to define the minimum time delay for the control action. This time applies only to the control response ***Inverse*** and the response cannot be shorter.

Parameter: T2 delay

- Default setting **(_:117) T2 delay** = ***5 s***

With the **T2 delay** parameter, you set the time the tap changer has to wait from one tap position to the next. During this time, several adjusting commands can be sent to the tap changer in one direction, which permits a correction of the actual voltage. The time delay T2 has an independent characteristic. The time T2 is generally set shorter than the time T1. If the time T2 is switched off by a setting equal to 0, the delay T1 is always active.

Parameter: Regulate with T2 at start

- Default setting **(_:14011:155) Regulate with T2 at start** = ***on***

With the **Regulate with T2 at start** parameter, you can activate a shorter time than T1. This can be necessary for controlling a voltage recovery or after switching on a transformer. If no voltage was available before, this setting controls with the shorter time T2 when starting the control action. You can switch this functionality on or off. If you always want to use the time T2 for control, you must set the ***Block T1*** controllable to ***On***.

For the three-winding transformer, the address of the **Regulate with T2 at start** parameter is _:15601:163 while the address is _:16351:163 for the grid coupling transformer.

Parameter: Fast step down

- Default setting **(_:121) Fast step down** = ***on***

Parameter: Fast step down limit

- Default setting **(_:122) Fast step down limit** = ***6.0 %***

Parameter: Fast step down T delay

- Default setting **(_:123) Fast step down T delay** = ***0.0 s***

With this parameter, you can specify the time delay of the fast step down mode. If the actual voltage is greater than the value of the limit for the fast step down mode (_:122), the fast step-down mode is activated. If the voltage limit is exceeded for only a brief period within the time delay, a fast step down mode is not activated.

Parameter: Fast step up

- Default setting **(_:118) Fast step up** = ***off***

Parameter: Fast step up limit

- Default setting **(_:119) Fast step up limit** = ***-6.0 %***

Parameter: Fast step up T delay

- Default setting **(_:120) Fast step up T delay** = ***2.0 s***

With this parameter, you can specify the time delay of the fast step up mode. If the actual voltage is less than the value of the limit for the fast step up mode (_:119), the fast step up mode is activated. If the value drops below the voltage limit for only a brief period within the time delay, a fast step up mode is not activated.

Parameter: Function monitoring

- Default setting **(_:124) Function monitoring** = ***15 min***

You can delay the pickup of the function monitor. With the setting **Function monitoring** = ***0 min***, the function monitor is switched off.

Voltage Controller Only Grid Coupling Transformer

Parameter: Power-flow supervision

- Default setting **(_:16351:162) Power-flow supervision** = ***on***

With the **Power-flow supervision** parameter, you can monitor the power flow. You can switch the parameter on or off.

Line Compensation for the Two-Winding Transformer

Parameter: Line drop compensation

- Default setting **(_:14011:125) Line drop compensation** = ***off***

You can use the **Line drop compensation** parameter to select the correction procedure of the load-dependent line voltage drop. There are 2 procedures available for selection: ***LDC-Z*** and ***LDC-XandR***.

Consider the following parameter for **Line drop compensation** = ***LDC-Z*** :

Parameter: Target voltage rising

- Default setting **(_:14011:126) Target voltage rising** = ***4.0 %***

With the **Target voltage rising** parameter, you set the voltage drop across the line. The value represents the voltage increase in % of the **Target voltage 1** that occurs at rated load. Only the magnitude of the current is considered. The set value is added to the **Target voltage 1**.

Target voltage rising [%] = ΔV_{load} [%] if I_{load} = 100 %

$$\text{Target voltage rising}[\%] = \left(V_{SetComp}[\%] - V_{Set}[\%]\right) \cdot \frac{100\ \%}{I_{load}[\%]}$$

[foschlst-211013, 1, en_US]

$V_{SetComp}$	Target voltage at the end of the line
V_{Set}	Target voltage
I_{load}	Load current in %

Parameter: Max load current

- Default setting **(_:14011:127) Max load current** = ***100.0 %***

With the setting of the parameter **Max load current**, you can prevent the voltage at the transformer from becoming too high in the event of extraordinarily high load current. If the load current exceeds the set value, no additional load-current compensation is calculated.

Consider the following parameter for **Line drop compensation** = ***LDC-XandR*** :

Parameter: R line

- Default setting **(_:14011:153) R line** = ***0.0 Ω***

With the **R line** parameter, you set the ohmic resistance of the power line.

Parameter: X line

- Default setting **(_:14011:154) X line** = ***0.0 Ω***

With the **X line** parameter, you set the reactance for the line to be protected.

In order to determine the voltage drop by the line, entering the parameter **R line** and **X line** is necessary for the procedure **Line drop compensation** = ***LDC-XandR***. If the primary values are known and you would like to set the secondary values, use the following formula for the calculation

$$X_{sec} = \frac{Ratio_I}{Ratio_V} X_{prim}$$

[fo-I-V-Ratio-250214, 1, en_US]

As an example, calculate X_{sec} with the following parameters:

Current transformer ratio	: 1000 A/1 A
Voltage transformer ratio	: 380 kV/0.1 kV
X_{prim}	: 21 Ω

Therefore, the result for X_{sec} is:

$$X_{sec} = \frac{1000\ A / 1\ A}{380\ kV / 0.1\ kV} 21\ \Omega = 5.53\ \Omega$$

[fo-I-V-Ratio_Value-250214, 1, en_US]

If you are implementing a parallel control with the X and R compensation, then the X value is negative and considers the voltage increase from the busbar to the transformer.

Line Compensation for the Three-Winding Transformers and Grid Coupling Transformers

Parameter: Line drop compensation

- Default setting **(_:125) Line drop compensation** = ***off***

Consider the following parameter for **Line drop compensation** = ***LDC-Z*** :

Parameter: Target voltage rising w1

- Default setting **(_:126) Target voltage rising w1** = ***4.0%***

Parameter: Target voltage rising w2

- Default setting **(_:147) Target voltage rising w2** = ***4.0%***

Parameter: Max load current

- Default setting **(_:127) Max load current** = ***100.0 %***

Consider the following parameter for **Line drop compensation** = ***LDC-XandR***:

Parameter: R line w1

- Default setting **(_:153) R line w1** = ***0.0 Ω***

Parameter: R line w2

- Default setting **(_:155) R line w2** = ***0.0 Ω***

Parameter: X line w1

- Default setting **(_:154) X line w1** = ***0.0 Ω***

Parameter: X line w2

- Default setting **(_:156) X line w2** = ***0.0 Ω***

Limiting Values for the Two-Winding Transformer

Parameter: Lower tap-position limit

- Default setting **(_:14011:102) Lower tap-position limit** = ***1***

Parameter: Higher tap-position limit

- Default setting **(_:14011:103) Higher tap-position limit** = ***1***

With the parameters **Lower tap-position limit** and **Higher tap-position limit**, you can restrict the taps available in automatic operation. For example, using the parameter **Higher tap-position limit**, changes to higher taps to excessive ratios that would result in overvoltages in the event of a sudden loss of load are blocked.

Parameter: Vmin limiting

- Default setting **(_:14011:128) Vmin limiting** = ***on***

Parameter: Vmin threshold

- Default setting **(_:14011:129) Vmin threshold** = ***105.000 V***

Parameter: Vmin time delay

- Default setting **(_:14011:130) Vmin time delay** = ***10 s***

Parameter: Vmax limiting

- Default setting **(_:14011:131) Vmax limiting** = ***on***

Parameter: Vmax threshold

- Default setting **(_:14011:132) Vmax threshold** = ***115.000 V***

Parameter: Vmax time delay

- Default setting **(_:14011:133) Vmax time delay** = ***10 s***

The voltage limits are necessary only for special control situations. The overvoltage limit prevents a change to a higher tap by the controller if the limiting value **Vmax threshold** is exceeded. The undervoltage limit prevents a change to a lower tap by the controller if the voltage drops below the limiting value **Vmin threshold**.

Limiting Values for Three-Winding Transformers and Grid Coupling Transformers

Parameter: Vmin threshold w1

- Default setting **(_:129) Vmin threshold w1** = ***105.000 V***

Parameter: Vmin threshold w2

- Default setting **(_:148) Vmin threshold w2** = ***105.000 V***

Parameter: Vmax threshold w1

- Default setting **(_:132) Vmax threshold w1** = ***115.000 V***

Parameter: Vmax threshold w2

- Default setting **(_:149) Vmax threshold w2** = ***115.000 V***

Blockings for the Two-Winding Transformers

Parameter: Blocking behavior

- Default setting **(_:14011:134) Blocking behavior** = ***Auto-Manual***

If the corresponding voltage limits are exceeded in either direction, the blockings prevent a change to a lower or higher tap. On the one hand, this prevents excessive wear of the contacts of the tap changer and, on the other hand, it prevents a system incident. With the parameter **Blocking behavior**, you set whether these blockings are effective only in automatic operation or in both automatic and manual operation.

Parameter: V< Blocking

- Default setting **(_:14011:135) V< Blocking** = ***on***

Parameter: V< Threshold

- Default setting **(_:14011:136) V< Threshold** = ***90.000 V***

Parameter: V< Time delay

- Default setting **(_:14011:137) V< Time delay** = ***0 s***

Parameter: I> Blocking

- Default setting **(_:14011:138) I> Blocking** = ***on***

Parameter: I> Threshold

- Default setting **(_:14011:139) I> Threshold** = ***150 %***

Parameter: I> Time delay

- Default setting **(_:14011:140) I> Time delay**= ***0 s***

If the load current exceeds the threshold value **I> Threshold** for the time **I> Time delay**, the overcurrent blocking prevents changing to a higher or lower tap. Set the threshold value **I> Threshold** in % in relation to the rated current. To do this, set the parameter **I reference** for % values.

Parameter: I< Blocking

- Default setting **(_:14011:141) I< Blocking** = ***off***

Parameter: I< Threshold

- Default setting **(_:14011:142) I< Threshold** = ***10 %***

Parameter: I< Time delay

- Default setting **(_:14011:143) I< Time delay** = ***10 s***

If the load current drops below the threshold value **I< Threshold** for the time **I< Time delay**, the undercurrent blocking prevents changing to a higher or lower tap. Set the threshold value **I< Threshold** in % in relation to the rated current. To do this, set the parameter **I reference** for % values.

Blockings for Three-Winding Transformers and Grid Coupling Transformers

Parameter: V< Threshold w1

- Default setting **(_:136) V< Threshold w1** = ***90.000 V***

Parameter: V< Threshold w2

- Default setting **(_:150) V< Threshold w2** = ***90.000 V***

8.9.5 Settings

Two-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:14011:1	90V V.contr.2w:Mode		• off • on • test	on
_:14011:101	90V V.contr.2w:Operating mode		• Manual • Auto	Manual
Control				
_:14011:107	90V V.contr.2w:Check switching authority		• no • yes	yes
_:14011:109	90V V.contr.2w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:14011:110	90V V.contr.2w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:14011:111	90V V.contr.2w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:14011:156	90V V.contr.2w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:14011:112	90V V.contr.2w:Target voltage 1		10.000 V to 340.000 V	110.000 V
_:14011:157	90V V.contr.2w:Target voltage 2		10.000 V to 340.000 V	110.000 V
_:14011:158	90V V.contr.2w:Target voltage 3		10.000 V to 340.000 V	110.000 V
_:14011:159	90V V.contr.2w:Target voltage 4		10.000 V to 340.000 V	110.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:113	90V V.contr.2w:Band-width		0.2 % to 10.0 %	1.0 %
_:14011:114	90V V.contr.2w:T1 char-acteristic		• Linear • Inverse	Linear
_:14011:115	90V V.contr.2w:T1 delay		5 s to 600 s	40 s
_:14011:116	90V V.contr.2w:T1 Inverse Min		5 s to 100 s	5 s
_:14011:117	90V V.contr.2w:T2 delay		0 s to 100 s	5 s
_:14011:118	90V V.contr.2w:Fast step up		• off • on	off
_:14011:119	90V V.contr.2w:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:14011:120	90V V.contr.2w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:14011:121	90V V.contr.2w:Fast step down		• off • on	on
_:14011:122	90V V.contr.2w:Fast step down limit		0.0 % to 50.0 %	6.0 %
_:14011:123	90V V.contr.2w:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:14011:124	90V V.contr.2w:Function monitoring		0 min to 120 min	15 min
_:14011:155	90V V.contr.2w:Regulate with T2 at start		• off • on	on
_:14011:160	90V V.contr.2w:Set point mode active		• off • on	on
Line drop comp.				
_:14011:125	90V V.contr.2w:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:14011:126	90V V.contr.2w:Target voltage rising		0.0 % to 20.0 %	4.0 %
_:14011:127	90V V.contr.2w:Max load current		0.0 % to 500.0 %	100.0 %
_:14011:153	90V V.contr.2w:R line		0.0 Ω to 30.0 Ω	0.0 Ω
_:14011:154	90V V.contr.2w:X line		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_:14011:102	90V V.contr.2w:Lower tap-position limit		-128 to 127	1
_:14011:103	90V V.contr.2w:Higher tap-position limit		-128 to 127	15
_:14011:128	90V V.contr.2w:Vmin limiting		• off • on	on
_:14011:129	90V V.contr.2w:Vmin threshold		10.000 V to 340.000 V	105.000 V
_:14011:130	90V V.contr.2w:Vmin time delay		0 s to 20 s	10 s
_:14011:131	90V V.contr.2w:Vmax limiting		• off • on	on
_:14011:132	90V V.contr.2w:Vmax threshold		10.000 V to 340.000 V	115.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:133	90V V.contr.2w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:14011:134	90V V.contr.2w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:14011:135	90V V.contr.2w:V< Blocking		• off • on	on
_:14011:136	90V V.contr.2w:V< Threshold		10.000 V to 340.000 V	90.000 V
_:14011:137	90V V.contr.2w:V< Time delay		0 s to 20 s	0 s
_:14011:138	90V V.contr.2w:I> Blocking		• off • on	on
_:14011:139	90V V.contr.2w:I> Threshold		10 % to 500 %	150 %
_:14011:140	90V V.contr.2w:I> Time delay		0 s to 20 s	0 s
_:14011:141	90V V.contr.2w:I< Blocking		• off • on	off
_:14011:142	90V V.contr.2w:I< Threshold		3 % to 100 %	10 %
_:14011:143	90V V.contr.2w:I< Time delay		0 s to 20 s	10 s

Three-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:103	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_:2311:106	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:15601:1	90V V.contr.3w:Mode		• off • on • test	on
_:15601:101	90V V.contr.3w:Operating mode		• Manual • Auto	Manual
_:15601:157	90V V.contr.3w:Winding selection		• Winding 1 • Winding 2 • WithMaxLoad	Winding 1
Control				
_:15601:107	90V V.contr.3w:Check switching authority		• no • yes	yes
_:15601:109	90V V.contr.3w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:15601:110	90V V.contr.3w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:15601:111	90V V.contr.3w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:15601:164	90V V.contr.3w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:15601:112	90V V.contr.3w:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:15601:165	90V V.contr.3w:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:15601:166	90V V.contr.3w:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:15601:167	90V V.contr.3w:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:15601:146	90V V.contr.3w:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:15601:168	90V V.contr.3w:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:15601:169	90V V.contr.3w:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:15601:170	90V V.contr.3w:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_:15601:113	90V V.contr.3w:Bandwidth		0.2 % to 10.0 %	1.0 %
_:15601:114	90V V.contr.3w:T1 characteristic		• Linear • Inverse	Linear
_:15601:115	90V V.contr.3w:T1 delay		5 s to 600 s	40 s
_:15601:116	90V V.contr.3w:T1 Inverse Min		5 s to 100 s	5 s
_:15601:117	90V V.contr.3w:T2 delay		0 s to 100 s	5 s
_:15601:118	90V V.contr.3w:Fast step up		• off • on	off

Addr.	Parameter	C	Setting Options	Default Setting
_:15601:119	90V V.contr.3w:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:15601:120	90V V.contr.3w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:15601:121	90V V.contr.3w:Fast step down		• off • on	on
_:15601:122	90V V.contr.3w:Fast step down limit		0.0 % to 50.0 %	6.0 %
_:15601:123	90V V.contr.3w:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:15601:124	90V V.contr.3w:Function monitoring		0 min to 120 min	15 min
_:15601:162	90V V.contr.3w:Power-flow supervision		• off • on	on
_:15601:163	90V V.contr.3w:Regulate with T2 at start		• off • on	on
_:15601:171	90V V.contr.3w:Set point mode active		• off • on	on
Line drop comp.				
_:15601:125	90V V.contr.3w:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:15601:126	90V V.contr.3w:Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_:15601:147	90V V.contr.3w:Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_:15601:127	90V V.contr.3w:Max load current		0.0 % to 500.0 %	100.0 %
_:15601:153	90V V.contr.3w:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_:15601:154	90V V.contr.3w:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_:15601:155	90V V.contr.3w:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_:15601:156	90V V.contr.3w:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_:15601:102	90V V.contr.3w:Lower tap-position limit		-128 to 127	1
_:15601:103	90V V.contr.3w:Higher tap-position limit		-128 to 127	15
_:15601:128	90V V.contr.3w:Vmin limiting		• off • on	on
_:15601:129	90V V.contr.3w:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_:15601:148	90V V.contr.3w:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_:15601:130	90V V.contr.3w:Vmin time delay		0 s to 20 s	10 s
_:15601:131	90V V.contr.3w:Vmax limiting		• off • on	on

Addr.	Parameter	C	Setting Options	Default Setting
_:15601:132	90V V.contr.3w:Vmax threshold w1		10.000 V to 340.000 V	115.000 V
_:15601:149	90V V.contr.3w:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_:15601:133	90V V.contr.3w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:15601:134	90V V.contr.3w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:15601:135	90V V.contr.3w:V< Blocking		• off • on	on
_:15601:136	90V V.contr.3w:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_:15601:150	90V V.contr.3w:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_:15601:137	90V V.contr.3w:V< Time delay		0 s to 20 s	0 s
_:15601:138	90V V.contr.3w:I> Blocking		• off • on	on
_:15601:139	90V V.contr.3w:I> Threshold		10 % to 500 %	150 %
_:15601:140	90V V.contr.3w:I> Time delay		0 s to 20 s	0 s
_:15601:141	90V V.contr.3w:I< Blocking		• off • on	off
_:15601:142	90V V.contr.3w:I< Threshold		3 % to 100 %	10 %
_:15601:143	90V V.contr.3w:I< Time delay		0 s to 20 s	10 s

Grid Coupling Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:103	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_:2311:106	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap

Addr.	Parameter	C	Setting Options	Default Setting
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:16351:1	90V V.contr.gc:Mode		• off • on • test	on
_:16351:101	90V V.contr.gc:Operating mode		• Manual • Auto	Manual
_:16351:161	90V V.contr.gc:Winding selection		• Winding 1 • Winding 2	Winding 1
Control				
_:16351:107	90V V.contr.gc:Check switching authority		• no • yes	yes
_:16351:109	90V V.contr.gc:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:16351:110	90V V.contr.gc:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:16351:111	90V V.contr.gc:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:16351:164	90V V.contr.gc:Number of target voltage		• 1 • 2 • 3 • 4	1
_:16351:112	90V V.contr.gc:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:16351:165	90V V.contr.gc:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:16351:166	90V V.contr.gc:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:16351:167	90V V.contr.gc:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:16351:146	90V V.contr.gc:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:16351:168	90V V.contr.gc:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:16351:169	90V V.contr.gc:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:16351:170	90V V.contr.gc:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_:16351:113	90V V.contr.gc:Bandwidth		0.2 % to 10.0 %	1.0 %
_:16351:114	90V V.contr.gc:T1 characteristic		• Linear • Inverse	Linear
_:16351:115	90V V.contr.gc:T1 delay		5 s to 600 s	40 s
_:16351:116	90V V.contr.gc:T1 Inverse Min		5 s to 100 s	5 s
_:16351:117	90V V.contr.gc:T2 delay		0 s to 100 s	5 s

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:118	90V V.contr.gc:Fast step up		• off • on	off
_:16351:119	90V V.contr.gc:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:16351:120	90V V.contr.gc:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:16351:121	90V V.contr.gc:Fast step down		• off • on	on
_:16351:122	90V V.contr.gc:Fast step down limit		0.0 % to 50.0 %	6.0 %
_:16351:123	90V V.contr.gc:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:16351:124	90V V.contr.gc:Function monitoring		0 min to 120 min	15 min
_:16351:162	90V V.contr.gc:Power-flow supervision		• off • on	on
_:16351:163	90V V.contr.gc:Regulate with T2 at start		• off • on	on
_:16351:171	90V V.contr.gc:Set point mode active		• off • on	on
Line drop comp.				
_:16351:125	90V V.contr.gc:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:16351:126	90V V.contr.gc:Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_:16351:147	90V V.contr.gc:Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_:16351:127	90V V.contr.gc:Max load current		0.0 % to 500.0 %	100.0 %
_:16351:153	90V V.contr.gc:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_:16351:154	90V V.contr.gc:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_:16351:155	90V V.contr.gc:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_:16351:156	90V V.contr.gc:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_:16351:102	90V V.contr.gc:Lower tap-position limit		-128 to 127	1
_:16351:103	90V V.contr.gc:Higher tap-position limit		-128 to 127	15
_:16351:128	90V V.contr.gc:Vmin limiting		• off • on	on
_:16351:129	90V V.contr.gc:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_:16351:148	90V V.contr.gc:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_:16351:130	90V V.contr.gc:Vmin time delay		0 s to 20 s	10 s
_:16351:131	90V V.contr.gc:Vmax limiting		• off • on	on
_:16351:132	90V V.contr.gc:Vmax threshold w1		10.000 V to 340.000 V	115.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:149	90V V.contr.gc:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_:16351:133	90V V.contr.gc:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:16351:134	90V V.contr.gc:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:16351:135	90V V.contr.gc:V< Blocking		• off • on	on
_:16351:136	90V V.contr.gc:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_:16351:150	90V V.contr.gc:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_:16351:137	90V V.contr.gc:V< Time delay		0 s to 20 s	0 s
_:16351:138	90V V.contr.gc:I> Blocking		• off • on	on
_:16351:139	90V V.contr.gc:I> Threshold		10 % to 500 %	150 %
_:16351:140	90V V.contr.gc:I> Time delay		0 s to 20 s	0 s
_:16351:141	90V V.contr.gc:I< Blocking		• off • on	off
_:16351:142	90V V.contr.gc:I< Threshold		3 % to 100 %	10 %
_:16351:143	90V V.contr.gc:I< Time delay		0 s to 20 s	10 s

8.9.6 Information List

Two-Winding Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O

No.	Information	Data Class (Type)	Type
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.2w			
_:14011:81	90V V.contr.2w:>Block	SPS	I
_:14011:85	90V V.contr.2w:>Reset min./max.	SPS	I
_:14011:53	90V V.contr.2w:Health	ENS	O
_:14011:54	90V V.contr.2w:Inactive	SPS	O
_:14011:52	90V V.contr.2w:Behavior	ENS	O
_:14011:301	90V V.contr.2w:End Higher pos. Auto	SPS	O
_:14011:302	90V V.contr.2w:End Lower pos. Auto	SPS	O
_:14011:326	90V V.contr.2w:Cmd. with feedback	BALANCED SCORECARD	C
_:14011:329	90V V.contr.2w:Block auto	SPC	C
_:14011:312	90V V.contr.2w:Operating mode	SPC	C
_:14011:305	90V V.contr.2w:Bandwidth >	SPS	O
_:14011:306	90V V.contr.2w:Bandwidth <	SPS	O
_:14011:307	90V V.contr.2w:Fast Step Up active	SPS	O
_:14011:308	90V V.contr.2w:Fast Step Down active	SPS	O
_:14011:309	90V V.contr.2w:Auto Monitor	SPS	O
_:14011:310	90V V.contr.2w:Vmin Limiting	SPS	O
_:14011:311	90V V.contr.2w:Vmax Limiting	SPS	O
_:14011:315	90V V.contr.2w:Auto Blocking	SPS	O
_:14011:316	90V V.contr.2w:Manual Blocking	SPS	O
_:14011:317	90V V.contr.2w:V< Blocking	SPS	O
_:14011:318	90V V.contr.2w:I> Blocking	SPS	O
_:14011:319	90V V.contr.2w:I< Blocking	SPS	O
_:14011:320	90V V.contr.2w:V act.	MV	O
_:14011:321	90V V.contr.2w:ΔV act.	MV	O
_:14011:322	90V V.contr.2w:I load	MV	O
_:14011:323	90V V.contr.2w:V max	MV	O
_:14011:324	90V V.contr.2w:V min	MV	O
_:14011:325	90V V.contr.2w:V target	MV	O
_:14011:354	90V V.contr.2w:Target voltage 1	SPC	C
_:14011:355	90V V.contr.2w:Target voltage 2	SPC	C
_:14011:356	90V V.contr.2w:Target voltage 3	SPC	C
_:14011:357	90V V.contr.2w:Target voltage 4	SPC	C
_:14011:358	90V V.contr.2w:Set target voltage	APC	C
_:14011:359	90V V.contr.2w:Block T1	SPC	C

Three-Winding Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

No.	Information	Data Class (Type)	Type
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.3w			
_:15601:81	90V V.contr.3w:>Block	SPS	I
_:15601:85	90V V.contr.3w:>Reset min./max.	SPS	I
_:15601:53	90V V.contr.3w:Health	ENS	O
_:15601:54	90V V.contr.3w:Inactive	SPS	O
_:15601:52	90V V.contr.3w:Behavior	ENS	O
_:15601:301	90V V.contr.3w:End Higher pos. Auto	SPS	O
_:15601:302	90V V.contr.3w:End Lower pos. Auto	SPS	O
_:15601:332	90V V.contr.3w:Cmd. with feedback	BALANCED SCORECARD	C
_:15601:335	90V V.contr.3w:Block auto	SPC	C
_:15601:336	90V V.contr.3w:Operating mode	SPC	C
_:15601:305	90V V.contr.3w:Bandwidth >	SPS	O
_:15601:306	90V V.contr.3w:Bandwidth <	SPS	O
_:15601:307	90V V.contr.3w:Fast Step Up active	SPS	O
_:15601:308	90V V.contr.3w:Fast Step Down active	SPS	O
_:15601:309	90V V.contr.3w:Auto Monitor	SPS	O
_:15601:357	90V V.contr.3w:Power-flow superv.	SPS	O
_:15601:310	90V V.contr.3w:Vmin Limiting w1	SPS	O
_:15601:311	90V V.contr.3w:Vmin Limiting w2	SPS	O
_:15601:312	90V V.contr.3w:Vmax Limiting w1	SPS	O
_:15601:313	90V V.contr.3w:Vmax Limiting w2	SPS	O
_:15601:314	90V V.contr.3w:Auto Blocking	SPS	O
_:15601:315	90V V.contr.3w:Manual Blocking	SPS	O
_:15601:316	90V V.contr.3w:V< Blocking w1	SPS	O
_:15601:317	90V V.contr.3w:V< Blocking w2	SPS	O
_:15601:318	90V V.contr.3w:I> Blocking	SPS	O
_:15601:319	90V V.contr.3w:I< Blocking	SPS	O
_:15601:320	90V V.contr.3w:Vact.w1	MV	O
_:15601:321	90V V.contr.3w:Vact.w2	MV	O

No.	Information	Data Class (Type)	Type
_:15601:322	90V V.contr.3w:ΔV act.	MV	O
_:15601:323	90V V.contr.3w:I load w1	MV	O
_:15601:324	90V V.contr.3w:I load w2	MV	O
_:15601:325	90V V.contr.3w:Vmax 1	MV	O
_:15601:326	90V V.contr.3w:Vmax 2	MV	O
_:15601:327	90V V.contr.3w:Vmin 1	MV	O
_:15601:328	90V V.contr.3w:Vmin 2	MV	O
_:15601:329	90V V.contr.3w:V tar.w1	MV	O
_:15601:330	90V V.contr.3w:V tar.w2	MV	O
_:15601:358	90V V.contr.3w:Target voltage 1 w1	SPC	C
_:15601:359	90V V.contr.3w:Target voltage 2 w1	SPC	C
_:15601:360	90V V.contr.3w:Target voltage 3 w1	SPC	C
_:15601:361	90V V.contr.3w:Target voltage 4 w1	SPC	C
_:15601:362	90V V.contr.3w:Target voltage 1 w2	SPC	C
_:15601:363	90V V.contr.3w:Target voltage 2 w2	SPC	C
_:15601:364	90V V.contr.3w:Target voltage 3 w2	SPC	C
_:15601:365	90V V.contr.3w:Target voltage 4 w2	SPC	C
_:15601:366	90V V.contr.3w:Set target voltage w1	APC	C
_:15601:367	90V V.contr.3w:Set target voltage w2	APC	C
_:15601:368	90V V.contr.3w:Block T1	SPC	C
_:15601:356	90V V.contr.3w:Winding act.	INS	O
_:15601:369	90V V.contr.3w:Winding selec. manual	SPC	C
_:15601:370	90V V.contr.3w:Winding selec. auto	SPC	C

Grid Coupling Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C

No.	Information	Data Class (Type)	Type
90V V.contr.gc			
_:16351:81	90V V.contr.gc:>Block	SPS	I
_:16351:85	90V V.contr.gc:>Reset min./max.	SPS	I
_:16351:53	90V V.contr.gc:Health	ENS	O
_:16351:54	90V V.contr.gc:Inactive	SPS	O
_:16351:52	90V V.contr.gc:Behavior	ENS	O
_:16351:301	90V V.contr.gc:End Higher pos. Auto	SPS	O
_:16351:302	90V V.contr.gc:End Lower pos. Auto	SPS	O
_:16351:332	90V V.contr.gc:Cmd. with feedback	BALANCED SCORECARD	C
_:16351:335	90V V.contr.gc:Block auto	SPC	C
_:16351:336	90V V.contr.gc:Operating mode	SPC	C
_:16351:305	90V V.contr.gc:Bandwidth >	SPS	O
_:16351:306	90V V.contr.gc:Bandwidth <	SPS	O
_:16351:307	90V V.contr.gc:Fast Step Up active	SPS	O
_:16351:308	90V V.contr.gc:Fast Step Down active	SPS	O
_:16351:309	90V V.contr.gc:Auto Monitor	SPS	O
_:16351:357	90V V.contr.gc:Power-flow superv.	SPS	O
_:16351:310	90V V.contr.gc:Vmin Limiting w1	SPS	O
_:16351:311	90V V.contr.gc:Vmin Limiting w2	SPS	O
_:16351:312	90V V.contr.gc:Vmax Limiting w1	SPS	O
_:16351:313	90V V.contr.gc:Vmax Limiting w2	SPS	O
_:16351:314	90V V.contr.gc:Auto Blocking	SPS	O
_:16351:315	90V V.contr.gc:Manual Blocking	SPS	O
_:16351:316	90V V.contr.gc:V< Blocking w1	SPS	O
_:16351:317	90V V.contr.gc:V< Blocking w2	SPS	O
_:16351:318	90V V.contr.gc:I> Blocking	SPS	O
_:16351:319	90V V.contr.gc:I< Blocking	SPS	O
_:16351:320	90V V.contr.gc:Vact.w1	MV	O
_:16351:321	90V V.contr.gc:Vact.w2	MV	O
_:16351:322	90V V.contr.gc:ΔV act.	MV	O
_:16351:323	90V V.contr.gc:I load w1	MV	O
_:16351:324	90V V.contr.gc:I load w2	MV	O
_:16351:325	90V V.contr.gc:Vmax 1	MV	O
_:16351:326	90V V.contr.gc:Vmax 2	MV	O
_:16351:327	90V V.contr.gc:Vmin 1	MV	O
_:16351:328	90V V.contr.gc:Vmin 2	MV	O
_:16351:329	90V V.contr.gc:V tar.w1	MV	O
_:16351:330	90V V.contr.gc:V tar.w2	MV	O
_:16351:358	90V V.contr.gc:Target voltage 1 w1	SPC	C
_:16351:359	90V V.contr.gc:Target voltage 2 w1	SPC	C
_:16351:360	90V V.contr.gc:Target voltage 3 w1	SPC	C
_:16351:361	90V V.contr.gc:Target voltage 4 w1	SPC	C
_:16351:362	90V V.contr.gc:Target voltage 1 w2	SPC	C
_:16351:363	90V V.contr.gc:Target voltage 2 w2	SPC	C
_:16351:364	90V V.contr.gc:Target voltage 3 w2	SPC	C

No.	Information	Data Class (Type)	Type
_:16351:365	90V V.contr.gc:Target voltage 4 w2	SPC	C
_:16351:366	90V V.contr.gc:Set target voltage w1	APC	C
_:16351:367	90V V.contr.gc:Set target voltage w2	APC	C
_:16351:368	90V V.contr.gc:Block T1	SPC	C
_:16351:356	90V V.contr.gc:Winding act.	INS	O
_:16351:369	90V V.contr.gc:Winding selec. manual	SPC	C
_:16351:370	90V V.contr.gc:Winding selec. auto	SPC	C

9 Supervision Functions

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9.1 Overview

SIPROTEC 5 devices are equipped with an extensive and integrated supervision concept. Continuous supervision:

- Ensures the availability of the technology used
- Avoids subfunction and overfunction of the device
- Protects persons and primary technical devices
- Offers effective assistance during commissioning and testing

The following areas are monitored:

- Supervision the resource consumption of the application
- Supervision of the secondary system
- Supervision of device hardware
- Supervision of device firmware
- Supervision of hardware configuration
- Supervision of communication connections

When the supervision functions pick up, that will be displayed and also indicated. Error responses are defined for the device. The error responses are grouped in defect severities.

The supervision functions work selectively. When the supervision functions pick up - as far as possible - only the affected parts of the hardware and firmware are blocked. If this is not possible, the device goes out of operation into a secure state (fallback mode). In addition to safety, this warrants a high degree of availability.

9.2 Resource-Consumption Supervision

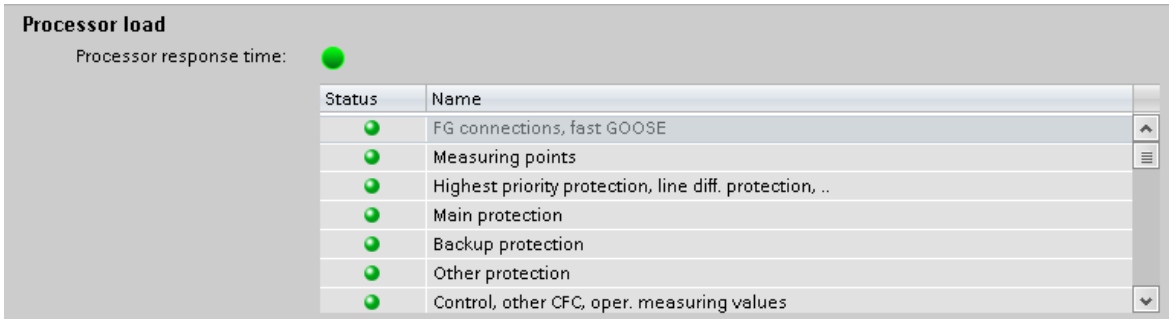
9.2.1 Load Model

SIPROTEC 5 devices are freely configurable. A load model is integrated in DIGSI 5. The load model prevents you from overloading the device with an excessively large application.

The load model shows the device utilization and the response times for device functions. If it determines that an application created is likely to overload the device, DIGSI prevents the application from being loaded into the device.

In this rare case, you must then reduce the application in order to be able to load it into the device.

The load model can be found in the DIGSI 5 project tree under **Name of the device → Device information**. In the operating range, select the **Resource consumption** setting sheet. The following figure shows an example of the view of the load model in DIGSI 5:



[sclasjsk-291112-01.tif, 1, en_US]

Figure 9-1 Visualization of the Load Model in DIGSI

A green total display for the processor response time indicates that the device is not overloaded by the present application. On the other hand, if you see a red exclamation mark, the planned application is overloading the device.

The list below the total display shows the individual functional areas. These areas combine functions with the same real-time requirements in groups. A green display in front of an area (see *Figure 9-1*) indicates that the response times of the functions grouped in this area can be maintained. A red exclamation point indicates that functions may have longer response times than are specified in the Technical data for the device. In such a case, loading of the application into the device is blocked.

The following table provides an overview of the functional areas and the most important influencing quantities on device utilization:

Functional Area	Brief Description	Change in Load
CFC event-triggered, fast	CFC charts that must be processed especially fast (for example, to invoke interlockings between protection functions)	Adding or removing CFC charts in the fast event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the fast event-triggered process area
Measuring points	Provision of measured values for protection, control, and measurement functions	Adding or removing • Measuring points (in the Measuring-points routing Editor) • Function groups that provide measured-value preprocessing for insertable functions (for example, Line function group and Circuit-breaker function group)

Functional Area	Brief Description	Change in Load
• FG connections • Fast GOOSE	• Interaction between individual function groups, for example, between the Line function group and the Circuit-breaker function group • Fast GOOSE communication	Adding or removing • Protection functions and their stages • Circuit-breaker function groups • Fast GOOSE connections
Protection Communication	Signal transmission via protection communication and differential protection communication	Adding or removing • Communication modules for the protection interface (in the DIGSI 5 Hardware and logs view) • Routings to the protection interface
Function Groups	Function Groups	Adding or removing function groups such as: • FG V/I 3-phase
Overcurrent protection	Overcurrent protection	Adding or removing • Overcurrent protection, phases • Overcurrent protection, ground
Measuring point supervising function, protection communication	• Measuring-point supervision functions • Scope of the data transmission via the protection communication	Adding or removing measuring points or individual supervising functions, such as • 3-phase current measuring point • 3-phase voltage measuring point • Measuring-voltage failure detection Add to or remove from transmission values via the protection communication • Single-point indications • Measured values
Other protection	Protection functions with low requirements for fast operate times	Adding or removing • Overload protection functions • Functions and stages of voltage protection • All functions not listed previously
CFC event-triggered, standard GOOSE	CFC charts with a maximum processing time of 40 ms	Adding or removing CFC charts in the event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the event-triggered process area
• Control • Other continuous function chart • Operational measured values	• Control and interlocking • CFC charts in the area of control, measured-value preprocessing, and event-controlled • Operational measured values	Adding or removing • Function blocks for control and interlocking • CFC charts in the control area • Switching devices (except circuit breakers), for example, disconnector function groups • Operational measured values • CFC charts in the measured values area

If the load model displays a warning, bear in mind the following general instructions:

The areas named in the table are listed in descending order of real time requirements. If a warning appears to the effect that the guaranteed response times may be exceeded in an area, you may be able to return to the permitted area by taking the following measures:

- Reduce the functional scope in the marked area (red exclamation mark)
- Reduce the functional scope in another area with higher real time requirements

When you have reduced the application, check the display in resource consumption! If a function or state has been switched off, it will continue to represent a load for the area. If you do not need the function or stage, delete it rather than switching it off.

Use the general **Circuit-breaker** function group only in the following cases:

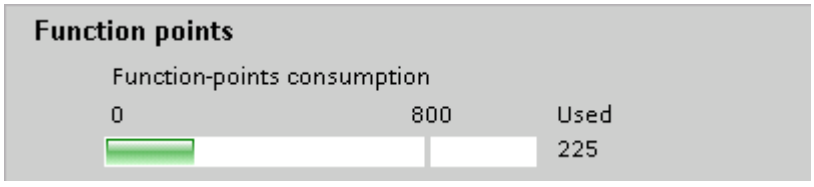
- Interaction with a protection-function group is essential.
  That is, operate indications of protection functions cause the circuit breaker assigned to the **Circuit-breaker** function group to be switched off.
- You want to use functions such as the automatic reclosing function or circuit-breaker failure protection in the **Circuit-breaker** function group.

If a circuit breaker is only to be modeled for control purposes, use the **Circuit breaker [state only]** function group.

9.2.2 Function Points

When you order a SIPROTEC 5 device, you are also ordering a function-points account for use of additional functions.

The following figure illustrates consumption of function points in the current application with respect to the existing function-points account.



[scfpunkt-141210-01, 1, en_US]

Figure 9-2 Resource Overview: Function-Points Consumption

The remaining white bar shows the function points that have not yet been used up by your configuration. The number of function points available in a device depends on the device purchase order (position 20 of the product code). You can also order function points subsequently, and so increase the function-points account for the device.

NOTE

Find out the function-points requirement for the desired application before ordering the device. For this, you can use the device configurator.

9.2.3 CFC Resources

Task Levels of the CFC Function

A CFC chart, and thus the configured CFC function, runs in the SIPROTEC 5 device on exactly one of the 4 task levels. The individual task levels differ, on the one hand, in the priority of processing tasks and, on the other, in the cyclic or event-triggered processing of the CFC charts.

You can select between the following task levels:

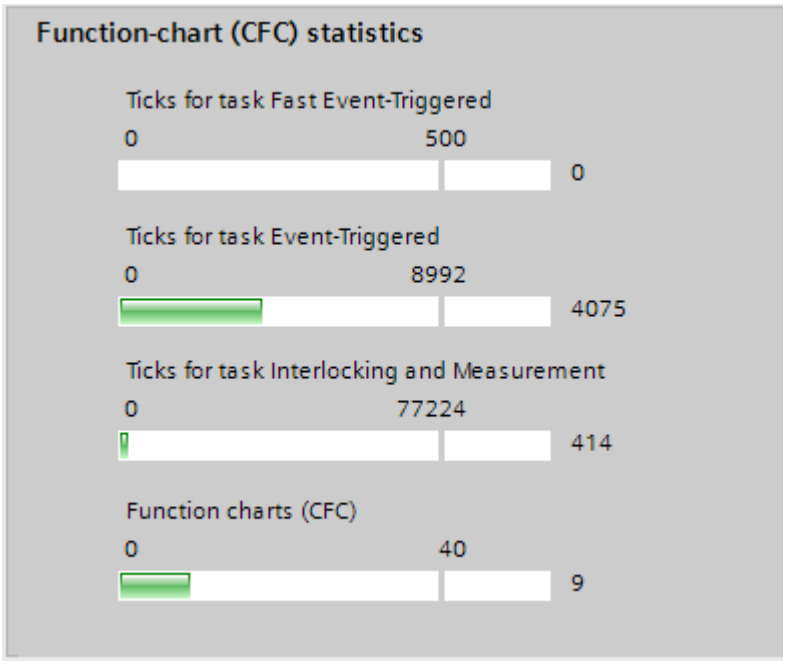
Task Level	Description
Fast Event-Triggered	Use the ***Fast Event-Triggered*** task level for time-critical tasks, for example, if a signal should block a protection function within 2 ms to 3 ms. Functions on this task level are processed in an event-triggered way with the highest priority. Each change to a logical input signal is immediately processed. Processing can interrupt the execution of protection functions and functions on the ***Event-Triggered*** task level.
Event-Triggered	Use the ***Event-Triggered*** task level preferably for logic functions that need not be executed with highest priority. Each change to a logical input signal is immediately processed. Protection functions or functions on the ***Fast event-triggered*** task level can disrupt processing. Functions on the ***Event-Triggered*** task level are typically processed within a maximum of 5 ms in all devices. For busbar protection or line protection, the functions on the ***Event-Triggered*** task level are processed within a maximum of 10 ms.
Measurement	Use the ***Measurement*** task level for processing measured values. Functions on this task level are processed cyclically every 500 ms.
Interlocking	Use the ***Interlocking*** task level preferably for logic functions that should be executed with lower priority than functions in the ***Event-Triggered*** task level. If the available ticks of the ***Event-Triggered*** task level shown in the following figure are sufficient for the required CFC functionality, you do not need to use the ***Interlocking*** task level.

All CFC function blocks can be assigned to all the task levels. There are no device-specific function blocks. If enough ticks are available, all CFC charts can be created in the same task level. A tick is the measure of the performance requirement of CFC blocks.

The number of available ticks for each task is calculated depending on the created device configuration. This calculation is based on the previously described load model. In this process, it is recommended to create all selected functions and objects first followed by configuration of the CFC charts so that a realistic information about the remaining system capacitance for CFC charts is available. Significantly exceeding the typical response time is prevented by the load model by limiting the number of CFC function blocks in the corresponding task level via the number of ticks available.

The typical response times for CFC tasks are listed in the Technical Data.

The following figure shows an example of the CFC chart capacitances in DIGSI calculated by the load model. The ticks available for each task are shown here. The green bars represent the ticks used in the task levels. You reach this dialog with the following call: Device → Device information → Resource consumption.



[sc-cfc-statistic, 1, en_US]

Figure 9-3 CFC Statistics

NOTE

The fast-event-triggered CFC charts have the highest priority and are processed before all other tasks. At this level, a considerable smaller number of ticks are available than at all other tasks. It is recommended to configure only very-high-priority logic functions at this task and to configure the other logic functions in any other level.

NOTE

Empty CFC charts also consume system resources. Empty charts that are not required any more should be deleted.

9.3 Supervision of the Secondary System

9.3.1 Overview

The secondary circuits establish a connection to the power system from the point of view of the device. The measuring-input circuit (currents, voltages) as well as the command circuits to the circuit breakers are monitored for the correct function of the device. The connection to the station battery is ensured with the supervision of the external auxiliary voltage. The secondary system has the following supervision systems:

Measuring circuits (voltage):

- Measuring-Voltage Failure
- Voltage-Transformer Circuit Breaker
- Voltage balance
- Voltage sum
- Voltage rotating field

Measuring circuits (current):

- Broken conductor of the current circuits
- Current balance
- Current sum
- Current rotating field

Trip circuits

External auxiliary voltage

When these supervisions pick up, corresponding warning indications are output. Some supervisions lead directly to the blocking of affected protection functions or to the marking of measuring points that have become invalid, so that affected protection functions can go into a secure state.

A detailed description of the supervision mechanisms and their error responses can be found in the Function Description and as overall overview at the end of chapter 8.

9.3.2 Measuring-Voltage Failure

9.3.2.1 Overview of Functions

The **Measuring-voltage failure detection** function monitors the voltage transformer secondary circuits:

- Non-connected transformers
- Pickup of the voltage transformer circuit breaker (in the event of short circuits in the secondary circuit)
- Broken conductor in one or more measuring loops

All these events cause a voltage of 0 in the voltage transformer secondary circuits which can lead to failures of the protection functions.

For the following protection functions, the response (block/not block) to a measuring-voltage failure can be set within the function:

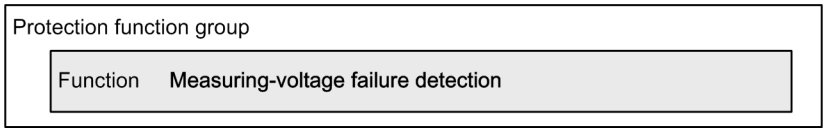
- Directional time-overcurrent protection, phases
- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

The following protection functions are automatically blocked in the case of a measuring-voltage failure:

- Distance protection
- Directional negative-sequence protection
- Ground-fault protection for high-resistance faults in grounded-neutral systems

9.3.2.2 Structure of the Function

The function is part of protection function groups which are connected with a 3-phase voltage and current measurement point.

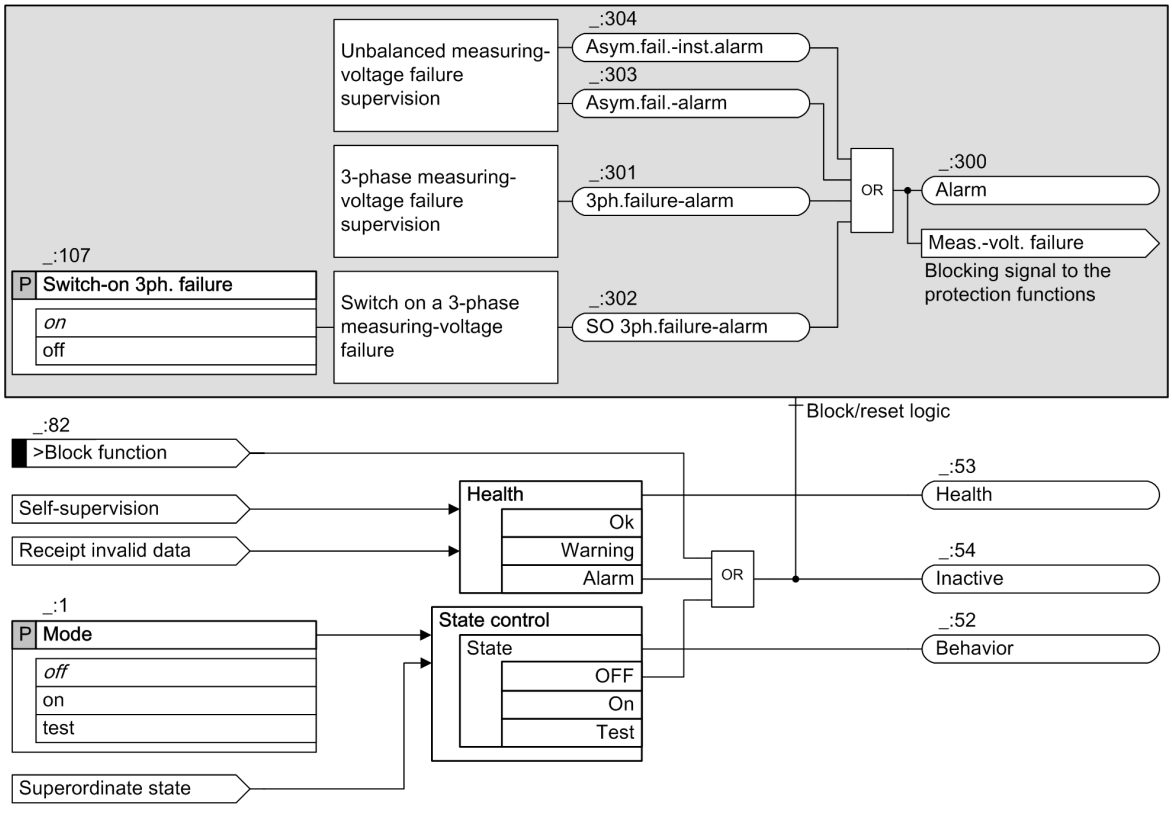


[dwstrffm-210113-01.tif, 1, en_US]

Figure 9-4 Structure/Embedding of the Function

The function is broken down into 3 subfunctions (see *Figure 9-5*):

- Supervision for unbalanced measuring-voltage failure
- Supervision for 3-phase measuring-voltage failure
- Supervision for switching onto a 3-phase measuring-voltage failure



[lozusamm-100611-01.tif, 2, en_US]

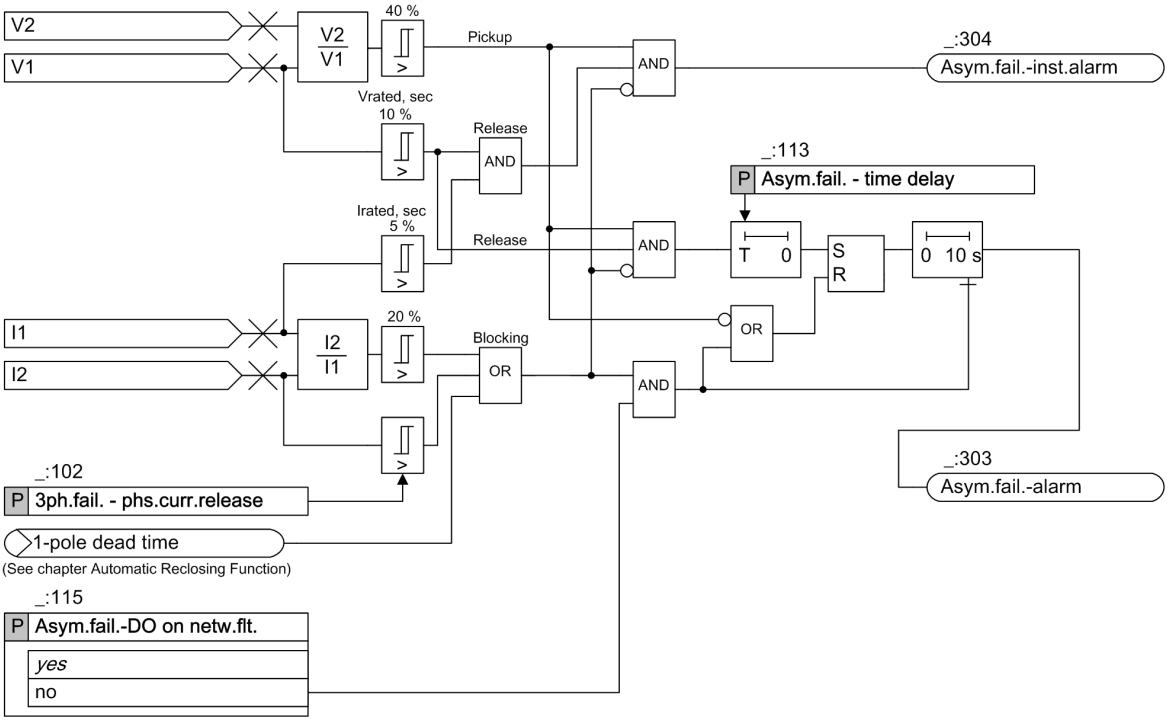
Figure 9-5 Breakdown of the Measuring-Voltage Failure Detection Function

Each subfunction creates its own monitoring indication. The function summarizes these indications via the group indication **Alarm**.

The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

9.3.2.3 Unbalanced Measuring-Voltage Failure

Logic



[looppode-200812-05.tif, 2, en_US]

Figure 9-6 Logic Diagram Unbalanced Measuring-Voltage Failure Detection

The criterion for detection of an unbalanced measuring-voltage failure is the voltage unbalance. This unbalance is determined based on the ratio between negative and positive-sequence voltage. If the threshold value is violated and the monitoring is released and not blocked, the monitoring picks up (see *Figure 9-6*). The indication *Asym.fail.-inst.alarm* is output.

The monitoring is released as soon as a certain minimum voltage is exceeded. This prevents a spurious response in the presence of low voltage measurands or a measurand of 0 (for example, circuit breaker open). Instantaneous monitoring also requires the presence of a minimum current. This prevents a spurious instantaneous pick up of the monitoring in the presence of a weak infeed (current < 10 % of rated current) combined with a power-system incident.

If the voltage unbalance is blocked by unbalanced faults in the primary system, the supervision is blocked. The device detects an unbalanced fault based on the ratio between negative-sequence and positive-sequence current. In the event of 1-pole automatic reclosing, the supervision is blocked.

Delay/Seal-In

In the presence of a weak infeed (current < 10 % of rated current), certain protection functions require more time for detection of a system incident. For this purpose, the monitoring can be delayed using the **Asym.fail. - time delay** parameter.

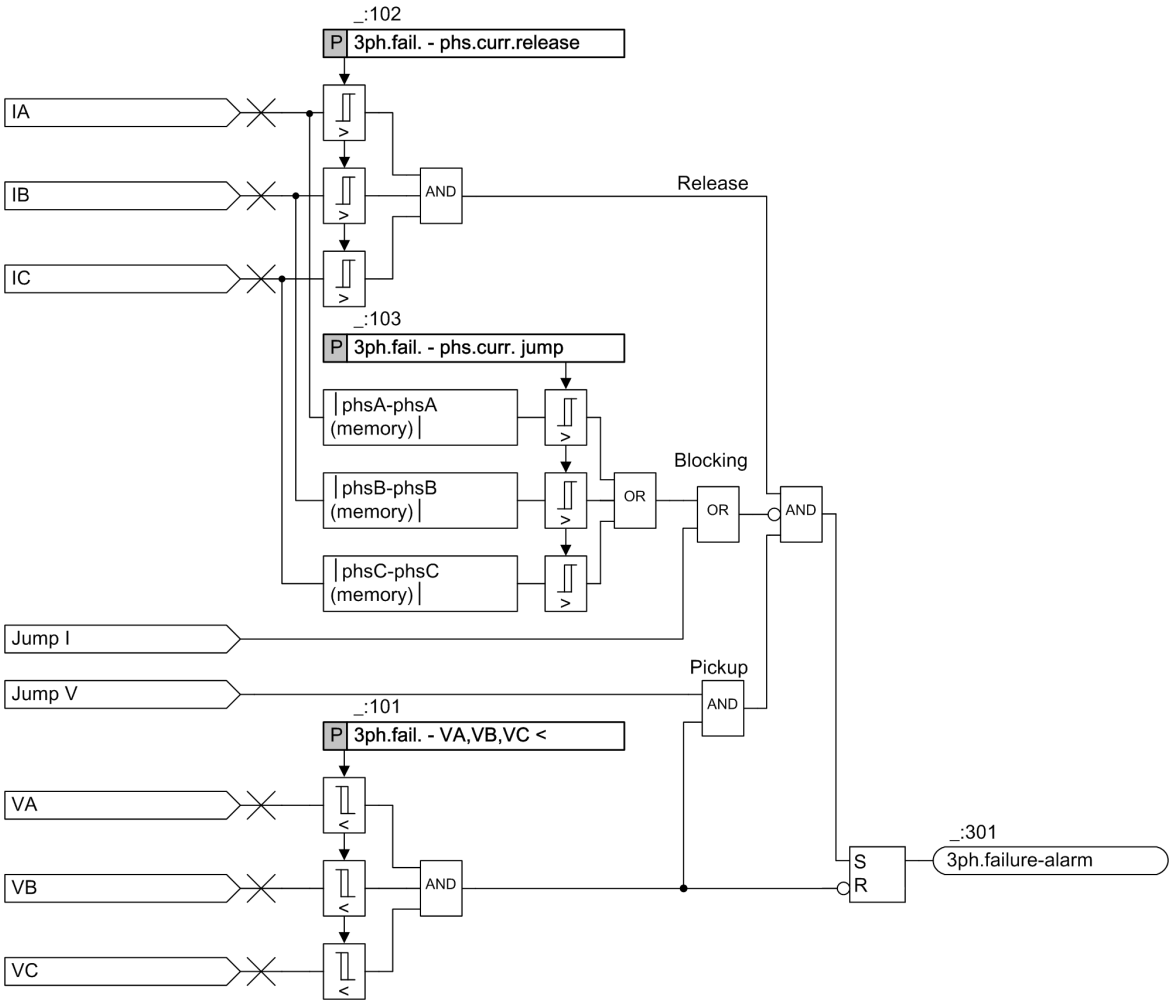
If a system incident is detected during the time delay, the supervision drops off. This is because the function assumes that the unbalance - and consequently the pickup of the supervision - is due to the system incident.

After the time delay has elapsed, it definitely assumes a measuring-voltage failure. The monitoring seals in and the *Asym.fail.-alarm* indication is output. The dropout does not happen until the voltage unbalance has disappeared after a seal-in time of 10 s. In the presence of 3-pole close-in faults outside the protection zone, this seal-in time prevents the monitoring from dropping off too quickly and thus releasing the protection functions.

The sealing-in function can be deactivated using the **Asym.fail.-DO on netw.flt.** parameter. As soon as a system incident is detected, the monitoring drops off instantaneously.

9.3.2.4 3-Phase Measuring-Voltage Failure

Logic



[losymmet-190912-01.tif, 1, en_US]

Figure 9-7 Logic Diagram 3-Phase Measuring-Voltage Failure

Balanced Fault – VA, VB, VC <

A 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages drop below the threshold value **3ph.fail. - VA,VB,VC <**
- A jump of the voltage (Signal **jump V**)

If these criteria are fulfilled and the monitoring is released and not blocked, the **3ph.failure-alarm** indication is output. When the voltage returns (even as 1-phase), the monitoring drops out.

Release by Phase Current

When all phase currents exceed the threshold value **3ph.fail. - phs.curr.release** the monitoring is released.

Blocking in the Case of a System Incident

In the case of a 3-phase system incident, supervision must be blocked. The device detects a 3-phase incident with a jump in the current. This change is detected via the internal signal **Jump I** or when the change in current of a phase current exceeds the threshold value **3ph.fail. - phs.curr. jump**. The change in

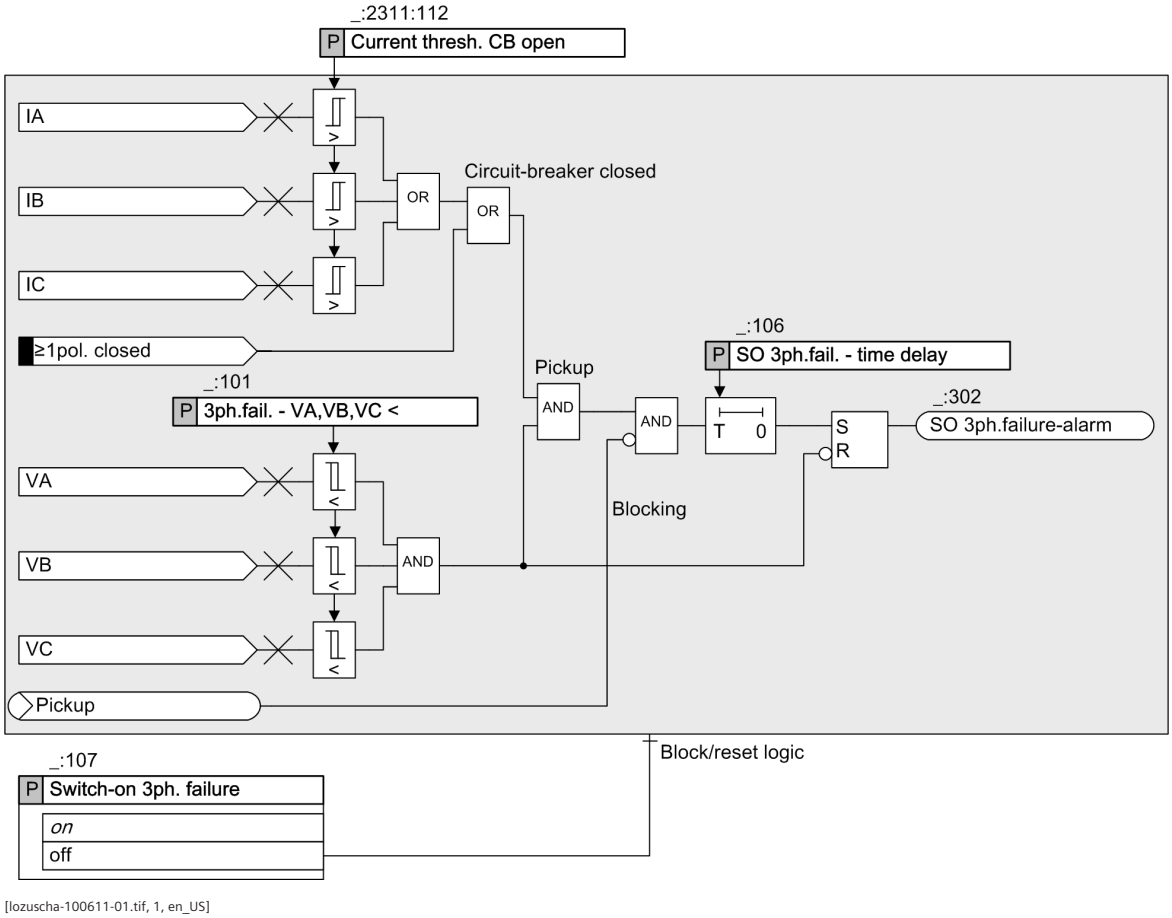
current of phase currents is formed from the difference between the present current phasor and the current phasor of the previous period. This allows to take into account a jump of the current phase.

NOTE

If a voltage transformer circuit-breaker is installed in the secondary circuit of the voltage transformers, its position is communicated to the device via a binary input (see chapter *9.3.4.1 Overview of Functions*).

9.3.2.5 Switching onto a 3-Phase Measuring-Voltage Failure, Low Load

Logic



[lozuscha-100611-01.tif, 1, en_US]

Figure 9-8 Logic Diagram Switching to 3-Phase Measuring-Voltage Failure

Switching onto a 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages have dropped below the threshold value **`3ph.fail. - VA,VB,VC <`**.
- The circuit breaker is detected to be in closed position. The detection takes place either via the phase currents or via the **`≥1-pole closed`** signal, which is generated via the circuit-breaker auxiliary contacts.
  You can find more detailed information in chapter *5.8.5 Circuit-Breaker Condition for the Protected Object*.

A voltage jump – such as in a 3-phase measuring-voltage failure with closed circuit breaker (see chapter*9.3.2.4 3-Phase Measuring-Voltage Failure*) – does not occur in the case of switching to a 3-phase measuring-voltage failure. If the monitoring is not blocked, the time delay **`SO 3ph.fail. - time delay`** is started. After the time has elapsed, the indication **`SO 3ph.failure-alarm`** is displayed. A dropout of the monitoring is only possible by a recovery of the voltage.

The supervision is blocked as soon as a pickup of a protection function is detected within a protection function group and the time delay of the supervision has not yet elapsed.

This subfunction also covers the situation of a low load with 3-phase measuring-voltage failure and closed circuit breaker, because the circuit-breaker condition is also determined from the circuit-breaker auxiliary contacts. The subfunction for detecting a 3-phase measuring-voltage failure (see chapter *9.3.2.4 3-Phase Measuring-Voltage Failure*) is not released in this situation, for example, because the current flow is too low.

This subfunction can be switched on or off separately using the **Switch-on 3ph. failure** parameter.

9.3.2.6 Application and Setting Notes

Parameter: Asym.fail. - time delay

- Recommended setting value **(_:113) Asym.fail. - time delay** = ***10.00 s***

The **Asym.fail. - time delay** parameter allows you to set the time during which a system incident detected after the occurrence of the unbalance resets the monitoring. This setting is important in the case of weak infeed (current < 10 % of rated current) in order to give certain protection functions (such as distance protection) more time for detecting system incidents. As long as the time delay runs, it is assumed that the unbalance is due to a system incident.

As soon as the time has elapsed, the supervision assumes a measuring-voltage failure and seals in.

Siemens recommends using the default setting.

If you want the seal-in function to operate sooner or at once, you can reduce the time.

Parameter: Asym.fail.-DO on netw.flt.

- Recommended setting value **(_:115) Asym.fail.-DO on netw.flt.** = ***No***

Parameter Value	Description
no	After elapse of the time delay the supervision function seals in. Even if the system incident criterion is fulfilled, the protection functions concerned will remain blocked. This avoids an unselective tripping of the protection functions due to an absence of the measuring voltage in the case of an unbalanced system incident. This is the default setting.
yes	The seal-in function is switched off. The supervision drops out immediately when a system incident is detected. With this setting, the unbalanced measuring-voltage failure is only reported, and in the event of a double failure (measuring-voltage failure and system incident in parallel), unselective tripping is preferred.

Parameter: 3ph.fail. - VA,VB,VC <

- Recommended setting value **(_:101) 3ph.fail. - VA,VB,VC <** = ***5 V***

The **3ph.fail. - VA,VB,VC <** parameter allows you to set the pickup value of the monitoring.

Siemens recommends using the default setting.

If you expect major disturbances acting upon the voltage inputs, you can increase this value. Increasing the values makes the supervision more sensitive to 3-phase system incidents.

Parameter: 3ph.fail. - phs.curr.release

- Recommended setting value **(_:102) 3ph.fail. - phs.curr.release** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **3ph.fail. - phs.curr.release** parameter is used to define the phase current threshold above which the monitoring is released.

Siemens recommends using the default setting.

Parameter: 3ph.fail. - phs.curr. jump

- Recommended setting value **(_:103) 3ph.fail. - phs.curr. jump** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **3ph.fail. - phs.curr. jump** parameter is used to set the differential current between the present current phasor and the stored phasor (from the previous period). If the value is exceeded, the function detects a system incident and blocks the monitoring.

Siemens recommends using the default setting.

Parameter: SO 3ph.fail. - time delay

- Recommended setting value **(_:106) SO 3ph.fail. - time delay** = ***3.00 s***

The **SO 3ph.fail. - time delay** parameter allows you to set the delay of the monitoring.

Siemens recommends using the default setting.



NOTE

Adapt the **SO 3ph.fail. - time delay** parameter to the inherent time of protection functions which are intended to block the monitoring function.

Note that with parameter values 0 s blocking of the monitoring function via a protection stimulation will not be possible any more.

Parameter: Switch-on 3ph. failure

- Recommended setting value **(_:107) Switch-on 3ph. failure** = ***on***

Parameter Value	Description
on	The subfunction **Switching to a 3-phase measuring-voltage failure** is active. In the case of low loads, the subfunction for detection of a 3-phase measuring-voltage failure is not released, for example, because the current flow is too low. In this situation, the subfunction **Switching to a 3-phase measuring-voltage failure** can perform the monitoring task. Siemens recommends to switch that subfunction on.
off	With the setting ***off*** the subfunction **Switching to a 3-phase measuring-voltage failure** is not active.

9.3.2.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mes.v.fail.det				
_:1	Mes.v.fail.det:Mode		• off • on • test	on
_:115	Mes.v.fail.det:Asym.fail.-DO on netw.flt.		• no • yes	yes
_:113	Mes.v.fail.det:Asym.fail. - time delay		0.00 s to 30.00 s	10.00 s
_:102	Mes.v.fail.det:3ph.fail. - phs.curr.release	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:103	Mes.v.fail.det:3ph.fail. - phs.curr. jump	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	Mes.v.fail.det:3ph.fail. - VA,VB,VC <		0.300 V to 340.000 V	5.000 V
_:107	Mes.v.fail.det:Switch-on 3ph. failure		• off • on	on
_:106	Mes.v.fail.det:SO 3ph.fail. - time delay		0.01 s to 30.00 s	3.00 s

9.3.2.8 Information List

No.	Information	Data Class (Type)	Type
Mes.v.fail.det			
_:82	Mes.v.fail.det:>Block function	SPS	I
_:54	Mes.v.fail.det:Inactive	SPS	O
_:52	Mes.v.fail.det:Behavior	ENS	O
_:53	Mes.v.fail.det:Health	ENS	O
_:300	Mes.v.fail.det:Alarm	SPS	O
_:304	Mes.v.fail.det:Asym.fail.-inst.alarm	SPS	O
_:303	Mes.v.fail.det:Asym.fail.-alarm	SPS	O
_:301	Mes.v.fail.det:3ph.failure-alarm	SPS	O
_:302	Mes.v.fail.det:SO 3ph.failure-alarm	SPS	O

9.3.3 Signaling-Voltage Supervision

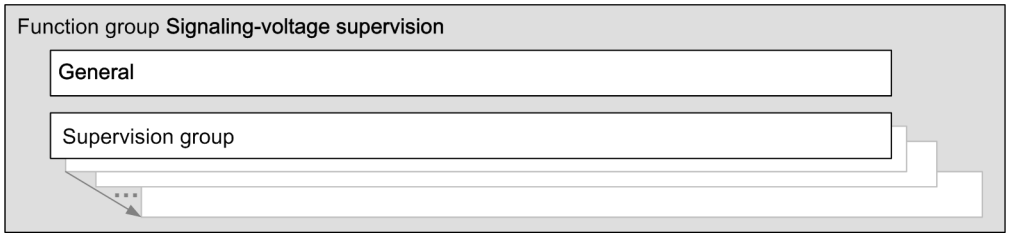
9.3.3.1 Overview of Functions

Signaling-voltage supervision is used to evaluate the validity of binary signals connected to the SIPROTEC device via binary inputs. For this purpose, one binary input is used to monitor the signaling voltage. If the signaling voltage fails, the associated binary signals are marked as invalid and a **Signaling-voltage malfunction** indication is issued.

Several signaling-voltage supervision groups can be created in one SIPROTEC device. Each of these groups monitors an adjustable area with binary inputs.

9.3.3.2 Structure of the Function

The **Signaling-voltage supervision** function group contains, besides the general functionality, one preinstantiated **Supervision group** stage. The **Supervision group** stage can be instantiated in DIGSI 5 multiple times.

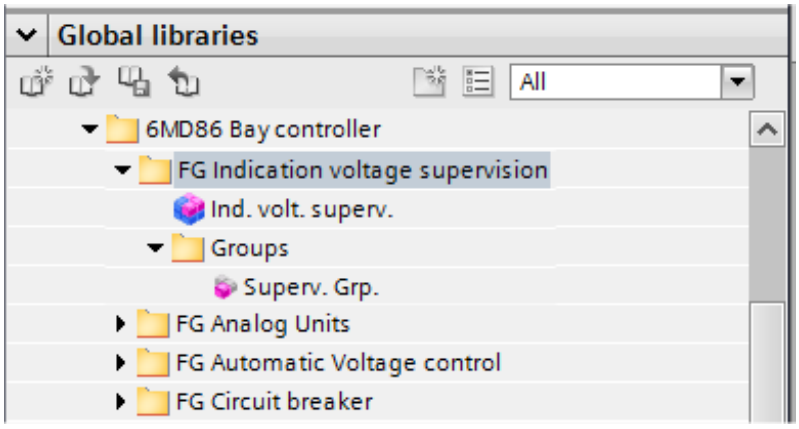


[dwivsstr-060214-01.vsd, 1, en_US]

Figure 9-9 Structure/Embedding of the Function Group

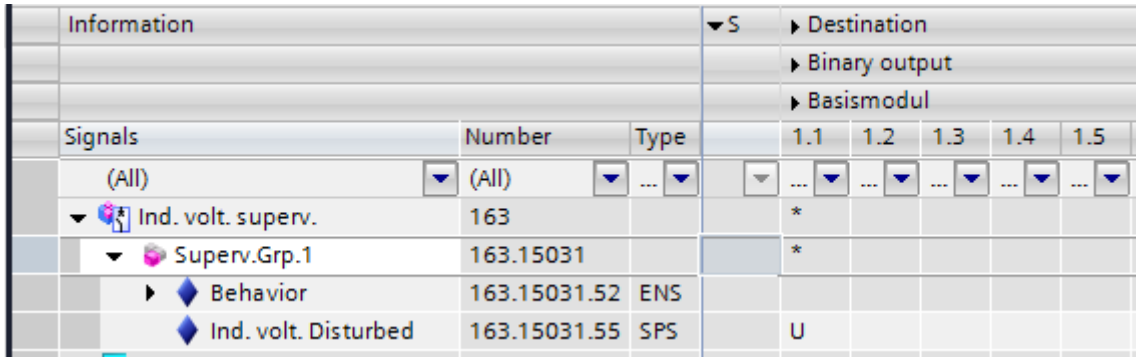
9.3.3.3 Function Description

You can instantiate the **Signaling-voltage supervision** function group in DIGSI from the global library. It contains 1 pre-instantiated **Supervision group** function block (see the following figure). You can instantiate a maximum of 25 supervision groups.



[sc_ivslib, 1, en_US]

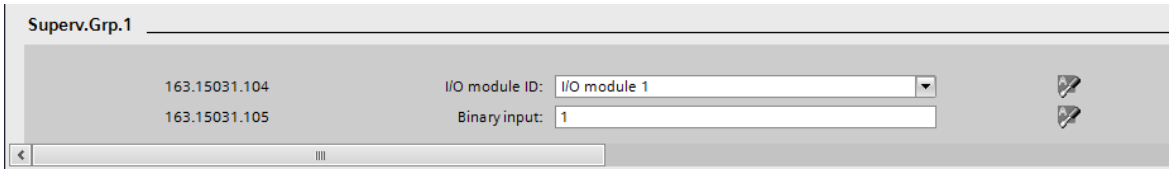
Following the instantiation of the function group in the DIGSI project tree, it appears in the information routing of DIGSI (see the following figure). The status indications of the supervision groups can be routed here, for example, to existing binary outputs and/or logs.



[sc_ivsrou, 1, en_US]

Set the binary input used for signaling-voltage supervision within one input/output module using the setting option (see the following figure). This binary input monitors the presence of the signaling voltage. If the signaling voltage fails, this sets the quality attribute for all other binary inputs of the parameterized input/output module to ***invalid***. The signal status of each of these binary inputs is frozen with its last valid value prior to the occurrence of the fault. The quality attribute of the binary inputs for other input/output modules are not taken into consideration by this.

If the signaling voltage again exceeds the binary threshold, the quality attribute of the binary inputs is reset to ***valid***.

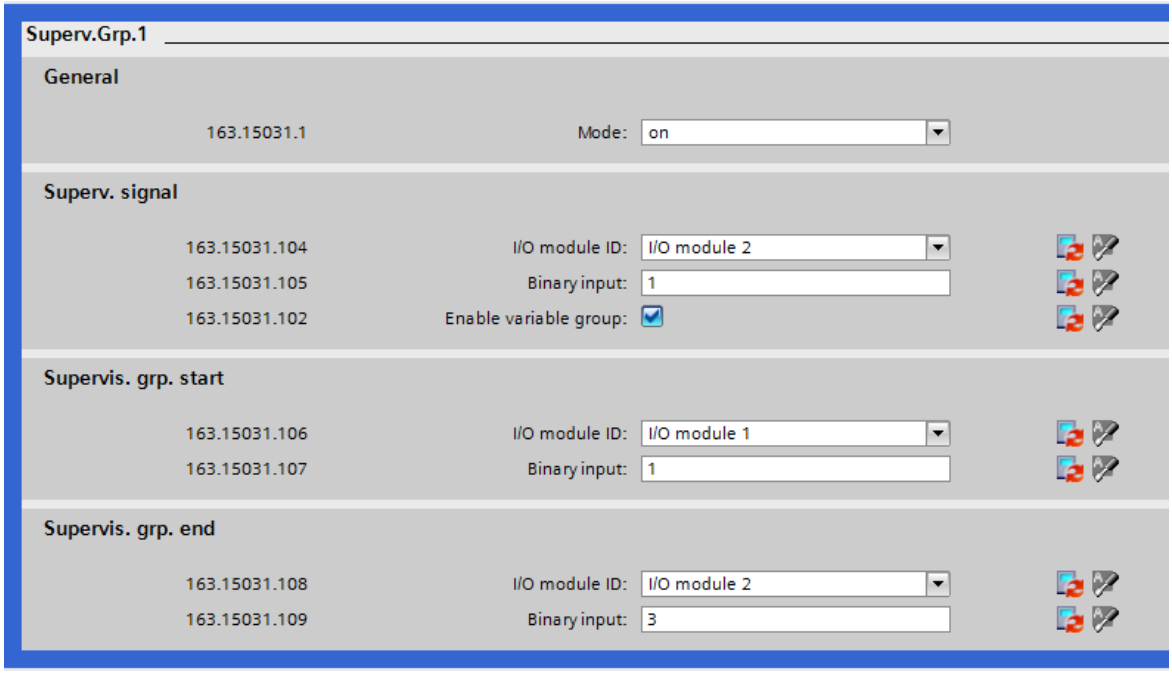


[sc_ivsgrp, 1, en_US]

NOTE

Each status change of the monitored binary inputs is delayed by 3 ms.

You can also combine binary inputs across modules in one **Supervision group** function block, and define any binary input within this group for the supervision of the signaling voltage. For this purpose, place a check mark at the parameter **(_:102) Enable variable group** when configuring the supervision group. This extends the parameter menu by the sections **Start supervision group** and **End supervision group** (see the following figure).



[sc_gruppe_de, 1, en_US]

There, for example, you are able to combine 1 to n different binary inputs into one supervision group. When doing so, the binary inputs on the input/output modules assignable to a supervision group must be related logically. With 3 input/output modules, for example, this allows only consecutive binary inputs to be grouped on the modules 1+2 or 2+3, but no binary inputs on modules 1+3. The binary inputs used for supervision can be located on any input/output module within the group defined in this manner.

If you have to monitor several binary inputs that, for example, work with different signaling voltages from different sources, then you can also instantiate and configure several **Supervision group** function blocks within the **Signaling-voltage supervision** function group accordingly.

Within different supervision groups, only those consecutive binary inputs that are not already assigned to another supervision group can be grouped. The overlapping of binary inputs in different supervision groups is not permitted.

Example: There are 4 input/output modules. Binary inputs of input/output module 1+2 are already combined in supervision group 1. The 2 last binary inputs on module 2 are not included in the grouping. Thus, only these 2 binary inputs not used in the supervision group 1 of the input/output module 2 as well as, where applicable, further consecutive binary inputs of input/output modules 3+4 can be combined in supervision group 2.

Error parameters are displayed to you by inconsistency indications in DIGSI.

9.3.3.4 Application and Setting Notes

Parameter (General): `Mode`

- Default setting **`(_:1) Mode`** = ***on***

With the **`Mode`** parameter, you specify whether you want to activate, deactivate, or test the supervision of the signaling voltage for the appropriate group. If you put the group into test mode, the *Sig. volt. disturbed* indication is given a test flag. If the supervision input drops out in test mode, the assigned inputs retain their status without their quality attribute being set to **invalid**.

Parameter (Supervision Signal): `I/O module ID`

- Default setting **`(_:104) I/O module ID`** = ***I/O module 1***

Using the **`I/O module ID`** parameter, you specify the I/O module for which you want to activate signaling-voltage supervision. Counting of the I/O modules starts in increasing order with the binary inputs of the base module. The binary inputs of the PS201 power-supply module permanently installed in the base module count as the 2nd I/O module followed by additional I/O modules (3 to n) in the expansion boards of the device.

Parameter (Supervision Signal): `Binary input`

- Default setting **`(_:105) Binary input`** = ***1***

Using the **`Binary input`** parameter, you specify the binary input responsible for the supervision of the signaling voltage for the parameterized I/O module. The quality attribute of all other binary inputs for this module are set to **valid** or **invalid** depending on the presence of the signaling voltage at the parameterized binary input.

Parameter (Supervision Signal): `Enable variable group`

- Default setting **`(_:102) Enable variable group`** = ***untrue***

You can activate the parameter **`Enable variable group`** by placing the check mark. If you have not set the check mark (default setting), only these 2 parameters are available for the configuration of the supervision signal. If you have set the check mark, the parameter menu is extended by the areas **Start supervision group** and **End supervision group**. You can then use that to carry out the grouping of binary inputs for supervision groups explained in the function description.

Parameter (Start Supervision Group): `I/O module ID`

- Default setting **`(_:106) I/O module ID`** = ***I/O module 1***

Parameter **`I/O module ID`** is used to define the first I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the lowest counter number that you can use for carrying out a grouping.

Parameter (Start Supervision Group): `Binary input`

- Default setting **`(_:107) Binary input`** = ***1***

Parameter **`Binary input`** is used to define the lowest binary input for the first I/O module (see **`(_:106) I/O module ID`**) that you want to assign to a supervision group.

Parameter (End Supervision Group): `I/O module ID`

- Default setting **`(_:108) I/O module ID`** = ***I/O module 1***

Parameter **`I/O module ID`** is used to define the last I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the highest counter number that you can use for carrying out a grouping.

Parameter (End Supervision Group): `Binary input`

- Default setting **`(_:109) Binary input`** = ***1***

Parameter **`Binary input`** is used to define the highest binary input for the last I/O module (see **`(_:108) I/O module ID`**) that you want to assign to a supervision group.

9.3.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Superv.Grp.#:Mode		• off • on • test	on
Superv. signal				
_:104	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:105	Superv.Grp.#:Binary input		1 to 256	1
_:102	Superv.Grp.#:Enable variable group		• 0 • 1	false
Supervis. grp. start				
_:106	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:107	Superv.Grp.#:Binary input		1 to 256	1

Addr.	Parameter	C	Setting Options	Default Setting
Supervis. grp. end				
_:108	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:109	Superv.Grp.#:Binary input		1 to 256	1

9.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Superv.Grp.#			
_:52	Superv.Grp.#:Behavior	ENS	O
_:55	Superv.Grp.#:Sig. volt. disturbed	SPS	O

9.3.4 Voltage-Transformer Circuit Breaker

9.3.4.1 Overview of Functions

The **Voltage-transformer circuit breaker** function detects the tripping of the voltage-transformer circuit breaker due to short circuits in the voltage-transformer secondary circuits.

The **Voltage-transformer circuit breaker** function works independently of **Measuring-voltage failure detection** and should be used – if possible – in parallel to it.

The tripping of the voltage-transformer circuit breaker has an impact on the quality of the recorded measured-value data (see chapter *3.3 Processing Quality Attributes*).

The following protection function is automatically blocked in cases of the tripping of the voltage-transformer circuit breaker:

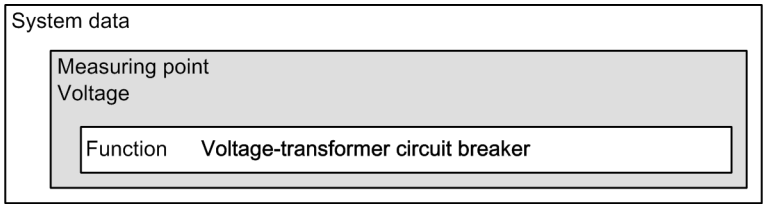
- Directional negative-sequence protection

For the following functions the reaction (block/not block) can be set within the function in cases of a tripping of the voltage-transformer circuit breaker:

- Directional time-overcurrent protection, phases
- Directional time-overcurrent protection, ground
- Directional sensitive ground-fault detection
- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

9.3.4.2 Structure of the Function

The *Figure 9-10* shows the position of the function in the device. Every voltage measuring point contains the **Voltage-transformer circuit breaker** function.



[dwmcbstr-040211-01.tif, 1, en_US]

Figure 9-10 Structure/Embedding of the Function

9.3.4.3 Function Description

The tripping of the voltage-transformer circuit breaker is captured via the binary input signal **>Open**. With an active input signal the information about the measuring-voltage failure is relayed to the affected functions (see *9.3.4.1 Overview of Functions*). The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

Response Time of the Voltage-Transformer Circuit Breaker

The response time of the voltage-transformer circuit breaker can be slower than the pickup time of the distance protection. This bears the risk of an overfunction. The response time is communicated to the device with the **Response time** parameter. For a timely detection of the tripping of the voltage-transformer circuit breaker, the pickup of the distance protection is delayed by that response time.

9.3.4.4 Application and Setting Notes

The function is always active and need not be switched on.

Input Signal: >Open

- Input signal: **(_:500) >Open**

The input signal **>Open** must be connected to the tripping of the voltage-transformer circuit breaker. As a rule, this occurs via the routing to a binary input.

Parameter: Response time of the voltage-transformer circuit breaker

- Recommended setting value **(_:101) Response time** = ***0 ms***

When the voltage-transformer circuit breaker drops out, the device must block the distance protection immediately to prevent an unwanted tripping of the distance protection due to the absence of the measuring voltage while the load current is flowing.

The blocking must be faster than the 1st stage of the distance protection. This requires an extremely short response time of the miniature circuit breaker (≤ 4 ms at 50 Hz, ≤ 3 ms at 60 Hz rated frequency). If the circuit-breaker auxiliary contact does not fulfill this requirement, you have to set the response time accordingly.

9.3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
VT miniatureCB				
_:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

9.3.4.6 Information List

No.	Information	Data Class (Type)	Type
Definite-T #			
_:500	VT miniatureCB:>Open	SPS	I

9.3.5 Voltage-Balance Supervision

9.3.5.1 Overview of Functions

In healthy system operation, a certain balance between voltages can be assumed.

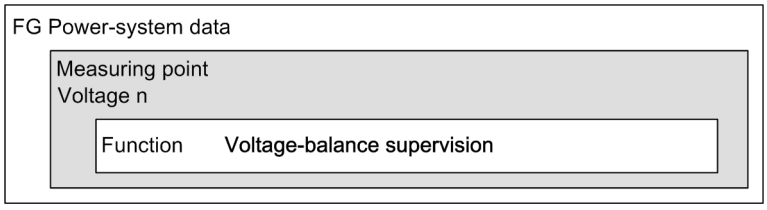
The **Voltage-balance supervision** function detects the following errors:

- Unbalance of phase-to-phase voltages in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The voltage measurement is based on the RMS values of the fundamental component.

9.3.5.2 Structure of the Function

The **Voltage-balance supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.



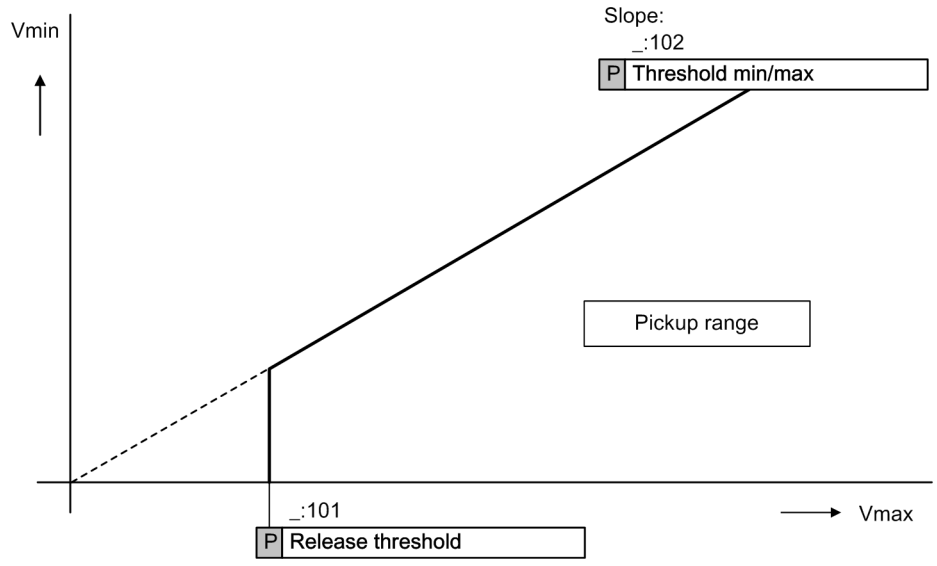
[dwstrusy-300913, 2, en_US]

Figure 9-11 Structure/Embedding of the Function

9.3.5.3 Function Description

The voltage balance is checked by a magnitude supervision function. This function relates the smallest phase-to-phase voltage to the largest phase phase-to-phase voltage. Unbalance is detected if

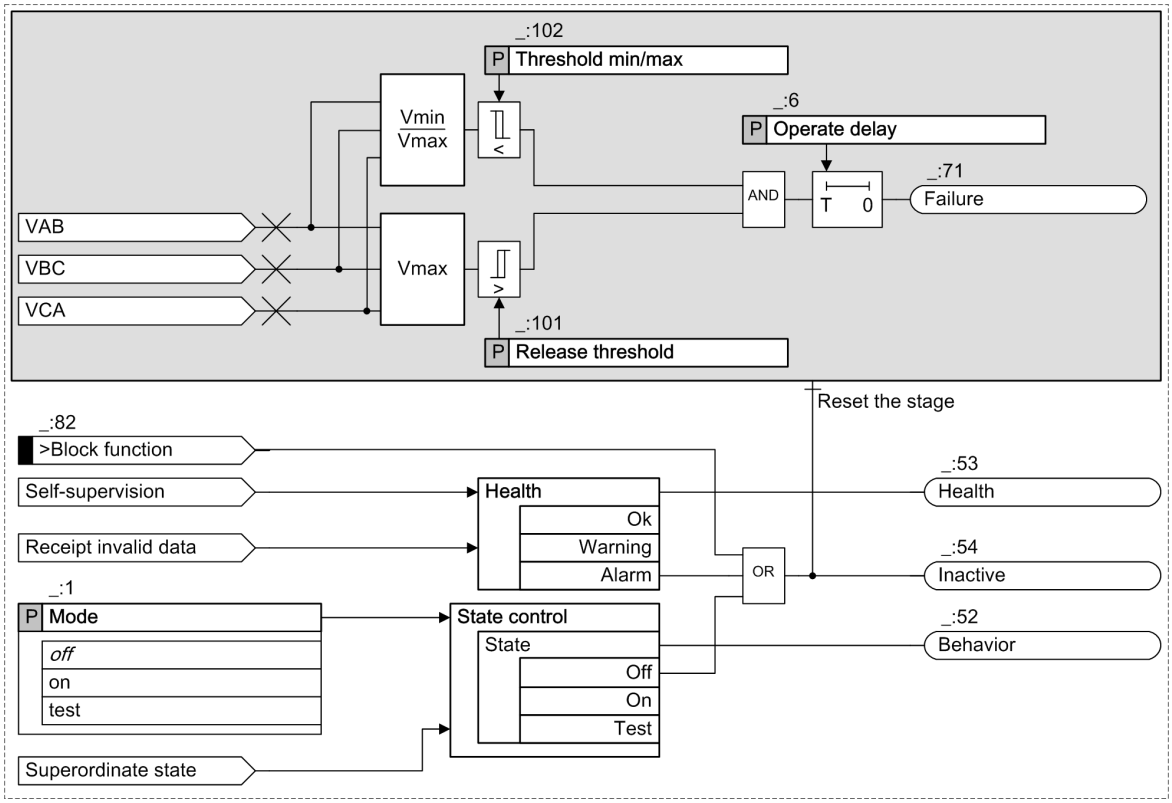
|Vmin| / |Vmax| < **`Threshold min/max`**, as long as Vmax > **`Release threshold`**.



[lokenuns-040211-01.tif, 1, en_US]

Figure 9-12 Characteristic of the Voltage-Balance Supervision

Logic



[lospasym-100611-01.tif, 2, en_US]

Figure 9-13 Logic Diagram of the Voltage-Balance Supervision

The **Threshold min/max** parameter is the criterion by which a phase-to-phase voltage unbalance is measured. The device calculates the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage.

Enter the lower limit of the maximum phase-to-phase voltage (V_{max}) with the parameter **Release threshold**. This specifies the lower limit of the operating range of this function.

Operate delay

If it falls below the balance factor **Threshold min/max** and at the same time the maximum phase-to-phase voltage exceeds the **Release threshold**, the **Operate delay** begins. If both conditions persist during this time, the indication **Failure** is generated.

9.3.5.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value **(_:102) Threshold min/max** = ***0.75***

The **Threshold min/max** parameter is used to set the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage. Siemens recommends using the default setting.

Parameter: Release threshold

- Recommended setting value **(_:101) Release threshold** = ***50 V***

With the **Release threshold** parameter you set the lower limit of the maximum phase-to-phase voltage (V_{max}). Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. V				
_:1	Supv. balan. V:Mode		• off • on • test	off
_:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75
_:6	Supv. balan. V:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.5.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. V			
_:82	Supv. balan. V:>Block function	SPS	I
_:54	Supv. balan. V:Inactive	SPS	O
_:52	Supv. balan. V:Behavior	ENS	O
_:53	Supv. balan. V:Health	ENS	O
_:71	Supv. balan. V:Failure	SPS	O

9.3.6 Voltage-Sum Supervision

9.3.6.1 Overview of Functions

In healthy system operation, the sum of all voltages at one measuring point must be approximately 0. The **Voltage-sum supervision** monitors the sum of all voltages of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit. For summation of the voltages, the 3 phase-to-ground voltages and the residual voltage (da-dn - voltage of an open-circuited delta winding) are required.

The voltage measurement is based on the RMS values of the fundamental component.

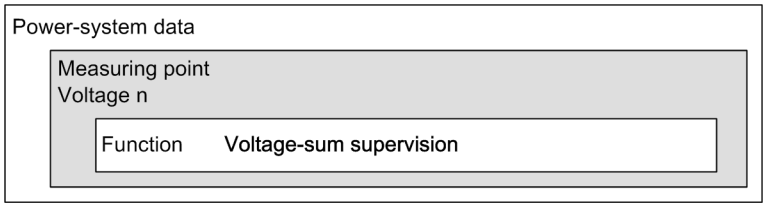
NOTE

For the **Voltage-sum supervision**, the externally generated residual voltage must be connected to the 4th voltage measuring input.

For the **Voltage-sum supervision** to work correctly, the **`Matching ratio Vph / VN`** parameter must be set accordingly.

9.3.6.2 Structure of the Function

The **Voltage-sum supervision** function is located in the **Power-system data** function group of each 3-phase voltage measuring point.

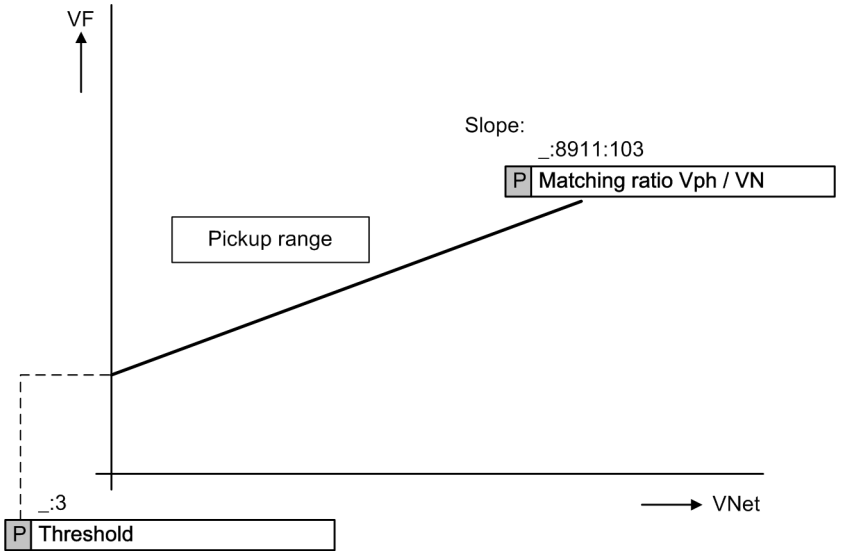


[dwstrvss-100611-01.tif, 2, en_US]

Figure 9-14 Structure/Embedding of the Function

9.3.6.3 Function Description

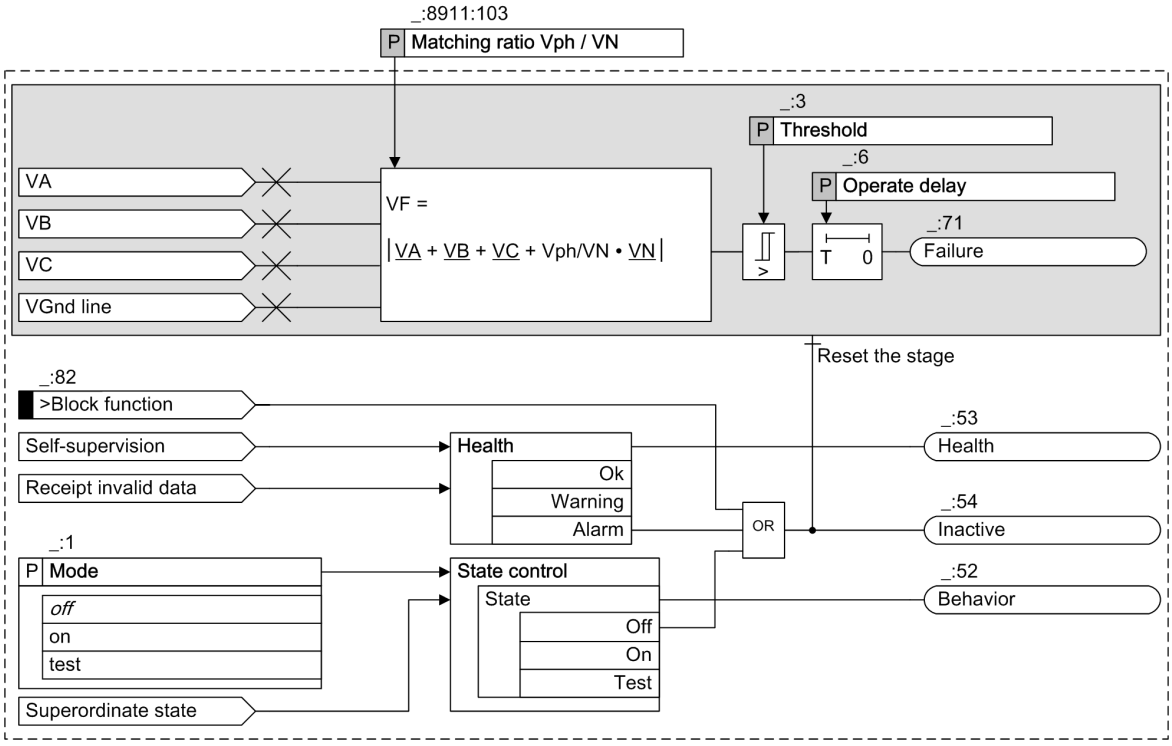
The voltage sum is generated by addition of the voltage phasors. Errors in the voltage circuits are detected if VF = |VA+ VB + VC + Vph/VN • VN | > **`Threshold`**, where Vph/VN forms the **`Matching ratio Vph / VN`** parameter.



[lokenvss-100611-01.tif, 1, en_US]

Figure 9-15 Characteristic of the Voltage-Balance Supervision

Logic



[lovssumm-140611-01.tif, 1, en_US]

Figure 9-16 Logic Diagram of the Voltage-Sum Supervision

The device measures the phase-to-ground voltage and the ground voltage of the lines to be protected. The sum of the 4 voltages must be 0.

Threshold

If the calculated fault voltage (V_F) exceeds the **Threshold**, the parameter **Operate delay** triggers the indication **Failure**.

The device calculates the fault voltage (V_F) with the formula:

VF = |VA+ VB + VC + Vph/VN • VN |, where Vph/VN forms the **Matching ratio Vph / VN** parameter.

The **Matching ratio Vph / VN** parameter takes into account the differing transformation ratios between the residual voltage input and the phase-voltage inputs.

More information in this respect can be found in chapter *9.3.6.1 Overview of Functions*).

Operate delay

When the threshold value for the **Operate delay** is exceeded, the indication **Failure** is generated.

9.3.6.4 Application and Setting Notes

Parameter: Threshold

- Recommended setting value **(_:3) Threshold** = ***25 V***

The **Threshold** parameter is used to set the voltage which the device uses to recognize the calculated fault voltage (V_F) as a failure of the voltage sums. Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum V				
_:1	Supv. sum V:Mode		• off • on • test	off
_:3	Supv. sum V:Threshold		0.300 V to 170.000 V	43.300 V
_:6	Supv. sum V:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.6.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum V			
_:82	Supv. sum V:>Block function	SPS	I
_:54	Supv. sum V:Inactive	SPS	O
_:52	Supv. sum V:Behavior	ENS	O
_:53	Supv. sum V:Health	ENS	O
_:71	Supv. sum V:Failure	SPS	O

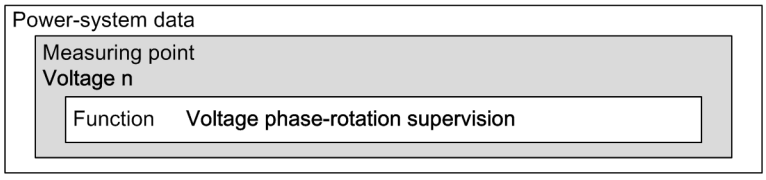
9.3.7 Voltage Phase-Rotation Supervision

9.3.7.1 Overview of Functions

The **Voltage phase-rotation supervision** function monitors the phase sequence of the secondary-circuit voltages by monitoring the sequence of the zero crossings (with same sign) of the voltages. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the **Phase sequence** parameter.

9.3.7.2 Structure of the Function

The **Voltage phase-rotation supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.

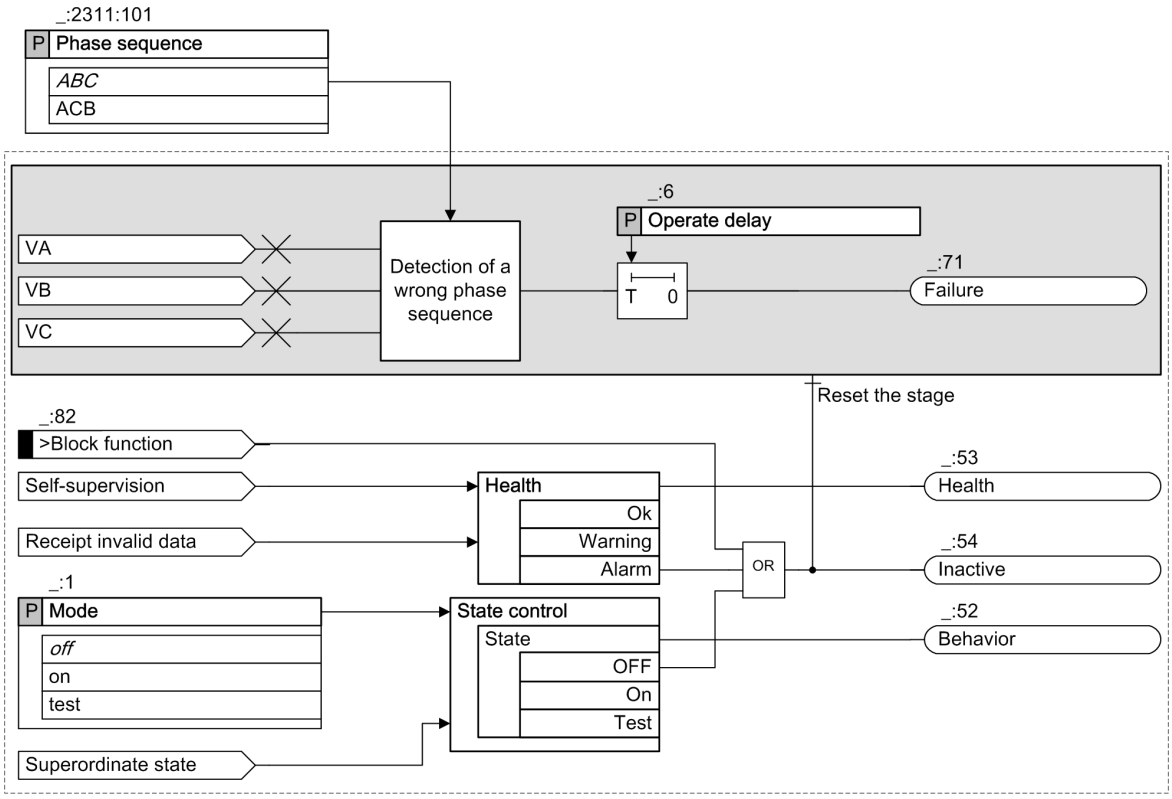


[dwstrvrs-060611-01.tif, 3, en_US]

Figure 9-17 Structure/Embedding of the Function

9.3.7.3 Function Description

Logic



[lovrsymm-100611-01.tif, 2, en_US]

Figure 9-18 Logic Diagram for the Voltage Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section **Power-system data**.

The phase rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.

The connection diagrams are shown in the section **Appendix**.

Operate delay

When the device detects an inverted phase-rotation direction for the duration of the **`Operate delay`**, the indication **`Failure`** is generated.

9.3.7.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **`(_:6) Operate delay`** = ***`5,00 s`***

Set the **`Operate delay`** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq.V				
_:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:6	Supv. ph.seq.V:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.7.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq.V			
_:82	Supv. ph.seq.V:>Block function	SPS	I
_:54	Supv. ph.seq.V:Inactive	SPS	O
_:52	Supv. ph.seq.V:Behavior	ENS	O
_:53	Supv. ph.seq.V:Health	ENS	O
_:71	Supv. ph.seq.V:Failure	SPS	O

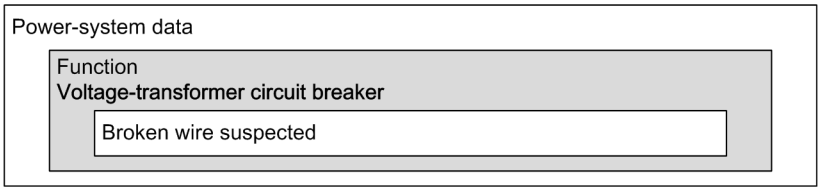
9.3.8 Broken-Wire Detection

9.3.8.1 Overview of Functions

The purpose of the broken-wire detection is to detect interruptions in the secondary circuit of the current transformers during steady-state operation.

9.3.8.2 Structure of the Function

The **Broken-wire detection** function is located in the power-system data of each 3-phase current measuring point.



[dwbwsjsk-301112-01.tif, 2, en_US]

Figure 9-19 Structure/Embedding of the Function

The tasks of **Broken-wire detection** are:

- The instantaneous values of all current measuring points are checked on a phase-selective basis for implausible values.
- The affected phases are marked with wire-break suspected.
- Depending on the supervision mode, you can add a marker for blocking protection functions for the affected phases.
- After 10 ms of broken-wire check, the wire break is reliably signaled.

9.3.8.3 Function Description

Broken Wire Suspected

The **Broken-wire detection** function monitors the dynamic behavior of the currents of each phase and of all measuring points. For this purpose, the instantaneous values of the currents are checked for their plausibility. Each expected violation must be confirmed by additional criteria before a wire break can be detected and signaled with assurance.

The detection of the local broken wire suspected is performed on each 3-phase current measuring point of the device selectively for each phase.

Detection:

A wire break initially manifests itself as a sudden decrease of the current below the minimum threshold of 0.06 $I/I_{rated.}$ A plausibility test on one period of past instantaneous values confirms this condition. If the criteria for the local wire break are satisfied, the affected phase is marked with **Broken wire suspected**.

Resetting:

The broken wire suspected is reset by phase current flowing again or by a binary input signal. Binary resetting can be useful during laboratory tests among other applications.

Indication

If the broken-wire detection has not been reset within 10 ms, it will be indicated. The indication is held stable for the duration of at least 3 periods.

When using the fast measuring transducer inputs as 4 mA to 20 mA inputs, broken-wire detection is active. With a < 2 mA current, wire breaks are detected and the ***wire break*** indication is set. The measured values display remains unaffected.

9.3.8.4 Application and Setting Notes

Parameter: Mode

- Recommended setting value **(_:1) Mode** = ***off***

The **Mode** parameter is used to switch the broken-wire detection to ***on***, ***off*** and ***test***.

9.3.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Brk.wire det.				
_:1	Brk.wire det.:Mode		• off • on • test	off

9.3.8.6 Information List

No.	Information	Data Class (Type)	Type
Brk.wire det.			
_:82	Brk.wire det.:>Block function	SPS	I
_:54	Brk.wire det.:Inactive	SPS	O
_:52	Brk.wire det.:Behavior	ENS	O
_:53	Brk.wire det.:Health	ENS	O
_:301	Brk.wire det.:Phs A BW suspected	SPS	O
_:302	Brk.wire det.:Phs B BW suspected	SPS	O
_:303	Brk.wire det.:Phs C BW suspected	SPS	O
_:304	Brk.wire det.:Phase A broken wire	SPS	O
_:305	Brk.wire det.:Phase B broken wire	SPS	O
_:306	Brk.wire det.:Phase C broken wire	SPS	O

No.	Information	Data Class (Type)	Type
_:307	Brk.wire det.:Broken wire suspected	SPS	O
_:308	Brk.wire det.:Broken wire confirmed	SPS	O

9.3.9 Current-Balance Supervision

9.3.9.1 Overview of Functions

In healthy network operation, a certain balance between currents can be assumed.

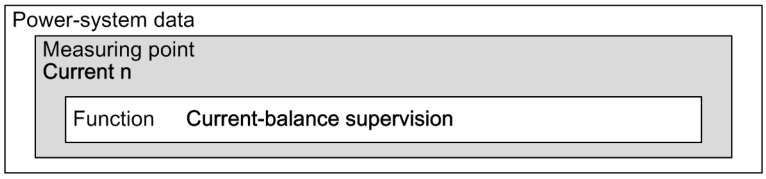
The **Current-balance supervision** function detects the following errors:

- Unbalance of phase currents in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The current measurement is based on the RMS values of the fundamental component.

9.3.9.2 Structure of the Function

The **Current-balance supervision** function is located in the **Power-system data** of each 3-phase current measuring point.



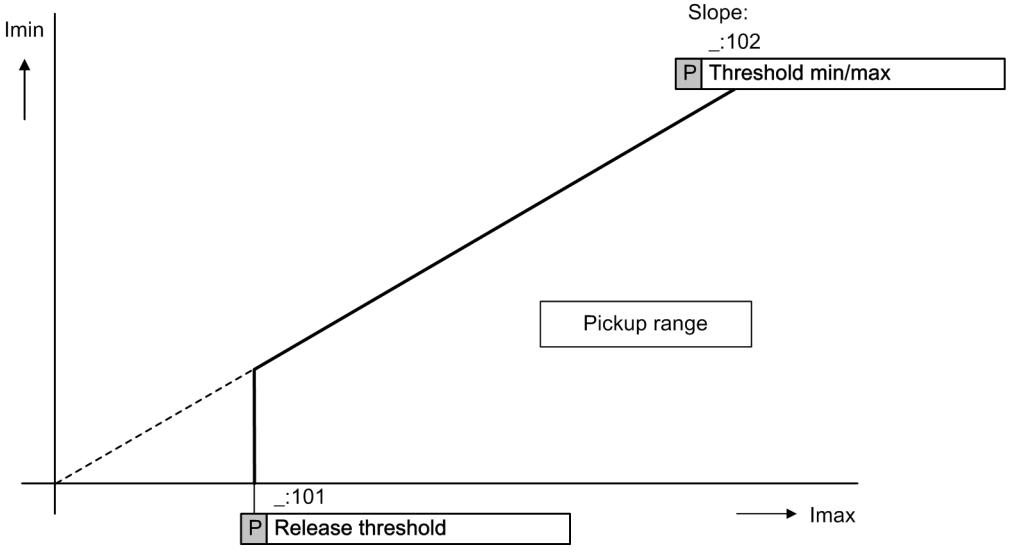
[dwstrsym-060611-01.tif, 2, en_US]

Figure 9-20 Structure/Embedding of the Function

9.3.9.3 Function Description

The current balance is checked by a magnitude monitoring function. This function relates the smallest phase current to the largest phase current. Unbalance is detected if

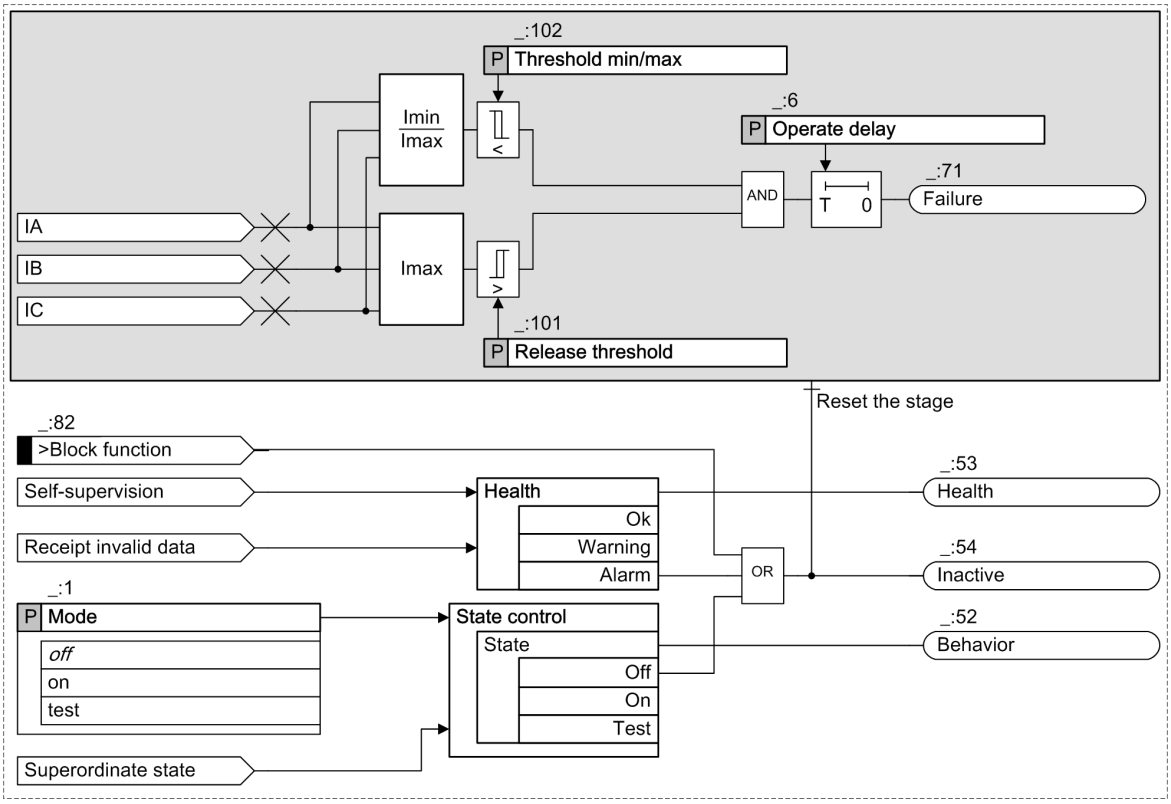
|Imin| / |Imax| < **`Threshold min/max`**, as long as Imax > **`Release threshold`** / IN.



[losymmke-040211-01.tif, 1, en_US]

Figure 9-21 Characteristic of the Current-Balance Supervision

Logic



[locbsymm-100611-01.tif, 1, en_US]

Figure 9-22 Logic Diagram of the Current-Balance Supervision

The **Threshold min/max** parameter is the criterion by which unbalance in the phase currents is measured. The device calculates the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Enter the lower limit of the maximum phase current (I_{max}) with the parameter **Release threshold**. This specifies the lower limit of the operating range of this function.

Operate delay

If it falls below the balance factor **Threshold min/max** and at the same time the maximum phase current exceeds the **Release threshold**, the tripping delay begins. If both conditions persist during this time, the indication **Failure** is generated.

9.3.9.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value **(_:102) Threshold min/max** = ***0.5***

The **Threshold min/max** parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Parameter: Release threshold

- Recommended setting value **(_:101) Release threshold** = ***0.5 A*** for I_{rated} = 1 A or ***2.5 A*** for I_{rated} = 5 A

The **Release threshold** parameter is used to set the lower limit of the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

9.3.9.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. I				
_:1	Supv. balan. I:Mode		• off • on • test	off
_:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:6	Supv. balan. I:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.9.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum I			
_:82	Supv. sum I:>Block function	SPS	I
_:54	Supv. sum I:Inactive	SPS	O
_:52	Supv. sum I:Behavior	ENS	O
_:53	Supv. sum I:Health	ENS	O
_:71	Supv. sum I:Failure	SPS	O

9.3.10 Current-Sum Supervision

9.3.10.1 Overview of Functions

In healthy system operation, the sum of all currents at one measuring point must be approximately 0. The **Current-sum supervision** monitors the sum of all currents of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit.

For summation of the currents, the device requires the phase currents and the ground current of the current transformer neutral point or of a separate ground-current transformer at this measuring point. The following connection variants are available:

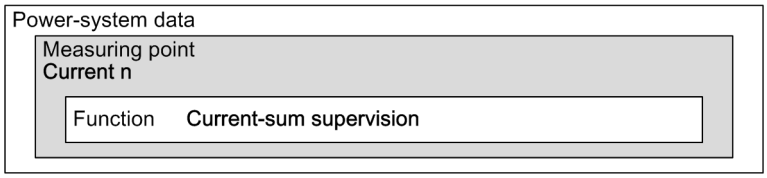
- Current-transformer connections connected to 3 current transformers and the neutral point (see *Figure A-12* in the Attachment)
- Ground current detected with 3 separate ground-current transformers (see *Figure A-14* in the Attachment)
- 3 current transformers and one summation current transformer connected (see *Figure A-13* in the Attachment)
- 2 current transformers and one summation current transformer connected (see *A.7 Connection Examples for Current Transformers* in the Attachment)

NOTE

For current-sum supervision, the ground current of the line to be protected must be connected to the 4th current measurement input (I_N).

9.3.10.2 Structure of the Function

The **Current-sum supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

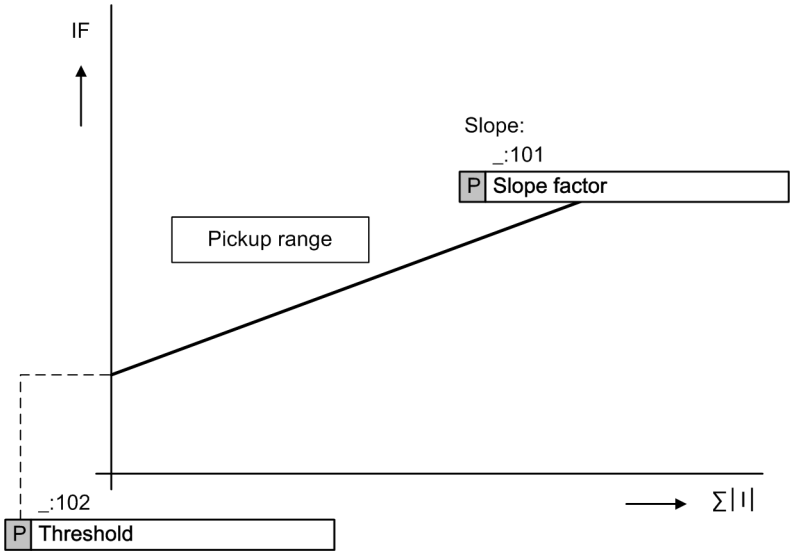


[dwstrcss-300913, 2, en_US]

Figure 9-23 Structure/Embedding of the Function

9.3.10.3 Function Description

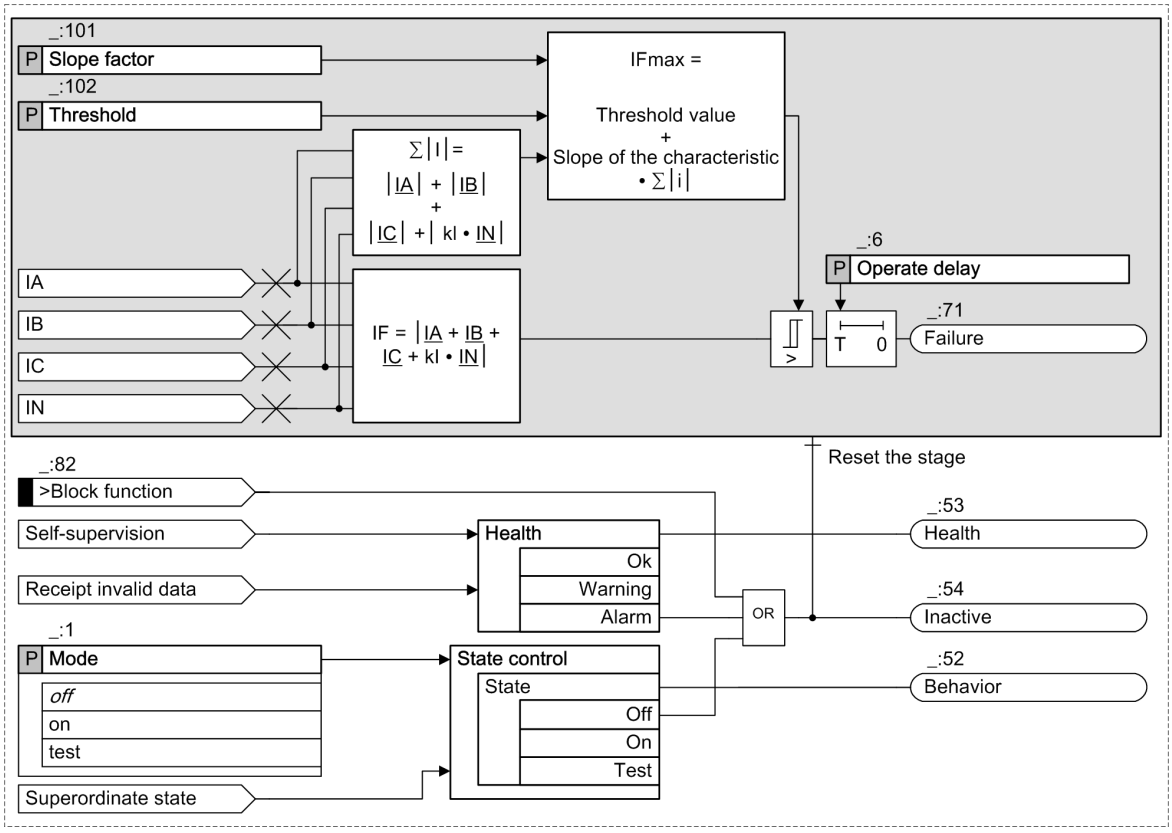
The current sum is generated by addition of the current phasors. Errors in the current circuits are detected if IF = |IA + IB + IC + kI• IN| > **Threshold** + **Slope factor** •Σ | I |.



[lokensum-300311-01.tif, 1, en_US]

Figure 9-24 Characteristic of the Current-Sum Supervision

Logic



[locssumm-140611-01.tif, 1, en_US]

Figure 9-25 Logic Diagram of the Current-Sum Supervision

Slope of the Characteristic Curve

The **Slope factor** • Σ | I | part takes into account permissible current-proportional transformation errors of the transformer, which can occur in the case of high short-circuit currents.

The **Slope factor** and **Threshold** parameters are used to set the fault-current limit (I_{Fmax}) for the current-sum supervision. The device calculates this fault current limit with the formula:

I_{Fmax} = **Threshold** + **Slope factor** • Σ| I |

The device uses the current inputs (IA, IB, IC and IN) to calculate:

- The fault current IF = |IA + IB + IC + kI• IN|
- The maximum current Σ| I | = | IA| + |IB| +| IC| + |kI• IN|

with $\mathbf{k_I}$ taking into account a possible difference from the transformation ratio of a separated ground-current transformer (I_N), for example, cable type current transformer.

- Transformation ratio of residual-current converter: $Ratio_N$
- Transformation ratio of phase-current converter: $Ratio_{ph}$

$$k_I = \frac{Ratio_N}{Ratio_{ph}}$$

[foglchki-040211-01.tif, 1, en_US]

Threshold

The **Threshold** parameter is the lower limit of the operating range of the **Current-sum supervision** function.

Operate delay

When the calculated fault current (I_F) exceeds the calculated fault current limit (I_{Fmax}), the **Operate delay** starts. If the threshold-value violation persists for that time, the **Failure** indication is generated.

9.3.10.4 Application and Setting Notes

Parameter: Slope factor

- Recommended setting value **(_:101) Slope factor** = ***0.1***

The **Slope factor** parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current. This function calculates the RMS values.

Parameter: Threshold

- Recommended setting value **(_:102) Threshold** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **Threshold** parameter is used to set the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

9.3.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum I				
_:1	Supv. sum I:Mode		• off • on • test	off
_:102	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

9.3.10.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum I			
_:82	Supv. sum I:>Block function	SPS	I
_:54	Supv. sum I:Inactive	SPS	O
_:52	Supv. sum I:Behavior	ENS	O
_:53	Supv. sum I:Health	ENS	O
_:71	Supv. sum I:Failure	SPS	O

9.3.11 Current Phase-Rotation Supervision

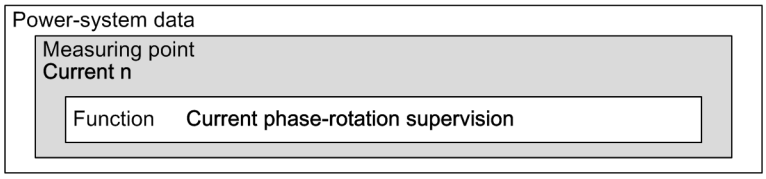
9.3.11.1 Overview of Functions

The **Current phase-rotation supervision** function monitors the phase sequence of the secondary-circuit currents by monitoring the sequence of the zero crossings (with same sign) of the currents. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the **`Phase sequence`** parameter.

The current measurement is based on the RMS values of the fundamental component.

9.3.11.2 Structure of the Function

The **Current phase rotation supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

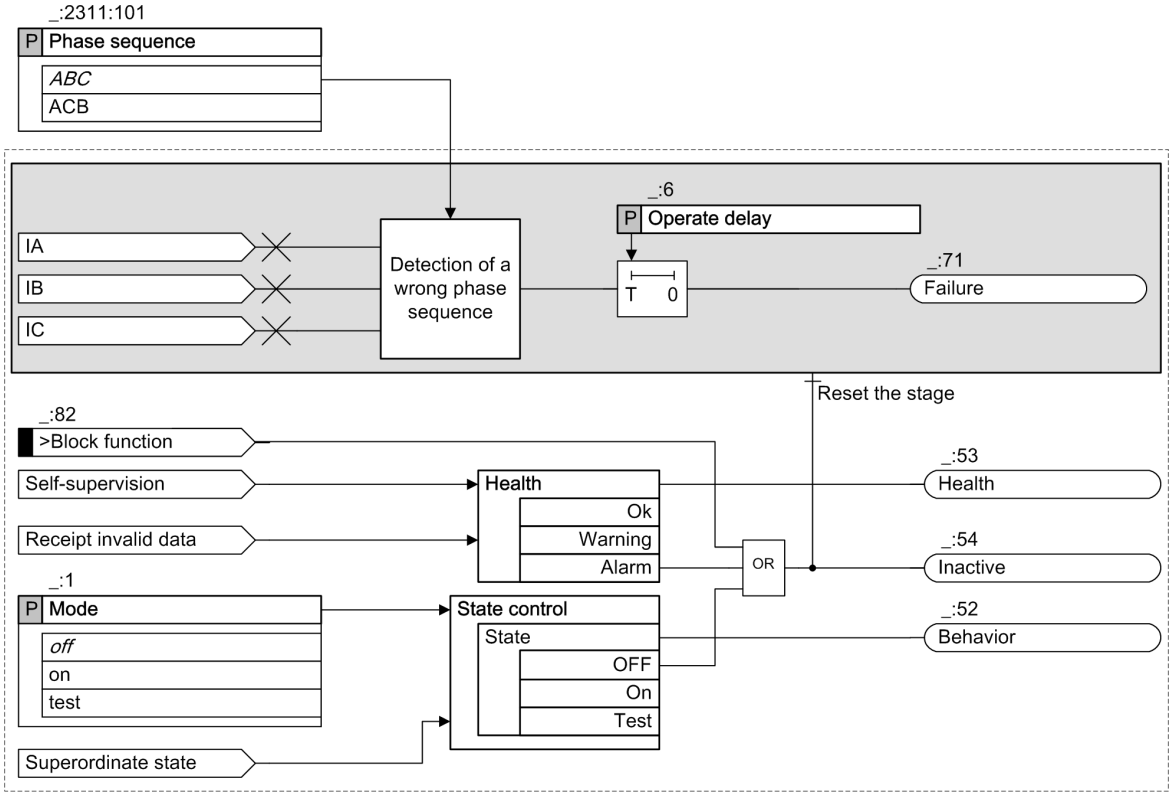


[dwstrcrs-040211-01.tif, 3, en_US]

Figure 9-26 Structure/Embedding of the Function

9.3.11.3 Function Description

Logic



[locrsymm-100611-01.tif, 2, en_US]

Figure 9-27 Logic Diagram Current Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section **Power-system data**.

The phase rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.
The connection diagrams are shown in the section **Appendix**.

Operate delay

When the device detects an inverted phase sequence for the duration of the **Operate delay** the indication **Failure** is generated.

9.3.11.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq.I				
_:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

9.3.11.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq.I			
_:82	Supv. ph.seq.I:>Block function	SPS	I
_:54	Supv. ph.seq.I:Inactive	SPS	O
_:52	Supv. ph.seq.I:Behavior	ENS	O
_:53	Supv. ph.seq.I:Health	ENS	O
_:71	Supv. ph.seq.I:Failure	SPS	O

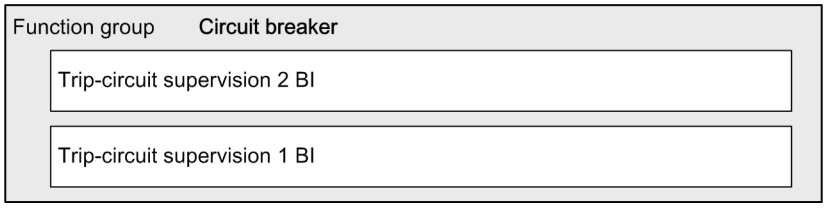
9.3.12 Trip-Circuit Supervision

9.3.12.1 Overview of Functions

The **Trip-circuit supervision** function recognizes disruptions in the trip circuit. When 2 binary inputs are used, the function recognizes all disruptions in the trip circuit. If only 1 binary input is available, it will not recognize disruptions at the circuit-breaker.
The control voltage for the circuit breaker must be greater than the sum of the minimum voltage drops at the binary inputs $V_{Ctrl} > 2\ V_{BImin}$. At least 19 V are required for each binary input. This makes the supervision usable only with a system-side control voltage of > 38 V.

9.3.12.2 Structure of the Function

The trip-circuit supervision is integrated into the **Circuit-breaker** function group. Depending on the number of available binary inputs, it works with 1 or 2 binary inputs.



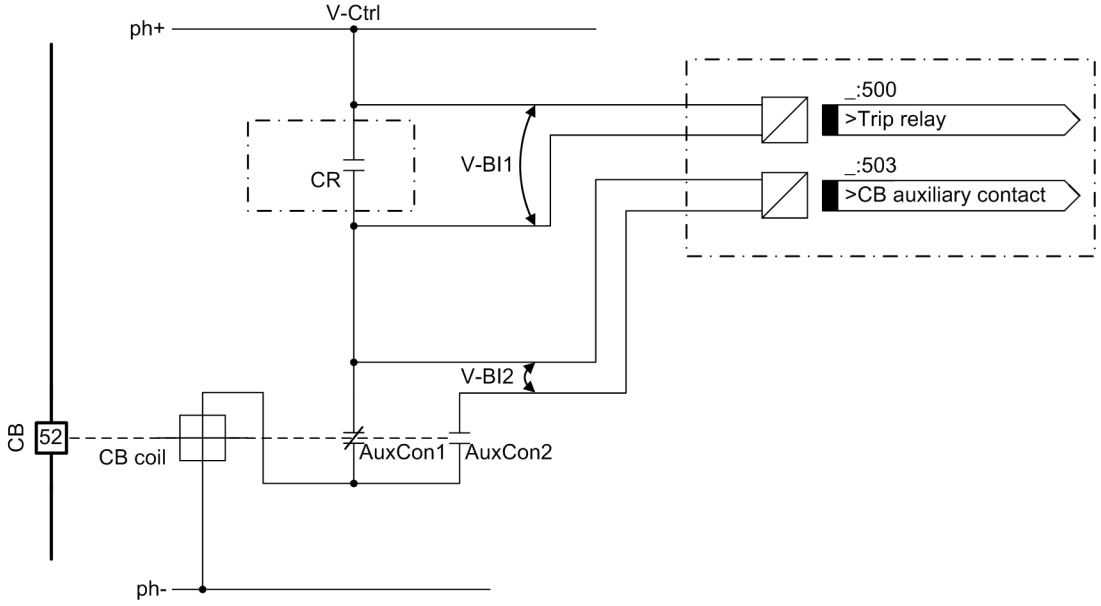
[dwtcsueb-010313-01.tif, 1, en_US]

Figure 9-28 Structure/Embedding of the Function

9.3.12.3 Trip-Circuit Supervision with 2 Binary Inputs

In order to recognize disruptions in the trip circuit for each switch position, you need 2 binary inputs. One input is connected parallel to the respective command relay of the protection, the other parallel to the circuit-breaker auxiliary contact.

The following figure shows the principle of the trip-circuit supervision with 2 binary inputs.



[dwtcs2be-110611-01.tif, 2, en_US]

Figure 9-29 Principle of Trip-Circuit Supervision with 2 Binary Inputs

CR	Command relay
CB	Circuit breaker
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NC)
AuxCon2	Circuit-breaker auxiliary contact (NO)
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2

Supervision with 2 binary inputs identifies disruptions in the trip circuit and the outage of the control voltage. It also monitors the reaction of the circuit breaker by way of the position of the circuit-breaker auxiliary contacts.

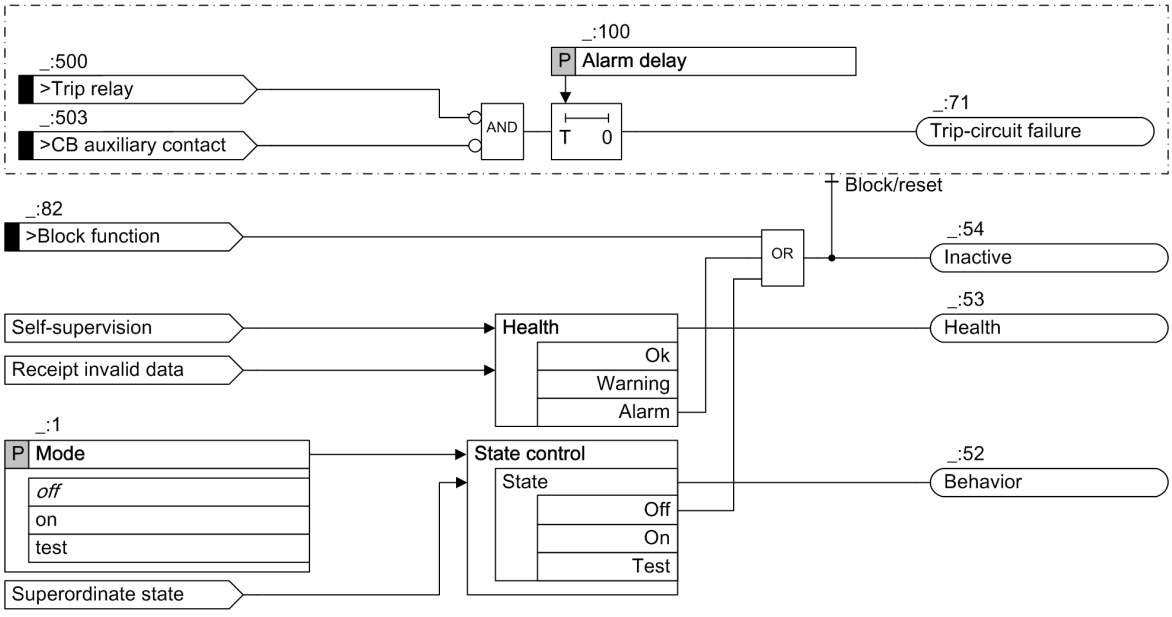
Depending on the switch position of the command relay and circuit breaker, the binary inputs are either activated (**H**) or not (**L**). If both binary inputs are not activated, there is a fault. The fault may be a interruption or a short circuit in the trip circuit, an outage of the battery voltage or a fault in the mechanics of the circuit breaker. With intact trip circuits, this state will occur only briefly while the command relay is closed and the circuit breaker has not yet been opened.

No.	Command Relay (CR)	CB	AuxCon1	AuxCon2	BI 1	BI 2	Dynamic State	Static State
1	Open	ON	Closed	Open	H	L	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	H	CR successfully activated the circuit breaker	

With the **`Alarm delay`** parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signals *`>Trip relay`* or *`>CB auxiliary contact`* are not routed on the binary inputs of the device, then the *`Input sig. not routed`* indication is generated and the **Trip-circuit supervision** function is not in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 2 binary inputs.



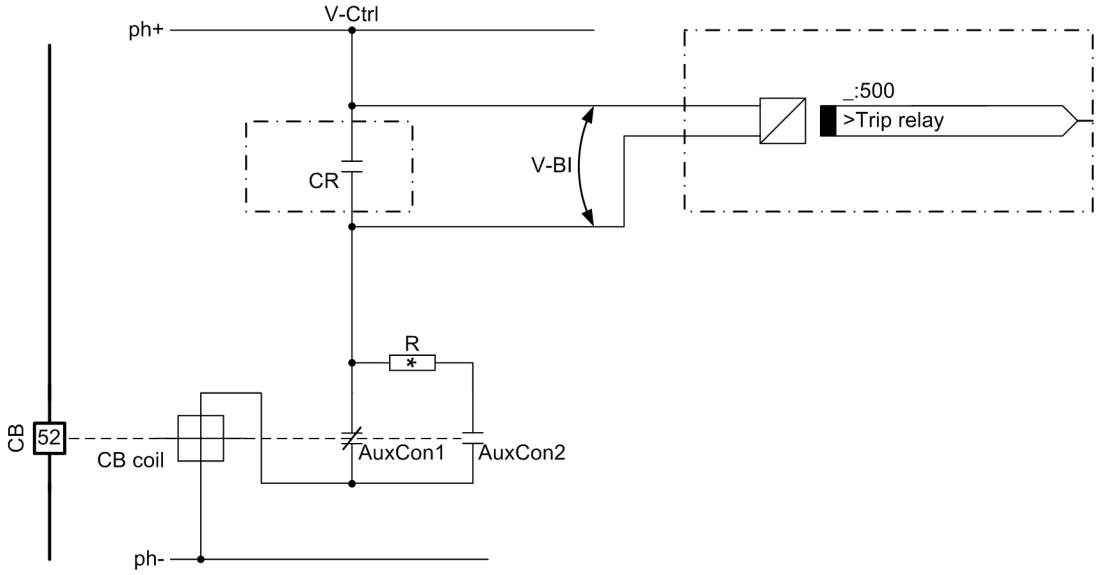
[lotcs2be-260912-01.tif, 1, en_US]

Figure 9-30 Logic Diagram of Trip-Circuit Supervision with 2 Binary Inputs

9.3.12.4 Trip-Circuit Supervision with 1 Binary Input

When using 1 binary input, you will not identify any disruptions on the circuit breaker. The binary input is connected in parallel with the respective command relay of the protection device. The circuit-breaker auxiliary contact is bridged with a high-resistance equivalent resistance R.

The following figure shows the principle of the trip-circuit supervision with 1 binary input.



[dwtcs1be-110611-01.tif, 2, en_US]

Figure 9-31 Principle of Trip-Circuit Supervision with 1 Binary Input

CR	Command relay
CB	Circuit breaker
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NC)
AuxCon2	Circuit-breaker auxiliary contact (NO)
V-Ctrl	Control voltage (tripping voltage)
V-BI	Input voltage for binary input
R	Equivalent resistance

The supervision with 1 binary input identifies disruptions in the trip circuit and the failure of the control voltage.

In normal operation, the binary input is activated with the command relay open and the trip circuit intact (**H**). The supervision circuit is closed with the equivalent resistance R or with the auxiliary contact AuxCon1 of the closed circuit breaker. The binary input is not activated while the command relay is closed (**L**). If the binary input is not activated for a prolonged time, there is a disruption in the trip circuit or the control voltage has failed.

No.	Command Relay	CB	AuxCon1	AuxCon2	BI	Dynamic State	Static State
1	Open	ON	Closed	Open	H	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	CR successfully activated the circuit breaker	

Use the parameter **`Blk.by trip/open cmd from`** to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

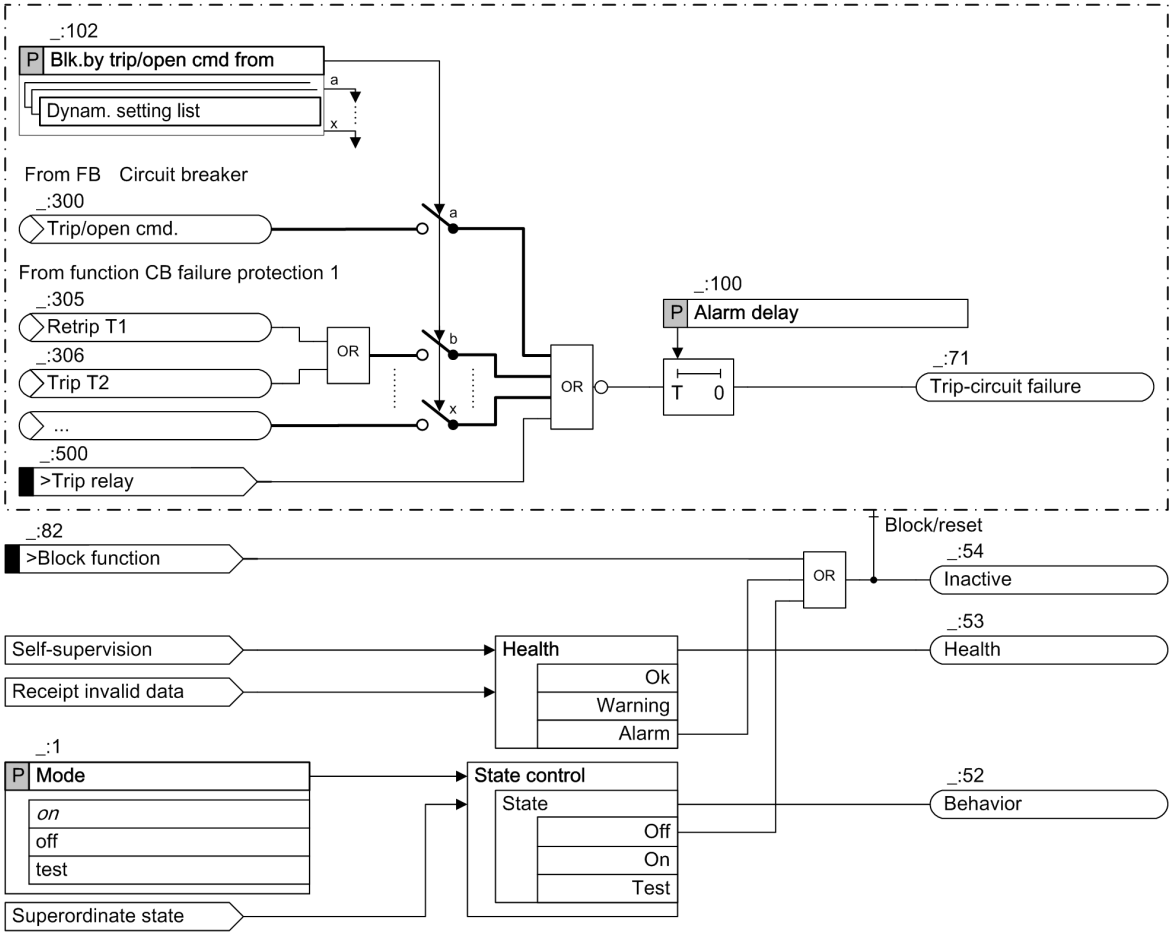
- The *`Trip/open cmd.`* of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.

As long as the trip-circuit supervision function is blocked, the closed contact of the command relay does not cause a failure indication.

If the command contacts of other devices work in parallel on the trip circuit, the failure indication must be delayed. With the **Alarm delay** parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signal *>Trip relay* is not routed to a binary input of the device (**information routing** in DIGSI 5), then the *Input sig. not routed* indication is generated and **Trip-circuit supervision** is no longer in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 1 binary input.



[lotcs1be-260912-01.tif, 1, en_US]

Figure 9-32 Logic Diagram of Trip-Circuit Supervision with 1 Binary Input

Equivalent Resistance R

The equivalent resistance R must be dimensioned such that the circuit-breaker coil is no longer activated when the circuit breaker is open. Simultaneously, the binary input must still be activated when the command relay is open.

In order to ensure the minimum voltage for activating the binary input, R_{max} results in:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BImin}}{I_{BI(High)}} \right) - R_{CBC}$$

[fofr1b02-090330-01.tif, 1, en_US]

So that the circuit-breaker coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC(Lowmax)}}{V_{CBC(Low)}} \right)$$

[fofr1b03-090330-01.tif, 1, en_US]

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

$$R = \frac{R_{max} + R_{min}}{2}$$

[fofr1b01-090330-01.tif, 1, en_US]

The following applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R + R_{CBC}} \right)^2 \cdot R$$

[fofr1b04-090330-01.tif, 1, en_US]

9.3.12.5 Application and Setting Notes

Parameter: Alarm delay

- Recommended setting value **(_:100) Alarm delay** = ***2 s*** (Trip-circuit supervision with 2 binary inputs)
- Recommended setting value **(_:100) Alarm delay** = ***300 s*** (Trip-circuit supervision with 1 binary input)

With the parameter **Alarm delay**, you can set the time for the delayed output of the indication *Trip-circuit failure*.

For **Trip-circuit supervision with 2 binary inputs**, you set the **Alarm delay** parameter so that the short-term transient states do not cause the function to activate.

For the **Trip-circuit supervision with 1 binary input,** you set the **Alarm delay** so that the longest duration of a trip command is bridged without fail. This ensures that the indication is emitted only if the trip circuit is actually interrupted.

Parameter: Blk.by trip/open cmd from

- Possible settings, application-dependent

The parameter works only with the trip-circuit supervision with 1 binary input.

Use the parameter **Blk.by trip/open cmd from** to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

- The *Trip/open cmd.* of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.
- One of the trip commands of the circuit-breaker reignition protection is activated.

The circuit-breaker failure protection is set to protect a different trip circuit than the local circuit breaker. Using the configuration options of the **Blk.by trip/open cmd from** parameter, multiple trip-circuit supervision functions can be operated in parallel. For instance, a trip-circuit supervision function dedicated to a local circuit breaker can also be operated parallel to a higher-level circuit breaker upon which the circuit-breaker failure protection acts.

9.3.12.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
74TC sup.1BI #				
_:1	74TC sup.1BI #:Mode		• off • on • test	on
_:100	74TC sup.1BI #:Alarm delay		1.00 s to 600.00 s	300.00 s
_:102	74TC sup.1BI #:Blk.by trip/ open cmd from		Setting options depend on configuration	
74TC sup.2BI #				
_:1	74TC sup.2BI #:Mode		• off • on • test	on
_:100	74TC sup.2BI #:Alarm delay		1.00 s to 30.00 s	2.00 s

9.3.12.7 Information List

No.	Information	Data Class (Type)	Type
74TC sup.1BI #			
_:82	74TC sup.1BI #:>Block function	SPS	I
_:500	74TC sup.1BI #:>Trip relay	SPS	I
_:54	74TC sup.1BI #:Inactive	SPS	O
_:52	74TC sup.1BI #:Behavior	ENS	O
_:53	74TC sup.1BI #:Health	ENS	O
_:71	74TC sup.1BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.1BI #:Input sig. not routed	SPS	O
74TC sup.2BI #			
_:82	74TC sup.2BI #:>Block function	SPS	I
_:500	74TC sup.2BI #:>Trip relay	SPS	I
_:503	74TC sup.2BI #:>CB auxiliary contact	SPS	I
_:54	74TC sup.2BI #:Inactive	SPS	O
_:52	74TC sup.2BI #:Behavior	ENS	O
_:53	74TC sup.2BI #:Health	ENS	O
_:71	74TC sup.2BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.2BI #:Input sig. not routed	SPS	O

9.4 Supervision of the Device Hardware

9.4.1 Overview

The correct state of the device hardware is a requirement for the correct functioning of the device. The failure or erroneous function of a hardware component leads to device malfunctions.

The following modules of the device hardware are monitored:

- Base module
- Expansion modules
- Plug-in modules on the interface locations

The fault responses result, depending on type and degree of the error, as follows:

Hardware errors where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can switch into a secure state. Such errors are, for example:

- Communication-module failure (module x)
- Measuring-transducer module failure (module x)
- USB interface
- Integrated Ethernet interface
- Real-time clock building block
- A/D converter (fast current sum)
- Battery voltage
- Faulty or missing compensation values (magnitude/phase)

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Memory error (RAM) in the base module
- Faulty module
- Module-connection error (PCB Link)
- Control circuit error binary output
- Outage of an internal auxiliary voltage



NOTE

If the error has not be rectified after 3 unsuccessful attempts, the system automatically recognizes it as a severe device malfunction. The device goes permanently out of operation into a secure state (fallback mode).

Fatal device errors with outage of central components: The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Memory error (flash) in the base module
- CPU/Controller/FPGA error in the base module
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the fault responses at the end of chapter 8 . You will find corresponding corrective measures there.

Device Operating Hours

The *Device operating hours* statistical value counts the operating hours of the physical device. The starting time and the time in Fallback mode are not considered.

You can neither reset nor change the statistical value.

9.4.2 Analog-Channel Supervision via Fast Current-Sum

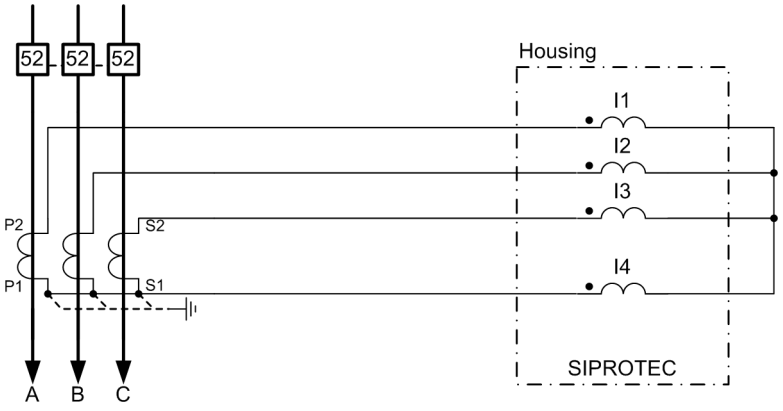
9.4.2.1 Overview of Functions

The function **Supervision of the device-internal analog-digital converters** it performs the following tasks:

- Supervision of the correct functioning of the device-internal analog-digital converters, based on the sum of all currents of one measuring point in the secondary circuit.
- Detection of failures in the device-internal measuring circuits (for example, analog-digital converter)
- Blocking of protection and control functions that process the measured values from this current measuring point (for example, differential protection). This avoids an overfunction of the device.

The supervision principle is based on fast current sum supervision with connection of the neutral-point current to the 4th current measurement input. In order to ensure that even the fast tripping stages of the protection functions can be blocked in time before a spurious pickup, the fast current measurement is based on instantaneous values.

For **Analog-digital converter supervision**, the neutral-point current of the line to be protected must be connected to the 4th current measuring input (I_N). The 4th current measuring input must be routed via the current-transformer neutral point (I_N neutral point) (see next figure).



[tileite2-070211-01.tif, 1, en_US]

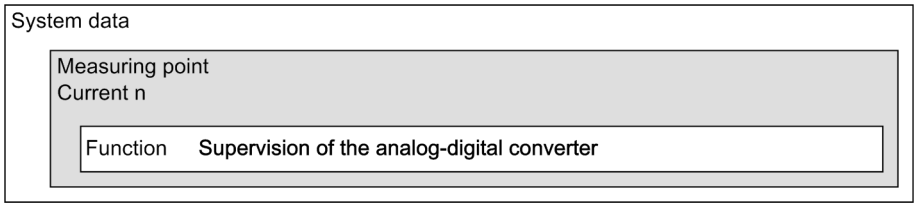
Figure 9-33 Connection to a 3-Phase Current Transformer and Measured Zero-Sequence Current (Current in Common Return Path)

NOTE

The analog channel supervision via fast current sum is only available when the 4th current input is a protection-class current transformer. In the DIGSI 5 project tree, under **Device** → **Measuring-point routing**, set the connection type ***3-phase + IN*** for the current measuring point.

9.4.2.2 Structure of the Function

The **Supervision of the device-internal analog-digital converters** function is located in the **Power-system data** function group of each 3-phase current measuring point.



[dwschstr-040211-01.tif, 1, en_US]

Figure 9-34 Structure/Embedding of the Function

9.4.2.3 Function Description

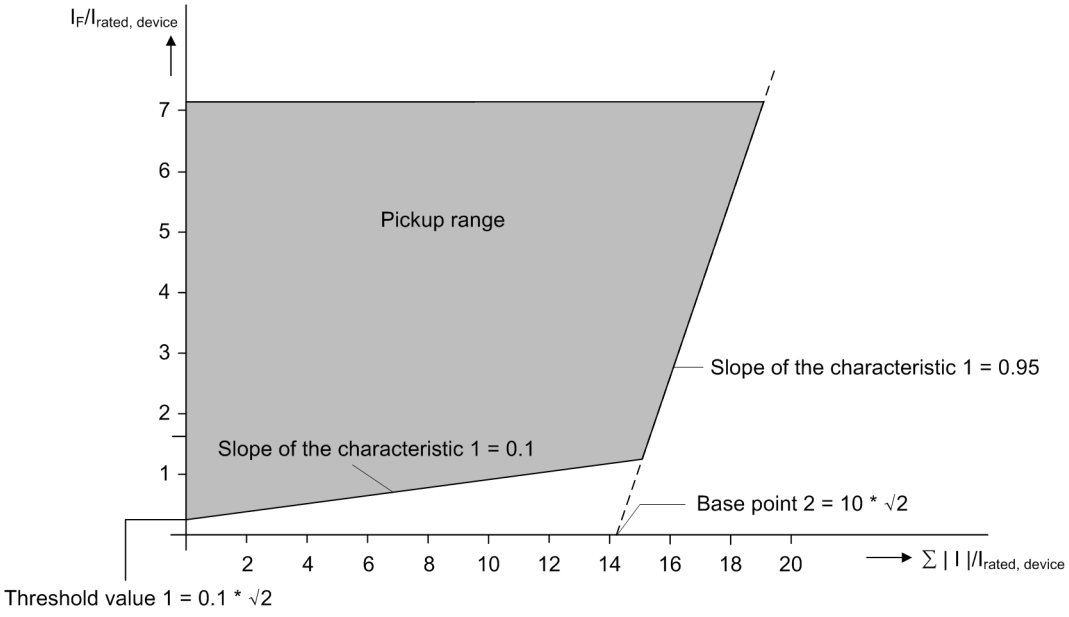
Errors in the current circuits are detected if

I_F = |iA + iB + iC + iN| > **Threshold value** + **Slope of the characteristic 1** •Σ| i | and

I_F > **Slope of the characteristic 2** • (Σ| i | - **Base point 2**)

With the current inputs (iA, iB, iC, and iN), the device calculates:

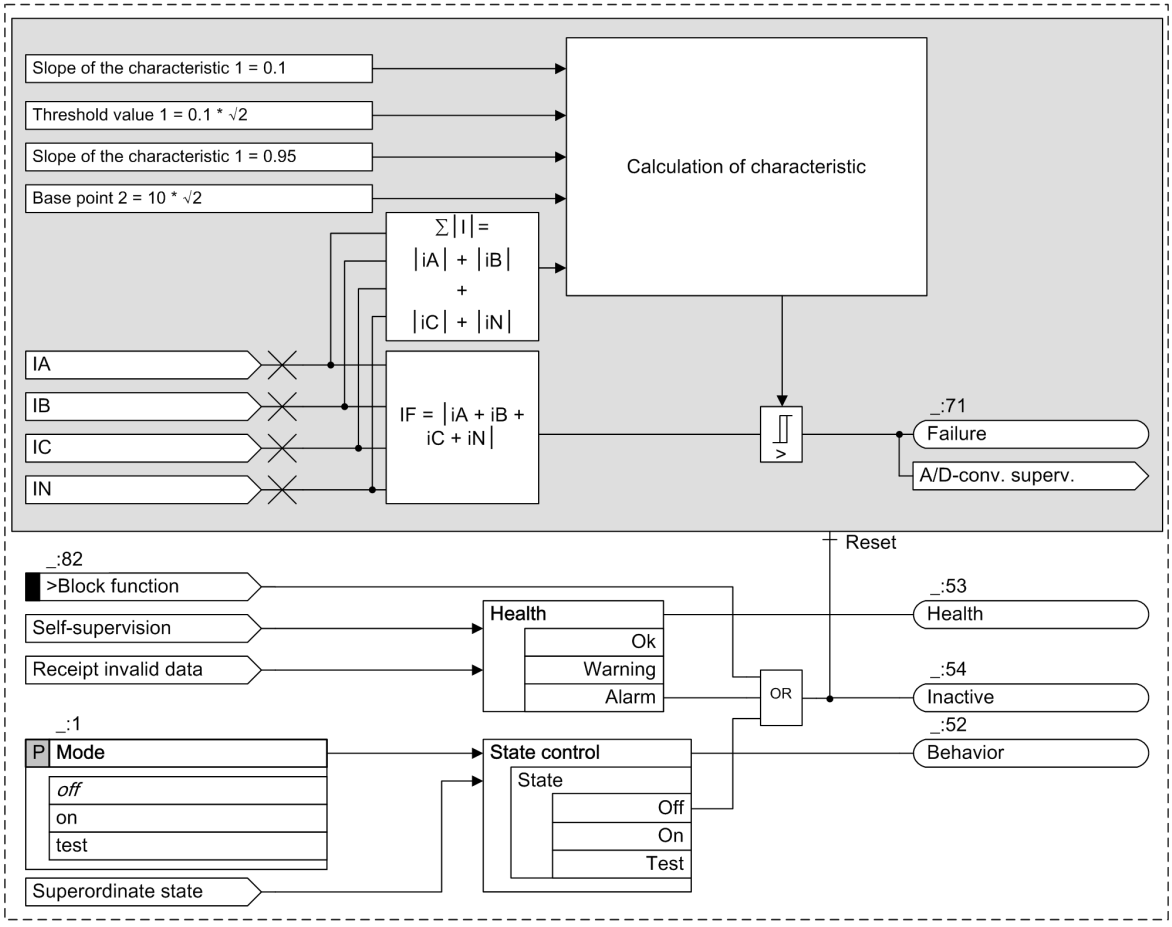
- The fault current I_F = |iA + iB + iC + iN|
- The maximum current Σ| i | = |iA|+|iB|+|iC| + |iN|



[lokenisu-240413-01.tif, 2, en_US]

Figure 9-35 Characteristic Curve of the Supervision of the Device-Internal Analog-Digital Converters

Logic



[losumsch-240413-01.tif, 3, en_US]

Figure 9-36 Logic Diagram of the Supervision of the Device-Internal Analog-Digital Converters

When the output signal **`A/D converter monit.`** is active, certain protection functions are blocked to avoid failures (see *12.64 Analog Channel Supervision via Fast Current Sum*).

NOTE

The parameters are fixed in the device and cannot be changed.

It is not necessary to change the parameters depending on the application.

Threshold Value

The **threshold value** is the lower limit of the operating range of the **Supervision of the device-internal analog-digital converters** function.

The **threshold value** is fixed to 10 % of the device rated current.

Slope of the Characteristic 1

The component **slope of characteristic 1** • Σ | i | takes into account permissible current-input errors, which can occur in the case of small overcurrents.

The **slope of characteristic 1** is fixed to 0.1.

Slope of the Characteristic 2

The component **slope of characteristic 2** takes into account permissible current-input errors, which can occur in the case of high overcurrents (high short-circuit currents).

The **slope of characteristic 2** is fixed to 0.95. The base point of the **slope of characteristic 2** is fixed to 10.

9.5 Supervision of Device Firmware

The device firmware determines essentially the functionality of the device.

The following supervisions ensure the stable function of the device:

- Supervisions of the data and version consistency
- Supervision of the undisturbed sequential activity of the device firmware
- Supervision of the available processor performance

When you start the device, load data via the interfaces and these supervisions of the device firmware will be in effect during the continuous operation. Depending on the type and severity of error, the following error responses will result:

Firmware failures where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in time synchronization (loss and errors).

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Device startup with faulty new parameter set. The old parameter set is still present.
- Overloading of the processor
- Program-sequence error

Fatal firmware error. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Device startup with faulty new parameter set. No usable parameter set is present.
- Device startup with version error
- CFC-runtime error
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the fault responsed at the end of chapter 8. You will find corresponding corrective measures there.

9.6 Supervision of Hardware Configuration

The modular hardware concept requires adherence to some rules within the product family and the modular system. Configuration errors show that the hardware configuration saved in the device does not agree with the hardware actually detected. Impermissible components and unallowed combinations must be detected just as missing configured components are.

Depending on the type and severity of error, the following error responses will result: The identified hardware configuration errors are assigned to the defect severities as follows:

Configuration errors where the device remains in operation.

The failure is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in IE converter configuration (loss and errors).

Fatal configuration error: The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Missing hardware module (module x)
- Incorrect hardware module (module x)
- Incorrect hardware combination
- Incorrect plug-in module (module x)

You can find the detailed description, in table form, of the error reactions at the end of chapter 8 . You will find corresponding corrective measures there. You can resolve configuration errors through another synchronization with DIGSI.

9.7 Supervision of Communication Connections

SIPROTEC 5 devices offer extensive communication possibilities via fixed and optional interfaces. Beyond the hardware supervision of the communication plug-in modules the transferred data must be monitored with respect to their consistency, failure, or outage.

Supervision

With the supervision of the communication connections, every communication port is monitored selectively.

- Failures are detected and indicated via the operational log. The device remains in operation!
- Each port additionally is equipped with a separate communication log, with which details of the failures (for example, error rate) are displayed.

Marking Fault Signals/Data

The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. In the following, some examples are named:

- GOOSE signals can automatically be set to defined values in case of disturbed IEC 61850 communication.
- Disturbed protection interfaces set phasor values, both analog measured values and binary information to **invalid** (for example, for differential protection). Binary signal traces can be set to defined values in cases of failures.
- Disturbed time-synchronization signals can lead to an automatic change of the source of time synchronization.

Normally, you can correct communication failures by checking the external connections or by replacing the affected communication modules. In chapter *9.8.2 Defect Severity 1* to *9.8.4 Defect Severity 3*, you will find the detailed description, in tabular form, of the error responses. Corresponding corrective measures can also be found there.

9.8 Error Responses and Corrective Measures

9.8.1 Overview

When device errors occur and the corresponding supervision functions pick up, this is displayed on the device and also indicated. Device errors can lead to corruption of data and signals. These data and signals are marked and tagged as **invalid**, so that affected functions automatically go into a secure state. If the supervision functions pick up, this will lead to defined error responses.

How Do Device Errors Make Themselves Noticeable

In case of a device error the supervision functions of the device pickup. The device responds according to the type and severity of the error. To report an error, supervision functions use outputs on the device and indications.

Run LED (green)	The external auxiliary voltage is present. The device is ready for operation.
Error LED (red)	The device is not ready for operation. The life contact is open.
Life contact	Signaling of device readiness following successful device startup.
Group-warning indication *Group warning*	The device remains in operation and signals an error via the prerouted LED and the log.
Log of the device	Indications of causes for defects and corrective measures

Determination of Causes for Defects and Corrective Measures

To determine the cause for defect and the corresponding corrective measure, proceed step by step.

Step 1: Pick up of supervisions leads to one of the following defect severities in all cases.

- **Defect severity 1:**
  Internal or external device error that is reported. The device stays in operation.
- **Defect severity 2:**
  Severe device failure, the device restarts (reset) to correct the cause for defect.
- **Defect severity 3:**
  Severe device failure, the device goes to a safe condition (fallback mode), as the correction of defects by a restart is not possible. In fallback mode, the protection and automated functions are inactive. The device is out of operation.
- **Defect severity 4:**
  Severe device-external failure, the device switches the protection and automatic functions to inactive for safety, but stays in operation. Normally, the user can correct the fault by himself.

Step 2: For every defect severity, you will find detailed tables with information about causes for defects, error responses, and corrective measures in the following chapters.

	Error Responses						
	Group-Warning Indication Group Warning	Indication in the Operational Log	Indication in the Device-Diagnosis Log	Indication of the Life Contact	All Protection and Automation Functions Are Inactive	Device Restart (Reset)	Fallback Mode
Defect severity 1	x	x	x				
Defect severity 2			x	x	During the starting time of the device	x	
Defect severity 3			x	x	x		x
Defect severity 4		x		x	x		

9.8.2 Defect Severity 1

Defect severity 1 faults allow the continued safe operation of the device. Defect severity 1 faults are indicated. The device remains in operation.

When the supervision functions pick up, corrupted data and signals are marked as **invalid**. In this way, the affected functions can go into a secure state. Whether functions are blocked is decided in the appropriate function itself. For more detailed information, refer to the function descriptions.

Live status contact	Remains activated
Red error LED	Is not activated

Log

For every device fault, a corresponding supervision indication is generated. The device records these indications with a real-time stamp in the operational log. In this way they are available for further analyses. If supervisions in the communication interfaces area of the device pick up, there is a separate communication log available for each port. Extended diagnostic indications and measured values are available there. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

Group-Warning Indication Group Warning

As delivered, all supervision indications of Defect Severity 1 are routed to the signal `(_:301)` **`Group warning`**. In this way, a device error can be indicated with only one indication. The majority of supervision indications are permanently connected to the **`Group warning`** indication (**Group warning** column = fixed). However, some supervision indications are routed flexibly to the **`Group warning`** via a CFC chart (**Group warning** column = CFC). If necessary, you can remove the routings via a CFC chart from the group indication.

In delivery condition, the **`Group warning`** is prerouted to an LED.

You can find further information on handling the logs in chapter 3.

Overview of Errors

Indication	Type	Group Warning	Explanation
General: (_:53) **Health**	ENS	CFC	If the **Health** of an individual function block, for example, a protection stage or an individual function, goes to the *warning* or *Alarm* state, this state is processed via the associated function group up to the general group indication **Health** (_:53). Check via the operational log from which function or function block the error originates. You can find additional information as to why the health of the function or a function block can change in the associated function description.
(_:53) **Health** = **Warning**	SPS		
(_:53) **Health** = **Alarm**	SPS		
Device: (_:320) **AuxVolt.fault**	SPS	Fixed	Fault with the auxiliary power supply: Check the external power supply.
Device: (_:305) **Battery fault**	SPS	Fixed	Battery fault: Replace the device battery.
Device: (_:312) **Compensation fault** x	ENS	Fixed	Calibration error in module x: Contact the Customer Support Center. **Quality**: Measured values are marked with the quality attribute of *questionable* (measured value display with ~).
Device: (_:314) **Offset error** x	ENS	Fixed	Offset error on module x: If this indication persists after the device start, contact the Customer Support Center. **Quality**: Measured values are marked with the quality attribute of *questionable* (measured value display with ~).
Device: (_:306) **Time failure**	SPS	Fixed	Internal time failure • Check the time settings first. • Then replace the device battery. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internal clock is marked with the quality attribute of *Clock Failure*.
Device: (_:319) **Memory fault**	SPS	Fixed	Checksum (CRC) error in monitored memory areas of the device
Device: Measuring-transducer error (x)	ENS	Fixed	Hardware error on measuring-transducer module in plug-in module position E/F/M/N/P: Contact the Customer Support Center.
Handling an alarm: (_:504) **>Group warning**	SPS	Fixed	Input signal for user-defined generation of the group warning
Time sync.: (_:305) **Time sync Fault**	SPS	Fixed	Time synchronization error, the timing master is faulty: • Check the external time source first. • Check the external connections. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internal clock is marked with the quality attribute of *Clock not synchronized*.

Indication	Type	Group Warning	Explanation
Power-system data:meas. point I-3ph:wire break: Wiring: (_:301) **Phase A possible wire break** (_:302) **Phase B possible wire break** (_:303) **Phase C possible wire break** (_:304) **Phase A wire break** (_:305) **Phase B wire break** (_:306) **Phase C wire break** (_:307) **Possible wire break** (_:308) **Confirmed wire break**	SPS SPS SPS SPS SPS SPS SPS SPS	 CFC CFC	Broken-wire detection indications (see chapter *9.3.8.1 Overview of Functions*) **Blocking**: Protection functions tending to over-function in the event of a wire break are blocked.
Power-system data:meas. point I-3ph:superv. sym I (_:71) **Failure**	SPS	CFC	Current balance failure (see chapter *9.3.9.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Phsseq.I: (_:71) **Failure**	SPS	CFC	Failure of current phase-rotation reversal (see chapter *9.3.11.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Sum I (_:71) **Failure**	SPS	CFC	Failure of current sum (see chapter *9.3.10.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv.ADC sum.I: (_:71) **Failure**	SPS	CFC	Failure of the quick current sum (see chapter *9.4.2.1 Overview of Functions*) The failure indication indicates a fault in the analog-digital converter at the power input. • Check the exterior wiring. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internally managed current measured values are marked with the *invalid* quality attribute. **Blocking**: The protection functions based on current measurement are blocked.
Power-system data:meas. point V-3ph: Volt.Trans.Cir.B: (_:500) **>Open**	SPS	CFC	Voltage-transformer circuit breaker is open. **Blocking**: Appropriate functions are either blocked definitely or you can set the blocking individually.
Power-system data:meas. point V-3ph: Superv. sym V: (_:71) **Failure**	SPS	CFC	Voltage balance failure (see chapter *9.3.5.1 Overview of Functions*)
Power-system data:meas. point V-3ph: Superv. Phsseq.V: (_:71) **Failure**	SPS	CFC	Failure of voltage phase-rotation monitoring (see chapter *9.3.7.1 Overview of Functions*)

Indication	Type	Group Warning	Explanation
Power-system data:meas. point V-3ph: Superv. of Sum V: (_:71) **Failure**	SPS	CFC	Failure of voltage sum (see chapter *9.3.6.1 Overview of Functions*)
2 devices prot. comm.: Protection interface #: (_:303) **Open connection** (_:316) **Fault rate/min exceeded** (_:317) **Fault rate/h exceeded** (_:318) **Runtime exceeded** (_:320) **Runtime jump detected**	SPS SPS SPS SPS SPS	CFC[26]	Protection interface connection defective: • Check the connections and the external communication infrastructure. • If the fault is not remedied, contact the Customer Support Center. **Transferred Signals**: Faulty or not received telegrams are detected at the receive end and discarded. They do not result in failure of the applications. Configured binary signals are reset after a time that can be set.
VI-3ph: Mess.Volt.Fail detected: (_:300) **Failure**	SPS	CFC	Measuring-voltage failure detected: Check the exterior wiring. **Blocking**: Appropriate functions are either blocked definitely or you can set the blocking individually.

9.8.3 Defect Severity 2

Faults of defect severity 2 are fatal device faults that lead to an immediate restart of the device (reset).

This occurs when the device data is corrupted (for example, RAM memory), if a restart prevents restoration of data consistency. The device goes briefly out of operation, a failure is avoided.

Life contact	Is terminated during the restart
Red error LED	Is activated during the restart



NOTE

If the fault of defect severity 2 has not be been removed after 3 unsuccessful restarts (reset), the fault is automatically assigned to defect severity 3. The device will automatically turn to the fallback mode.

Log

For every device error with a subsequent restart (reset), only the restart can be detected in the operational log. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection and before the restart. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3 .

Overview of Errors

Number	Device-Diagnosis Log
826	Processor error on the base module: If the fault occurs numerous times, contact the Customer Support Center.
830	FPGA hardware error on the base module: Contact the Customer Support Center.

[26] The indications are not prerouted in the CFC chart. The indications must be added to the CFC chart by the user!

Number	Device-Diagnosis Log
834	Memory error (short term): Reset initiated.
3823	Program run error: If the fault occurs numerous times, contact the Customer Support Center.
826	CPU overload: If the fault occurs numerous times, contact the Customer Support Center.
Miscellaneous	Internal firmware error: If the fault occurs numerous times, contact the Customer Support Center.

9.8.4 Defect Severity 3

Faults of defect severity 3 are fatal device faults that lead to device immediately going into the fallback mode. The signal *(_:301) Device status* goes to the ***Alarm*** state. The ***Warning*** state is not supported for this signal.

Fatal device errors are errors that cannot be resolved by a restart of the device. In this case, contact the Customer Support Center. The device goes permanently out of operation, a failure is avoided. In the fallback mode, minimal operation of the device via the on-site operation panel and DIGSI is possible. In this way, for example, you can still read out information from the device-diagnosis log.

Life contact	Is terminated in the fallback mode
Red error LED	Is activated in the fallback mode

Log

For every device error that immediately leads to entry into the fallback mode, entries from supervision messages and from the signal *(_:301) Device status* into the operational log are not possible. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection, that is, before entry into the fallback mode. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There, you are offered recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3 .

Overview of Errors

Number	Device-Diagnosis Log
2822	Memory error (continuous) Contact the Customer Support Center.
4727, 5018-5028	Hardware failure at module 1-12: Contact the Customer Support Center.
4729	Device bus error (repeated): • Check the module configuration and the module connections. • Contact the Customer Support Center.
4733	Incorrect hardware configuration: Synchronize the hardware configuration of the device with DIGSI.
5037-5048	Wrong module 1-12 detected: Synchronize the hardware configuration of the device with DIGSI.
5031-5035	Identified wrong plug-in module on plug-in module position E/F/M/N/P: Synchronize the hardware configuration of the device with DIGSI.
	Wrong application configuration: Search for the cause in the operational log and load a valid configuration to the device.
3640, 4514	Data-structure error: Contact the Customer Support Center.

Number	Device-Diagnosis Log
956	Firmware-version error: Contact the Customer Support Center.
2013, 2025	Signature error: Contact the Customer Support Center.
	CFC error: In DIGSI, check your CFC chart for the cause.
5050-5061	Binary-output error in module 1 - 12: Contact the Customer Support Center.
5088, 5089	A missing display configuration was established: Synchronize the hardware configuration of the device with DIGSI.

9.8.5 Defect Severity 4 (Group Alarm)

Errors of defect severity 4 are not device failures in the classical meaning. These errors do not affect the device hardware and are not detected or reported by internal device supervision functions. The condition of the defect severity 4 – the group alarm – is set user-specifically by the binary input signal *(_:503) >Group alarm*. If the binary input signal is reset, the device is no longer in the *Group alarm* condition and all functions return to the normal operating state.

If the group alarm is generated, the device reacts as follows:

- The group indication *(_:300) Group alarm* is generated and recorded in the operational log.
- The life contact is terminated.
- The red Error LED is activated.
- All protection and automation functions are blocked.
- The device remains in operation, does not carry out any restart (reset), and does not switch to the safe condition (Fallback mode).
- The signals managed internally are marked with the ***invalid*** quality attribute. Signals managed internally are, for example, measured values, binary input and output signals, GOOSE and CFC signals.

In the delivery condition, every device has the CFC chart **Process mode inactive**, that initiates the Group alarm (see chapter *9.9 Group Indications and Predefined CFC Charts*).

Life contact	Is terminated in case of Group alarm
Red error LED	Is initiated in case of Group alarm

Log

The group indication *(_:300) Group alarm* is recorded in the operational log. Depending on the cause of the initiation, further information can be found in the operational log.

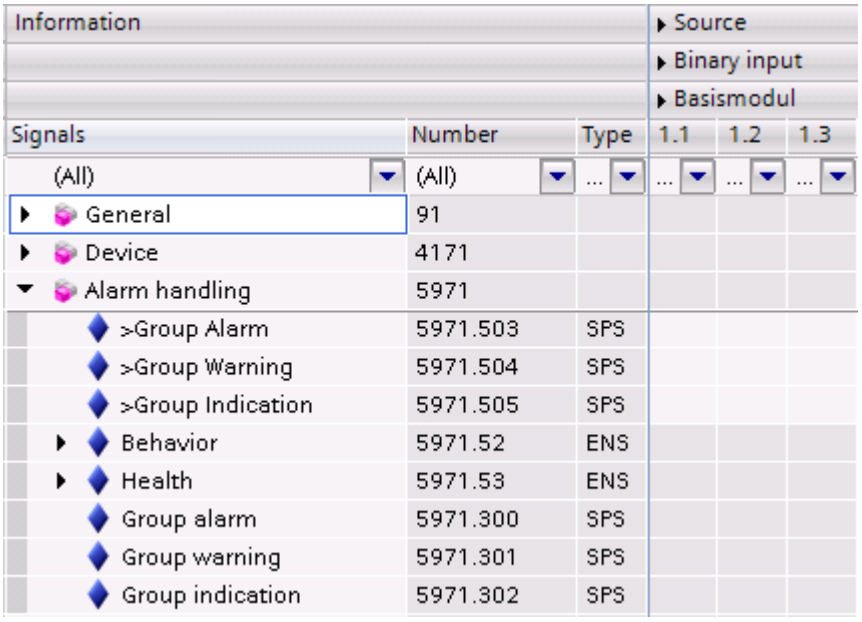
You can find further information on handling the logs in chapter 3 .

9.9 Group Indications and Predefined CFC Charts

The following group indications are available:

- *(_:300) Group alarm*
- *(_:301) Group warning*
- *(_:302) Group indication*

You can find the signals in the DIGSI 5 project tree under **Name of the device**) → **Information routing**. In the operating range, you can find the signals under **Alarm handling** (see the following figure).



[scgrwarn-010313-01, 1, en_US]

Figure 9-37 Group Monitoring Indication in the DIGSI 5 Information Routing Matrix

Group Indication Group Alarm

The indication *(_:300) Group alarm* is the group indication for defect-severity 4 monitoring. This monitoring has a special purpose, as it is set in a user-specific way by a binary input signal and not by internal device supervision. Nevertheless, the response of the device is serious, for example, the blocking of all protection and automatic functions (see chapter *9.8.5 Defect Severity 4 (Group Alarm)*).

If the binary input signal *(_:503) >Group Alarm* is set, the group indication *(_:300) Group alarm* is activated. If the binary input signal *(_:503) >Group Alarm* is reset, the signal *(_:300) Group alarm* is also reset and the device returns to the normal operating state.

In the delivery condition, every device has the CFC chart **Process mode inactive** that initiates the *>Group Alarm*. This CFC chart checks whether the device is still accidentally in the simulation or commissioning mode.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts**.

Group Indication Group Warning

The indication *(_:301) Group warning* is the group indication for defect-severity 1 monitoring. Some error messages of defect severity 1 are firmly connected to the signal *(_:301) Group warning*, others are connected in a flexible way via a CFC chart in the device delivery condition. This allocation is described in chapter *9.8.2 Defect Severity 1* .

In the delivery condition, every device has the CFC chart **Group warning** that initiates the *Group warning*.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts**.

The group-warning indication *(_:301) Group warning* is prerouted to an LED of the base module.

Group Indication

The *Group indication* is used only for user-specific purposes. There is no internal device supervision function that activates this indication. If the binary input signal *(_:505) >Group Indication* is set, the indication *(_:302) Group indication* is activated and recorded in the operational log. In the delivery condition, there is no further response of the device. If the binary input signal is reset, the signal *(_:302) Group indication* drops out. You can define via a CFC chart when the binary input signal *(_:505) >Group Indication* is to be set.

10 Measured Values, Energy Values, and Supervision of the Primary System

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10.10	Measuring Transducers	1269
10.11	Statistical Values of the Primary System	1275
10.12	Circuit-Breaker Wear Monitoring	1276

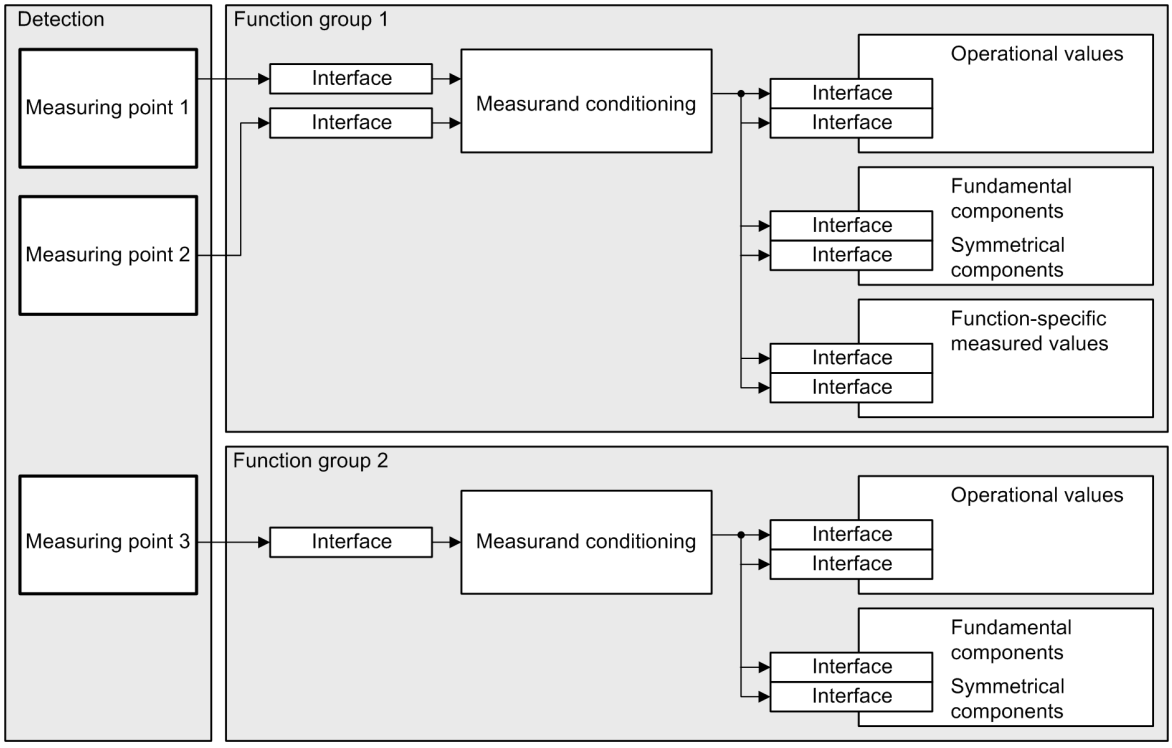
10.1 Overview of Functions

The measurands are recorded at the measuring points and forwarded to the function groups.

Within the function groups, further measurands are calculated from these measured values, which are required for the functions of this function group. This is how, for example, the electric power is calculated from the voltage and current measurands.

Measuring transducers are an exception as they already form various calculation parameters from the analog current and voltage inputs themselves.

Basic instructions for recording and editing process data can be found in the chapter *2.1 Function Embedding in the Device*.



[dwomverf-010212-01.tif, 1, en_US]

Figure 10-1 Structure of Measured-Value Acquisition and Processing

For the display, the measured values of a SIPROTEC 5 device are summed up in the following groups:

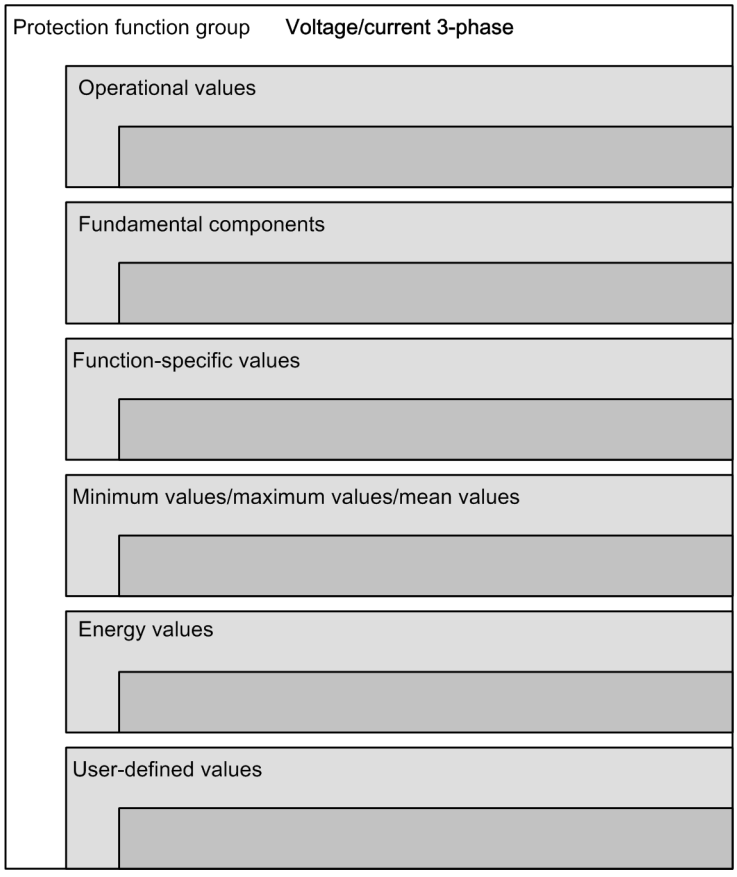
- Operational measured values
- Fundamental and symmetrical components
- Function-specific measured values
- Minimum values, maximum values, average values
- Energy metered values
- User-defined measured and metered values
- Statistic Values

10.2 Structure of the Function

Depending on the interconnection of the function groups, these can contain different measured-value groups. A typical function group is displayed below.

Voltage/Current 3-Phase Function Group Type

In the simplest version the **Voltage/Current 3-phase** function group obtains the measured values of the 3-phase voltage and current system and contains the following measured-value groups:



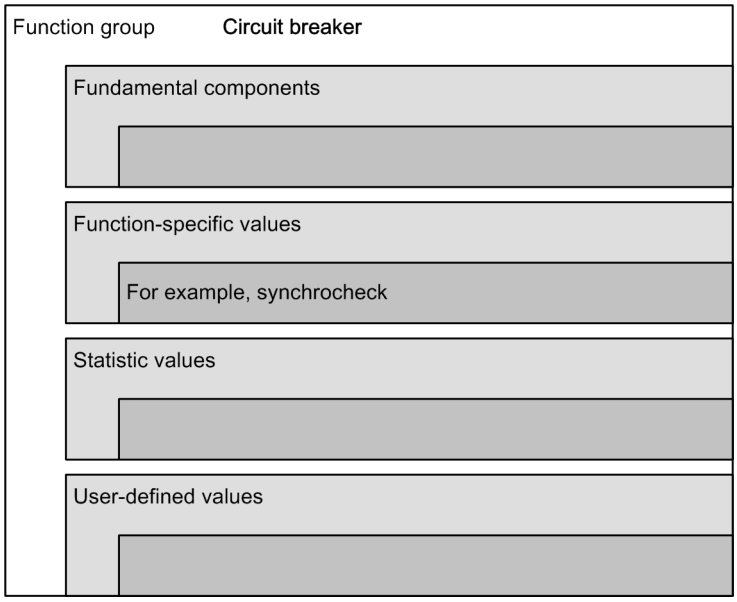
[dwstrciv-011012-01.tif, 1, en_US]

The **Minimum values/Maximum values/Average values** and **User-defined values** can be inserted from the library into the **Voltage/Current 3-phase** function group.

Details regarding the individual measured value groups can be found in the tables in the following chapters.

Circuit-Breaker Function Group

The **Circuit breaker** function group may contain the following measured values:



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Inversion of Output-Related Measured and Statistical Values

The calculated, directional values in the operational measured values (power, power factor, energy and minimum, maximum, and average values based on these) are normally defined as positive in the direction of the protected object. This requires that the connection polarity for the measuring points used be correctly set (also compare **(_:8881:116) Neutr.point in dir.of ref.obj** parameter of the measuring point current, 3-phase). It is, however, possible, to set the "forward" direction for the protection functions and the positive direction for the powers, etc., differently, for example, such that the active power import (from the line to the busbar) is displayed positively. Then set the option **P, Q sign** in the affected function groups on the ***reversed*** parameter. With the parameter ***not reversed*** (default setting), the positive direction for the powers, etc., corresponds with the "forward" direction for the protection functions.

The affected values are given in detail in the Chapters *10.3 Operational Measured Values* - *10.11 Statistical Values of the Primary System* .

10.3 Operational Measured Values

Operational measured values are assigned to different function groups.

The values can be displayed as primary and secondary values and as percentage values.

The operational measured values are calculated according to the following definition equations:

RMS values

$$X = \sqrt{\frac{1}{T}\int_{t}^{t+T} x^2(t)dt}$$

Active power

$$P = \frac{1}{T}\int_{t}^{t+T} v(t)\,i(t)\,dt$$

Apparent power

$$S = \sqrt{3} * V * I$$

Reactive power

$$Q = \sum_{n} V_n \cdot I_n \cdot \sin(\varphi_n)$$

n Harmonic order

φ_n The angle difference between the voltage and current of the nth harmonic

Power factor

$$\lambda = \frac{|P|}{S}$$

Active power factor

$$\cos\varphi = \frac{P}{S}$$

Voltage/Current 3-Phase Function Group Type

The following table describes the operational measured values of the **3-phase voltage/current** function group.

All protection functions have access to the values.

Table 10-1 Operational Measured Values of the Voltage/Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of primary values/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$

Measured Values		Primary	Secon-dary	% Referenced to
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$

NOTE

With the **`P, Q sign`** parameter in the function block **General** of the respective function group, the sign of the following measured values can be inverted:

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B and Q_C

10.4 Fundamental and Symmetrical Components

The fundamental components are calculated from the frequency-tracked instantaneous values through a Fourier filter (integration interval: one period). The results are phasor values that are described by way of the amount and phase angle.

In accordance with the transformation matrix, the symmetrical components are calculated from the voltage and current phasors. These are also phasor quantities.

Fundamental Components

Table 10-2 Fundamental Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_A$, $\underline{V}_B$, $\underline{V}_C$	Phase-to-ground voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_N$	Measured neutral-point displacement voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_{12}$, $\underline{V}_{23}$, $\underline{V}_{31}$	Phase-to-phase voltage	kV	V	°	Rated operating voltage of the primary values
$\underline{I}_A$, $\underline{I}_B$, $\underline{I}_C$	Phase currents	A	A	°	Rated operating current of the primary values
$\underline{I}_N$	Neutral-point phase current	A	A	°	Rated operating current of the primary values

Symmetrical Components

Table 10-3 Symmetrical Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_0$	Zero-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_1$	Positive-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_2$	Negative-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{I}_0$	Zero-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_1$	Positive-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_2$	Negative-sequence component of the current	A	A	°	Rated operating current of the primary values

10.5 Average Values

10.5.1 Function Description of Average Values

Average values can be formed based on different measurands:

- Operational measured values
- Symmetrical components

Through the settings, you can set how and when the average values are formed. The settings describe:

- Time slot over which the average value is formed
  (Parameter: **`Average calc. interval`**)
- Update interval for the display of the average values
  (Parameter: **`Average update interval`**)
- Synchronization time for establishing the date of commencement updating information, for example, at the top of the hour (hh:00) or at one of the other times (hh:15, hh:30, hh:45).
  (Parameter: **`Average synchroniz. time`**)

Average values are formed through the following measurands:

- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components

You reset the average value formation via the

- Binary input >Reset average value
- DIGSI
- The integrated operation panel



NOTE

With the **`P, Q sign`** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Active power (total): P total
- Reactive power (total): Q total

10.5.2 Application and Setting Notes for Average Values

The average value formation functionality is not preconfigured with the devices in the function group. If you use the functionality, you must load it from the library into the respective function group.

The following settings listed for the calculation of the average values can be set with DIGSI and at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Average calc. interval

- Default setting: **`(_:104) Average calc. interval`** = ***`60 min`***

Parameter Value	Description
1 min to 60 min	Time slot for averaging, for example 60 minutes

Parameter: Average update interval

- Default setting: **`(_:105) Average update interval`** = ***`60 min`***

Parameter Value	Description
1 min to 60 min	Update interval for displaying the average value, for example 60 minutes

Parameter: Average synchroniz. time

- Default setting: **(_:106) Average synchroniz. time** = ***hh:00***
  The parameter describes the synchronization time for average value formation.

Parameter Value	Description
hh:00	The parameter **Average update interval** will be effective on the full hour
hh:15	The parameter **Average update interval** will be effective 15 minutes after the full hour
hh:30	The parameter **Average update interval** will be effective 30 minutes after the full hour
hh:45	The parameter **Average update interval** will be effective 45 minutes after the full hour



NOTE

The average value calculation restarts after

- Changing one of the 3 settings for the average-value calculation
- Resetting the device (initial or normal reset)
- Changing the time
- Resetting the average values

The average values are reset immediately. The display changes to "---".

The following examples explain how to set parameters and to make a change.

Average calc. interval = **60 min**
Average update interval = **30 min**
Average synchroniz. time = ***hh:15***.

A new average value is formed every 30 min, at hh:15 (15 min after the top of the hour) and hh:45 (15 min before the top of the hour). All measured values obtained during the last 60 min are used for average value formation.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 12:15:00.

In this example, the **Average synchroniz. time** = ***hh:45*** acts as described above for = ***hh:15***.

Average calc. interval = **60 min**
Average update interval = **60 min**
Average synchroniz. time = ***hh:15***.

A new average value is formed every 60 min at hh:15 (15 min after the top of the hour). All measured values obtained during the last 60 min are used for average value formation.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 12:15:00.

Average calc. interval = **5 min**
Average update interval = **10 min**
Average synchroniz. time = ***hh:00***.

A new average value is formed every 10 min at hh:00, hh:10, hh:20, hh:30, hh:40, hh:50. All measured values obtained during the last 5 min are used to form the average value.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 11:10:00.

10.6 Minimum/Maximum Values

10.6.1 Function Description of Minimum/Maximum Values

Minimum and maximum values can be formed based on different measured or calculated measurands:

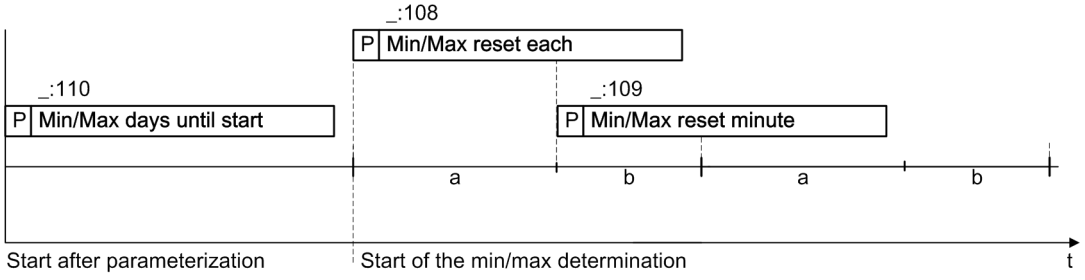
- Operational measured values
- Symmetrical components
- Selected values

You can set which measurand will be used. The measurands for the minimum/maximum formation are loaded from DIGSI.

Calculation and resetting of the minimum and maximum values are controlled through settings. The settings describe the following points:

- Memories of the minimum/maximum values are reset to 0 cyclically or not at all.
  (Setting **`Min/Max cyclic reset`**)
- Point in time when the memories of the minimum/maximum values are reset to 0.
  (Setting **`Min/Max reset each`** and setting **`Min/Max reset minute`**)
- Point in time at which the cyclical reset procedure of the minimum/maximum values begins (after the parameterization)
  (Setting **`Min/Max days until start`**)

The following figure shows the effect of the settings.



[dwminmax-100611-01.tif, 1, en_US]

Figure 10-2 Minimum and Maximum-Value Formation

Minimum and maximum values are time-stamped.

Minimum/maximum values are formed through:

- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components
- Average values

The minimum and maximum values are reset on a regular basis or via the

- Binary input >Reset min/max
- DIGSI
- The integrated operation panel

NOTE

With the **P, Q sign** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Minimum/maximum values of the active and reactive power:
  Min:Ptotal, Max:Ptotal, Min:Qtotal, Max:Qtotal
- Minimum/maximum values of the average values of the active and reactive power:
  AverageMin:Ptotal, AverageMax:Ptotal, AverageMin:Qtotal, AverageMax:Qtotal

10.6.2 Application and Setting Notes for Minimum/Maximum Values

The minimum/maximum values functionality is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The following settings listed for the calculation of the minimum/maximum values can be set with DIGSI or at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Min/Max cyclic reset

- Default setting: **(_:107) Min/Max cyclic reset** = ***yes***

Parameter Value	Description
Yes	Cyclical resetting of the minimum and maximum value memories is activated
No	Cyclical resetting of the minimum and maximum value memories is deactivated None of the following parameters are visible

Parameter: Min/Max reset each

- Default setting: **(_:108) Min/Max reset each** = ***1 day***

Parameter Value	Description
1 day to 365 days	Resetting of the minimum value and the maximum value, cyclically on all specified days, for example each day (1 day)

Parameter: Min/Max reset minute

- Default setting: **(_:109) Min/Max reset minute** = ***0 min***

Parameter Value	Description
0 min to 1439 min	Resetting the minimum value and the maximum value at the specified minute of the day, which is stated in the parameter **Min/Max Reset takes place every**, for example 0 min (= 00:00)

Parameter: Min/Max days until start

- Default setting: **(_:110) Min/Max days until start** = ***1 day***:

Parameter Value	Description
1 day to 365 days	Indication of when the cyclical reset procedure of the minimum values and maximum values begins, for example in 1 day (after the parameterization)

10.7 Energy Values

10.7.1 Function Description of Energy Values

The device continually determines the values for the active and reactive energy from the power-measured values. It calculates the exported and imported electrical energy. The calculation (summation over time) begins immediately after the device startup. You can read the present energy values on the device display or through DIGSI, delete the energy value (set to 0), or set it to any initial value. After input, the energy-value calculation will continue with the new setting values.

Energy values can be transferred to a control center through an interface. The energy values are converted into energy metered values. Here the following applies:

$$\text{Energy metered value} = \frac{\text{Energy value}}{S_{N,obj.}} \cdot 60000 \frac{\text{Pulses}}{\text{h}}$$

[foomverg-020311-01.tif, 1, en_US]

Through the settings, you set how the metered values are processed. The setting parameters apply for all energy metered values of the device, and do not have a function-group specific effect. You determine the following points:

- Parameter **`Energy restore time`**

  Hour-related point in time; at this point in time, the device will provide a metered value at the communication interface for transmission. After this, it will be transferred in accordance with the selected log.

  Note: If the parameter is activated through a time setting, the parameter **`Energy restore interval`** will automatically be deactivated.

- Parameter **`Energy restore interval`**

  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.

  Note: The transfer interval is used alternatively to the transfer time, and deactivates the set transfer time. The display of the device is always up to date.

  You will find these parameters in the device settings under **measured values**.

In addition, restoring can be triggered via a routable binary input (*>Restoring*). The rising edge of the binary input leads to restoring, that is, provision of the energy-metered value at the communication interface.

The metered-value memory and the energy values can be set to 0 via a binary input (*>Resetting*) if there is a rising edge.

Note: The binary inputs affect all energy/energy metered values simultaneously.

The following energy values are available:

Energy Values		Primary
Wp+	Active energy, output	kWh, MWh, GWh
Wp-	Active energy, input	kWh, MWh, GWh
Wq+	Reactive energy, output	kvarh, Mvarh, Gvarh
Wq-	Reactive energy, input	kvarh, Mvarh, Gvarh

In compliance with IEC 61850, when individually measured values are missing, the quality of the energy-metered values changes to the state **Questionable**.

This quality state is retained until a new meter content is specified for the energy value by:

- Confirmation of the current meter content via **Set**
- **Setting** a new meter content
- **Resetting** the meter content to 0

NOTE

With the **P, Q sign** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Active energy, output: Wp+
- Active energy, input: Wp-
- Reactive energy, output: Wq+
- Reactive energy, input: Wq-

10.7.2 Application and Setting Notes for Energy Values

The set parameters apply for all electricity meters of the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Energy restore interval

- Default setting: **(_:111) Energy restore interval** = ***10 min***

Parameter Value	Description
0 min	Restoring deactivated
60 min	Cyclical restoring after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter **Energy restore time** is not in effect and will be deactivated automatically.

Parameter: Energy restore time

- Default setting: **(_:112) Energy restore time** = **--**

Parameter Value	Description
--	Deactivated
hh:00	Restoring on the full hour
hh:15	Restoring 15 minutes after the full hour
hh:30	Restoring 30 minutes after the full hour
hh:45	Restoring 45 minutes after the full hour

Note: If the parameter is activated through a time setting, the parameter **Energy restore interval** is not in effect and will be deactivated automatically.

Parameter: Energy restore

- Default setting: **(_:120) Energy restore** = ***latest value***

Parameter Value	Description
latest value	Restoring of the current energy value
delta value	Restoring the difference value between the current energy value and the energy value of the last restoring operation

Parameter: Energy restore by A.time

- Default setting: **(_:121) Energy restore by A.time** = ***Wrong***

Parameter Value	Description
Wrong	Restoring deactivated

Parameter Value	Description
True	The cyclic restoring after the set time of the parameter **(_:111) Energy restore interval** will be synchronized with the system time as well. Example: **Energy restore interval** = 30 min; current system time: 12:10 o'clock. First restore: 12:30 o'clock; next restore: 13:00 o'clock etc.

Note: If the parameter is activated, the following setting values are possible for the parameter **(_:111) Energy restore interval** : 1 min; 2 min; 3 min; 4 min; 5 min; 6 min; 10 min; 12 min; 15 min; 20 min; 30 min; 60 min.

Input Signals: >Restoring and >Resetting

Binary Inputs	Description
>Restoring	The restoring of the metered values is initiated via a binary input.
>Reset	The metered value memory is set to 0 through the binary input.

You route these logical signals in the DIGSI routing matrix. Open the function group, for example, Line, where you created the energy value. Under the tab **Measured values** you will find the tab **Energy, 3-phase**. In this tab, you will find the logical signals in addition to the measured values.

10.8 User-Defined Metered Values

10.8.1 Pulse-Metered Values Function Description



NOTE

You can define additional metered values through DIGSI for user-specific applications.

Use pulse meters; then you can define the respective metered values through DIGSI and set parameters for them analogously to the energy values. You can read out the metered values on the display of the device or via DIGSI.

Through settings, you can individually set how each pulse-metered value is processed:

- Parameter **`Restore time`**

  Hour-related point in time when the device will provide a metered value at the communication interface for transmission. After this, the transfer takes place in accordance with the selected protocol.

  Note: If the parameter is activated through a time setting, the parameter **`Restore interval`** will automatically be deactivated.

- Parameter **`Restore interval`**

  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.

  Note: If the parameter is activated through a time setting, the parameter **`Restore time`** will automatically be deactivated.

In addition, restoring can be triggered via a routable binary input (**`>Restore trigger`**) or via a logical internal binary input. The rising edge of the binary input leads to restoring and thus to provision of the metered value at the communication interface.

The counter pulse of any external/internal pulse generator is connected to the device via a routable binary input (**`>Pulse input`**). If this does not deliver any plausible values, this can be signaled to the device via another routable binary input (**`>External error`**).

In compliance with IEC 61850, in the event of an external error, the quality of the pulse-metered value changes to the state **Questionable**. No more pulses are added as long as the external error persists. Once the external fault condition has been cleared, pulses are added again.

The quality of the pulse-metered value remains **Questionable** until a new meter content is specified for the pulse-metered value by:

- Confirmation of the current meter content via **Setting**
- **Setting** a new meter content
- **Resetting** the meter content to 0

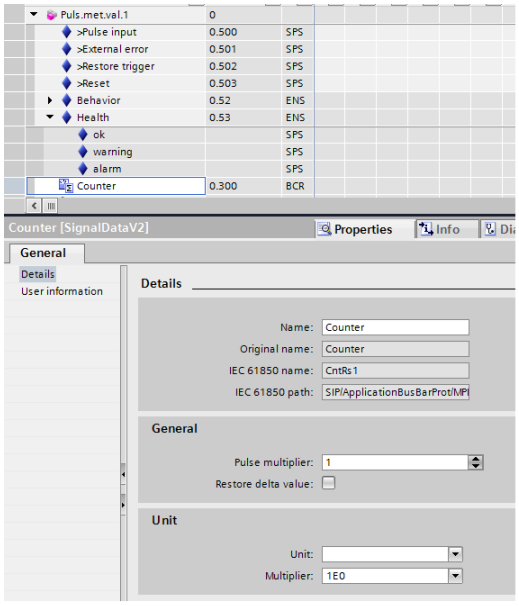
- Parameter **`Edge trigger`**

  Through settings, you can select between counting only with a rising edge or with rising and falling edges on the pulse input.

The pulse counter can be reset to 0. You can perform this resetting via the rising edge of a routable binary input (**`>Reset`**) or via operation on the device.

To display the counting amount at the device display, use DIGSI to set the desired weighting of the counter pulses, the unit of the metered value and a multiplication factor for every pulse generator. You can also assign a user-specific name.

To do this, open the functional area **Pulse-metered value** in DIGSI information routing. (see *Figure 10-3*). Select the metered value and enter the settings under **Properties**.



[scomvimp-010313-01.tif, 2, en_US]

Figure 10-3 Setting with DIGSI, General Settings, Pulse-Metered Values

10.8.2 Application and Setting Notes for Pulse-Metered Values

The functionality **Pulse-metered values** is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The parameters can be set individually for every pulse counter. You will find the setting parameters in DIGSI in the project tree under **Parameter > Function group**

For pulse-metered values, the following described settings and binary inputs are available.

Parameter: **`Restore time`**

- Default setting: **`(_:101) Restore time`** = **`--`**

Parameter Value	Description
--	Deactivated
hh:00	Transfer on the full hour
hh:15	Transfer 15 minutes after the full hour Note:
hh:30	Transfer 30 minutes after the full hour Note:
hh:45	Transfer 45 minutes after the full hour Note:

Note: If the parameter is activated through a time setting, the parameter **`Restore interval`** is not in effect and will be deactivated automatically.

Parameter: **`Restore interval`**

- Default setting: **`(_:102) Restore interval`** = ***`0 min`***

Parameter Value	Description
0 min	Deactivated
1 min to 60 min	Cyclical transfer after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter **Restore time** is not in effect and will be deactivated automatically.

Parameter: Edge trigger

- Default setting: **(_:103) Edge trigger** = ***rising edge***

Parameter Value	Description
rising edge	Counting with rising edge at the pulse input
rising & falling edge	Counting with rising and falling edge at the pulse input

Parameter: Restore by absolute time

- Default setting: **(_:104) Restore by absolute time**= ***False***

Parameter Value	Description
False	Deactivated
True	The cyclic restoring of setting **Restore interval** after the set time is also synchronized with the system time. Example: **Restore interval** = 30 min; current system time: 12:10 o'clock. First restoring operation: 12:30 o'clock; next restoring operation: 13:00 o'clock, etc.

Input Signals: >Pulse input, >External error, >Restore trigger, >Reset

Binary inputs	Description
>Pulse input	Input for the counting pulses of an external pulse generator
>External error	Indication that the counter pulses of the external pulse generator are faulty. The indication has an effect on the quality identifier of the pulse value.
>Restore trigger	The transfer of the metered values is initiated via a binary input.
>Reset	The rising edge at the binary input resets the pulse counter to 0.

The amount of energy indicated by a pulse generator is to be displayed as a measured value.

1 pulse corresponds to 100 Wh.

The pulse weighting, the SI unit, and the factor must be adjusted to one another.

Display value = Calculated metered value * Pulse weighting * Factor * SI unit.

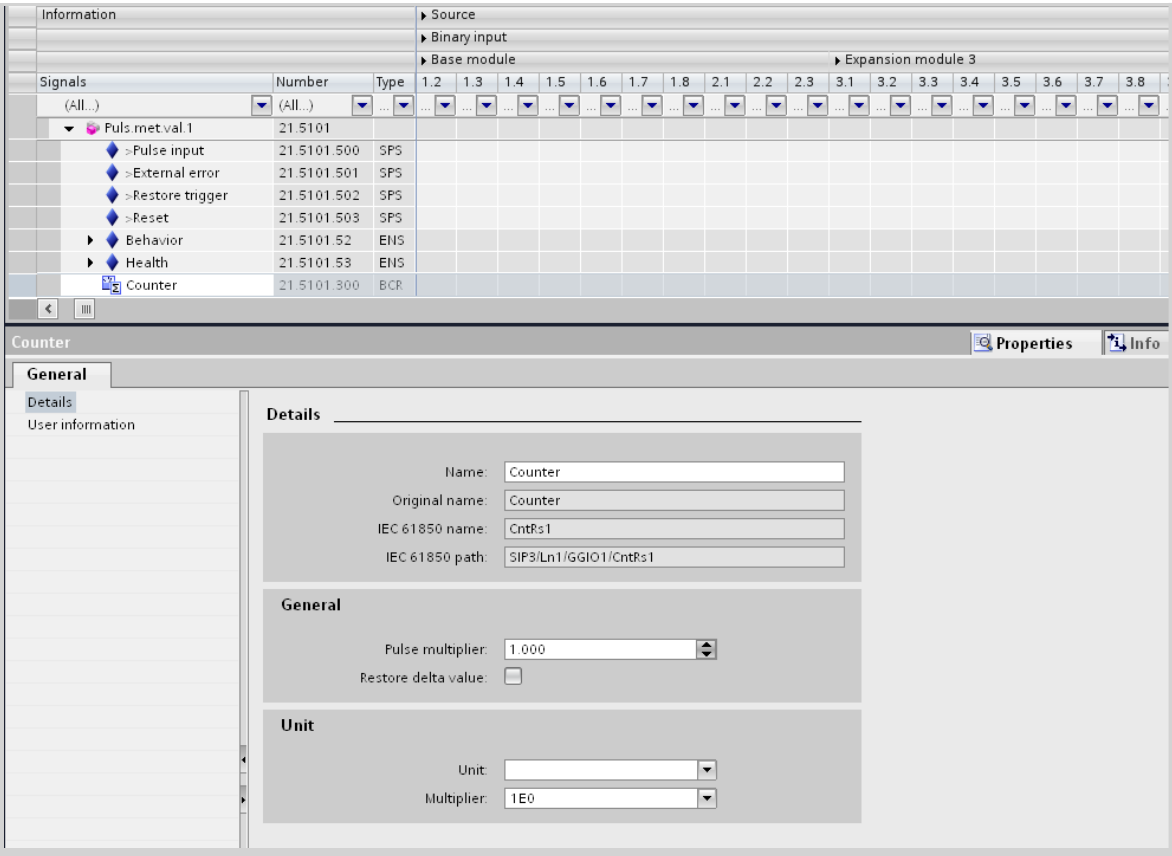
If the check box **Restore delta value** is activated, the differential value is transferred at the restore time set via the communication interface. The difference value is formed by subtracting the counter content of the last restoring operation from the current counter content.

You route the logical signal ***>Pulse input*** to a binary input to which the pulse generator is connected.

Set the following values:

Name	Active Power Meter
Pulse weighting	100
Restore differential value	Activated
SI unit	Wh
Factor	1

The factor is used for adaptation to larger units (for instance, 1000 for kWh). It is adjustable in powers of ten (1, 10, 100, 1000, etc.). The following figure shows the signals that can be arranged in the DIGSI information matrix. Open the function group where you created the pulse-metered value, for example, Line 1. There, you will find the function area **Pulse-metered value**. Here you will also find the logical signals next to the metered value. Select the metered value and enter the settings under **Properties**.



[scimpzwe-260912-01.tif, 1, en_US]

Figure 10-4 Setting with DIGSI

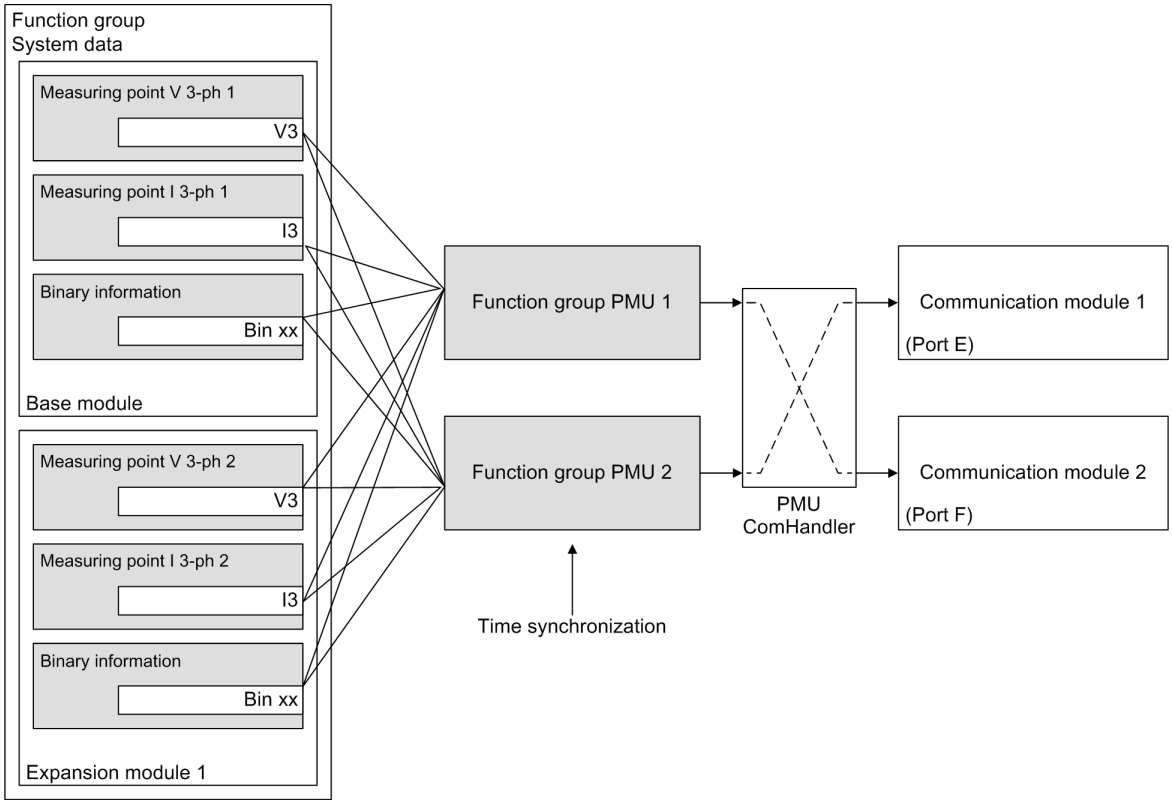
10.9 Phasor Measurement Unit (PMU)

10.9.1 Overview of Functions

A Phasor Measurement Unit (PMU) measures the phasor values of current and voltage. These values get a high precision time stamp and together with the values of power frequency, power frequency change rate and optional binary data that are also time stamped are transmitted to a central analysis station. The standardized transmission protocol IEEEC 37.118 is used to do this.

10.9.2 Structure of the Function Group

The **PMU** function group is activated by selecting the protocol *IEEE C37.118PMU* on an Ethernet module (electrical or optical). The PMU obtains the measured values from the measuring points and the precise time from time synchronization. The time-stamped synchrophasors for current and voltage are formed from this and transferred together with additional values via the communication module to a server (PDC, Phasor Data Concentrator).



[dwstrpmu-250613-01.tif, 2, en_US]

Figure 10-5 Structure/Embedding of the Function

10.9.3 Function Description

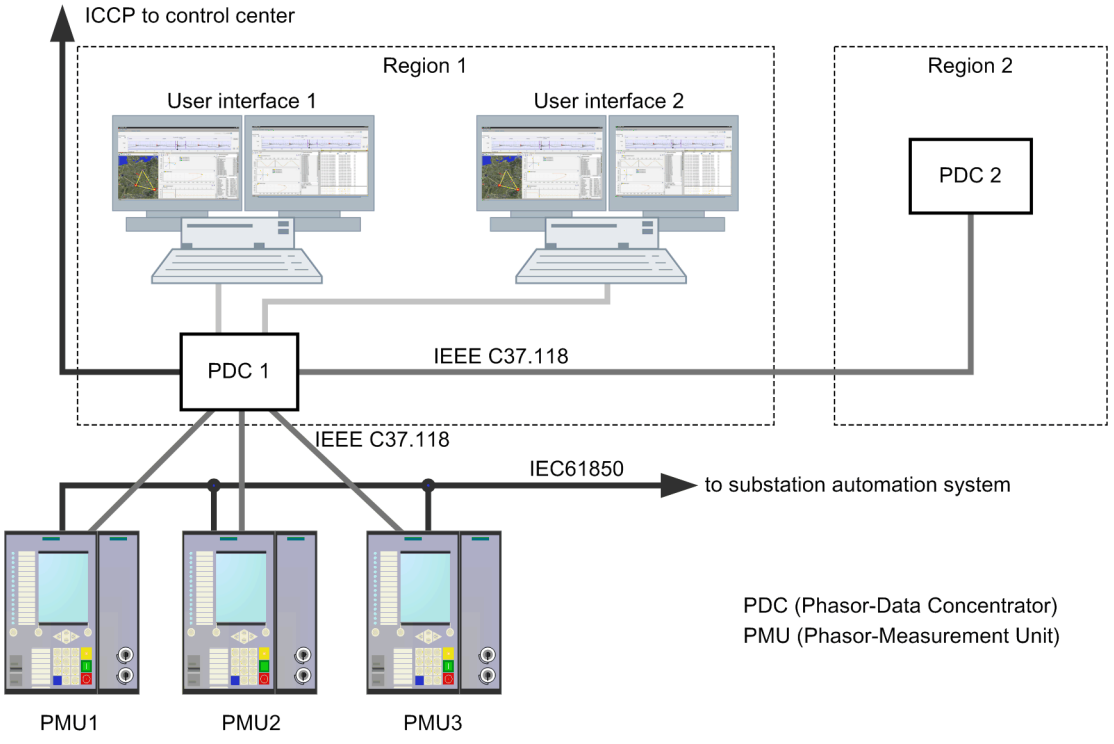
The synchrophasors, sent from the **PMU** in a continuous data stream to a PDC, are provided with time stamps and thus are comparable with the measured values of other PMUs. The power frequency, the power frequency change rate and optional binary information are also transmitted as time-stamped measured values. Therefore, you receive an overview of the transient processes in a distributed energy transfer system, for example network fluctuations and compensating processes.

The following table shows the differences between the PMU measured values and the remaining measured values of the device.

Table 10-4 Comparison of Synchrophasors and Conventional Measured Values

Synchrophasors of the PMU	Measured Values from the Measuring Points
Continuous updating (measured value of current) with, for example, 10 values per second (reporting rate)	Slow updating (typically every 5 seconds)
Every measured value has a time stamp	No time stamp for the measured values
Phasor values of current and voltage (amplitude and phase angle)	RMS values without phase angle

The following figure shows the structure of such a Wide Area Monitoring System. The data delivered from the PMUs on the PDC are transmitted via the Inter-Control Center Communications Protocol (ICCP) according to DIN EN 60870-6 to the network control center.



[dwstrwam-120124-01.tif, 1, en_US]

Figure 10-6 Structure of a Wide-Area Monitoring System with Phasor-Measurement Units

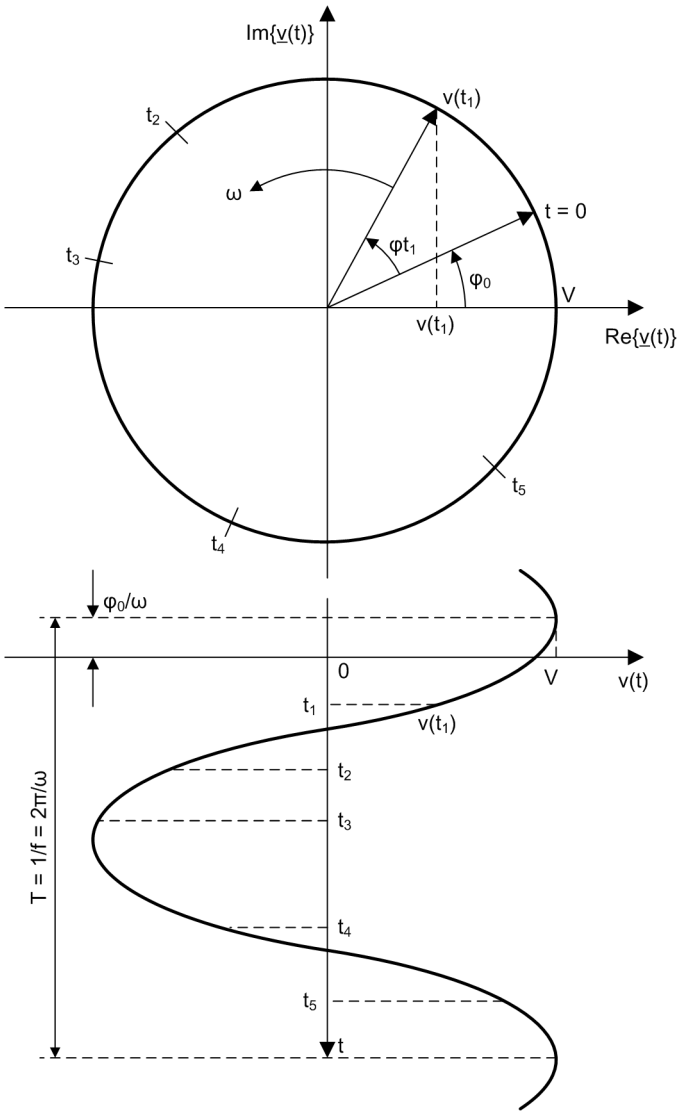
The phasor-measurement units each have 2 communication interfaces: an Ethernet module for synchrophasor communication via IEEE C37.118 and another module for communication with the substation automation technology, for example, through the IEC 61850 protocol.

The central evaluation system, e.g. SIGUARD PDP Phasor Data Processor, receives the data, files, archives them and graphically displays them on a User Interface. In this system, a self-checking function may also be performed, for example, on undamped power swings. The further distribution of information to other PDCs or to a control station is done here.

To maintain the required maximum errors (TVE) required in the standard IEEE C37.118, the time tolerance relative to the UTC time reference (UTC = Universal Time Coordinated) may be maximum 10 µs. Therefore, the device must be directly synchronized with a GPS precise time signal for the correct function of the PMU.

Phasors

A phasor $u(t) = \underline{U}e^{j\omega t}$ can be displayed as a phasor that moves counterclockwise in the complex plane at the angular frequency ω. Therefore, the voltage function $u(t) = Re\{\underline{u}(t)\}$ is obtained as a projection of the phasor $\underline{u}(t)$ on the real axis.

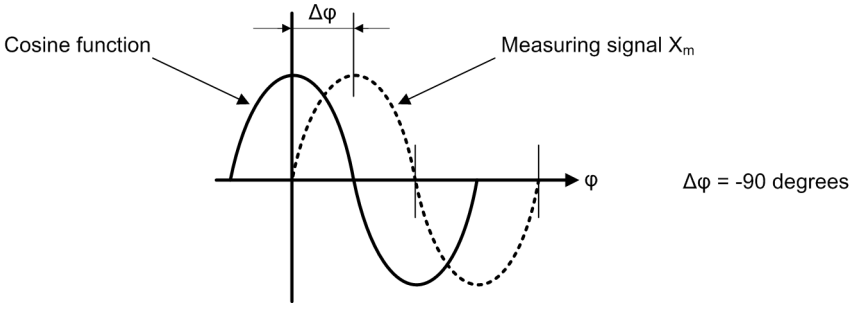


[dwgeopdc-061011-01.tif, 1, en_US]

Figure 10-7 Geometric Representation of a Phasor

Reference Point for Determining the Angle

The phase angle of a measuring signal X_m is determined relative to a cosine function having a rated frequency, which is synchronized with the UTC time reference (see *Figure 10-8*).



[dwutcphi-260112-01.tif, 1, en_US]

Figure 10-8 Determination of Phase Angle ρ of Measuring Signal X_m Relative to the Cosine Function

The number of phasors that are transmitted per second is configurable. The transmission rate is defined according to IEEE C37.118 as the reporting rate. The reporting rate defines the number of phasors that are transmitted per second. Extremely precise time synchronization is essential so that phasor measurement can be carried out to enable phasors from different sites to be compared.

Reporting Rate

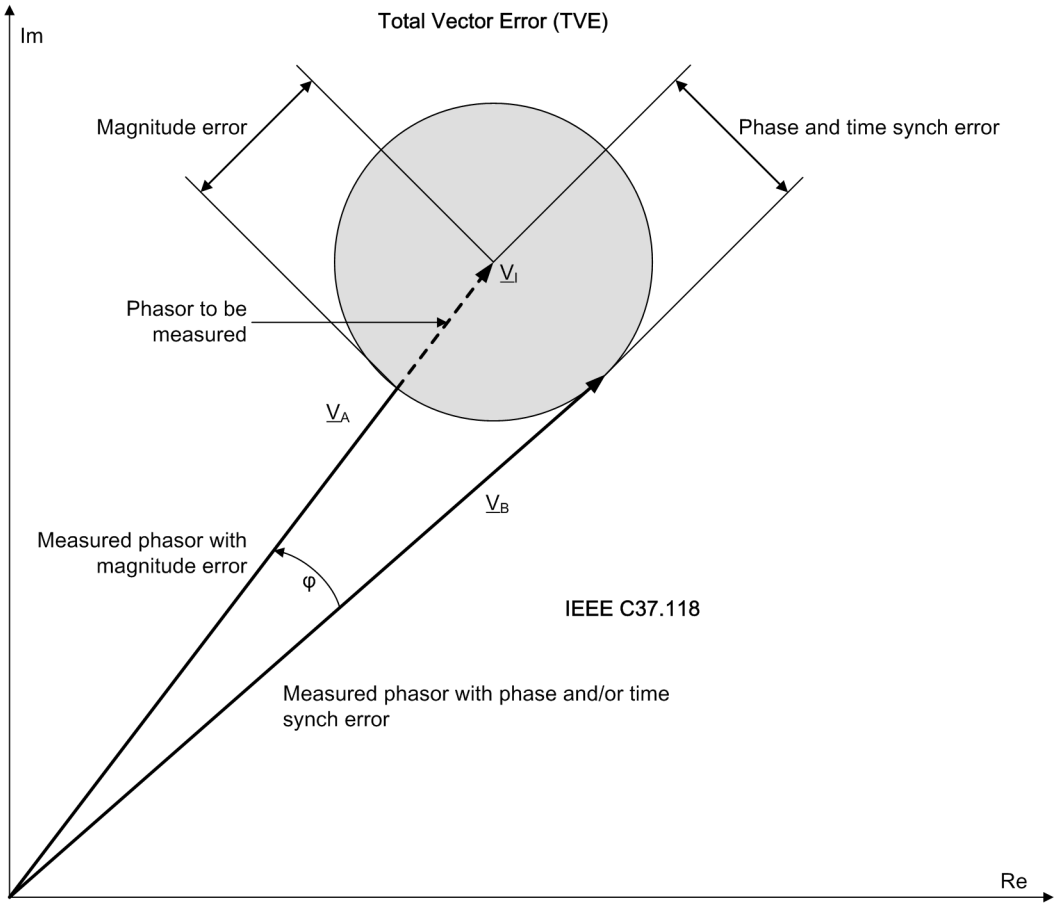
You use the configurable reporting rate (parameter **(_:10621:102) Reporting rate**) to specify the number of telegrams that are compiled and sent to the PDC per second. It is adjustable, depending on the rated frequency, and applies to all currents and voltages of the relevant **PMU** function group. If several **PMU** function groups are created on the device, these can work with different reporting rates.

Total Vector Error (TVE)

The TVE describes the error between the actual and the measured values of the input signal. The Synchrophasor Standard IEEE 37.118 defines upper limiting values of 120 % V_N and 200 % I_N, among other things. Up to these limiting values, the TVE of 1 % must not be exceeded for stationary signals. The standard defines the 2 performance classes, Class P and Class M, as ranges within which influencing variables are acceptable and the TVE of ≤1 % must be maintained. The SIPROTEC 5 devices support Class P and Class M, which specify the following influencing variables for a TVE of 1 %:

- Signal frequency (relative to f_N)
- Signal magnitude (relative to 100 % nominal magnitude) for voltage and current
- Phase angle (relative to 0°)
- Harmonic distortions (relative to < 0.2 % (THD) up to the 50th harmonic

The following figure graphically represents the total vector error. As well as the amplitude, the TVE also enters into the angle error.



[dwklatve-120124-01.tif, 1, en_US]

Figure 10-9 Representation of the Total Vector Error

The TVE is defined as follows:

$$TVE = \sqrt{\frac{(X_{r(n)} - X_r)^2 + (X_{i(n)} - X_i)^2}{X_r^2 + X_i^2}}$$

[fo_utcphi-111011-01.tif, 1, --_--]

where:

- $X_{r(n)}$ = Real part of measured signal
- $X_{i(n)}$ = Imaginary part of measured signal
- X_r = Real part of input signal
- X_i = Imaginary part of input signal

Variables that influence the TVE are:

- Amplitude errors
- Phase errors
- Synchronization accuracy (deviation from the UTC)

Synchronization accuracy is affected by a GPS timer and the precise correction of the time delay within the GPS receiver module, as well as by the optimal setup of the GPS antenna.

10.9.4 Transmitted Data

The following data is transmitted from the PMU to the PDC:

- Current and voltage phasors
- Frequency
- Frequency rate of change
- Binary information

The current and voltage channels transferred from a **PMU** function group are selected through the **Function group connections** editor in DIGSI 5. The frequency and frequency change rate are determined once per PMU. In this case, only the current and voltage channels selected via the **Function group connections** editor for this PMU are taken into consideration. You may route the binary information in the information routing matrix of DIGSI 5.

The channel used for specifying the frequency is selected dynamically during the device runtime. Each channel is checked for the presence of a signal in the following order:

1. 3-phase voltage measuring points
2. 1-phase voltage measuring points
3. 3-phase current measuring points
4. 1-phase current measuring points

The 1st measuring point found with a valid signal is used for specifying the frequency in the **PMU** function group.

In the case of 3-phase measuring points, the positive-sequence system can also be transmitted instead of 3 individual sychrophasors. This setting can be made via the parameter **(_:10621:103) Only positive sequence**.

10.9.5 PMU Communication (IEEE C37.118)

PMU communication according to standard IEEE C37.118 is a client-server communication format in which the PDC (Phasor Data Concentrator) functions as both the client and the server.

Once the PDC has been successfully connected to the device PMU and the PMU configuration data has been queried, the PDC initiates transmission of the synchrophasor data by sending a close command to the PMU. In addition to the phasors, the channel names of the routed measuring points and the binary information are transferred. Per default, these are automatically generated by the respective PMU function groups.

Where applicable, you can also edit the channel names of the measuring point and assign a designation of its own for this purpose. For more information, see chapter *10.9.6 Parameterizing the PMU with DIGSI*. The names for the binary information carried out are however, generally automatically generated by the respective PMU function group and cannot be edited.

As an example, the names (generated) for measuring points or binary information may be as follows:

Table 10-5 Possible Measuring-Point Names

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point U-3ph 1[ID 1]	MP-V3ph VAB ID01 MP-V3ph VBC ID01 MP-V3ph VCA ID01 MP-V3ph VA ID01 MP-V3ph VB ID01 MP-V3ph VC ID01 MP-V3ph V1 ID01

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point I-3ph 1[ID 2]	MP-I3ph IA ID02 MP-I3ph IB ID02 MP-I3ph IC ID02 MP-I3ph I1 ID02
Measuring point I-1ph 1[ID 3]	MP-I1ph ID03
Measuring point U-1ph 1[ID 4]	MP-V1ph ID03

Table 10-6 Possible Binary Information Names

Path Displayed in DIGSI 5 (Can Be Edited)	Name Transferred to the PDC (Cannot be Edited)
PMU 1: Transf.bin.1: >BinaryInfo.6	BIN-01-INFO-6
PMU 1: Transf.bin.2: >BinaryInfo.8	BIN-02-INFO-8
PMU 1: Transf.bin.10: >BinaryInfo.3	BIN-10-INFO-3

Data is transmitted continuously from the PMU to the PDC at the configured reporting rate. The transmission is terminated by a corresponding switch-off command from the PDC or when the connection between the PDC and the PMU is interrupted.

Communication between the PMU and the PDC can be passed via TCP or UDP protocols.

The following ports are used for data transmission:

- TCP: Port 4712
- UDP: Port 4713

The ports must be configured on the PDC.

Up to 3 different PDCs can be connected to one device PMU at the same time. The IP addresses of the maximum 3 PDCs are set in the **PMU** function group. If 4 device PMUs are configured, this enables support for up to 12 PDCs.

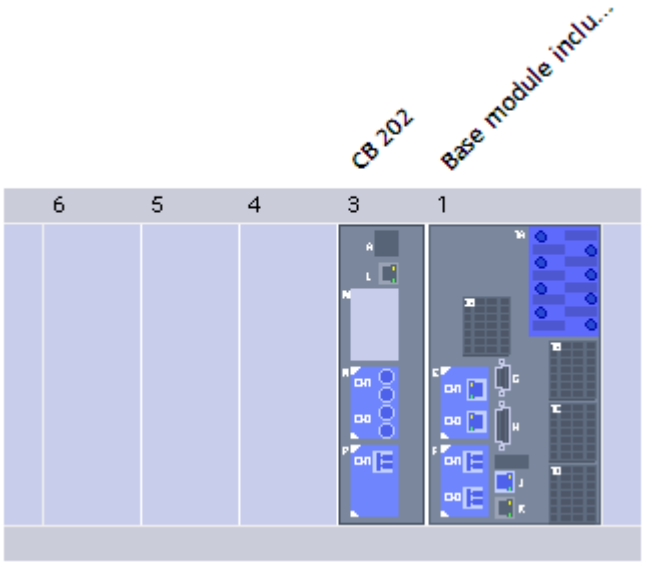
10.9.6 Parameterizing the PMU with DIGSI

You configure and parameterize the Phasor-Measurement Unit with DIGSI. After a device has been added in a DIGSI project, one or more communication modules that support synchrophasors can be configured as PMUs. The device module supports a maximum of 2 communication modules that can be configured as PMUs. If more than 2 PMUs are needed, the device must be expanded with a CB202 plug-in module assembly (expansion module), which can accommodate 2 more communication modules.

The following communication modules support synchrophasors:

- ETH-BA-2EL (2 x Ethernet electric, RJ45)
- ETH-BB-2FO (2 x Ethernet optical, 2 km, LC duplex)

These modules are then freely assignable to ports E, F, N or P of the device, see *Figure 10-10*. You can view the selected port in the **(_:10621:104) Port**. This parameter is automatically managed by DIGSI and cannot be changed.



[sccommod-140213-01.tif, 1, en_US]

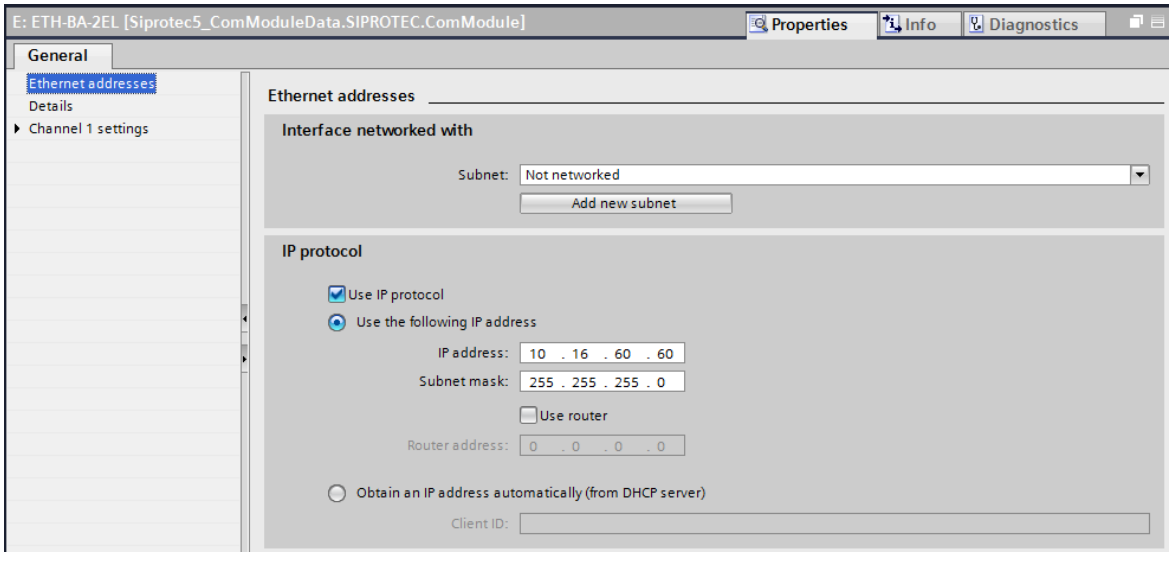
Figure 10-10 Placement of Communication Modules

NOTE

Port M of the CB202 plug-in module assembly is used to accommodate measuring-transducer modules and cannot be used for the installation of communication modules.

Addressing

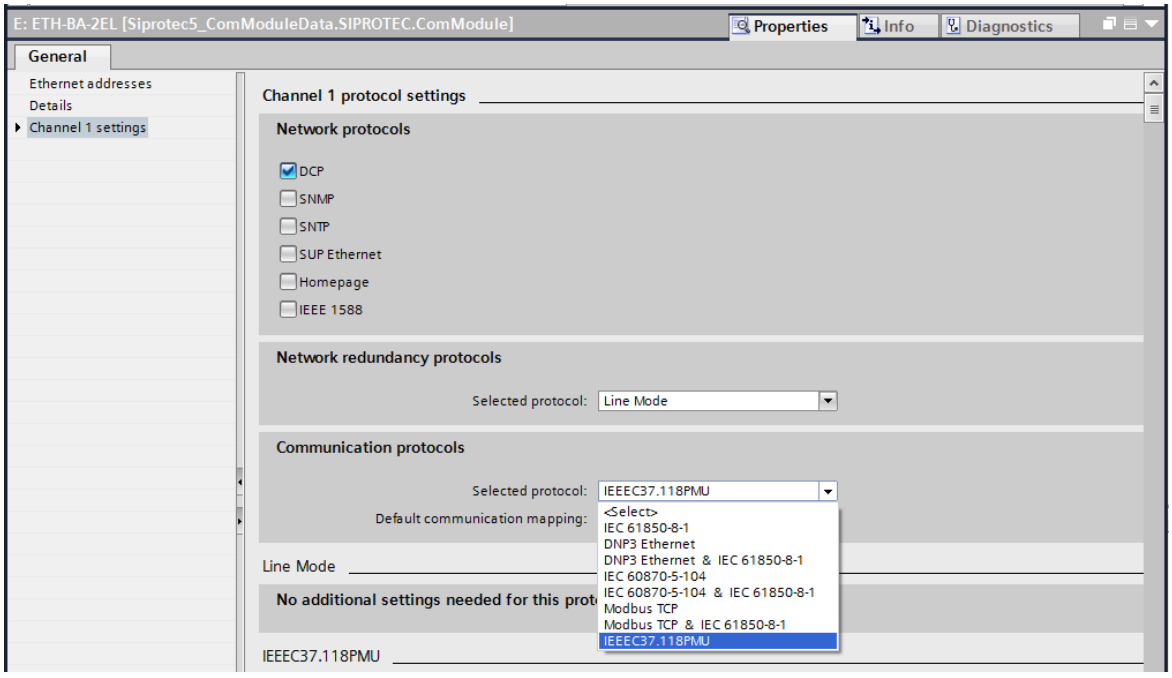
You must configure the respective Ethernet address (IP address, subnet mask, etc.) for each communication module in DIGSI. This is done in the DIGSI **General settings** properties dialog of the communication module in item **Ethernet addresses** and so forms the IP address for the respective PMU.



[scethern-210415, 1, en_US]

Figure 10-11 Ethernet Address Configuration

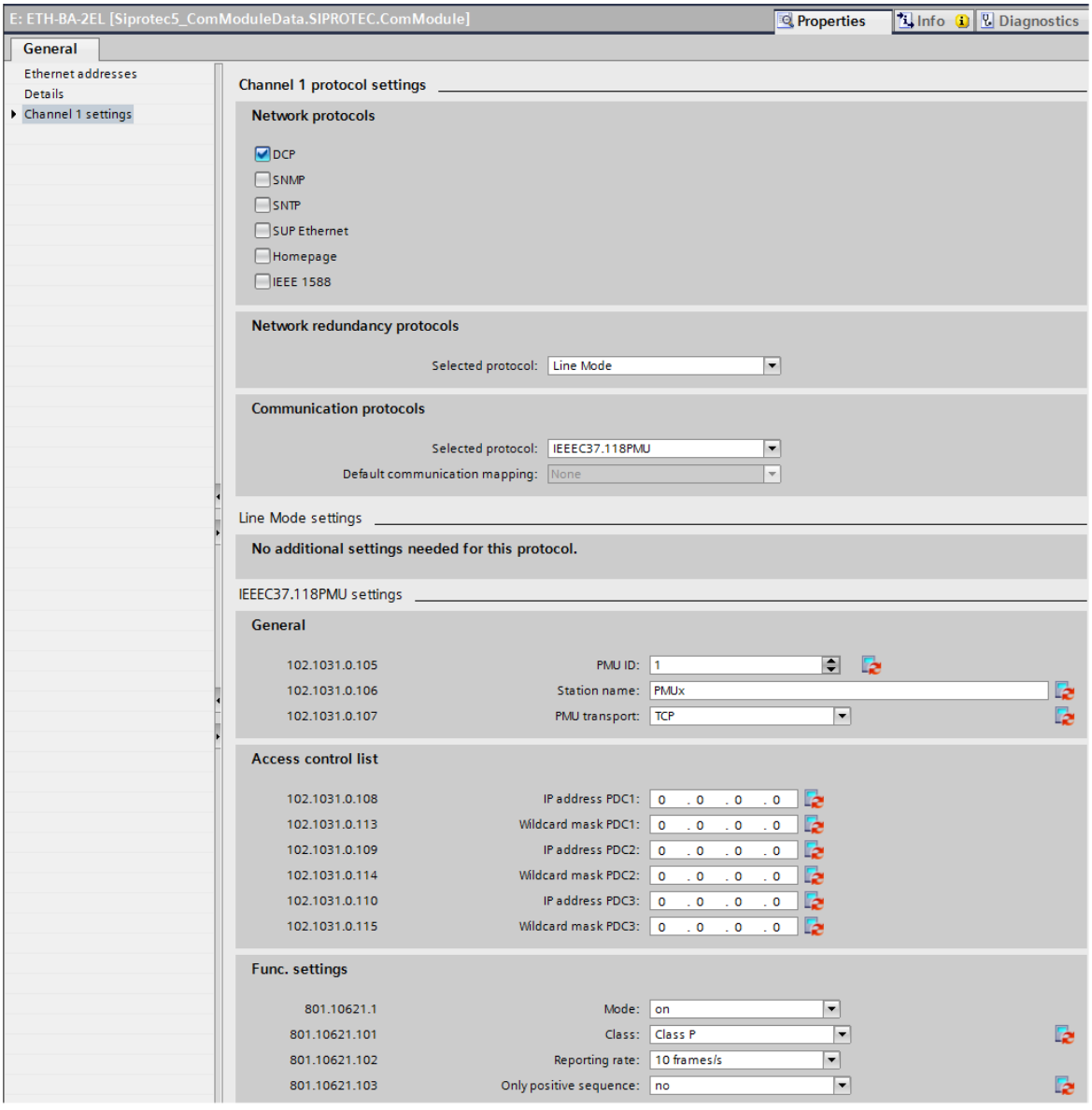
In the DIGSI properties dialog for channel 1, select the synchrophasor protocol, see the following figure.



[scprotoc-210415, 1, en_US]

Figure 10-12 Protocol Selection

After you have selected the synchrophasor protocol for the communication module, an advanced settings dialog for PMU-specific configuration opens, see the following figure.



[scwildcard_de, 1, en_US]

Figure 10-13 PMU-Specific Configuration

You configure the specific settings for the communication protocol in the top section of this settings dialog. In the bottom section, you specify the corresponding PMU-specific settings.

In order to permit a better configuration of larger wide-area supervision systems, changes have been implemented in the IEEE C37.118 communication configuration that permit a flexible IP configuration without the loss of safety aspects in the systems administrated.

Configurable placeholders are permitted for each PDC IP address. These placeholders allow you to define a range of IP addresses where they are accepted within these accesses. The purpose of this is to permit each individual device or system access within the respective system without limits with regard to their hierarchy level. Therefore, with regard to security aspects, the limitation to individual IP addresses is eliminated. You are thus allowed to configure complete sections of IP addresses in each PMU and, as a result, very flexible when making changes to the configuration of the entire system, for example. The placeholder character must follow consecutively at the bit level, starting with the bit with the lowest value.

EXAMPLE of Placeholder Characters:

Example 1:

- binary 00000000.00000000.00000000.00101011 is not permitted
- binary 00000000.00000000.00000000.00111111 is permitted

Example 2:

- The PDC IP address is: 192.172.16.1
- Placeholder: 0.0.0.127

The device accepts requests within the IP address range of 192.172.16.1 to 192.172.16.127.

Example 3:

- The PDC IP address is: 192.172.16.100
- Placeholder: 0.0.0.3

The device accepts requests within the IP address range of 192.172.16.100 to 192.172.16.103.

If a PDC attempts to establish a connection to the device, the PDC IP addresses and corresponding placeholders are checked in the same order as they had been configured (IP address PDC1, IP address PDC2, IP address PDC3). Running through the list is stopped with the first match of the IP address, placeholder and requested IP address range and the connection is built-up. If there are no matches, the attempt to connect is rejected.

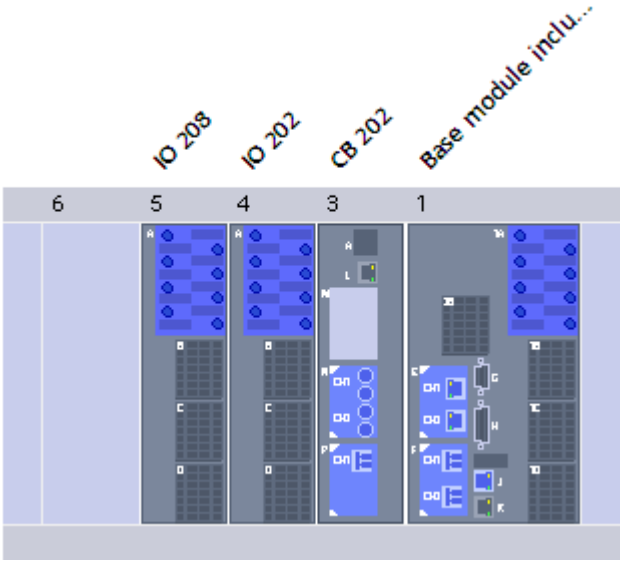
If you have configured IP address 0.0.0.0 and the placeholder 255.255.255.255, every IP address received is accepted as valid. This could be of use in the course of commissioning measures.

NOTE

You must have configured at least 1 IP address in order to establish a connection between the device and PDC.

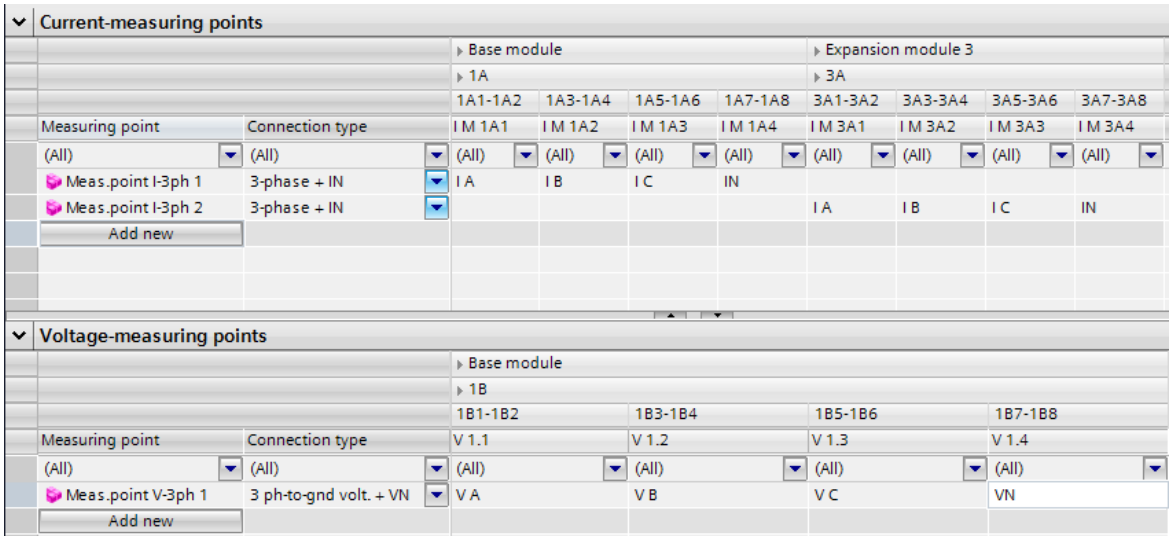
Measuring-Point Assignment

After adding measuring points to the device, you can assign these measuring points to each configured PMU. *Figure 10-14* shows as an example expansion of the device configuration by 2 additional input/output modules. You connect the current and voltage inputs of these I/O modules to measuring points via the DIGSI routing matrix, see example in *Figure 10-15*.



[scaddios-140213-01.tif, 1, en_US]

Figure 10-14 Adding Additional Input/Output Modules



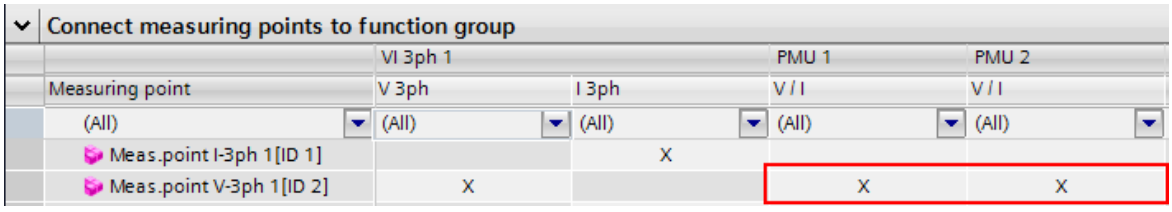
[scroutin-210415, 1, en_US]

Figure 10-15 Assignment of the Current and Voltage Inputs of the Added Input/Output Modules on Measuring Points

The maximum numbers of measuring points that can be routed for one PMU are:

- 2 x 3-phase voltage measuring points
- 2 x 3-phase current measuring points
- 2 x 1-phase voltage measuring points
- 2 x 1-phase current measuring points

You can assign all supported measuring points to any PMU, see the following figure. However, each PMU must be connected to a 3-phase voltage measuring point.



[scfgconn-210415, 1, en_US]

Figure 10-16 Connecting Measuring Points to the Configured PMU Function Groups

When these setting steps have been completed, the PMUs are fully configured. The **PMU** is a function group that functions independently of all the other function groups instantiated in the device.

The device load, however, is dependent on:

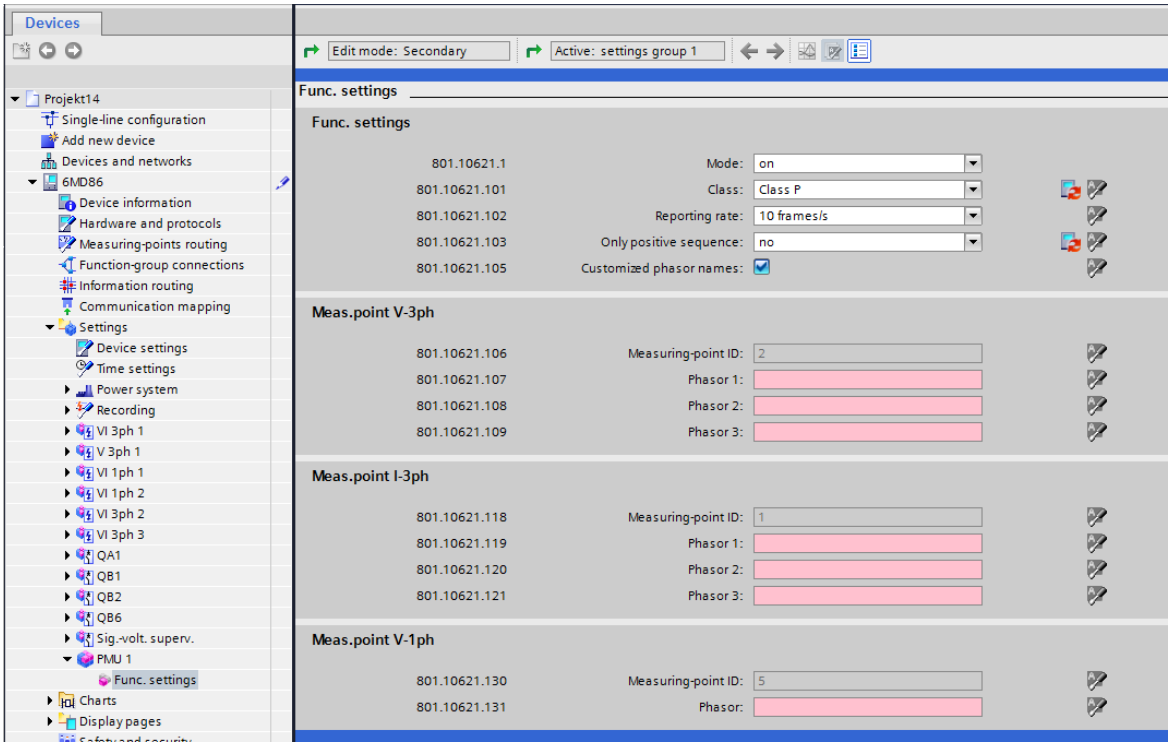
- Number of PMUs
- Performance class (where Class M generates the greater load)
- Number of assigned channels
- Configured reporting rate of each PMU
- Number of binary signals to be transferred

Changing the Channel Names of Phasors

You can edit the names of the individual phasor channels for voltage and current in DIGSI. The clearly structured channel designations assist with when testing and commissioning PMU systems. Furthermore, only the names visible in the IEEE C37.118 interface can be changed. The function block designations themselves cannot.

The IEEE C37.118 defines the ASCII character set for changing the channel names in the scope of the SIPROTEC 5-PMU support. Due to the protocol, the designation length is limited to 16 ASCII characters per channel. However, when renaming, you have to assign at least 1 character. The renaming of binary channels is not supported in the current implementation.

You can start the renaming by setting the check mark at **Own phasor names** with the parameterization in the PMU function block **Functional settings**. Once you have activated this check mark, define a separate name for each phasor. For this purpose, DIGSI shows all routed measuring points on the PMU in the function group connections (see following figure).



[scPMUnam_de, 1, en_US]

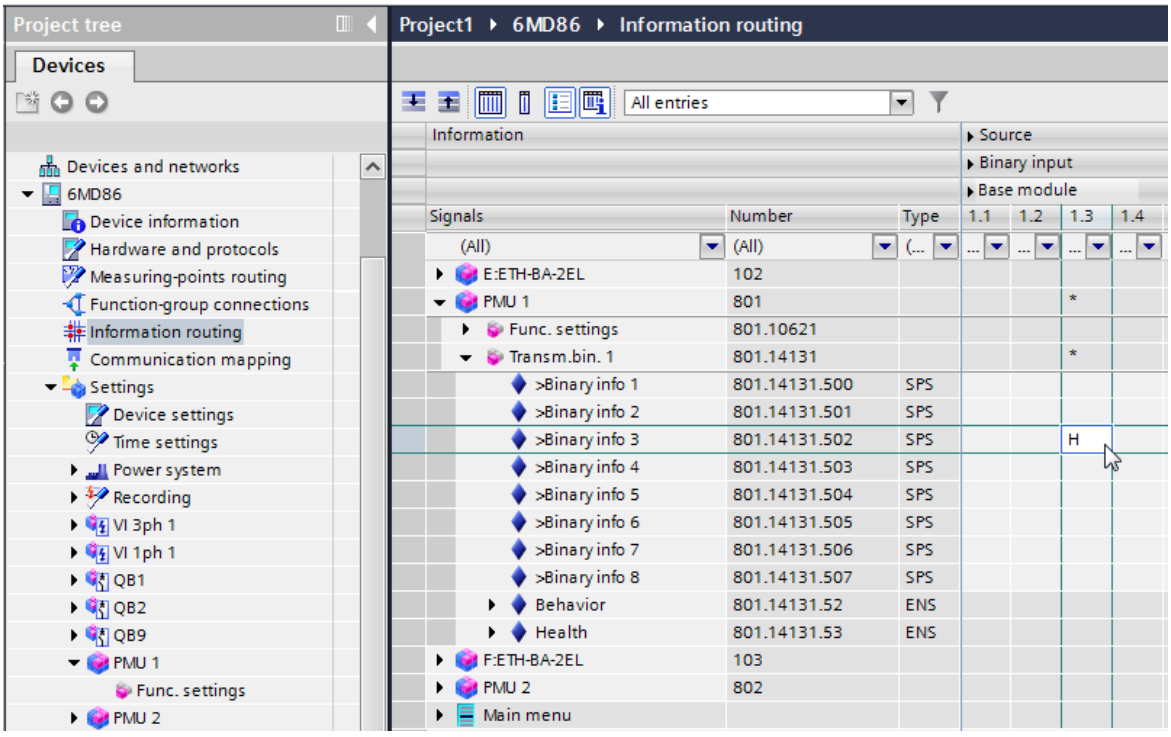
Figure 10-17 Options for Editing the Names of the Individual Phasors

NOTE

You can only rename each individual phasor when you set the parameter **Positive-sequence system only** to ***No*** in the functional settings. Otherwise you will only be offered one single phasor for each 3-phase measuring point for renaming.

Routing Binary Signals

You can connect binary inputs or CFC information with binary channels of the PMU via DIGSI information routing. You will find, in the **Phasor Measurement Unit (PMU)** folder, the **Binary information transmission** function block in the DIGSI function library (see the following figure). You can instantiate this function block up to 10 times in one **PMU** function group. Each of these function blocks contains 8 options for routing binary channels.



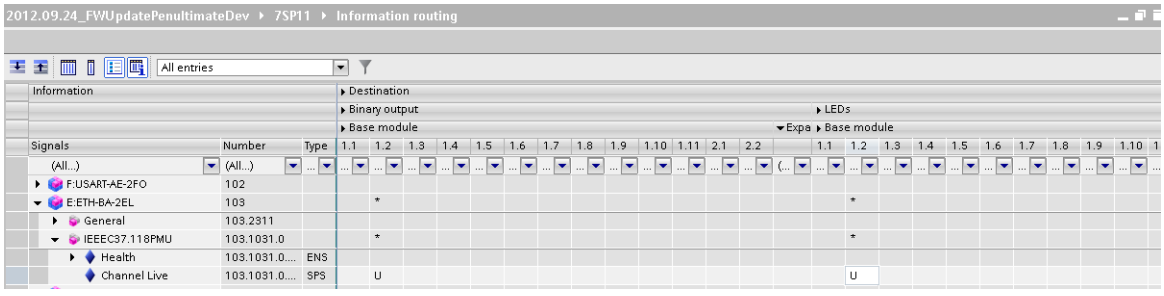
[scpmubif-210415, 1, en_US]

Figure 10-18 Information Routing in DIGSI 5

Routing Indications

The routable indication *ChannelLive* of the PMU log

- raises when the PMU is connected to the PDC
- clears when the connection to the PDC is interrupted.



[scparami-260912-01.tif, 1, en_US]

Figure 10-19 Log Indication for Display of the PMU/PDC Connection

10.9.7 Parameterizing the PMU on the Device

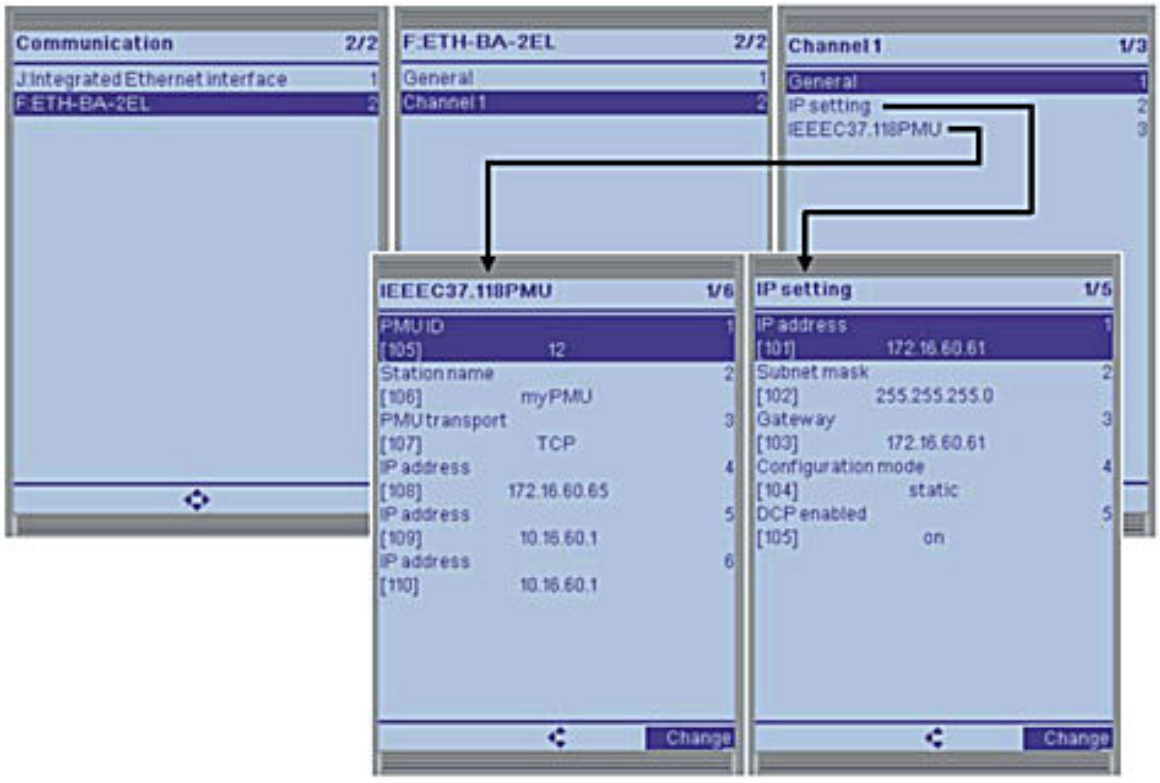
You can also change the PMU settings directly on the device. To do this, select the desired PMU instance on the device display. By selecting menu item **Settings** you then access the editable setting values (see *Figure 10-20*). Note that the parameter **Port** cannot be changed, because this corresponds to the physical slot position of the communication module in question.



[scdevpmu-210415, 1, en_US]

Figure 10-20 Changing the PMU Setting Values via the Device Display

You can also change the communication settings in the same way. To do this, select the corresponding communication port in the **Communication** menu on the device display. From the **Channel 1** menu item, you can then access the detailed setting options for the IP or PMU communication settings (see *Figure 10-21*).



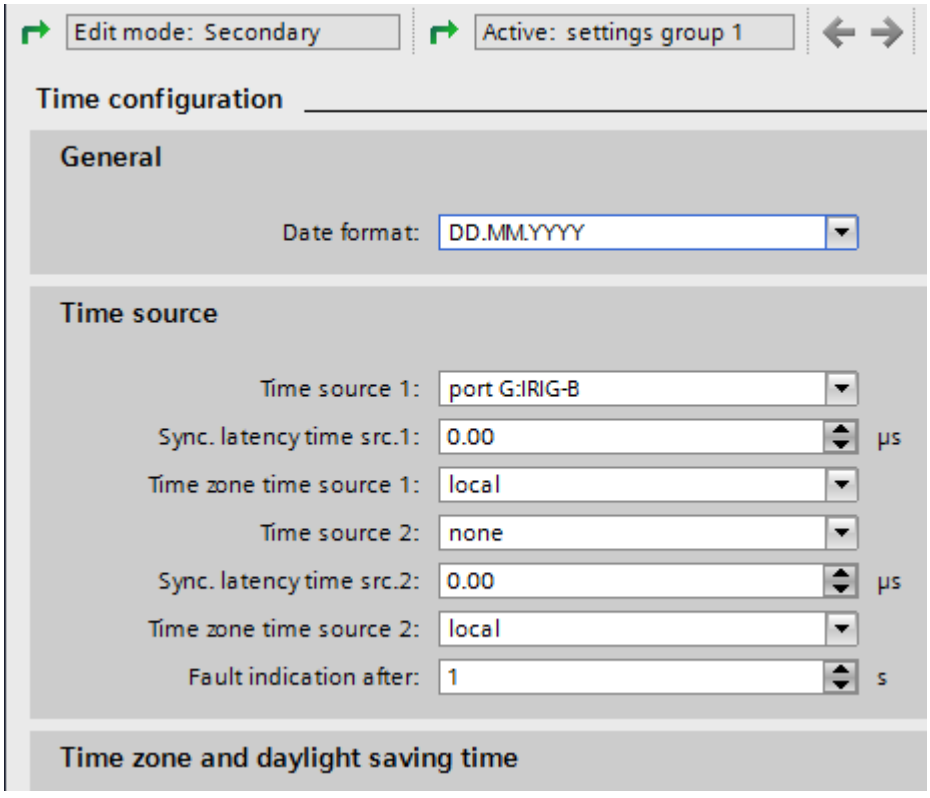
[scdevcom-210415, 1, en_US]

Figure 10-21 Changing the Communication Setting Values Via the Device Display

10.9.8 Application and Setting Notes

Time Synchronization

In order to ensure the time accuracy of the PMU, you must select **IRIG-B** as protocol for the GPS clock, see the following figure. With other settings, the **PMU function** function group indicates that it is not time synchronized.



[sc_setting time source_2014-09-09, 1, en_US]

Figure 10-22 Setting Time Synchronization

To detect a lack of synchronization quickly, also set the waiting time for the failure indication of the loss of time synchronization to the smallest possible value, thus to 1 s.

Parameter: Mode

- Default setting **(_:10621:1) Mode** = ***on***

Activate and deactivate the PMU or switch to Test mode via the parameter **Mode**. The possible setting values are ***on***, ***off*** and ***test***. In Test mode, the PMU data is marked as invalid.

Parameter: Reporting rate

- Default setting **(_:10621:102) Reporting rate** = ***10 frames/s***

With the parameter **Reporting rate**, you specify the number of telegrams that are compiled and sent to the PDC per second.

NOTE

Different setting values are shown or hidden, depending on the rated frequency set.

Parameter: Only positive sequence

- Default setting **(_:10621:103) Only positive sequence** = ***no***

With the parameter **Only positive sequence**, you set whether the positive-sequence system is to be transmitted instead of 3 individual synchrophasors in the case of 3-phase measuring points. The setting you make here is then valid for all PMUs with 3-phase measuring points.

Parameter: Class

- Default setting **(_:10621:101) Class** = ***Class P***

With the setting **Class**, you set which performance class is used for the calculation of the measured values. ***Class P*** is the standard case for PMUs. In this case, filters are used that are suitable for a short response time and therefore are well suited for recording dynamic processes. ***Class M*** is conceived for applications that are unfavorably affected by alias effects and in which short response times are not relevant.

Parameter: Port

This parameter cannot be set because the **Port** results from the physical position where the corresponding communication module is inserted.

10.9.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Func. settings				
_:10621:1	Func. settings:Mode		• off • on • test	on
_:10621:101	Func. settings:Class		• Class P • Class M	Class P
_:10621:102	Func. settings:Reporting rate		• 1 frame/s • 5 frames/s • 6 frames/s • 10 frames/s • 12 frames/s • 15 frames/s • 20 frames/s • 25 frames/s • 30 frames/s • 50 frames/s • 60 frames/s • 100 frames/s • 120 frames/s	10 frames/s
_:10621:103	Func. settings:Only positive sequence		• no • yes	no
_:10621:104	Func. settings:Port		• port J • port F • port E • port P • port N • port G •	port F
_:10621:105	Func. settings:Customized phasor names		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Meas.point V-1ph				
_:10621:130	Func. settings:Measuring-point ID		0to0	0
_:10621:131	Func. settings:Phasor		Freely editable text	
Meas.point V-1ph				
_:10621:133	Func. settings:Measuring-point ID		0to0	0
_:10621:134	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_:10621:136	Func. settings:Measuring-point ID		0to0	0
_:10621:137	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_:10621:139	Func. settings:Measuring-point ID		0to0	0
_:10621:140	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:106	Func. settings:Measuring-point ID		0to0	0
_:10621:107	Func. settings:Phasor 1		Freely editable text	
_:10621:108	Func. settings:Phasor 2		Freely editable text	
_:10621:109	Func. settings:Phasor 3		Freely editable text	
_:10621:111	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:112	Func. settings:Measuring-point ID		0to0	0
_:10621:113	Func. settings:Phasor 1		Freely editable text	
_:10621:114	Func. settings:Phasor 2		Freely editable text	
_:10621:115	Func. settings:Phasor 3		Freely editable text	
_:10621:117	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:118	Func. settings:Measuring-point ID		0to0	0
_:10621:119	Func. settings:Phasor 1		Freely editable text	
_:10621:120	Func. settings:Phasor 2		Freely editable text	
_:10621:121	Func. settings:Phasor 3		Freely editable text	
_:10621:123	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:124	Func. settings:Measuring-point ID		0to0	0
_:10621:125	Func. settings:Phasor 1		Freely editable text	
_:10621:126	Func. settings:Phasor 2		Freely editable text	
_:10621:127	Func. settings:Phasor 3		Freely editable text	
_:10621:129	Func. settings:Phasor		Freely editable text	

10.9.10 Information List

No.	Information	Data Class (Type)	Type
General			
_:10621:52	Func. settings:Behavior	ENS	O
_:10621:53	Func. settings:Health	ENS	O

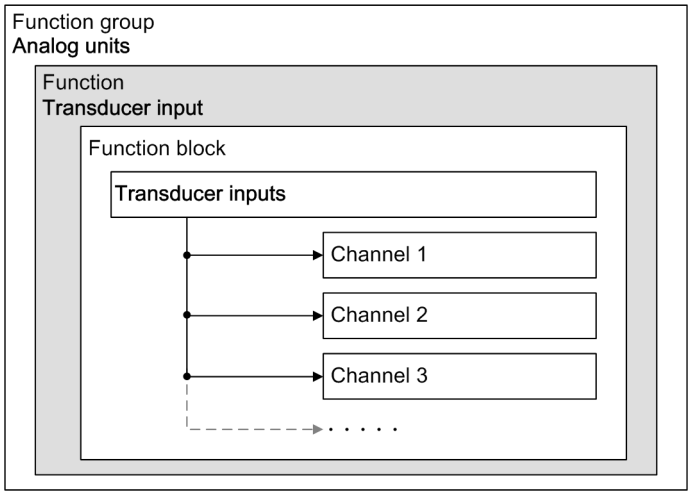
10.10 Measuring Transducers

10.10.1 Overview of Functions

Measuring transducers with an input rated at 20 mA can be used in the devices. 4 such inputs are available as module ANAI-CA-4EL, which can be plugged into a communication module slot (for instance, port E or F). Up to 4 such modules can be plugged in. Typically, slowly changing process variable such as temperature or gas pressure are recorded with such 20-mA measured values and reported to the substation automation technology.

10.10.2 Structure of the Function

The measuring-transducer blocks are embedded in the **Analog units** function group and contain input and output channels that are configurable independently of each other.

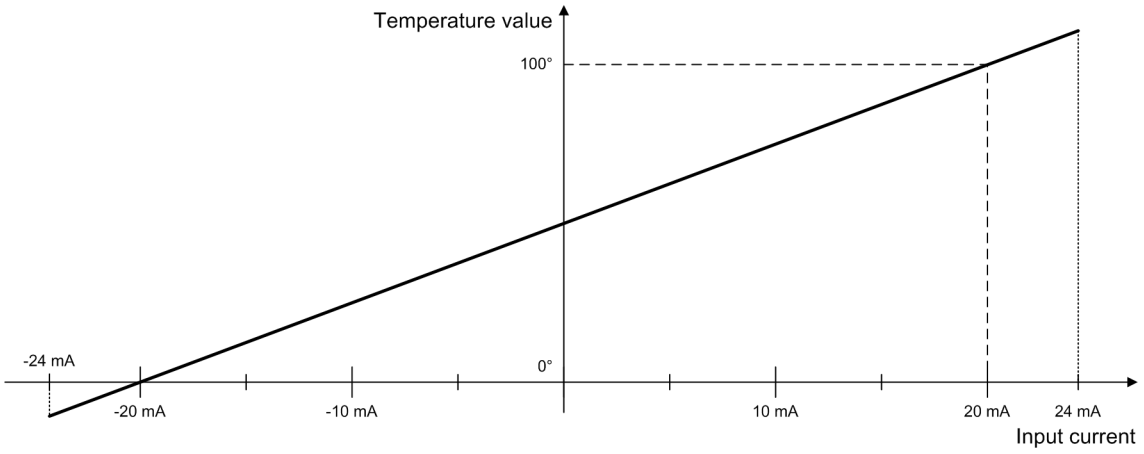


[dwstrumu-050313-01.tif, 1, en_US]

Figure 10-23 Structure/Embedding of the Function

10.10.3 Function Description

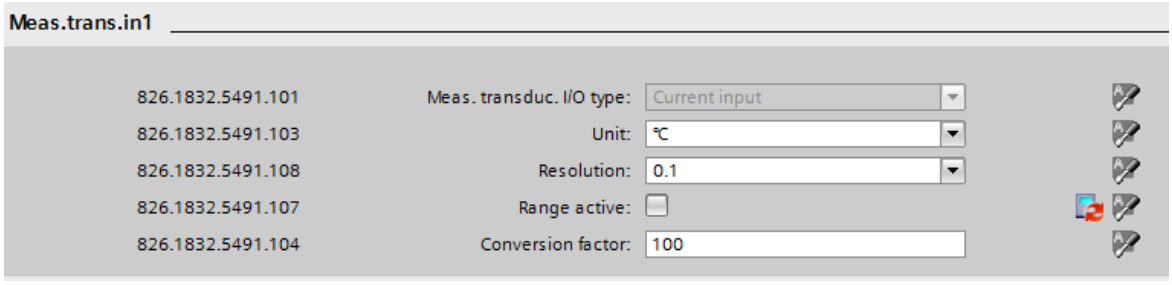
The 20-mA inputs typically transmit a value which represents a physical quantity such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that assigns the physical quantity to the 20-mA value. If the parameter **Range active** is not activated (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA. The following figure shows an example.



[dwklbsp1-120124-01.tif, 1, en_US]

Figure 10-24 Characteristic Curve of a 20-mA Input (Example 1)

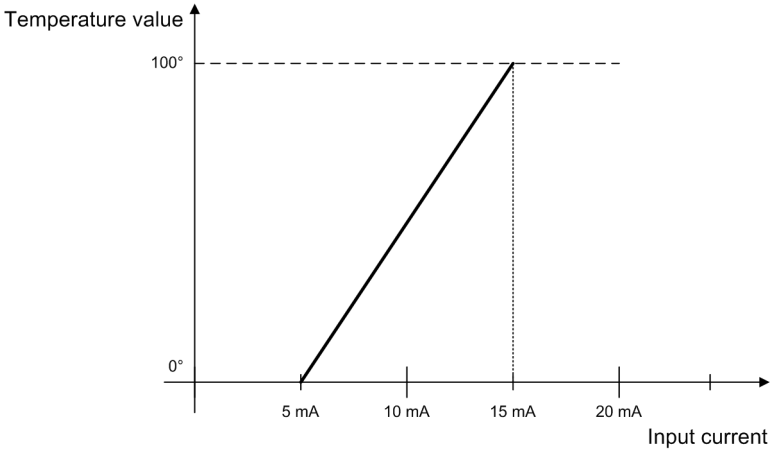
In this example, the measured value -20 mA means a temperature of 0 degrees Celsius and the measured value 20 mA a temperature of 100 degrees Celsius. Thus, **Unit** = ***°C*** and **Conversion factor** = ***100*** are entered. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select **Resolution** = ***0.1***.



[sctransd-210415, 1, en_US]

Figure 10-25 Settings for Example 1

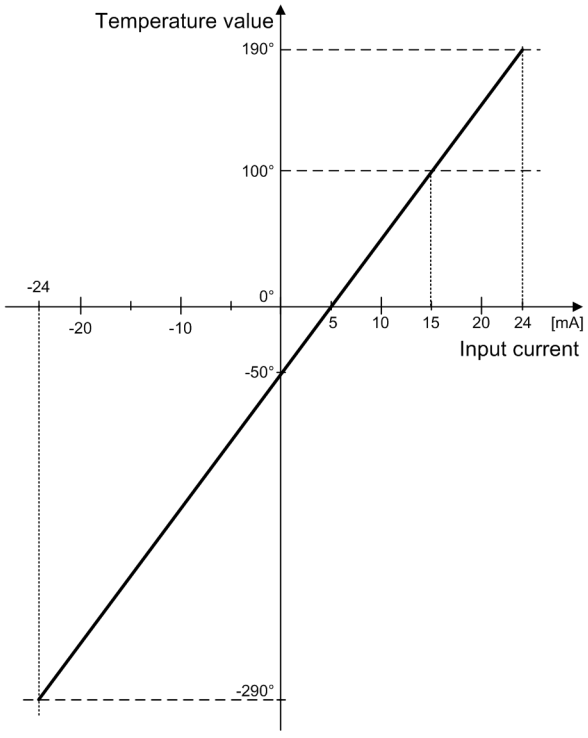
If a value smaller than -24 mA or larger than +24 mA is applied to the measuring-transducer input, the measured value is marked as **invalid**. If the parameter **Range active** is activated, the 2 additional parameters **Upper limit** and **Lower limit** appear. Both limiting values indicate the input currents in mA, for which the value set by the **Conversion factor** (**Upper limit**) and the value 0 (**Lower limit**) of the calculated measurand are valid (see following figure).



[dwklbsp2-120124-01.tif, 1, en_US]

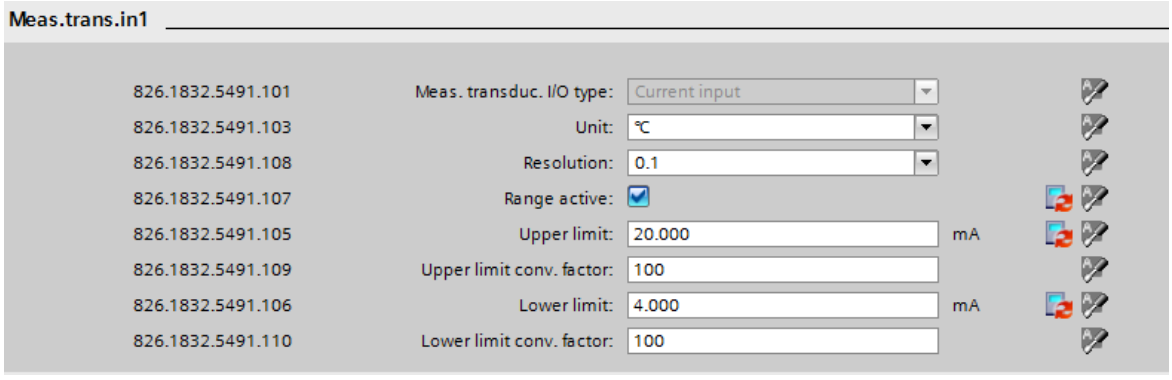
Figure 10-26 Characteristic Curve of a 20-mA Input (Example 2)

In this example, **Range active** is selected. The **Upper limit** is at 15 mA, the **Lower limit** is at 5 mA and the **Conversion factor** remains at 100. The total results in a characteristic curve as shown in the following figure, taking into account all possible valid measured values from -24 mA to +24 mA. The parameter **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The parameter **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.



[dwklges2-120124-01.tif, 2, en_US]

Figure 10-27 Total Characteristic Curve in Example 2



[sctrans2-210415, 1, en_US]

Figure 10-28 Settings for Example 2

Each measuring transducer makes available the scaled measured value in the information matrix (these are the temperature values in the examples) and the original current measured value in mA for further processing. The measuring-transducer values can be displayed in the display image and processed with CFC charts.

10.10.4 Application and Setting Notes

Parameter: Unit

- Recommended setting value **(_:103) Unit** = ***°C***

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

The **(_:104) Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:108) Resolution** = ***0.1***

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting **(_:107) Range active** = ***false***

If you do not activate the **Range active** setting (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Upper limit - Sensor**, **Lower limit** and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting **(_:105) Upper limit** = ***20000 mA***
- Default setting **(_:109) Upper limit - Sensor** = ***100***
- Default setting **(_:106) Lower limit** = ***4000 mA***
- Default setting **(_:110) Lower limit - Sensor** = ***100***

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

10.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT in #				
_:101	MT in #:Meas. transduc. I/O type		• Voltage input • Current input • Voltage output • Current output • Temperature input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• • % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • W • Wh	m
_:108	MT in #:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		1 to 10000	100
_:105	MT in #:Upper limit		-20.00 mA to 20.00 mA	20.00 mA
_:109	MT in #:Upper limit - Sensor		-10000 to 10000	100
_:106	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-10000 to 10000	100

10.10.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:301	MT in #:TD scale MV	MV	O
_:302	MT in #:TD direct MV	MV	O

10.11 Statistical Values of the Primary System

The device has statistical values for circuit breakers and disconnectors.

The following values are available for each circuit-breaker:

- Total number of trippings of the circuit-breaker initiated by the device.
- Number of trippings of the circuit breaker initiated by the device, separately for each circuit breaker pole (if 1-pole tripping is possible)
- Total sum of primary breaking currents
- Sum of the primary breaking currents, separately for each breaker pole
- Hours with open circuit breaker
- Hours under load

The following values are available for each disconnector switch:

- Total number of switching operations of the disconnector switch initiated by the device
- Number of switching operations of the disconnector switch initiated by the device, separately for each switch pole (if 1-pole switching is possible)

10.12 Circuit-Breaker Wear Monitoring

10.12.1 Overview of Functions

The **Circuit-breaker wear monitoring** function:

- Records the wear of circuit breakers
- Allows maintenance intervals of the CB poles to be carried out when their actual degree of wear makes it necessary
- Sends a warning signal when the wear of a circuit breaker reaches a specified degree
- Allows the supervision of the circuit-breaker make time

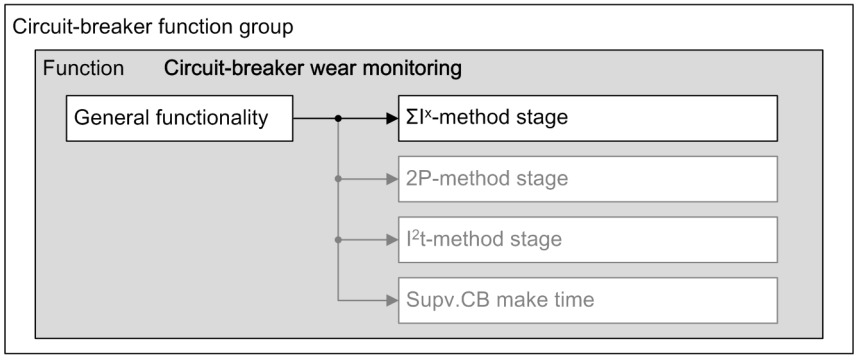
Savings on maintenance and servicing costs is one of the main benefits this functionality offers.

10.12.2 Structure of the Function

The **Circuit-breaker wear monitoring** function can be used in the **Circuit breaker** function group.
The function offers 4 independent operating stages with different measuring methods:

- **ΣI^x-method** stage
  Sum of tripping current powers
- **2P-method stage**
  2 points method for calculating the remaining switching cycles
- **I^2t-method stage**
  Sum of all squared fault-current integrals
- **Supv.CB make time stage**
  Supervision of the circuit-breaker make time

The function is preconfigured by the manufacturer with 1 **ΣI^x-method** stage. A maximum of 1 **ΣI^x-method** stage, 1 **2P-method** stage, 1 **I^2t-method** stage, and 1 **Supv.CB make time** stage can be operated simultaneously within this function.
The general functionality is available across stages and provides a uniform start criterion for the stages.



[DwCBWear, 2, en_US]

Figure 10-29 Structure/Embedding of the Function

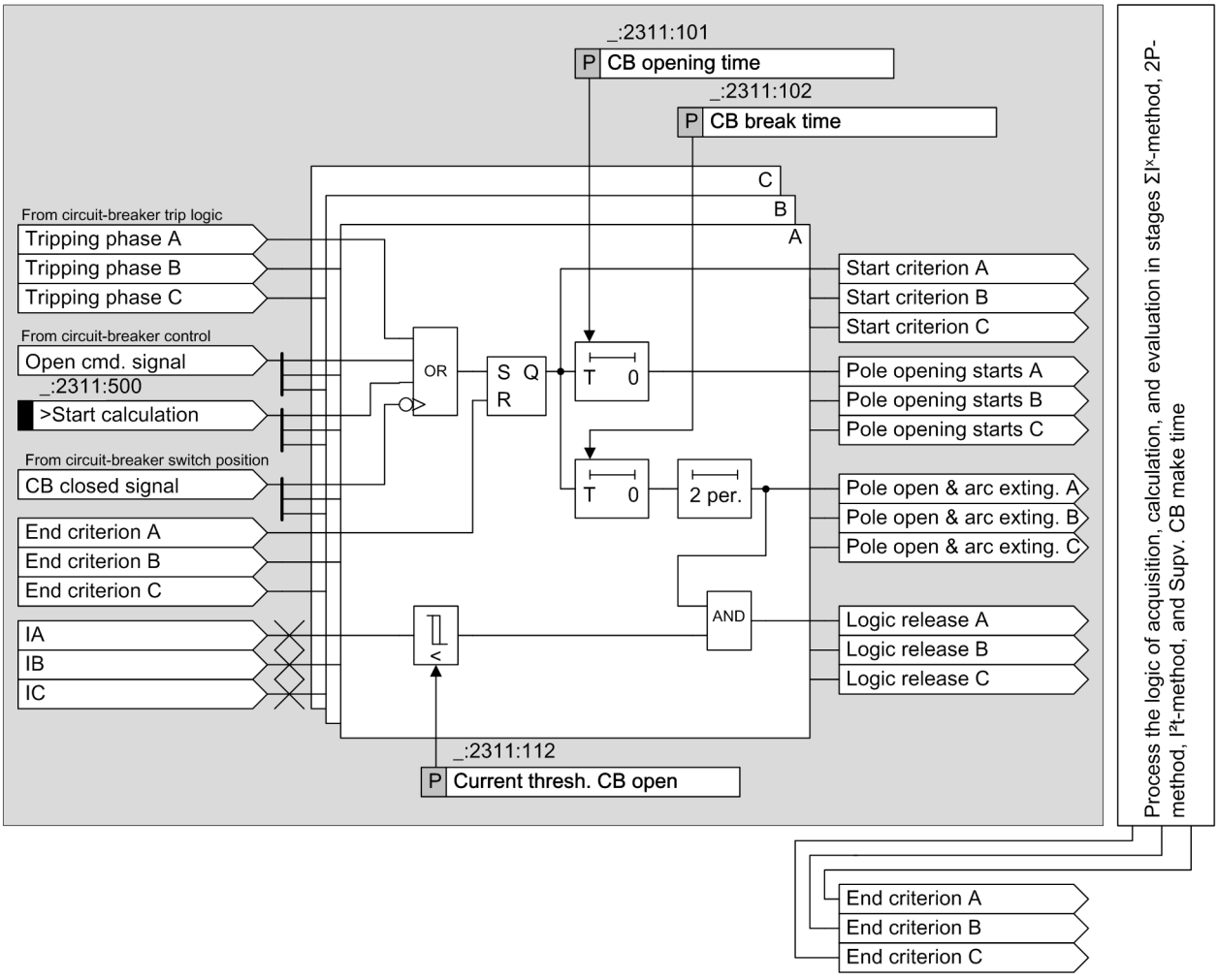
10.12.3 General Functionality

10.12.3.1 Description

Logic

As the wear on the circuit breaker depends on the current amplitude and duration of the actual switching action, including arc deletion, determination of the start and end criteria is important. The following general functionality provides starting and further timing information to the different stages (methods).

The general functionality operates phase-selectively. The following figure shows the logic of the functionality across stages.



[LoCBWear, 3, en_US]

Figure 10-30 Logic Diagram of the Functionality Across Stages of the Circuit-Breaker Wear Monitoring Function

Start Criterion for the Circuit-Breaker Wear Monitoring Function

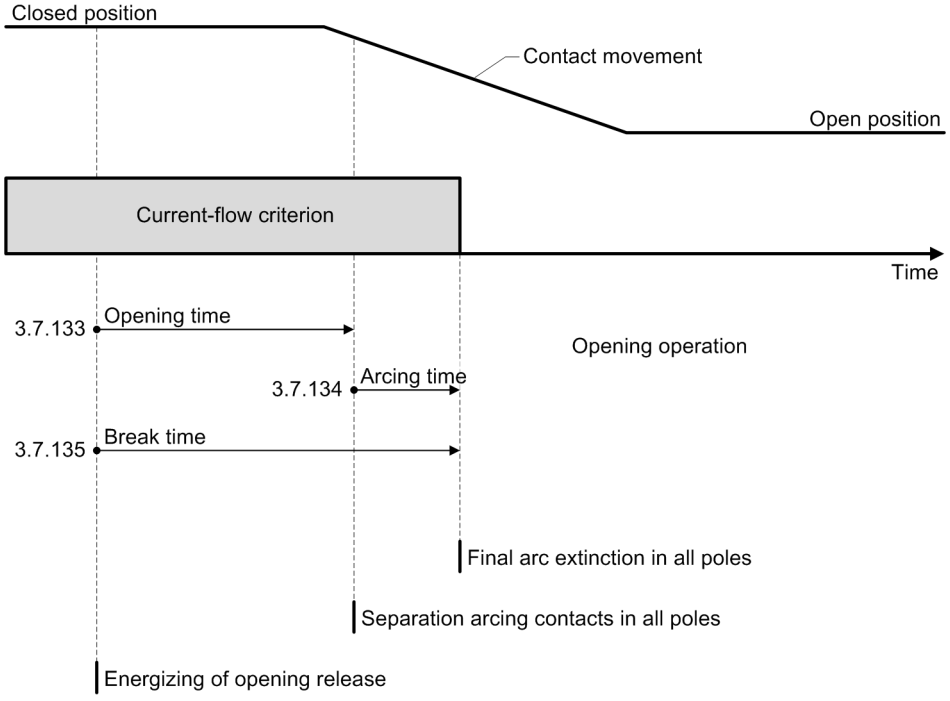
The **Circuit-breaker wear monitoring** function starts when any of the following criteria is fulfilled:

- Internal protection-function tripping signal from the function block **Trip logic** is received
- Open command signal from the internal **Control** function is received.
- Binary input signal *>Start calculation* is initiated, for example, from external.

- Closed position signal of circuit breaker is going
  This signal is derived form the circuit-breaker auxiliary contacts. In this way, opening the circuit-breaker manually is detected.

Logic Input Signals for Stages

As soon as the start criterion has been fulfilled, the timers of the parameterized opening time and break time are started. With the parameter **CB opening time**, the time when the circuit-breaker pole begins to open is defined. With the parameter **CB break time**, the time of the pole being open including the arc extinction is defined. The following figure shows the relationship between these circuit-breaker times.



[DwCBTime, 2, en_US]

Figure 10-31 Circuit-Breaker Times

In order to prevent an incorrect calculation in case of a circuit-breaker failure, the parameter **Current thresh. CB open** is used to verify whether the current actually returns to 0 after 2 additional cycles. Fundamental components are used for comparing the threshold values. When the current criterion fulfills the requirement of the phase-selective logic release, the calculation and evaluation of the respective methods are initiated.

End Criterion for the Circuit-Breaker Wear Monitoring Function

After calculation and evaluation have been completed, the end criterion of the circuit-breaker maintenance is fulfilled. The **Circuit-breaker wear monitoring** function is ready for a new initiation.

10.12.3.2 Application and Setting Notes

Parameter: CB opening time

- Default setting value **(_:2311:101) CB opening time** = ***0.065 s***

You use the **CB opening time** parameter to define the time span from energizing the shunt release of the circuit breaker until the start of opening of switching poles.

You can find the information on the setting value in the technical data of the used circuit breaker. Also refer to *Figure 10-31*.

Parameter: CB break time

- Default setting **(_:2311:102) CB break time** = ***0.080 s***

You use the **CB break time** parameter to define the time span from energizing the shunt release of the circuit breaker to the instant of arc extinction (and switching pole open).
You can find the information on the setting value in the technical data of the used circuit breaker. Also refer to *Figure 10-31*.

Parameter: CB make time

- Default setting **(_:2311:103) CB make time** = ***0.080 s***

With the parameter **CB make time**, you define the typical time interval between the activation of the closing procedure for the circuit breaker and the point in time when the first current flows.
You can find more information on the setting value in the technical data of the used circuit breaker.

10.12.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:CB opening time		0.001 s to 0.500 s	0.065 s
_:2311:102	General:CB break time		0.001 s to 0.600 s	0.080 s
_:2311:103	General:CB make time		0.001 s to 0.600 s	0.080 s

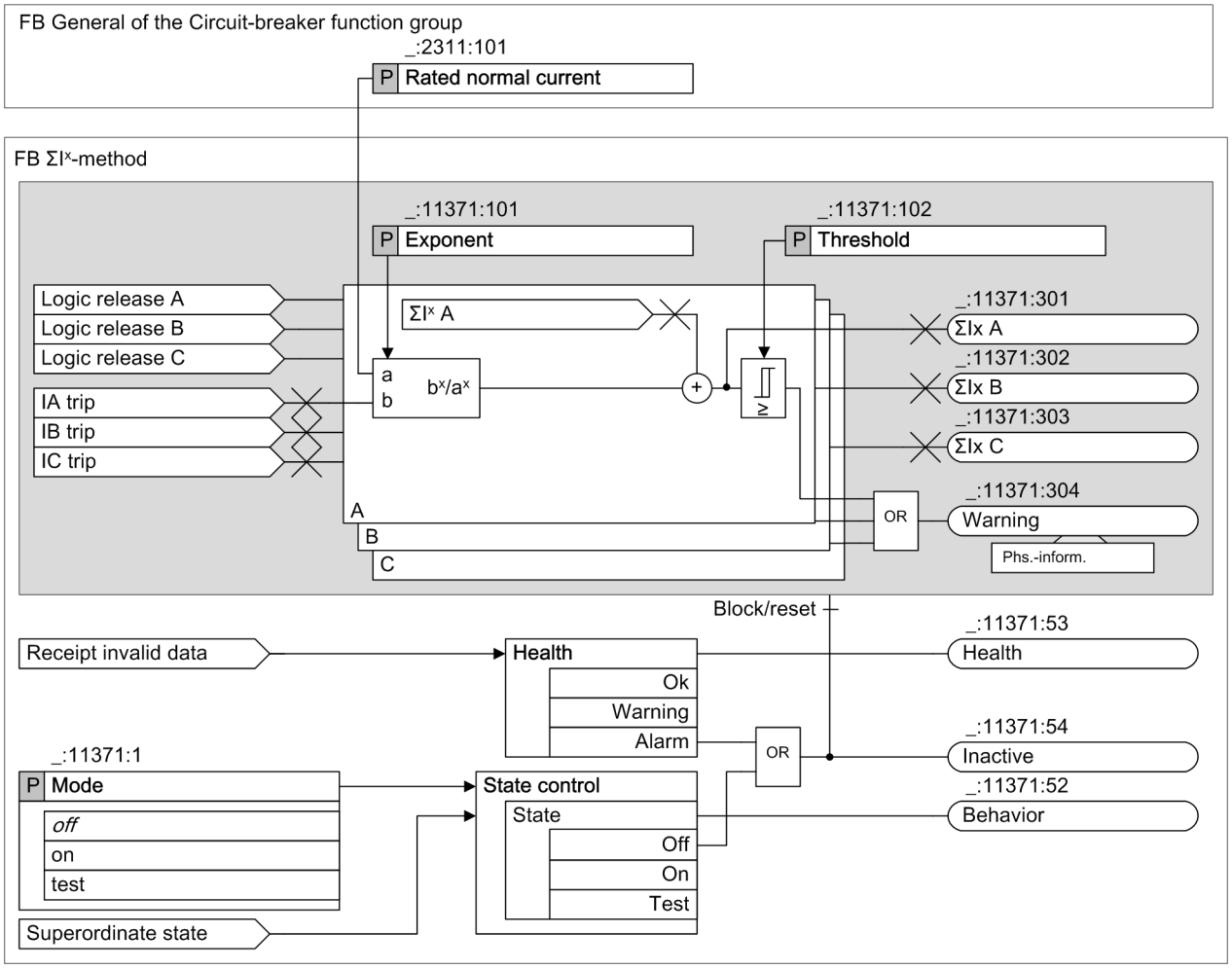
10.12.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calculation	SPS	I

10.12.4 Stage Description ΣI* Method

10.12.4.1 Description

Logic of the Stage



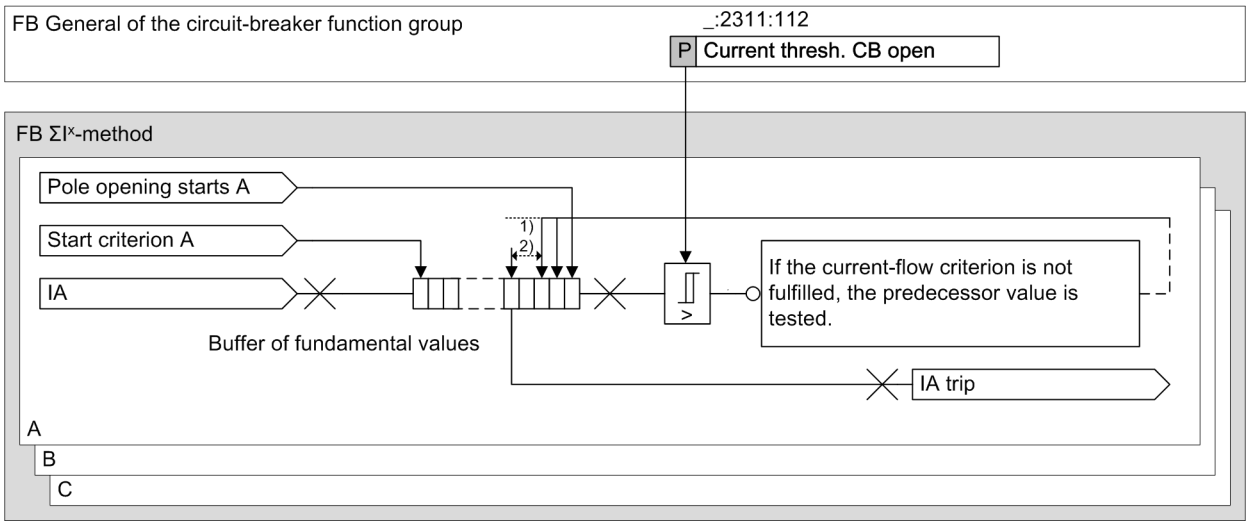
[LoCBWIxS, 3, en_US]

Figure 10-32 Logic of the ΣIx-Method Stage

Determination of the Tripping/Opening Current Value

RMS values of the fundamental components are stored for each phase in a buffer during the time between the start criterion and the pole-opening-starts criterion. With the coming pole-opening-starts criterion, the latest value in the buffer is searched for whose value is above the setting of parameter **`Current thresh. CB open`**. The 20 ms prior value is used as tripping/opening current for further calculation.

If no value within the buffer is above the setting value, this circuit-breaker opening affects only the mechanical lifetime of the circuit breaker and is consequently not considered by this method.



[LoCBWIxF, 1, en_US]

Figure 10-33 Logic of the Determination of the Tripping Current Value

(1) Current-flow criterion fulfilled

(2) 20 ms prior value

Calculation of the Wear

If the **ΣIx-method** stage receives the logic release signal, the determined tripping current is used in the calculation of wear. The calculation results are then added to the existing statistic values of the ΣIx method as follows, with phase A as example.

$$\sum I_A^x = \frac{1}{I_{rated}^x} \sum_{q=1}^{m} I_{A\,trip,q}^x$$

[FoCBWIxA-301012-01.tif, 1, en_US]

Where:

x	Parameter exponent
q	No. of circuit-breaker switching cycle
$I_{A\,trip,q}^x$	Tripping/opening current of phase A to the power of x in the qth circuit-breaker operation
I_{rated}^x	Rated normal current to the power of x
$\sum I_A^x$	Statistic value of current phase A calculated with the ∑Ix method
m	Total number of switching cycles

The phase-selective ΣIx value is available as statistical value. You can reset or preset the statistics according to the specific application.

To simplify the interpretation of the sum of the tripping current powers, the values are set in relation to the exponentiated rated normal current I_{rated} of the circuit-breaker (see also Setting notes).

Circuit-Breaker Maintenance Warning

If the summated ΣIx value of any phase is greater than the threshold, a phase-selective warning signal is generated.

10.12.4.2 Application and Setting Notes

Parameter: Exponent

- Default setting **(_:11371:101) Exponent** = *2.0*

You use the **Exponent** parameter to specify the exponent for the ΣI^x method.

A typical value is the default setting of 2. However, due to practical experiences with individual circuit breakers, slightly different values may be requested.

Parameter: Threshold

- Default setting **(_:11371:102) Threshold** = *10 000.00*

You use the parameter **Threshold** to define the threshold of the statistic value.

The relation of the tripping current powers to the exponentiated rated normal current I_{rated} allows the limiting value of the ΣI^x method to correspond to the maximum number of make-break operations. For a circuit breaker, whose contacts have not yet been worn, the maximum number of make-break operations can be entered directly as limiting value.

10.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
ΣIx-method				
_:11371:1	ΣIx-method:Mode		• off • on • test	off
_:11371:101	ΣIx-method:Exponent		1.0 to 3.0	2.0
_:11371:102	ΣIx-method:Threshold		0 to 10000000	10000

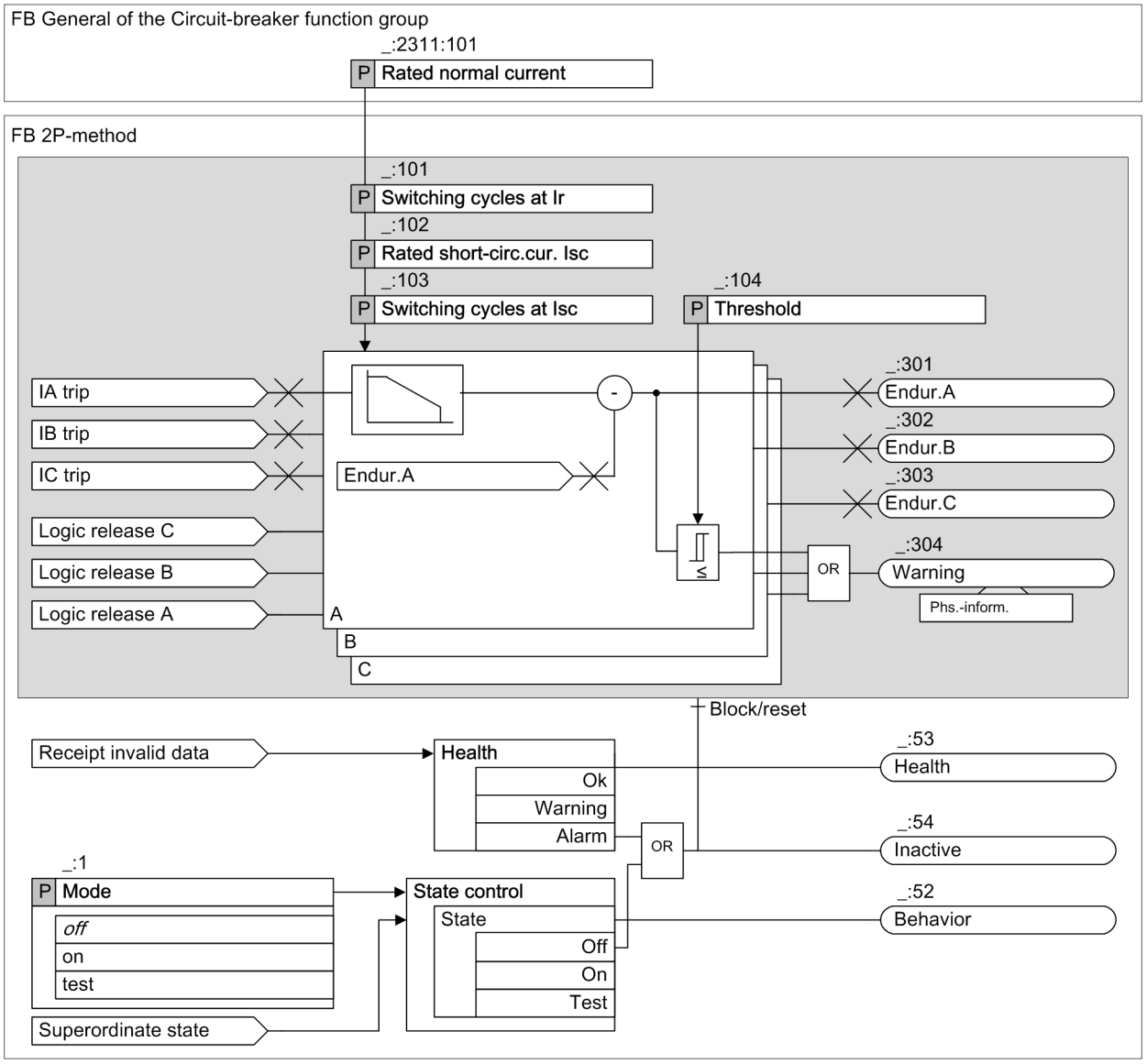
10.12.4.4 Information List

No.	Information	Data Class (Type)	Type
ΣIx-method			
_:11371:54	ΣIx-method:Inactive	SPS	O
_:11371:52	ΣIx-method:Behavior	ENS	O
_:11371:53	ΣIx-method:Health	ENS	O
_:11371:301	ΣIx-method:ΣIx A	BCR	O
_:11371:302	ΣIx-method:ΣIx B	BCR	O
_:11371:303	ΣIx-method:ΣIx C	BCR	O
_:11371:304	ΣIx-method:Warning	ACT	O

10.12.5 Stage Description 2P Procedure

10.12.5.1 Description

Logic of the Stage



[LoCBW2PS, 2, en_US]

Figure 10-34 Logic of the 2P-Method Stage

Determination of the Tripping/Opening Current Value

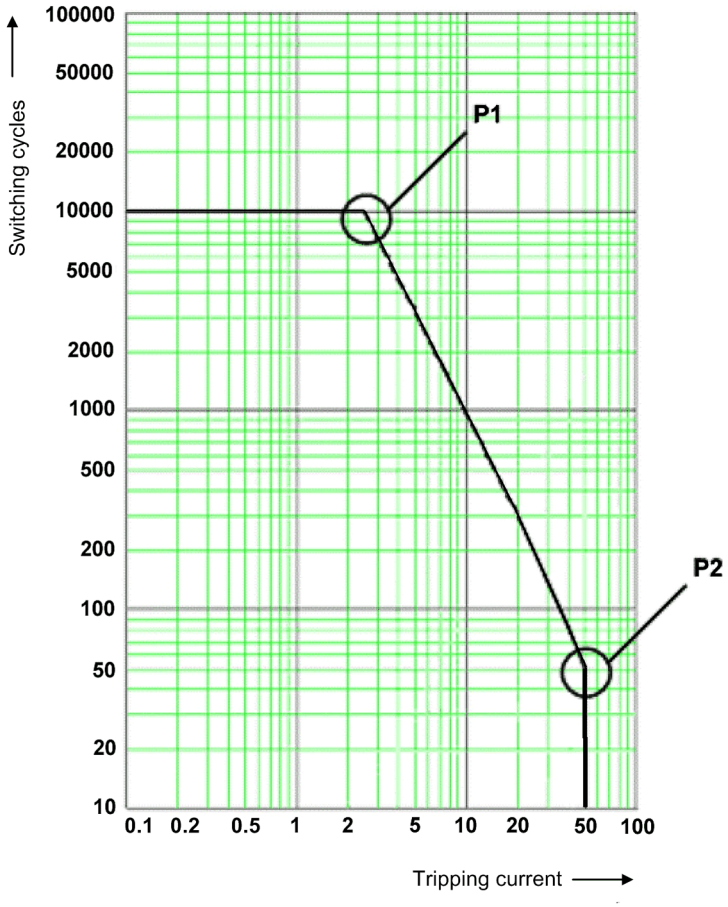
For the description to determine the tripping/opening current value, refer to chapter *10.12.4.1 Description*.

Calculation of Remaining Switching Cycles

A double-logarithmic diagram provided by the circuit-breaker manufacturer illustrates the relationship of permitted switching cycles and the tripping/opening current, see the following figure. According to the example, this circuit breaker can operate approximately 1000 times at a tripping current of 10 kA.

2 points and their connecting line determine the relationship of switching cycles and tripping current. Point P1 is determined by the number of permitted switching cycles at rated normal current I_{rated}. Point P2 is deter-

mined by the maximum number of switching cycles at rated short-circuit breaking current I_{sc}. The 4 associated values can be configured with the parameters **Rated normal current**, **Switching cycles at Ir**, **Rated short-circ.cur. Isc**, and **Switching cycles at Isc**.



[DwCBWOpC, 1, en_US]

Figure 10-35 Diagram of Switching Cycles for the 2P Method

As shown in the preceding figure, a double-logarithmic diagram, the straight line between P1 and P2 can be expressed by the following exponential function:

$$n = b \cdot \left(\frac{I_{rated}}{I_{trip}} \right)^{m}$$

[FoCBW2P1-301012-01.tif, 1, en_US]

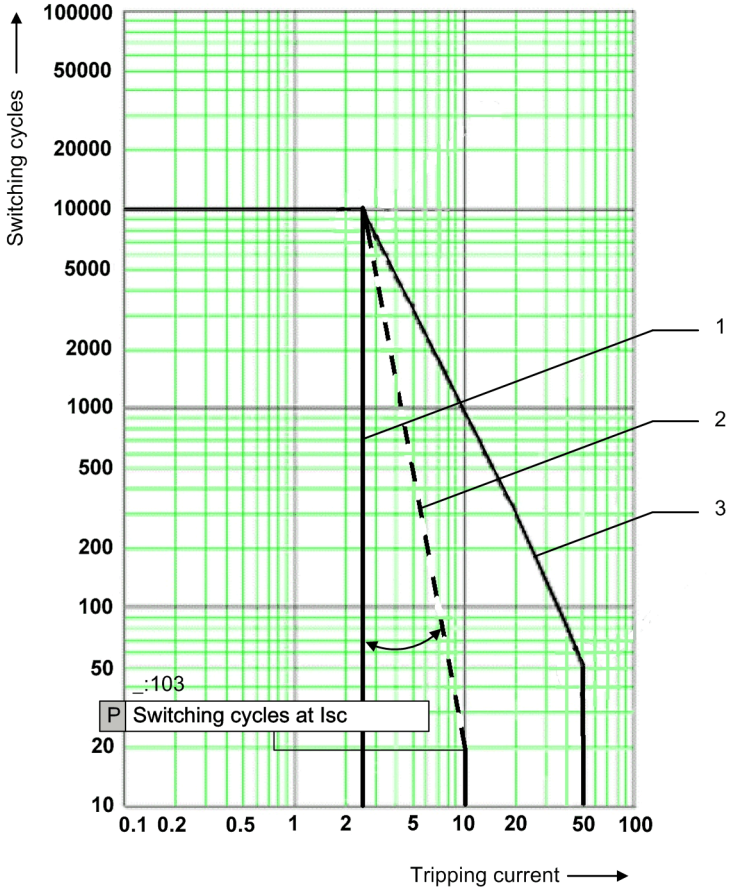
Where:

I_{trip}	Tripping/opening current
I_{rated}	Rated normal current
m	Slope coefficient
b	Switching cycles at rated normal current
n	Number of switching cycles

The general line equation for the double-logarithmic representation can be derived from the exponential function and leads to the coefficients b and m.

NOTE

Since a slope coefficient of m < -4 is technically irrelevant, but could theoretically be the result of incorrect settings, the slope coefficient is limited to -4. If a coefficient is smaller than -4, the exponential function in the switching-cycles diagram is deactivated. The maximum number of switching cycles with I_{sc} is used instead as the calculation result for the current number of switching cycles, as the dashed line with m = -4.48 shows in following figure.



[DwCBWSlo, 1, en_US]

Figure 10-36 Value Limitation of Slope Coefficient

(1) Applied function from m < -4
(2) Parameterized function with m = -4.48
(3) Parameterized function with m = -1.77

If the **2P-method** stage receives the logic release signal, the current number of used up switching cycles (in relation to the number of switching cycles at rated normal current) is calculated based on the determined tripping current. This value is subtracted from the the remaining lifetime (switching cycles). The remaining lifetime is available as statistic value. For better understanding, refer to the example below.

You can reset or preset the statistical values according to the specific application. The reset operation changes the statistic values to 0, and not to their default values of 10 000.

The statistic value of the residual switching cycles is calculated according to the following formula:

$$Endur_{i} = Endur_{i-1} - \frac{n_{rated}}{n_{trip}}$$

[FoCBW2P2-301012-01.tif, 1, en_US]

Where:

i	No. of latest circuit-breaker switching cycle
$Endur._i$	Residual switching cycles with rated normal current, after the ith switching cycle
n_{rated}	Overall permissible switching cycles at rated normal current
n_{trip}	Overall permissible switching cycles at tripping current I_{trip}
n_{rated}/n_{trip}	Lost switching cycles referring to rated normal current

EXAMPLE

For calculating the residual switching cycles of a circuit breaker, the following is assumed:
P1 (2.5 kA, 10 000)
P2 (50.0 kA, 50)
The circuit breaker has made 100 opening operations with rated normal current, 2 tripping operations with rated short-circuit breaking current, and 3 tripping operations with 10 kA tripping current. Then, the residual switching cycles with rated normal current are:

$$\text{Endurance} = n_{rated} - \left(100 \cdot \frac{n_{rated}}{n_{2.5kA}}\right) - \left(2 \cdot \frac{n_{rated}}{n_{50kA}}\right) - \left(3 \cdot \frac{n_{rated}}{n_{10kA}}\right)$$
$$= 10000 - \left(100 \cdot \frac{10000}{10000}\right) - \left(2 \cdot \frac{10000}{50}\right) - \left(3 \cdot \frac{10000}{861}\right) = 9465$$

[FoCBW2P3-301012-01.tif, 1, en_US]

There are still 9465 possible break operations at rated normal current.

Circuit-Breaker Maintenance Warning

If the residual switching cycles of any phase lie below the threshold, a phase-selective warning signal is generated.

10.12.5.2 Application and Setting Notes

Parameter: **Switching cycles at Ir**

- Default setting **(_:101) Switching cycles at Ir** = ***10 000***

You use the **Switching cycles at Ir** parameter to define the number of permitted switching cycles at rated normal current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: **Rated short-circ.cur. Isc**

- Default setting **(_:102) Rated short-circ.cur. Isc** = ***25 000 A***

You use the **Rated short-circ.cur. Isc** parameter to define the rated short-circuit breaking current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: **Switching cycles at Isc**

- Default setting **(_:103) Switching cycles at Isc** = ***50***

You use the **Switching cycles at Isc** parameter to define the number of permitted switching cycles at rated short-circuit breaking current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: `Threshold`

- Default setting **`(_:104) Threshold`** = ***1000***

You use the **`Threshold`** parameter to define the threshold of residual switching cycles with rated normal current. A warning signal is generated when the statistic is less than the **`Threshold`**.

Example

Here is an example that shows you how to set the **`Threshold`** parameter. Assuming a circuit breaker with the same technical data as provided in the example for residual switching cycles, 50 breaking operations with rated short-circuit breaking current are permitted.

A warning signal should be issued when the number of possible breaking operations with rated short-circuit breaking current is less than 3. For that condition, you set the **`Threshold`** value based on the following calculation:

$$3 \cdot \frac{n_{rated}}{n_{50kA}} = 3 \cdot \frac{10000}{50} = 600$$

[FoCBW2P4-301012-01.tif, 1, en_US]

10.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2P-method				
_:1	2P-method:Mode		• off • on • test	off
_:101	2P-method:Switching cycles at Ir		100 to 1000000	10000
_:102	2P-method:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:103	2P-method:Switching cycles at Isc		1 to 1000	50
_:104	2P-method:Threshold		0 to 10000000	100

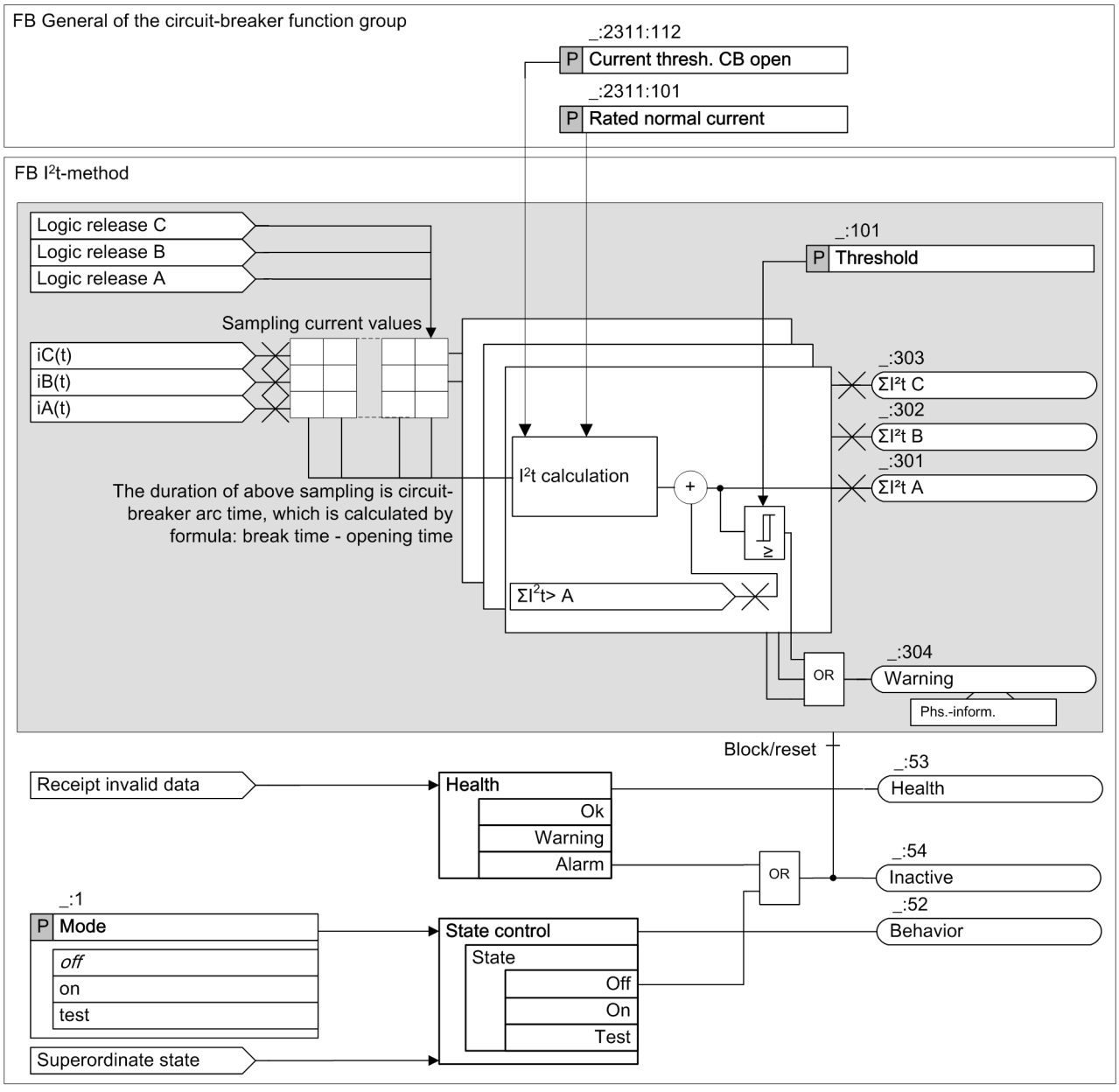
10.12.5.4 Information List

No.	Information	Data Class (Type)	Type
2P-method			
_:54	2P-method:Inactive	SPS	O
_:52	2P-method:Behavior	ENS	O
_:53	2P-method:Health	ENS	O
_:301	2P-method:Endur.A	INS	O
_:302	2P-method:Endur.B	INS	O
_:303	2P-method:Endur.C	INS	O
_:304	2P-method:Warning	ACT	O

10.12.6 Stage Description I²t Method

10.12.6.1 Description

Logic of the Stage



[LoCBWI2t, 1, en_US]

Figure 10-37 Logic of the I²t-Method Stage

Calculation of the Wear

The I²t method evaluates the wear of a circuit breaker based the sampled measuring values of the phase currents during the arc time. The duration of the arc time is defined by the difference between the 2 settings of parameters **`CB break time`** and **`CB opening time`** (see also *Figure 10-31*). The stage determines the ending point of the arc time by searching backward the zero-crossing point of the phase currents after it receives the logic release signal. Then, the squared fault currents during the arc time are integrated phase-

selectively. The integrals are referred to the squared rated normal current of the circuit breaker as shown in the following formula, with phase A as example.

$$I^2t_A = \frac{1}{I^2_{rated}} \int_{\text{Start arc time}}^{\text{End arc time}} i_A^2(t)\,dt$$

[FoCBWI2T-301012-01.tif, 1, en_US]

Where:

I_{rated}	Rated normal current
$i_A(t)$	Sampled measured current value of phase A

The calculated squared tripping current integrals are added to the existing statistic values.You can reset or preset the statistic value according to the specific application.

Circuit-Breaker Maintenance Warning

If the statistic value of any phase lies above the threshold, a phase-selective warning signal is generated.

10.12.6.2 Application and Setting Notes

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***`10 000.00 I/Ir*s`***

You use the **`Threshold`** parameter to specify the maximum permitted integral of squared sampled measured values of the phase currents.

10.12.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I2t-method`				
_:1	I2t-method:Mode		• off • on • test	off
_:101	I2t-method:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s

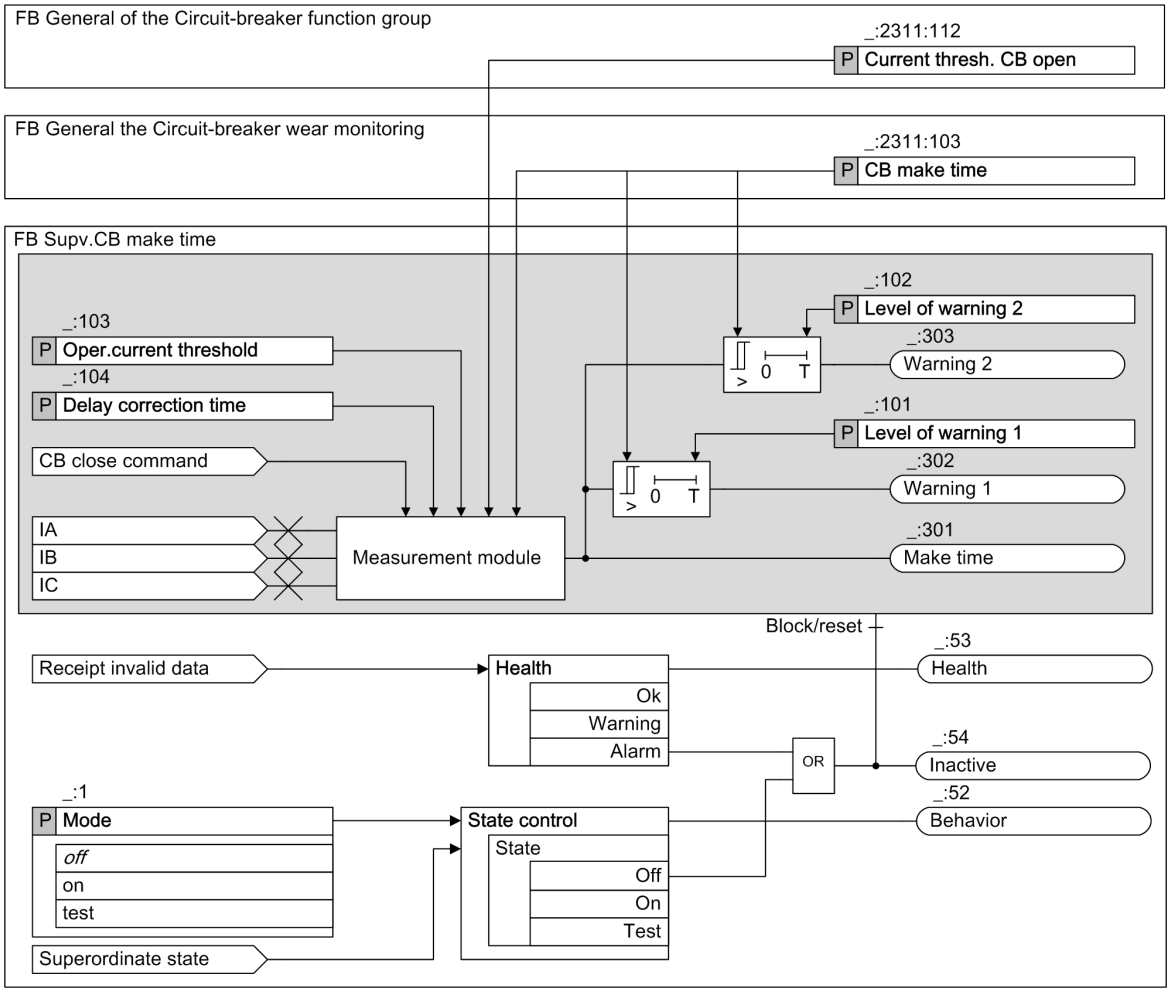
10.12.6.4 Information List

No.	Information	Data Class (Type)	Type
`I2t-method`			
_:54	I2t-method:Inactive	SPS	O
_:52	I2t-method:Behavior	ENS	O
_:53	I2t-method:Health	ENS	O
_:301	I2t-method:ΣI²t A	BCR	O
_:302	I2t-method:ΣI²t B	BCR	O
_:303	I2t-method:ΣI²t C	BCR	O
_:304	I2t-method:Warning	ACT	O

10.12.7 Stage Description Supervision CB Make Time

10.12.7.1 Description

Logic of the Stage



[Lo_sup-cb-make-time, 1, en_US]

Figure 10-38 Logic of the Supv.CB Make Time Stage

Operating Mode

The stage for the supervision of the circuit-breaker make time calculates the time between the circuit-breaker closing command and the point in time when the current from at least one phase exceeds the **Oper.current threshold**. If this threshold has not been exceeded after 2.5 times the value of the parameter **CB make time**, the measurement is canceled and the output value *Make time* is set to 0 and marked with the quality invalid.

If at least one phase of the current has exceeded the parameter **Oper.current threshold** or the parameter **Current thresh. CB open** at the time of the circuit-breaker closing command, the measurement is canceled and the output value *Make time* is marked with the quality invalid.

You can define 2 independent thresholds for the supervision of the measured make time. When these thresholds are exceeded, the corresponding outputs *Warning 1* and *Warning 2* are activated for 100 ms. These can be routed in the log.

10.12.7.2 Application and Setting Notes

Parameter: Level of warning 1

- Default setting **(_:101) Level of warning 1** = *5 %*

With the parameter **Level of warning 1**, you define the percentage the measured value is allowed to exceed the parameter **CB make time** at the output *Make time*, before the output *Warning 1* is set. The output *Warning 1* then drops out after 100 ms.

Parameter: Level of warning 2

- Default setting **(_:102) Level of warning 2** = *10 %*

With the parameter **Level of warning 2**, you define the percentage the measured value is allowed to exceed the parameter **CB make time** at the output *Make time*, before the output *Warning 2* is set. The output *Warning 2* then drops out after 100 ms.

Parameter: Oper.current threshold

- Default setting **(_:103) Oper.current threshold** = *0.100 A*

With the parameter **Oper.current threshold**, you define the current threshold. If the measured value exceeds this threshold, the measured value is detected as flowing operating current. As soon as an operating current flows, the end of the time interval *Make time* is detected.

Parameter: Delay correction time

- Default setting **(_:104) Delay correction time** = *0.000 s*

With the parameter **Delay correction time**, you define a correction value which will be subtracted from the *Make time* during calculation. This allows you to compensate delays caused by the system, for example, relay residual times, if necessary.

10.12.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv.CB make time				
_:1	Supv.CB make time:Mode		• off • on • test	off
_:101	Supv.CB make time:Level of warning 1		1 % to 100 %	5 %
_:102	Supv.CB make time:Level of warning 2		1 % to 100 %	10 %
_:103	Supv.CB make time:Oper.current threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:104	Supv.CB make time:Delay correction time		-0.050 s to 0.050 s	0.000 s

10.12.7.4 Information List

No.	Information	Data Class (Type)	Type
Supv.CB make time			
_:54	Supv.CB make time:Inactive	SPS	O
_:52	Supv.CB make time:Behavior	ENS	O
_:53	Supv.CB make time:Health	ENS	O
_:301	Supv.CB make time:Make time	MV	O
_:302	Supv.CB make time:Warning 1	SPS	O
_:303	Supv.CB make time:Warning 2	SPS	O

11 Functional Tests

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11.1 General Notes

Various tests have to be performed for commissioning to warrant the correct function of the device.

For tests using secondary test equipment, make sure that no other measurands are locked in and trip and close commands to the circuit breakers are interrupted, unless otherwise indicated.

Secondary tests can never replace primary tests because they cannot include connection faults. They provide a theoretical check of the setting values only.

Primary tests may be done only by qualified personnel who are familiar with the commissioning of protection systems, with the operation of the system, and with safety regulations and provisions (switching, grounding, etc.).

Switching operations also have to be performed for the commissioning. The described tests require that these be capable of being performed safely. They were not conceived for operational checks.

11.2 Direction Test of the Phase Quantities (Current and Voltage Connection)

The proper connection of the current and voltage transformer is checked with load current over the line to be protected. For this, the line must be switched on. A load current of at least 0.1 I_{rated} has to flow over the line; it should be ohmic to ohmic inductive. The direction of the load current has to be known. In case of doubt, meshed and ring systems should be unraveled. The line remains switched on the for the duration of the measurements.

The direction can be derived directly from the operational measured value. First make sure that the power measured values correspond to the power direction. Normally, it can be assumed that the forward direction (measuring direction) goes from the busbar toward the line.

Using the power measured values at the device or DIGSI 5, make sure that it corresponds to the power direction:

- **P** is positive if the active power flows in the line or protected object.
- **P** is negative if the active power flows to the busbar or out of the protected object.
- **Q** is positive if the inductive reactive power flows in the line or protected object.
- **Q** is negative if the inductive reactive power flows to the busbar or out of the protected object.

If the power measured values have a different sign than expected, then the power flow is opposite the current-direction definition. This can be the case, for example, at the opposite end of the line . The current-transformer neutral point then points in the direction of the protected object (for example line).

If the values are not as expected, it may be due to a polarity reversal at the voltage connection.

As a final step, switch off the system.

11.3 Direction Test of Ground Quantities for Directional Ground-Fault Functions

11.3.1 Overview

If the CT and VT connections are in the way that the ground quantities (3I0 and V0) are calculated by the device from the phase quantities, then, no additional directional test is required. Testing according to *11.2 Direction Test of the Phase Quantities (Current and Voltage Connection)* is sufficient.

If the ground current IN or the ground voltage VN is directly measured via a device input (usually I4 or V4), the correct polarity of the ground current and the ground voltage path must be checked.



DANGER

Live system parts! Capacitive coupled voltages on dead parts!

Noncompliance with the following measures can lead to death, serious physical injury, or considerable material damage.

✧ Primary measures may be performed only on dead and grounded system parts.

11.3.2 Directional Testing for Solid or Resistive-Grounded Systems

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

To generate a zero-sequence voltage V0, the e-n winding of one phase in the voltage-transformer set (for example, phase A) is bypassed, see *Figure 11-1*. If no connection on the e–n windings of the voltage transformer is provided, the corresponding phase is disconnected on the secondary side, see *Figure 11-2* . Only the current of the transformer in the phase of which the voltage is missing is transferred via the current circuit. If the line carries resistive-inductive load, the protection is subject to the same conditions as existing during a ground fault in line direction.

For directional testing, the **Directional ground-fault protection** function (67N) is configured and at least one stage is switched on. The pickup threshold of the stage must be below the load current of the line. If not, the binary input signal *(_:2311:501) >Test of direction* can be activated to lower the threshold temporarily for testing means without changing the respective parameter.

After switching the line on and off again, you can check the pickup signal of the directional protection stage in the fault log. A forward information must be logged. If no pickup information is logged at all, the 3I0 or U0 threshold is not exceeded.

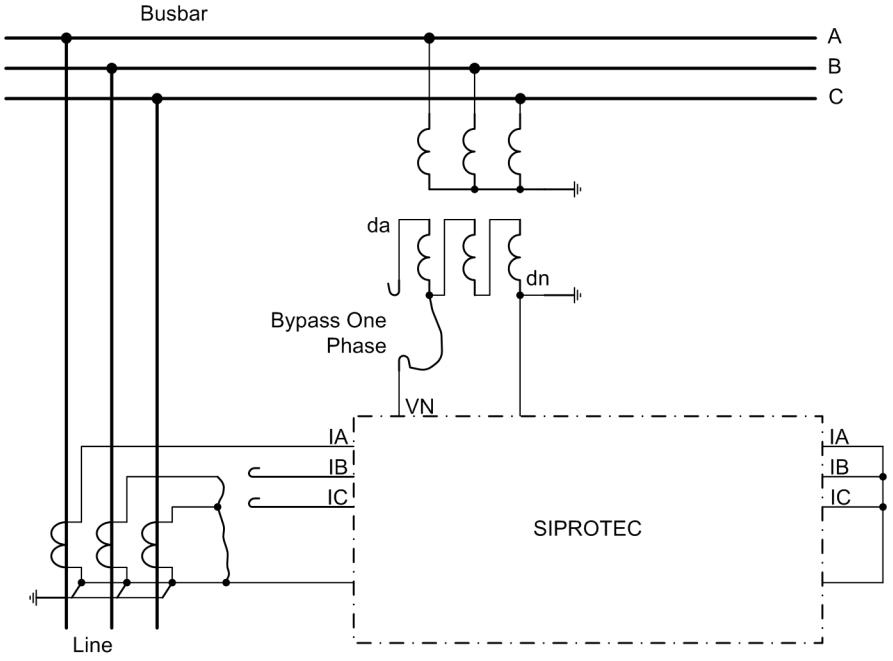
If a wrong direction is logged, one of the following conditions may have occurred:

- The direction of the load flow is from the line towards the busbar.
- The ground-current connection is incorrect.
- The voltage connection is incorrect.



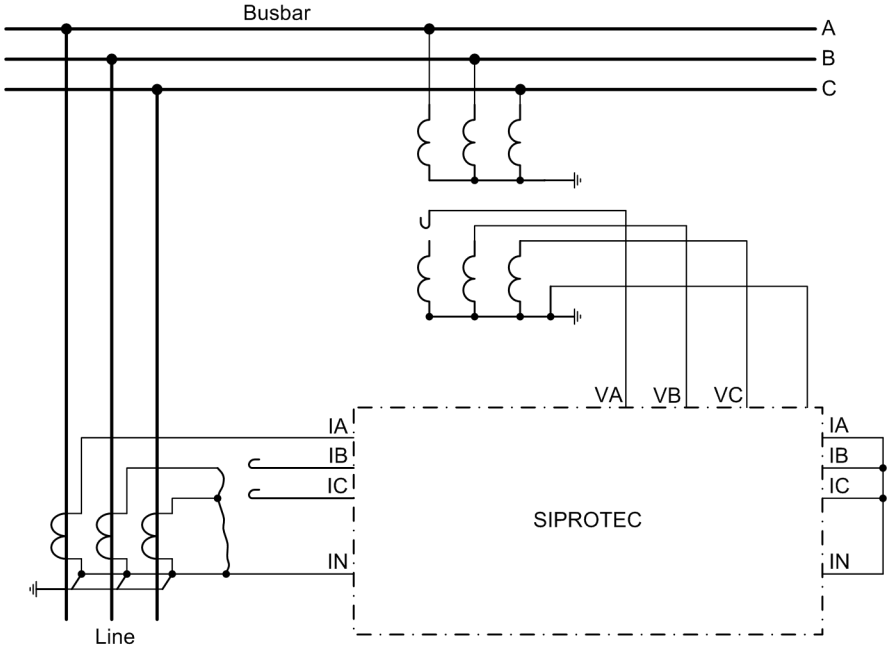
NOTE

Siemens recommends not to change parameter settings for the test. However, if parameters were changed for this test, they must be returned to their original state after completing the test!



[ConnPolarit1_diagram, 1, en_US]

Figure 11-1 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Broken-Delta Connection



[ConnPolarit2_201507, 1, en_US]

Figure 11-2 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Star Connection

11.3.3 Directional Testing for Isolated or Resonant-Grounded Systems

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

For directional testing, the **Directional sensitive ground-fault detection** function (67Ns) is configured and a directional stage is switched on. For example, the directional 3I0> stage with cos φ or sin φ measurement.

The most reliable test is the one with a primary ground fault. Proceed as follows:

- ✧ Isolate the line and ground it on both sides; on the farthest line end it must remain open during the entire test.
- ✧ Place a **1-phase** ground fault bridge on the line. For overhead lines, this can be done at an arbitrary location, in any case behind the current transformer (as seen from the busbar of the feeder to be tested). For cables, the grounding is done on the farthest end (sealing end).
- ✧ Remove the protective grounding from the line.
- ✧ Switch on the circuit breaker on the line to be tested.
- ✧ Check direction indicator (LED if routed).
- ✧ Check the indication *(_:302) Ground fault* in the ground-fault log or fault log with regard to its direction. The indication *(_:302) Ground fault forward* must be logged as direction information.

  If *backward* is determined as the direction, either with the current connections or the voltage connections, there is an inversion in the neutral path. For the display *unknown*, the ground current is probably too low.
- ✧ Switch the line off and ground it.

This completes the test.

11.4 Functional Test of Thermal Overload Protection

Secondary Test

For the secondary test for the overload protection, note that all setting parameters refer to primary variables of the protected object. The protection device extracts the current transformer ratio from the power-system data and internally performs the adjustments to device nominal variables. Take these characteristics into account for the test.

✧ Reset the thermal memory before you repeat the test. This is possible, for instance, via the binary input indication **>Reset thermal replica**. If the function is reparameterized or is switched off, the thermal replica will also be reset.

Test without Previous Load

✧ Test the operate time at 1.5 $I/I_{rated, obj.}$

In the example, the following power-system data are assumed:

$I_{rated, obj}$ = 483 A

$I_{rated, transf.prim}$ = 750 A

$I_{rated, transf.sec}$ = 1 A

The primary test current is 1.5 * 483 A = 724.5 A. This results in a secondary current of 724.5 A *1A/750A = 0.966 A. A secondary current of 0.966 A must therefore be supplied.

✧ Calculate the operate time with the following formula. Enter only primary variables here.

✧ Set $I_{previous\ load}$ = 0. The setting parameters reveal the **K-factor** (for example, 1.1) and the **Thermal time constant** (for example, 600 s or 10 min).

✧ Test from the cold state.

$$t = \tau_{th} \cdot \ln\left(\frac{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{preload}}{I_{rated,obj.}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot \ln\left(\frac{\frac{1}{1.1^2}\left(\frac{1.5I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 0}{\frac{1}{1.1^2}\left(\frac{1.5I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot 0.772 = 463\,s$$

[foauslpr-190309-01.tif, 2, en_US]

✧ At a current of 0.966 A supplied on the secondary side, the protection function must trip after 463 s.

Test with Previous Load

✧ The object rated current ($I_{previous\ load}$= $I_{rated, obj}$) flows at a previous load of 1 (100 %).

✧ Supply 483 A *1 A/750 A = 0.644 A in this case.

After a finite time (greater than 5 τ_{th}), the stationary previous load sets in.

K-factor

✧ If you abruptly increase the supplied secondary current from 0.644 A to 0.966 A (1.5 $I/I_{rated, obj}$), the overload protection will trip in the following time.

$$t = \tau_{th} \cdot \ln\left(\frac{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{preload}}{I_{rated,obj.}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot \ln\left(\frac{\frac{1}{1.1^2}\left(\frac{1.5I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - \frac{1}{1.1^2}\left(\frac{1.0I_{rated,obj.}}{I_{rated,obj.}}\right)^2}{\frac{1}{1.1^2}\left(\frac{1.5I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot 0.184 = 110\,s$$

[foauslpr-190309-02.tif, 2, en_US]

✧

NOTE

Owing to the relatively large time constants in practice, the tests are carried out with significantly reduced time constants. Reset the original setting value after completing the tests.

11.5 Primary and Secondary Tests of the Circuit-Breaker Failure Protection

Integration of the Protection Function into the Station

The integration of the protection function into the station must be tested in the real-life application. Because of the multitude of possible applications and possible system configurations, the required tests cannot be described here in detail.

NOTE

Always keep the local conditions, the station plans, and protection plans in mind.

NOTE

Siemens recommends isolating the circuit breaker of the tested feeder at both ends before starting the tests. Line disconnector switches and busbar disconnector switches must be open so that the circuit breaker can be operated without risk.

General Precautions

CAUTION

Tests on the local circuit-breaker of the feeder cause a trip command to the output to the adjacent (busbar) circuit breakers.

Noncompliance with the following measure can result in minor personal injury or physical damage.

✧ In a first step, interrupt the trip commands to the adjacent (busbar) circuit breakers, for example, by disconnection of the corresponding control voltages.

For testing the circuit-breaker failure protection, it must be ensured that the protection (external protection device or device-internal protection functions) cannot operate the circuit breaker. The corresponding trip command must be interrupted.

Although the following list does not claim to be complete, it can also contain points, which have to be ignored in the current application.

Test Modes

The device and the function can be switched to test mode. These test modes support the test of the function in different ways:

Test Modes	Explanation
Device in test mode	This operating mode is relevant for the following tests: 1. Approach of current thresholds in the case of an external start: Supervision of the binary input signals in the case of an external start is disabled. This setting allows a static activation of the starting signals in order to approach the current threshold. 2. Check whether the issued trip commands actuate the corresponding circuit breakers, because the device contacts are also actuated in the device test mode.
CBFP function in test mode (device is NOT in test mode)	This operating mode is important for function tests in which the generated operate indications are NOT supposed to actuate the binary outputs.

NOTE

When the function or device is in test mode, all indications are given a test bit.

NOTE

In the mode **Device in test mode**, the operate indications generated by the function operate the binary outputs.

The function must also be tested in its normal, switched-on condition.

Consider the following in this case:

- ✧ The device contacts are actuated.
- ✧ Binary input signal supervision (in the case of an external start) is enabled and blocks the function.
- ✧ All indications generated are generated without test bit.

Circuit-Breaker Auxiliary Contacts

When circuit-breaker auxiliary contacts are connected to the device, they make an essential contribution to the reliability of the circuit-breaker failure protection, provided that their settings are set accordingly.

- ✧ Make sure that the correct assignment has been checked.

Internal Starting Conditions (Trip Command from Internal Protection Function)

The internal start can be tested by means of tripping a protection function, for example, the main protection function of the device.

- ✧ Check the settings for circuit-breaker failure protection. See also chapter *6.39.4 Application and Setting Notes* .
- ✧ For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the Operating manual). It can also be a secondary test current.
- ✧ Generate the trip for the protection function. This can be generated within the device by a test sequence (see description in the Operating manual) or by creating corresponding secondary test values.
- ✧ The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

External Starting Conditions (Trip Command from External Protection Function)

If external protection devices are also able to start the circuit-breaker failure protection, the external starting conditions require checking.

- ✧ Check the settings for circuit-breaker failure protection.
  See also chapter *6.39.4 Application and Setting Notes* .
- ✧ For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the Operating manual). It can also be a secondary test current.
- ✧ Activate the binary input or inputs to which the start signal and possibly also the release signal for the CBFP function are routed. This can be done in 2 ways:
  – 1) Via internal test sequences
  – 2) By controlling the binary input or inputs via an auxiliary voltage
- ✧ Check the start input signal, and if available, check the enable input signal in the spontaneous or fault messages.
- ✧ Check the pickup indication in spontaneous or fault indications.
- ✧ The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

Start by Trip Command from the External Protection

- ✧ Check the static and - in case of 2-channel operation - also the dynamic supervision of the binary input signals. For this purpose, induce pickup of the supervision and check the supervision indications and the ready signal in the event log buffer.

Start by Trip Command from the External Protection without Current Flow

- ✧ If start is possible without current flow: (see **Start by trip command from the external protection**).

Repetition of the Local Tripping (T1)

- ✧ Make sure that the trip repeat signal controls a 2nd circuit (2nd coil) for switching off the circuit-breaker.

Backup Tripping in the Case of a Circuit-Breaker Failure (T2)

For tests in the station, it is important to check that the distribution of trip commands to the adjacent circuit breakers in the case of a circuit-breaker failure is correct. The adjacent circuit breakers are all circuit breakers, which must be tripped in order to ensure interruption of the short-circuit current if the feeder circuit-breaker fails. They are therefore the circuit breakers of all feeders which feed the busbar or busbar section to which the feeder with the fault is connected.

A general detailed test guide cannot be specified because the layout of the adjacent circuit-breakers depends largely on the system topology.

- ✧ With multiple busbars, the trip distribution logic for the adjacent circuit breakers must be checked.

  The test has to check for every busbar section that, in case of a failure of the feeder circuit-breaker under observation, only those circuit-breakers which are connected to the same busbar section are tripped.

Backup Tripping on Circuit-Breaker Failure (T2), Tripping of the Opposite End

If the trip command of the circuit-breaker failure protection must also trip the circuit-breaker at the opposite end of the tested feeder, the communication channel for this remote trip has to be tested as well.

- ✧ It is practical to test the communication channel for the remote trip while transmitting other signals in accordance with *11.15.1 Checking the Protection-Data Communication* .

Termination

- ✧ All temporary measures taken for testing must be undone, such as special switch positions, interrupted trip commands, changes to setting values, or individually switched off protection functions.

11.6 Circuit-Breaker Test

The **Circuit-breaker test** function enables you to easily perform a complete test of the trip circuit, the closing circuit, and the circuit breaker. For this, the circuit-breaker test carries out an automatic opening and closing cycle of the circuit breaker during operation.

NOTE

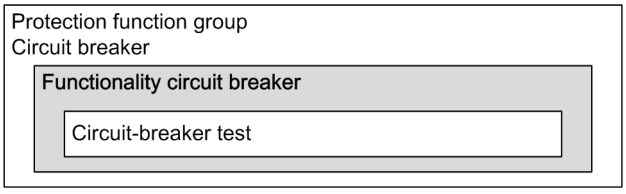
If the auxiliary contacts are not connected, a circuit breaker that has been opened may be permanently closed.

The following test program is available for you to carry out the circuit-breaker test.

No.	Test Program
1	3-phase open/closed cycle

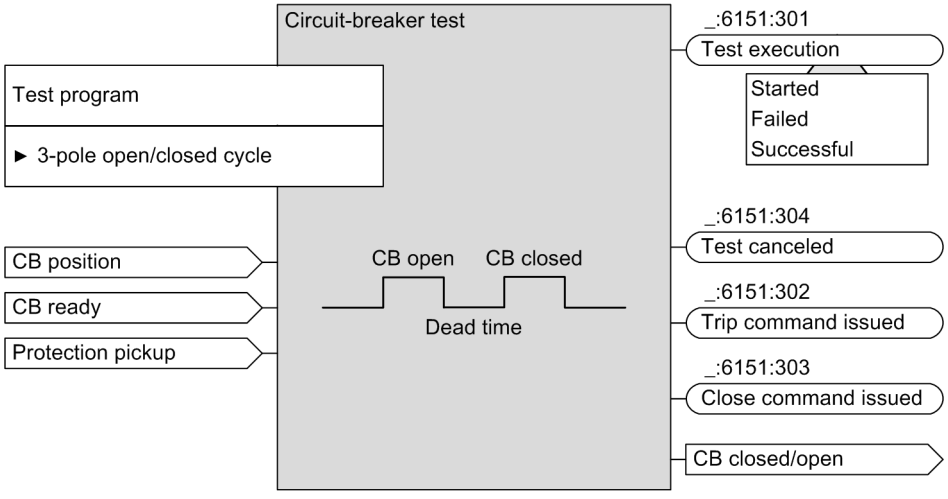
Structure of the Function

The **Circuit-breaker test** function is used in protection function groups for circuit breakers.



[dwcbch01-300913, 1, en_US]

Figure 11-3 Embedding of the Function



[dwcbc3p2-300913, 1, en_US]

Figure 11-4 Structure of the Function

Test Procedure

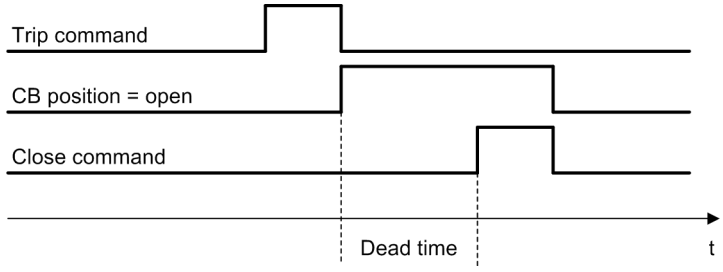
The following conditions must be satisfied before the circuit-breaker test can start:

- ✧ If a circuit-breaker auxiliary contact signals the position of the breaker pole to the device via the **Position** binary input, the test cycle is not initiated unless the circuit breaker is closed. If the circuit-breaker auxiliary contact has not been routed, you must ensure that the circuit breaker is closed.
- ✧ The circuit breaker must be ready for an open-closed-open cycle (indication **>Ready**).
- ✧ A protection function must not have been picked up in the circuit-breaker protection function group responsible for the circuit breaker.

Figure 11-5 shows the progression over time of an open-close test cycle.

If a circuit-breaker auxiliary contact is connected, the function waits for the indication circuit breaker **Position** = ***open*** after the trip command is generated. When the indication **Position** = ***open*** is received, the close command is transmitted after a dead time (parameter **(_:6151:101) Dead time**). If the feedback from the circuit-breaker positions is not received within the maximum transmission time (**Dead time**+ 2 · **Output time** + 5 s), the circuit-breaker test is aborted and considered to be failed. The proper functioning of the circuit breaker is monitored via the feedback on the circuit-breaker positions.

If the circuit-breaker auxiliary contact is not connected, the trip command is generated for the parameterized output time (parameter **(_:4261:101) output time**)). After the dead time (parameter **(_:6151:101) Dead time**) has elapsed, the close command follows, also for the duration of the parameterized time (**Output time**). In this case, you must ensure that the circuit breaker is closed.



[dwcbch03-300913, 1, en_US]

Figure 11-5 Progress over Time of a Circuit-Breaker Test Cycle

The **Circuit-breaker test** function is used in protection function groups for circuit breakers. If the actual **Circuit-breaker** functionality has been configured and wired further configuration is not necessary.

✧ You define the time between the trip command and the close command with the **(_:6151:101) Dead time** parameter.

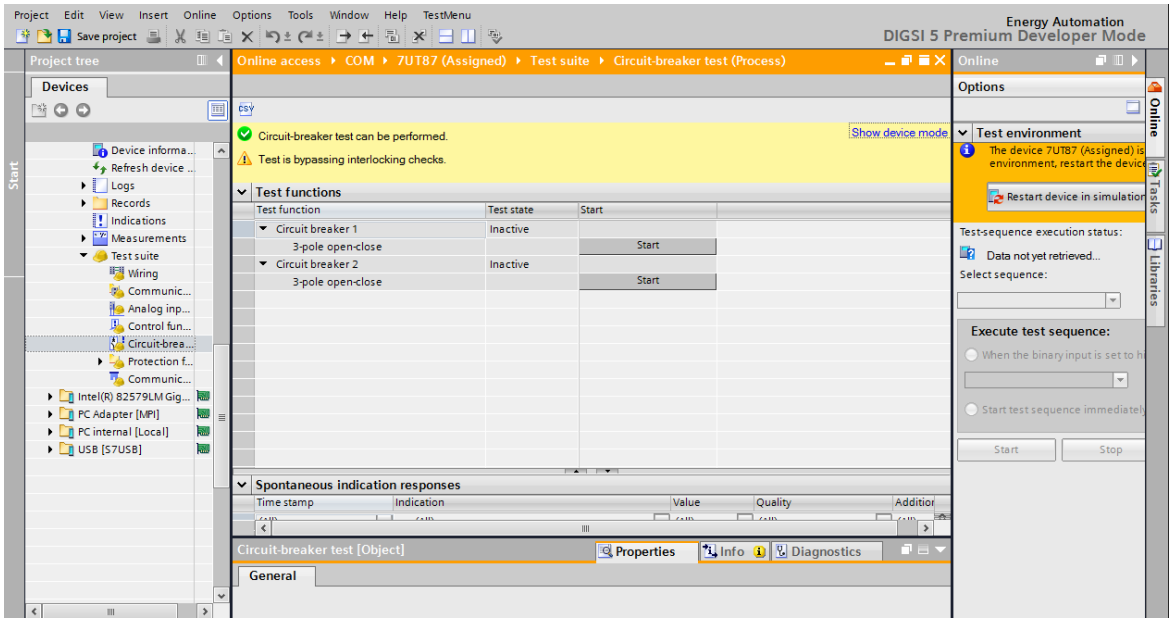
NOTE

The circuit-breaker test does not perform a synchrocheck even if the synchrocheck has been configured in the protection-function groups for circuit breakers. This may cause stability problems in the system during a 3-pole interruption. Therefore, a 3-pole circuit-breaker test should be very short, or not performed at all under load.

You can start the test program as follows:

- Via the device-control panel
- Via DIGSI
- Via control commands, which you can also connect in the CFC

The following figure illustrates operation of the circuit-breaker test in DIGSI.



[sccb_3pol, 1, en_US]

Figure 11-6 Circuit-Breaker Test in the Test Suite in DIGSI

- ✧ Select the function in the project tree on the left in the online access.
- ✧ Start the desired test program in the upper portion of the middle window.
- ✧ The corresponding feedback is displayed in the bottom portion of the middle window. Additional information about the behavior of other functions while the circuit-breaker test is being performed can be read in the operational log.

11.7 Functional Test of the Inrush-Current Detection

General

- ✧ For the test, make sure that the test current reflects the typical inrush current.
- ✧ Perform the test with transient signals. These can be recorded inrush currents or simulated currents from a transient system model.
- ✧ When using synthetic signals, observe the notes on the individual measuring principles.

Harmonic Analysis

- ✧ Superimpose on the fundamental-component current a test current of double frequency (2nd harmonic) and test the pickup behavior with this.
- ✧ Cause a threshold value excess (internal pickup) for one of the protection functions that you want to block.

  - or -

- ✧ Apply a test current with a load current as lead (current step).

The inrush current detection creates a blocking signal.

CWA Process

- ✧ Create a test current that has flat ranges of a minimum width of 3 ms simultaneously in all 3 phase currents.

The inrush current detection creates a blocking signal.

11.8 Functional Test of Transient Ground-Fault Protection

General

This function requires the correct polarity of the ground current IN and the neutral-point displacement voltage VN respectively the zero-sequence voltage V0. For the direction test of these quantities, refer to chapter *11.3 Direction Test of Ground Quantities for Directional Ground-Fault Functions*.

The function is based on the evaluation of the transient in the zero-sequence system after the ground-fault ignition.

For issuing the signal *(_:302) Ground fault*, the following 2 conditions must be met:

- There is a transient in the ground quantities.
- The fundamental compoment of the zero-sequence voltage V0 exceeds the threshold **(_:103) V0> threshold value**.

The following 2 methods are available for testing of the signal *(_:302) Ground fault* :

- Replaying real transient ground-fault recordings to the device
- Using secondary test equipment which allows to simulate transients ground faults

However, the setting of parameter **(_:103) V0> threshold value** cannot be tested precisely with the mentioned 2 methods, since this test requires a static V0. An easy way to test the setting is described in the following.

Secondary Test

This test must be carried out by injecting static secondary quantities. The test equipment needs to be configured in a way that it generates zero-sequence current 3I0 and zero-sequence voltage V0, which are injected to the SIPROTEC 5 device. By carrying out a shot, for example, a status change from zero-sequence values of 0 A and 0 V to the values not equal to zero, a transient is generated. The signal *(_:302) Ground fault* is issued as long as the static zero-sequence voltage of the 2nd state is greater than the set threshold. As amplitude for the secondary 3I0, 100 mA is a suitable value. In this test, the directional result contained in the signal *(_:302) Ground fault* is not defined and relevant, since the task is to test the setting of parameter **(_:103) V0> threshold value** only.

For testing the threshold, shots must be carried out with a static V0 slightly below the threshold and slightly above the threshold, for example, to 98 % and 102 % of the threshold value or to a threshold value of -0.2 V and +0.2 V (the greater absolute deviation of the threshold value must be selected) .

Consider that the V0 threshold is defined according to the definition of the symmetrical components. A full neutral-point displacement voltage VN of 100 V causes V0 = 57.7 V.

Example

- **(_:103) V0> threshold value** = 15 V
- 3 shots from 0 to V0 = 14.7 V and 3I0 = 100 mA
  No signal *(_:302) Ground fault* is issued.
- 3 shots from 0 to V0 = 15.3 V and 3I0 = 100 mA
  Signal *(_:302) Ground fault* is issued

If the test result is not as expected, check the injected static V0 voltage via the operational measurement of the device which contains the zero-sequence components.

11.9 Functional Test of the Trip-Circuit Supervision

General

- ✧ For the test, make sure that the switching threshold of the binary inputs is clearly below half the rated value of the control voltage.

2 Binary Inputs

- ✧ Make sure that the binary inputs used are isolated.

1 Binary Input

- ✧ Make sure that, in the circuit of the 2nd circuit-breaker auxiliary contact, an equivalent resistance R is connected.
- ✧ Observe the dimensioning notes under the section **Equivalent resistance R**.

11.10 Functional Test for the Phase-Rotation Reversal

- ✧ Check the phase sequence (direction of rotating field) at the device terminals. It must correspond to the setting of the **Phase sequence** parameter.
- ✧ The output indication *Phase sequence ABC* or *Phase sequence ACB* displays the determined phase sequence. This must correspond to the phase sequence that was set.
- ✧ You can also determine the phase sequence via the **Symmetrical components** measured values. If you obtain negative-sequence system variables (V_2, I_2) and no positive-sequence system variables (V_1, I_1) with symmetrical 3-phase infeed, the setting parameter **Phase sequence** does not correspond to the connection.

11.11 Functional Test for Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Checking the Stator Ground-Fault Protection with the Machine

You have to check whether the protection function and the protection ranges are functioning correctly. The following tests are intended for the unit connection.

You can check the protection range by performing a test with a ground fault at the generator terminals. The ground fault test in the power system enables you to verify the noise suppression of the load resistor.

Checking the Protection Range with a Machine Ground Fault



DANGER

Touching live parts or reaching into rotating machines will result in death or serious injury.

- ✧ Perform primary measures only when the machine is at standstill and the system components are de-energized and grounded.

- ✧ Insert a 1-phase-to-ground jumper into the terminal circuit of the machine.
- ✧ Set the **Mode** parameter in the protection stage to ***test***. This prevents the trip command from being generated for the stage.
- ✧ Start the machine and excite it slowly up to approx. 20 % of the rated machine voltage.
- ✧ From the operational measured values, check the plausibility of the zero-sequence voltage V_0 and the input voltage at the connected input.
- ✧ Determine the protection range from the pickup voltage.
  The following applies for the protection range S:

$$S = \frac{\frac{V_{NG}}{\sqrt{3}} - V_{0,\text{pickup value}}}{\frac{V_{NG}}{\sqrt{3}}} \cdot 100\,\%$$

[foschzbe-130309-01.tif, 2, en_US]

Example: Measurement with secondary voltages

V_{NG} Generator voltage transformed to the transformer secondary side = 100 V

$V_{0,\text{ pickup value}}$: Measured zero-sequence voltage at pickup = 5.68 V

S: Resulting protection range = 90 %

- ✧ Check the messages in the message buffer. If the **Detection of faulty phase** parameter is set to ***yes***, check the display of the phase affected by the fault.
- ✧ Shut the machine down and remove the ground fault bridge.
- ✧ Set the **Mode** protection stage parameter to ***on***.

Checking Disturbance-Voltage Suppression in the Load Resistor with a System Ground Fault

DANGER

Touching live parts or reaching into rotating machines will result in death or serious injury.

✧ Perform primary measures only when the machine is at standstill and the system components are de-energized and grounded.

✧ With the primary system de-energized and grounded, insert a 1-pole ground fault bridge on the high-voltage side of the unit transformer.

CAUTION

Material can be damaged during the test if there is a neutral-point grounding at the transformer and simultaneously a grounding on the high-voltage side.

✧ Neutral grounding at the transformer must be interrupted during the test.

✧ Start the machine and excite it slowly up to 30 % of the rated machine voltage.

✧ Read the zero-sequence voltage $V_{0,\ measured\ value}$ from the operational measured values.

✧ Extrapolate the zero-sequence voltage to 100 % of the machine voltage ($V_{0,\ fault}$).

✧ Calculate the safety margin by dividing the calculated fault value by the set threshold value.

If the result is less than 0.5, the safety margin is sufficient. If the fault voltage is lower, you can increase the sensitivity of the protection function.

EXAMPLE:

$V_{0,\ meas.}$ = 0.75 V

$V_{threshold\ value}$ = 5.68 V

$V_{0,\ fault}$ = 0.75 V * 100 % / 30 % = 2.5 V

Safety margin = 2.5 V / 5.68 V = 0.44

The calculated safety margin of 0.44 is sufficient because it is below 0.5.

✧ Shut the machine down and de-excite it. Remove the ground-fault bridge.

✧ Restore neutral-point grounding if you require grounded operation of the neutral on the high-voltage side of the unit transformer.

When using the function for startup ground-fault protection on a busbar connection, carry out the same check as for the unit connection, but only the part **Test during machine ground fault**.

11.12 Primary and Secondary Testing of the Synchronization Function

Measuring the Circuit-Breaker Closing Time

Under asynchronous system conditions, the circuit-breaker closing time must be measured and set correctly. This achieves an exact parallel switching with a phase angle 0°. If switching occurs only in synchronous system conditions, this section can be skipped.

The closing time can be determined via the following 2 methods:

- 1. By reading from a fault record (recommended method)
- 2. With external timer

1. A simple option for determining the closing time involves reading out the time between the close command and closure of the switch pole via the fault record. The time determined here is the real closing time and not the operating time of the circuit beaker. You do not have to add any further time.

Siemens recommends the following procedure:

✧ Establish a condition in which the circuit breaker can be closed without hazard.

✧ If V2 switching through, activate the operating mode **Close cmd. at V1< & V2>** for the synchronization stage by setting to ***yes***.

If V1 is switched through, activate the operating mode **Close cmd. at V1> & V2<**.

✧ Make sure that the fault recorder is turned on. Via a temporary CFC chart, link the signal **Release close cmd.** of the active synchronization stage to the binary input signal **>Manual start** (of the fault recorder). With the release of closure, a fault record of the parameterized duration is set up (the default setting of 500 ms is more than adequate for this).

✧ Starting the synchronization stage. The device activates immediately.

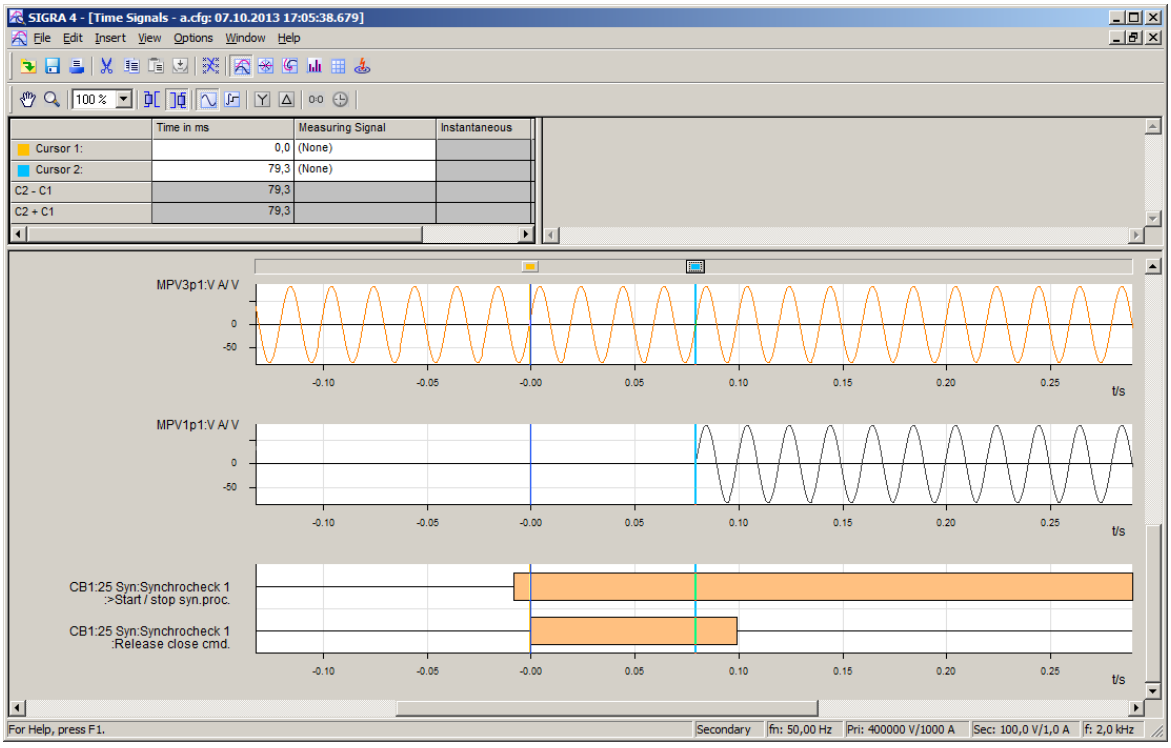
✧ Read the fault record and determine the closing time via SIGRA (see *Figure 11-7*).

Use the 2 cursors and the time-measuring function for this. Position the first cursor on the raising close command. The occurrence of the second voltage signals the closed power-switching poles. Place the second cursor on the raising second voltage.

✧ Set the determined time with the **CB make time** parameter. Round off to the next lower adjustable value. Proceed in the same way for all other sync stages.

✧ Set the parameter **Close cmd. at V1< & V2>** or parameter **Close cmd. at V1< & V2<** back to its original value.

✧ Delete the CFC chart.



[scsyn001-170510-01.tif, 1, en_US]

Figure 11-7 Measurement of the Circuit-Breaker Closing Time

2. The arrangement in *Figure 11-8* is suitable for measuring the circuit-breaker operating time with external timer. Set the timer to the range 1 s or a tripping of 1 ms.

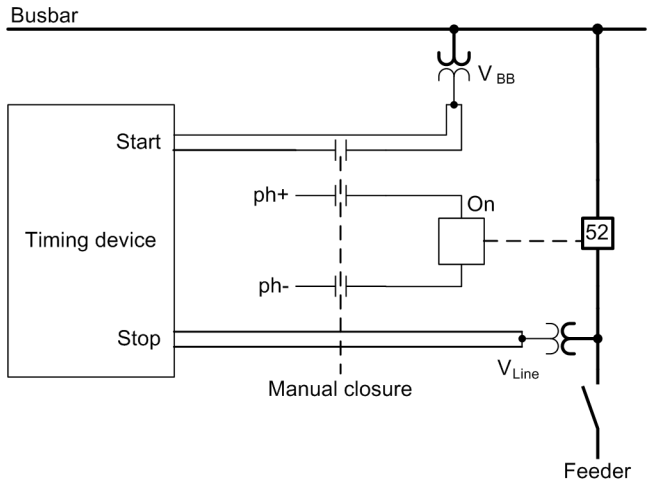
Connect the circuit breaker manually. The timer is started simultaneously by this. After the poles of the circuit breaker close, the voltage V_{Line} appears. The timer is then stopped.

If the timer is not stopped owing to an unfavorable closing moment, repeat the attempt.

Siemens recommends calculating the average value from several (3 to 5) successful switching attempts.

NOTE

Add the command output time of the protected device to measured time. This exclusively depends in good approximation on the binary output used for the close command. You can find the switching times for the different binary outputs in the Technical data. Set the total time with the parameter **`CB make time`**. Round off to the next lower adjustable value. Proceed in the same way for all other synchronization stages used.



[dwsynae6-080211-01.tif, 1, en_US]

Figure 11-8 Measurement of the Circuit-Breaker Closing Time

Checking the Measurement Chain

The measurement chain for the voltage measurement must be checked. As soon as one of the synchronization stages to be used is closed, all the necessary functional measured values are calculated. The synchronization stage, thus, does not have to be started for this check.

Proceed as follows when checking the measurement chain as a primary or secondary test:

a) As primary test

✧ Establish a synchronous state by closing the circuit breaker, if possible.

✧ Check the functional measured values within the synchronization function:

– The delta values must be 0.

– Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.

– Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

b) As secondary test

✧ Establish a synchronous state by applying synchronous voltage values at both measuring points.

✧ Check the functional measured values within the synchronization function:

– The delta values must be 0.

– Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.

– Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

Blind Switching Attempts when Used in Machines

Perform blind switching attempts when using the function in machines.

Requirement:

✧ You have checked the setting values again.

✧ The circuit breaker is switched off. The close command for the circuit breaker is interrupted (disconnecting the close command). The system voltage is switched through for the measurement.

a) Attempt with asynchronous systems:

✧ Via manual control set the generator to a speed slightly below the permitted frequency difference according to the setting values **`Max. frequency diff. f2>f1`** and **`Max. frequency diff. f2<f1`**. The generator is excited to line voltage. You can read out the values in the operational measured values.

- ✧ Start the synchronization stage, for example, externally with binary input signal or via the integrated controller. You can use a synchroscope to trigger the start at synchronism, that is, at **12 hours**. The duration until the close command then corresponds to a cycle with the duration 1/Δf. At a frequency difference of 0.1 Hz, the duration is thus 10 s.
- ✧ Insofar as permissible, perform this attempt several time for oversynchronous switching and subsynchronous switching.
- ✧ The switching performance can be checked with an external recorder or the integrated fault recording function. You have to start the fault recording explicitly.
- ✧ You can repeat the blind switching attempts at the limits of the permissible voltage difference.

b) Attempt with synchronous systems:

- ✧ Start the synchronization stage, for example, externally with binary input signal or via the integrated controller.
- ✧ Check the proper release for activation with the message log or via a fault record. You have to start the fault recording explicitly. All activation conditions have to be fulfilled within the time **Delay close command**.

  If you observe the change between synchronous and asynchronous operation, raise the changeover threshold **f-threshold ASYN<->SYN** slightly.

c) Attempt with synchrocheck:

- ✧ If you use this function in conjunction with the manual synchronization, check the proper release for closure.
- ✧ Synchronize the generator manually. Start the synchronization stage externally via a binary input. Check the proper release for closure with the indicatiion log or via the fault record. You have to start the fault recording explicitly.

11.13 Testing the Negative-Sequence Current

When testing, keep in mind that the measured values are standardized. In the setting $I_2/I_{rated, obj.}$, they are standardized to the rated current of the protected object. The conversion to secondary transformer values is accomplished in the device.

EXAMPLE:

The threshold value is set to 10 % of the protected object.

Transformer: 100 A/1 A

Rated current of the protected object: 80 A

Action Steps

✧ At a setting of 10 %, the primary negative-sequence current is 80 A • 10 %/100 % = 8 A.

For a current transformer ratio of 100, test with a secondary current of 0.08 A.

✧ With a transformer of 100 A/5 A, the test current is higher by the factor 5. Test with 0.4 A. The pickup value is at 1.1 • 0.4 A = 0.44 A.

✧ If deviations occur during the testing, you must check whether the power-system data were entered correctly.



NOTE

Keep in mind that the function works starting from the set minimum current.

11.14 Reverse Power Protection

11.14.1 Secondary Test

When performing the secondary test, note that the setting value for the reverse power refers to the machine variables. Due to the mismatching of the current transformer, you must check with reduced currents. You can deduce the reduction from the ratio $I_{rated, generator}$/ $I_{rated, CT}$. Check the reverse-power protection at rated voltage.

If the voltage transformer is not adjusted to the rated generator voltage, correct the secondary voltage, too. Use the following ratio:

$V_{rated, generator}/V_{rated, VT}$

11.14.2 Primary Test

For measurements on the protection current transformers and with sensitive setting of the reverse-power protection, Siemens recommends determining the reverse power and the angle-correction values. Regardless of the generator excitation, that is regardless of the reactive power Q, the reverse power P as a pure active power is constant. The resulting characteristic curve is a straight line that runs parallel to the Q axis. Due to possible angle errors of current transformers and voltage transformers, the protection device does not measure a constant active power. The current flowing at this time, which can be assumed as being proportional to the reactive power, has a substantial influence.

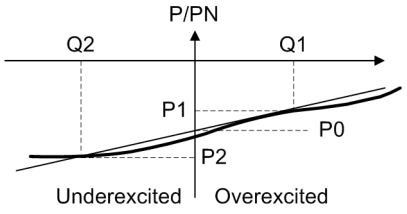
The deviations are determined with 3 measurements and the correcting quantity φ_{corr} is determined from the results.

To calculate the correction angle, enter the active power and reactive power measured with the device in the following table.

Use the functional measured values **`P1avg`** and **`Q1avg`** (type averaged).

Table 11-1 Value Table for Angle Correction

State	Reverse Power	Reactive Power
Reactive power near zero	P_0 =	Q_0 =
Overexcited	P_1 =	Q_1 =
Underexcited	P_2 =	Q_2 =



[dw_RPP_02, 1, en_US]

Figure 11-9 Determining the Correction Angle φ_{corr}



CAUTION

Be careful if you operate the turbine without a certain minimum steam flow (cooling effect).

Operating the turbine without a certain minimum steam flow (cooling effect) can overheat the turbine blades!

✧ The consumption of reverse power for a turbo-generator set is only allowed for a short time!

CAUTION

If the generator is underexcited, there is the risk of an out-of-step condition!

Non-observance of the following measures can result in minor personal injury or material damage.

✧ The following measures prevent the risk of an out-of-step condition.

✧ Regulate the driving power to 0 by closing the control valves. The generator draws its reverse power from the electrical power system.

✧ Change the excitation until the reactive power Q = 0. As a control measurement, read the active power P_0 and the reactive power Q_0 with the sign, and enter the values in *Table 11-1* .

✧ Increase the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (overexcited).
Read the reverse power P_1 with the sign (negative) and the reactive power Q_1 with the sign (positive) in the functional measured values and note these 2 values in the values table.

✧ Reduce the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (underexcited).
Read the reverse power P_2 with the sign (negative) and the reactive power Q_2 with the sign (negative) in the functional measured values and note these 2 values in the values table.

✧ Run the generator again at no-load excitation and select the desired operating state.

✧ With the measured value pairs (P_1, Q_1 and P_2, Q_2), calculate the correction angle φ_{corr} with the following formula:

$$\varphi_{corr} = \arctan \frac{P_1 - P_2}{Q_1 - Q_2}$$

[fo_RPP_01, 1, en_US]

NOTE

Insert the power values with the signs that you read previously!

✧ Enter this angle φ_{corr} with the same sign as the new correction angle (parameter ***(_:2311:101) Angle correction***):

Setting value ***(_:2311:101) Angle correction*** = φ_{corr}

✧ You can determine the pickup value of the reverse-power protection from the measured values P1 and P2.

Use the following formula: $P_{pickup} = (P_1+P_2)/4$

Set the value as pickup value: Parameter **(_:991:3) Threshold** = ***Ppickup***

Check of the Reverse-Power Protection

With a generator that is connected to the power system, the reverse power results from closing the control valves or from closing the quick stop.

✧ In both cases, check the consumed active power (reverse power). The valves could be leaking.

✧ Repeat the reverse-power measurement to confirm that the settings are correct.

✧ To check the efficiency of the reverse-power protection on the basis of the indications, use the parameter **(_:991:1) Mode** to switch the reverse-power protection to ***test*** .
Proceed as follows:

- ✧ Start the generator and synchronize it with the power system.
- ✧ Close the control valves.
- ✧ From the functional measured value, take the reverse power that was measured by the protection device as the active power. Use 50 % of the functional measured value as setting value for the reverse-power protection.
- ✧ Increase the driving power up to normal operation.
- ✧ Check the quick-stop criterion.
  Proceed as follows:



NOTE

Make sure that the binary input **>Stop valve closed** is properly routed. The quick-stop criterion (the pressure-operated switch or the limit switch on the quick-stop valve) must control this binary input.

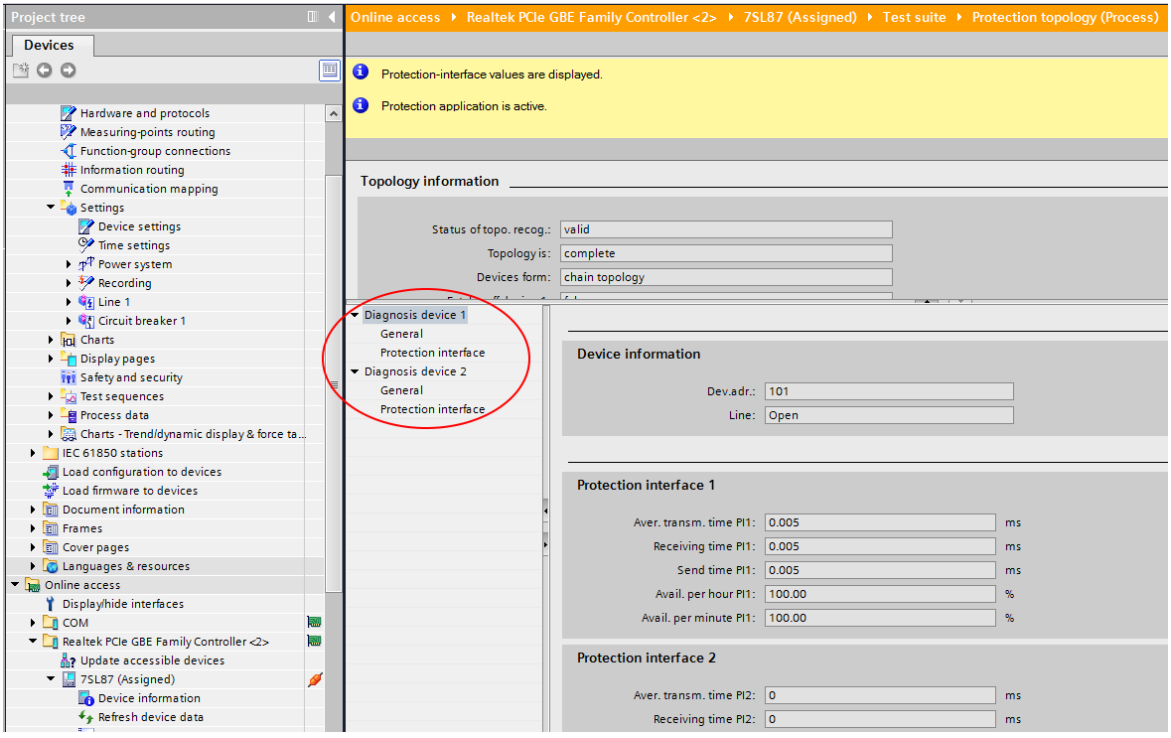
- ✧ Close the quick-stop valve.
- ✧ From the functional measured value **P1avg** , take the reverse power that was measured by the protection device as the active power.
- ✧ If – contrary to expectations – this value is smaller than the reverse power when the control valves are closed, take 50 % of this value as the setting value for the reverse-power protection.
- ✧ Shut down the machine by activating the reverse-power protection. Set the parameter **(_:991:1) Mode** to ***on*** .

11.15 Functional Test Protection Communication

11.15.1 Checking the Protection-Data Communication

Checking the Protection-Data Communication

If the devices are connected to one another via the protection interface and switched on, they contact each other automatically. If, for example, device 1 recognizes device 2, the successful connection is indicated (see next figure). Accordingly, each device signals to all devices that aProtection-data communication is available.



[scprotec, 1, en_US]

Figure 11-10 Connection Establishment in DIGSI 5

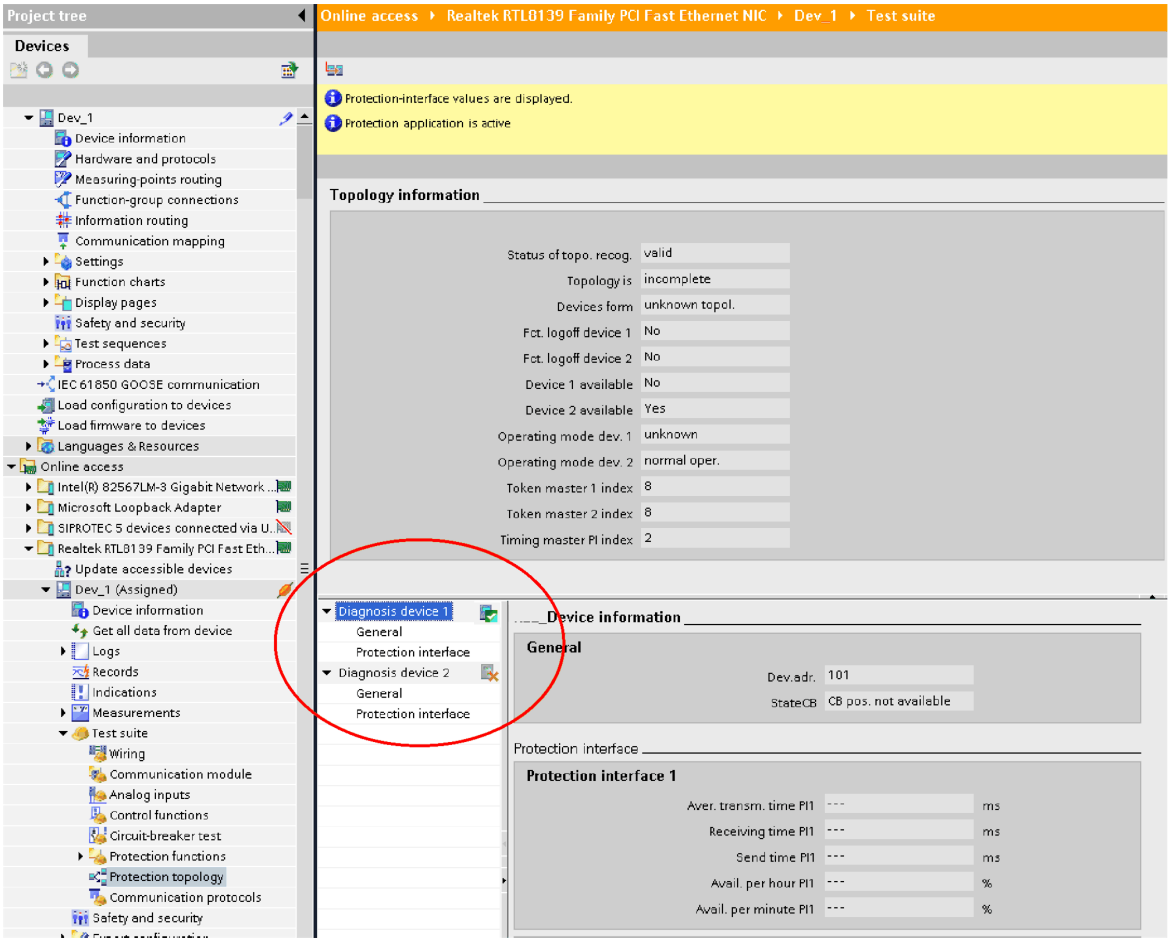
Proper communication of the devices among each other can be supervised during operation.

✧ Check the connections for each protection interface in DIGSI 5.

If a connection is successfully established, the field **Status of topo recog.** shows the indication *valid* in DIGSI 5 (see *Figure 11-10*).

If 2 devices are parameterized incorrectly, the **Status of topo recog.** field shows the indication *invalid* (see *Figure 11-10*).

In *Figure 11-11* there is no protection-data communication between device 1 and device 2, that is, the protection interfaces 1 and 2 of device 1 do not receive data. The transmission of protection data is interrupted and differential protection is ineffective. One reason for this can be a remote control with DIGSI via the protection interface. In this case, the protection connection is interrupted and the connection is used exclusively for DIGSI.



[scprotco-061210-01.tif, 1, en_US]

Figure 11-11 Protection-Data CommunicationDeactivated

11.15.2 Directional Test

In the case of protection interfaces of type 1 and type 2, the complex phasors of the voltage and current measuring point are exchanged between devices of one communication topology in order to be able to carry out a directional test during commissioning, for example. DIGSI 5 depicts this in the form of a phasor diagram. You can only route the measuring point to the protection interface. For 1 1/2 circuit-breaker layouts, a measuring point can therefore be transferred and checked optionally. You can also check and test the 2nd measuring point by rerouting. Furthermore, communication with DIGSI 5 can take place via the protection interface to other devices of the constellation. For this purpose, the protection-interface connection is interrupted and DIGSI 5 uses this connection for communication with the remote device.

✧ After completing the remote connection by DIGSI 5, the system switches back over to protection communication.

11.16 Functional Test for Overexcitation Protection

Secondary Test

NOTE

While performing the secondary test, ensure that the data of the protected object refer to the protection function.

This means that a mismatch between the voltage transformer and the protected object will be corrected automatically. For instance, when applying the secondary rated voltage and the rated frequency, this must not result in a V/f value of 1.

The mismatch of the voltage transformer must be taken into consideration when selecting the test voltage. Multiply the secondary test voltage with the following 'k' factor.

$$k = \frac{V_{rated,obj}}{V_{rated,transf.}}$$

[fokfakuf-070513-01.tif, 1, en_US]

Example

$V_{rated,obj}$ = 110 kV; $V_{rated,\ transf.}$ = 100 kV

It follows from the above that k = 1.1. For example, when verifying the nominal conditions if the secondary rated voltage is 100 V, a voltage of 1.1 * 100 V = 110 V must be supplied. The measured value of the function **Measured value V/f** must display 1.0000.

NOTE

When checking the dependent stage, ensure it is associated with a **thermal replica**. When repeating a test, always reset the replica, using the binary input indication **>Reset therm. replica** (_:13951:501).

Primary Test

The plausibility check between instantaneous overexcitation and the displayed operational measured value is used to verify the functionality of overexcitation.

Instantaneous overexcitation is a result of the following function:

$$\frac{V}{f} \cdot \frac{f_{rated}}{V_{rated}}$$

[fomoweuf-070513-01.tif, 1, en_US]

where:

V	Instantaneous voltage
V_{rated}	Primary rated voltage of the protected object
f	Instantaneous frequency in f
f_{rated}	Rated frequency

11.17 Functional Test Differential Protection for Capacitor Banks

11.17.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following chapter *11.17.2 Primary Tests*, because they cannot include connection faults.

Secondary tests are used to check the following:

- Checking the setting values
- Proper reaction of the protection function
- Engineering (for example, routing the respective logic signals, display images with measured values, logics in CFC, and much more)

If you want to perform secondary tests, observe the following instructions.



NOTE

For tests with secondary test equipment, ensure that no other measurands are connected and the trip commands to the circuit breakers are interrupted, otherwise, the circuit breakers could be activated.

Perform the tests with the current setting values for the device. If these values are not (yet) present, check with the default values.



NOTE

The measuring accuracy to be attained depends on the electrical data of the test sources. The accuracies stated in the Technical Data can be expected only if the reference conditions stipulated in VDE 0435/ part 303 and IEC 60255 are ensured and precision instruments are used. The stated tolerances refer to the default data for the protected objects. If the rated current of the protected object in relation to the rated current of the current transformer deviates considerably from the rated current of the device, you must assume higher response tolerances.

For differential protection, you can check each side separately. This corresponds to the simulation of a fault supplied from one side. If a side has several measuring points, the measuring inputs not included in the test carry no current. The pickup value is tested by increasing the test current slowly.



NOTE

Tests of currents via quadruple device-rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find more information in chapter *12.28 Differential Protection for Capacitor Banks*. Interrupt testing to allow cool-down!

The set pickup values refer to symmetrical 3-phase current in the case of 3-phase protected objects.

If you are testing parameters set during operation, you must ensure that the setting value for the differential protection refers to the rated current of the protected object.

If you wish to check the characteristic curve, Siemens recommends using the standard testing programs of digital test equipment. For the manual checking of points on the characteristic curve, feed in a **through-flowing** current which corresponds to a current value on the stabilization axis. Then change the phase angle of the test current on one side, so that the necessary differential current is achieved. Check a value with a tolerance of 5 % above and below the point on the characteristic curve which is to be tested.

For capacitor banks, the actual pickup values for 2-phase testing also depend on the vector group of the capacitor bank.

To obtain the actual pickup value, multiply the setting value by a vector-group factor k_{SG} according to the following formula:

$$\frac{I_{\text{rated transf.}}}{I_{\text{rated transf. prim}}} k_{SG}$$

[foscgrfa-170712-01.tif, 1, en_US]

The following table shows this factor k_{SG} in dependence of the vector group and the fault type.

Table 11-2 Correction Factor k_{SG} for the Vector Group (SG) and Fault Type

Fault Type	Reference Winding (High Voltage)	Even SG Number (0, 2, 4, 6, 8, 10)	Odd SG Number (1, 3, 5, 7, 9, 11)
3-phase	1	1	1
2-phase	1	1	$\sqrt{3}/2 \approx 0.866$
1-phase with I_0 elimination	3/2 = 1.5	3/2 = 1.5	$\sqrt{3} \approx 1.73$
1-phase without I_0 elimination	1	1	$3/(1+\sqrt{3}) \approx 1.1$

11.17.2 Primary Tests

Restricted primary testing is possible for capacitor-bank applications. A wiring fault in the connection to the system could be a possible cause of the fault. With the system at a standstill, you can apply a test current of approx. 10 % to 20 % of the rated current directly to the transformer terminals and connected transformer with a primary testing device. Simulate a load (through-flowing current). The differential current must be 0 and the restraint current is the current which is fed in.

To rule out overfunction on initial switch-on, for example, due to the incorrect installation of a transformer, Siemens recommends switching the differential protection to test mode. The protection function operates, but does not issue a trip command. With the protection measurement values in the fault log, check the differential and the restraint current. The differential current must be 0 and the restraint current must correspond to the actual capacitor current.

If the differential protection is functioning correctly, switch the protection function **ON**.



NOTE

If the differential protection is disabled (for example, function in test mode), an overcurrent protection must be active as short-circuit protection (without delay and set via the starting current).

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12.1 General Device Data

12.1.1 Analog Inputs

Current Inputs

All current, voltage, and power data are specified as RMS values.			
Rated frequency f_{rated}	50 Hz, 60 Hz		
Protection-class current transformers	Rated current I_{rated}	Measuring range of the modular devices	Measuring range of the non-modular devices
	5 A	0 A to 500 A	0 A to 250 A
	1 A	0 A to 100 A	0 A to 50 A
Instrument transformers	5 A	0 A to 8 A	0 A to 8 A
	1 A	0 A to 1.6 A	0 A to 1.6 A
Power consumption per current circuit at rated current	Approx. 0.1 VA		
Thermal rating (protection and instrument transformers)	500 A for 1 s		
	150 A for 10 s		
	20 A continuously		
	25 A for 3 min		
	30 A for 2 min		
Dynamic load-carrying capacity	1250 A one half wave		

Voltage Input

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
Input and output modules	IO202/IO208/IO211/IO214	IO215
Measuring range	0 V to 200 V	0 V to 7.07 V
Input impedance	< 0.1 VA	< 0.01 VA
Thermal rating	230 V continuously	20 V continuously

Measuring-Transducer Inputs (via Module ANAI-CA-4EL)

Connector type	8-pin multiple contact strip
Differential current input channels	4
Measuring range	DC -24 mA to +24 mA
Fault	< 0.5 % of measuring range
Input impedance	140 Ω
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 20 V
Galvanic separation from ground/ housing	DC 700 V
Permissible overload	DC 100 mA continuously
Measurement repetition	200 ms

Measuring-Transducer Inputs (via Module ARC-CD-3FO)

Connector type	AVAGO AFBR-4526Z
Number of transceivers	3

Fiber type	Polymer Optical Fiber (POF) 1 mm
Receiver	
Maximum	-10 dBm ± 2 dBm
Minimum	-40 dBm ± 2 dBm
Spectrum	400 nm to 1100 nm
Attenuation	In the case of plastic optical fibers, you can expect a path attenuation of 0.2 dB/m Additional attenuation comes from the plug and sensor head.
Optical budget [1]	Minimal 25 dB
Analog sampling rate	16 kHz
ADC type	10-bit successive approximation
Transmitter	
Type	LED
Wavelength	λ = 650 nm
Transmit power	Minimum 0 dBm Maximum 2 dBm
Numerical aperture	0.5 [2]
Signal rate connection test	1 pulse per second
Pulse duration connection test	11 µs
Comment: [1] All values in combination with sensors approved by Siemens. [2] Numerical aperture (NA = sin θ (launch angle))	

High-Speed Measuring-Transducer Inputs, Voltage/Current (via IO210, IO212)

NOTE

Current and voltage may not be connected to a measuring-transducer input at the same time; only either current or voltage may be connected. Due to EMC, no line may be connected to an input that is not used (current or voltage).

Use shielded cables.

Table 12-1 High-Speed Measuring-Transducer Inputs, Voltage

Differential voltage input channels	8[27]
Measuring range	DC -10 V to +10 V
Fault	< 0.5 % of the measuring range
Input impedance	48 kΩ
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation from ground/ housing	DC 3.5 kV
Permissible overload	DC 20 V continuously DC 60 V continuously (IO210 MT3 terminal point C9)
Measurement repetition	62.5 µs

Table 12-2 High-Speed Measuring-Transducer Inputs, Current

Differential current input channels	8[28]

[27] The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or as a current input.
[28] The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or as a current input.

Measuring range	DC -20 mA to +20 mA
Fault	< 0.5 % of the measuring range
Input impedance, current	12 Ω
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation from ground/ housing	DC 3.5 kV
Permissible current overload	DC 100 mA continuously
Measurement repetition	62.5 µs

12.1.2 Supply Voltage

Integrated Power Supply			
For modular devices, the following printed circuit-board assemblies have a power supply: PS201 – Power supply of the base module and of the 1st device row PS203 – Voltage supply of 2nd device row CB202 – Plug in module assembly with integrated power supply, for example, to accommodate communication modules			
Permissible voltage ranges (PS201, PS203, CB202)	DC 19 V to DC 60 V	DC 48 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz	
Auxiliary rated voltage V_H (PS201, PS203, CB202)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/DC 125 V/DC 220 V/ DC 250 V or AC 100 V/AC 115 V/AC 230 V, 50 Hz/60 Hz	
Permissible voltage ranges (PS101)	DC 19 V to DC 60 V	DC 48 V to 150 V	DC 88 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz
Auxiliary rated voltage V_H (PS101)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/ DC 125 V	DC 110 V/ DC 125 V/ DC 220 V/DC 250 V or AC 100 V/AC 115 V/ AC 230 V, 50 Hz/60 Hz
Superimposed alternating voltage, peak-to-peak, IEC 60255-11		≤ 15% of the DC auxiliary rated voltage (applies only to direct voltage)	
Inrush current		≤ 18 A	
Recommended external protection		Miniature circuit breaker 6 A, characteristic C according to IEC 60898	
Internal fuse			
–	DC 24 V to DC 48 V	DC 60 V to DC 125 V	DC 24 V to DC 48 V AC 100 V to AC 230 V
PS101	4 A intert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
PS201, PS203, CB202	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20		
Power consumption (life relay active)			
–	DC	AC 230 V/50 Hz	AC 115 V/50 Hz

Integrated Power Supply			
1/3 base module, non-modular Without plug-in modules	7.0 W	16 VA	12.5 VA
1/3 base module, modular Without plug-in modules	13 W	33 VA	24 VA
1/6 expansion module	3 W	6 VA	6 VA
1/6 plug-in module assembly without plug-in modules (modules CB202)	3.5 W	14 VA	7 VA
Plug-in module for base module or plug-in module assembly (for example, communication module)	< 5 W	< 6 VA	< 6 VA
Stored-energy time for auxiliary voltage outage or short circuit, modular devices		For V ≥ DC 24 V ≥ 50 ms For V ≥ DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 50 ms	
Stored-energy time for auxiliary voltage outage or short circuit, non-modular devices		For V ≥ DC 24 V ≥ 20 ms For V ≥ DC 60 V/DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 200 ms	

12.1.3 Binary Inputs

Rated voltage range	DC 24 V to 250 V The binary inputs of SIPROTEC 5 are bipolar with the exception of the binary inputs on the IO230 and on the IO231.	
Current consumption, excited	Approx. DC 0.6 mA to 1.8 mA (independent of the operating voltage)	
Power consumption, max.	0.6 VA	
Pickup time	Approx. 3 ms	
Dropout time	Approx. 4 ms	
Switching thresholds	Adjustable with DIGSI 5	
	Range 1 for 24 V, 48 V, and 60 V Operating voltage	V_{low} ≤ DC 10 V V_{high} ≥ DC 19 V
	Range 2 for 110 V and 125 V Operating voltage	V_{low} ≤ DC 44 V V_{high} ≥ DC 88 V
	Range 3 for 220 V and 250 V Operating voltage	V_{low} ≤ DC 88 V V_{high} ≥ DC 176 V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. In order to ensure EMC, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

12.1.4 Relay Outputs

Standard Relay (Type S)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 30 W/VA at L/R ≤ 40 ms
AC and DC contact voltage	250 V

Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	≤ 10 ms, typically 8 ms
Max. rated data of the output contacts in accordance with UL certification	DC 24 V, 8 A, General Purpose DC 48 V, 0.8 A, General Purpose DC 240 V, 0.1 A, General Purpose AC 240 V, 5 A, General Purpose AC 120 V, 1/3 hp AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V

Fast Relay (Type F)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 30 W/VA at L/R ≤ 40 ms
AC and DC contact voltage	250 V
Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Closing time, typical: 4 ms Opening time, typical: 2 ms ≤ 5 ms
Rated data of the output contacts in accordance with UL certification	AC 120 V, 8.5 A, General Purpose AC 277 V, 6 A, General Purpose AC 277 V, 0.7 hp AC 347 V, 4.5 A, General Purpose B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Supervision	2-channel activation with cyclic testing (only for make contact)

High-Speed Relay with Semiconductor Acceleration (Type HS)

Switching capacity	On/Off: 1000 W/VA
Contact voltage	AC 200 V, DC 250 V
Permissible current per contact (continuous)	5 A

Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Closing time, typical: 0.2 ms Opening time, typical: 6 ms Maximum: ≤ 9 ms
Rated data of the output contacts in accordance with UL certification	B150 Q300

Power Relay (for Direct Control of Motor Switches)

Switching capacity for permanent and periodic operation		
250 V/4.0 A 220 V/4.5 A 110 V/5.0 A 60 V/5.0 A 48 V/5.0 A 24 V/5.0 A	1000 W 1000 W 550 W 300 W 240 W 120 W	In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
Turn on switching power for 30 s, recovery time until switching on again is 15 minutes. For short-term switching operations, an impulse/pause ratio of 3 % must be considered.		
100 V/9.0 A 60 V/10.0 A 48 V/10.0 A 24 V/10.0 A	1000 W 600 W 480 W 240 W	Continuous and inching operation is not permitted. In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
AC and DC contact voltage		250 V
Permissible continuous current per contact		5 A
Permissible current per contact (switching on and holding)		30 A for 1 s
Short-time current across closed contact		250 A for 30 ms
Total permissible current for contacts connected to common potential		5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used		≤ 16 ms
Rated data of the output contacts in accordance with UL certification		DC 300 V, 10 A, Resistive DC 250 V, 1 hp motor - 30 s ON, 15 min OFF DC 110 V, 3/4 hp motor - 30 s ON, 15 min OFF DC 60 V, 1/2 hp motor - 30 s ON, 15 min OFF DC 48 V, 1/3 hp motor - 30 s ON, 15 min OFF DC 24 V, 1/6 hp motor - 30 s ON, 15 min OFF
Interference suppression capacitors across the contacts		4.7 nF, ± 20 %, AC 250 V
The power relays operate in interlocked mode, that is, only one relay of each switching pair picks up at a time thereby avoiding a power-supply short circuit.		

12.1.5 Design Data

Masses

	Device Size Weight of the Modular Devices				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	4.8 kg	8.1 kg	11.4 kg	14.7 kg	18.0 kg
Surface-mounted device with integrated on-site operation panel	7.8 kg	12.6 kg	17.4 kg	22.2 kg	27.0 kg
Surface-mounted device with detached on-site operation panel	5.1 kg	8.7 kg	12.3 kg	15.9 kg	19.5 kg

	Size	Weight
Detached on-site operation panel	1/3	1.9 kg
Detached on-site operation panel	1/6	1.1 kg

	Device Size Weight of the Non-Modular Devices 7xx82
Type of construction	1/3
Flush-mounting device	3.7 kg
Bracket for non-modular surface-mounting variant	1.9 kg

Dimensions of the Basic and 1/3 Modules

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [29](in Inches)
Flush-mounting device	150 mm x 268 mm x 229 mm (5.91 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)

Dimensions of Device Rows

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [30](in Inches)				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	150 mm x 268 mm x 229 mm (5.91 x 10.55 x 9.02)	225 mm x 268 mm x 229 mm (8.86 x 10.55 x 9.02)	300 mm x 268 mm x 229 mm(11.81 x 10.55 x 9.02)	375 mm x 268 mm x 229 mm (14.76 x 10.55 x 9.02)	450 mm x 268 mm x 229 mm (17.72 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)	225 mm x 314 mm x 337 mm (8.86 x 12.36 x 13.27)	300 mm x 314 mm x 337 mm (11.81 x 12.36 x 13.27)	375 mm x 314 mm x 337 mm (14.76 x 12.36 x 13.27)	450 mm x 314 mm x 337 mm (17.72 x 12.36 x 13.27)

[29] Width and depth rounded to whole numbers in mm
[30] Width and depth rounded to whole numbers in mm

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [30](in Inches)				
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)	225 mm x 314 mm x 230 mm (8.86 x 12.36 x 9.06)	300 mm x 314 mm x 230 mm (11.81 x 12.36 x 9.06)	375 mm x 314 mm x 230 mm (14.76 x 12.36 x 9.06)	450 mm x 314 mm x 230 mm (17.72 x 12.36 x 9.06)

Expansion Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth [31] (in Inches)
Flush-mounting device	75 mm x 268 mm x 229 mm (2.95 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	75 mm x 314 mm x 337 mm (2.95 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	75 mm x 314 mm x 230 mm (2.95 x 12.36 x 9.06)

Plug-In Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth (in Inches)
USART-Ax-xEL, ETH-Bx-xEL	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)
USART-Ax-xFO, ETH-Bx-xFO (without protection cover)	61 mm x 45 mm x 132.5 mm (2.4 x 1.77 x 5.22)
ANAI-CA-4EL	61 mm x 45 mm x 119.5 mm (2.4 x 1.77 x 4.7)
ARC-CD-3FO	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)

Minimum Bending Radii of the Connecting Cables Between the On-Site Operation Panel and the Base Module

Fiber-optic cable	R = 50 mm Pay attention to the length of the cable protection sleeve, which you must also include in calculations.
D-Sub cable	R = 50 mm (minimum bending radius)

Degree of Protection to IEC 60529

For equipment in the surface-mounting housing	IP50
For equipment in the flush-mounting housing	Front IP51 Back side of the modular devices IP50 Back side of the non-modular devices IP40
For operator protection	IP2x for current terminal (installed removed) IP1x for voltage terminal (removed/without cover) IP2x for voltage terminal (removed/with cover) IP2x for voltage terminal (installed)
Degree of pollution, IEC 60255-27	2
Maximum altitude above sea level	2000 m (6561.68 ft)

[30] Width and depth rounded to whole numbers in mm
[31] Width and depth rounded to whole numbers in mm

UL Note

Type 1 if mounted into a door or front cover of an enclosure. When expanding the device with the 2nd device row, then they must be mounted completely inside an enclosure.

Tightening Torques for Terminal Screws

Type of Line	Current Terminal	Voltage Terminal with Spring-Loaded Terminals	Voltage Terminal with Screw Connection
Litz wire with ring-type lug	2.7 Nm	No ring-type lug	No ring-type lug
Stranded wires with boot-lace ferrules or pin-type lugs	2.7 Nm	1.0 Nm	0.6 Nm
Solid conductor, bare (2 mm^2)	2.0 Nm	1.0 Nm	–



NOTE

Use copper cables only.

Torques for Other Screw Types

Screw Type	Torque
M4 x 20	1.2 Nm
M4 x 8	1.2 Nm
M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 8	0.39 Nm
Collar screw, M4 x 20	0.7 Nm

12.2 Protection Interface and Protection Topology

Setting Values

Mode	On Off	
PPS Synchronization	Telegr. and PPS Telegr. or PPS PPS synchronization off	
Blocking of the unbalanced runtimes	Yes No	
Maximum signal runtime threshold	0.1 ms to 30.0 ms	Increments of 0.1 ms
Maximum runtime difference	0.000 ms to 3.000 ms	Increments of 0.001 ms
Failure indication after	0.05 s to 2.00 s	Increments of 0.01 s
Failure indication after	0.0 s to 6.0 s	Increments of 0.1 s
Max. error rate/h	0.000 % to 100.000 %	Increments of 0.001 %
Max. error rate/min	0.000 % to 100.000 %	Increments of 0.001 %
PPS failure indication after	0.5 s to 60.0 s	Increments of 0.1 s

Transmission Rate

Direct connection:	
Transmission rate	2048 kbit/s
Connection via communication networks:	
Supported network interfaces	G703.1 with 64 kBit/s G703-T1 with 1.455 MBit/s G703-E1 with 2.048 MBit/s
	X.21 with 64 kBit/s or 128 kBit/s or 512 kBit/s
	Pilot wires with 128 kbit/s
Transmission rate	64 kBit/s at G703.1 1.455 MBit/s at G703-T1 2.048 MBit/s at G703-E1
	512 kBit/s or 128 kBit/s or 64 kBit/s at X.21
	128 kBit/s for pilot wires

Transmission Times

Priority 1		
Response time, total approx.		
For 2 ends	Minimum	8 ms
	Typical	10 ms
For 3 ends	Minimum	10 ms
	Typical	14 ms
For 6 ends	Minimum	15 ms
	Typical	18 ms
Dropout times, total approx.		
For 2 ends	Typical	20 ms
For 3 ends	Typical	20 ms
For 6 ends	Typical	26 ms

Priority 2		
Response time, total approx.		
For 2 ends	Minimum	9 ms
	Typical	16 ms
For 3 ends	Minimum	12 ms
	Typical	18 ms
For 6 ends	Minimum	17 ms
	Typical	23 ms
Dropout times, total approx.		
For 2 ends	Typical	24 ms
For 3 ends	Typical	25 ms
For 6 ends	Typical	32 ms

Priority 3[32]		
Response time, total approx.		
For 2 ends	Minimum	
	Typical	100 ms
For 3 ends	Minimum	
	Typical	150 ms
For 6 ends	Minimum	
	Typical	200 ms
Dropout times, total approx.		
For 2 ends	Typical	100 ms
For 3 ends	Typical	150 ms
For 6 ends	Typical	200 ms

[32] Times cannot be determined because the signals are transmitted in fragments.

12.3 Date and Time Synchronization

Date format	DD.MM.YYYY (Europe)
	MM/DD/YYYY (USA)
	YYYY-MM-DD (China)
Time source 1, time source 2	None
	IRIG-B 002(003) IRIG-B 006(007) IRIG-B 005(004) with extension according to IEEE C37.118-2005
	DCF77
	PI (protection interface)[33]
	SNTP
	IEC 60870-5-103
	DNP3
	IEEE 1588
Time zone 1, time zone 2	Local
	UTC
Failure indication after	0 s to 3600 s
Time zone and daylight saving time	Transfer of PC settings
	Manually setting the time zones
Time zone offset with respect to GMT	-720 min to 840 min
Switching over to daylight saving time	Active
	Inactive
Beginning of daylight saving time	Input: day and time
End of daylight saving time	Input: day and time
Offset daylight saving time	-120 to 120 [steps of 15]

[33] If provided

12.4 Analog-Units Function Group

20-mA Unit Ether. 7XV5674-0KK00-1AA1

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

20-mA Unit Serial 7XV5674-0KK30-1AA1 (RS485) and 7XV5674-0KK40-1AA1 (fiberglass)

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

RTD Unit (Ziehl TR1200) 7XV5662-6AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 as per EN 60751

RTD Unit (Ziehl TR1200 IP) 7XV5662-8AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 as per EN 60751; connection of Ni 100 and Ni 120 sensors possible. The measured values must be converted in the evaluation unit.

Temperature Measured Values

Unit of measurement for temperature	°C or °F, can be adjusted
Pt 100	-199 °C to 800 °C (-326 °F to 1472 °F)
Resolution	1 °C or 1 °F
Tolerance	±0.5 % of the measured value ±1 K

12.5 Overcurrent Protection, Phases

12.5.1 Stage with Definite-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value[34]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT [35] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

[34] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[35] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[36] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [37]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [38]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [39]
Time delays	1 % of the setting value or 10 ms

[36] In case that the filter response exactly matches the user-defined gain factors
[37] In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.
[38] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[39] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.5.2 Stage with Inverse-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

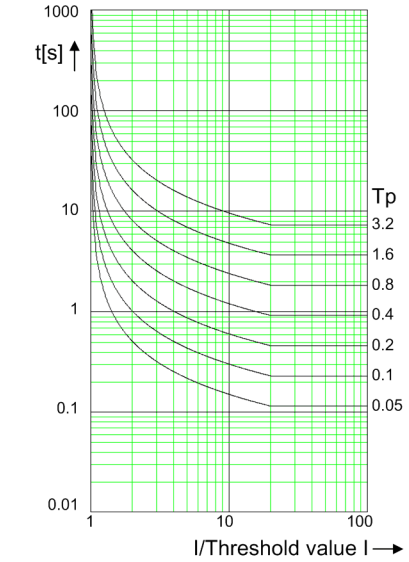
Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

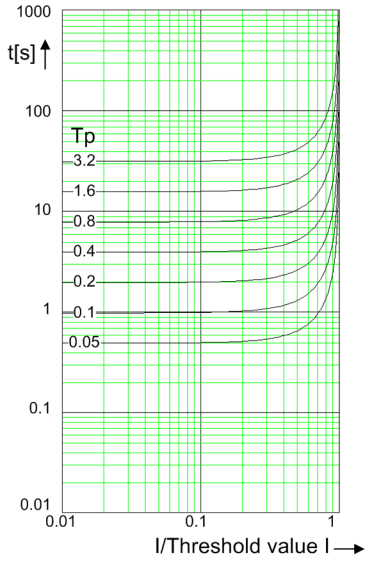
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

NORMAL INVERSE: Type A



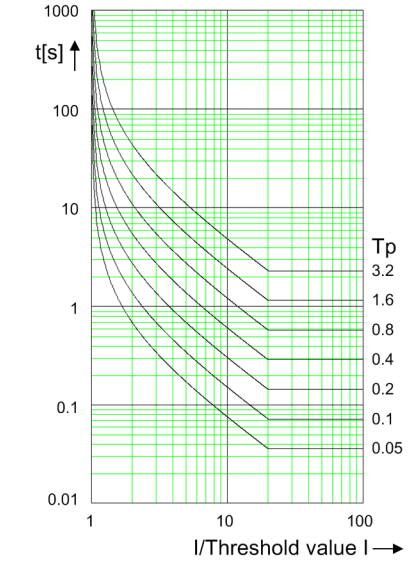
$$t = \frac{0.14}{(I/\text{Threshold value } I)^{0.02} - 1} \cdot T_p \ [s]$$

RESET NORMAL INVERSE: Type A



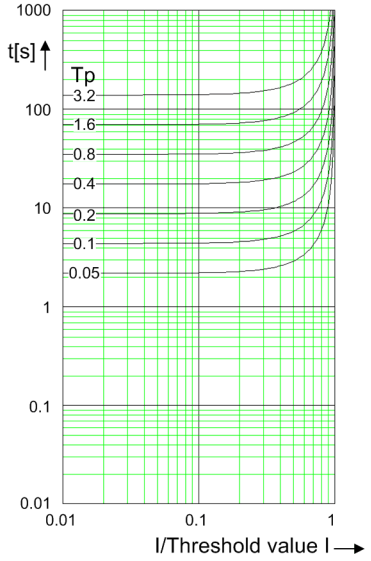
$$t = \frac{9.7}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

VERY INVERSE: Type B



$$t = \frac{13.5}{(I/\text{Threshold value } I)^{1} - 1} \cdot T_p \ [s]$$

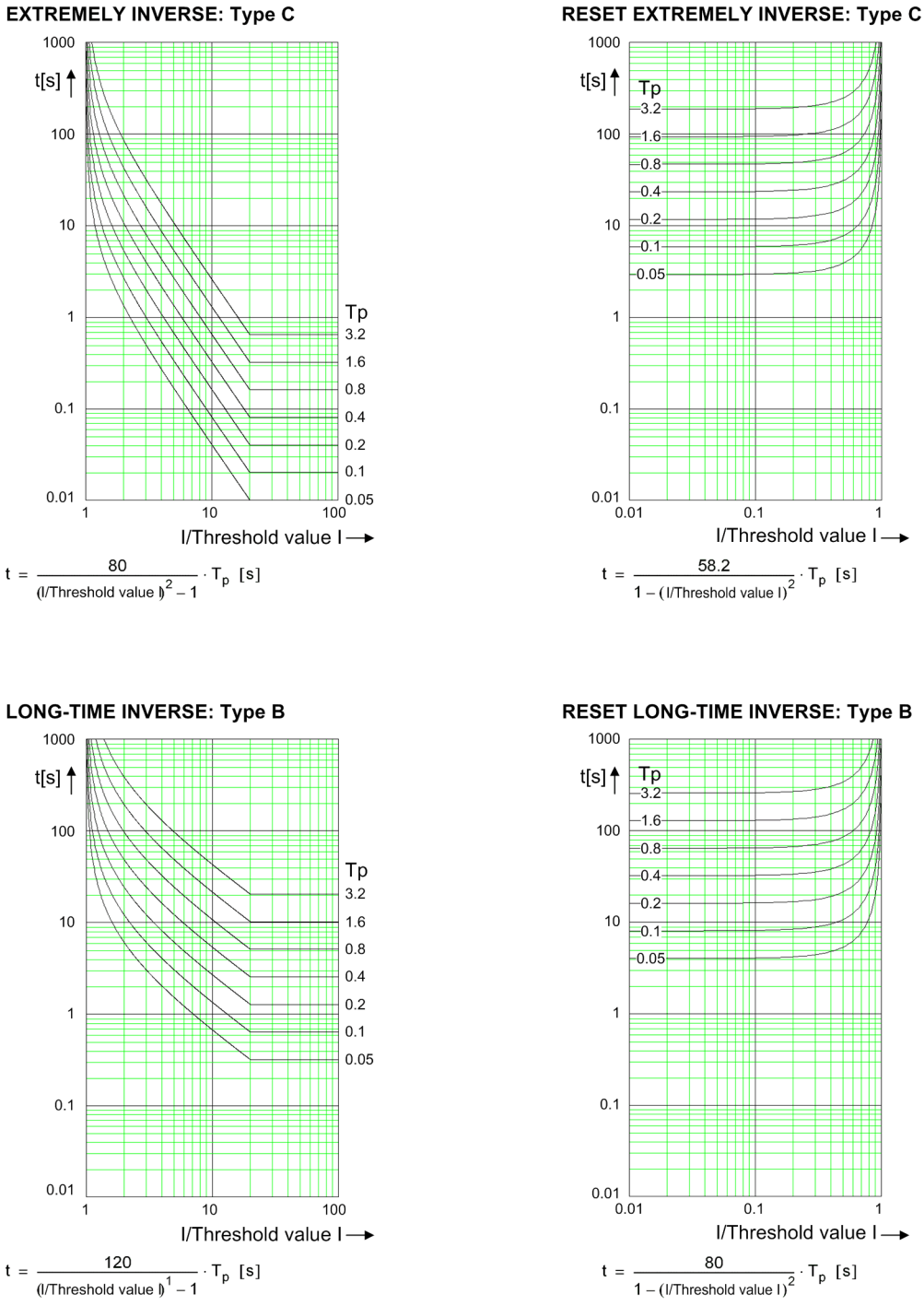
RESET VERY INVERSE: Type B



$$t = \frac{43.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dwocpki1-080213-01.tif, 1, en_US]

Figure 12-1 Operate Curves and Dropout-Time Characteristic Curves According to IEC

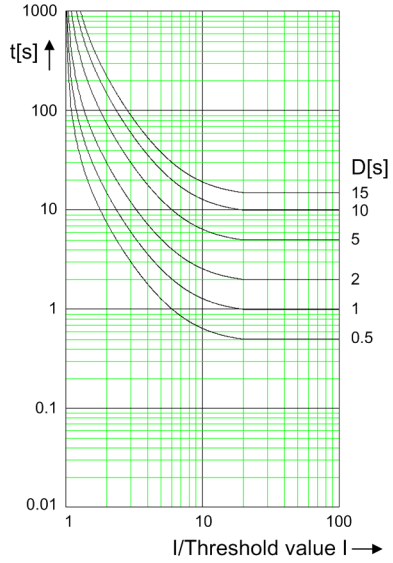


[dwocpki2-080213-01.tif, 1, en_US]

Figure 12-2 Operate Curves and Dropout-Time Characteristic Curves According to IEC

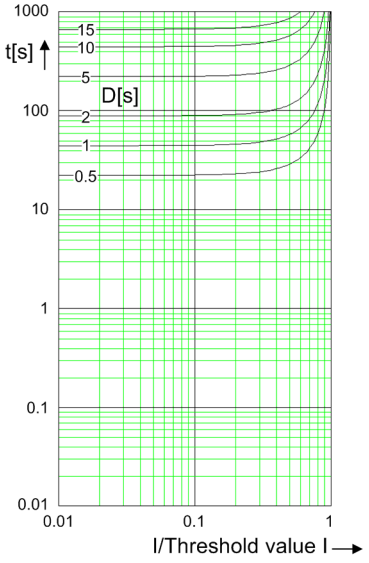
Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Inverse: Type C



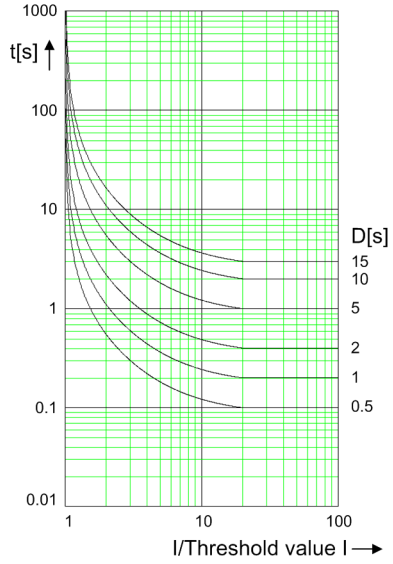
$$t = \left(\frac{44.6705}{\left(\text{I/Threshold value I} \right)^{2.0938} - 1} + 0.8983 \right) \cdot D \quad [s]$$

RESET INVERSE: Type C



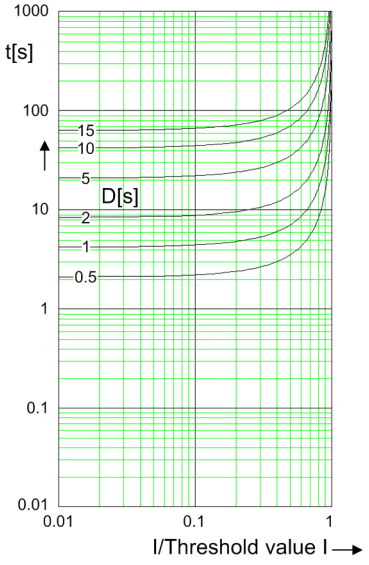
$$t = \frac{44}{1 - \left(\text{I/Threshold value I} \right)^{2.0938}} \cdot D \quad [s]$$

SHORT INVERSE



$$t = \left(\frac{1.3315}{\left(\text{I/Threshold value I} \right)^{1.2969} - 1} + 0.16965 \right) \cdot D \quad [s]$$

RESET SHORT INVERSE

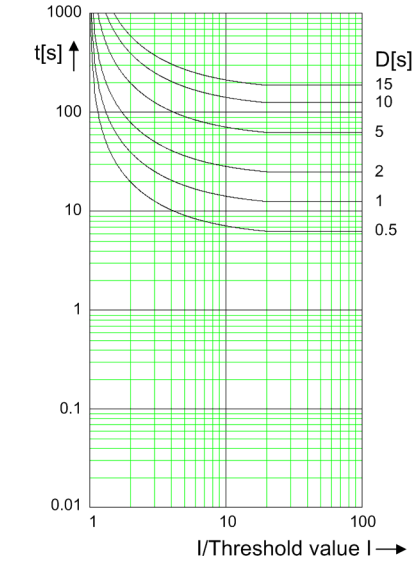


$$t = \frac{4.155}{1 - \left(\text{I/Threshold value I} \right)^{1.2969}} \cdot D \quad [s]$$

[dwocpka1-080213-01.tif, 2, en_US]

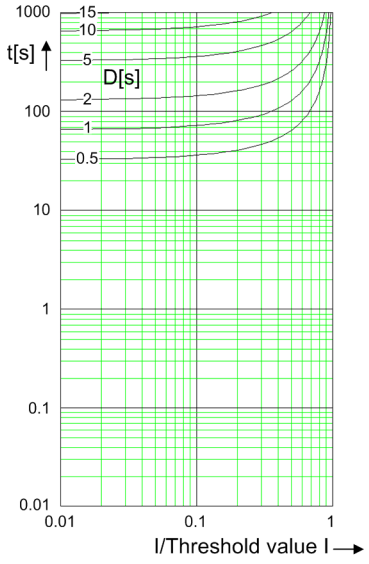
Figure 12-3 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

LONG INVERSE



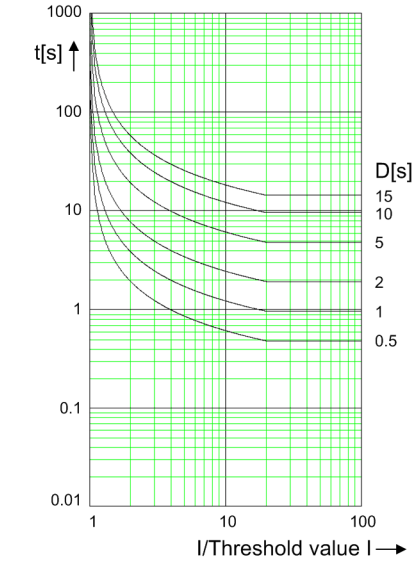
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



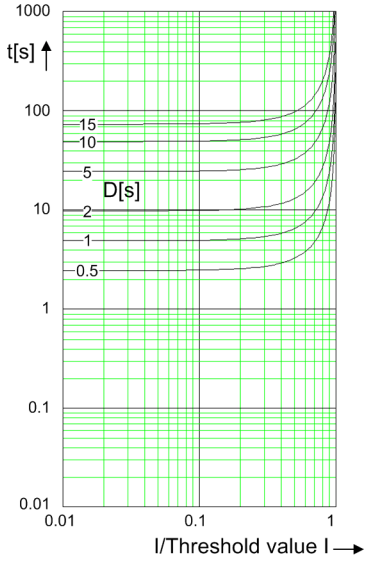
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

MODERATELY INVERSE



$$t = \left(\frac{0.0515}{\left(\text{I/Threshold value I} \right)^{0.02} - 1} + 0.114 \right) \cdot D \quad [s]$$

RESET MODERATELY INVERSE

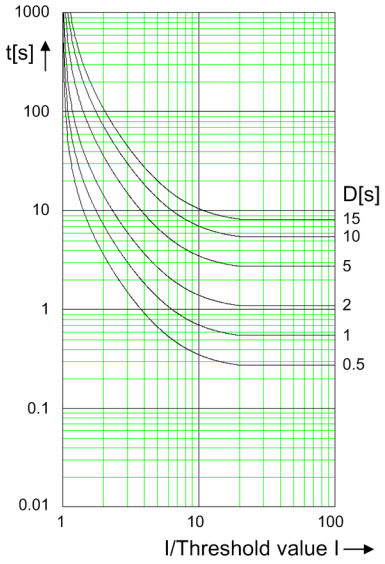


$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

[dwocpka2-080213-01.tif, 2, en_US]

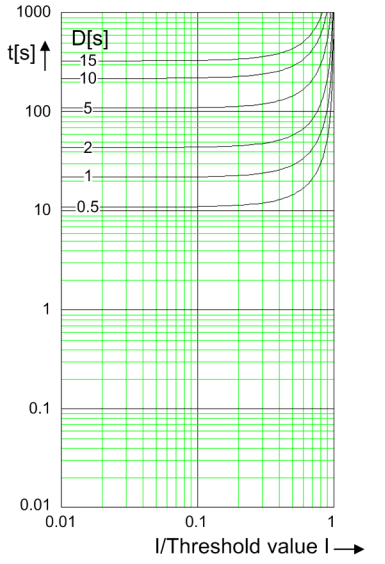
Figure 12-4 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

VERY INVERSE



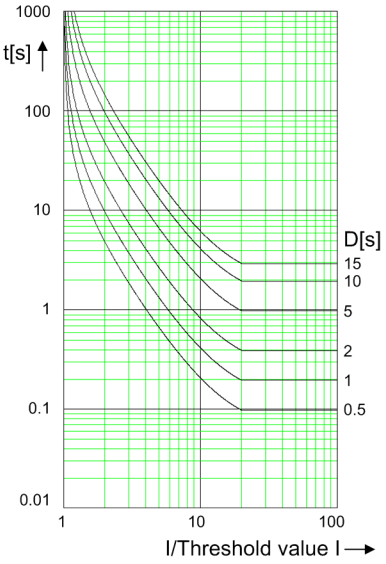
$$t = \left(\frac{19.61}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.491 \right) \cdot D \quad [s]$$

RESET VERY INVERSE



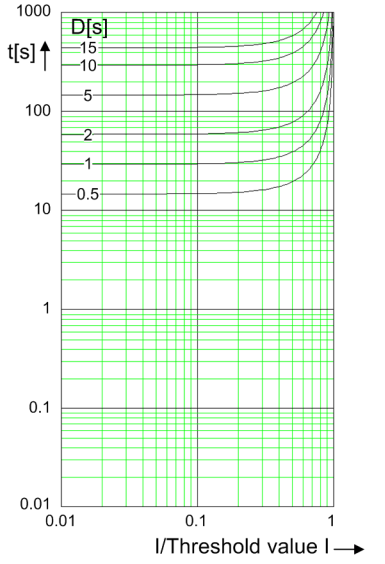
$$t = \frac{21.6}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

EXTREMELY INVERSE



$$t = \left(\frac{28.2}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.1217 \right) \cdot D \quad [s]$$

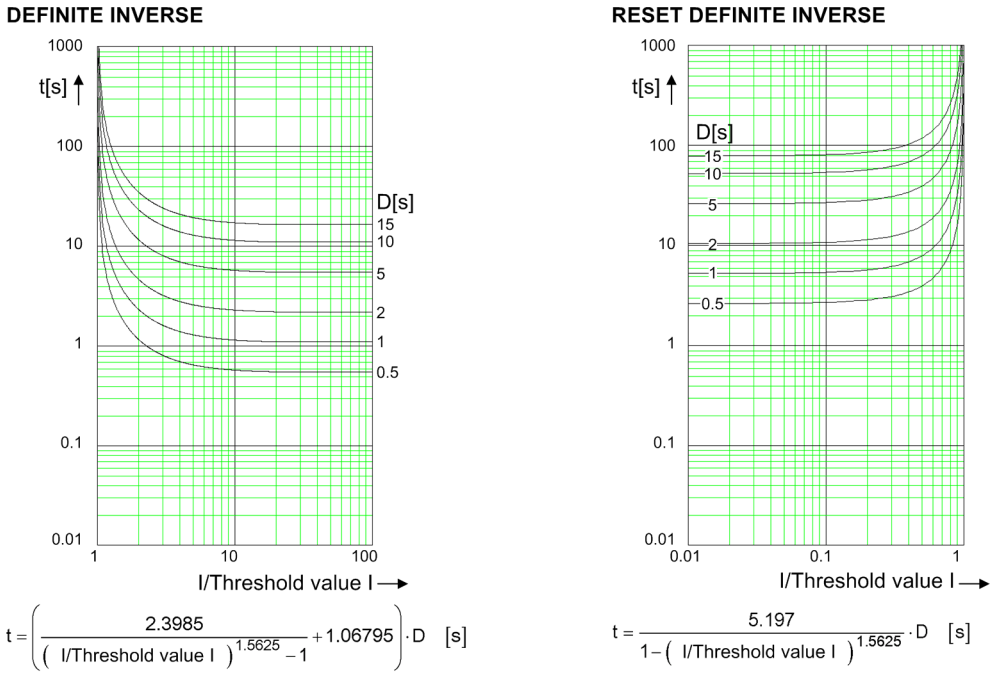
RESET EXTREMELY INVERSE



$$t = \frac{29.1}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

[dwocpka3-080213-01.tif, 2, en_US]

Figure 12-5 Tripping Characteristic Curves and Dropout Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dwocpka4-080213-01.tif, 2, en_US]

Figure 12-6 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[40] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [41]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [42]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [43]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.5.3 Stage with User-Defined Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–

[40] In case that the filter response exactly matches the user-defined gain factors
[41] In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.
[42] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[43] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Time multiplier	0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve	2 to 30	Increments of 1
X values of the operate curve	1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve	0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	2 to 30	Increments of 1
X values of the dropout characteristic curve	0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve	0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[44] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [45]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [46]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [47]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[44] In case that the filter response exactly matches the user-defined gain factors
[45] In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.
[46] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[47] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

12.6 Voltage-Dependent Overcurrent Protection, Phases

Setting Values for All Stage Types

Method of measurement		Fundamental component RMS value	–
Overcurrent threshold value	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Time delay		0.10 s to 60.00 s	Increments of 0.01 s

Setting Values for Inverse Time-Overcurrent Stages

Method of measurement	Fundamental component RMS value	–
Dropout ratio of undervoltage[48]	1.01 to 1.20	Increments of 0.01
Undervoltage threshold value[48]	0.300 V to 175.000 V	Increments of 0.001 V
Dropout	Disk emulation Instantaneous	–
Time multiplier	0.05 to 15.00	Increments of 0.01

Setting Values for Definite Time-Overcurrent Stages

Seal-in voltage	0.300 V to 175.000 V	Increments of 0.001 V
Phase-to-phase voltage	0.300 V to 175.000 V	Increments of 0.001 V
Negative-sequence voltage V2	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Duration of V-seal-in time	0.10 s to 60.00 s	Increments of 0.01 s

Dropout for Inverse Time-Overcurrent Stages

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	
Current	95 % of 1.1 · threshold value
Voltage[48]	105 % of threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer [48]	150 mV sec.

Reset of the Integration Timer for Inverse Time-Overcurrent Stages

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

[48] The value is for the inverse time-overcurrent voltage-released stage.

Dropout for Definite Time-Overcurrent Stages

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with inrush-current detection	Approx. 10 ms

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % part of harmonic in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltage	0.5 % of the setting value or 0.05 V
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.7 Overcurrent Protection, Ground

12.7.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[49]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[50] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

[49] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[50] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances

3I0 measured via I4[51], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[52], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.7.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[53]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

[51] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[52] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[53] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

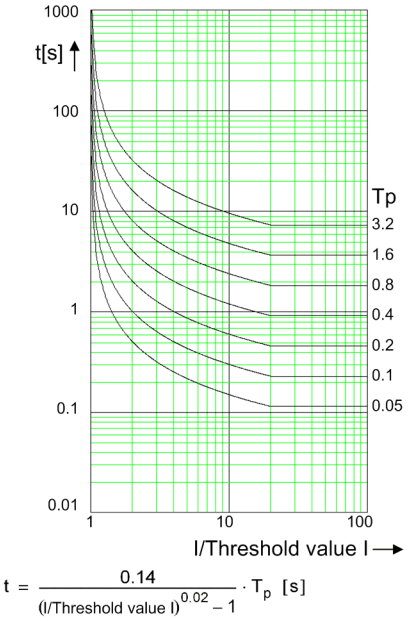
Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves According to IEC

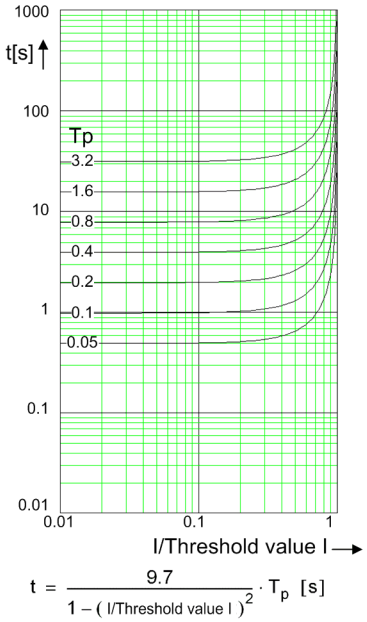
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

NORMAL INVERSE: Type A



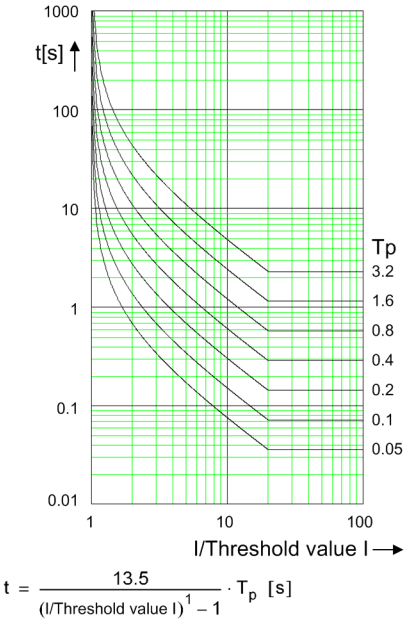
$$t = \frac{0.14}{(\text{I/Threshold value I})^{0.02} - 1} \cdot T_p \ [s]$$

RESET NORMAL INVERSE: Type A



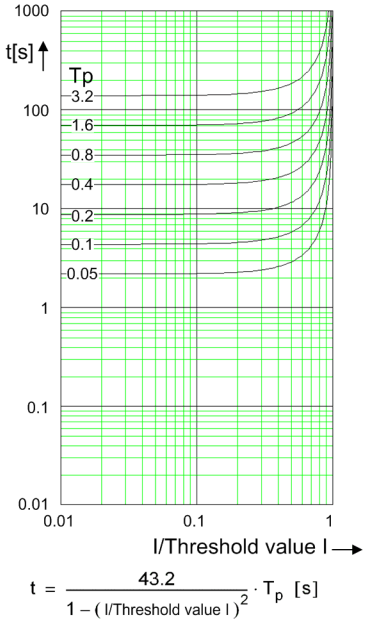
$$t = \frac{9.7}{1 - (\text{I/Threshold value I})^2} \cdot T_p \ [s]$$

VERY INVERSE: Type B



$$t = \frac{13.5}{(\text{I/Threshold value I})^{1} - 1} \cdot T_p \ [s]$$

RESET VERY INVERSE: Type B

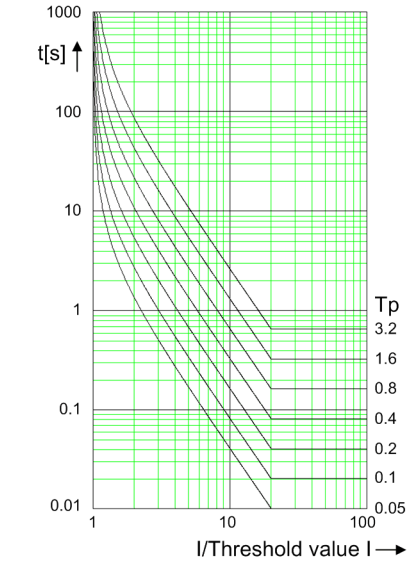


$$t = \frac{43.2}{1 - (\text{I/Threshold value I})^2} \cdot T_p \ [s]$$

[dwocpki1-080213-01.tif, 1, en_US]

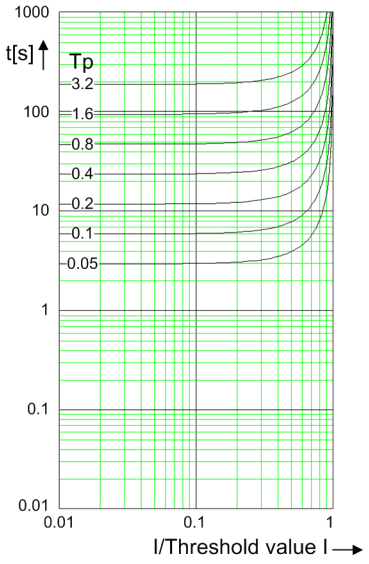
Figure 12-7 Operate Curves and Dropout-Time Characteristic Curves According to IEC

EXTREMELY INVERSE: Type C



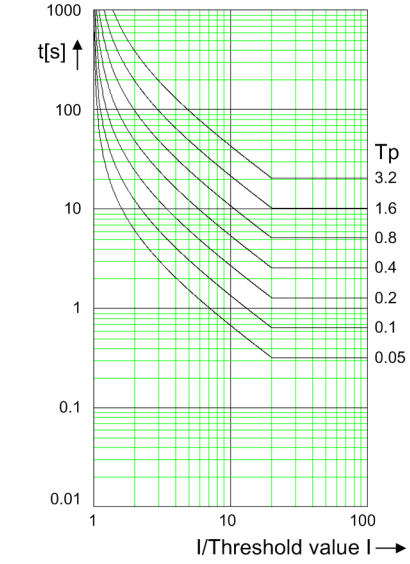
$$t = \frac{80}{(I/\text{Threshold value } I)^2 - 1} \cdot T_p \ [s]$$

RESET EXTREMELY INVERSE: Type C



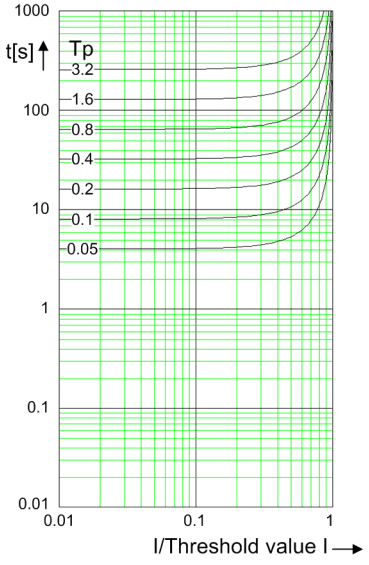
$$t = \frac{58.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

LONG-TIME INVERSE: Type B



$$t = \frac{120}{(I/\text{Threshold value } I)^1 - 1} \cdot T_p \ [s]$$

RESET LONG-TIME INVERSE: Type B



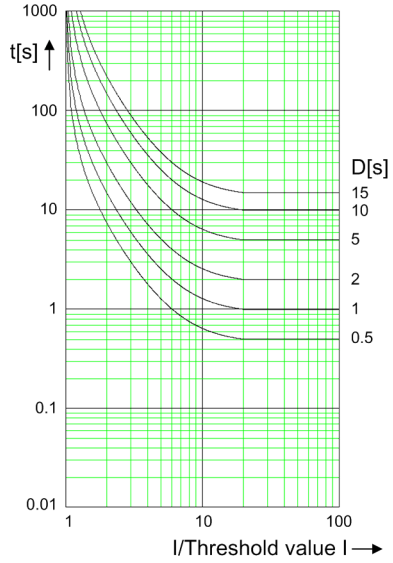
$$t = \frac{80}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dwocpki2-080213-01.tif, 1, en_US]

Figure 12-8 Operate Curves and Dropout-Time Characteristic Curves According to IEC

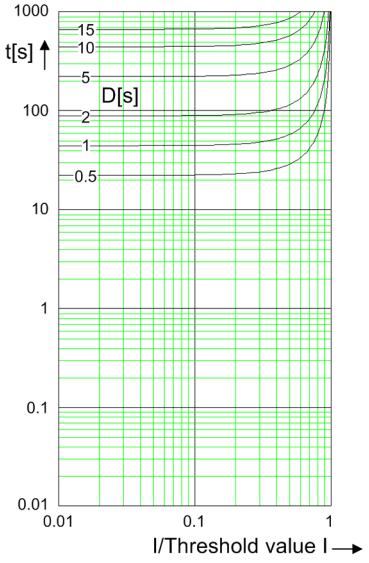
Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Inverse: Type C



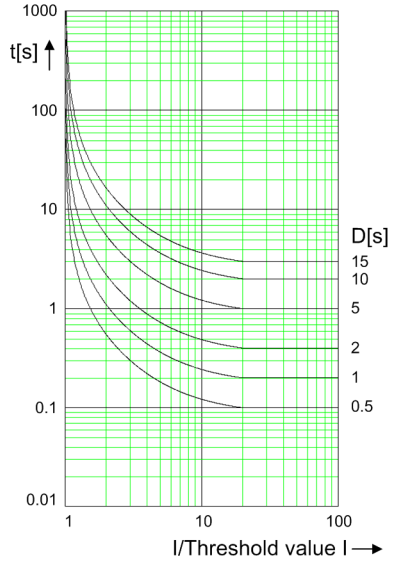
$$t = \left(\frac{44.6705}{\left(\text{I/Threshold value I} \right)^{2.0938} - 1} + 0.8983 \right) \cdot D \quad [s]$$

RESET INVERSE: Type C



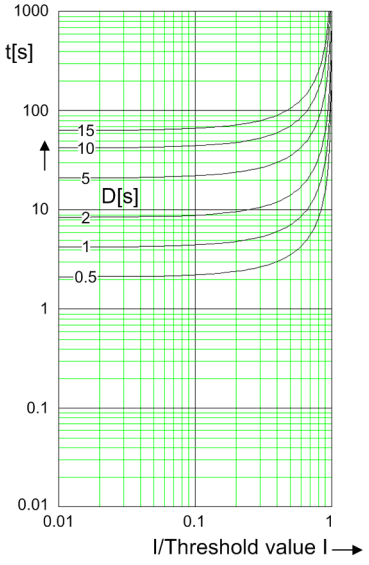
$$t = \frac{44}{1 - \left(\text{I/Threshold value I} \right)^{2.0938}} \cdot D \quad [s]$$

SHORT INVERSE



$$t = \left(\frac{1.3315}{\left(\text{I/Threshold value I} \right)^{1.2969} - 1} + 0.16965 \right) \cdot D \quad [s]$$

RESET SHORT INVERSE

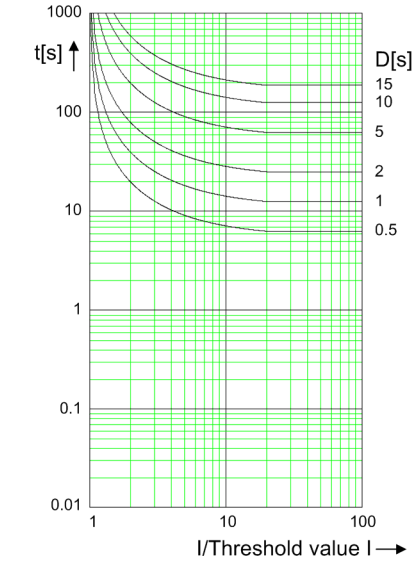


$$t = \frac{4.155}{1 - \left(\text{I/Threshold value I} \right)^{1.2969}} \cdot D \quad [s]$$

[dwocpka1-080213-01.tif, 2, en_US]

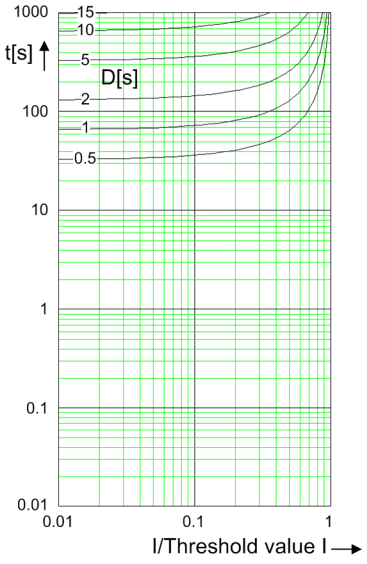
Figure 12-9 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

LONG INVERSE



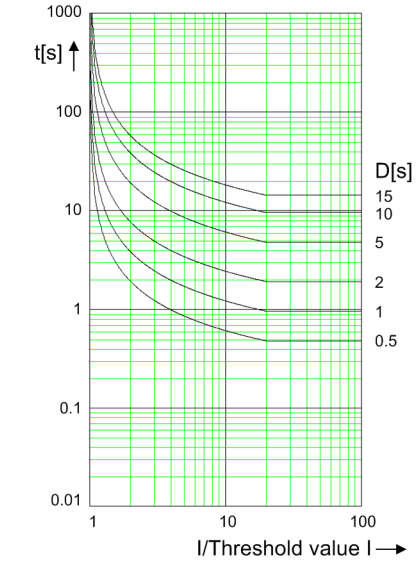
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



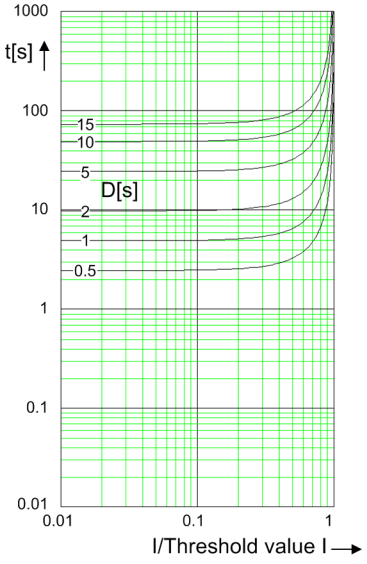
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

MODERATELY INVERSE



$$t = \left(\frac{0.0515}{\left(\text{I/Threshold value I} \right)^{0.02} - 1} + 0.114 \right) \cdot D \quad [s]$$

RESET MODERATELY INVERSE

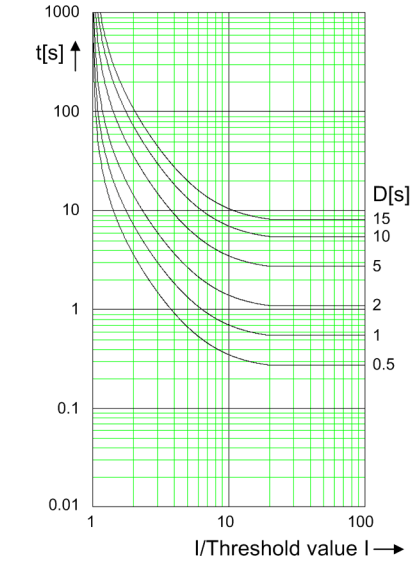


$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

[dwocpka2-080213-01.tif, 2, en_US]

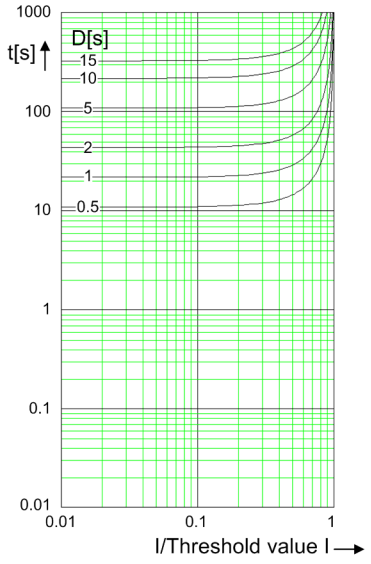
Figure 12-10 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

VERY INVERSE



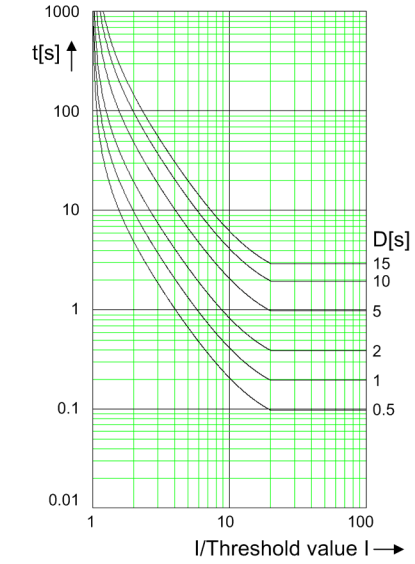
$$t = \left(\frac{19.61}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.491 \right) \cdot D \quad [s]$$

RESET VERY INVERSE



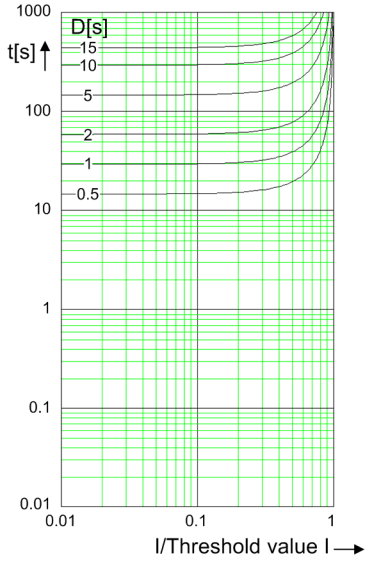
$$t = \frac{21.6}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

EXTREMELY INVERSE



$$t = \left(\frac{28.2}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.1217 \right) \cdot D \quad [s]$$

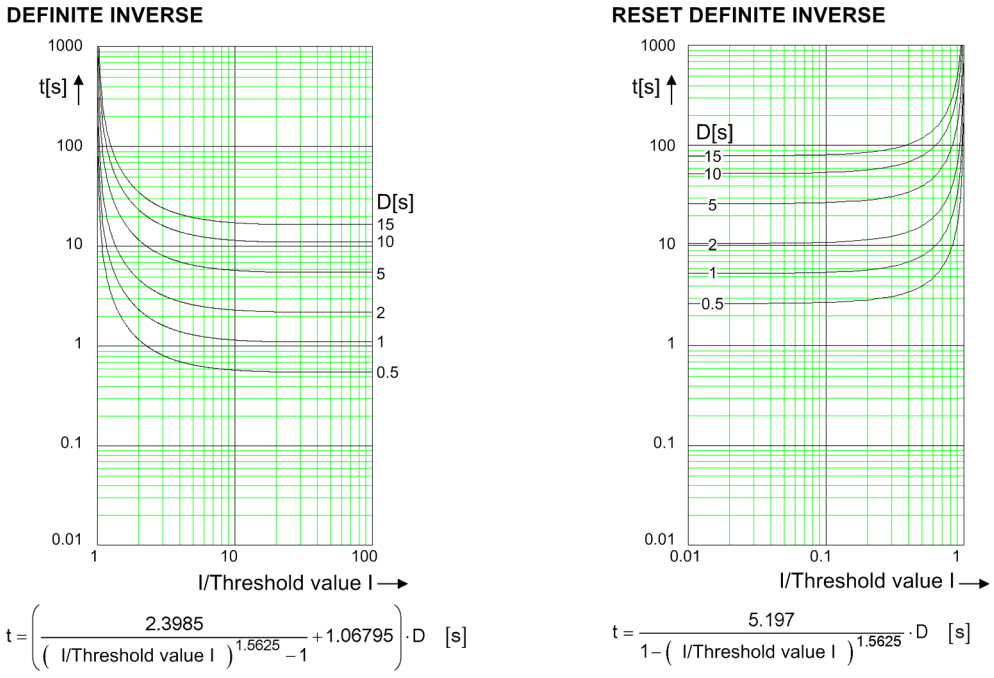
RESET EXTREMELY INVERSE



$$t = \frac{29.1}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

[dwocpka3-080213-01.tif, 2, en_US]

Figure 12-11 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dwocpka4-080213-01.tif, 2, en_US]

Figure 12-12 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

3I0 measured via I4[54], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[55], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

[54] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[55] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

Dropout time for 2 ≤ I/threshold value I ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.7.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p. u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p. u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

f < 10 Hz f > 80 Hz	Active

Tolerances

3I0 measured via I4[56], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[57], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[56] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[57] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

12.8 Directional Overcurrent Protection, Phases

12.8.1 Stage with Definite-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value[58]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [59] at 50 Hz Approx. 22 ms + OOT at 60 Hz

[58] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[59] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delay	1 % of the setting value or 10 ms
Direction-determination angle error	1 °

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.8.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Backward	–
Method of measurement		Fundamental component RMS value	–
Threshold value[60]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–

[60] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Time multiplier	0.00 to 15.00	Increments of 0.01
Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-1*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-2*
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-3*
Short inverse	
Long inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-4*
Moderately inverse	
Very inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-5*
Extremely inverse	
Definite inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-6*

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [61] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for $2 \leq I/I$ threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.8.3 Stage with User-Defined Characteristic Curve

Setting Values

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°
Directional mode	Forward Reverse	–
Method of measurement	Fundamental component RMS value	–

[61] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Threshold value[62]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Insatantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate characteristic curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [63] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[62] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[63] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for $2 \leq I/I$ threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.9 Directional Overcurrent Protection, Ground

12.9.1 Stage with Definite-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances

10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.2 Stage with Inverse-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Type of characteristic curve		Characteristic curves according to IEC and ANSI	
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01

Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	Refer to the respective figure of the technical data for the non-dir-OC-ground function *12.7.2 Stage with Inverse-Time Characteristic Curve*
Very inverse: type B	
Extremely inverse: type C	
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	Refer to the respective figure of the technical data for the non-dir-OC-ground function *12.7.2 Stage with Inverse-Time Characteristic Curve*
Short inverse	
Long inverse	
Moderately inverse	
Very inverse	
Extremely inverse	
Definite inverse	

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.3 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

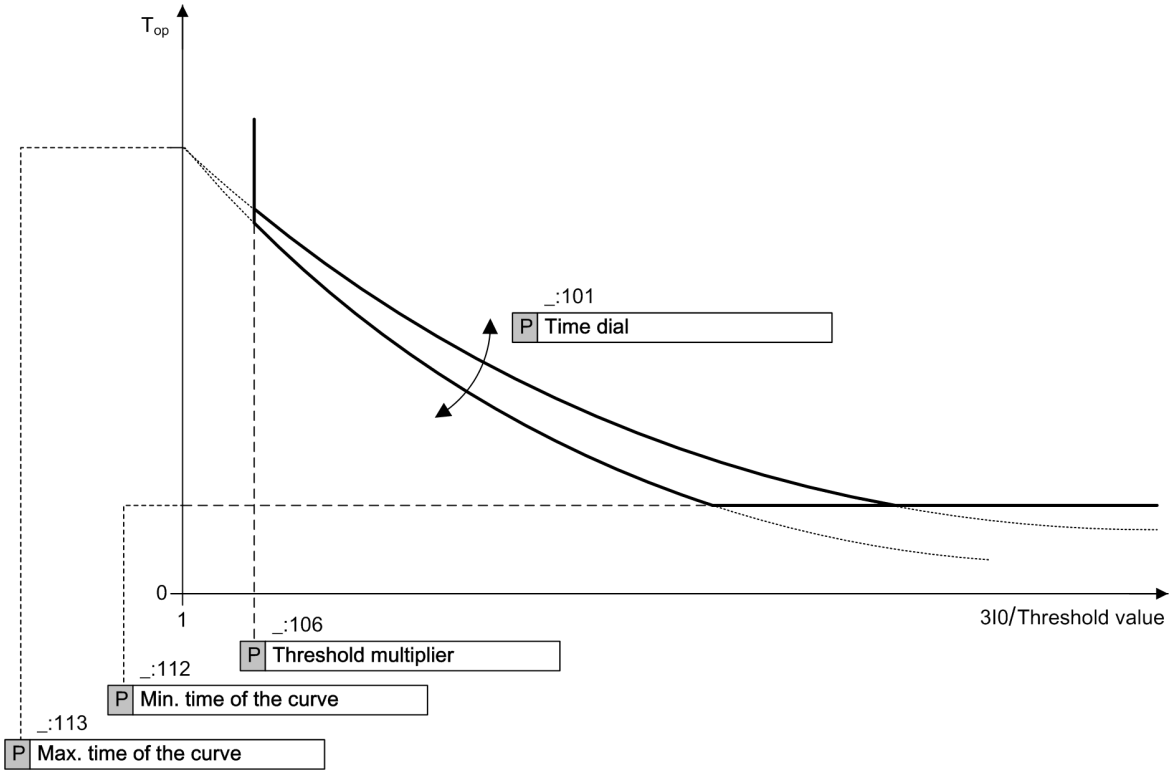
Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Characteristic curve: see *Figure 12-13*			
Threshold value multiplier		1.00 to 4.00	Increments of 0.01
Time multiplier		0.000 s to 60.000 s	Increments of 0.001 s
Minimum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s

Additional time delay	0.000 s to 60.000 s	Increments of 0.001 s



[dwloginv-300913, 2, en_US]

Figure 12-13 Operate Curve of Logarithmic Inverse-Time Characteristic

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances

10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.4 Stage with Knee-Point Characteristic Curve

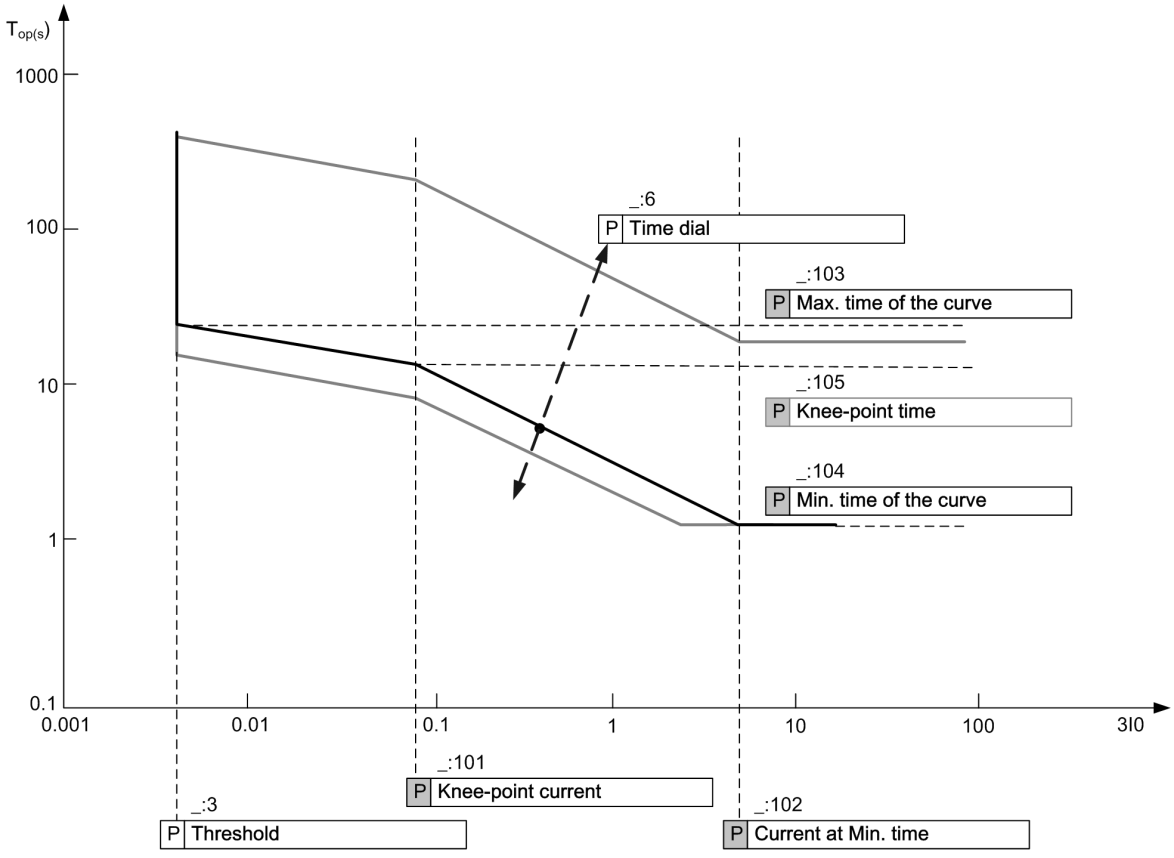
Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Characteristic curve: see *Figure 12-14*		
Minimum time of the characteristic curve	0.00 s to 30.00 s	Increments of 0.01 s
Knee-point time of the curve	0.00 s to 100.00 s	Increments of 0.01 s
Maximum time of the characteristic curve	0.00 s to 200.00 s	Increments of 0.01 s
Knee-point value	0.030 A to 35.000 A	Increments of 0.001 A
Current at minimum time of the curve	0.030 A to 35.000 A	Increments of 0.001 A
Time multiplier	0.05 to 1.50	Increments of 0.01



[dwdrloinkn-171013, 1, en_US]

Figure 12-14 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (In the Example of **`Threshold`** = ***`0.004 A`***)

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.9.5 Stage with User-Defined Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
X values of the operate curve		1.00 p. u. to 66.67 p. u.	Increments of 0.01 p. u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p. u. to 0.95 p. u.	Increments of 0.01 p. u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.10 Inrush-Current Detection

Setting Values

Operat.-range limit Imax	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Component of 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of the crossblock function		0.03 s to 200.00 s	Increments of 0.01 s

Times

Pickup times	Approx. 29 ms

Dropout Ratios

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	0.95

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Current measurement I_{max}	1 % of the setting value or 5 mA
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value for settings of $I_{2nd\ harm}/I_{1st\ harm}$
Time delays	1 % of the setting value or 10 ms

12.11 Arc Protection

Setting Values

Threshold I>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold 3I0>>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
External trip initiation		yes no	
Operating mode		Light only Current and light	
Sensor		Point sensor Line sensor Custom	
Threshold Light		-28.00 dB to 0.00 dB	Increments of 0.01
Channel		Possible settings, application-dependent	

Dropout

The larger dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overcurrent protection and a dropout ratio of 105 % applies to the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated}= 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated}= 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Shortest operate time Operating mode = light only	Approx. 2.6 ms + OOT[64]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

[64] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with a fast relay, see Chapter *12.1.4 Relay Outputs*

12.12 Instantaneous High-Current Tripping

Setting Values

Threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 50 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.50 to 0.90	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time for current > 2·√2·threshold value	Approx. 8 ms + OOT[65]

Tolerances

Response tolerance, current	5 % of setting value or 10 mA at I_{rated} = 1 A 5 % of setting value or 50 mA at I_{rated} = 5 A
Time delays	1 % of the setting value or 10 ms

[65] OOT (Output Operating Time) Additional delay of the output medium used, see Chap. *12.1.4 Relay Outputs*

12.13 Instantaneous Tripping at Switch onto Fault

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Tolerances

Times	< 1 % of the setting value or 10 ms

12.14 Overcurrent Protection, 1-Phase

12.14.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[66]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.95	–
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 15 ms + OOT[67] at 50 Hz Approx. 14 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 17 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

[66] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[67] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.14.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[68]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout

[68] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

The tripping characteristic curves and dropout characteristic curves according to IEC can be found in the Technical Data chapter under Inverse Time-Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The tripping characteristic curves and dropout characteristic curves according to ANSI/IEEE can be found in the Technical Data chapter under Inverse Time-Overcurrent Protection.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.14.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement	Fundamental component RMS value	–

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p. u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p. u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \leq f/f_{rated} < 1.1$	According to specified tolerances
10 Hz $\leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80$ Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with less sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

12.15 Overcurrent Protection, 1-Phase (Fast Stage)

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 8 ms + OOT[69]
Dropout time	Approx. 25 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Pickup tolerance, current	5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

[69] OOT (Output Operating Time) additional time delay of the output medium used, for example, 5 ms with fast relay

12.16 Non-Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0> interm.	For current transformer type **protection** and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type **protection** and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pickups until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[70] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity

[70] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	-3I0 via protection-class current transformers: 1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	-3I0 via sensitive current transformer: 1 % of setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or ± 10 ms

12.17 Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0>	For current transformer type **protection** and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type **protection** and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pulses until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s
Number of pulses for operate			2 to 100	Increments of 1

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Pickup time	Approx. 30 ms + OOT[71] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity

[71] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or ± 10 ms

12.18 Sensitive Ground-Fault Detection

12.18.1 General

Setting Values

Decay time V0			0.06 s to 0.20 s	Increments of 0.01 s
Dropout delay			0.00 s to 60.00 s	Increments of 0.01 s
Core balance current transformer current 1 Core balance current transformer current 2	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Core balance current transformer angle correction F1 Core balance current transformer angle correction F2			0.0° to 5.0°	Increments of 0.1°

Times

Pickup times	Approx. 25 ms + OOT[72] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout times	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances [73]
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity [74]

Tolerances

Currents	-3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %)
	-3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %)
Voltages	1 % of the setting value or 0.05 V
Times	1 % of the setting value or ±10 ms

[72] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays
[73] Transient ground-fault stage is inactive
[74] Transient ground-fault stage is inactive

Direction-calculation angle error[75]	≤ 1° at 3I0 > 5 mA, V0 = 0.6 V ≤ 2° at 3I0 ≤ 5 mA, V0 = 0.6 V

12.18.2 Directional 3I0 Stage with Cos φ or Sin φ Measurement

Setting Values

Direction method of measurement			cos φ sin φ	–
Threshold value 3I0> Minimum directional 3I0> for direction determination	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of the direction range α2 constraint of the direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[76] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[75] Not applicable to *12.18.4 Directional 3I0 Stage with φ(V0,3I0) Measurement*
[76] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

12.18.3 Directional Transient Ground-Fault Stage

Setting Values

Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Maximum operational V0			0.300 V to 340.000 V	Increments of 0.001 V
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 115 ms + OOT[77] at 50 Hz Approx. 112 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 15 ms + OOT at 60 Hz

[77] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.18.4 Directional 3I0 Stage with φ(V0,3I0) Measurement

Setting Values

Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Min. V0> for direction determination			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
Rotation angle of the reference voltage			-180° to 180°	Increments of 1°
Forward range +/-			0° to 180°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 23 ms + OOT[78] at 50 Hz Approx. 21 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 21 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

Tolerances

Direction-calculation angle error	≤ 1° at 3I0 ≥ 10 mA, V0 = 0.6 V ≤ 2° at 2 mA < 3I0 < 10 mA, V0 = 0.6 V ≤ 3° at 3I0 ≤ 2 mA, V0 = 0.6 V

[78] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.18.5 Directional Y0 Stage with G0 or B0 Measurement (Admittance)

Setting Values

Direction method of measurement			B0 G0	–
Release Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Threshold value Y0>			0.10 mS to 100.00 mS	Increments of 0.01 mS
Time delay of direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of direction range α2 constraint of direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[79] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

[79] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1.6 A) or 0.25 mS (I_{rated} = 8 A), (f_{rated} = ± 10 %)

12.18.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Setting Values

Threshold value[80]	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[81] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[80] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[81] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

12.18.7 Non-Directional 3I0 Stage

Setting Values

Method of Measurement			Fundamental component RMS value	
Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For transformer type I-sensitive and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For transformer type I-sensitive and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Pickup delay			0.00 s to 60.00 s	Increments of 0.01 s
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[82] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

12.18.8 Non-Directional Y0 Stage

Setting Values

V0> threshold value	0.300 V to 200.000 V	Increments of 0.001 V
Threshold Y0>	0.10 mS to 100.00 mS	Increments of 0.01 mS

[82] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[83] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1.6 A) or 0.25 mS (I_{rated} = 8 A), (f_{rated} = ± 10 %)

[83] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.19 Undercurrent Protection

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value I<	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time	Approx. 25 ms + OOT[84] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % portion harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

[84] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter Relay Outputs

Up to 50th harmonic, f_{rated} = 50 Hz	3 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

12.20 Negative-Sequence Protection

12.20.1 Stage with Definite-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated, obj.}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout ratio		0.40 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **Dropout ratio**
- Dropout differential of 3 % of the object rated current

Times

Pickup time	Approx. 40 ms + OOT[85] at 50 Hz
	Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{release}$
	All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

[85] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Pickup value	
$I_2/I_{rated,\ obj}$	Approx. 2 % of the setting value or 0.8 % of the absolute value
I_2/I_1	Approx. 2 % of the setting value or 4 % of the absolute value (I_1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))
Time delays	1 % of the setting value or 10 ms

12.20.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated,obj.}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout		Disk emulation Instantaneous	
Time multiplier		0.05 to 15.00	Increments of 0.01
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **Dropout ratio**
- Dropout differential of 3 % of the object rated current

Times

Pickup time	Approx. 40 ms + OOT[86] at 50 Hz
	Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

Dropout Ratio

Disk emulation	Approx. 0.90 · threshold value
Instantaneous	Approx. 1.05 · threshold value Approx. 0.95 · pickup value

[86] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Operate and Dropout Characteristic Curves

You can select from the following operate and dropout characteristic curves:

Table 12-3 Standard Characteristic Curves to IEC

Normal inverse: type A	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-1*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-2*
Long-time inverse: type B	

Table 12-4 Standard Characteristic Curves to ANSI

Inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-3*
Short inverse	
Long inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-4*
Moderately inverse	
Very inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-5*
Extremely inverse	
Definite inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-6*

Extension of the Operating Time

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{release}$
	All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 \text{ Hz} \le 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80 \text{ Hz}$	Slightly expanded tolerances
$f < 10 \text{ Hz}$ $f > 80 \text{ Hz}$	Inactive

Tolerances

Reference value = rated current	
Pickup value	Approx. 2 % of the setting value or 0.8 % of the absolute value
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Reference value = pos. seq. current	
Pickup value	Approx. 2 % of the setting value or 4 % of the absolute value (I1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))

Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

12.21 Directional Negative-Sequence Protection with Definite-Time Delay

Setting Values

Directional mode	Forward, backward, non-directional	
Stabilization with phase currents	0 % to 30 %	Increments of 1 %

Threshold value (pickup value) at $I_{N\text{-rated}}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
Threshold value (pickup value) at $I_{N\text{-rated}}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A

Extension time of the blocking after a 1-pole pause	0.00 s to 60.00 s	Increments of 0.01 s

Setting Values for Direction Determination

Minimum negative-sequence system voltage V2		0.150 V to 20.000 V	Increments of 0.001 V
Minimum negative-sequence system current I2	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Upper limit angle forward, β		0° to 360°	Increments of 1°
Lower limit angle forward, α		0° to 360°	Increments of 1°

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **`Dropout ratio`**
- Dropout differential of 3 % of the object rated current

Times

Operate time with time delay = 0 ms	Approx. 40 ms + OOT[87] at 50 Hz Approx. 40 ms + OOT at 60 Hz
Dropout time	Approx. 39 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Threshold values:	
Negative-sequence voltage V2	1 % of the setting value or 0.5 V
Negative-sequence current I2	2 % of the setting value or 10 mA at I_{rated} = 1 A
	1 % of the setting value or 5 mA at I_{rated} = 5 A
Times:	
Independent time delays	1 % of the setting value or 10 ms

[87] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Limit angle in determining the direction	5°

12.22 Thermal Overload Protection, 3-Phase

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values/Increments for the Protection Stage

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
K-factor acc. to IEC 60225-8		0.10 to 4.00	Increments of 0.01
Thermal time constant		10 s to 60 000 s	Increments of 1 s
Cooling time constant		10 s to 60 000 s	Increments of 1 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Temperature rise at Irated		40 K to 200 K	Increments of 1 K
Default temperature		-55°C to 55°C	Increments of 1°C
Minimal temperature		-55°C to 40°C	Increments of 1°C

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

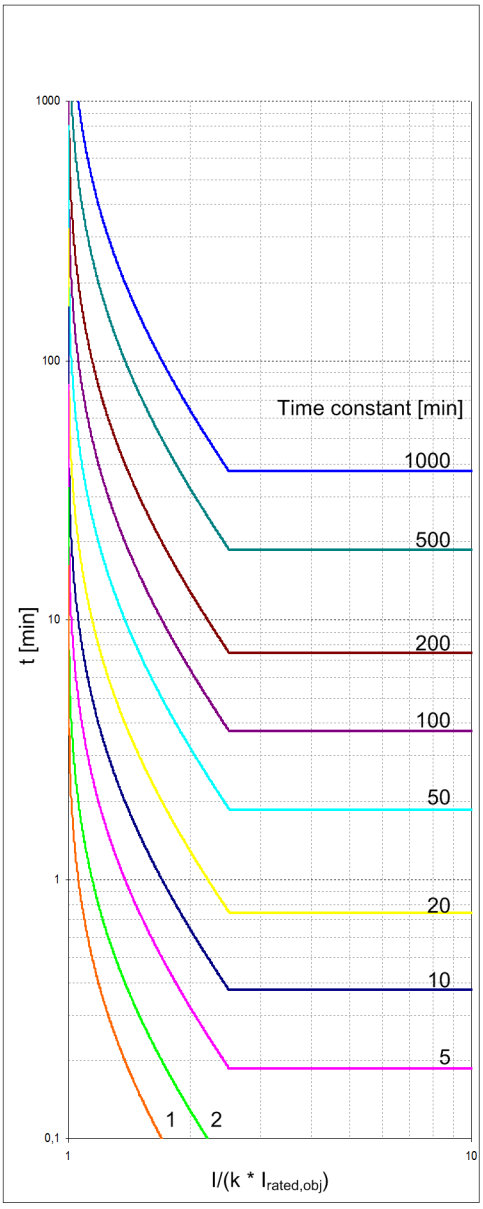
Tolerances

No filter applied (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-8
With the filter for compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 50 Hz	3 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 3 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 60 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8
With the filter for gain of harmonics including compensation of the amplitude attenuation[88] (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8[89]
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8[90]
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-8[90]
With reference to the operate time	Up to 30th harmonic	3 % or 1 s for $I/(k \cdot I_{rated}) > 1.25$, 3 % class acc. to IEC 60255-8

Operate Curve

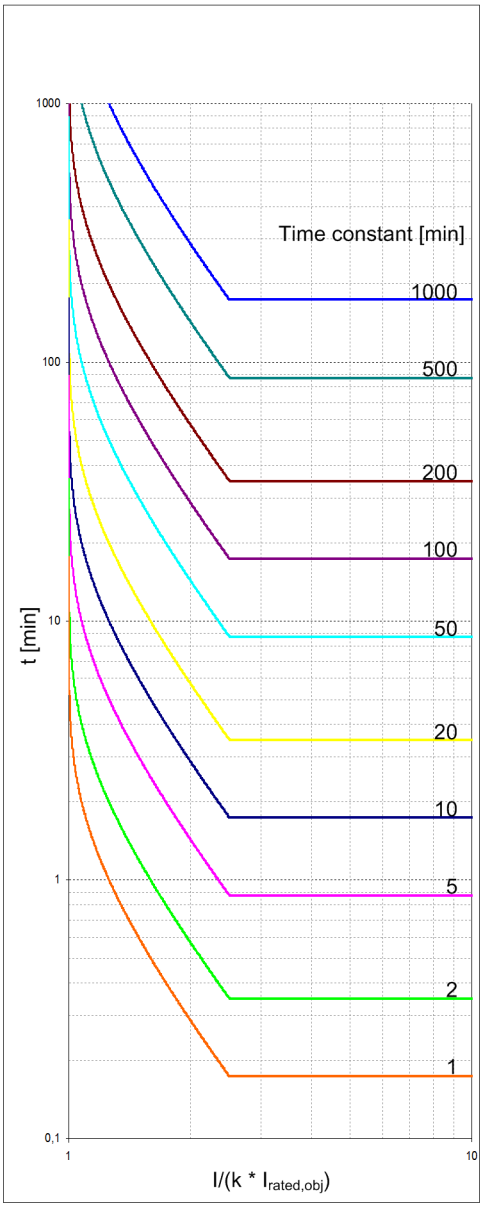
Operate curve	$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$	
Where	t	Operate time
	τ_{th}	Time constant
	I	Current load current
	$I_{preload}$	Preload current
	k	Setting factor according to VDE 0435 part 3011 or IEC 60255-8 (K factor)
	$I_{rated, obj}$	Rated current of the protected object

[88] In case that the filter response exactly matches the user-defined gain factor.
[89] In case that the user-defined gain factor is set below 3. The tolerance is increased if the gain factor is larger.
[90] In case that the user-defined gain factor is set below 7. The tolerance is increased if the gain factor is larger.



With 80 % preload and with $I_{max, therm} = 2.5 * k * I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$



Without preload and with $I_{max, therm} = 2.5*k*I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$

[dwauslke-100611-01.tif, 1, en_US]

Figure 12-15 Operate Curve of Overload Protection

12.23 Thermal Overload Protection, User-Defined Characteristic Curve

Setting Values

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Curve based on preload		1 % to 100 %	Increments of 1 %
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.10 p.u. to 20.00 p. u.	Increments of 0.0 p.u.
Y values of the operate curve		1.00 s to 20 000.00 s	Increments of 0.01 s

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

Tolerances

With reference to $k \cdot I_{rated}$	For I_{rated} = 1 A	2 % or 10 mA, class 2 % acc. to IEC 60255-8
	For I_{rated} = 5 A	2 % or 50 mA, class 2 % acc. to IEC 60255-8
With reference to operate time		3 % or 1 s, class 3 % acc. to IEC 60255-8 for $I/(k \cdot I_{rated}) > 1.25$

12.24 Unbalanced-Load Protection

Setting Values

Maximum continuously perm. I2	3.0 % to 30.0 % I2/ $I_{rated,machine}$	Increments of 0.1 %
Unbalanced load factor K	1.0 s to 100.0 s	Increments of 0.1 s
Warning delay	0.0 s to 60.0 s; ∞	Increments of 0.1 s
Cooling time thermal replica	0 s to 50 000 s	Increments of 1 s

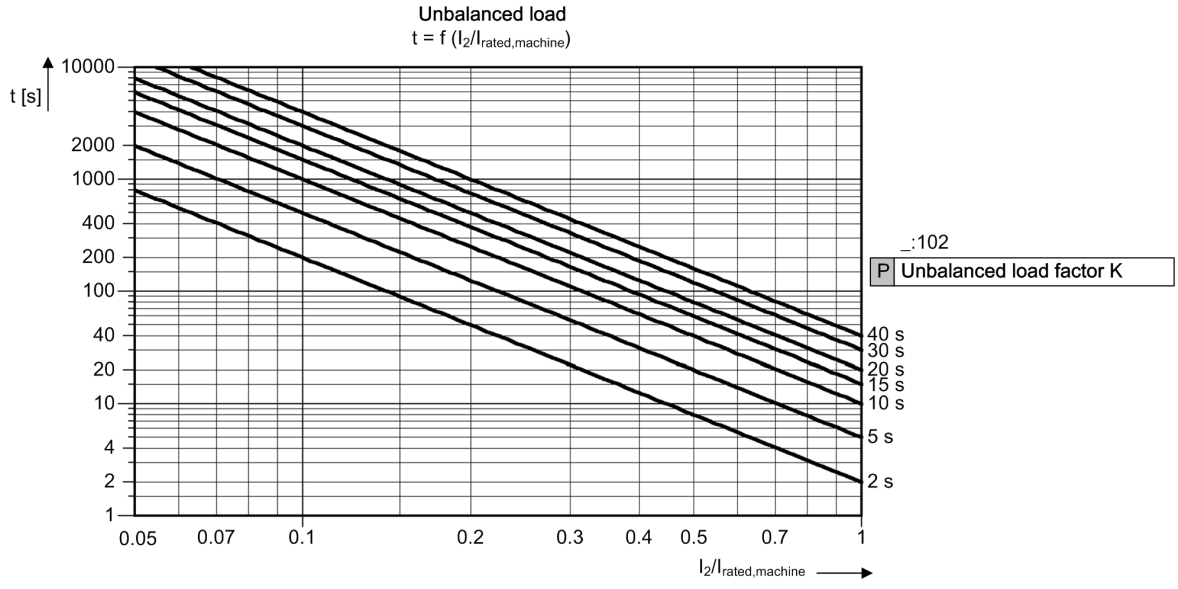
Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

- Dropout differential derived from a dropout ratio of 95 %
- Dropout differential of 3 % of the object rated current

Operate Characteristics

Characteristic of the thermal replica	$t_{I2\,Perm} = \frac{K}{(I_2/I_{rated,machine})^2}$	
Where:	t_{I2Perm}	Permissible application time of the negative-sequence current
	K	Unbalanced load factor K
	$I_2/I_{rated,machine}$	Unbalanced load (negative-sequence current/rated current of the machine)



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Figure 12-16 Thermal Characteristic for Unbalanced Load Protection

Times

Pickup time of the warning stage	Approx. 60 ms + OOT[91] at 50 Hz Approx. 50 ms + OOT at 60 Hz

[91] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays

Dropout time	Approx. 50 ms or better

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Negative-sequence current I_2	Approx. 3 % of setting value or 0.030 A at I_{rated} = 1 A Approx. 3 % of setting value or 0.150 A at I_{rated} = 5 A
Warning delay	1 % of the setting value or 10 ms
Time for $2 \le I_2/I_{2Perm} \le 20$	5 % of reference (calculated) value or 100 ms ± (1 % current tolerance or 10 mA) at I_{rated} = 1 A 5 % of reference (calculated) value or 100 ms ± (1 % current tolerance or 50 mA) at I_{rated} = 5 A

Influencing Variables for the Thresholds

Harmonics	
– Up to 10 % 3rd harmonic	≤ 1 %
– Up to 10 % 5th harmonic	≤ 1 %

12.25 Current-Unbalance Protection for Capacitors, 3-Phase

Setting Values for the Function

Automatic compensation		Yes No	
Time between switch off and switch on		0.00 s to 60.00 s	Increments of 0.01 s
Normalization with Ic		Yes No	
Threshold of defective C-element	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Setting Values (Overcurrent-Protection Stage I>)

Measured value		compensated non-compensated	
$I_{unbal.}$	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
$I_{unbal.}$	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s

Setting Values (Counter Stage)

Type of counting groups	segregated sum	
Max. no. of def. elem. phs A	1 to 1000	Increments of 1
Max. no. of def. elem. phs B	1 to 1000	Increments of 1
Max. no. of def. elem. phs C	1 to 1000	Increments of 1
Operate delay	0.00 s to 10000.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[92] at 50 Hz Approx. 29 ms + OOT at 60 Hz

[92] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents I_c, $I_{unbal.}$ Protection-class current transformers	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents $I_{unbal.}$ Sensitive current transformer	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

12.26 Current-Unbalance Protection for Capacitors, 1-Phase

Setting Values for the Function

Automatic compensation		Yes No	
Time between switch off and switch on		0.00 s to 60.00 s	Increments of 0.01 s
Normalization with Ic		Yes No	
Threshold of defective C-element	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Setting Values (Overcurrent-Protection Stage I>)

Current threshold $I_{unbal.}$	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.150 A to 175.000 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.005 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Measured value			compensated non-compensated

Setting Values (Counter Stage)

Type of counting groups		segregated sum
Type of counting phases		segregated sum
Max. no. of def. elem. phs A	1 to 1000	Increments of 1
Max. no. of def. elem. phs B	1 to 1000	Increments of 1
Max. no. of def. elem. phs C	1 to 1000	Increments of 1
Max. no. of def. elem.	1 to 1000	Increments of 1
Operate delay	0.00 s to 10000.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.
Minimum absolute dropout differential

Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[93] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents I_c, $I_{unbal.}$ Protection-class current transformers	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Currents $I_{unbal.}$ Sensitive current transformer	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A), (f_{rated} ± 10%)
Time delays	1 % of the setting value or 10 ms

[93] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.27 Voltage-Differential Protection for Capacitor Banks

Setting Values (General Functionality)

Voltage matching factor k	0.5000 to 2000.0000	Increments of 0.0001

Setting Values (Protection Stage V_{diff}>)

Threshold	0.005 p.u. to 1.000 p.u.[94]	Increments of 0.001 p.u.
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

Dropout ratio for sec. threshold > 3 V	95 %
Dropout differential for sec. threshold 0.3 V to 3 V	150 mV
Dropout ratio for sec. threshold 0.2 V to 0.3 V	50 %

Times

Operate time with time delay = 0 ms	Approx. 30 ms + OOT (Output Operating Time) at 50 Hz Approx. 27 ms + OOT (Output Operating Time) at 60 Hz
Dropout time	Approx. 20 ms + OOT (Output Operating Time) at 50 Hz Approx. 18 ms + OOT (Output Operating Time) at 60 Hz

Tolerances

Threshold ≥ 0.2 V	1 % of the setting value or 0.05 V (compensated)
Time delays	1 % of the setting value or 10 ms

Operating Range of the Secondary Differential Voltage

Operating Range of the secondary differential voltage	≥ 0.1 V (compensated)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

[94] Minimum secondary setting threshold = 0.2 V

12.28 Differential Protection for Capacitor Banks

Setting Values

Operate Curve			
Threshold value	$I/I_{ratedObj}$	0.05 to 2.00	Increments of 0.01
Gradient 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Irest	$I/I_{ratedObj}$	0.00 to 5.00	Increments of 0.01
Gradient 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Irest	$I/I_{ratedObj}$	1.00 to 20.00	Increments of 0.01
Startup Recognition			
Startup threshold value	$I/I_{ratedObj}$	0.1 to 2.0	Increments of 0.1
Characteristic-curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-Component Recognition			
Characteristic-curve increase factor DC		1.0 to 5.0	Increments of 0.1
Inrush-current detection			
Content 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of crossblk. 2. har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Recognition of External Faults			
Additional stabilization threshold value	$I/I_{ratedObj}$	1.00 to 20.00	Increments of 0.01
Additional stabilization duration		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Operate curve		See *Figure 12-17*	

Idiff Fast

Threshold value	$I/I_{ratedObj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout Ratio

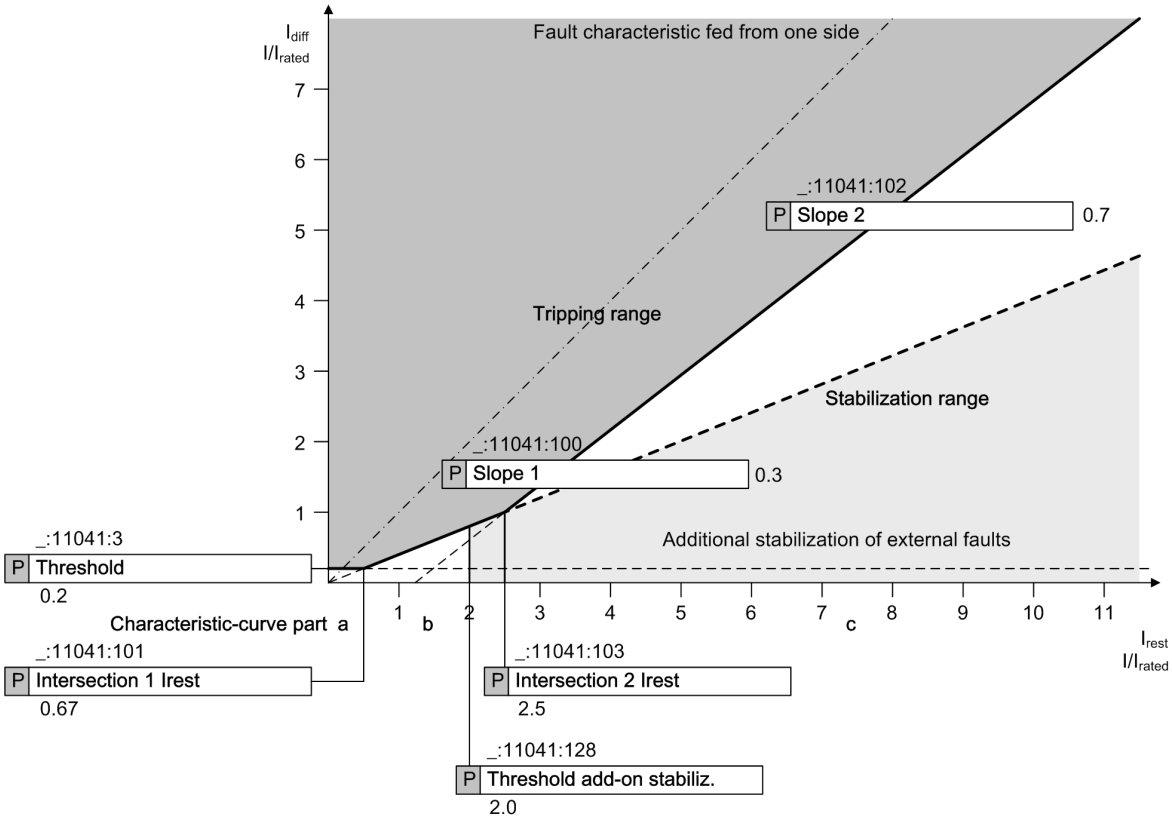
Idiff stage	Approx. 0.7
Idiff fast stage	Approx. 0.8

Response Tolerance

For preset characteristic-curve parameters; for 2 sides with one measuring point each	
Idiff stage and characteristic curve	2 % of the setting value
Idiff fast stage	2 % of the setting value

Time Delays

Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Idiff fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	



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Figure 12-17 Operate Curve of the Differential Protection

Operating Times

Operate times for infeed on one side		
Idiff stage, min	50 Hz 60 Hz	23 ms + OOT[95] 20 ms + OOT[1)]
Idiff fast stage, min	50 Hz 60 Hz	8 ms + OOT[1)] 8 ms + OOT[1)]
Dropout time, approx.	50 Hz 60 Hz	29 ms 26 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

[95] Refer to protection functions, for example, Overcurrent protection

12.29 Overvoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value[96]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 300.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Setting Values for Stage Type Inverse Time-Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value	0.300 V to 340.000 V	Increments of 0.001 V
Pickup factor	1.00 to 1.20	Increments of 0.01
Characteristic constant k	0.00 to 300.00	Increments of 0.01
Characteristic constant α	0.010 to 5.000	Increments of 0.001
Characteristic constant c	0.000 to 5.000	Increments of 0.001
Time multiplier	0.05 to 15.00	Increments of 0.01
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s
Reset time	0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve for Stage Type Inverse Time-Overvoltage Protection

$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (parameter **`Additional time delay`**)

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv} Inverse-time delay

T_p Time multiplier (parameter **`Time dial`**)

V Measured voltage

[96] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

V_{thresh}	Threshold value (parameter **Threshold**)
k	Curve constant k (parameter **Charact. constant k**)
α	Curve constant α (parameter **Charact. constant α**)
c	Curve constant c (parameter **Charact. constant c**)

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[97] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances for Stage Type Definite Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

Tolerances for Stage Type Inverse Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Operate time for 1.2 ≤ V/V threshold value ≤ 20	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

[97] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.30 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Setting Values

Method of Measurement	RMS value Fundamental component Fundamental component over 2 cycle filters	
Block. on measuring-voltage outage	Yes No	
Determ. ph. aff. by grd. flt.	Yes No	
Threshold value[98]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 320.00 s	Increments of 0.01 s
Dropout Ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[99] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout Time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

[98] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[99] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.31 Overvoltage Protection with Positive-Sequence Voltage

Setting Values

Pickup value	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[100] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[100] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

12.32 Overvoltage Protection with Negative-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle

Setting Values

Pickup value of V2	0.300 V to 200.000 V	Increments of 0.001 V
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT [101] (depends on the measuring-window length) at 50 Hz 48 ms to 185 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout time	20 ms to 70 ms + OOT (depends on the measuring-window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[101] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.33 Overvoltage Protection with Any Voltage

Setting Values

Measured value[102]	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[103]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[104] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[102] If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the measured-value parameter is not visible.
[103] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[104] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

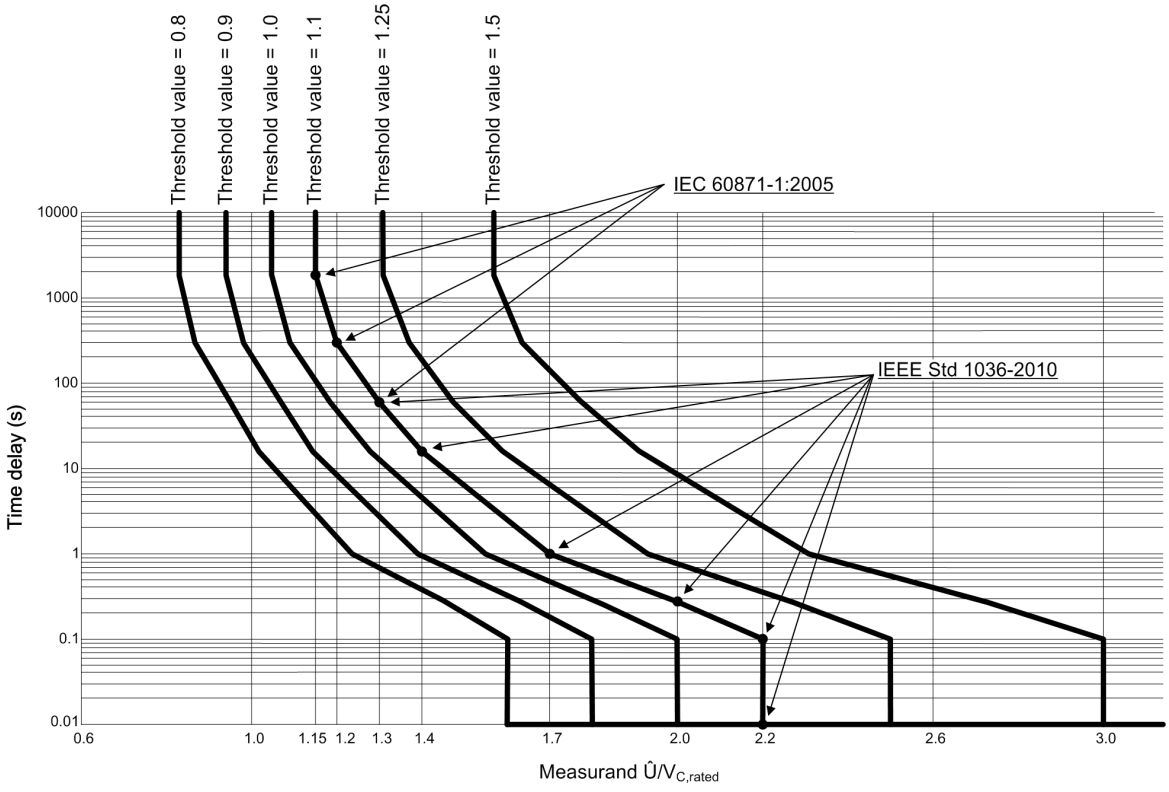
Time delays	1 % of the setting value or 10 ms

12.34 Peak Overvoltage Protection for Capacitors

Setting Values

Threshold value		
Inverse-time stage	0.80 to 3.00 p.u.	Increments of 0.01
Definite-time stage	0.80 to 10.00 p.u.	Increments of 0.01
User-defined characteristic curve	0.80 to 3.00 p.u.	Increments of 0.01
Tripping delay	0.01 s to 3600.00 s	Increments of 0.01 s
Dropout delay	0.00 s to 3600.00 s	Increments of 1.00 s
Down integration time	1 min to 1500 min	Increments of 1 min
Time multiplier	0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve	30	Increments of 1
X values of the operate curve	1.00 p.u. to 4.00 p.u.	Increments of 0.01 p.u.
Y values of the operate curve	0.00 s to 9999.99 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	30	Increments of 1
X values of the dropout characteristic curve	0.01 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve	0.00 s to 9999.99 s	Increments of 0.01 s

Inverse-Time Characteristic Curve (IEC/IEEE)



[dw_pecinv-230813, 2, en_US]

Figure 12-18 Inverse-Time Characteristic Curve

The points on the characteristic curve defined in the standards result from a threshold setting of 1.1. These single points are connected via semi-logarithmic line segments.

Table 12-5 Peak Overvoltage Inverse-Time Characteristic (for Threshold Setting 1.1)

Measurand $\hat{U}/V_{c,rated}$	**Time Delay**	**Curve Point According to**
<1.15	∞ (no pickup)	Siemens definition
1.15	1800.00 s	IEC 60871-1:2005
1.2	300.00 s	IEC 60871-1:2005
1.3	60.00 s	IEC 60871-1:2005, IEEE Std 1036-2010
1.4	15.00 s	IEEE Std 1036-2010
1.7	1.00 s	IEEE Std 1036-2010
2	0.25 s	IEEE Std 1036-2010
2.2	0.1 s	IEEE Std 1036-2010
>2.2	0.01 s	IEEE Std 1036-2010

Times

Pickup time	Approx. 35 ms + OOT at 50 Hz[1] Approx. 25 ms + OOT at 60 Hz[1]
Dropout Time	Depending on settings
[1] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays	

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Peak overvoltage (33 % harmonics, with reference to fundamental component)	
Up to 30th harmonic Up to 50th harmonic, $f_{rated} = 50\ Hz$ Up to 50th harmonic, $f_{rated} = 60\ Hz$	1 % of the setting value or 0.005 p.u. (f_{rated} ± 10%) 3 % of the setting value or 0.02 p.u. (f_{rated} ± 10%) 4 % of the setting value or 0.02 p.u. (f_{rated} ± 10%)
Time delays	
Measured value of inverse-time stage	5 % of the setting value +1 % of the measured value or 30 ms
Measured value of definite-time stage	1 % of the setting value or 10 ms
Down integration time	5 % of the setting value or 30 ms

12.35 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V

Setting Values for Stage Types

Pickup value of V2/V1	0.50 % to 100.00 %	Increments of 0.01 %
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT[105] (depends on the measuring-window length) at 50 Hz 48 ms to 190 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout times	22 ms to 55 ms + OOT (depends on the measuring-window length) at 50 Hz 18 ms to 45 ms + OOT (depends on the measuring-window length) at 60 Hz

Frequency Operating Range

0.9 f/f_{rated} to 1.1 f/f_{rated}	According to specified tolerances
10 Hz to 0.9 f/f_{rated} 1.1 f/f_{rated} to 80 Hz	Slightly expanded tolerances
$f < 10$ Hz $f > 80$ Hz	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[105] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.36 Undervoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup value[106]		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Setting Values for Stage Type Inverse Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold		0.300 V to 175.000 V	Increments of 0.001 V
Pickup factor		0.80 to 1.00	Increments of 0.01
Characteristic constant k		0.00 to 300.00	Increments of 0.01
Characteristic constant α		0.010 to 5.000	Increments of 0.001
Characteristic constant c		0.000 to 5.000	Increments of 0.001
Time multiplier		0.05 to 15.00	Increments of 0.01
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s
Reset time		0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve

$T_{op}=T_{Inv}+T_{add}$

Where:

T_{op} Operate delay

T_{Inv} Inverse-time delay

T_{add} Additional time delay (parameter **`Additional time delay`**)

[106] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_UVP3ph_inverse, 2, en_US]

Where

T_{Inv}	Inverse-time delay
T_p	Time multiplier (parameter **`Time dial`**)
V	Measured undervoltage
V_{Thresh}	Threshold value (parameter **`Threshold`**)
k	Curve constant k (parameter **`Charact. constant k`**)
α	Curve constant α (parameter **`Charact. constant α`**)
c	Curve constant c (parameter **`Charact. constant c`**)

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 25 ms + OOT[107] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 \text{ Hz} \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80 \text{ Hz}$	Slightly expanded tolerances
$f < 10 \text{ Hz}$ $f > 80 \text{ Hz}$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances for Stage Type Definite Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

[107] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances for Stage Type Inverse Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Operate time for $0 < V/V_{Thresh} < 0.9$	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

12.37 Undervoltage Protection with Positive-Sequence Voltage

Setting Values

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup value		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time	Approx. 25 ms + OOT [108] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[108] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

12.38 Undervoltage Protection with Any Voltage

Setting Values

Measured value	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated phase-to-phase voltage V_{AB} Calculated phase-to-phase voltage V_{BC} Calculated phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[109]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[110] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[109] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[110] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.39 Overfrequency Protection

Setting Values

Pickup values f>	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f>	Angle difference method	
	50 Hz 60 Hz	Approx. 70 ms + OOT[111] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 75 ms + OOT Approx. 75 ms + OOT
Dropout times f>	60 ms to 80 ms	

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f>
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz ± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz ± 10 mHz at V = V_{rated}
Time delay T(f>) 1 % of the setting value or 10 ms
Minimum voltage 1 % of the setting value or 0.5 V

[111] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter *12.1.4 Relay Outputs*

12.40 Underfrequency Protection

Setting Values

Pickup values f<	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f<	Angle difference method	
	50 Hz 60 Hz	Approx. 70 ms + OOT[112] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 75 ms + OOT Approx. 75 ms + OOT
Dropout times f<	60 ms to 80 ms	

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following two criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f<	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f<)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[112] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter *12.1.4 Relay Outputs*

12.41 Rate of Frequency Change Protection

Setting Values for the Function

Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V
Measuring window	2 periods to 5 periods	Increments of 1 period

Setting Values for Stage Types

Threshold	0.1 Hz/s to 20.0 Hz/s	Increments of 0.1 Hz/s
Dropout differential	0.02 Hz/s to 0.99 Hz/s	Increments of 0.01 Hz/s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx.165 ms to 225 ms (depends on measuring window length)
Dropout time	Approx.165 ms to 225 ms (depends on measuring window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Threshold, measuring window > 3 periods	Approx. 3 % or 0.06 Hz/s
Threshold, measuring window ≤ 3 periods	Approx. 5 % or 0.06 Hz/s
Minimum voltage	1 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

12.42 3-Phase Power Protection (P,Q)

Setting Values

Measured value	Positive sequence power Power of phase A Power of phase B Power of phase C	
Threshold value	-200.0 % to +200.0 %	Increments of 0.1
Tilt-power characteristic	-89.0° to +89.0°	Increments of 0.1°
Dropout delay time	0.00 s to 60.00 s	Increments of 0.01 s
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	Upper stage: 0.90 to 0.99 Lower stage: 1.01 to 1.10	Increments of 0.01 Increments of 0.01

Times

Pickup times	Approx. 55 ms + OOT[113] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout times	Approx. 55 ms + OOT at 50-Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Power	0.5 % S_{rated} ± 3 % of setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms

Variables That Influence Pickup Values

Auxiliary DC voltage in the range $0.8 \leq V_{Aux}/V_{AuxRated} \leq 1.15$	≤ 1 %
Frequency in the range $0.95 \leq f/f_{rated} \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % of 3rd harmonics - Up to 10 % of 5th harmonics	 ≤ 1 % ≤ 1 %

[113] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

12.43 Reverse-Power Protection

Setting Values

Reverse power $P_{reverse}$ (p.u.)	-0.30 % to -30.00 %	Increments of 0.01 %
Angle correction	-10.00 ° to 10.00 °	Increments of 0.01 °
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 60.00 s	0.00 s to 60.00 s
Tripping delay with quick stop	0.00 s to 60.00 s	0.00 s to 60.00 s
Dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.40 to 0.99	Increments of 0.01

Times

Pickup times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz
Dropout times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Reverse power	0.15 % S_{rated} or 5 % of the setting value when $Q < 0.5\ S_{rated}$
Time delays	1 % or 10 ms

12.44 Overexcitation Protection

Setting Values

Threshold value (characteristic curve dependent on pickup)		$\frac{U/U_{nenn}}{f/f_{nenn}}$	1.00 to 1.20	Increments of 0.01
Threshold value (characteristic curve independent on pickup)		$\frac{U/U_{nenn}}{f/f_{nenn}}$	1.00 to 1.40	Increments of 0.01
Time delay (warning delay and tripping delay)			0.00 s to 60.00 s	Increments of 0.01 s
Characteristic value pairs			2 to 30	
	Value ranges	V/f	1.00 p.u. to 10.00 p.u.	Increments of 0.01 p.u.
		t	0 s to 100 000 s	Increments of 1 s
Cooling time therm. replica			0 s to 100 000 s	Increments of 1 s

Functional Measured Values

Measured Value	Description
(_:2311:322) V/f	Value calculated from voltage and frequency.
(_:13591) Therm.charact.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, tripping occurs.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Operating Times

Operate times/dropout times		
Operate time at frequency	50 Hz	60 Hz
Minimum	33 ms + OOT[1]	30 ms + OOT[1][14]
Dropout time	10 ms + OOT[1]	10 ms + OOT[1]

Dropout Ratios

Warning, tripping (independent stage)	Approx. 0.98

Operate Curve

Thermal replica	For default setting refer to the following characteristic curve *Figure 12-19*

Tolerances

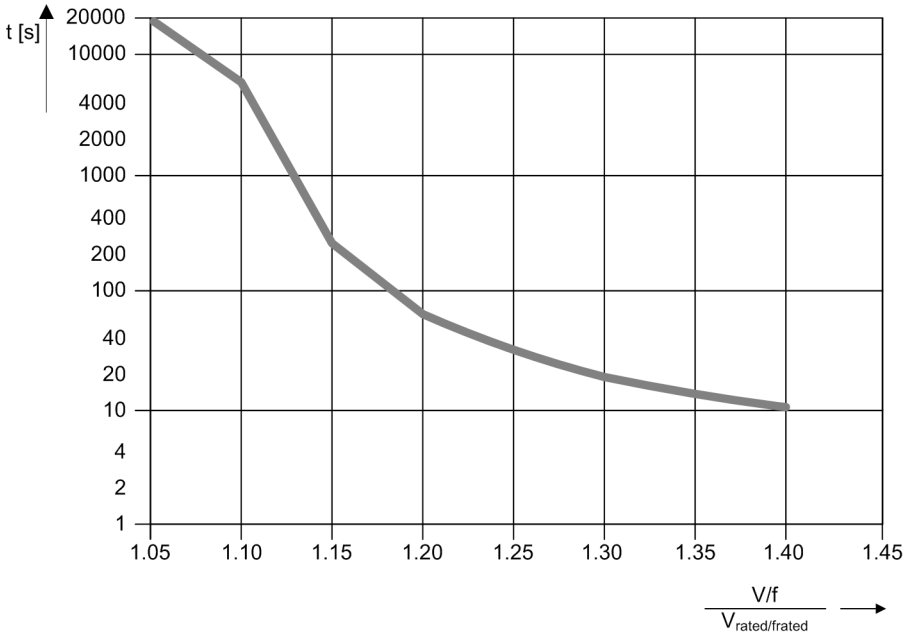
V/f pickup	2 % of the setting value
Time delays	1 % of the setting value or 10 ms (min. 1.5 periods)
Thermal replica	5 % based on V/f ± 600 ms

[114] Refer to protection functions, for example overcurrent protection

Voltage measurement accuracy	0.5 % of the setting value or 0.5 V in the range fn ± 10 %
Frequency measurement accuracy	1.0 % of the setting value or 1.0 Hz in the frequency range 10 Hz to 80 Hz

Influencing Quantities

Auxiliary direct voltage in the 0.8 range	≤ 1 %
Time delays	≤ 0.5 %/10 K
Thermal replica	≤ 1 %
Harmonics	
Up to 10 % of 3rd harmonic Up to 10 % of 5th harmonic	≤ 1 % ≤ 1 %



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Figure 12-19 Operate Curve from the Thermal Replica of the Overexcitation Protection (Default Setting)

12.45 Undervoltage-Controlled Reactive-Power Protection

Setting Values

Threshold value	Power Q	1.00 % to 200.00 %	Increments of 0.01 %
	Voltage of protection stage	3.000 to 175.000	Increments of 0.001 V
	Voltage of reclosure stage	3.000 V to 340.000 V	Increments of 0.001 V
Current I_1 release threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Release time delay of reclosure stage		0.00 s to 3600.00 s	Increments of 0.01 s

Dropout Ratio

Protection stage	
Reactive-power flow Q	Approx. 0.95
Voltage	Approx. 1.05
Release current	Approx. 0.95

Reclosure stage	
Voltage	Approx. 0.95
Release current	Approx. 0.95

Times

Pickup time	Approx. 55 ms + OOT[115] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout time	Approx. 55 ms + OOT at 50 Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Current I_1	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Voltage	0.5 % of the setting value or 0.05 V
Power Q	0.5 % S_{rated} ± 3 % of the setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms
Reclosure time delay	1 % of the setting value or 10 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances

[115] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

f < 10 Hz f > 80 Hz	Active

12.46 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	3-pole tripping internal or external[116]

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Sensitive threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Supervision time of release signal		0.06 s to 1.00 s	Increments of 0.01 s
Time delays		0.05 s to 60.00 s	Increments of 0.001 s
Supervision time of binary inputs		0.05 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3-pole CB tripping	1 input each for make contact and break contact

NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated.

Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow is absent or too low for tripping (for example with a transformer or a Buchholz protection).

[116] Via binary inputs

Times

Pickup time, in the case of an internal start Pickup time, in the case of an external start	< 1 ms < 5 ms
Typical dropout time	< 15 ms
Dropout time via circuit-breaker auxiliary-contact criterion	< 5 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Threshold values, dropout thresholds	2 % of the setting value or 1 % of the rated current
Times	1 % of the setting value or 10 ms

12.47 Circuit-Breaker Restrike Protection

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Monitoring duration		1.00 s to 600.00 s	Increments of 0.01 s
Position recognition delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Trip delay time		0.05 s to 60.00 s	Increments of 0.01 s
Retrip delay time		0.00 s to 60.00 s	Increments of 0.01 s
Minimum operate (trip) time		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Threshold	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

12.48 Restricted Ground-Fault Protection

Setting Values

Threshold value[117]	0.05 A to 2.00 A	Increments of 0.01 A
Gradient	0.00 to 0.95	Increments of 0.01
Operate curve	See figure	
Pickup tolerance (for preset characteristic curve parameters; for 2 sides with 1 measuring point each)	2 %	
Tripping delay	0.00 s to 60.00 s or ∞ (no tripping)	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF
(_:301) I diff.	Differential current
(_:302) I restr.	Restraint current

Dropout Ratio

Threshold value	0.7

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

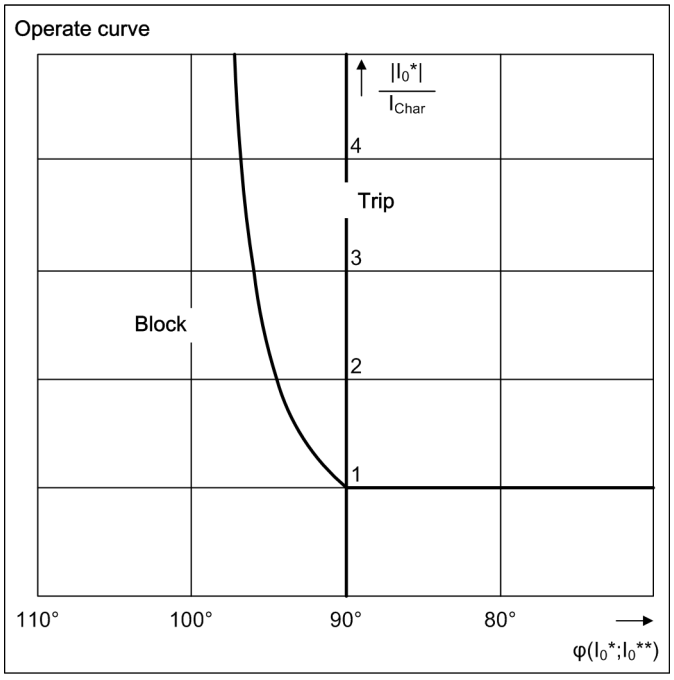
Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

7UT82/7UT85/7UT86/7UT87		
Frequency	50 Hz	60 Hz
	Operate time	Operate time

[117] The specified setting limit can be dynamically further limited, depending on the transformer adaptation factor, (for this refer to Chapter *6.41.4 Application and Setting Notes*).

At 1.5 · setting value threshold value At 2.5 · setting value threshold value	33 ms + OOT 27 ms + OOT	32 ms + OOT 26 ms + OOT
Dropout time approx.	80 ms	67 ms



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Figure 12-20 Restricted Ground-Fault Protection Operate Curve depending on the Phase Angle between II_0* and II_0** at $|II_0*| = |II_0**|$ (180° = External fault)

12.49 External Trip Initiation

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Operate time with time delay = 0 ms - At initiation via binary input signal	Approx. 10 ms + OOT [118].

Tolerance

Sequence tolerance for delay times	1 % of the setting value or 10 ms

[118] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

12.50 Automatic Reclosing

Function specifications	Cyclic automatic reclosing function Automatic reclosing function with adaptive dead time (ADT) Operation with External Automatic Reclosing Function	
Number of reclosings	Max. 8, per individual settings	
Type (depending on the order variation)	1-pole, 3-pole, or 1-/3-pole	
Operating mode of the automatic reclosing function	With trip command, without action time With trip command, with action time With pickup, without action time With pickup, with action time	
Reclaim time after reclosing	0.50 s to 300.00 s	Increments of 0.01 s
Blocking time after dynamic blocking	0.5 s	-
Blocking time after manual closure	0.00 s to 300.00 s	Increments of 0.01 s
Start supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Circuit-breaker supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Evolving-fault detection	With trip command with Pickup	
Reaction to evolving faults	Blocks automatic reclosing function Start, evolving fault, dead time	
Action times (separated for all cycles)	0.00 s to 300.00 s or oo (ineffective)	Increments of 0.01 s
Dead times after trip command (separated for all types and all cycles)	0.00 s to 1 800.00 s or oo (ineffective)	Increments of 0.01 s
Dead time after evolving-fault detection (separated for all cycles)	0.00 s to 1 800.00 s	Increments of 0.01 s
Synchrocheck after 3-pole dead time	None Internal External	
Transmission delay, inter close command	0.00 s to 300.00 s or oo (ineffective)	Increments of 0.01 s
Dead-line check/reduced dead time	Without Reduced dead time (VWE) Dead line checking	
Voltage supervision warning time	0.10 s to 30.00 s	Increments of 0.01 s
Limiting value for fault-free line	0.3 V to 340.0 V	Increments of 0.1 V
Limiting value for zero potential	0.3 V to 340.0 V	Increments of 0.1 V

12.51 Fault Locator

Setting Values

Reactance per unit length of the line per kilometer or per mile Line length for the correct output of the fault distance as a percentage of the line length The residual compensation factors in the setting format Kr and Kx or K0 and angle (K0)	
Consideration of the load current for 1-pole ground faults	Correction of the X value, for connection and disconnection

Fault Distance

Output of the fault distance (line length)	In Ω primary and secondary In km, miles or in percent. [119]

Tolerances

Measuring tolerances during sinusoidal measurands and error duration > 25 ms at 60 Hz or > 30 ms at 50 Hz	1.5 % from fault location at $V_K/V_{rated} \geq 0.01$ and one of the following scenarios: • Metal fault • Non-metallic fault for one-side infeed without load

[119] The output of the fault distance in km, miles and percent presupposes a homogenous line.

12.52 Temperature Supervision

Setting Values

Pickup value	-50 °C to 250 °C -58 °F to 482 °F	Increments of 1°C Increments of 1°F
Time delay	0 s to 60 s or ∞	Increments of 1 s

Dropout Conditions

Dropout differential	3 °C or 6 °F

Tolerances

Tripping delay	±1 % of the setting value or ±10 ms
Measured temperature value	±0.5 % of the setting value or ±1 °C or ±2 °F

12.53 Current-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[120] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Currents	3 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), ($f_{rated} \pm 10$ %) for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[120] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.54 Voltage-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[121] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Voltages	2 % of the setting value or 0.100 V for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[121] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.55 Synchronization Function

Operating Modes

Synchrocheck
Switching synchronous systems
Switching asynchronous systems
De-energized switching
Direct closing command

Setting Values

Supervision/Delay times:		
Max. Duration of synchronization process	0.00 s to 3 600.00 s or ∞ (ineffective)	Increments of 0.01 s
Supervision time de-energized switching	0.00 s to 60.00 s	Increments of 0.01 s
Closure delay	0.00 s to 60.00 s	Increments of 0.01 s
Voltage threshold values:		
Upper voltage limit V_{max}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Lower voltage limit V_{min}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
V<, for off-circuit conditions V>, for voltage present	0.300 V to 170.000 V (phase-to-phase) 0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V Increments of 0.001 V
Differential values, changeover thresholds asynchronous/synchronous:		
Voltage differences V2 > V1; V2 < V1	0.000 V to 170.000 V	Increments of 0.001 V
Frequency difference f2 > f1; f2 < f1	0.000 Hz to 2.000 Hz (synchronous) 0.000 Hz to 4.000 Hz (asynchronous)	Increments of 0.001 Hz
Angular difference α2 > α1; α2 < α1	0° to 90°	Increments of 1°
Δf threshold ASYN <-> SYN	0.010 Hz to 0.200 Hz	Increments of 0.001 Hz
Adjustments of the sides:		
Angle adjustment	0.0° to 360.0°	Increments of 0.1°
Voltage adjustment	0.500 to 2.000	Increments of 0.001
Circuit breaker		
Closing time of the circuit breaker	0.01 s to 0.60 s	Increments of 0.01 s

Dropout Ratio

Min./max. operating limit	1 % of the setting value
Voltage differential	10 % of the setting value or 0.5 V
De-energized/energized	5 % of the setting value
Frequency difference	3 mHz
Angular difference	0.1°

Measured Values of the Synchronization Function

Reference voltage V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Voltage to be synchronized V2 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Frequency of the voltage V1f1 • Range • Tolerance at rated frequency	f1 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Frequency of the voltage V1f2 • Range • Tolerance at rated frequency	f2 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Voltage difference V2-V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage in relation to side 1 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Frequency difference f2-f1 • Range • Tolerance at rated frequency	In mHz f_{rated} ± 10 % 1 mHz
Angular difference λ2-λ1 • Range • Tolerance at rated frequency	In ° -180° to +180° 0.5°

Times

Measuring time, after switching on the variables	Approx. 80 ms

Operating Range

Voltage	20 V to 340 V
Frequency	f_{rated} -4 Hz ≤ f_{rated} ≤ f_{rated} +4 Hz

Tolerances

Tolerances of the voltage settings	2 % of the pickup value or 1 V
Voltage difference V2>V1; V2<V1	1 V
Frequency difference f2>f1; f2<f1	10 mHz
Angular difference α2>α1; α2<α1	1°
Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

12.56 Voltage Controller

Setting Values

General Information		
I reference for % values	0.20 A to 100 000.00 A	Increments of 0.01 A
V reference for % values	0.20 kV to 1 200.00 kV	Increments of 0.01 kV
Volt. cont. 2W		
Target voltage 1	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Target voltage 2		
Target voltage 3		
Target voltage 4		
Volt. cont. 3W and GC		
Target voltage 1 w1	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Target voltage 2 w1		
Target voltage 3 w1		
Target voltage 4 w1		
Target voltage 1 w2		
Target voltage 2 w2		
Target voltage 3 w2		
Target voltage 4 w2		
Volt. cont. 2W, 3W, and GC		
Bandwidth	0.2 % to 10.0 %	Increments of 0.1 %
T1 delay	5 s to 600 s	Increments of 1 s
T1 Inverse Min	5 s to 100 s	Increments of 1 s
T2 delay	0 s to 100 s	Increments of 1 s
Fast step down limit	0.0 % to 50.0 %	Increments of 0.1 %
Fast step down T delay	0.0 s to 10.0 s	Increments of 0.1 s
Fast step up limit	-50.0 % to 0.0 %	Increments of -0.1 %
Fast step up T delay	0.0 s to 10.0 s	Increments of 0.1 s
Function monitoring	1 min to 120 min	Increments of 1 min
Line compensation LDC-Z		
Target voltage rising	0.0 % to 20.0 %	Increments of 0.1 %
Max load current	0.0 % to 500.0 %	Increments of 0.1 %
Line compensation LDC-X and R		
R line	0.0 Ω to 30.0 Ω	Increments of 0.1 Ω
X line	-30.0 Ω to 30.0 Ω	Increments of 0.1 Ω
Limiting values		
Vmin threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Vmin time delay	0 s to 20 s	Increments of 1 s
Vmax threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Vmax time delay	0 s to 20 s	Increments of 1 s
Blockings		
V< Threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
V< Time delay	0 s to 20 s	Increments of 1 s
I> Threshold	10 % to 500 %	Increments of 1 %
I> Time delay	0 s to 20 s	Increments of 1 s
I< Threshold	3 % to 100 %	Increments of 1 %

I< Time delay	0 s to 20 s	Increments of 1 s

Measured Values, Two-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Current, measured positive-sequence voltage (referenced to phase-to-phase)	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load	Current measured load current (positive-sequence system)	A	A	Load current referenced to the rated current of the winding
V max	Maximum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive-sequence voltage ever measured (reference to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding
V target	Calculated target voltage with consideration of Z compensation	kV	V	Target voltage of the winding referenced to the rated voltage of the winding

Measured Values, Three-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to the rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to the rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1

Measured Value	Description	Primary	Secondary	% Referenced to
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Dropout Ratio

Threshold of the voltage limit	About 0.99 of the setting value
Threshold of the current limit	About 0.99 of the setting value

12.57 Current-Balance Supervision

Setting Values

Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value min/max		0.10 to 0.95	Increments of 0.01
Tripping delay		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overcurrent dropout ratio	About 0.97
Undercurrent dropout ratio	About 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.58 Voltage-Balance Supervision

Setting Values

Release threshold value	0,300 V to 170,000 V	Increments of 0.001 V
Threshold value min/max	0.58 to 0.95	Increments of 0.01
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overvoltage dropout ratio	Approx. 0.97
Undervoltage dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.59 Current-Sum Supervision

Setting Values

Slope of the characteristic curve		0.00 to 0.95	Increments of 0.01
Threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Tripping delay		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	About 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.60 Voltage-Sum Supervision

Setting Values

Threshold value	0.300 V to 170.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.61 Current Phase-Rotation Supervision

Setting Values

Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.62 Voltage Phase-Rotation Reversal

Setting Values

Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.63 Trip-Circuit Supervision

Setting Values

Number of monitored circuits per circuit-breaker function group	1 to 3	
Operating mode per circuit	With 1 binary input With 2 binary inputs	
Pickup and dropout time	About 1 s to 2 s	
Adjustable indication delay with 1 binary input	1.00 s to 600.00 s	Increments of 0.01 s
Adjustable indication delay with 2 binary inputs	1.00 s to 600.00 s	Increments of 0.01 s

12.64 Analog Channel Supervision via Fast Current Sum

Times

Pickup times	Approx. 2 ms (faster than the fastest protection function)
Dropout time	Approx. 100 ms

Blockings

Blocked functions	All functions that process the measured values from this current measuring point (for example, differential protection).

12.65 Measuring-Voltage Failure Detection

Setting Values

3ph.fail. - VA,VB,VC <		0.300 V to 340 000 V	Increments of 0.001 V
3ph.fail. - phs.curr.release	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
3ph.fail. - phs.curr. jump	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Asym.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s
SO 3ph.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 10 ms + OOT[122] at 50 Hz Approx. 10 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Times

Use in function group **Line**	
Pickup time	Approx. 10 ms + OOT[123] at 50 Hz Approx. 9 ms + OOT at 60 Hz

Use in other function group types	
Pickup time	Approx. 20 ms + OOT[124] at 50 Hz Approx. 18 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

[122] OOT (Output Operating Time) Additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*
[123] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*
[124] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

f < 10 Hz f > 80 Hz	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Voltages	0.5 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

12.66 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

12.67 Operational Measured Values and Statistical Values

The following applies to the tolerances of currents and voltages:

- The values apply both to the RMS values and the absolute value and phase angle of the fundamental components.
- The values were determined for pure sinusoidal signals – without harmonics.

Voltages

V_A, V_B, V_C Voltage range	V secondary < 200 V secondary
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
V_{AB}, V_{BC}, V_{CA} Voltage range	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Instrument Transformers

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 100 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 to 25 A 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 50 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 to 25 A 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.6 % of the measured value in the above mentioned measuring range

Currents, Sensitive Ground-Current Transformer

$3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Phase Angle

ΦV	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz

Tolerance ΦV	0.2 ° at rated voltage
ΦI	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦI	0.2 ° at rated current

Power Values

Active power P	W secondary
Measuring range Voltage range Current range Frequency range	|cosφ| ≥ 0.01 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range
Reactive power Q	var secondary
Measuring range Voltage range Current range Frequency range	|cosφ| ≥ 0.984 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	1.0 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	1.5 % of the measured value in the above mentioned measuring range
Apparent power S	VA
Measuring range Voltage range Current range Frequency range	(0.01 to 2) · S_{rated} (0.8 to 1.2) · V_{rated} (0.01 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range

Frequency

Frequency f	Hz

Range	f_{rated} - 0.20 Hz < f_{rated} + 0.20 Hz
Tolerance	± 5 mHz in the V_{rated} range
Range	f_{rated} - 3.00 Hz < f_{rated} + 3.00 Hz
Tolerance	± 10 mHz in the V_{rated} range
Frequency range (expanded)	25 Hz to 80 Hz; operational measured values 10 Hz to 80 Hz; functional measured values, system frequency
Tolerance	20 mHz in the range f_{rated} ± 10 % for rated values

Statistical Values of the Device

Device operating hours	h
Range	0 to 9 999 999 h
Tolerance	1 h

Statistical Values of the Circuit Breaker

Op.cnt. (operation counter)	
Range	0 to 999 999 999
Tolerance	None
∑**I Off** (sum of the primary currents switched off)	A, kA, MA, GA, TA, PA primary
Range	0 to 9.2 e+15
Operating hours	h
Range	0 to 9 999 999 h
Tolerance	1 h
Circuit breaker open hours	h
Range	0 to 9 999 999 h
Tolerance	1 h

Statistical Values of the Disconnector

Op.cnt. (operation counter)	
Range	0 to 999 999 999
Tolerance	None

12.68 Energy Values

Setting Values

Active energy W_p Reactive energy W_q	kWh, MWh, GWh kvarh, Mvarh, Gvarh
Range	≤ 2% for $I > 0.1\ I_{rated}$, $V > 0.1\ V_{rated}$ $\lvert\cos\varphi\rvert \geq 0.707$
Tolerance at rated frequency	1 %

12.69 Phasor Measurement Unit

Accuracy

As per IEEE Std C37.118.1a-2013

Synchrophasor Standard

IEEE Std C37.118.1-2011

12.70 Circuit-Breaker Wear Monitoring

Setting Values

Threshold value	ΣI^x-method stage	0 to 10 000 000	Increments of 1
	2P-method stage	0 to 10 000 000	Increments of 1
	I^2t-method stage	0.00 I/Ir*s to 21 400 000.00 I/Ir*s	Increments of 0.01
CB opening time		0.001 s to 0.500 s	Increments of 0.001 s
CB break time		0.001 s to 0.600 s	Increments of 0.001 s
CB make time		0.001 s to 0.600 s	Increments of 0.001 s
Exponent for the ΣI^x method		1.0 to 3.0	Increments of 0.1
Switching cycles at I_{rated}		100 to 1 000 000	Increments of 1
Rated short-circuit breaking current I_{sc}		10 to 100 000	Increments of 1
Switching cycles at I_{sc}		1 to 1000	Increments of 1
Level of warning 1		1 % to 100 %	Increments of 1 %
Level of warning 2		1 % to 100 %	Increments of 1 %
Operating current threshold	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Delay correction time		-0.050 s to 0.050 s	Increments of 0.001 s

Tolerances

Tolerance of the measured value make time	± 2 ms

12.71 CFC

Typical response times and maximum number of ticks of the CFC task levels:

Task Level	Time (in ms)	Ticks for Non-Modular Devices with CP100	Ticks for Modular Devices with CP200	Ticks for Modular Devices with CP300
Fast Event-Triggered	<1	500	500	1000
Event-Triggered	<10	12 367	12757	14702
Interlocking	<10	117 564 in total	121 537 in total	141 398 in total
Measurement	250			

The times describe the response time of a typical CFC chart at the respective task level. The maximum number of ticks applies to a typical load for the device based on the application template **Directional time-overcurrent protection, grounded electrical power system**. The maximum number can be lower in case of extensive protection applications.

The task level ***Measurement*** runs in cycles every 500 ms. All other task levels are event-triggered.

In order to estimate the tick consumption of a CFC chart, you can use the following formula:

$$T_{chart} = 5 \cdot n_{Inp} + 5 \cdot n_{Outp} + T_{TLev} + \sum_i T_{int} + \sum_j T_{Block}$$

where:

n_{Inp} Number of indications routed as input in the CFC chart

n_{Outp} Number of indications routed as output in the CFC chart

T_{TLev} 101 Ticks in Fast Event-Triggered Level
104 Ticks in Event-Triggered Level
54 Ticks in Measurement Level
74 Ticks in Interlocking Level

T_{int} Number of internal connections between 2 CFC blocks in one chart

T_{Block} Used ticks per CFC block (see Technical Data)

Table 12-6 Ticks of the Individual CFC Blocks

Element	Ticks
ABS_D	2.3
ABS_R	1.5
ACOS_R	6.9
ADD_D4	3.4
ADD_R4	3.3
ADD_XMV	6.4
ALARM	1.8
AND_SPS	1.1
AND10	2.9
APC_DEF	1.2
APC_EXE	1.0
APC_INFO	3.9
ASIN_R	1.3
ATAN_R	1.2
BLINK	1.3
BOOL_CNT	2.0
BOOL_INT	1.5

Element	Ticks
BSC_DEF	1.3
BSC_EXE	1.1
BSC_INFO	2,7
BUILD_ACD	2.9
BUILD_ACT	2.2
BUILD_BSC	1.2
BUILD_CMV	2.3
BUILD_DEL	2.1
BUILD_DPS	1.4
BUILD_ENS	1.3
BUILD_INS	0.5
BUILD_Q	0.8
BUILD_SPS	0.6
BUILD_WYE	3.2
BUILD_XMV	2.9
BUILDC_Q	3.0
CHART_STATE	5.9
CMP_DPS	1.5
CON_ACD	0.7
CON_ACT	0.5
CONNECT	0.4
COS_R	2.5
CTD	1.8
CTU	1.6
CTUD	2.3
DINT_REAL	3.0
DINT_UINT	3.0
DIV_D	2.9
DIV_R	1.6
DIV_XMV	2.2
DPC_DEF	0.4
DPC_EXE	0.4
DPC_INFO	1.1
DPC_OUT	1.3
DPS_SPS	1.0
DRAGI_R	1.7
EQ_D	1.0
EQ_R	1.9
EXP_R	1.5
EXPT_R	2.7
F_TRGM	0.3
F_TRIG	0.3
FF_D	0.9
FF_D_MEM	1.4
FF_RS	0.7
FF_RS_MEM	1.2
FF_SR	0.8

Element	Ticks
FF_SR_MEM	1.1
GE_D	0.9
GE_R	1.1
GT_D	0.9
GT_R	1.2
HOLD_D	1.1
HOLD_R	1.0
INC_INFO	0.9
LE_D	1.1
LE_R	1.1
LIML_R	1.5
LIMU_R	1.5
LN_R	3.3
LOG_R	1.2
LOOP	1.5
LT_D	0.9
LT_R	0.9
MAX_D	0.9
MAX_R	1.4
MEMORY_D	0.9
MEMORY_R	1.1
MIN_D	0.7
MIN_R	1.3
MOD_D	1.5
MUL_D4	2.5
MUL_R4	2.7
MUL_XMV	2.8
MUX_D	1.2
MUX_R	0.9
NAND10	3.5
NE_D	0.9
NE_R	0.9
NEG	1.2
NEG_SPS	0.8
NLC_LZ	7.1
NLC_XMV	4.4
NLC_ZP	3.0
NOR10	3.2
OR_DYN	1.1
OR_SPS	1.3
OR10	2.6
R_TRGM	0.4
R_TRIG	0.4
REAL_DINT	3.0
REAL_SXMV	3.0
SIN_R	0.8
SPC_DEF	0.4

Element	Ticks
SPC_EXE	0.4
SPC_INFO	0.4
SPC_OUT	0.4
SPLIT_ACD	3.4
SPLIT_ACT	1.0
SPLIT_BSC	1.3
SPLIT_CMV	2.2
SPLIT_DEL	2.0
SPLIT_DPS	1.0
SPLIT_INS	0.5
SPLIT_Q	0.7
SPLIT_SPS	0.8
SPLIT_WYE	2.6
SPLIT_XMV	2.1
SQRT_R	0.6
SUB_D	1.3
SUB_R	1.6
SUB_XMV	2.4
SUBST_B	1.0
SUBST_BQ	1.5
SUBST_D	1.0
SUBST_R	1.0
SUBST_XQ	1.4
SXMV_REAL	3.0
TAN_R	1.1
TLONG	2.2
TOF	1.0
TON	1.1
TT	2.5
TSHORT	1.9
UINT_DINT	3.0
XOR2	2,6

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A.1 Order Configurator and Order Options

Order Configurator

The order configurator assists you in the selection of SIPROTEC 5 products. The order configurator is a Web application that can be used with any browser. The order configurator can be used to configure complete devices or individual components, such as communication modules, expansion modules, or other accessories. At the end of the configuration process, the product code and a detailed presentation of the configuration result are provided. The product code unambiguously describes the selected product and also serves as an order number.

Ordering Options

The following ordering options are possible for SIPROTEC 5 products:

- Device
- Single part
- DIGSI 5
- Functional enhancement



NOTE

To order single parts in the order configurator, use the **Single part** link.

Individual parts are:

- Replacement base module
- Expansion module
- Plug-in module
- Sensors for arc protection
- Operation panel
- Terminal
- Accessories

A.2 Ordering Accessories

NOTE

To order terminals, terminal accessories, and mechanical accessories in the order configurator, use the **Single part** link.

Table A-1 Accessories

Group	Accessories
Terminal	Voltage terminal, terminal block, 14-pole
Terminal	Voltage input (power supply) Terminal block, 2-pole[125]
Terminal	Type A current terminal, 4 x protection (for modular devices)
Terminal	Type A current terminal, 3 x protection and 1 x measurement (for modular devices)
Terminal	Type A current terminal, 4 x measurement (for modular devices)
Terminal	Type B current terminal, 4 x protection (for non-modular devices)
Terminal	Type B current terminal, 3 x protection and 1 x measurement (for non-modular devices)
Terminal	2-pole cross connector for current terminal
Terminal	Terminal pair component IO110[125]
Terminal	Terminal kit only for IO230/231[125]
Terminal	2-pole cross connector for voltage terminal
Terminal	Cover for current terminal block
Terminal	Cover for voltage terminal block
Accessories	Cable, integrated operation panel 0.43 m
Accessories	Cable, detached operation panel 2.50 m
Accessories	Cable, detached operation panel 5.00 m
Accessories	Cable set COM link cable
Accessories	Cover plate for plug-in modules
Accessories	Set of angle brackets
Accessories	Labeling strips for LEDs/keypad
Accessories	Set of parts for mounting bracket 1/2
Accessories	Set of parts for mounting bracket 2/3
Accessories	Set of parts for mounting bracket 5/6
Accessories	Set of parts for mounting bracket 1/1
Accessories	Screw cover 1/3, type C11
Accessories	Screw cover 1/3, type C22
Accessories	Screw cover 1/6, type C21
Accessories	Bus termination plate
Accessories	Assembly frame for panel surface mounting for non-modular 7xx82 devices
Accessories	SDHC memory card for 7KE85

[125] Recommended tightening torque for fixing the terminal at the rear side: 0.3 Nm

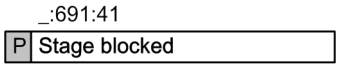
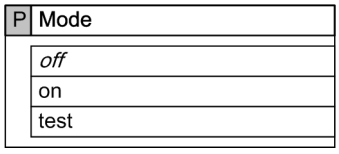
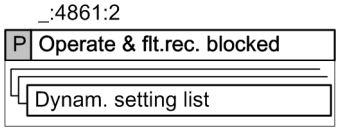
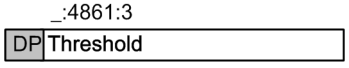
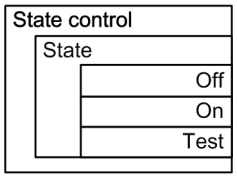
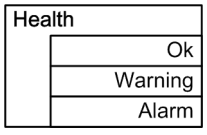
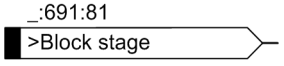
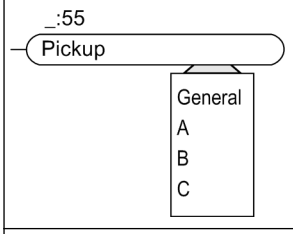
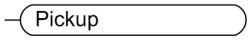
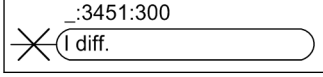
Group	Accessories
Accessories	Battery holder
Accessories	Connecting cable for 2nd row
Accessories	Arc push-buttons
Sensors for arc protection	Point sensor with line length of 3 m
Sensors for arc protection	Point sensor with line length of 4 m
Sensors for arc protection	Point sensor with line length of 5 m
Sensors for arc protection	Point sensor with line length of 10 m
Sensors for arc protection	Point sensor with line length of 15 m
Sensors for arc protection	Point sensor with line length of 20 m
Sensors for arc protection	Point sensor with line length of 35 m
Sensors for arc protection	Line sensor with line length of 5 m
Sensors for arc protection	Line sensor with line length of 10 m
Sensors for arc protection	Line sensor with line length of 20 m
Sensors for arc protection	Line sensor with line length of 30 m
Sensors for arc protection	Line sensor with line length of 40 m
Sensors for arc protection	Supply line for line sensors, length: 3 m
Sensors for arc protection	Supply line for line sensors, length: 5 m
Sensors for arc protection	Supply line for line sensors, length: 10 m

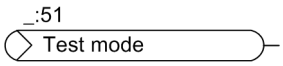
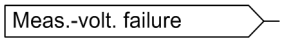
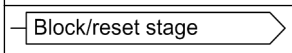
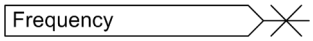
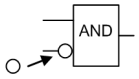
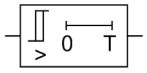
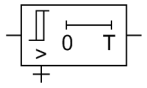
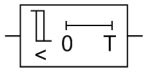
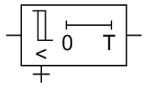
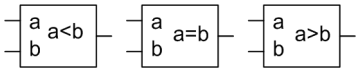
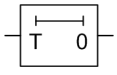
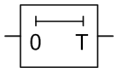
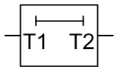
A.3 Typographic and Symbol Conventions

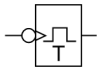
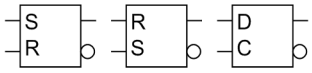
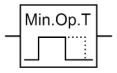
The following typefaces are used to characterize parameters in the text:

Mode	Parameter name
_:661:1	Parameter address _ stands for the address combination from function group:function 661, for example, stands for the address of the setting parameter
from	Parameter state

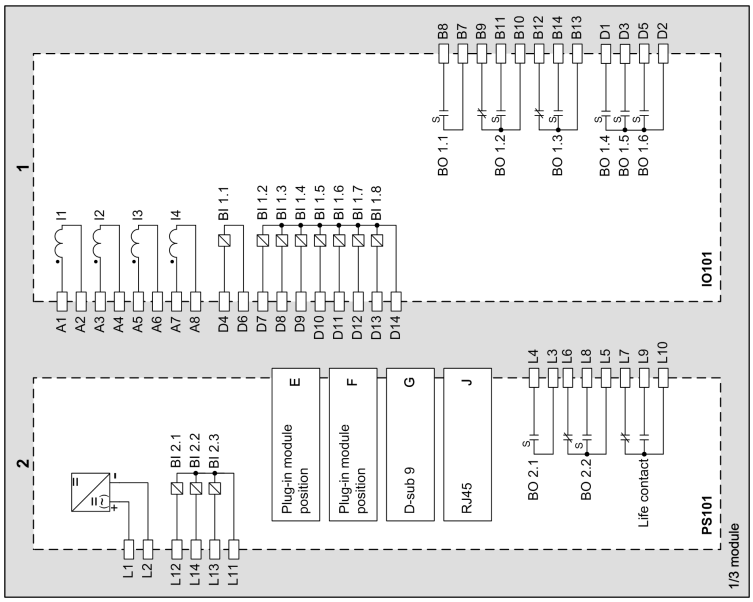
The following symbols are used in drawings:

Icon	Description
	Parameter
	Parameters with setting values The default setting is in the 1st position and displayed in italics
	Parameters with application-dependent setting values
	Dynamic settings:
	State logic
	Health of a function, stage, or function block
	External binary input signal with indication number
	External output signal with indication number and additional information
	External output signal without indication number
	Measured output value

Icon	Description
	Binary input signal derived from an external output signal
	Internal input signal
	Internal output signal
	Analog input signal
	Reset/Block a logic element
	AND gate
	OR gate
	XOR gate
	Negation
	Threshold stage exceeded
	Threshold stage exceeded with reset of input
	Threshold stage shortfall
	Threshold stage shortfall with reset of input
	Threshold stage exceeded with dropout delay
	Threshold stage exceeded with dropout delay and reset of input
	Threshold stage shortfall with Dropout delay
	Threshold stage shortfall with dropout delay and reset of input
	Comparators
	Pickup delay
	Dropout delay
	Pickup and dropout delay

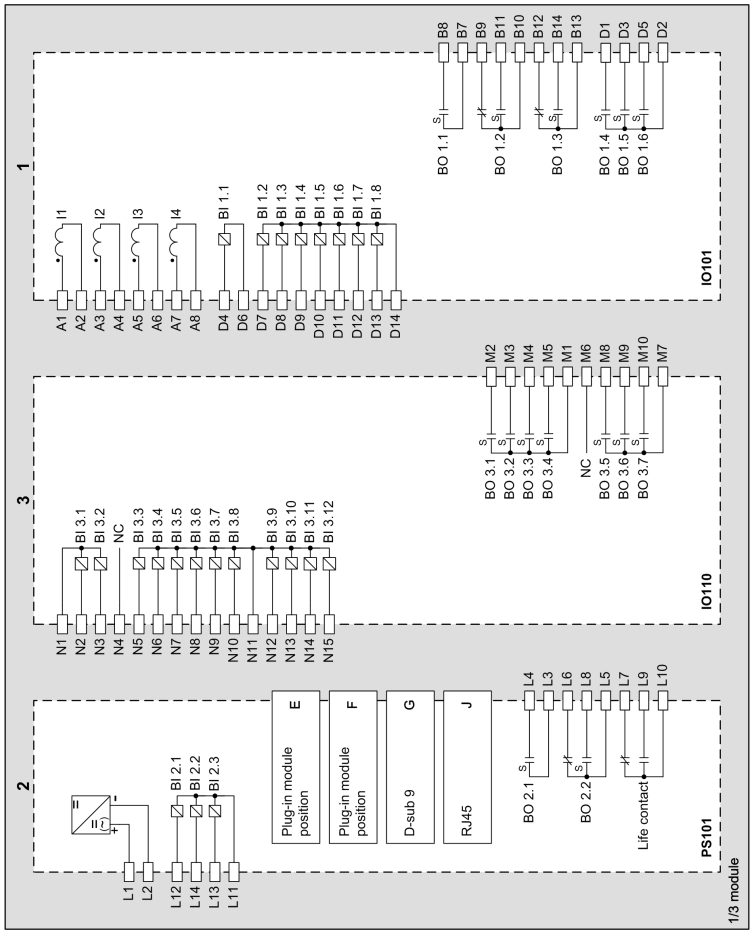
Icon	Description
	Trigger the pulse of duration T with a positive signal edge
	Trigger the pulse of duration T with a negative signal edge
	SR-Flip-Flop, RS-Flip-Flop, D-Flip-Flop
	Characteristic curve
	Minimum operate time

A.4 Standard Variants for 7SJ82



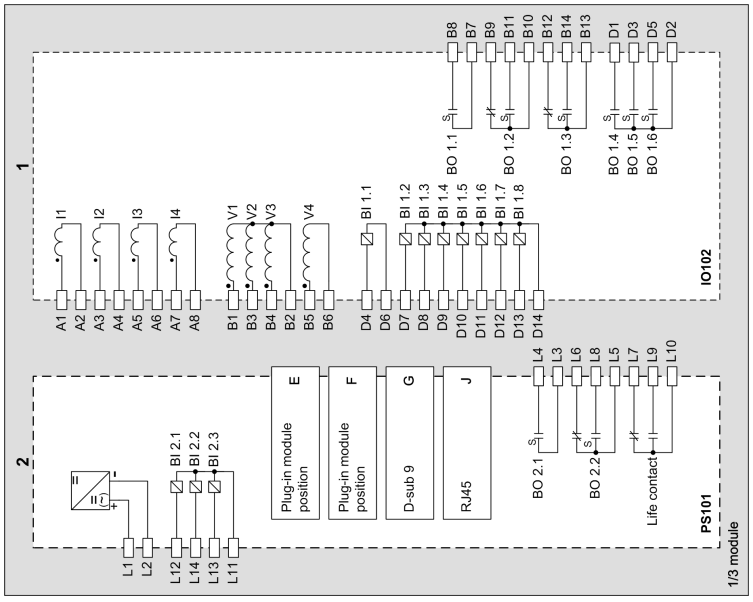
[sv82typ01-120913-01.tif, 1, en_US]

Figure A-1 Standard Variant Type U1



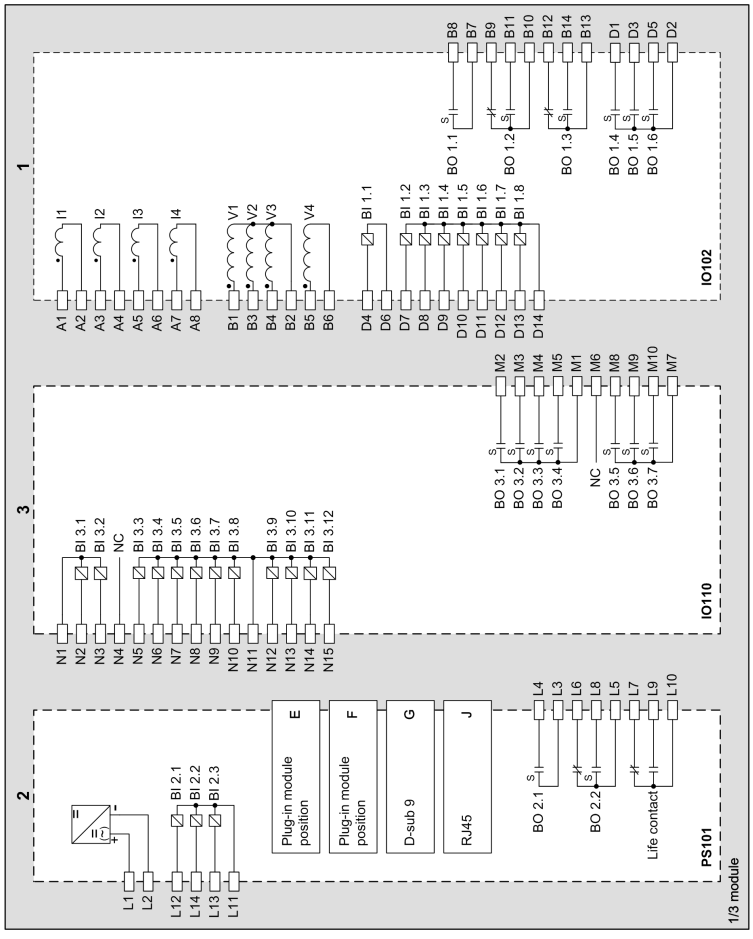
[sv82typ02-120913-01.tif, 1, en_US]

Figure A-2 Standard Variant Type U2



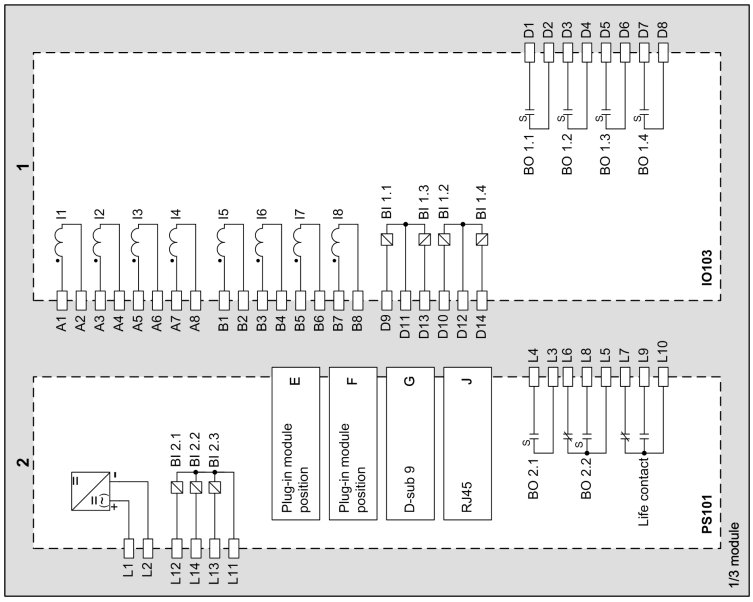
[sv82typ03-120913-01.tif, 1, en_US]

Figure A-3 Standard Variant Type U3



[sv82typ04-120913-01.tif, 1, en_US]

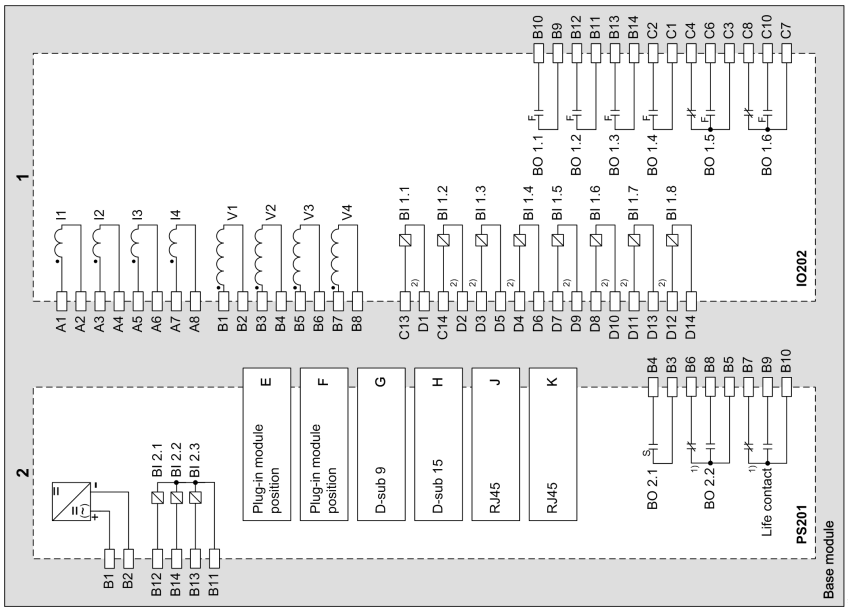
Figure A-4 Standard Variant Type U4



[svut82typ01-210114-01, 1, en_US]

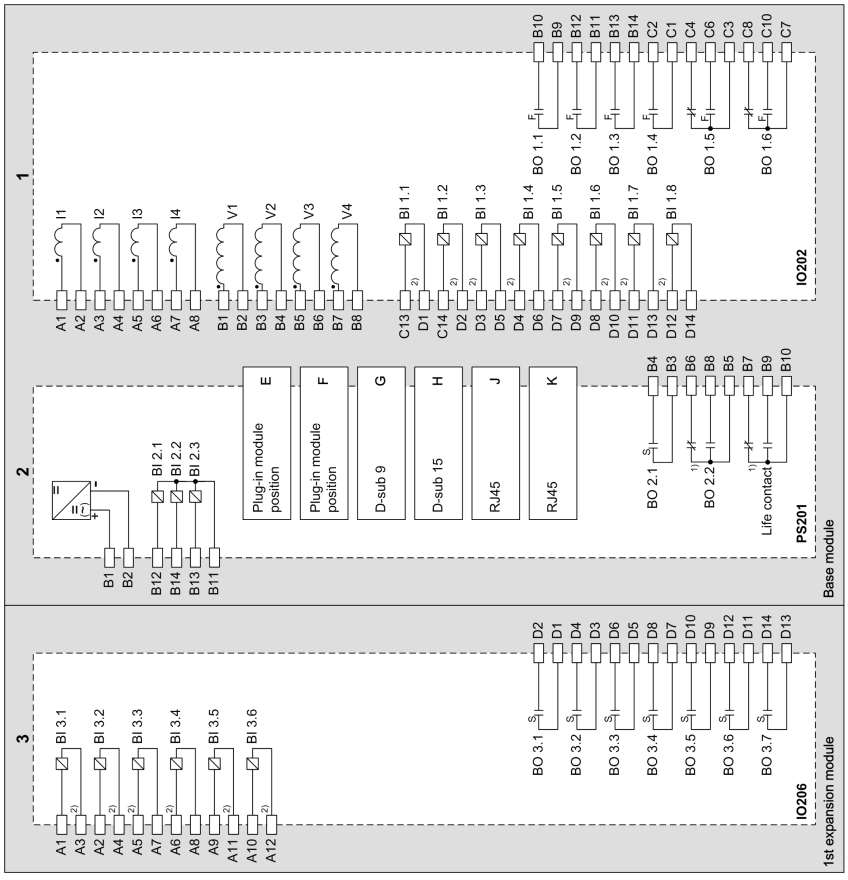
Figure A-5 Standard Variant Type U5

A.5 Standard Variants for 7SJ85



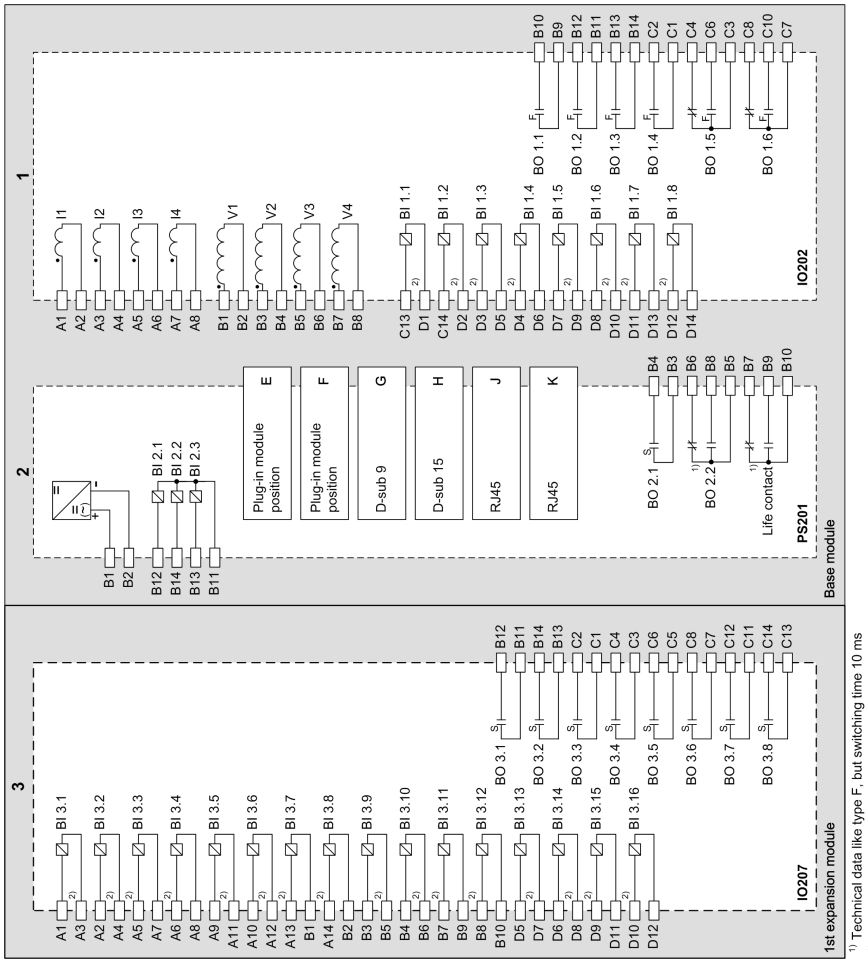
[svstyp01-191112-01.tif, 1, en_US]

Figure A-6 Standard Variant Type S1



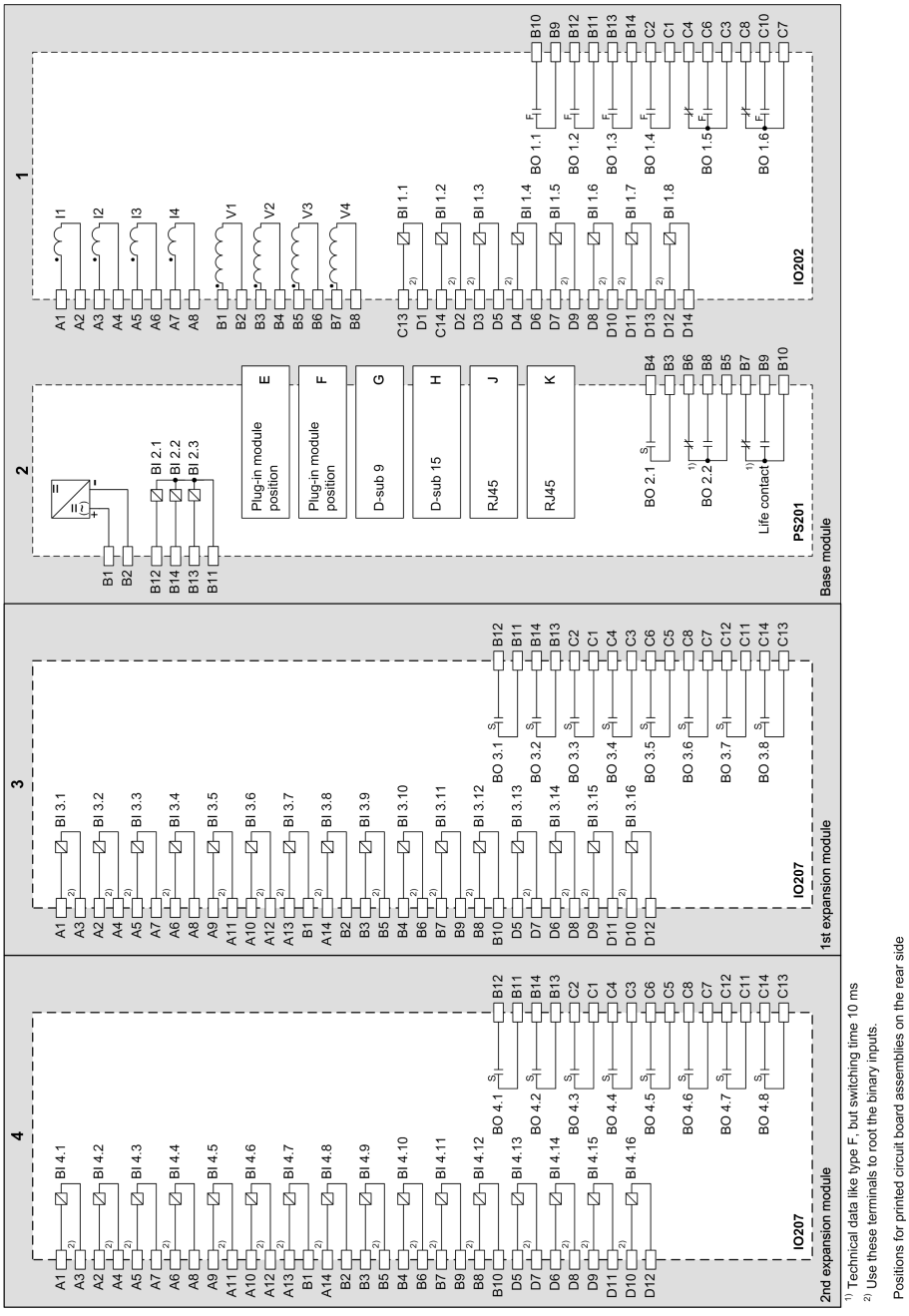
[svstyp02-191112-01.tif, 1, en_US]

Figure A-7 Standard Variant Type S2



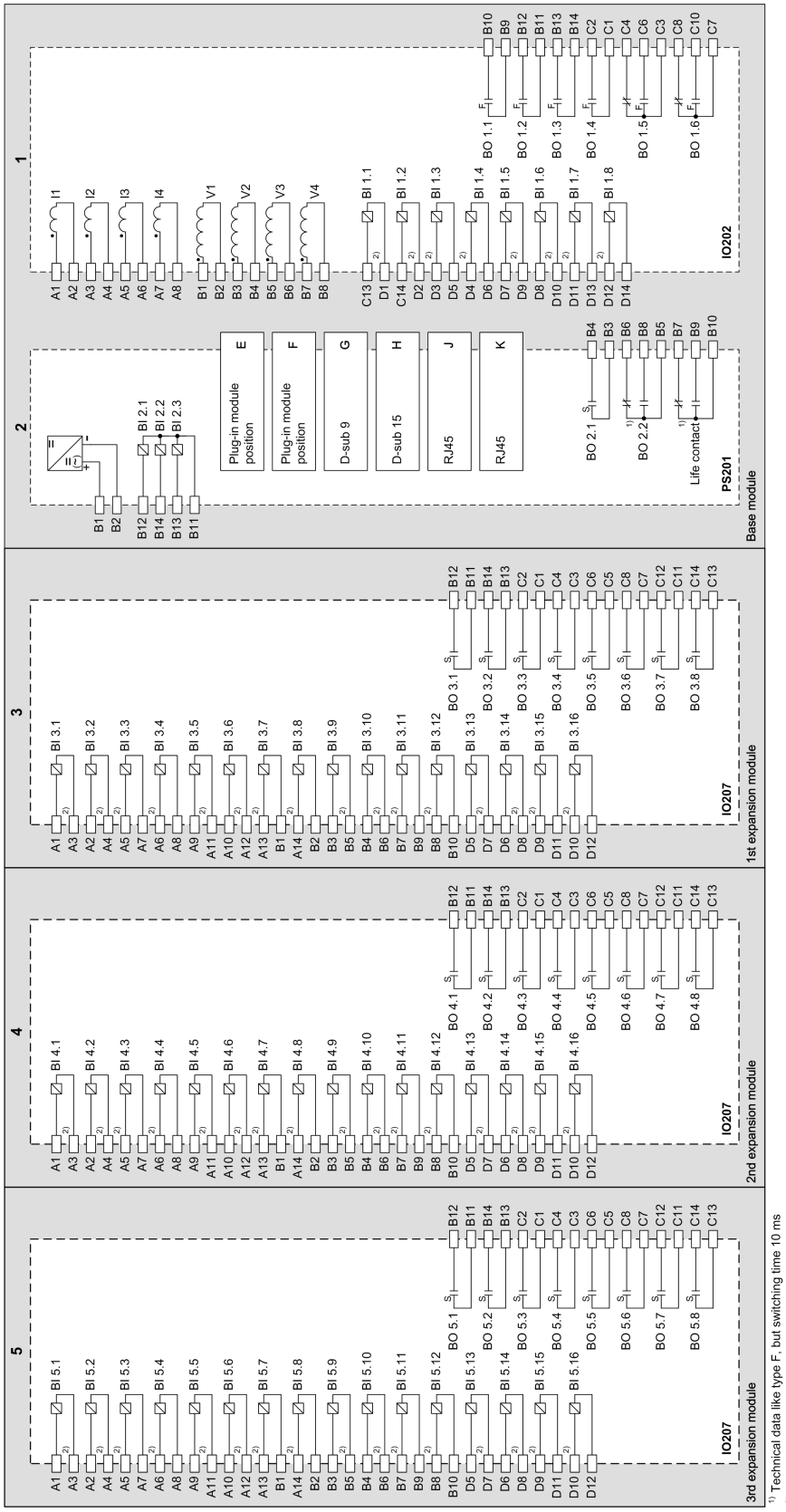
[svstyp03-191112-01.tif, 1, en_US]

Figure A-8 Standard Variant Type S3



[svstyp04-191112-01.tif, 1, en_US]

Figure A-9 Standard Variant Type S4



[svstyp05-191112-01.tif, 1, en_US]

Figure A-10 Standard Variant Type S5

1) Technical data like type F, but switching time 10 ms
2) Use these terminals to root the binary inputs.
Positions for printed circuit board assemblies on the rear side

A.6 Current Transformer Requirements

The requirements for phase current transformers are usually determined by the overcurrent protection, particularly by the high-current element settings. Besides, there is a minimum requirement based on experience.

The recommendations are given according to the standard IEC 60044-1.

The standards IEC 60044-6, BS 3938 and ANSI/IEEE C 57.13 are referred to for converting the requirement into the knee-point voltage and other transformer classes.

Accuracy Limiting Factors

Table A-2 Effective and Rated Accuracy Limiting Factor

Required minimum effective accuracy limiting factor	$K_{ALF'} = \frac{I \gg_{PU}}{I_{rated,\ prim}}$ but at least 20	
	with	
	$K_{ALF'}$	Minimum effective accuracy limiting factor
	$I>>_{PU}$	Primary pickup value of the high-current element
	$I_{rated,prim}$	Primary rated transformer current
Resulting rated accuracy limiting factor	$K_{ALF} = \frac{R_{BC} + R_{Ct}}{R_{BN} + R_{Ct}} \cdot K_{ALF'}$	
	with	
	K_{ALF}	Rated accuracy limiting factor
	R_{BC}	Connected burden (device and cables)
	R_{BN}	Rated burden
	R_{Ct}	Internal burden

Table A-3 Calculation Example According to IEC 60044–1

$I_{rated,sec}$ = 1 A $K_{ALF'}$ = 20 R_{BC} = 0.6 Ω (device and cables) R_{Ct} = 3 Ω R_{BN} = 5 Ω (5 VA)	$K_{ALF} = \frac{0.6 + 3}{5 + 3} \cdot 20 = 9$ K_{ALF} set to 10, so that: 5P10, 5 VA
with $I_{rated,sec}$ = Secondary rated transformer current	

Class Conversion

Table A-4 Conversion into Other Classes

British Standard BS 3938	$V_k = \frac{(R_{Ct} + R_{BN}) \cdot I_{rated,sec}}{1.3} \cdot K_{ALF}$
ANSI/IEEE C 57.13, class C	$V_{st\ max} = 20 \cdot I_{rated,sec} \cdot R_{BN} \cdot \frac{K_{ALF}}{20}$ $I_{rated,sec}$ = 5 A (typical value)

IEC 60044-6 (transient response), class TPS Classes TPX, TPY, TPZ	$V_{al} = K \cdot k_{SSC} \cdot (R_{Ct} + R_{BN}) \cdot I_{rated,sec}$ K≈ 1 $K_{SSC} \approx K_{ALF}$ You can find a calculation example in the above section Accuracy Limiting Factors with: $K_{SSC} \approx K_{ALF}$ T_P depending on power system and specified closing sequence	
	with	
	V_k	Knee-point voltage
	R_{Ct}	Internal burden
	R_{BN}	Rated burden
	$I_{rated,sec}$	Secondary rated transformer current
	K_{ALF}	Rated accuracy limiting factor
	$V_{s.t.max}$	Secondary terminal voltage at 20 $I_{rated,prim}$
	V_{al}	Secondary magnetization limit voltage
	K	Dimensioning factor
	K_{SSC}	Factor symmetric rated fault current
	T_P	Primary time constant

Cable Core Balance Current Transformer

The requirements to the cable core balance current transformer are determined by the function **Sensitive ground-fault detection**.
The recommendations are given according to the standards IEC 60044-1 and IEC 61869-2.

Table A-5 Requirements to the cable core balance current transformer according to IEC 60044-1 and IEC 61869-2

Transformation ratio, typical It may be necessary to select a different transformation ratio to suit the specific power system and thus the corresponding amount of the maximum ground fault current.	60 / 1
Accuracy limiting factor	FS = 10
Power	1 to 4 times the connected burden (device input plus infeeds)
Notes concerning the power: The burden of the sensitive ground-current input is very low (0.05 VA or 0.1 VA). Thus, an underburden of more than factor 4 is probable. In this case, clarify the suitability of the class accuracy concerning an important underburden with the transformer manufacturer. If necessary, request the accuracy for the range from 0 VA to the rated burden. This specification is then outside the standard, but in practice, it is possible in most cases. (Relevant standard: IEC 61869-2, Chapter 5.6.201.4 Extended burden range. There, the range 1 VA to rated burden is specified for rated burdens smaller than 15 VA.)	

Table A-6 Minimum Required Class Accuracy Depending on Neutral Grounding and Function Operating Principle

Neutral Point	**Isolated**	**Resonant-Grounded**	**High-Resistance Grounded**
Function directional	Class 1	Class 1	Class 1

Function non-directional	Class 3	Class 1	Class 3



NOTE

The class accuracy according to IEC 61869-2 below 5% I_{rated} (< 50 mA secondary) is not defined in general.

For very sensitive directional measurements, Siemens recommends the classes 0.5S or 0.1S that define the class accuracy via an extended current range (up to 1% I_{rated}) (see chapter 5.6.201.5, IEC 61869-2).

Another possibility is to correct the phase-angle error of the transformer on the device, if this error is known (see function description **Sensitive ground-fault detection**.

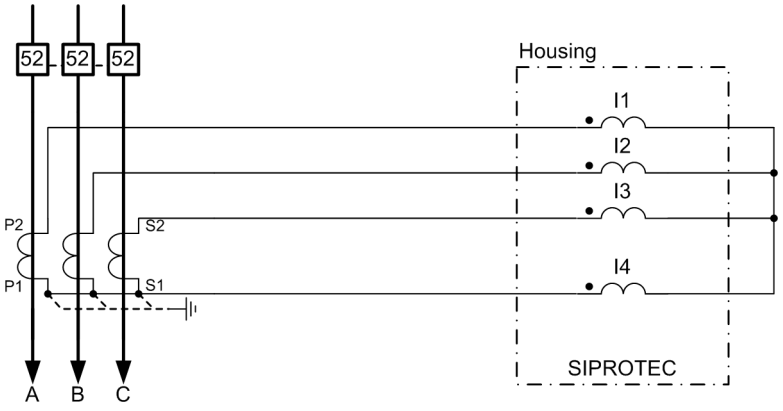
A.7 Connection Examples for Current Transformers



Current transformer 3-phase: connection = **3-phase**

[ti3leit1-070211-01.tif, 1, en_US]

Figure A-11 Connection to a 3-Wire Current Transformer (Residual Current to be Calculated)



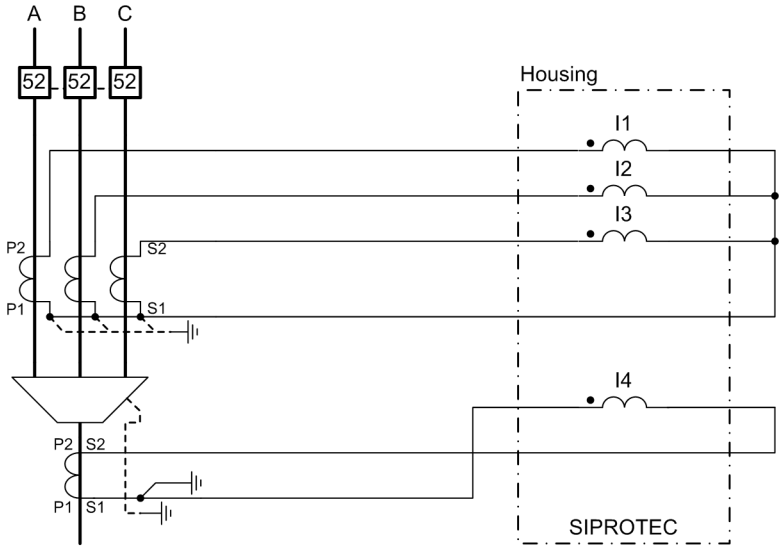
Current transformer 3-phase: connection = **3-phase + IN**

[tileite2-070211-01.tif, 1, en_US]

Figure A-12 Connection to a 3-Wire Current Transformer and Measured Zero-Sequence Current (Current in Common Return Path)

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 (I_N)!



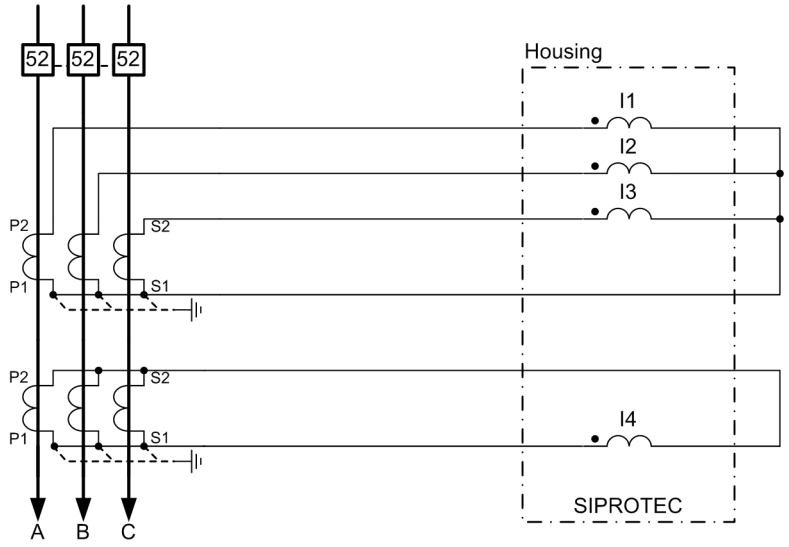
Current transformer 3-phase: connection = **3-phase + IN-separate**

[tileite3-260313-01.tif, 1, en_US]

Figure A-13 Connection to a 3-Wire Current Transformer and Cable Type Current Transformer for Sensitive Ground-Fault Detection

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



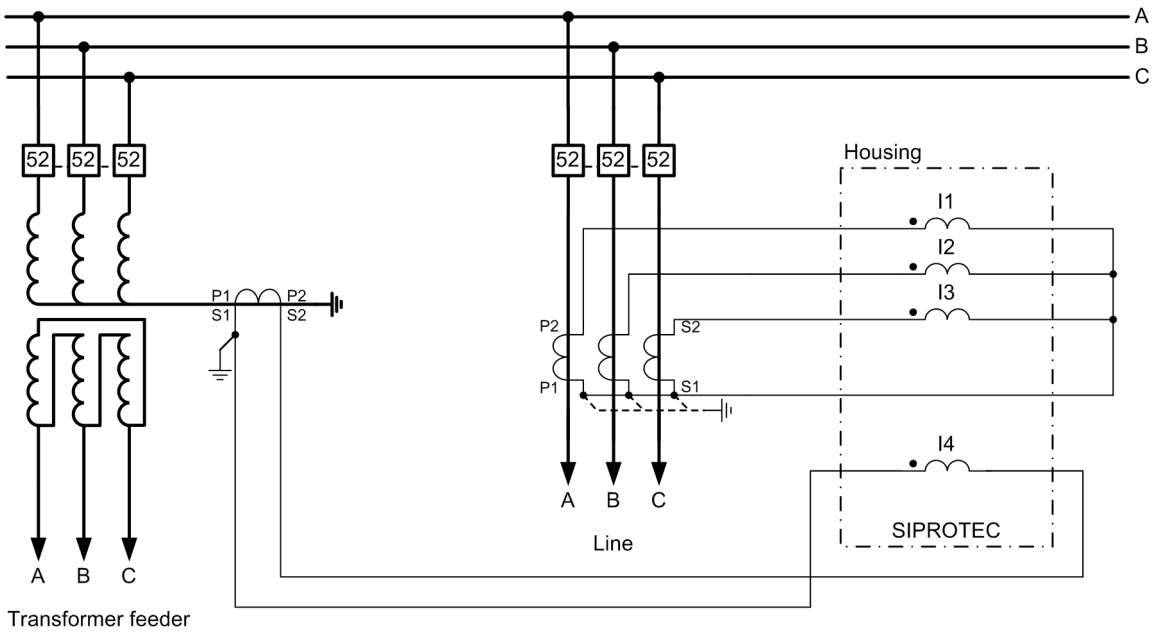
Current transformer 3-phase: connection = **3-phase + IN-separate**

[tileite4-260313-01.tif, 1, en_US]

Figure A-14 Connection to a 3-Wire Current Transformer and Measured Ground Current from a Complete Holmgreen Connection

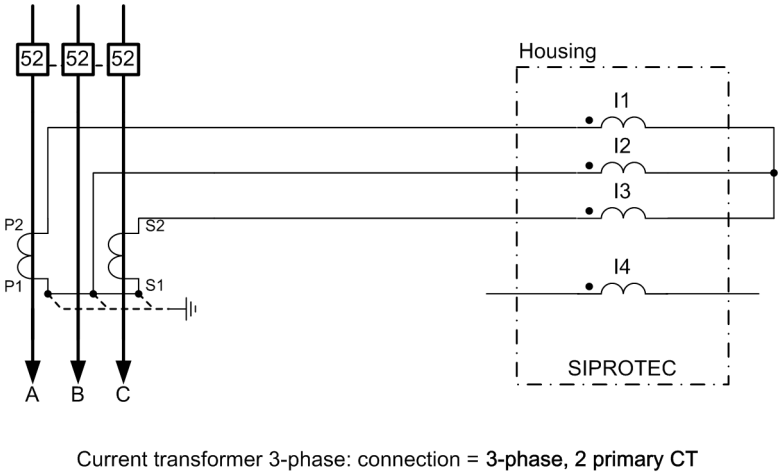
NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



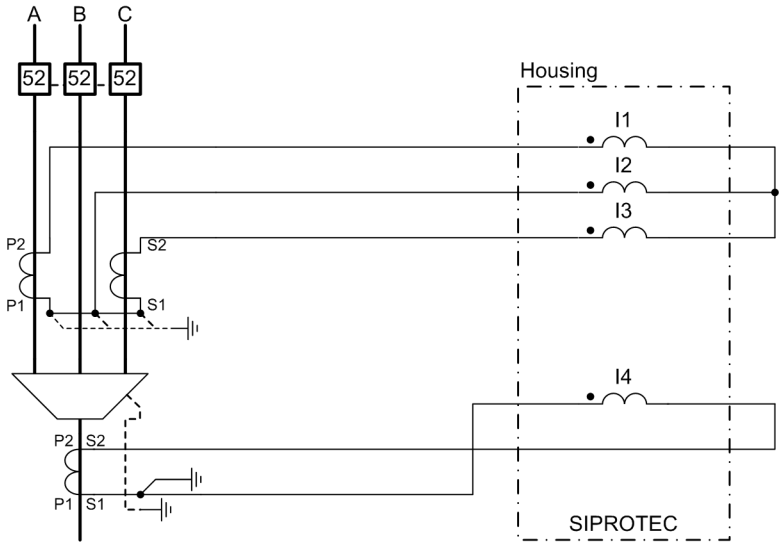
[tileite6-060313-01.tif, 1, en_US]

Figure A-15 Connection to a 3-Wire Current Transformer and Measured Ground Current via the Neutral-Point Current Transformer of a Grounded Power Transformer



[tileite7-070211-01.tif, 1, en_US]

Figure A-16 Connection to a 2-Wire Current Transformer - for Isolated or Resonant-Grounded Systems Only



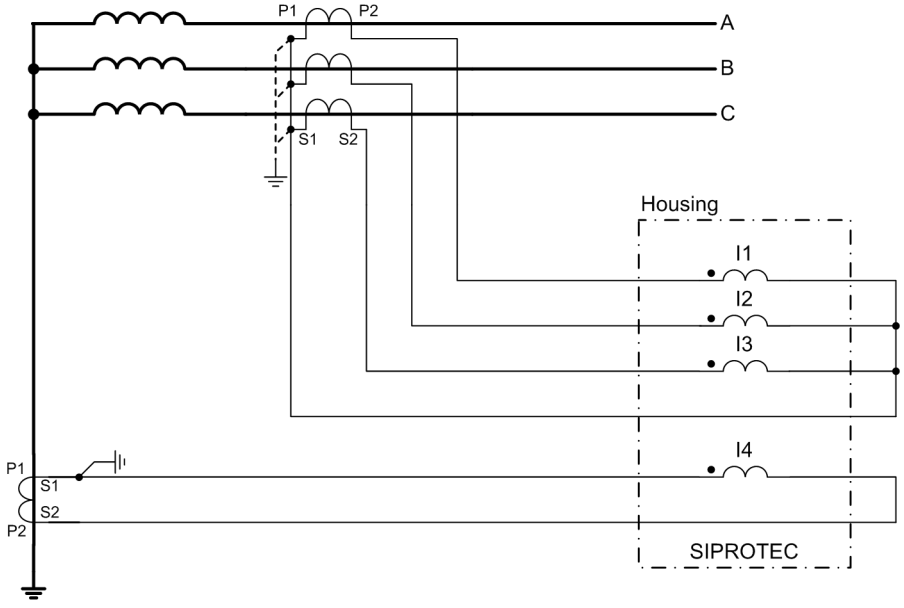
Current transformer 3-phase: connection = **3ph,2prim.CT + IN-sep**

[tileite8-260313-01.tif, 1, en_US]

Figure A-17 Connection to a 2-Wire Current Transformer and Cable Type Current Transformer for Sensitive Ground-Fault Detection - for Isolated or Resonant-Grounded Systems Only

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!

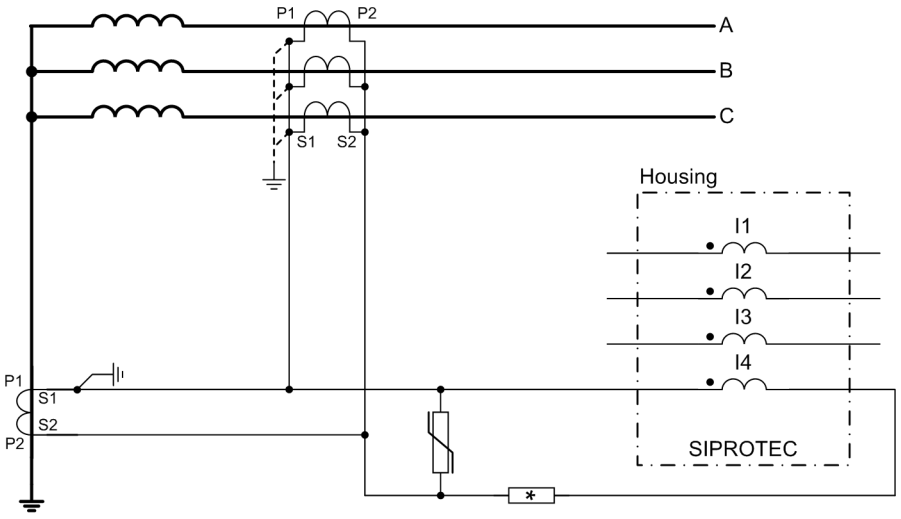


Current transformer 3-phase: connection = **3-phase**

Current transformer 1-phase: connection = **Ix**

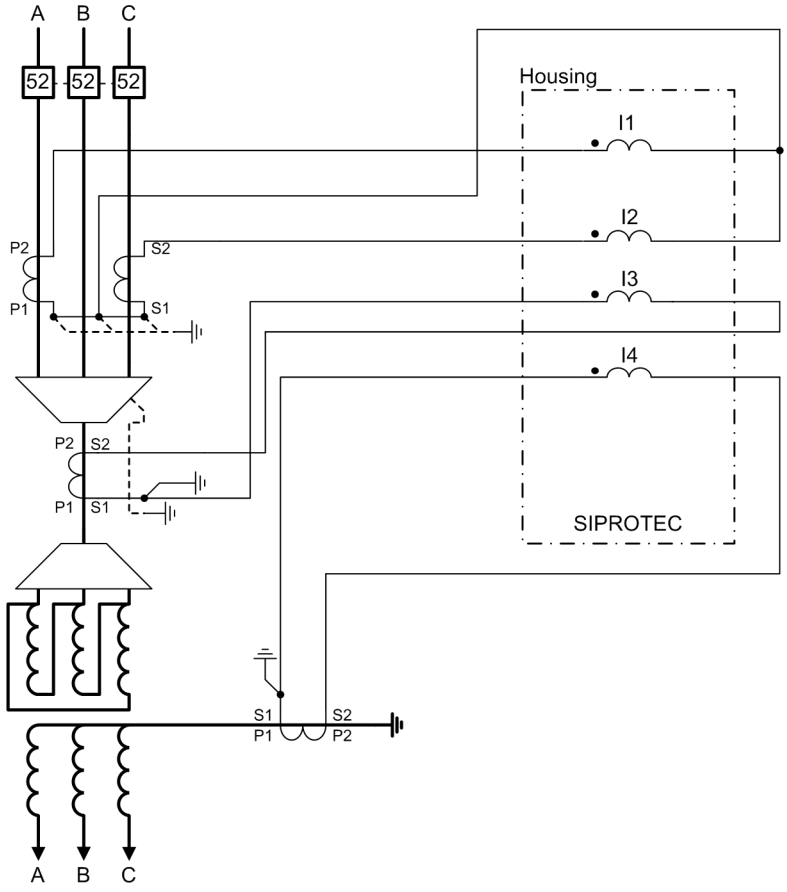
[tileite9-260313-01.tif, 1, en_US]

Figure A-18 Connection to a 3-Wire Current Transformer and an Additional Current Transformer in the Neutral Point of a Grounded Power Transformer



[tileit10-260313-01.tif, 1, en_US]

Figure A-19 Current Transformer Connection for High-Impedance Differential Protection (for Example, a Power Transformer, in Preparation)



Current transformer 3-phase: connection = **2ph, 2p. CT + IN-sep**

Current transformer 1-phase: connection = **Ix**

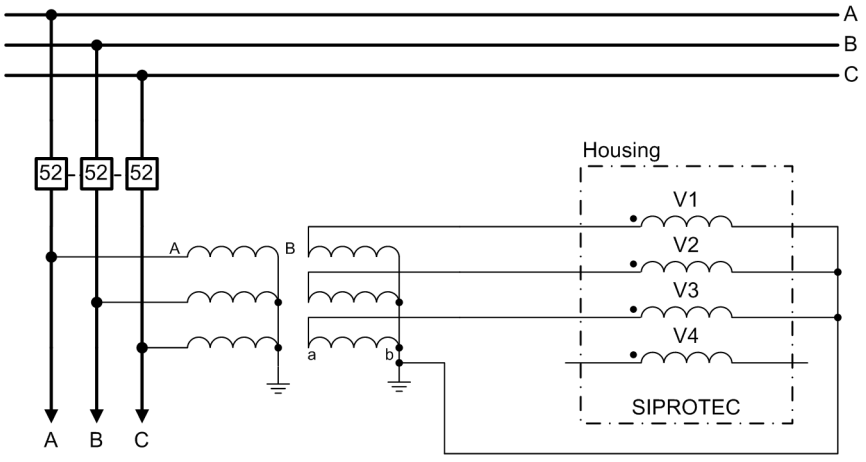
[tileit14-260313-10.tif, 2, en_US]

Figure A-20 Connection to a 2-Phase Current Transformer and Cable Type Current Transformer for Sensitive Ground-Fault Detection of the Line and Additional Sensitive Ground-Fault Detection via the Neutral-Point Current Transformer of a Grounded Power Transformer

NOTE

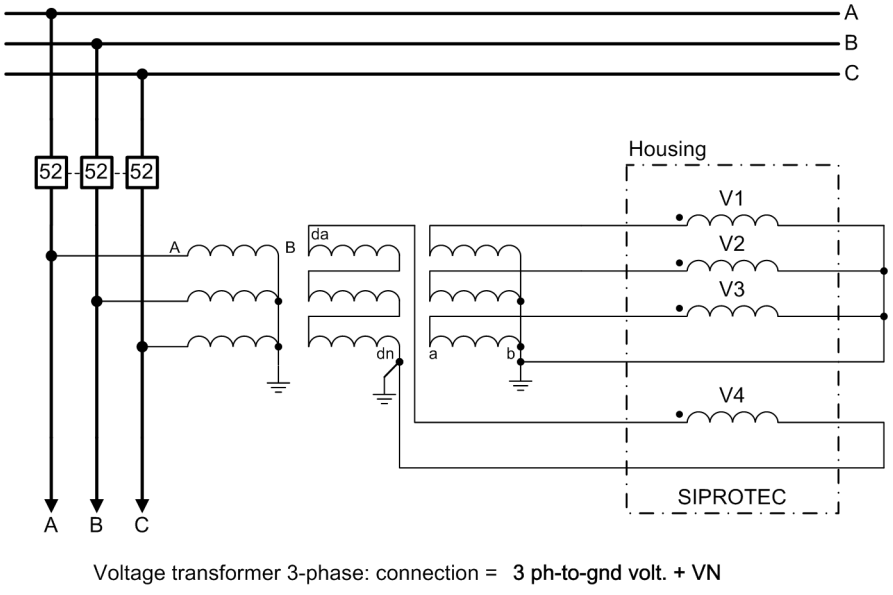
The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I3 ($I_{N\text{-}sep}$)!

A.8 Connection Examples for Voltage Transformers for 7SJ85



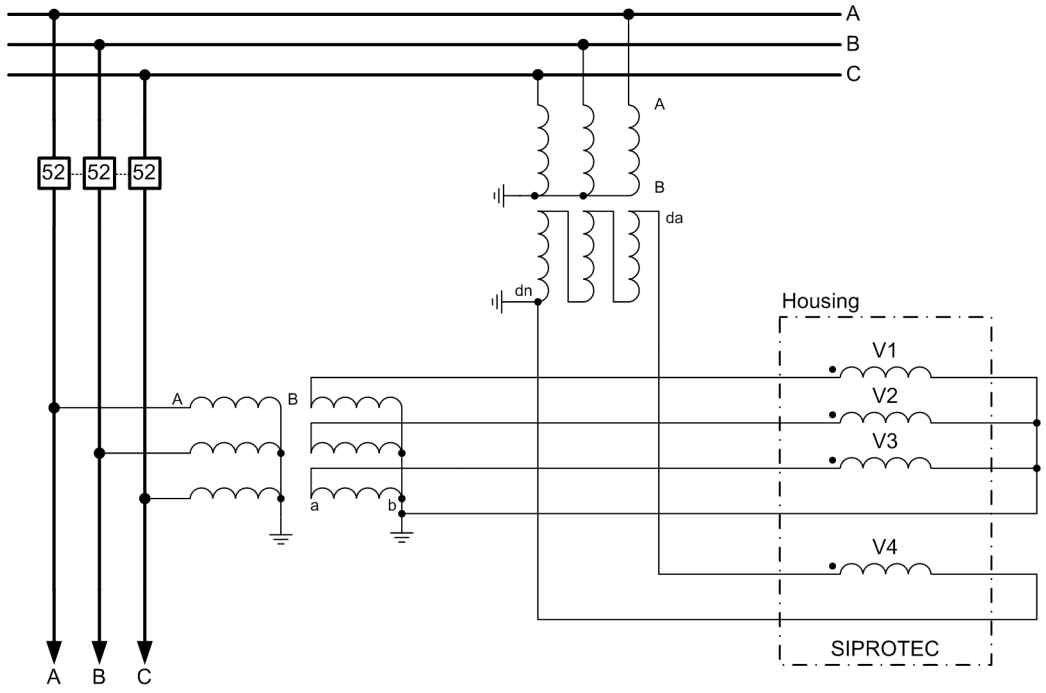
[tvvolta1-260313-01.tif, 1, en_US]

Figure A-21 Connection to 3 Star-Connected Voltage Transformers



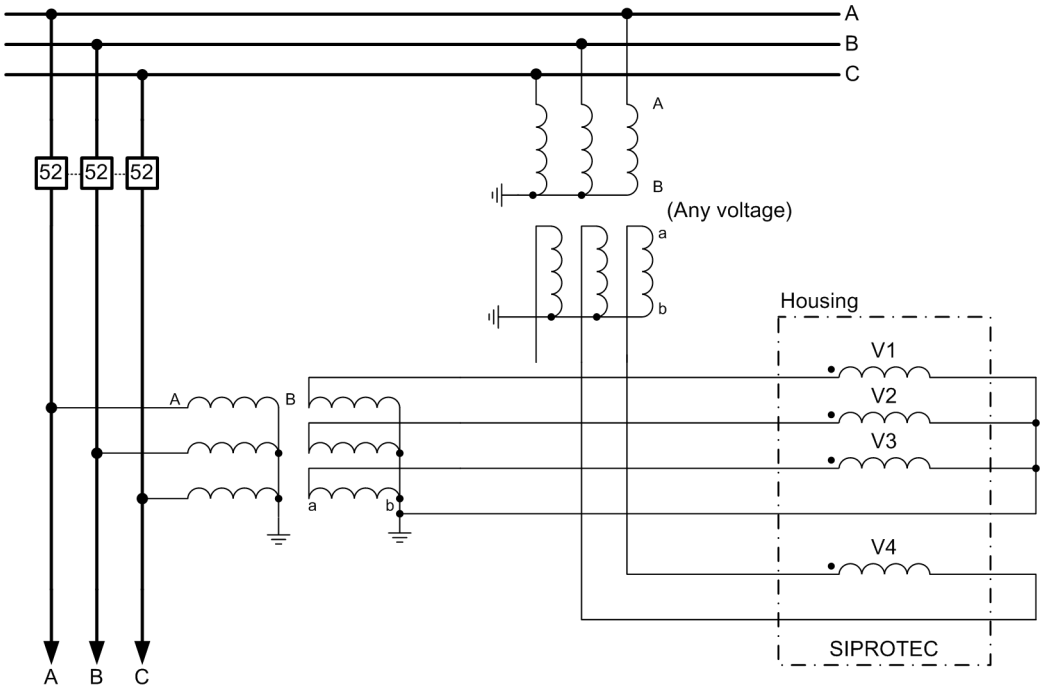
[tvvolta2-260313-01.tif, 1, en_US]

Figure A-22 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding



[tvvolta3-260313-01.tif, 1, en_US]

Figure A-23 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer (for example, Busbar)

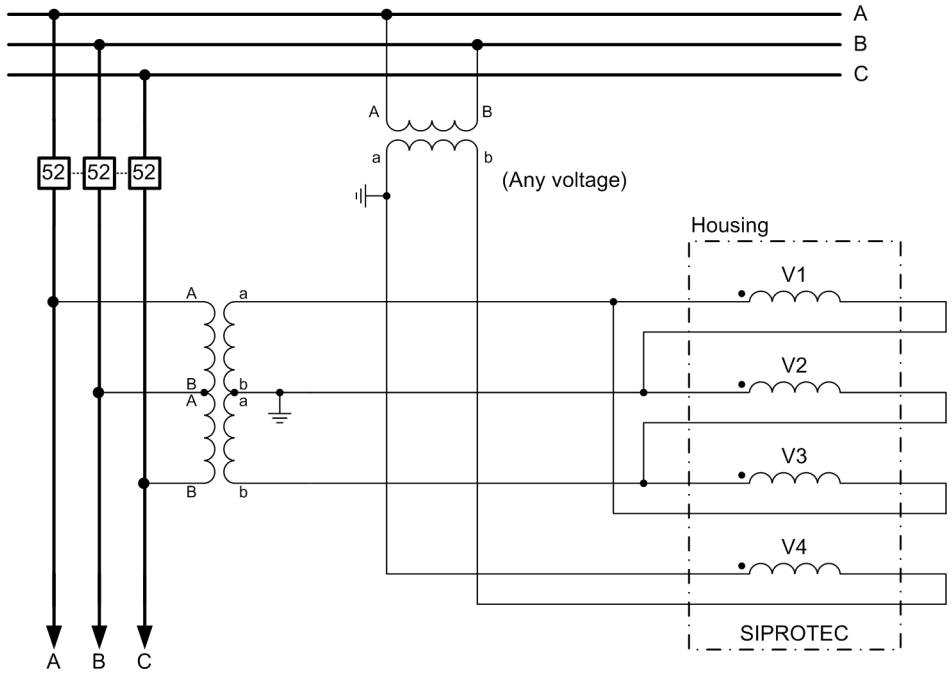


Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

[tvvolta4-260313-01.tif, 2, en_US]

Figure A-24 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)



Voltage transformer 3-phase: connection = **3 ph-to-ph voltages**

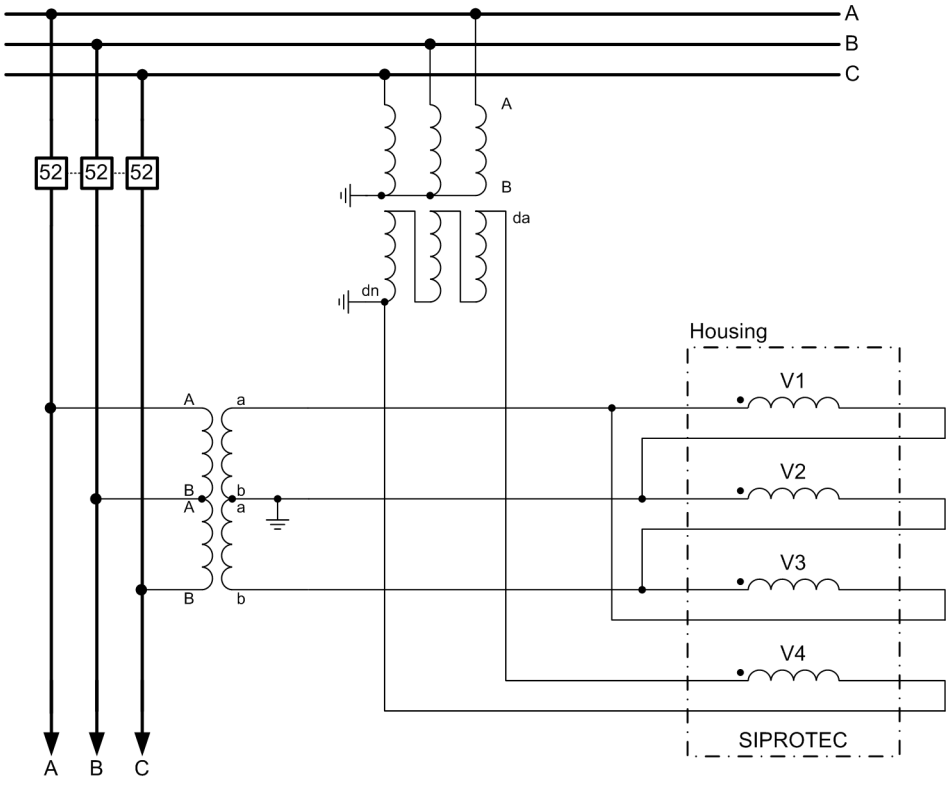
Voltage transformer 1-phase: connection = **VAB**

[tvvolta5-260313-01.tif, 1, en_US]

Figure A-25 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer

NOTE

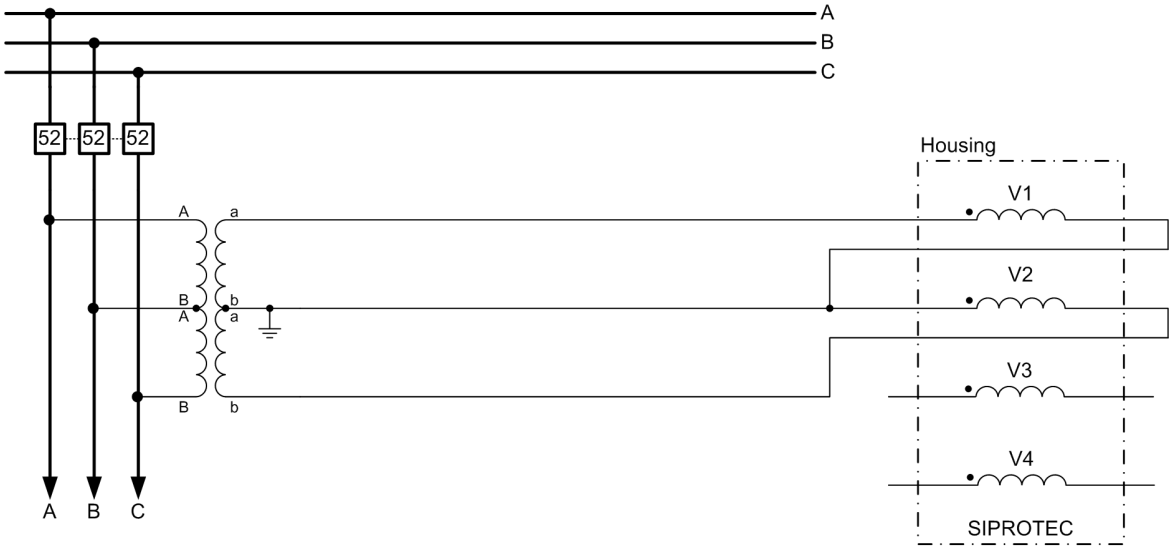
When using the connection type 3-phase-to-phase voltage, the zero-sequence voltage cannot be detected.



Voltage transformer 3-phase: connection = 3 ph-to-ph volt. + VN

[tvvolta6-260313-01.tif, 1, en_US]

Figure A-26 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer

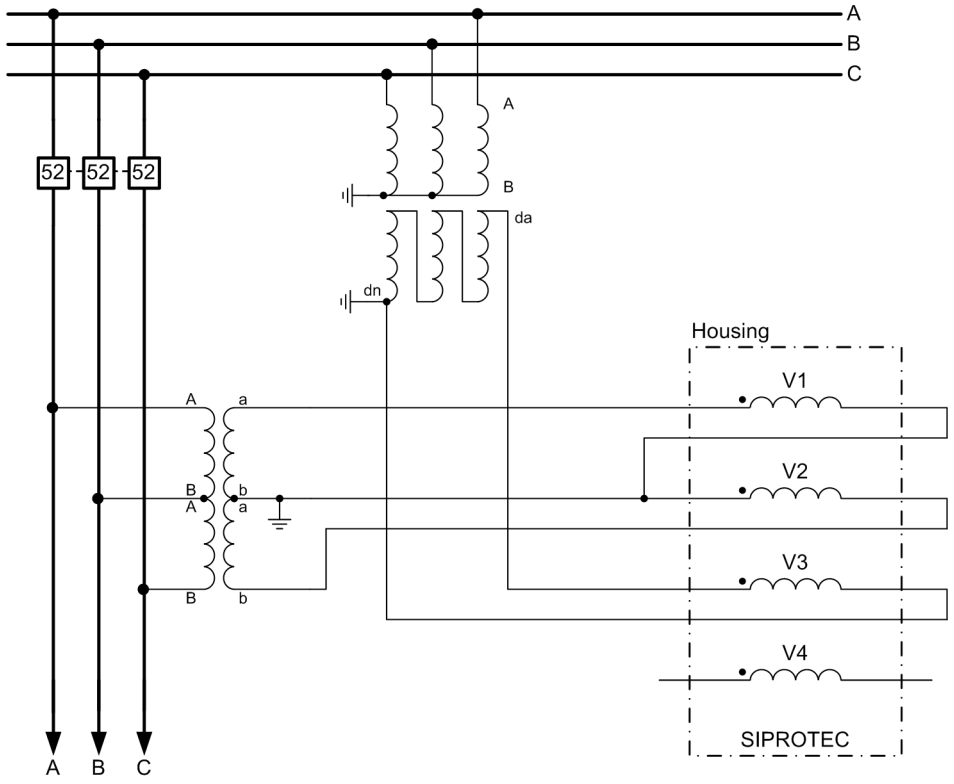


Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

Phase voltages = VAB, VBC

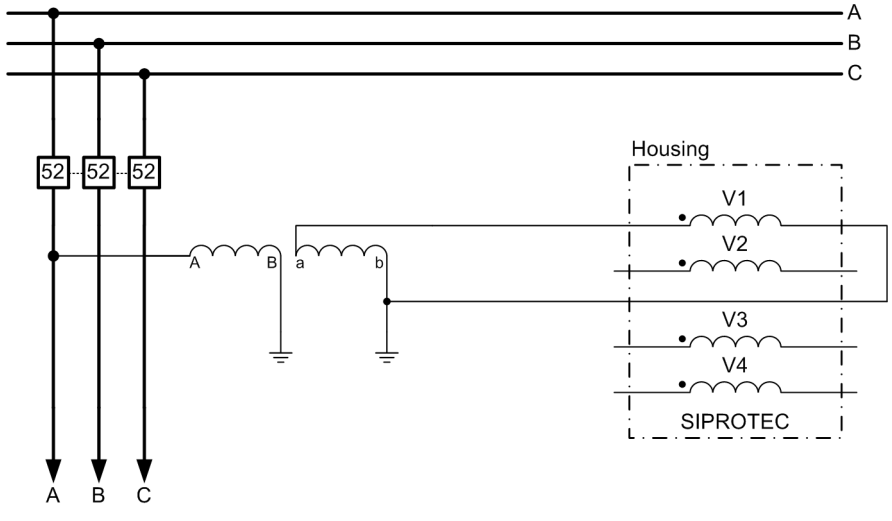
[tvvol2ll-260313-01.tif, 2, en_US]

Figure A-27 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)



[tvl2lluu-260313-01.tif, 2, en_US]

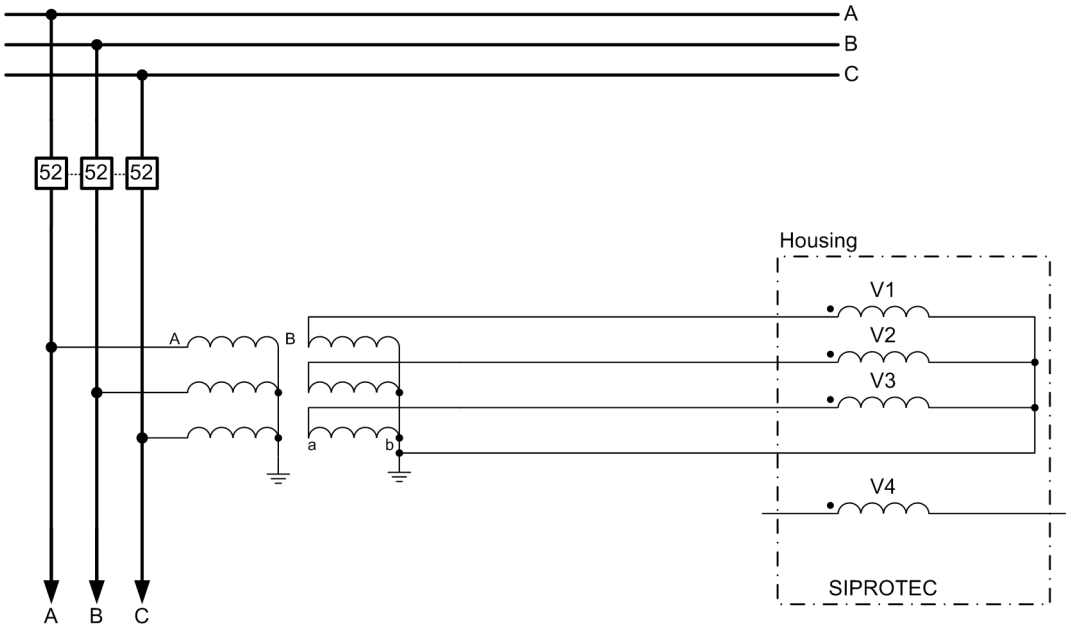
Figure A-28 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



[tvvolta7-260313-01.tif, 1, en_US]

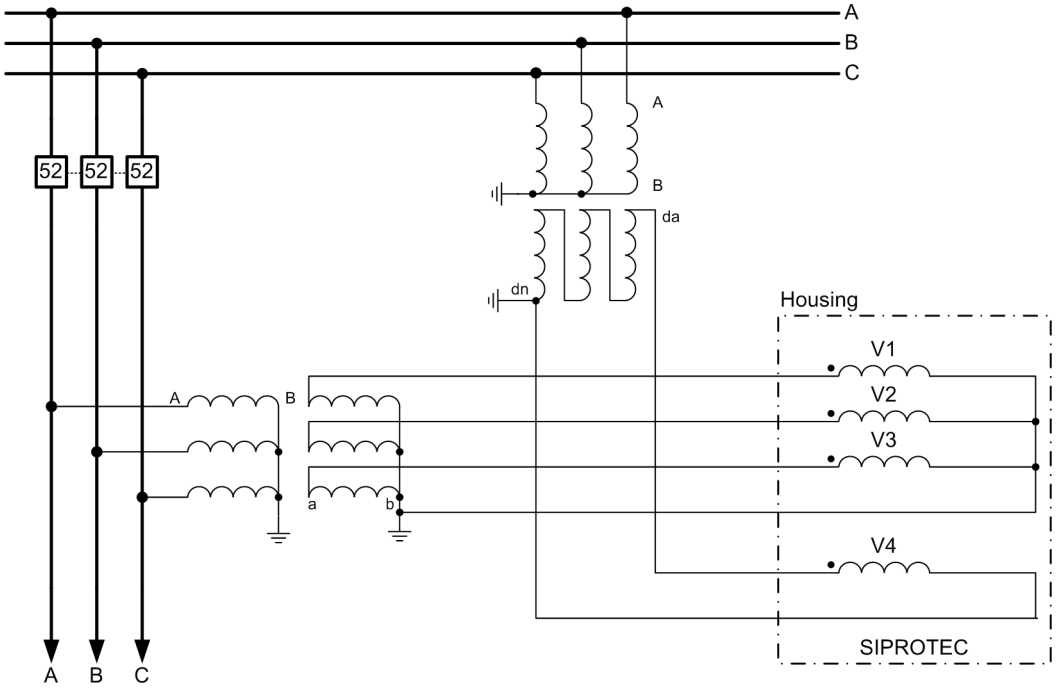
Figure A-29 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

A.9 Connection Examples for Voltage Transformers for 7SJ82



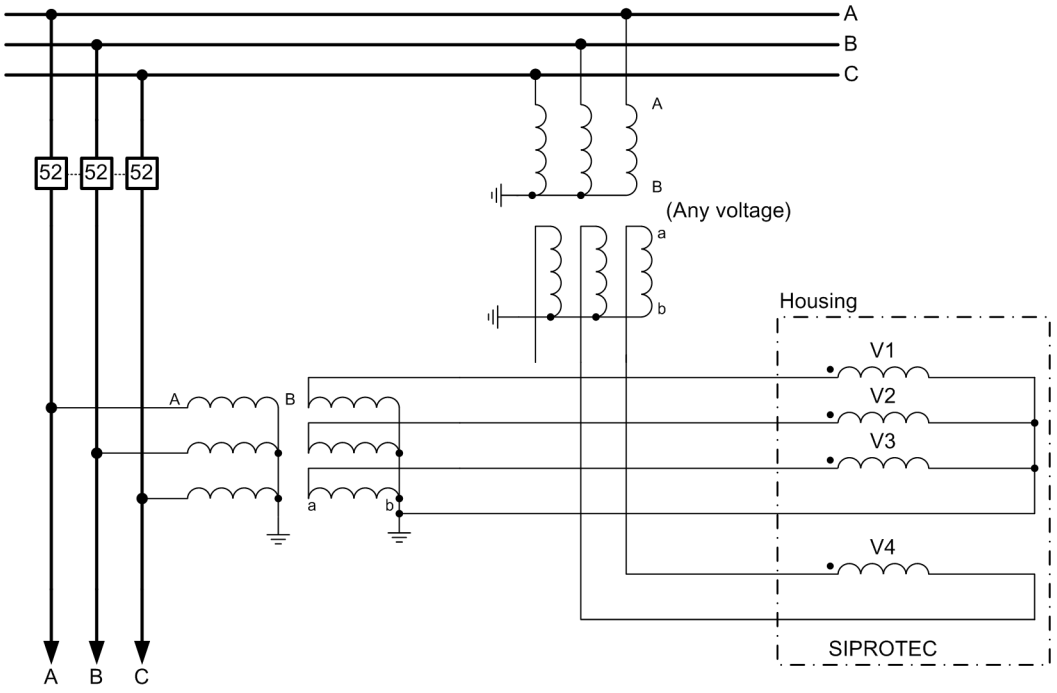
[tvvolta3phVN-260313-01.vsd, 1, en_US]

Figure A-30 Connection to 3 Star-Connected Voltage Transformers



[tvvolta4light-260313-01.vsd, 1, en_US]

Figure A-31 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer

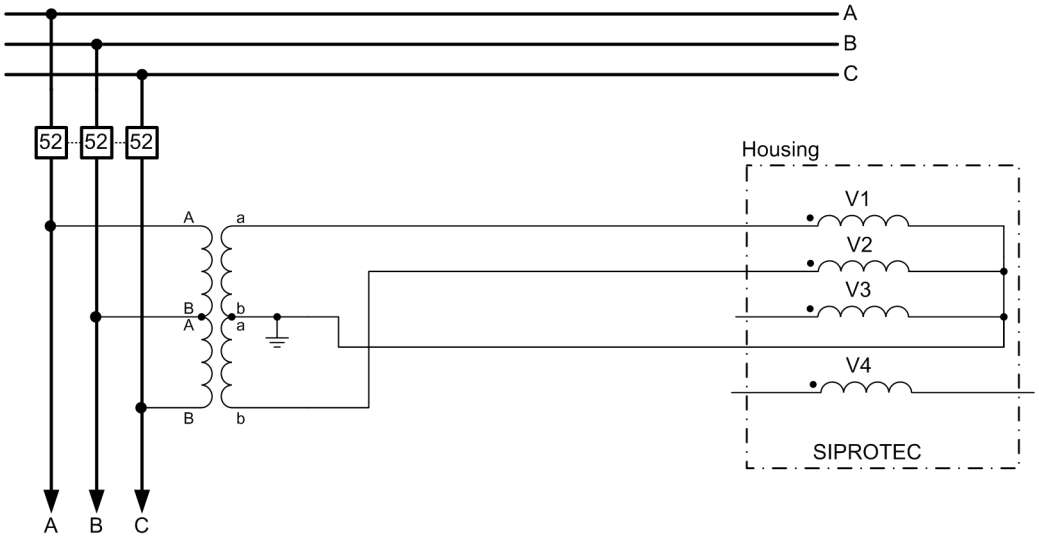


Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

[tvvolta4SJ82-260313-01.vsd, 1, en_US]

Figure A-32 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)

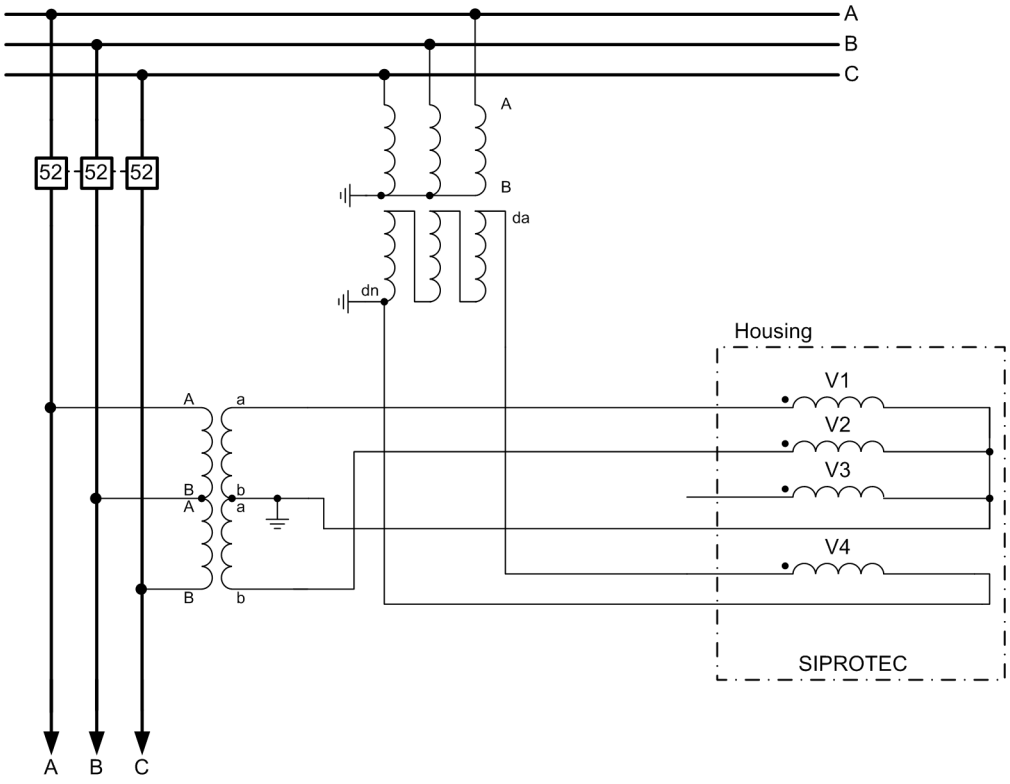


Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

Phase voltages = VAB, VCB

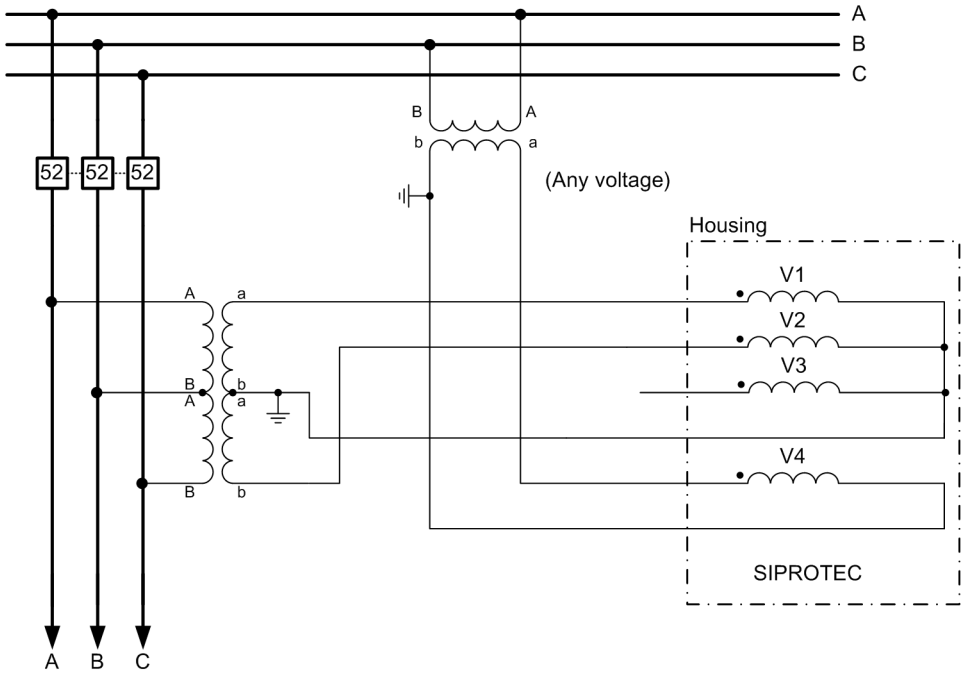
[tvvol2ll82-260313-01.vsd, 1, en_US]

Figure A-33 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)



[tvl2lluu82-260313-01.vsd, 1, en_US]

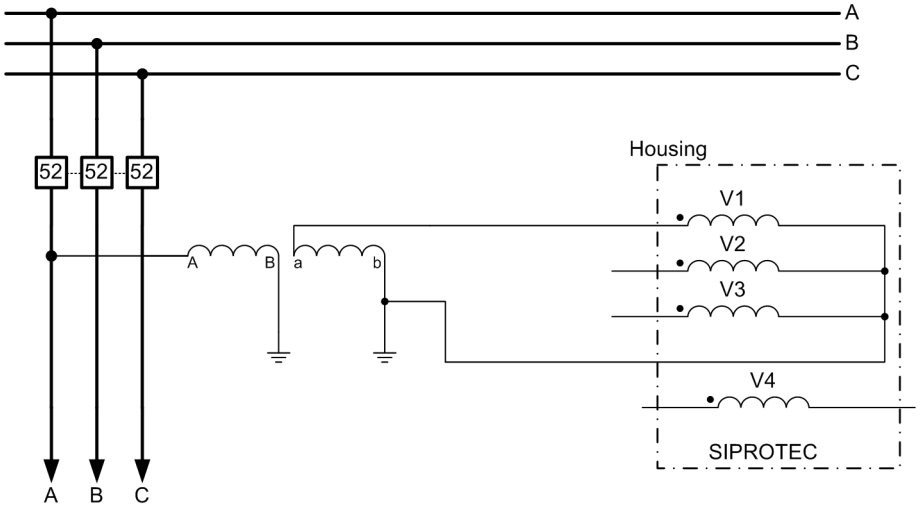
Figure A-34 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 3-phase: connection = 2 ph-to-ph voltages
Phase voltages = VAB, VCB
Voltage transformer 1-phase: connection = VAB

[tvvolta5SJ82-260313-01.vsd, 2, en_US]

Figure A-35 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)



Voltage transformer 1-phase: connection = VA

[tvvolta7SJ82-260313-01.vsd, 1, en_US]

Figure A-36 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

A.10 Prerouting 7SJ82/85 General

Meaning of the abbreviations in DIGSI, see *8.2.2.3 Connection Variants of the Circuit Breaker*.

Binary Inputs

Table A-7 Default Binary Inputs, Using the Example of Overcurrent Protection

Binary Input	Signal	Number	Signal Type	Configuration
BI1	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	OH
BI2	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	CH
BI3	Disconnector 1:Circuit break.:Position	601.5401.58	DPC	OH
BI4	Disconnector 1:Circuit break.:Position	601.5401.58	DPC	CH
BI5	Disconnector 2:Circuit break.:Position	602.5401.58	DPC	OH
BI6	Disconnector 2:Circuit break.:Position	602.5401.58	DPC	CH
BI7	Disconnector 3:Circuit break.:Position	603.5401.58	DPC	OH
BI8	Disconnector 3:Circuit break.:Position	603.5401.58	DPC	CH
BI9	Power system:Meas. point V-3ph 1:VT-miniature CB:>Open	11.941.2641.500	SPS	H

Binary Outputs

Table A-8 Default Output Relays, Using the Example of Overcurrent Protection

Binary Output	Signal	Number	Signal Type	Configuration
BO1	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U
BO2	Circuit breaker 1:Circuit break.:Close command	201.4261.301	SPS	X
BO3	Disconnector 1:Disconnector:Open command	601.5401.300	SPS	X
BO4	Disconnector 1:Disconnector:Close command	601.5401.301	SPS	X
BO5	Disconnector 2:Disconnector:Open command	602.5401.300	SPS	X
BO6	Disconnector 2:Disconnector:Close command	602.5401.301	SPS	X
BO7	Disconnector 3:Disconnector:Open command	603.5401.300	SPS	X
BO8	Disconnector 3:Disconnector:Close command	603.5401.301	SPS	X

Function Keys

Table A-9 Default Setting Function Key Using the Example of Overcurrent Protection

Function Key	Signal	Number	Signal Type	Configuration
F-key1	Main menu:Logs:Operational log			X
F-key2	Main menu:Measurements:VI 3ph 1:Operational values			X
F-key3	Main menu:Logs:Fault log			X

Light-Emitting Diodes

Table A-10 Default LED Displays, Using the Example of Overcurrent Protection

LEDs	Signal	Number	Signal Type	Configuration
LED1	VI 3ph 1:Group indicat.:Pickup:phs A		SPS	NT
LED2	VI 3ph 1:Group indicat.:Pickup:phs B		SPS	NT
LED3	VI 3ph 1:Group indicat.:Pickup:phs C		SPS	NT
LED4	VI 3ph 1:Group indicat.:Pickup:phs gnd		SPS	NT
LED5	Circuit breaker 1:Circuit break.:Trip/ open cmd.	201.4261.300	SPS	L
LED15	Alarm handling:Group warning	5971.301	SPS	U
LED16	Device:Process mode inactive		SPS	U

A.11 Prerouting 7SJ82/85 Capacitor Bank Applications

Meaning of the abbreviations in DIGSI, see*8.2.2.3 Connection Variants of the Circuit Breaker*

Binary Inputs

Table A-11 Default Binary Inputs, Using the Example of Overcurrent Protection

Binary input	Signal	Number	Signal type	Configuration
BI1	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	OH
BI2	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	CH

Binary Outputs

Table A-12 Default Output Relays, Using the Example of Overcurrent Protection

Binary output	Signal	Number	Signal type	Configuration
BO1	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U
BO2	Circuit breaker 1:Circuit break.:Close command	201.4261.301	SPS	X

Function Keys

Table A-13 Default Setting Function Key Using the Example of Overcurrent Protection

Function key	Signal	Number	Signal type	Configu-ration
F-key1	Main menu:Logs:Opera-tional log			X
F-key2	Main menu:Meas-urements :Capacitor bank 1:Operational values			X
F-key3	Main menu:Logs:Fault log			X

Light-Emitting Diodes

Table A-14 Default LED Displays, Using the Example of Overcurrent Protection

LEDs	Signal	Number	Signal type	Configura-tion
LED1	Capacitor bank 1:Group indicat.:Pickup:phs A		SPS	NT
LED2	Capacitor bank 1:Group indicat.:Pickup:phs B		SPS	NT

LEDs	Signal	Number	Signal type	Configura-tion
LED3	Capacitor bank 1:Group indicat.:Pickup:phs C		SPS	NT
LED4	Capacitor bank 1:Group indicat.:Pickup:phs gnd		SPS	NT
LED5	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	L
LED15	Alarm handling:Group warning	5971.301	SPS	U
LED16	Device:Process mode inac-tive		SPS	U

Glossary

ACD

IEC 61850 data type: Directional protection activation information

ACK

Data transfer acknowledgment

ACT

IEC 61850 data type: Protection activation information

APC

Controllable analog set point information

ASDU

ASDU stands for Application Service Data Unit. An ASDU can consist of one or more identical information objects. A sequence of the same information elements, for example measured values, is identified by the address of the information object. The address of the information object defines the associated address of the first information element of the sequence. A consecutive number identifies the subsequent information elements. The number builds on this address in integral increments (+1).

BAC

Binary Controlled Analog Process Value

Back-up battery

The back-up battery ensures that specified data areas, flags, times and counters are kept retentive.

Bay Controller

Bay controllers are devices with control and monitoring functions without protection functions.

BCR

IEC 61850 data type: Binary counter reading

Best master clock algorithm

A PTP network contains communicating clocks. With the best master clock algorithm (BMC), the device indicating the most precise time is determined. This device is used as a reference clock and is designated as grandmaster. If the network topology is changed, the BMC algorithm is executed again on network segments that are possibly disconnected from the grandmaster. If a participating device is a master and a slave, it is called a boundary clock.

Big-endian

Big-endian and little-endian describe the order in which a sequence of bytes is stored. In big-endian systems, the most significant byte is stored at the lowest storage address. In little-endian systems, the most significant byte is stored at the highest storage address.

Binary Controlled Analog Process Value

The data type BAC represents a command with or without feedback. The BAC is used for example for the control of an arc suppression coil. The commands **Higher**, **Lower**, and **Stop** are possible. The feedback from the process is an analog value.

Binary Controlled Step Position

The data type BSC can, for example, be used to control a transformer tap changer. The commands **up**, **down** can be given.

Bit pattern indication

A bit pattern indication is a processing function, with the help of which adjacent numerical process information can be logged coherently and processed further in parallel via multiple inputs. The bit pattern indication can be selected as 1, 2, 3 or 4 bytes.

BMC

See best master clock algorithm

Boundary Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The boundary clock transports time information over a network limit, for example, in a router connecting different switched networks: As a slave, the clock of the router receives the time information and transmits this further on as a master.

BRCB

Buffered Report Control Block

BSC

Binary Controlled Step Position

Buffered Report Control Block

Buffered Report Control Block (BRCB) is a form of report controlling. Internal events trigger the immediate sending of reports or saving of events for the transfer. Data values cannot therefore be lost on account of transport flow control conditions or connection interruptions. BRCB provides the functionality **SOE** (See Sequence of Events).

CB

Circuit breaker

CDC

Common Data Class

CFC

Continuous Function Chart

Chatter Blocking

A rapidly intermittent input (for example, owing to a relay contact fault) is disconnected after a parameterizable monitoring time and therefore cannot generate any more signal changes. The function prevents the system from overloading in the event of an error.

CID

Configured IED Description

CMV

Complex measured value

Combination Device

Combination devices are bay units with protection functions and with feeder mimic diagram.

Common Data Class

Generic term for a data class according to the IEC 61850 model.

Communication branch

A communication branch corresponds to the configuration of 1 to n participants communicating via a joint bus.

Configured IED Description

A Configured IED Description (CID) is a file for data exchange between the IED Configuration Tool and the IED itself.

Container

If an object contains other objects, this is referred to as a container. The object **Folder** for example is such a container.

Continuous Function Chart

The Continuous Function Chart (CFC) is a programming language. It is used for programmable logic controllers. The programming language Continuous Function Chart is not defined in the standard IEC 61131-3, but represents a current extension of IEC programming environments. CFC is a graphic programming language. Function blocks are linked to one another. This represents an essential difference from conventional programming languages, where sequences of commands are entered.

Control display

The control display becomes visible for devices with a large display after pressing the Control key. The diagram contains the switching devices to be controlled in the feeder. The control display serves for implementing switching operations. Specification of this diagram forms part of configuring.

Controllable Integer Status

The data type INC can be used to issue a command (to one or more relays, selectable under information routing) that is monitored via a whole number as feedback.

Controller

The controller initiates the IO data communication.

CRC

Cyclic redundancy check

Data type

The data type is a value set of a data object, together with the operations allowed on this value set. A data type contains a classification of a data element, such as the determination whether it consists of integers, letters, or similar.

Data unit

Information item with a joint transmission source. Abbreviation: DU = Data Unit

Data window

The right area of the project window visualizes the content of the area selected in the navigation window. The data window contains for example, indications or measured values of the information lists or the function selection for parameterization of the device.

DCF

Device Configuration File: Device parameterization

DCF77

The precise official time is determined in Germany by the Physikalisch-Technische Bundesanstalt PTB in Brunswick. The atomic clock unit of the PTB transmits this time via the long-wave time signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 1500 km from Frankfurt/Main.

DCP

Discovery and Basic Configuration Protocol

DDD

SIPROTEC 5 device driver (DIGSI 5 Device Driver)

DEL

Phase-to-phase related measurements of a 3-phase system

Device 5 Export Format

DEX5

Device Container

In the component view, all SIPROTEC devices are subordinate to an object of the device container type. This object is also a special object from the DIGSI-5 Manager. However, as there is no component view in the DIGSI 5 Manager, this object only becomes visible in conjunction with STEP 7.

DEX5

Device 5 Export Format

You can archive the data from an individual SIPROTEC 5 device in DEX5 format.

DHCP

Dynamic Host Configuration Protocol

DIGDNP

DIGSI 5 protocol settings for DNP3

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGMOD

DIGSI 5 protocol settings for Modbus TCP

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGSI 5 Display Pages

You can archive individual or all display pages of a SIPROTEC 5 device in DSP5 format. You can also use this format to exchange display pages between SIPROTEC 5 devices. The DSP5 format is based on XML.

DIGSI 5 protocol settings for DNP3

If the DNP3 protocol is configured for a system interface, you can export the protocol settings in DIGDNP format. The DIGDNP format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-103

If the IEC 60870-5-103 protocol is configured for a system interface, you can export the protocol settings in DIGT103 format. The DIGT103 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-104

If the IEC 60870-5-104 protocol is configured for a system interface, you can export the protocol settings in DIGT104 format. The DIGT104 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for Modbus TCP

If the Modbus TCP protocol is configured for a system interface, you can export the protocol settings in DIGMOD format. The DIGMOD format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 Test Sequences

You can archive individual or all test sequences of a SIPROTEC 5 device in SEQ5 format. You can also use this format to exchange test sequences between SIPROTEC 5 devices. The SEQ5 format is based on XML.

DIGSI

Configuration software for SIPROTEC

DIGT103

DIGSI 5 protocol settings for IEC 60870-5-103

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGT104

DIGSI 5 protocol settings for IEC 60870-5-104

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

Discovery and Basic Configuration Protocol

The DCP protocol is used to detect devices without IP addresses and to assign addresses to these devices.

DNP3

DNP3 is a communications standard for telecontrol engineering. DNP3 is used as a general transmission protocol between control systems and substations and between bay devices and the systems control.

Double Command

Double commands (DPC – Double Point Control) are process outputs which visualize 4 process states at 2 outputs: 2 defined states (for example, On/Off) and 2 undefined states (for example, disturbed positions).

Double-point indication

Double-point indications (DPS – Double point status) are process indications which visualize 4 process states at 2 inputs: 3 defined states (for example, On/Off and disturbed position) and 1 undefined state (00).

DPC

IEC 61850 data type: Double Point Control

DPS

IEC 61850 data type: Double-point status

Drag and drop

Copying, moving, and linking function, used in graphic user interfaces. The mouse is used to highlight and hold objects and then move them from one data area to another.

DSP5

DIGSI 5 Display Pages

DU

Data unit

Dynamic Host Configuration Protocol

In order to configure PCs automatically, centralized and uniformly in a TCP/IP network, a dynamic assignment of IP addresses is used. DHCP is used. The system administrator determines how the IP addresses are to be assigned and specifies the time lapse over which they are assigned. DHCP is defined in the Internet standards RFC 2131 (03/97) and RFC 2241 (11/97).

For SIPROTEC 5, a device can also be assigned an IP address via DIGSI via DHCP.

ELCAD

Electrical CAD

Electrical CAD

You can import the topology information contained in an ELCAD file into a project and use it as the basis for a single-line configuration. The other information contained in the ELCAD file is not included in this process.

Electromagnetic Compatibility

Electromagnetic compatibility (EMC) means that an item of electrical equipment functions without error in a specified environment. The environment is not influenced in any impermissible way here.

ENC

Enumerated Status Controllable

ENS

Enumerated Status

ESD Protection

The ESD protection is the entirety of all means and measures for the protection of electrostatic-sensitive devices.

Far End Fault Indication

Far End Fault Indication (FEFI) is a special setting of switches. It is always only possible to log a line interruption on the receive line. If a line interruption is detected, the link status of the line is changed. The status change leads to deletion of the MAC address assigned to the port in the switch. However, outage of the receive line from the aspect of the switch can only be detected in the receiver, that is, by the switch. The receiver then immediately blocks the transmit line and signals the connection failure to the other device. The FEFI setting in the switch triggers detection of the error on the receive line of the switch.

FEFI

Far End Fault Indication

FG

Function group

Fleeting indication

Fleeting indications are single-point indications present for a very short time, in which only the coming of the process signal is logged and further processed time-correctly.

Floating

Floating means that a free potential not connected to ground is generated. Therefore no current flows through the body to ground in the event of touching.

Folder

This object type helps when structuring a project hierarchically.

Function group

Functions are brought together into function groups (FG). The assignment of functions to current and/or voltage transformers (assignment of functions to measuring points), the information exchange between the function groups via interfaces as well as the generation of group indications are important for this bringing together.

General interrogation

The state of all process inputs, of the status, and of the error image are scanned on system startup. This information is used to update the system-side process image. Likewise, the current process state can be interrogated after data loss with a general interrogation (GA).

General Station Description Mark-up Language

GSDML is an XML-based description language for creating a GSD file.

Generic Object-Oriented Substation Event

GOOSE. Protocol of IEC 61850 for communication between bay units.

GI

General interrogation

GIN

Generic Identification Number

GOOSE

Generic Object-Oriented Substation Event

Ground

The conductive ground whose electric potential can be set equal to 0 at every point. In the area of grounding conductors, the ground can have a potential diverging from 0. The term **reference ground** is also used for this situation.

Grounding

The grounding is the entirety of all means and measuring for grounding.

GSDML

General Station Description Mark-up Language

Hierarchy Level

In a structure with superordinate and subordinate objects, a hierarchy level is a level of equal-ranking objects.

High Availability Seamless Redundancy Protocol

Like PRP (Parallel Redundancy Protocol), HSR (High Availability Seamless Redundancy Protocol) is specified in IEC 62439-3. Both protocols offer redundancy without switching time.

The principal function can be found in the definition of PRP. With PRP, the same indication is sent via 2 separated networks. In contrast to this, in the case of HSR the indication is sent twice in the 2 directions of the ring. The recipient receives it correspondingly via 2 paths in the ring, takes the 1st message and discards the 2nd (see PRP).

Whereas NO indications are forwarded in the end device in the case of PRP, a switch function is installed in the HSR node. Thus, the HSR node forwards indication in the ring that are not directed at it.

In order to avoid circular messages in the ring, corresponding mechanisms are defined in the case of HSR.

SAN (Single Attached Node) end devices can only be connected with the aid of a REDBOX in the case of HSR. PRP systems and HSR systems can be coupled redundantly with 2 REDBOXES.

HMI

Human-Machine Interface

HSR

High Availability Seamless Redundancy Protocol

HV bay description

The HV project description file contains data concerning which bays are present within a ModPara project. The actual bay information is saved for each bay in an HV bay description file. Within the HV project description file, each bay receives an HV bay description file through a reference to the file name.

HV Project Description

If the configuring and parameterization of PCUs and submodules is completed with ModPara, all the data will be exported. The data is distributed to several files during this process. A file contains data on the basic project structure. This typically includes information on which bays are present within this project. This file is designated as an HV project description file.

ICD

IED Capability Description

IEC

International Electrotechnical Commission

IEC 60870-5-103

International standard protocol for communication with IEDs (especially protective equipment). Many protective relays, bay devices, bay controllers and measurement acquisition devices use the IEC 60870-5-103 protocol to communicate with the SICAM system.

IEC 60870-5-104

Internationally standardized telecontrol protocol. Transmission protocol based on IEC 60870-5-101 for the connection of the substation control level to the telecontrol center using TCP/IP via a Wide Area Network (WAN) connection.

IEC 60870-5-104 is also used for the communication with IEDs.

IEC 61850

IEC 61850 is an international standard for consistent communication in substations. This standard defines the communication amongst devices in substations and the related system requirements. All substation automation functions as well as engineering functions are supported. IEC 61850 can also be transferred to automation systems in other applications, for example, for the control and monitoring of distributed power generation.

IEC address

A unique IEC address must be assigned to each SIPROTEC device within an IEC bus. A total of 254 IEC addresses per IEC bus are available.

IEC communication branch

Within an IEC communication branch, the participants communicate on the basis of the protocol IEC 60870-5-103 via an IEC bus.

IED Capability Description

Data exchange from the IED configuration software (DIGSI) to the system configurator. This file describes the performance properties of an IED.

IEEE 1588

Time-synchronization protocol according to IEEE Std 1588-2008: Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (IEEE 1588 v2) and IEEE Std C37.238-2011: IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications (Power Profile).

IID

Instantiated IED Description

INC

Controllable Integer Status

Initialization string

An initialization string consists of a series of modem-specific commands. If the modem is initialized, these commands are transferred to the modem. The commands can force definite settings for the modem, for example.

Input Data/Input Direction

Data is sent from the protocol slave to the protocol master.

INS

Integer Status

Instantiated IED Description

Files in IID format are ICD files adapted for the concrete application in the project. This format is mainly suitable for exchanging data between DIGSI 5 and an external system configurator or also a substation automation system such as SICAM PAS. The ICD format uses SCL as the description language for this purpose.

International Electrotechnical Commission

IEC

Internet protocol

An Internet protocol (IP) enables the connection of participants which are positioned in different networks.

IO

Input-Output

IO Provider Status

The provider (sender) of an IO data element uses this to signal the status (good/bad with error location).

IOPS

IO Provider Status

IP

Internet protocol

IPv4

Internet protocol version 4

ISC

Integer Step Controlled Position Information

LAN

Local Area Network

Link Address

The link address indicates the address of a SIPROTEC device.

Link Layer Discovery Protocol

The Link Layer Discovery Protocol supplies the basis for topology detection and for determination of the configuration.

List view

The right area of the project window displays the names and symbols of the objects which are within a container selected in the tree view. As the visualization is in the form of a list, this area is also referred to as list view.

LLDP

Link Layer Discovery Protocol

Local Area Network

A Local Area Network (LAN) is a regional, local PC network. The PCs are all equipped with a network interface card and work with one another via data exchange. The LAN requires an operating system on each PC and standardized data transport software. The operating systems can be different, as can the data transport software, but both must support a common transmission protocol (= TCP/IP protocols), so that all PCs can exchange data with one another.

LSB

Least Significant Bit

MAC address

The MAC address (Media Access Control) is the hardware address of each single system adaptor. With the MAC address, the device can be identified unambiguously in the system.

Management Information Base

A Management Information Base (MIB) is a database which saves information and statistics concerning each device in a network continuously. The performance of each device can be monitored with this information and statistics. In this way, it can also be ensured that all devices in the network function properly. MIBs are used with SNMP.

Manufacturing Message Specification

The standard Manufacturing Message Specification (MMS) serves for data exchange. The standard is used for the transmission protocols IEC 61850 and IEC 60870-6 TASE.2.

Measured Value

This data type provides a measured value that can be used as a CFC result, for instance.

Metered value

Metered values are a processing function, used to determine the total number of discrete similar events (counting pulses), for example, as integral over a time span. In the power supply utility field, electrical energy is often recorded as a metered value (energy import/delivery, energy transport).

MIB

Management Information Base

MICS

Model Implementation Conformance Statement

MMS

Manufacturing Message Specification

Modbus

The Modbus protocol is a communication protocol. It is based on a Master/Slave or Client/Server architecture.

Model Implementation Conformance Statement

Model Implementation Conformance Statement (see MICS)

The Model Implementation Conformance Statement describes in detail the standard data object models that are supported by the system or by the device.

Modem

Modem profiles for a modem connection are saved in this object type.

Modem Connection

This object type contains information on the two partners of a modem connection, local modem and remote modem.

Modem Profile

A modem profile comprises the name of the profile, a modem driver and optionally several initialization commands as well as a participant address. You can create multiple modem profiles for a physical modem. For this, link different initialization commands or participant addresses with a modem driver and its properties, and save these under various names.

Module

Self-contained unit at the device level. This can be a real module or a functional unit of the device.

MSB

Most Significant Bit

MV

Data type Measured Value

NACK

Negative acknowledgment

Navigation Window

Left area of the project window, which visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure.

Object

Each element of a project structure is designated as an object in DIGSI 5.

Object Property

Each object has properties. These can on the one hand be general properties that are common to several objects. Otherwise, an object can also have object-specific properties.

Offline

If there is no communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is **offline**. The PC program executes in Offline mode.

Online

If there is a communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is **online**. The PC program executes in Online mode.

Optical Switch Module

An Optical Switch Module (OSM) is a process for switching over switches in Ethernet networks that are ring-shaped in structure. OSM is a proprietary process from Siemens, which later became standard under the term MRP. OSM is integrated in the optical Ethernet module EN100-O. OSM is hardly used in IEC 61850 networks. RSTP is used there, this having become established as an international standard.

OSM

Optical Switch Module

Output data/Output direction

Data is sent from the protocol master to the protocol slave.

Parallel Redundancy Protocol

Parallel Redundancy Protocol (PRP) is a redundancy protocol for Ethernet networks that is specified in IEC 62439-3. Unlike conventional redundancy procedures, such as RSTP (Rapid Spanning Tree Protocol, IEEE 802.1D-2004), PRP offers uninterruptible switching, which avoids any down time in the event of a fault, and thus the highest availability.

PRP is based on the following approach: The redundancy procedure is generated in the end device itself. The principle is simple: The redundant end device has 2 Ethernet interfaces with the same address (DAN, Double Attached Node). Now, the same indication is sent twice, in the case of PRP (**parallel**) to 2 separate networks, and uniquely marks both with a sequence number. The recipient takes the information that it receives first, stores its ID based on the source address and the sequence number in a duplicate filter and thus recognizes the 2nd, redundant information. This redundant information is then discarded. If the 1st indication is missing, the 2nd indication with the same content comes via the other network. This redundancy avoids a switching procedure in the network and is thus interruption-free. The end device forwards no messages to the other network. Since the process is realized in the Ethernet layer (same MAC address), it is transparent and usable for all Ethernet payload protocols (IEC 61850, DNP, other TCP/IP based protocols). In addition, it is possible to use one of the 2 networks for the transmission of non-redundant messages.

There are 2 versions of PRP: PRP-0 and its successor PRP-1. Siemens implements PRP-1.

Parameterization

Comprehensive term for all setting work on the device. You can parameterize the protection functions with DIGSI 5 or sometimes also directly on the device.

Parameter set

The parameter set is the entirety of all parameters that can be set for a SIPROTEC device.

Participant address

A participant address consists of the name of the participant, the international dialing code, the local dialing code and the participant-specific telephone number.

PICS

Protocol Implementation Conformance Statement

PLC

See Programmable Logic Controller

PLC

Programmable Logic Controller

PROFIBUS

PROcess Feld BUS, German Process and Fieldbus standard (EN 50170). The standard specifies the functional, electrical and mechanical characteristics for a bit-serial fieldbus.

PROFIBUS Address

A unique PROFIBUS address must be assigned to each SIPROTEC device within a PROFIBUS network. A total of 254 PROFIBUS addresses per PROFIBUS network are available.

Profile_ID

A Profile_ID in combination with an API uniquely identifies the access and the behavior of an application.

PROFINET IO

PROFINET is an open Industrial Ethernet Standard from PROFIBUS for the automation.

Programmable Logic

The programmable logic is a function in Siemens devices or station controllers, enabling user-specific functionality in the form of a program. This logic component can be programmed by various methods: CFC (= Continuous Function Chart) is one of these. SFC (Sequential Function Chart) and ST (Structured Text) are others.

Programmable Logic Controller

Programmable logic controllers (PLC) are electronic controllers whose function is saved as a program in the control unit. The construction and wiring of the device do not therefore depend on the function of the control. The programmable logic controller has the structure of a computer; it consists of CPU with memory, installation/extension groups (for example, DI, AI, CO, CR), power supply (PS) and rack (with bus system). The peripherals and programming language are oriented towards the circumstances of the control system.

Programmable Logic Module

Modules are parts of the user program delimited by their function, structure and intended use.

Project

In terms of content, a project is the replication of a real energy supply system. In graphic terms, a project is represented as a number of objects which are incorporated in a hierarchical structure. Physically, a project consists of a series of directories and files containing project data.

Project tree

The Project tree is used to display a data structure. This data structure represents the content of the project and is created by a Generic Browser.

Protection communication

Protection communication includes all functionalities necessary for data exchange via the protection interface. Protection communication is created automatically during configuration of communication channels.

Protection Device

A protection device detects erroneous states in distribution networks, taking into account various criteria, such as error distance, error direction or fault direction, triggering a disconnection of the defective network section.

Protocol Implementation Conformance Statement

The performance properties of the system to be tested are summarized in the report on the conformity of implementation of a protocol (PICS = Protocol Implementation Conformance Statement).

PRP

Parallel Redundancy Protocol

Rapid Spanning Tree Protocol

The Rapid Spanning Tree Protocol (RSTP) is a standardized redundancy process with a short response time. In the Spanning Tree Protocol (STP protocol), structuring times in the multidigit second range apply in the case of a reorganization of the network structure. These times are reduced to several 100 milliseconds for RSTP.

Real Time

Real time

RedBox

Reduncancy box

The RedBox is used for the redundant connection of devices with only one interface to both the LAN A and the LAN B PRP network. The RedBox is a DAN (Double Attached Node) and operates as a proxy for the devices connected to it (VDANs). The RedBox has its own IP address in order to be able to configure, manage, and monitor it.

Relay Information by OMICRON

Files in RIO format can be used to exchange data between test systems from the OMICRON company and any other project-protection planning system. With DIGSI 5, you can export different settings from protection functions in RIO format, which the OMICRON test equipment 7VP15 can then continue to process. The relevant settings are described in the Test equipment manual.

RIO

Data format Relay Information by OMICRON

RSTP

Rapid Spanning Tree Protocol

SAN

Single Attached Node

A SAN is a non-redundant node in the PRP network. It is only connected with one port to one network (LAN A or LAN B). It can only communicate with nodes in the connected network. Via a RedBox, devices with only one connection can be redundantly connected to the 2 LAN A and LAN B networks. In order to obtain symmetrical LAN A and LAN B networks, Siemens recommends avoiding SANs and to connect the devices either via a RedBox or in a separate network without PRP support.

SBO

Select before operate

SC

See Single Command

SCD

See Substation Configuration Description

SCL

Substation Configuration Description Language

SED

System Exchange Description

SEQ

Data type Sequence

SEQ5

DIGSI 5 Test Sequences

Sequence of Events

Acronym: SOE. An ordered, time-stamped log of status changes at binary inputs (also referred to as state inputs). SOE is used to restore or analyze the performance, or an electrical power system itself, over a certain period of time.

Service Interface

Device interface for interfacing DIGSI 5 (for example, through a modem)

SICAM SAS

Substation Automation System – Modularly structured station control system, based on the substation controller SICAM SC and the SICAM WinCC operator control and monitoring system..

SICAM WinCC

The operator control and monitoring system SICAM WinCC graphically displays the state of your network. SICAM WinCC visualizes alarms and messages, archives the network data, provides the option of intervening manually in the process and manages the system rights of the individual employees.

SIM

Simulation data format for single/multiple devices

Simple Network Management Protocol

The Simple Network Management Protocol (SNMP) is an Internet standard protocol and serves for the administration of nodes in an IP network.

Simple Network Time Protocol

The Simple Network Time Protocol (SNTP) is a protocol for the synchronization of clocks via the Internet. With SNTP, client computers can synchronize their clocks via the Internet with a time server.

Simulation data format for single/multiple devices

You can export the simulation-related files of a SIPROTEC 5 device in the SIM format. This new functionality in DIGSI 5 provides the ability to export the simulation data and simulate all the devices in the DIGSI 5 project for test and commissioning needs. The simulation is achieved by importing the simulation file into a signal processing and automation system which will then simulate the device/devices with the process data as in a real-time system. This feature also ensures the testing of a device for various real-time system conditions.

Single Command

Single commands (SPC - Single Point Control) are process outputs which visualize 2 process states (for example, On/Off) at an output.

Single-line diagram

A single-line diagram (SLD) is a simplified electric overview of the switchgear. Only 1 phase is shown instead of all 3 phases of a line. Therefore, the diagram is called single-line.

Single-Line Editor

A Single-Line Editor contains a catalog of topological components to create a single-line diagram. The customer may use the single-line elements to configure the topological view of his substation.

Single-point indication

Single-point indications (SPS – Single point status) are process indications which visualize 2 process states (for example, On/Off) at an input.

SIPROTEC 5 device

This object type represents a real SIPROTEC device with all the contained setting values and process data.

SIPROTEC

The registered trademark SIPROTEC designates the product family of protection devices and fault recorders.

Slave device

A slave may only exchange data with a master after its has been requested to do so by this master. SIPROTEC devices work as slaves. A master computer controls a slave computer. A master computer can also control a peripheral device.

SLD

Single-line diagram

SLE

Single-Line Editor

SNMP

Simple Network Management Protocol

SNTP

Simple Network Time Protocol

SOE

Sequence of Events

SP

See Single-Point Indication

SPC

IEC 61850 data type: Single Point Control

SPS

IEC 61850 data type: Single point status

SSD

System Specification Description

ST

Structured Text file

Station Description

A station description is an IEC 61850-compliant file for data exchange between the system configurator and the IED configurator. The station description contains information on the network structure of a substation. The station description contains for example, information on the assignment of the devices to the primary equipment, as well as on the station-internal communication.

Structured Text file

You can import function charts (CFC) from DIGSI 4 in ST format. First, however, export your function charts from DIGSI 4.83 or higher.

Substation Configuration Description Language

A description language standardized in IEC 61850, SCL is based on XML. This description language allows all information relevant to an IEC 61850 substation to be documented consistently. This format is therefore suitable for exchanging IEC 61850-specific data between different applications, even if these come from different manufacturers. The described import checks are basically done for all SCL formats, not only for SCD imports.

System Exchange Description

Files in SED format can be used to exchange interface information between DIGSI 5 projects and thus between substations. To do this, the project extracts the data for the other projects from the file during import and writes its own data in the same file during export. The contents of an SED file are formulated in SCL.

System Specification Description

Files in SSD format contain the complete specification of a station automation system, including a single-line configuration of the station. The assignment of logical nodes from IEC 61850 to primary equipment can also be described in SSD files. This allows device requirements to be defined in the SSD file so that the devices can be used in the substation. The contents of an SED file are formulated in SCL.

TAI

Temps Atomique International - International Atomic Time

TC

Tap-position command – see Transformer Tap Position Command

TCP

Transmission Control Protocol

TEA-X

You can archive the data from individual SIPROTEC 5 devices or whole project in TEA-X format. This format is also suitable for data exchange between different applications, such as DIGSI 5 and Engineering Base (EB). The TEA-X format is based on XML.

Telephone book

Participant addresses for the modem connection are saved in this object type.

Time stamp

A time stamp is a value in a defined format. The time stamp assigns a time point to an event, for example, in a log file. Time stamps ensure that events can be found again.

Topological view

The Topological View is oriented to the objects of a system (for example, switch gear) and their relation to one another. The Topological View describes the structured layout of the system in hierarchical form. The Topological View does not assign the objects to the devices.

Transmission Control Protocol

The Transmission Control Protocol (TCP) is a transmission protocol for transport services in the Internet. TCP is based on IP and ensures connection of the participants during the data transmission. TCP ensures the correctness of the data and the correct sequence of the data packages.

Transparent Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The transparent clock was added to the specification in 2008 and

improves the time-information transmission within a network by receiving PTP messages and transmitting them after modification (correction).

Tree view

The left area of the project window visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure. This area is referred to as a tree view.

Tunneling

Technology for connecting two networks via a third network, whereby the through traffic is completely isolated from the traffic of the third network.

UDP

User Datagram Protocol

Unbuffered Report Control Block

Unbuffered Report Control Block (URCB) is a form of report controlling. Internal events trigger the immediate sending of reports based on **best effort**. If no association exists or if the transport data flow is not fast enough, events can be lost.

URCB

Unbuffered Report Control Block

USART

Universal Synchronous/Asynchronous Receiver/Transmitter

User Datagram Protocol (UDP)

UDP is a protocol. The protocol is based on IP as TCP. In contrast to this, however, UDP works without a connection and does not have any safety mechanisms. The advantage of UDP in comparison to IP is the higher transmission rate.

UTC

Universal Time Coordinated

Vendor ID

Manufacturer-specific part of the device identification for PROFINET.

Virtual Device

A VD (virtual device) comprises all communication objects, as well as their properties and states, which a communication user can utilize in the form of services. A VD can be a physical device, a module of a device or a software module.

WYE

Phase-to-ground related measurements of a 3-phase system

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