SIEMENS

SIPROTEC 5
High-Speed Busbar Transfer
7VU85

V9.50 and higher

Manual

C53000-G5040-C090-3

Preface

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NOTE

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

Disclaimer of Liability

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

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Preface

Purpose of the Manual

This manual describes the functions of the high-speed busbar transfer device.

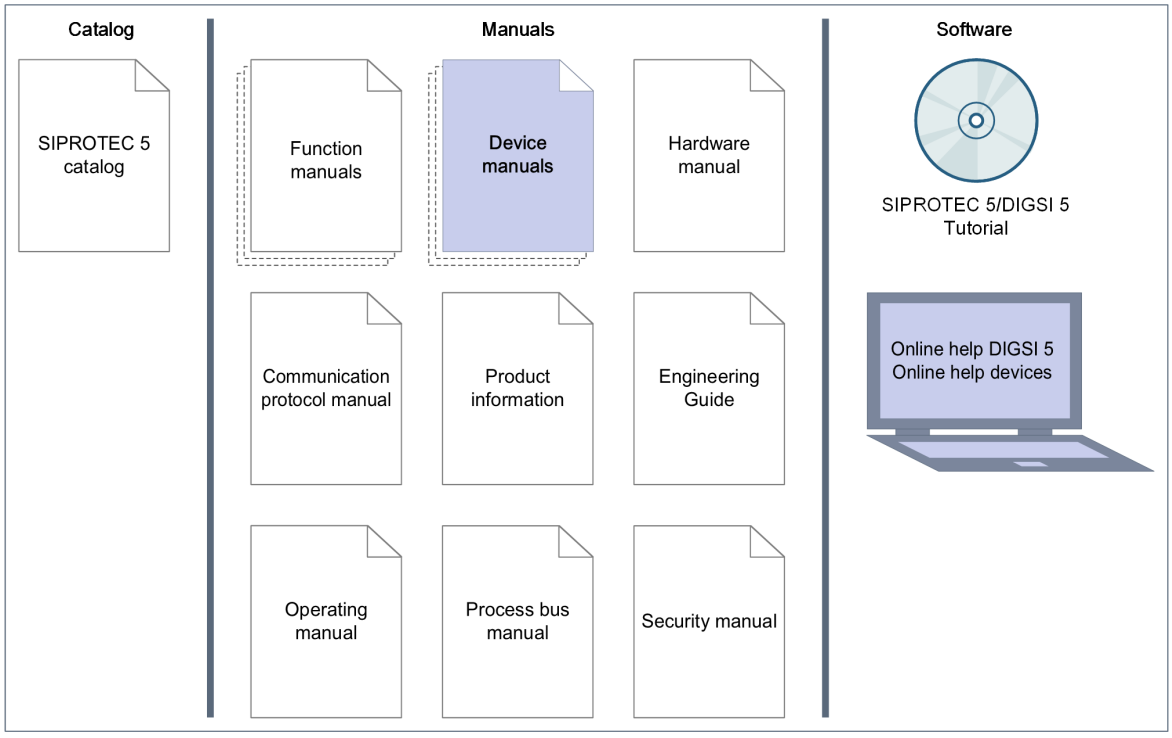
Target Audience

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



[dw_product-overview_SIP5_device-manual, 5, en_US]

- 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.
- Security manual
  The Security manual describes the security features of the SIPROTEC 5 devices and DIGSI 5.
- Process bus manual
  The process bus manual describes the functions and applications specific for process bus in SIPROTEC 5.
- 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.

Indication of Conformity

CE

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States concerning electromagnetic compatibility (EMC Directive 2014/30/EU), restriction on usage of hazardous substances in electrical and electronic equipment (RoHS Directive 2011/65/EU), and 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), the standard EN IEC 63000 (for RoHS directive), and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens.

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.

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 *ul.com*

You can find the product with the **UL File Number E194016**.



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Additional Support

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

Customer Support Center

Our Customer Support Center provides a 24-hour service.

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Training Courses

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

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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 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 document 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.

Selection of Used Symbols on the Device

No.	Symbol	Description
1		Direct current, IEC 60417, 5031
2		Alternating current, IEC 60417, 5032
3		Direct and alternating current, IEC 60417, 5033
4		Earth (ground) terminal, IEC 60417, 5017
5		Protective conductor terminal, IEC 60417, 5019

No.	Symbol	Description
6		Caution, risk of electric shock
7		Caution, risk of danger, ISO 7000, 0434
8		Protective insulation, IEC 60417, 5172, safety class II devices
9		Guideline 2002/96/EC for electrical and electronic devices
10		Guideline for the Eurasian market
11		Mandatory conformity mark for electronics and electrotechnical products in Morocco

OpenSSL

This product includes software developed by the OpenSSL Project for use in OpenSSL Toolkit (*http://www.openssl.org/*).

This product includes software written by Tim Hudson (*tjh@cryptsoft.com*).

This product includes cryptographic software written by Eric Young (*eay@cryptsoft.com*).

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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 fitted 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 5device consists of inputs for measuring current and voltage. The current inputs are 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 voltage measured values.

The analog values are digitized in the microprocessor for data processing.

Microprocessor System

All device functions are processed in the microprocessor 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 sequences
- Control of signals for logic functions
- Control of open and close commands
- Recording of indications, fault data, and fault values for fault analysis
- Administration of the operating system and its functions, for example data storage, real-time clock, communication, interfaces
- 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 panel 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 rear are used to implement 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 bridged by capacitor storage (see also the Technical Data).

1.2 Properties of SIPROTEC 5

The SIPROTEC 5devices 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 microprocessor
- 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 circuits 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 security-critical operations on the devices and systems

Redundant Communication

SIPROTEC 5devices maintain full 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 Embedding of Functions 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 7VU85 serves as an example. The following protection functions are required for implementation (simplified and reduced):

- Circuit-breaker failure protection (50BF)
- Basic functionality (for example switchgear interlocking protection, control)

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.

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 transformer, or circuit breaker.

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

- Assignment of functions to currentand/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.

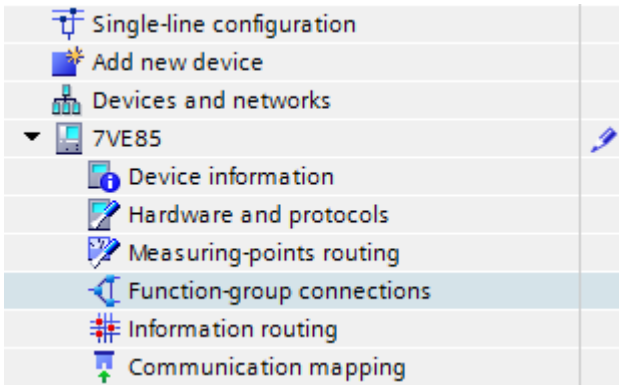
Interface Between Function Group and Measuring Point

The function groups receive the measurands of the current and voltage transformers from measuring points. For this, the function groups are connected to 1 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.

You can change the assignment on demand, that is, function groups can be assigned to any available measuring points of the device.

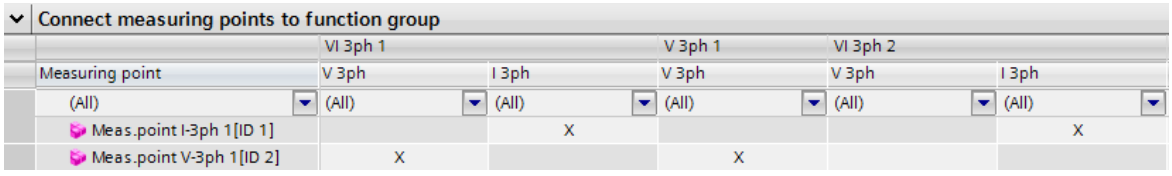
To check or change the assignment of measuring points to the function groups, double-click **Function-group connections** in the DIGSI 5 project tree.



[sc_navi_7VE85, 1, en_US]

Figure 2-1 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).



[sc_mp_fgconnect, 2, en_US]

Figure 2-2 Connecting Measuring Points and Function Groups

2.2 Application Templates/Adaptation of 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.

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 stage 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 adaptation of the functional scope consists of adding and deleting functions, 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 *2.1 Embedding of Functions in the Device*). You must connect newly added protection function groups to a circuit-breaker function group (see *2.1 Embedding of Functions 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. You can find more detailed information in the description of application templates, in *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.

In addition to function-point classes (10, 20, 30, 40, 50, 75, 100 to 1400) beginning with firmware version V09.20, any function-point values in the range from 0 to 5000 are supported as a credit in the device. Thus, the precise function-point credit required can be loaded into the device by the Function-Point Manager. Alternatively, you can order classless devices with 0 points (new option beginning with V09.20) or class-bound with the required function-point class.

Extending the Function-Point Credit

You can reorder function points if the function-point credit for the device is not enough or if you have ordered a classless device with 0 points. Proceed as follows:

- Determine the function-point requirement of certain functions, for example, with DIGSI 5 or the SIPROTEC 5 Configurator.
- Create a signed license file for your device with the SIPROTEC Function-Point Manager at *www.siprotec-function-point-manager.siemens.com* or order the license file from your sales partner.
- Once you have ordered the license file using the Function-Point Manager, you can download it from there directly.
- Once you have ordered the license file from your sales partner, you will receive it by e-mail or to download.
- Use DIGSI 5 to load the signed license file onto 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

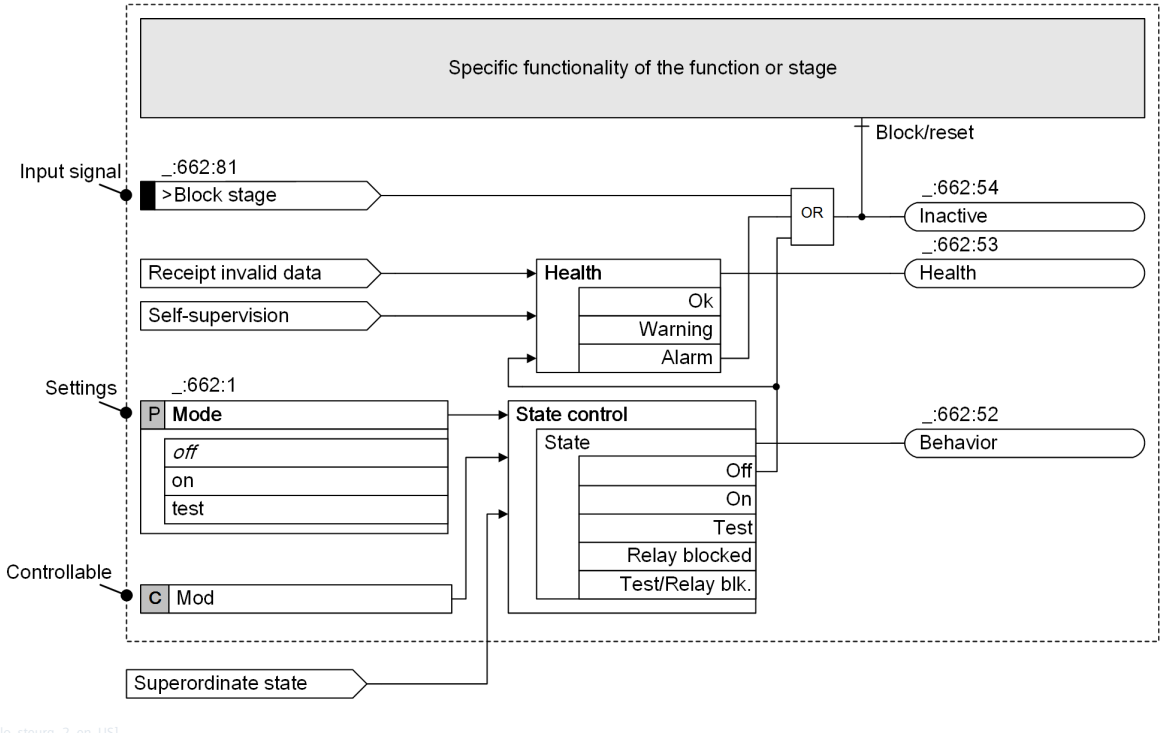
NOTE

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***). Furthermore, the state of the tripping stage can be influenced with the help of the controllable **Mod** in the IEC 61850 representation. The controllable **Mod** (in the DIGSI 5 information routing **_:51 Mode (controllable)**) supports the states ***On***, ***Off***, ***Test***, ***Relay blocked***, and ***Test/Relay blk.***.

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 2-3*. It is standardized for all functions. Therefore, this control is not discussed further in the individual function descriptions.



[lo_steurg, 2, en_US]

Figure 2-3 General Control of a Function

State Control

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

You set the specified operating state of the function via the parameter **Mode**. You can set the function mode 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
- Browser-based user interface
- Certain systems control protocols (IEC 61850, IEC 60870-5-103)

You can also set the setpoint operating state of the function through the controllable **Mod**. You can set the function mode to ***On***, ***Off***, ***Test***, ***Relay blocked*** and ***Test/Relay blk.***. The operating principle is described in *Table 2-2*. You can set the controllable **Mod** via:

- IEC 61850-8-1
- CFC

The **superordinate state** can accept the values ***On***, ***Relay blocked*** ***Test*** and ***Test/Relay blk.***.
The state of the function resulting from the parameter **Mode**, the controllable **Mod** and the **Superordinate state** is shown in the following table. The resulting state of the function results from the combination of all sources (parameters **Mode**, Controllable **Mod** and **Superordinate state**). For simplicity, the table represents only the combination of 2 sources.

Table 2-1 Resulting State of the Function

Inputs		State of the Function
Source A	Source N	
On	On	On
On	Off	Off
On	Test	Test[1]
On	Relay blocked	Relay blocked
On	Test/Relay blk.	Test/Relay blk.
Test	On	Test[1]
Test	Off	Off
Test	Test	Test[1]
Test	Relay blocked	Test/Relay blk.
Test	Test/Relay blk.	Test/Relay blk.
Off	On	Off
Off	Off	Off
Off	Test	Off
Off	Relay blocked	Off
Off	Test/Relay blk.	Off
Relay blocked	On	Relay blocked
Relay blocked	Off	Off
Relay blocked	Test	Test/Relay blk.
Relay blocked	Relay blocked	Relay blocked
Relay blocked	Test/Relay blk.	Test/Relay blk.
Test/Relay blk.	On	Test/Relay blk.
Test/Relay blk.	Off	Off
Test/Relay blk.	Test	Test/Relay blk.

1 With the parameter (_:151) Oper.bin.outp. under test, you can fix the settings whether the relay outputs are to be picked up by functions in the state **Test**. If this parameter is inactive (default setting), the state **Test** of a function is modified to **Test/Relay blk.**.

Inputs		State of the Function
Test/Relay blk.	Relay blocked	Test/Relay blk.
Test/Relay blk.	Test/Relay blk.	Test/Relay blk.

NOTE

The browser-based user interface shows an easy-to-read list of the states of all functions if they deviate from the state ***On***.

The following table describes the possible states of a function:

Table 2-2 Possible States of a Function

State of the Function	Explanation
On	The function is activated and operating as defined. The prerequisite is that the health of the function is ***OK***.
Relay blocked	The function is activated and operating as defined. The prerequisite is that the health of the function is ***OK***. All outputs of indications of this function to relays are blocked. **Note:** Logics outside this function block, for example, superordinate group indications, are not affected by the blocking. Their output to a relay still leads to an activation.
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>State of the Function</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 indication is labeled 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 side. You must route the Test signal in the DIGSI 5 project tree → Device → Communication routing.
The test mode of the differential protection is dealt with separately in the application.</td></tr>
<tr><td>Test/Relay blk.</td><td colspan="2">The function works as described under Test. All output information (indications) of this function which is routed to a relay is blocked.
All output information from the function (indications and, if available, measured values) is provided with a test bit. This test bit significantly influences the further processing of the information, depending on the target.
Logics outside this function block, for example, superordinate group indications, are not affected by the blocking. If the state of these functions allows the processing of indications with a test bit (target function in the state Test or Test/Relay blk.), the output information routed to a relay continues to the control of the relays.</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-monitoring can cause functions to assume the health *Alarm* (see *10 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 disabled
- The function is in the health state *Alarm*
- Function is blocked by an input signal (see *Figure 2-3*)
- All protection-function steps are disabled via the *Enable protection* controllable (state = false). The indication *Protection inactive* is active.

Blocking of the Operate Indication, No Fault Recording at Pickup

With the parameter **Blk. Op. Ind. & Fault Rec.** , you define whether a function works as a protection or a monitoring 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 unique 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 reference numbers follows the hierarchy:

- 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.

3 System Functions

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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):

- Operational log 2000 indications
- Fault log 1000 indications
- Switching-device log 2000 indications
- Ground-fault log 100 indications
- User-defined log 200 indications
- Motor-starting log 200 indications

If the maximum capacity of the user-defined log or of the operational log is exhausted, the newest entries overwrite the oldest entries. If the maximum capacity of the fault log or of the ground-fault log is reached, the number of the last fault is output via the signal **Fault recording buffer 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 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 request via general interrogation. In DIGSI 5, indications can be tracked spontaneously duringonline mode 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 can 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

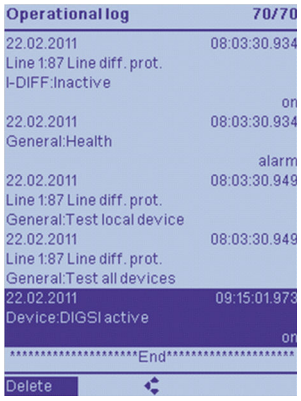
To read the indications of your SIPROTEC 5 device you can use the on-site operation panel of the device or a PC on which you have installed DIGSI 5. The subsequent section describes the general procedure.

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***.



[sc_oprlog, 1, en_US]

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

Menu Path	Log
Main menu → Indications →	Operational log Fault log Switch. device log Ground-fault log Setting-history log User log 1 User log 2 Motor-starting log Com supervision log
Main Menu → Test & Diagnosis → Log →	Device diagnosis Security log Communication log

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 predefined. Every indication contains date, time, and its state as additional information.

You will find information about this in chapter *3.1.5.1 General*.

In some logs, you are given the option of deleting the entire indication list by softkey in the footer of the display. To learn 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

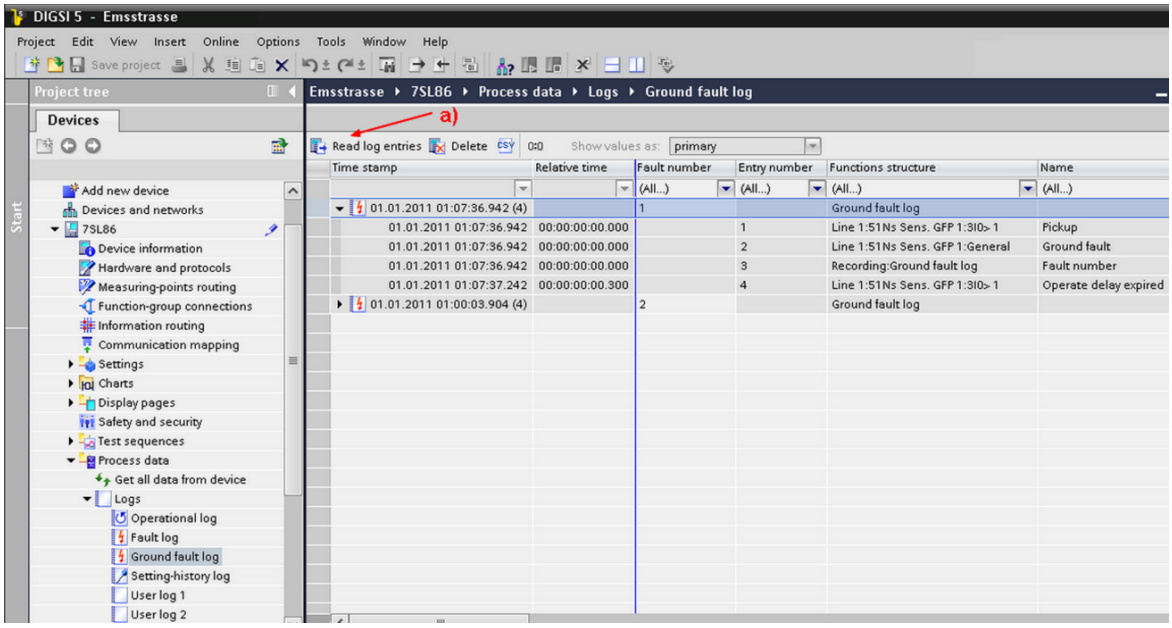
Menu Path (Project)	Log
Project → Device → Process data → Log →	Operational log Fault log Switch. device log Ground-fault log Setting-history log User log 1 User log 2 Motor-starting log Com supervision log
Online access → Device → Device information → **Logs** tab →	Device-diagnosis log Security indications
Online access → Device → Test suite → Communication module → Hardware[2]	Communication log

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. You can establish a direct connection to your PC via the Ethernet interfaces. It is also possible to access all connected SIPROTEC 5 devices via a data network from your DIGSI 5 PC.

✧ You reach the desired logs of the SIPROTEC 5 device using the project-tree window. If you have not created the device within a project, you can also do this via the **Online access** menu item.

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.

✧ Synchronize the log. For this purpose, click the appropriate button in the headline of the log (see the ground-fault indications example in *Figure 3-2* a)).



[sc_grflmd, 1, en_US]

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

2 There may potentially be several communication modules to select from

You will find additional information about deleting and saving logs in chapter *3.1.6 Saving and Deleting the Logs*.
Which indications can be shown in the selected log 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*.

Setting Relative Time Reference

✧ Reference the display of log entries, if needed, to the real time of a specific entry. In this way, you determine a relative time for all other indications. The real-time stamps of events remain unaffected.

3.1.4 Displaying Indications

Displayed indications are supplemented in DIGSI 5 and on the on-site operation panel 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 and switching-device indications	Time stamp (date and time), Relative time, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Function structure, Name, Value
Log for fault indications	Time stamp (date and time), Relative time, Fault number, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Fault number, Value
Log for motor-starting indications	Time stamp (date and time), Motor-starting time, Starting current, Starting voltage, Starting duration	Time stamp (date and time), Function structure, Name, Value

Indications in	DIGSI 5 Information	Device Display Information
Log for ground-fault indications	Time stamp (date and time), Relative time, Fault number, Entry number, Function structure, Name, Value, Indication number, Quality, Cause, Number	Time stamp (date and time), Fault number, Value
Log for parameter changes	Time stamp (date and time), Relative time, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Function structure, Name, Value
Spontaneous indication window (DIGSI 5)	Time stamp (date and time), Relative time, Indication, Value, Quality, Additional Information	Time stamp (date and time), Fault number, Value
Log for safety indications[3]	Time stamp (date and time), Indication number, Indication	Time stamp (date and time), Indication
Log for device-diagnostic indications[3]	Time stamp (date and time), Indication number, Indication	Time stamp (date and time), Indication
Log for communication indications[3]	Time stamp (date and time), Indication number, Indication	Time stamp (date and time), Indication
Log for communication supervision (GOOSE)	Time stamp (date and time), Relative time, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Function structure, Name, Value

3 Only online access

Overview of Displayed Quality Attributes

If values are shown on the device display or in DIGSI, the following quality attributes are different for measured values and metered values.

Table 3-2 Measured Values

IEC 61850				Device Display/ DIGSI	Description
Detail Quality	Validity				
	Good	Invalid	Questionable		
–	X			Value	The measured value is valid.
Failure		X		Fault	The device is defective. Contact Support.
Inaccurate			X	---	The measured value was not calculated (for example, the angle between current and voltage if 1 of the 2 variables is missing).
Bad Reference			X	≈ Value	The measured value can be inaccurate (for example, outside the frequency-tracking range).
Out of Range			X	> Value	The measured value exceeds the measuring range.

Table 3-3 Metered Values

IEC 61850			Device Display/ DIGSI	Description
Validity				
Good	Invalid	Questionable		
X			Value	The metered value is invalid.
	X		---	The metered value was not calculated.
		X	≈ Value	The metered value has no reference.

Indication Columns

The following table shows the meaning of the individual columns in the log:

Indication Column	Meaning
Time stamp	Time stamp of the indication in device time using the local time zone of the device or the query time for the motor log
Relative time	Relative time to a reference entry
Error number	Number of the error that occurred in the device. This number increments continuously.
Entry number	Entry identification of buffer entries. This identification displays the sequence of buffer entries.
Indication number	Number of the indication that occurred in the device. This number increments continuously and is necessary for an analysis by Siemens.
Indication	Indication text
Function structure	Path of the signal with the signal name
Name	Signal name
Value	Current state of the command. Also pay attention to the value quality to check whether the value is up to date.

Indication Column	Meaning
Quality	The quality of the value shows the source of the value and whether the value is up to date.
Cause	Additional information such as the cause and validity
Number	DIGSI address of the signal
Motor startup time	Time of motor starting
Starting current	Current needed by the motor to start up
Starting voltage	Voltage needed by the motor to start up
Start duration	Time needed by the motor to start up

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 3-4 Log Overview

Log	Logging
Operational log	Operational indications
Fault log	Fault indications
Switching-device log	Switching operation and circuit-breaker statistics
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-starting log	Information on the motor starting
Communication-supervision log	Communication supervision (GOOSE)

Log Management

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 output via the signal **Fault recording buffer 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:

- Open the information routing.
  Project → Device → **Information routing**

- Select the appropriate routing column.
  Destination → Logs → Column **Ground-fault log (G)**

The routing of the selected indication is done via right click.

- Select one of the options in the list box shown:
  - Routed (X)
  - Unrouted

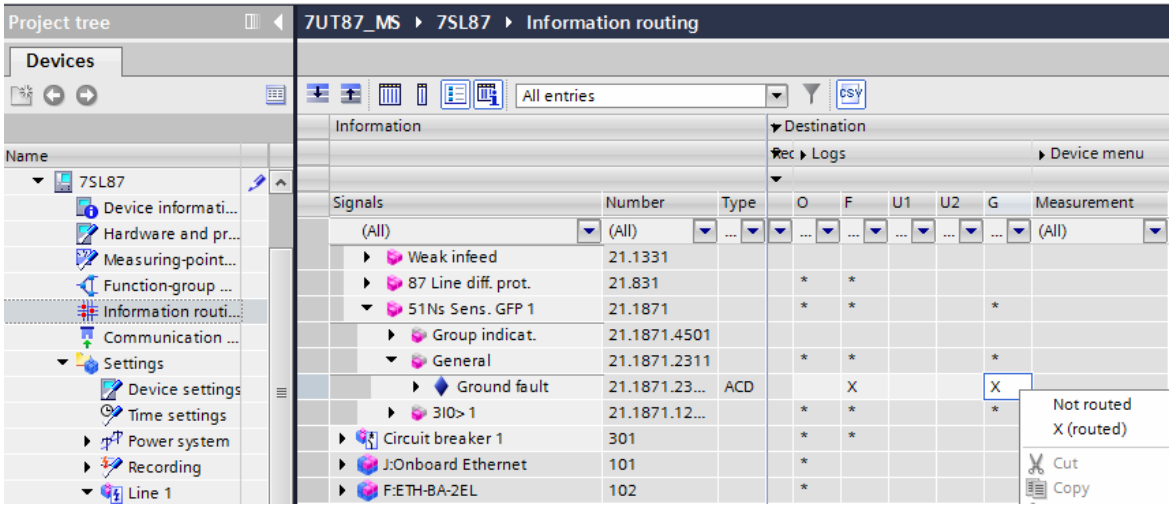


Figure 3-3 Indication Configuration in DIGSI 5 (Example: Ground-Fault Log, Column G)

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

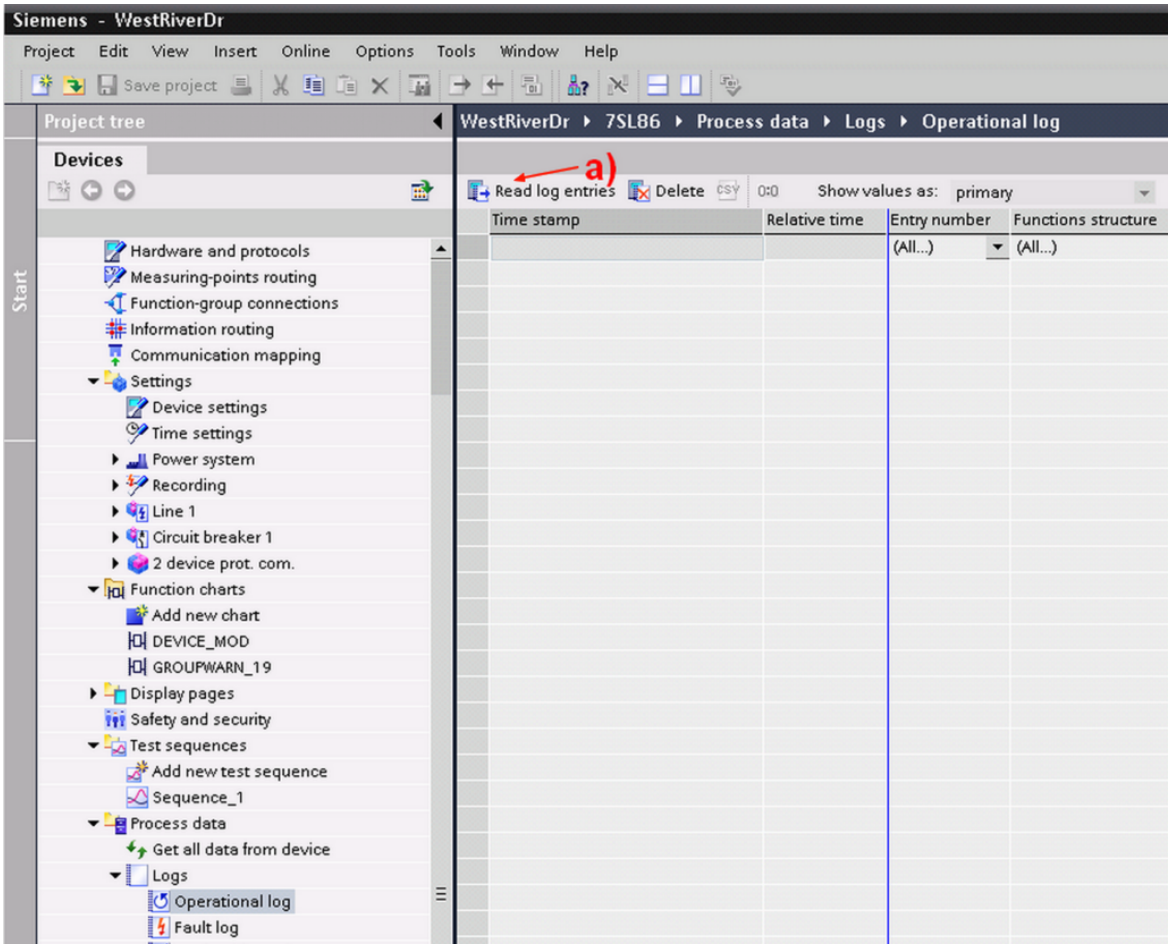
Operational indications are information that the device generates during operation. This includes information about:

- 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, refer to the description of the fault log (chapter *3.1.5.3 Fault Log*). Up to 2000 indications can be stored in the operational 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)).

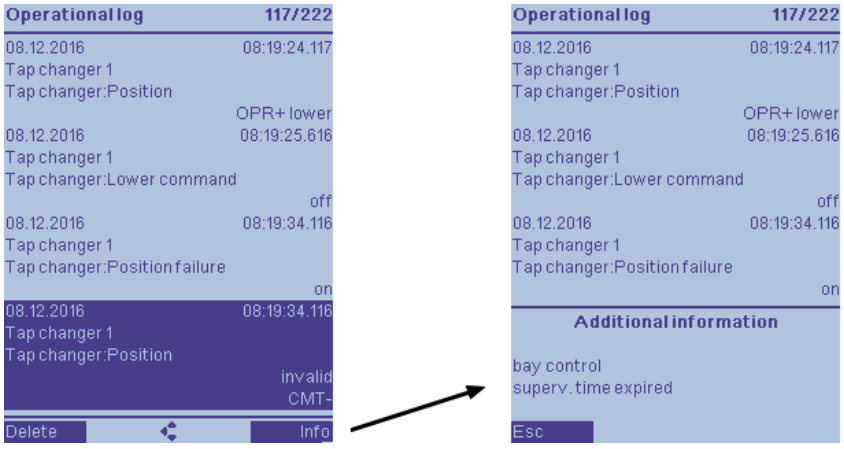


[sc_betrmd, 1, en_US]

Figure 3-4 Reading the Operational Log with DIGSI 5

Reading on the Device via 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.
- Using the **Info** softkey, you can retrieve auxiliary information on the entry depending on the context.



[sc_operlog1, 2, en_US]

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.

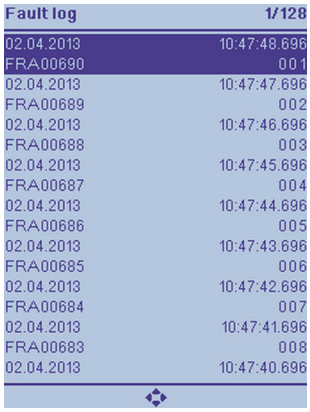
Apart from the recording of fault indications in the fault log, spontaneous display of fault indications of the last fault on the device display is also done. You will find details about this in chapter *3.1.8 Spontaneous Fault Display on the On-Site Operation Panel*.

Deletability

The fault log of your SIPROTEC 5 device can be deleted. For more details about this, refer to 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.



[sc_faullg, 1, en_US]

Figure 3-6 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 Device 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**

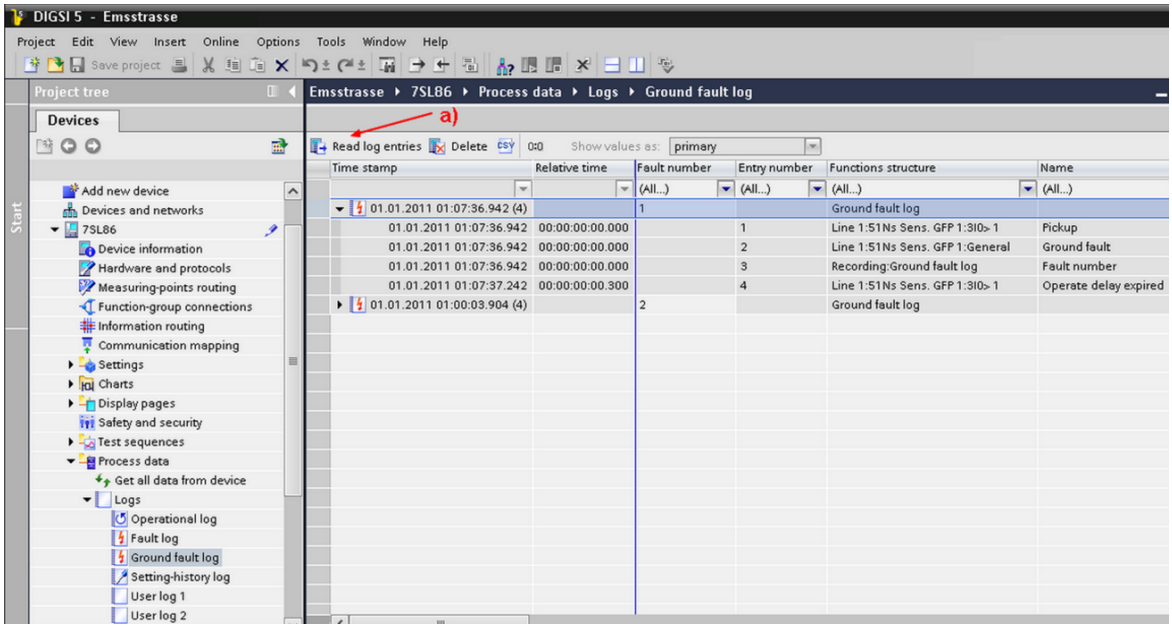
The logging ends with the clearing ground-fault indication.

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 3-7* a)).

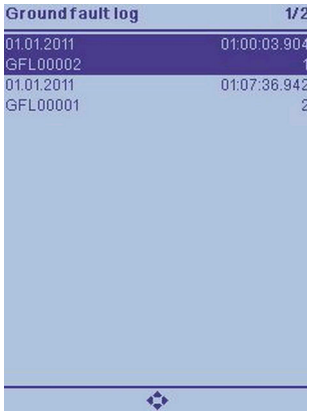


[sc_grflmd, 1, en_US]

Figure 3-7 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.



[scgfllg1-191012-01.tif, 1, en_US]

Figure 3-8 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 details about this 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 Setting-History Log

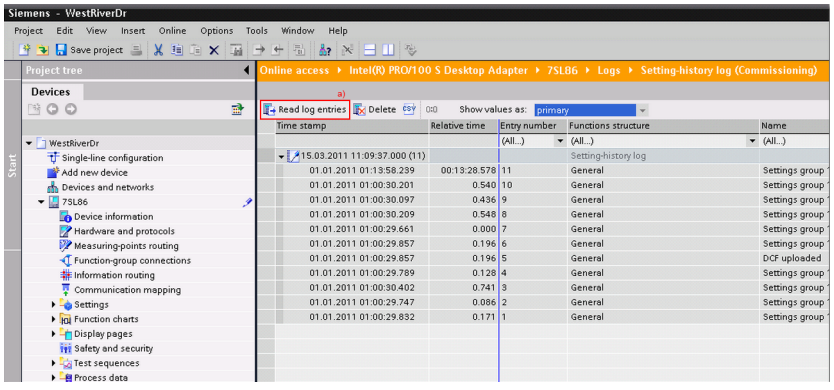
All individual setting changes and the downloaded files of entire parameter sets are recorded in the log for setting changes. This enables you to determine setting changes made are associated with events logged (for example faults). On the other hand, it is possible to obtain verification with fault 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 3-9*).



[sc_paramd, 1, en_US]

Figure 3-9 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.
  Main menu → Indications → **Setting changes**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[sc_hislog, 1, en_US]

Figure 3-10 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 3-5 Overview of Indication Types

Displayed Information	Explanation
Selection edit+	Selection of settings group to be edited
Cancelation+	Cancelling of all changes successful
SG activation+	SG activation via command successful
SG activation-	SG activation via command failed
Set+	Parameter value was changed
Confirmation+	Confirmation of change successful
Confirmation-	Confirmation of change failed
DCF uploaded	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

NOTE

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

3.1.5.6 User Log

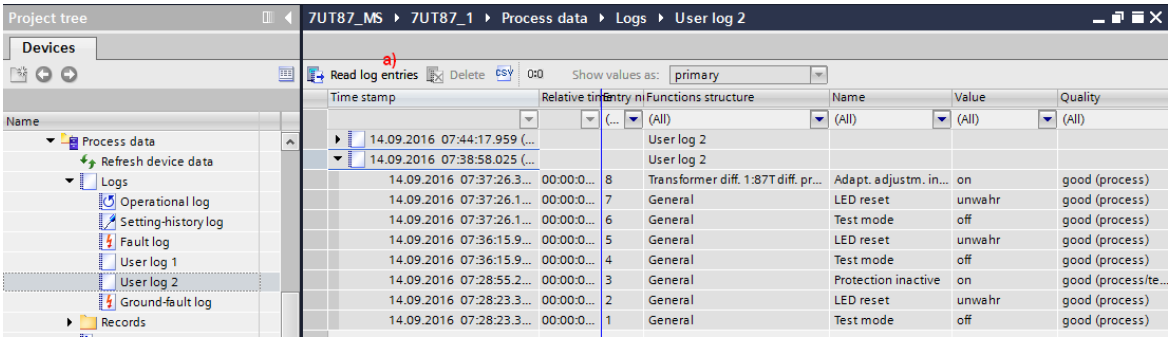
With the user-defined log (up to 2), you have the possibility of individual indication logging parallel to the operational log. This is helpful, for example, in special monitoring tasks but also in the classification into different areas of responsibility of the logs. Up to 200 indications can be stored 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 **Read log entries** button in the headline of the indication list (*Figure 3-11* a)).

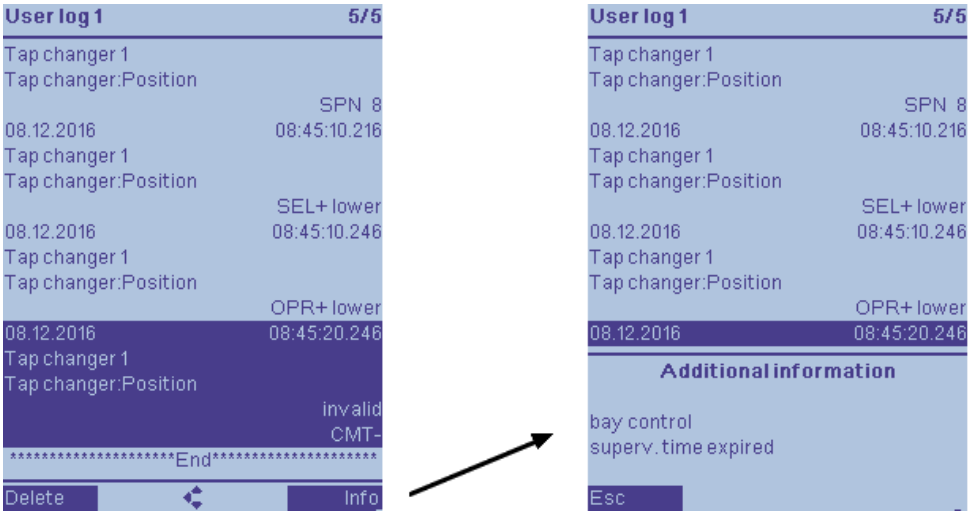


[sc_application_md, 2, en_US]

Figure 3-11 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.
- Using the **Info** softkey, you can retrieve auxiliary information on the entry depending on the context.



[sc_userrlog1, 1, en_US]

Figure 3-12 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. You will find details about this 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

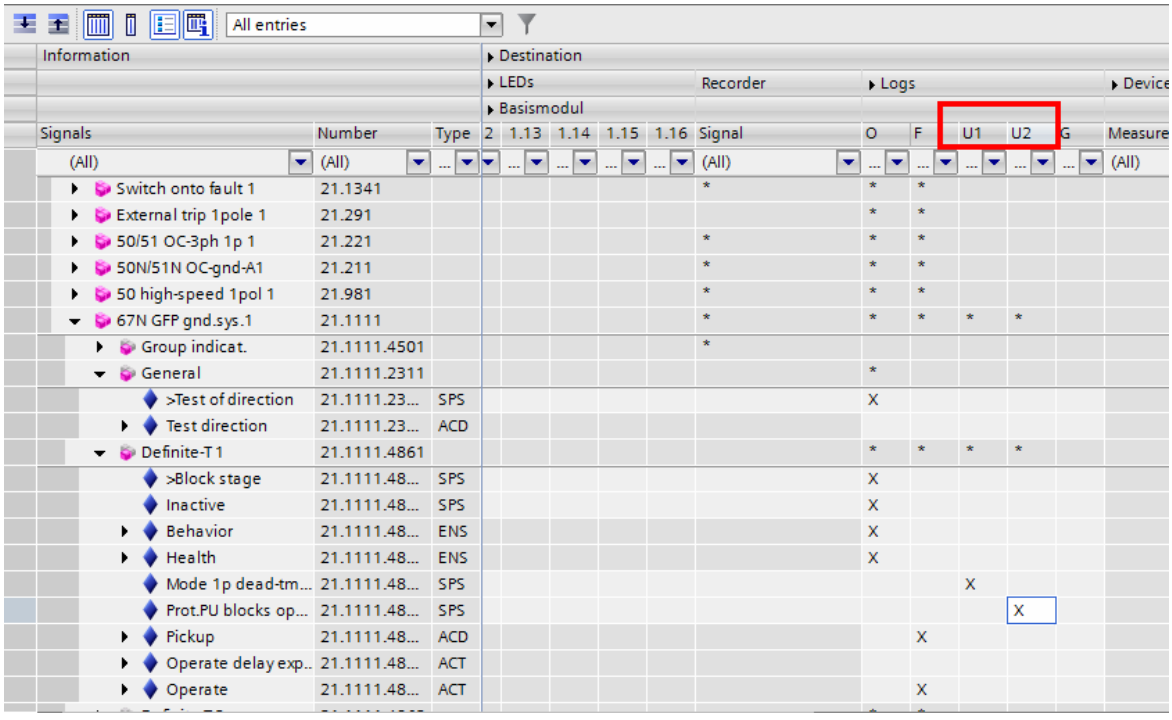


Figure 3-13 Indication Configuration in DIGSI 5 (Example: User-Defined Log U1/2)

3.1.5.7 Communication Log

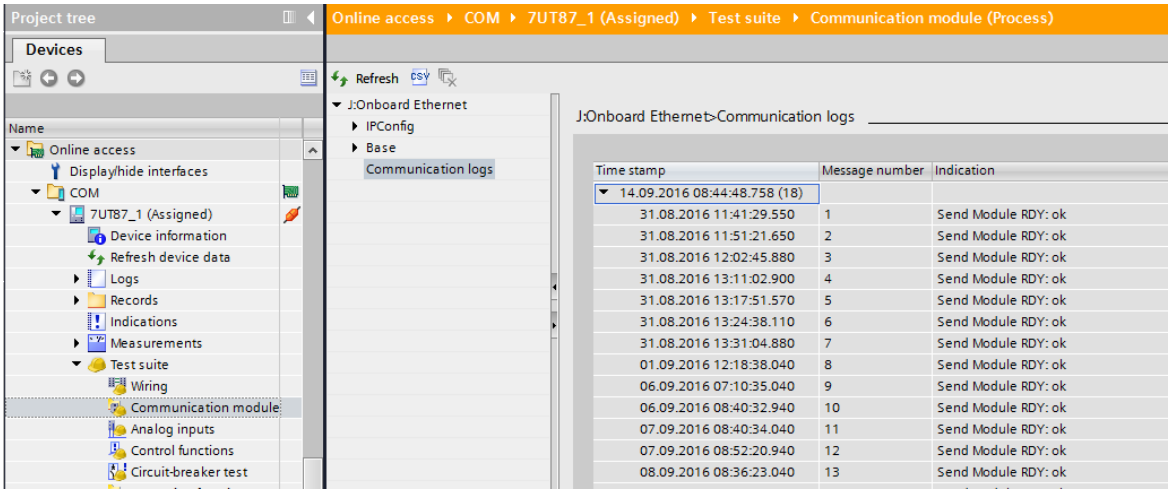
The logging of the respective status such as ensuing faults, test and diagnosis operation, and communication capacity utilizations is done for all hardware-based configured communication interfaces. Up to 500 indications can be stored in the communication log. Logging occurs separately for each communication 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 → Device → Test suite → Communication module
- Then select:
  J:Onboard Ethernet → **Communication log**

The communication log is shown to you in the state last loaded from the device.

- Before this, refresh the contents by clicking the update arrows in the headline.

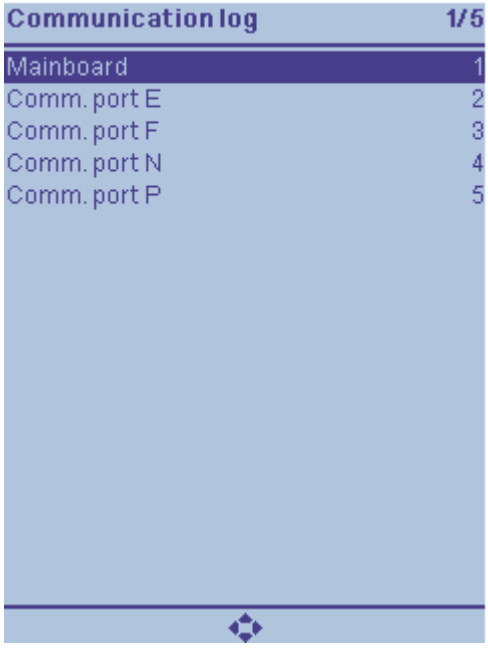


[sc_compuf, 2, en_US]

Figure 3-14 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 → Logs → **Communication logs**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[sc_commlg, 1, en_US]

Figure 3-15 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 Communication-Supervision Log

The communication-supervision log is used to log communication events.
The following events are currently logged:

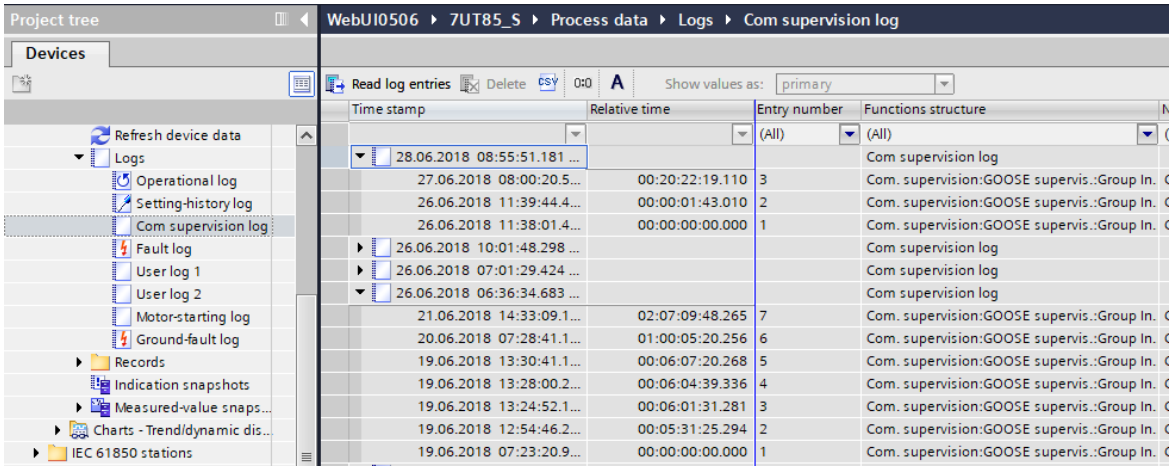
- Status for each GOOSE subscription (if configured)
  A log is kept of whether the GOOSE subscription has received valid messages or not.
- Aggregated status for all GOOSE subscriptions
  The status is **TRUE** if at least one GOOSE subscription does not receive any valid message.
- Subscriber in simulation mode
  GOOSE messages are processed with a simulation flag. The status is **TRUE** if at least one GOOSE subscription processes simulated messages.

Reading from the PC with DIGSI 5

- To reach the communication-supervision log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process data → Logs → **Com supervision log**

The status of the communication-supervision log last loaded from the device is shown.

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

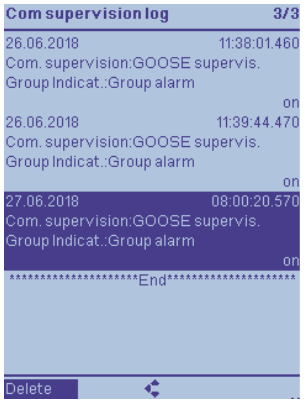


[sc_comsuperv, 1, en_US]

Figure 3-16 Reading the Communication-Supervision Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the communication-supervision log from the main menu, use the navigation keys on the on-site operation panel.
  Main menu → Logs → **Com supervision log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[sc_comsupervlg, 1, en_US]

Figure 3-17 Reading the Communication-Supervision Log on the On-Site Operation Panel of the Device

Deletability

The communication-supervision log 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-supervision log cannot be freely configured. The entries are preconfigured.

3.1.5.9 Security Log

Access to areas of the device with restricted access rights is recorded in the security log. Unsuccessful and unauthorized access attempts are also recorded. Up to 2048 indications can be stored in the security log.

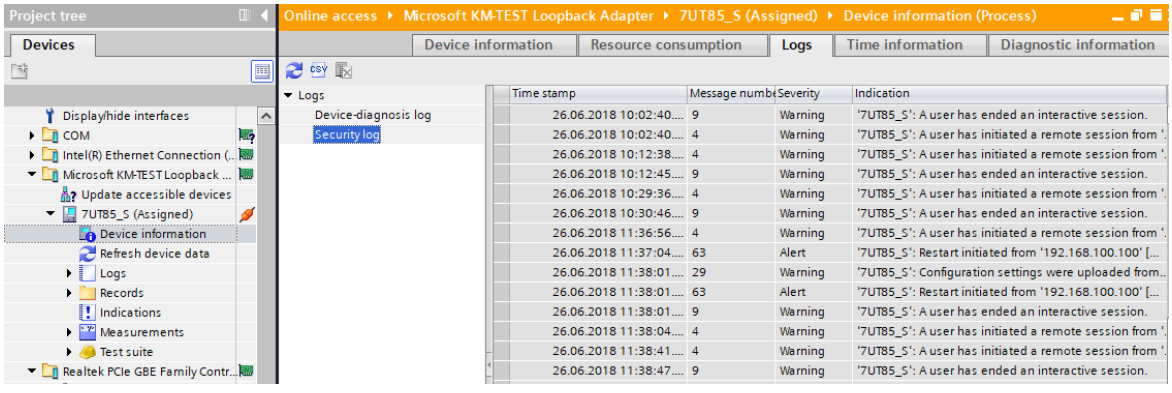
Reading from the PC with DIGSI 5

- To reach the security log of your SIPROTEC 5 device, use the project-tree window. The device must be in Online access.

  Project → Online access → Device → Device Information → **Logs** tab → Security logs

The state of the security log last loaded from the device is displayed.

- Before this, refresh the contents by clicking the update arrows in the headline.

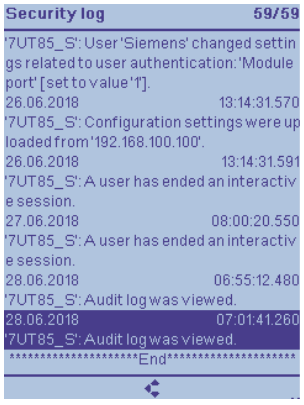


[sc_secmld, 2, en_US]

Figure 3-18 Reading the Security Indications 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 → Logs → **Security log**
- You can navigate on the on-site operation panel using the navigation keys (top/bottom) inside the displayed indication list.



[sc_seclog, 1, en_US]

Figure 3-19 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 of the device without loss of information, you must regularly read this log.

3.1.5.10 Device-Diagnosis Log

Concrete take-action instructions are logged and displayed in the device-diagnosis log for the following items:

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

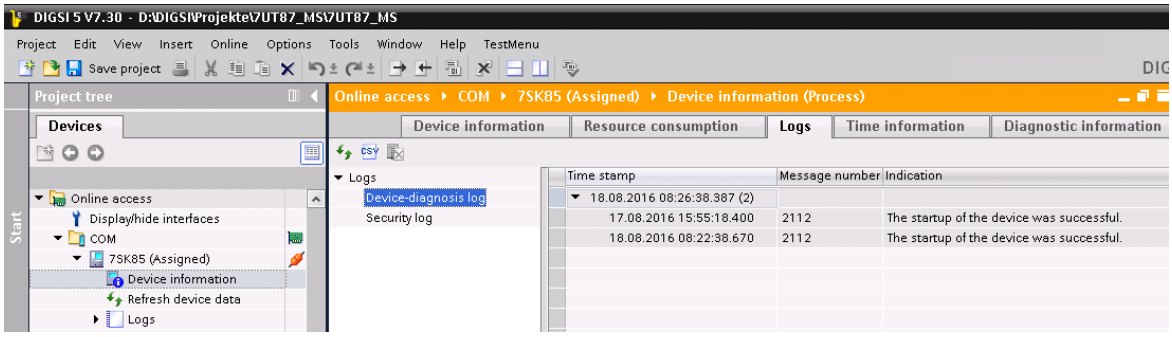
Up to 500 indications can be stored in the device-diagnosis log. In normal operation of the device, it is sufficient for diagnostic purposes to follow the entries of the operational log. This specific significance is assumed by the device-diagnosis log when the device is no longer ready for operation 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 → Online access → Device → Device information → **Logs** tab → Device-diagnosis log

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

- Before this, refresh the contents by clicking the update arrows in the headline.



[sc_devdia, 1, en_US]

Figure 3-20 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 → Logs → **Device diagnosis**
- You can navigate on the on-site operation panel using the navigation keys (top/bottom) inside the displayed indication list.



[sc_devdia_01, 1, en_US]

Figure 3-21 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!

3.1.5.11 Motor-Starting Log

The motor-starting log records the starting current, starting voltage and the start duration each time a motor starts. The motor-starting current and the motor-starting voltage are displayed as primary values. Up to 200 indications can be stored in the motor-starting log.

Measurement of the motor statistics starts when the motor state changes to ***Start***. Measurement of the motor starting time ends as soon as the motor state changes to ***Standstill*** or ***Running***. The motor state is obtained from the **Motor-state detection** function.

No entry is recorded in the motor-starting log if the motor state changes to ***Start*** and the current drops below the motor starting current within 500 ms.

Table 3-6 Motor-Starting Log

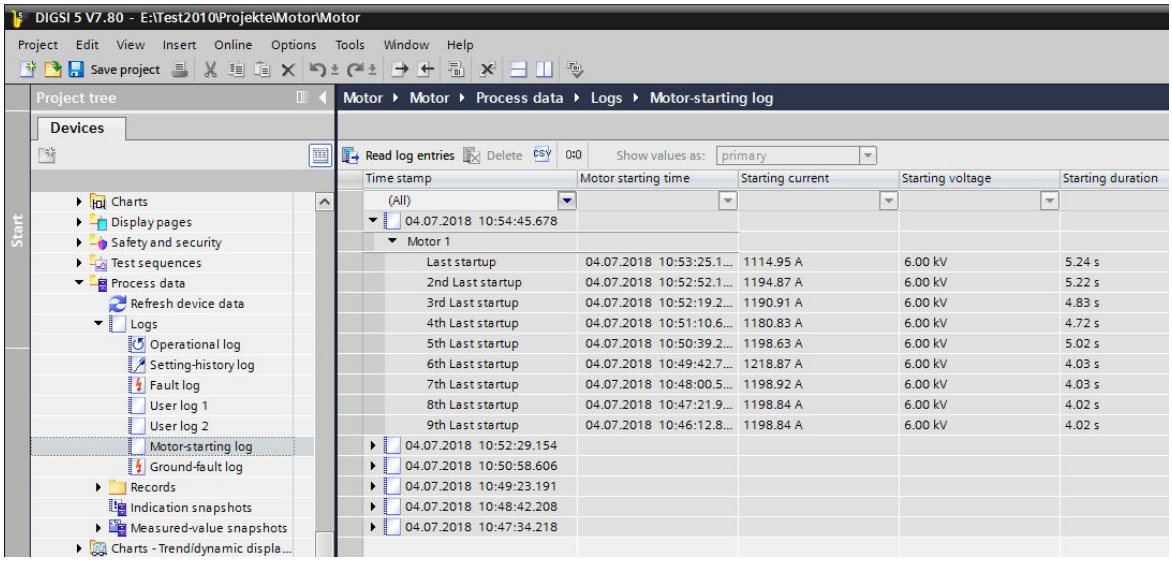
Measured Values		Primary
Start duration	Motor starting time	s
Starting current	Motor-starting current (primary)	A (or kA)
Starting voltage	Motor-starting voltage (primary)	V (or kV)

Reading from the PC with DIGSI 5

- Use the project-tree window to reach the motor-starting log of your SIPROTEC 5 device.
  Project → Device → Process data → Logs → **Motor-starting log**

The state of the motor-starting 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 3-22*).



[scmotmlp-160713-01, 2, en_US]

Figure 3-22 Reading the Motor-Starting Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

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



[ScMotLog-280618, 1, en_US]

Figure 3-23 Reading the Motor-Starting Log on the On-Site Operation Panel of the Device

Deletability

The motor-starting log of your SIPROTEC 5 device can be deleted. Read details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The motor-starting log is only present in the **Motor** function group. There is no column for the motor-starting log in the DIGSI information routing. The entries in the motor-starting log 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 a revision 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

If you delete any files directly from the fault log or fault record, the error number for new fault records continues incrementing up to the maximum number 2^32. It does not reset to 0.

If you initialize flash partitioning of the fault log and fault record, the error number for new fault records resets to 0.

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
- Switching-device log
- Ground-fault log
- Setting-history log
- User-defined log
- Motor-starting log
- Communication-supervision log

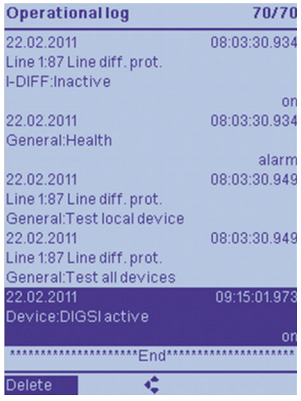
Back up the deletable logs using DIGSI 5.

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 → Logs → **Operational log**



[sc_oprlog, 1, en_US]

Figure 3-24 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 requested, enter the password and confirm with **Enter**.
- After being requested, confirm the **Deletion of all entries** with **Ok**.

Deleting Logs from the PC with DIGSI 5

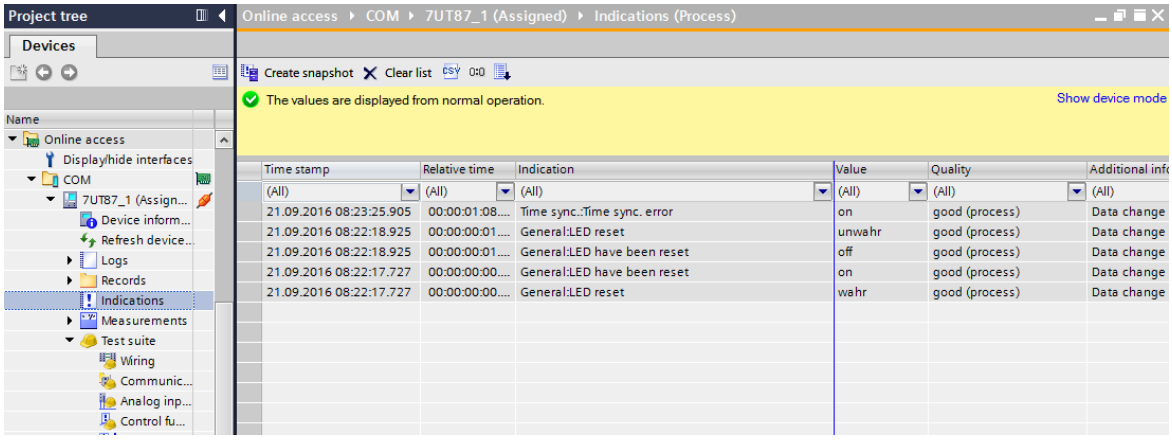
- To reach the selected log of your SIPROTEC 5 device, use the project-tree window (for example operational log).
  Project → Device → Process data → Logs → **Operational log**

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.



[sc_spnmld, 2, en_US]

Figure 3-25 Displaying Spontaneous Device Indications in DIGSI 5

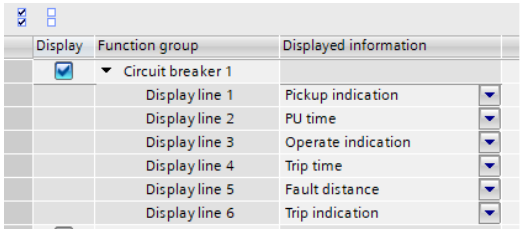
3.1.8 Spontaneous Fault Display on the On-Site Operation Panel

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 released 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 shown for each pickup or only pickups with the trip command.



[sc_konstf, 2, en_US]

Figure 3-26 Configuration of the Spontaneous Fault Display on the Device

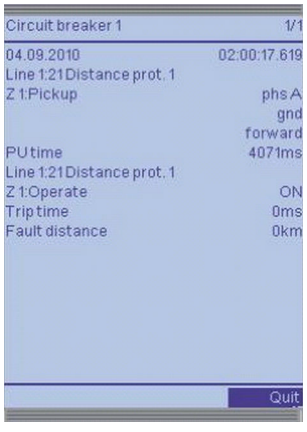
For every display line the following display options can be selected:

Table 3-7 Overview of Display Options

Displayed Information	Explanation
Pickup indication	Display of the first function stage picked up in a fault, as needed with auxiliary 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 auxiliary 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
Operate result indication	Display of the control or switching device triggered in a fault, with auxiliary information (phases) where necessary

Acknowledgment 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 manual acknowledgment or release by LED reset.



[sc_stfanz, 1, en_US]

Figure 3-27 Spontaneous Fault Display on the Device

Method 1: Manual acknowledgment

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

Method 2: Acknowledgment 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.

- To do this, proceed in the project tree to:
  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 3-8 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, BO) occurs automatically via the binary-signal value.
G	(latched)	X	X		The binary signal is latched when the output (LED) is activated. To reset, a targeted confirmation must occur.

Routing Options		LEDs	BOs	BIs	Description
NT	(conditioned latching)	X			Fault indications are stored during control of the output (LED) as a function of the parameter **(_:91:139) Fault-display**. In the event of a new fault, the previously stored states are reset. • If the fault gets terminated via a trip command from the assigned circuit breaker, the status of an indication remains as latched with the setting option ***with trip***. Without a trip command, the status is displayed before the fault (if necessary, the status of the last fault) is restored. • With the setting option ***with pickup*** the current indication image of a pickup gets stored. The image comprises all indications of functions that are effective in the event of tripping on the same circuit breaker, like the picked up function.
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.

3.1.10 Application Mode/Test Mode and Influence of Indications on Substation Automation Technology

With the controllable *Application mode* = ***Test*** or ***Test/Relay blk.***, you switch on or off the test mode for the entire device.

For further information, refer to *12.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

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.

3.1.11 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.

3.2 Measured-Value Acquisition

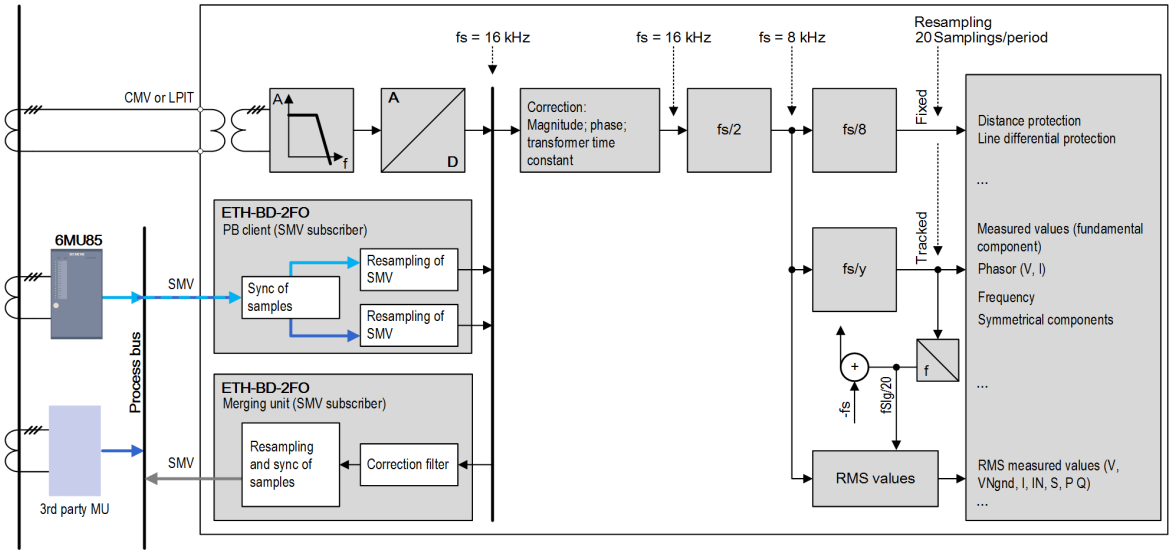
Basic Principle

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 90 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. Meaning that magnitude, phase, and transformer time constant are corrected. The compensation is designed to ensure that the current transformer terminal blocks can be exchanged randomly between the devices.



[dw_meserf, 2, en_US]

Figure 3-28 Measured-Value Acquisition Chain

f_a	Sampling frequency
SMV	Sampled measured value
CMV	Conventional measured value
LPIT	Low-power instrument transformer

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 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 90 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. You can find detailed information in the corresponding function description.



NOTE

The **Power-system data** (starting in *8.1 Power-System Data*) contain the measuring points for current and voltage. Each measuring point has its own parameters.

3.3 Sampling-Frequency Tracking and Frequency Tracking Groups

3.3.1 Overview

Starting from platform version V07.80, you can merge measuring points into **Frequency tracking groups** in SIPROTEC 5 devices. The device operates with a maximum of 6 **Frequency tracking groups**.

The chapter *3.3.2 Sampling-Frequency Tracking* provides the necessary hints on the operating principle of sampling-frequency tracking and its application.

The chapter *3.3.3 Frequency Tracking Groups* describes the principle and application of frequency tracking groups.

3.3.2 Sampling-Frequency Tracking

SIPROTEC 5 devices are equipped with powerful sampling-frequency tracking as explained in *3.2 Measured-Value Acquisition* . This ensures high measuring accuracy over a wide frequency operating range (10 Hz to 90 Hz).

To determine the actual sampling frequency, the voltage and current measuring points are checked for valid input signals, the actual power frequency is determined and the tracking frequency (sampling frequency = 20 · tracking frequency) is adapted. The method is implemented in such a way that the number of samplings per actual power frequency or the frequency of the system is always constant. The number of samplings is 20 per cycle, as described in *3.2 Measured-Value Acquisition* .

During engineering, you set the parameters specifying which measuring points are used for frequency tracking. All 3-phase voltage and current measuring points and 1-phase voltage and current measuring points are allowed.



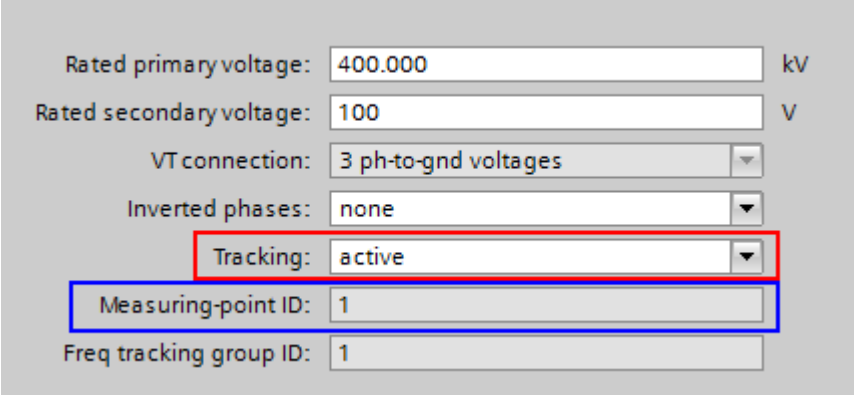
NOTE

Using a measuring point for sampling-frequency tracking requires this measuring point to be suitable for reliably determining the power frequency. This is the case, as long as the measuring point has been connected to the power system and the rated voltages and currents are measured. If the measured values for the rated voltages and currents are unavailable, sampling-frequency tracking must be switched off for this measuring point.

Examples of these kind of conditions are as follows:

- 1-phase measuring points: Measuring points that measure zero-sequence voltages or zero-sequence currents must not be used for frequency tracking.
- 3-phase measuring points: Measuring points that measure unbalanced currents and voltages for a capacitor bank must not be used for frequency tracking.

The following figure shows where you set the parameters for the corresponding measuring point and activate sampling-frequency tracking in the DIGSI 5 project tree under **Settings** → **Power-system data**.



[sc_MP_Powersys trackfreq, 1, en_US]

Figure 3-29 Using the Measuring Point to Determine the Sampling Frequency

If the parameter **Tracking** = ***active***, the measuring point is used to determine the actual tracking frequency. If the parameter **Tracking** is set to ***active*** for several measuring points, the ID of the measuring point determines the sequence in which these are checked for valid input signals. The algorithm starts with the lowest ID number, as follows:

- First, the 3-phase measuring points are scanned. If no valid voltage is found, the selected current measuring points are next. In this case, the following sequence applies:

  3-phase voltage measuring point → 3-phase current measuring point → 1-phase voltage measuring point → 1-phase current measuring point

  If a trigger signal comes from a current measuring point, the voltage measuring points are still continuously scanned for valid voltages and switched immediately if a voltage is found.
- If the true RMS value is greater than 2.5 % of the set secondary device rated value, a measuring point is valid. For example, this is 2.5 V at 100 V, 25 mA at 1 A or 125 mA at 5 A.
- A 3-phase measuring point is scanned in the sequence of phase A → phase B → phase C.

  In the case of the voltage measuring points, the phase-to-phase voltage V_{AB}, V_{BC}, and V_{CA} is always used for evaluation. The phase-to-phase voltage is calculated in the event of a phase-to-ground connection.
- The tracking frequency is tracked using different interval steps. If the tracking frequency deviates only slightly from the measured frequency, the frequency is tracked using small steps of 0.010 Hz. In the case of greater deviations, the interval is 1 Hz. To react faster in the event of larger deviations, for example in switchover conditions, tracking occurs in 5-Hz steps. When switching on measurands immediately the measured tracking frequency is used.
- If no tracking frequency can be determined, the appropriate rated frequency of the electrical power system is used as the tracking frequency. This case occurs before the measurands are switched on, after they are switched off or when the device is powered on. If the measurands are switched on, the starting frequency is the set power frequency, for example 50 Hz or 60 Hz. Since rated-frequency input variables can be assumed for most applications, the measuring algorithms start with the fixed sampling frequency, for example, 1 kHz for 50 Hz and 1.2 kHz for 60 Hz.

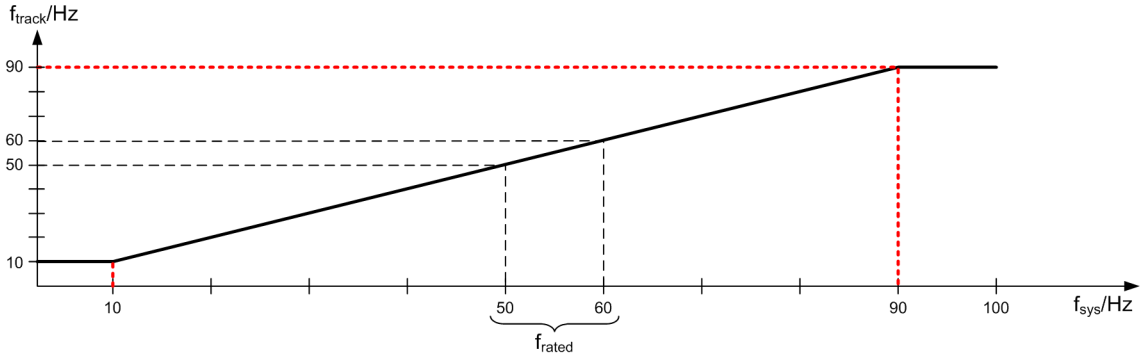
Figure 3-30 shows the behavior of sampling-frequency tracking across the frequency band and at the frequency limits.

The x-axis shows the actual power frequency (f_{sys}) and the y-axis shows the set tracking frequency (f_{track}).

Between 10 Hz and 90 Hz, the relationship is linear. If the actual power frequency is less than 10 Hz, the tracking frequency is kept at 10 Hz. In this case, sampling occurs at 20 · 10 Hz = 200 Hz. If the power frequency is greater than 90 Hz, the tracking frequency is kept constant at 90 Hz.

If the frequency is outside the frequency operating range (10 Hz to 90 Hz), frequency tracking generates the indication ***Freq. out of range***. The individual protection functions evaluate this indication. If an overfunction can occur, the protection functions are blocked internally to avoid a failure.

You can find more detailed information on the behavior of the protection functions in *13 Technical Data*.



[dw_working-area_sampling-frequency-tracking, 2, en_US]

Figure 3-30 Operating Range of Sampling-Frequency Tracking

Siemens recommends routing the calculated power frequency (f_{sys}) and the determined tracking frequency (f_{track}) as a measured value trace in the fault record. In this way, you can document the behavior of the device in transient conditions. The following figure shows that you find the both measured values in the information routing under **Power-system data → General**:

Information			S	Destination		
				BO	LED	Recorder
Signals	Number	Type				Signal
(All)	(All)	...				(All)
General	91					
Device	4171					
Alarm handling	5971					
Time managem.	8821					
Time sync.	8851					
Res. bin. out.	4711					
LED not in FG	7411					
Power system	11					*
General	11.2311					*
>Phs-rotation reversal	11.2311.500	SPS				
>Invert Phases	11.2311.501	SPS				
Phase sequence ABC	11.2311.319	SPS				
Phase sequence ACB	11.2311.320	SPS				
Freq.out of oper.range	11.2311.321	SPS				
f sys	11.2311.322	MV				X
f track	11.2311.323	MV				X

[sc_rout meas freq, 1, en_US]

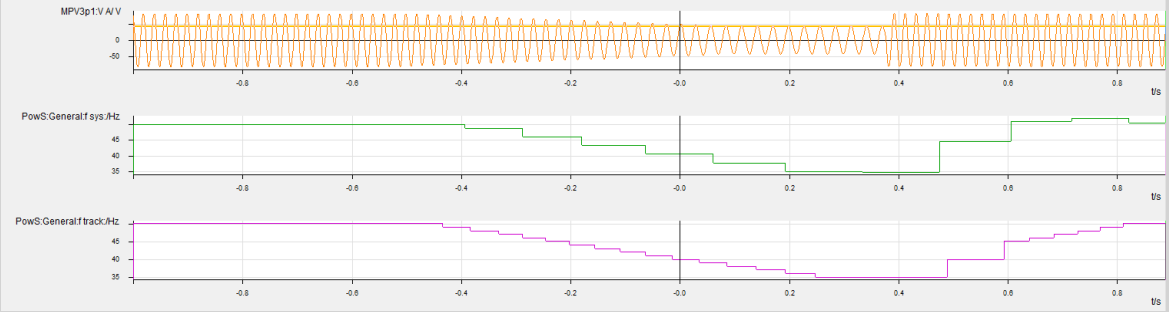
Figure 3-31 Routing of the Frequency Measured Values

EXAMPLE:

Figure 3-32 shows the behavior of sampling-frequency tracking using an example.

The voltage was reduced linearly from 57.7 V (100 V phase-to-phase) to 35 V (60.6 V phase-to-phase) and, at the same time, the frequency was reduced from 50 Hz to 35 Hz, for example motor coasting down. Then, an abrupt switch to the rated values of 57.7 V at 50 Hz was made.

The upper trace shows the power-system voltage on 1 phase (A) as an example. The center trace is the calculated power frequency and the lower trace is the determined tracking frequency. If you multiply the determined tracking frequency of the lower trace by 20, you can determine the sampling frequency.



[sc_example freqtrack, 1, en_US]

Figure 3-32 Example of Frequency Tracking and Reaction to a Step Change in the Input Variable

3.3.3 Frequency Tracking Groups

In the SIPROTEC 5 devices before platform version V07.80, sampling-frequency tracking applies to the entire device. This means that the 1st valid measuring point, for example, a 3-phase voltage measuring point, determines the selected tracking frequency based on the detected frequency.

If all measuring points in a system are galvanically coupled to each other, the power frequency is identical for all measuring points.

There are problems with electrical power system states or system states where galvanic separation is possible and measuring points of the separated system parts are connected to the SIPROTEC 5 device. For these problematic electrical power system states or system states, different frequencies are possible for a limited time. Depending on the measuring point set for tracking, the device selects which frequency to use. As a result, measuring errors and a failure of protection functions are possible.

Starting with platform version V7.80, you can assign the measuring points to different frequency tracking groups. This ensures high flexibility and high measuring accuracy for a variety of applications. In this case, every frequency tracking group specifies its own sampling frequency. In the case of galvanic separation and different system frequencies, different sampling frequencies arise as a result. This occurs temporarily in systems with rotating machines, for example. A way to achieve galvanic separation is to use an open circuit breaker.

NOTE

In the measured-value acquisition chain in *Figure 3-28* in the chapter *3.2 Measured-Value Acquisition* , only the data stream designated as tracked is adapted. The data stream represented as fixed derives its sampling frequency exclusively from the set rated frequency. In this case, the constant sampling frequency of 1 kHz at f_{rated} = 50 Hz and 1.2 kHz at f_{rated} = 60 Hz is used. This applies to every measuring point, regardless of the frequency tracking group to which it is assigned.

EXAMPLE:

Figure 3-33 shows an example for the necessity of frequency tracking groups. The generator circuit breaker (GCB) and the high-voltage circuit breaker (HVCB) are the galvanic disconnection points. In this way, different switching states are possible. The device uses current measuring points (CTs 1 to 6) and voltage measuring points (VTs 1 to 4) located on different sides of the circuit breakers. In addition, it is assumed that the generator is started using a starting-frequency converter. In a gas-turbine application, the starting-frequency converter accelerates the generator from 0 Hz to about 70 % of the rated speed (roughly 35 Hz at f_{rated} = 50 Hz). After this, the gas turbine is fired up and brings the generator to the rated speed. Then, the voltage is built up to the rated voltage and synchronized. During this start-up operation, the GCB is open and the HVCB is closed. As a result, the measuring points VT 1, CTs 1, 2, 4 have a frequency that deviates from

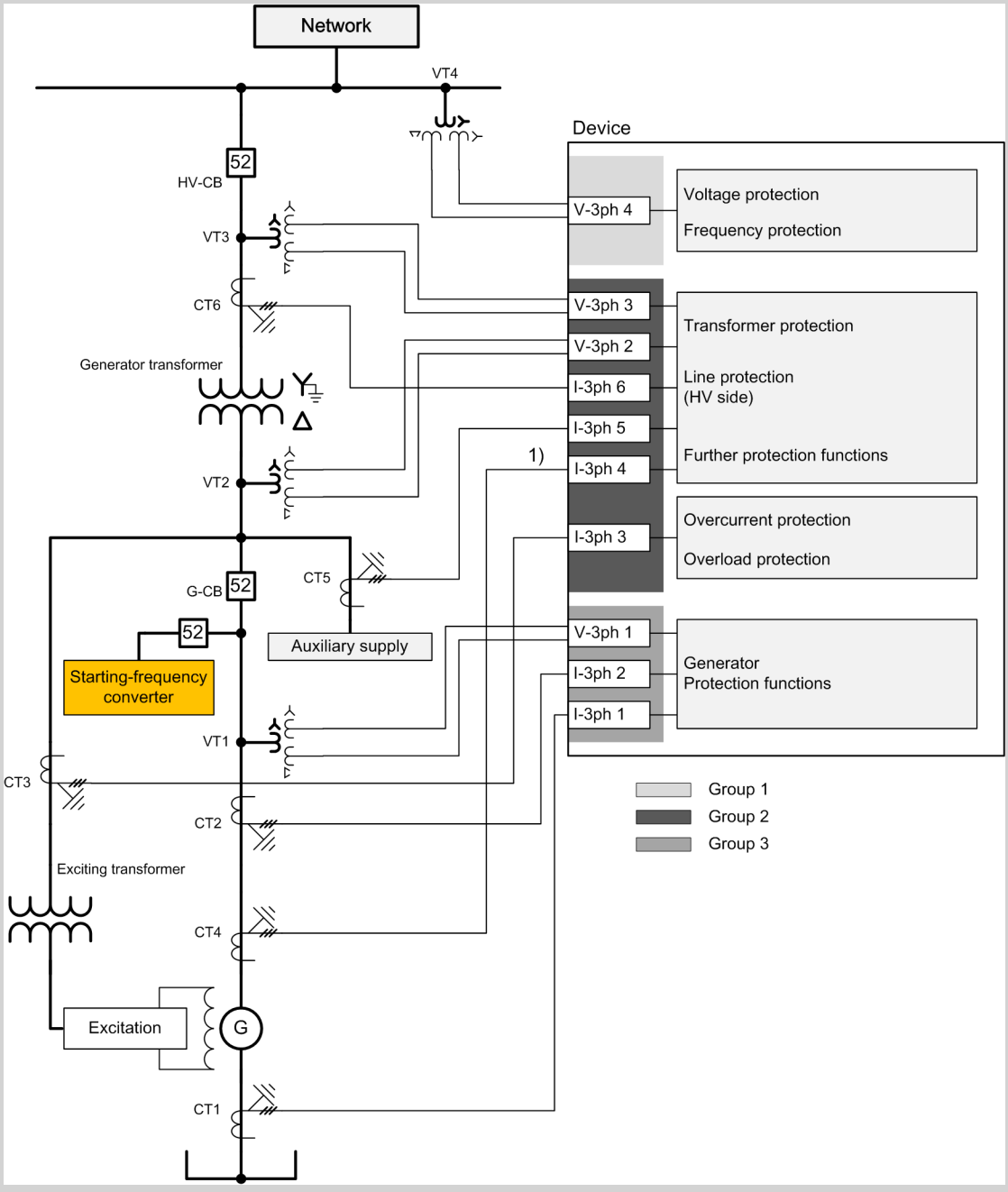
the other measuring points during start-up operation. The other measuring points are usually at the rated frequency due of the connection to the power system.

Furthermore, protection tripping can result in a switching state where the HVCB is open and the GCB remains closed. In this case, the generator and a generator transformer can assume a frequency that deviates from the power frequency. In the event of load shedding, the generator accelerates before the speed controller intervenes. This is particularly pronounced in hydro generators.

An evaluation of the individual scenarios shows that different frequencies can occur at the different measuring points for a limited time. For this reason, 3 frequency tracking groups are necessary in this example. These groups are marked with different colors in the following figure.

NOTE

The measuring point (CT 4) marked with 1) in the following figure will be discussed later.



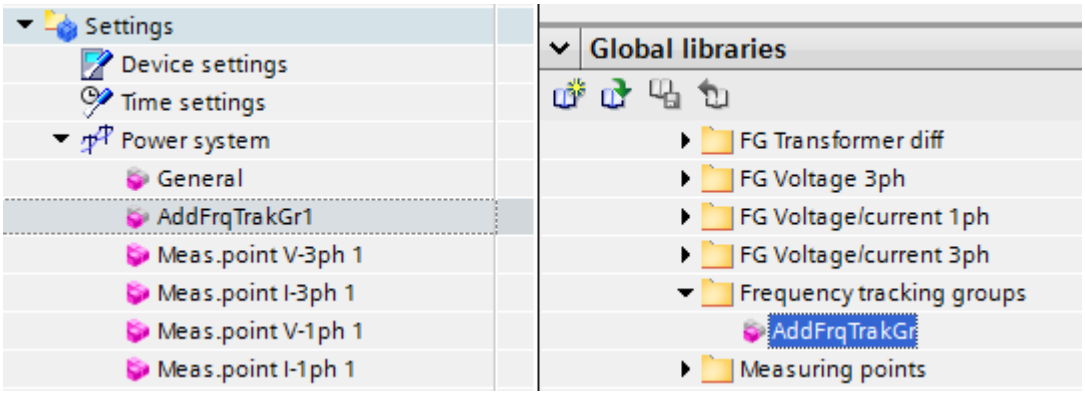
[dw_example_frequency-tracking-groups, 1, en_US]

Figure 3-33 Example of the Necessity of Frequency Tracking Groups

To strike a balance between application flexibility and the required computing power, the number of additional frequency tracking groups was limited to 5. Together with the basic functionality, a total of 6 frequency tracking groups are possible.

If you wish to use frequency tracking groups, use the following engineering recommendations. Before starting work, make sure you know how many frequency tracking groups are needed. Select only the required number.

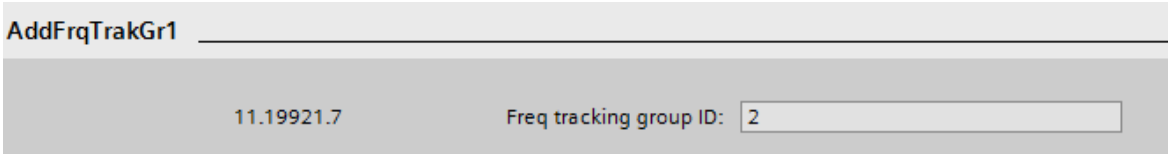
If you start with an application template that you have expanded by the necessary measuring points, you must load the necessary number of additional frequency tracking groups from the Global DIGSI 5 Library into the **Power system** folder.



[sc_loading freq group, 1, en_US]

Figure 3-34 Loading the Required Frequency Tracking Groups

If you instantiate an additional frequency tracking group, the system automatically assigns the ID of the frequency tracking group in DIGSI using consecutive numbers. As the device already has 1 frequency tracking group, the ID numbering for additional frequency tracking groups starts with 2.



[sc_ID freqgroup, 1, en_US]

Figure 3-35 ID of the Frequency Tracking Group

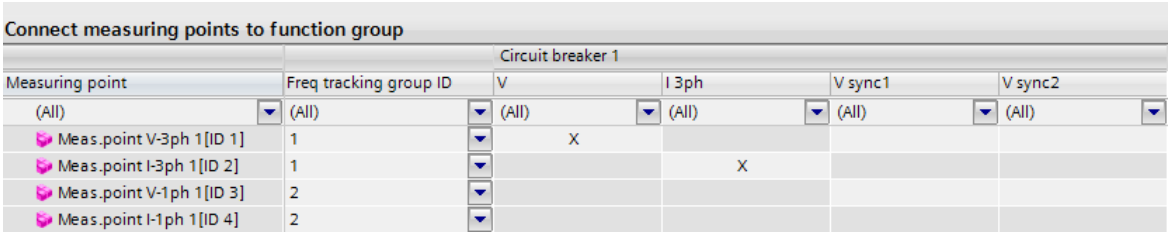
NOTE

If you have activated several frequency tracking groups during engineering and you then delete a frequency tracking group again later, the assigned ID is also deleted. All other frequency tracking groups retain their assigned IDs.

Try to avoid discontinuities by deleting the frequency tracking group with the highest ID if possible.

You will find the frequency measured values and the indications of the corresponding frequency tracking group in the routing matrix (see *Figure 3-31*).

Assign the measuring points to the frequency tracking groups in the **Function-group connections** Editor. As soon as you have instantiated another frequency tracking group from the Global DIGSI 5 Library, the additional column **Frequency tracking group ID** appears in the routing matrix. In this column, you select the number of the corresponding frequency tracking group for each measuring point using the list box.



[sc_routing MP to freqgroup, 1, en_US]

Figure 3-36 Assignment of the Measuring Point to the Frequency Tracking Group

NOTE

Keep the following in mind when assigning the measuring points to the frequency tracking groups:

- The function groups (FGs) can operate only with 1 frequency tracking group.
- This applies also to interconnections between the function groups as for the **Transformer differential protection**.
  In the case of the **Transformer differential protection**, the **Transformer side** FG is interconnected with the **Transformer** FG and all **Transformer side** FGs of one transformer must operate in the same frequency tracking group.
  The same applies when the neutral-point current is measured using a 1-phase function group.

There are also exceptions such as the FG **Circuit breaker**. The voltage measured values are processed by the **Synchronization function** which operates only with a fixed sampling frequency. In this way, voltage measuring points from different frequency tracking groups can be connected.

The cited rules are checked using scripts and infractions reported during engineering.

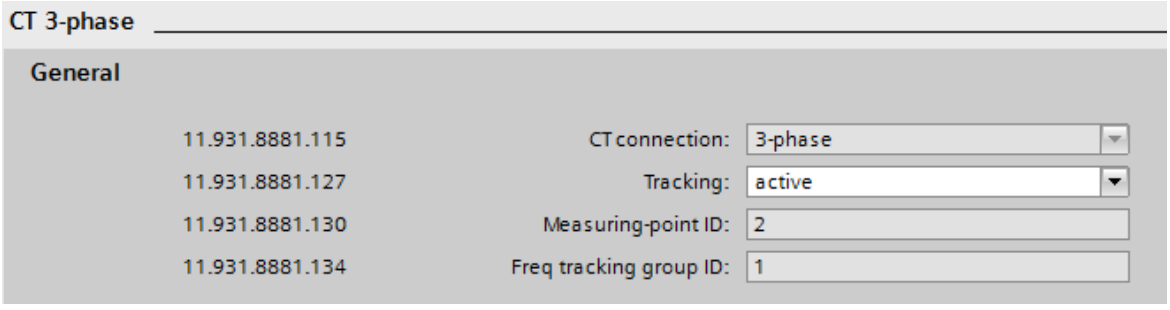
Now, you can select the measuring points to be used to determine the tracking frequency for the appropriate frequency tracking group as explained in chapter *3.3.2 Sampling-Frequency Tracking*. If possible, use at least 1 voltage measuring point and 1 current measuring point. Give preference to 3-phase measuring points.

When the tracking frequency has been determined, all measuring points of the frequency tracking group are set to this frequency and the tracked sampling frequency is adapted.

NOTE

As described in the chapter *3.2 Measured-Value Acquisition* , the measured-value current with fixed sampling frequency is unaffected by this.

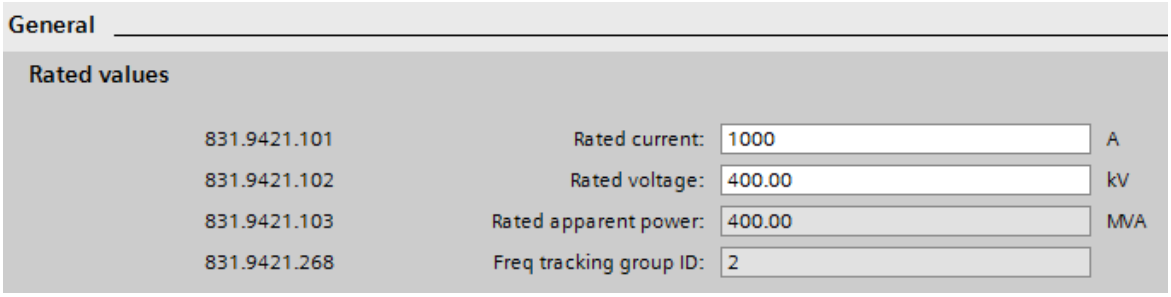
To avoid errors, the ID of the measuring point and the ID of the assigned frequency tracking group are displayed in the setting sheet of the measuring points in DIGSI 5 (see *Figure 3-37*).



[sc_MP additional setting freqgroup, 1, en_US]

Figure 3-37 Example: Settings of the 3-Phase Current Measuring Point; Additional Display of the ID for the Frequency Tracking Group

In addition, the ID of the frequency tracking group is displayed in the function group in the **General** block (see *Figure 3-38*). Here, you can also check the consistency.



[sc_MP additional setting FG, 1, en_US]

Figure 3-38 Display of the ID for the Frequency Tracking Group in the Block **General** of the Function Group

A special feature is explained using *Figure 3-33* as an example.

The measuring point marked in *Figure 3-33* with **1)** uses a current transformer that is located on the generator side but is used by the transformer differential protection. As a result, this current transformer must be assigned to the frequency tracking group 2 in accordance with the rules above. Since the generator is started using a starting-frequency converter in the application example, the frequency at this measuring point deviates from the frequency at the other measuring points of group 2. For this reason, the measuring point with CT 4 must **not** be used to determine the tracking frequency.

Depending on the application, the current of the CT 4 acts as a disturbance variable when forming the Kirchhoff's current law. As a rule, this current is not particularly strong (< 15 % of I_{rated}) so that the disturbance effect remains small. If required, you must set the differential protection to be less sensitive. Decide this for the specific application.

The following table shows the possible assignment of measuring points used to determine the tracked sampling frequency for the example. For this purpose, the parameter **`Tracking`** = ***`active`*** in the corresponding measuring point:

Frequency Tracking Group	1	2	3
Recommended measuring points for tracking	VT 4	VT 3 VT 2 CT 5	VT 1 CT 1

3.3.4 Frequency Tracking Groups – Interpretation of Measured Values

If you use frequency tracking groups, you must keep in mind special features when interpreting the measured values. The measuring points of a frequency tracking group are to be treated as decoupled for measurement purposes. This means that the complex measured values of a single function group, like phasor measured values, always match. Since phase A of the 1st measuring point is always assumed to be the reference value when representing the measured value, the phasor measured values cannot be compared between frequency tracking groups. This also applies if all measuring points are galvanically connected to one another.

NOTE

When selecting the reference variable, a voltage measuring point always takes precedence over a current measuring point. If the frequency tracking group does not contain a voltage measuring point, the 1st current measuring point is used.

EXAMPLE:

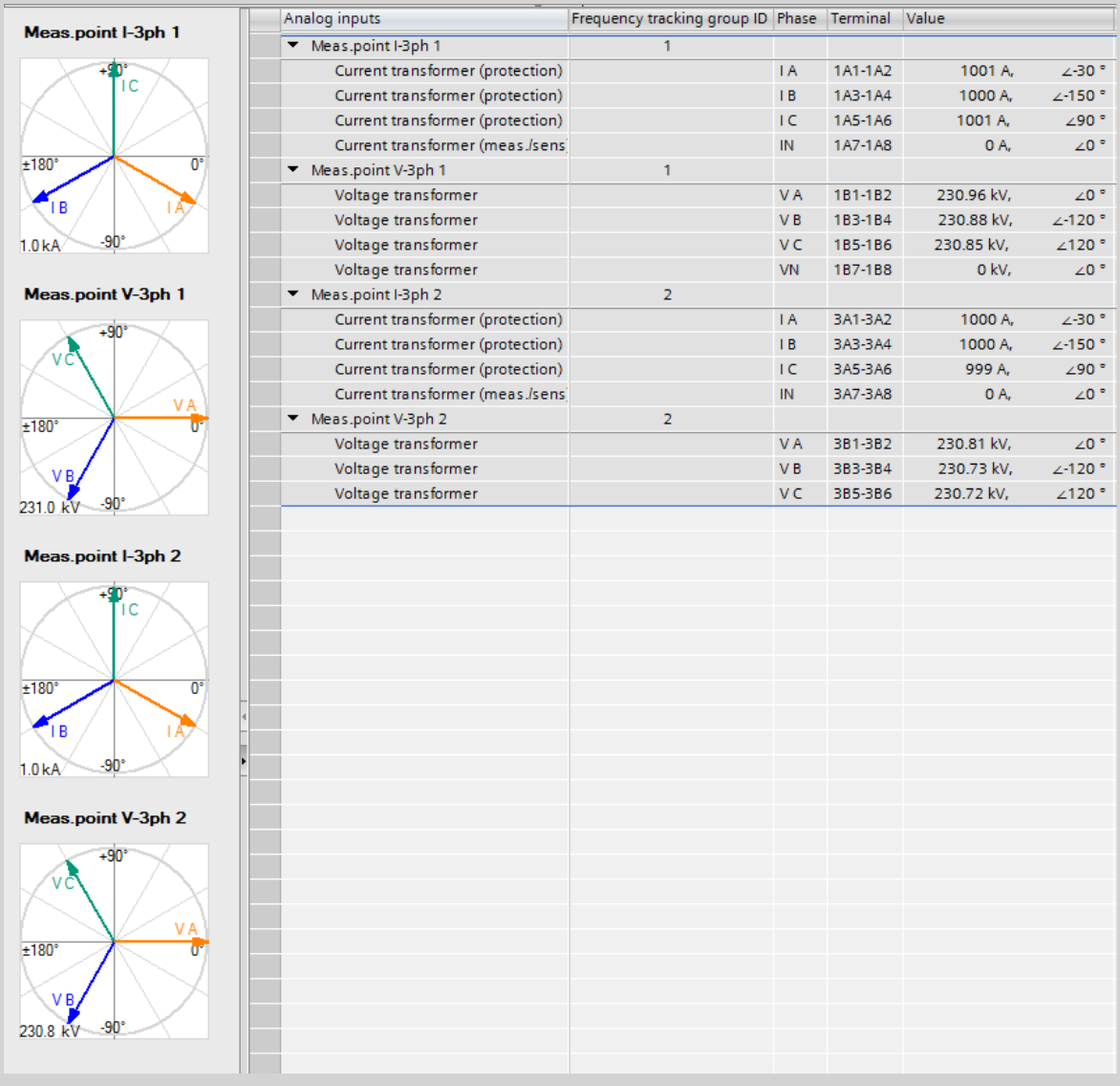
Figure 3-39 shows an example of the phasor representation of the analog measured values of the measuring points.

The phasor representation of the analog measured values of the measuring points can be found in the DIGSI 5 project tree under **Online access** → **Device** → **Test suite** → **Analog inputs**.

Each of the 2 frequency tracking groups contains one 3-phase voltage measuring point **V-3ph** and one 3-phase current measuring point **I-3ph**.

Frequency tracking group **1** contains the measuring points **V-3ph 1** and **I-3ph 1**, frequency tracking group **2** contains the measuring points **V-3ph 2** and **I-3ph 2**. The frequencies between the frequency tracking groups differ by 0.5 Hz. A phase displacement of -30° is set between the voltage and the current.

In *Figure 3-39*, you can see that the fundamental RMS measured values are identical. The phasor measured angles are shown as decoupled (see Phase angle). In this case, V_A is the reference value in the corresponding frequency tracking group. With decoupled sampling-frequency tracking, the measurement of the measurands is exact, even with a different system frequency.



Analog inputs	Frequency tracking group ID	Phase	Terminal	Value	
Meas.point I-3ph 1	1				
Current transformer (protection)		I A	1A1-1A2	1001 A,	∠-30 °
Current transformer (protection)		I B	1A3-1A4	1000 A,	∠-150 °
Current transformer (protection)		I C	1A5-1A6	1001 A,	∠90 °
Current transformer (meas./sens		IN	1A7-1A8	0 A,	∠0 °
Meas.point V-3ph 1	1				
Voltage transformer		V A	1B1-1B2	230.96 kV,	∠0 °
Voltage transformer		V B	1B3-1B4	230.88 kV,	∠-120 °
Voltage transformer		V C	1B5-1B6	230.85 kV,	∠120 °
Voltage transformer		VN	1B7-1B8	0 kV,	∠0 °
Meas.point I-3ph 2	2				
Current transformer (protection)		I A	3A1-3A2	1000 A,	∠-30 °
Current transformer (protection)		I B	3A3-3A4	1000 A,	∠-150 °
Current transformer (protection)		I C	3A5-3A6	999 A,	∠90 °
Current transformer (meas./sens		IN	3A7-3A8	0 A,	∠0 °
Meas.point V-3ph 2	2				
Voltage transformer		V A	3B1-3B2	230.81 kV,	∠0 °
Voltage transformer		V B	3B3-3B4	230.73 kV,	∠-120 °
Voltage transformer		V C	3B5-3B6	230.72 kV,	∠120 °

[sc_measured_val_DIGSI, 1, en_US]

Figure 3-39 DIGSI Online Mode: Phasor Representation of the Measuring Points with 2 Frequency Tracking Groups and a Different Frequency

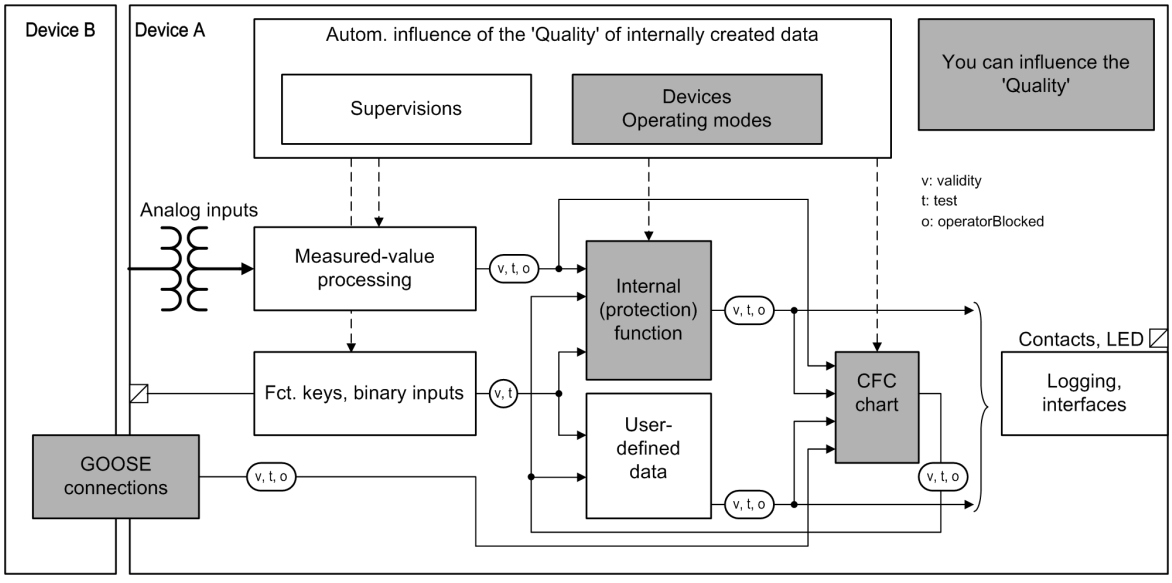
If the circuit breaker in a system is closed, the measuring points are galvanically connected to one another. If you want to compare the phasor variables of all measuring points to one another when using frequency tracking groups, Siemens recommends starting a fault record. Evaluate the fault record using SIGRA in the **Phasor representation** mode. The comparison is possible here because sampled values that are not frequency-tracked are used in the fault record. If the frequency deviates from the rated frequency, the measured values differ slightly.

3.4 Processing Quality Attributes

3.4.1 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 depending on 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.



[lo_quali1, 2, en_US]

Figure 3-40 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 *3.4.2 Quality Processing/Affected by the User for Received GOOSE Values*). 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 *3.4.2 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 *3.9.2 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 *3.4.2 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 or measured values) receive the device-internal quality attribute **Off**. The states of the inputs and measured values remain unchanged in this case; input changes are not processed. As the quality attribute **Off** is not provided for in communication protocol IEC 61850, the data objects are transferred with the quality attribute *Invalid*.

Influencing the Quality through Hardware Supervision

Supervision functions monitor the device hardware (see *10.4 Supervision of the Device Hardware*). If the supervision functions identify failures in the data acquisition of the device, then 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 *10.3.3 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 from 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.

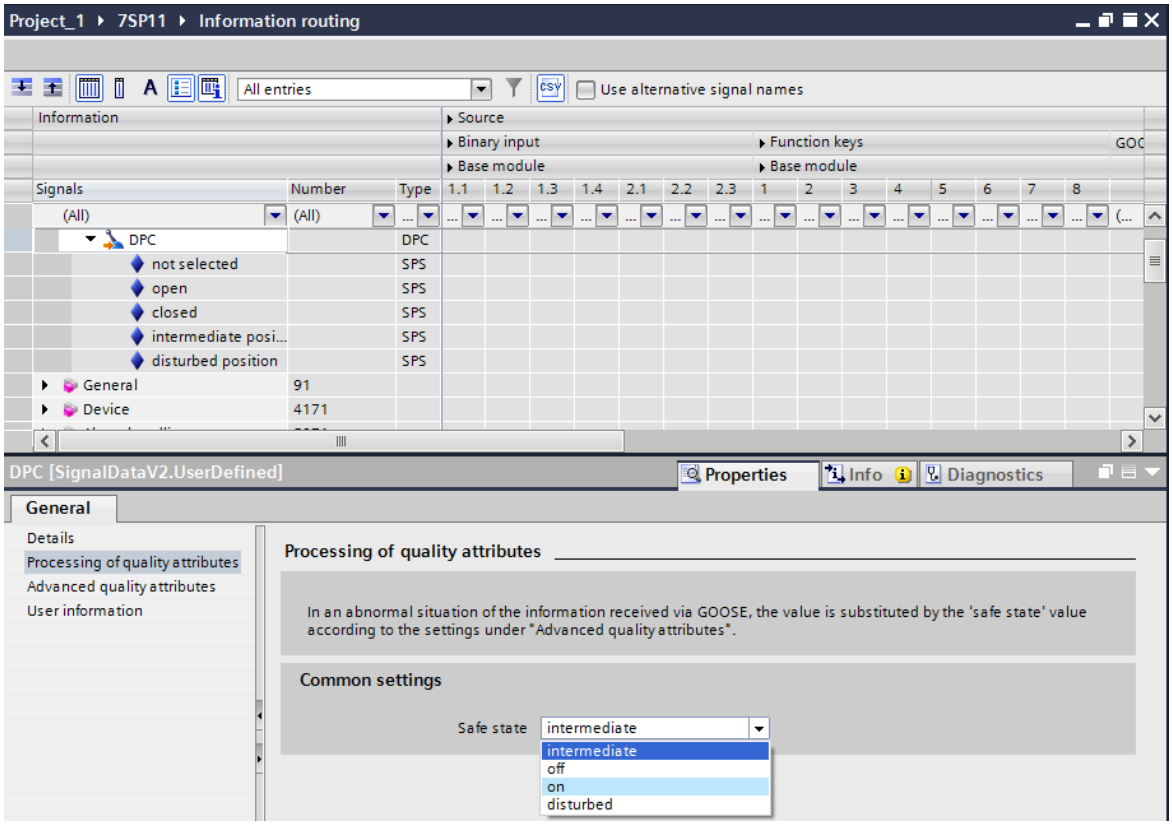
If a GOOSE connection is the data source of a binary input signal of a device-internal function, you can influence processing of the quality at 2 locations: at the GOOSE connection and at the input signal of the function. This is based on the following: A GOOSE date can be distributed within the receiving 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.

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

The properties of quality processing have changed with the introduction of GOOSE Later Binding. You can find information about the former quality processing in *Previous Quality Processing/Affected by the User for Received GOOSE Values, Page 96*.

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 a DPC data type. All setting options are effective for the device receiving the data.

- In the DIGSI 5 project tree, double-click **Information Routing**.
- Select either the desired signal in the **External Signals** group or the signal of a function activated via the GOOSE column.
- Open the **Properties** window and select the **Processing Quality Attributes** sheet.



[sc_LB_GOOSE_2, 2, en_US]

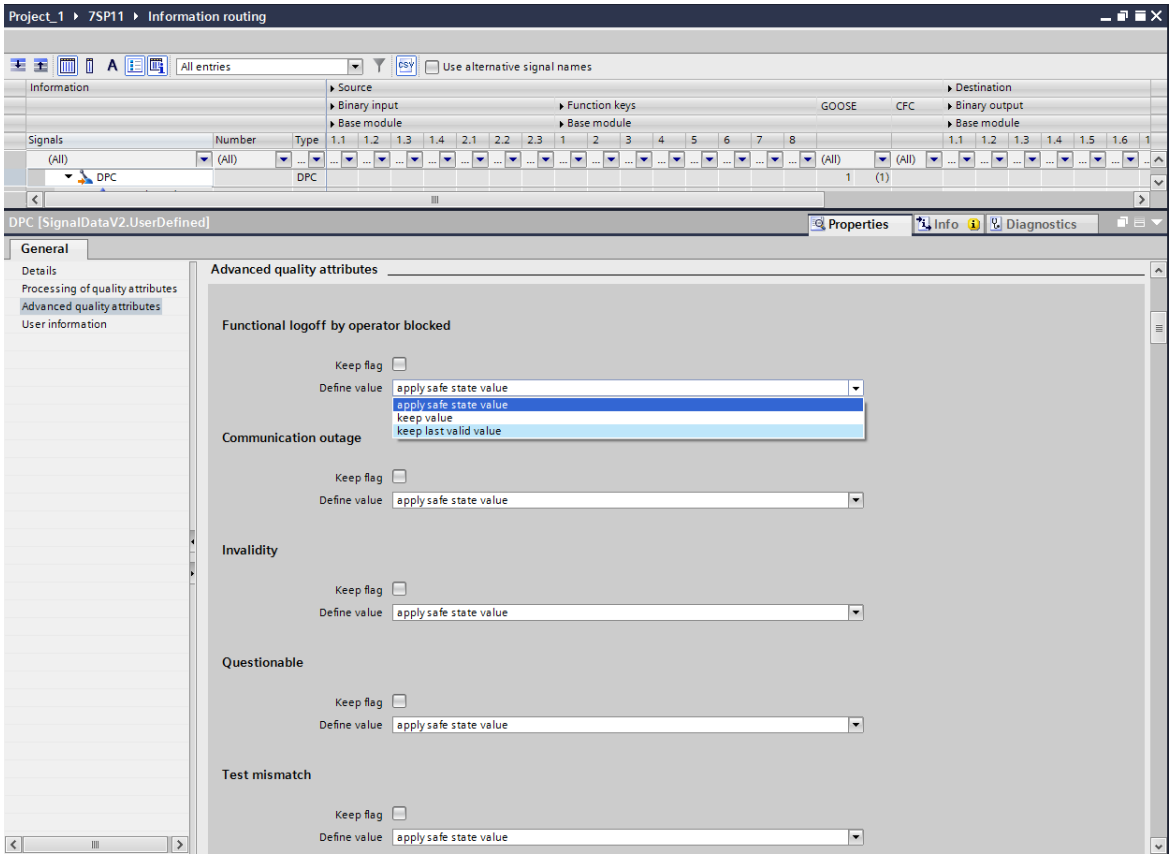
Figure 3-41 Influence Option When Linking a DPC Type Data Object

Depending on the selected data type of the object, various selection options are offered to you for the **Safe state** item in the **Common settings** section. At this point, you select the manually updated values that allow a safe operating state as soon as the data access via the communication path is disturbed.

- Select the property for the selected data object.

You can also set the **Advanced quality attributes** of the data object for GOOSE Later Binding.
The following figure shows the advanced quality attributes using the example of a DPC data type.

- Open the **Properties** window and select the **Advanced quality attributes** sheet.



[sc_LB_GOOSE_1, 2, en_US]

Figure 3-42 Advanced Quality Attributes for GOOSE Later Binding

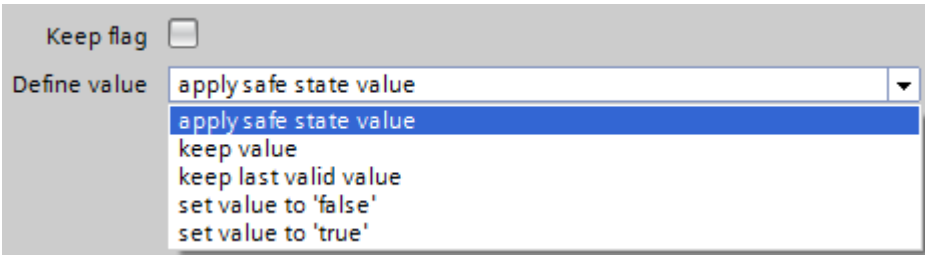
With the following advanced quality attributes, you can filter the transmitted GOOSE indications and check and set their quality. The values that have been adapted, if necessary, are forwarded to the receiver.

For the tests, you can select from the following setting options depending on the data type.

Table 3-9 Value Definitions

Setting Value	Description
Apply safe state value	The value configured in the **Safe state** is forwarded as valid to the application as soon as communication disturbance occurs.
Keep value	The disturbed quality attribute is overwritten with *good* and the received value is forwarded as valid to the application. If no value was received, the output value is assumed being in safe state.
Keep last valid value	If an invalid quality attribute is received, the last valid value is forwarded to the application. If no value has yet been received, the output value is assumed being in safe state.
Set value to "false"	Applies only to Boolean communication objects. Every invalid quality attribute causes the valid value *false* to be forwarded to the application.
Set value to "true"	Applies only to Boolean communication objects. Every invalid quality attribute causes the valid value *true* to be forwarded to the application.

These settings of the **Advanced quality attributes** apply to the advanced quality attributes listed below. The selection can vary depending on the data type.



[sc_LB_GOOSE_3, 2, en_US]

Figure 3-43 Value Definition of a Data Object of the SPS Type

You can also forward the quality attributes unchanged. To do this, you must mark the **Keep flag** check box.

NOTE

By default, the ***Keep flag*** checkbox is disabled when the signal is routed to the LED or the binary output.

Functional Logoff by Operator Blocked

You have set the *Operation mode* to *Device logoff* = *true* in the transmitting device. As a result, every indication issued from the functions and subject to *Device logoff* is transmitted with the quality information *operator blocked* and **Validity** = *good*. The receiver recognizes this for this indication and reacts according to the settings (*Table 3-9*). A different quality processing can take place only once you have set the *Operation mode* to *Device logoff* = *false* in the transmitting device.

Communication Outage

There is communication disturbance (time allowed to live) between the transmitter and the receiver indicated by the transmitter. The indication is set in accordance with the settings (*Table 3-9*).

Invalidity

The transmitting device sends this indication with the quality information **Validity** = *invalid*. The receiver recognizes this for this indication and reacts according to the settings (*Table 3-9*).

Questionable

The transmitting device sends this indication with the quality information **Validity** = *questionable*. The receiver recognizes this for this indication and reacts according to the settings (*Table 3-9*).

Test Mismatch

The transmitting device or the function in the transmitting device that issues this indication is in test mode. As a result, the indication is transmitted with the quality information *test*. The receiving function block recognizes this for this indication and reacts, depending on its own test-mode state (specified in IEC 61850-7-4 Annex A), according to the settings (*Table 3-9*).

NOTE

Follow the sequence of tests. First, the **Functional logoff by operator blocked** is tested. Then comes **Communication outage** and so on. If a case is recognized as *active*, the test chain is canceled with the configured setting for the active case.

In the case of **Invalidity**, the tests are first performed for **Functional logoff by operator blocked** (not applicable) and then for **Communication outage** (not applicable) and canceled with the configured action for **Invalidity**.

If an indication is routed into the log, manual updating of a value is also logged based on the conditions listed above and on the reason for the manual update. Manually updating a value based on the conditions listed

above causes a change in the *Health Warning* function block, inherited up to *Device health* (specified in IEC 61850-7-4).

Keep Flag

The quality attributes and values indicated by the transmitter are accepted without change. Quality processing must be performed by the user via a logic diagram. The outputs of the logic diagram following the user-specific quality processing can be connected to the function-block inputs as before.

Data Substitute Values

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

Data Type	Possible Data Substitute Values	
ACD, ACT	general	0 (False), 1 (True) The directional information is manually updated with *unknown* if the option ***Apply safe state value***, ***Set value to "false"***, and ***Set value to "true"*** are selected; or maintain the received value with the options ***Keep value*** or ***Keep last valid value*** selected. PhsA, phsB, phsC, and neut are manually updated with the same value just like how the general value is set.)
BAC, APC	mxVal	Floating-point range and range of values according to IEEE 754 (single precision)
BCR	actVal	-2^{63} to $2^{63} - 1$
CMV	mag, ang	Floating-point range and range of values according to IEEE 754 (single precision)
DPC, DPS	stVal	0, 1, 2, 3 (intermediate-state, off, on, bad-state)
INC	stVal	–2 147 483 648 to 2 147 483 647
INS	stVal	–2 147 483 648 to 2 147 483 647
ISC, BSC	valWTr.posVal	–64 to 64
	valWTr.transInd	0 (False), 1 (True)
SPC, SPS	stVal	0 (False), 1 (True)
MV	mag	Floating-point range and range of values according to IEEE 754 (single precision)

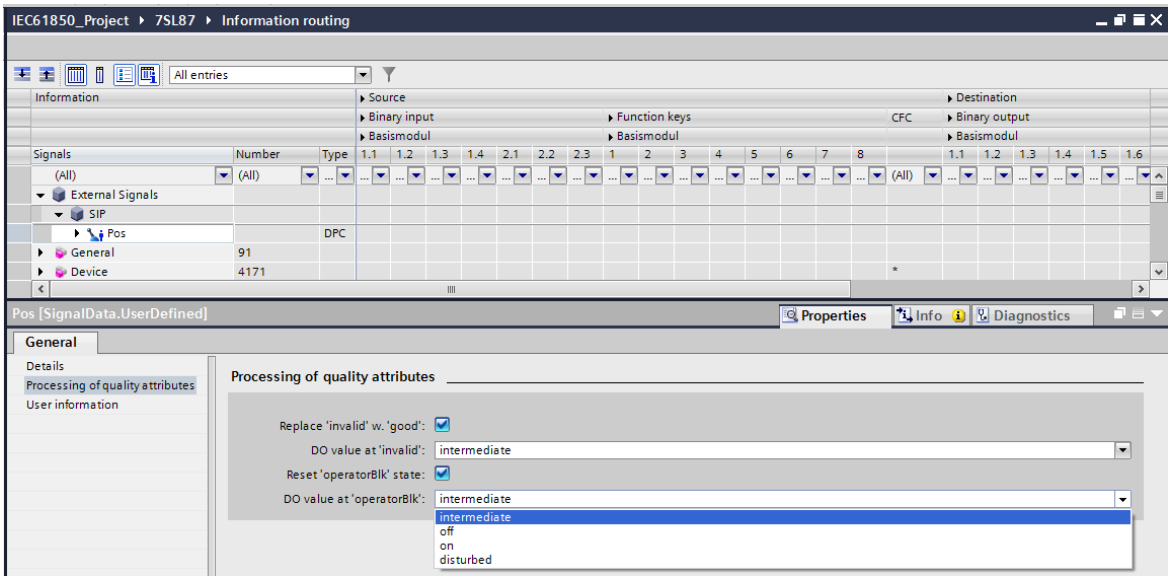
For controllable types, the following substitute values apply in addition to the settable state values or measured values:

ctlNum	=	0
stSeld	=	False
origin.orIdent	=	Substituted by quality processing
origin.orCat	=	AUTOMATIC_BAY

Previous 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 a 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 3-44 Influence Option When Linking a DPC Type Data Object

The setting options work for the device receiving the data.

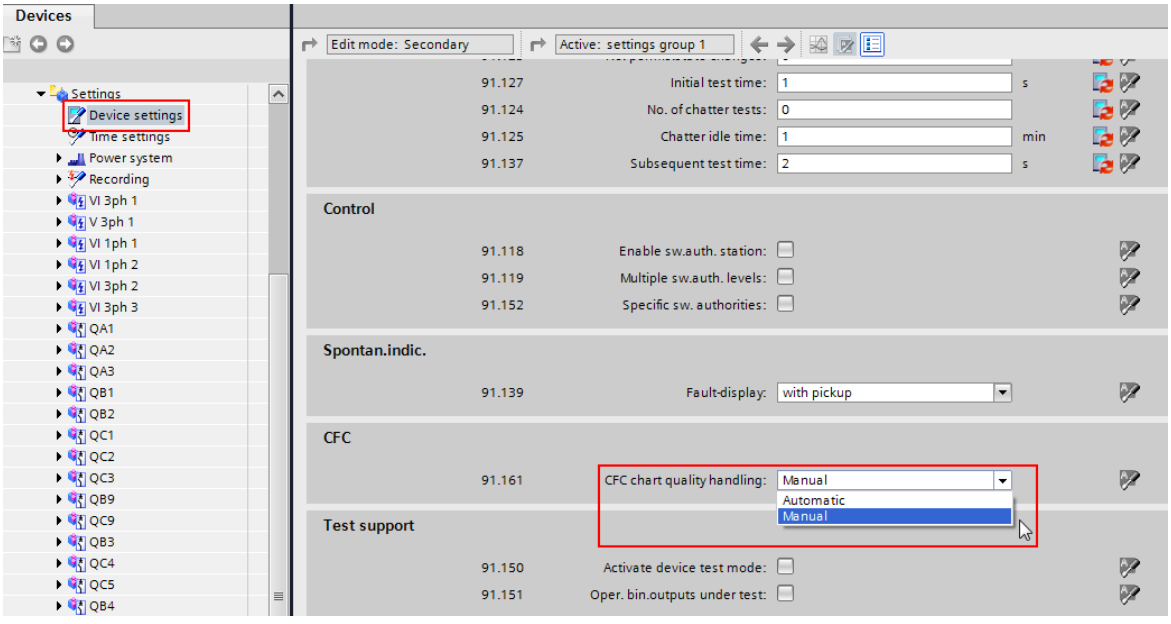
Quality Attribute: Validity	
The validity values *reserved* and *questionable* are replaced at the receiving end by the *invalid* value.	
• Check box is not set. • Check box is set and receipt of **Validity** = *good*	The validity attribute and data value are forwarded without change.
Check box is set 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.
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.

3.4.3 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** building block (see the following figure) under **Device name** →, **Settings** → **Device settings** in the editor:



[sc_quali_cfc, 1, en_US]

Figure 3-45 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 building 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 building blocks that are specifically designed for quality processing.

General Processing

Most of the CFC building blocks do not have an explicit quality processing. For these building 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 building 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 building 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 building blocks (x_SPS) process the quality automatically according to the stated logic. The other building 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>Description</th></tr>
<tr><td>OR_SPS

AND_SPS

NEG_SPS</td><td>The building 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></td><td>OR_SPS<table>
<tr><th>A (Value, Attribute)</th><th>B (Value, Attribute)</th><th>Q (Value, Attribute)</th></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>
</table>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></td><td>AND_SPS<table>
<tr><th>A (Value, Attribute)</th><th>B (Value, Attribute)</th><th>Q (Value, Attribute)</th></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>
</table>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></td><td>NEG_SPS<table>
<tr><th>A (Value, Attribute)</th><th>Q (Value, Attribute)</th><th></th></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>
</table></td></tr>
<tr><td>SPLIT_SPS

SPLIT_DPS
SPLI_XMV</td><td>The building 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 building 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>The building 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 building block must be connected downstream to a SPLIT_(DO) building block.</td></tr>
</table>

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

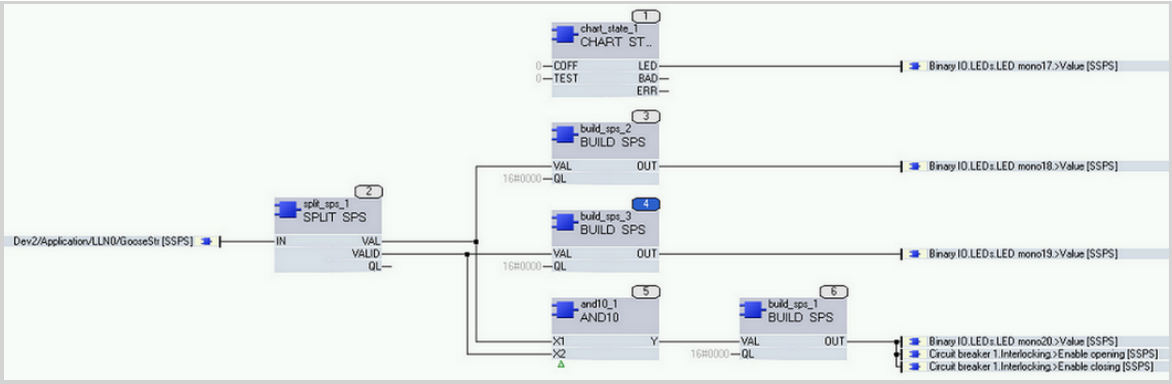


Figure 3-46 CFC Chart with Building Blocks for Quality Processing (Switchgear Interlocking via GOOSE)

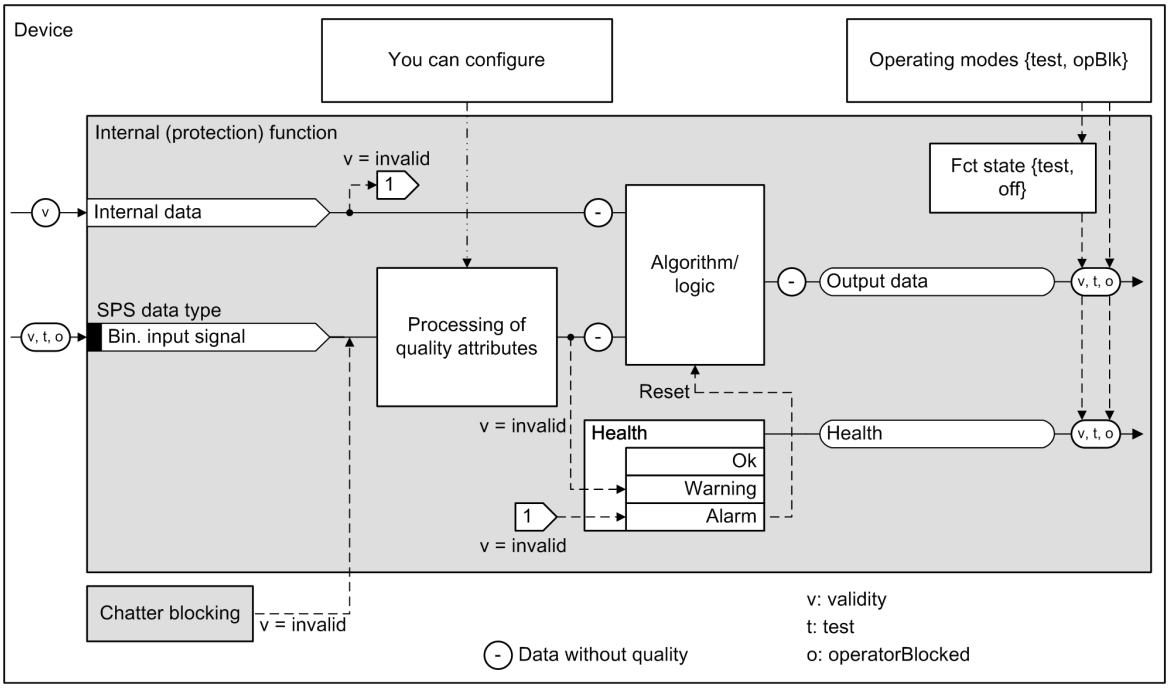
If you do not want to convert the invalid release signal to a valid signal, as described, during the communication interruption, you can also assign a defined data value to the release signal. Proceed as follows: With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value 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.

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

Figure 3-47 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 *3.9.1 Signal Filtering and Chatter Blocking for Input Signals*) sets the corresponding **Validity** attribute to *invalid*.



[lo_quali3, 2, en_US]

Figure 3-47 Overview for Processing Quality within an Internal Function

Internal Input Data

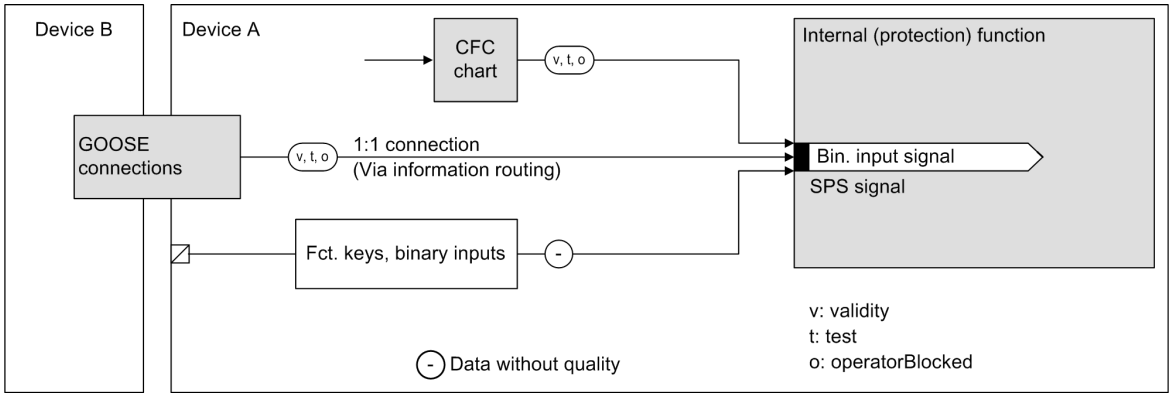
The quality processing is automatic for internal input data.

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 3-48 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 *3.4.3 Quality Processing/Affected by the User in CFC Charts*
- GOOSE connection: See description in chapter *3.4.2 Quality Processing/Affected by the User for Received GOOSE Values*
- Device hardware: No quality attributes are set and supported.

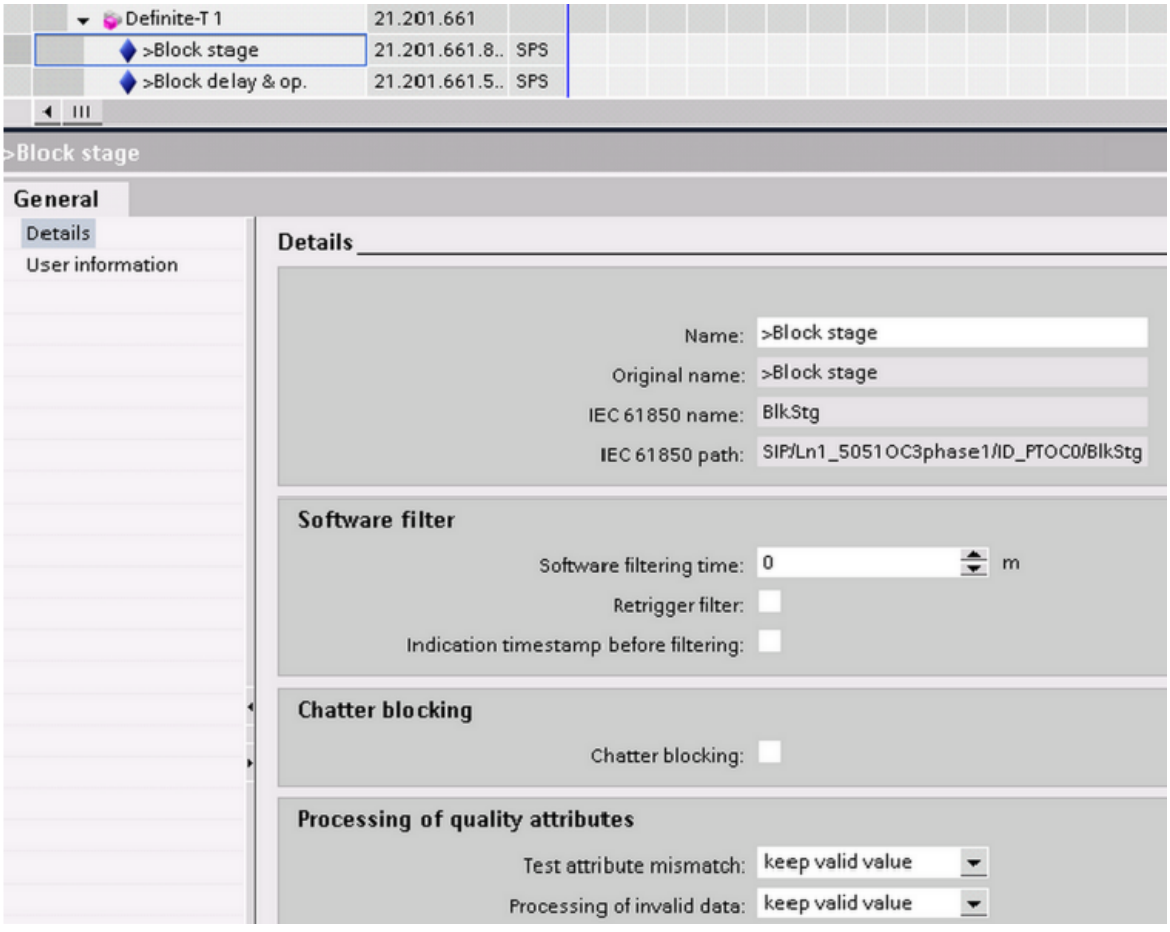


[lo_quali2, 2, en_US]

Figure 3-48 Sources for Connecting a Binary Input Signal

For this signal type (SPS), you can influence the processing of the quality, see overview in *Figure 3-47*. 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**.



[sc_influence, 1, en_US]

Figure 3-49 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.
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*

Cause	D0 Value	Quality Attribute	
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*

3.5 Fault Recording

3.5.1 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.

3.5.2 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.

3.5.3 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

For detailed information about selecting and deleting fault records, refer to the Operating Manual (C53000-G5040-C003).

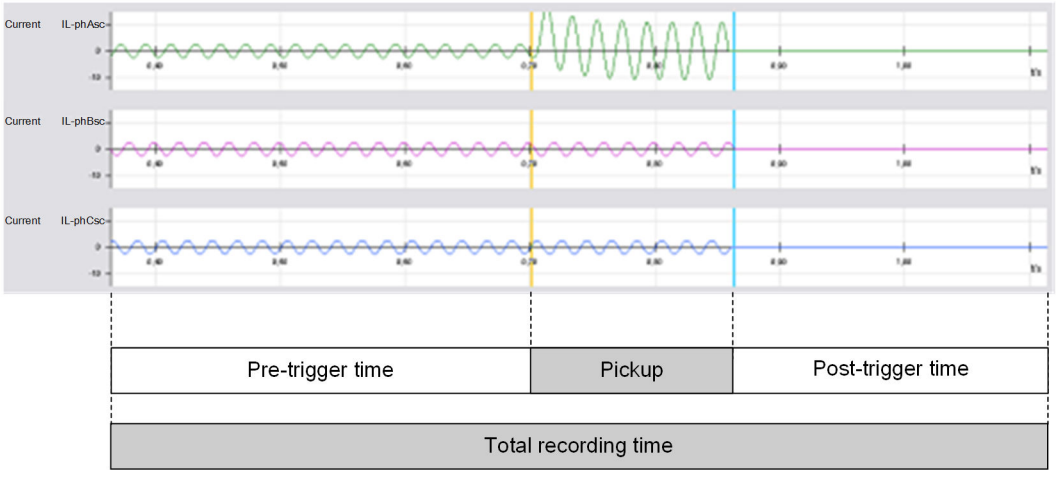
The fault memory of the device is automatically updated with every recording. When the fault memory is filled completely, the oldest recordings are overwritten automatically. Thus, the most recent recordings are always stored safely. The maximum number of recordings is 128.

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.



[dw_sigrar, 2, en_US]

Figure 3-50 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.
- ***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 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**).
- From 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 record is closed after the **Maximum record time** expires and the fault recording is not restarted!

Saving the Recording

Not every fault recording that is started actually needs to be saved. With the **`Storage`** parameter, you specify whether 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 **Recorder** column is available.

You can rename the signals in the DIGSI Information-routing matrix. You can change the order of the binary signals and measured-value channels to be recorded in DIGSI under **Signal order**. You can find more detailed information on this in the DIGSI 5 Online Help, version V07.50 and higher (Order number: C53000-D5000-C001-D).

The operational measured values and the measured values of the fundamental components and symmetrical components (see the Device Manual, chapters *9.3 Operational Measured Values* and *9.4 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 recording has a corresponding fault log with the same number. This ensures that the fault recording can be uniquely assigned to the event log.



NOTE

When the **Fault recorder** function detects a negative time stamp of the measurand or the binary signal, an entry is added in the **Device-diagnosis log** in DIGSI. Meanwhile, the fault recording continues. The entry for an incorrect measurand or binary signal shows the prefix **Bad quality**.

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 recordings 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 recordings possible. Parallel to the sampled tracks, up to 50 tracks with function-specific measured values and up to 200 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 3-10 Maximum Length of All Stored Recordings

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

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
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 recordings. The output signals provide information about the function status.

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

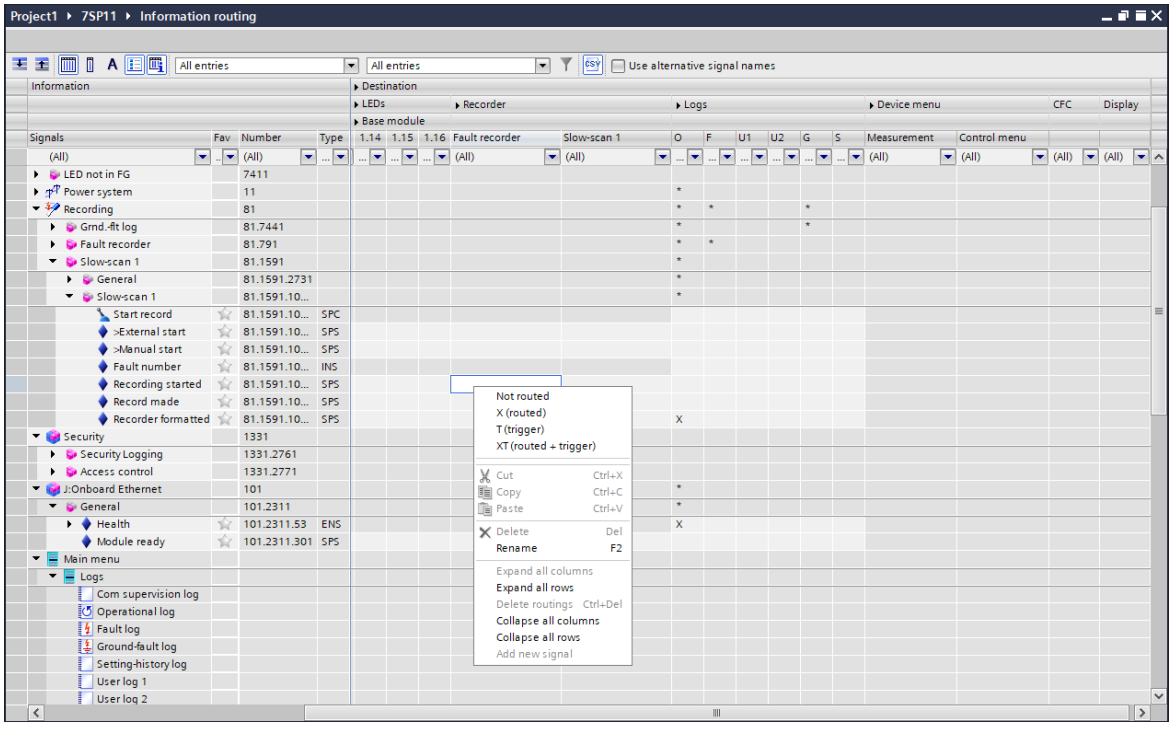
Name	Type	Description
Control: Start recording	SPC	Start recording via the function key
Control: Reset memory	SPC	Delete all recording via the function key. The error numbers are reset.
Control: Delete memory	SPC	Delete all recording via the function key. The error numbers remain as is.
Control: >External start	SPS	Start recording with an external binary signal, for example, by the trip command of an external protection device. The set pre-trigger 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
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
Control: Recording done	SPS	Fault recording done
Control: Tmax reduced	SPS	Fault recording ends before the set **`Maximum record time`** expires, because the fault log is full.
Control: Fault log is full	INS	The fault log is full.

Configuring Stored Indications Using DIGSI 5

- In the **Information Routing** of each device set up in DIGSI 5, you can route binary signals to LEDs and output contacts. To do this, open 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.



[sc_FR_information routing, 1, en_US]

Figure 3-51 Routing of the Signals in the Information Routing

3.5.4 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 considered. 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.
user-defined	The fault recording time is defined user-specific. Note: 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 is 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.

The following table shows how the setting range changes for the **Post-trigger time** parameter depending on the **Sampling frequency**.

Sampling Frequency	Setting Range for the Post-trigger time Parameter
8 kHz	0.05 s to 4 s
4 kHz	0.05 s to 8 s
2 kHz	0.05 s to 16 s
1 kHz	0.05 s to 24 s

Parameter: Manual record time

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

With the **Manual record time** parameter, you set the length of a recording if the fault recording 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.

Parameter: Sampling frequency

- Recommended setting value **(_:2761:140) Sampling frequency** = ***2 kHz***

With the **Sampling frequency** parameter, you define the sampling frequency of the fault record that you want to download via DIGSI 5. Possible setting values are 1 kHz, 2 kHz, 4 kHz, and 8 kHz for the bay units and 1 kHz and 2 kHz for the central unit. Possible setting values are 1 kHz and 2 kHz.

Parameter: Sampl. freq. IEC 61850 rec.

- Recommended setting value **(_:2761:141) Sampl. freq. IEC 61850 rec.** = ***1 kHz***

With the parameter **Sampl. freq. IEC 61850 rec.**, you define the sampling frequency of the fault record that you want to download using the IEC 61850 communication protocol. Possible setting values are 8 kHz, 4 kHz, 2 kHz, and 1 kHz.

You cannot set the parameter **Sampl. freq. IEC 61850 rec.** to be greater than the set value of the parameter **Sampling frequency**. The setting options of the parameter **Sampl. freq. IEC 61850 rec.** which are greater than the set value of the parameter **Sampling frequency** are invisible.

If the size of the COMTRADE file exceeds the maximum permissible storage capacity of the device, the original recording is truncated. The truncated data are discarded.

NOTE

If you have created a fault record with a certain sampling frequency and then set the sampling frequency to a lower value, you can no longer download this fault record using the IEC 61850 communication protocol.

You must reset the sampling frequency to the original value. Then you can download the fault record again using the IEC 61850 communication protocol.

Parameter: Cal.zero.seq.cur.channel

- Default setting **(_:2761:129) Cal.zero.seq.cur.channel** = ***no***

With the **Cal.zero.seq.cur.channel** parameter, you determine whether the calculated zero-sequence current ***3I0*** or ***-3I0*** is recorded in a separate channel or not. The separate channel is visible in the DIGSI 5 Information routing under the **I 3-phase** measuring point.

The zero-sequence currents can be calculated only with the following current-transformer connection types:

- ***3-phase + IN-separate***
- ***3-phase + IN***
- ***3-phase***

Parameter Value	Description
no	The zero-sequence current calculated from the sampled values of the currents is not recorded.
-3I0	The calculated zero-sequence current ***-3I0*** is recorded for each **I 3-phase** measuring point. ***-3I0*** is calculated from the sampled current values using the following equation: -3I0 = - (I_A + I_B + I_C).
3I0	The calculated zero-sequence current ***3I0*** is recorded for each **I 3-phase** measuring point. ***3I0*** is calculated from the sampled current values using the following equation: 3I0 = (I_A + I_B + I_C).

Parameter: Cal.zero seq.volt.channel

- Default setting **(_:2761:132) Cal.zero seq.volt.channel** = ***no***

With the **Cal.zero seq.volt.channel** parameter, you determine whether the calculated zero-sequence voltage ***V0*** or ***3V0*** is recorded in a separate channel or not. The separate channel is visible in the DIGSI 5 Information routing under the **V 3-ph** measuring point.

The zero-sequence voltages can be calculated only with the following current-transformer connection types:

- ***3 ph-to-gnd volt. + VN***
- ***3 ph-to-gnd voltages***

Parameter Value	Description
no	The zero-sequence voltage calculated from the sampled voltage values is not recorded.
V0	The calculated zero-sequence voltage ***V0*** is recorded for each **V 3-ph** measuring point. ***V0*** is calculated from the sampled voltage values using the following equation: $V0 = (V_A + V_B + V_C)/3$.
3V0	The calculated zero-sequence voltage ***3V0*** is recorded for each **V 3-ph** measuring point. ***3V0*** is calculated from the sampled voltage values using the following equation: $3V0 = (V_A + V_B + V_C)$.

Parameter: HSBT recording

- Default setting **`(_:2761:144) HSBT recording`** = ***`Start transfer direction`***

With the **`HSBT recording`** parameter, you determine which channels are recorded.

Parameter Value	Description
`All transfer directions`	All preconfigured channels are recorded.
`Start transfer direction`	• When the parameter **`Fault recording`** is set to ***`with pickup`*** and the fault recorder is triggered by the HSBT (High-speed busbar transfer) start signal, the following channels are recorded: – Measured values and SPS indications that are routed in the started **Transfer direction** function – Measured values and SPS indications that are preconfigured through the application templates but not routed in any **Transfer direction** function – All sampled values that are preconfigured through the application templates • When the parameter **`Fault recording`** is set to ***`with pickup`***, and the fault recorder is triggered by other triggers such as external trigger, manual trigger, controllable trigger, and protection trigger, all preconfigured channels are recorded. • When the parameter **`Fault recording`** is set to ***`user-defined`***, all preconfigured channels are recorded.

For more information on the function **Transfer direction** in the function group **HSBT**, refer to *6.2 Transfer Direction*.

3.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Control`				
_:2761:130	Control:Fault recording		• with pickup • user-defined	with pickup
_:2761:131	Control:Storage		• always • with trip	always
_:2761:111	Control:Maximum record time		0.20 s to 80.00 s	5.00 s
_:2761:112	Control:Pre-trigger time		0.05 s to 16.00 s	0.50 s
_:2761:113	Control:Post-trigger time		0.05 s to 16.00 s	0.50 s

Addr.	Parameter	C	Setting Options	Default Setting
_:2761:116	Control:Manual record time		0.20 s to 80.00 s	0.50 s
_:2761:140	Control:Sampling frequency		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	2 kHz
_:2761:141	Control:Sampl. freq. IEC 61850 rec.		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	1 kHz
_:2761:129	Control:Cal.zero.seq.cur. channel		• no • -3I0 • 3I0	no
_:2761:132	Control:Cal.zero seq.volt.channel		• no • V0 • 3V0	no
_:2761:144	Control:HSBT recording		• All transfer directions • Start transfer direction	Start transfer direction

3.5.6 Information List

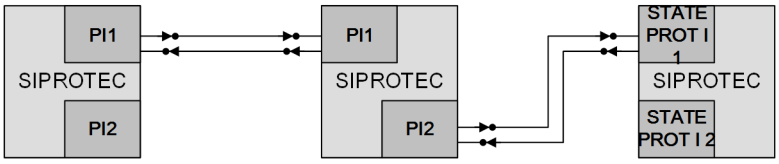
No.	Information	Data Class (Type)	Type
_:2761:300	Control:Start record	SPC	C
_:2761:305	Control:Reset memory	SPC	C
_:2761:306	Control:Clear memory	SPC	C
_:2761:502	Control:>External start	SPS	I
_:2761:503	Control:>Manual start	SPS	I
_:2761:310	Control:Fault number	INS	O
_:2761:311	Control:Recording started	SPS	O
_:2761:314	Control:Record made	SPS	O
_:2761:327	Control:Tmax reduced	SPS	O
_:2761:324	Control:Fault log is full	INS	O

3.6 Protection Communication

3.6.1 Overview

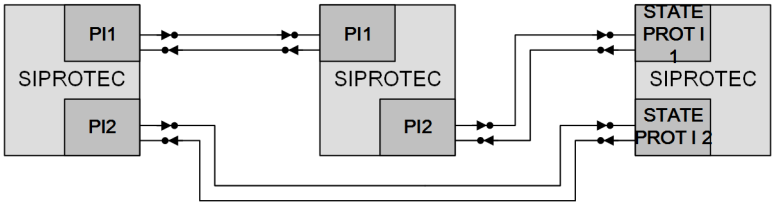
The **Protection communication** includes all functionalities necessary for data exchange via the protection interface (PI).

Devices that communicate with each other via protection interfaces form a device combination. A device combination consists of 2 to 6 devices. The devices communicate via point-to-point connections (protection connections). In this case, a device has only one connection to another device via a protection interface (PI). With a 2nd protection interface, you can establish a connection to another device or a redundant connection to the same device. With their protection connections, the devices form a protection topology in the form of a redundant ring (ring topology) or as a chain structure (chain topology).



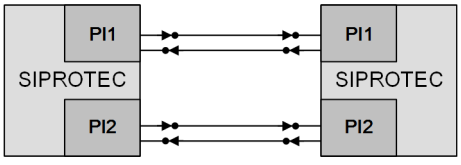
[dw_PDC_chain_3devices, 1, en_US]

Figure 3-52 Device Combination of 3 Devices in a Chain Topology



[dw_PDC_ring_3devices, 1, en_US]

Figure 3-53 Device Combination of 3 Devices in a Ring Topology



[dw_PDC_ring_2devices, 1, en_US]

Figure 3-54 Device Combination of 2 Devices in a Ring Topology

Within a device combination, the point-to-point connections can have different bandwidths. Depending on the bandwidth, a certain amount of binary information and measured values can be transmitted bidirectionally between the devices. The connection with the lowest bandwidth defines the amount of binary information and measured values.

The following information is important for protection communication and is transmitted additionally. You cannot change this information:

- Topology data and values are exchanged for monitoring and testing the connection and displayed on the device or with DIGSI 5.
- Protection data and measured values, such as line differential protection data or binary data of the teleprotection schemes for distance protection and ground-fault protection are transmitted.
- The time synchronization of the devices is possible directly via the connection, whereby a device of the protection topology assumes the role of the timing master.

The point-to-point connection between the devices is continuously monitored for data faults and failure and the signal-transit time of the data is measured.

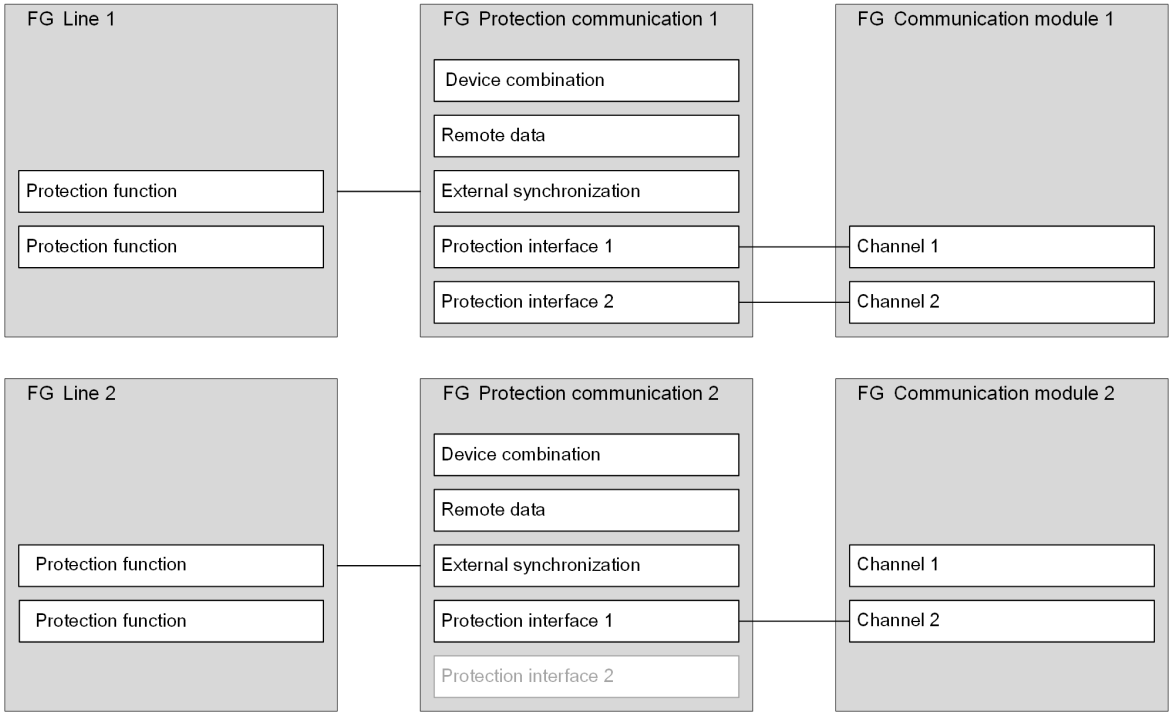
The protection communication is typically used for line differential protection and with the teleprotection schemes for distance protection and ground-fault protection. In SIPROTEC 5, you can configure the protection communication in all devices and use it for further protection applications. At the same time, any binary information and measured values can be transferred between the devices.

NOTE

The protection communication is compatible with the successor versions from firmware version V04.00 and higher.

3.6.2 Protection Communication in the Overall System

The following figure illustrates the interaction of protection communication, protection function groups, and communication modules. The **Protection communication** is integrated as follows in the overall system:



[dw_protcom_compl_system, 2, en_US]

Figure 3-55 Protection Communication in the Overall System

If protection functions want to use the protection interfaces, their superordinate protection function group, for example, the FG **Line 1**, must be connected to a **Protection communication** function group. With this connection, each protection function in the FG **Line 1** can use protection communication.

In addition, a connection must be configured between the logical protection interface in the FG **Protection communication** and a channel on the physical communication module. The physical communication module must support the protection-interface protocol.

The following chapters describe the configuration of the connections.

3.6.3 Function Description

Type of Protection Communication

The protection communication in a device can be either type 1 or type 2. The following table shows the typical applications:

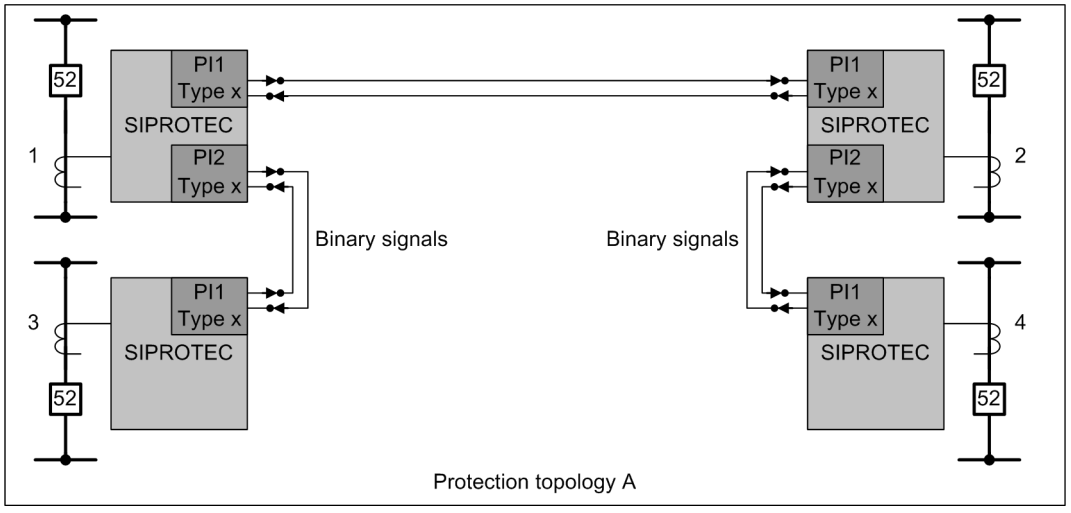
Types	Description
Type 1 Application during use of Line differential protection	With type 1, the **Line differential protection** function is the primary application. This application requires the greatest portion of the bandwidth, so that with type 1 the quantity of customer-specific remote data available is lower. This becomes noticeable with a 64 kBit/s protection connection via a G703.1 or X21 interface. If a multiple-end line differential protection application is realized, all protection communications in the devices must be of type 1. A maximum of 6 line ends (devices) is possible. If the **Line differential protection** and **Teleprotection scheme** functions are to operate in parallel in the device, the bit rate must not be less than 512 kBit/s!
Type 2 Application without use of Line differential protection	Type 2 provides considerably more bandwidth for customer-specific remote data, as the line differential protection application is not used in this example. The transmission of protection data and other data, such as measured values as well as the teleprotection scheme, 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.

NOTE

In the case of devices with the **Line differential protection** function, for instance 7SD and 7SL, protection communication type 1 is preset in the application templates of the devices. Type 2 is preset in the application templates for other devices, and is used for other data transmission.

Type 1 and type 2 protection communication do not work together in pairs via a protection function.

The protection interfaces (PI) establish a direct point-to-point connection between devices via different communication media. Devices connected to one another via protection interfaces form a protection topology. See following figure.



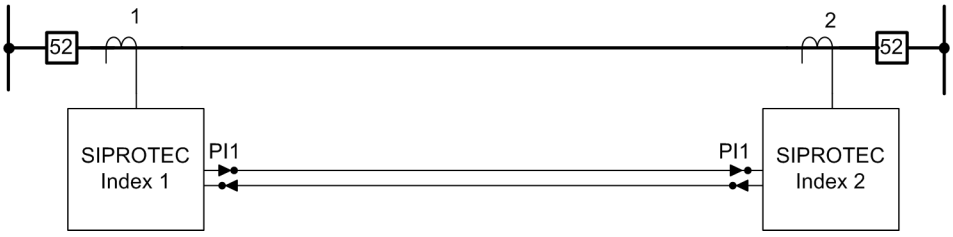
[dw_intert, 1, en_US]

Figure 3-56 Data Exchange between 4 Devices with Protection Communication of Type 1 or Type 2 in a Protection Topology

Device Combination with 2 Devices: Simple or Redundant Transmission

In a device combination with 2 devices, one protection communication with a protection interface is required per device to establish a protection connection (see next figure).

The most frequent application is the two-line-end differential protection (the protection communication is of type 1) or the point-to-point exchange of data between 2 devices (the protection communication is of type 2), as performed by protection transmission devices.



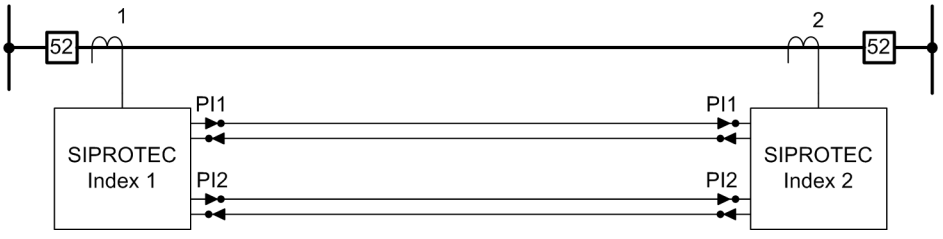
[dw_interface, 1, en_US]

Figure 3-57 Data Exchange for 2 Devices, Each with Protection Connection

NOTE

The index describes the consecutive numbering of the devices in a device combination (see parameter **(_:5131:101) Local device is device**).

A maximum of 2 protection interfaces per FG **Protection communication** are possible in one device, see following figure. If the **Protection communication** function groups are connected to each other in the devices via 2 protection connections of the same type, 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 protection connection fails, the system switches over automatically to the 2nd protection connection until the 1st protection connection is available again. As the protection connection with lower bandwidth defines the maximum amount of transferable information, the same information is exchanged via both protection connections. One application of this is line differential protection routed via a redundant communication connection. Both protection communications in the device are then of type 1.



[dw_intera, 1, en_US]

Figure 3-58 Data Exchange for 2 Devices, Each Having 2 Protection Connections, Redundant Transmission Route

Device Combination with more than 2 Devices: Ring or Chain Topology

When there are more than 2 devices, a communication chain (chain topology) or a communication ring (ring topology) can be established. An arrangement with a maximum of 6 devices is possible.

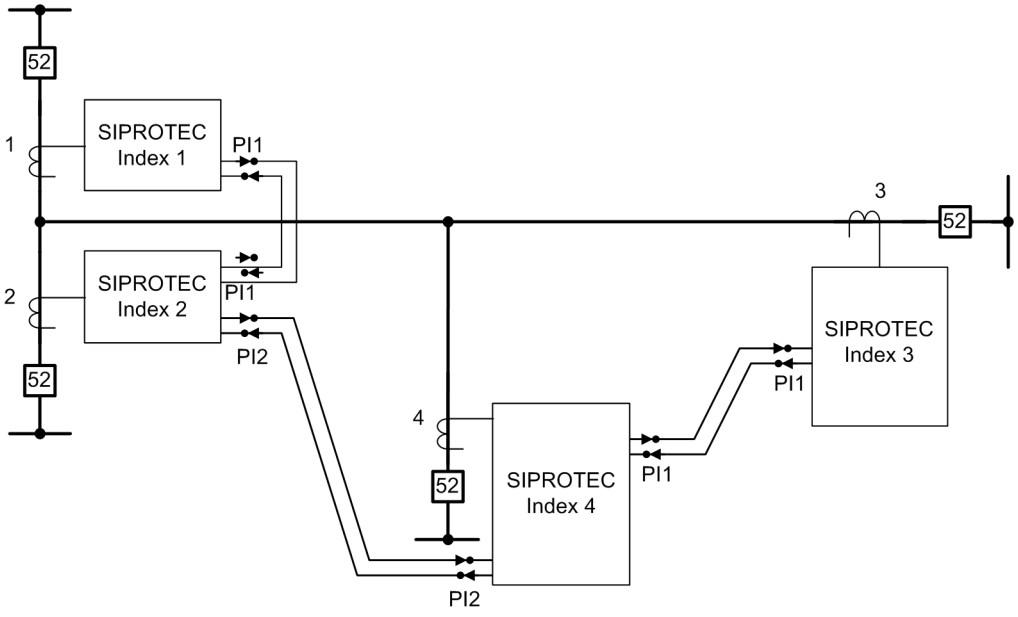
To enable the devices in their device combination to communicate with one another, all devices must contain the FG **Protection communication** of the same type. The devices automatically detect the type of topology and their position within this topology.

A distinction is made between the following types of topology:

- Chain topology
- Ring topology

The chain topology is shown in the following figure.

This configuration shows that the indexing of the devices does not have to correspond to the order in the communication chain.



[dw_chaint, 1, en_US]

Figure 3-59 4 SIPROTEC Devices in a Chain Topology

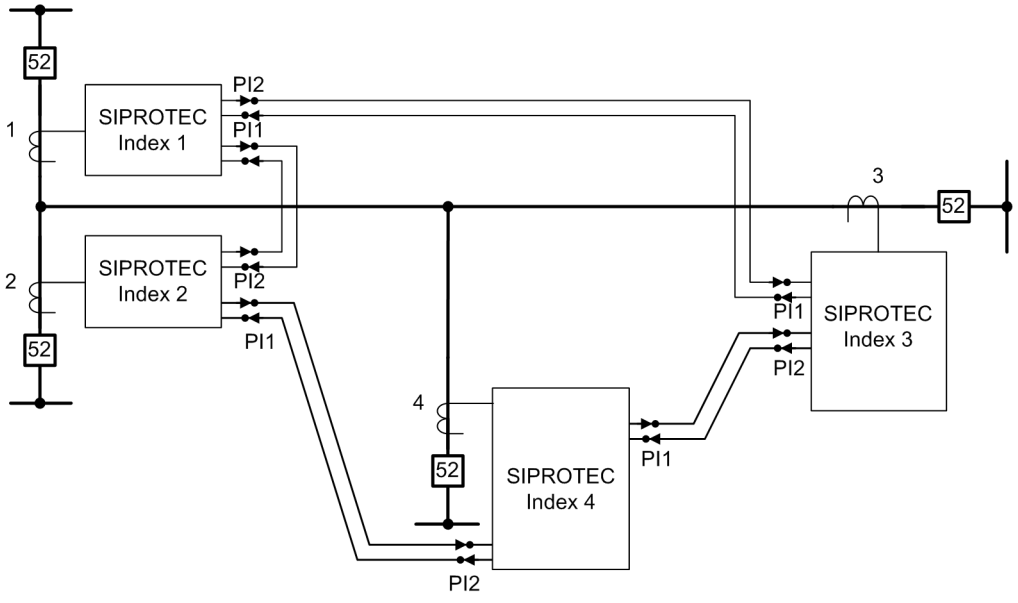
The ring topology is shown in the following figure.

The communication ring has the advantage over the communication chain that the entire communications system and, for example, the **Line differential protection** function also works if one of the communication connections fails or if any desired device in the device combination is taken out of operation.

For more information, refer to *3.6.5.5 Setting Notes for the Device Combination*.

The devices detect failure or logging off, and switch over automatically to the remaining transmission routes.

The following figure shows, for example, a four-line-end differential-protection application if all FGs **Protection communication** are of type 1 in the devices. A typical application with protection communications of type 2 is the exchange of indications and measured values between 4 devices, for example, between switchgears, whereby the protection connection can occur via different communication media. This is the application for a protection-data transmission device.



[dw_ringto, 1, en_US]

Figure 3-60 4 SIPROTEC Devices in a Ring Topology

NOTE

If a connection fails in the ring topology, this configuration continues to function as a chain topology. In a ring topology, any device can be logged off from the device combination, for example, during inspection works at a line end without current flow (open disconnector).

Remote Data

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

There are 3 different priorities for the transmission of remote data:

- **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 available conform with the remaining bandwidth. The remaining bandwidth is lower when using Line differential protection (type 1) than with all other protection functions (type 2). 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 a high transmission rate and is immune to failures in the transmission route while offering the shortest transmission time. This also enables the transmission of a large amount of remote data in line differential protection applications and the remote control of remote devices with DIGSI 5.

The distance to be bridged and the transmission paths (communication media) 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 MBit/s, offers a direct fiber-optic connection to a multiplexer with the corresponding interface.

Table 3-11 to *Table 3-12* 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, 2 protection-interface channels 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 3-11 Plug-In Modules for Applications with Protection Communication

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[4]	Module Type: USART-AJ-1LDFO[5]	Module Type: USART-AX-2LDFO[6]	Module Type: USART-AY-2LDFO[7]	Module Type: ETH-BD-2FO[8]
Physical Connection											
1 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fiber or 4 km via 62.5/125 µm multimode optical fiber	●										
2 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fiber or 4 km via 62.5/125 µm multimode optical fiber		●									
1 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fiber			●								
2 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fiber				●							
1 x optical serial, 1550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fiber					●						
2 x optical serial, 1550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fiber						●					
1 x optical serial, bidirectional using 1 optical fiber, 1300/1550 nm (Tx/Rx), simplex LC plug, 40 km using 9/125 µm singlemode optical fiber							●				
1 x optical serial, bidirectional using 1 optical fiber, 1550/1300 nm (Tx/Rx), simplex LC plug, 40 km using 9/125 µm singlemode optical fiber								●			
2 x optical serial, bidirectional using 1 optical fiber, 1300/1550 nm (Tx/Rx), 2 x simplex LC plug, 40 km using 9/125 µm singlemode optical fiber									●		
2 x optical serial, bidirectional using 1 optical fiber, 1550/1300 nm (Tx/Rx), 2 x simplex LC plug, 40 km using 9/125 µm singlemode optical fiber										●	
2 x optical Ethernet 100 Mbit/s, 1300 nm, duplex LC plug, 2 km via 50/125 µm or 62.5/125 µm multimode optical fiber											●

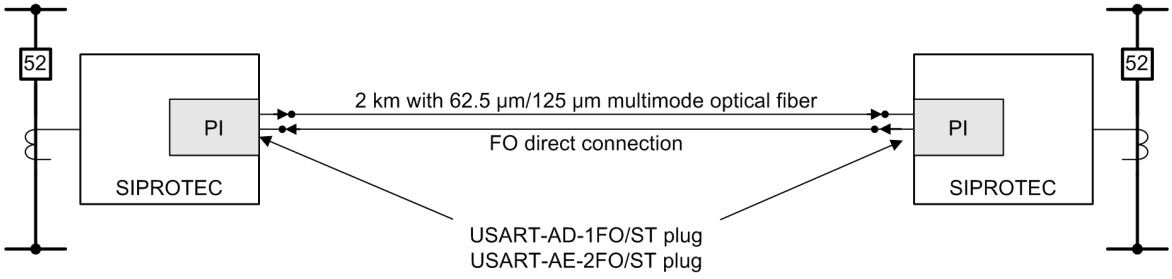
4 USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO
5 USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO
6 USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO
7 USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO
8 Suitable for DIGSI 5, IEC 61850, process bus, busbar protection etc.

Table 3-12 Plug-In Modules USART-AD-1FO and USART-AE-2FO

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

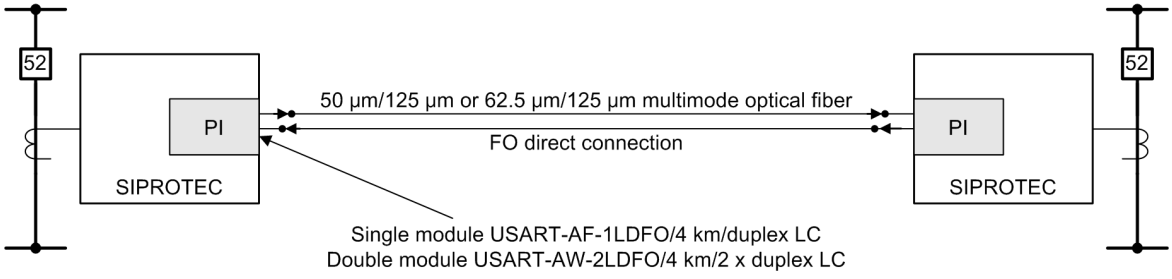
NOTE

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.



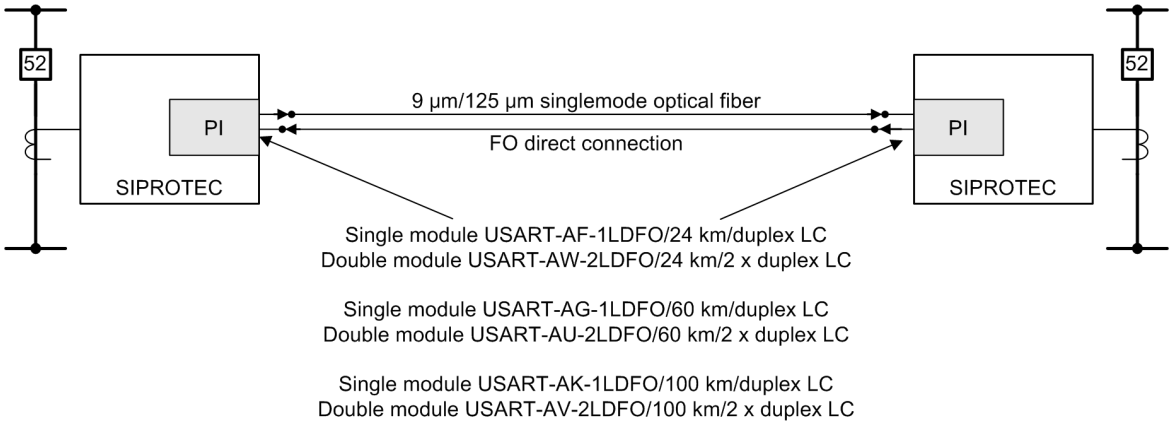
[dw_multim, 1, en_US]

Figure 3-61 Connection over Short Distances, up to 2 km via Multimode Optical Fiber



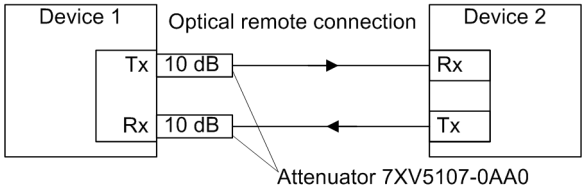
[dw_multim-02, 1, en_US]

Figure 3-62 Connection over Maximum 4 km via Multimode Optical Fiber



[dw_single2, 1, en_US]

Figure 3-63 Connection via Different Distances via Singlemode Optical Fiber

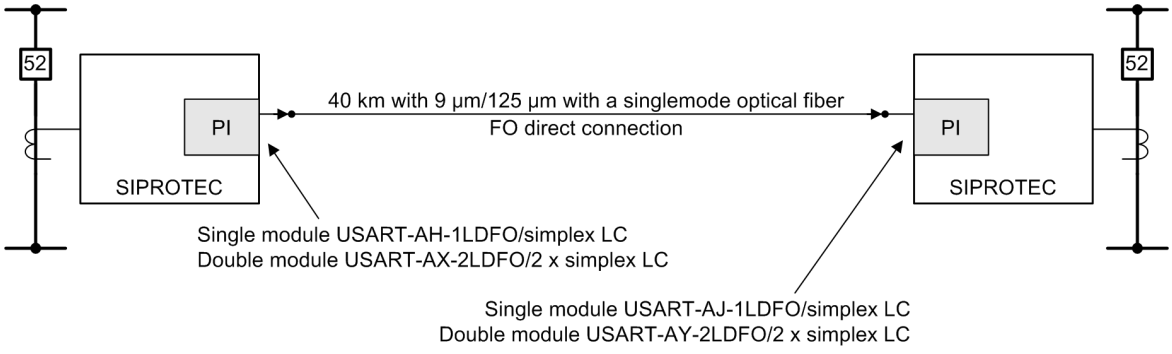


[dw_attenuator, 2, en_US]

Figure 3-64 Optical Remote Connection with Attenuators

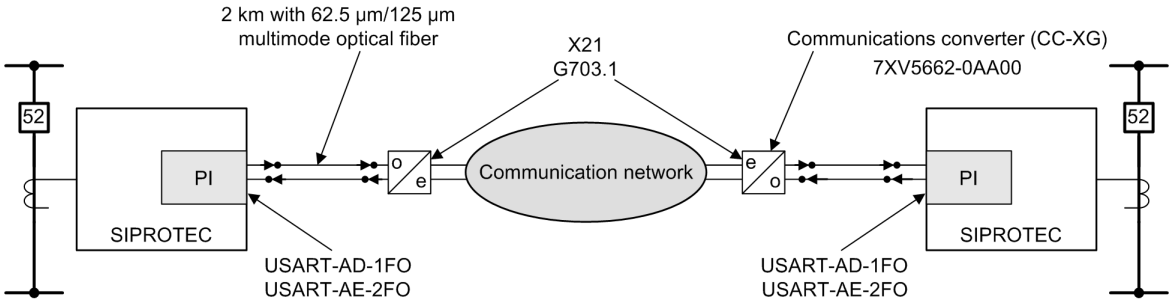
NOTE

Connect two 7XV5107-0AA00 attenuators if you use the communication modules USART-AV-2LDFO or USART-AK-1LDFO for transmission routes of less than 30 km. To continue using the duplex LC plug, attach both attenuators to one end of the protection connection (see *Figure 3-64*).



[dw_single, 1, en_US]

Figure 3-65 Connection via Singlemode Optical Fiber

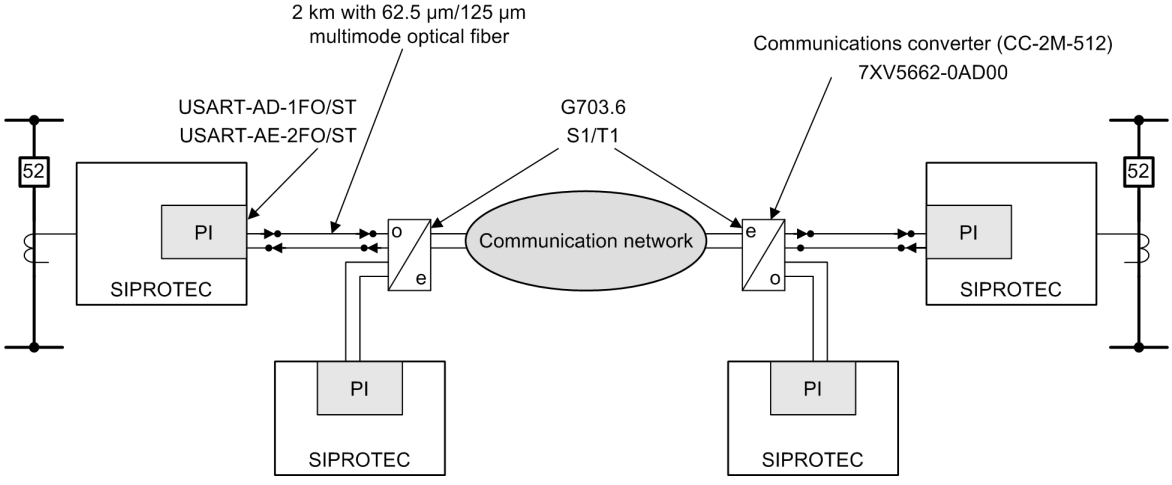


[dw_multim-05, 1, en_US]

Figure 3-66 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 kBit/s) or X21 interface (64 kBit/s to 512 kBit/s). 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 3-13*.

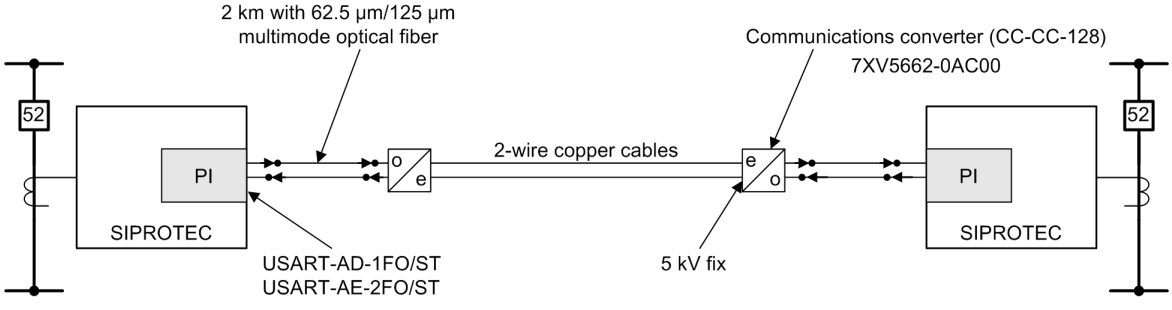


[dw_multim-06, 1, en_US]

Figure 3-67 Connection via Communication Network with a G703.6 Interface

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

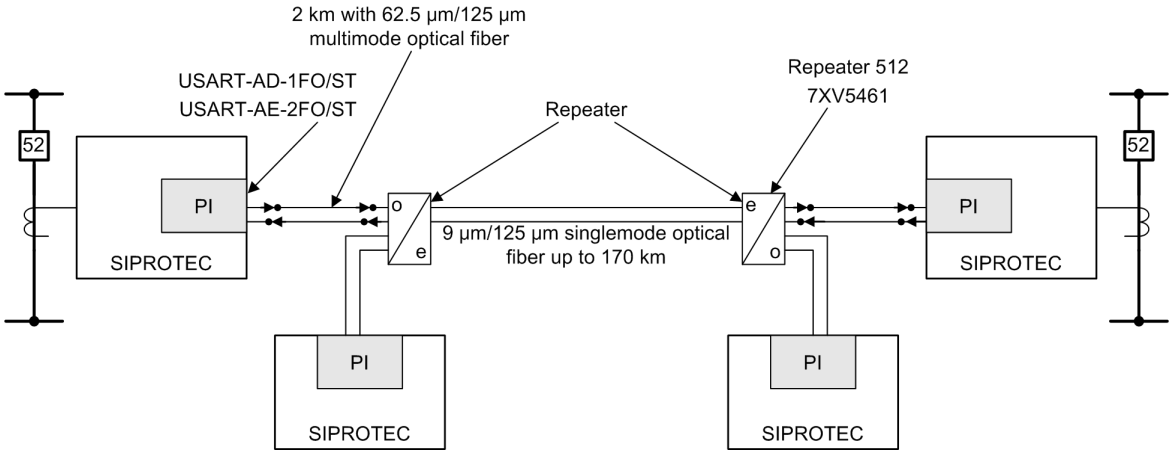
Adjust the setting for the bit rate with KU-2M-512 at 512 kBbit/s in accordance with *Table 3-13* with the parameter **`(_:105) Connection via`**.



[dw_multi_7, 1, en_US]

Figure 3-68 Connection via 2-Wire Copper Cables

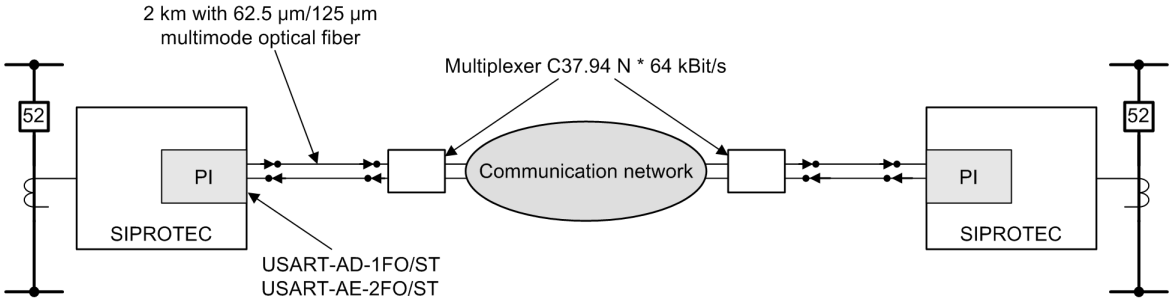
The connection to a communication converter with an integrated isolation voltage of 5 kV is established with 128 kBit/s (KU-KU-128 setting in accordance with *Table 3-13*). An isolation of 20 kV of the 2-wire connection is possible via an external 7XR9516 isolating transformer.



[dw_repeat, 1, en_US]

Figure 3-69 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 kBit/s (repeater 512 kBit/s setting in accordance with *Table 3-13*).



[dw_mutip8, 1, en_US]

Figure 3-70 Direct Optical Connection to a Multiplexer with a C37.94 N * 64 kBit/s 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 transmission routes via the same multiplexer board, as no more substitute paths are possible if the board fails.

Supervision of the Communication

Communication is continuously monitored by the devices and displayed with indications and measured values.

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. For each protection interface, 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 transmission route exists (as in the ring topology), the protection function operating with the protection interface is not operating and remote data is 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, Timing Master

All devices in a device combination can synchronize their time with each other. Synchronization is carried out with millisecond accuracy. The synchronization works independently of the protection function and is used exclusively for simultaneous time keeping in the devices of a device combination.

The device you set in the parameter **(_:5131:102) Address of device 1** is the device with index 1. This device functions takes on the role of the timing master in a device combination. 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 via the protection interfaces.

The time of the timing master itself can be synchronized via the following time sources:

- IRIG B
- DCF77
- IEEE 1588
- SNTP

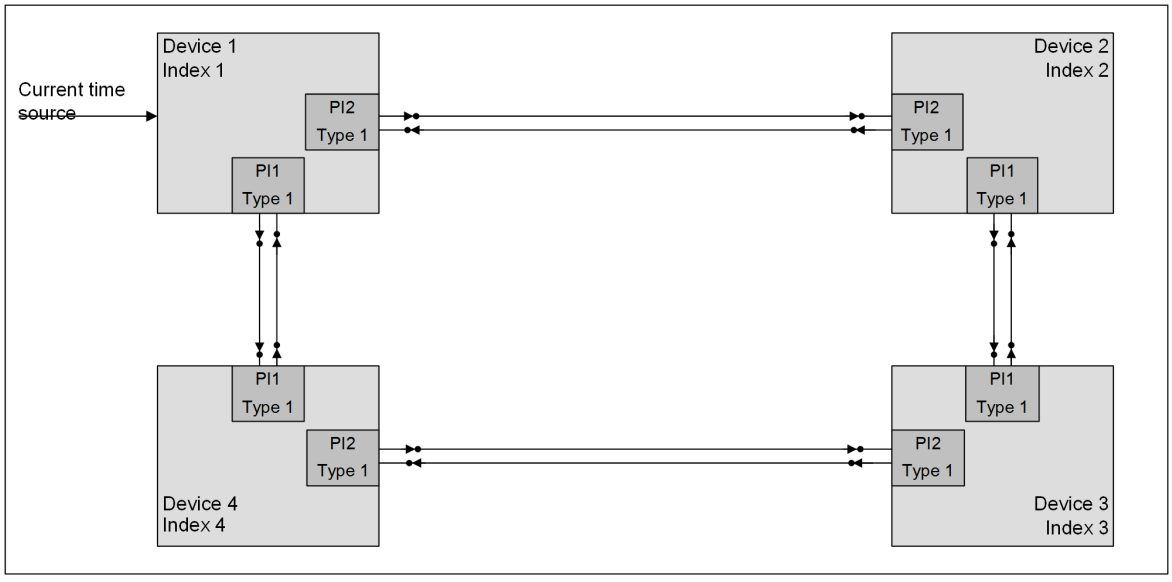
For this, these time sources must be set as the 1st time source and optionally as the 2nd time source in the timing master. If available, the system switches over to the 2nd time source upon failure of the 1st time source in the timing master.

The following chapters describe how a device is set as a timing master:

- For classic protection communication, see *Parameter: Address of Device x, Page 137*.
- For advanced protection communication, see *Parameter: Device index, Page 175*.

Set the protection interface as the 1st time source in the other devices of the device combination. You can find the setting value in DIGSI 5 via the **Project tree** → **Parameters** → **Time settings** → **Timer** → **Time source 1** → ***PI***.

In this way, all events in the devices of the device combination are recorded with the same time and are time-synchronized even across different switchgears. This simplifies fault analysis and the fault records are recorded with the same time in all devices.



[dw_time_sy, 2, en_US]

Figure 3-71 Time Synchronization in a Device Combination

Figure 3-71 shows how device 1 with index 1 is synchronized with devices 2, 3, and 4 via the protection interface. Device 1 is the timing master, whose time is synchronized with a selectable, external time source.

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

The measured values of the devices connected via the protection interfaces are synchronized via telegram measurement with microsecond accuracy (1*10E-06 s). The protection interface displays this state with the indication *PI synchronized* RAISING.

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



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**.

For special line differential protection applications or synchrophasor measuring devices, you can also time-synchronize the measured values with microsecond accuracy as follows:

- Via a high-precision electrical synchronization pulse (**PPS electrical**, 1-second pulse) from a satellite receiver at time-synchronization port G
- Via a high-precision optical synchronization pulse (**PPS optical**, 1-second pulse) from a satellite receiver at a USART communication module
- Via the **IEEE 1588** time-synchronization protocol

This allows you to measure and display the signal-transit time of the transmission route in transmit and receive direction separately. This lets you achieve the maximum responsivity with the line differential protection in communication networks even with differences in the signal-transit time in the transmit and receive direction (unbalanced runtimes). For the transmission of protection data in **type 2** protection communication, different signal-transit times are irrelevant.

Log Off the Device

A device can be logged off for protection-function tests, system inspections, or disconnection of a feeder for operational reasons from the device combination. The logged off device no longer participates in the distributed functionality and is therefore no longer an active component of the device combination. 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 device combination is not in a transient state and is stable in operation without switchovers of the protection connections. This displays the message of the device combination *Status of topo. recog.* with the value ***Valid***.
- In a given chain topology, the device to be logged off is one of the 2 devices at the end of the communication chain.
- The circuit breaker must be open on the side of the device to be logged off and current must not be flowing.



NOTE

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

You can find more detailed information in *3.9.4 Device Logout*.

Constellation Measured Values

Constellation measured values are measured values predefined by Siemens with the following properties:

- They are synchronized in the devices in a device combination.
- They are substituted using the protection interface.
- They are available on every device.

You can view the constellation measured values with DIGSI 5.

In the device, current and voltage measured values are displayed in absolute value and phase as a percentage. 100 % conform to the rated current or the rated voltage of the line (see next figure). These measured values are recorded every 2 seconds by the devices participating in the device combination and then sent to the other respective devices. At the same time, the current and voltage values of the different devices are time-synchronous with one another.

When displaying the constellation measured values the local device is prioritized. The device connected directly with DIGSI 5 is the local device.

For the protection communication, the display of the constellation measured values differs between **Type 1** and **Type 2**.

- Protection communication **Type 1**:
  The phasors of the current and voltage measured values of the local device have an angle of 0°. The angles of the measured values of the other devices relate to the local values, meaning that the angle difference to the remote ends is displayed.
- Protection communication **Type 2**:
  The voltage phasor V_A of the local device has an angle of 0°. The angles of the other local measured values and the measured values of the remote devices relate to V_A (0°).

You can find these measured values in the device under the following DIGSI mask:

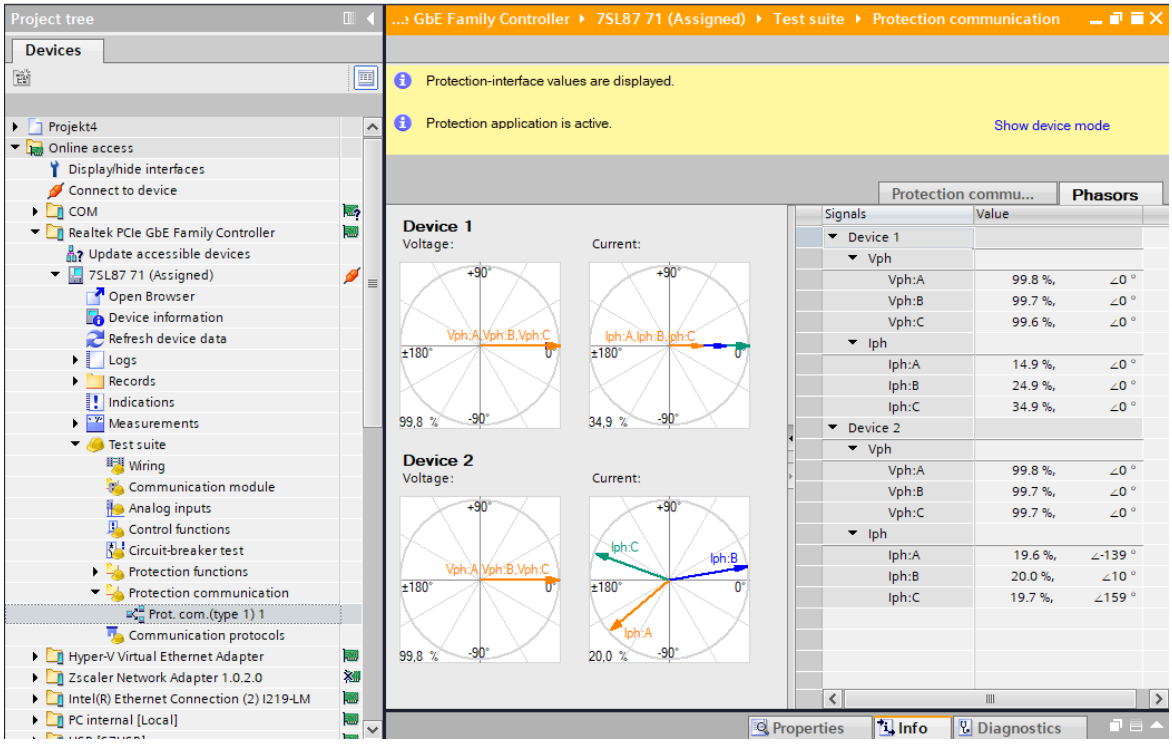
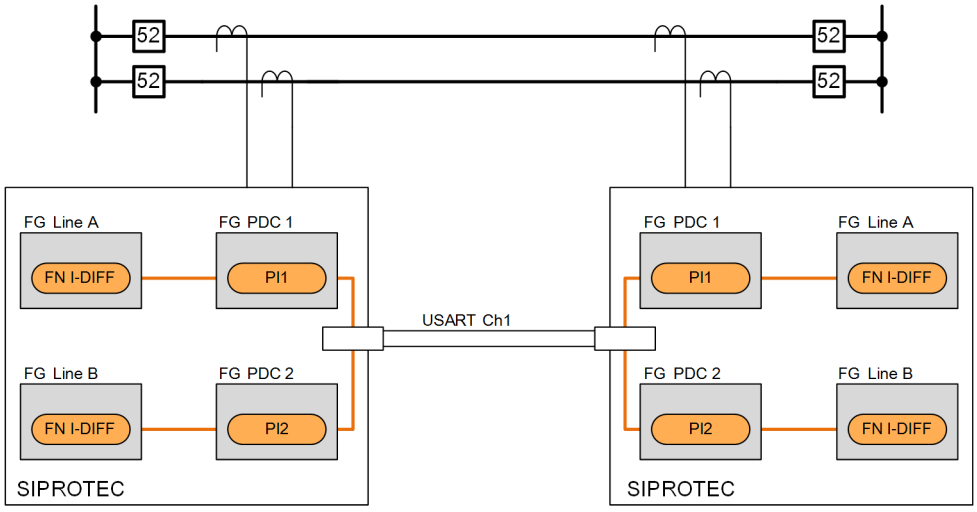


Figure 3-72 Example of Constellation Measured Values with Phases

Multiplex Operation

With extended protection communication, you have the option of having a physical USART channel used by 2 logical protection interfaces. In this way, a transmission route can be double used, for example to implement **Parallel line protection** with **Line differential protection** without additional hardware. To do this, configure the channel according to chapter *3.6.6.4 Configuration of the Advanced Protection Communication in DIGSI 5*.



[dw_channel-mux, 1, en_US]

Figure 3-73 Multiplex Operation

NOTE

Note that in case of multiple use of a physical channel, the available bandwidth is divided equally between the logical protection interfaces. Therefore, this operating mode is not suitable for baud rates under 128 kBit/s.

NOTE

In case of multiple use of a physical USART connection – for example, for protection of a double line – you must provide further redundancy concepts.

3.6.4 Available Variants for the Protection Communication

The following variants are available for protection communication:

- **Classic protection communication**
  The scope of parameterization is small for the classic protection communication. The following constraints exist:
  - IP-based communication protocols are not supported.
  - Increased parameterization effort when changing the number of devices in the device combination subsequently, for example, protection of a multi-terminal line.

- **Advanced protection communication**
  The advanced protection communication provides greater flexibility and is used with IP-based communication protocols. For this purpose, the devices must be equipped with an Ethernet BD module. The following advantages also exist for devices equipped with USART communication modules:
  - Easy subsequent expansion of the number of devices in a device combination
  - Multiple function groups **Protection communication** can be instantiated
  - Multiplex operation of a physical protection connection
  - Hierarchically structured representation in DIGSI 5 project tree

For further information on the 2 variants, refer to *3.6.5 Classic Protection Communication* and *3.6.6 Advanced Protection Communication* .



NOTE

Do not confuse the 2 variants of the protection communication with type 1 and type 2 of the protection communication!



NOTE

If you are unsure about the suitable variant for your use case during selection, use the advanced protection communication.



NOTE

If you want to change an existing classic protection communication to an advanced protection communication or vice versa, a window appears in DIGSI where you are asked whether you want to keep the mapping or not - that is, the communication settings or communication-information routing that has previously been set. In this case, click **No**

3.6.5 Classic Protection Communication

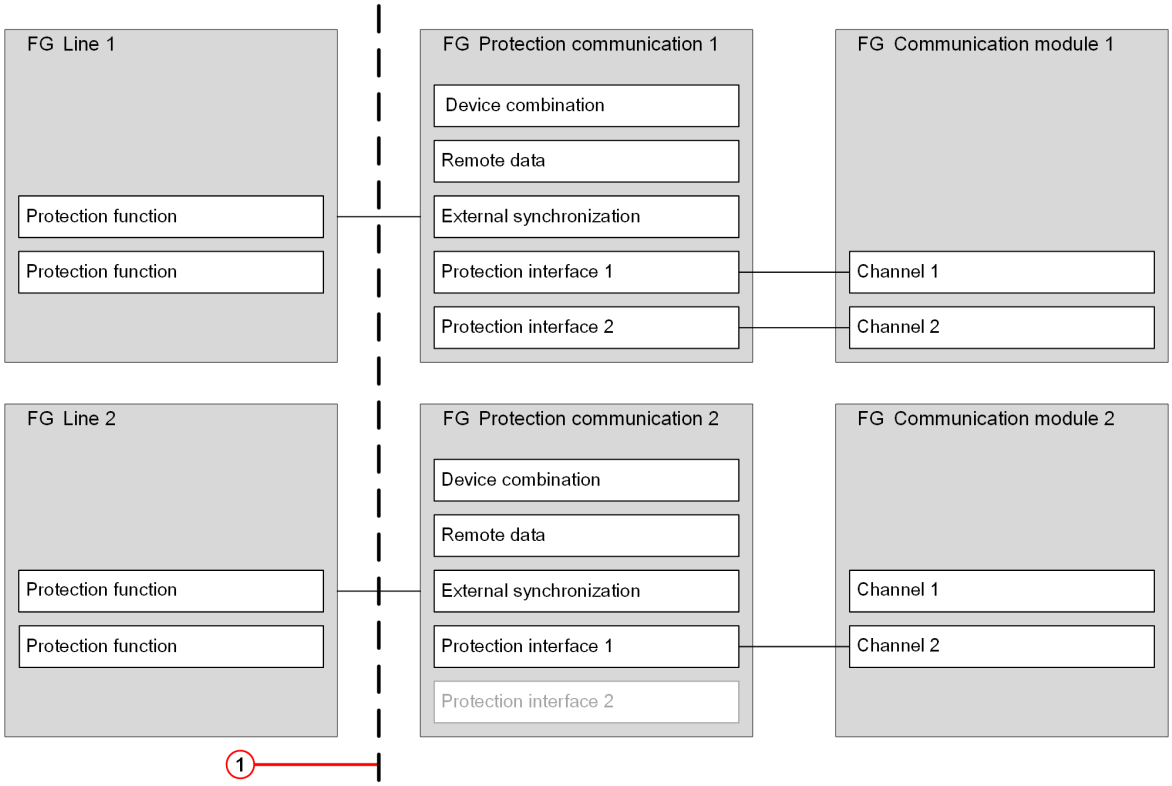
3.6.5.1 Overview

The classic protection communication enables the data exchange between the devices via synchronous serial point-to-point connections from 64 kBit/s to 2 mBit/s. These connections can be directly via optical fiber or via other communication media, for example, via dedicated lines or via communication networks. IP-based communication is not supported.
The function groups of the classic protection communication always support a fixed number of devices in the device combination:

- 2-device protection communication
- 3-device protection communication
- 4-device protection communication
- 5-device protection communication
- 6-device protection communication

3.6.5.2 Classic Protection Communication in the Overall System

The classic **protection communication** is integrated as follows in the overall system:



[dw_simple_protcom_compl_system, 2, en_US]

Figure 3-74 Classic Protection Communication in the Overall System

(1) The device automatically routes the connection between the protection FG and the **Protection communication** FG in DIGSI 5.

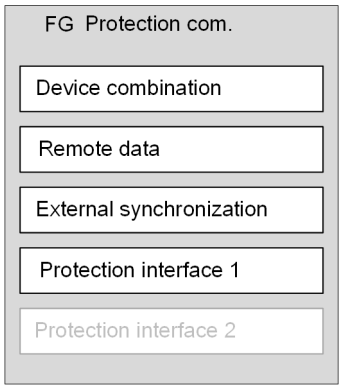
3.6.5.3 Structure of the Function Group

If you select the communication protocol **Protection interface** and the **number of devices** on a channel in the communication module, the classic function group **Protection communication** is automatically created in the DIGSI 5 information routing.

The classic function group **Protection communication** contains the following functionalities and function blocks (FB):

- **Device combination**
- **Protection interface**
- FBs for **Remote data**
- FB **External synchronization** for the synchronization of the transferred data through an external synchronous pulse (1-second-pulse, PPS[9])

9 PPS - **P**ulse **P**er **S**econd



[dw_structure_FG_protcom_simple, 1, en_US]

Figure 3-75 Structure of the Classic FG Protection Communication

The function **Device combination** manages the devices that exchange data via protection communication. In the device-combination settings, you set the general settings for the device combination and the device addresses.

The function **Device combination** issues the following indications:

- General indications like the
  - Number of devices
  - Type and status of the device topology
- Indications of the devices in the device combination like:
  - The availability of the device
  - The state of the device, that is whether the device is logged on or off in the device combination

Measured values are transmitted via protection communication and are acquired and exchanged at the same time in the devices. The synchronization of the measured-value acquisition can be done either internally via the telegram measurement or via an external synchronous pulse (1-second pulse, PPS) using the function block **External synchronization**. The external synchronization is switched on in the function block of the protection interface. You can find the indications of the external synchronization in the function block **External synchronization**.

The function block **Remote data** is used to transfer selected and user-specific signals and measured values from the SIPROTEC 5 system. You select the signals and measured values to be transmitted in the communication mapping of DIGSI. The remote data does not issue status indications.

The function block **Protection interface** is automatically connected to a physical channel of a communication module and can therefore send signals and measured values to the neighboring device or receive them from the neighboring device. You can find the status indications of the FB **Protection interface** in the DIGSI 5 information routing in the function group **Protection communication**.



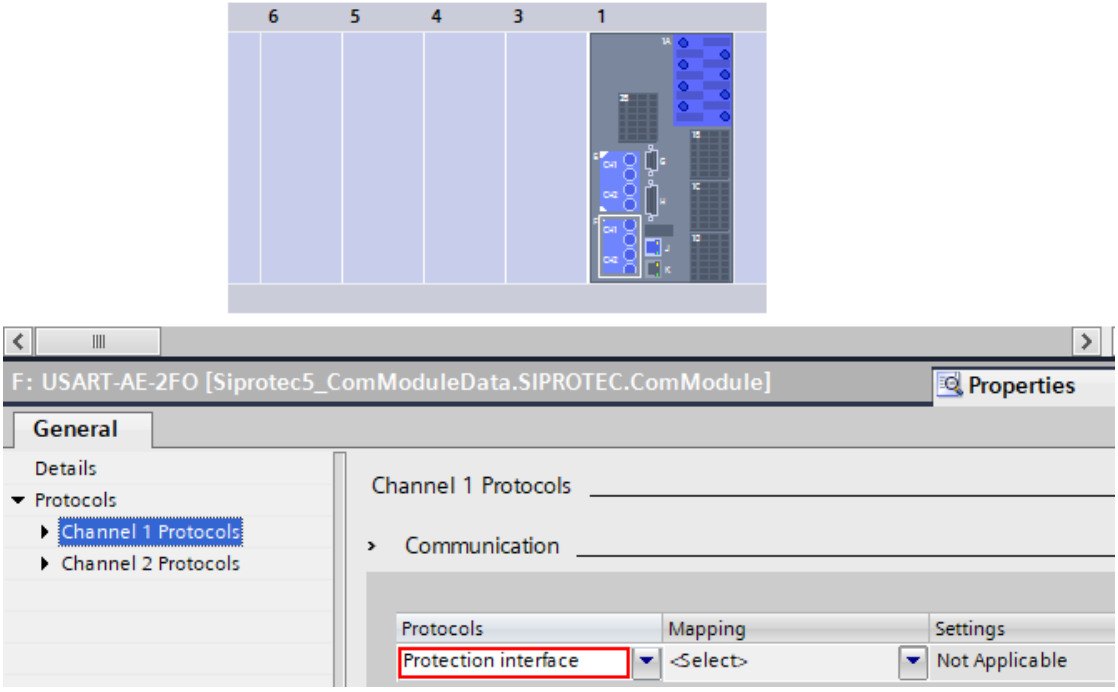
NOTE

In contrast to the protection interface in extended protection communication, the protection interface in classic protection communication is automatically connected to a physical channel of the communication module (refer to *Figure 3-74*).

3.6.5.4 Configuration of the Protection Interface in DIGSI 5

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

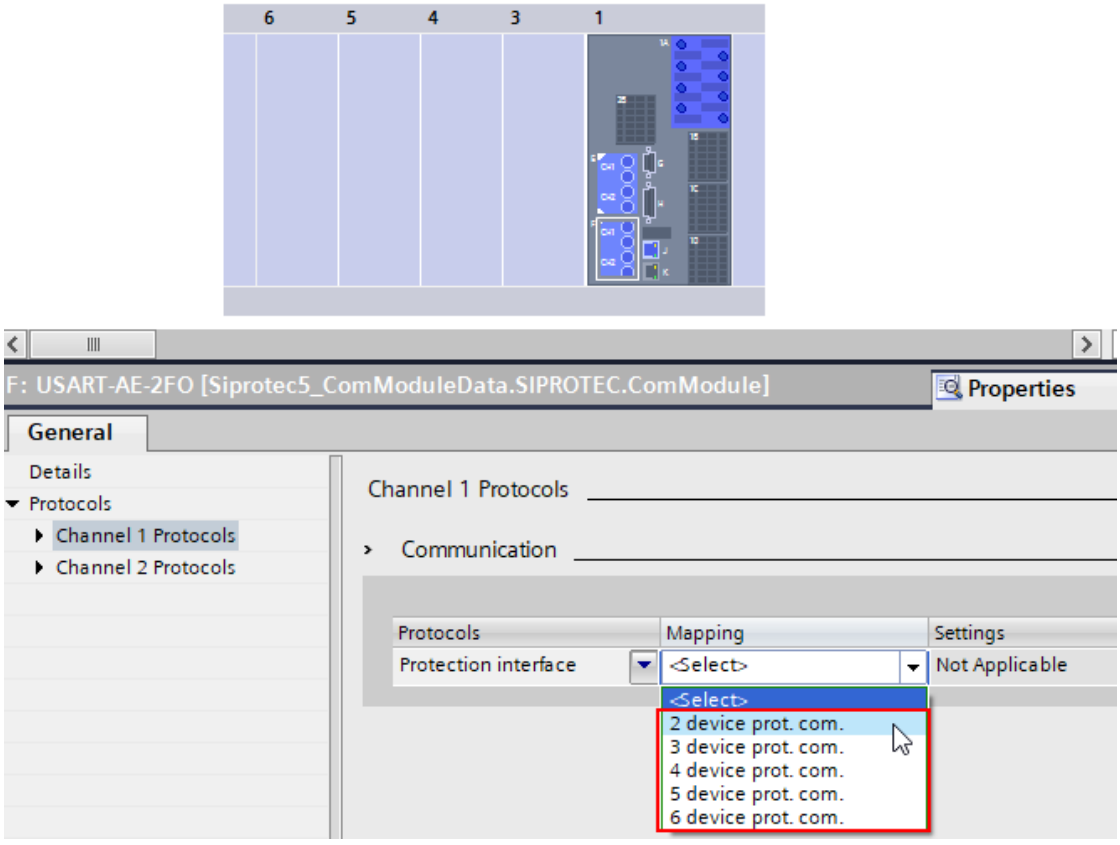
- Select the desired communication module in the rear view of the device.
- In the **Properties of the communication module** > **Protocols** > **Channel x Protocols**, select the ***Protection interface*** protocol.



[sc_PDC_classic_protocol, 1, en_US]

Figure 3-76 Selection of the Communication Protocol

- Then select the number of devices under **Mapping** (see next figure).
  Depending on the device, the selection of device combinations can be restricted to 2 or 3 devices.
  The number of devices is an order option with regard to the line differential protection.



[sc_PDC_classic_mapping, 1, en_US]

Figure 3-77 Selecting the Device Combination

NOTE

The function groups shown in *Figure 3-77* are not available in the DIGSI library.

You can change the number of devices (for example **2 protection communication devices**) depending on the product code any way you like via the **Mapping** text box.

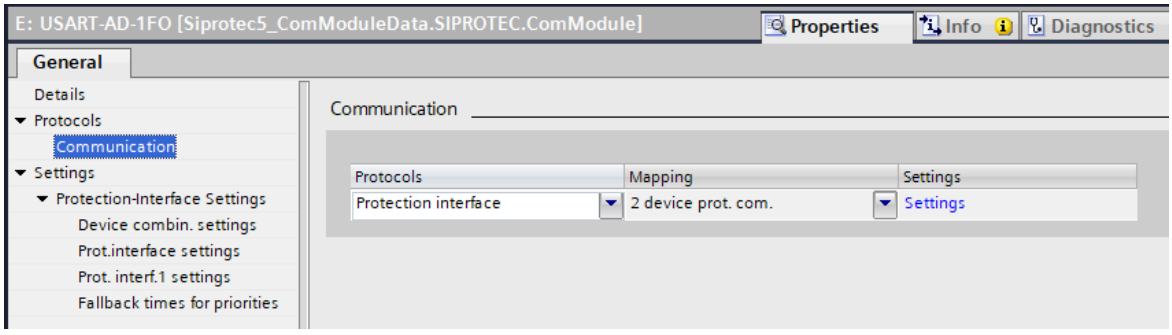
If you change the number of devices via the **Mapping** text box, all activated remote data, settings of the device combination and of the protection interface are lost.

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 **Protocols** text box to select the ***Protection interface***, see *Figure 3-76*.
- Then use the **Mapping** text box to select the number of devices, for example **2 devices protection com.**, see *Figure 3-77*.

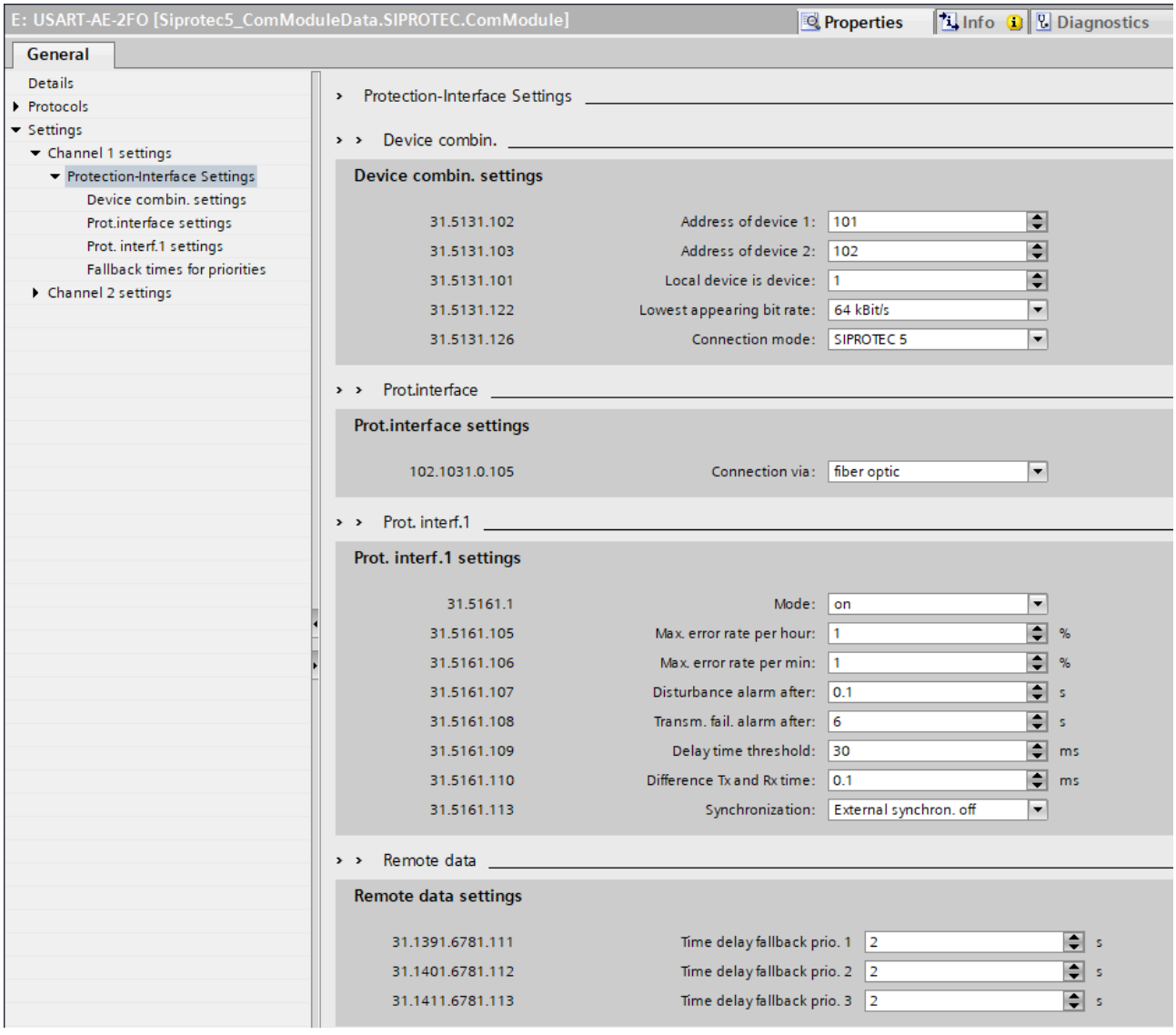
3.6.5.5 Setting Notes for the Device Combination

Select the communication module in the **Project tree** > **Hardware and protocols** in the **Device view**. In the properties of the communication module, you can find the setting sheets for the parameterization of the device-combination settings and the settings for protection communication.



[sc_config1, 1, en_US]

Figure 3-78 Selection of the Protocol: Communication via the Protection Interface



[sc_config, 4, en_US]

Figure 3-79 Protection-Interface Initialization and Configuration

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

Parameter: Address of Device x

- 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.



NOTE

The number of device addresses displayed corresponds to that of the number selected during the device-combination configuration.



NOTE

The device **1** is the timing master device in a device combination.

If all other devices in the device combination are to obtain their time from the timing master device, note the following:

- Under **Address of device 1** set the address for the timing master device.
- Parameterize the other devices such that they get their time from the timing master device via the protection connections.

  For more information, refer to *3.7.3 Function Description*. Select as the adjustable synchronization option ***Protection interface***.

  In the timing master device you must **not** set the protection interface as the synchronization source!

Parameter: Local device is device

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

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

APPLICATION EXAMPLE

You have a device combination 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 local device is the device that you parametrize.

The addresses must be set identically for all devices in the device combination. Functional protection communication requires that you also assign the same index in all devices of the device combination for a device with a unique address.

Parameter: Lowest appearing bit rate

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

With the parameter **Lowest appearing bit rate**, you set the lowest bit rate occurring in the device group. Set the lowest value in each device with a three-end constellation with 2 fiber-optic connections (2 MBit/s) and one 64 kBit/s connection with the lowest value (64 kBit/s). This value determines the maximum number of selected and self-created signals and measured values which are to be transmitted within the device combination (refer to *3.6.5.9 Configuring Remote Data*).

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 optical fibers for a connection between the devices, set the value to ***2048 kBit/s***.

Parameter: Number of devices

- Default setting **(_:5131:125) Number of devices** = ***6***

With the parameter **Number of devices**, you set the number of devices actually connected via protection interfaces. This parameter is set by default to the maximum number of devices permitted in the device combination.

This parameter lets you configure a planned final expansion of a system with a planned number of devices already at this point in time and to put it into operation with a lower number of devices. When configuring the protection interface, select the number of devices present in the final phase of the system in the **Mapping** text box. If you set the parameter **Number of devices** to a smaller value than the maximum value, you achieve functional protection communication with fewer devices. In this procedure, all settings, for example, routing, you made for the device combination are retained, even if you subsequently increase the number of devices. If you wish to operate, for example, a planned 3-device protection communication as a 2-device protection communication, you must set the parameter **Number of devices** to ***2***. If you expand the system later, change the **Number of devices** parameter to the planned maximum number.

For more detailed information regarding the configuration of the protection interface, refer to *3.6.5.4 Configuration of the Protection Interface in DIGSI 5*.



NOTE

The **Number of devices** parameter is only visible for device combinations with more than 2 devices.

Set the same number of devices used in all devices that are part of the device combination.

Connection mode

- Default setting **Connection mode** = ***SIPROTEC 5***

With the parameter **Connection mode**, you select the device type with which the SIPROTEC 5 device is to work in the device combination. As soon as a SIPROTEC 4 device works in the device combination, you must set the parameter **Connection mode** accordingly.

Parameter Value	Description
SIPROTEC 5	The SIPROTEC 5 device only works with SIPROTEC 5 devices in the device combination.
SIPROTEC 4 7SD610	The SIPROTEC 5 device works with at least one SIPROTEC 4 Differential protection device 7SD610 with firmware version V4.72 and higher in the device combination.

Parameter Value	Description
SIPROTEC 4 7SD5	The SIPROTEC 5 device works with at least one SIPROTEC 4 Differential protection device 7SD5x with firmware version V4.72 and higher in the device combination.
SIPROTEC 4 7SA5/6	The SIPROTEC 5 device works with at least one SIPROTEC 4 Distance protection device 7SA522 and 7SA6x with firmware version V4.72 and higher in the device combination.

3.6.5.6 Setting Notes on Selecting the Communication Medium

- 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).
Also refer to *Communication Media, Page 121*

Table 3-13 Means of Communication

Means of Communication	See	Setting Value	Bit Rate
Fiber-optic direct connection	*Figure 3-61* to *Figure 3-65*	***fiber optic***	2 MBit/s
CC-XG-512 communication converter	*Figure 3-66*	***CCXG 512 kBit/s***	512 kBit/s
CC-XG-128 communication converter	*Figure 3-66*	***CCXG 128 kBit/s***	128 kBit/s
CC-XG-64 communication converter	*Figure 3-66*	***CCXG 64 kBit/s***	64 kBit/s
Repeater 512 communication converter	*Figure 3-69*	***repeater 512 kBit/s***	512 kBit/s
CC-CC-128 Communication converter	*Figure 3-68*	***CCPW 128 kBit/s***	128 kBit/s
CC-2M-512 Communication converter	*Figure 3-67*	***CC2M 512 kBit/s***	512 kBit/s
Multiplexer with C37.94 interface	*Figure 3-70*	***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 2,048 kBit/s

3.6.5.7 Setting Notes for the Classic Protection Interface

Parameter: Max. error rate per hour

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

If the number of faulty telegrams per hour exceeds the value set in the parameter **Max. error rate per hour**, you receive the error message *Error rate / hour exc.*.

Parameter: Max. error rate per min

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

If the number of faulty telegrams per minute exceeds the value set in the parameter **Max. error rate per min**, you receive the error message *Error rate / min exc.*.

Parameter: Disturbance alarm after

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

With the parameter **Disturbance alarm after**, you determine the time delay after which defective or missing telegrams are signaled as faulty where the indication *Status of lay. 1 and 2* is *PI data fault*.

Parameter: Transm. fail. alarm after

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

With the parameter **Transm. fail. alarm after**, you determine the time delay after which a communication failure is signaled where the indication *Status of lay. 1 and 2* is *PI data failure*.

Parameter: Delay time threshold

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

The time taken to transmit and receive a signal via a protection connection is the signal-transit time. You can monitor the signal-transit time. For the **Delay time threshold**, the default setting is selected in such a way that normal communication networks do not exceed the signal-transit time. If this signal-transit time is exceeded during operation (for example upon switchover to another transmission route), the indication **Time delay exceeded** is issued.

Increased runtimes only affect the operate time, and therefore the fault-clearing time of the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.

Parameter: Difference Tx and Rx time

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

For time synchronization of the measured values with microsecond accuracy using telegram measurement, the signal-transit times in the send and reception direction must be approximately the same. The device monitors the signal-transit times in the send and reception direction.

With the parameter **Difference Tx and Rx time**, you set a maximum permitted signal-transit time difference between the send and reception paths (runtimes unbalanced). Set the parameter **Difference Tx and Rx time** to the maximum difference expected.

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).

If the difference in the signal-transit times between the send and reception path exceeds the value set, the indication *Time delay jump* is issued.

If the difference from consecutive measurements of the signal-transit times between the send and reception paths exceeds the set value and remains for more than 5 s, the indication *Time delay different* is issued. The **Line differential protection** function is no longer working properly and is ***ineffective***.



NOTE

The parameter **Difference Tx and Rx time** only shows when the function **Line differential protection** is instantiated and the parameter **Synchronization** is not set to ***External synch. only***.



NOTE

If you use a multiplexer with a C37.94 interface as a means of communication, Siemens recommends a setting value of ***0.25 ms*** to ***0.6 ms***.

Parameter: Synchronization

- Default setting **(_:5161:113) Synchronization** = ***External synchron. off***

With the parameter **Synchronization**, you control the time synchronization of the measured values with microsecond accuracy.

If the SIPROTEC device operates with the external synchronization, use the **Synchronization** parameter to define how the protection is activated after restoration of the communication connection (basic state or after transmission fault). See *Figure 3-81*.

Parameter Value	Description
External synchron. off	The external synchronization is disabled: No external synchronization is performed at the protection interface. Select this setting value if you do not expect any differences between the signal-transit times in the transmission and reception directions. Then the measured values are only synchronized internally with the telegram measurement.
Telegr. and ext. synch.	Synchronization via telegram measurement and external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. You can set the external synchronization with the parameter **External synchronization**. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver. In this case, an existing line differential protection is only released when a new connection is established and one of the following conditions is met. • The protection connection is synchronized with the help of the external synchronization. • Symmetric signal-transit times are signaled via the binary input signal *>Sync reset* or the controllable ***Reset synchronization***. This means that the signal-transit times are the same in the send and receive direction.
Telegr. or ext. synch.	Synchronization via telegram measurement or external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. You can set the external synchronization with the parameter **External synchronization**. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver. An available line differential protection is enabled immediately upon renewed establishment of connection (data telegrams are received). The internal synchronization is used up to synchronization.
External synch. only	External synchronization only: The measured values are synchronized only through the external synchronization. You can set the external synchronization with the parameter **External synchronization**. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver.

Parameter: External synchronization

- Default setting **(_:5161:117) External synchronization** = ***PPS electrical (Port G)***

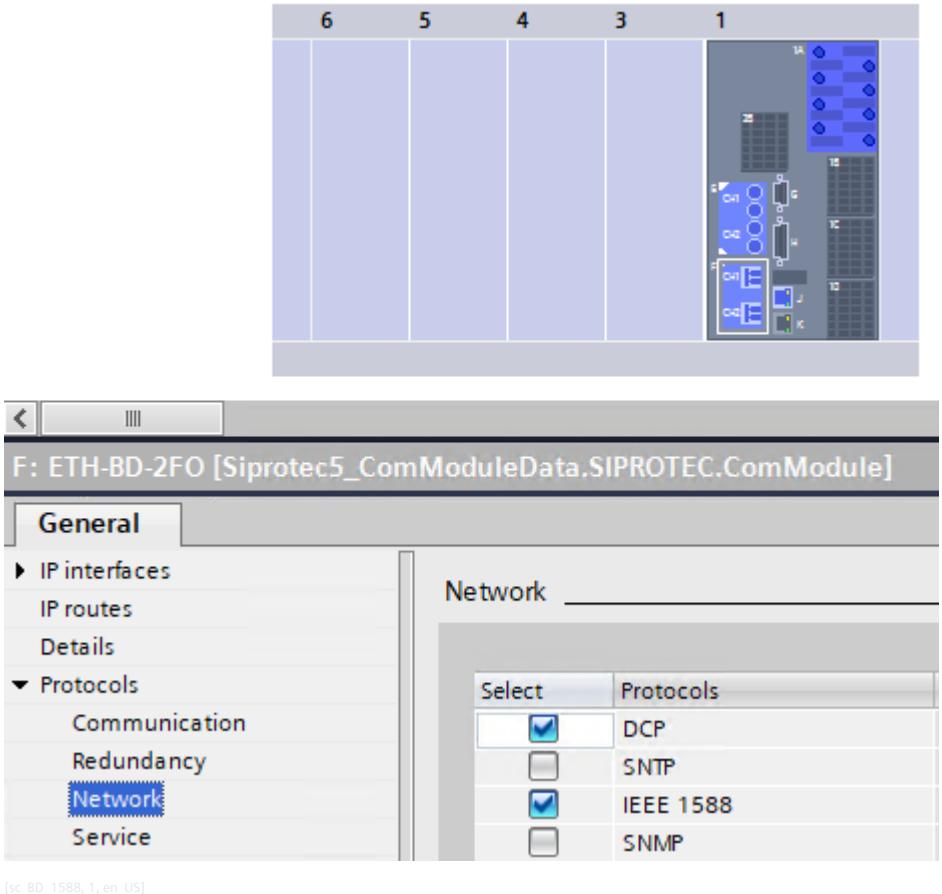
The parameter **External synchronization** is visible only if the parameter **Synchronization** is not set to ***External synchron. off***.

External synchronization is possible separately for each protection interface.

Parameter Value	Description
PPS electrical (Port G)	The electrical synchronous pulse of a satellite receiver (1-second-pulse, PPS[10]) is the synchronization source on the port **G**, the time synchronization interface.
IEEE 1588	The time synchronization protocol IEEE 1588 for an Ethernet-BD communication module is used for synchronization.

NOTE

The configuration option ***IEEE 1588*** is only visible if the device has an Ethernet-BD communication module and you have selected the communication protocol IEEE 1588, see following figure.



[sc_BD_1588, 1, en_US]

Figure 3-80 Ethernet-BD Communication Module: Selection of the IEEE 1588 Protocol

NOTE

External synchronization takes into account the signal-transit time in the transmission and reception directions. If external synchronization fails for a short time, for example, due to a receiving interference or an unfavorable satellite position for a brief period, internal synchronization via telegram measurement is still active.

10 PPS - **P**ulse **P**er **S**econd

NOTE

In contrast to the protection interface in extended protection communication, the protection interface in classic protection communication is automatically connected to a channel of a communication module (see *Figure 3-74*).

Parameter: Max. inaccuracy

- Default setting **(_:5161:119) Max. inaccuracy** = ***0.500 ms***

With the parameter **Max. inaccuracy**, you configure the maximum expected inaccuracy of the synchronization sourced used. The set value is only effective if the synchronization source used does not supply any information on the current inaccuracy in the synchronization signals. If you have not used any of the information on the inaccuracy of the synchronization source used, use the default setting.

NOTE

The inaccuracy of the synchronization source enters the stabilization of the **Line differential protection** as an error signal.

This means that a greater inaccuracy increases the calculated restraining quantity and makes the **Line differential protection** less sensitive.

If **IEEE 1588** is used as the synchronization source in the synchronization status ***SmpSynch*** = ***global***, accuracy values are supplied with the synchronization signals and the parameter **Max. inaccuracy** is not used. If the supplied accuracy values become invalid, the value set in the parameter **Max. inaccuracy** is used.

If the synchronization source **IEEE 1588** works in the synchronization status ***SmpSynch*** = ***local***, then the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

If the synchronization source **PPS electrical (Port G)** or **PPS optical (USART)** is used, then the value set in the parameter **Max. inaccuracy** is used as permanent inaccuracy.

If a USART communication module with the **PPS** protocol and the **PPS generator**operating mode is also used as a synchronization source at the same time, the value set in the parameter **Max. inaccuracy** is used as permanent inaccuracy.

Parameter: Check synchron.-source

- Default setting **(_:5161:121) Check synchron.-source** = ***yes***

With the parameter **Check synchron.-source**, you can switch on or off the synchronization-sources check. During the check of the synchronization sources on the ends of a protection connection, a check is conducted as to whether both synchronization sources are working in the same synchronization status ***SmpSynch***.

If both synchronization sources are working in the synchronization status ***SmpSynch*** = ***global***, the check has been passed.

If both synchronization sources are working in the synchronization status***SmpSynch*** = ***local***, that is decoupled from a global reference time, an additional check is conducted as to whether the synchronization source (***gmIdentity***) is the same. Synchronicity can only be guaranteed if the synchronization sources are the same.

If the synchronization sources display a different synchronization status, that is one displays the synchronization status ***SmpSynch*** = ***local*** and the other the synchronization status ***SmpSynch*** = ***global***, synchronization cannot be guaranteed.

Siemens recommends using the default setting **Check synchron.-source** = yes.

If you have problems with the synchronization-source check, you can switch off the synchronization-source check. Switch off the synchronization-source check only if the synchronization sources are synchronous at the end of their protection connection.

The parameter **Check synchron.-source** is visible only if the parameter **(_:5161:113) Synchronization** is set to ***External synch. only***.

NOTE

If you use **PPS electrical (port G)** as the synchronization source, the synchronization status (***SmpSynch***) is permanently set to ***global***.

If you use **PPS optical (USART)** as the synchronization source, you can use the setting (_:107) **Received. SmpSynch** to set the synchronization status to (***SmpSynch***) ***local*** or ***global***.

For synchronization with microsecond accuracy, for example with **Line differential protection**, adjust the parameter (_:107) **to Accepted. SmpSynch** = ***global***.

3.6.5.8 Indications and Measured Values in the Classic Protection Interface

Each individual protection interface provides different indications for commissioning and diagnostics of communication:

Indication *(_:5161:301) Status of lay. 1 and 2*

The indication *(_:5161:301) Status of lay. 1 and 2* informs you about the status of the connection. The following indications are possible:

Table 3-14 Status Indications Status of lay. 1 and 2

Indication	Description
initialized:	The protection interface is not connected and is in the Initial state.
PI connected:	The protection interface is connected to the protection interface of the partner device.
PI data fault:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:107) Disturbance alarm after** .
PI data failure:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:108) Transm. fail. alarm after** .
not existing:	The protection interface has not been assigned to a communication channel.

Indication *(_:5161:302) Status of lay. 3 and 4*

The indication *(_:5161:302) Status of lay. 3 and 4* informs about errors during the connection establishment. The following indications values are possible:

Status Indication	Description
no error:	No errors occurred during the connection establishment.
SW ver.incomp.:	The connection is not established because the firmware versions of the devices are incompatible. Update the firmware.
wrong dev. ID:	The connection is not established because the device address of the local device or the partner device is incorrect or set incorrectly. Check the settings for the parameters **Address of device 1** to **Address of device n** (_:5131:102 and following).
const.sett.error:	The connection is not established because the parameters are set differently. Check whether the parameter **(_:5131:122) Lowest appearing bit rate** has been set the same in all devices in the device combination.

Status Indication	Description
diff.sett error:	The connection is not established because the parameters are set differently. The line differential protection settings for the connected devices are incompatible. Check whether the devices are set to operate with or without line differential protection. The rated current of the line (parameter **(_:9001:101) Rated current**) must have the same setting in all devices. With a transformer in the line, the **(_:9001:103) Rated apparent power** must be set to the same value in all devices.
net mirroring	The connection is not established. The protection interface is receiving its own data. Check the wiring.
wrong dev. idx.	The connection is not established because the device index of the local device or the partner device is incorrect. Check the setting for the parameter **(_:5131:101) Local device is device**.

Furthermore, the following output signals are available:

Output Signal	Description
(_:5161:303) Connection broken	The signal *Connection broken* indicates that during a parameterized time (parameter **(_:5161:107) Disturbance alarm after**) no telegrams or faulty telegrams were continuously received. If the indication *Connection broken* is issued, the affected protection connection is reset. This can cause the blocking of an active line differential protection or a ring topology can change to a chain topology.
(_:5161:316) Error rate / min exc.	The 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. In this manner, a brief increase of the operate time and thus of the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:317) Error rate / hour exc.	The 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. In this manner, a brief increase of the operate time and thus of the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:318) Time delay exceeded	The signal *Time delay exceeded* indicates that the threshold value for the set signal-transit time (parameter **(_:5161:109) Delay time threshold**) has been exceeded. Increased transmission times only affect the operate time, and therefore the fault-clearing time of the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.

Output Signal	Description
(_:5161:319) Time delay different	The signal *Time delay different* indicates that the threshold value for the difference in signal runtimes in the transmission and reception direction (asymmetrical runtimes) has been exceeded. The setting value results from the setting value of the parameter **(_:5161:110) Difference Tx and Rx time**. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***. If the indication *Time delay different* appears, the **Line differential protection** function is no longer working properly and is ***ineffective***.
(_:5161:320) Time delay jump	The signal *Time delay jump* indicates that the signal runtimes of the data changed abruptly. This is caused by a switchover of the communication path in the communication network. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.
(_:5161:321) PI synchronized	The signal *PI synchronized* indicates that the synchronization with microsecond accuracy of the measured values transferred between the local device and partner device is working correctly. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.
(_:5161:340) Telegram lost	The signal *Telegram lost* indicates that an expected telegram has failed to arrive or a faulty telegram has been received. Reasons for this can be for example switching operations in the primary system or operations on the components of the communication network. If you want to assign the communication failures or faults to other events, route the signal *Telegram lost* temporarily into the operational log. **Note:** If the signal is constantly routed, the operational log can overflow. Siemens recommends routing the signal only for clarification of problems.
(_:5161:343) Partner	The indication shows the address of the partner device. A value of 0 means that no partner address is available.
(_:5161:323) PPS: time del. unsym.	This indication is only visible if you are working with a synchronous pulse. The indication shows that the difference in the signal runtimes between the sending and receiving path exceeds the value set with the parameter **(_:5161:110) Difference Tx and Rx time**. **Note:** The **Line differential protection** function remains ***effective***.
(_:5161:324) PI with PPS synchron.	This indication is only visible if you are working with a synchronous pulse. This indication is only visible if, in parallel to synchronization with the synchronization pulse, you are also working with the synchronization via telegram measurement. If both synchronization methods are working properly, the indication *PI with PPS synchron.* = RAISING is generated.

Measured Values of the Protection Interface

The protection interface provides the following measured value for the diagnosis of the protection-interface communication:

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams transmitted during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams transmitted 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	Receive error rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute

Measured Value	Description
(_:5161:315) Rx err/min	Receive error rate during the last minute
(_:5161:325) Aver.Δt	Average singal runtime (average value of the runtime in transmission and reception path divided by 2, without external synchronization)
(_:5161:326) Rec. Δt	Signal runtime for reception path (with external synchronization)
(_:5161:327) Sen. Δt	Signal runtime for transmission path (with external 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
(_:5161:331) Recept.	Receipt of a telegram (0 = no receipt, 1 = receipt) You can use this indication to make the telegram exchange visible in the fault record.

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 > Release measured values**.

Indications of External Synchronization

The following indications are visible only if the parameter **(_:5161:117) External synchronization** is set to ***PPS electrical (Port G)***.

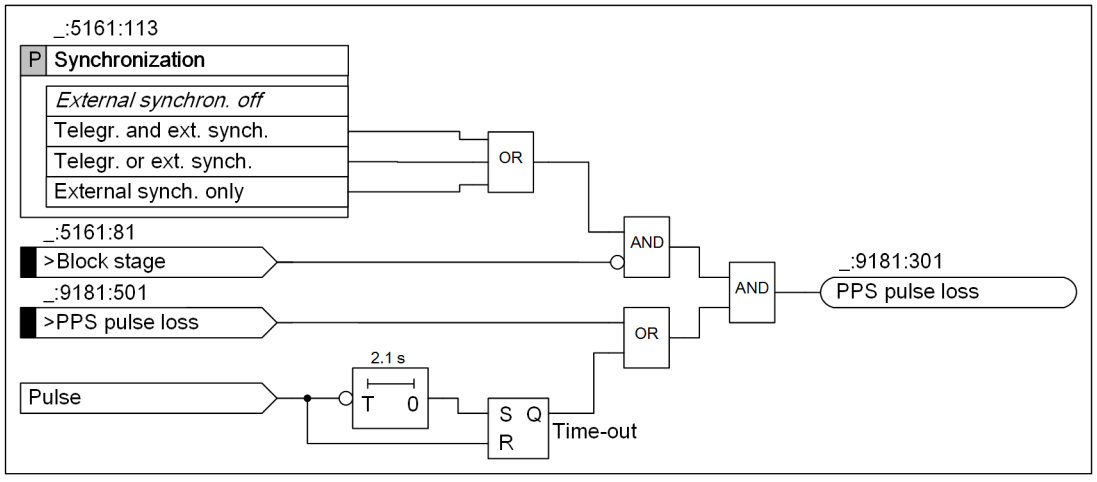
- *(_:9181:501) >PPS pulse loss*
- *(_:9181:301) PPS pulse loss*
- *(_:9181:302) PPS pulse*
- *(_:9181:303) PPS pulse OK*

The following indications are visible only if the parameter **(_:5161:117) External synchronization** is set to ***IEEE 1588***.

- *(_:304) Synchronization loss*
- *(_:305) Synchronization OK*
- *(_:306) Synchronization pulse*

Indication	Description
(_:9181:500) >Block stage	This indication shows the blocking of the external synchronization via a binary input. The external synchronization can be set to inactive through this binary input indication.
(_:9181:501) >PPS pulse loss	The binary input *(_:9181:501) >PPS pulse loss* can be used to signal an externally detected failure in the PPS synchronous pulse (for example, an error message from the satellite receiver). Setting this binary input also leads to the indication *(_:9181:301) PPS pulse loss*. The external synchronization detects immediately that there is a problem with the connected synchronization pulse. Otherwise, the problem will only be noticed after approx. 2.1 s – after the test for synchronous-pulse failure.

Indication	Description
(_:9181:301) PPS pulse loss	This indication shows that the synchronization has failed. This can be due to the following reasons: • The input indication *(_:9181:501) >PPS pulse loss* has occurred. • The synchronous pulse has failed. • The quality of the synchronous pulse is inadequate. • There is another problem with the synchronization source. If no further PPS synchronous pulse is received within 2.1 s, the time-out monitoring responds. If no new second pulse occurs after the expiry of the monitoring time, the indication *(_:9181:301) PPS pulse loss* is issued (see *Figure 3-81*).
(_:9181:302) PPS pulse	This indication displays the synchronous pulse directly. As a rule, one pulse is generated per second. This indication works well to make the synchronous pulse visible.
(_:9181:303) PPS pulse OK	This indication shows that the synchronization is working properly.
(_:9181:304) Synchronization loss	The synchronization has failed. This can be due to a problem with the synchronization source.
(_:9181:305) Synchronization OK	The synchronization is working properly.
(_:9181:306) Synchronization pulse	You can use this indication to make the virtual synchronous pulse visible. As a rule, one pulse is generated per second.
(_:9181:307) Synchron. imprecise	If the set synchronization source operates in the ***global*** synchronization status (SmpSynch) and the time of the synchronization source deviates from the global time by more than 0.5 ms, the indication *Synchron. imprecise* is generated and the **Line differential protection** becomes ineffective. The indication *Synchron. imprecise* is visible only if the parameter **External synchronization** is set to ***IEEE 1588***.

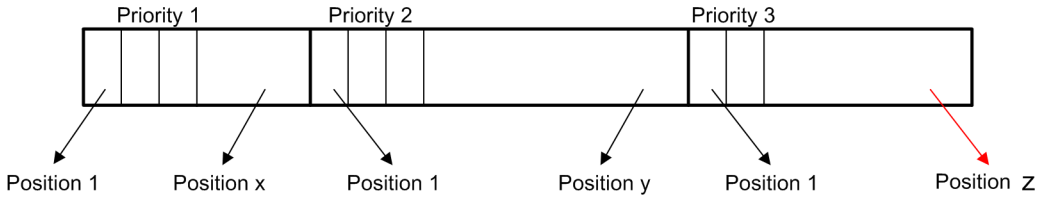


[lo_pps_syn, 2, en_US]

Figure 3-81 Logic for the Generation of the Indication *PPS pulse loss*

3.6.5.9 Configuring Remote Data

Between the devices in a device combination, a data bar is exchanged which can be described or read 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.



[dw_data, 1, en_US]

Figure 3-82 Data Bar Exchanged Between Devices

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

For all signals to be sent, the basic principle is that 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 predefined 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 3-18*).

NOTE

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

Signals 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, there are no differences between priority 1 and priority 2.

Priority 3 signals are 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.

Signals 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 3-17*.

Table 3-15 and *Table 3-16* show the number of data areas in the data bar in relation to the available baud rate.

NOTE

Adjust the parameter **(_:5131:122) Lowest appearing bit rate** in each device for the protection interfaces in a device combination. This determines the number of data areas.

If, for example, in a device combination with 3 devices with a type 2 chain topology 2 devices are connected via direct optical fibers and 2 devices with a bit rate of 64 kBit/s, the 64 kBit/s section is the limiting factor for the entire device combination.

Table 3-15 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 3-16 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 3-17 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
MW (measured values)[11]	32 bits
ACT	4 bits

Table 3-18 Possible Dropout Values

Signal Type	Dropout Thresholds
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-kBit channel. This is a type 1 protection communication. There are 8 bits 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

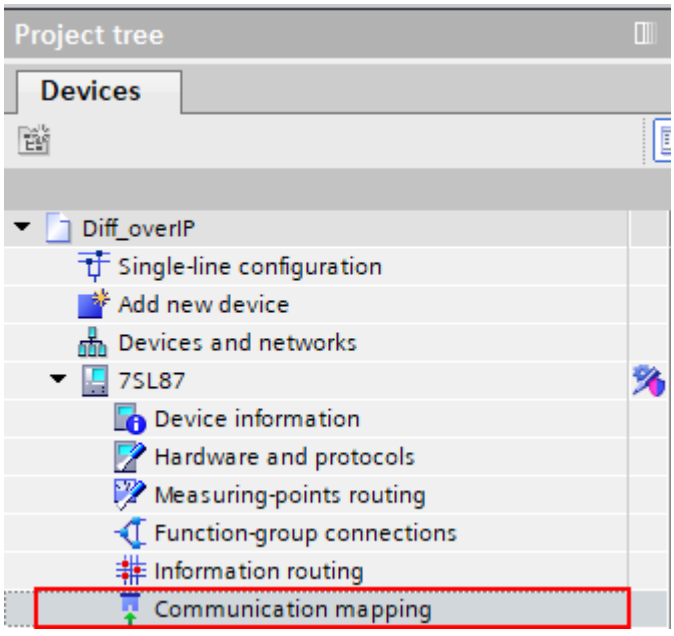
For the display of the rated current in the receiving device

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

Configuration of Remote Data in DIGSI 5:

To configure remote data, navigate in DIGSI 5 through the project tree to the communication mapping.

11 The complex phasors of a measuring point are prerouted



[sc_comm_select, 1, en_US]

Figure 3-83 Communication Mapping in DIGSI 5

Figure 3-84 to *Figure 3-88* show the routing for a type 1 protection communication.

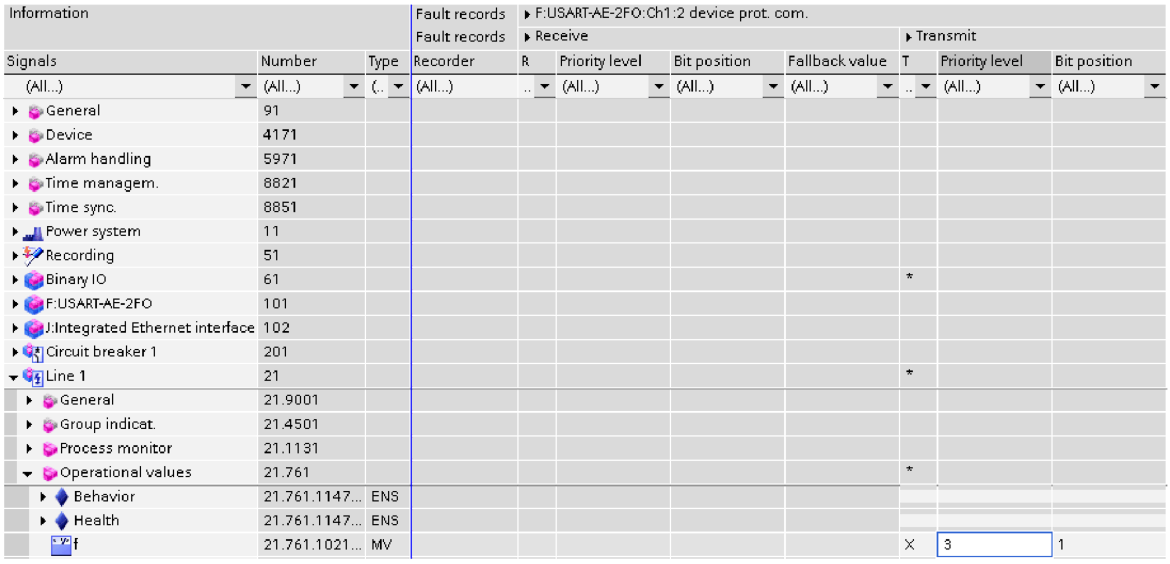
To transmit signals to other devices, these signals must be routed in the communication matrix under **Transmit**. Binary inputs 1 and 2 are single-point indications (SPS) and are routed to bit position 1 and bit position 2 of the transmission with the highest priority (priority 1). For 64 kBit/s, for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

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

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	

[sc_ran_sps, 1, en_US]

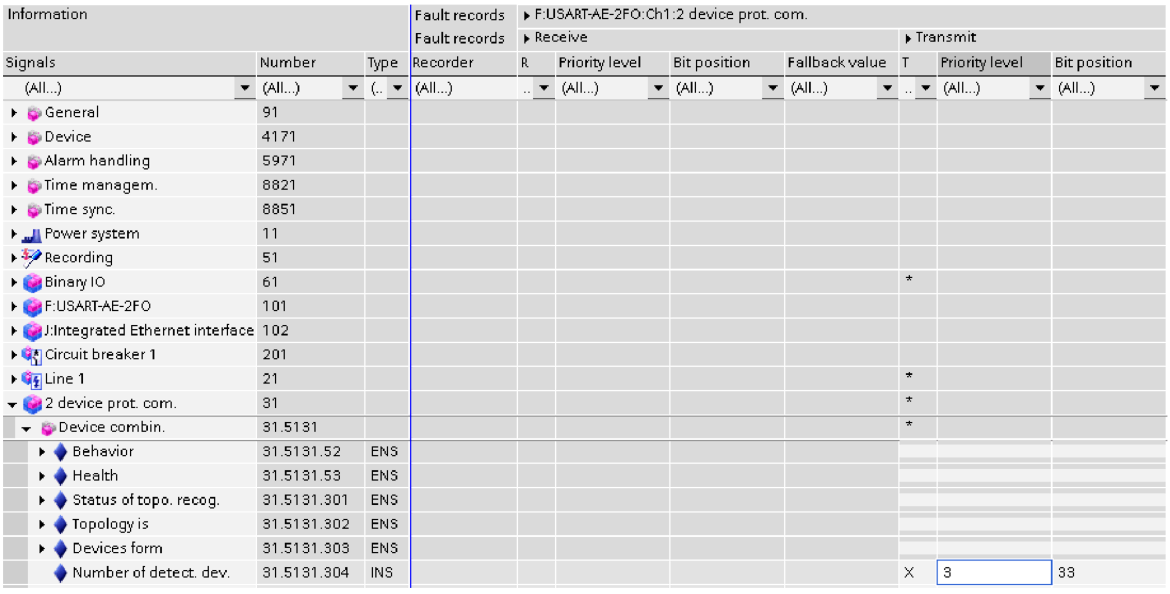
Figure 3-84 Routing of Single-Point Indications to Protection Communication in Device 1



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	

[sc_rang_mw, 1, en_US]

Figure 3-85 Routing of Measured Values to Protection Communication in Device 1

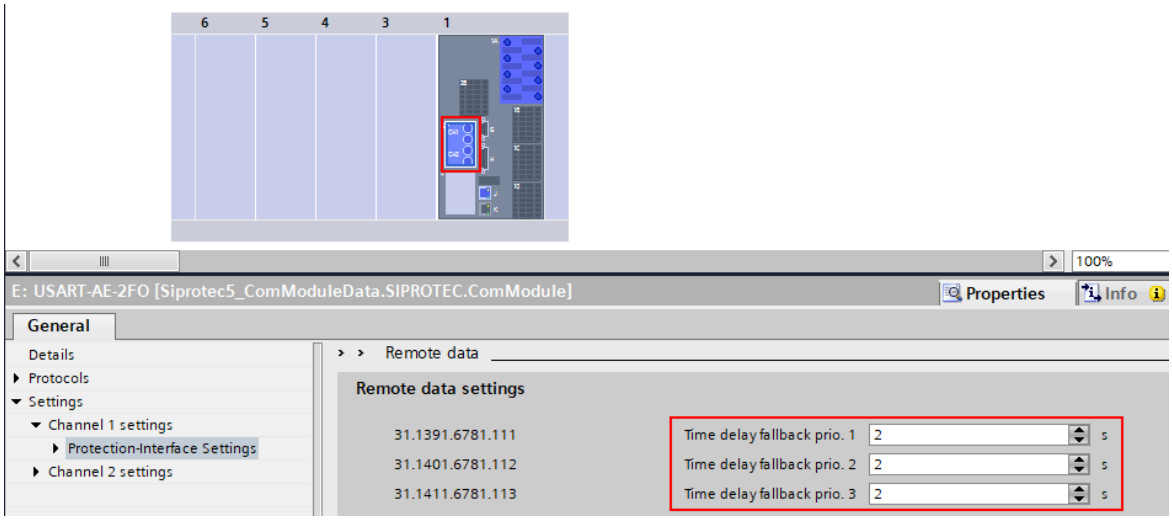


Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position	
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)	
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	

[sc_rang_zw, 1, en_US]

Figure 3-86 Routing of Metered Values to Protection Communication in Device 1

Device 1 also receives signals (in the communication mapping under **Receive**, see next figure). These signals must be routed with the other devices under **Transmit**. The binary outputs 1 and 2 in device 1 receive their information via the protection communication. This is priority 1 information, which has been routed in another device to position 3 and 4 of the data bar for transmission. The secure state is predefined in the **Fallback value** column. If the protection connection fails, the single-point indication is reset to ***raising*** or **cleared** as the **fallback value** or its value is retained (***Hold***). For signals of the various priorities, you can also set a dropout time after which the reset (see following figure) 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 signals of one transmission priority and are set as parameters.



[sc_remotedata, 2, en_US]

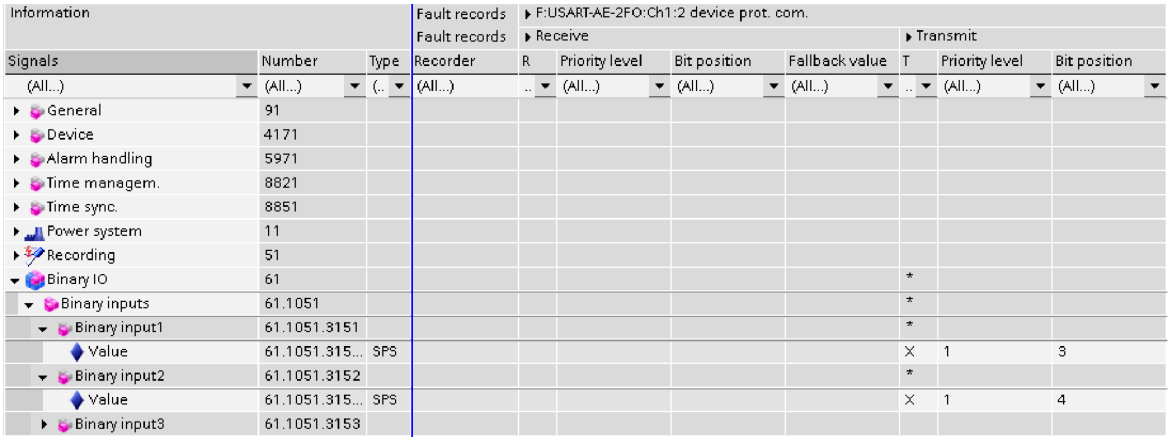
Figure 3-87 Parameterization of Dropout Time for Signals of Different Priorities

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				

[sc_spsemp, 1, en_US]

Figure 3-88 Routing of Single-Point Indications (Receive) to Protection Communication in Device 1

The following figure shows the routing in the 2nd device. Binary inputs 1 and 2 are routed with priority 1 to bit positions 3 and 4 there. In device 1, bit positions 1 and 2 are already occupied (see *Figure 3-84*). If you also route the signals to bit positions 1 and 2, the signals of both devices are then connected to the corresponding bit 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. As a user, you are therefore responsible for the correct routing.



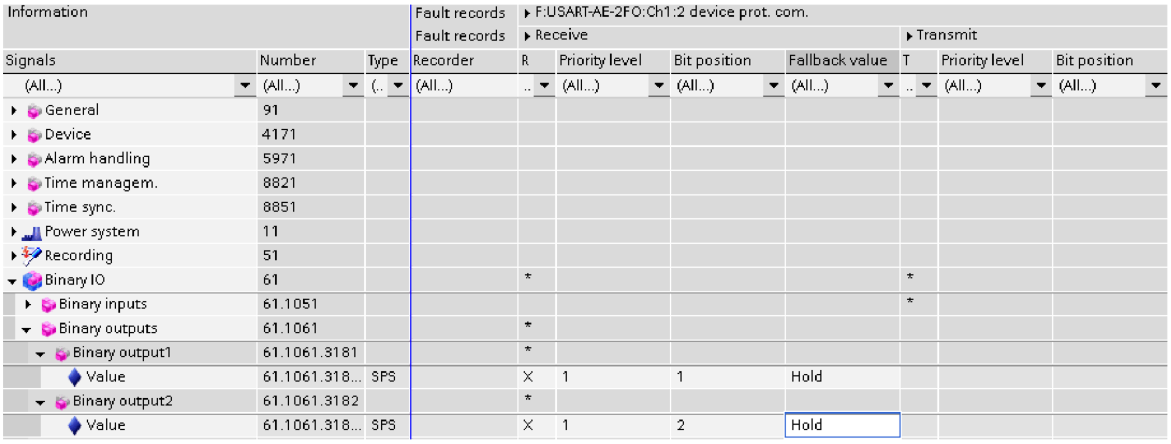
Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	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									

[sc_baspsr, 1, en_US]

Figure 3-89 Routing of Single-Point Indications to be Sent to Protection Communication 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 signals. Other devices can also read this information and logically 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. With single-point indications, states 0 or 1 make sense. In the case of double-point indications, bit combinations 00, 01, 10, or 11 are possible to directly signal a disturbed position upon failure of the protection connection, for example.

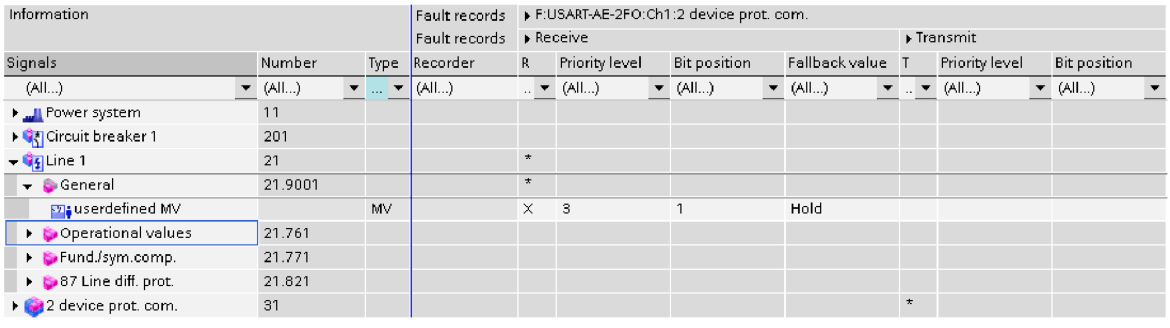
Hold is used to retain the state before the failure of the protection connection.



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			

[sc_bausps, 1, en_US]

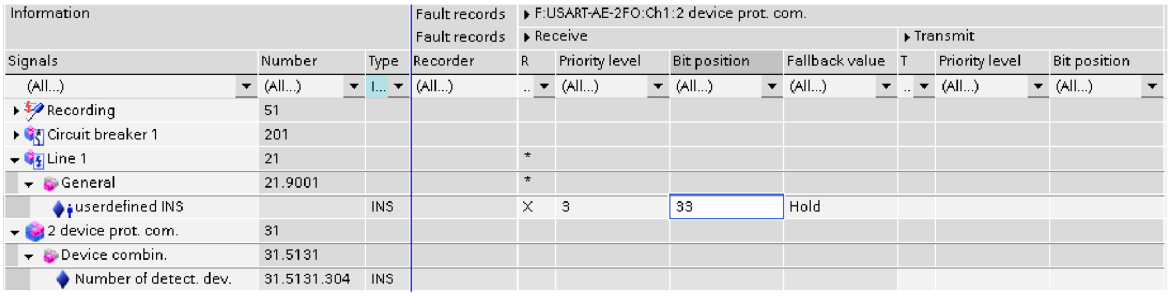
Figure 3-90 Routing of Received Single-Point Indications to Protection Communication in Device 2



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							*		

[sc_bausmw, 1, en_US]

Figure 3-91 Routing of Received Measured Values to Protection Communication 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								

[sc_bauszw, 1, en_US]

Figure 3-92 Routing of Metered Values to Protection Communication in Device 2

3.6.5.10 Constellation Measured Values for Type 1 and Type 2



NOTE

The constellation measured values are only available for the FG **Line**.

Each device in the device combination determines measured values predefined by Siemens, known as constellation measured values. You can find the constellation measured values in the DIGSI 5 information routing under the FG **n Device protection comm.** > **Constell. measured values**. The following measured values and indications are issued for each device:

Measured Value	Meaning
(_:1351:6811:302) Vph	This measured value shows the voltage of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:1351:6811:303) Iph	This measured value shows the current of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:1351:6811:300) Dev.adr.	This indication shows the device address. This allows you to assign the measured values and the circuit-breaker position in a better way.
(_:1351:6811:301) CB	This indication shows the position of the local circuit breaker and can have the following values: • *0*: The switch position of the local circuit breaker is unknown. • *1* The local circuit breaker is open. • *2* The local circuit breaker is closed.

The constellation measured values have the following properties:

- They are synchronized in the devices in a device combination.
- They are substituted using the protection interface.
- They are available on every device in the device combination.

You can view the constellation measured values with DIGSI 5.

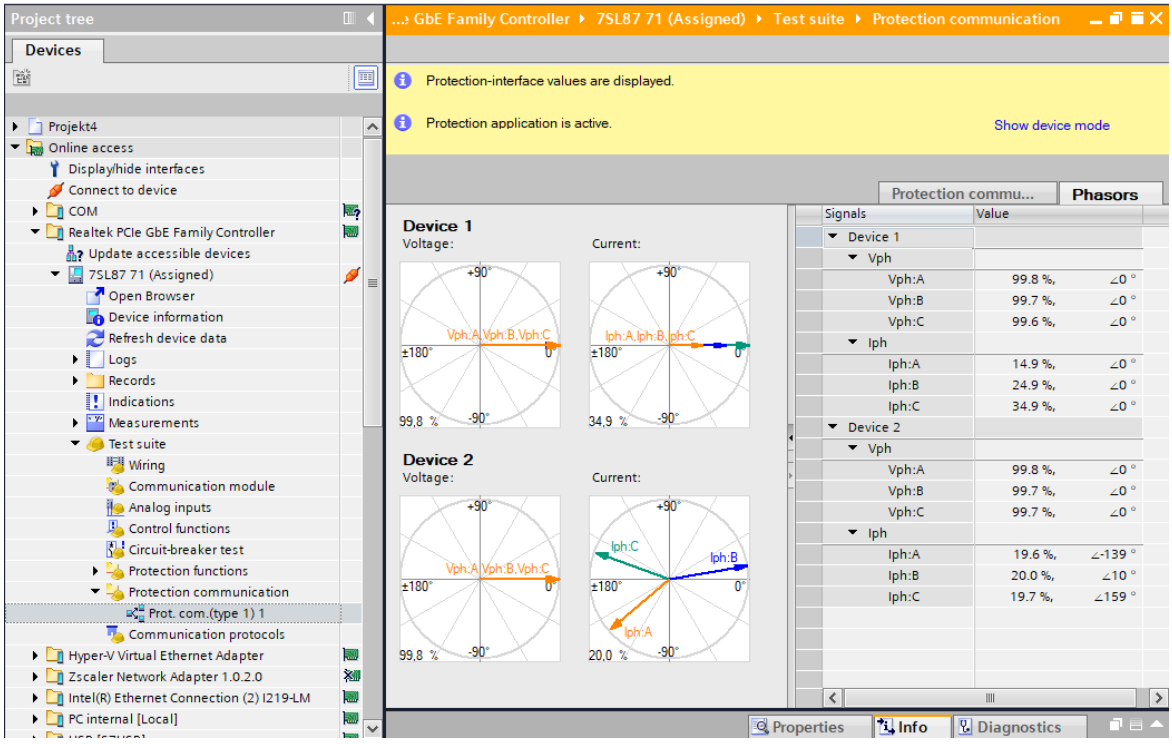
In the device, current and voltage measured values are displayed in absolute value and phase as a percentage. 100 % conform to the rated current or the rated voltage of the line (see *Figure 3-93*). These measured values are recorded every 2 seconds by the devices and then sent to the other respective devices. At the same time, the current and voltage values of the different devices are time-synchronous with one another.

When displaying the constellation measured values, the local device is prioritized. The device connected directly with DIGSI 5 is the local device.

The angle reference depends on the type of the FG **Protection communication** used:

- Protection communication **Type 1**:
  - The angle values of the voltages show the angle difference between the local and the remote voltage. The local voltage serves as the reference with an angle of 0°.
  - The angle values of the currents show the angle difference between the local and the remote current. The local current serves as the reference with an angle of 0°.
- Protection communication **Type 2**:
  The angles of the phase-to-ground voltages and the phase currents relate to the voltage V_A of the remote device.

You can find these measured values in the device under the following DIGSI mask:



[sc_const mv, 2, en_US]

Figure 3-93 Example of Constellation Measured Values with Phases

3.6.5.11 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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
_:5131:125	Device combin.:Number of devices		2 to 6	6
_:5131:127	Device combin.:Dev. comb. is time source		• no • yes	yes
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:Synchronization		• External synchron. off • Telegr. and ext. synch. • Telegr. or ext. synch. • External synch. only	External synchron. off
_:5161:117	Prot. interf.1:External synchronization		• PPS electrical (Port G) • IEEE 1588	PPS electrical (Port G)

3.6.5.12 Information List

No.	Information	Data Class (Type)	Type
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. logout device 1	SPS	O
_:5131:306	Device combin.:Fct. logout device 2	SPS	O
_:5131:307	Device combin.:Fct. logout device 3	SPS	O
_:5131:309	Device combin.:Fct. logout device 4	SPS	O
_:5131:310	Device combin.:Fct. logout device 5	SPS	O

No.	Information	Data Class (Type)	Type
_:5131:311	Device combin.:Fct. logout 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
Ext. Synchron.			
_:9181:500	Ext. Synchron.:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:9181:501	Ext. Synchron.:>PPS pulse loss	SPS	I
_:9181:52	Ext. Synchron.:Behavior	ENS	O
_:9181:54	Ext. Synchron.:Inactive	SPS	O
_:9181:53	Ext. Synchron.:Health	ENS	O
_:9181:301	Ext. Synchron.:PPS pulse loss	SPS	O
_:9181:303	Ext. Synchron.:PPS pulse OK	SPS	O
_:9181:302	Ext. Synchron.:PPS pulse	SPS	O
_:9181:304	Ext. Synchron.:Synchronization loss	SPS	O
_:9181:305	Ext. Synchron.:Synchronization OK	SPS	O
_:9181:306	Ext. Synchron.:Synchronization 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:CB	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:CB	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:CB	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:CB	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:CB	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:CB	ENS	O
_:1351:6961:302	Meas.val.dev.6:Vph	WYE	O
_:1351:6961:303	Meas.val.dev.6:Iph	WYE	O

3.6.6 Advanced Protection Communication

3.6.6.1 Overview

The advanced protection communication contains all functionalities of classic protection communication. The view of parameters and indications is structured differently in DIGSI 5. In addition, the advanced protection communication supports the IP-based communication protocol.

You can easily change the number of devices in the device combination. Further differences include support for external synchronization sources and an exchange of phase-selective information while sending and receiving.

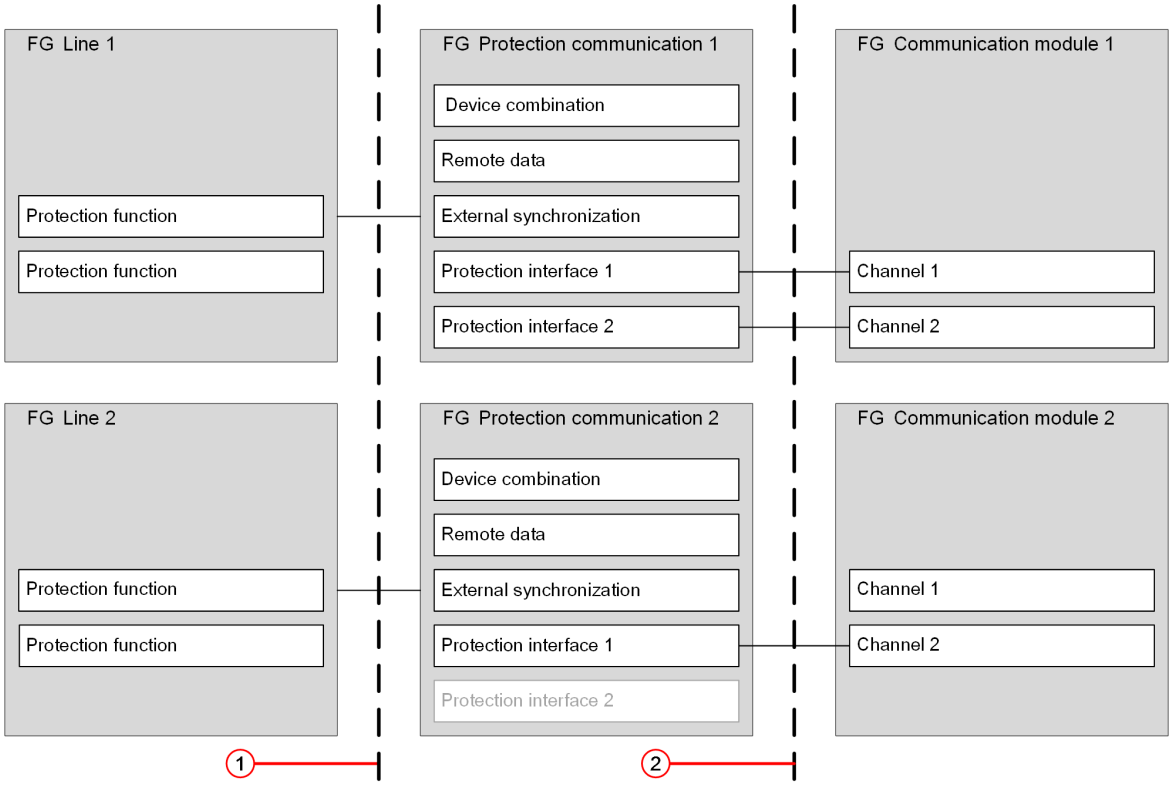
In the DIGSI 5 library, you can find the available function groups for the advanced protection communication in the **Advanced protection communication** folder. The following function-group types can be instantiated:

- FG **Protection communication type 1 (line differential protection)**
- FG **Protection communication type 2**

For configurations with line differential protection, instantiate the FG **Protection communication type 1 (line differential protection)**. In all other cases, instantiate the FG **Protection communication type 2**.

3.6.6.2 Advanced Protection Communication in the Overall System

The **Advanced protection communication** is integrated as follows in the overall system:



[dw_advanced_protcom_compl_system, 2, en_US]

Figure 3-94 Advanced Protection Communication in the Overall System

(1) The following applies for the FG **Line** and the FG **Voltage/Current 3-phase**: You must route the connection between the protection FG and the FG **Protection communication** in DIGSI 5.

(2) You must assign a channel to the protection interface, see *Parameter: PI assignment, Page 166*.

3.6.6.3 Structure of the FG Protection Communication

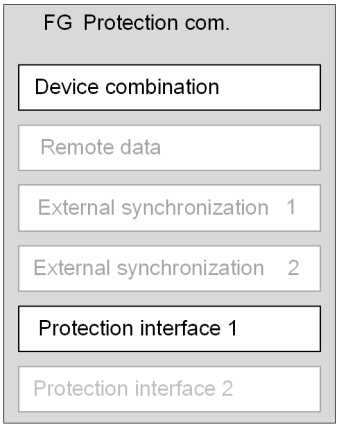
The instantiated FG **Protection communication** contains the FBs for a protection interface and for the device combination. If you need a 2nd protection interface, add another instance.

The FG **Protection communication** contains the following functionalities and function blocks (FB):

- FB **Device combination**
- FB for the **Protection interface**

In addition, the following FBs can be instantiated:

- A 2nd protection interface
  You can find the 2nd protection interface in the Global DIGSI 5 library under **Extended protection communication** > **Second protection interface**.
- 1 or 2 FBs for the **External synchronization** of the transmitted measured values by an external synchronization pulse (1-second pulse, PPS) or via the IEEE 1588 synchronization protocol
  You can find the FB **External synchronization** in the Global DIGSI 5 library under **Extended protection communication** > **Synchronization**.
- The FB **Remote data** is instantiated automatically, as soon as you configure remote data.



[dw_structure_FG_protcom_adv_without_phase_swap, 1, en_US]

Figure 3-95 Structure of the FG Extended Protection Communication

Device Combination

The function **Device combination** manages the devices that exchange data via the protection communication.

The following FBs are preconfigured in the device combination:

- FB **General**
- FBs for each device in the device combination

In the **Device combination**, you configure general settings for the protection communication and the device addresses. The function **Device combination** issues the following indications:

- General indications like the
  - Amount of devices
  - Type and status of the device topology

- Indications of the devices in the device combination like:
  - The availability of the device
  - The state of the device, that is whether the device is logged on or off in the device combination
  - Measured values of the device that have been recorded and synchronized through the device combination (constellation measured values)
  - Test of the function **Line differential protection** in the device combination (only for protection communication type 1)
  - Test of the function **Line differential protection** in the local device (only for protection communication type 1)

Protection Interface

The FB **Protection interface** transmits and receives signals and measured values to/from the partner device. For this, the protection interface uses the channel of a communication module.

External Synchronization

Measured values that are acquired and exchanged in the devices at the same time, with microsecond accuracy are transmitted via the protection communication. The measured values can be synchronized as follows:

- Internally via the telegram measurement with the Ping-Pong method
- Externally via
  - An external, synchronous pulse 1-second-pulse (PPS)
  - Via the **IEEE 1588** protocol

  If you want to use an external synchronization, you must instantiate the FB **External synchronization**.

  You can use a different synchronization procedure for the 2nd protection interface than for the 1st protection interface.

Remote Data

If you want to exchange selected and user-specific data or measured values via the protection communication, you must use the **Remote data** function. If you route a specific signal or a measured value to the protection communication, the device automatically creates the **Remote data** functionality. The routed signals are then transmitted and received via the protection interface. The available bandwidth limits the amount of remote data that can be transmitted.

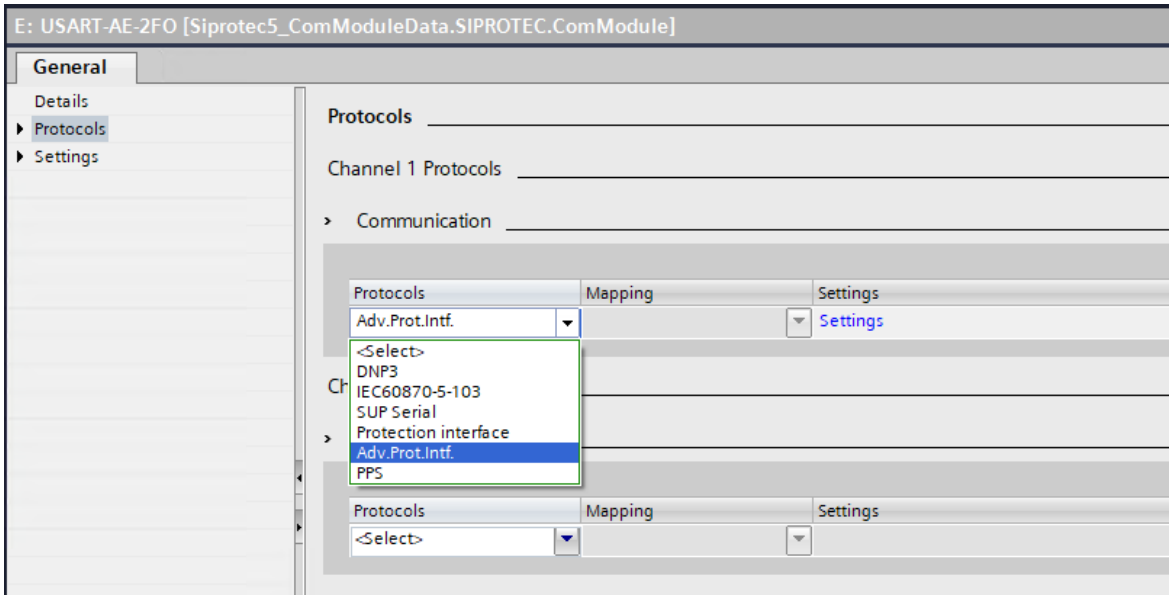
3.6.6.4 Configuration of the Advanced Protection Communication in DIGSI 5

Steps during Configuration

Siemens recommends the following procedure when configuring the advanced protection communication:

- Select the desired communication module.
- Select the protocol ***Adv.Prot.Intf.***.
- The further parameterization depends on the selected communication module and is described in the following under:
  - *Advanced Protection Interface for a USART Communication Module, Page 163*
  - *Advanced Protection Interface for an Ethernet-BD Communication Module, Page 165*

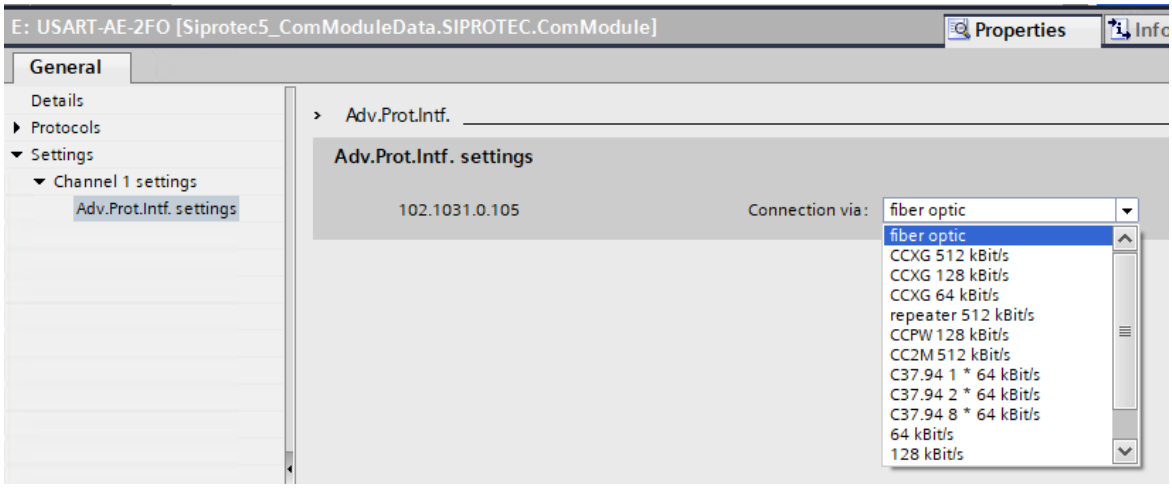
Advanced Protection Interface for a USART Communication Module



[sc_USART_01, 1, en_US]

Figure 3-96 USART Communication Module: Selection of the Protocol Advanced Protection Interface

After selecting the protocol, click **Settings** in the right column to get to the connection settings of the USART protection-interface module for channel 1.



[sc_USART_02, 1, en_US]

Figure 3-97 USART Communication Module: Settings for the Advanced Protection Interface

Parameter: Connection via

- 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 3-19 Communication Media

Communication Media	See	Setting Value	Bit Rate
Fiber-optic direct connection	*Figure 3-61* to *Figure 3-65*	***fiber optic***	2 MBit/s
CC-XG-512 communication converter	*Figure 3-66*	***CCXG 512 kBit/s***	512 kBit/s
CC-XG-128 communication converter	*Figure 3-66*	***CCXG 128 kBit/s***	128 kBit/s
CC-XG-64 communication converter	*Figure 3-66*	***CCXG 64 kBit/s***	64 kBit/s
Repeater 512 communication converter	*Figure 3-69*	***repeater 512 kBit/s***	512 kBit/s
CC-CC-128 communication converter	*Figure 3-68*	***CCPW 128 kBit/s***	128 kBit/s
CC-2M-512 communication converter	*Figure 3-67*	***CC2M 512 kBit/s***	512 kBit/s
Multiplexer with C37.94 interface	*Figure 3-70*	***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

Parameter: Multiplex operation

- Default setting **`(_:112) Multiplex operation`** = ***no***

With the parameter **`Multiplex operation`**, you can designate the physical channel for multiplex operation. You can then route 2 protection interfaces to this channel.

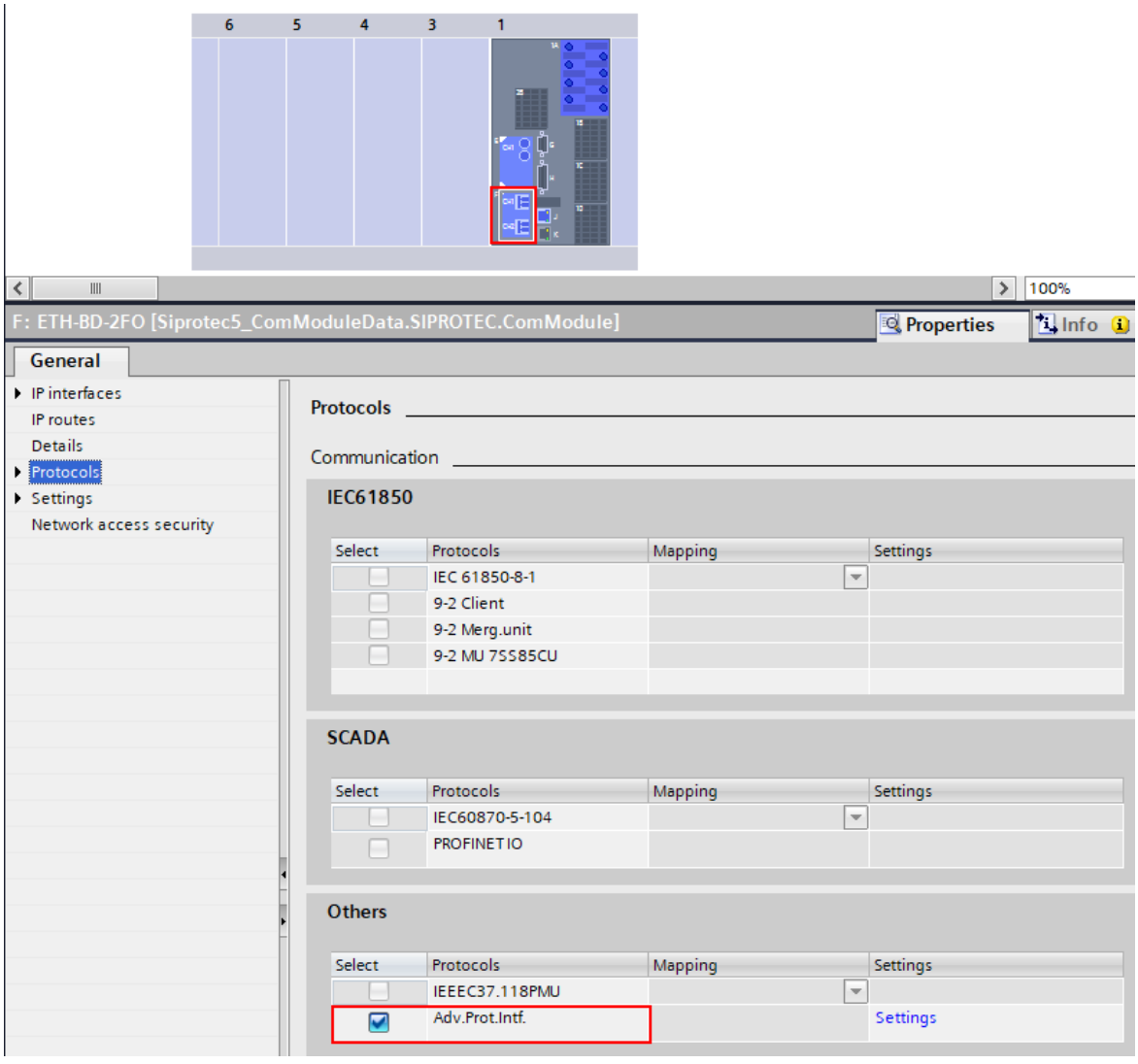
Refer to *3.6.3 Function Description*.



NOTE

For safety reasons, you cannot route 2 protection interfaces from the same device combination to one channel, as this results in apparent redundancy.

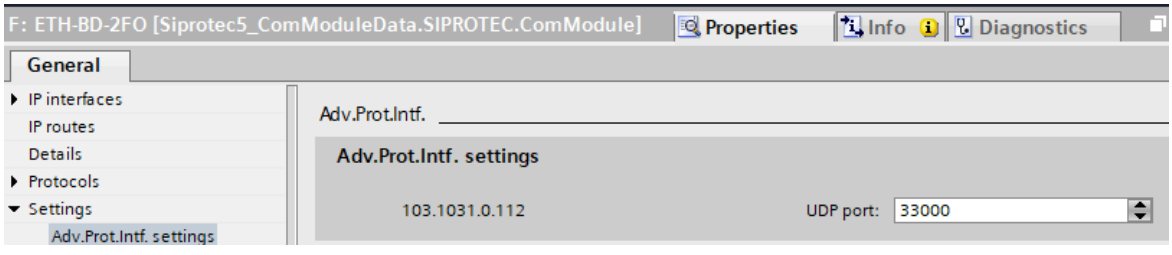
Advanced Protection Interface for an Ethernet-BD Communication Module



[sc_ETH-BD_01, 1, en_US]

Figure 3-98 Ethernet-BD Communication Module: Selection of the Protocol Advanced Protection Interface

After selecting the protocol, click **Settings** in the right column to get to the connection settings of the Ethernet-BD communication module for channel 1.



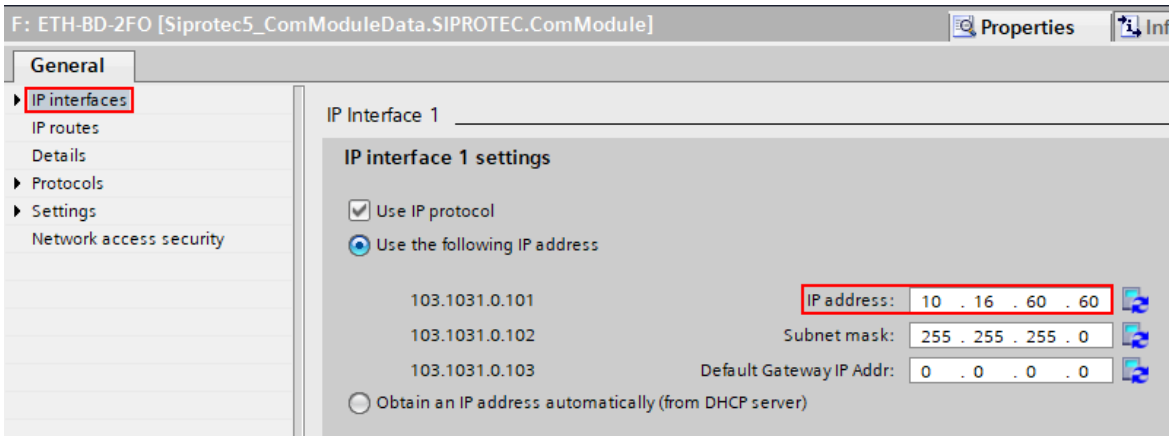
[sc_ETH-BD_02, 1, en_US]

Figure 3-99 Ethernet-BD Communication Module: Settings for the Advanced Protection Interface

Parameter: UDP Port

- Default setting **(_:112) User port** = ***33000***

With the **UDP port** parameter, you set the value of the destination port in the UDP header of the protection-interface IP messages. You must set the same value for the parameter **UDP port** for all protection devices of a device combination that use the IP-based protection interface. Different device combinations can use the same value for the **UDP port** parameter. Normally, the default setting can always be applied. It can be necessary, for example, due to firewall policies, to configure a UDP port that differs from the default setting.
Parameterize the IP address of the Ethernet-BD communication module in the properties of the module.



[sc_IPadr, 1, en_US]

Figure 3-100 Parameterization of the IP Address for the Ethernet-BD Communication Module

The configuration and parameterization of the protection-interface communication module is now complete.

3.6.6.5 Setting Notes for the Protection Interface

The chapters provides setting notes for the logical protection interface (FB **Protection interface**).

Parameter: PI assignment

- Default setting **(_:5161:120) PI assignment** = ***Setting options depend on configuration***

In addition, you must select the channel for the protection interface in DIGSI 5 as follows: **Project tree** > **Prot. com.** > **Prot. interf.**.
In the input area under **PI assignment**, select the channel of a communication module that supports the required protection-interface protocol. As a prerequisite for this, you must have selected the protocol ***Advanced protection interface*** for the channel of the desired communication module, see *3.6.6.4 Configuration of the Advanced Protection Communication in DIGSI 5*.

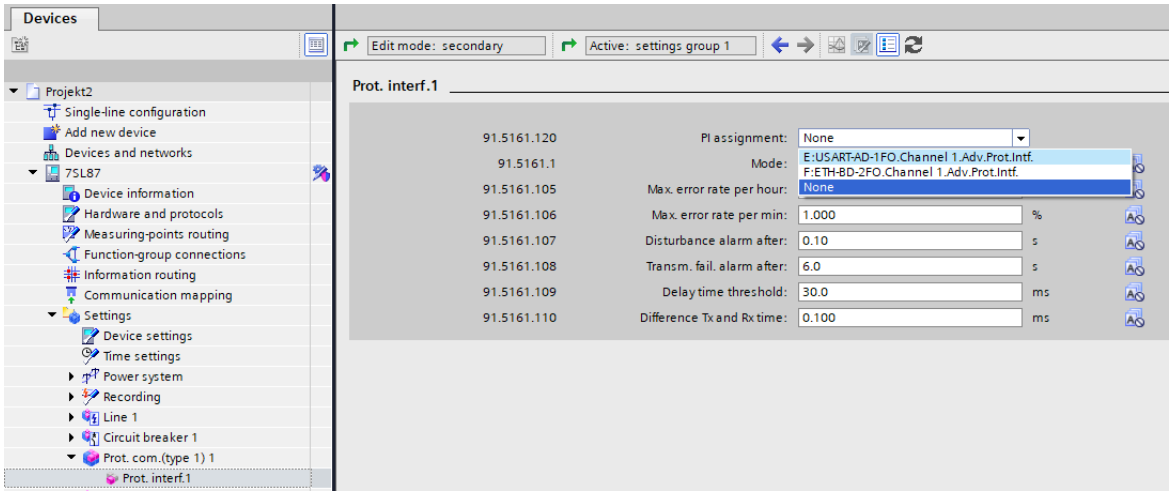


Figure 3-101 Assignment of the Protection-Interface Channel to the Protection Interface

Parameter: Max. error rate per hour

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

If the number of faulty telegrams per hour exceeds the value set in the parameter **Max. error rate per hour**, you receive the error message *Error rate / hour exc.*.

Parameter: Max. error rate per min

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

If the number of faulty telegrams per minute exceeds the value set in the parameter **Max. error rate per min**, you receive the error message *Error rate / min exc.*.

Parameter: Disturbance alarm after

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

With the parameter **Disturbance alarm after**, you determine the time delay after which faulty or missing telegrams are signaled as disturbed with the indication *Status of lay. 1 and 2 = PI data fault*.

Parameter: Transm. fail. alarm after

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

With the parameter **Transm. fail. alarm after**, you determine the time delay after which a communication failure is signaled with the indication *Status of lay. 1 and 2 = PI data failure*.

Parameter: Delay time threshold

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

The time taken to transmit and receive a signal via a protection connection is called the signal-transit time. You can monitor the signal-transit time. For the **Delay time threshold**, the default setting is selected in such a way that it is not exceeded by normal communication networks. If the signal-transit time is exceeded during operation (for example, upon switchover to another transmission path), the indication **Time delay exceeded** is issued.

Increased runtimes only affect the operate time, and therefore the fault-clearing time of the protection functions that use the protection interface. If you use the **Line differential protection** function, this remains in effect.

Parameter: Difference Tx and Rx time

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

For a time synchronization of the measured values with microsecond accuracy by means of telegram measurement, the signal-transit times in the transmission and receive direction must be approximately the same. The device monitors the signal-transit times in the transmission and reception direction.

With the **Difference Tx and Rx time** parameter, you can set a maximum permitted signal-transit time difference between the transmission and reception paths (runtimes unbalanced). Set the parameter **Difference Tx and Rx time** to the maximum difference expected.

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

If the difference in the signal-transit times between the transmission and reception path exceeds the set value, the indication *Time delay jump* is issued.

If the difference in the signal-transit times between the transmission and reception path exceeds the set value and remains for more than 5 s, the indication *Time delay different* is issued. The **Line differential protection** function is no longer working properly and is ***ineffective***.



NOTE

The**Difference Tx and Rx time** parameter only visible if the **Line differential protection** function is instantiated and the parameter **Synchronization** is not set to ***External synch. only***.



NOTE

If you use 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: Synchronization

- Default setting **(_:5161:113) Synchronization** = ***External synchron. off***

With the parameter **Synchronization**, you control the time synchronization of the measured values with microsecond accuracy.

The parameter **Synchronization** is only visible if you have instantiated the FB **External synchronization** from the Global DIGSI 5 library in the FG **Protection communication**.

If you have not instantiated the FB **External synchronization**, the measured values are time-synchronized internally with microsecond accuracy.

Parameter Value	Description
External synchron. off	The external synchronization is disabled: No external synchronization is performed on the protection interface. Select this setting value if you do not expect any differences between the signal-transit times in the transmission and reception directions. Then, the measured values are only synchronized internally with the telegram measurement.
Telegr. and ext. synch.	Synchronization via telegram measurement and external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver and configurable in the FB **External synchronization**. In this case, an existing line differential protection is only enabled when a new connection is established and one of the following conditions is met. • The protection connection is synchronized with the help of the external synchronization. • Symmetric signal-transit times are signaled via the binary input signal *<Sync-Reset* or the controllable ***Resetting sync.***. This means that the signal-transit times are the same in the send and receive direction.
Telegr. or ext. synch.	Telegram measurement or external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver and configurable in the FB **External synchronization**. An existing line differential protection is enabled immediately upon renewed establishment of a connection (data telegrams are received). The internal synchronization is used up to synchronization.
External synch. only	External synchronization only: The measured values are synchronized only via the external synchronization. You can set the external synchronization in the FB **External synchronization**. This enables synchronization via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver.

NOTE

If the protection interface is connected to a channel on a USART communication module (see *Parameter: PI assignment, Page 166*), the external synchronization is used to take into account the signal-transit times in the transmission and receive direction.

If the external synchronization fails for a short time, for example, due to a receiving interference or an unfavorable satellite position for a brief period, the internal synchronization via the telegram measurement is still active.

NOTE

If the protection interface is connected to a channel on an Ethernet-BD communication module (see *Parameter: PI assignment, Page 166*), the parameter **Synchronization** is permanently set to ***External synch. only***.

Parameter: FB External synchron.

- Default setting **(_:5161:117) FB External synchron.** = ***Ext. synchronization 1***

With the external synchronization, the time synchronization of the measured values with microsecond accuracy is possible through an external synchronization source.

The parameter **FB External synchron.** is only visible if you have instantiated at least 1 FB **External synchronization** from the Global DIGSI 5 library into the FG **Protection communication**. You can instantiate a maximum of 2 FBs for external synchronization.

With the parameter **FB External synchron.**, you specify whether the protection interface uses the FB **Ext. synchronization 1** or the FB **Ext. synchronization 2** for the synchronization. You parameterize the synchronization source in the corresponding FB **External synchronization**, see *3.6.6.9 Setting Notes for External Synchronization*.

NOTE

The external synchronization is possible separately for each protection interface.

Parameter: Check synchron.-source

- Default setting **(_:5161:121) Check synchron.-source** = ***yes***

With the parameter **Check synchron.-source**, you can switch the synchronization-sources check on or off. During the check of the synchronization sources on the ends of a protection connection, a check is conducted as to whether both synchronization sources are working in the same synchronization status ***SmpSynch***.

If both synchronization sources are working in the synchronization status ***SmpSynch*** = ***global***, the inspection has been passed.

If both synchronization sources are working in the synchronization status ***SmpSynch*** = ***local***, that is decoupled from a global reference time, an additional check is conducted as to whether the synchronization source (***gmIdentity***) is the same. Synchronicity can only be guaranteed if the synchronization sources are the same.

If the synchronization sources display a different synchronization status, that is one displays the synchronization status ***SmpSynch*** = ***local*** and the other the synchronization status ***SmpSynch*** = ***global***, synchronization cannot be guaranteed.

Siemens recommends using the default setting **Check synchron.-source** = ***yes***.

If you have problems with the synchronization-source check, you can switch off the synchronization-source check. Switch off the synchronization-source check only if the synchronization sources are synchronous at the end of their protection connection.

The parameter **Check synchron.-source** is visible only if the parameter **(_:5161:113) Synchronization** is set to ***External synch. only***.

NOTE

If you use **PPS electrical (port G)** as the synchronization source, the synchronization status (***SmpSynch***) is permanently set to ***global***.

If you use **PPS optical (USART)** as the synchronization source, you can use the parameter (_:107) **Received. SmpSynch** to set the synchronization status to (***SmpSynch***) ***local*** or ***global***.

For a synchronization with microsecond accuracy, for example, for the **Line differential protection**, set the parameter (_:107) **Received. SmpSynch** = ***global***.

3.6.6.6 Indications and Measured Values of the Advanced Protection Interface

Each individual protection interface provides different indications for commissioning and diagnostics of communication:

Indication *(_:5161:301) Status of lay. 1 and 2*

The indication *(_:5161:301) Status of lay. 1 and 2* informs you about the status of the connection. The following indications are possible:

Table 3-20 Status Indications Status of lay. 1 and 2

Indication	Description
initialized:	The protection interface is not connected and is in the Initial state.
PI connected:	The protection interface is connected to the protection interface of the partner device.
PI data fault:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:107) Disturbance alarm after**.
PI data failure:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:108) Transm. fail. alarm after**.
not existing:	The protection interface has not been assigned to a communication channel.

Indication *(_:5161:302) Status of lay. 3 and 4*

The indication *(_:5161:302) Status of lay. 3 and 4* informs about errors during the connection establishment. The following indications are possible:

Status indication	Description
no error:	No errors occurred during the connection establishment.
SW ver.incomp.:	The connection is not established because the firmware versions of the devices are incompatible. Update the firmware.
wrong dev. ID:	The connection is not established because the device address of the local device or the partner device is incorrect or set incorrectly. Check the settings for the parameters **Address of device 1** to **Address of device n** (_:5131:102 and following).
const.sett.error:	The connection is not established because the parameters are set differently. Check whether the parameter **(_:5131:122) Lowest appearing bit rate** has been set the same in all devices in the device combination.
diff.sett error:	The connection is not established because the parameters are set differently. 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 current of the line (parameter **(_:9001:101) Rated current**) must have the same setting in all devices. With a transformer in the line, the **(_:9001:103) Rated apparent power** must be set to the same value in all devices.
net mirroring	The connection is not established. The protection interface is receiving its own data. Check the wiring.
wrong dev. idx.	The connection is not established because the device index of the local device or the partner device is incorrect. Check the setting for the parameter **(_:5131:101) Local device is device**.

Furthermore, the following output signals are available:

Output Signal	Description
(_:5161:303) Connection broken	The signal *Connection broken* indicates that during a parameterized time (parameter **(_:5161:107) Disturbance alarm after**) no telegrams or faulty telegrams were continuously received. If the indication *Connection broken* is issued, the affected protection connection is reset. This can cause the blocking of an active line differential protection or a ring topology can change to a chain topology.
(_:5161:316) Error rate / min exc.	The 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. In this manner, a brief increase of the operate time and thus of the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:317) Error rate / hour exc.	The 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. In this manner, a brief increase in operate time and thus the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:318) Time delay exceeded	The signal *Time delay exceeded* indicates that the threshold value for the set signal runtime (parameter **(_:5161:109) Delay time threshold**) has been exceeded. Increased runtimes only affect the operate time, and therefore the fault-clearing time of the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:319) Time delay different	The signal *Time delay different* indicates that the threshold value for the difference in signal runtimes in the transmission and reception direction (asymmetrical runtimes) has been exceeded. The setting value results from the setting value of the parameter **(_:5161:110) Difference Tx and Rx time**. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***. If the indication *Time delay different* appears, the **Line differential protection** function is no longer working properly and is ***ineffective***.
(_:5161:320) Time delay jump	The signal *Time delay jump* indicates that the signal runtimes of the data changed abruptly. This is caused by a switchover of the communication path in the communication network. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.
(_:5161:321) PI synchronized	The signal *PI synchronized* indicates that the synchronization with microsecond accuracy of the measured values transferred between the local device and partner device is working correctly. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.
(_:5161:340) Telegram lost	The signal *Telegram lost* indicates that an expected telegram has failed to arrive or a faulty telegram has been received. If you want to assign the communication failures or faults to other events, route 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 problems.

Output Signal	Description
(_:5161:343) Partner	The indication shows the address of the partner device. A value of 0 means that no partner address is available.
(_:5161:323) PPS: time del. unsym.	This indication is only visible if you are working with a synchronous pulse. The indication shows that the difference in the signal runtimes between the sending and receiving path exceeds the value set with the parameter **(_:5161:110) Difference Tx and Rx time**. **Note:** The **Line differential protection** function remains ***effective***.
(_:5161:324) PI with PPS synchron.	This indication is only visible if you are working with a synchronous pulse. This indication is only visible if, in parallel to synchronization with the synchronization pulse, you are also working with the synchronization via telegram measurement. If both synchronization methods are working properly, the indication *PI with PPS synchron.* = RAISING is generated.

Measured Values of the Protection Interface

The protection interface provides the following measured value for the diagnosis of the protection-interface communication:

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams transmitted during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams transmitted 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	Receive error rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute
(_:5161:315) Rx err/min	Receive error rate during the last minute
(_:5161:325) Aver.Δt	Average signal runtime (average value of the runtime in transmission and reception direction divided by 2, without external synchronization)
(_:5161:326) Rec. Δt	Signal runtime for reception path (with external synchronization)
(_:5161:327) Sen. Δt	Signal runtime for transmission path (with external 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
(_:5161:331) Recept.	Receipt of a telegram (0 = no receipt, 1 = receipt) You can use this indication to make the telegram exchange visible in the fault record.



NOTE

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

3.6.6.7 Setting Notes for the Device Combination

In the **Project tree** > **Settings** > **Protection comm. (type 1)** or **Protection comm. (type 2)**, select the function block **Device combination**. In the input area, you parameterize the general settings for the device combination, instantiate the number of devices in the device combination, and set the parameters for each device. A device combination consists of at least 2 devices.

Parameter: Local device is device

- Default setting **(_:2311:101) Local device is device** = ***1***

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

Parameter: Lowest appearing bit rate

- Default setting **(_:2311:122) Lowest appearing bit rate** = ***64 kBit/s***

With the parameter **Lowest appearing bit rate**, you set the lowest bit rate occurring in the device combination. This value determines the maximum number of signals and measured values to be transferred in the **Remote data** function within the device combination.

EXAMPLE:

For a device combination consisting of 3 devices in a ring topology with 2 fiber-optic connections (2 MBit/s) and a 64-kBit/s connection, set the smallest value (64 kBit/s) in each device.

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

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

NOTE

If you use optical fibers for all protection connections, set the value to ***2048 kBit/s***.

Connection mode

- Default setting **(_:2311:126) Connection mode** = ***SIPROTEC 5***

With the parameter **Connection mode**, you select the device type with which the SIPROTEC 5 device works in the device combination via the protection connections.

NOTE

As soon as a SIPROTEC 4 device is present in the device combination, the SIPROTEC 5 devices must operate in a compatibility mode. For this reason, the parameter **Connection mode** must be set to the same value in all SIPROTEC 5 devices in the device combination. Select the type of SIPROTEC 4 device from the following table:

Parameter Value	Description
SIPROTEC 5	The SIPROTEC 5 device works with a SIPROTEC 5 device in the device combination.
SIPROTEC 4 7SD610	The SIPROTEC 5 device works with a SIPROTEC 4 differential protection device 7SD610 with firmware version V4.72 and higher in the device combination.
SIPROTEC 4 7SD5	The SIPROTEC 5 device works with a SIPROTEC 4 differential protection device 7SD5x with firmware version V4.72 and higher in the device combination.
SIPROTEC 4 7SA5/6	The SIPROTEC 5 device works with a SIPROTEC 4 distance protection device 7SA522 and 7SA6x with firmware version V4.70 and higher in the device combination.

Parameter: Dev. comb. is time source

- Default setting **(_:2311:129) Dev. comb. is time source** = ***yes***

The parameter **Dev. comb. is time source** is only visible if you have instantiated several function groups **Protection comm.** and you have selected the setting value ***PI*** for the parameters **Time source 1** or **Time source 2**.

The parameter **Dev. comb. is time source** determines from which FG **Protection comm.** the time is taken over.

Parameter: Protection com.

- Default setting **(_:2311:128) Protection com.** = ***Type 1 (Line diff. prot.)***

The parameter **Protection com.** is write-protected and displays only the type of the instantiated device combination.

The device combination ***Type 1 (Line diff. prot.)*** supports the function **Line differential protection**. The device combination ***Type 2 (no Line diff. pr.)*** does not support the function **Line differential protection**.



NOTE

In the Global DIGSI 5 library, the function groups **Protection communication type 1 (line diff. protection)** and **Protection com. Type 2** are available for the advanced protection communication. When instantiating the respective function group, the corresponding type of the device combination is automatically pre-instantiated.



NOTE

If you have instantiated the FG **Protection com. Type 2**, the **Device combination Type 2** is automatically pre-instantiated in this FG and the **Line differential protection** function is not supported.

If you subsequently want to use the **Line differential protection** function in the device combination of the FG **Protection com. Type 2**, proceed as follows:

- In the DIGSI 5 project tree, delete the function block **Device combination** from the **FG protection comm. (type 2)**.
- Instantiate the function block **Device combination type 1 (line diff. protection)** from the Global DIGSI 5 library into the FG **Protection com. Type 2**.
- Parameterize the **device combination** in the input area again.
- Reroute the indications of the device combination in the DIGSI 5 information routing.

All other parameterizations and routings are retained!

Parameter: Device index

- Default setting **(_:22711:101) Device index** = ***1***
- Default setting **(_:22712:101) Device index** = ***2***
- Default setting **(_:22713:101) Device index** = ***3***
- Default setting **(_:22714:101) Device index** = ***4***
- Default setting **(_:22715:101) Device index** = ***5***
- Default setting **(_:22716:101) Device index** = ***6***

The value of the parameter **Device index** is the number of the device in the device combination. Set the device index in all devices of a device combination for the same devices in the same way. The device indices must start with 1 and be incremented continuously. DIGSI 5 assigns the device indices automatically. You can change the device indices if necessary.

NOTE

The device with the **Device index** = ***1*** is the timing-master device in a device combination.

If all other devices in the device combination are to obtain their time from the timing-master device, consider the following

- Set the **Device index** to ***1*** for the timing-master device.
- Parameterize the other devices in such a way that they get their time from the timing-master device via the protection connections.

  For more information, refer to *3.7.3 Function Description*. Select ***Protection interface*** as the adjustable synchronization option.

  In the timing-master device, you must **not** set the protection interface as the synchronization source!

Parameter: Address in Device combi.

- Default setting **(_:22711:102) Address in Device combi.** = ***101***
- Default setting **(_:22712:102) Address in Device combi.** = ***102***
- Default setting **(_:22713:102) Address in Device combi.** = ***103***
- Default setting **(_:22714:102) Address in Device combi.** = ***104***
- Default setting **(_:22715:102) Address in Device combi.** = ***105***
- Default setting **(_:22716:102) Address in Device combi.** = ***106***

With the parameter **Address in Device combi.**, you assign a unique and unambiguous address for each device.

NOTE

If the preset values do not fit, Siemens recommends the following procedure:

Define a number for the device combination that is unambiguous in your area of responsibility and that must be at least 2 digits, for example, 100. The setting value of the parameter **Address in Device combi.** is then calculated as follows: **Number in the device combination** + **Device index**.

For device **2**, this leads to **Address in Device combi.** = ***102***.

Parameter: IP Address

- Default setting **(_:22711.103) IP address** = ***0.0.0.0***
- Default setting **(_:22712.103) IP address** = ***0.0.0.0***
- Default setting **(_:22713.103) IP address** = ***0.0.0.0***
- Default setting **(_:22714.103) IP address** = ***0.0.0.0***
- Default setting **(_:22715.103) IP address** = ***0.0.0.0***
- Default setting **(_:22716.103) IP address** = ***0.0.0.0***

The IP address of the local device is taken from the settings of the Ethernet-BD communication module and displayed. The local IP address cannot be edited at this point.

NOTE

If all devices of a device combination are equipped with an Ethernet-BD communication module and use the IP communication, you must enter the IP addresses for all other devices in the device combination here. The topology detection automatically sets a ring or chain topology.

NOTE

If you have a hybrid configuration, that is not all protection connections of a device combination use the IP communication, you must observe the following when setting the IP addresses:

- The topology detection does not generate the topology automatically.
- First define the order for the communication between the devices. Define chain or ring topologies for this purpose.

  The defined topology results in the partner devices for each device, with which the device communicates directly.

  Only set the IP addresses for the partner devices that are equipped with an Ethernet-BD communication module here.
- You can find examples of the parameterization of the IP addresses in hybrid configurations in the chapters *3.6.8.4 Device Combination of 3 Devices and Hybrid Communication Media* and *3.6.8.5 Device Combination of 6 Devices and Hybrid Communication Media*.

Indications and Measured Values in the Device Combination

Indication	Meaning
(_:3321:2311:301) Status of topo. recog.	The devices form a topology via the protection connections. This indication shows the status of the topology detection and can have the following values: • *Unknown*: The topology is unknown. • *Invalid*: The detected topology is not supported. • *Transient*: The topology has just been modified. • *Valid*: The topology has been detected. The indication *Devices form* shows the type of the detected topology.
(_:3321:2311:302) Topology is	The indication shows whether all configured devices in the device combination communicate with each other via the protection connections. The indication can have the following values: • *Unknown*: The topology is unknown. • *Incomplete*: At least one device in the device combination does not communicate via the protection connections. • *Complete*: All configured devices in the device combination communicate via the protection connections.

Indication	Meaning
(_:3321:2311:303) Devices form	This indication shows the type of the detected topology that the devices in the device combination form via the protection connections. The indication can have the following values: • *Unknown topol*: The topology is unknown. • *Chain topology*: The devices and their protection connections form a chain topology. • *Ring topology* The devices and their protection connections form a ring topology.
(_:3321:2311:304) Number of detect. dev.	The indication shows the number of devices that communicate via the protection connections in the device combination.

Indication and Measured Values of the Devices

The following indications and measured values are displayed for each device in the device combination and are explained using the example of a device.

Indication	Meaning
(_:22711:300) Dev.addr.	This indication shows the address of the device.
(_:22711:318) is present	This indication shows whether the device is involved in protection communication.
(_:22711:317) is logged off	This indication shows whether the local device has been logged off. If the device has been logged off, it is no longer involved in communication via the protection interfaces. If a device has been logged off, information relevant for the protection functions is no longer exchanged.
(_:22711:301) circuit breaker	This indication shows the position of the circuit breaker and can have the following values: • *0*: The switch position of the circuit breaker is unknown. • *1* The circuit breaker is open. • *2* The circuit breaker is closed.
(_:22711:328) Line diff. test [12]	This message indicates whether the function **Line differential protection** is in the state ***Test*** or ***Test/Relay blk.***.
(_:22711:329) Local Line diff. test [12]	This message indicates whether the function **Line differential protection** is in the special test mode *Test local device*.

3.6.6.8 Constellation Measured Values for Type 1 and Type 2

NOTE

The constellation measured values are only available for the FG **Line**.

Each device in the device combination determines measured values predefined by Siemens, known as constellation measured values. You can find the constellation measured values in the DIGSI 5 information routing under the FG **Protection comm. (Type x)** > **Device combination** > **Device x**. The following measured values and indications are issued for each device:

12 This message is only available in the FG Protection communication type 1 (line diff. protection).

Measured value	Meaning
(_:3321:22711:302) Vph	This measured value shows the voltage of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:3321:22711:303) Iph	This measured value shows the current of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:3321:22711:304) f	The measured value supplies the locally calculated frequency of the measured voltage or the current.

The constellation measured values have the following properties:

- They are synchronized in the devices in a device combination.
- They are substituted using the protection interface.
- They are available on every device.

You can view the constellation measured values with DIGSI 5.

In the device, current and voltage measured values are displayed in absolute value and phase as a percentage. 100 % conform to the rated current or the rated voltage of the line (see *Figure 3-102*). These measured values are recorded every 2 seconds by the devices involved in the device combination and then sent to the other respective devices. At the same time, the current and voltage values of the different devices are time-synchronous with one another.

When displaying the constellation measured values the local device is prioritized. The device connected directly with DIGSI 5 is the local device.

The reference of the angle information depends on whether a line differential protection has been instantiated in the FG **Line**. If a line differential protection is instantiated, the protection communication is type 1, otherwise type 2.

- Protection communication **Type 1**:
  - The angle values of the voltages show the angle difference between the local and the remote voltage. The local voltage serves as the reference with an angle of 0°.
  - The angle values of the currents show the angle difference between the local and the remote current. The local current serves as the reference with an angle of 0°.
- Protection communication **Type 2**:
  The angles of the phase-to-ground voltages and the phase currents relate to the voltage V_A of the relevant device.

You can find these measured values in the device under the following DIGSI mask:

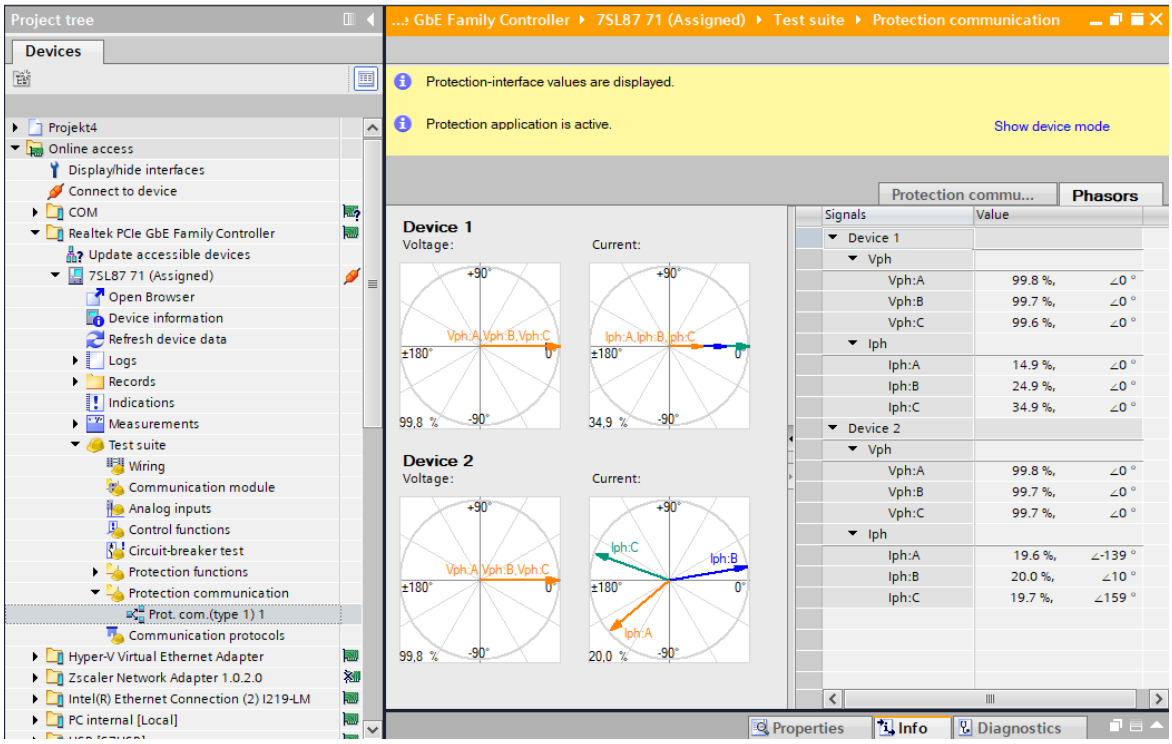


Figure 3-102 Example of Constellation Measured Values with Phases

3.6.6.9 Setting Notes for External Synchronization

With the FB **External synchronization**, you can synchronize the measured values of the devices connected via protection connections with microsecond accuracy using external synchronization sources (1*10E-06 s).

The measured values transmitted via protection communication for the line differential protection must be time-synchronized. The synchronization is possible as follows:

- Internally via telegram measurement
- Externally via the IEEE 1588 protocol
- Externally via a synchronous pulse from a satellite receiver

If you use Ethernet-BD communication modules for the protection communication of the line differential protection, the external synchronization of the measured values transmitted via the protection interface is mandatory.

If you use USART communication modules, you can synchronize the transmitted measured values either internally via telegram measurement or via external synchronization. If you do not use the external synchronization, the device automatically uses the internal synchronization.

If you want to use the external synchronization of the measured values, you must instantiate the FB **External synchronization** from the Global DIGSI 5 library into the FG **Protection comm.**. You can find the **External synchronization** in the Global DIGSI 5 library under **Advanced protection communication** > **Synchronization**.

The external synchronization is possible for line differential protection applications or synchrophasor measuring devices as follows:

- Via a high-precision electrical synchronous pulse (***PPS electrical (Port G)***, 1-second pulse) from a satellite receiver at the time-synchronization interface (Port **G**)
- Via a high-precision optical synchronous pulse (***PPS optical (USART)***, 1-second pulse) from a satellite receiver at a USART communication module
- Via the ***IEEE 1588*** time-synchronization protocol

With external synchronization, you can measure and display the signal-transit time of the transmission and receive path separately. This allows you to achieve maximum sensitivity even with unequal (unbalanced) signal-transit times in communication networks with the line differential protection. For the transmission of protection data in the **type 2** protection communication, different signal-transit times do not play a role.

If an FB **External synchronization** is instantiated, the parameter **Synchronization** is visible in the FB **Protection interf.**. With this parameter, you establish the connection between the protection interface and the type of external synchronization. See *3.6.6.5 Setting Notes for the Protection Interface*.

If you use 2 protection interfaces in the FG **Protection comm.**, you can set a different synchronization source for each protection interface if required. For this use case, you must instantiate 2 FBs **External synchronization** into the FG **Protection comm.** and set the desired synchronization source separately.

Parameter: Name of synchron. block

- Default setting **(_:101) Name of synchron. block** = ***Ext. synchronization 1***

The parameter **FB External synchron.** shows the name of the FB **External synchronization**.

If you have instantiated 2 FBs **External synchronization** into the FG **Protection comm.**, you can use this parameter to switch between the FB ***Ext. synchronization 1*** and the FB ***Ext. synchronization 2***.

Parameter: Synchronization source

- Default setting **(_:117) Synchronization source** = ***nothing***

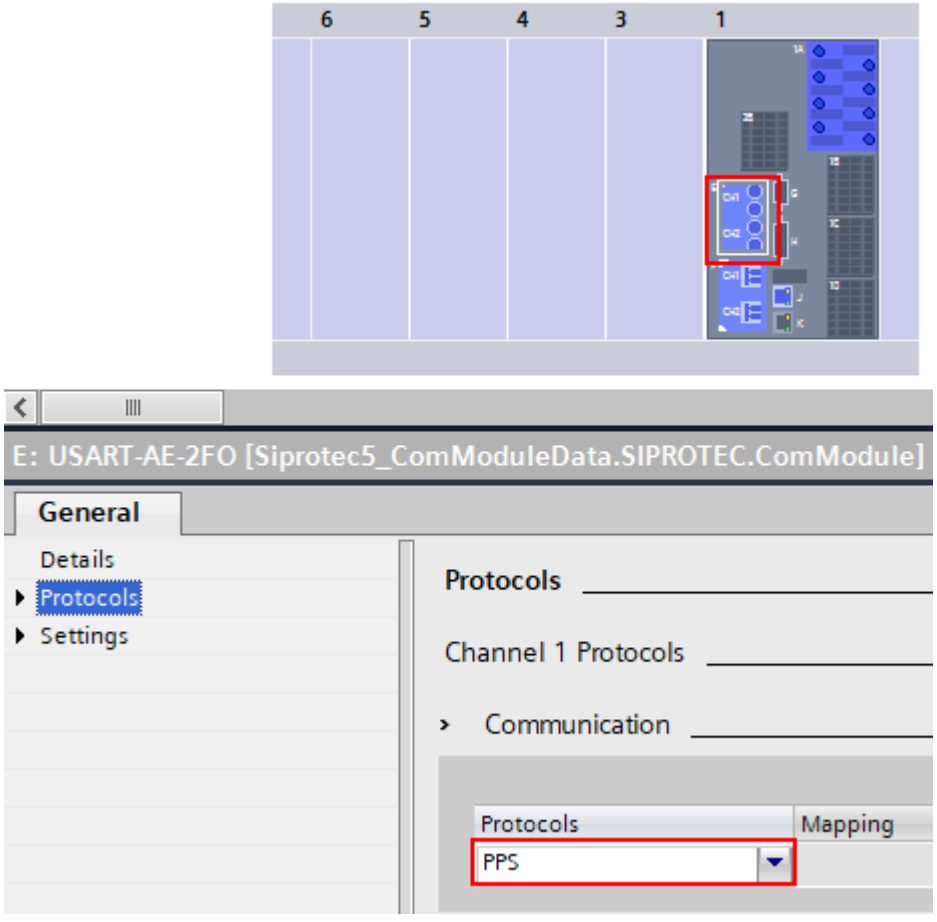
With the parameter **Synchronization source**, you select the desired synchronization source for the external synchronization of the measured values.



NOTE

The possible setting options of the parameter **Synchronization source** depend on the configuration of the protocol for the respective channel of the communication module.

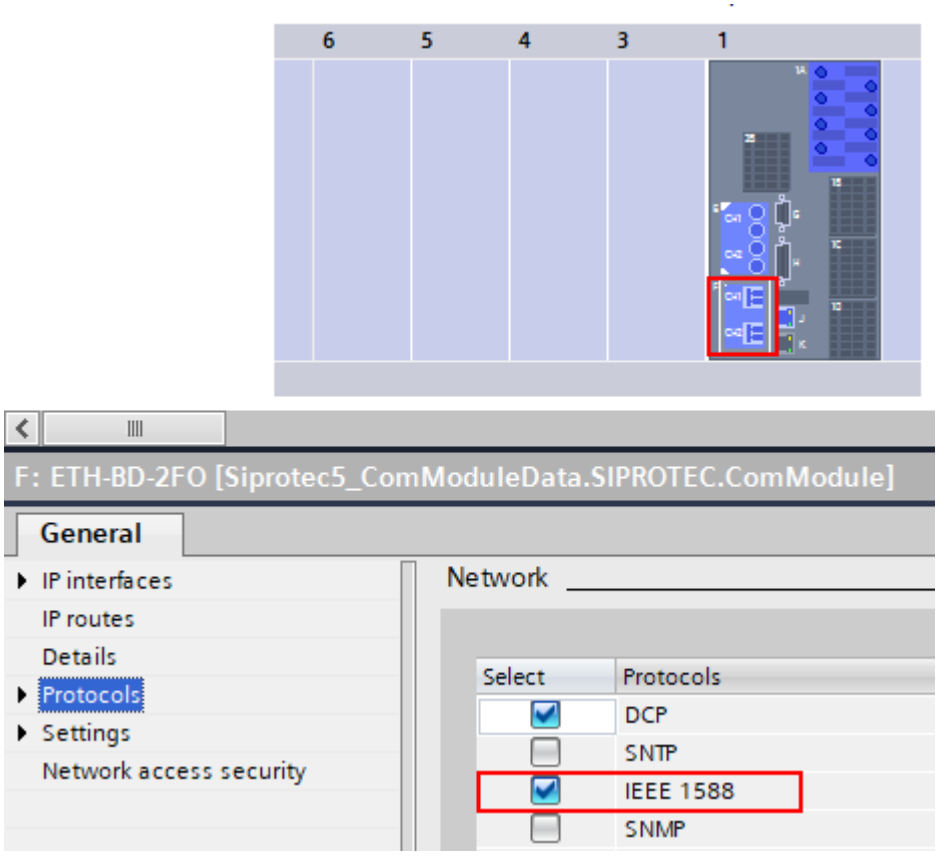
To display the selection text for the selection of an optical synchronous pulse, you must configure the protocol **PPS** on a USART communication module as follows:



[sc_PPS, 1, en_US]

Figure 3-103 Configuration of the Optical Synchronous Pulse (PPS) on a Channel of a USART Communication Module

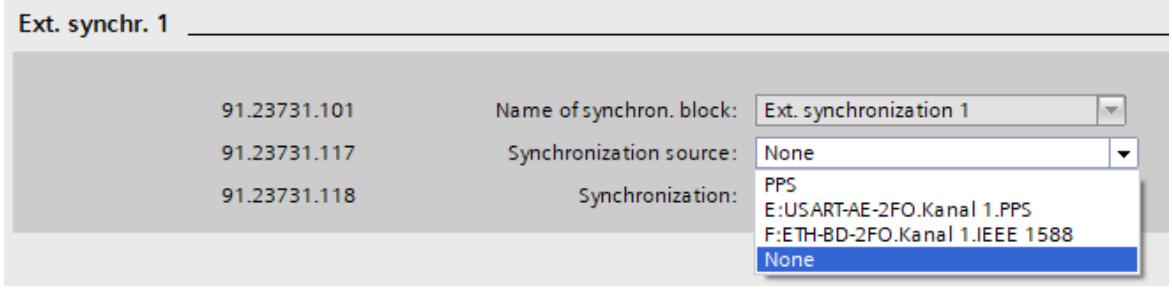
To display the selection text for the selection of the protocol IEEE 1588, you must configure the protocol **IEEE 1588** on an Ethernet-BD communication module as follows:



[sc_1588, 1, en_US]

Figure 3-104 Configuration of the Protocol IEEE 1588 on an Ethernet-BD Communication Module

The setting options for the parameter **`Synchronization source`** then look as follows, for example:



[sc_syncopt, 1, en_US]

Figure 3-105 Possible Setting Options for the Synchronization Source

Depending on the configuration, the following synchronization sources are displayed:

Parameter Value	Description
G:Timesynchron..PPS	The electrical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) at the time-synchronization interface Port G is the synchronization source.
[Port]:USART-AD-1FO.Channel 1.PPS	The optical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) on channel 1 of a USART communication module is the synchronization source.

Parameter Value	Description
[Port]:USART-AE-2FO.Channel 2.PPS	The optical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) on channel 2 of a USART communication module is the synchronization source.
[Port]:ETH-BD-2FO.Channel 1.IEEE 1588	The time-synchronization standard IEEE 1588 on an Ethernet-BD communication module is the synchronization source.



NOTE

You can select different synchronization sources for the same protection connection in the devices involved, for example, the synchronization via the **IEEE 1588** protocol in device **1** and via the protocol **PPS** electrical in device **2**.

Siemens recommends using the same synchronization source for the same protection connection. If it is not possible to use the same synchronization source, check the differential current in the line differential protection in the mode **Test on all devices**. If the differential current is not in the expected range, the set synchronization sources are not synchronous to each other and therefore not usable.



NOTE

For detailed information on the communication protocols, refer to the SIPROTEC 5 manual Communication Protocols.

Parameter: Synchronization using

- Default setting **(_:118) Synchronization using** = ***nothing***

This parameter **Synchronization using** cannot be adjusted. The parameter shows further information for the selected synchronization source:

Parameter Value	Description
nothing	You have not selected any external synchronization source.
PPS electrical (Port G)	The electrical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) at the time-synchronization interface Port **G** is the synchronization source.
PPS optical (USART)	The optical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) on channel 1 of a USART communication module is the synchronization source.
IEEE 1588	The time-synchronization standard IEEE 1588 on a BD communication module is the synchronization source.

Parameter: Max. inaccuracy

- Default setting **(_:119) Max. inaccuracy** = ***0.500 ms***

With the **Max. inaccuracy** parameter, you set the maximum expected inaccuracy of the synchronization sourced used. The set value is only effective if the synchronization source used does not supply any information on the current inaccuracy in the synchronization signals. If you no information on the inaccuracy of the synchronization source used, use the default setting.



NOTE

The inaccuracy of the synchronization source enters the stabilization of the **Line differential protection** as an error signal.

This means that greater inaccuracy increases the calculated stabilization quantity and makes the **Line differential protection** less sensitive.

If **IEEE 1588** is used as the synchronization source in the synchronization status ***SmpSynch*** = ***global***, accuracy values are supplied with the synchronization signals and the parameter **Max. inaccuracy** is not

used. If the supplied accuracy values become invalid, the value set in the parameter **Max. inaccuracy** is used.

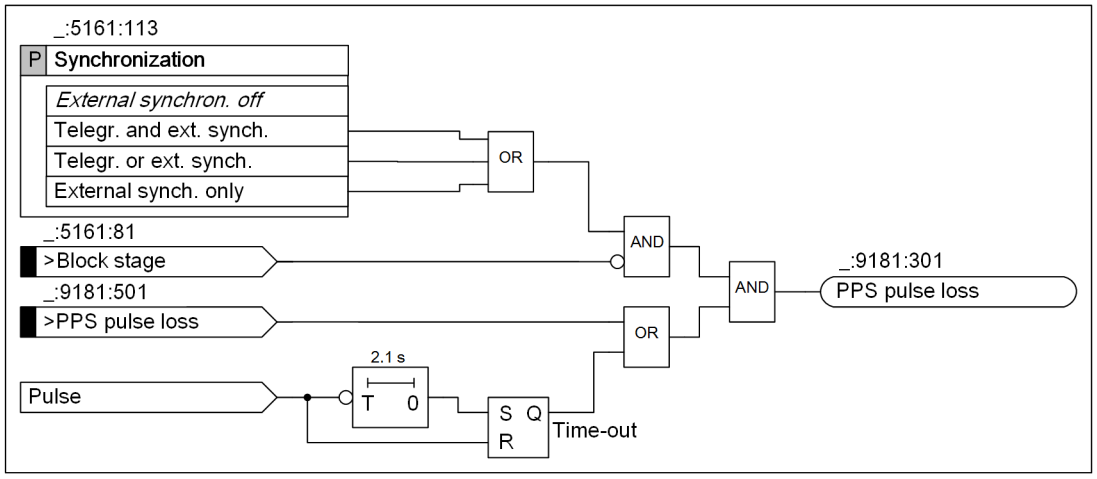
If the synchronization source **IEEE 1588** works in the synchronization status ***SmpSynch*** = ***local***, then the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

If **PPS electrical (Port G)** or **PPS optical (USART)** are used as synchronization source, then the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

If a USART communication module with the **PPS** protocol and the **PPS generator** operating mode is also used as a synchronization source at the same time, the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

3.6.6.10 Indications and Measured Values of the External Synchronization

Indication	Description
(_:501) >PPS pulse loss	The indication *(_:501) >PPS pulse loss* is only visible with the following setting options of the parameter **(_:117) Synchronization source**: • G:Timesynchron.PPS • [Port]:USART-AD-1FO.Channel x.PPS • [Port]:USART-AE-2FO.Channel x.PPS The binary input *(_:501) >PPS pulse loss* can be used to signal an externally detected failure in the PPS synchronous pulse, for example, an error message from the satellite receiver. If the binary input *(_:501) >PPS pulse loss* is set, this leads to the indication *(_:304) Synchronization loss*. The external synchronization detects immediately that there is a problem with the connected synchronization pulse. Otherwise, the problem will only be noticed after approx. 2.1 s – after the test for synchronous-pulse failure.
(_:304) Synchronization loss	The synchronization has failed. This can be due to a problem with the synchronization source. The indication *(_:304) Synchronization loss* shows that the synchronization has failed. This can be due to the following reasons: • The input indication *(_:501) >PPS pulse loss* has occurred. • The synchronous pulse has failed. • The quality of the synchronous pulse is inadequate. • There is another problem with the synchronization source.
(_:305) Synchronization OK	The synchronization is operating correctly.
(_:306) Synchronization pulse	You can use this indication to make the synchronous pulse visible. As a rule, one pulse is generated per second.
(_:307) Synchron. imprecise	If the set synchronization source operates in the ***global*** synchronization status and the time of the synchronization source deviates from the global time by more than 0.5 ms, the indication *Synchron. imprecise* is generated and the line differential protection becomes ineffective. The indication *Synchron. imprecise* is visible if you select ***ETH-BD-2FO.Channel1.IEEE1588*** in the parameter _:103 Synchronization source. The read-only parameter **(_:118) Synchronization using** then displays ***IEEE 1588***.



[lo_pps_syn, 2, en_US]

Figure 3-106 Logic for the Generation of the Indication *>PPS pulse loss*

3.6.6.11 Setting Notes for the Remote Data

Parameter: Dropout Time Prio. x

- Default setting **(_:22741:111) Dropout time prio. 1** = ***2.00 s***
- Default setting **(_:22741:112) Dropout time prio. 2** = ***2.00 s***
- Default setting **(_:22741:113) Dropout time prio. 3** = ***2.00 s***

If you use user-specific remote data, you can set how long the last received state of your remote data is held in case of a communication failure. This allows you to bridge short-term communication failures. The time can be set separately for each priority of the remote data.

3.6.6.12 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Remote data				
_:22741:111	Remote data:Dropout time prio. 1		0.00 s to 300.00 s	2.00 s
_:22741:112	Remote data:Dropout time prio. 2		0.00 s to 300.00 s	2.00 s
_:22741:113	Remote data:Dropout time prio. 3		0.00 s to 300.00 s	2.00 s
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:Distur-bance 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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:Synchronization		• External synchron. off • Telegr. and ext. synch. • Telegr. or ext. synch. • External synch. only	External synchron. off
_:5161:117	Prot. interf.1:FB External synchron.		• Ext. synchronization 1 • Ext. synchronization 2	Ext. synchronization 1
_:5161:120	Prot. interf.1:Check synchron.-source		• no • yes	yes
_:5161:120	Prot. interf.1:PI assignment		Setting options depend on configuration	

3.6.6.13 Information List

No.	Information	Data Class (Type)	Type
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
_:5161:323	Prot. interf.1:PPS: time del. unsym.	SPS	O
_:5161:324	Prot. interf.1:PI with PPS synchron.	SPS	O
_:5161:343	Prot. interf.1:Partner	INS	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

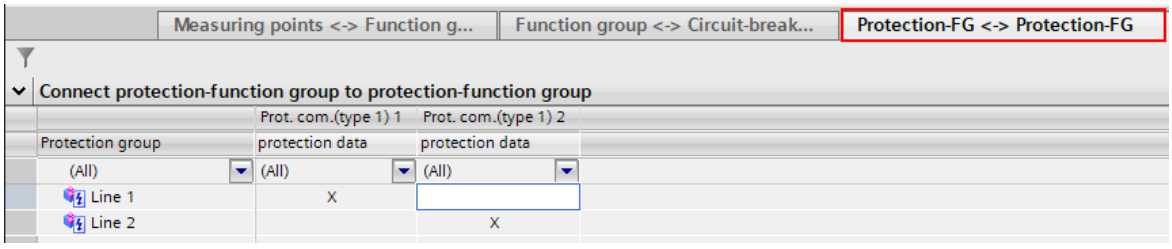
No.	Information	Data Class (Type)	Type
_:5161:337	Prot. interf.1:Miss.tel/w	MV	O
_:5161:338	Prot. interf.1:M. loss/d	MV	O
_:5161:339	Prot. interf.1:M. loss/w	MV	O
_:5161:331	Prot. interf.1:Recept.	MV	O
_:5161:325	Prot. interf.1:Aver.Δt	MV	O
_:5161:326	Prot. interf.1:Rec. Δt	MV	O
_:5161:327	Prot. interf.1:Sen. Δt	MV	O
Prot.interf.1B			
_:23461:81	Prot.interf.1B:>Block stage	SPS	I
_:23461:500	Prot.interf.1B:>Sync reset	SPS	I
_:23461:341	Prot.interf.1B:Reset synchronization	SPC	C
_:23461:342	Prot.interf.1B:Reset measurements	SPC	C
_:23461:52	Prot.interf.1B:Behavior	ENS	O
_:23461:53	Prot.interf.1B:Health	ENS	O
_:23461:301	Prot.interf.1B:Status of lay. 1 and 2	ENS	O
_:23461:302	Prot.interf.1B:Status of lay. 3 and 4	ENS	O
_:23461:303	Prot.interf.1B:Connection broken	SPS	O
_:23461:316	Prot.interf.1B:Error rate / min exc.	SPS	O
_:23461:317	Prot.interf.1B:Error rate / hour exc.	SPS	O
_:23461:318	Prot.interf.1B:Time delay exceeded	SPS	O
_:23461:340	Prot.interf.1B:Telegram lost	SPS	O
_:23461:323	Prot.interf.1B:PPS: time del. unsym.	SPS	O
_:23461:324	Prot.interf.1B:PI with PPS synchron.	SPS	O
_:23461:343	Prot.interf.1B:Partner	INS	O
_:23461:308	Prot.interf.1B:Tx tel/h	MV	O
_:23461:309	Prot.interf.1B:Rx tel/h	MV	O
_:23461:310	Prot.interf.1B:Tx tel/min	MV	O
_:23461:311	Prot.interf.1B:Rx tel/min	MV	O
_:23461:312	Prot.interf.1B:Tx err/h	MV	O
_:23461:313	Prot.interf.1B:Rx err/h	MV	O
_:23461:314	Prot.interf.1B:Tx err/min	MV	O
_:23461:315	Prot.interf.1B:Rx err/min	MV	O
_:23461:334	Prot.interf.1B:Miss.tel/min	MV	O
_:23461:335	Prot.interf.1B:Miss.tel/h	MV	O
_:23461:336	Prot.interf.1B:Miss.tel/d	MV	O
_:23461:337	Prot.interf.1B:Miss.tel/w	MV	O
_:23461:338	Prot.interf.1B:M. loss/d	MV	O
_:23461:339	Prot.interf.1B:M. loss/w	MV	O
_:23461:331	Prot.interf.1B:Recept.	MV	O
_:23461:325	Prot.interf.1B:Aver.Δt	MV	O
_:23461:326	Prot.interf.1B:Rec. Δt	MV	O
_:23461:327	Prot.interf.1B:Sen. Δt	MV	O

3.6.7 Assignment of the Protection Function Group to the FG Protection Communication

If protection functions want to use the protection interfaces in a protection function group, you must route the connection of the protection function group, for example, the FG **Line 1**, with a function group **Protection communication** in DIGSI 5. Then, each protection function in the FG **Line 1** can use the protection communication.

Route the connection between the FG **Line** and the FG **Protection communication** in DIGSI 5 as follows:

Project tree > **Function-group connections** > Tab **Protection FG** ↔ **Protection FG**. Right-click to route the connection in the desired line/column.



[sc_PDC_rout1, 1, en_US]

Figure 3-107 Routing of the Connection between the Protection FG and the FG Protection Communication in DIGSI 5

NOTE

If only one protection function group and one FG **Protection communication** are instantiated in the device, DIGSI 5 connects both function groups automatically.

3.6.8 Application Examples and Setting Notes for IP Communication

3.6.8.1 Overview

The advanced protection communication supports the IP communication via MPLS[13] communication networks.

- If existing systems are to be upgraded for protection-interface communication via IP, you must retrofit an Ethernet-BD communication module in the respective SIPROTEC 5 devices.
- The protection-interface communication via IP requires an Ethernet-BD communication module per device in the device combination.
- In a device, only one Ethernet-BD communication module can be used per device combination.
- However, another device combination can use the same Ethernet-BD communication module of the device.

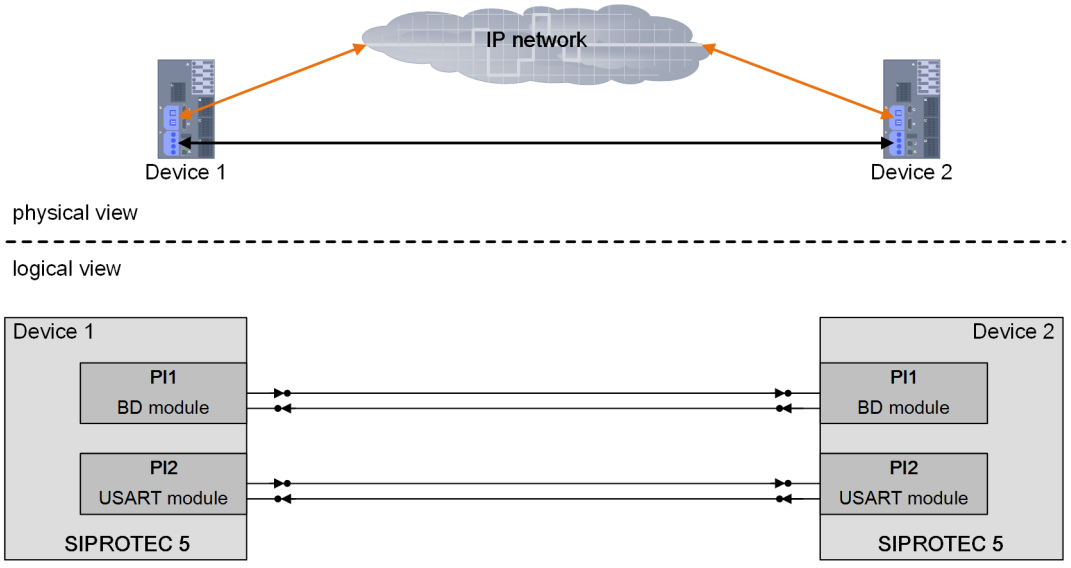
The following application examples show what you must consider when using the IP communication via MPLS communication networks.

13 MPLS = Multi-Protocol Label Switching

3.6.8.2 Device Combination of 2 Devices and Redundant Communication Connection

If redundancy of the communication connection is required for a device combination consisting of 2 devices, 2 different procedures are possible:

- You can use the redundancy mechanisms of the LAN and the Ethernet-BD communication module (PRP, HSR, RSTP). In this case, the redundant communication route runs through the same Ethernet-BD communication module.
- You can set up a 2nd communication connection via a physically separate path. It is best to use a different medium for this, for example, a fiber-optic direct connection, a direct cable connection (pilot wire), or a connection based on C37.94. That is, for the 2nd communication connection, you must use another communication module in each device. The following figure shows this case from a physical and logical view:



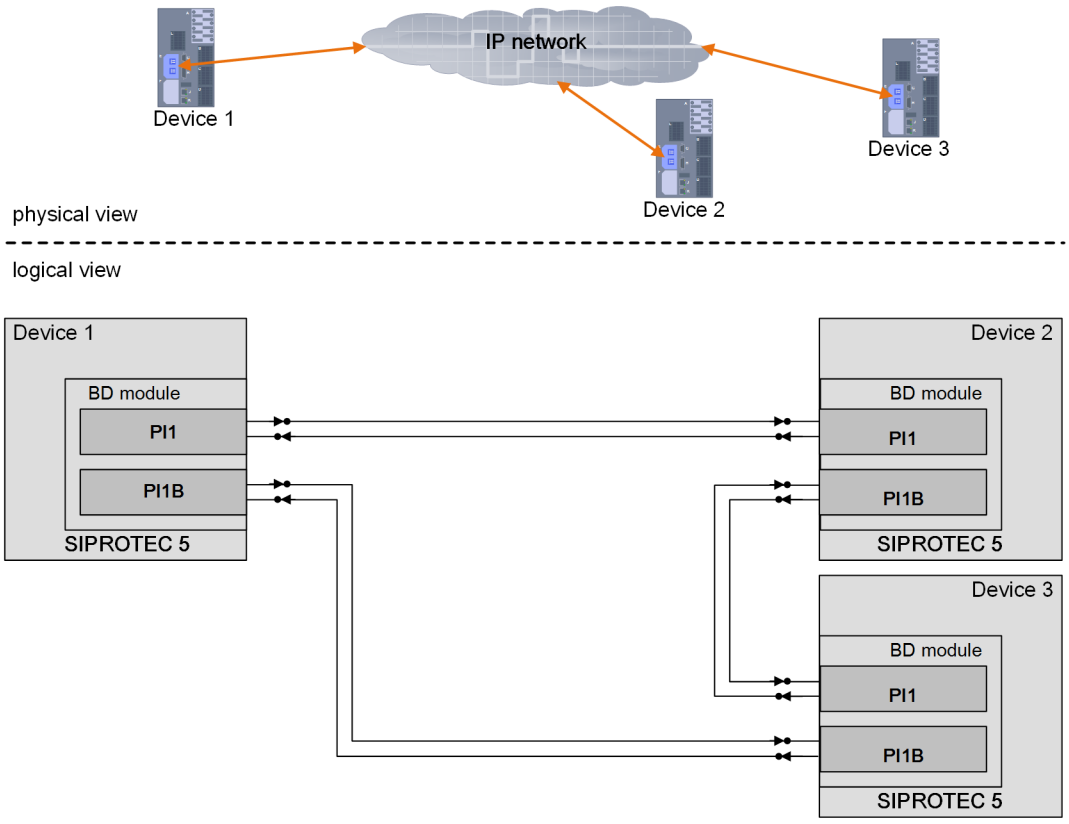
[dw_network_with_2-device_redundant-comm, 1, en_US]

Figure 3-108 Device Combination with 2 Devices and Redundant Communication Connection

3.6.8.3 Device Combination of 3 Devices and Only IP Communication

If you configure a device combination with 3 devices and all devices are using the IP communication, then, from the view of a device, the 2 other devices in the network are visible and reachable. For this, you configure in each device the protocol ***Advanced protection interface*** on the Ethernet-BD communication module and the **Protection interface 1**. The Ethernet-BD communication module is assigned to the **Protection interface 1**.

The special feature of this configuration is that the topology detection automatically generates a 3-device ring topology (logical view). That is, 3 point-to-point communication connections are established between the devices. In addition, another **Protection interface 1B** is automatically visible in each device, which provides the necessary 2nd communication channel for the ring topology, see the following figure:



[dw_network_with_3-device_redundant-comm, 1, en_US]

Figure 3-109 Device Combination with 3 Devices in the IP Communication Network

The **Protection interface 1B** takes over the settings of **Protection interface 1**, that is **Protection interface 1B** does not have its own settings view. The **Protection interface 1B** has its own indications and measured values, which you can see in the information routing.

NOTE

If you use 3 devices in the device combination with IP communication, the aim of the topology detection is to form a ring topology, as in addition to a redundant connection, shorter transmission times are also possible.

If you have instantiated a 2nd protection interface, for example to establish a communication connection via another medium, the device hides the **Protection interface 1B**.

NOTE

In the following cases, the **Protection interface 1B** becomes inactive and does not have any messages or measured values:

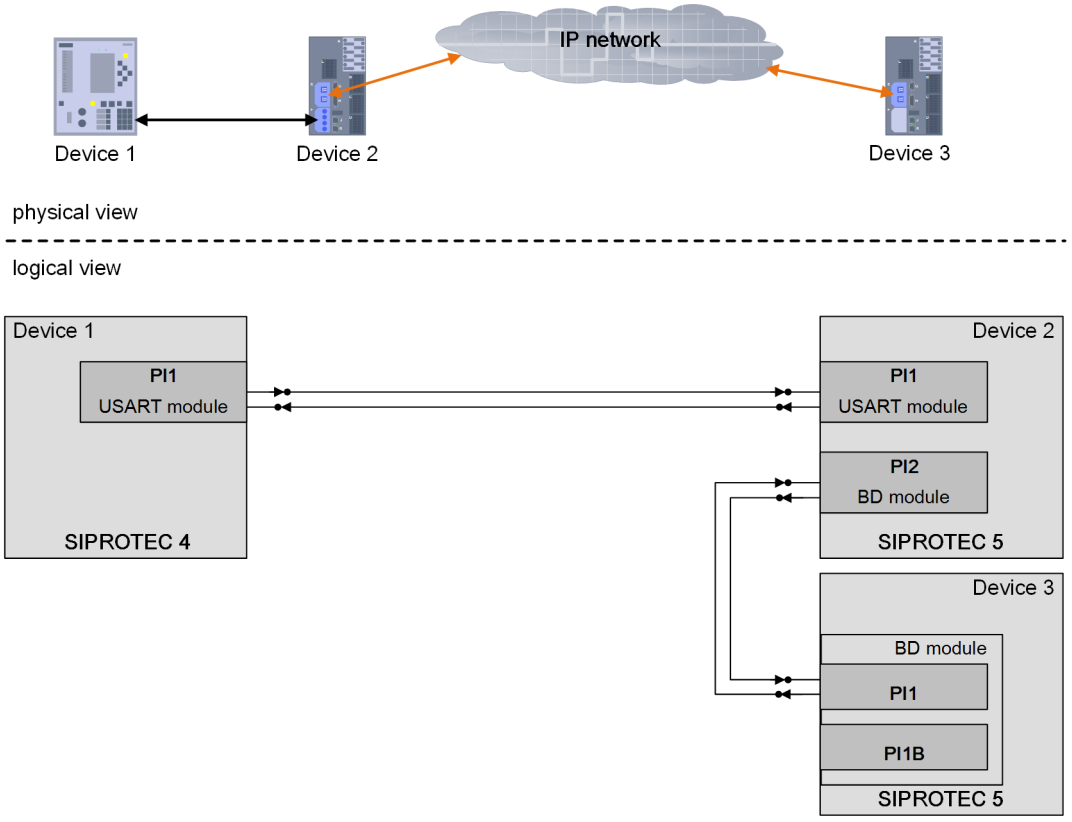
- A 2nd protection interface is instantiated.
- Only 2 devices are present in the device combination.
- No protection interface is assigned to an Ethernet-BD communication module.

3.6.8.4 Device Combination of 3 Devices and Hybrid Communication Media

If you extend a system, it can be necessary to extend a device combination consisting of 2 existing devices by 1 device, see the following figure.

The previous 2 devices are connected to each other, for example, via a fiber-optic direct connection or via other communication media. The left device, for example, a SIPROTEC 4 device, and the middle SIPROTEC 5

device are the 2 devices previously present in the system. This device combination is to be extended by adding the right SIPROTEC 5 device. The communication between the middle and the right device is to take place via an IP communication network.



[dw_network_with_3-device_mixed-comm, 1, en_US]

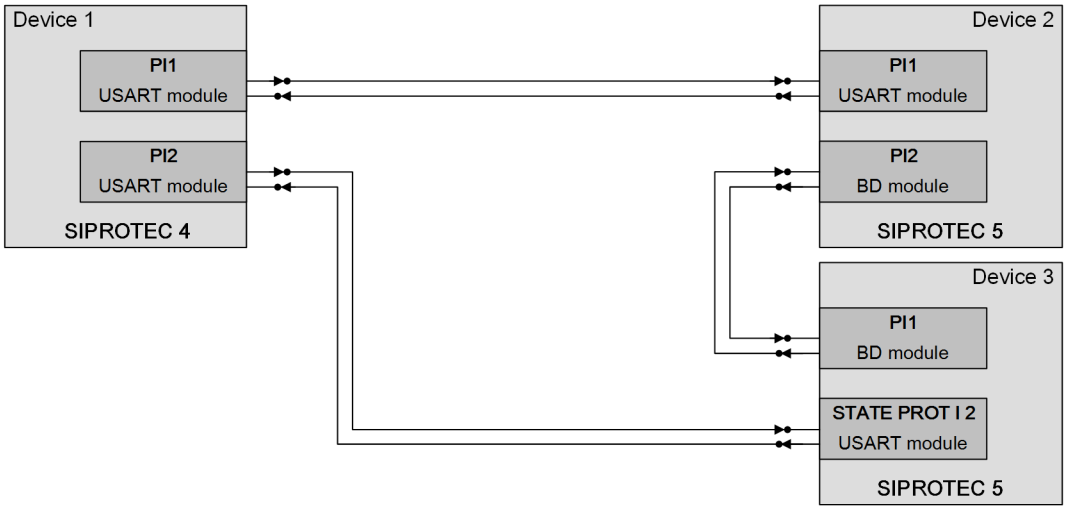
Figure 3-110 Device Combination with 3 Devices and Hybrid Communication Media

For this configuration of a 3-device chain topology, you must configure a **device combination with 3 devices** in all devices.

In the middle device, an Ethernet-BD communication module is additionally required. Configure the protocol ***Advanced protection interface*** in the properties of the Ethernet-BD communication module. Instantiate the function block **Protection interface 2** in the FG **Protection communication**. Assign the Ethernet-BD communication module to the **Protection interface 2**.

The device on the right must also have an Ethernet-BD communication module. Also configure here the protocol ***Advanced protection interface*** in the properties of the Ethernet-BD communication module and assign the Ethernet-BD communication module to the **Protection interface 1**. **Protection interface 1B** is created here as a special feature, but it is not used.

If a redundant communication connection is required for this configuration, Siemens recommends establishing a 3-device ring topology. For this purpose, you must connect the left and right devices via another communication channel. This creates the 3-device ring topology. The following figure shows this configuration:



[dw_3-device_and_mixed-comm, 1, en_US]

Figure 3-111 Device Combination with 3 Devices and Hybrid Communication Media and Redundant Communication Connection

The SIPROTEC 4 device (left device) does not support any IP communication. In this case, you must switch to another communication medium and retrofit a corresponding SIPROTEC 4 communication module. In any case, the communication medium used is also supported by the SIPROTEC 5 device on the right side, by retrofitting a corresponding equivalent communication module there. Configure this communication module with the protocol ***Advanced protection interface***, add an additional **Protection interface 2** to the FG **Protection communication**. Assign the **Protection interface 2** to the communication module.

3.6.8.5 Device Combination of 6 Devices and Hybrid Communication Media

IP Addresses in Hybrid Topologies

To ensure redundancy or downward compatibility, the devices also allow a mix of classic and IP-based communication media.

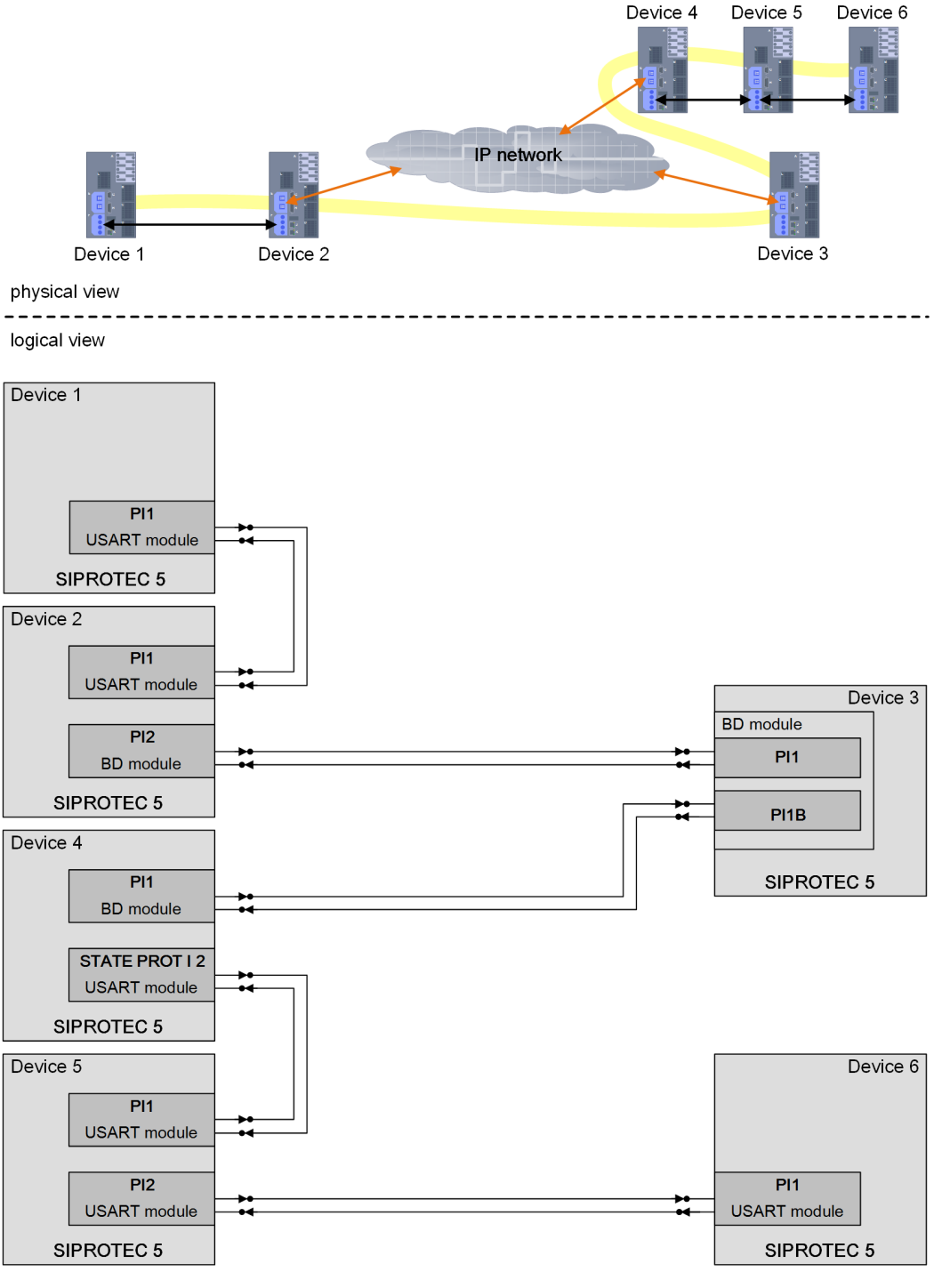
In such applications, special consideration must be given to the configuration of the IP addresses. When parametrizing the devices, you must first clarify which path the communication is to take through the network. That is, it must be clear which devices communicate with each other. To define a route, you may only configure its planned communication partners in a device. The following examples illustrate the correct IP configuration.

For device combinations with more than 3 devices and hybrid communication media, different configurations are possible. If you want to use the IP communication, consider that only one Ethernet-BD communication module per device combination is supported for the protection-interface communication.

The following figure shows a device combination with 6 devices. In the example, several devices are connected by other communication media, which form 3 device groups. The device groups are connected by an IP network. The result is a 6-device chain topology. The yellow line illustrates the communication route.

To establish this communication route, you may only parameterize the IP addresses of their direct communication partners in the devices. The following example applies:

- The devices **2** and **4** only know the IP address of device **3**.
- Device **3** only knows the IP addresses of the devices **2** and **4**.
- Leave all other IP addresses at ***0.0.0.0***.



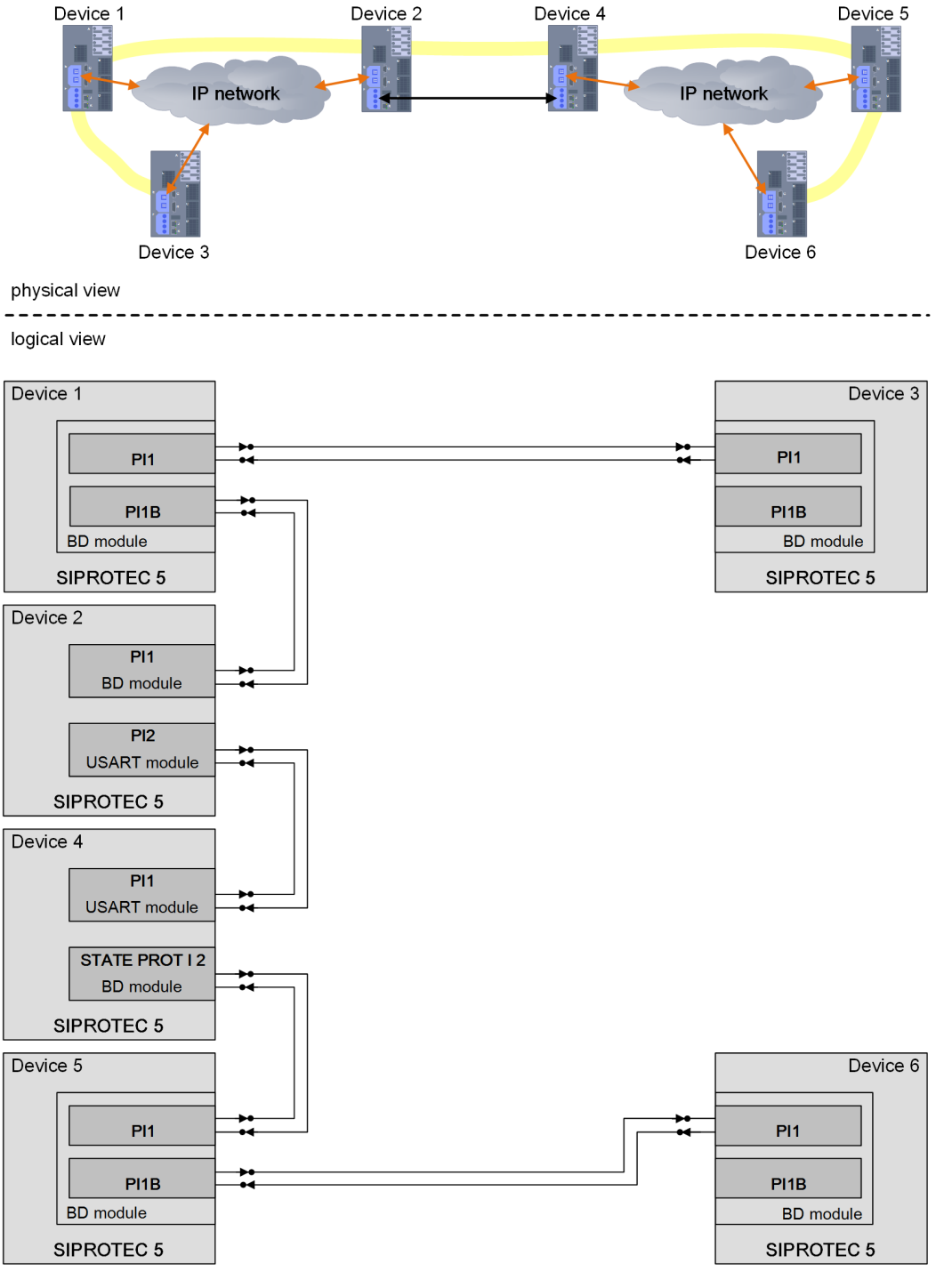
[dw_network_with_6-device_redundant-comm; 1; en_US]

Figure 3-112 Example 1 of a Device Combination with 6 Devices

Another example shows 2 device groups whose devices are connected to each other via IP networks. The 2 device groups are connected to each other by a different communication medium. The topology detection in turn forms a 6-device chain topology.

To establish this communication route, you may only parameterize the IP addresses of their direct communication partners in the devices. The following example applies:

- Device **1** only knows the IP addresses of the devices **2** and **3**.
- The devices **2** and **3** only know the IP address of device **1**.
- Device **5** only knows the IP addresses of the devices **4** and **6**.
- The devices **4** and **6** only know the IP address of device **5**.
- Leave all other IP addresses at *0.0.0.0*.



[dw_network_with_6-device, 1, en_US]

Figure 3-113 Example 2 of a Device Combination with 6 Devices

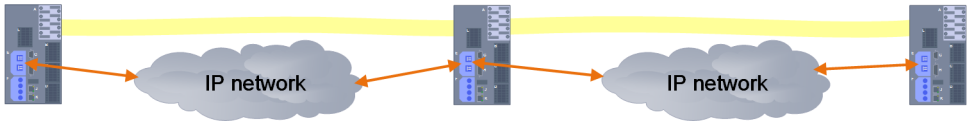
3.6.8.6 Unsupported Configurations

The following figure shows an example of a device combination with 3 devices. In the example, all devices use the IP communication. The middle device contains 2 Ethernet-BD communication modules, which are both configured with the ***Advanced protection interface*** protocol.

NOTE

You can only use 1 Ethernet-BD communication module in one device!

2 Ethernet-BD communication modules with the ***Advanced protection interface*** protocol are not supported.



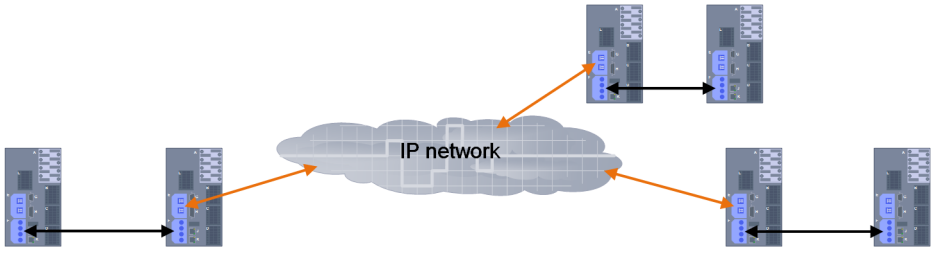
[dw_non-supported-confic_network_with_3-device, 1, en_US]

Figure 3-114 Unsupported Configuration of a Device Combination with 3 Devices

NOTE

If you use the IP communication, the aim of the topology detection is to form a chain topology if there are 4 or more devices. For certain configurations, the topology detection cannot form a working chain topology.

The following figure shows an example of a device combination with 6 devices and hybrid communication media. In this case, the topology detection cannot form a functioning 6-device chain topology.



[dw_non-supported-confic_network_with_6-device, 1, en_US]

Figure 3-115 Unsupported Configuration of a Device Combination with 6 Devices

3.7 Date and Time Synchronization

3.7.1 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.

3.7.2 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.**

3.7.3 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 startup 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 pickup 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 pick up, 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: *Leap second*	This indication signals that a Leap second has occurred during time synchronization using an external GPS receiver (protocol variant IRIG B 005(004) with extension according to IEEE C37.118-2005).
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.

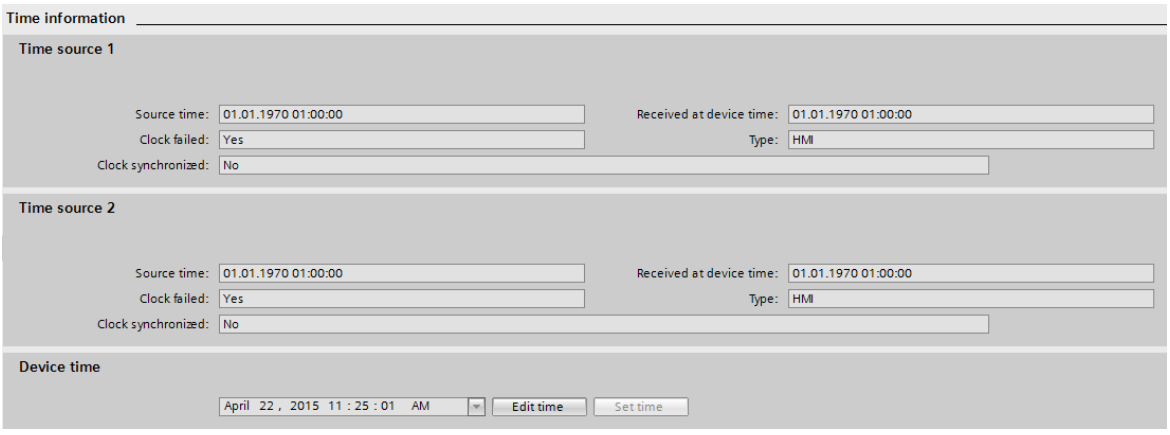


NOTE

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**



[sc_time_dg, 1, en_US]

Figure 3-116 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).

3.7.4 Application and Setting Notes

Parameter: Date Format

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

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

Parameter Value	Description
`DD.MM.YYYY`	Day.Month.Year: Typical European display Example: 24.12.2010
`MM/DD/YYYY`	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 parameters **`Time zone time source 1`** and **`Time zone time source 2`**, 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 parameters **Time source 1** and **Time source 2**, 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.
IRIG-B	Time synchronization by an external GPS receiver: SIPROTEC 5 devices support several protocol variants of the IRIG-B standard: • **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 in UTC or in the case of local time, specifies the appropriate offset to UTC in each set time telegram.
DCF77	Time synchronization by an external DCF77 receiver **Time zone time source 1** or **Time zone time source 2** = ***local*** Note: There are also clocks that generate a DCF77 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.

Parameter Value	Description
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 interoperability 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.
DNP3	The time is synchronized via telegram with the appropriately configured communication interface in accordance with the DNP3 protocol. 2 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 parameter **Fault indication after**, 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 option buttons or check box.



[sc_time_zo, 1, en_US]

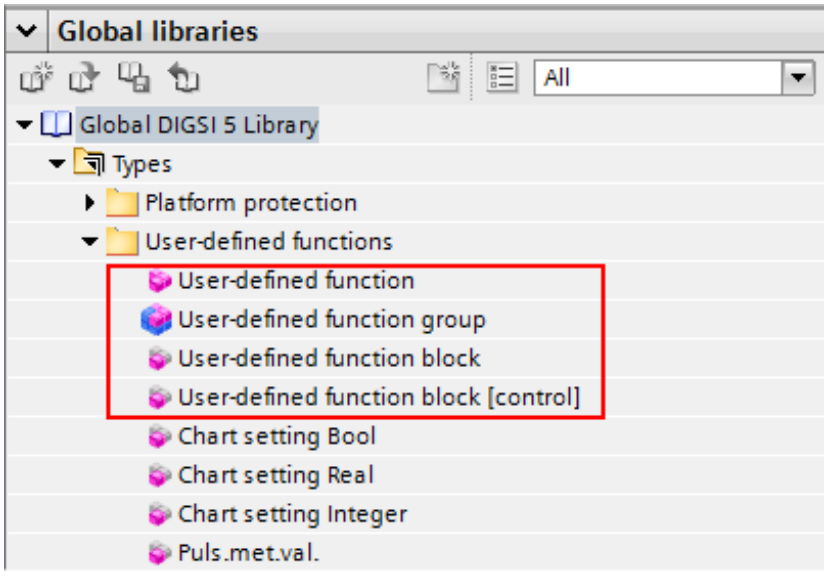
Figure 3-117 Settings for Time Zone and Daylight Saving Time in DIGSI

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

3.8 User-Defined Objects

3.8.1 Overview

With help from user-defined function groups and user-defined functions you can group user-defined objects, for example user-defined function blocks. 2 user-defined function blocks are available (see following figure).



[sc_udef_lib, 1, en_US]

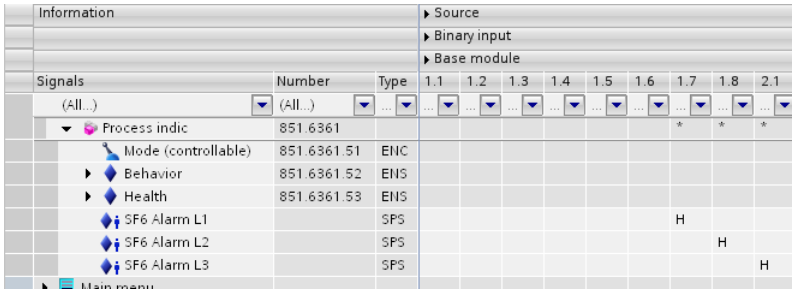
Figure 3-118 User-Defined Objects in the DIGSI 5 Library

The **user-defined function block** allows you to add (see following figure) single-point indications, pickup indications, operate indications (ADC, ACT), single and double commands, commands with a controllable whole number as well as measured values. You can assign the group a superordinate name (for example **process indications** for a group of single-point indications which are read via binary inputs). This function can be deactivated using the mode. The standby mode is also analyzed or displayed.

The user-defined function blocks can be instantiated at the highest level (alongside other function groups) as well as within function groups and functions.

In addition, there is a **user-defined function block [control]**. Alongside the aforementioned possibilities presented by **user-defined function blocks**, this block offers additional tests for user-defined control signals, for example SPC or DPC.

These are described in chapter *7.9.1 Overview of Functions*.



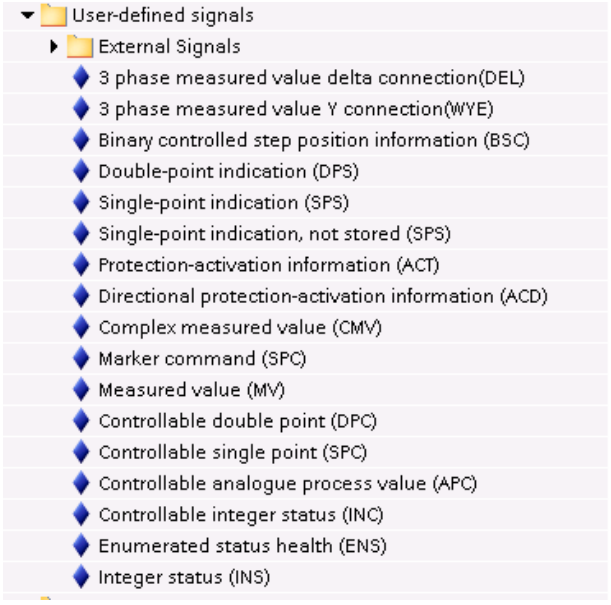
[sc_user, 1, en_US]

Figure 3-119 Information Routing with Incorporated User-Defined Function Block: Process Indications and some Single-Point Indications

3.8.2 Basic Data Types

The following data types are available for user-defined objects in the DIGSI 5 library under the heading **User-defined signals**. Additionally, a folder for external signals is available (see chapter *3.8.5 External Signals*).

User-Defined Signals



[sc_LB_userdefsig, 1, en_US]

Figure 3-120 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***.

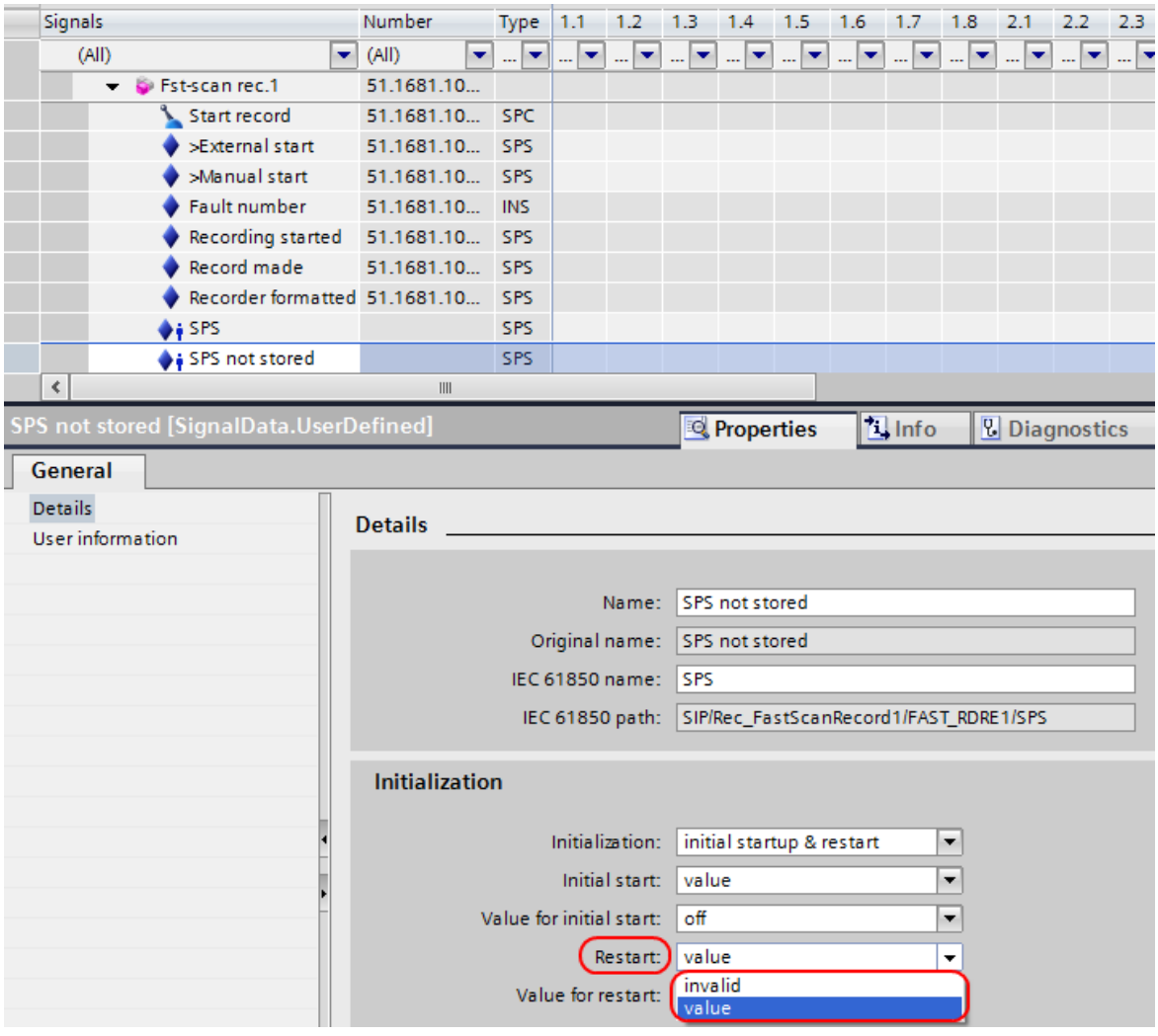


Figure 3-121 Single-Point Indication SPS Unsaved (Example: 7KE85 Fault Recorder)

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).

Integer Status Value (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 example.



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.

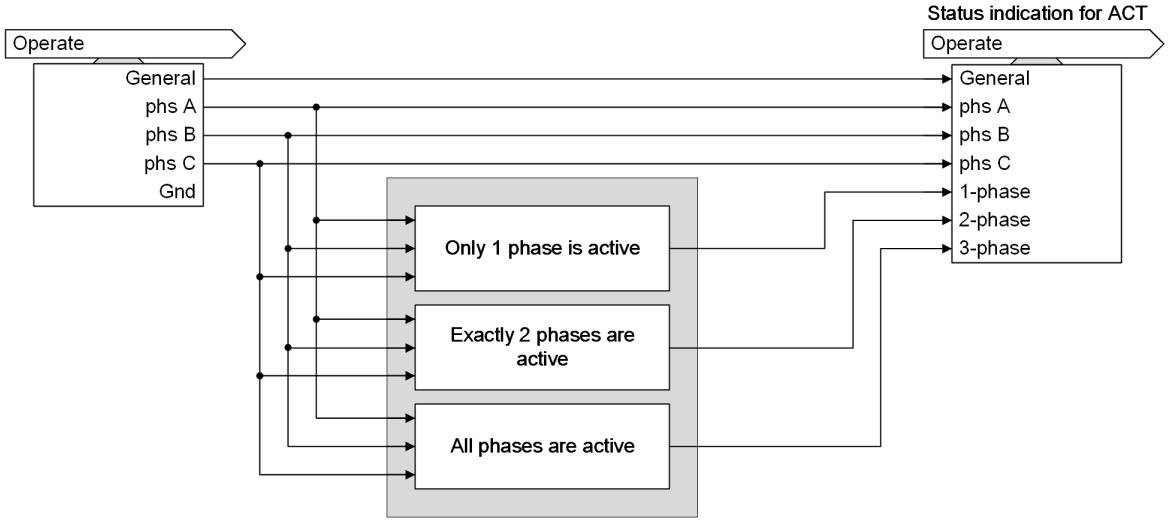
Phase-to-Phase Measured Values (DEL, Delta)

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**.

The status indications for the **ACT** data type are built as follows:



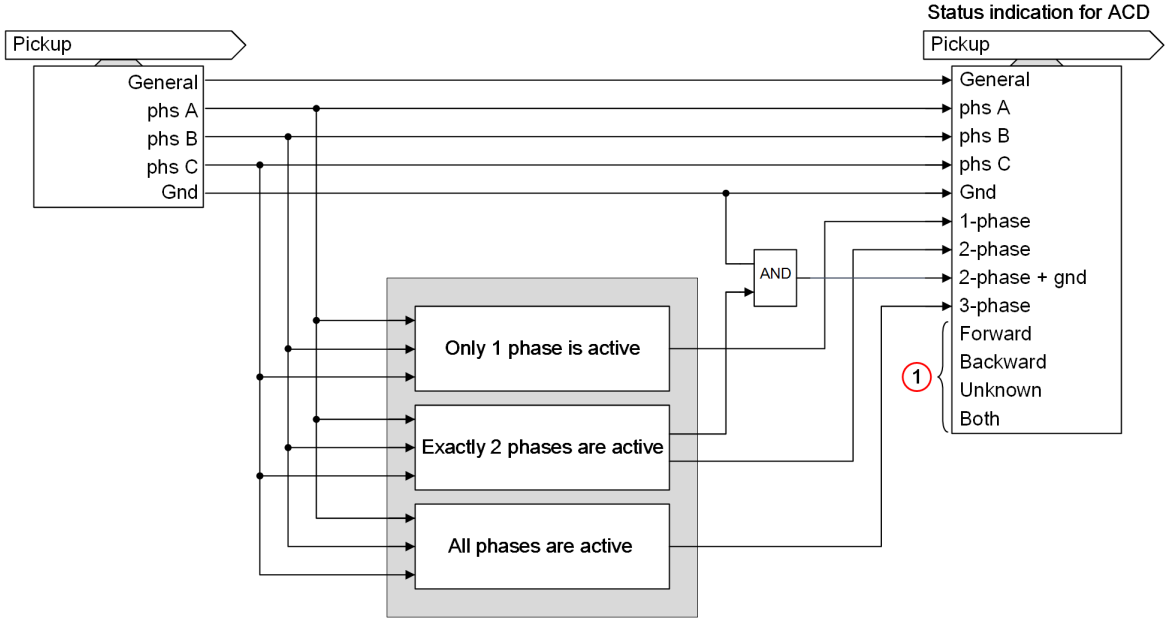
[lo_ACT-information, 1, en_US]

Figure 3-122 Building of the Status Indications ACT

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.

The status indications for the **ACD** data type are built as follows:



[lo_ACD-information, 1, en_US]

Figure 3-123 Building of the Status Indications ACD

(1) Further information, see *Table 3-21*

Table 3-21 Building of the Direction Information for the Data Type **ACD**

Direction Information	Description
forward	All picked up phases have picked up in forward direction.
backward	All picked up phases have picked up in backward direction.
unknown	The direction could not be determined for the pickup.
both	At least 1 phase has picked up in forward direction and at least 1 phase has picked up in backward direction.

3.8.3 PulseMetered Values

Pulse-Metered Values

Pulse-metered values are available as data types **BCR** (Binary Counter Reading) in the DIGSI library under **User-defined Functions**.

You can find the functionality and the settings of the pulse-metered values in *9.9.1 Function Description of Pulse-Metered Values*.

3.8.4 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:

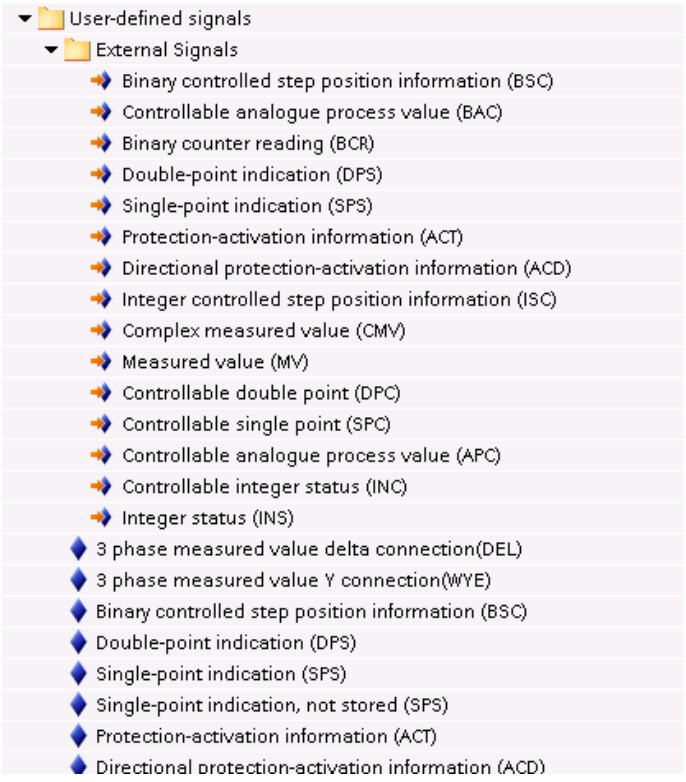
- **ENC** (Enumerated Setting Controllable)
  The data type **ENC** models a command with which the user can set predefined values.
- **SEQ** (Sequence)
- **BSC** (Binary Controlled Step Position)
  The data type **BSC** can, for example, be used to control a transformer tap changer. The commands **up**, **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 step position information).

3.8.5 External Signals

User-defined signals of different types (see *Figure 3-124*) are available for GOOSE Later Binding. After instantiation in a logical node, an external reference is generated during IID export and provided to a IEC 61850 system tool (for example, System Configurator) for GOOSE Later Binding (according to the Later-Binding procedure specified in IEC 61850-6).



[sc_LB_extsign, 1, en_US]

Figure 3-124 External Signals

NOTE

Consider the chapter on GOOSE Later Binding in the DIGSI Online Help. User-defined signals exist as external signals and as preconfigured inputs that have been activated via the GOOSE column.

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

One 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

Data Type	Type
SPC	C
MV	O

For further information, refer to *3.8.2 Basic Data Types*.

3.9 Other Functions

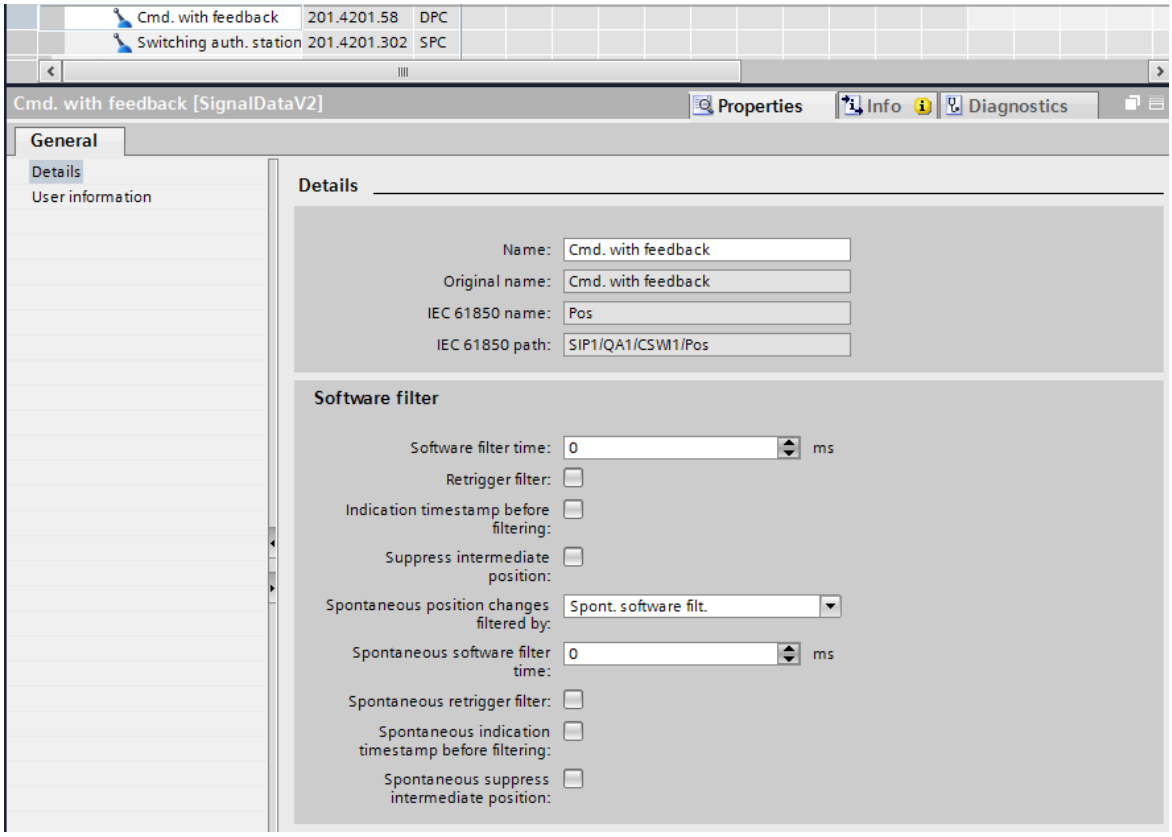
3.9.1 Signal Filtering and Chatter Blocking for Input Signals

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

The software filtering time is available only for the circuit breaker and disconnector in the controllable **Cmd. with feedback** (**control** function block), as this is used for logging purposes. The controllable **position** (**circuit breaker** or **disconnector** function block) is used for interlocking conditions and must always show the unfiltered position of the switching object.



[sc_lposi, 1, en_US]

Figure 3-125 Settings for Circuit-Breaker Switch Position

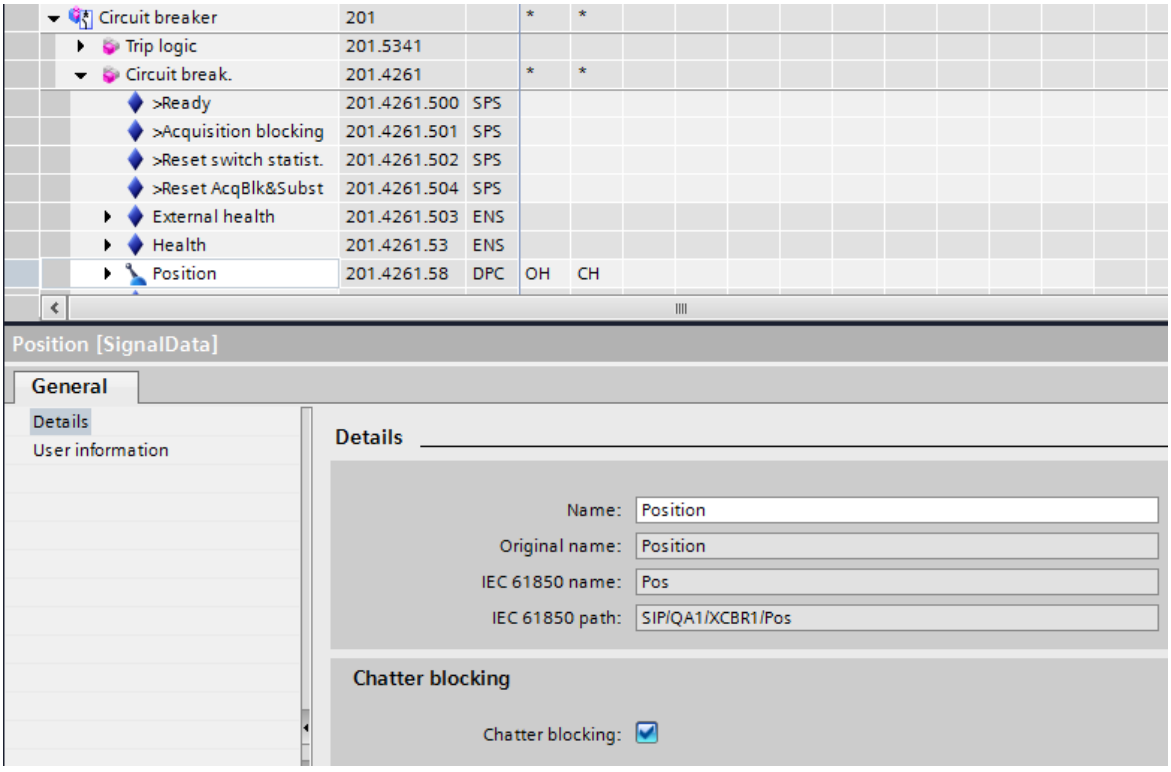
The setting range for the **Software filter time** parameter ranges from 0 ms to 100 000 ms in ms increments. The **Retrigger filter** check box can be used to select whether to restart the filtering time whenever a status change is performed within the software filtering time. When activated, the **Indication timestamp before filtering** check box backdates the time stamp by the set software 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 filtering time.

If you leave the software filtering time at 0 ms, the time for the suppression of the intermediate position is also 0 ms. The activated **Suppress intermediate position** check box then remains ineffective.

If you do not activate the **Suppress intermediate position** check box, the software filtering time affects the **on**, **off**, **intermediate**, and **disturbed** positions of the circuit breaker or disconnector switch.

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 you select the ***General software filter*** setting, 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 then cannot 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.

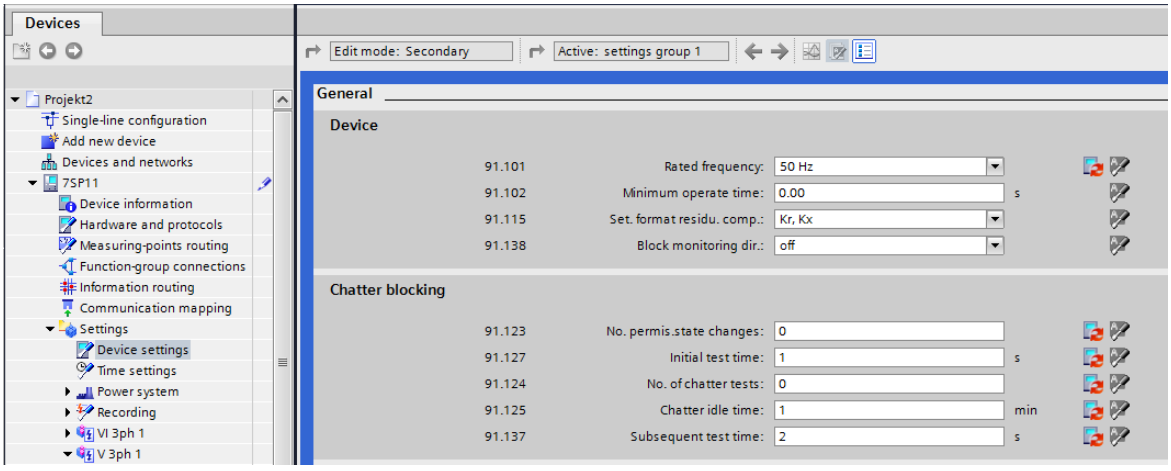
Chatter blocking can be activated or deactivated as an input parameter, for example as a parameter of the position in the **Circuit breaker** or **Disconnector** function block.



[sc_flatte, 1, en_US]

Figure 3-126 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).



[sc_chattr, 1, en_US]

Figure 3-127 Chatter-Blocking Settings

The chatter-blocking settings have the following meaning (see also *Figure 3-128* and *Figure 3-129* 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 status changes is exceeded during the initial test time, the signal is temporarily blocked and the indication *Chatter blocking* is set.

  Enter a number from 1 to 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 status changes of the signal 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) is 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 from 1 to 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 to 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 from 2 to 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.

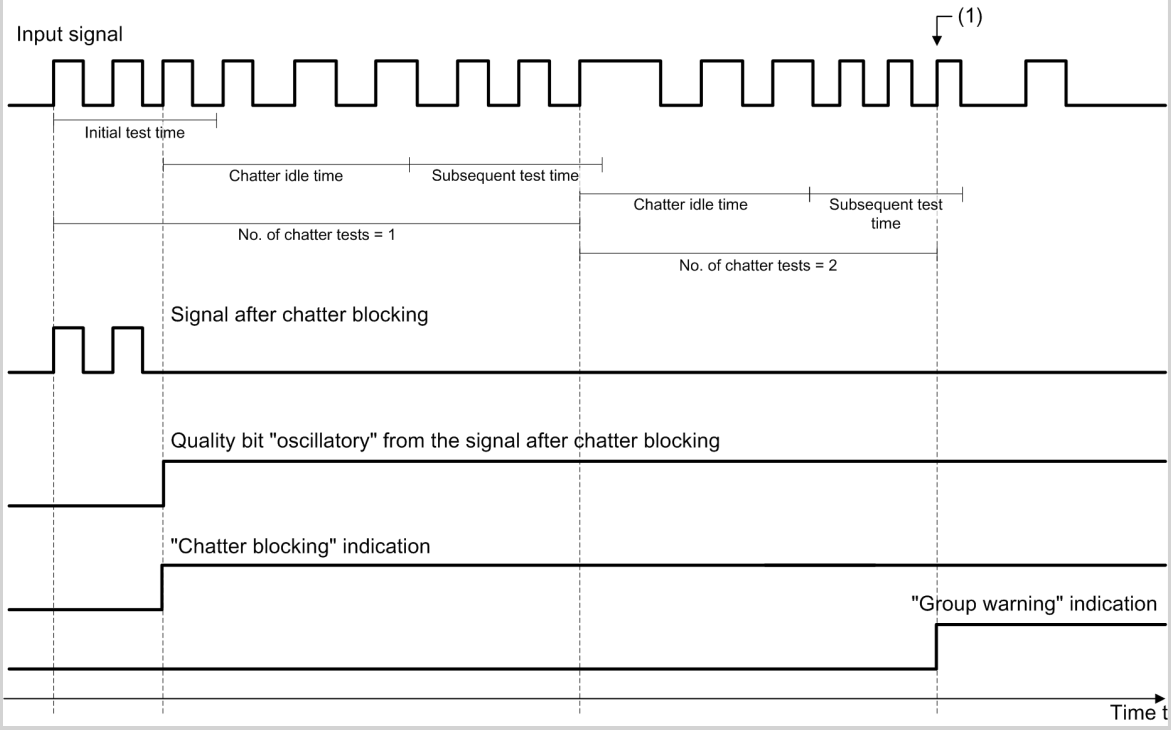
Example 1: Permanent Blocking

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 status 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 3-128 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:

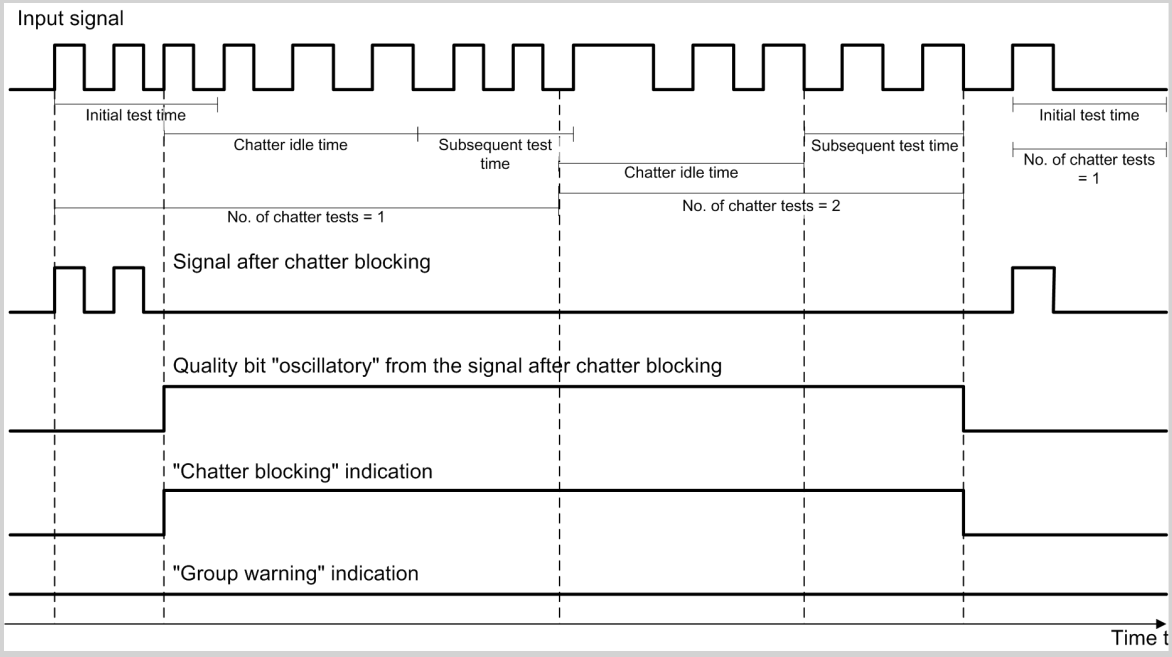
- **No. permis.state changes** = 4
- **No. of chatter tests** = 2

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 3-129 Signal Change during Chatter Blocking with Permissible Number of Signal State Changes During 2nd Subsequent Test Time

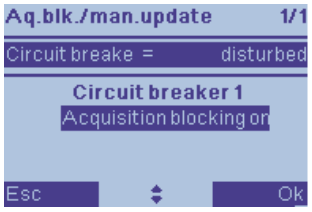
3.9.2 Acquisition Blocking and Manual Updating

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.

To set the acquisition blocking, proceed as follows:

- Using the navigation keys, move in the **main menu** of the device display to **Commands→Equipment→Aq.blkman. update**.
- Select the appropriate device (for example, a circuit breaker) from among the several switching devices using the navigation keys.
- Press the **Change** softkey.
- Enter the confirmation ID (not relevant for active role-based access control (RBAC) in the device).
- Confirm the process with the softkey marked **OK** in the display.

After entering the confirmation ID (only with the RBAC inactive), acquisition blocking is switched on.

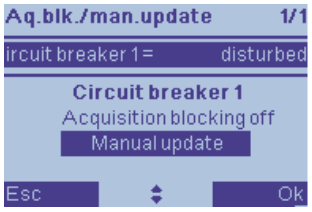


[sc_detection, 1, en_US]

Figure 3-130 Activating the Acquisition Blocking

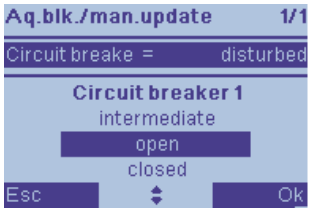
Manual updating of the switching device is possible from within the same menu.

- Select **Manual update** (*Figure 3-131*) using the navigation keys.
- Select the switching device setting to be manually updated using the navigation keys (for example, **off**, *Figure 3-132*).
- Confirm the process with the softkey marked **Ok** in the display.



[sc_status, 1, en_US]

Figure 3-131 Activating Manual Update



[sc_statu2, 1, en_US]

Figure 3-132 Selecting Position

The manually updated position of the switching device will be displayed.



[sc_statu3, 1, en_US]

Figure 3-133 Position of the Switching Device

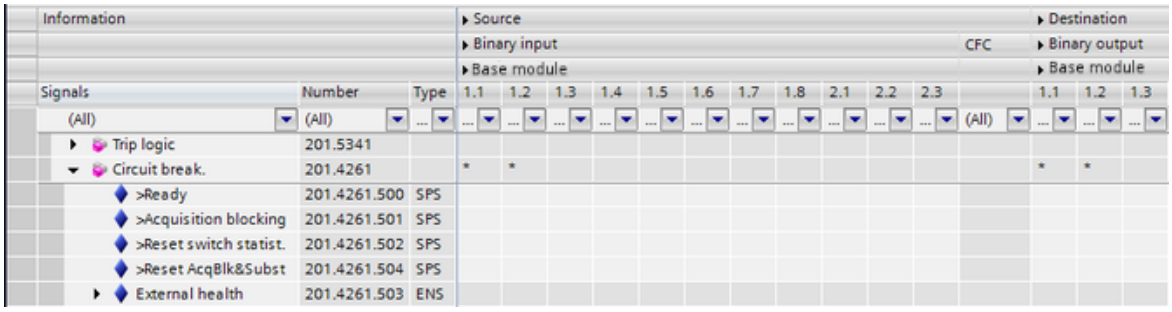
NOTE

For security 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.

You can set acquisition blocking also via a binary input. If you want to put in the feeder or the switching device in revision, you can set the acquisition blocking with an external toggle switch for one or more switching devices. 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.



[sc_beerfa, 1, en_US]

Figure 3-134 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

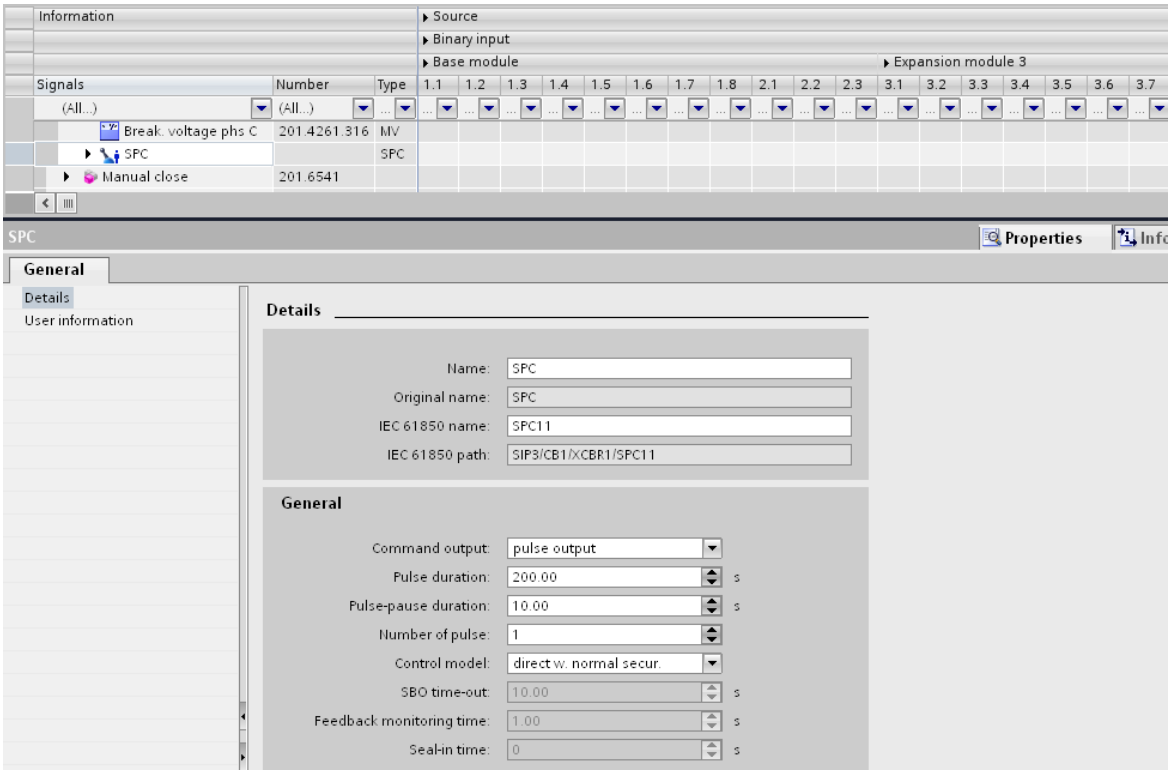
When the acquisition blocking is activated or the switching device updated manually while the entire device or the switching device is in application mode, these states are not saved. The acquisition blocking and the manual updating are not retained after a restart.

The acquisition blocking and the 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.

3.9.3 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.



[sc_command, 1, en_US]

Figure 3-135 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.

3.9.4 Device Logout

3.9.4.1 Overview

In the case of multibay functions, a device uses information from one or more other devices. For some applications, it may be necessary for you to remove a device with all effective functions temporarily from the plant and even to switch it off. These applications are, for example:

- Maintenance work
- System upgrades
- Testing the local protection functions, for example, the local line differential protection

The *Device logout* functionality informs the receiver devices about the imminent disconnection of the transmitter devices. To do this, the last valid received information is stored in the receiver devices and used for the multibay functions.



NOTE

If you need to remove a device temporarily from the plant, you must log off the device.

Protection functions distributed to several devices operate in a healthy manner with the remaining devices only if you have logged off the device.

You can log off the device as follows:

- Via the on-site operation panel
- Via a communication interface using the *Device logout* (*_:319*) controllable
- Via the binary inputs, general: *>Dev. funct.logout on* (*_:507*) or *>Dev. funct.logout off* (*_:508*)

You can find the controllable and the binary inputs in the DIGSI 5 project tree under **Name of the device** → **Information routing** in the working area in the **General** block.

During the log-off process, the device checks whether all conditions for a logout have been met. If the conditions for the log off have not been met, the logout is rejected.

The logout is rejected under the following conditions:

- The devices are communicating via the protection interface and switching off the device leads to an interruption in protection-interface communication.
- The **Line differential protection** function is operating in the device and the local circuit breaker is still switched on.

  In this case, you must switch off the local circuit breaker and repeat the log-off process for the device. After the logout, the local **Line differential protection** function is removed from the summation of the currents for the **Line differential protection** of the other devices. The **Line differential protection** function remains active in the other devices.



NOTE

The path used to log the device off is stored in the operational log.

Even if you switch off the device after logout, the *Device logged off* (_:315) state is stored.

If you want to establish the initial state again after logging off the device, you must log on the device again. To log on the device, you must use the same option used for logout. For example, if you have logged off the device via binary inputs, you must log it on again via the binary inputs. This applies in similar manner if you have logged off the device via DIGSI or via on-site operation.

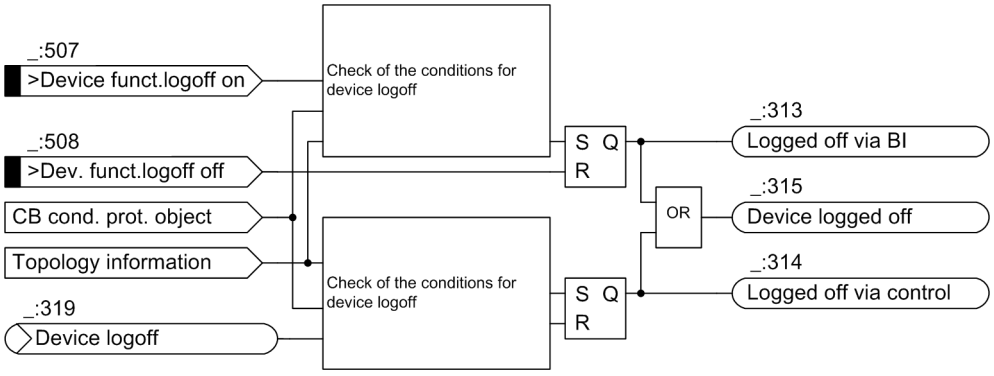
3.9.4.2 Application and Setting Notes

Logoff Options for a Device

You can log a device off as follows:

- Via the on-site operation panel
- Via communication through the controllable *Device logout* (*_:319*)
- Via the binary inputs, general: *>Dev. funct.logout on* (*_:507*) or *>Dev. funct.logout off* (*_:508*)

Conditions for Logging off the Device



[lo_functional logoff device, 1, en_US]

Figure 3-136 Logic for Logging off the Device

The conditions for a successful logout of the device result from the conditions for every activated protection function.

Logoff of a Device from a Device Combination with Communication via the IEC 61850-8-1 (GOOSE) Protocol

If devices are exchanging data using the IEC 61850-8-1 (GOOSE) protocol – for example in the case of substation interlocking – for each received data point the value of this data point can be set in the receiver device when the transmitter device logs off. This value remains effective in the receiver device until the logout is canceled by the transmitter device, even if the transmitter and/or the receiver are switched off in the meantime.

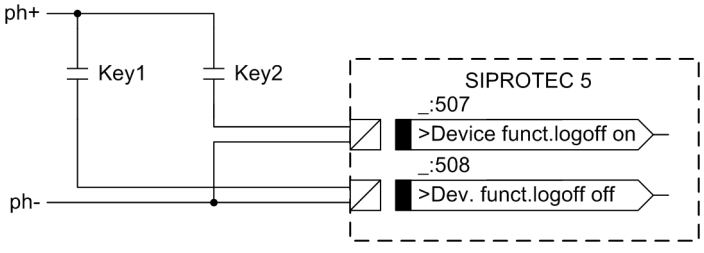
Logoff of a Device from a Device Combination Using Protection Communication

If devices in a device combination communicate via the protection interface, you can only log off a device under the following conditions:

- Logging off and switching off a device in a device combination must not result in an interruption in the protection communication.
- For series-connected topologies, the device must be located at one end of the communication chain as otherwise the protection communication is interrupted when the device is logged off and switched off.
  For this reason, devices not at one of the ends in series-connected topologies cannot be logged off.

Logout via Binary Inputs

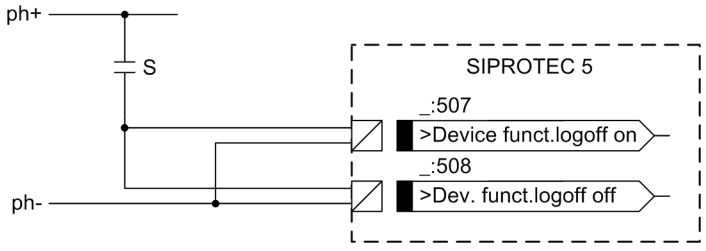
The following diagrams show potential variants on how to control binary inputs. If you want to use push-buttons, switch on this function as shown in the following figure. Log off the device using the push-button **Key2**; log on the device again with the push-button **Key1**.



[lo_extta logoff device, 1, en_US]

Figure 3-137 External Push-Button Wiring for Logging off the Device

If a switch is being used for control, route the binary input *>Dev. funct.logout on* as ***H (active with voltage)*** and the binary input *>Dev. funct.logout off* as ***L (active without voltage)***. If the switch **S** is closed, the device is logged off.



[lo_extsx logoff device, 1, en_US]

Figure 3-138 External Switch Wiring for Logging off the Device

Indications

The logged-off device reports the status (*(_:315) Device logged off*) and cause of the logout.

If you have logged off the device using binary inputs, the indication *(_:313) Logged off via BI* results.

If you have logged off the device using on-site operation, via DIGSI 5 or via the protection interface,the indication *(_:314) Logged off via control* is issued.

The indications are stored in the operational log.

3.9.4.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:507	General:>Dev. funct.logout on	SPS	I
_:508	General:>Dev. funct.logout off	SPS	I
_:319	General:Device logout	SPC	C
_:313	General:Logged off via BI	SPS	O
_:314	General:Logged off via control	SPS	O
_:315	General:Device logged off	SPS	O

3.10 General Notes for Setting the Threshold Value

3.10.1 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.

3.10.2 Modifying the Transformer Ratios in DIGSI 5

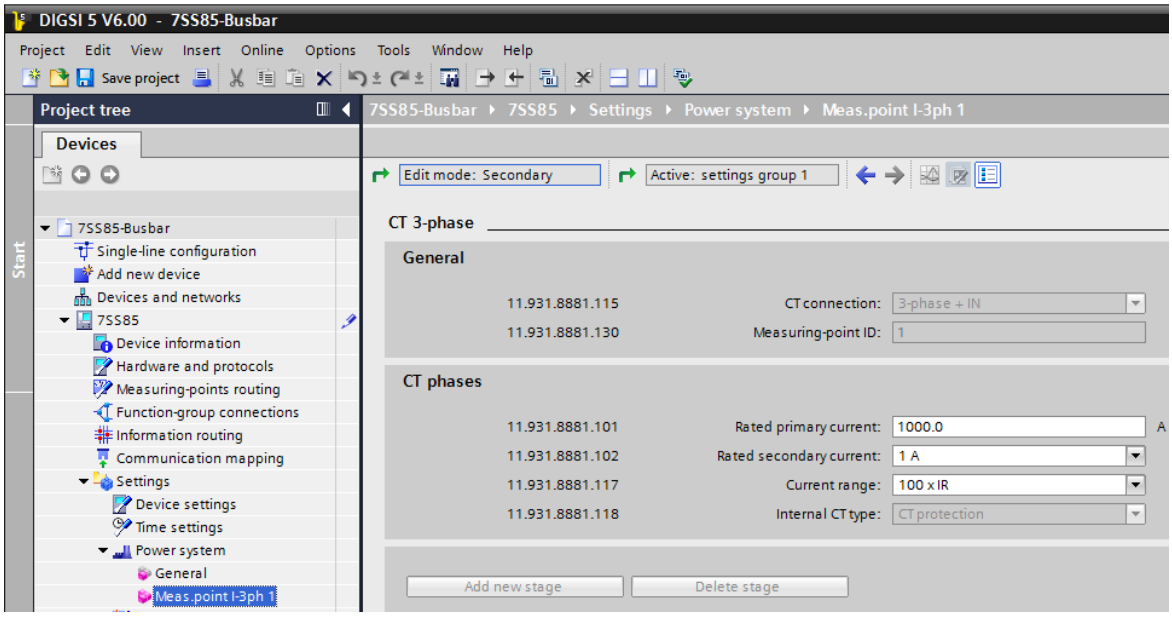
In the delivery setting, DIGSI 5 is set to the **Secondary** edit mode.

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 shown in the example of the **Power-system data** function.

The following output data are assumed:

Current transformer: 1000 A/1 A

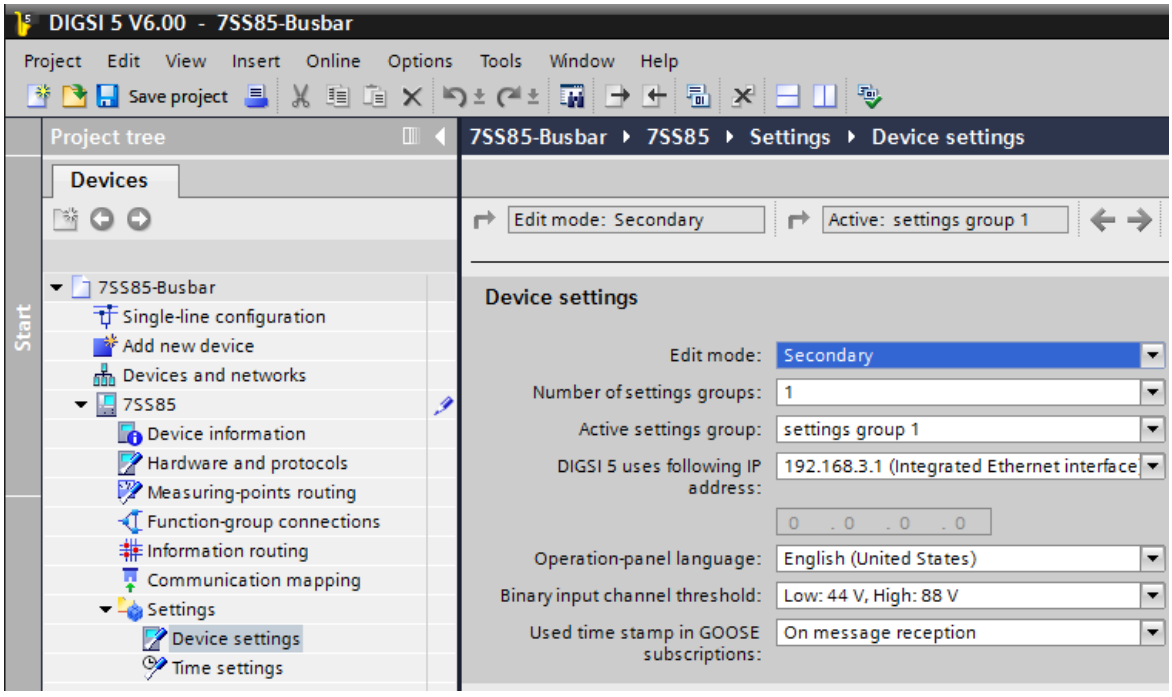
The following figure shows the protection setting in the **Power-system data** function in the secondary view.



[sc_mod_s_bbp-oh, 1, en_US]

Figure 3-139 Protection Setting, Display of the Active Setting Sheet

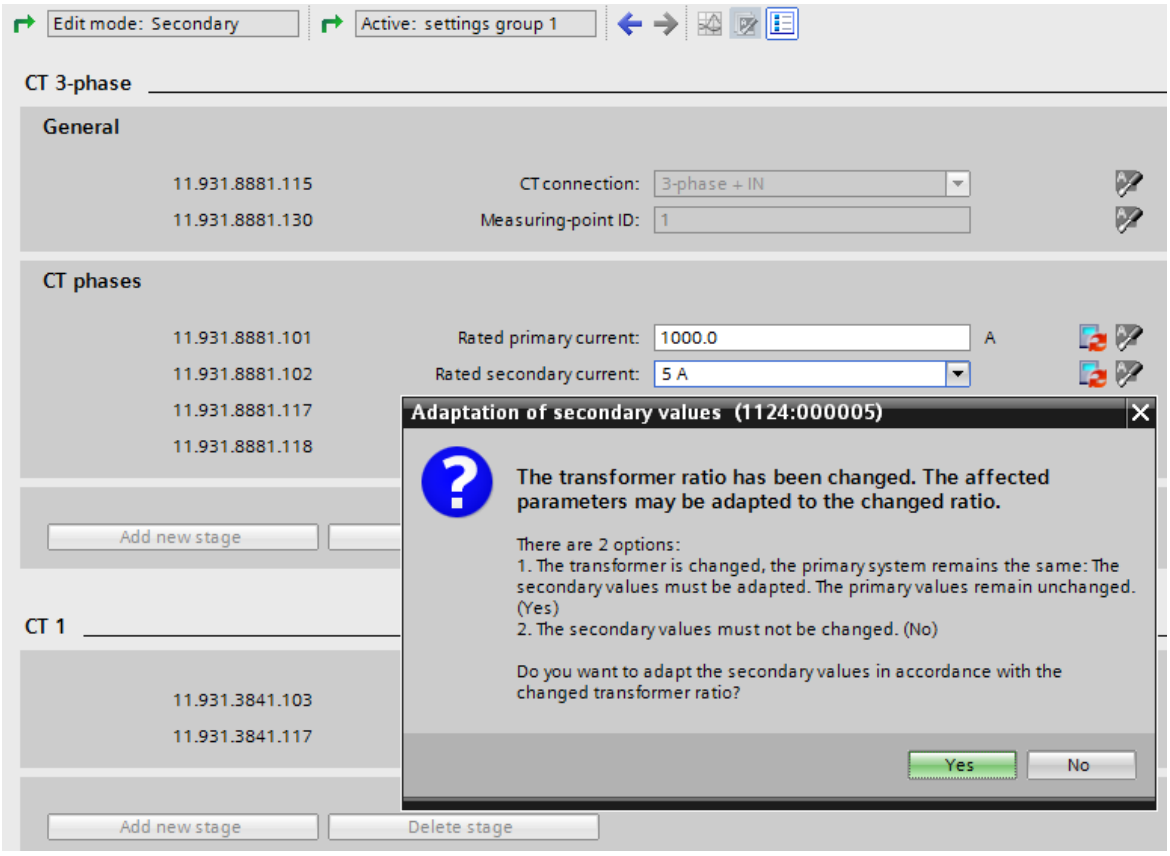
When you click the green arrow in the setting sheet at the upper left, you get to the window for switching over to the setting view (see the following figure). Select the setting view you prefer.



[sc_mod_u_bbp-oh, 1, en_US]

Figure 3-140 Switchover to the Desired Setting View

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.



[sc_fragewbbp, 1, en_US]

Figure 3-141 Query after Changing the Transformer Data (Setting View: Secondary)

If you have already set the settings in the secondary view by including the new transformation ratio of the transformer in the calculation, then 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.

Changing the Transformation Ratio in the Single-Line Editor

If you want to change the primary or secondary rated currents of the current transformers in the Single-line Editor, select the current transformer. You can view and change the currents in the **Properties** tab of the object bar.

If you change the rated currents, the corresponding bay has a red border to indicate currents that differ between the Single-line Editor and the power-system data. During **synchronization** in the Single-line Editor, these rated currents are adopted into the power-system data.

3.10.3 Changing the Transformation Ratios of the Transformer on the Device

In the delivery setting, the device is preset to secondary values. 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 previous image). Instead, the device assumes that all settings remain unchanged in the secondary view.

NOTE

If the device works with IEC 61850 protocol, then 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.

3.11 Device Settings

3.11.1 Settings-Group Switching

3.11.1.1 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.

For detailed information about the settings groups, refer to the *Operating Manual* and to the *DIGSI 5 Online Help*.

3.11.1.2 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

3.11.1.3 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 2dfcbba843c4f68d9da3529601704025 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 3-22 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.

3.11.1.4 Application and Setting Notes

Parameter: Number settings groups

- Default setting **(_:113) Number settings groups** = ***1***

With the parameter **Number settings groups**, 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 parameter **Activat. of settings group**, 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 parameter **Number settings groups**.

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.

3.11.1.5 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

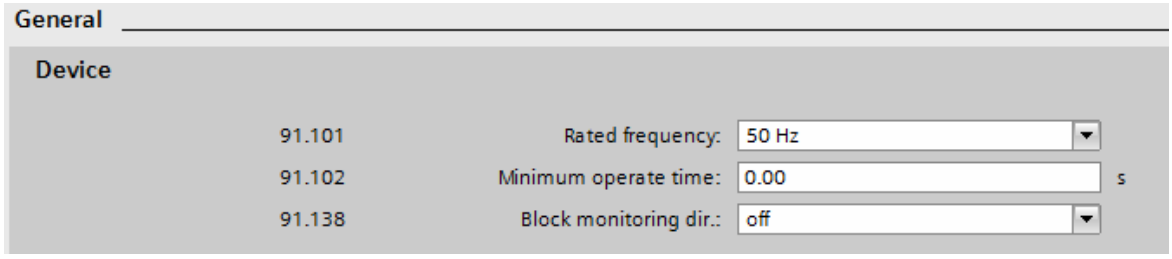
3.11.1.6 Information List

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

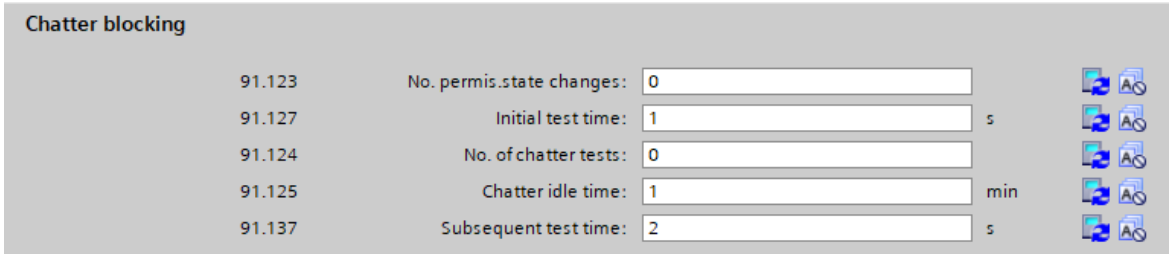
3.11.2 General Device Settings

3.11.2.1 Overview

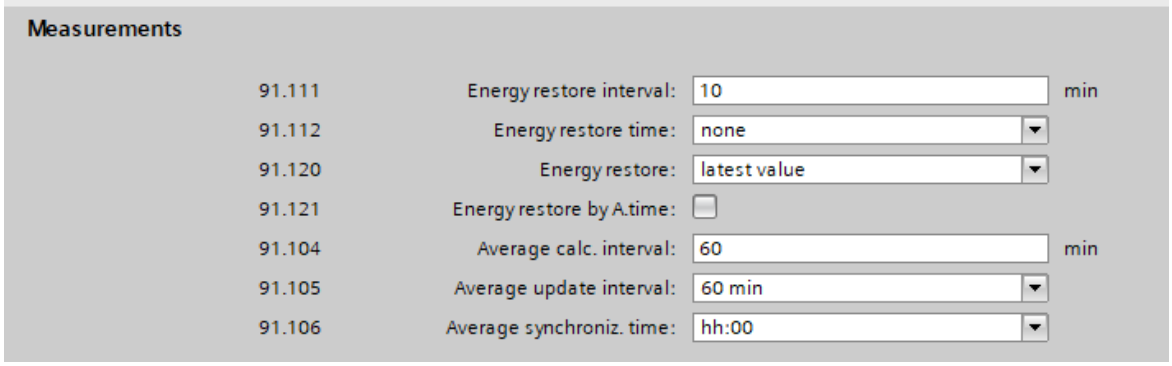
In **Device settings** in DIGSI 5, you find the following general settings.



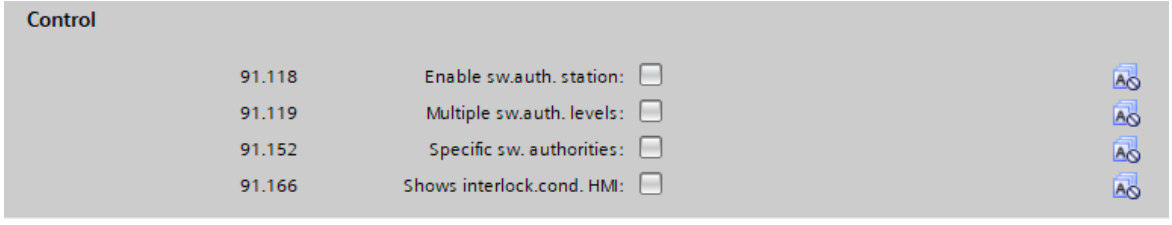
[sc_deSeDe1, 1, en_US]



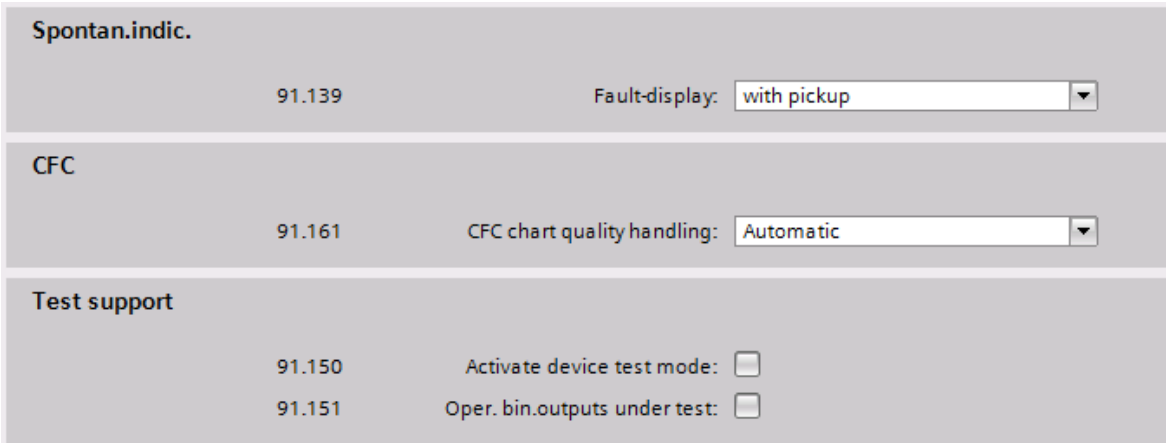
[sc_deSeAl, 4, en_US]



[sc_measurement, 1, en_US]



[sc_control, 1, en_US]



[sc_deSeall, 1, en_US]

Figure 3-142 General Device Settings

The following list shows you the chapters containing the desired information.
You can find more about:

- **Chatter blocking** in *3.9.1 Signal Filtering and Chatter Blocking for Input Signals*.
- **Control** in *7.4 Control Functionality*.
- **Measured values** in *9.1 Overview of Functions*
- **Spontaneous indications** in *3.1.7 Spontaneous Indication Display in DIGSI 5*.
- **Continuous Function Chart Quality Treatment** in *3.4.3 Quality Processing/Affected by the User in CFC Charts*.

Under **Device**, you set the parameters for the device that are valid across functions.
With **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 whether an indication is generated in a test and all or individual functions of the device are in the test mode. In this manner 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.

3.11.2.2 Application and Setting Notes

The major portion of the settings is described in the chapters cited above. Then, the parameters on the section **Device**, **Spontaneous indication**, and **Test support** are described.

Parameter: Rated frequency

- Default setting **(_:101) Rated frequency** = ***50 Hz***

With the parameter **Rated frequency**, you set the rated frequency of the electrical power system.

Parameter: Minimum operate time

- Default setting **(_:102) Minimum operate time** = ***0.00 s***

With the parameter **Minimum operate time**, 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 parameter **Block monitoring dir.**, you set whether indications are output via the system interface(s) of the SIPROTEC 5 device or not.

If transmission blocking is switched on, no indications are output via the system interface(s) of a SIPROTEC 5 device, except via the IEC 61850 interface(s).

To avoid receiving IEC 61850 data, the corresponding IEC 61850 Client must stop the reporting or freeze the data. You can find more information in the Communication Protocols Manual (C53000-L1840-C055-3).

Parameter: Fault-display

- Default setting **(_:139) Fault-display** = ***with pickup***

With the parameter **Fault-display**, you set whether spontaneous fault indications which are signed as ***NT (conditioned latching)*** in the matrix, get stored with every pickup or only for one tripping.

Keep the DIGSI 5 routing options in chapters *3.1.7 Spontaneous Indication Display in DIGSI 5* and *3.1.9 Stored Indications in the SIPROTEC 5 Device* in mind.

Parameter: Activate device test mode

- Default setting **(_:150) Activate device test mode** = inactive

With the parameter **Activate device test mode**, you can activate the test mode for the complete device. This means that all indications generated in the device are given a test bit.

For further information, refer to *12.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

Apart from activating the test mode via this parameter, you can also activate the test mode using the IEC 61850-8-1 protocol. For more information, refer to the *SIPROTEC 5 Communication protocol* manual.

When the test mode is activated for the complete device, but the parameter **Oper.bin.outp. under test** is not, the routed relay outputs of the device are not activated by the generated the indications.



NOTE

The device remains in test mode during every restart until you intentionally set the device back into the process mode or you have carried out an initial start.

You can set the process mode by switching the parameter **Activate device test mode** to inactive again (removing the check mark) or by deactivating the test mode again via the IEC 61850-8-1 protocol.



NOTE

Besides the cross device test mode, you also have the option to place an individual function or stage into test mode depending on the supported operating modes of a function or stage. To do this, see the description of the relevant function or stage.

When you place an individual function or stage into the test mode, all indications issued by this function or stage are given a test bit.

When you activate the test mode for an individual function or stage, but not the parameter **Oper.bin.outp. under test**, the routed relay outputs of the function or stage are not activated by the generated indications.

An individual function or stage remains in the test mode during every restart until you have intentionally deactivated the test mode for this function or stage again or carried out an initial start.

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**, the indications generated in the device and marked with a test bit can be issued to a routed relay output of the device, that is, you enable the relay outputs of the device to be opened and closed.

If only one individual function or stage of the device is in test mode, that is, the cross device tested mode has not been activated, only the indications of this function or stage are marked with a test bit and the routed relay outputs of the device are activated.

NOTE

If the parameter **Oper.bin.outp. under test** is inactive (default setting), the **Test** state of a function or stage is changed to **Test/Relays blocked**.

Output Signal: Functions in Test mode

Normally, the output signal *Functions in Test mode* is prerouted to the last LED of the device base module. If one or more protection or control functions are in test mode, the output signal *Functions in Test mode* is generated and the corresponding LED of the device lights up red.

3.11.2.3 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
Setting change				
_:163	General:Reserv.time for com.prot.		0 s to 65535 s	120 s
Spontan.indic.				
_:139	General:Fault-display		• with pickup • with trip	with pickup
Control				
_:166	General:Shows interlock.cond. HMI		• 0 • 1	false
Test support				
_:150	General:Activate device test mode		• 0 • 1	false
_:151	General:Oper.bin.outp. under test		• 0 • 1	false

3.11.2.4 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
_:503	General:>Sw. authority local	SPS	I
_:504	General:>Sw. authority remote	SPS	I
_:505	General:>Sw. mode interlocked	SPS	I
_:506	General:>Sw. mode non-interl.	SPS	I
_:510	General:>Test mode on	SPS	I
_:511	General:>Test mode off	SPS	I
_:507	General:>Dev. funct.logout on	SPS	I

No.	Information	Data Class (Type)	Type
_:508	General:>Dev. funct.logout off	SPS	I
_:512	General:>LED reset	SPS	I
_:513	General:>Light on	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
_:318	General:Active settings group	INS	O
_:308	General:Switching auth. station	SPC	C
_:324	General:Enable sw. auth. 1	SPC	C
_:325	General:Enable sw. auth. 2	SPC	C
_:326	General:Enable sw. auth. 3	SPC	C
_:327	General:Enable sw. auth. 4	SPC	C
_:328	General:Enable sw. auth. 5	SPC	C
_:311	General:Switching authority	ENS	O
_:312	General:Switching mode	ENS	O
_:309	General:Sw.authority key/set	ENS	O
_:310	General:Sw.mode key/set	ENS	O
_: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
_:319	General:Device logout	SPC	C
_:313	General:Logged off via BI	SPS	O
_:314	General:Logged off via control	SPS	O
_:315	General:Device logged off	SPS	O
_:323	General:LED reset	SPC	C
_:320	General:LED have been reset	SPS	O
_:509	General:>Block monitoring dir.	SPS	I
_:317	General:Block monitoring dir.	SPS	O
_:329	General:Functions in Test mode	SPS	O

3.12 Display-Page Editor

If you order a SIPROTEC 5 device with display, you can preconfigure one or more display pages with the DIGSI 5 Editor **Display page**.

Via a display page, you can quickly obtain an overview of the following information:

- Text
- Signals
- Static and dynamic graphics

In DIGSI 5 Editor **Display page**, default names that are numbered in a consecutive order are assigned to the newly added display pages. When a display page is added or deleted, a binary signal (SPS) that has the same name is created or deleted automatically in **Information routing** > **Display pages**. With the activation of this binary signal, the device display switches to the corresponding display page automatically. The display page is maintained until another display-page signal is activated or the HMI is used.

From firmware version V9.50, you can create up to 30 different display pages for each SIPROTEC 5 device. By pressing the left and right navigation keys, you can toggle between the display pages in the device.

For more information, refer to *DIGSI 5 Online Help*.

4 Applications

4.1	Overview	238
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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 automation 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, note the following items:

- Adapt the application template to your specific use (check/adapt default settings, delete/add functions). For more detailed information, refer to *2.1 Embedding of Functions in the Device*.
- Check the routing of binary outputs regarding fast and normal relays.
- Check the CFC charts for the group-warning indications and group-fault indications.

The following sections describe the application templates and the maximum functional scope for the device **7VU85**.



NOTE

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

4.2 Application Template and Functional Scope for Device 7VU85

Application templates are available in **DIGSI 5** for the applications of the device **7VU85**. The application templates contain the basic configurations, required functions, and default settings.
The following application templates are available for the device **7VU85** in the **DIGSI 5** function library:

- HSBT single busbar with 2 incomers
- HSBT single busbar with 3 incomers
- HSBT sectionalized busbar with 2 incomers

For the application templates to function in the device, the following minimum requirements for the hardware configuration must be met:

Application Templates		Hardware Configuration Minimum Requirements	
Template 1	HSBT single busbar with 2 incomers	Base module (with IO202) and expansion module IO202	8 BI, 8 BO (type F), 8 V, 8 I
Template 2	HSBT single busbar with 3 incomers	Base module (with IO202) and expansion modules IO202 and IO201	14 BI, 10 BO (type F), 8 V, 12 I
Template 3	HSBT sectionalized busbar with 2 incomers	Base module (with IO202) and expansion module IO202	12 BI, 10 BO (type F), 8 V, 8 I

The following table shows the functional scope and the function-point requirements of the application templates for the device **7VU85**:

Table 4-1 Functional Scope of the Application Templates for the Device 7VU85

ANSI	Function	Abbre-viation	Available	Template 1	Template 2	Template 3
	Hardware quantity structure expandable	I/O	x	x	x	x
	Transfer direction		x	2	6	6
	Transfer-priority group		x	0	3	0
25	Synchrocheck, synchronization function	Sync	x			
25	Paralleling function 1.5 channel (significant feature: up to 4 sync. locations)	Sync	x			
25	Paralleling function 1.5 channel (significant feature: up to 8 sync. locations)	Sync	x			
25	Paralleling function 2 channel (significant feature: up to 4 sync. locations)	Sync	x			
25	Paralleling function 2 channel (significant feature: up to 8 sync. locations)	Sync	x			
	Balancing commands		x			
27	Undervoltage protection, 3-phase or universal Vx	V<	x			
32, 37	Power protection active/reactive power	P<>, Q<>	x			
37	Power-plant disconnection protection	-dP	x			
50/51 TD	Overcurrent protection, phases	I>	x			
50N/ 51N TD	Overcurrent protection, ground	IN>	x			
50HS	Instantaneous high-current tripping	I>>>	x			

ANSI	Function	Abbre-viation	Available	Template 1	Template 2	Template 3
50BF	Circuit-breaker failure protection, 3-pole	CBFP	x			
50RS	Circuit-breaker restrike protection	CBRS	x			
59	Overvoltage protection, 3-phase or universal Vx	V>	x			
60	Voltage-comparison supervision	ΔV>	x			
74TC	Trip-circuit supervision	TCS	x			
74CC	Closing-circuit supervision	CCS	x			
74CC	Closing-circuit supervision for paralleling	CCS	x			
81	Frequency protection, f>, f< or df/dt	f<>; df/dt<>	x			
	Vector-jump protection	Δφ>	x			
AFD	Arc protection (only with plug-in module ARC-CD-3FO)		x			
PMU	Synchrophasor measurement (1 PMU transmits up to max. 8 voltages and 8 currents)	PMU	x			
	Measured values, standard		x			
	Instantaneous tripping at switch onto fault	SOTF	x			
	Measured values, extended: Min, Max, Avg		x			
	Switching-statistic counters		x			
Monit	Circuit-breaker monitoring	ΣIx, I²t, 2P	x			
	CFC (Standard, control)		x			
	CFC arithmetic		x			
	Switching sequences function		x			
	Inrush-current detection		x			
	External trip initiation		x			
	External trip initiation with current-flow criterion 3-pole		x			
	Fault recording of analog and binary signals		x	1	1	1
	Monitoring and supervision		x			
	Protection interface, serial		x			
	Circuit breaker		x	2	3	3
	Circuit-breaker test		x	2	3	3
	Control		x	2	3	3
	Interlocking		x	2	3	3
	Disconnector/grounding switch		x			
	Frequency-tracking groups		x			
	Synchronization tap-changer adaption		x			
VSEL	Voltage measuring-point selection		x			
	Voltage measuring-point selection for paralleling		x			
20mAMT	20-mA unit Ethernet		x			
20mAMS	20-mA unit serial		x			
	2nd harmonic ground detection		x			
	Rate-of-voltage-change protection	dv/dt	x			
	LPIT module IO240		x			
	Voltage variation		x			
	Voltage unbalance		x			
	THD and harmonics		x			

ANSI	Function	Abbre-viation	Available	Template 1	Template 2	Template 3
	Total demand distortion		x			
	Auxiliary direct-voltage supervision		x			
	Disconnector-switch monitoring		x			
Function-point class				0	470	410

Besides the high-speed busbar transfer, the device 7VU85 also contains protection functions with the following electrical variables:

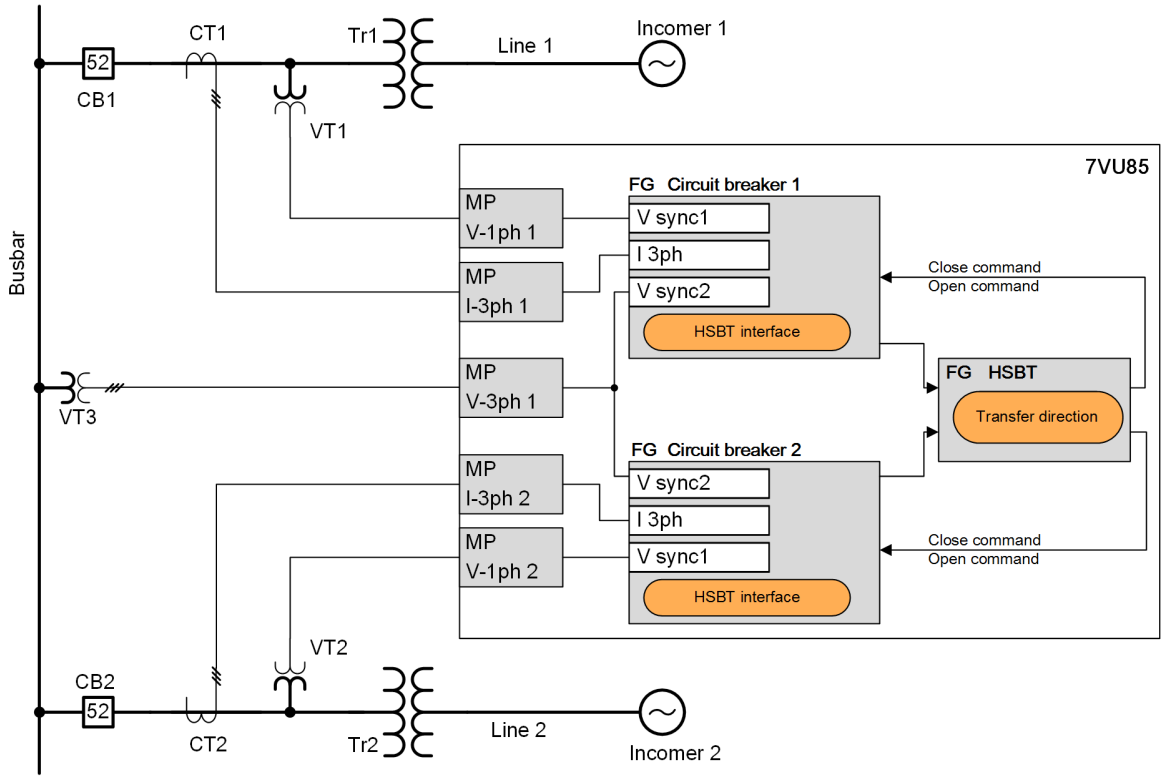
- Voltage
- Current
- Power
- Frequency

Thus, the device 7VU85 can be used for protection. You can add further functions from the Global DIGSI 5 Library to your application.

Application Template: Single Busbar with 2 Incomers

Figure 4-1 shows an extract of the 1st application template for the device 7VU85. The application template is suitable for typical applications in a thermal power plant.

- During the normal running status of the power plant, the low-voltage busbar which energizes the motors is energized by the auxiliary transformer of the generator-transformer unit.
- If the running incomer is not available, for example, during the startup or shutdown of the generator, the alternative incomer is used.



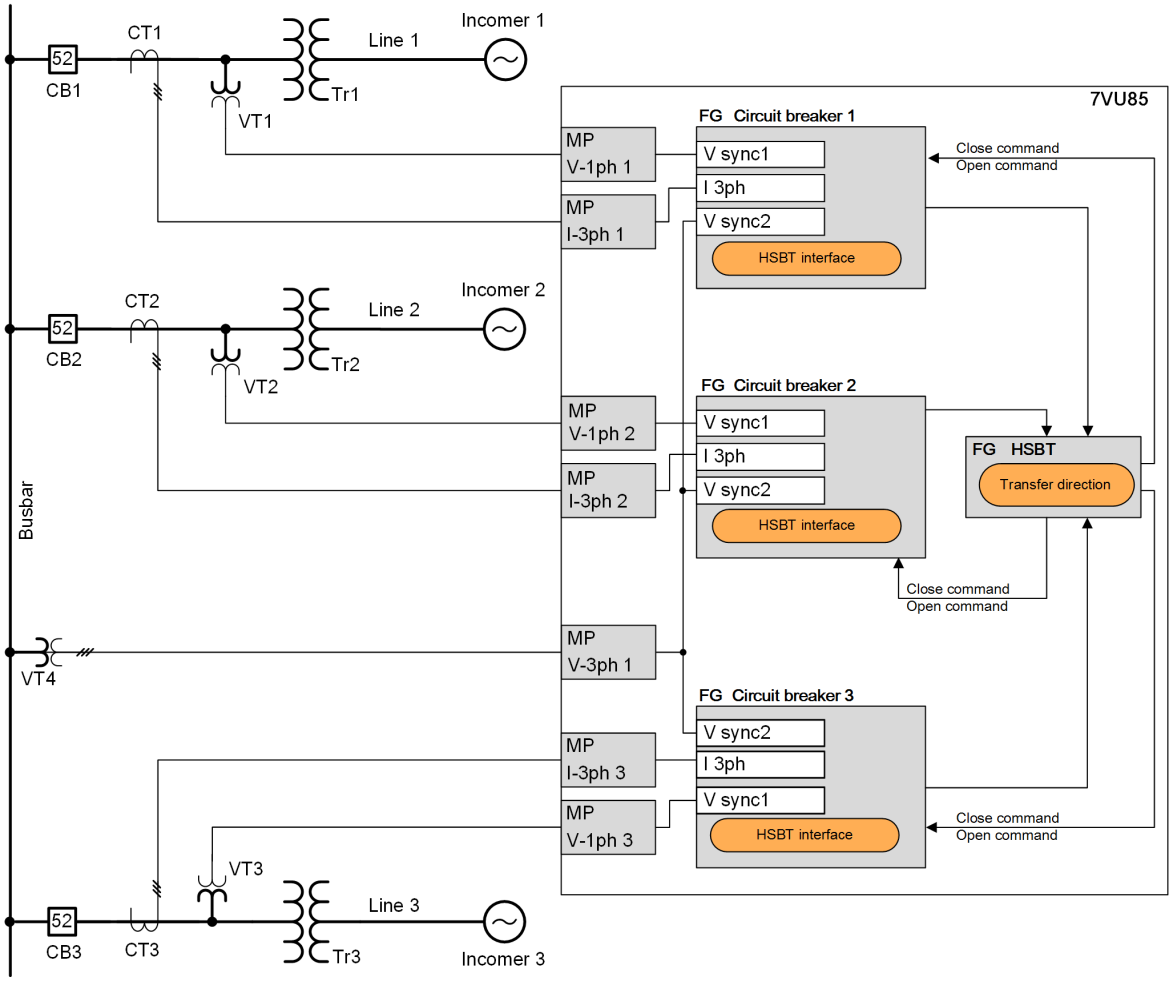
[dw_application template_1BB_2S, 1, en_US]

Figure 4-1 Application Template: Single Busbar with 2 Incomers

Application Template: Single Busbar with 3 Incomers

Figure 4-2 shows an extract of the 2nd application template for the device 7VU85.

- During the normal running status of the power plant, the motor busbar is energized by one of the 3 incomers.
- During maintenance, for example due to an incomer fault, the motor busbar is energized by another one of the 3 incomers.



{dw_application template_1BB_3S, 1, en_US}

Figure 4-2 Application Template: Single Busbar with 3 Incomers

Application Template: Sectionalized Busbar with 2 Incomers

Figure 4-3 shows an extract of the 3rd application template for the device 7VU85. The application template is suitable for typical applications in an industrial plant.

- During the normal running status of the industrial plant, the section CB (CB3) is open, and the 2 motor busbars are energized by the 2 incomers respectively.
- During maintenance or in case of an incomer fault, the section CB (CB3) is closed, and both motor busbars are energized by 1 incomer.

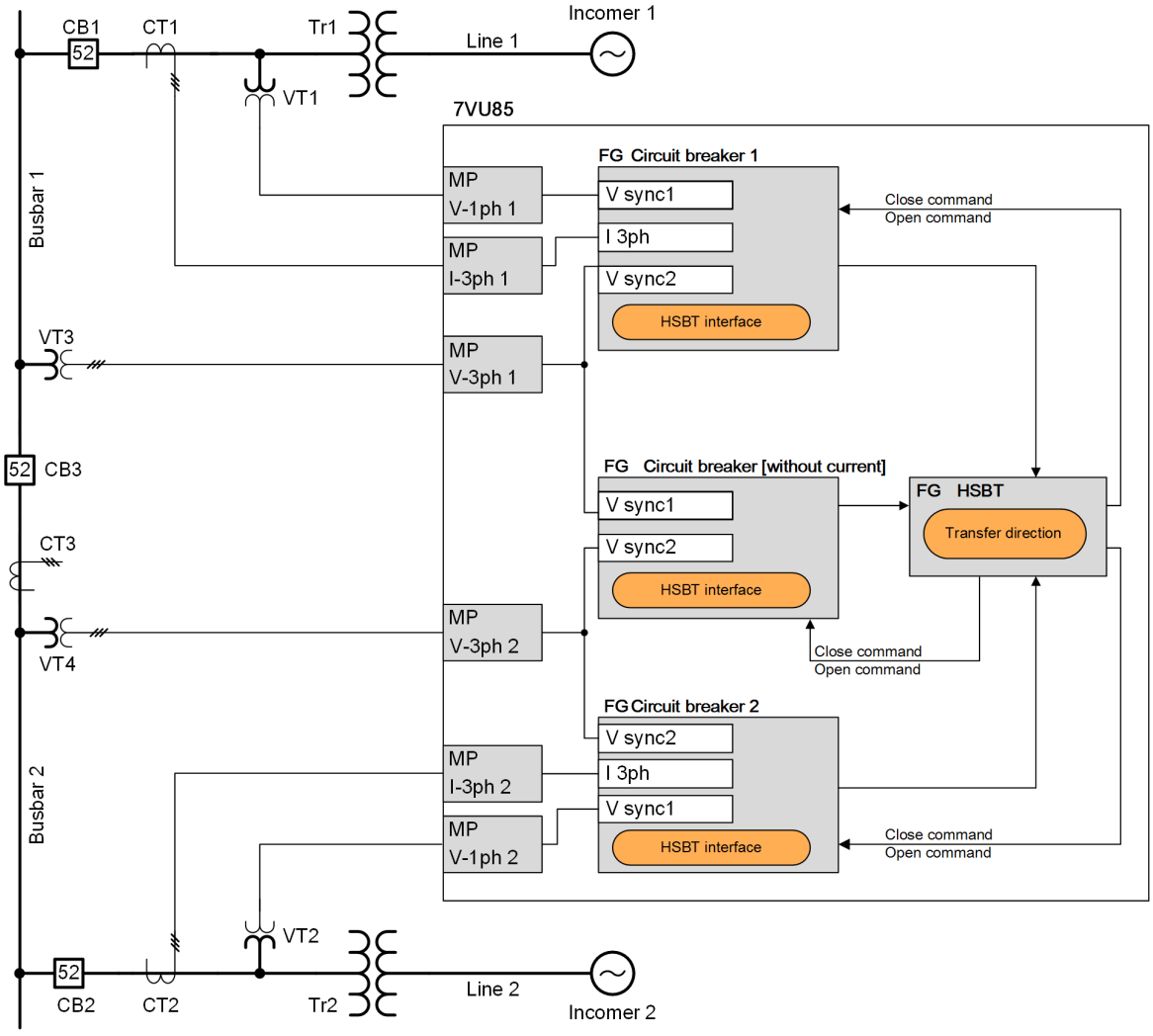
In this application template, the following CB-related function groups are instantiated:

- 2 function groups **Circuit breaker** are instantiated for 2 incomer CBs.

  The current of the incomer CB[14] is an essential quantity that is monitored to avoid the overfunction of HSBT. With a function group **Circuit breaker**, the current of an incomer CB is measured.

- 1 function group **Circuit breaker [without current]** is instantiated for the section CB.

  For most applications of HSBT, the current of the section CB is useless. The function group **Circuit breaker [without current]** does not measure the CB current, which reduces the hardware consumption and the engineering effort. If the current of the section CB is necessary in an application, you can change the type of the function group accordingly.



[dw_application template_sect.BB_2S, 2, en_US]

Figure 4-3 Application Template: Sectionalized Busbar with 2 Incomers

CT3 In this application template, the current of CB3 (section CB) is unnecessary, CT3 is not connected.

When using this application template, pay attention to the configuration of the following transfer directions:

Transfer Directions	CB to Be Opened	CB to Be Closed	Additional Open CB	Additional Closed CB
Incomer 2 to incomer 1	CB2	CB1	–	CB3
Busbar 2 to incomer 1	CB3	CB1	–	–

14 Incomer CB: Circuit breaker that switches on or off the connection between incomer and busbar.

Transfer Directions	CB to Be Opened	CB to Be Closed	Additional Open CB	Additional Closed CB
Incomer 1 to incomer 2	CB1	CB2	–	CB3
Busbar 1 to incomer 2	CB3	CB2	–	–

Take the transfer directions **Incomer 2 to incomer 1** and **Busbar 2 to incomer 1** as an example to illustrate the configuration rules. The transfer directions **Incomer 1 to incomer 2** and **Busbar 1 to incomer 2** must follow the same configuration rules.

The simultaneous self-starting of the transfer directions **Incomer 2 to incomer 1** and **Busbar 2 to incomer 1** causes unwanted competition. To avoid the simultaneous self-starting, execute one of the following operations according to the actual transfer requirement:

- Delete one of the transfer directions directly.
- Disable one of the transfer directions (parameter **Mode** = off)
- Adjust one of the transfer directions to the manual start (parameter **Manual start only** = yes):
  - The default setting in the application template is as follows. This setting is the common setting for most applications.
    For the transfer direction **Busbar 2 to incomer 1**, the parameter **Manual start only** is set to ***yes***.
    For the transfer direction **Incomer 2 to incomer 1**, the parameter **Manual start only** is set to ***no***.
  - The other setting option is as follows:
    For the transfer direction **Busbar 2 to incomer 1**, set the parameter **Manual start only** to ***no***.
    For the transfer direction **Incomer 2 to incomer 1**, set the parameter **Manual start only** to ***yes***.

5 Function-Group Types

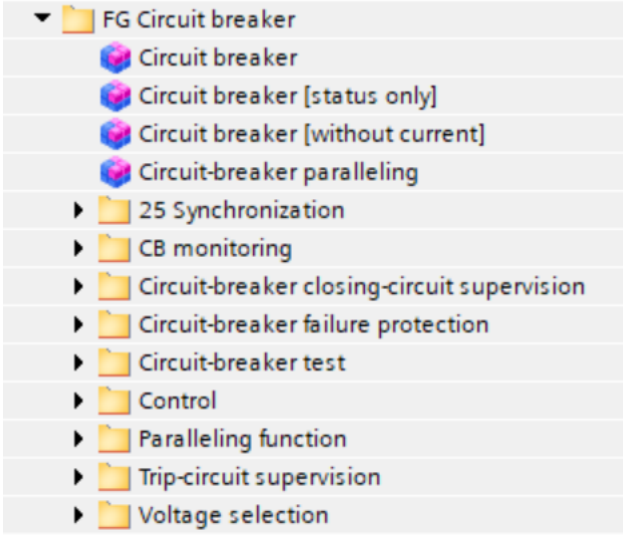
5.1	Function-Group Type Circuit Breaker	246
5.2	Function-Group Type Circuit Breaker [without Current]	266
5.3	Function-Group Type Circuit-Breaker Paralleling	284
5.4	Function-Group Type Voltage 3-Phase	300
5.5	Function-Group Type Voltage/current 1-Phase	303
5.6	Function-Group Type Voltage/current 3-Phase	308
5.7	Function-Group Type Analog Units	314
5.8	Function-Group Recording	389
5.9	Process Monitor	391

5.1 Function-Group Type Circuit Breaker

5.1.1 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.



[sc_fg_cb_vu, 2, en_US]

Figure 5-1 Circuit-Breaker Function Group – Functional Scope

The Circuit-breaker function group includes 2 different types of circuit breakers:

- Circuit breaker
- Circuit breaker [status only]
- Circuit breaker [without current]
- Circuit breaker paralleling

The type circuit breaker can accept additional basic function blocks for protection functions along with the actual circuit-breaker control.

The type 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 type circuit-breaker [without current] is described in *5.2.1 Overview*.

The type circuit-breaker paralleling is described in *5.3.1 Overview*.

The available functions are described in *8 Protection and Automation Functions* and *7 Control Functions*.

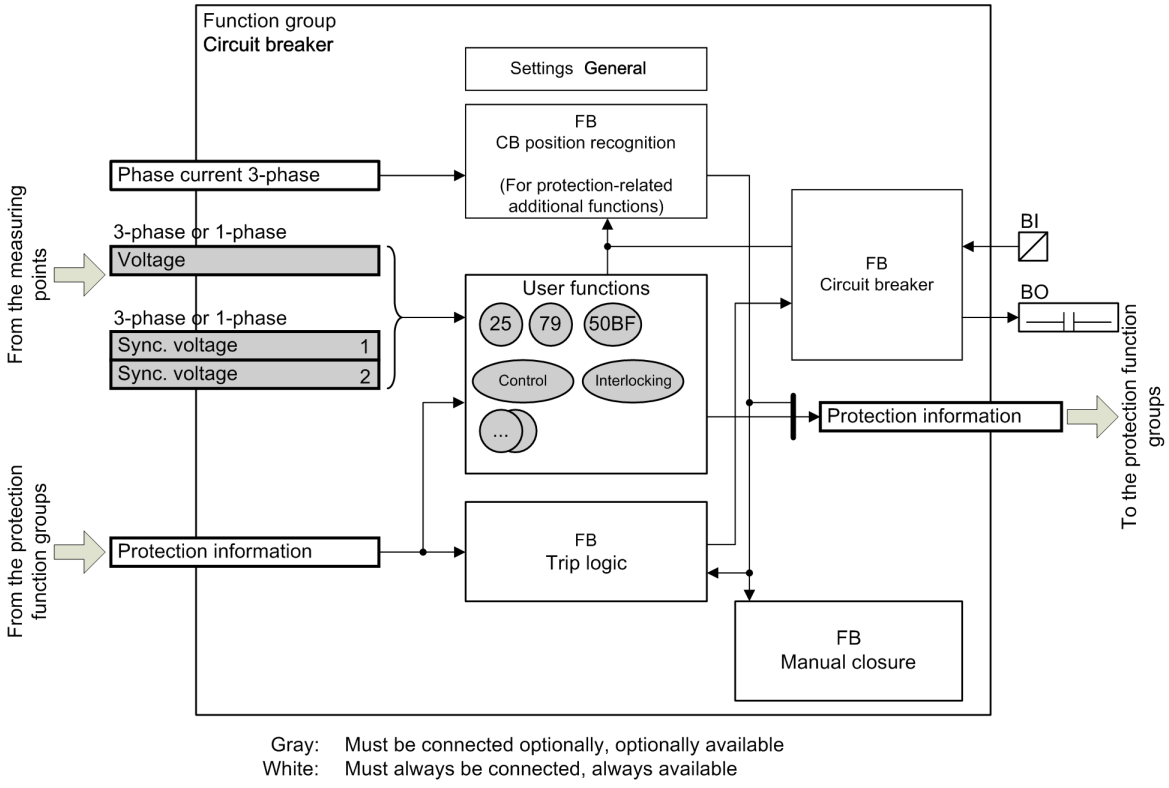
5.1.2 Structure of the Function Group

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.



[dw_fg_stru, 1, en_US]

Figure 5-2 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. The configuration is done via the **Function-group connections** editor in DIGSI 5.

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 function group **Circuit breaker** has interfaces with the following measuring points:

- **3-phase line current**

  The measurands from the 3-phase current system are supplied via this interface. The function group must always be connected to this measuring point.

- **Voltage**
  The measurands from the 3-phase voltage system 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 the feeder. The connection of the function group to this measuring point is optional.
- **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 are exchanged between the protection function group and the function groups **Circuit breaker** via the interfaces of the function group **Circuit breaker**. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the function group circuit-breaker and, for example, the circuit-breaker position 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.

If the linkage 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?

5.1.3 Application and Setting Notes

Interface with Measuring Points

The interface with the 3-phase current 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 power-supply units to be synchronized must be connected.

For further information refer to *7.8 Synchronization Function*.

Interface with Protection-Function Groups

The protection-function group is connected to 2 circuit breakers (2 function groups **Circuit breaker**) for 1 1/2 circuit-breaker layouts.

Parameter: I Reference for % Values

- Default setting **(_:2311:101) Rated normal current** = ***1000.00 A***

With the parameter **Rated normal current**, you set the primary current, which serves as a reference for all current-related % values within the function group Circuit breaker. 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 the setting value of the parameter only 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: V Reference for % Values

- Default setting **(_:2311:102) Rated voltage** = ***400.00 kV***

With the parameter **Rated voltage**, you set the primary voltage, which serves as a reference for all voltage-related % values within the function group Circuit breaker. 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 the setting value of the parameter only 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 parameter **Current thresh. CB open**, you specify the current threshold below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the parameter **Current thresh. CB open** 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.

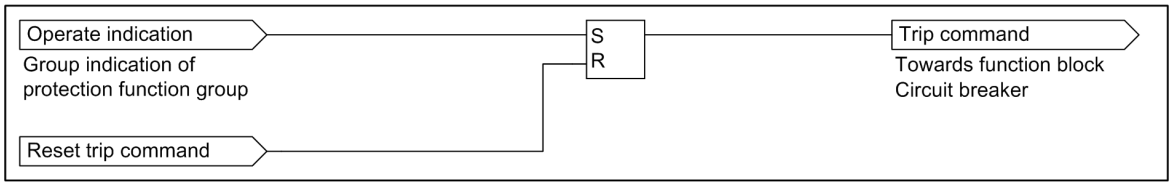
5.1.4 Trip Logic

5.1.4.1 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 *5.1.5 Circuit Breaker*). The command output time is also effective here.

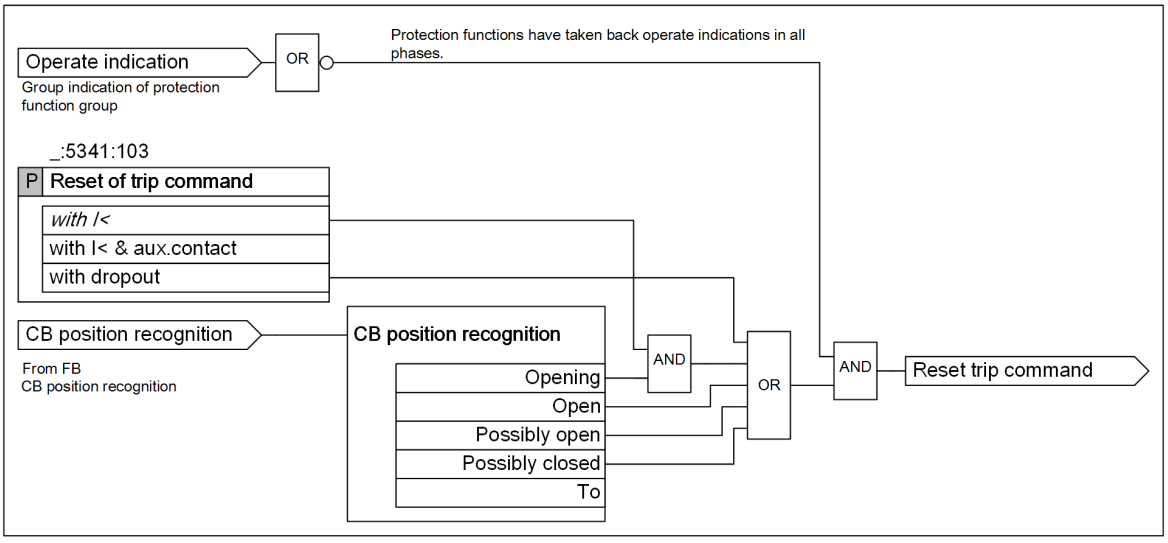
The trip logic also decides when the protection trip command is reset (see *Figure 5-4*).



[lo_ausbef, 1, en_US]

Figure 5-3 Trip Command

Trip-Command Reset



[lo_befe3p, 1, en_US]

Figure 5-4 Trip-Command Reset

Once a trip command is issued, it is stored (see *Figure 5-3*).

You determine the criteria for resetting a trip command that has been issued with the parameter **`Reset of trip command`**. The following setting options are possible:

- **`with dropout`**

  If the function that initiated tripping resets its operate indication the trip command is reset. 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 and the determination of the various conditions is supplied by the **Circuit-breaker position recognition** function block. You can find further information in chapter *5.1.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

5.1.4.2 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<	The trip command is reset under the following conditions: • Dropout of the tripping function • The current falls short of the value set in the parameter **(_:2311:112) Current thresh. CB open**
with I< & aux.contact	The trip command is reset under the following conditions: • The current falls short of the value set in the parameter **(_:2311:112) Current thresh. CB open** • The circuit-breaker auxiliary contact reports 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 *5.1.5.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).
with dropout	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 this setting is useful. 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.

5.1.4.3 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<

5.1.4.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O

5.1.5 Circuit Breaker

5.1.5.1 Overview

The function block **Circuit breaker** represents the physical switch in the SIPROTEC 5 device.
The basic tasks of this function block are:

- Operation of the circuit breaker (CB)
- Acquisition of the circuit-breaker auxiliary contacts
- Acquisition of other circuit-breaker information

The function block **Circuit breaker** provides the following information:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

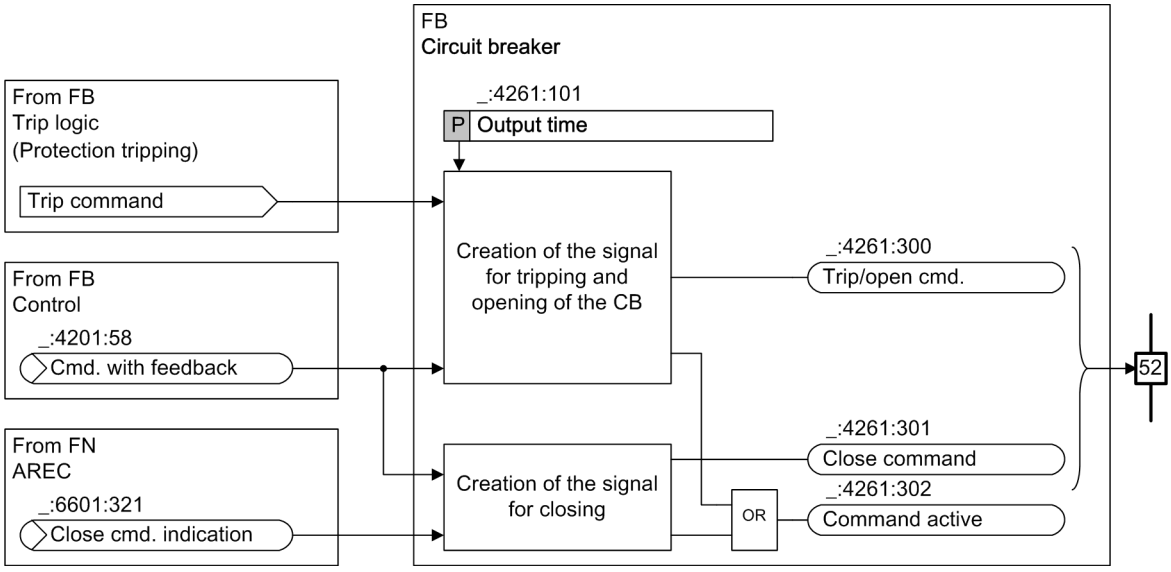
5.1.5.2 Tripping, Opening, and Closing the Circuit Breaker

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 an automatic reclosing or of 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 function block **Circuit breaker** is generated there.

For the operational handling of the circuit breaker, the function block **Circuit breaker** provides the output signals that must be routed to the corresponding binary outputs of the device (see *Table 5-1*).



[lo_aussc, 1, en_US]

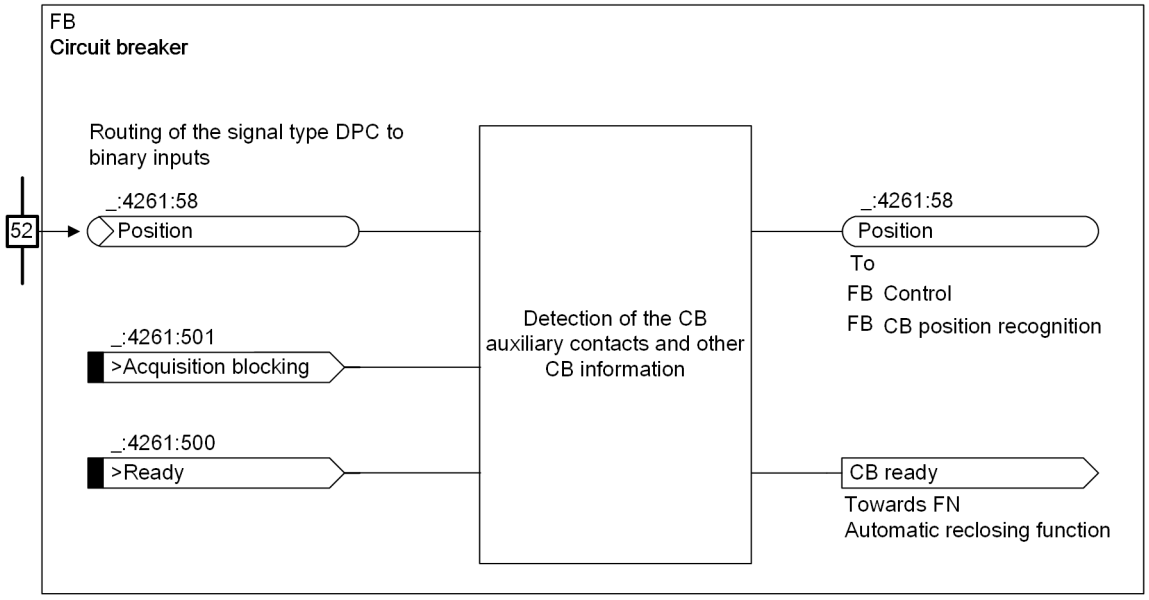
Figure 5-5 Tripping, Opening, and Closing the Circuit Breaker

Table 5-1 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 the output time, with the following exceptions: • **Only when switched off by the control:** The signal is reset 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 *5.1.4.1 Function Description*). If the trip signal is no longer active and the auxiliary contacts report that the circuit breaker is open before expiration of the period, the signal is canceled before expiration of the period. – 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 the output time, 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 if one of the following binary outputs is active: • **Trip/open cmd.** • **Close command** The binary outputs are active as long as a switching command is being executed by the control.	Normal routing

5.1.5.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit-breaker position, the function block **Circuit breaker** provides position signals. 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 switch positions can be reliably acquired.



[lo_erfass, 2, en_US]

Figure 5-6 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker switch position The switch position CB 3-pole **open** and/or the position CB 3-pole **closed** can be detected by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is 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. If you route only one signal (**open** or **closed**), you cannot determine an intermediate position or a disturbed position.

In the monitoring direction, the position signals generate the following information when the **open** and **closed** positions are detected (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Open	SPS	The circuit-breaker switch position is **opened**.
Closed	SPS	The circuit-breaker switch position is **closed**.
Intermediate position	SPS	The circuit-breaker switch position is in the **intermediate position**. The signal **open** and the signal **closed** have not been set.
Disturbed position	SPS	The circuit-breaker switch position is in the **disturbed position**. The signal **open** and the signal **closed** have been set simultaneously.
Not selected	SPS	The circuit breaker is **not selected** for a control operation.

The following table shows the additional input signals:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see *Other Functions 3.9.3 Persistent Commands* for a description of acquisition blocking).
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. If the signal is active, acquisition blocking and manual update are reset.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an **Open-Closed-Open** 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.

The following table shows one additional output signal:

Signal	Type	Description
External health	ENS	This can be used to indicate the health of the physical circuit breaker. For this, all failure information of the circuit breaker must be detected 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.

5.1.5.4 Circuit-Breaker Tripping Alarm Suppression

Circuit-Breaker Tripping Alarm Suppression

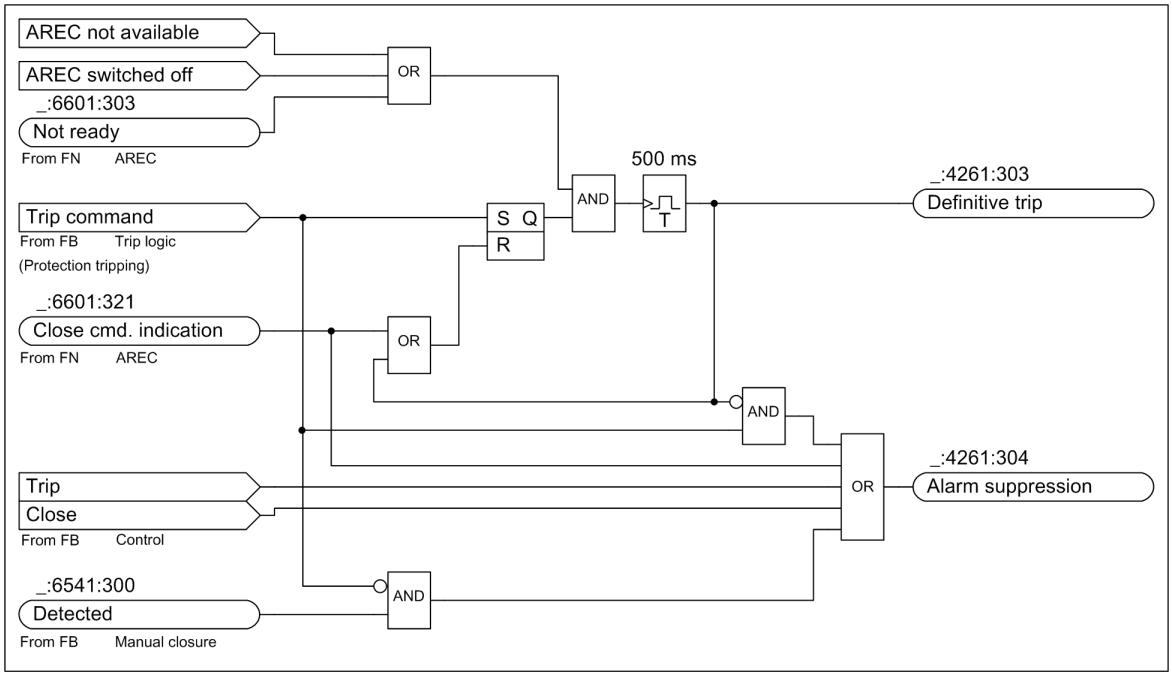
In certain systems, the user may wish to actuate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not be issued if it is to be reclosed automatically after tripping, or if it is to be closed or opened via the control. The alarm is only to be issued in the event of definitive 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.

If one of the following conditions is met, the *Alarm suppression* signal is generated:

- The definitive protection tripping is not present.
- The integrated automatic reclosing function executes a closure.
- The integrated control executes a closure or opening action.
- The function **Manual close** detects an external closing.

For further information about its use, refer to *5.1.7.2 Application and Setting Notes*.

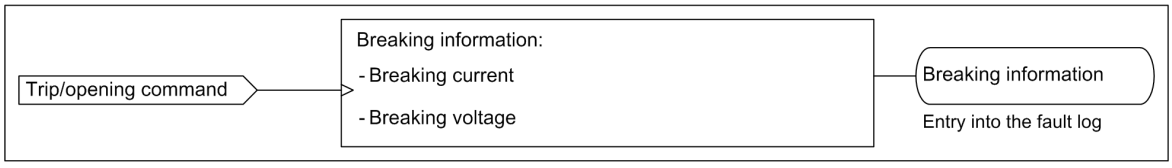


[lo_unterd, 2, en_US]

Figure 5-7 Definitive Tripping and Circuit-Breaker Tripping Alarm Suppression

5.1.5.5 Tripping and Opening Information

When a trip or opening command is issued, the breaking information shown in the next figure is saved in the fault log.



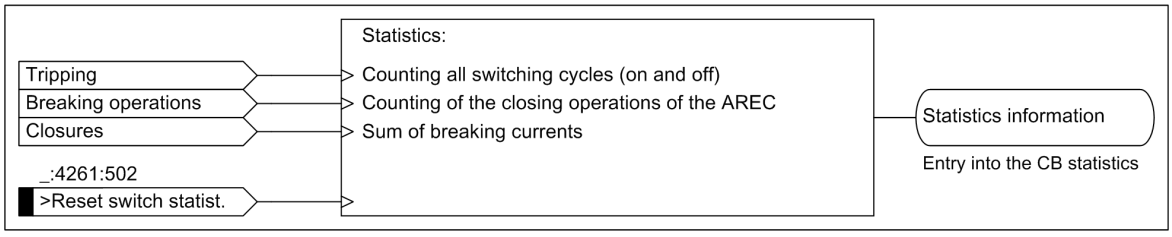
[lo_ausloe, 2, en_US]

Figure 5-8 Breaking 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 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.`**.



[lo_statistics information circuit-breaker, 2, en_US]

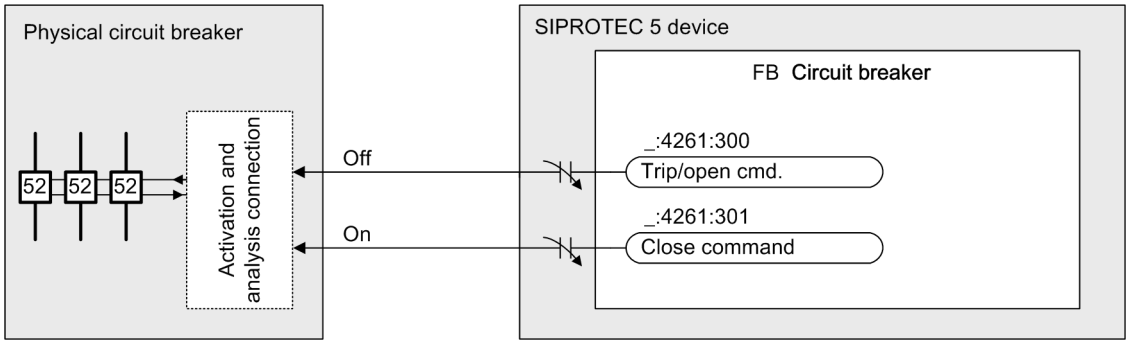
Figure 5-9 Statistics Information About the Circuit Breaker

5.1.5.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-10 shows the necessary routings for the device:

- 3-pole tripping via the protection
- 3-pole opening via the control



[lo_ansteu, 2, en_US]

Figure 5-10 Activation of the Circuit Breaker

By routing the **`Trip/open cmd.`** signals to 1 or 2 binary outputs, you can carry out 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker. You can find a detailed description of this in chapter *7.2.2.3 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.

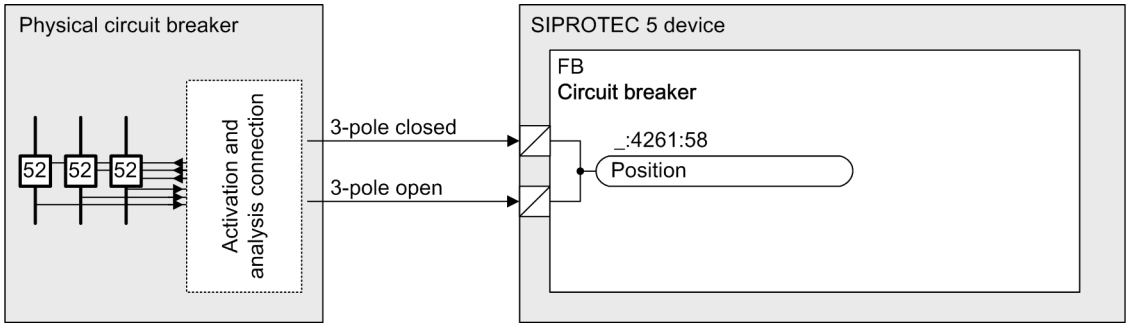
Routing to Evaluate the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. The following shows a number of examples:

- **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.

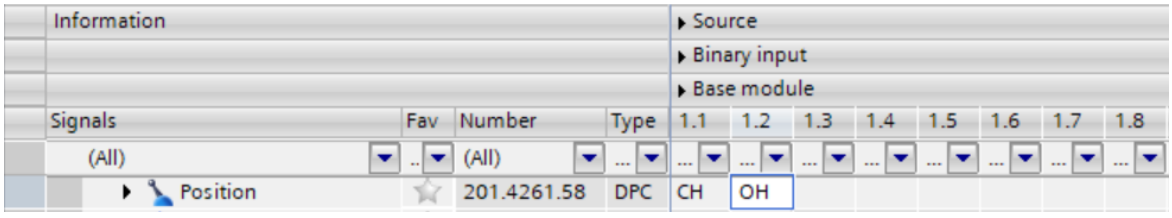
Siemens recommends capturing the information *`Circuit breaker is open in 3 poles`* and *`Circuit breaker is closed in 3 poles`* via auxiliary contacts. This is the optimal configuration for the control functionality. For purely protection applications, it is also sufficient to acquire just one of the 2 circuit-breaker switch positions. When used as a protection and control device, Siemens recommends the following evaluation of the circuit-breaker switch position:



[lo_evaluation2, 1, en_US]

Figure 5-11 Recommended Evaluation of the Circuit-Breaker Switch Position

The following diagram shows the recommended routing, in which **OH** stands for **active with voltage**.



[sc_polg3p, 1, en_US]

Figure 5-12 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.

Parameter: Indicat. of breaking values

- Default setting **(_:105) Indicat. of breaking values** = ***always***

With the parameter **Indicat. of breaking values**, you specify whether the measured values are to be reported if the circuit breaker is opened via the control function.

Parameter Value	Description
always	With this setting, the measured values are reported if the circuit breaker is opened either via the control function or via the trip command of a protection function.
with trip	With this setting, the measured values are only reported if the circuit breaker is opened via the trip command of a protection function.

Measured Values

When a protection function opens the circuit breaker, the following measured values can be stored in the fault log:

- *Break.-current phs A*
- *Break.-current phs B*
- *Break.-current phs C*
- *Break. current 3I0/IN*
- *Break. voltage phs A*
- *Break. voltage phs B*
- *Break. voltage phs C*

The measured value *Break. current 3I0/IN* is the neutral-point current. Dependent on the connection type of the **measuring point I-3ph** that is connected with the function group **Circuit breaker**, the neutral-point current differs as follows:

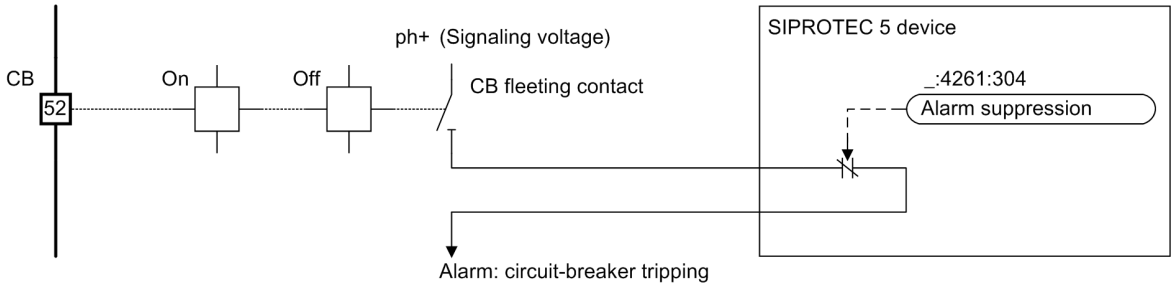
Connection Type of the Measuring Point I-3ph	Neutral-Point Current
3-phase	Calculated zero-sequence current $3I_0$
3-phase + IN 3-phase + IN-separate 3ph,2prim.CT + IN-sep 2ph, 2p. CT + IN-sep	Measured neutral-point current I_N If the secondary ground current exceeds the linear section of the sensitive measuring input (1.6 Irated) with sensitive current transformers, the neutral-point current of the measured I_N is switched to the calculated $3I_0$.

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 always 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.

You can find more detailed information in the logic in *5.2.6.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information*.



[lo_schalt, 2, en_US]

Figure 5-13 Circuit-Breaker Tripping Alarm Suppression

5.1.5.7 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
_:105	Circuit break.:Indicat. of breaking values		• with trip • always	always

5.1.5.8 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
_:317	Circuit break.:Break. current 3I0/IN	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

5.1.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.1.6.1 Overview

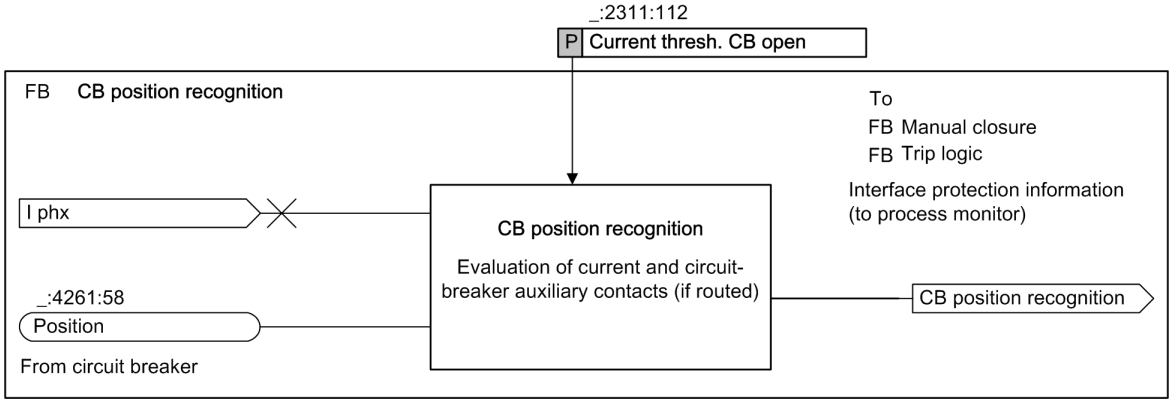
This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see)
- Detection of manual closing (see *5.1.7.1 Function Description*)
- Process monitor (see)

The specified chapters describe the way the protection-related additional functions are processing the information of this function block.

The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.



[lo_zust3p, 1, en_US]

Figure 5-14 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, shown in *Figure 5-14*, the circuit breaker can assume the following positions. The following table shows the possible circuit-breaker conditions:

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. The reason for that is that the current-flow criterion takes effect faster than the auxiliary contact can open.

5.1.7 Detection Manual Closure (for AREC and Process Monitor)

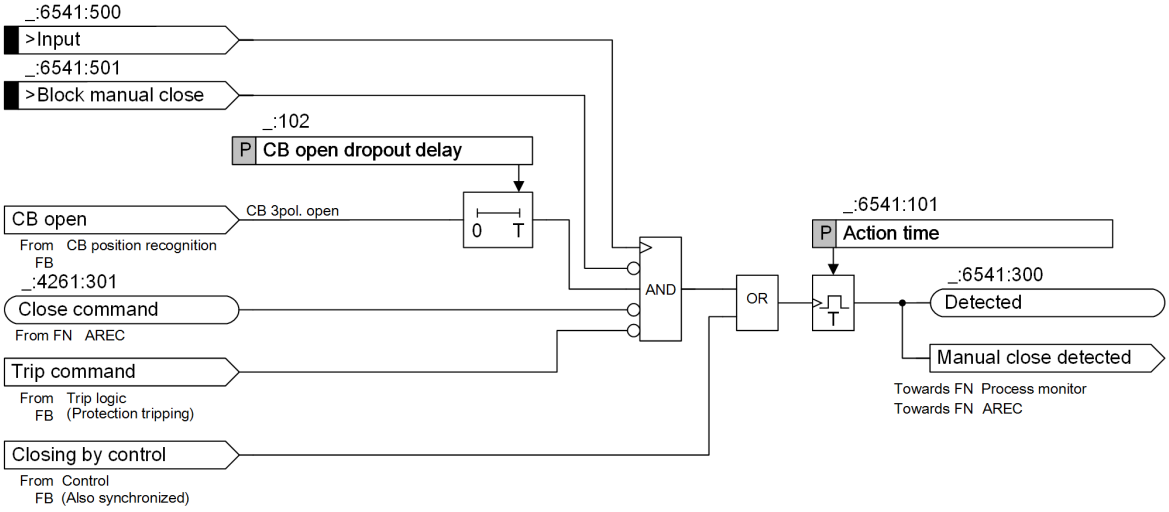
5.1.7.1 Function Description

Detection of Manual Closure (for Process Monitor)

The **Manual closure** function block detects any closure carried out by hand. This information is used in **Process monitor** functions (within protection function groups).

You can find detailed information in the chapter *Process monitor*.

The following figure shows the logic for manual closure detection.



[lo_hand_3p, 4, en_US]

Figure 5-15 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. Detection via the input signal **>Input** is also blocked if the circuit breaker is closed or if a protection trip is active.

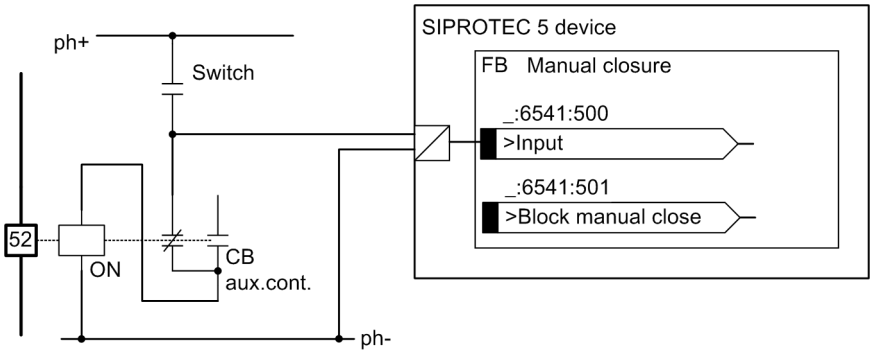
Internal Manual Closure

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.

5.1.7.2 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).



[lo_steuer, 1, en_US]

Figure 5-16 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.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to promptly detect a manual closure, 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** = ***0.30 s***

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 ***0.30 s***.

Parameter: CB open dropout delay

- Default setting **(_:102) CB open dropout delay** = ***0.00 s***

With the **CB open dropout delay** parameter, you can maintain the effectiveness of internal indication *CB open* for the set time. If the input signal **>Input** becomes active after external delayed manual closure, the indication *(_:300) Detected* is output as long as the dropout delay is effective.

5.1.7.3 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
_:102	Manual close:CB open dropout delay		0.00 s to 60.00 s	0.00 s

5.1.7.4 Information List

No.	Information	Data Class (Type)	Type
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

5.1.8 HSBT Interface

5.1.8.1 Description

The function block **HSBT interface** is an interface without any logic. It contains the circuit-breaker related parameters that are used in the function group **HSBT**.

5.1.8.2 Application and Setting Notes

Parameter: CB make time

- Default setting **(_:22591:113) CB make time** = ***0.060 s***

With the parameter **CB make time**, you specify the time interval between the activation of the closing procedure and the instant when the current begins to flow. You can measure the make time during commissioning or directly get the make time from the technical data of the circuit breaker.

Parameters for the Measured-Values Calculation in the Function Group HSBT

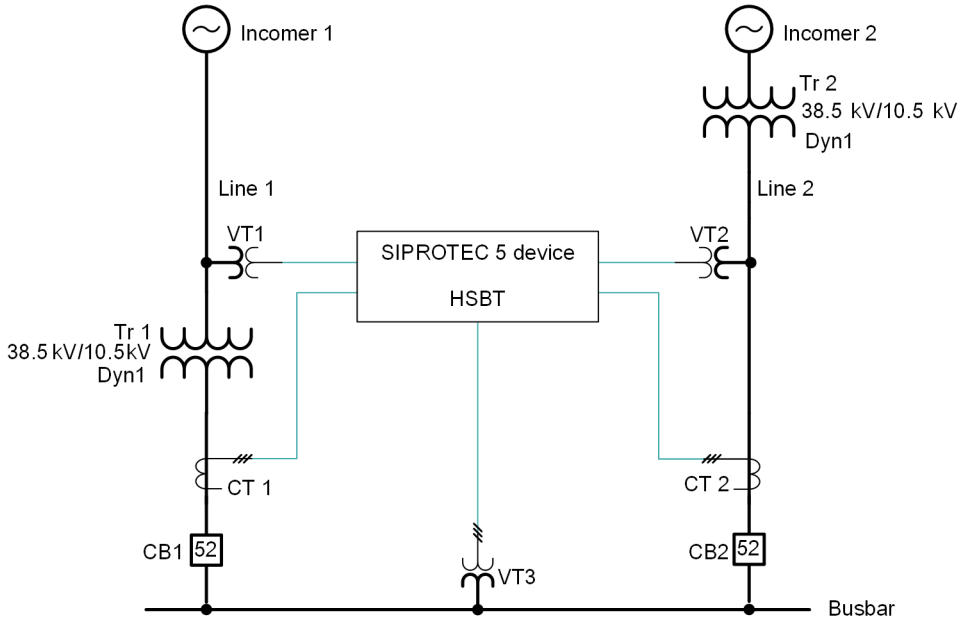
- Default setting **(_:22591:126) Vsync ratio (transform.)** = ***1.000***
- Default setting **(_:22591:127) Angle adjust. (transform.)** = ***0.0°***

If a power transformer is located between a voltage transformer and a circuit breaker on the same incoming line, set these 2 parameters for the specific circuit breaker according to the actual data of the power transformer. For other cases, keep the default values for the relevant circuit breakers.

Set the parameter **Vsync ratio (transform.)** to the actual power transformer ratio. The calculation of the voltage measured values in the function group **HSBT** takes the power transformer ratio into account.

Set the parameter **Angle adjust. (transform.)** to the phase-displacement angle of the power transformer. The calculation of the angle difference in the function group **HSBT** takes the phase-displacement angle into account.

EXAMPLE



[dw_example_adjustment, 2, en_US]

Figure 5-17 Application Example

The power transformer Tr1 is located between the voltage transformer VT1 and the circuit breaker CB1 on the incoming line 1. In this case, you must set the parameters **Vsync ratio (transform.)** and **Angle adjust. (transform.)** according to the actual data of the power transformer Tr1.

The power transformer Tr2 is not located between the voltage transformer VT2 and the circuit breaker CB2 on the incoming line 2. In this case, keep the default values of the parameters **Vsync ratio (transform.)** and **Angle adjust. (transform.)**.

The actual ratio of the power transformer Tr1 is calculated as follows. Set the parameter **Vsync ratio (transform.)** for the circuit breaker CB1 to ***3.667***.

$$K_{act.} = \frac{V_{HV\,act.}}{V_{LV\,rated}} = \frac{38.5\ kV}{10.5\ kV} \approx 3.667$$

[fo_K factor, 1, en_US]

With:

$V_{HV\,act.}$	Actual voltage on the high-voltage side of the power transformer Tr1, which already considers the tap changer
$V_{LV\,rated.}$	Rated voltage on the low-voltage side of the power transformer Tr1

The vector-group number of the power transformer Tr1 is 1, so the phase-displacement angle is 30°. Set the parameter **Angle adjust. (transform.)** for the circuit breaker CB1 to ***30°***.

5.1.8.3 Settings

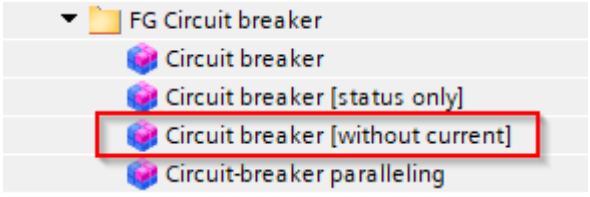
Addr.	Parameter	C	Setting Options	Default Setting
HSBT interface				
_:22591:113	HSBT interface:CB make time		0.020 s to 0.150 s	0.060 s
_:22591:126	HSBT interface:Vsync ratio (transform.)		1.000 to 100.000	1.000
_:22591:127	HSBT interface:Angle adjust. (transform.)		-179.0 ° to 180.0 °	0.0 °

5.2 Function-Group Type Circuit Breaker [without Current]

5.2.1 Overview

The function group **Circuit breaker [without current]** is a circuit-breaker function group that does not measure the primary current of the circuit breaker. For the applications that do not need to monitor the current information of circuit breakers, the function group **Circuit breaker [without current]** is a good option.

You can find the function group **Circuit breaker [without current]** under the device types in the Global DIGSI 5 Library.



[sc_fg cb without I_7vu85, 1, en_US]

Figure 5-18 Function Group Circuit Breaker [without Current]

The following functions are available in the function group **Circuit breaker [without current]**:

- Circuit-breaker control
- Circuit-breaker interlocking
- Circuit-breaker test
- Synchronization
- External synchronization
- Trip-circuit supervision
- Closing-circuit supervision
- Voltage measuring-point selection

NOTE

When working with the function group **HSBT**, a function group **Circuit breaker [without current]** is usually instantiated for a section CB. For the incomer CB[15], Siemens recommends using the normal function group **Circuit breaker**. By using the normal function group **Circuit breaker** which monitors the current information, the functionalities **Underfrequency start**, **Undervoltage start**, and **CB inadvertent opening start** work more safe.

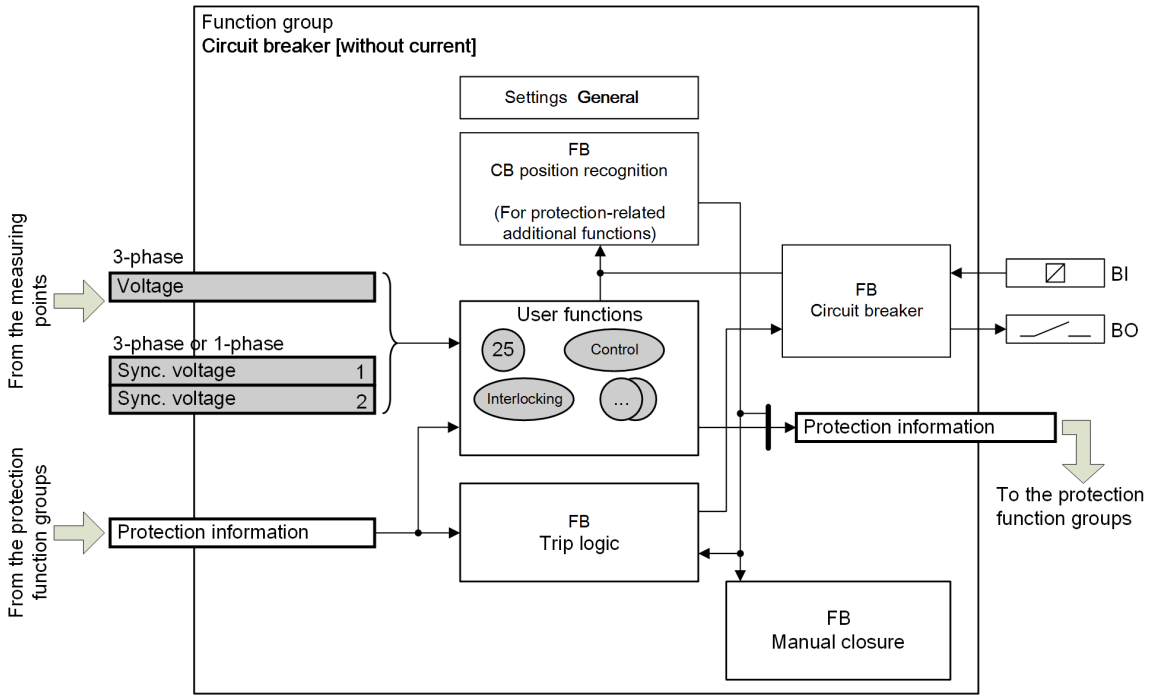
5.2.2 Structure of the Function Group

Besides the user functions, the function group **Circuit breaker [without current]** contains certain functionalities that are essential for general purposes. These functionalities 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

15 Incomer CB: Circuit breaker that switches on or off the connection between incomer and busbar.

The following figure shows the structure of the function group **Circuit breaker [without current]**. The individual function blocks in the figure are described in the following chapters.



[dw_fg_stru, 1, en_US]

Figure 5-19 Structure of the Function-Group Type Circuit breaker [without current]

Gray: Optionally connected

The function group **Circuit breaker [without current]** has interfaces with the following items:

- Measuring points
- Function groups

Interfaces with Measuring Points

The function group receives the required measured values from the measuring points which are connected to this function group.

If a user function, for example, the function **Synchronization**, is used in the function group, but the required measuring point is not linked to the function group, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The function group **Circuit breaker [without current]** has interfaces with the following measuring points:

- **3-phase voltage**

  The measurands of the 3-phase voltage system are supplied via this interface. The voltages are different due to the different connection types of the voltage transformers, for example, V_A, V_B, and V_C in one 3-phase voltage system, but V_{AB}, V_{BC}, and V_{CA} in another 3-phase voltage system.

  The connection to the corresponding measuring point is necessary only if a function that needs the measurand of the 3-phase voltage system is used.

- **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 the function **Synchronization** is used.

Interface with Function Groups

All required data is exchanged between the function group **Circuit breaker [without current]** and the other function groups via the interfaces of the function group **Circuit breaker [without current]**. This data includes, for example, the circuit-breaker position information in the direction of the other 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 Editor **Function-group connections** in DIGSI 5. If the connection is missing, DIGSI 5 reports an inconsistency.

Besides the general assignments of other function groups to the circuit-breaker function groups, you can assign the protection functions to the desired circuit-breaker function groups for the tripping operation in the Editor **Circuit-breaker interaction** under the corresponding protection function group.

For more information, refer to *2.1 Embedding of Functions in the Device*.

5.2.3 Application and Setting Notes

Interface with Measuring Points

If the function **Synchronization** is used, the measuring points that represent voltages V1 and V2 of the parts of the electrical power systems to be synchronized must be connected.

You can find more detailed information in *7.8 Synchronization Function*.

Parameter: `Rated voltage`

- Default setting **`(_:2311:102) Rated voltage`** = ***`400.00 kV`***

With the parameter **`Rated voltage`**, you set the primary rated voltage of the protected object. The primary rated voltage serves as a reference for all voltage-related % values within the function group **Circuit breaker [without current]**. This setting applies both for the operational measured values and for the setting values in %.

If the device works with the IEC 61850 protocol, you can only change the setting value of the parameter via DIGSI 5. If you change the setting value directly on the device, the IEC 61850 configuration of the metered values can be faulty.

5.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Ref. for %-values`				
_:2311:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV

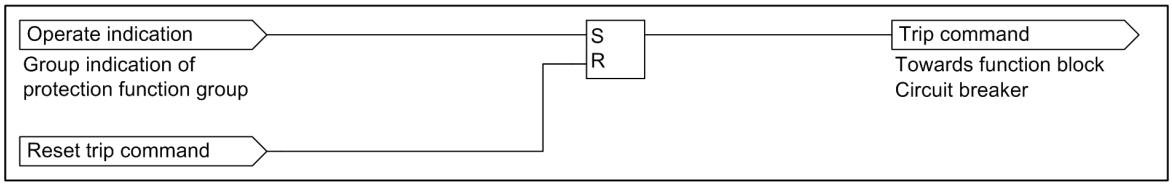
5.2.5 Trip Logic

5.2.5.1 Function Description

The **Trip logic** function block receives the operate group indication from the 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 *5.1.5 Circuit Breaker*). The command output time is also effective here.

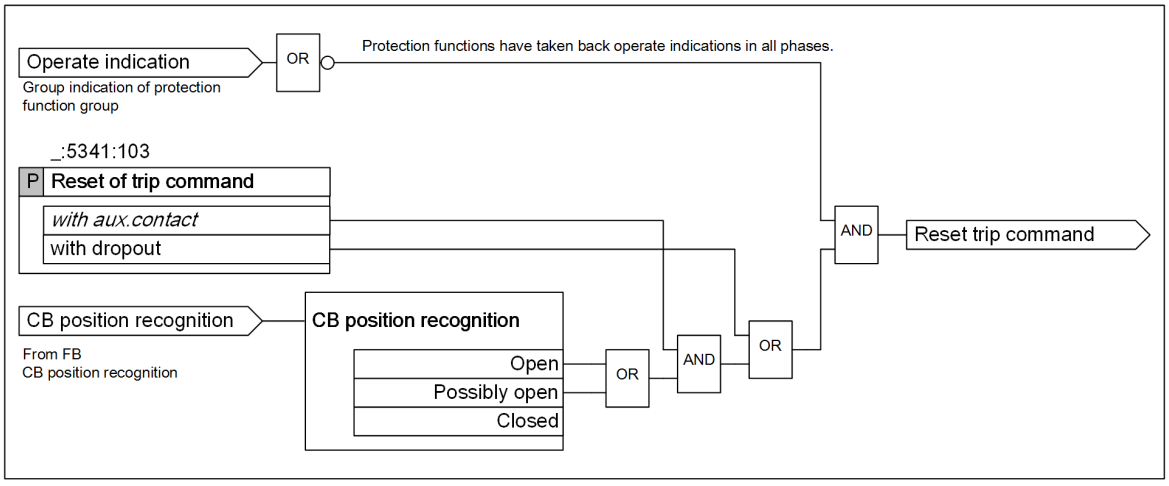
The trip logic also decides when the protection trip command is reset (see *Figure 5-21*).



[lo_ausbef, 1, en_US]

Figure 5-20 Trip Command

Trip-Command Reset



[lo_befe3p_4CB_without_I, 1, en_US]

Figure 5-21 Trip-Command Reset

Once a trip command is issued, it is stored (see *Figure 5-20*).

You determine the criteria for resetting a trip command that has been issued with the parameter **`Reset of trip command`**. The following setting options are possible:

- ***`with dropout`***

  If the function that initiated tripping resets its operate indication the trip command is reset. This occurs typically with dropout. Command reset of the trip command takes place regardless of verification of the circuit-breaker condition.

- ***`with aux.contact`***

  For this 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). The state is determined by the circuit-breaker auxiliary contacts (***`with aux.contact`***).

  As long as the circuit breaker is detected unambiguously as closed (**fully closed**), the trip command will not be reset with this setting option.

  The information about the condition of the circuit breaker and the determination of the various conditions is supplied by the **Circuit-breaker position recognition** function block. You can find further information in chapter *5.1.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

5.2.5.2 Application and Setting Notes

Parameter: Reset of trip command

- Default setting **`(_:5341:103) Reset of trip command`** = ***`with aux.contact`***

Parameter Value	Description
with aux.contact	The trip command is reset if the state of the circuit-breaker auxiliary contact indicates 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, refer to *5.2.6.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information*.
with dropout	The trip command is reset if the pickup of the tripping protection function drops out.

5.2.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:103	Trip logic:Reset of trip command		• with aux.contact • with dropout	with aux.contact

5.2.5.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O

5.2.6 Circuit Breaker

5.2.6.1 Overview

The function block **Circuit breaker** represents the physical switch in the SIPROTEC 5 device.
The basic tasks of this function block are:

- Operation of the circuit breaker
- Acquisition of the circuit-breaker auxiliary contacts
- Acquistion of other circuit-breaker information

The function block **Circuit breaker** provides the following information:

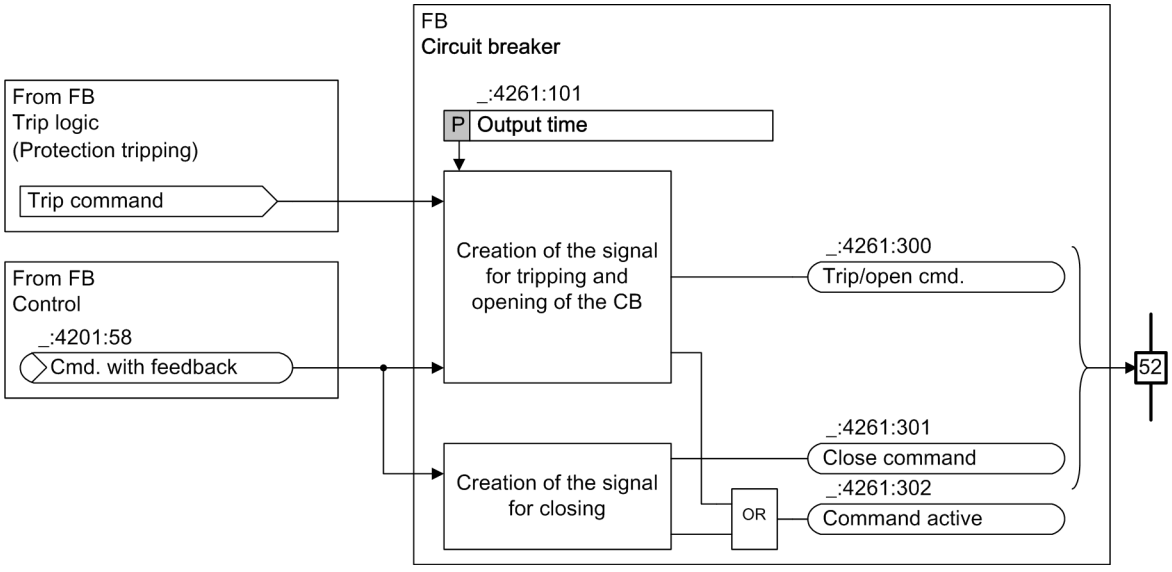
- Number of switching cycles
- Breaking voltage and breaking frequency

5.2.6.2 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 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 function block **Circuit breaker** 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 5-1*).



[lo_CB_tripping-opening-closing, 1, en_US]

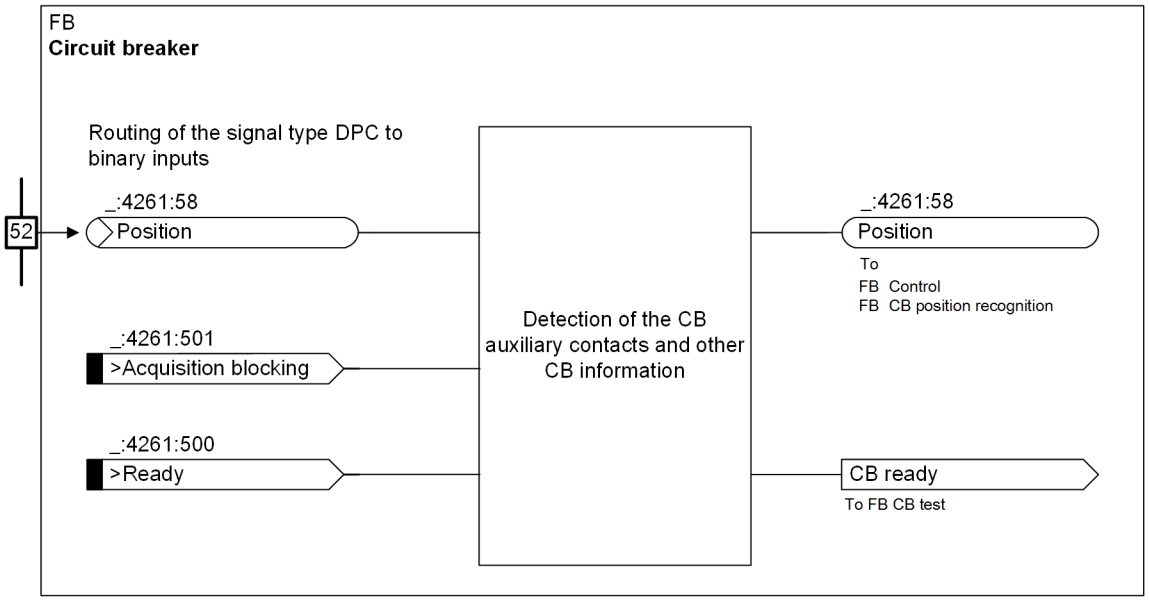
Figure 5-22 Tripping, Opening, and Closing the Circuit Breaker

Table 5-2 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 the output time, with the following exceptions: • **Only when switched off by the control:** The signal is reset 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 *5.1.4.1 Function Description*). If the trip signal is no longer active and the auxiliary contacts report that the circuit breaker is open before expiration of the period, the signal is canceled before expiration of the period. – 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 the output time, 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 if one of the following binary outputs is active: • **Trip/open cmd.** • **Close command** The binary outputs are active as long as a switching command is being executed by the control.	Normal routing

5.2.6.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit-breaker position, the function block **Circuit breaker** provides position signals. 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 switch positions can be reliably acquired.



[lo_erfass_4CB_withoout_I, 1, en_US]

Figure 5-23 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker switch position The switch position CB 3-pole **open** and/or the position CB 3-pole **closed** can be detected by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is 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. If you route only one signal (**open** or **closed**), you cannot determine an intermediate position or a disturbed position.

In the monitoring direction, the position signals generate the following information when the **open** and **closed** positions are detected (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Open	SPS	The circuit-breaker switch position is **opened**.
Closed	SPS	The circuit-breaker switch position is **closed**.
Intermediate position	SPS	The circuit-breaker switch position is in the **intermediate position**. The signal **open** and the signal **closed** have not been set.
Disturbed position	SPS	The circuit-breaker switch position is in the **disturbed position**. The signal **open** and the signal **closed** have been set simultaneously.
Not selected	SPS	The circuit breaker is **not selected** for a control operation.

The following table shows the additional input signals:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see *Other Functions 3.9.3 Persistent Commands* for a description of acquisition blocking).
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. If the signal is active, acquisition blocking and manual update are reset.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an **Open-Closed-Open** cycle. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the **Circuit-breaker test** function.

The following table shows one additional output signal:

Signal	Type	Description
External health	ENS	This can be used to indicate the health of the physical circuit breaker. For this, all failure information of the circuit breaker must be detected 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.

5.2.6.4 Circuit-Breaker Tripping Alarm Suppression

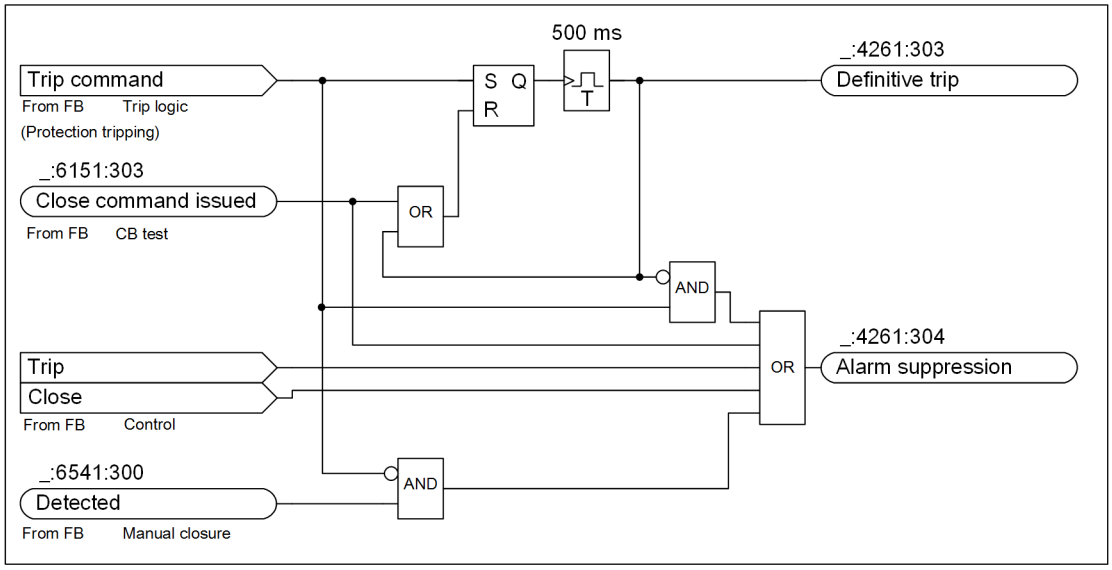
Circuit-Breaker Tripping Alarm Suppression

In certain systems, you possibly want to actuate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not to be issued if the control is used to switch on or off. 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.

If one of the following conditions is met, the *Alarm suppression* signal is generated:

- The definitive protection tripping is not present.
- A close command is issued via the **Circuit-breaker test** function.
- The integrated control executes a closure or opening action.
- External closing is detected via the **Manual close** function.

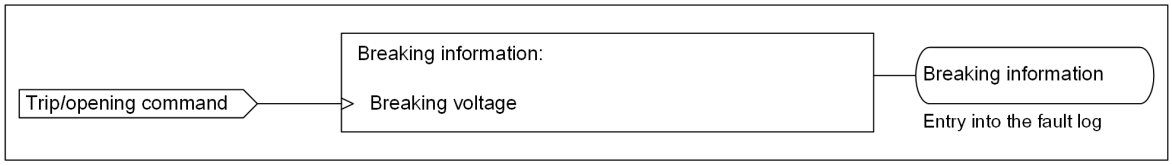


[lo_unterd_4CB_without_I, 2, en_US]

Figure 5-24 Definitive Tripping and Circuit-Breaker Tripping Alarm Suppression

5.2.6.5 Tripping and Opening Information

When a trip or opening command is issued, the breaking information shown in the next figure is saved in the fault log.

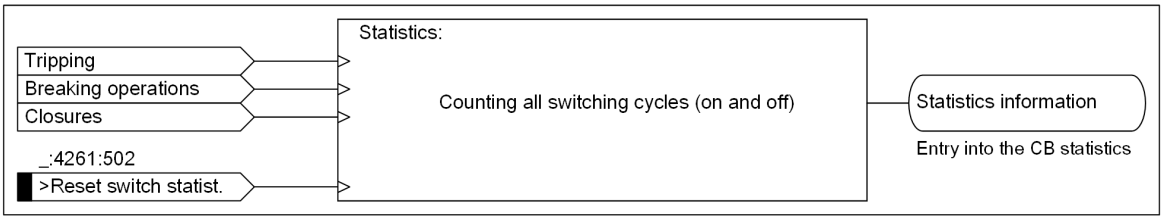


[lo_ausloe_4CB_without_I, 1, en_US]

Figure 5-25 Breaking Information

The number of switching cycles is saved for the circuit breaker as the statistics information. All tripping, opening, and closing operations are counted.

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.**.



[lo_statistics information CB_4CB_without_I, 1, en_US]

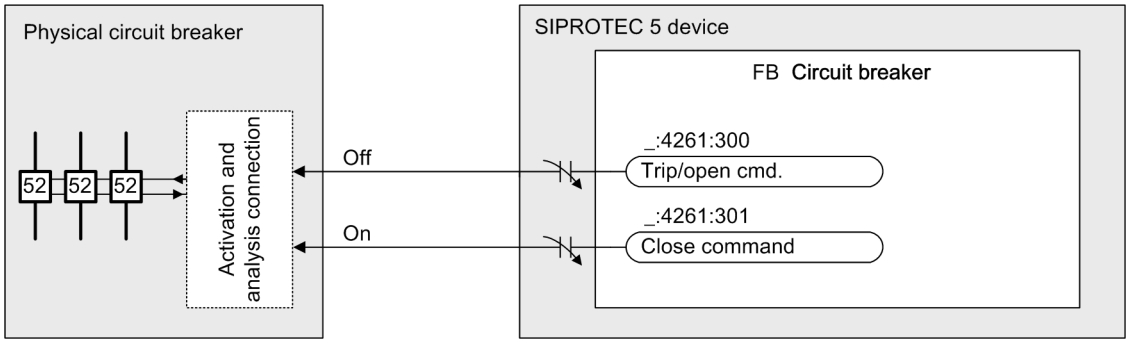
Figure 5-26 Statistics Information about the Circuit Breaker

5.2.6.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-27 shows the necessary routings for the device:

- 3-pole tripping via the protection
- 3-pole opening via the control



[lo_ansteu, 2, en_US]

Figure 5-27 Activation of the Circuit Breaker

By routing the **`Trip/open cmd.`** signals to 1 or 2 binary outputs, you can carry out 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker. You can find a detailed description of this in chapter *7.2.2.3 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.

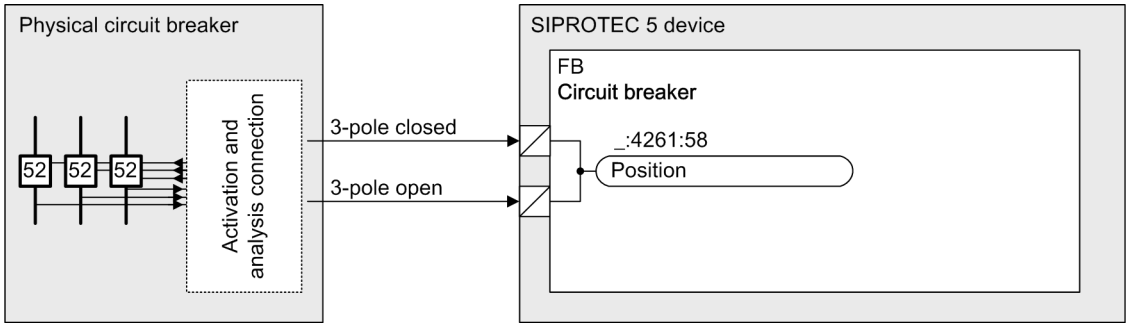
Routing for Analysis of the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. The following shows a number of examples:

- Function block **Circuit-breaker position recognition**
- Function block **Control**

The operating principle of the auxiliary contacts is described in the individual functions.

Siemens recommends detecting 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 sufficient to detect just one of the 2 circuit-breaker switch positions. When used as a protection and control device, Siemens recommends the following analysis of the circuit-breaker switch position:



[lo_evaluation2, 1, en_US]

Figure 5-28 Recommended Analysis of the Circuit-Breaker Switch Position

The following figure shows the recommended routing, in which **OH** stands for **active with voltage**.

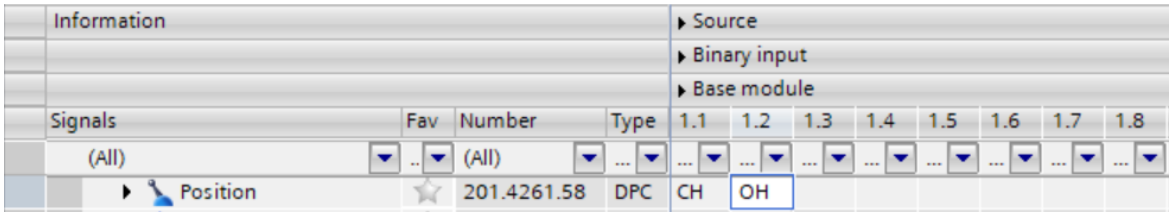


Figure 5-29 Routing for Acquisition of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

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 the 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.

Parameter: Indicat. of breaking values

- Default setting **(_:105) Indicat. of breaking values** = ***always***

With the parameter **Indicat. of breaking values**, you specify whether the measured values are to be reported if the circuit breaker is opened via the control function.

Parameter Value	Description
always	With this setting, the measured values are reported if the circuit breaker is opened either via the control function or via the trip command of a protection function.
with trip	With this setting, the measured values are only reported if the circuit breaker is opened via the trip command of a protection function.

Measured Values

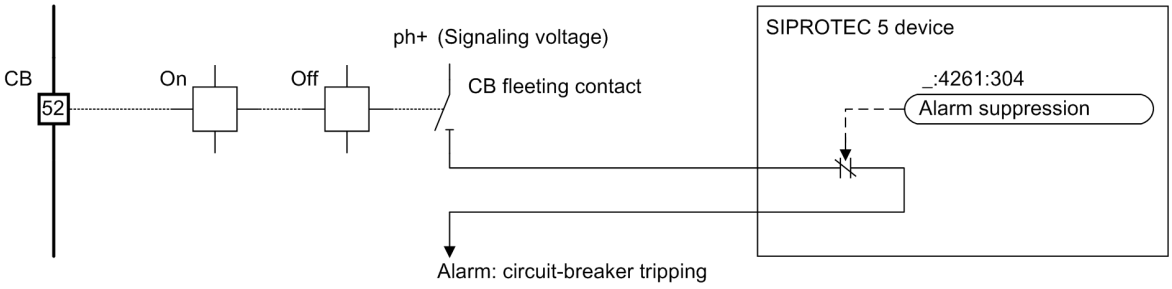
When a protection function opens the circuit breaker, the following measured values can be stored in the fault log:

- *Break. voltage phs A*
- *Break. voltage phs B*
- *Break. voltage phs C*

Output Signal: Indication Suppression

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 always 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.

You can find more detailed information in the logic in *5.2.6.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information*.



[lo_schalt, 2, en_US]

Figure 5-30 Circuit-Breaker Tripping Alarm Suppression

5.2.6.7 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
_:105	Circuit break.:Indicat. of breaking values		• with trip • always	always

5.2.6.8 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
_:506	Circuit break.:>Manual start HSBT	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
_: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

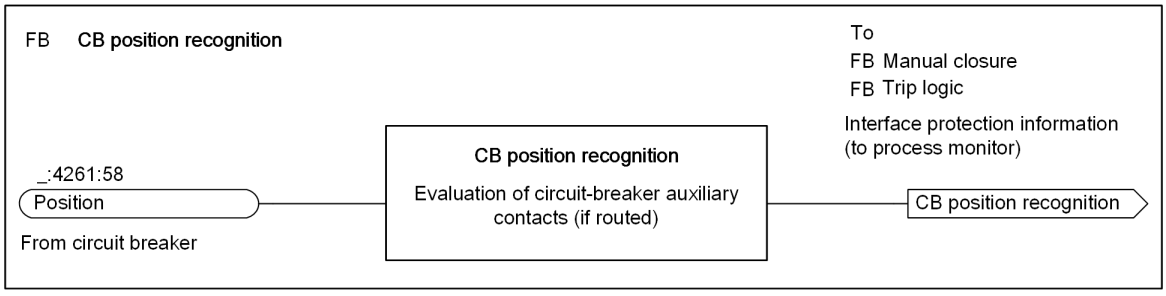
5.2.7 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.2.7.1 Overview

This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts.
This information is needed in the following protection-related additional functions:

- Trip logic (see *5.2.5.1 Function Description*)
- Detection of manual closing (see *5.2.8.1 Function Description*)
- Process monitor (Standard V/I) (see *5.9 Process Monitor*)

The specified chapters describe the way the protection-related additional functions are processing the information of this function block.
The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.



[lo_zust3p_4CB_without_I, 1, en_US]

Figure 5-31 Overview of the Circuit-Breaker Position Recognition

Based on the link between the information from the auxiliary contacts, shown in *Figure 5-14*, the circuit breaker can assume the following positions. The following table shows the possible circuit-breaker positions:

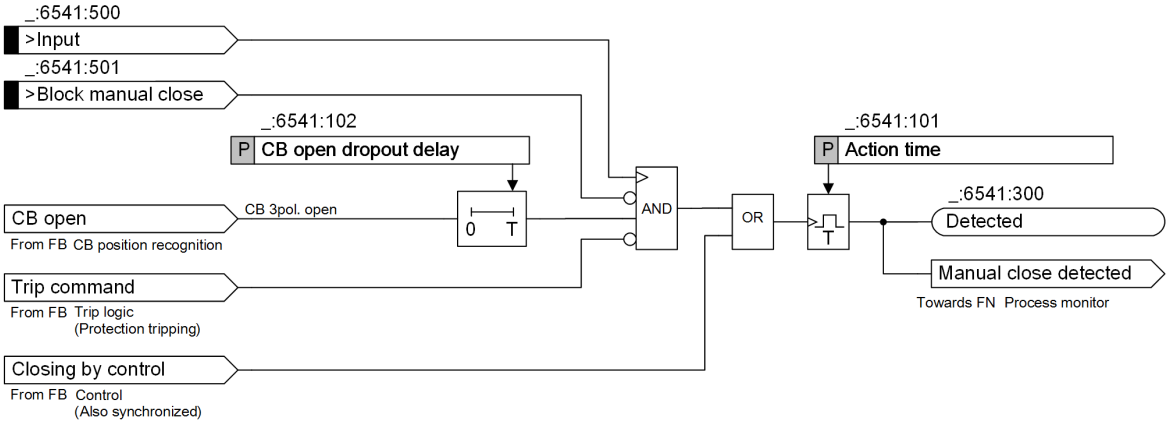
Circuit-Breaker Position	Description
Open	The circuit-breaker pole is detected unambiguously as ***open*** according to both criteria.
Closed	The circuit-breaker pole is detected unambiguously as ***closed*** according to both criteria.
Possibly open	This condition occurs if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. This uncertain condition is evaluated differently by certain functions.

5.2.8 Detection Manual Closure (for Processor Monitor)

5.2.8.1 Function Description

Detection of Manual Closure (for Process Monitor)

The **Manual closure** function block detects any closure carried out by hand. This information is used in the **Process monitor** functions (within protection function groups).
You can find detailed information in the chapter *Process monitor*.
The following figure shows the logic for manual closure detection.



[lo_hand_3p_4CB_without_I, 1, en_US]

Figure 5-32 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. Detection via the input signal **>Input** is also blocked if the circuit breaker is closed or if a protection trip is active.

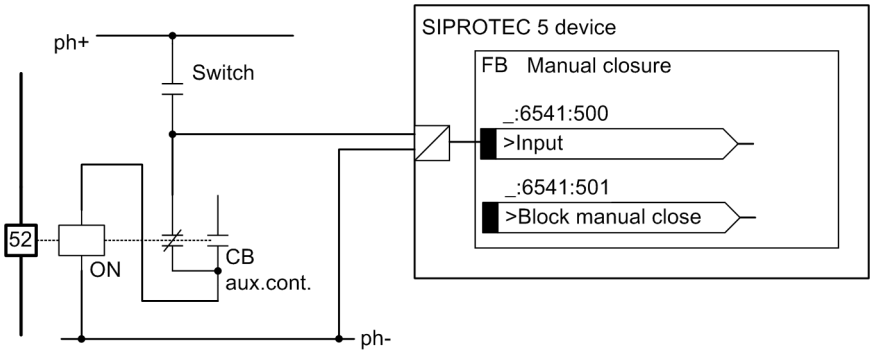
Internal Manual Closure

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.

5.2.8.2 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).



[lo_steuer, 1, en_US]

Figure 5-33 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.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to promptly detect a manual closure, 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** = ***0.30 s***

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 ***0.30 s***.

Parameter: CB open dropout delay

- Default setting **(_:102) CB open dropout delay** = ***0.00 s***

With the **CB open dropout delay** parameter, you can maintain the effectiveness of internal indication *CB open* for the set time. If the input signal **>Input** becomes active after external delayed manual closure, the indication *(_:300) Detected* is output as long as the dropout delay is effective.

5.2.8.3 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
_:102	Manual close:CB open dropout delay		0.00 s to 60.00 s	0.00 s

5.2.8.4 Information List

No.	Information	Data Class (Type)	Type
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

5.2.9 HSBT Interface

5.2.9.1 Description

The function block **HSBT interface** is an interface without any logic. It contains the circuit-breaker related parameters that are used in the function group **HSBT**.

5.2.9.2 Application and Setting Notes

Parameter: CB make time

- Default setting **(_:22591:113) CB make time** = ***0.060 s***

With the parameter **CB make time**, you specify the time interval between the activation of the closing procedure and the instant when the current begins to flow. You can measure the make time during commissioning or directly get the make time from the technical data of the circuit breaker.

Parameters for the Measured-Values Calculation in the Function Group HSBT

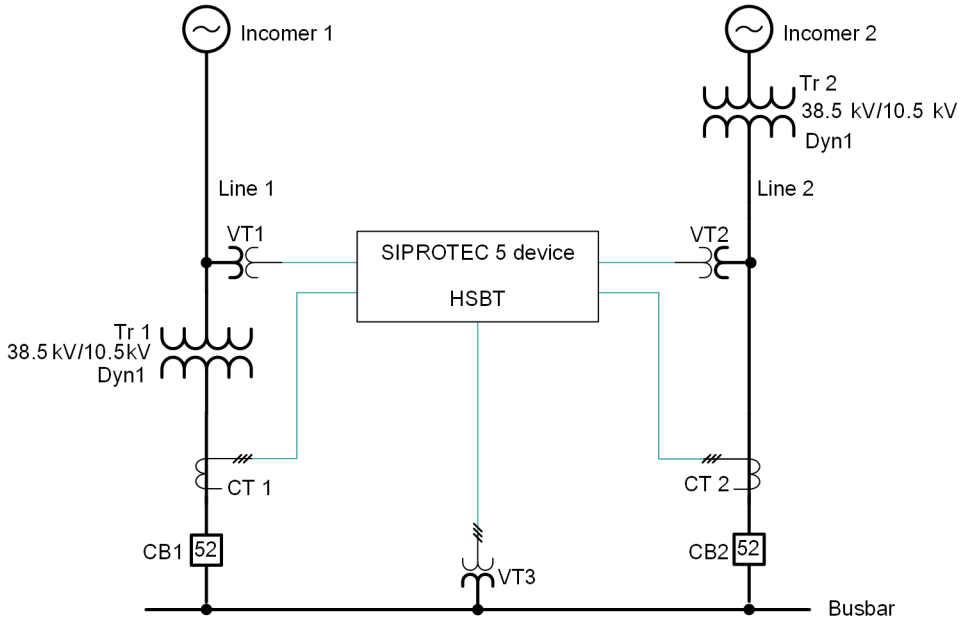
- Default setting **(_:22591:126) Vsync ratio (transform.)** = ***1.000***
- Default setting **(_:22591:127) Angle adjust. (transform.)** = ***0.0°***

If a power transformer is located between a voltage transformer and a circuit breaker on the same incoming line, set these 2 parameters for the specific circuit breaker according to the actual data of the power transformer. For other cases, keep the default values for the relevant circuit breakers.

Set the parameter **Vsync ratio (transform.)** to the actual power transformer ratio. The calculation of the voltage measured values in the function group **HSBT** takes the power transformer ratio into account.

Set the parameter **Angle adjust. (transform.)** to the phase-displacement angle of the power transformer. The calculation of the angle difference in the function group **HSBT** takes the phase-displacement angle into account.

EXAMPLE



[dw_example_adjustment, 2, en_US]

Figure 5-34 Application Example

The power transformer Tr1 is located between the voltage transformer VT1 and the circuit breaker CB1 on the incoming line 1. In this case, you must set the parameters **Vsync ratio (transform.)** and **Angle adjust. (transform.)** according to the actual data of the power transformer Tr1.

The power transformer Tr2 is not located between the voltage transformer VT2 and the circuit breaker CB2 on the incoming line 2. In this case, keep the default values of the parameters **Vsync ratio (transform.)** and **Angle adjust. (transform.)**.

The actual ratio of the power transformer Tr1 is calculated as follows. Set the parameter **Vsync ratio (transform.)** for the circuit breaker CB1 to ***3.667***.

$$K_{act.} = \frac{V_{HV\,act.}}{V_{LV\,rated}} = \frac{38.5\ kV}{10.5\ kV} \approx 3.667$$

[fo_K factor, 1, en_US]

With:

$V_{HV\,act.}$	Actual voltage on the high-voltage side of the power transformer Tr1, which already considers the tap changer
$V_{LV\,rated.}$	Rated voltage on the low-voltage side of the power transformer Tr1

The vector-group number of the power transformer Tr1 is 1, so the phase-displacement angle is 30°. Set the parameter **Angle adjust. (transform.)** for the circuit breaker CB1 to ***30°***.

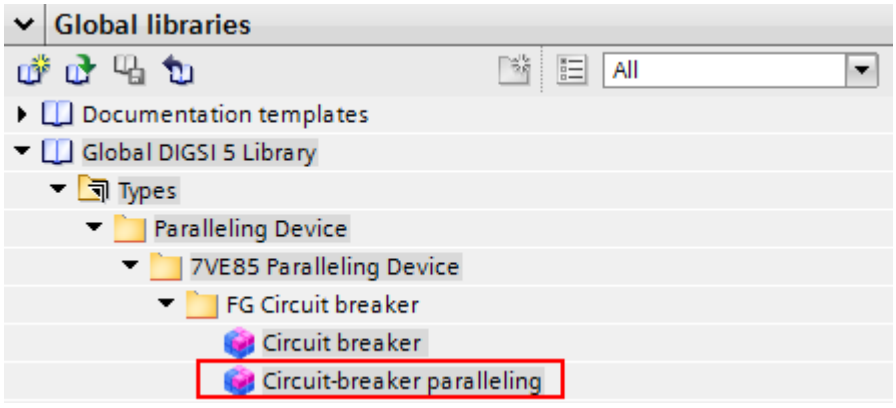
5.2.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
HSBT interface				
_:22591:113	HSBT interface:CB make time		0.020 s to 0.150 s	0.060 s
_:22591:126	HSBT interface:Vsync ratio (transform.)		1.000 to 100.000	1.000
_:22591:127	HSBT interface:Angle adjust. (transform.)		-179.0 ° to 180.0 °	0.0 °

5.3 Function-Group Type Circuit-Breaker Paralleling

5.3.1 Overview

The **Circuit-breaker paralleling** function group is used in the **Paralleling** device.
You can find the **Circuit-breaker paralleling** function group under the device types in the Global DIGSI 5 Library.



[sc_CB paralleling_struc, 1, en_US]

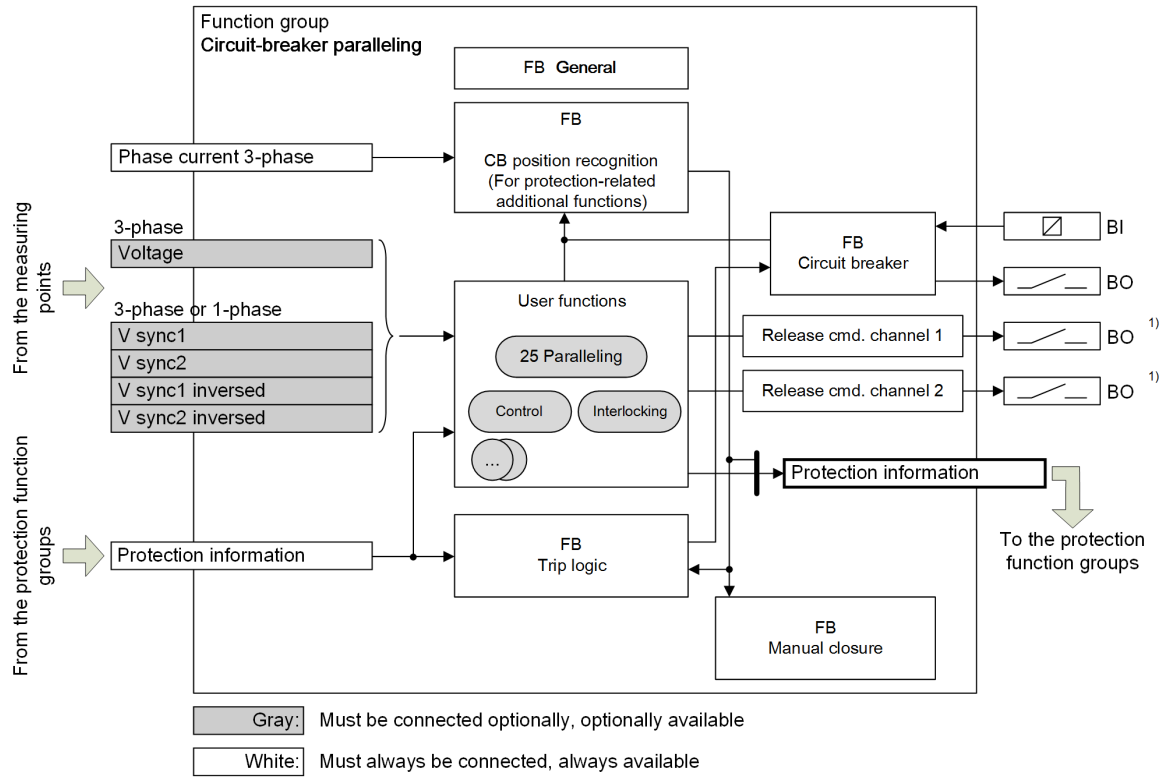
Figure 5-35 Circuit-Breaker Paralleling Function Group

5.3.2 Structure of the Function Group

Besides the user functions, the **Circuit-breaker paralleling** function group contains certain functionalities that are essential for general purposes. These functionalities 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 paralleling** function group. The individual function blocks in the figure are described in the following chapters.



[dw_struc_FG CB paralleling, 1, en_US]

Figure 5-36 Structure of the Circuit-Breaker Paralleling Function Group

(1) Siemens recommends routing the 2 BOs to the fast relays (Type F).

The **Circuit-breaker paralleling** function group has interfaces with the following items:

- Measuring points
- Function groups, for example, the **Voltage-current 3-phase** function group

Interfaces with Measuring Points

The function group receives the required measured values from the measuring points which are connected to this function group.

If an application template is used, the function group must be connected to a 3-phase current measuring point because this connection is essential. Depending on the type of the used functions, it is necessary to connect additional measuring points to the function group. Configuration is carried out using the **Function-group connections** Editor in DIGSI 5. You can find more information in chapter *2.1 Embedding of Functions in the Device*.

If a user function, for example, the **Paralleling** function, is used in the function group, but the required measuring point is not linked to the function group, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The **Circuit-breaker paralleling** function group has interfaces with the following measuring points:

- **3-phase 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.

  The 3-phase current can be used to monitor the closing result of the circuit breaker.

- **3-phase voltage**

  The measurands of the 3-phase voltage system are supplied via this interface. The voltages are different due to the different connection types of the transformers, for example, V_A, V_B, and V_C in one 3-phase voltage system, but V_{AB}, V_{BC}, and V_{CA} in another 3-phase voltage system.

  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.

- **V_{sync1}, V_{sync2}, $V_{sync1\ inversed}$, and $V_{sync2\ inversed}$**

  2 synchronization voltages and their inverse voltages are supported via these interfaces. The synchronization voltages are derived from the busbar side and the generator side respectively.

  The connection to the corresponding measuring point is necessary only if the **Paralleling** function is used.

Interface with Function Groups

All required data is exchanged between the **Circuit-breaker paralleling** function group and the other function groups via the interfaces of the **Circuit-breaker paralleling** function group. This data includes, for example, the circuit-breaker position information in the direction of the other 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. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more information in chapter *2.1 Embedding of Functions in the Device*.

5.3.3 Application and Setting Notes

Interface with Measuring Points

The interface of the 3-phase power system must be configured. Otherwise, DIGSI 5 reports an inconsistency.

If the **Paralleling** function is used, the measuring points that are used to obtain the reference-side voltages (V_{sync1} and $V_{sync1,\ inv}$) and the paralleled voltages (V_{sync2} and $V_{sync2,\ inv}$) must be connected.

You can find more information in chapter *7.5 Paralleling Function*.

Parameter: `Rated normal current`

- Default setting **`(_:2311:101) Rated normal current`** = ***`1000 A`***

With the **`Rated normal current`** parameter, you set the primary rated current of the protected object. The primary rated current serves as a reference for all current-related % values within the **Circuit-breaker paralleling** function group. This setting applies both for the operational measured values and for the setting values in %.

If the device works with the IEC 61850 protocol, you can only change the setting value of the parameter via DIGSI 5. If you change the setting value directly on the device, the IEC 61850 configuration of the metered values can be faulty.

Parameter: `Rated voltage`

- Default setting **`(_:2311:102) Rated voltage`** = ***`400 kV`***

With the **`Rated voltage`** parameter, you set the primary rated voltage of the protected object. The primary rated voltage serves as a reference for all voltage-related % values within the **Circuit-breaker paralleling** function group. This setting applies both for the operational measured values and for the setting values in %.

If the device works with the IEC 61850 protocol, you can only change the setting value of the parameter via DIGSI 5. If you change the setting value directly on the device, 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`** = ***`0.100 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.

If the circuit-breaker pole is open, the current value falls below the setting value of the **Current thresh. CB open** parameter. 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 ***0.050 A*** for example.

If no special requirement exists, Siemens recommends retaining the setting value of ***0.100 A*** for secondary purposes.

5.3.4 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		0.10 kV to 1200.00 kV	400.00 kV
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A	0.030 A to 10.000 A	0.100 A
		5 A	0.150 A to 50.000 A	0.500 A

5.3.5 Circuit Breaker

5.3.5.1 Overview

The function block **Circuit breaker** represents the physical switch in the SIPROTEC 5 device.

The basic tasks of this function block are:

- Operation of the circuit breaker (CB)
- Acquisition of the circuit-breaker auxiliary contacts
- Acquisition of other circuit-breaker information

The function block **Circuit breaker** provides the following information:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

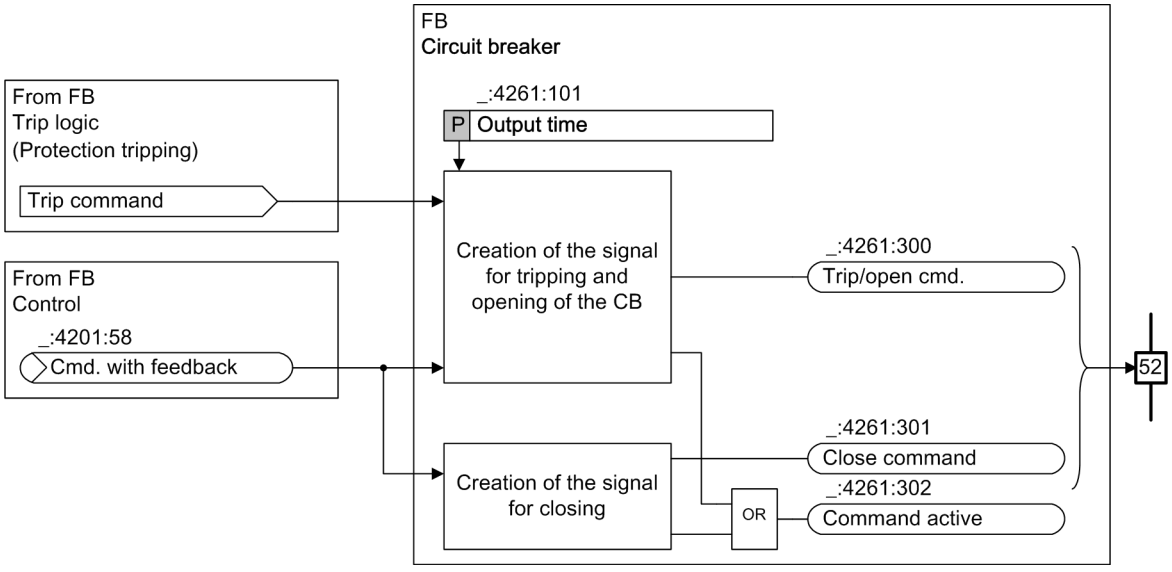
5.3.5.2 Tripping, Opening, and Closing the Circuit Breaker

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 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 function block **Circuit breaker** is generated there.

To operate the circuit breaker, the function block **Circuit breaker** provides the output signals that must be routed to the corresponding binary outputs of the device (see *Table 5-1*).



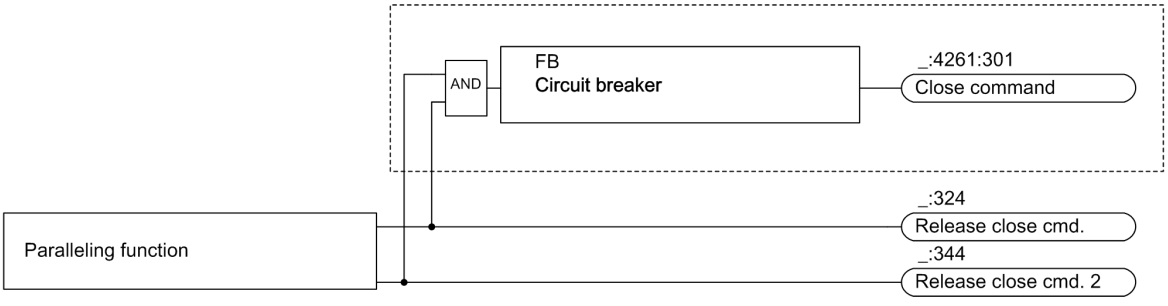
[lo_CB_tripping-opening-closing, 1, en_US]

Figure 5-37 Tripping, Opening, and Closing the Circuit Breaker

Table 5-3 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 the output time, with the following exceptions: • **Only when switched off by the control:** The signal is reset 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 *5.1.4.1 Function Description*). If the trip signal is no longer active and the auxiliary contacts report that the circuit breaker is open before expiration of the period, the signal is canceled before expiration of the period. – 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 the output time, 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 if one of the following binary outputs is active: • **Trip/open cmd.** • **Close command** The binary outputs are active as long as a switching command is being executed by the control.	Normal routing

Closing of the Circuit Breaker



[loeinbefpara, 1, en_US]

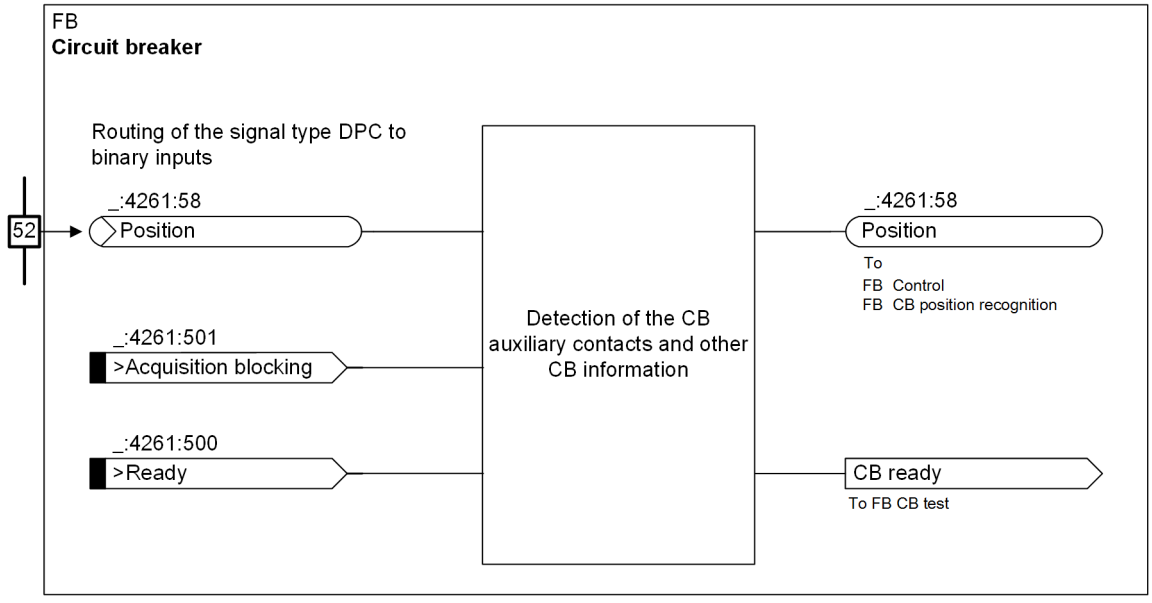
Figure 5-38 Closing of the Circuit Breaker

The paralleling device can be used to close the circuit breaker in the following 2 ways:

- Via the control operation, for example protocol IEC 61850, DIGSI and HMI
  This activates the **Synchronization** function. In the meantime, the indications *Release close cmd.* and *Release close cmd. 2* are generated. The **Circuit breaker** function block then generates the indication *Close command*.
- Via the **Synchronization** function
  This starts the **Synchronization** function via the binary input signal *>Start syn. process* or *>Start/stop syn.proc.*. The indications *Release close cmd.* and *Release close cmd. 2* are generated. The indication *Close command* is not generated.

5.3.5.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit-breaker position, the function block **Circuit breaker** provides position signals. 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 switch positions can be reliably acquired.



[lo_erfass_4CB_withoout_I, 1, en_US]

Figure 5-39 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker switch position The switch position CB 3-pole **open** and/or the position CB 3-pole **closed** can be detected by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is 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. If you route only one signal (**open** or **closed**), you cannot determine an intermediate position or a disturbed position.

In the monitoring direction, the position signals generate the following information when the **open** and **closed** positions are detected (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Open	SPS	The circuit-breaker switch position is **opened**.
Closed	SPS	The circuit-breaker switch position is **closed**.
Intermediate position	SPS	The circuit-breaker switch position is in the **intermediate position**. The signal **open** and the signal **closed** have not been set.

Information	Type	Description
Disturbed position	SPS	The circuit-breaker switch position is in the **disturbed position**. The signal **open** and the signal **closed** have been set simultaneously.
Not selected	SPS	The circuit breaker is **not selected** for a control operation.

The following table shows the additional input signals:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see *Other Functions 3.9.3 Persistent Commands* for a description of acquisition blocking).
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. If the signal is active, acquisition blocking and manual update are reset.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an **Open-Closed-Open** cycle. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the **Circuit-breaker test** function.

The following table shows one additional output signal:

Signal	Type	Description
External health	ENS	This can be used to indicate the health of the physical circuit breaker. For this, all failure information of the circuit breaker must be detected 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.

5.3.5.4 Circuit-Breaker Tripping Alarm Suppression

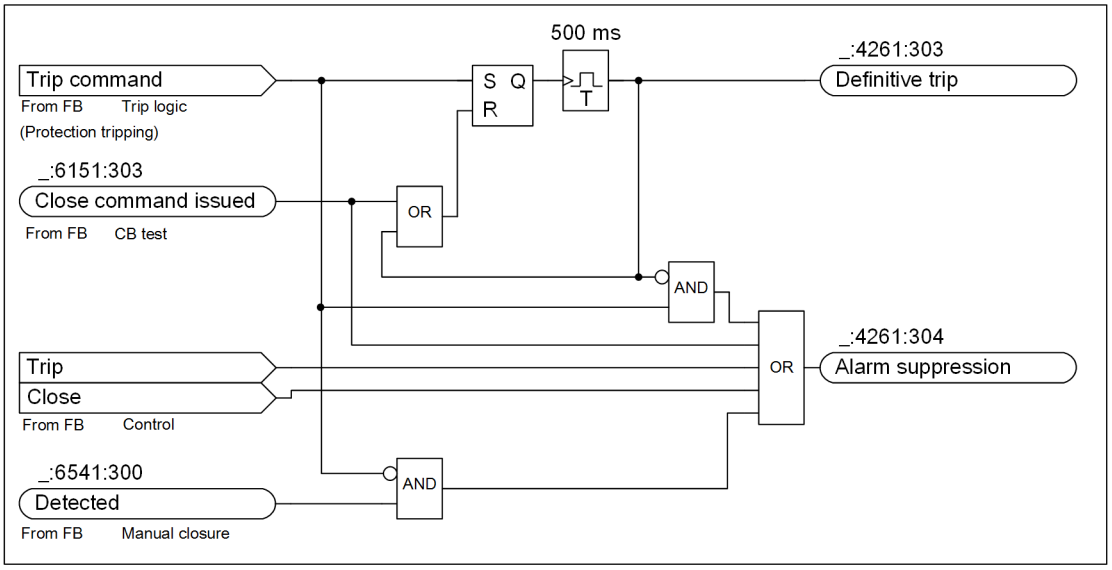
Circuit-Breaker Tripping Alarm Suppression

In certain systems, you possibly want to actuate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not to be issued if the control is used to switch on or off. 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.

If one of the following conditions is met, the *Alarm suppression* signal is generated:

- The definitive protection tripping is not present.
- A close command is issued via the **Circuit-breaker test** function.
- The integrated control executes a closure or opening action.
- External closing is detected via the **Manual close** function.

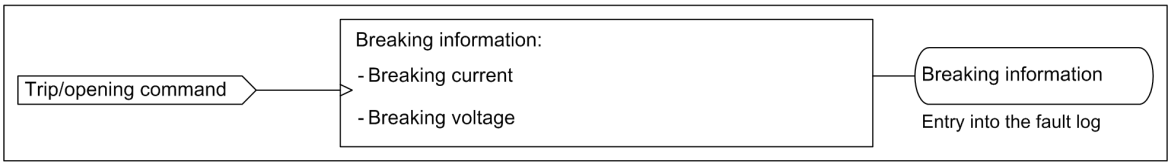


[lo_unterd_4CB_without_I, 2, en_US]

Figure 5-40 Definitive Tripping and Circuit-Breaker Tripping Alarm Suppression

5.3.5.5 Tripping and Opening Information

When a trip or opening command is issued, the breaking information shown in the next figure is saved in the fault log.



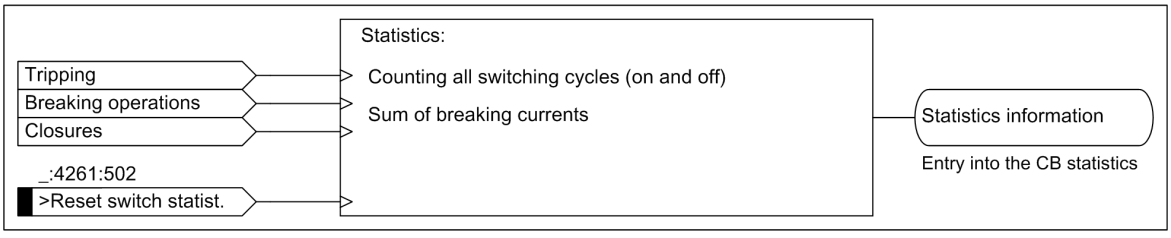
[lo_ausloe, 2, en_US]

Figure 5-41 Breaking Information

The following statistics information is saved for the circuit breaker:

- Number of switching cycles:
  All tripping, opening, and closing operations are counted.
- Total of 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.**.



[lo_statistics information CB, 1, en_US]

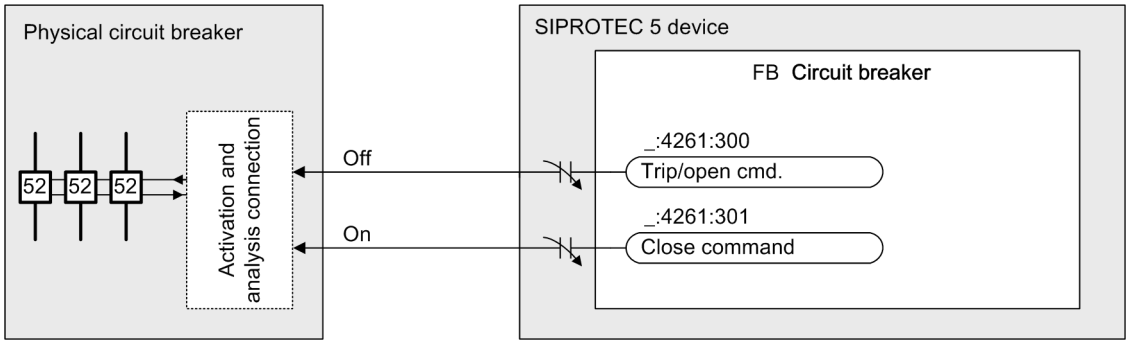
Figure 5-42 Statistics Information about the Circuit Breaker

5.3.5.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-10 shows the necessary routings for the device:

- 3-pole tripping via the protection
- 3-pole opening via the control



[lo_ansteu, 2, en_US]

Figure 5-43 Activation of the Circuit Breaker

By routing the **`Trip/open cmd.`** signals to 1 or 2 binary outputs, you can carry out 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker. You can find a detailed description of this in chapter *7.2.2.3 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.

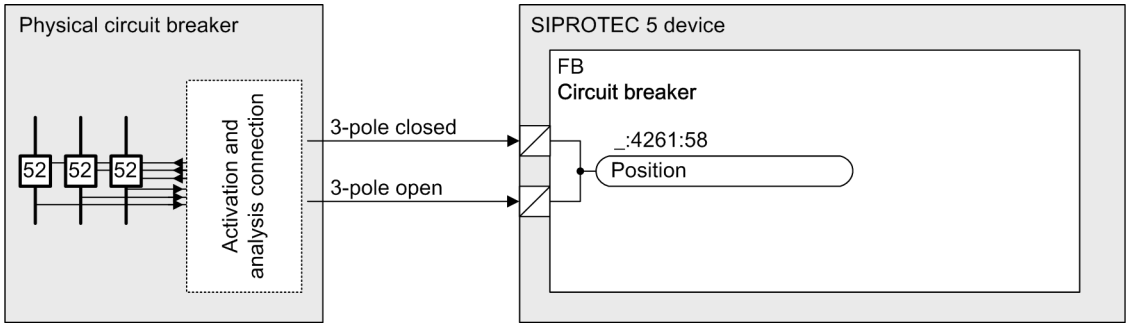
Routing to Evaluate the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. The following shows a number of examples:

- **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.

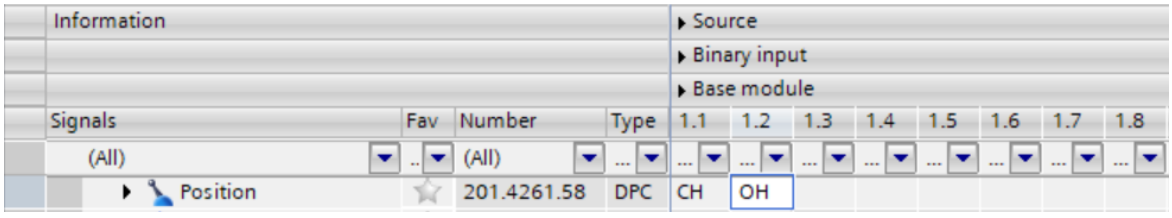
Siemens recommends capturing the information *`Circuit breaker is open in 3 poles`* and *`Circuit breaker is closed in 3 poles`* via auxiliary contacts. This is the optimal configuration for the control functionality. For purely protection applications, it is also sufficient to acquire just one of the 2 circuit-breaker switch positions. When used as a protection and control device, Siemens recommends the following evaluation of the circuit-breaker switch position:



[lo_evaluation2, 1, en_US]

Figure 5-44 Recommended Evaluation of the Circuit-Breaker Switch Position

The following diagram shows the recommended routing, in which **OH** stands for **active with voltage**.



[sc_polg3p, 1, en_US]

Figure 5-45 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.

Parameter: Indicat. of breaking values

- Default setting **(_:105) Indicat. of breaking values** = ***always***

With the parameter **Indicat. of breaking values**, you specify whether the measured values are to be reported if the circuit breaker is opened via the control function.

Parameter Value	Description
always	With this setting, the measured values are reported if the circuit breaker is opened either via the control function or via the trip command of a protection function.
with trip	With this setting, the measured values are only reported if the circuit breaker is opened via the trip command of a protection function.

Measured Values

When a protection function opens the circuit breaker, the following measured values can be stored in the fault log:

- *Break.-current phs A*
- *Break.-current phs B*
- *Break.-current phs C*
- *Break. current 3I0/IN*
- *Break. voltage phs A*
- *Break. voltage phs B*
- *Break. voltage phs C*

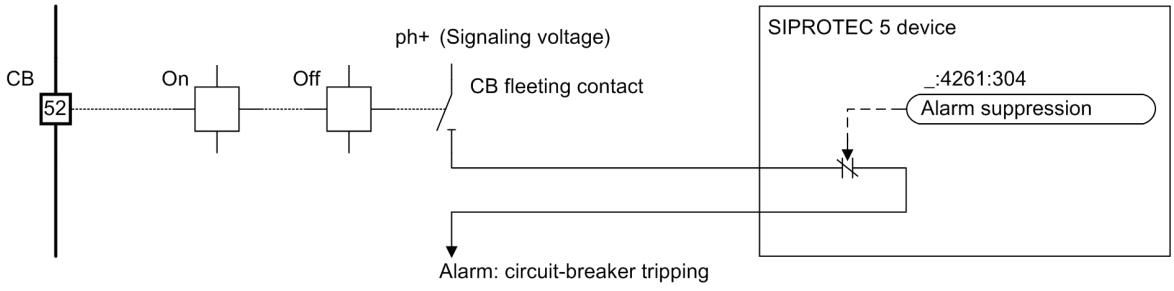
The measured value *Break. current 3I0/IN* is the neutral-point current. Dependent on the connection type of the **measuring point I-3ph** that is connected with the function group **Circuit breaker**, the neutral-point current differs as follows:

Connection Type of the Measuring Point I-3ph	Neutral-Point Current
3-phase	Calculated zero-sequence current $3I_0$
3-phase + IN 3-phase + IN-separate 3ph,2prim.CT + IN-sep 2ph, 2p. CT + IN-sep	Measured neutral-point current I_N If the secondary ground current exceeds the linear section of the sensitive measuring input (1.6 Irated) with sensitive current transformers, the neutral-point current of the measured I_N is switched to the calculated $3I_0$.

Output Signal: Indication Suppression

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 always 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.

You can find more detailed information in the logic in *5.2.6.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information*.



[lo_schalt, 2, en_US]

Figure 5-46 Circuit-Breaker Tripping Alarm Suppression

5.3.5.7 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
_:105	Circuit break.:Indicat. of breaking values		• with trip • always	always

5.3.5.8 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
_:506	Circuit break.:>Manual start HSBT	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
_:317	Circuit break.:Break. current 3I0/IN	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

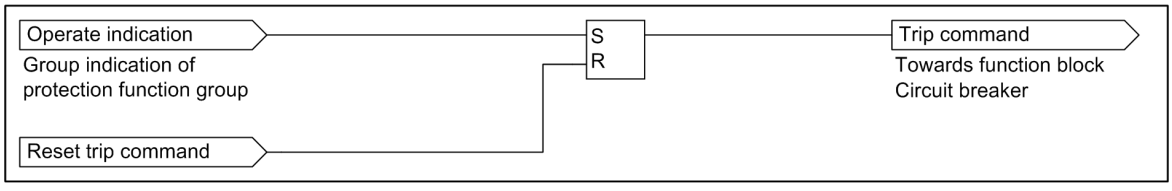
5.3.6 Trip Logic

5.3.6.1 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 *5.1.5 Circuit Breaker*). The command output time is also effective here.

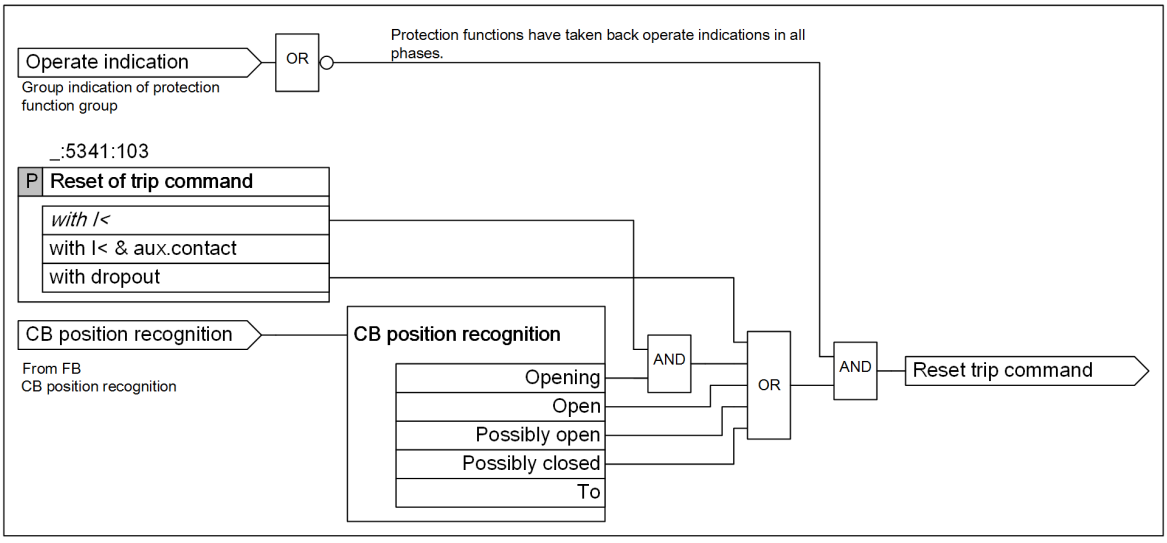
The trip logic also decides when the protection trip command is reset (see *Figure 5-4*).



[lo_ausbef, 1, en_US]

Figure 5-47 Trip Command

Trip-Command Reset



[lo_befe3p, 1, en_US]

Figure 5-48 Trip-Command Reset

Once a trip command is issued, it is stored (see *Figure 5-3*).

You determine the criteria for resetting a trip command that has been issued with the parameter **`Reset of trip command`**. The following setting options are possible:

- **`with dropout`**

  If the function that initiated tripping resets its operate indication the trip command is reset. 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 and the determination of the various conditions is supplied by the **Circuit-breaker position recognition** function block. You can find further information in chapter *5.1.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

5.3.6.2 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<	The trip command is reset under the following conditions: • Dropout of the tripping function • The current falls short of the value set in the parameter **(_:2311:112) Current thresh. CB open**
with I< & aux.contact	The trip command is reset under the following conditions: • The current falls short of the value set in the parameter **(_:2311:112) Current thresh. CB open** • The circuit-breaker auxiliary contact reports 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 *5.1.5.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).
with dropout	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 this setting is useful. 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.

5.3.6.3 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<

5.3.6.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O

5.3.7 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.3.7.1 Overview

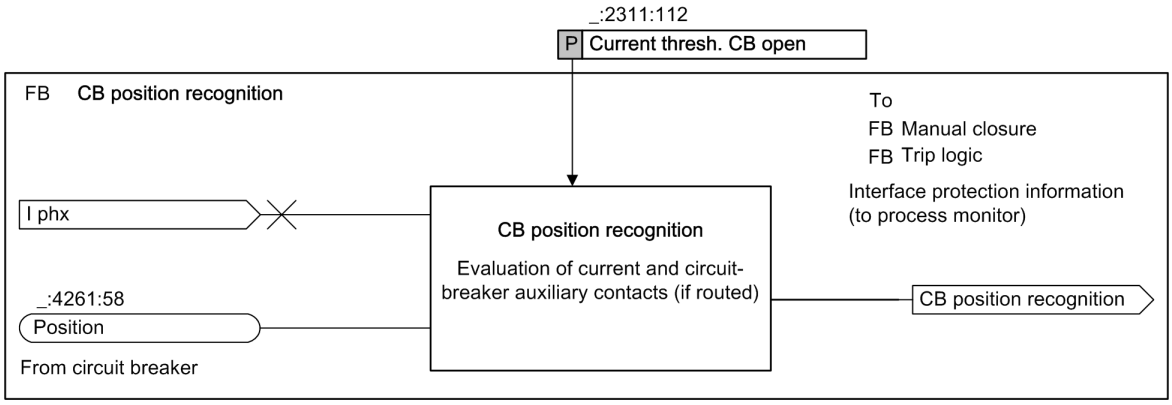
This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see *5.1.4.1 Function Description*)
- Detection of manual closing

The specified chapters describe the way the protection-related additional functions are processing the information of this function block.

The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.



[lo_zust3p, 1, en_US]

Figure 5-49 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, shown in *Figure 5-14*, the circuit breaker can assume the following positions. The following table shows the possible circuit-breaker conditions:

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. The reason for that is that the current-flow criterion takes effect faster than the auxiliary contact can open.

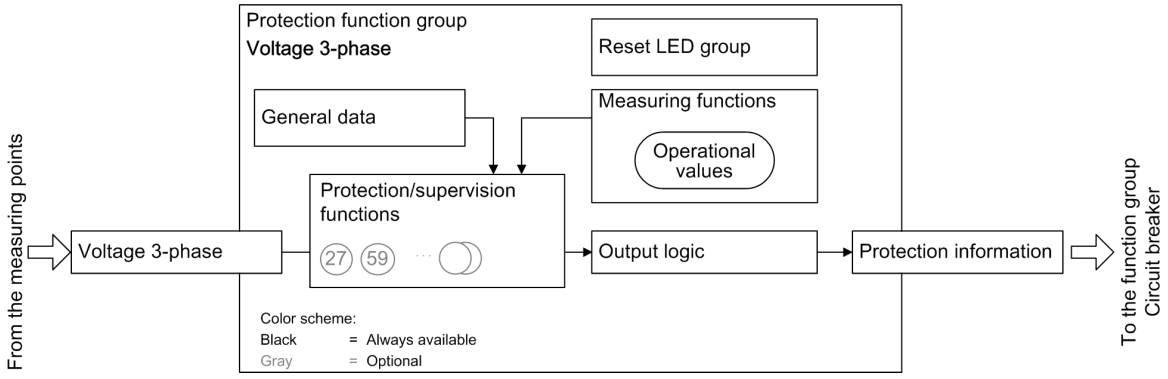
5.4 Function-Group Type Voltage 3-Phase

5.4.1 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 *9 Measured Values, Energy Values, and Supervision of the Primary System*). Applicable functions are, for example, Voltage protection or Frequency protection.

5.4.2 Structure of the Function Group

The **Voltage 3-phase** function group has interfaces to the measuring points and the **Circuit-breaker** function group.

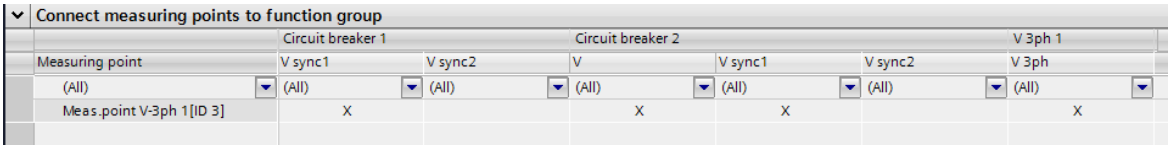


[dw_3phase_voltage, 1, en_US]

Figure 5-50 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.



Connect measuring points to function group

	Circuit breaker 1		Circuit breaker 2			V 3ph 1
Measuring point	V sync1	V sync2	V	V sync1	V sync2	V 3ph
(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-3ph 1 [ID 3]	X		X	X		X

[sc_3_voltage1, 1, en_US]

Figure 5-51 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. For more information, refer to chapter *8.24 Voltage Measuring-Point Selection*.

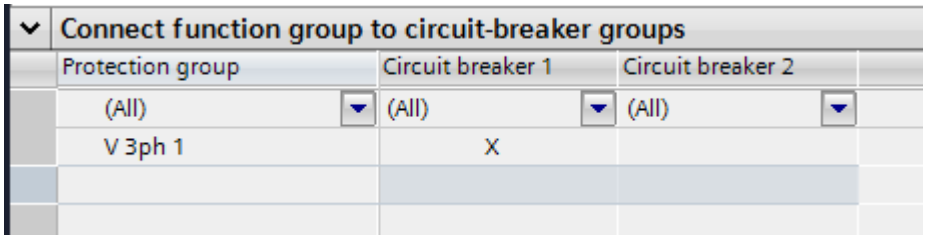
The measurands from the 3-phase voltage system are supplied via the **V 3-ph** interface. Depending on the connection type of the transformers, for example, V_A, V_B, V_C, V_{gnd}. All values that can be calculated from the measurands are also provided via this interface.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the **Voltage 3-phase** function group and the **Circuit-breaker** function group via the interface of 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.



[sc_3_voltage2, 1, en_US]

Figure 5-52 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 5-4 Operational Measured Values of the Voltage 3-Phase Function Group

Measured Values		Primary	Secondary	% with respect 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

5.4.3 Application and Setting Notes

NOTE

Before creating the protection functions in the function group, you should connect them 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 parameter **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

5.4.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV

5.4.5 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

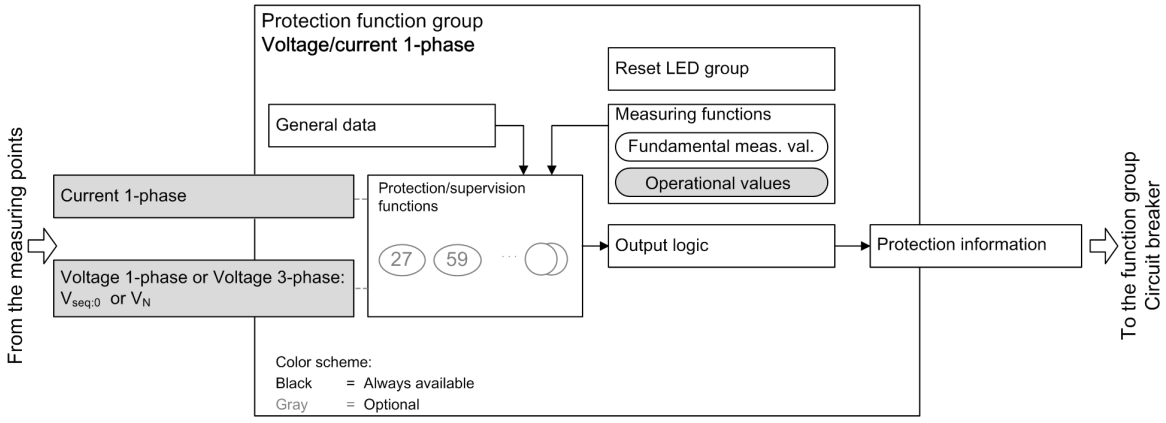
5.5 Function-Group Type Voltage/current 1-Phase

5.5.1 Overview

In the **Voltage-current 1-phase** function group, all functions can be used for protecting and for monitoring a protection object or equipment that allow a 1-phase current and voltage measurement or a zero-sequence voltage measurement via the 3-phase voltage measuring point. The function group also contains the operational measurement for the protected object or equipment (see chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*).

5.5.2 Structure of the Function Group

The function group **Voltage-current 1-phase** has interfaces to the measuring points and the function group **Circuit breaker**.



[dw_FG VI 1ph_structure, 1, en_US]

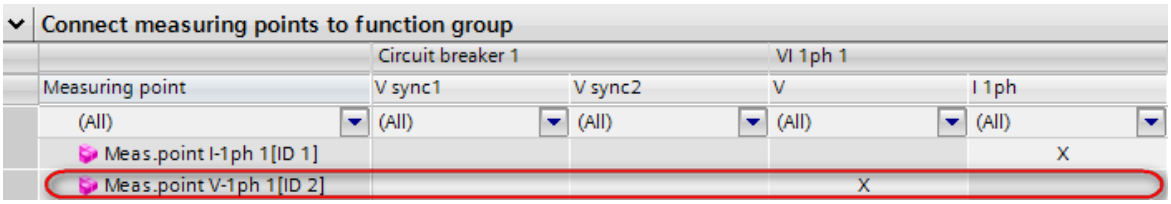
Figure 5-53 Structure of the Function Group Voltage-Current 1-Phase

Interface with Measuring Points

You connect the function group **Voltage-current 1-phase** 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:

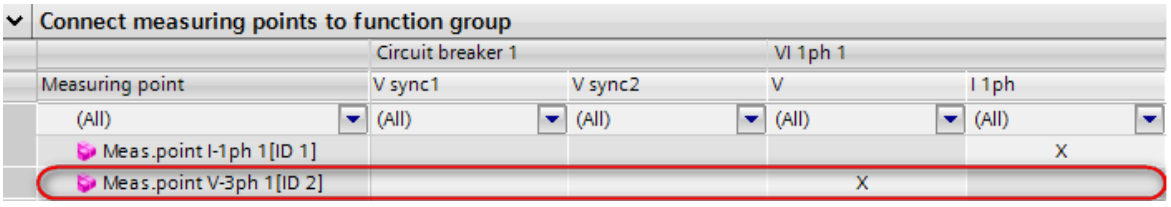
- **1-phase current**
  The 1-phase current measured values are provided via this interface.
  You can only connect a 1-phase current measuring point to the interface **1-phase current**.
- **Voltage 1-phase** or **Voltage 3-phase**
  You can connect the voltage interface of the function group **Voltage-current 1-phase** with a 1-phase or a 3-phase measuring point. The calculated zero-sequence voltage or the measured residual voltage is 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).



[scVI1ph_V1ph, 1, en_US]

Figure 5-54 Connecting Measuring Points to the Function Group Voltage-Current 1-Phase

The zero-sequence voltage calculated from the 3-phase voltage system or the measured residual voltage is available via the voltage interface (see figure below).



[scVI1ph_V3ph, 1, en_US]

Figure 5-55 Connecting Measuring Points 3-Phase Voltage and 1-Phase Current to the Function Group 1-Phase Voltage-Current

You can connect the voltage interface of the function group **Voltage-current 1-phase** with precisely one 3-phase voltage measuring point. 3 types of 3-phase voltage measuring-point connection are supported. With the different connection types, the type of voltage input for the functions in the function group **Voltage-current 1-phase** also changes.

The following table shows the properties of the voltage input for the function group **Voltage-current 1-phase** depending on the connection types.

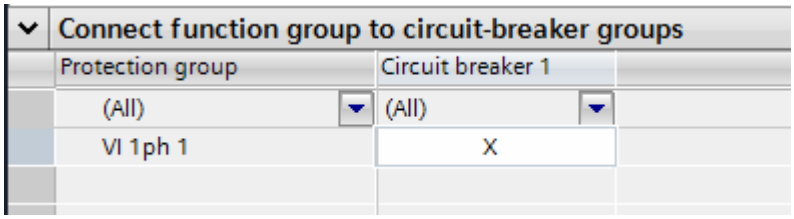
Connection Type of the 3-Phase Voltage Measuring Point	Voltage Input
3 ph-to-gnd voltages	The zero-sequence voltage is calculated from the phase-to-ground voltages and used as a voltage input for all functions.
3 ph-to-gnd volt. + VN	The residual voltage VN is converted into the voltage equivalent of the zero-sequence voltage. This 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 function group **Voltage-current 1-phase** and the function group **Circuit breaker** via the interface of the function group **Circuit breaker**.

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 function group **Voltage-current 1-phase** with the function group **Circuit breaker**. 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 function group **Voltage-current 1-phase**.



[sc_1stspc, 1, en_US]

Figure 5-56 Connecting Function Group Voltage-Current 1-Phase with Function Group Circuit Breaker

Fundamental Components

The fundamental components are always present in the function group **Voltage-current 1-phase** and cannot be deleted.

The following table shows the fundamental components of the function group **Voltage-current 1-phase**:

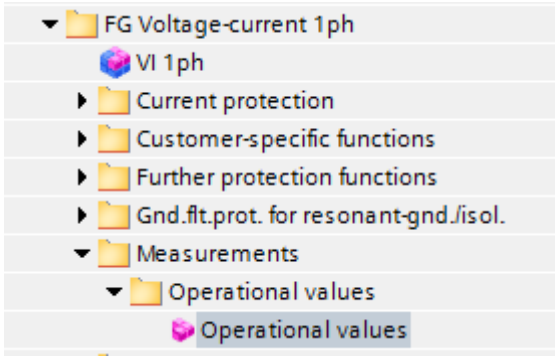
Table 5-5 Fundamental Components of the Function Group Voltage-Current 1-Phase

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	Parameter **Rated operating current**
V[16]	1-phase voltage	kV	V	Parameter **Rated operating voltage**
V_0[17]	Zero-sequence voltage	kV	V	Parameter **Rated operating voltage** /√3
V_N[18]	Residual Voltage	kV	V	Parameter **Rated operating voltage** /√3

You can find the parameters **Rated operating current** and **Rated operating voltage** in the function block **General** of the function group **Voltage-current 1-phase**.

Operational Measured Values

The operational measured values are not preconfigured in the function group **Voltage-current 1-phase**. You can instantiate them in the function group or delete them from the function group. You can find the operational measured values in the DIGSI library, in the folder **FG Voltage-current 1-phase** under **Measurements** → **Operational values**.



[scui1pom, 1, en_US]

Figure 5-57 Operational Measured Values

16 The 1-phase voltage V is only visible if it is connected to a 1-phase voltage measuring point.

17 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.

18 The residual voltage VN is only visible if it is connected to a 3-phase voltage measuring point with the connection type 3-phase phase-to-ground voltage + VN or 3-phase phase-to-phase voltage + VN.

Table 5-6 Operational Measured Values of the Function Group Voltage-Current 1-Phase

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	Parameter **Rated operating current**
V[19]	1-phase voltage	kV	V	Parameter **Rated operating voltage**
V_N[20]	Residual voltage	kV	V	Parameter **Rated operating voltage**/√3
V_0[21]	Zero-sequence voltage	kV	V	Parameter **Rated operating voltage**/√3
f	Frequency	Hz	Hz	Parameter **Rated frequency**
P	Active power	MW	W	Parameter **Rated apparent power**
Q	Reactive power	Mvar	var	Parameter **Rated apparent power**

You can find the parameters **Rated operating current**, **Rated operating voltage**, and **Rated apparent power** in the function block **General** of the function group **Voltage-current 1-phase**. You can find the parameter **Rated frequency** in the function block **General** of the **Device settings**.

NOTE

The frequency can be calculated from the voltage or current measured value.

The active and reactive power are only displayed if the voltage and the 1-phase current are connected to the function group. If the connected voltage is a phase-to-ground voltage (VA, VB , VC) or any voltage Vx, the specific power values are displayed. Otherwise the power is displayed as not available.

5.5.3 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	Setting Options	Default Setting
Rated values				
_:9421:103	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:223	General:CT mismatch M I-1ph		0.00 to 100.00	0.00

5.5.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100 000 A	1000 A
_:9421:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Measurements				
_:9421:150	General:P, Q sign		• not reversed • reversed	not reversed

19 V is only visible if it is connected to a 1-phase voltage measuring point.

20 VN is only visible if it is connected to a 3-phase voltage measuring point of the type 3 ph-to-gnd volt. + VN or 3 ph-to-ph volt. + VN.

21 V0 is only visible if it is connected to a 3-phase voltage measuring point of the type 3 ph-to-gnd voltages.

5.5.5 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 Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O

5.6 Function-Group Type Voltage/current 3-Phase

5.6.1 Overview

In the **Voltage-current 3-phase** function group, you can use all the functions for protection and supervision of a protected object or equipment that allows 3-phase current and voltage measurement. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *9 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 *8 Protection and Automation Functions*.

For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function*. For information regarding the functional scope of the application templates for the various device types, refer to chapter *4 Applications*.

5.6.2 Structure of the Function Group

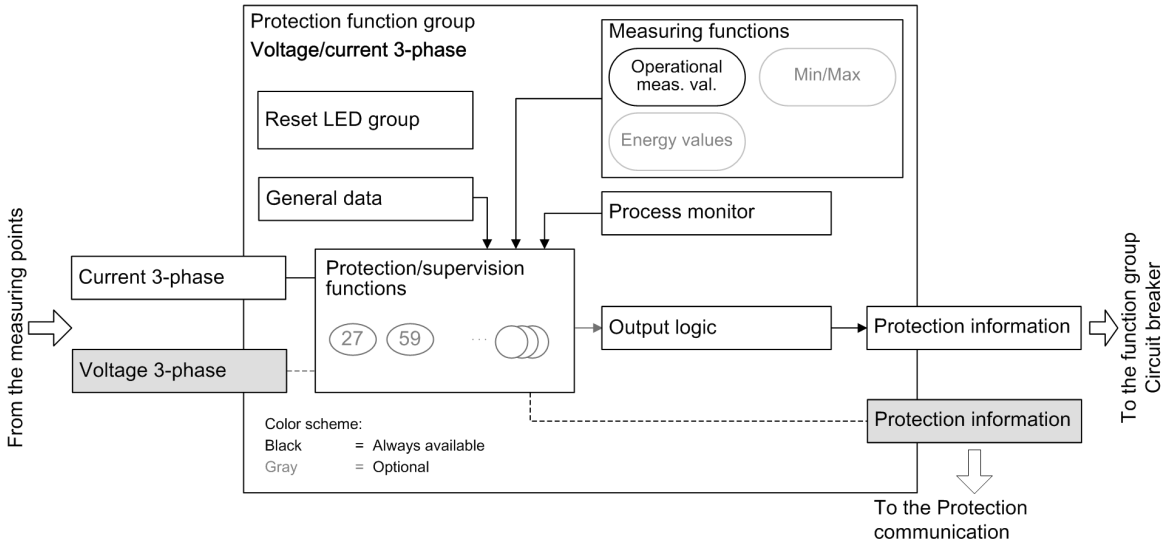
The function group always contains the following blocks:

- Protected object/equipment data (FB General)
- Operational measured values
- Process monitor
- Output logic of the function group
- Reset the 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 function library in DIGSI 5. 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**:



[dw_FG VI 3ph_structure, 1, en_US]

Figure 5-58 Structure of the Voltage-Current 3-Phase Function Group

The function group has interfaces with:

- **Measuring points**
- Function group **Circuit breaker**

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. For more detailed information, refer to *2 Basic Structure of the Function*.

The function group has the following interfaces with the measuring points:

- **3-phase voltage**

  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. The function group must always be linked to the **V-3ph** measuring point.

  You can connect multiple measuring points with this interface. For more information, refer to *8.24 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)** > **Measuring point routing** (Connection type = 3 phase-to-ground voltage). For more information, refer to the description of the power-system data starting with *8.1 Power-System Data*.

- **3-phase current**

  The measurands from the 3-phase current 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.

Interface to the Circuit-Breaker Function Group

All required data are exchanged between the function groups **Voltage-current 3-phase** and **Circuit breaker** via the interface of 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 position 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.

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.

For more detailed information, refer to *3.1.11 Resetting Stored Indications of the Function Group* .

Operational Measured Values

The operational measured values are always present in the **Voltage-current 3-phase** function group and cannot be deleted.

The following table shows the operational measured values of the **Voltage-current 3-phase** function group:

Table 5-7 Operational Measured Values of the Voltage-Current 3-Phase Function Group

Measured Values		Primary	Secon-dary	% 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	Rated operating voltage of the 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	Rated operating voltage of the primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Rated operating voltage of the primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P_{total}	Active power (total power)	MW	W	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
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 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 $V_{rated\ phsx} \cdot I_{rated\ phsx}$

Measured Values		Primary	Secon-dary	% Referenced to
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 $V_{rated\ phsx} \cdot I_{rated\ phsx}$

For a more detailed explanation of the operational measured values, refer to *9.3 Operational Measured Values*.

Inversion of Power-Related Measured and Statistical Values (FB General)

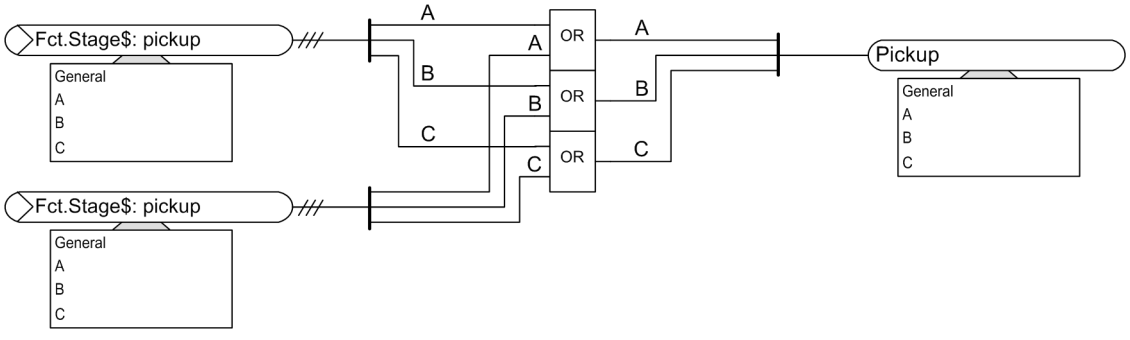
The following directional values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Active factor
- Energy
- Minimum, maximum values
- Average values

With the parameter **`P, Q sign`**, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.
For more information on this, refer to *9.1 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.



[lo_anrlin, 3, en_US]

Figure 5-59 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.

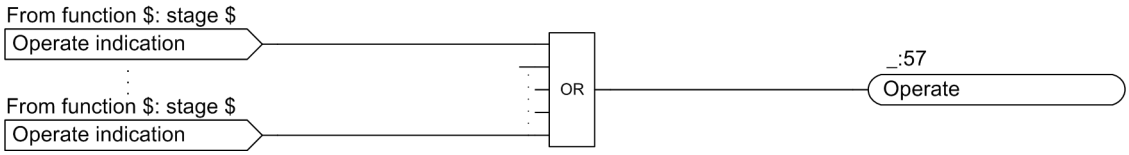


Figure 5-60 Creation of the Operate Indication of the Voltage-Current 3-Phase Function Group

5.6.3 Write-Protected Settings

Parameter: Rated apparent power

- Default setting (_:103) **Rated apparent power** = ***692.82 MVA***

With the **Rated apparent power** parameter, you can set the primary rated apparent power for the auto transformer to be protected. The **Rated apparent power** parameter is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only 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.

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

5.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9451:101	General:Rated current		1.00 A to 100000.00 A	1000.00 A
_:9451:102	General:Rated voltage		0.10 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

5.6.5 Information List

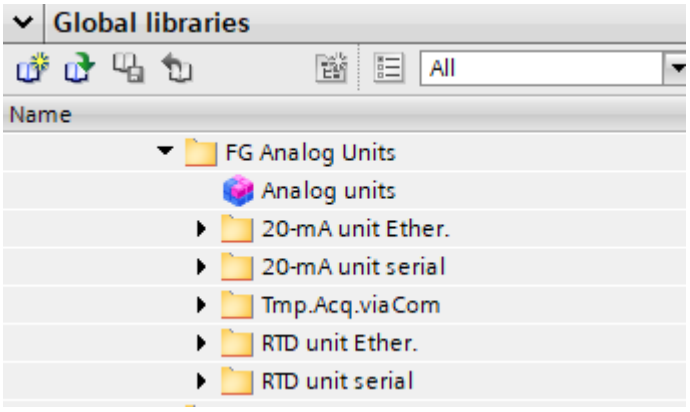
No.	Information	Data Class (Type)	Type
General			
_:9451:52	General:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_: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
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

5.7 Function-Group Type Analog Units

5.7.1 Overview

The function group **Analog units** is used to map analog units and communicate with them. Analog units are external devices, such as RTD units, or analog plug-in modules or measuring-transducer modules.
You can find the function group **Analog units** for many device types in the Global DIGSI 5 library.

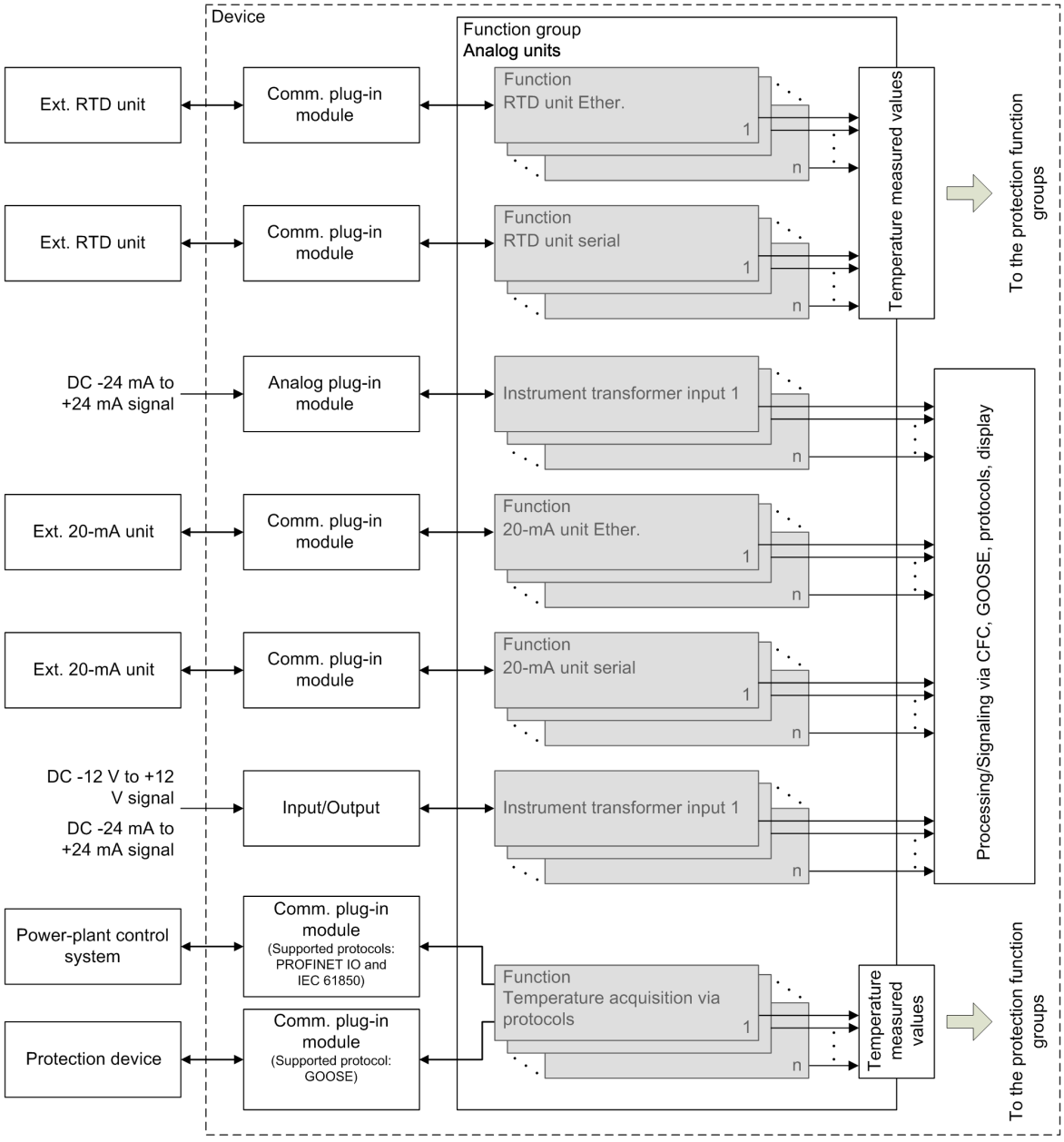


[sc_20_maee, 3, en_US]

Figure 5-61 Analog Unit Function Group in DIGSI

5.7.2 Structure of the Function Group

If the device has a measuring transducer, it is automatically mapped in the function group **Analog units**. 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 5 library in order to map the RTD units.
If the device is connected to a power-plant control system or another protection device, you must load one or more **Temperature acquisition via protocols** functions from the Global DIGSI 5 library to form the protocols.
The following figure shows the structure of the function group.



[dw_str_the, 3, en_US]

Figure 5-62 Structure of the Function Group Analog Unit

Gray: Optionally wired, optionally available

White: Always wired, always available

The function group **Analog units** has interfaces to protection function groups. The function group **Analog units** provides, for example, measured temperature values that come from an external RTD unit , a measuring transducer or via protocols. These measured temperature values are available for all protection function groups in which a temperature monitoring function works.

The function **RTD unit Ether.** is not preconfigured by the manufacturer. A maximum of 20 function instances can operate simultaneously.

The structure of the function **RTD unit serial** is identical to the structure of the function **RTD unit Ether.**.

The function **20-mA unit Ether.** is not preconfigured by the manufacturer. A maximum of 4 function instances can operate simultaneously. The structure of the function **20 mA serial unit** is identical to the structure of the function **20-mA unit Ether.**.

The function **Temperature acquisition via protocols** has 2 stage types: The **Temperature acquisition via PROFINET IO or IEC 61850** and the **Temperature acquisition via GOOSE**. One instance of the **Temperature acquisition via PROFINET IO or IEC 61850** is preconfigured by the manufacturer. A maximum of 12 instances can operate simultaneously for both stage types.

5.7.3 20-mA Unit Ethernet

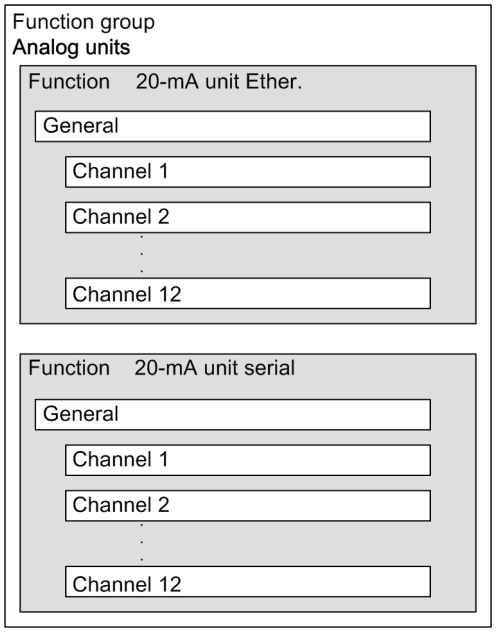
5.7.3.1 Overview

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

5.7.3.2 Structure of the Function

The function **20-mA unit Ether.** can only work 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.

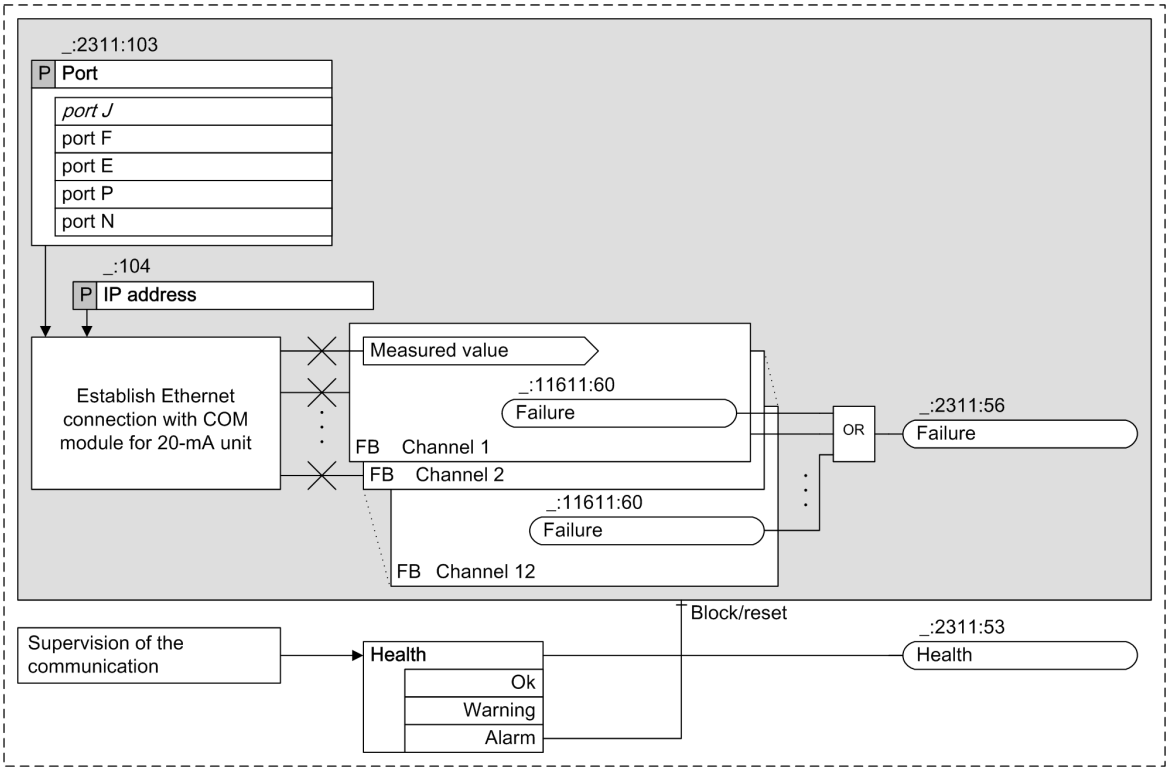


[dw_str_fn2, 2, en_US]

Figure 5-63 Structure/Embedding of the Function

5.7.3.3 Communication with 20-mA Unit Ethernet

Logic



[lo_20mtcp, 1, en_US]

Figure 5-64 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 *5.7.3.4 Application and Setting Notes*.

The 20-mA measuring unit **7XV5674** is supported.

Error Responses

The following table lists the conditions under which the status *Health* transitions to the Alarm or Warning state.

Table 5-8 Error Responses

Error Description	Status Health
The function **20-mA unit Ether.** cannot establish a connection witha 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

Error Description	Status Health
The connection between the communication module and the 20-mA unit causes a time-out indication.	Warning
A communication module has not received any more data from the 20-mA unit for 9 sec.	Warning

The signal *Failure* is issued as soon as one of the channel function blocks reports a failure.

5.7.3.4 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***port J***

With the parameter **Port**, you 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 parameter **IP address**, 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 parameter **IP address** for the communication module to the same address.

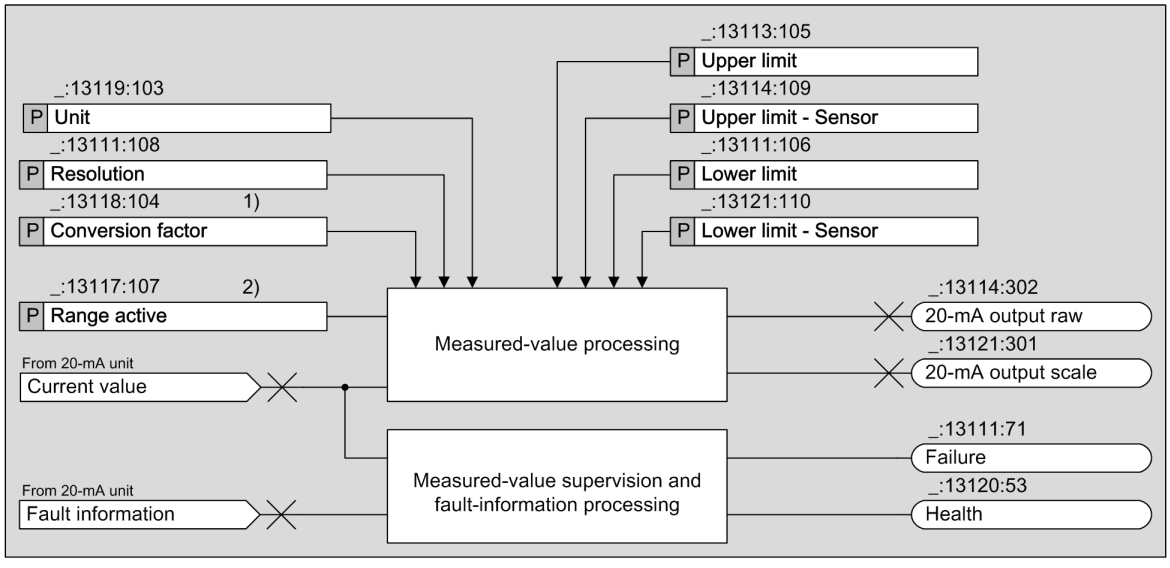
Settings on the 20-mA Unit

Set the **7XV5674 20-mA unit** with a Web browser on the laptop computer via the latter's Ethernet interface. Set ***Modbus TCP*** as a 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 (*www.support.industry.siemens.com*).

5.7.3.5 20-mA Channel

Logic



[lo_20mcha, 1, en_US]

Figure 5-65 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.

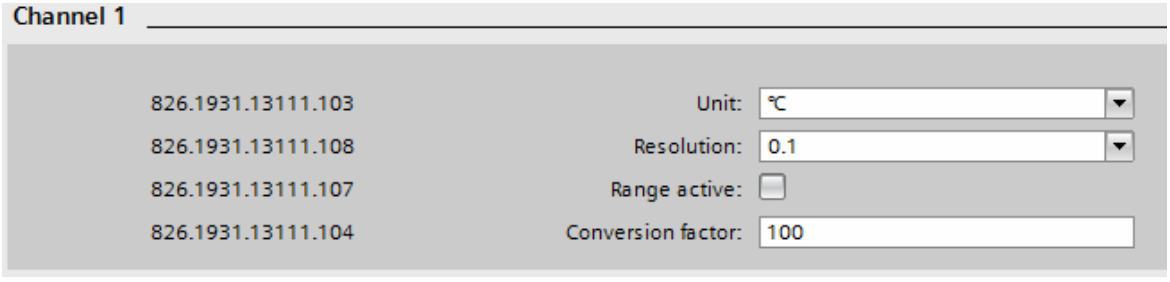
(2) If the setting **Range active** is set to ***false***, the settings **Upper limit**, **Transformation ratio upper limit**, **Lower limit** and **Transformation ratio** are not displayed.

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

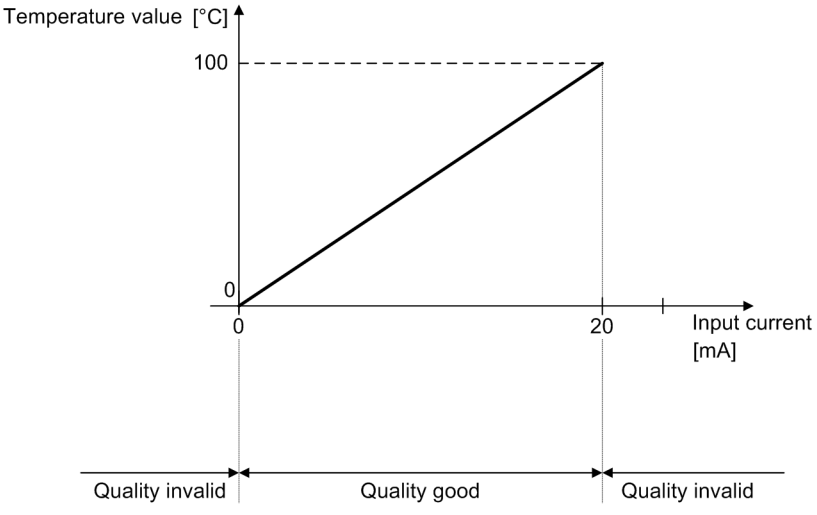
The 20-mA unit typically transmits a value which represents a physical quantity, such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that maps the physical quantity to the 20-mA value. If you do not activate the **Range active** setting (no x in the check box), 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 5-66 Settings for Example 1

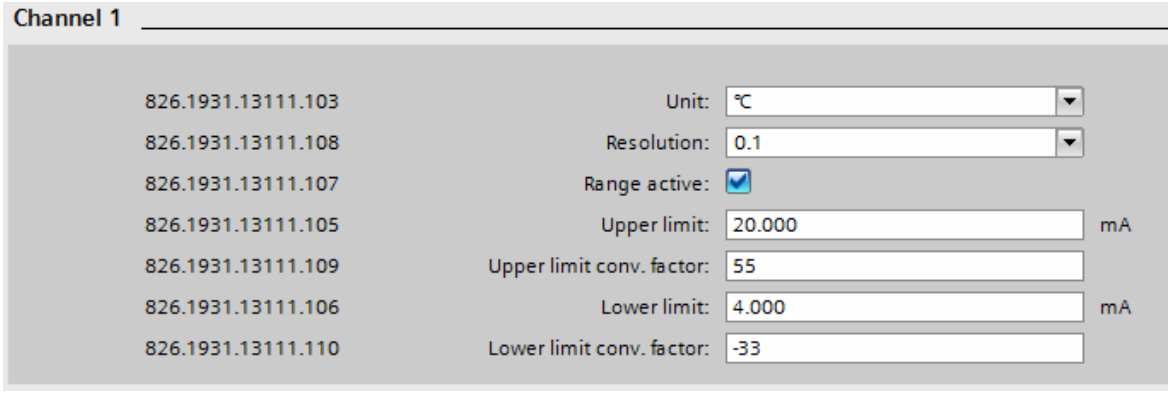
In this example, the measured value 0 mA means a temperature of 0 °C and the measured value 20 mA means a temperature of 100 °C. So enter as **Unit** = ***°C*** and **Conversion factor** = ***100***. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select **Resolution** = ***0.1***.



[dw_knges3, 1, en_US]

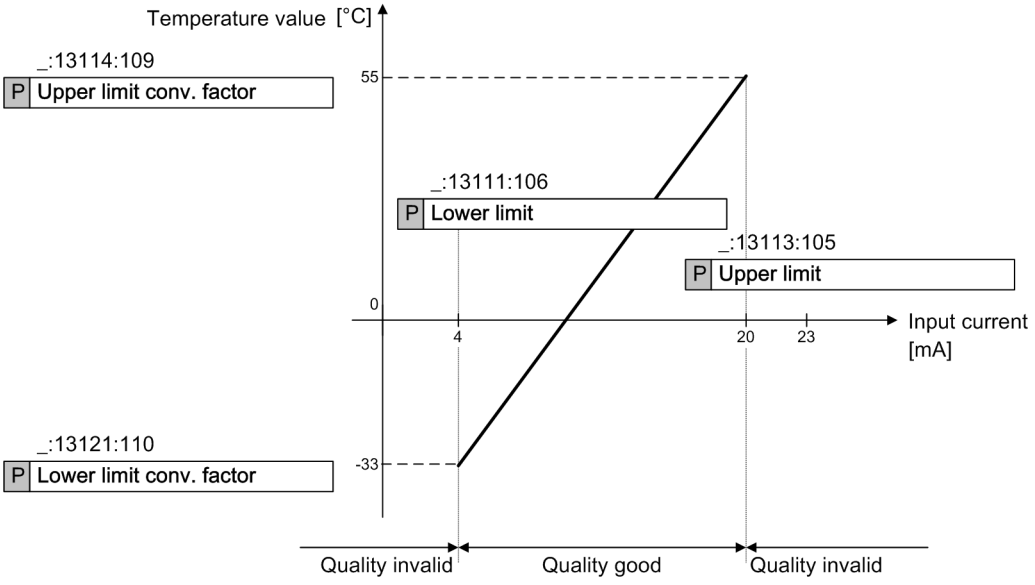
Figure 5-67 Characteristic Curve of a 20-mA Input (Example 1)

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 5-68 Settings for Example 2



[dw_knges2, 1, en_US]

Figure 5-69 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 5-9 Error Responses

Error Description	Status *Health*	Error Status
The input value lies outside the given limits	OK	Yes
Channel not connected	OK	No

5.7.3.6 Application and Setting Notes

Parameter: Unit

- Default setting **(_:13111:103) Unit** = ***°C***

With the **Unit** parameter, you set the physical unit of measurement the measured values. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = ***100***

With the **Conversion factor** parameter, you set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = ***0.1***

With the **Resolution** parameter, you set the resolution of the scaled values.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = ***false***

If you do not activate the parameter **Range active** (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 parameter **Range active**, the 4 additional parameters **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor** appear.

Parameter: Upper limitLower limitUpper limit - Sensor and Lower limit - Sensor

- Default setting **(_:13111:105) Upper limit** = ***20.000 mA***
- Default setting **(_:13111:109) Upper limit - Sensor** = ***100***
- Default setting **(_:13111:106) Lower limit** = ***4.000 mA***
- Default setting **(_:13111:110) Lower limit - Sensor** = ***100***

If you activate the parameter **Range active** , the 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. 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.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.7.3.7 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

Addr.	Parameter	C	Setting Options	Default Setting
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	m

Addr.	Parameter	C	Setting Options	Default Setting
			• W/s • Wh	
_: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 1000000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-1000000 to 1000000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-1000000 to 1000000	100

5.7.3.8 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

5.7.4 20-mA Unit Serial

5.7.4.1 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 *5.7.3.2 Structure of the Function*.

5.7.4.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***Port J***

With the parameter **Port**, 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 parameter **Channel number**, 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***

With the parameter **Slave address**, you 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 parameter **Slave address** in the 3 functions **20-mA Unit Serial**.

Parameter: Unit

- Default setting **(_:13111:103) Unit** = ***°C***

With the parameter **Unit**, you set the physical unit of measurement the measured values. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = ***100***

With the parameter **Conversion factor**, you set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = ***0.1***

With the parameter **Resolution**, you set the resolution of the scaled values.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = ***false***

If you do not activate the parameter **Range active** (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 parameter **Range active**, the 4 additional parameters **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 parameter **Range active**, the 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. 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.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.7.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port F • port E • 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

Addr.	Parameter	C	Setting Options	Default Setting
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	m

Addr.	Parameter	C	Setting Options	Default Setting
			• W/s • Wh	
_: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 1000000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-1000000 to 1000000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-1000000 to 1000000	100

5.7.4.4 Information List

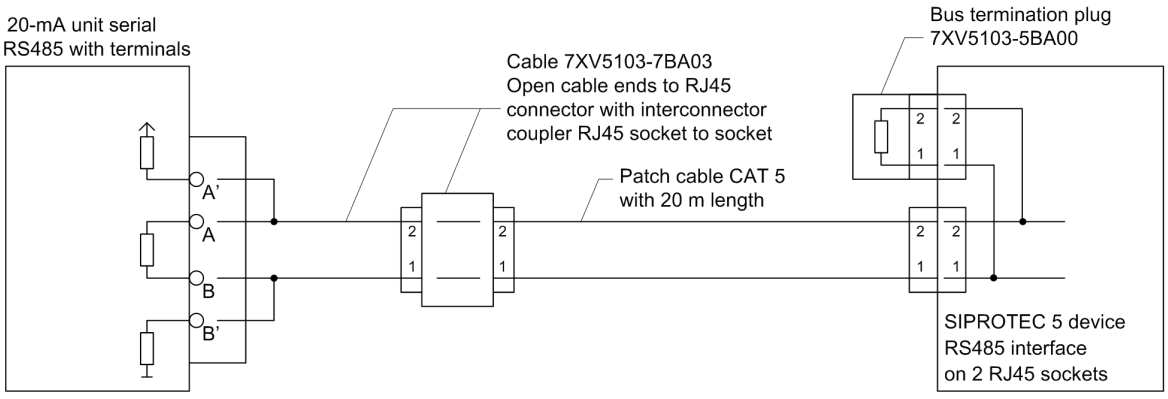
No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.7.5 Communication with 20-mA Unit

5.7.5.1 Integration of a Serial 20-mA Unit

Connection of the Communication Lines

Figure 5-70 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.

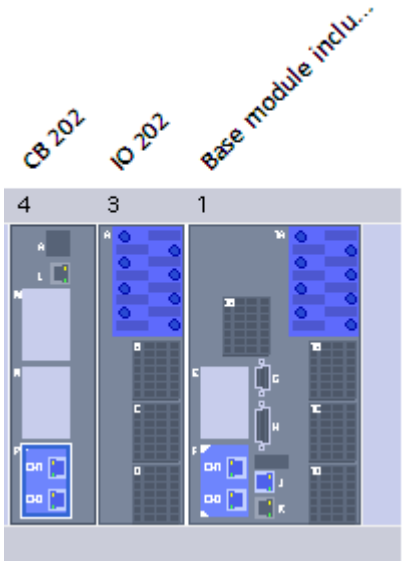


[dwve20au-150213-01.tif, 1, en_US]

Figure 5-70 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).

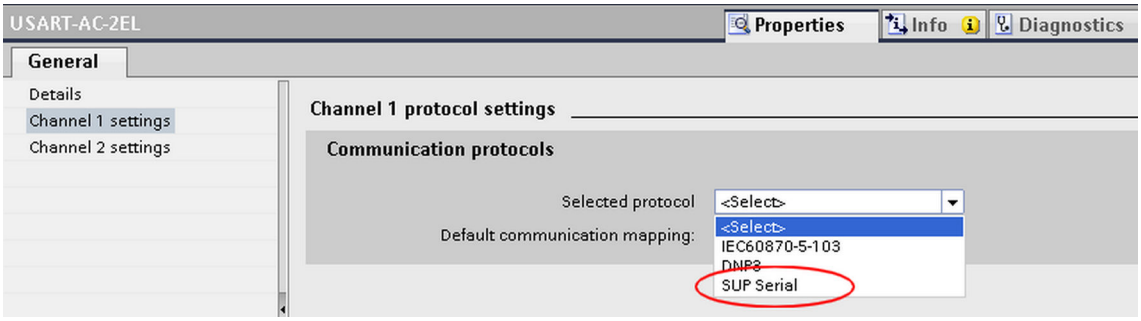


[sc20ser3-220114-01-DE, 1, en_US]

Figure 5-71 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.



[scauser4-301012-01.tif, 1, en_US]

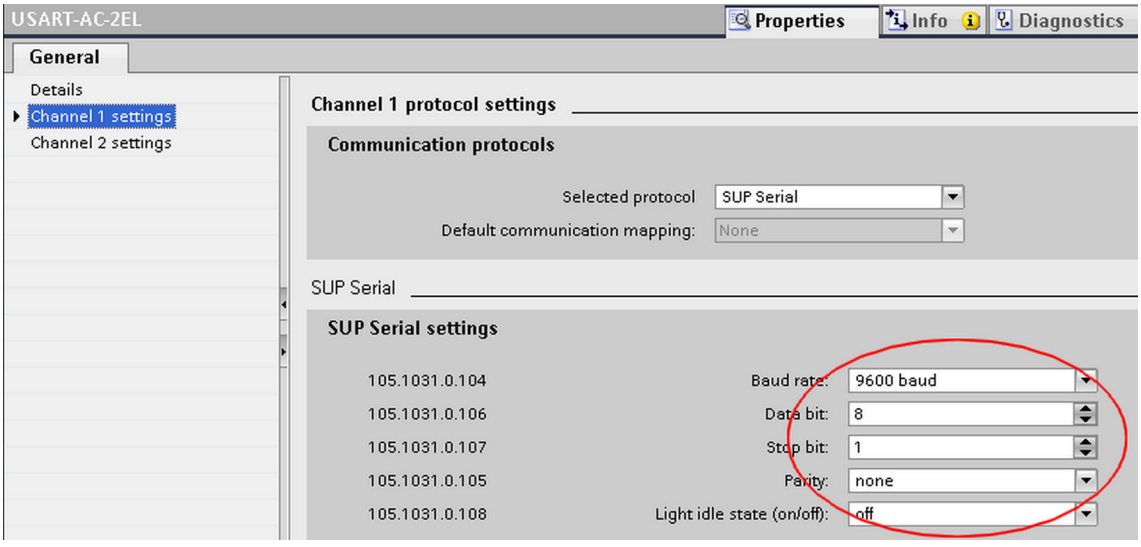
Figure 5-72 Selecting the SUP Protocol

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 setting of the parameter **`Non-flickering light (on/off):`** is not relevant for the RS485 interface.

NOTE

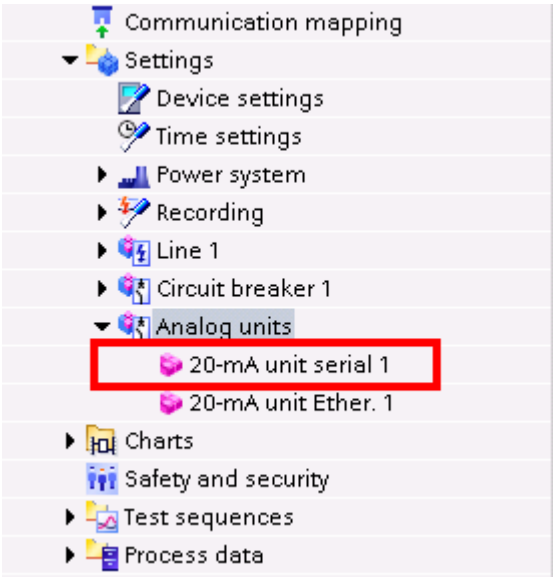
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-301012-01.tif, 1, en_US]

Figure 5-73 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 the following figure).



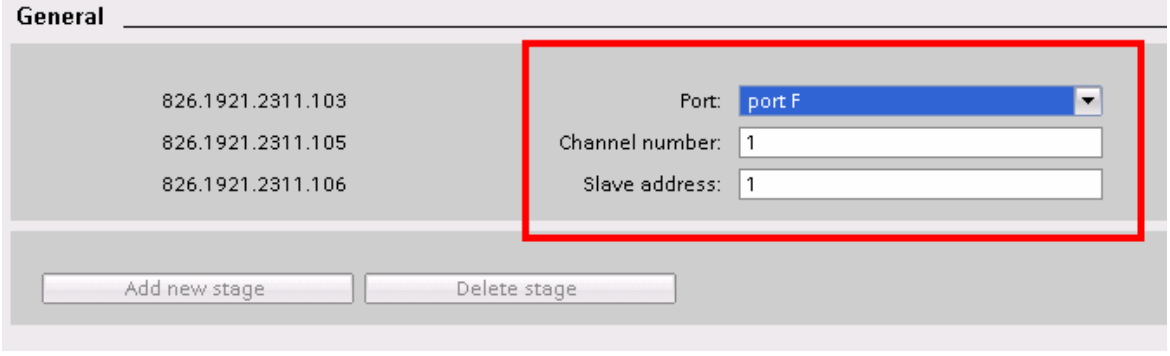
[sc20ser6-220114-01-DE, 1, en_US]

Figure 5-74 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]

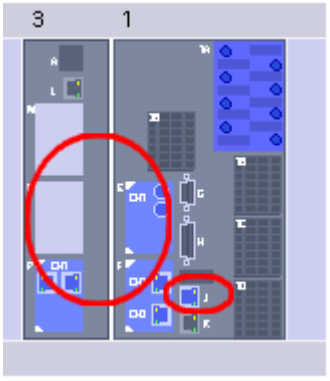
Figure 5-75 Setting the Port, Channel Number, and Device Address

Finally, load the configuration in the device.

5.7.5.2 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 5-76* displays the available slots in the base module or on the expansion module CB202. Alternatively, you can also use the integrated Ethernet interface Port J.

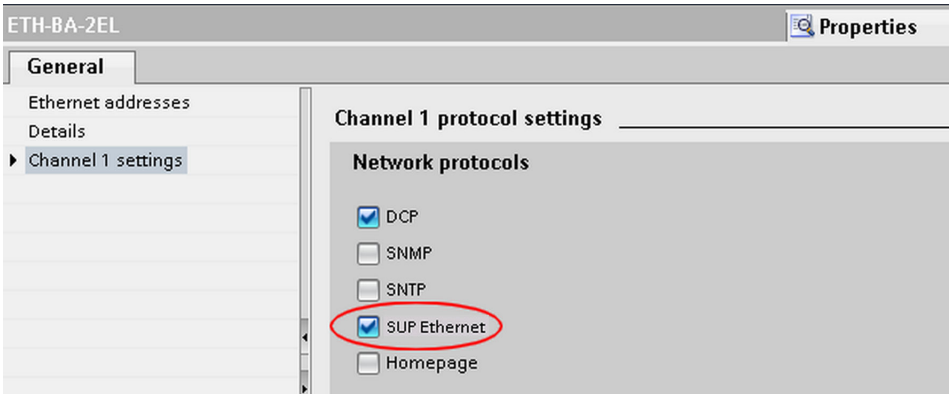


[sc_autcp1, 1, en_US]

Figure 5-76 Inserting an Ethernet Module

Communication Settings

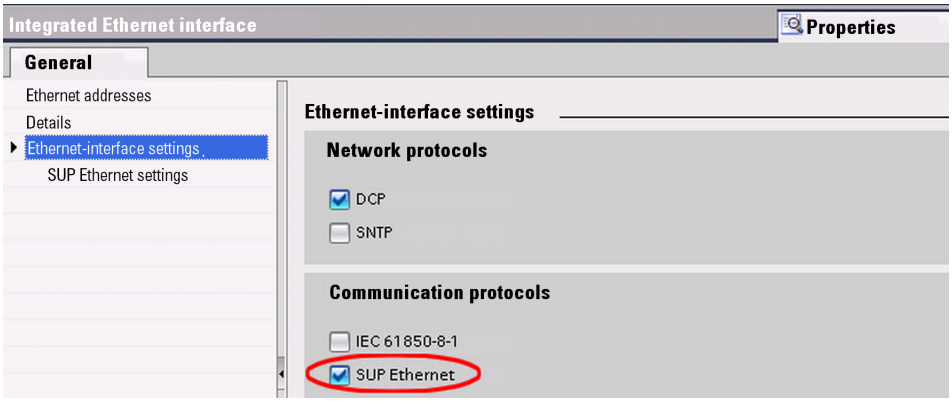
Activate the SUP Ethernet protocol for the Ethernet module.



[sc_autcp2, 1, en_US]

Figure 5-77 Activation of the Protocol

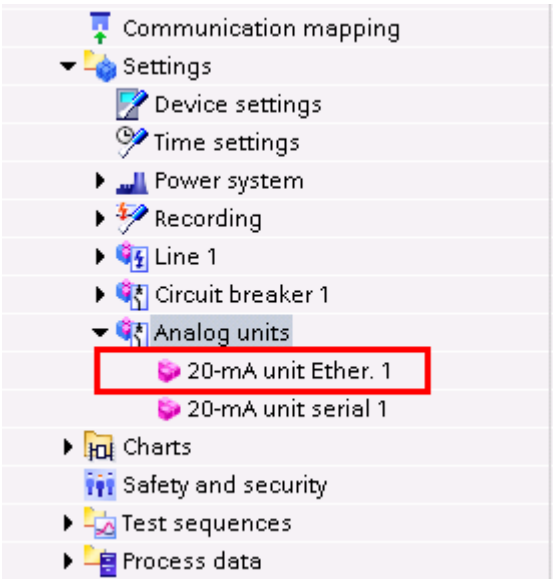
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[sc_autcp3, 1, en_US]

Figure 5-78 Selection of the Protocol

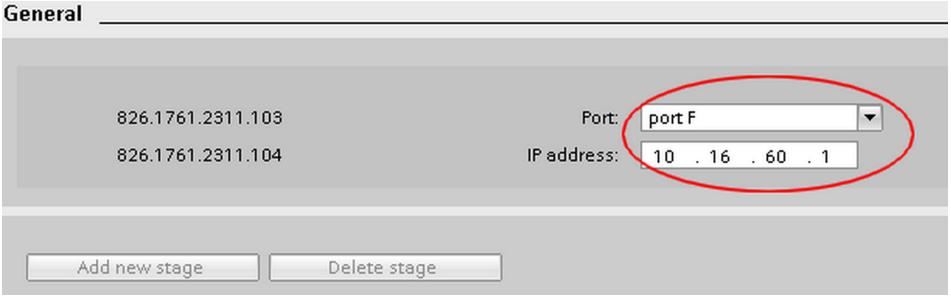
With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the **Analog units** function group and the **20-mA unit Ether. 1** function to your device configuration (refer to the following figure).



[sc_20tcp4, 1, en_US]

Figure 5-79 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.



[sc_autcp5, 1, en_US]

Figure 5-80 Setting the Port and IP Address

Finally, load the configuration in the device.

5.7.6 V/I-Measuring-Transducer Unit with Fast Inputs

5.7.6.1 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**:

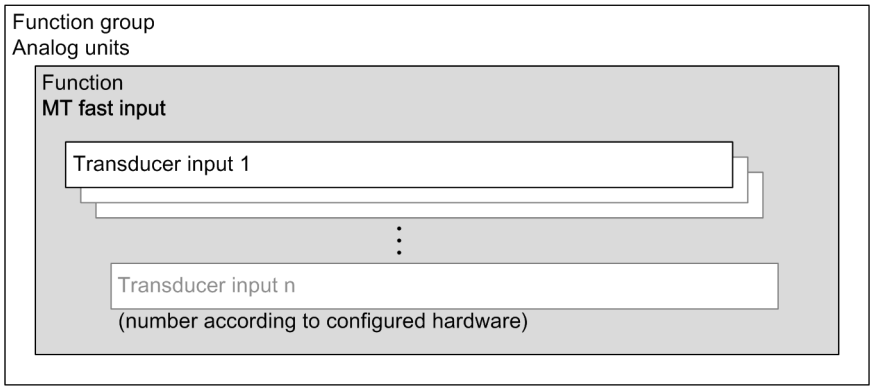
- Provides sampled values for recording in the fault record (the maximum sampling frequency is 8 kHz for all other SIPROTEC 5 devices). The recorded sampling frequency results from the setting of the fault-recorder function.
- Calculated measured values from the sampled values. These measured values 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).

5.7.6.2 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]

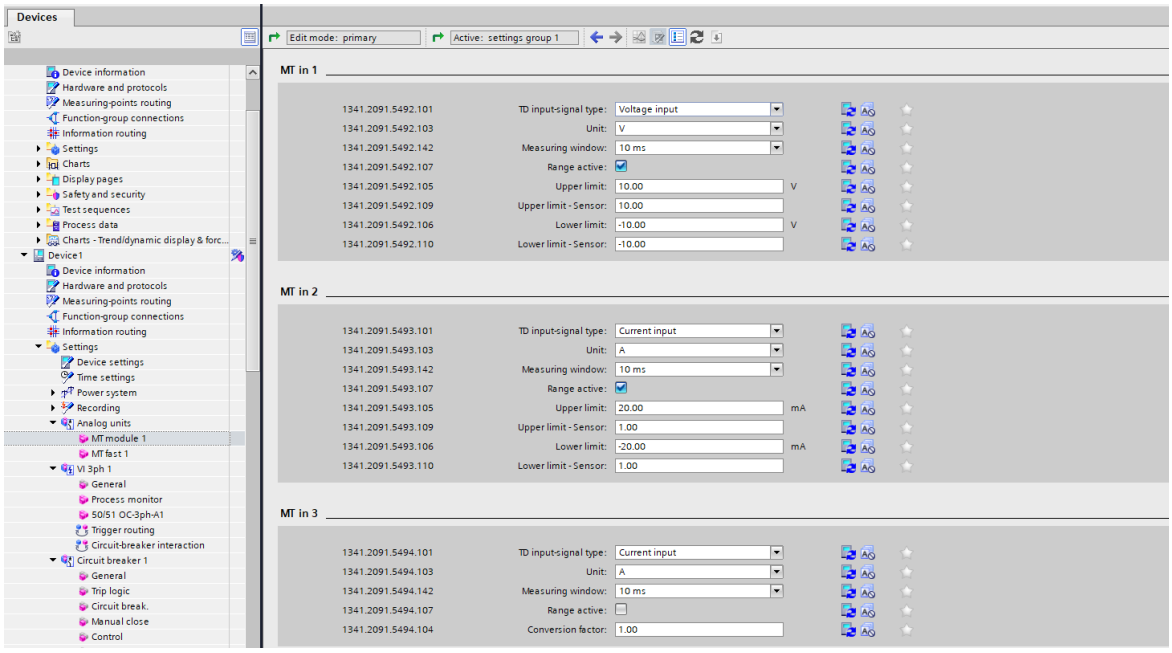
Figure 5-81 Structure/Embedding of the Function

5.7.6.3 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 *5.7.6.4 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, 2, en_US]

Figure 5-82 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 *5.7.3.5 20-mA Channel*).

5.7.6.4 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 parameter **Range active**, the 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 5-82*).

Parameter: Conversion factor

- Default setting **(_:104) Conversion factor** = ***1.00***

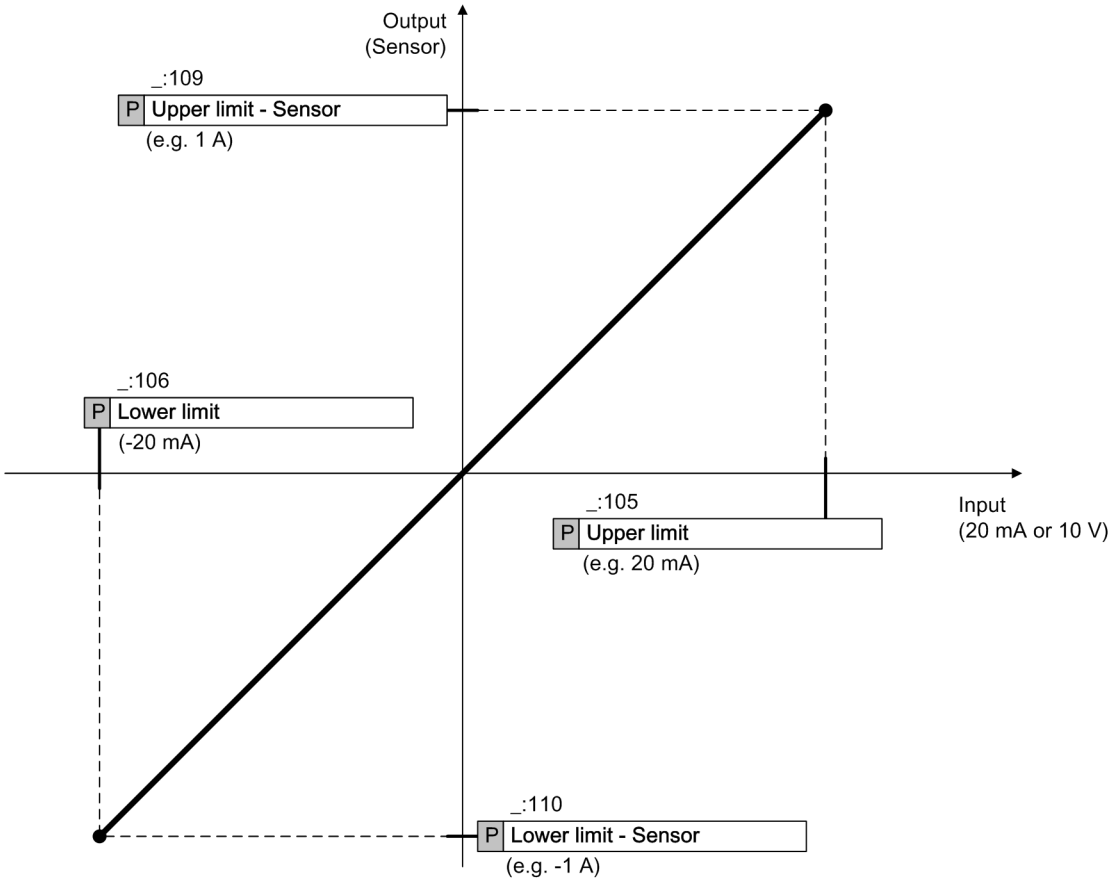
With the parameter **Conversion factor**, you set the conversion factor for the measuring transducer.

Parameter: Upper limit, Upper limit - Sensor, Lower limit, 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]

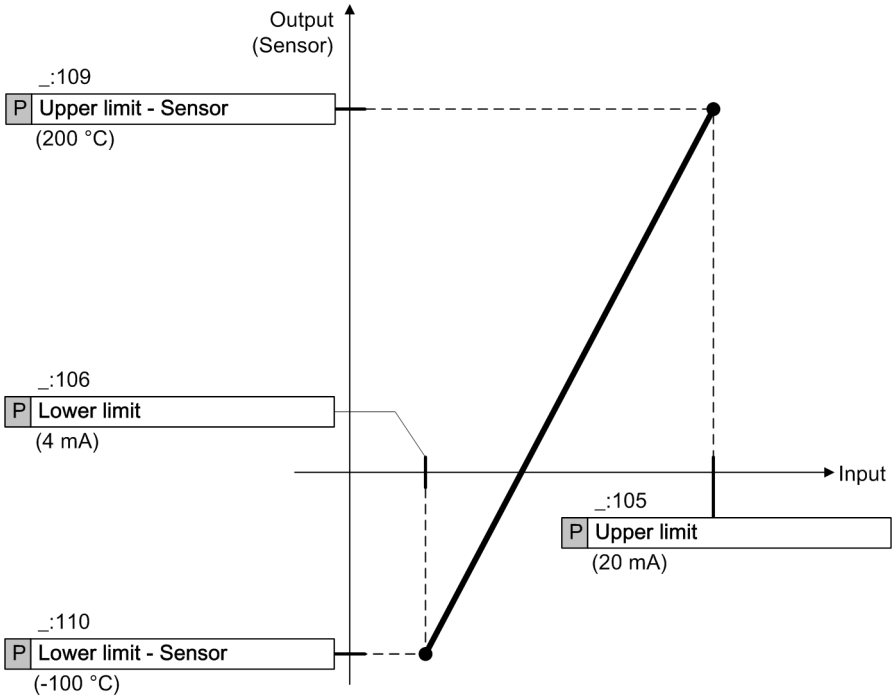
Figure 5-83 Scaling Principle

If you keep the preset limiting values, the following conditions are possible:

- If the input current is < 2.000 mA
  The function issues the indication *Broken wire* and the quality of the output value is invalid. The functions that use the output value as the measured value can be deactivated.
- If the input current is > 2.500 mA
  The indication *Broken wire* drops out.

Setting Example 1:

A measuring transducer transmitting a current signal of 4 mA to 20 mA is used as a transmitter. Currents well below -25.6 mA or above +25.6 mA indicate a transmitter failure. 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 5-84 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 are at approx. +20 mA and -20 mA or +10 V and -10 V.

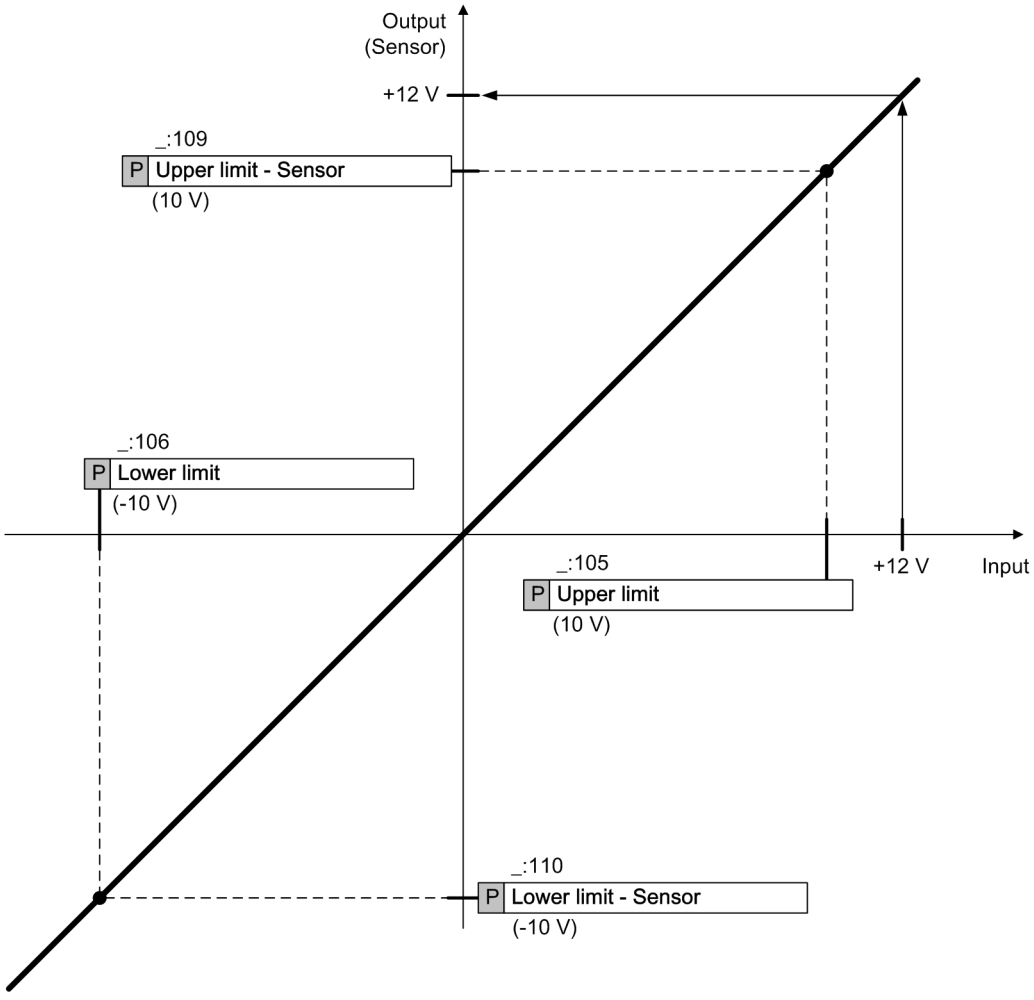
Setting Example 2:

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 5-85 Parameter Settings and Representation of an Input Signal Greater than 10 V

5.7.6.5 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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		-1000000.00 to 1000000.00	1.00
_:105	MT in #:Upper limit		-20.00 m Ato 20.00 mA	5.00 mA
_:109	MT in #:Upper limit - Sensor		-1000000.00 to 1000000.00	1.00
_:106	MT in #:Lower limit		-20.00 m Ato 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-1000000.00 to 1000000.00	1.00

5.7.6.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:307	MT in #:Broken wire	SPS	O
_:302	MT in #:TD scale MV	MV	O
_:306	MT in #:TD scale SAV	SAV	O

5.7.7 RTD Unit Ethernet

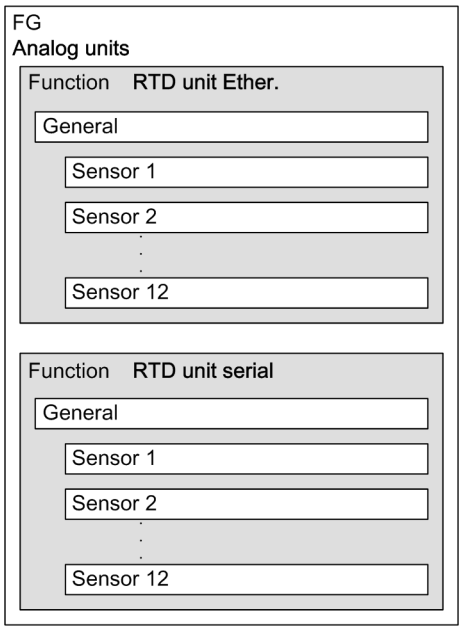
5.7.7.1 Overview

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

5.7.7.2 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.

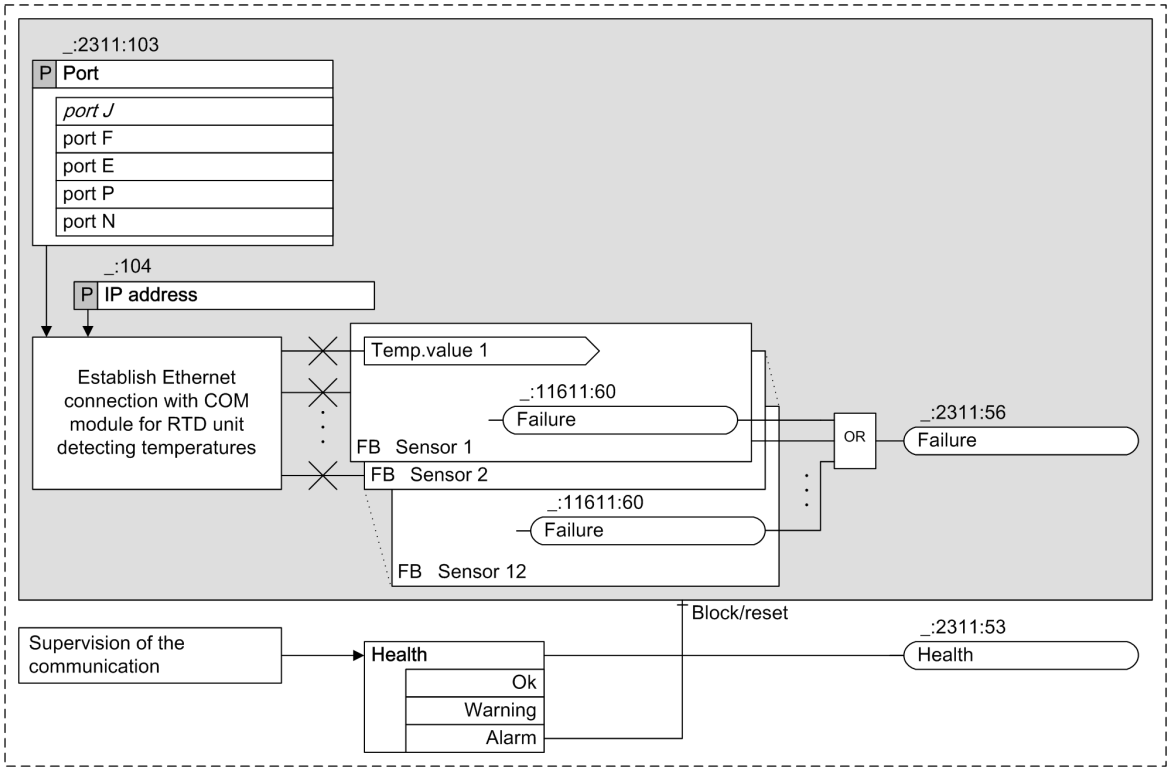


[dw_str_fnc, 2, en_US]

Figure 5-86 Structure/Embedding of the Function

5.7.7.3 Communication with an RTD Unit

Logic



[lo_rtdtcp, 1, en_US]

Figure 5-87 Logic of the RTD Unit Ether. Function

Communication with an RTD Unit

The function is used to communicate with an RTD unit connected via an Ethernet connection. If the connection of the function is successfully established to the external RTD unit via the Ethernet interface, the RTD unit transmits the temperatures of all connected sensors to the **RTD unit Ether.** function. For the connection to be established successfully, specific communication settings must be set, see chapter *5.7.7.4 Application and Setting Notes*.

The RTD unit **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 unit 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 *5.7.7.4 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 5-10 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
A communication module has not received any more data from the RTD unit for 9 sec.	Warning

The *Failure* signal is issued as soon as one of the sensor function blocks reports a failure.

5.7.7.4 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 parameter **IP address**, 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 parameter **IP address** 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.

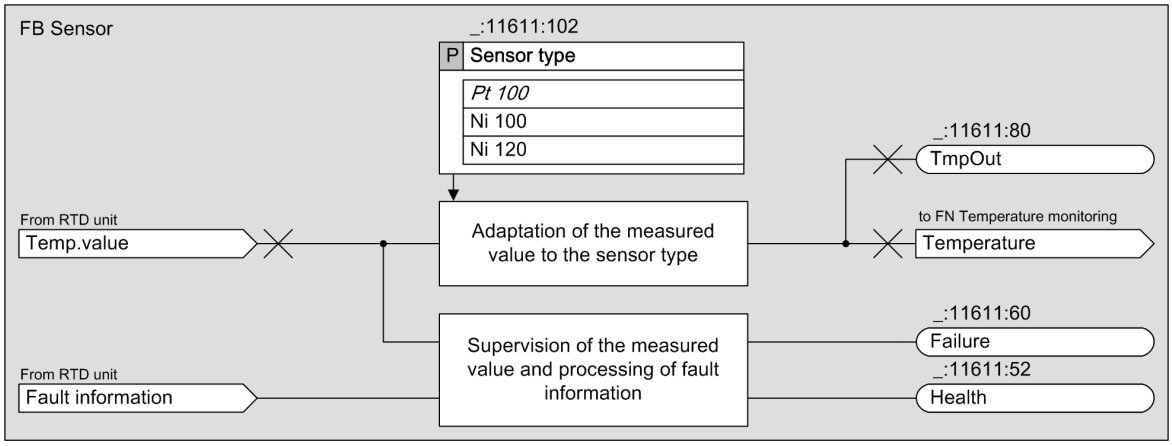
The code lock has to be switched off for parameterization. This is only possible using the front keys of the RTD unit. The code lock is **off** (switched off) in as-delivered condition and has pin **504**.

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 / on** 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.

5.7.7.5 Temperature Sensor

Logic



[lo_tmpval, 1, en_US]

Figure 5-88 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 unit for the assigned sensor. 12 temperature sensor function blocks are always available in each RTD unit function (both via Ethernet and serial), even if fewer sensors are connected to the RTD unit.

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 5-11 Error response

Error Description	Health Status	Error Status
Sensor or line short circuited	Alarm	Yes
Sensor or line interrupted	Alarm	Yes

Error Description	Health Status	Error Status
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

5.7.7.6 Application and Setting Notes

Parameter: Sensor type

- Default setting **(_:11611:102) Sensor type** = ***Pt 100***

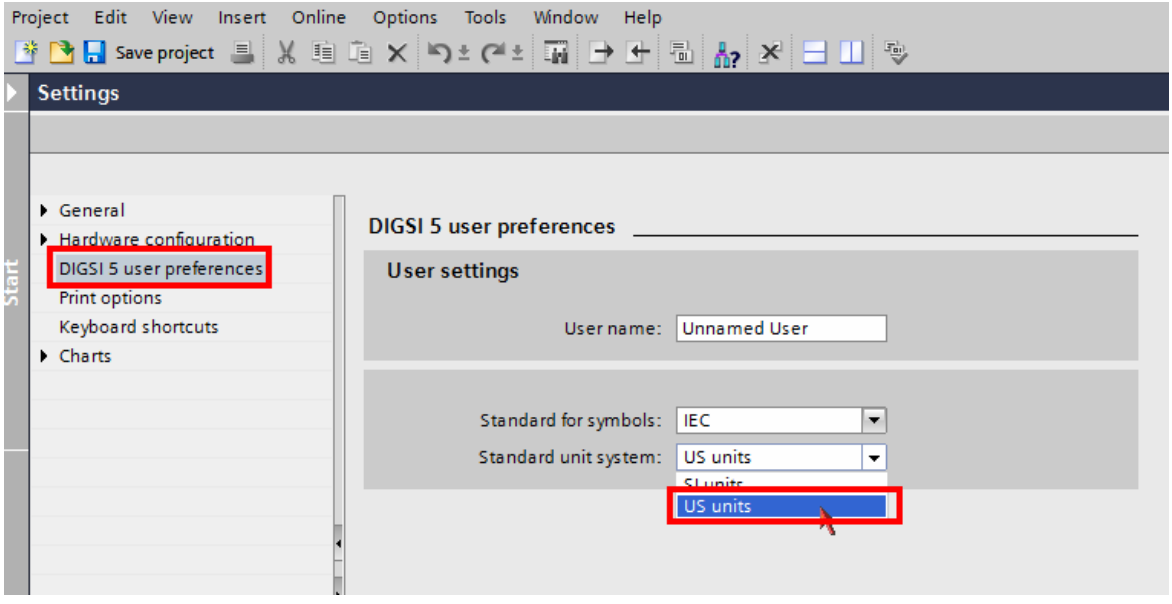
The **Sensor type** parameter is used to set the sensor element used. You can select between ***Pt 100***, ***Ni 100*** and ***Ni 120***.

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 5-89 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.

5.7.7.7 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

5.7.7.8 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

5.7.8 RTD Unit, Serial

5.7.8.1 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 *5.7.7.3 Communication with an RTD Unit*).

5.7.8.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***F***

With the parameter **Port**, 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 unit 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 parameter **Channel number**, 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*

With the parameter **Slave address**, you 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.

5.7.8.3 Parameter

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

Addr.	Parameter	C	Setting Options	Default Setting
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
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

5.7.8.4 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

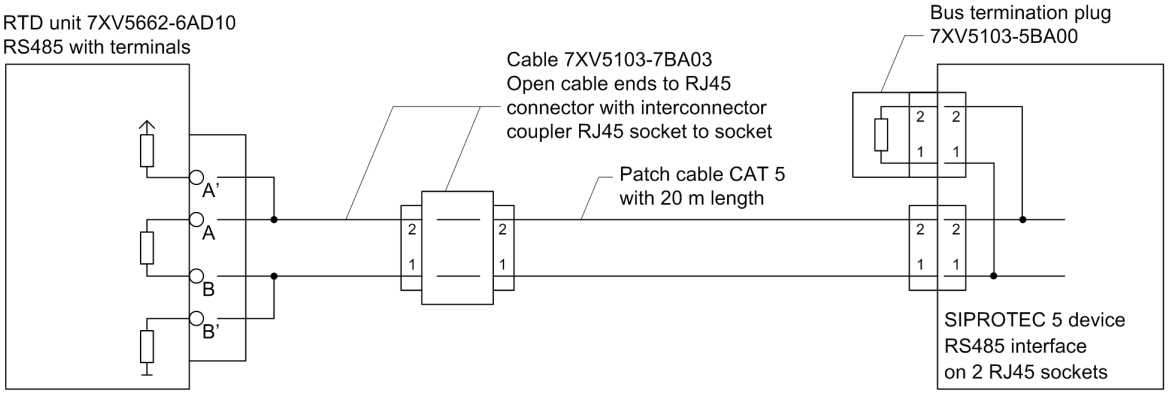
No.	Information	Data Class (Type)	Type
_:11613:60	Sensor 3:Failure	SPS	O
_:11613:80	Sensor 3:TmpOut	MV	O
Sensor 4			
_:11614:52	Sensor 4:Health	ENS	O
_:11614:60	Sensor 4:Failure	SPS	O
_:11614:80	Sensor 4:TmpOut	MV	O
Sensor 5			
_:11615:52	Sensor 5:Health	ENS	O
_:11615:60	Sensor 5:Failure	SPS	O
_:11615:80	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
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

5.7.9 Communication with RTD Unit

5.7.9.1 Integration of a Serial RTD Unit (Ziehl TR1200)

Connection of the Communication Lines

Figure 5-90 shows how you connect the RTD 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.



[dwverbau-201112-01.tif, 1, en_US]

Figure 5-90 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).

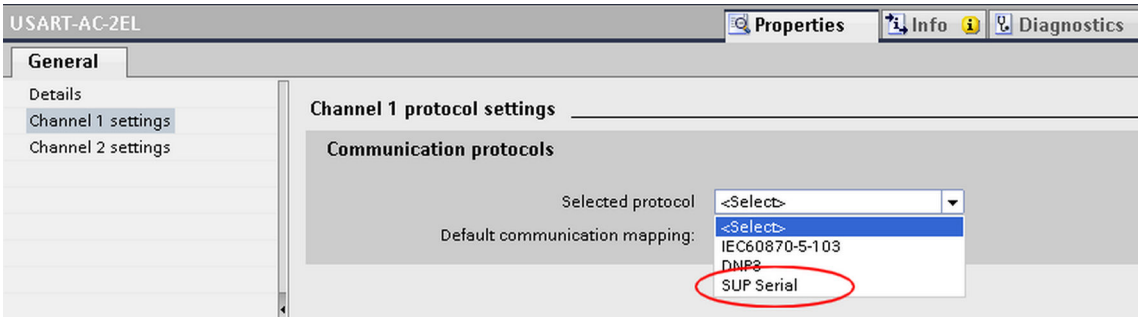


[scauser3-190214-01, 1, en_US]

Figure 5-91 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.



[scauser4-301012-01.tif, 1, en_US]

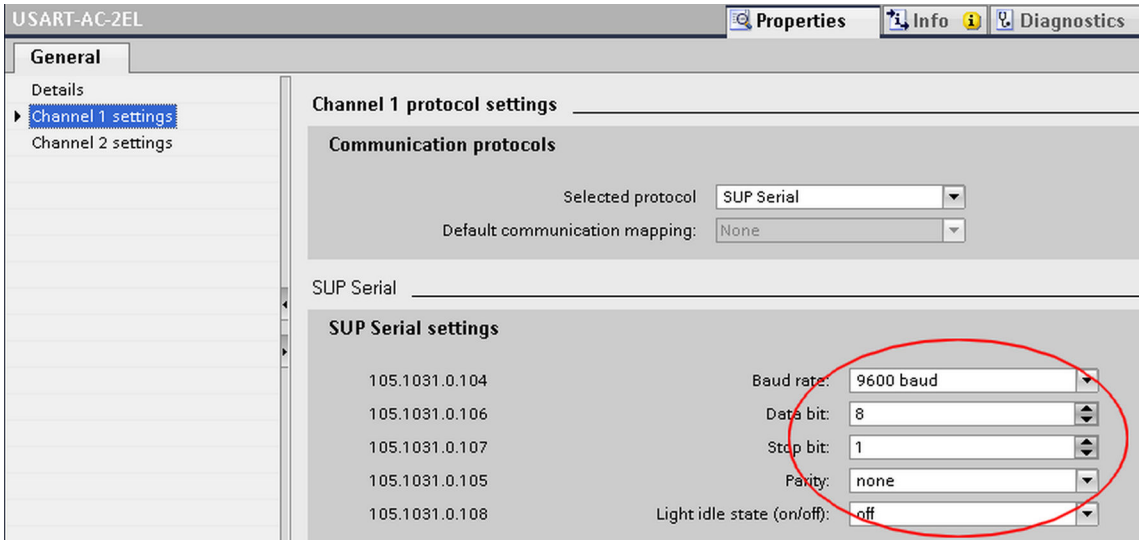
Figure 5-92 Selecting the SUP Protocol

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 setting of the parameter **`Non-flickering light (on/off):`** is not relevant for the RS485 interface.

NOTE

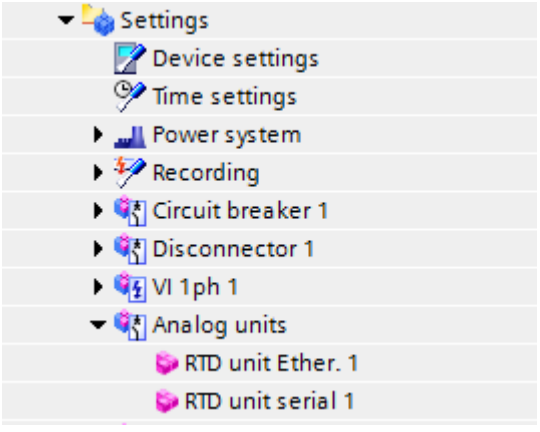
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-301012-01.tif, 1, en_US]

Figure 5-93 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 unit serial 1** (refer to the following figure).



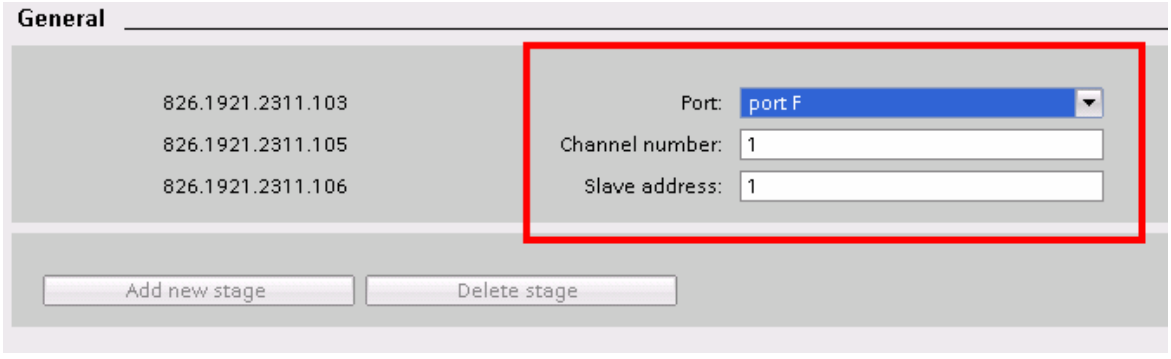
[sc_auser6, 1, en_US]

Figure 5-94 Analog-Unit Instance

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the RTD unit. 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 5-95 Setting the Port, Channel Number, and Slave Address

Finally, load the configuration in the device.

5.7.9.2 Integration of an RTD Unit Ether. (TR1200 IP)

Device Configuration

In the DIGSI, insert an Ethernet module into the provided slot, thus adding the module to the device configuration. *Figure 5-96* displays the available slots in the base module or on the expansion module CB202. Alternatively, you can also use the integrated Ethernet interface port J.

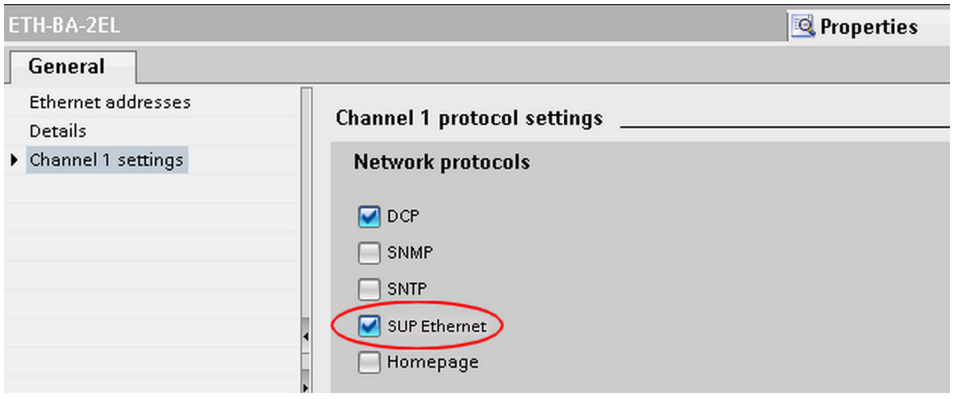


[sc_autcp1, 1, en_US]

Figure 5-96 Inserting an Ethernet Module

Communication Settings

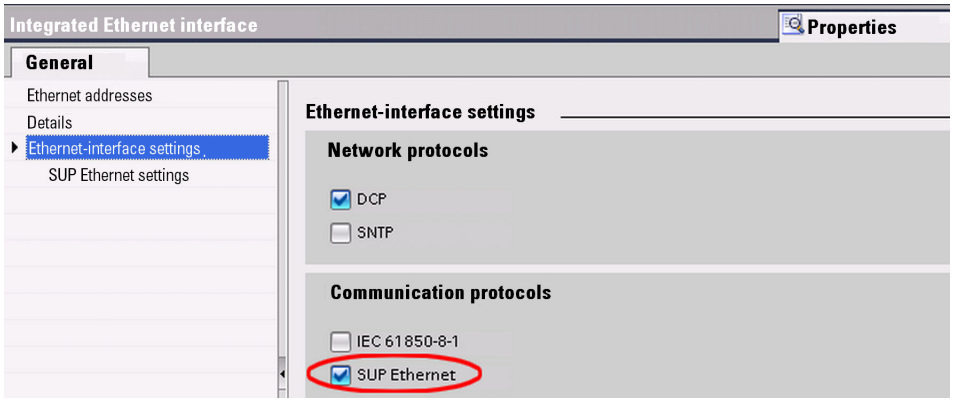
Activate the SUP Ethernet protocol for the Ethernet module.



[sc_autcp2, 1, en_US]

Figure 5-97 SUP Ethernet Protocol Activation

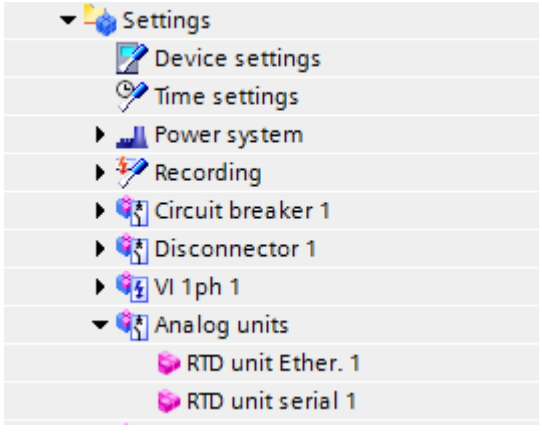
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[sc_autcp3, 1, en_US]

Figure 5-98 SUP Ethernet Protocol Activation (Base Module)

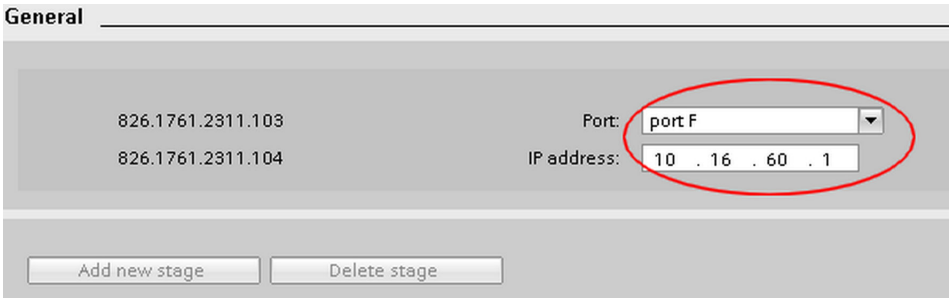
With the selection of the SUP protocol for the RTD unit, DIGSI automatically adds the **Analog units** function group and the **RTD unit Ether.** function to your device configuration (refer to the following figure).



[sc_auser6, 1, en_US]

Figure 5-99 Analog Unit Instance

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the RTD unit (refer to the following figure). This address must be set with the same value in the RTD unit.



[sc_autcp5, 1, en_US]

Figure 5-100 Setting the Port and IP Address

Finally, load the configuration in the device.

5.7.9.3 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.

5.7.10 Temperature Acquisition via Protocols

5.7.10.1 Overview

The function **Temperature acquisition via protocols**:

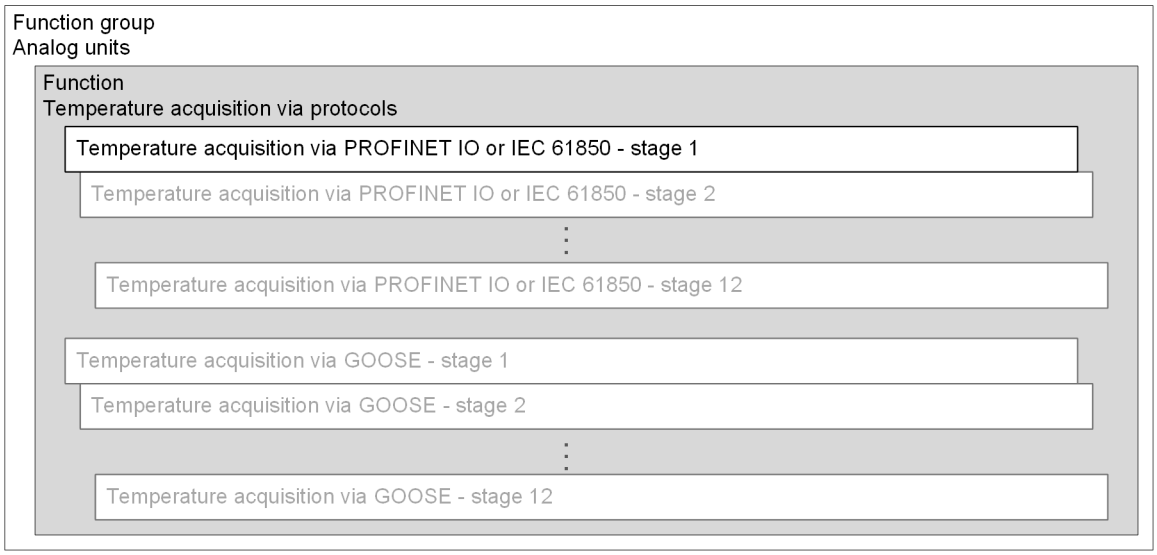
- Obtains the temperature from a power-plant control system or from another protection device
- Processes the temperature, for example, supervises the temperature in the CFC
- Transfers the temperature to other protection devices

5.7.10.2 Structure of the Function

The function **Temperature acquisition via protocols** can work only in the function group **Analog units**. In this function, the following stages can operate simultaneously:

- 12 stages **Temperature acquisition via PROFINET IO or IEC 61850**
  The stage can obtain the temperature from a power-plant control system via the PROFINET IO protocol or the IEC 61850 protocol.
- 12 stages **Temperature acquisition via GOOSE**
  The stage can obtain the temperature from another SIPROTEC 5 protection device via the GOOSE protocol.

The function **Temperature acquisition via protocols** comes factory-set with 1 stage **Temperature acquisition via PROFINET IO or IEC 61850**.

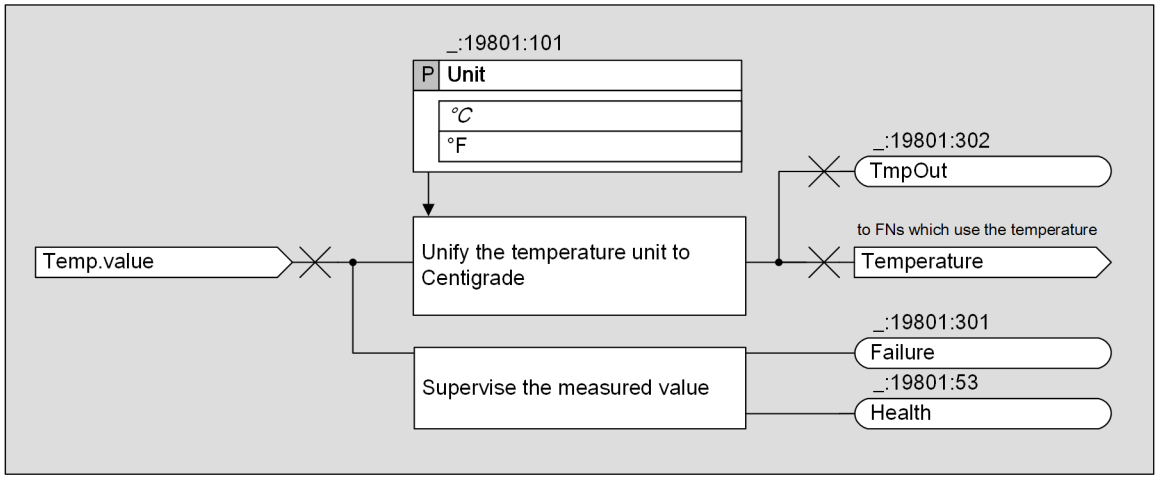


[dw_structure_TmpviaProt, 1, en_US]

Figure 5-101 Structure/Embedding of the Function

5.7.10.3 Stage Temperature Acquisition via PROFINET IO or IEC 61850

Logic



[lo_tmpval, 1, en_US]

Figure 5-102 Logic Diagram of the Stage

The stage **Temperature acquisition via PROFINET IO or IEC 61850** supports 2 protocols:

- PROFINET IO protocol
  If you set the PROFINET IO protocol for the temperature acquisition, you can only get the analog value.
- IEC 61850 protocol
  If you set the IEC 61850 protocol for the temperature acquisition, you get the analog value, the quality, and the time stamp.

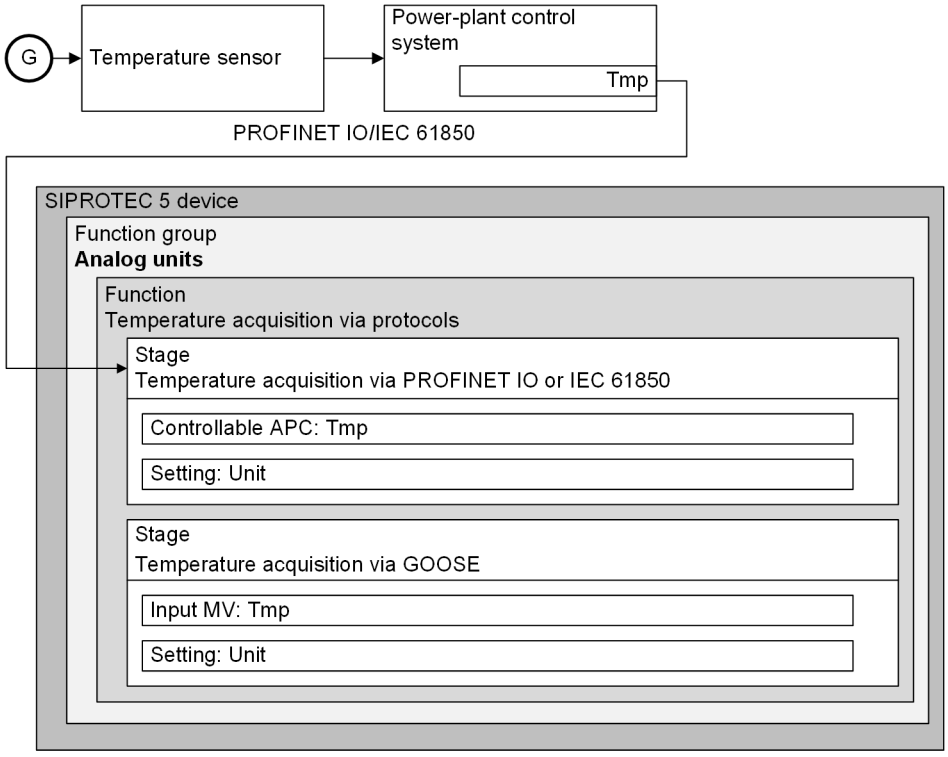
Invalid Temperature Indication

If the received temperature is invalid, the failure indication *Temperature failure* is issued.

Stage Application

You can use the stage **Temperature acquisition via PROFINET IO or IEC 61850** for the following purposes:

- Acquire the cold-gas temperature from the power-plant control system
- Process the received cold-gas temperature value
- Send the processed cold-gas temperature value to other functions for further processing



[dw_app-example_IEC, 1, en_US]

Figure 5-103 Application Example

The following table explains the data.

Data Name	Description
Tmp	With this variable, you can set the PROFINET IO protocol or the IEC 61850 protocol for the temperature acquisition. In the stage **Temperature acquisition via PROFINET IO or IEC 61850**, the data type is APC.
Unit	With this parameter, you can select the unit ***°F*** or ***°C*** for the temperature which is acquired from the power-plant control system.

5.7.10.4 PROFINET IO Configuration for the Temperature Acquisition

With the stage **Temperature acquisition via PROFINET IO or IEC 61850**, to acquire the cold-gas temperature via the PROFINET IO protocol, the following configurations are necessary.

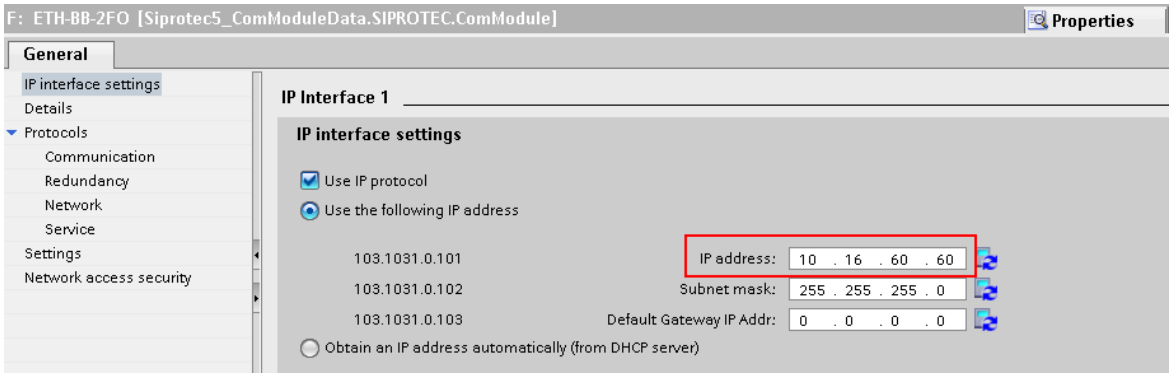
IP-Address Configuration and Protocol Selection

✧ In the project tree, navigate to your device and double-click **Hardware and protocols**.

✧ In the **Device view** tab, select an Ethernet communication module for which you want to configure the PROFINET IO protocol.

✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.

✧ Set the **IP address** for the communication module.

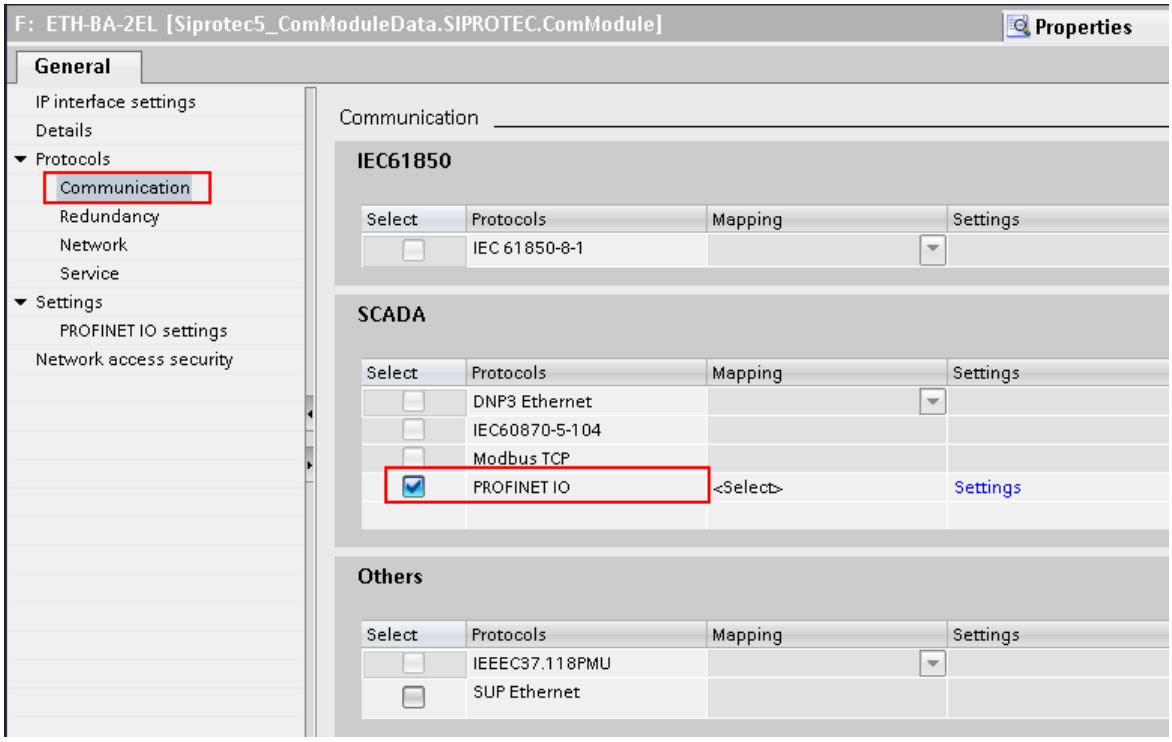


[sc_PROFINET IP, 2, en_US]

Figure 5-104 IP-Address Configuration

✧ Select **General** > **Protocols** > **Communication**.

✧ Under **SCADA**, select the item ***PROFINET IO***.



[sc_PROFINET_IO, 2, en_US]

Figure 5-105 Protocol Selection

Function Instantiation

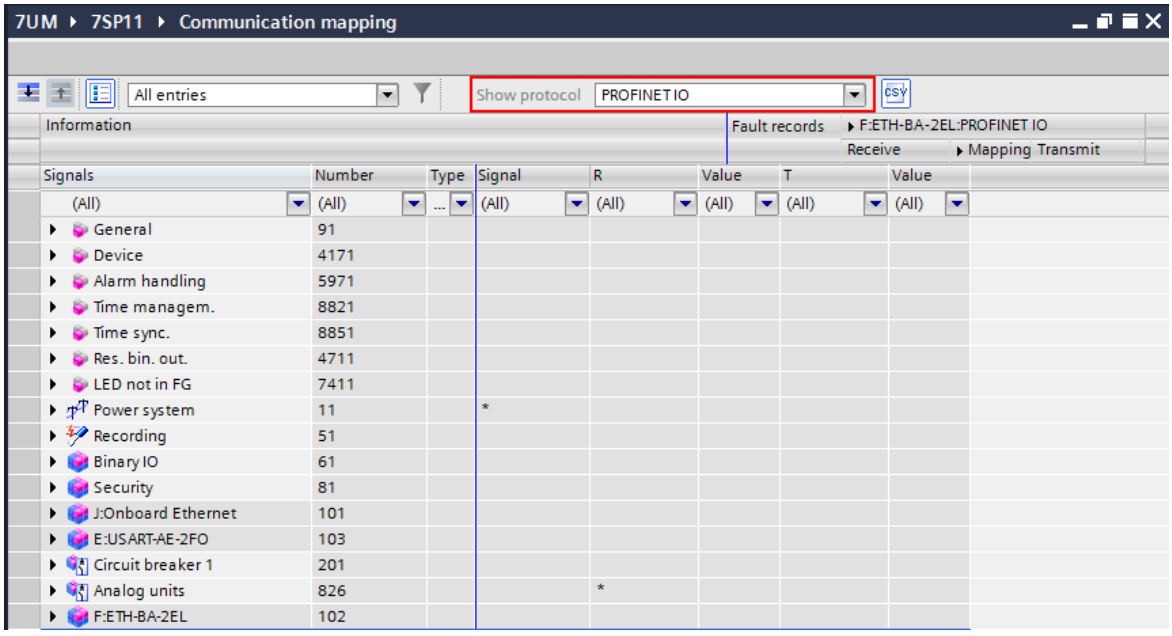
✧ In the project tree, navigate to your device and select **Settings** > **Analog units**.
If there is no function group **Analog units**, instantiate one.

✧ Instantiate the function **Tmp.Acq.viaCom** in the function group **Analog units**.

Signal Mapping and Configuration

✧ In the project tree, navigate to your device and double-click **Communication mapping**.

✧ In the **Communication mapping** matrix, set **Show protocol** to ***PROFINET IO***.

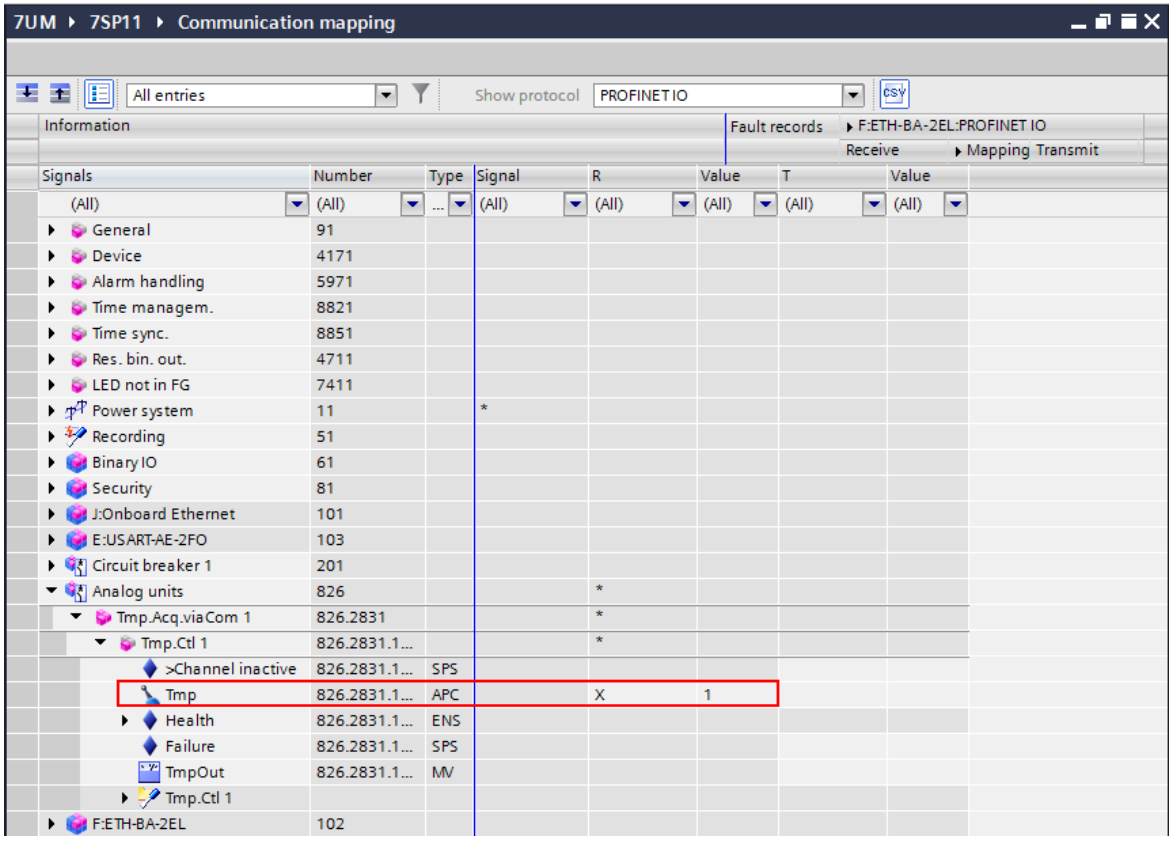


[sc_PROFI_Filter, 2, en_US]

Figure 5-106 Protocol Filter

✧ In the column **Signals**, select **Analog units** > **Tmp.Acq.viaCom 1** > **Tmp.Ctl 1**.

✧ Route the data *Tmp* in column **R** and set the value to ***1***.



[sc_PROFI_Setting, 1, en_US]

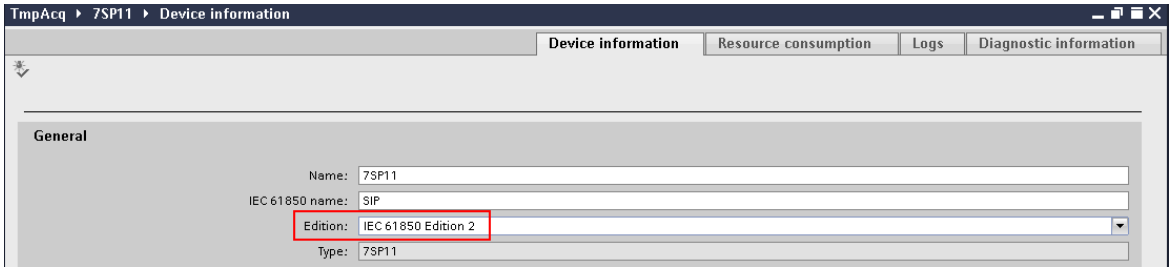
Figure 5-107 Signal Configuration

5.7.10.5 IEC 61850 Configuration for the Temperature Acquisition

With the stage **Temperature acquisition via PROFINET IO or IEC 61850**, to acquire the cold-gas temperature via the IEC 61850 protocol, the following configurations are necessary.

IEC 61850 Edition Selection

- ✧ In the project tree, navigate to your device and double-click **Device information**.
- ✧ In the **Device information** tab, set the parameter **Edition** to ***IEC 61850 Edition 2*** or a higher edition.

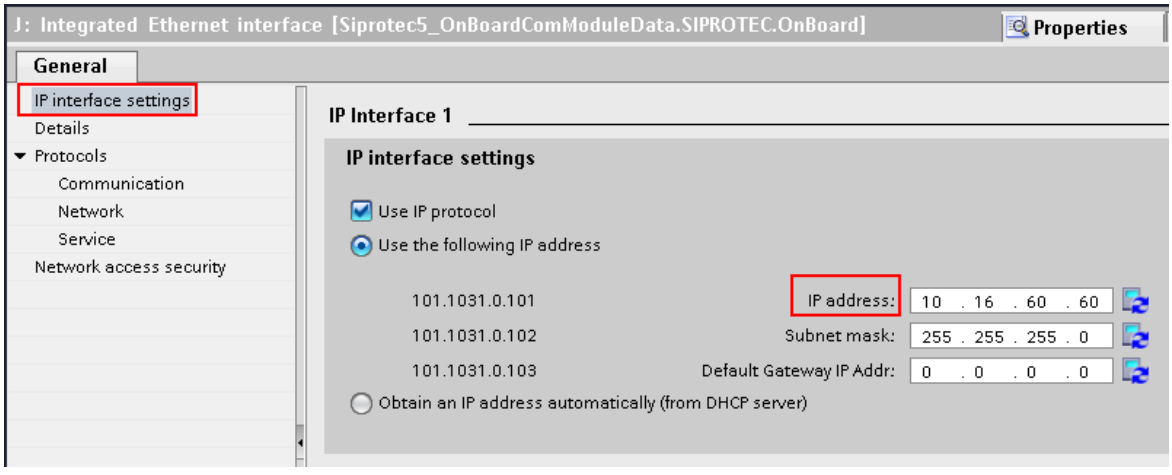


[sc_iec_edition, 1, en_US]

Figure 5-108 IEC 61850 Edition

IP-Address Configuration and Protocol Selection

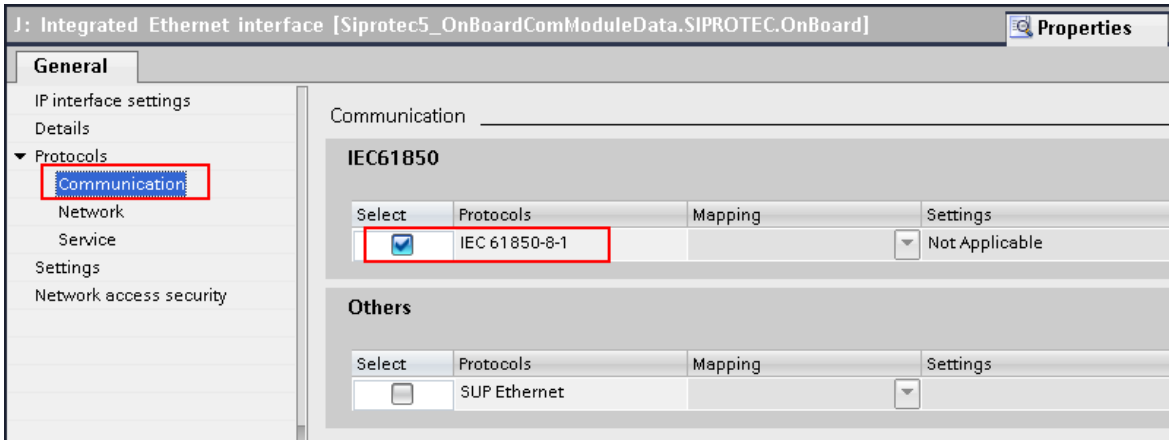
- ✧ In the project tree, navigate to your device and double-click **Hardware and protocols**.
- ✧ In the **Device view** tab, select the communication module for which you want to configure the IEC 61850 protocol.
- ✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.
- ✧ Set the **IP address** for the communication module.



[sc_iec_61850_ip, 2, en_US]

Figure 5-109 IP-Address Configuration

- ✧ Select **General** > **Protocols** > **Communication**.
- ✧ Under **IEC61850**, select the item ***IEC 61850-8-1***.

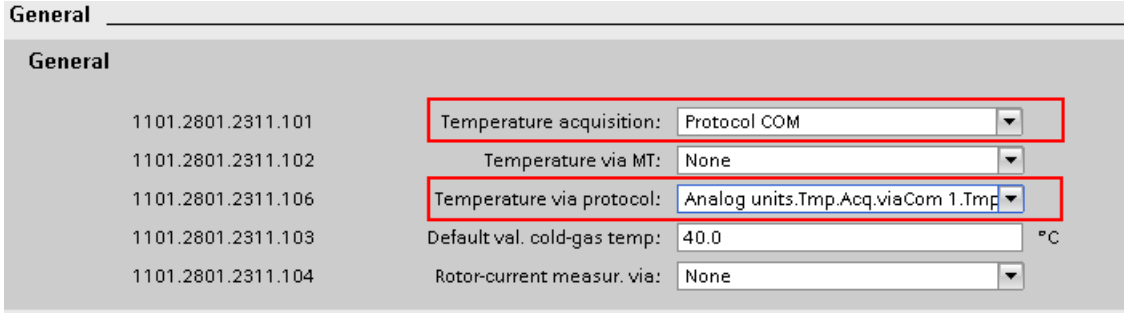


[sc_iec_61850_sel, 2, en_US]

Figure 5-110 Protocol Selection

Function Instantiation

- ✧ In the project tree, navigate to your device and select **Settings** > **Analog units**.
  If there is no function group **Analog units**, instantiate one.
- ✧ Instantiate the function **Tmp.Acq.viaCom** in the function group **Analog units**.
- ✧ Instantiate the function that requires the cold-gas temperature in the corresponding function group.
  The function **49R RotorTOLP** is taken as an example in the following steps.
- ✧ Under **General** of the function **49R RotorTOLP**, set the parameter **`Temperature acquisition`** to ***`Protocol COM`***.
- ✧ Set the parameter **`Temperature via protocol`** to ***`Analog units.Tmp.Acq.viaCom 1.Tmp.Ctl 1`***.

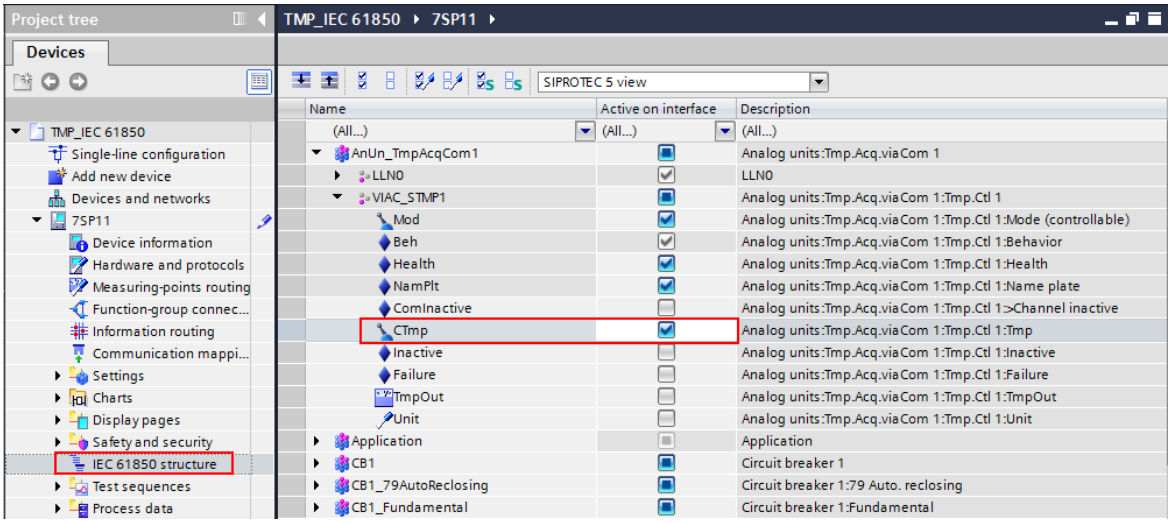


[sc_iec_61850_3, 2, en_US]

Figure 5-111 Parameter Configuration

Configuration in the IEC 61850 structure

- ✧ In the project tree, navigate to your device and double-click **IEC 61850 structure**.
- ✧ In the column **Name**, select **AnUn_TmpAcqCom 1** > **VIAC_STMP1** > **CTmp**.

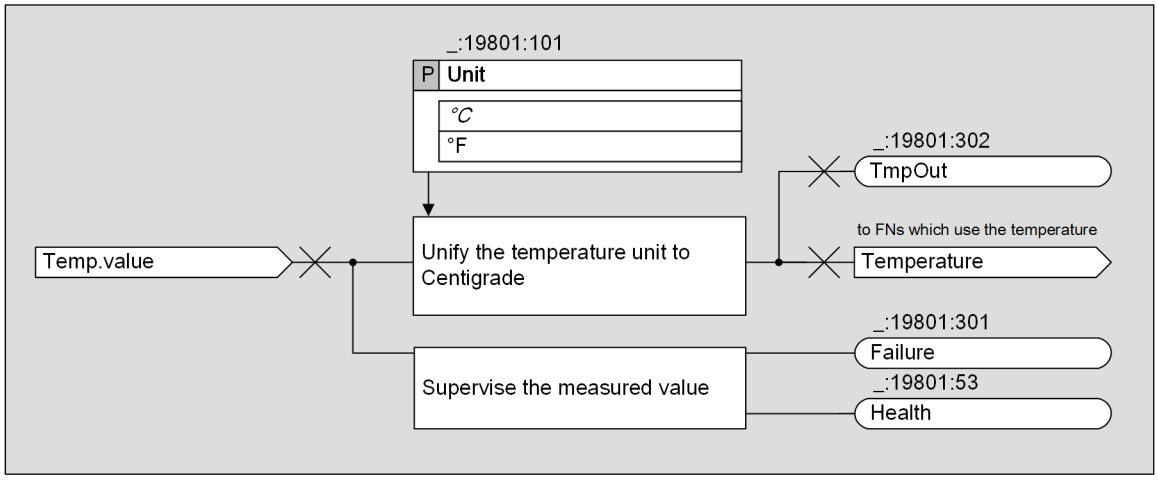


[sc_iec_61850_cgt, 1, en_US]

Figure 5-112 Data Selection

5.7.10.6 Stage Temperature Acquisition via GOOSE

Logic



[lo_tmpval, 1, en_US]

Figure 5-113 Logic Diagram of the Stage

Invalid Temperature Indication

If the received temperature is invalid, the failure indication *Temperature failure* is issued.

Stage Application

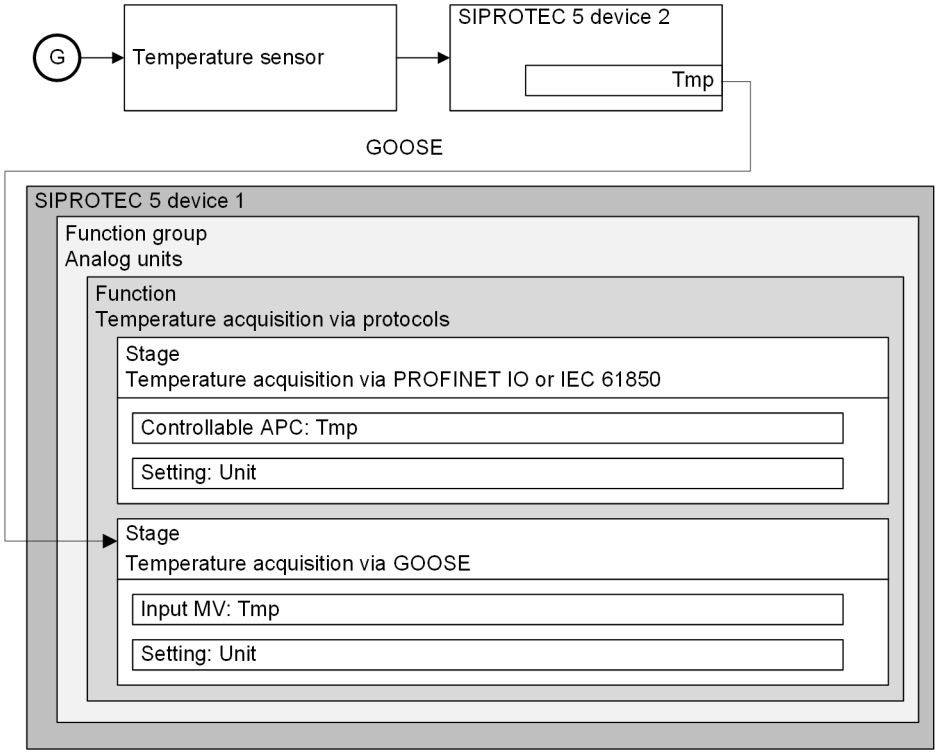
The following terms are used for the stage **Temperature acquisition via GOOSE**:

- Source device
  SIPROTEC 5 protection device that provides data
- Target device
  SIPROTEC 5 protection device that requests data from the source device

In the target device, you can use the stage **Temperature acquisition via GOOSE** for the following purposes:

- Acquire the cold-gas temperature from the source device
- Process the received cold-gas temperature value
- Send the processed cold-gas temperature value to other functions for further processing

In the following figure, the source device is SIPROTEC 5 device 2 and the target device is SIPROTEC 5 device 1.



[dw_app-example_GOOSE, 2, en_US]

Figure 5-114 Application Example

The following table explains the data.

Data Name	Description
Tmp	With this variable, you can set the GOOSE protocol for the temperature acquisition. In the stage **Temperature acquisition via GOOSE**, the input measured value with a COM template is designed to acquire the data from another SIPROTEC 5 protection device.
Unit	With this parameter, you can select the unit ***°F*** or ***°C*** for the temperature which is acquired from another SIPROTEC 5 protection device.

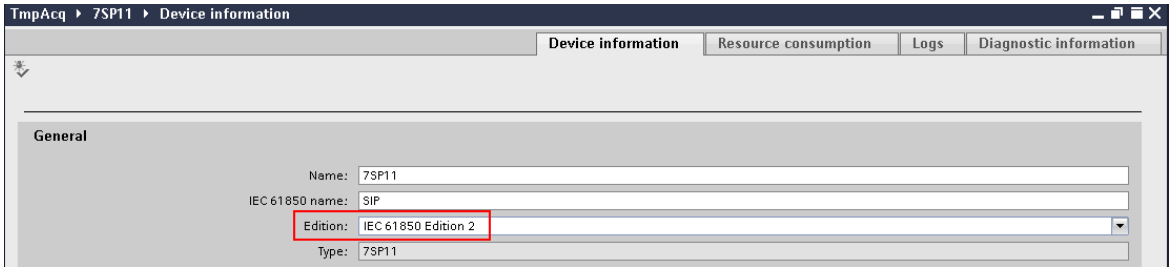
5.7.10.7 GOOSE Configuration for the Temperature Acquisition

To acquire the cold-gas temperature with the stage **Temperature acquisition via GOOSE**, the following configurations are necessary.

IEC 61850 Edition Selection – Source Device

✧ In the project tree, select the source device and double-click **Device information**.

✧ In the **Device information** tab, set the parameter **Edition** to ***IEC 61850 Edition 2*** or a higher edition.

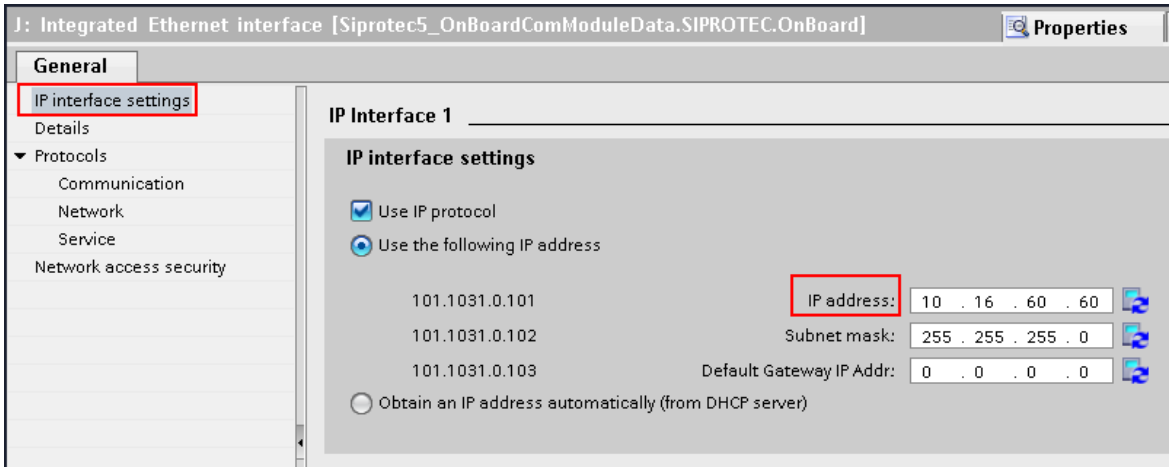


[sc_iec_edition, 1, en_US]

Figure 5-115 IEC 61850 Edition

IP-Address Configuration and Protocol Selection – Source Device

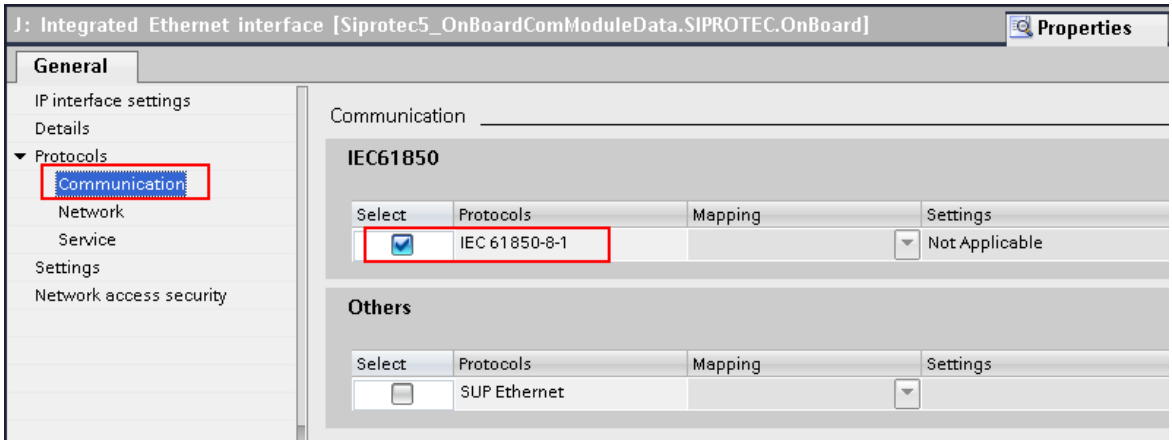
- ✧ In the project tree, select the source device and double-click **Hardware and protocols**.
- ✧ In the **Device view** tab, select the communication module for which you want to configure the IEC 61850 protocol.
- ✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.
- ✧ Set the **IP address** for the communication module.



[sc_iec_61850_ip, 2, en_US]

Figure 5-116 IP-Address Configuration

- ✧ Select **General** > **Protocols** > **Communication**.
- ✧ Under **IEC61850**, select the item ***IEC 61850-8-1***.

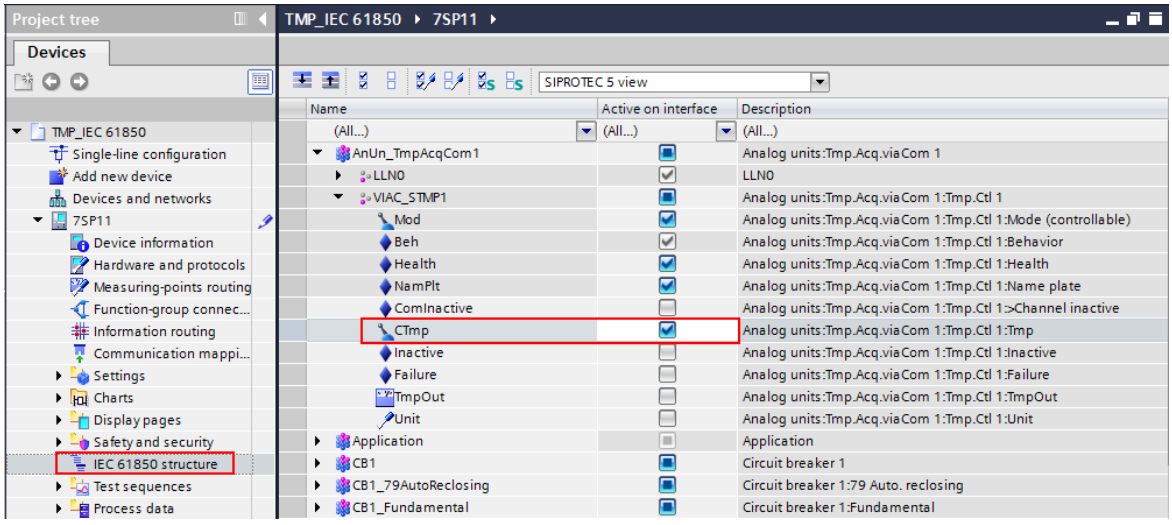


[sc_iec_61850_sel, 2, en_US]

Figure 5-117 Protocol Selection

Configuration in IEC 61850 structure – Source Device

- ✧ In the project tree, select the source device and double-click **IEC 61850 structure**.
- ✧ In the column **Name**, select **AnUn_TmpAcqCom 1** > **VIAC_STMP1** > **CTmp**.



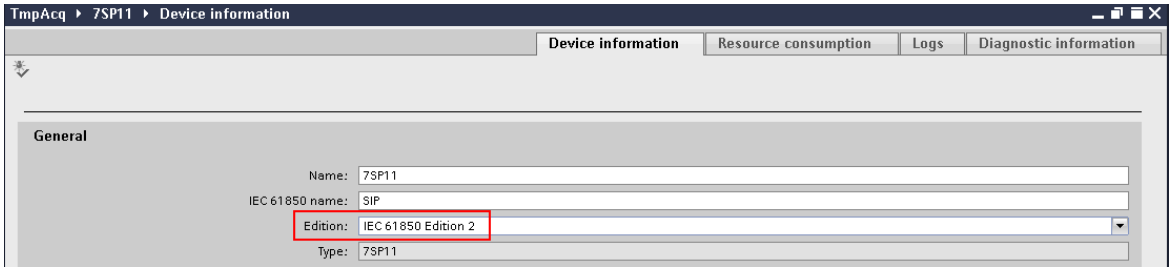
[sc_iec_61850_cgt, 1, en_US]

Figure 5-118 Data Selection

Now, the device can be used to send the cold-gas temperature to other devices.

IEC 61850 Edition Selection – Target Device

- ✧ In the project tree, select the target device and double-click **Device information**.
- ✧ In the **Device information** tab, set the parameter **`Edition`** to ***`IEC 61850 Edition 2`*** or a higher edition.

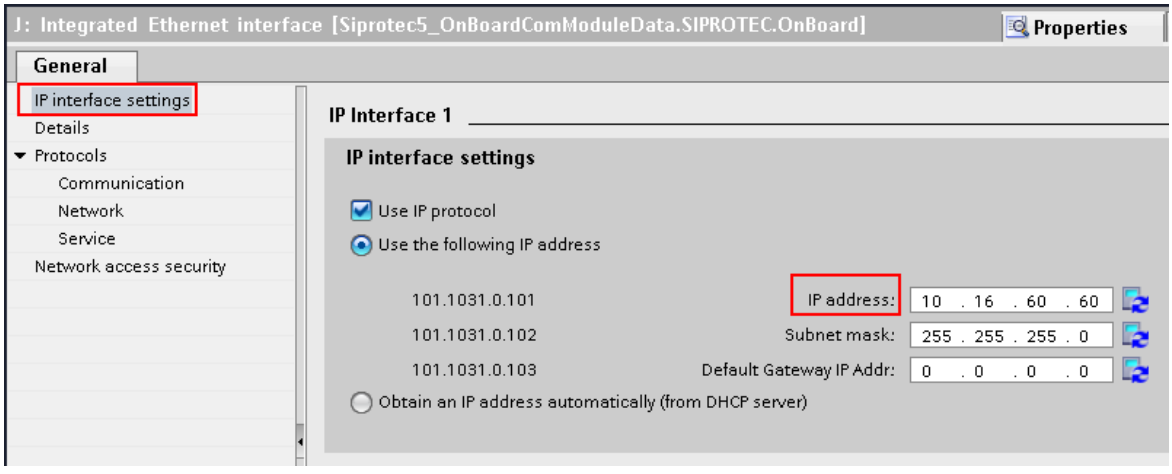


[sc_iec_edition, 1, en_US]

Figure 5-119 IEC 61850 Edition

IP-Address Configuration and Protocol Selection – Target Device

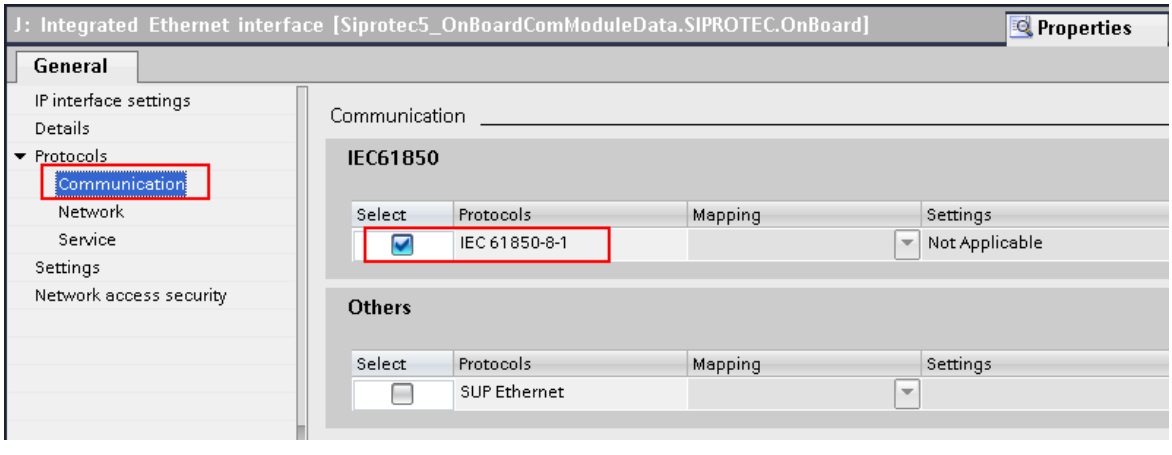
- ✧ In the project tree, select the target device and double-click **Hardware and protocols**.
- ✧ In the **Device view** tab, select the communication module for which you want to configure GOOSE.
- ✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.
- ✧ Set the **IP address** for the communication module.



[sc_iec_61850_ip, 2, en_US]

Figure 5-120 IP-Address Configuration

- ✧ Select **Protocols** > **Communication** > **IEC 61850-8-1**.



[sc_iec_61850_sel, 2, en_US]

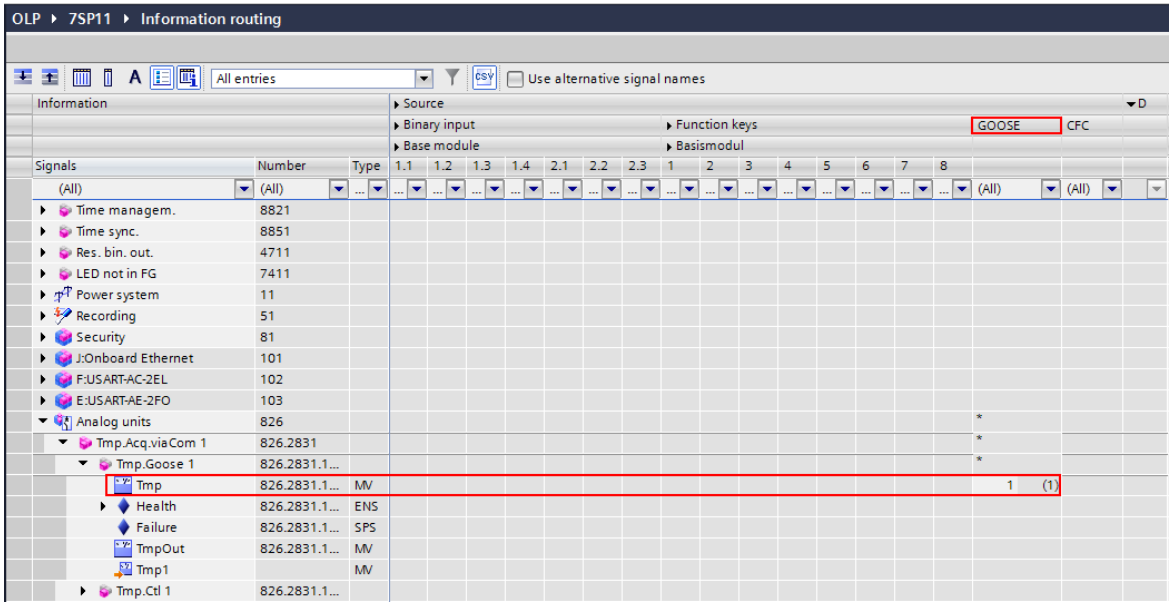
Figure 5-121 Protocol Selection

Function Instantiation – Target Device

- ✧ In the project tree, select the target device and select **Settings** > **Analog units**.
  If there is no function group **Analog units**, instantiate one.
- ✧ Instantiate the function **Tmp.Acq.viaCom** in the function group **Analog units**.
- ✧ Instantiate the stage **Tmp.GOOSE** in the function **Tmp.Acq.viaCom**.

Configuration in Information Routing – Target Device

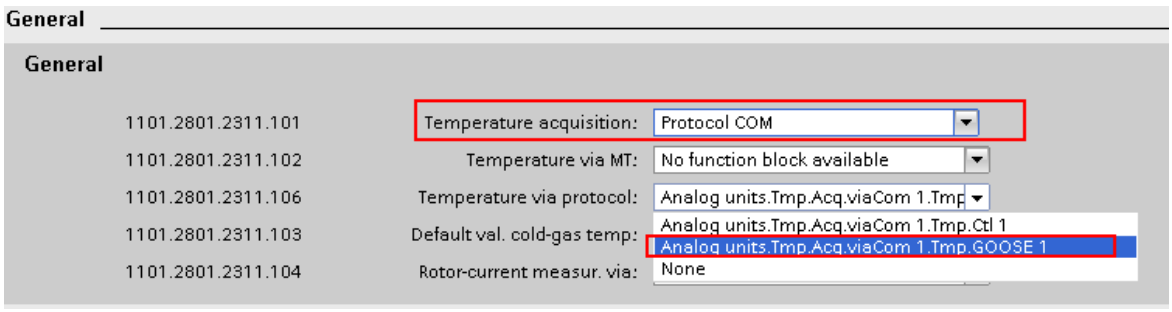
- ✧ In the project tree, select the target device and double-click **Information routing**.
- ✧ In the column **Signals**, select **Analog units** > **Tmp.Acq.viaCom 1** > **Tmp.Goose 1**.
- ✧ Set the value to ***1*** in the column **GOOSE** for the data **Tmp**.



[sc_station_10, 1, en_US]

Configuration of the Protection Function – Target Device

- ✧ Instantiate the function that requires the cold-gas temperature in the corresponding function group.
  The function **49R RotorTOLP** is taken as an example in the following steps.
- ✧ Under **General** of the function **49R RotorTOLP**, set the parameters **`Temperature acquisition`** to ***`Protocol COM`***.
- ✧ Set the parameter **`Temperature via protocol`** to ***`Analog units.Tmp.Acq.viaCom 1.Tmp.GOOSE 1`***.



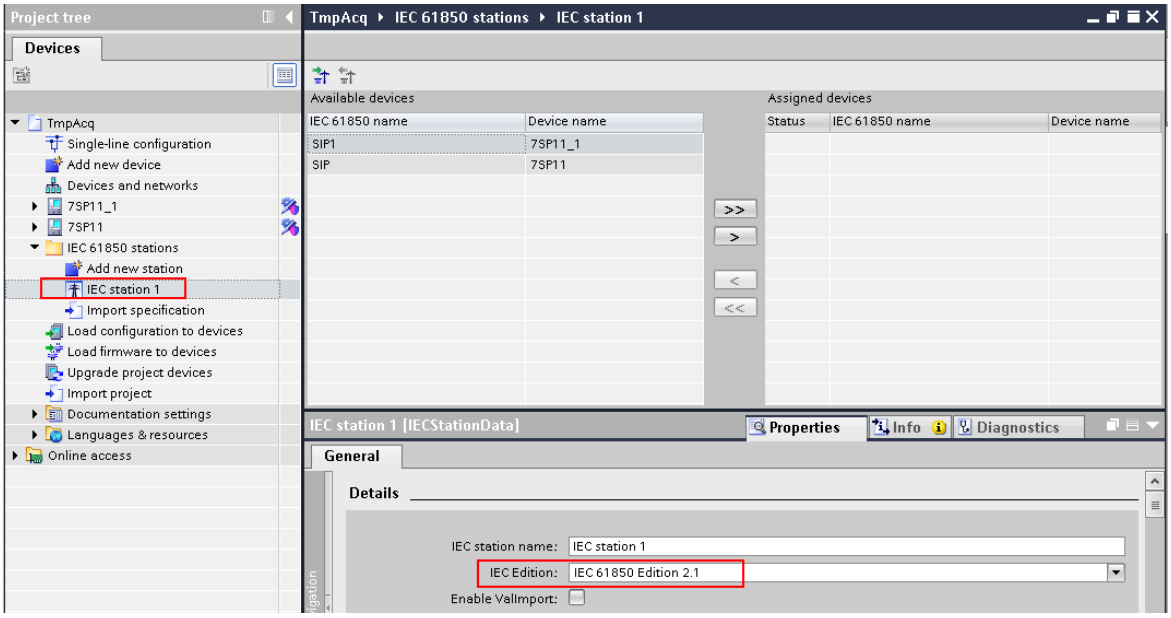
[sc_GOOSE_CGT, 2, en_US]

Figure 5-122 Parameter Configuration

Connection of the Source Device and the Target Device

✧ In the project tree, select **IEC 61850 stations** > **IEC station 1**.
If there is no station, double-click **Add new station** and create one.

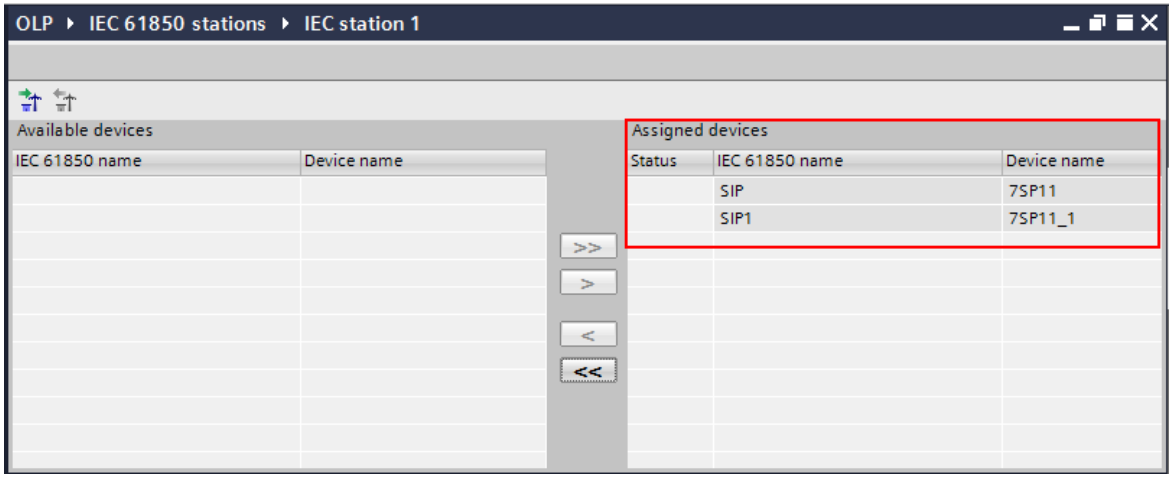
✧ Double-click **IEC station 1** and set the parameter **`IEC Edition`** to ***`IEC 61850 Edition 2`*** or a higher edition in the **Properties** tab.



[sc_iec_station, 2, en_US]

Figure 5-123 IEC 61850 Edition

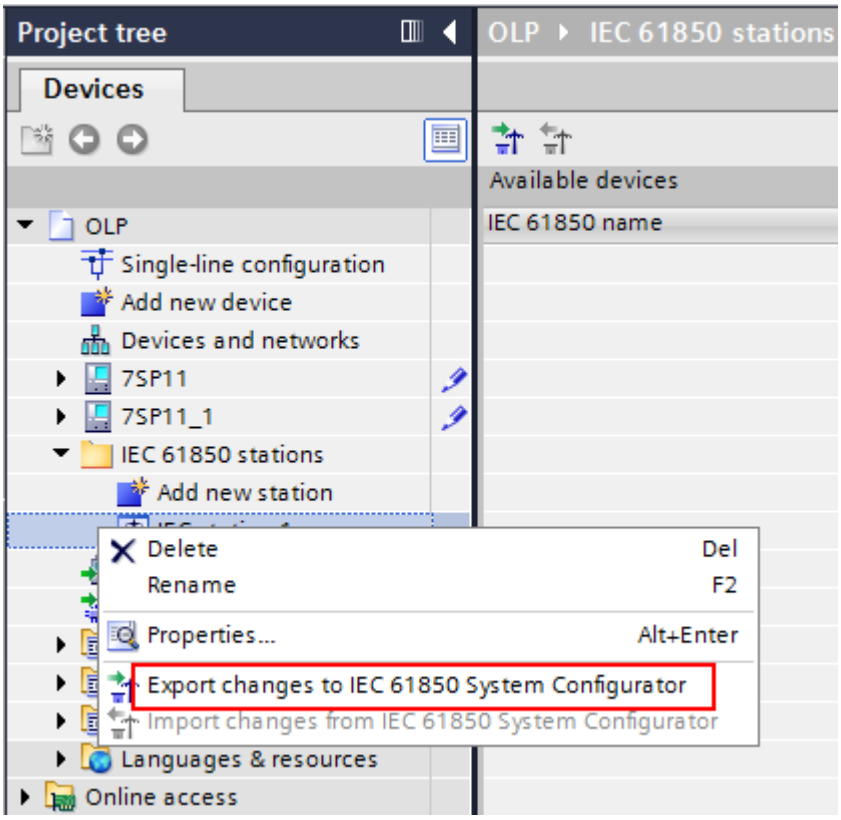
✧ Assign the available devices to the IEC station.



[sc_device_assign, 1, en_US]

Figure 5-124 Device Assignment

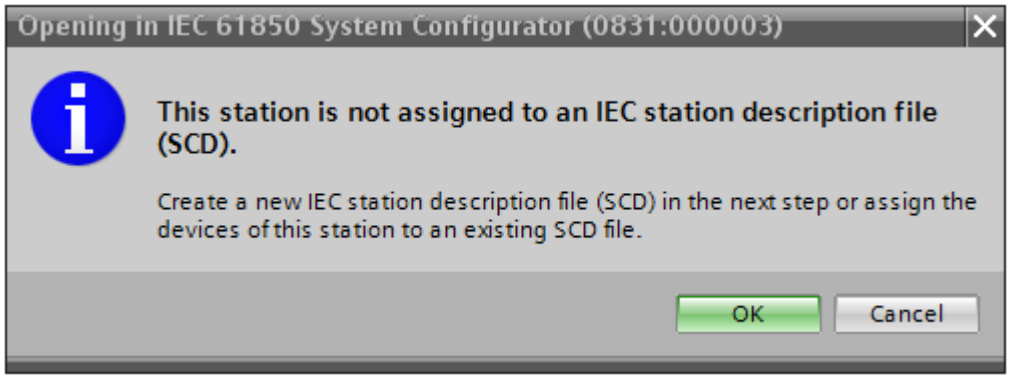
✧ Right-click the station and select **Export changes to IEC 61850 System Configurator** in the context menu.



[sc_export_IEC, 1, en_US]

Figure 5-125 Export Changes to IEC 61850 System Configurator

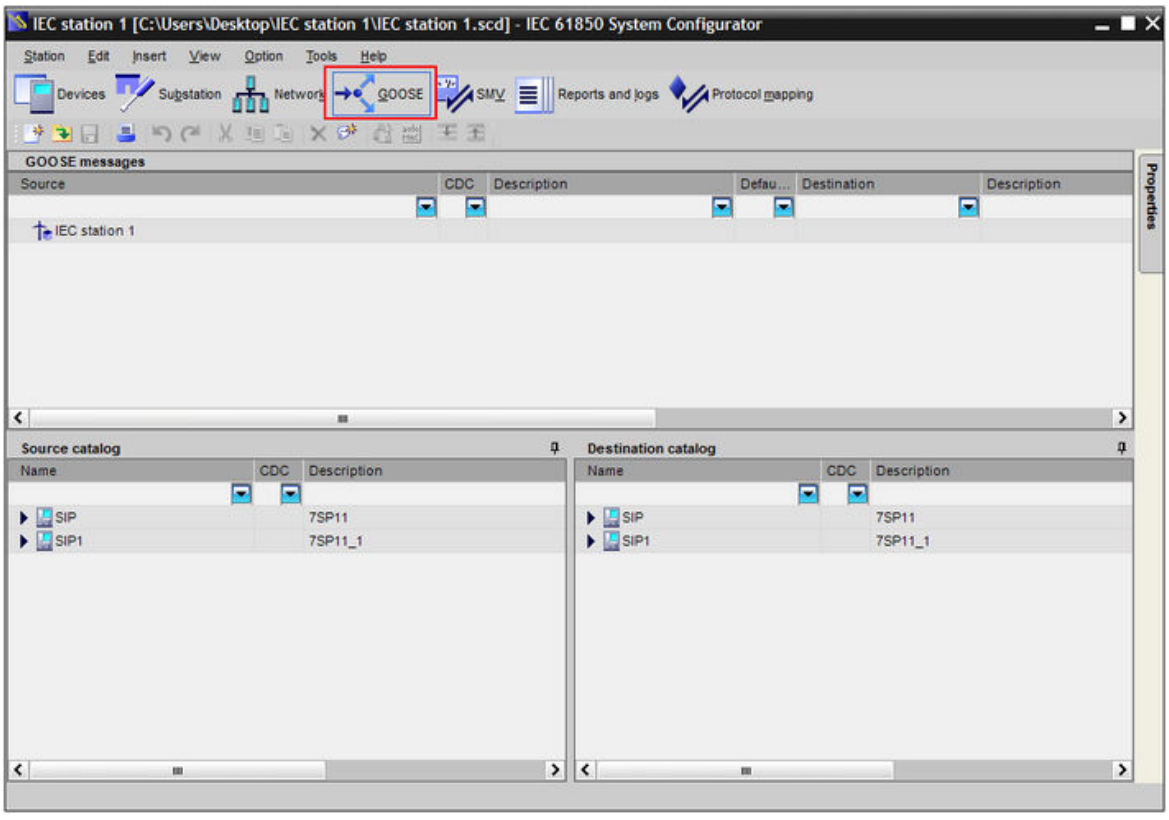
✧ If the following dialog appears, click **OK** and save the SCD file to a folder.



[sc_iec_confim, 1, en_US]

Figure 5-126 SCD File Creation

✧ In the opened **IEC 61850 System Configurator** window, select **GOOSE** in the toolbar.

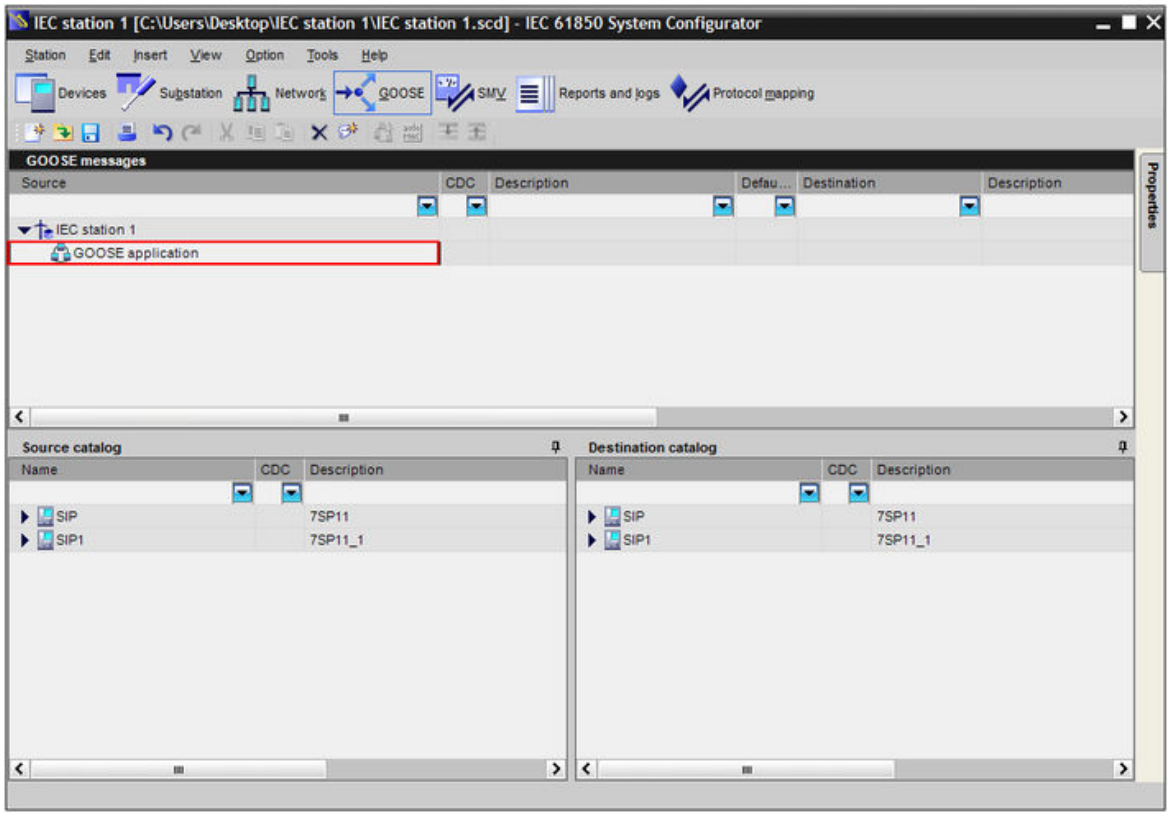


[sc_station_01, 2, en_US]

Figure 5-127 GOOSE-Function Selection

✧ In the **GOOSE messages** view, right-click the IEC station and select **GOOSE application** in the context menu.

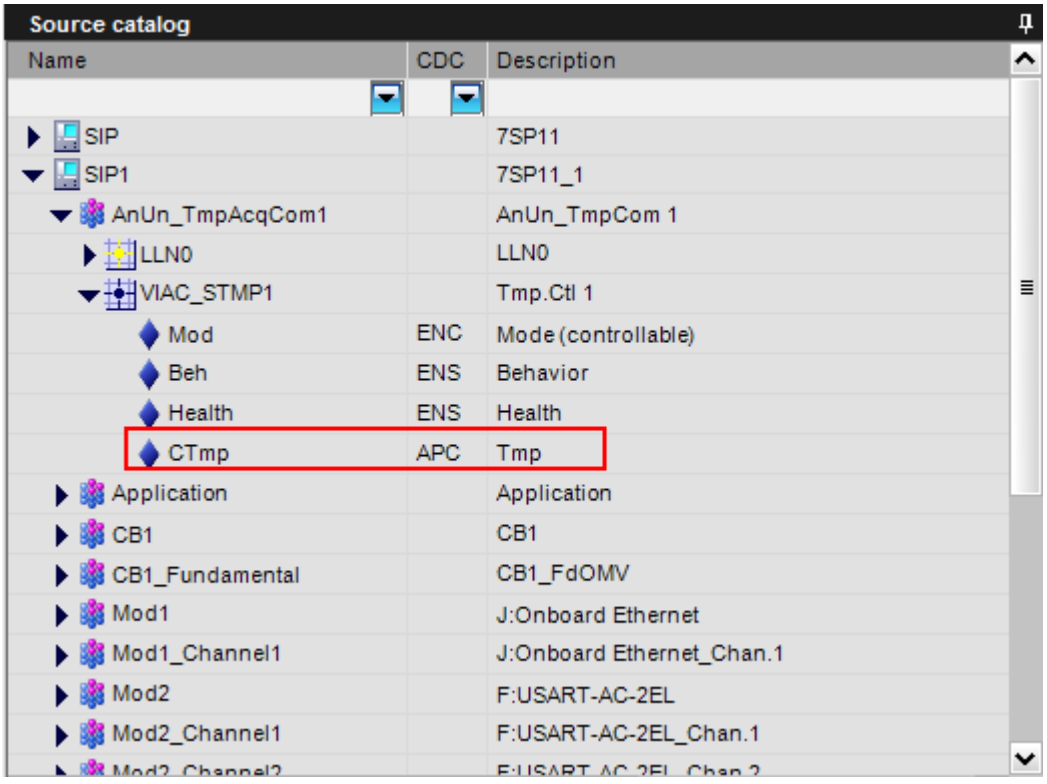
The **GOOSE application** is listed under the IEC station.



[sc_station_02, 2, en_US]

Figure 5-128 GOOSE Application Creation

✧ In the **Source catalog** area, navigate to the source device and select **AnUn_TmpAcqCom 1** > **VIAC_STMP1** > **CTmp**.

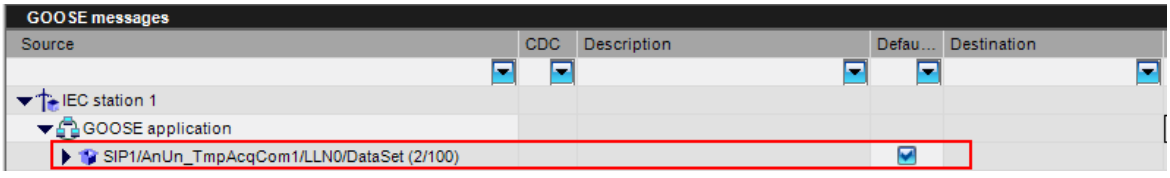


[sc_station_03, 1, en_US]

Figure 5-129 Source-Data Selection

✧ Drag the data **CTmp** and drop it to **GOOSE application** in the **GOOSE messages** view.

You can see the assigned source data.

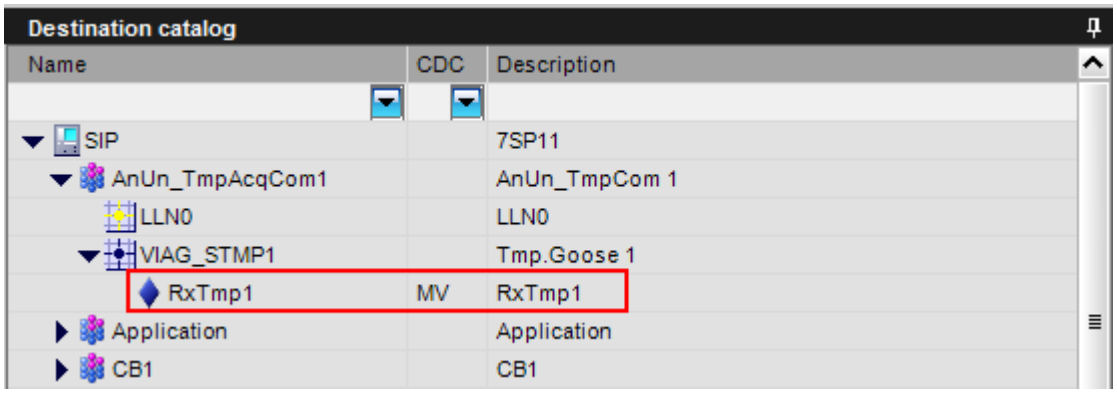


[sc_station_04, 1, en_US]

Figure 5-130 Source-Data Assignment

✧ Unfold the assigned source data.

✧ In the **Destination catalog** area, navigate to the target device and select **AnUn_TmpAcqCom1** > **RxTmp1**.

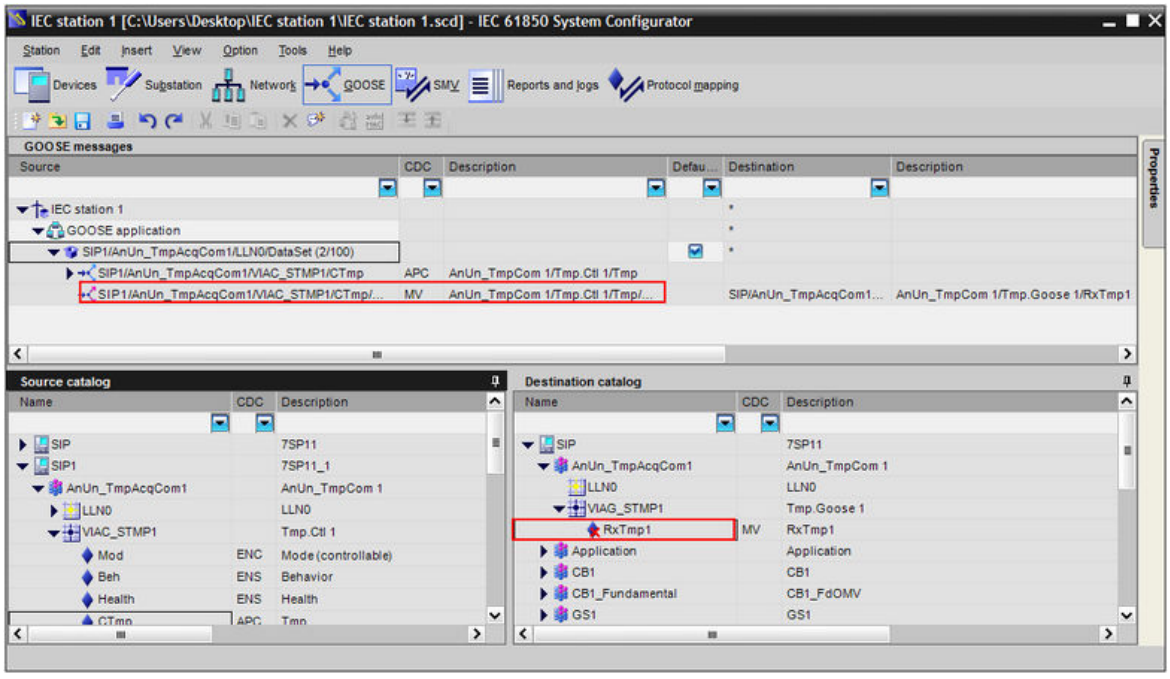


[sc_station_06, 1, en_US]

Figure 5-131 Target-Data Selection

✧ Drag the data **RxTmp1** and drop it to the assigned source data.

Now, the target data is connected with the source data.

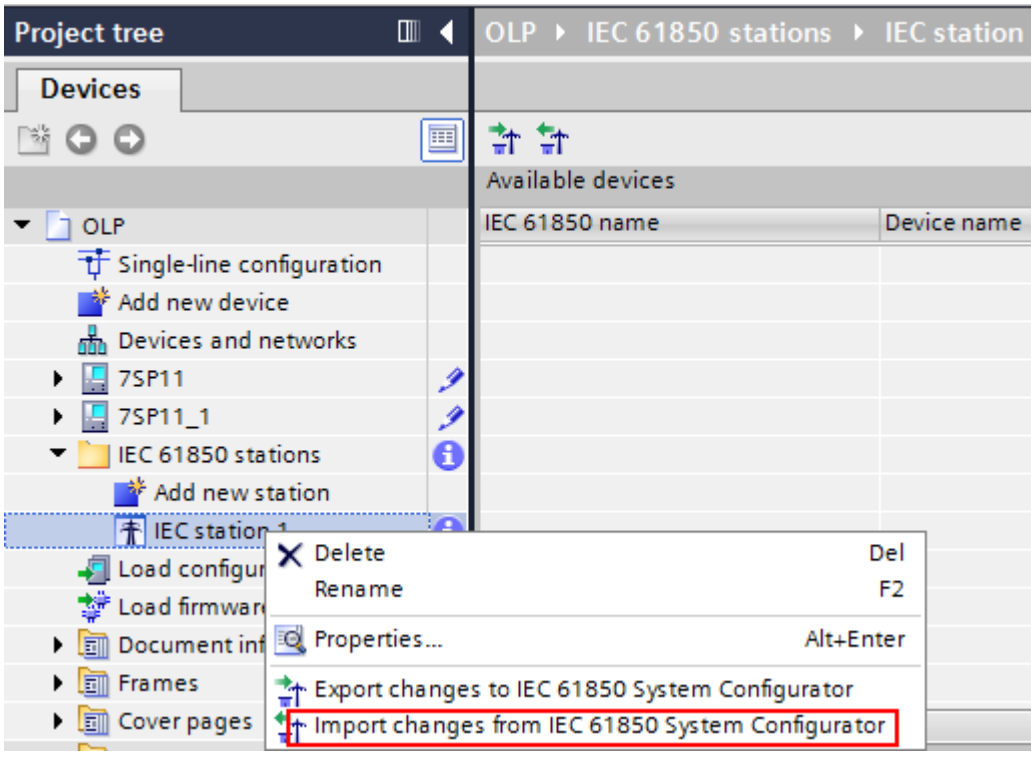


[sc_station_11, 2, en_US]

Figure 5-132 Destination-Data Assignment

✧ Save the configurations.

✧ In DIGSI 5 in the project tree, right-click the IEC station and select **Import changes from IEC 61850 System Configurator** in the context menu.



[sc_station_08, 1, en_US]

Figure 5-133 Import Changes from IEC 61850 System Configurator

If the following dialog appears, the source device and the target device are successfully connected.



[sc_End, 1, en_US]

Figure 5-134 Successful Device Connection

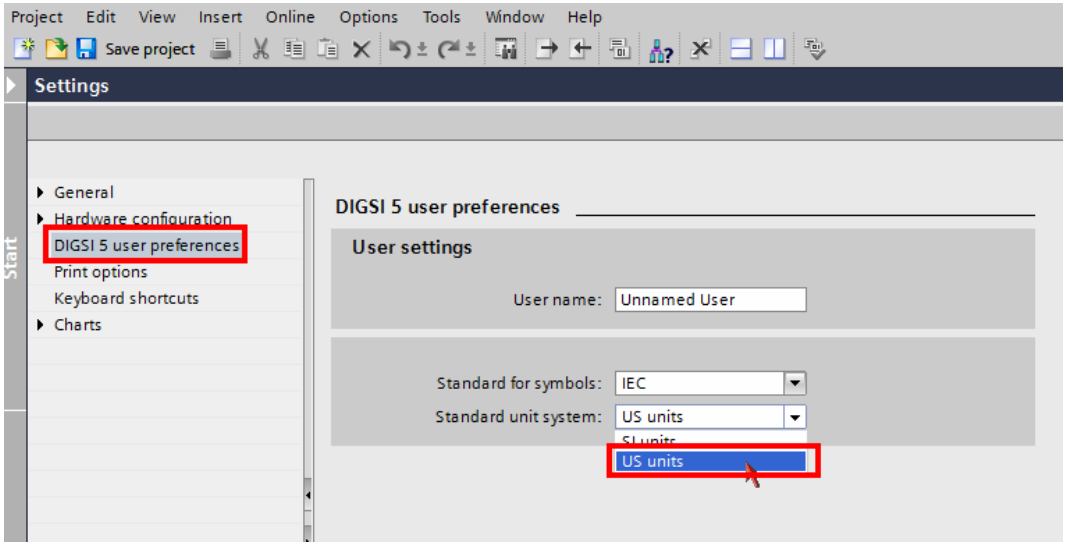
✧ Click **OK** to finish the connection.

5.7.10.8 Application and Setting Notes

Change of the Temperature Unit

Commonly, the temperature unit °C is used in the display and evaluation of measured temperature values.

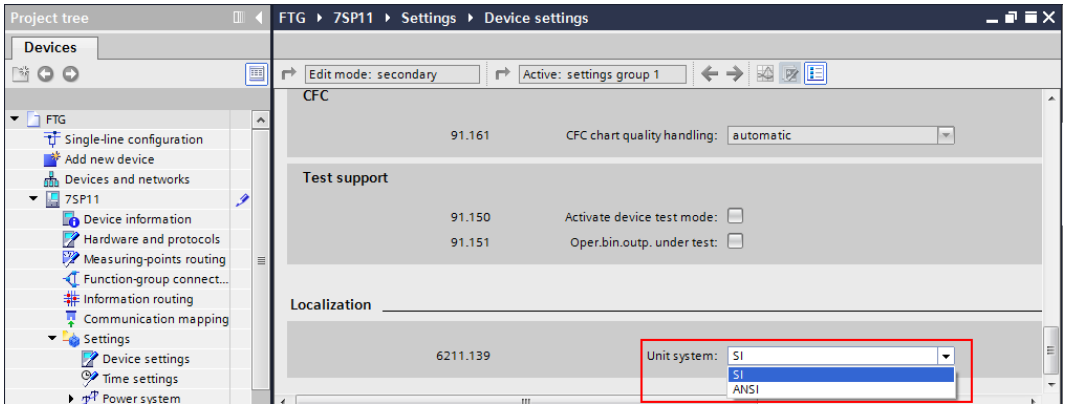
- To change the temperature unit from °C to °F for all devices in the current DIGSI project, proceed as follows:
  - In DIGSI, select the menu item **Options** > **Settings**.
  - In the **Settings** view, select the menu item **DIGSI 5 user preferences**.
  - Set the parameter **`Standard unit system`** to ***`US units`***.



[scfahrht-190214-01, 1, en_US]

Figure 5-135 Change of the Temperature Unit between °C and °F for all Devices

- To change the temperature unit from °C to °F for 1 device, proceed as follows:
  - In the project tree, navigate to your device and select **Settings** > **Device settings**.
  - In the **Device settings** view, navigate to the menu item **Localization**.
  - Set the parameter **`Unit system`** to ***`ANSI`***.



[sc_SITmp, 1, en_US]

Figure 5-136 Change of the Temperature Unit between °C and °F for 1 Device

NOTE

If the parameter **Unit system** is set to ***ANSI***, only the unit of the measuring values and parameters changes to °F.

The unit of the following data is still °C:

- Other temperature data in the device
- The temperature thresholds in DCF

Parameter: Unit

- Default setting **(_:19801:101) Unit** = ***°C***

You use the setting **Unit** to specify which physical unit of the source data the measured values represent. The possible setting values are listed in the settings table.

5.7.10.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Tmp.Ctl 1				
_:19801:101	Tmp.Ctl 1:Unit		• °C • °F	°C

5.7.10.10 Information List

No.	Information	Data Class (Type)	Type
Tmp.Ctl 1			
_:19801:300	Tmp.Ctl 1:Tmp	APC	C
_:19801:53	Tmp.Ctl 1:Health	ENS	O
_:19801:301	Tmp.Ctl 1:Failure	SPS	O
_:19801:302	Tmp.Ctl 1:TmpOut	MV	O

5.7.11 LPIT Module IO240

5.7.11.1 Overview

The input module IO240 for the low-power instrument transformer in the gas insulated switchgear (GIS-LPIT) and for the resistive-capacitive voltage transformer (RCVT) from Siemens Energy (**LPIT module IO240**):

- Measures temperature values, voltage values, and current values
- Provides an interface for SIPROTEC 5 modular devices to connect to Siemens Energy GIS-LPIT (GIS-LPVT and GIS-LPCT) and RCVT
- Converts current values into primary values
- Converts voltage values into primary values according to the sensor type (GIS-LPVT or RCVT)
- Provides primary values for protection functions, the voltage measurement, and the current measurement

The input module IO240 is available in a hardware variant of the 6MU85 device as part of the 1/3 base module or as an expansion module for installation in modular SIPROTEC 5 devices.

NOTE

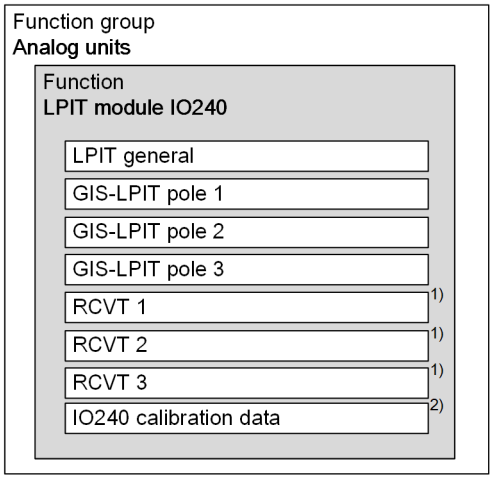
Due to the higher power demand of the IO240 boards, a maximum of 2 IO240 modules are allowed per device row and totally a maximum of 4 IO240 modules are allowed in a SIPROTEC 5 device. This limitation also applies to the case that 1 of the IO240 modules is used in the 1/3 basic housing.

For more information on the use and configuration of the IO240 module combined with the connected LPIT, refer to the *Application Note APN-090 IO240 and LPITs*.

5.7.11.2 Structure of the Function

The function **LPIT module IO240** works in the function group **Analog units**.
The function **LPIT module IO240** contains the following function blocks:

- 3 for **GIS-LPIT pole**
- 3 for **RCVT**
- 1 for **IO240 calibration data**

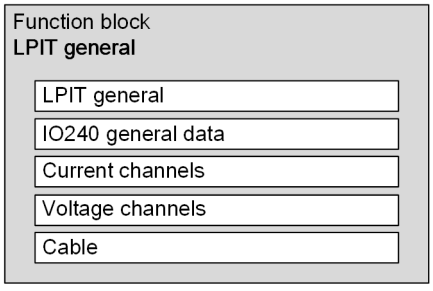


[dw_strIO240, 4, en_US]

Figure 5-137 Structure of the Function LPIT module IO240

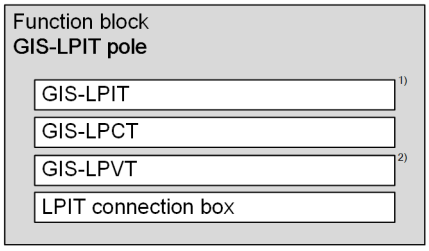
(1) It is available when the parameter **`Use RCVT as volt. sensor`** under **LPIT General** is checked.

(2) It is available when the parameter **`Use cal. data IO240 board`** under **IO240 general data** is checked.



[dw_strIO240_LPIT General, 3, en_US]

Figure 5-138 Structure of the Function Block LPIT general



[dw_strIO240_LPIT Sensor, 4, en_US]

Figure 5-139 Structure of the Function Block GIS-LPIT pole

(1) It is available when the parameter **GIS-LPIT type** under **LPIT General** is set to ***LPIT 1-phase***.

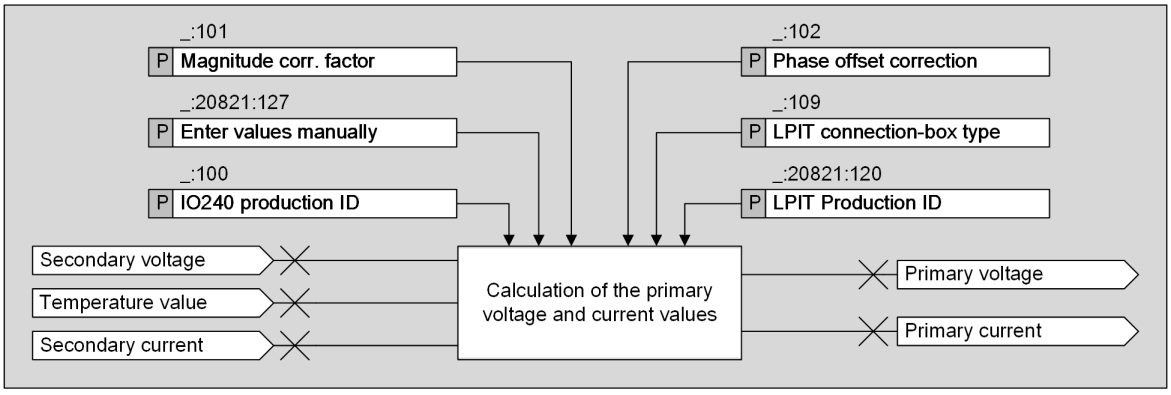
(2) It is available when the parameter **Use RCVT as volt. sensor** under **LPIT General** is checked.

5.7.11.3 Function Description

Once you have instantiated the **LPIT module IO240**, it is visible in the project tree in the function group **Analog units**. You can find the function group **Analog units** in the folder **Settings** of the device in the DIGSI 5 project tree.

If you open the subdirectory **LPIT-IO240**, you reach the setting sheet for the function blocks **LPIT General**, **GIS-LPIT pole**, **RCVT**, and **IO240 cal.data**. For more information, refer to *5.7.11.4 Application and Setting Notes* and *5.7.11.5 Settings*.

Logic of the LPIT Module IO240



[lo_IO240_logic_diagram, 3, en_US]

Figure 5-140 Logic of the LPIT Module IO240

NOTE

The parameter **IO240 production ID** is only used for calculation when the parameter **Use cal. data IO240 board** in the function block **IO240 general data** is checked.

The parameters **Magnitude corr. factor** and **Phase offset correction** are only used for calculation when the parameter **Use RCVT as volt. sensor** in the function block **LPIT General** is checked.

Calculation of the Primary Values

When RCVT is not used, the **LPIT module IO240** obtains the temperature values and secondary values from the GIS-LPIT sensor. When RCVT is used, the **LPIT module IO240** obtains the temperature values and secondary-current values from the GIS-LPIT sensor, and the secondary-voltage values from the RCVT sensor. The secondary values are converted into the corresponding primary values based on the settings in the function blocks **LPIT general**, **GIS-LPIT pole**, **RCVT**, and **IO240 calibration data**. The primary values are then

internally provided to the device for the measurement functions or protection functions, and can be optionally published as sampled measured values.

Temperature Value of the GIS-LPIT Sensor

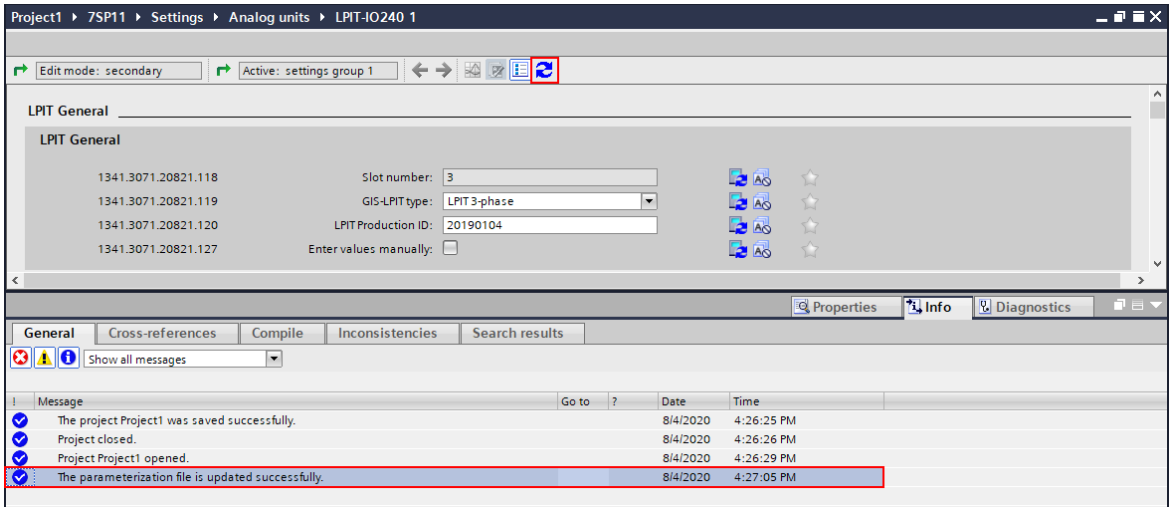
The **LPIT module IO240** measures the temperature value of the GIS-LPIT sensor via the PT100 sensors of the GIS-LPIT. The temperature is used to compensate the temperature influence of the measured secondary values. This allows an accurate calculation of the primary values. The measured resistance of the PT100 sensor and the resulting temperature are available as information in the device for further use, such as customized logic charts (CFC) and recording. The resistance and temperature values are shown on the HMI.

If RCVT is used as the voltage input, the temperature value of the GIS-LPIT sensor has no influence on the voltage measurement.

5.7.11.4 Application and Setting Notes

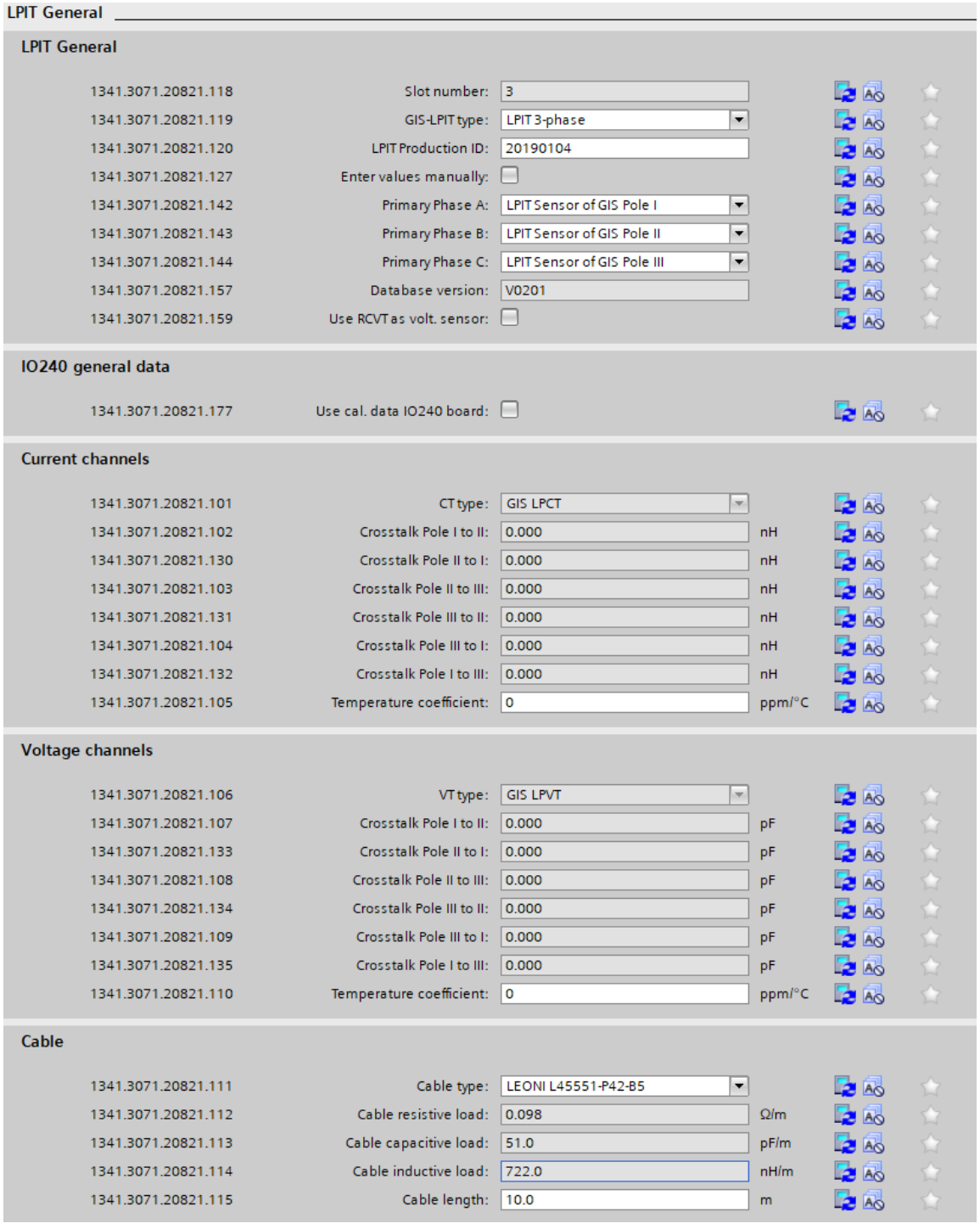
Calibration Data

The calibration data of the GIS-LPIT sensor, the GIS-LPIT connection box, and the IO240 board are stored in a cloud storage. Therefore, the calibration data for DIGSI are available independently from the DIGSI 5 version and can be updated for newly produced GIS-LPIT and IO240 board. To update the local copy of the calibration data file, you can click the refresh button . The feedback of a successful or unsuccessful update of the calibration data file is given in the **Info** tab.



[sc_refresh button and message, 1, en_US]

Settings of the LPIT General



[sc_LPIT_General, 2, en_US]

Figure 5-141 Settings of the LPIT General

Parameter: `Slot number`

The parameter specifies the mounting location of the IO240 board in the SIPROTEC 5 device and is used to identify the board mounting location when multiple IO240 boards are used in a device.

Parameter: **GIS-LPIT type**

- Default setting **(_:20821:119) GIS-LPIT type** = ***LPIT 3-phase***

With the parameter **GIS-LPIT type**, you set the GIS type used.

Parameter Value	Connection to the LPIT Module IO240	GIS-LPIT Sensor Type
LPIT 3-phase	Rogowski coil Capacitive voltage sensor	3-phase encapsulated (8DN8-5, 8DN8-6, 8VN1)
3-phase without LPVT	Rogowski coil	
LPIT 1-phase	Rogowski coil Capacitive voltage sensor	1-phase encapsulated
1-phase without LPVT	Rogowski coil	

Parameter: **LPIT Production ID**

To load the calibration data of your GIS-LPIT sensor from the calibration data file, enter the corresponding GIS-LPIT production ID. You can find the GIS-LPIT Production ID at the GIS-LPIT sensor name plate.

Parameter: **Enter values manually**

- Default setting: the parameter **(_:20821:127) Enter values manually** is unchecked.

With the parameter **Enter values manually**, you decide to use the default values or enter the values manually.



NOTE

Each **LPIT Production ID** is unique.

Parameter: **Primary Phase A**, **Primary Phase B**, **Primary Phase C**

- Default setting **(_:142) Primary Phase A** = ***LPIT Sensor of GIS Pole I***
- Default setting **(_:143) Primary Phase B** = ***LPIT Sensor of GIS Pole II***
- Default setting **(_:144) Primary Phase C** = ***LPIT Sensor of GIS Pole III***

With these parameters, you define the mapping relationship between the primary phase and the LPIT sensor of GIS pole, according to the physical connection. The **LPIT module IO240** takes the settings of the corresponding LPIT sensor of GIS pole for each phase.

Parameter: **Use RCVT as volt. sensor**

- Default setting: the parameter **(_:20281:159) Use RCVT as volt. sensor** is unchecked.

With the parameter **Use RCVT as volt. sensor**, you decide whether to use the GIS-LPVT or RCVT as the voltage sensor type for the primary-voltage measurement. When this parameter is checked, the 3 function blocks for **RCVTs** are available and all the settings related to GIS-LPVT are invisible.

Parameter: **Crosstalk RCVT 1 to 2**, **Crosstalk RCVT 2 to 1**, **Crosstalk RCVT 2 to 3**, **Crosstalk RCVT 3 to 2**, **Crosstalk RCVT 3 to 1**, **Crosstalk RCVT 1 to 3**

- Default setting **(_:160) Crosstalk RCVT 1 to 2** = ***0.000*** **%**
- Default setting **(_:161) Crosstalk RCVT 2 to 1** = ***0.000*** **%**
- Default setting **(_:162) Crosstalk RCVT 2 to 3** = ***0.000*** **%**
- Default setting **(_:163) Crosstalk RCVT 3 to 2** = ***0.000*** **%**
- Default setting **(_:164) Crosstalk RCVT 3 to 1** = ***0.000*** **%**
- Default setting **(_:165) Crosstalk RCVT 1 to 3** = ***0.000*** **%**

With these parameters, you configure the mutual influence of crosstalk from the RCVT in one phase to the one in another phase.

Parameter: `Use cal. data IO240 board`

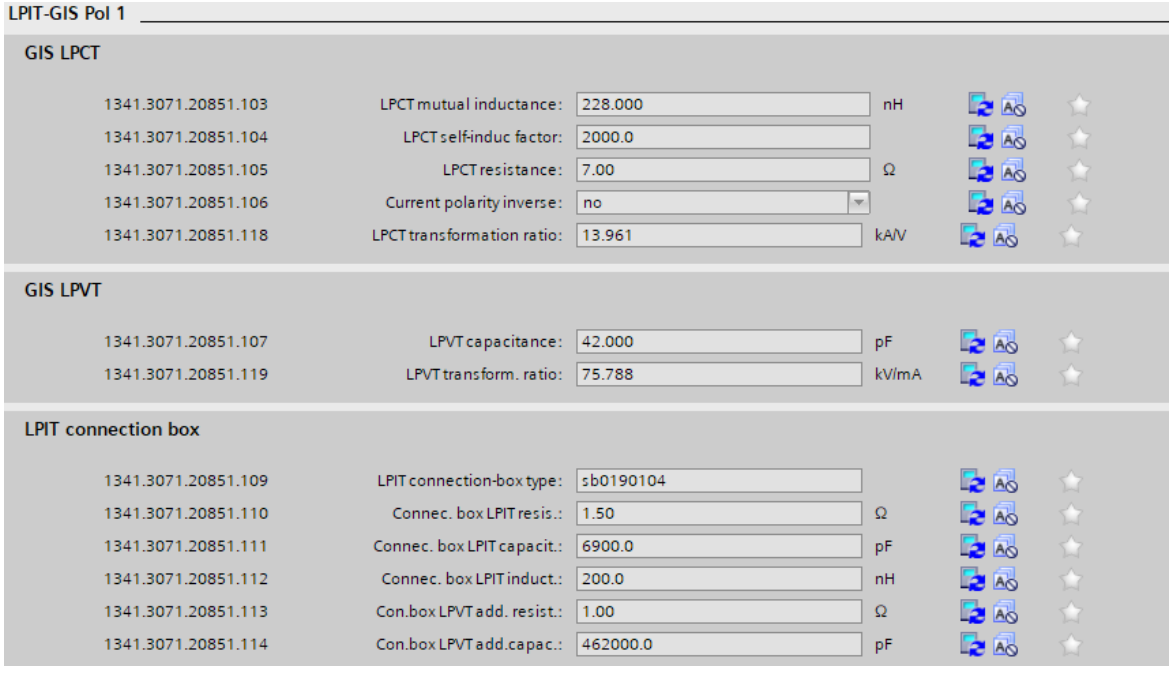
- Default setting: the parameter **`(_:20821:177) Use cal. data IO240 board`** is unchecked.

With the parameter **`Use cal. data IO240 board`**, you decide whether to use the calibration data of the IO240 board for the primary-value calculation to achieve measuring accuracy class 0.1. When this parameter is checked, the function block **IO240 cal.data** is available.

Parameter: `Temperature coefficient`

- Default setting **`(_:105) Temperature coefficient`** = ***0 ppm/°C***
  This parameter refers to the influence of the LPCT temperature on the calculated primary current value.
- Default setting **`(_:110) Temperature coefficient`** = ***0 ppm/°C***
  This parameter refers to the influence of the LPVT temperature on the calculated primary voltage value.

Settings of the LPIT-GIS Pole



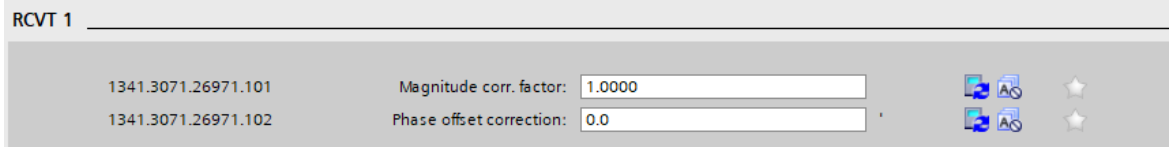
[sc_LPIT-GIS_pole, 1, en_US]

Figure 5-142 Settings of the LPIT-GIS Pole, Example

Parameter: `LPIT connection-box type`

After the GIS-LPIT production ID is entered, the type of the LPIT connection box is visible in DIGSI. It is not configurable.

Settings of the RCVT Sensors



[sc_settings_RCVT, 1, en_US]

Figure 5-143 Settings of the RCVT

Parameter: **Magnitude corr. factor**, **Phase offset correction**

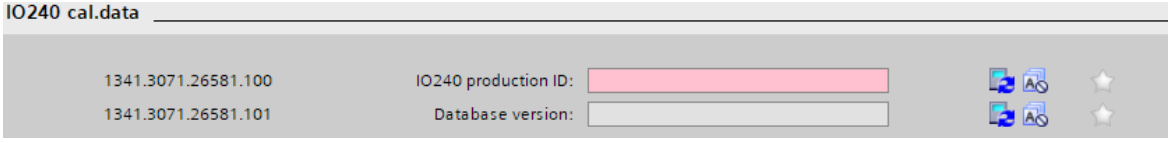
- Default setting **(_:101) Magnitude corr. factor** = *1.0000*
  With the parameter **Magnitude corr. factor**, you adjust the magnitude for the voltage input.
- Default setting **(_:102) Phase offset correction** = *0.0 '*
  With the parameter **Phase offset correction**, you adjust the phase angle for the voltage input.

These parameters allow you to correct the tolerances of the primary-voltage transformer phase-selectively. Magnitude correction and phase-offset correction are probably required for high-precision measurements.

Settings of the IO240 Calibration Data

To achieve the measuring accuracy class 0.1, the calibration data of the IO240 board used are required. The board-specific calibration data can be ordered separately from the supplier of the LPIT sensor.

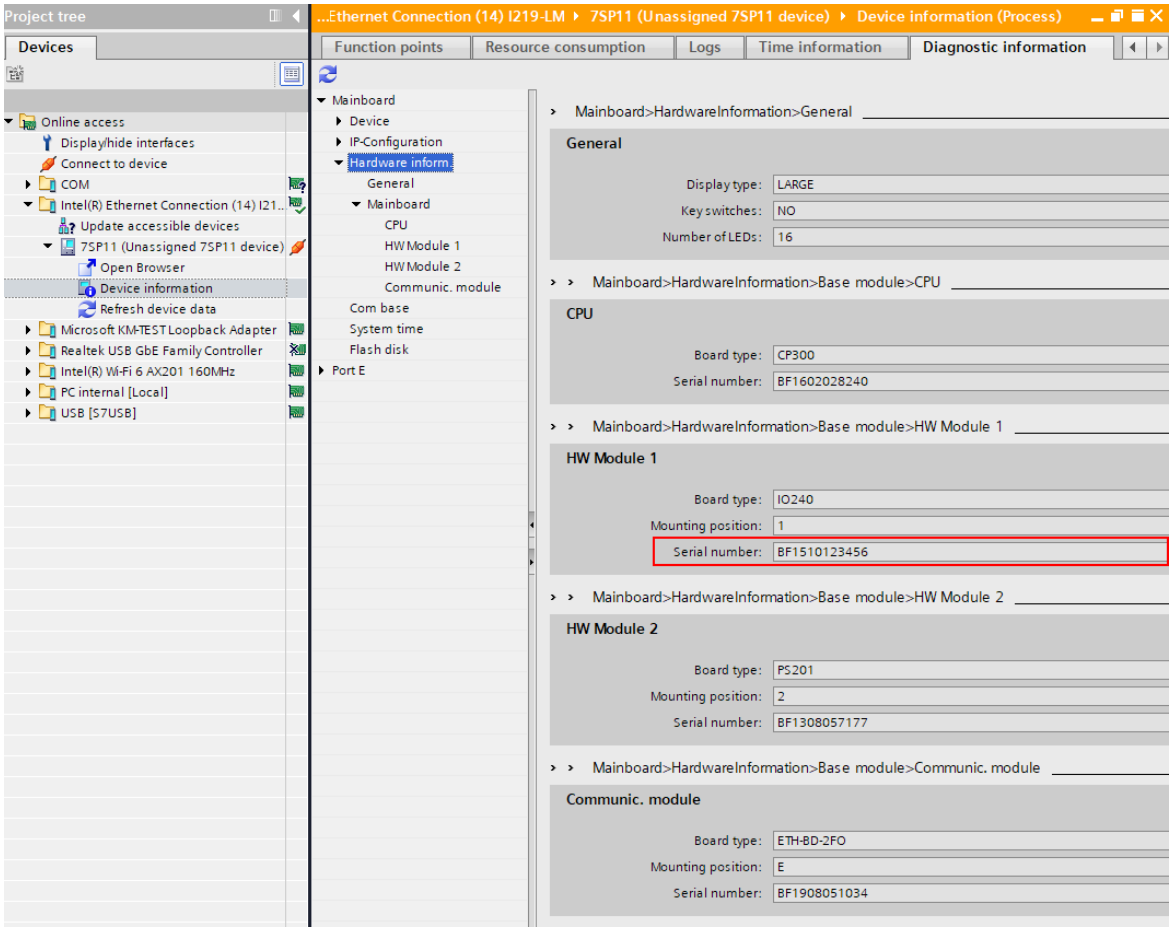
In the function block **IO240 cal.data**, there are 2 parameters **IO240 production ID** and **Database version**.



[sc_IO240 cal. data, 1, en_US]

Figure 5-144 Settings of the IO240 Calibration Data

For the parameter **IO240 production ID**, you must enter the value manually. You can find the production ID of the IO240 board in DIGSI 5 via **Online access** > **Device information** > **Hardware inform.** > HW module with the board type: IO240. You can also get the production ID of the specific IO240 board from the LPIT supplier.



[sc_IO240_production_ID, 1, en_US]

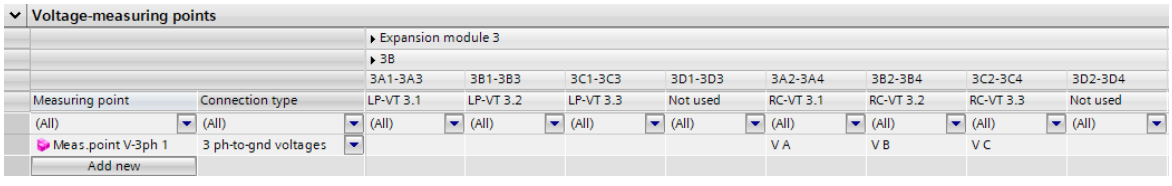
Figure 5-145 IO240 Production ID

After the production ID is entered, the corresponding version of database is visible in DIGSI. The version is not configurable.

Measuring-Points Routing

The **LPIT module IO240** only supports the ***3 ph-to-gnd voltages*** connection type of voltage and the ***3-phase*** connection type of current in the **Measuring-points routing**.

2 groups of 3-phase voltage measuring channels with different voltage-transformer types derived from the connected voltage sensor are available in the **Measuring-points routing**. For each **LPIT module IO240**, you can only route 1 group of the 3-phase voltage measuring channels according to the connected voltage sensor, either GIS-LPVT or RCVT. The measuring-points routing must be consistent with the configuration of the parameter **`Use RCVT as volt. sensor`**. Otherwise, DIGSI 5 reports an inconsistency.



[sc_IO240 voltage connection type, 2, en_US]

Figure 5-146 IO240 Voltage Connection Type

NOTE

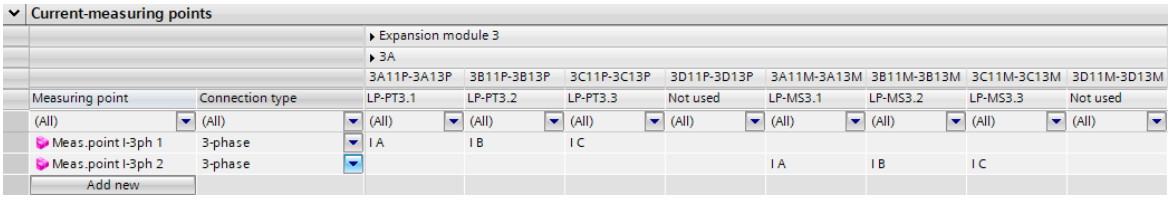
The voltages in the following channels are for the GIS-LPVT sensor:

- LP-VT3.1
- LP-VT3.2
- LP-VT3.3

The voltages in the following channels are for the RCVT sensor:

- RC-VT3.1
- RC-VT3.2
- RC-VT3.3

2 groups of 3-phase current measuring channels with different measuring ranges derived from the connected Rogowski coil are available in the **Measuring-points routing**. The protection channel supplies a dynamic range of 100 times the rated primary current of the assigned current measuring point. The measuring channel supplies a dynamic range of 1.6 times the rated primary current of the assigned measuring point, with higher accuracy than the protection channel. The rated primary current must be set accordingly in the settings for the current measuring points. The settings for the current measuring points can be found in the device settings under **Settings** and **Power System**.



[sc_IO240 current connection type, 2, en_US]

Figure 5-147 IO240 Current Connection Type

NOTE

The currents in the following channels are for the protection function:

- LP-PT3.1
- LP-PT3.2
- LP-PT3.3

The currents in the following channels are for the measurement function:

- LP-MS3.1
- LP-MS3.2
- LP-MS3.3

Measuring Point Voltage 3-Phase (V-3ph)

For the voltage measuring points of the **LPIT module IO240**, the value of the parameter **`Rated secondary voltage`** is the basis for the configuration of the parameters in secondary values. When connected to the GIS-LPVT sensor, the rated secondary voltage is preset permanently to a virtual voltage of 100 V and is invisible in DIGSI. When connected to the RCVT sensor, the rated secondary voltage is preset permanently to a real voltage of 100 V, which is visible and read-only in DIGSI.

For more information on the measuring point voltage 3-phase (V-3ph), refer to *8.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)*.

Measuring Point Current 3-Phase (I-3ph)

For the current measuring point of the **LPIT module IO240** for both the protection and measuring channels, the rated secondary current is preset permanently to a virtual current of 1 A. This value is the basis for the parameterization of the settings in secondary values. The parameter **`Rated secondary current`** is invisible in DIGSI.

For more information on the measuring point current 3-phase (I-3ph), refer to *8.1.6 Application and Setting Notes for Measuring-Point Current 3-Phase (I-3ph)*.

Avoiding Unauthorized Access to IO240 Terminals

For revenue metering, to protect the measurement chain against unauthorized access, you have the following options:

- Use a shield cover; if necessary a sealing can be applied.
- Extend the shield cover with an optional microswitch (product code P1X596).

Application of the Optional Microswitch

After connection of the 2 leads from the microswitch to the terminals D9 and D10, the IO240 module can detect an opening of the shield cover and report it via SCADA communication. When the connected microswitch is actuated, the information *`(_:76) Shield cover`* changes the status. The information can be further processed via the information routing and reported to the control system, for example.

For more information on the installation, refer to the *SIPROTEC 5 Hardware manual*.

5.7.11.5 Settings

Addr.	Parameter	Setting Options	Default Setting
`LPIT General`			
_:118	LPIT General:Slot number	1 to 12 Not settable	Physical slot number of the IO240 board connection
_:119	LPIT General:GIS-LPIT type	• LPIT 1-phase • LPIT 3-phase • 1-phase without LPVT • 3-phase without LPVT	LPIT 3-phase
_:120	LPIT General:LPIT Production ID[22]	Production ID of the GIS sensor	–
_:127	LPIT General:Enter values manually[22]	• no • yes	no
_:142	LPIT General:Primary Phase A	• LPIT Sensor of GIS Pole I • LPIT Sensor of GIS Pole II • LPIT Sensor of GIS Pole III	LPIT Sensor of GIS Pole I
_:143	LPIT General:Primary Phase B	• LPIT Sensor of GIS Pole I • LPIT Sensor of GIS Pole II • LPIT Sensor of GIS Pole III	LPIT Sensor of GIS Pole II
_:144	LPIT General:Primary Phase C	• LPIT Sensor of GIS Pole I • LPIT Sensor of GIS Pole II • LPIT Sensor of GIS Pole III	LPIT Sensor of GIS Pole III

22 This parameter is visible under **GIS-LPIT** of each sensor when you set **GIS-LPIT type** to **LPIT 1-phase**.

Addr.	Parameter	Setting Options	Default Setting
_:20821:157	LPIT General:Database version	The database version from which the LPIT calibration data are derived It is not configurable, but obtained from the used calibration data after the LPIT production ID is entered.	–
_:20281:159	LPIT General:Use RCVT as volt. sensor	• no • yes	no
IO240 general data			
_:20821:177	LPIT General:Use cal. data IO240 board	• no • yes	no
Current channels			
_:101	LPIT General:CT type	GIS LPCT	GIS LPCT
_:102	LPIT General:Crosstalk Pole I to II	-100.000 nH to 100.000 nH	0.000 nH
_:130	LPIT General:Crosstalk Pole II to I	-100.000 nH to 100.000 nH	0.000 nH
_:103	LPIT General:Crosstalk Pole II to III	-100.000 nH to 100.000 nH	0.000 nH
_:131	LPIT General:Crosstalk Pole III to II	-100.000 nH to 100.000 nH	0.000 nH
_:104	LPIT General:Crosstalk Pole III to I	-100.000 nH to 100.000 nH	0.000 nH
_:132	LPIT General:Crosstalk Pole I to III	-100.000 nH to 100.000 nH	0.000 nH
_:105	LPIT General:Temperature coefficient	-1000 ppm/°C to 1000 ppm/°C	0 ppm/°C
Voltage channels for GIS-LPVT			
_:106	LPIT General:VT type	GIS LPVT	GIS LPVT
_:107	LPIT General:Crosstalk Pole I to II	-100.000 pF to 100.000 pF	0.000 pF
_:133	LPIT General:Crosstalk Pole II to I	-100.000 pF to 100.000 pF	0.000 pF
_:108	LPIT General:Crosstalk Pole II to III	-100.000 pF to 100.000 pF	0.000 pF
_:134	LPIT General:Crosstalk Pole III to II	-100.000 pF to 100.000 pF	0.000 pF
_:109	LPIT General:Crosstalk Pole III to I	-100.000 pF to 100.000 pF	0.000 pF
_:135	LPIT General:Crosstalk Pole I to III	-100.000 pF to 100.000 pF	0.000 pF
_:110	LPIT General:Temperature coefficient	-1000 ppm/°C to 1000 ppm/°C	0 ppm/°C
Voltage channels for RCVT			
_:160	LPIT General:Crosstalk RCVT 1 to 2	-5.000 % to 5.000 %	0.000 %
_:161	LPIT General:Crosstalk RCVT 2 to 1	-5.000 % to 5.000 %	0.000 %
_:162	LPIT General:Crosstalk RCVT 2 to 3	-5.000 % to 5.000 %	0.000 %

Addr.	Parameter	Setting Options	Default Setting
_:163	LPIT General:Crosstalk RCVT 3 to 2	-5.000 % to 5.000 %	0.000 %
_:164	LPIT General:Crosstalk RCVT 3 to 1	-5.000 % to 5.000 %	0.000 %
_:163	LPIT General:Crosstalk RCVT 1 to 3	-5.000 % to 5.000 %	0.000 %
Cable			
_:111	LPIT General:Cable type	LEONI L45551-P42-B5	LEONI L45551-P42-B5
_:112	LPIT General:Cable resistive load	0.000 Ω/m to 1.000 Ω/m	0.098 Ω/m
_:113	LPIT General:Cable capacitive load	0.0 pF/m to 100.0 pF/m	51.0 pF/m
_:114	LPIT General:Cable inductive load	0.0 nH/m to 1000.0 nH/m	722.0 nH/m
_:115	LPIT General:Cable length	0.1 m to 100.0 m	10.0 m

The following setting table shows only 1 of the 3 LPIT-GIS poles, as the setting possibilities of the 3 poles are the same.

Addr.	Parameter	Setting Options	Default Setting
GIS-LPIT[23]			
_:102	LPIT-GIS Pol #:LPIT Production ID	Production ID of the GIS sensor	–
_:120	LPIT-GIS Pol #:Enter values manually	• no • yes	no
GIS LPCT			
_:103	LPIT-GIS Pol #:LPCT mutual inductance	0.001 nH to 8 000 000.000 nH	228.000 nH
_:104	LPIT-GIS Pol #:LPCT self-induc factor	0.1 to 4000.0	2000.0
_:105	LPIT-GIS Pol #:LPCT resistance	0.01 Ω to 200.00 Ω	7.00 Ω
_:106	LPIT-GIS Pol #:Current polarity inverse	• no • yes	no
_:118	LPIT-GIS Pol #:LPCT transformation ratio	0.000 kA/V to 3 200 000.000 kA/V	17.000 kA/V
GIS LPVT			
_:107	LPIT-GIS Pol #:LPVT capacitance	0.001 pF to 800 000.000 pF	42.000 pF
_:119	LPIT-GIS Pol #:LPVT transform. ratio	0.000 kV/mA to 3 200 000.000 kV/mA	75.000 kV/mA
LPIT connection box			
_:109	LPIT-GIS Pol #:LPIT connection-box type	Type of the LPIT connection box	–
_:110	LPIT-GIS Pol #:Connec. box LPIT resis.	0.01 Ω to 10.00 Ω	1.50 Ω
_:111	LPIT-GIS Pol #:Connec. box LPIT capacit.	1.0 pF to 10000.0 pF	6900.0 pF

23 The following parameters are visible under **LPIT General** when you set **GIS-LPIT type** to **LPIT 3-phase**.

Addr.	Parameter	Setting Options	Default Setting
_:112	LPIT-GIS Pol #:Connec. box LPIT induct.	0.1 nH to 10000.0 nH	490.0 nH
_:113	LPIT-GIS Pol #:Con.box LPVT add. resist.	0.01 Ω to 20.00 Ω	1.00 Ω
_:114	LPIT-GIS Pol #:Con.box LPVT add.capac.	4000.0 pF to 800 000.0 pF	462 000.0 pF

The following setting table shows only 1 of the 3 RCVTs, as the setting possibilities of the 3 RCVTs are the same.

Only when the parameter **Use RCVT as volt. sensor** is checked, the following function block is available.

Addr.	Parameter	Setting Options	Default Setting
RCVT #			
_:101	RCVT #:Magnitude corr. factor	0.9000 to 1.1000	1.0000
_:102	RCVT #:Phase offset correction	-300.0 ' to 15.0 '	0.0 '

Only when the parameter **Use cal. data IO240 board** is checked, the following function block is available.

Addr.	Parameter	Setting Options	Default Setting
IO240 cal.data			
_:100	IO240 cal.data:IO240 production ID	Production ID of the IO240 board	–
_:101	IO240 cal.data:Database version	The database version from which the IO240 board calibration data are derived It is not configurable, but obtained from the used calibration data after the IO240 production ID is entered.	–

5.7.11.6 Information List

No.	Information	Data Class (Type)	Type
LPIT General			
_:20821:76	LPIT General:Shield cover	SPS	O
_:20821:77	LPIT General:GIS LPIT cali. data error	SPS	O
_:20281:315	LPIT General:RCVT unsupported	SPS	O
_:20281:316	LPIT General:RCVT cali. data error	SPS	O

The following table shows only 1 of the 3 sensors, as the setting possibilities of the 3 sensors do not differ.

No.	Information	Data Class (Type)	Type
LPIT-GIS Pol #			
_:80	LPIT-GIS Pol #:TmpOut	MV	O
_:79	LPIT-GIS Pol #:R	MV	O

5.8 Function-Group Recording

5.8.1 Overview

The device has a flash memory in which records can be saved. The recording documents operations within the power system and how devices respond to them. You can read out records from the device and analyze them. Depending on the recorder, the records are available in different file formats (see the following table).

Table 5-12 File Format Used by Individual Recorders

Interface	File Format	FR[24]	SSR[25]	CR[26]	TR[27]
DIGSI 5	SIPROTEC 5	–	X	X	X
DIGSI 5	COMTRADE	–	–	X	X
IEC 61850	SIPROTEC 5	–	X	–	–
IEC 61850	COMTRADE	X	X	–	–
IEC 61850	PQDIF	–	–	X	X
Browser-based user interface	SIPROTEC 5	–	X	–	–
Browser-based user interface	COMTRADE	X	X	–	–
Browser-based user interface	PQDIF	–	–	X	X
T103	COMTRADE	X	–	–	–
T104	COMTRADE	X	–	–	–
DNP	COMTRADE	X	–	–	–

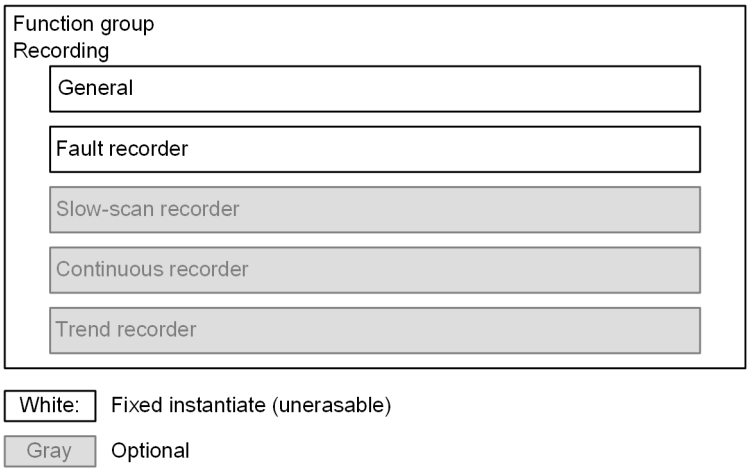
5.8.2 Structure of the Function Group

The **Recording** function group consists of the following functionalities:

- **General** function block
- **Fault recorder** function
- **Slow-scan recorder** function
- **Continuous recorder** function
- **Trend recorder** function

The following figure shows the structure of the **Recording** function group. The function blocks are described in the following chapters.

24 FR: Protection fault recorder
25 SSR: Slow-scan recorder
26 CR: Continuous recorder
27 TR: Trend recorder



[dw_fg_recorder, 4, en_US]

Figure 5-148 Structure of the Recording Function Group

NOTE

If you want to use one of the following functions, the device must be equipped with the CP300, CP150, or CP050 CPU printed circuit board assembly:

- Slow-scan recorder
- Continuous recorder
- Trend recorder

The **Recording** function group 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 can individually adapt the configuration in DIGSI 5.

For more information on the **Fault recorder** function, refer to **Fault Recording**, starting at *3.5.1 Overview of Functions* .

For more information on the **Recording** function group, refer to the *Manual for the **Recording** function group* (C53000-H5040-C089).

5.9 Process Monitor

5.9.1 Overview of Functions

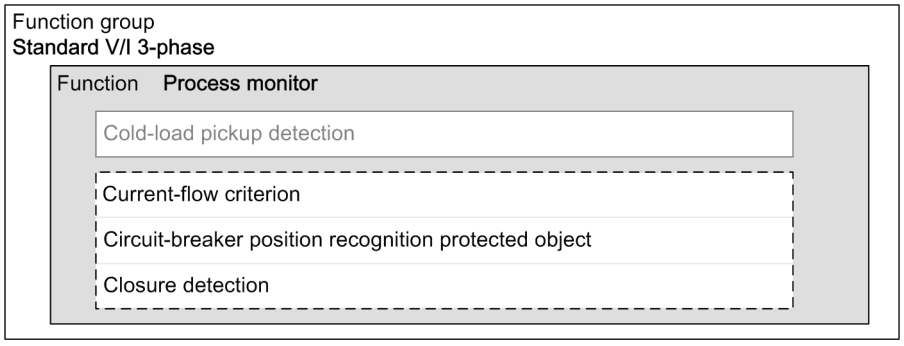
All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

5.9.2 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

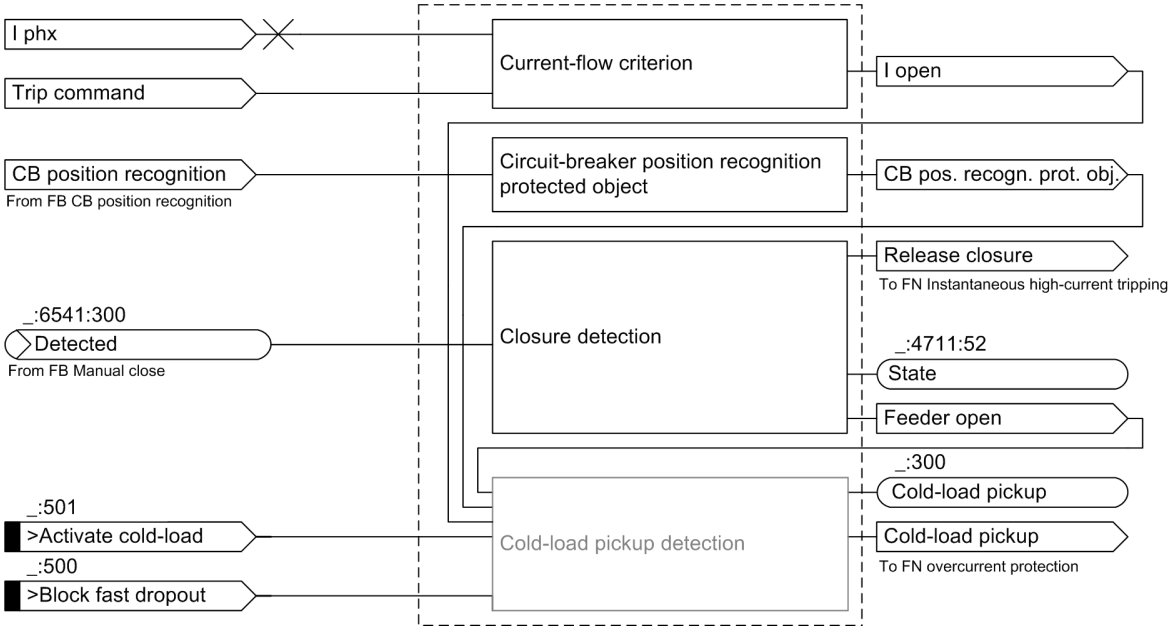


[dw_pro3pt, 2, en_US]

Figure 5-149 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.

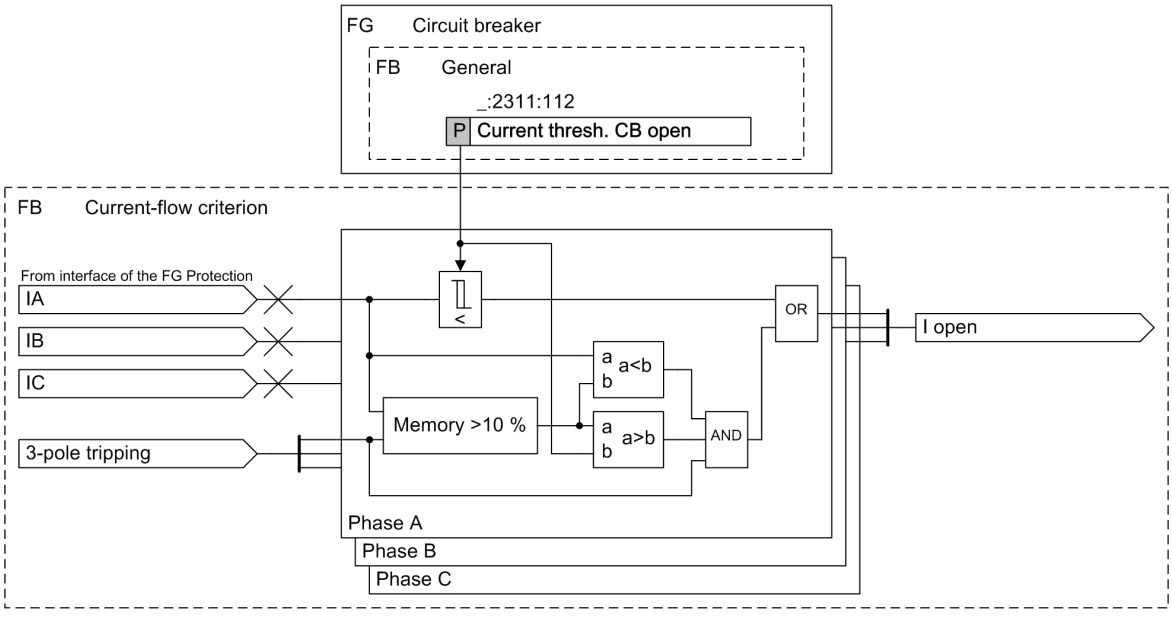


[lo_pro_3pt, 2, en_US]

Figure 5-150 Logic Diagram of the Overall Function Process Monitor

5.9.3 Current-Flow Criterion

Logic



[lo_proikr, 2, en_US]

Figure 5-151 Logic Diagram of the Current-Flow Criterion Function Block

The phase currents are provided via the interface to the protection function group.

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.

If a protection function group with integrated process monitor is connected to several **Circuit breaker** FGs, the **Current thresh. CB open** parameter is present in each FG **Circuit breaker**. The smallest setting value of the parameter **Current thresh. CB open** is used.

5.9.4 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.

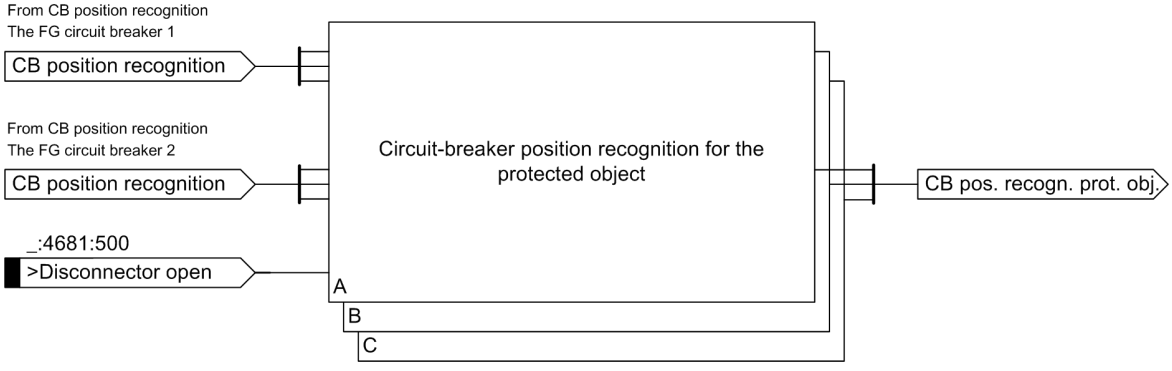
Set the **Current thresh. CB open** parameter so that the current measured when the feeder is deactivated falls below the value of the **Current thresh. CB open** parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

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***.

5.9.5 Circuit-Breaker Condition for the Protected Object

Logic



[lo_prolsz, 2, en_US]

Figure 5-152 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.

5.9.6 Closure Detection

5.9.7 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

6 High-Speed Busbar Transfer

6.1	Function-Group Type High-Speed Busbar Transfer	396
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6.3	Transfer-Priority Group	454
6.4	Basic Configurations for the High-Speed Busbar Transfer	457
6.5	Primary and Secondary Tests for High-Speed Busbar Transfer	462

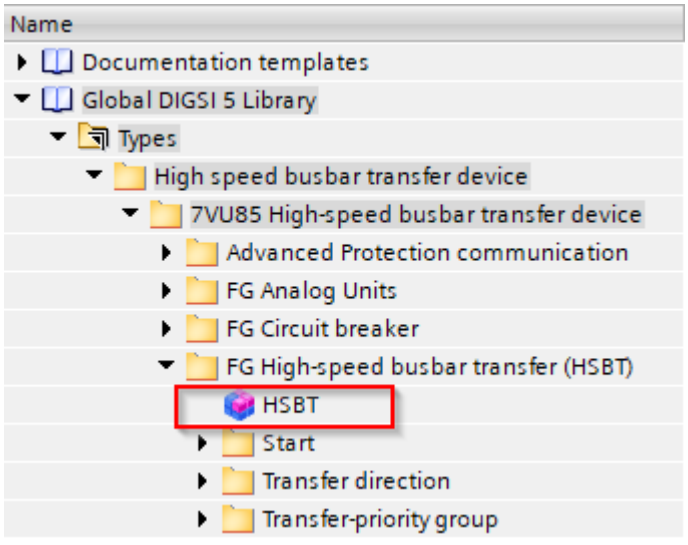
6.1 Function-Group Type High-Speed Busbar Transfer

6.1.1 Overview

In the medium-voltage system of the power plant and industrial plant where lots of rotating loads are installed, the continuous availability of electricity is essential for reliable production controlled by numerous processes. For this purpose, 2 or more incomers are required. Normally, only one of the incomers works to energize the system. In the case of interruption or failure of this incomer, a high-speed busbar transfer from the faulty incomer to the other healthy incomer is desired. The function group **HSBT** (High-speed busbar transfer) is used to realize this high-speed busbar transfer.

One function group **HSBT** supports all transfer directions in a specific application.

You can find the function group **HSBT** under the device types in the Global DIGSI 5 Library.



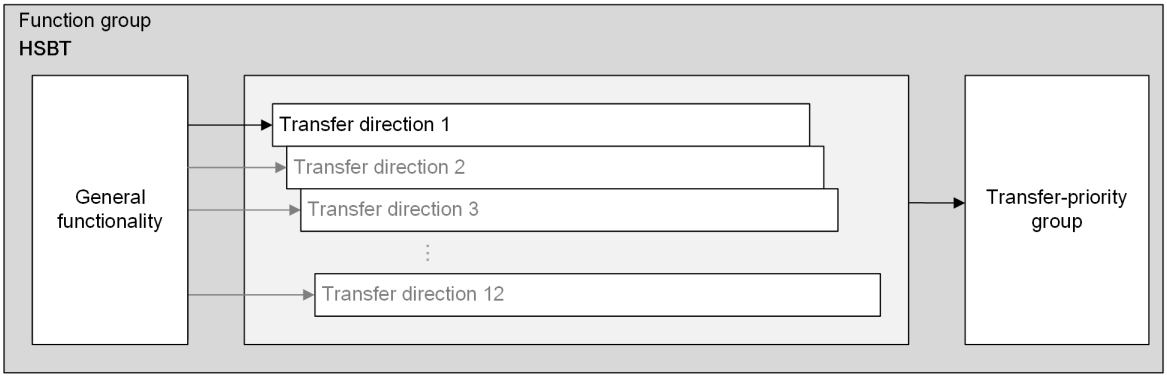
[sc_HSBT, 2, en_US]

Figure 6-1 Function Group HSBT

6.1.2 Structure of the Function Group

The function group **HSBT** consists of the following parts:

- General functionality
- **Transfer direction**
  The function group **HSBT** comes factory-set with 1 function **Transfer direction**. A maximum of 12 functions **Transfer direction** can be instantiated simultaneously within the function group.
- **Transfer-priority group**

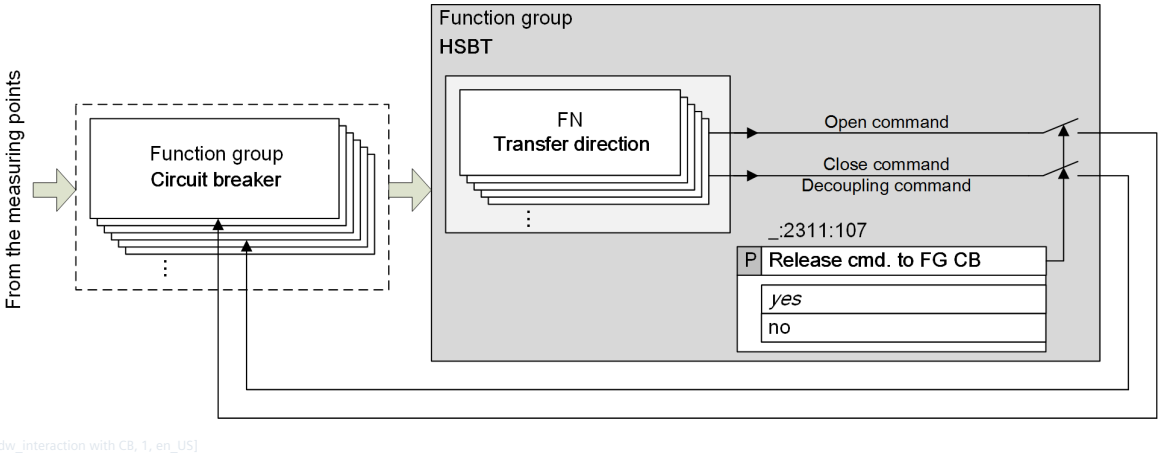


[dw_FG HSBT_structure, 2, en_US]

Figure 6-2 Structure/Embedding of the Function Group HSBT

Interaction with the Function Groups Circuit Breaker

The following figure shows the interaction between the function group **HSBT** and the function groups **Circuit breaker**.



[dw_interaction with CB, 1, en_US]

Figure 6-3 Interaction with the Function Group Circuit Breaker

The function group **HSBT** obtains the information (for example current, voltage, position) of all circuit breakers from the function groups **Circuit breaker**. If a circuit breaker is not controlled in the function group **HSBT**, you can also use the function group **Circuit breaker [status only]** to obtain the position information of this circuit breaker. If the current of a circuit breaker is unnecessary, but other information is required, you can use the function group **Circuit breaker [without current]**.

NOTE

The function group **Circuit breaker [without current]** is instantiated for a section CB. For the incomer CB[28], Siemens recommends using the normal function group **Circuit breaker**. By using the normal function group **Circuit breaker** which monitors the current information, the functionalities **Underfrequency start**, **Undervoltage start**, and **CB inadvertent opening start** work more safe.

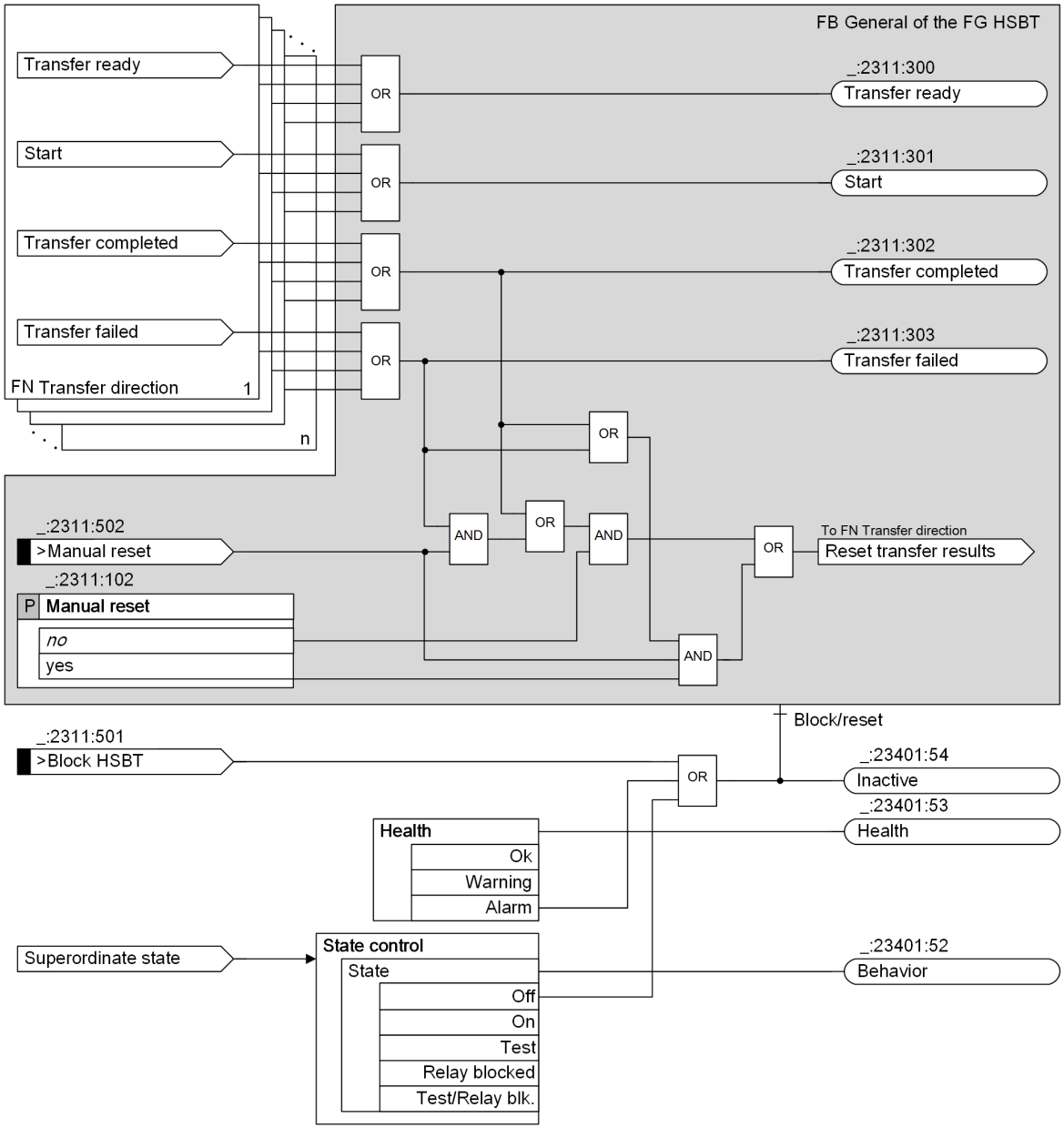
For a transfer, if the value of the parameter **`Release cmd. to FG CB`** is ***yes***, the function group **HSBT** sends the output commands (open command, close command, and decoupling command) to the relevant function groups **Circuit breaker** for CB control. If the value of the parameter **`Release cmd. to FG CB`** is ***no***, the function group **HSBT** does not send the output commands to the relevant function groups **Circuit breaker**.

28 Incomer CB: Circuit breaker that switches on or off the connection between incomer and busbar.

6.1.3 General Functionality

6.1.3.1 Description

Logic



[lo_FG_general, 4, en_US]

Figure 6-4 Logic Diagram of the General Functionality in the Function Group HSBT

Transfer Status in the Function-Group Level

The general functionality of the function group **HSBT** detects the following messages of all instantiated functions **Transfer direction** to determine the transfer status in the function-group level:

- *Transfer ready*
  A transfer can be started by a start type only when the transfer direction is ready. If one of the functions **Transfer direction** in the function group **HSBT** is ready, the indication *Transfer ready* is issued.

- *Start*
  One of the functions **Transfer direction** in the function group **HSBT** is started.
- *Transfer completed*
  One of the functions **Transfer direction** in the function group **HSBT** is executed successfully.
- *Transfer failed*
  One of the functions **Transfer direction** in the function group **HSBT** failed due to the expiration of the transfer time or the failures in operating the circuit breakers.

For more information about the function **Transfer direction**, refer to *6.2 Transfer Direction*.

Resetting All Transfer Results

After a transfer ends, all transfer results are reset under the following conditions:

- With a manual reset (parameter **Manual reset** = ***yes***):
  - No matter a transfer is successfully completed (indication *Transfer completed*) or fails (indication *Transfer failed*), you can only reset all transfer results by activating the binary input *>Manual reset*.
- Without a manual reset (parameter **Manual reset** = ***no***):
  - If a transfer is successfully completed (indication *Transfer completed*), all transfer results are reset directly and immediately.
  - If a transfer fails (indication *Transfer failed*), you can reset all transfer results by activating the binary input *>Manual reset*.

For more information about resetting transfer results, refer to *Resetting Transfer Results, Page 439*.

Blocking the Function Group via a Binary Input

You can block the function group via the binary input *>Block HSBT*.

Test Mode

To activate the test mode of the function group **HSBT**, Siemens recommends switching all the instantiated functions **Transfer direction** to the test mode (parameter **Mode** = ***test***). You can find the parameter **Mode** in the function **Transfer direction**. For more information about the test mode, refer to *2.3 Function Control*.

6.1.3.2 Application and Setting Notes

Parameter: Manual reset

- Default setting **(_:2311:102) Manual reset** = ***no***

With the parameter **Manual reset**, you determine whether a manual reset is required after a transfer is successfully completed (indication *Transfer completed*).

Parameter Value	Description
no	A manual reset is not required: • If a transfer is successfully completed, all transfer results are reset directly and immediately.
yes	A manual reset is required: • If a transfer is successfully completed, you must reset all transfer results by activating the binary input *>Manual reset*.

If a transfer fails (indication *Transfer failed*), regardless of the setting of the parameter **Manual reset**, you must reset all transfer results by activating the binary input *>Manual reset*. Otherwise, the next transfer cannot be processed.

Parameter: **`Release cmd. to FG CB`**

- Default setting **`(_:2311:107) Release cmd. to FG CB`** = ***`yes`***

With the parameter **`Release cmd. to FG CB`**, you determine whether the function group **HSBT** sends the output commands (open command, close command, and decoupling command) to the relevant function groups **Circuit breaker**. If you want to open or close a circuit breaker via the command of the function group **Circuit breaker**, use the default setting ***`yes`***.

6.1.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:101	General:Max. transfer duration		10.00 s to 60.00 s	20.00 s
_:2311:102	General:Manual reset		• no • yes	no
_:2311:103	General:Min. operating limit Vmin		30.0 % to 100.0 %	90.0 %
_:2311:107	General:Release cmd. to FG CB		• no • yes	yes

6.1.3.4 Information List

No.	Information	Data Class (Type)	Type
`General`			
_:2311:501	General:>Block HSBT	SPS	I
_:2311:502	General:>Manual reset	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:54	General:Inactive	SPS	O
_:2311:300	General:Transfer ready	SPS	O
_:2311:301	General:Start	SPS	O
_:2311:302	General:Transfer completed	SPS	O
_:2311:303	General:Transfer failed	SPS	O

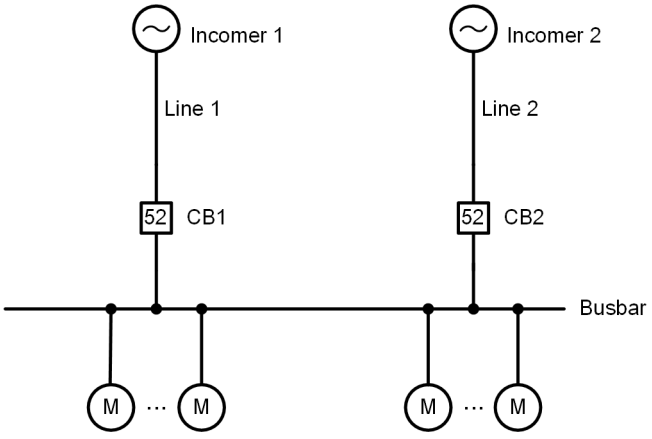
6.2 Transfer Direction

6.2.1 Overview

The function **Transfer direction** is used to change the incomer which energizes the busbar from one incomer to another.

For an application of the high-speed busbar transfer, multiple functions **Transfer direction** can be instantiated to meet the requirements in different transfer directions. In the following application example, there are 2 different transfer directions:

- **Incomer 1 to incomer 2**
- **Incomer 2 to incomer 1**



[dw_1BB_2L, 1, en_US]

Figure 6-5 Application Example: Single Busbar with 2 Incomers

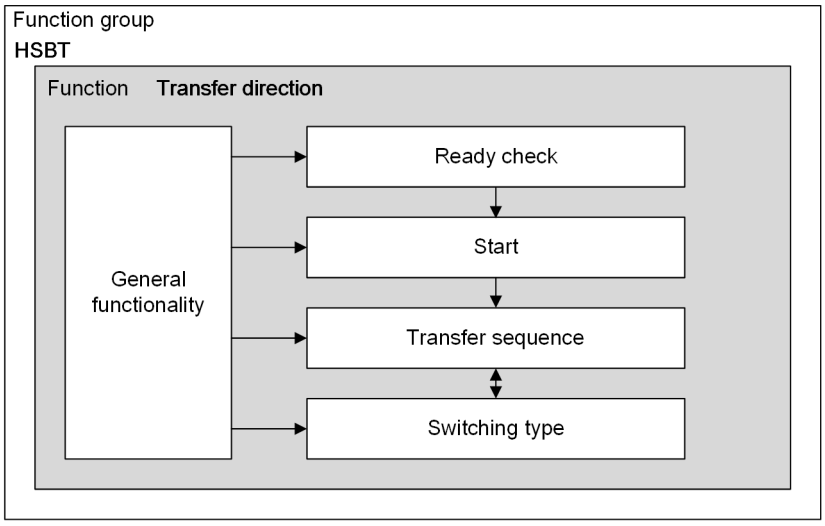
6.2.2 Structure of the Function

The function **Transfer direction** is used in the function group **HSBT**.

The function **Transfer direction** consists of the following function blocks:

- **Ready check**
  Checks the conditions of the power system to secure a reliable transfer. The transfer is available only when the conditions of the power system meet the ready criterion.
- **Start**
  Checks the conditions to start the transfer
- **Transfer sequence**
  Executes the defined operating sequence of the circuit breaker to be closed and the circuit breaker to be opened
- **Switching type**
  Determines if the current instant is suitable for the closing of the circuit breaker to be closed, which ensures the fast and safe transfer

The general functionality works across all function blocks on the function level.



[dw_FN_structure, 1, en_US]

Figure 6-6 Structure/Embedding of the Function **Transfer direction**

6.2.3 Basic Concepts

This chapter describes 4 applications of the busbar transfer and the basic concepts used in the function **Transfer direction**.

Single Busbar with 2 Incomers

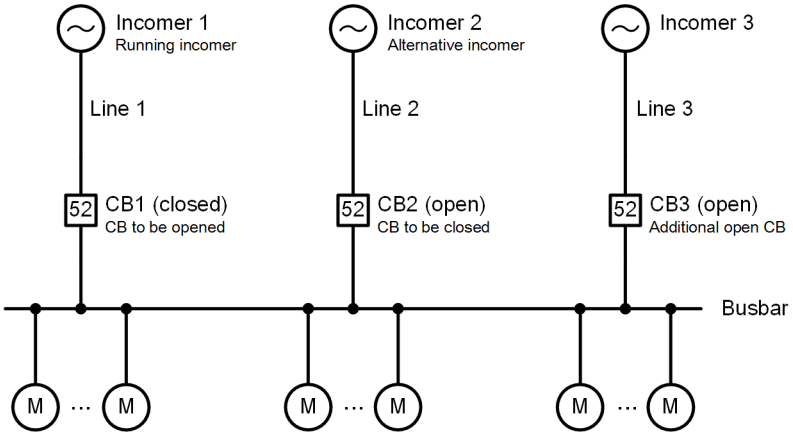
Figure 6-5 shows the application of the single busbar with 2 incomers. For a transfer direction in this application, one of the 2 incomers must be running to energize the busbar. The following operations must be carried out:

- Open a circuit breaker to disconnect the running incomer from the busbar.
- Close the other circuit breaker to connect the alternative incomer to the busbar.

In this application, there are 2 applicable transfer directions:

- Transfer direction 1: **Incomer 1 to incomer 2**
  For this transfer direction, the operations are to open CB1 and to close CB2.
  CB1 is the CB to be opened to disconnect incomer 1 (Running incomer) from the busbar.
  CB2 is the CB to be closed to connect incomer 2 (Alternative incomer) to the busbar.
- Transfer direction 2: **Incomer 2 to incomer 1**
  For this transfer direction, the operations are to open CB2 and to close CB1.
  CB2 is the CB to be opened to disconnect incomer 2 (Running incomer) from the busbar.
  CB1 is the CB to be closed to connect incomer 1 (Alternative incomer) to the busbar.

One Transfer Direction in the Application of a Single Busbar with 3 Incomers



[dw_1BB_3L_1, en_US]

Figure 6-7 Single Busbar with 3 Incomers: Transfer Direction **Incomer 1 to incomer 2**

The preceding figure shows the preconditions (before the transfer) for the transfer direction **Incomer 1 to incomer 2** in the application of a single busbar with 3 incomers. In this application, there are 3 incomers. For each transfer direction, only one incomer works to energize the busbar.

Preconditions for the transfer direction **Incomer 1 to incomer 2**:

- Incomer 1 (Running incomer) energizes the busbar.
- CB1 is closed.
- CB2 is open.
- CB3 is open.

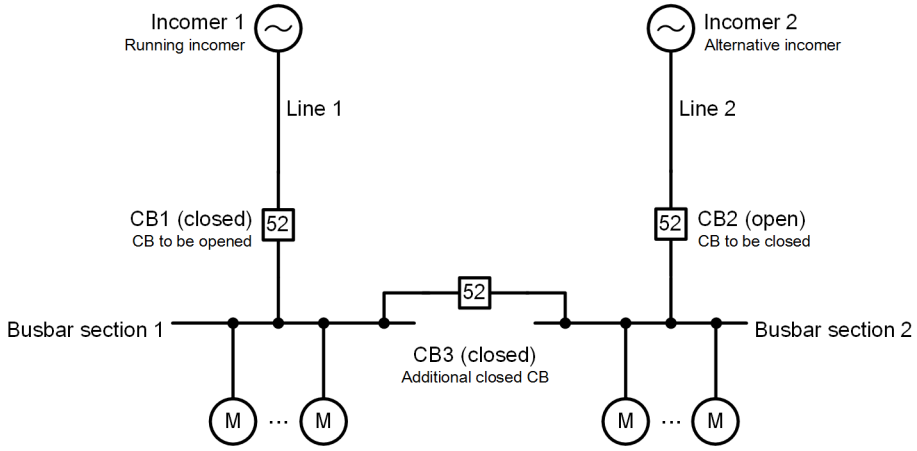
Desired transfer results for the transfer direction **Incomer 1 to incomer 2**:

- Incomer 2 (Alternative incomer) energizes the busbar.
- CB1 (CB to be opened) is opened to disconnect incomer 1 (Running incomer) from the busbar.
- CB2 (CB to be closed) is closed to connect incomer 2 (Alternative incomer) to the busbar.
- CB3 remains open to ensure that incomer 3 is still disconnected from the busbar.

  CB3 is an additional open CB. For this transfer direction, incomer 3 is not the preferred alternative incomer for the transfer purpose.

  In general, the additional open CB must remain open to isolate the irrelative circuit for a transfer direction.

One Transfer Direction in the Application of a Sectionalized Busbar with 2 Incomers



[dw_sectionalized BB_2L, 1, en_US]

Figure 6-8 Sectionalized Busbar with 2 Incomers: Transfer Direction **Incomer 1 to incomer 2**

The preceding figure shows the preconditions (before the transfer) for the transfer direction **Incomer 1 to incomer 2** in the application of a sectionalized busbar with 2 incomers. The sectionalized busbar is divided into 2 busbar sections by the section CB (CB3).

Preconditions for the transfer direction **Incomer 1 to incomer 2**:

- Incomer 1 (Running incomer) energizes the sectionalized busbar.
- CB1 is closed.
- CB2 is open.
- CB3 is closed.

Desired transfer results for the transfer direction **Incomer 1 to incomer 2**:

- Incomer 2 (Alternative incomer) energizes the sectionalized busbar.
  The sectionalized busbar is the busbar to be transferred for this transfer direction.
- CB1 (CB to be opened) is opened to disconnect incomer 1 (Running incomer) from the busbar.
- CB2 (CB to be closed) is closed to connect incomer 2 (Alternative incomer) to the busbar.
- CB3 remains closed to ensure that 2 busbar sections of the sectionalized busbar (busbar to be transferred) can be energized.
  CB3 is an additional closed CB.
  In general, the additional closed CB can be one or several section CBs for a transfer direction. With the additional closed CB, the busbar sections are connected together as the busbar to be transferred. For a transfer direction, all additional closed CBs must remain closed before the start of the transfer. Therefore, the busbar to be transferred is energized by the alternative incomer after the transfer is completed.

Basic Concepts

According to the preceding applications, the basic concepts used in the function **Transfer direction** are summarized as follows:

Concepts	Description
Running incomer	Before the transfer, this incomer energizes the busbar.
Alternative incomer	After the transfer, this incomer energizes the busbar.

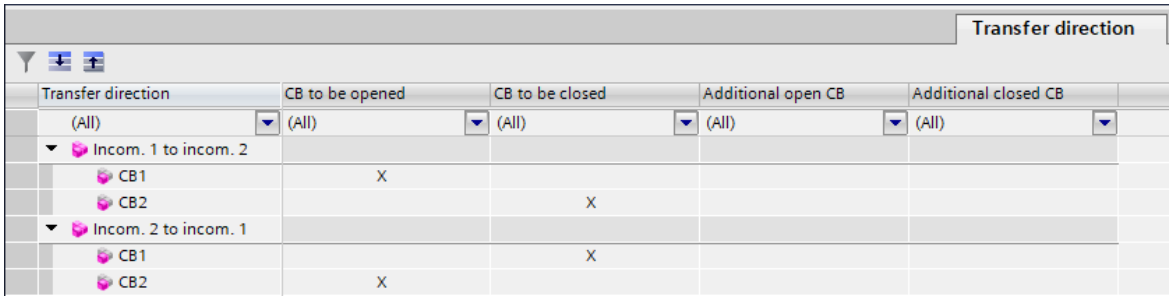
Concepts	Description
Busbar to be transferred	The energized busbar or busbar sections Before the transfer, the busbar to be transferred is energized by the running incomer. After the transfer, the busbar to be transferred is energized by the alternative incomer.
CB to be opened	The circuit breaker that is to be opened to disconnect the running incomer from the busbar for a transfer direction
CB to be closed	The circuit breaker that is to be closed to connect the alternative incomer to the busbar for a transfer direction
Additional open CB	The circuit breakers that must remain open to isolate the irrelative circuits for a transfer direction
Additional closed CB	The additional closed CB can be one or several section CBs in one transfer direction. With the additional closed CB, the busbar sections are connected together as the busbar to be transferred. For a transfer direction, all additional closed CB must remain closed before the start of the transfer. Therefore, the busbar to be transferred is energized by the alternative incomer after the transfer is completed.

6.2.4 General Functionality

6.2.4.1 Description

Circuit-Breaker Routing

The circuit-breaker routing is performed in the tab **Transfer direction**. You can find the tab **Transfer direction** in DIGSI 5 under **Project tree** > **Name of the device** > **Settings** > **HSBT** > **Transfer routing**. In the tab **Transfer direction**, you can add the function **Transfer direction** and route the circuit breakers of the transfer direction.



[sc_transfer-direction routing, 2, en_US]

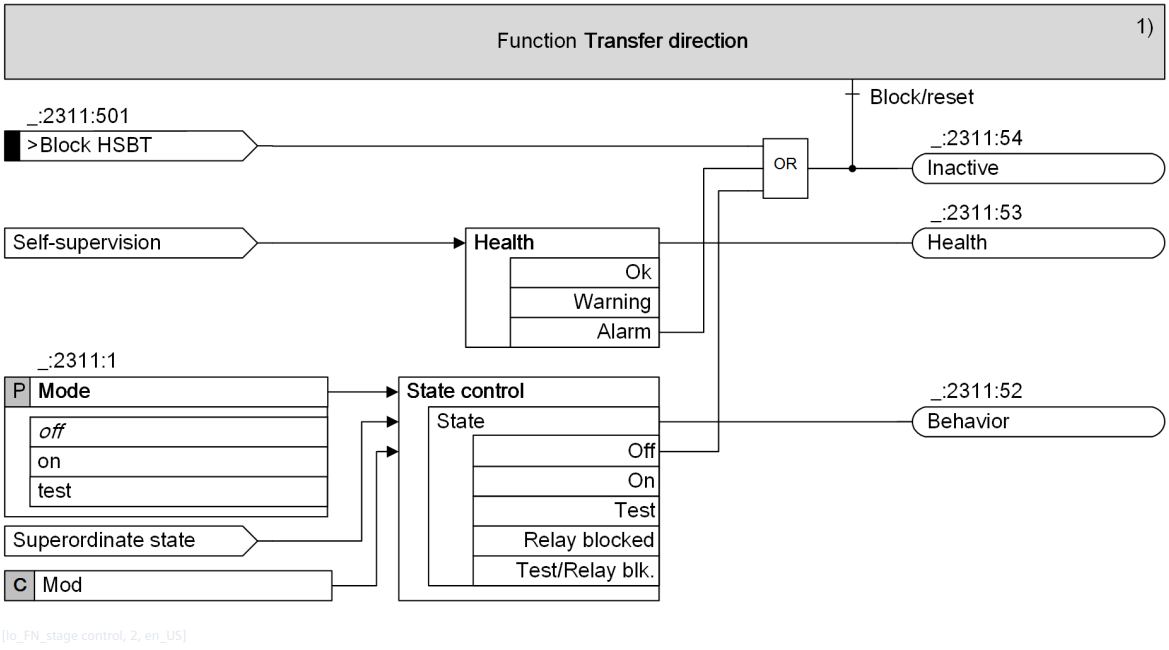
Figure 6-9 Tab **Transfer direction**

Table 6-1 4 Columns for Circuit-Breaker Routing

Column	Description
CB to be opened	In this column, you route the circuit breaker that is to be opened to disconnect the running incomer from the busbar for a transfer direction. For each transfer direction, there is only one circuit breaker to be opened.
CB to be closed	In this column, you route the circuit breaker that is to be closed to connect the alternative incomer to the busbar for a transfer direction. For each transfer direction, there is only one circuit breaker to be closed.

Column	Description
Additional open CB	In this column, you route the circuit breakers that must remain open to isolate the irrelative circuits for a transfer direction. The column supports multiple routings. If several circuit breakers must remain open to isolate the irrelative circuit for a transfer direction, route this column. If there is no circuit breaker that must remain open, leave this column blank.
Additional closed CB	In this column, you route the circuit breakers that must remain closed to ensure the full connection of the busbar to be transferred for a transfer direction. This column supports multiple routings. If several circuit breakers must remain closed to ensure that the busbar to be transferred is energized, route this column. If there is no circuit breaker that must remain closed, leave this column blank.

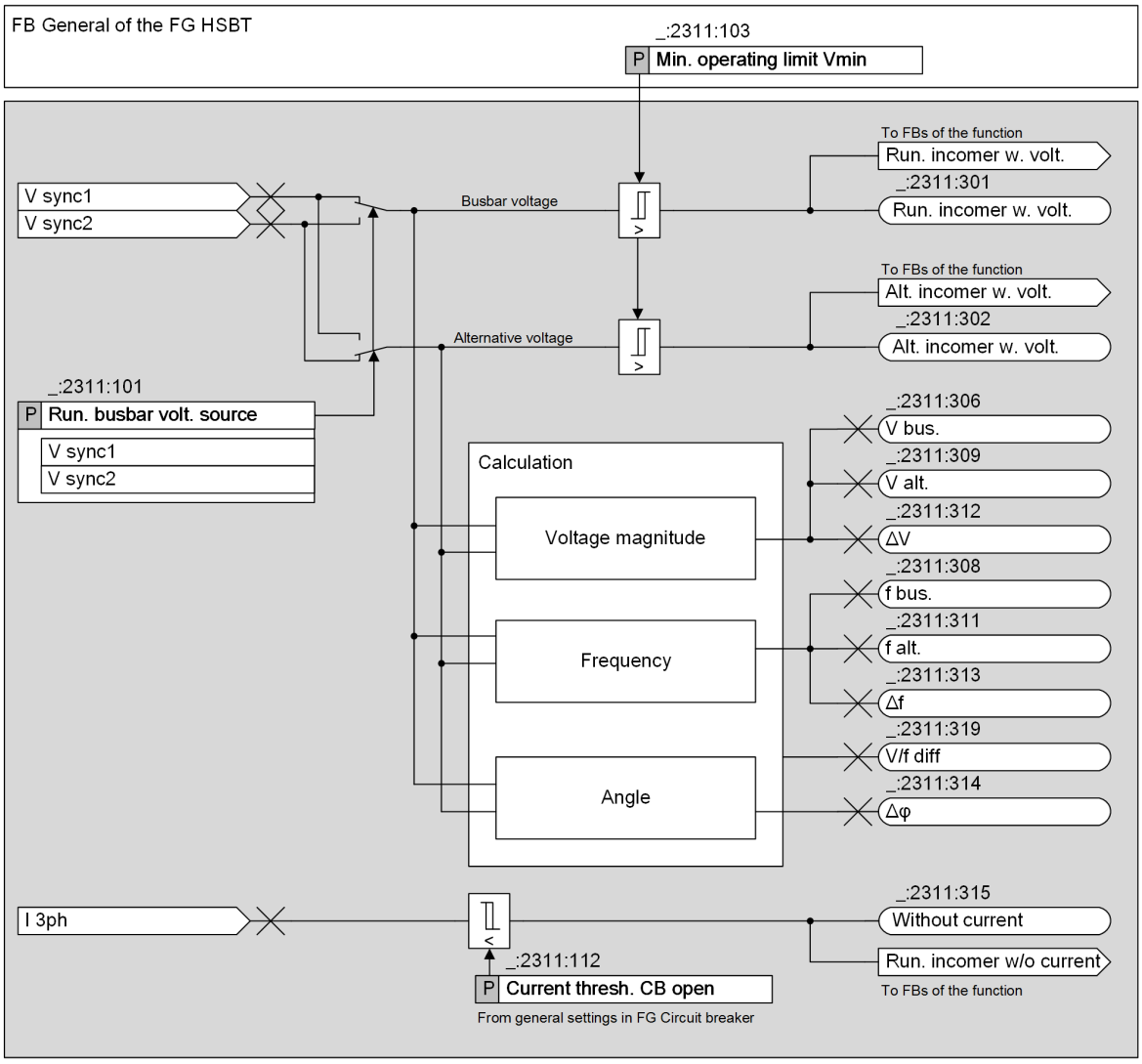
Logic



[lo_FN_stage control, 2, en_US]

Figure 6-10 Logic Diagram of the Function Control

(1) For the detailed logic of the function **Transfer direction**, refer to the following chapters.



[lo_FN_general, 1, en_US]

Figure 6-11 Logic Diagram of the General Functionality

Measurands

The voltages V_{sync1} and V_{sync2} are from both sides of the CB to be closed.

The current ***I 3ph*** is the 3-phase current of the CB to be opened.

Busbar to Be Transferred

Due to the complexity of the actual applications, the voltage source of the busbar to be transferred must be specified in each transfer direction. In this function, you set the voltage source of the busbar to be transferred with the parameter **Run. busbar volt. source**.

You can set the parameter **Run. busbar volt. source** to ***V sync1*** or ***V sync2*** according to the busbar location on the specific side of the circuit breaker to be closed:

- If the busbar to be transferred is on the side where the voltage V_{sync1} comes from, set the parameter **Run. busbar volt. source** to ***V sync1***.
  Here, V_{sync1} is the busbar voltage and V_{sync2} is the alternative voltage.

- If the busbar to be transferred is on the side where the voltage V_{sync2} comes from, set the parameter **`Run. busbar volt. source`** to ***`V sync2`***.
  Here, V_{sync2} is the busbar voltage and V_{sync1} is the alternative voltage.

Fundamental Components

The function **Transfer direction** provides the following fundamental components. These fundamental components are real-time values and are displayed on the operation panel.

Table 6-2 Fundamental Components

Values	Description	Unit			% Referenced to
		Primary	Secondary	Phase Angle	
V bus.: A V bus.: B V bus.: C	Real-time phase-to-ground voltages on the busbar to be transferred These values are visible only when the relevant voltage transformer is connected in one of the following connection types: • ***`3 ph-to-gnd voltages`*** • ***`3 ph-to-gnd volt. + VN`***	kV	V	°	Primary rated voltage of the voltage transformer connected to the busbar side of the CB to be closed
V bus.: AB V bus.: BC V bus.: CA	Real-time phase-to-phase voltages on the busbar to be transferred These values are visible only when the relevant voltage transformer is connected in one of the following connection types: • ***`3 ph-to-gnd voltages`*** • ***`3 ph-to-gnd volt. + VN`*** • ***`3 ph-to-ph voltages`*** • ***`3 ph-to-ph volt. + VN`*** • ***`2 ph-to-ph voltages`*** • ***`2 ph-to-ph volt. + VN`***	kV	V	°	

Values	Description	Unit			% Referenced to
		Primary	Secondary	Phase Angle	
V alt.: A V alt.: B V alt.: C	Real-time phase-to-ground voltages of the alternative incomer or the busbar energized by the alternative incomer These values are visible only when the relevant voltage transformer is connected in one of the following connection types: • ***3 ph-to-gnd voltages*** • ***3 ph-to-gnd volt. + VN***	kV	V	°	Primary rated voltage of the voltage transformer connected to the other side of the CB to be closed
V alt.: AB V alt.: BC V alt.: CA	Real-time phase-to-phase voltages of the alternative incomer or the busbar energized by the alternative incomer These values are visible only when the relevant voltage transformer is connected in one of the following connection types: • ***3 ph-to-gnd voltages*** • ***3 ph-to-gnd volt. + VN*** • ***3 ph-to-ph voltages*** • ***3 ph-to-ph volt. + VN*** • ***2 ph-to-ph voltages*** • ***2 ph-to-ph volt. + VN***	kV	V	°	
V alt.	Real-time 1-phase voltage of the alternative incomer This value is visible only when the 1-phase voltage measuring point is connected.	kV	V	°	

Functional Measured Values

The function **Transfer direction** provides the following functional measured values. These functional measured values are calculated and are displayed on the operation panel.

Table 6-3 Functional Measured Values

Values	Description	Unit		% Referenced to
		Primary	Secondary	
V bus.	Magnitude of the calculated busbar voltage	kV	V	**`Rated voltage`** set in the function group **Circuit breaker** for the CB to be closed
V alt.	Magnitude of the calculated alternative voltage	kV	V	
ΔV	Voltage difference: ΔV = V bus. - V alt. The calculation of ΔV takes the actual power-transformer ratio (parameter **`Vsync ratio (transform.)`**) into account.	kV	V	
f bus.	Frequency of the calculated busbar voltage	Hz	Hz	Rated frequency
f alt.	Frequency of the calculated alternative voltage	Hz	Hz	
Δf	Frequency difference: Δf = f bus. - f alt.	Hz	Hz	
Δφ	Angle difference: Δφ = φ bus. - φ alt. The calculation of Δφ takes the phase-displacement angle (parameter **`Angle adjust. (transform.)`**) into account.	°		–
V/f diff	V/f difference between the busbar voltage per Hz and the alternative voltage per Hz	–		–

6.2.4.2 Application and Setting Notes

Parameter: **`Run. busbar volt. source`**

- Default setting **`(_:2311:101) Run. busbar volt. source`** = ***`none`***

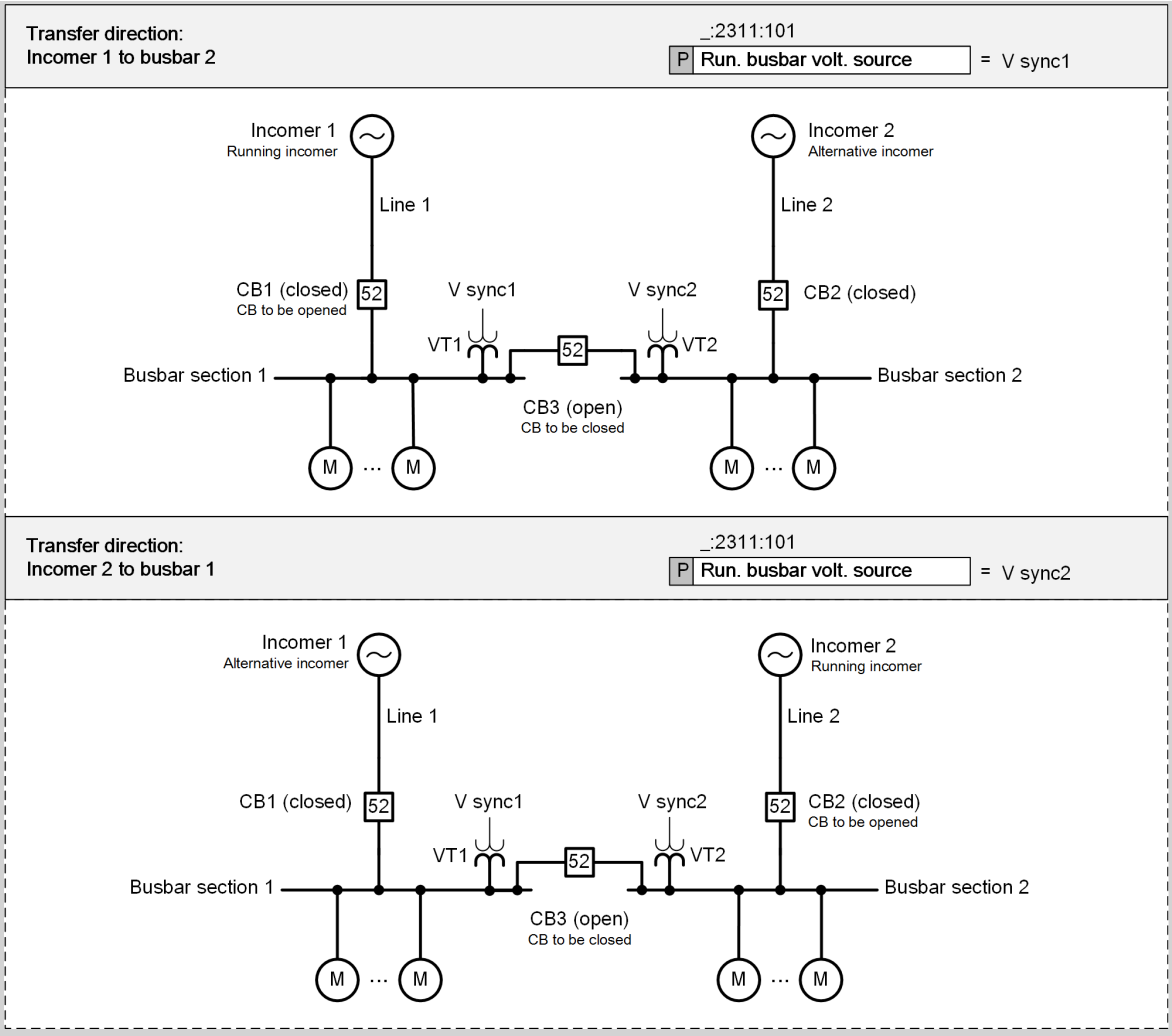
With the parameter **`Run. busbar volt. source`**, you specify the voltage source of the busbar to be transferred by setting the busbar voltage to V_{sync1} or V_{sync2}. The voltages V_{sync1} and V_{sync2} are from both sides of the circuit breaker to be closed.

Parameter Value	Description
`none`	When instantiating a new function **Transfer direction**, this parameter is set to ***`none`*** by default. Set the parameter according to the specific application. If you keep the default setting ***`none`***, DIGSI 5 reports an inconsistency.
`V sync1`	The voltage source of the busbar to be transferred is V_{sync1} of the circuit breaker to be closed. The voltage V_{sync1} is the busbar voltage and the voltage V_{sync2} is the alternative voltage.
`V sync2`	The voltage source of the busbar to be transferred is V_{sync2} of the circuit breaker to be closed. The voltage V_{sync2} is the busbar voltage and the voltage V_{sync1} is the alternative voltage.

EXAMPLE

The following figure shows the setting example for the 2 transfer directions in the application of a sectionalized busbar with 2 incomers:

- Transfer direction 1: **Incomer 1 to busbar 2** (Incomer 1 to Busbar section 2)
- Transfer direction 2: **Incomer 2 to busbar 1** (Incomer 2 to Busbar section 1)



[dw_example_2_en_US]

Figure 6-12 Setting Example

Table 6-4 Circuit Breakers Used for the 2 Transfer Directions

Transfer Directions	CB to be Closed	CB to be Opened
Incomer 1 to busbar 2	CB3	CB1
Incomer 2 to busbar 1	CB3	CB2

For the 2 transfer directions, the circuit breakers to be closed are both CB3 (section CB). According to *Figure 6-12*, voltages from both sides of CB3 are defined as follows:

- The voltage V_{sync1} is measured via VT1. The measuring point from VT1 is routed to the interface $\mathbf{V_{sync1}}$.
- The voltage V_{sync2} is measured via VT2. The measuring point from VT2 is routed to the interface $\mathbf{V_{sync2}}$.

The busbars to be transferred for the 2 transfer directions are different:

- For the transfer direction **Incomer 1 to busbar 2**, the busbar to be transferred is the busbar section 1. The voltage source of the busbar section 1 is V_{sync1}. For this case, set the parameter **`Run. busbar volt. source`** to ***`V sync1`***.
- For the transfer direction **Incomer 2 to busbar 1**, the busbar to be transferred is the busbar section 2. The voltage source of the busbar section 2 is V_{sync2}. For this case, set the parameter **`Run. busbar volt. source`** to ***`V sync2`***.

Parameter: **`Manual start only`**

- Default setting **`(_:2311:102) Manual start only`** = ***`yes`***

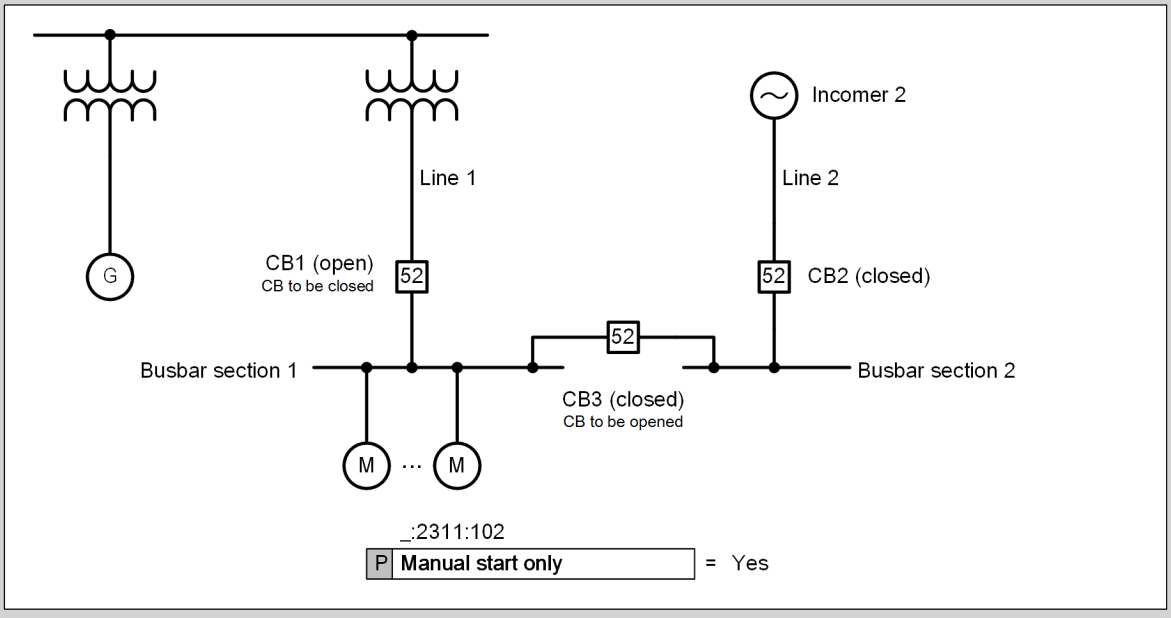
With the parameter **`Manual start only`**, you specify whether a transfer can only be started manually or not.

Parameter Value	Description
`yes`	The transfer can only be started manually. If a transfer is only allowed to be started manually, set the parameter to ***`yes`***.
`no`	The transfer can be started via all supported start types.

EXAMPLE

The following figure shows the transfer direction **Busbar 2 to incomer 1** in the application of a sectionalized busbar with 2 incomers. The generator acts as incomer 1.

For this transfer direction, the operations are to open CB3 (section CB) on the sectionalized busbar and to close CB1. This transfer must be started manually after the generator is running. For this case, set the parameter **`Manual start only`** to ***`yes`***.



[dw_example_manual start only, 2, en_US]

Figure 6-13 Setting Example

Parameter: **`Min. operating limit Vmin`**

- Default setting **`(_:2311:103) Min. operating limit Vmin`** = ***`90.0 %`***

You can find the parameter in the FB **General** of the FG **HSBT**.

With the parameter **`Min. operating limit Vmin`**, you set the threshold value to identify whether the system is live or not. If the measured voltage is larger than the setting value, the system is live.

The value of the parameter **`Min. operating limit Vmin`** is given in percentage. For both the busbar voltage and the alternative voltage, the reference value is the primary rated voltage of the CB to be closed.

Parameter: **`Current thresh. CB open`**

- Default setting **`(_:2311:112) Current thresh. CB open`** = ***`0.100 A`*** for I_{rated} = 1 A
- Default setting **`(_:2311:112) Current thresh. CB open`** = ***`0.500 A`*** for I_{rated} = 5 A

You can find the parameter in the FG **Circuit breaker**.

For the FG **HSBT**, the setting value of the parameter **`Current thresh. CB open`** must be greater than the no-load current.

For more information, refer to *Parameter: Current Threshold Circuit Breaker Open, Page 249*.

6.2.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	off
_:2311:102	General:Manual start only		• no • yes	yes
_:2311:101	General:Run. busbar volt. source		• none • V sync1 • V sync2	none
_:2311:103	General:Low volt. load-shedding		• no • yes	no

6.2.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:502	General:>Block transfer	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:54	General:Inactive	SPS	O
_:2311:51	General:Mode (controllable)	ENC	C
_:2311:301	General:Run. incomer w. volt.	SPS	O
_:2311:302	General:Alt. incomer w. volt.	SPS	O
_:2311:315	General:Without current	SPS	O
_:2311:306	General:V bus.	MV	O
_:2311:308	General:f bus.	MV	O
_:2311:309	General:V alt.	MV	O
_:2311:311	General:f alt.	MV	O
_:2311:312	General:ΔV	MV	O
_:2311:313	General:Δf	MV	O
_:2311:314	General:Δφ	MV	O
_:2311:319	General:V/f diff	MV	O

6.2.5 Ready Check

6.2.5.1 Description

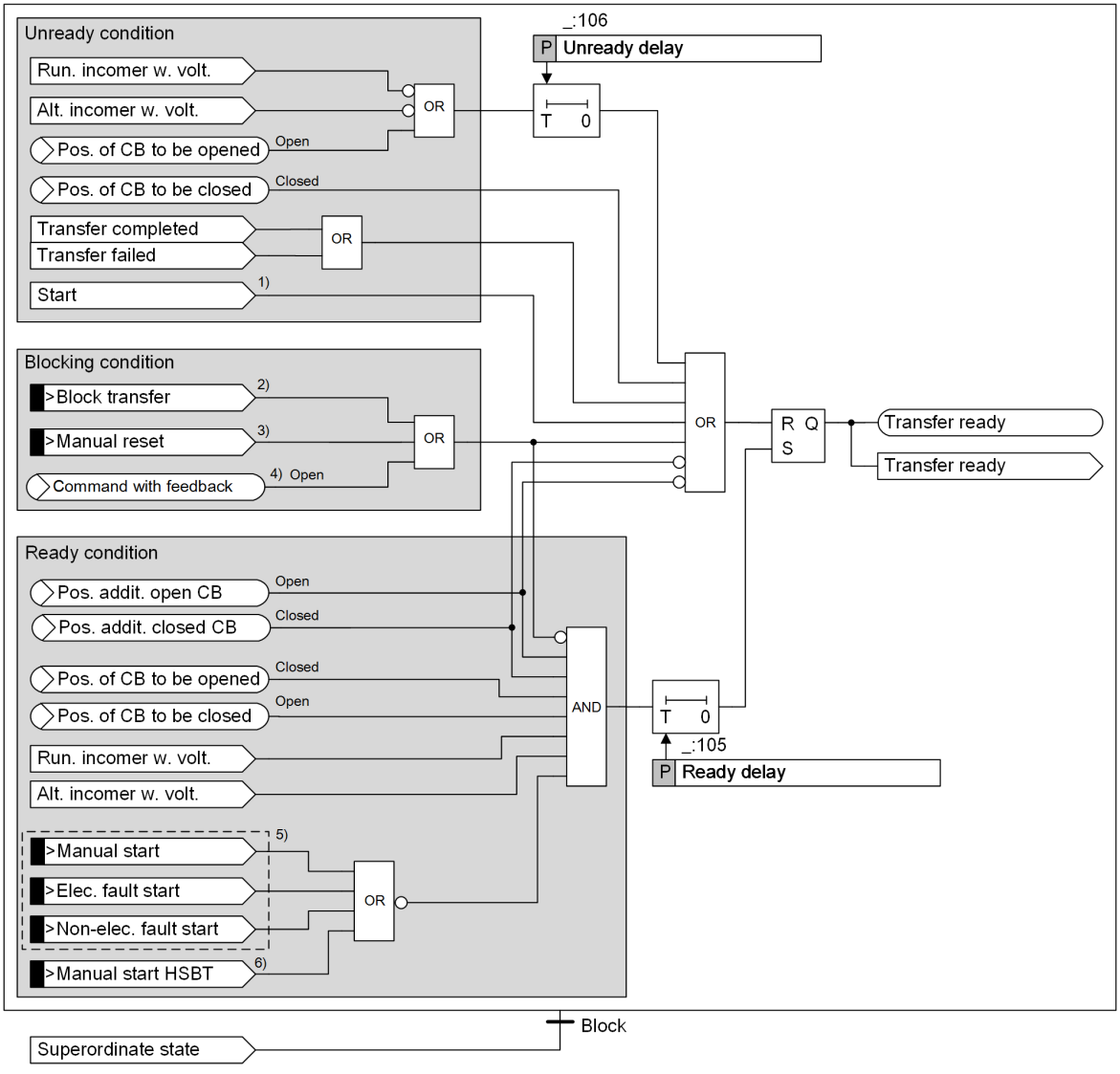
To secure reliable transfers, the function block **Ready check** checks the power-system conditions and estimates if the busbar transfer is possible in a direction. Transfers are possible only when the power-system conditions indicate the ready criterion (see *Figure 6-14*).

In DIGSI 5, the function block **Ready check** is available once the function group is instantiated.

The function block **Ready check** is composed of 3 logic blocks:

- Ready condition
- Unready condition
- Blocking condition

The following figure shows the general logic.



[lo_FB_Readiness_HSBT, 4, en_US]

Figure 6-14 General Logic of the Function Block Ready Check

(1) Any other transfer that is started in the same transfer priority group
(2) From FB **General** of FN **Transfer direction**
(3) From FB **General** of FG **HSBT**
(4) From FB **Control** of the CB to be opened
(5) From FB **Start**
(6) From FG **Circuit breaker** for the CB to be opened

For more information, refer to *6.2.5.2 Application Example*.

Command with Feedback

If you manually open the CB to be opened via the operation panel or via sending a control command to the device, the signal **Command with feedback** of the CB is issued and the transfer is blocked.

NOTE

If the CB is manually opened outside the device, the signal with the opening information must be connected to the binary input *>Block HSBT* to block the transfer.

Result of Ready Check

Transfer ready indicates the result of the ready check. If the status of the indication *Transfer ready* is *on*, the power system is ready for a busbar transfer in the direction. Otherwise, the busbar transfer in this direction is impossible.

In DIGSI 5, you can route the indication *Transfer ready* by navigating to the target device and selecting **Information routing** > **HSBT** > **General**.

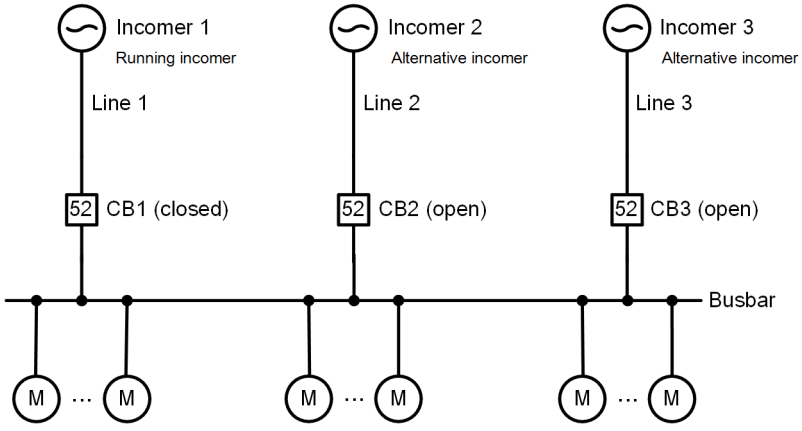
Time Delay

With the parameters **Ready delay** and **Unready delay**, you define the time delay that the busbar transfer takes in a direction to enter the ready condition or the unready condition.

In DIGSI 5, you can configure the parameters **Ready delay** and **Unready delay** by navigating to the target device and selecting **Settings** > **HSBT** > **General** > **Ready check**.

6.2.5.2 Application Example

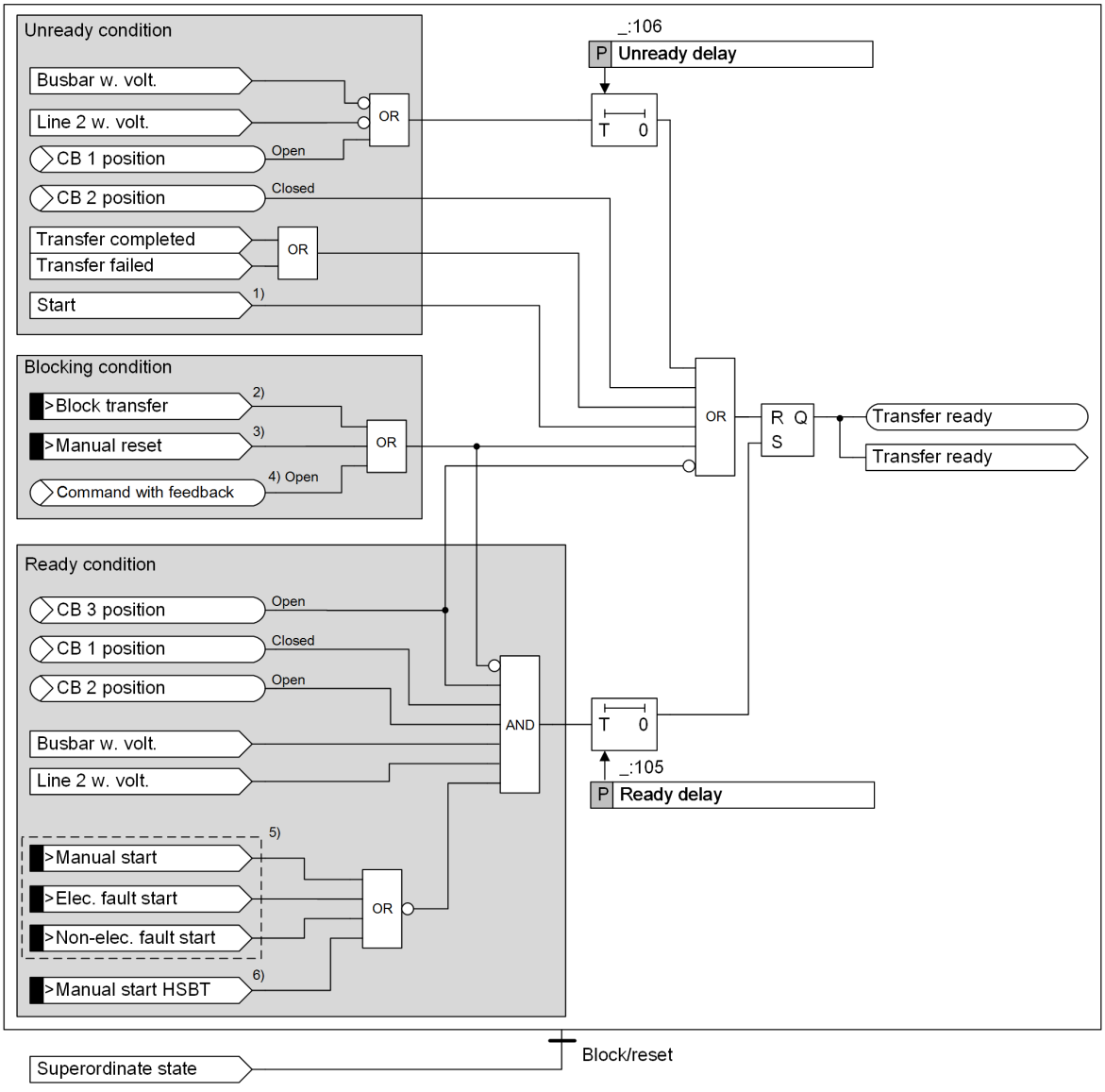
The following figure shows an application example of a single busbar with 3 incomers. The transfer direction is from incomer 1 to incomer 2.



[dw_1BB_3L-readiness, 2, en_US]

Figure 6-15 Application Example

The following figure shows the corresponding logic diagram.



[lo_FB_Readiness_HSBT_exp, 4, en_US]

Figure 6-16 Example: Logic Diagram Function Block Ready Check

(1) Any other transfer that is started in the same transfer priority group
(2) From FB **General** of FN **Transfer direction**
(3) From FB **General** of FG **HSBT**
(4) From FB **Control** of CB 1
(5) From FB **Start**
(6) From FG **Circuit breaker** for the CB to be opened

Ready Condition

If the following prerequisites are met, the transfer enters the ready condition with a time delay:

- The busbar voltage is above the threshold value **`Min. operating limit Vmin`**.
- The voltage of line 2 is above the threshold value **`Min. operating limit Vmin`**.
- CB 1 is closed.

- CB 2 is open.
- CB 3 which is taken as the additional CB remains open.
- The signals *>Manual start*, *>Elec. fault start*, and *>Non-elec. fault start* are inactive.

Unready Condition

There are 2 kinds of unready condition:

- With time delay
  If any of the following requisitions is met, the transfer enters the unready condition with a time delay:
  - The busbar voltage is below the dropout value of the threshold value **Min. operating limit Vmin**.
  - The voltage of line 2 is below the dropout value of the threshold value **Min. operating limit Vmin**.
  - CB 1 is open.
- Without time delay
  If any of the following requisitions is met, the transfer enters the unready condition without a time delay:
  - If CB 2 is closed, the transfer enters the unready condition immediately.
  - The transfer is completed or failed.
  - Another transfer is started in the same transfer priority group.

Block Condition

If any of the following prerequisites is met, the transfer enters the unready condition immediately:

- The function block **Ready check** receives the signal *>Block transfer*.
  You can find the signal in DIGSI 5 under **Target device** > **Information routing** > **HSBT** > **Transfer direction** > **General**.
- The function block **Ready check** receives the signal *>Manual reset*.
  You can find the signal in DIGSI 5 under **Target device** > **Information routing** > **HSBT** > **General**.
- CB 1 is opened manually via the operation panel or via sending a control command to the device.

6.2.5.3 Settings

Settings from the FB General of the FG HSBT

Addr.	Parameter	C	Setting Options	Default Setting
Ready check				
_:2311:105	General:Ready delay		5.00 s to 60.00 s	10.00 s
_:2311:106	General:Unready delay		5.00 s to 60.00 s	10.00 s

6.2.5.4 Information List

No.	Information	Data Class (Type)	Type
Ready check			
_:21931:300	Ready check:Transfer ready	SPS	O

6.2.6 Start

6.2.6.1 Description

Once the signal *Transfer ready* is issued, the device checks whether there is any start required in the transfer direction. The start type determines the transfer sequence which you set with the corresponding parameter in each transfer direction.

- Start types
  - Manual start
  - Fault start (electric fault start, non-electric fault start)
  - Undervoltage start
  - Underfrequency start
  - CB inadvertent opening start
  - Additional start
- Transfer-sequence types
  - Parallel
  - Simultaneous
  - Sequential

  For more information, refer to *6.2.7.1 Overview*.

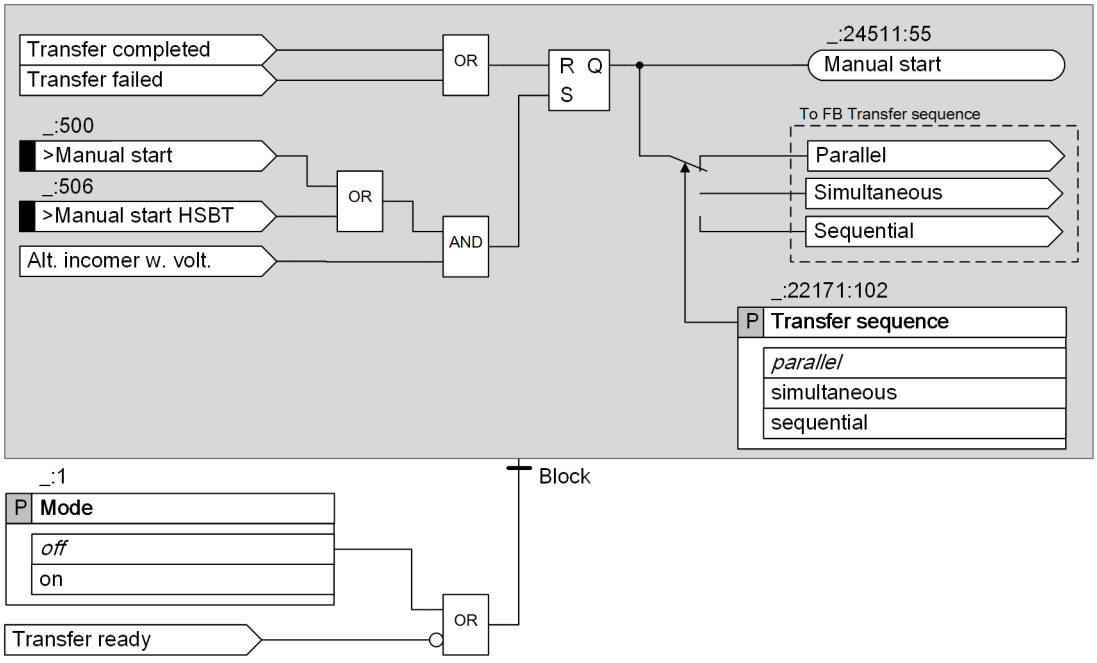
6.2.6.2 Manual Start

The functionality **Manual start** is used when a transfer must be started manually for a planned transfer (for example, a transfer during the maintenance of the incomer).

To enable the functionality **Manual start**, you must configure as follows in DIGSI 5:

- In the Editor **Start**, set the parameter **Mode** of the functionality **Manual start** to *on*.
- In the Editor **Information routing**, route the start command of the function **Transfer direction** to the binary input *>Manual start* or route the binary input *>Manual start HSBT* in the FG **Circuit breaker** for the CB to be opened.

With the functionality **Manual start**, all 3 transfer-sequence types are possible.



[lo_FB_Manual_Start_HSBT, 3, en_US]

Figure 6-17 Logic Diagram Manual Start Condition

6.2.6.3 Fault Start

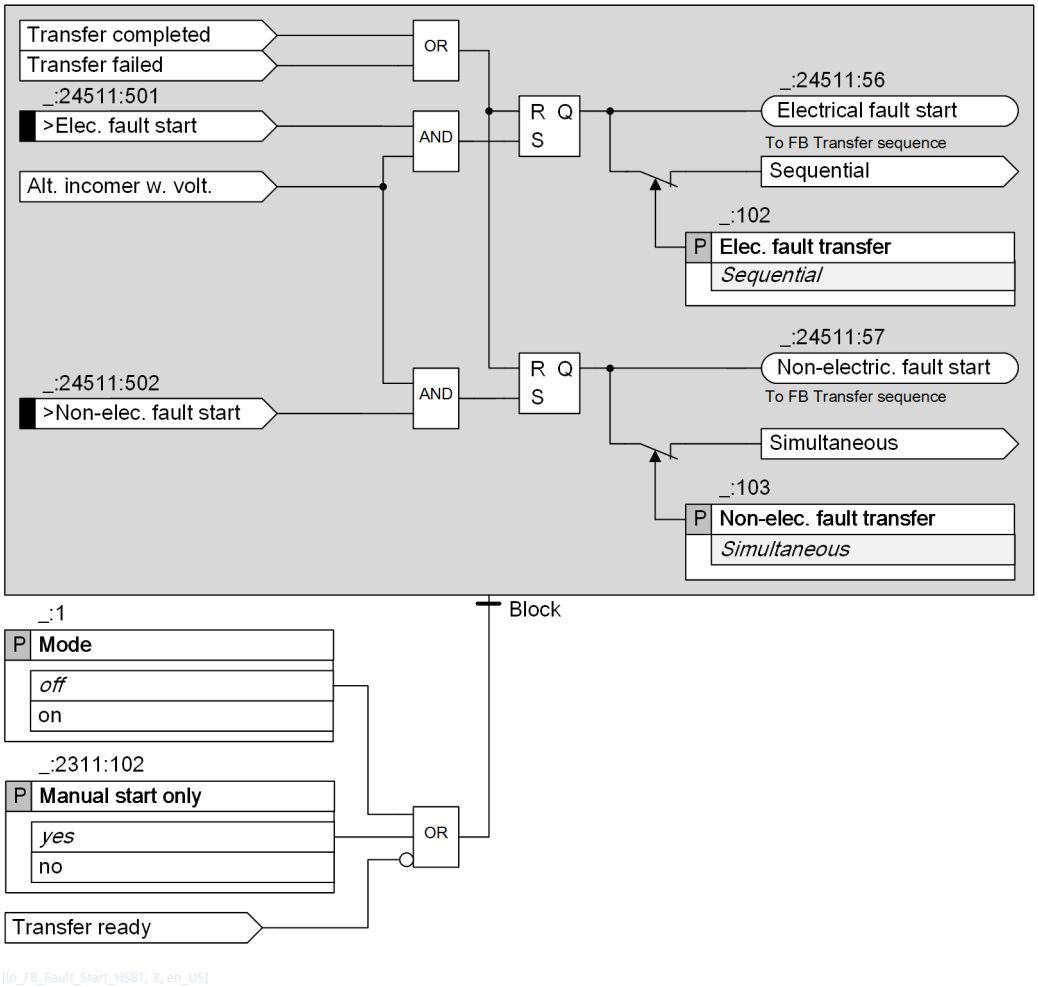
The functionality **Fault start** is used when a transfer is started externally. The start command must be issued by an external device, for example, a protection device. A protection device detects and clears faults that occur on the running incomer. For example, the function **Transformer differential protection** (ANSI 87T) clears faults on the transformer.

The faults are classified into 2 types:

- Electrical faults
  Faults that occur in the circuit, for example, a 1-phase ground fault of the transformer or line
- Non-electrical faults
  Faults that do not occur in the circuit, for example, a mechanical fault

To optimize the transfer sequence, 2 fault-start types are provided:

- Electrical fault start
  This start type only supports the sequence type ***sequential***.
- Non-electrical fault start
  This start type only supports the sequence type ***simultaneous***.



[lo_FB_Fault_Start_HSBT, 3, en_US]

Figure 6-18 Logic Diagram Fault-Start Condition

To enable the **Fault start** condition, you must configure as follows in DIGSI 5:

- In the Editor **Start**, set the parameter **Mode** of the functionality **Fault start** to ***on***.
- In the Editor **Information routing**, route the **Operate** command from the protection device for the running incomer to the binary input signal *>Elec. fault start* or *>Non-elec. fault start*.

6.2.6.4 Fault Detection

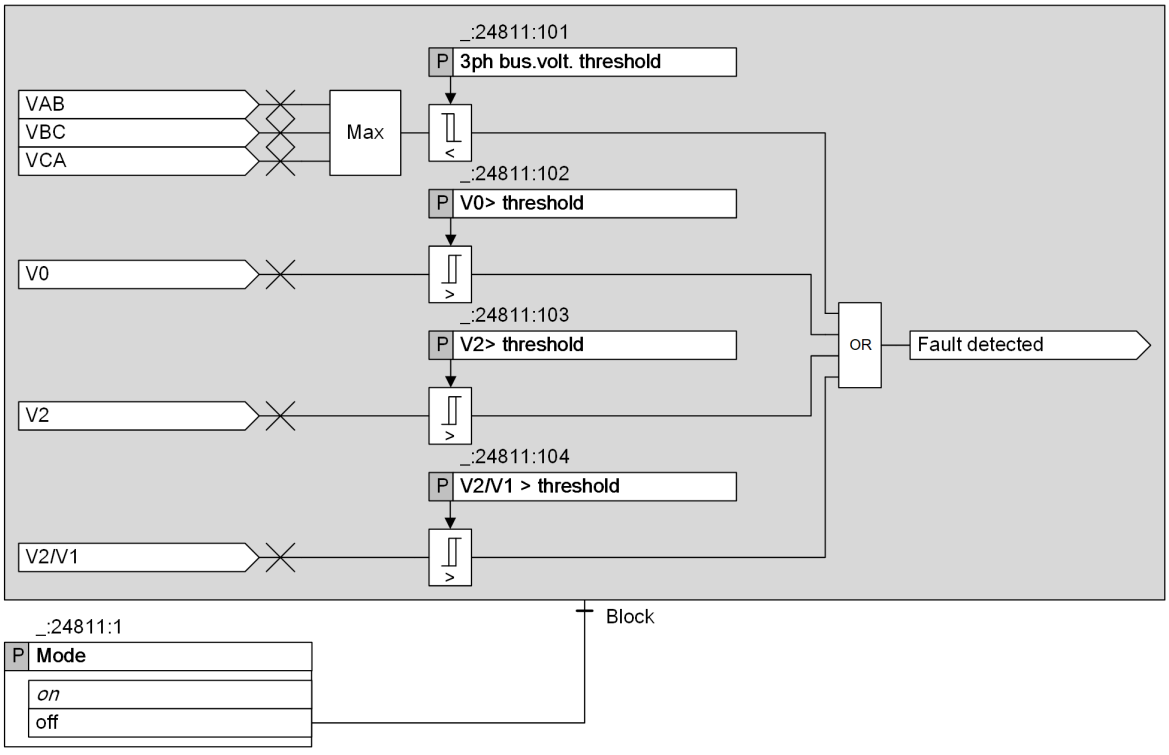
In the function group **HSBT**, if an upstream power loss occurs, the functionality **Undervoltage start** or **Underfrequency start** is activated. If an electrical fault occurs, the functionalities **Undervoltage start** and **Underfrequency start** are blocked. For reliable transfer, electrical faults (for example, faults on the busbar) must be monitored.

The functionality **Fault detection** is used to detect the electrical fault.

NOTE

During the primary test, if no rotating load is connected to the busbar, the opening of the circuit breaker which connects the running incomer and the busbar results in the voltage dip of the busbar. For this situation, the functionality **Fault detection** must be used to detect the voltage dip and to block the self-starting of a transfer.

Logic



[lo_fault detection, 1, en_US]

Figure 6-19 Logic Diagram of the Functionality Fault Detection

Measurands

The input voltages for the fault detection are all voltages of the busbar to be transferred.

Fault Detection

An electrical fault is detected if one of the following criteria is fulfilled:

- The maximum phase-to-phase voltage (V_{AB}, V_{BC}, or V_{CA}) of the busbar falls below the threshold value specified by the parameter **`3ph bus.volt. threshold`**.
- The zero-sequence voltage V0 of the busbar exceeds the threshold value specified by the parameter **`V0> threshold`**.
- The negative-sequence voltage V2 of the busbar exceeds the threshold value specified by the parameter **`V2> threshold`**.
- The ratio of the negative-sequence voltage to the positive-sequence voltage V2/V1 exceeds the threshold value specified by the parameter **`V2/V1 > threshold`**.

If an electrical fault is detected, the following functionalities are blocked:

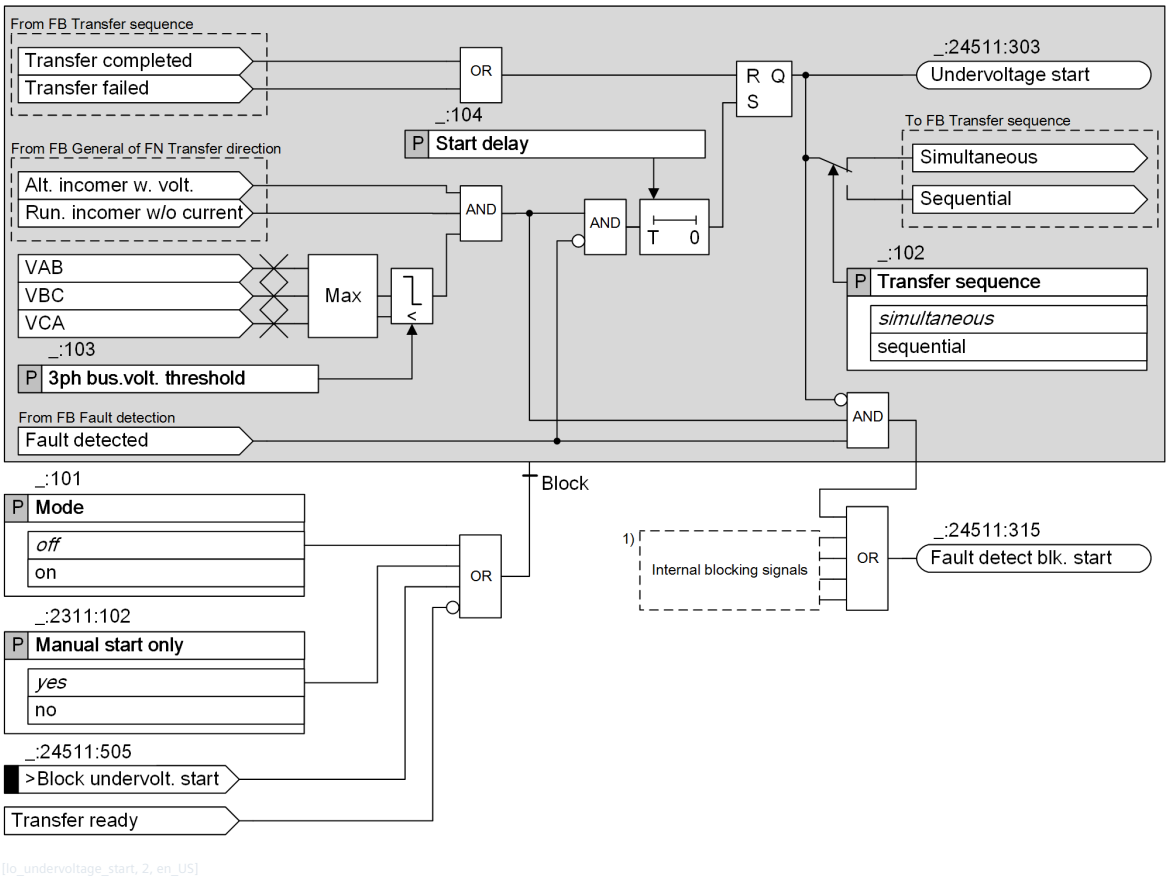
- **Undervoltage start**
- **Underfrequency start**
- **CB inadvertent opening start**
- **Additional start** which is optionally blocked by setting the parameter **`Block by fault detection`**.

For more information, refer to the respective chapters.

6.2.6.5 Undervoltage Start

The functionality **Undervoltage start** is used to realize the self-starting of a transfer due to the power loss on the busbar caused by an upstream power loss (for example, the upstream CB is tripped due to a fault).

Logic



[lo_undervoltage_start, 2, en_US]

Figure 6-20 Logic Diagram of the Functionality Undervoltage Start

(1) Internal blocking signals from other start conditions with the fault-detection logic

Pickup of the Undervoltage Start

The functionality **Undervoltage start** picks up only when all the following conditions are fulfilled:

- The alternative incomer is energized. That is, the alternative voltage exceeds the threshold value **`Min. operating limit Vmin`** from the function block **General** of the function **Transfer direction**.
  It is a precondition for a transfer, which ensures that the busbar can be energized by the alternative incomer after the completion of this transfer.
- The running incomer is de-energized, which leads to the current loss in all the 3 phases of the CB to be opened.
- All phase-to-phase voltages (V_{AB}, V_{BC}, and V_{CA}) of the busbar fall below the undervoltage limit set using the parameter **`3ph bus.volt. threshold`**.



NOTE

If the functionality **Fault detection** picks up, the functionality **Undervoltage start** is blocked.

Resetting of the Undervoltage Start

After a transfer is completed (indication *Transfer completed*) or fails (indication *Transfer failed*), the functionality **Undervoltage start** is reset.

Blocking of the Undervoltage Start

The functionality **Undervoltage start** can be blocked via one of the following ways:

- Via the voltage-transformer miniature circuit breaker
  If the voltage-transformer miniature circuit breaker (MCB) on the busbar is open, the undervoltage start is blocked. The opening status of the MCB is detected via the binary input signal *>Open* of the function block **VT miniature CB** in the power-system data.
- Via the electrical fault on the busbar or in the motor

6.2.6.6 Underfrequency Start

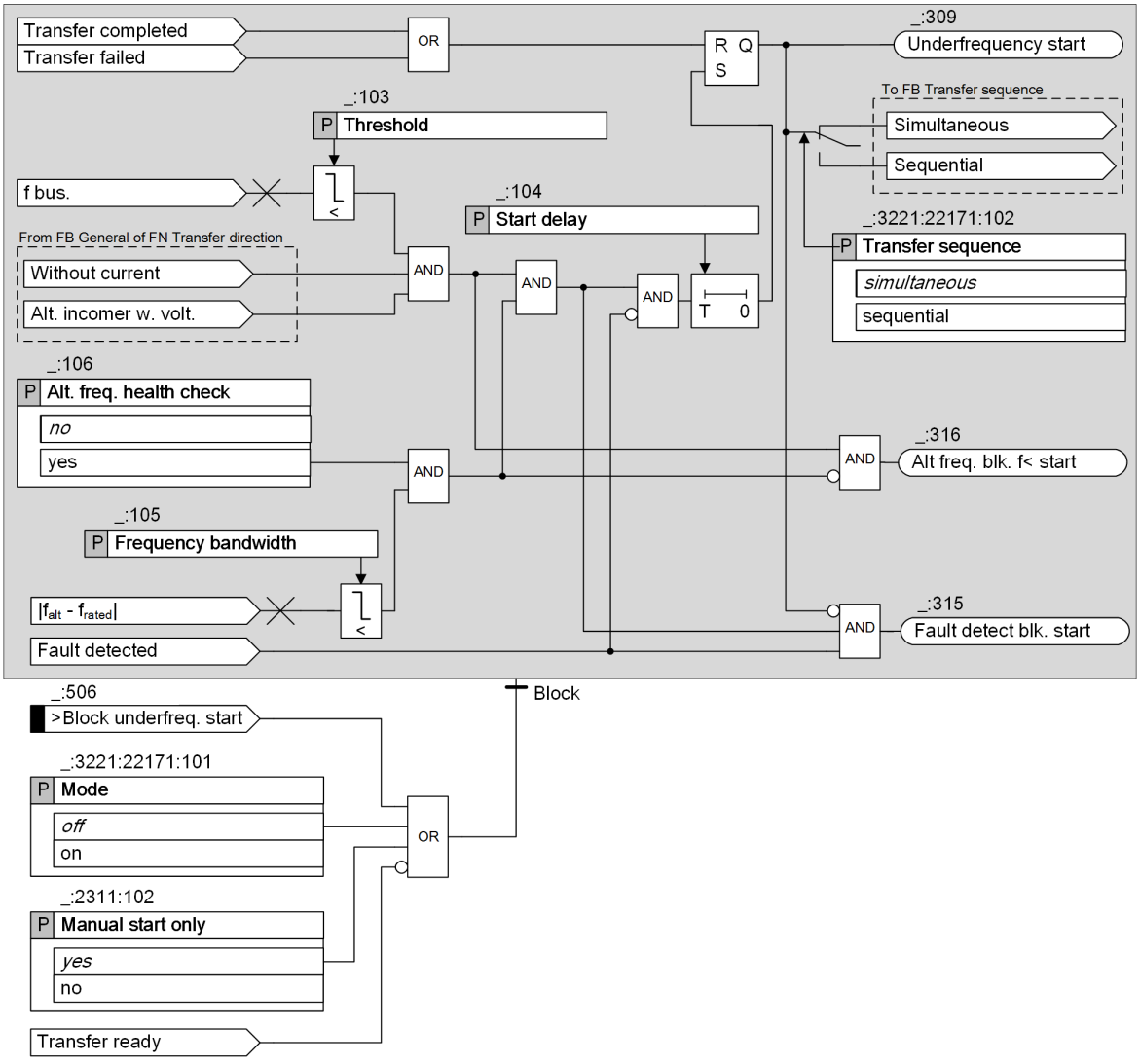
Description

The functionality **Underfrequency start** is used to realize the self-starting of a transfer when the upstream power loss occurs.

If the following conditions are met, the **Underfrequency start** operates:

- The busbar frequency is under the set threshold value.
- There is no current in the running incomer.
- The alternative incomer is reliable:
  - The alternative incomer is energized.
  - The frequency of the alternative incomer is in the allowed frequency band.
    This condition is selective. You can determine whether to check the frequency of the alternative incomer via the parameter **`Alt. freq. health check`**.
- There is no fault on the busbar or in the motor.

Logic



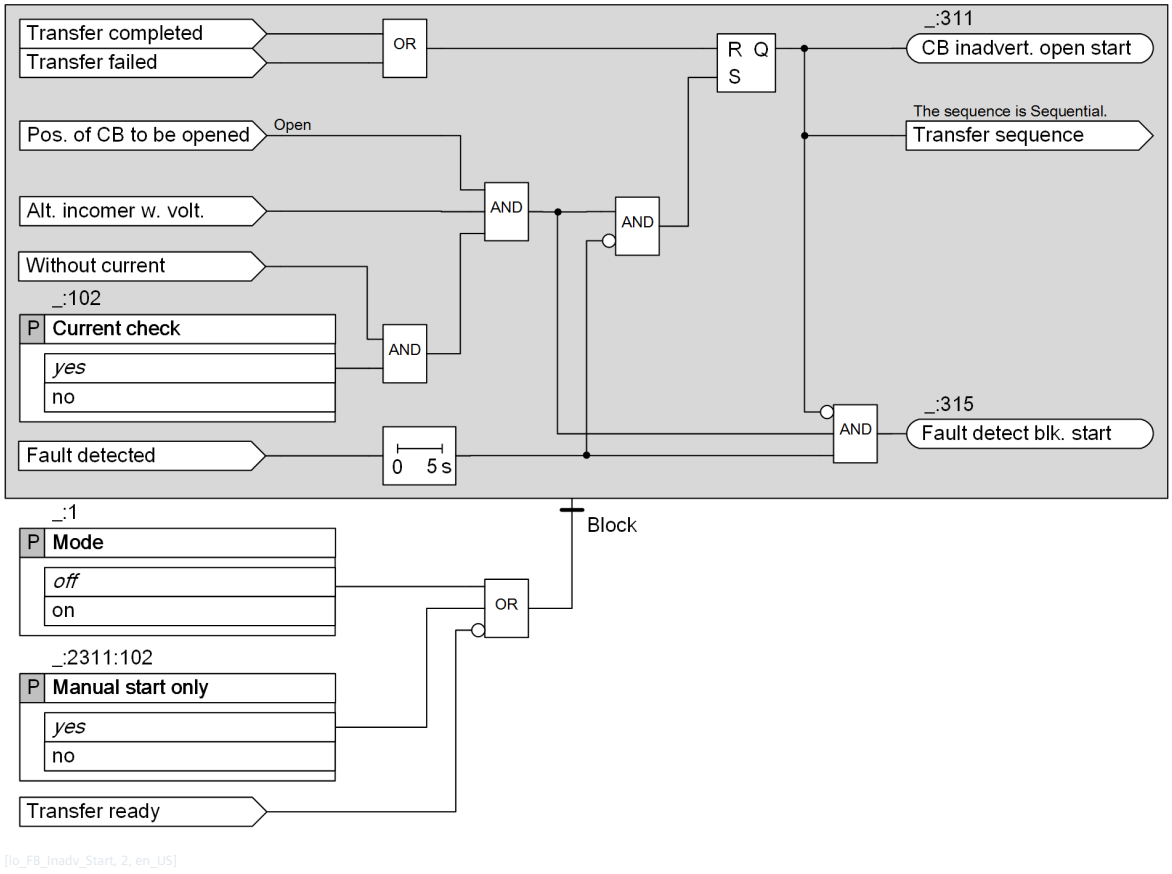
[lo_FB_underfreq_Start, 2, en_US]

Figure 6-21 Logic Diagram of the Underfrequency Start

6.2.6.7 CB Inadvertent Opening Start

The functionality **CB inadvertent opening start** is used due to the power loss of the busbar when the circuit breaker of the running incomer opens inadvertently.

Logic



[lo_FB_Inadv_Start, 2, en_US]

Figure 6-22 Logic Diagram of the Functionality CB Inadvertent Opening Start

6.2.6.8 Additional Start

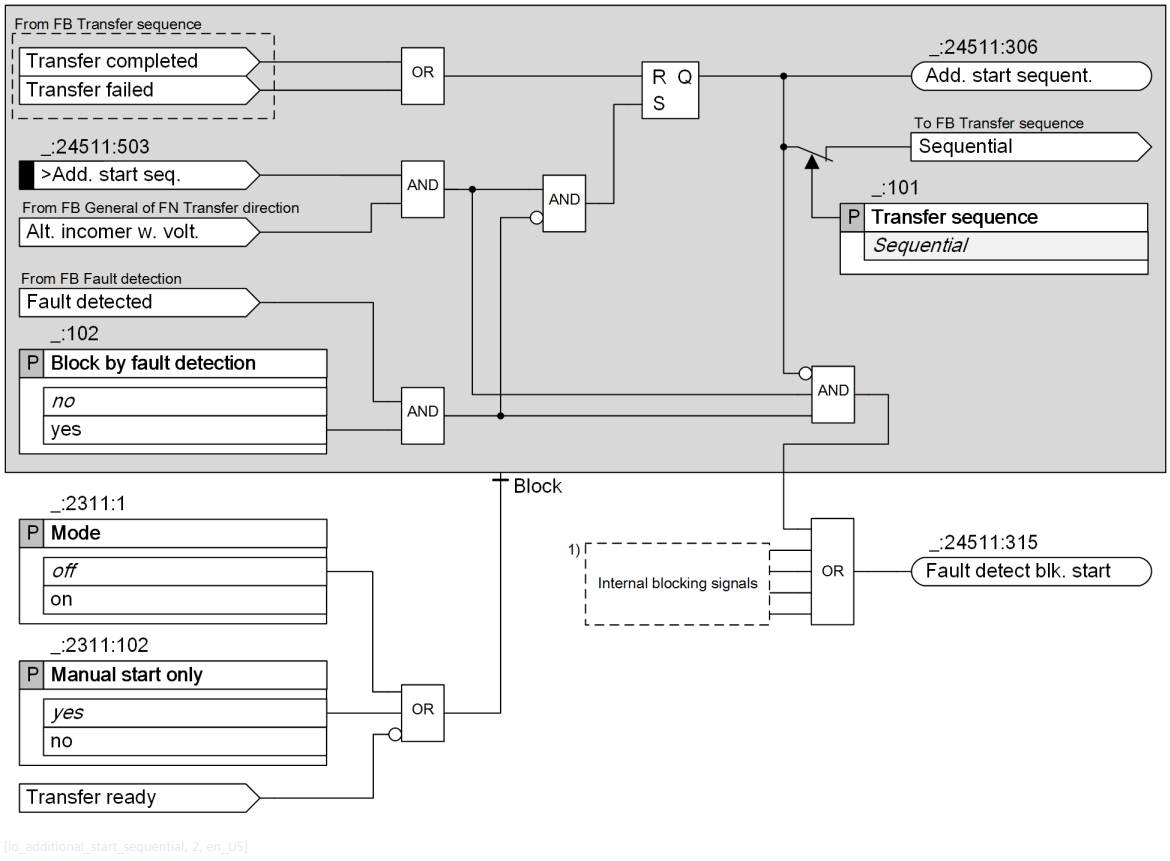
Besides the preceding start conditions, the functionality **Start** provides a possibility which is called the additional start. With the additional start, you can use internal or external commands to define new start conditions. The command can be a signal which indicates a reverse power or indicates an inadmissible rate of frequency change. The command can also be an output signal from a CFC chart.

To work with the function block **Transfer sequence**, the additional start provides the following types:

- **Additional start - sequential**, which can only work with the sequence type **Sequential**.
- **Additional start - simultaneous**, which can only work with the sequence type **Simultaneous**.

For more information about the sequence type, refer to *6.2.7 Transfer Sequence*.

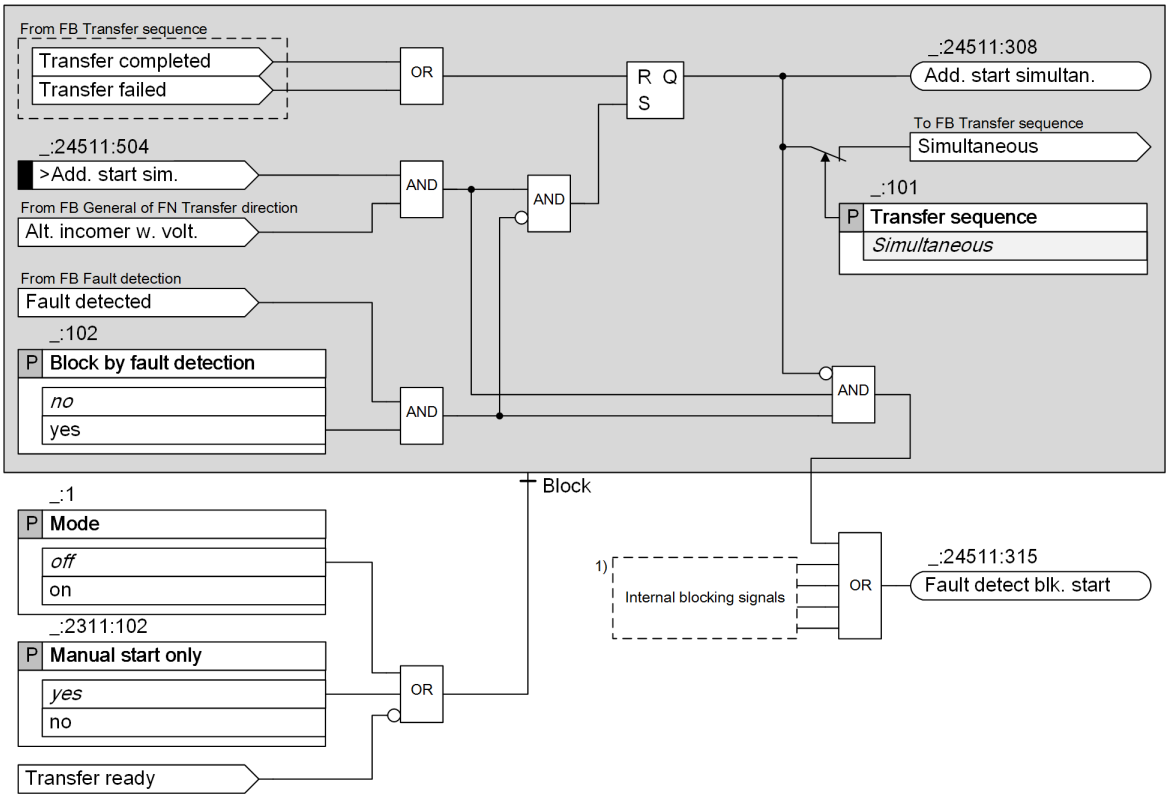
Logic



[lo_additional_start_sequential, 2, en_US]

Figure 6-23 Logic Diagram of the Functionality **Additional Start – Sequential**

(1) Internal blocking signals from other start conditions with the fault-detection logic



[lo_additional_start_simultaneous, 2, en_US]

Figure 6-24 Logic Diagram of the Functionality **Additional Start – Simultaneous**

(1) Internal blocking signals from other start conditions with the fault-detection logic

If the alternative incomer is energized, you can use the binary input signal *>Add. start seq.* to activate the functionality **Additional start - sequential**.

You can use the parameter **Block by fault detection** to specify whether to block the functionality **Additional start - sequential** by a detected electrical fault on the busbar.

The functionality **Additional start - simultaneous** is activated and blocked in the same way.

6.2.6.9 Application and Setting Notes (Fault Detection)

Parameter: 3ph bus.volt. threshold, V0> threshold, V2> threshold, V2/V1 > threshold

- Default setting **(_:24811:101) 3ph bus.volt. threshold** = *10.00 %*
- Default setting **(_:24811:102) V0> threshold** = *8.00 %*
- Default setting **(_:24811:103) V2> threshold** = *8.00 %*
- Default setting **(_:24811:104) V2/V1 > threshold** = *10.00 %*

With the parameter **3ph bus.volt. threshold**, you specify a threshold value for the maximum phase-to-phase voltage (VAB, VBC, or VCA) of the busbar.

With the parameter **V0> threshold**, you specify a threshold value for the zero-sequence voltage V0 of the busbar.

With the parameter **V2> threshold**, you specify a threshold value for the negative-sequence voltage V2 of the busbar.

With the parameter **V2/V1 > threshold**, you specify a threshold value for the ratio of the negative-sequence voltage to the positive-sequence voltage V2/V1.

The threshold values are percentage values referring to the rated voltage of the busbar.

If one of the following conditions is fulfilled, an electrical fault on the busbar is detected:

- The maximum phase-to-phase voltage (VAB, VBC, or VCA) of the busbar falls below the value of the parameter **3ph bus.volt. threshold**.
- The zero-sequence voltage V0 of the busbar exceeds the value of the parameter **V0> threshold**.
- The negative-sequence voltage V2 of the busbar exceeds the value of the parameter **V2> threshold**.
- The ratio of the negative-sequence voltage to the positive-sequence voltage V2/V1 exceeds the value of the parameter **V2/V1 > threshold**.

6.2.6.10 Application and Setting Notes (Undervoltage Start)

Parameter: Transfer sequence

- Default setting **(_:102) Transfer sequence** = ***simultaneous***

With the parameter **Transfer sequence**, you specify the sequence type in which the transfer is started.

The functionality can be started only when the fault of the upstream power-supply system is isolated. Siemens recommends using the sequence type ***simultaneous*** to shorten the dead time.

Parameter: 3ph bus.volt. threshold

- Default setting **(_:103) 3ph bus.volt. threshold** = ***85.0 %***

With the parameter **3ph bus.volt. threshold**, you specify an undervoltage limit for the busbar voltage. If all phase-to-phase voltages of the busbar fall below the value of the parameter **3ph bus.volt. threshold**, the busbar voltage is in the undervoltage status.

The threshold value is a percentage value referring to the rated voltage of the CB to be closed.

Parameter: Start delay

- Default setting **(_:104) Start delay** = ***0.00 s***

With the parameter **Start delay**, you specify a time delay for the undervoltage start. After all undervoltage criteria are fulfilled, the indication ***Undervoltage start*** is issued after a set time delay.

6.2.6.11 Application and Setting Notes (Underfrequency Start)

Parameter: Mode

- Default setting **(_:101) Mode** = ***off***

With the parameter **Mode**, you can enable the **Underfrequency start**.

Parameter: Transfer sequence

- Default setting **(_:102) Transfer sequence** = ***simultaneous***

With the parameter **Transfer sequence**, you specify the sequence type in which the transfer is started.

The functionality can be started only when the fault of the upstream power-supply system is isolated. Siemens recommends using the sequence type ***simultaneous*** to shorten the dead time.

Parameter: Threshold

- Default setting **(_:103) Threshold** = ***48.50 Hz*** for f_{rated} = 50 Hz
- Default setting **(_:103) Threshold** = ***57.00 Hz*** for f_{rated} = 60 Hz

With the parameter **Threshold**, you define the threshold value of the functionality **Underfrequency start**.

The functionality **Underfrequency start** works after a loss of voltage in the upstream electricity-supply system. When the source is lost, the frequency of the residual voltage at the busbar decreases starting from the rated frequency. Depending on the connected electrical machines, the **Underfrequency start** function

results in an initial frequency. If the slip of an asynchronous motor is 2 %, the initial frequency of the residual voltage on the busbar is 0.98 f_{rated}. Siemens recommends setting the parameter **Threshold** to a value less than or equal to the initial frequency.

Parameter: Start delay

- Default setting **(_:104) Start delay** = ***0.00 s***

With the parameter **Start delay**, you can delay the start of the stage **Underfrequency start**.

Parameter: Alt. freq. health check

- Default setting **(_:106) Alt. freq. health check** = ***no***

With the parameter **Alt. freq. health check**, you can check the frequency of the alternative incomer.

Parameter: Frequency bandwidth

- Default setting **(_:105) Frequency bandwidth** = ***0.50 Hz***

With the parameter **Frequency bandwidth**, you define the frequency bandwidth for the alternative incomer. With the default setting of ***0.50 Hz***, the frequency band is f_{rated} ± 0.50 Hz.

6.2.6.12 Application and Setting Notes (CB Inadvertent Opening Start)

Parameter: Mode

- Default setting **(_:1) Mode** = ***off***

With the parameter **Mode**, you can enable or disable the functionality **CB inadvertent opening start**.

Parameter: Current check

- Default setting **(_:102) Current check** = ***yes***

With the parameter **Current check**, you define whether the current-flow criterion is used to determine whether the circuit breaker is open.

Parameter Value	Description
yes	Both the current-flow criterion and the circuit-breaker auxiliary contact criterion are considered for determining whether the circuit breaker is open.
no	Only the circuit-breaker auxiliary contact criterion is considered for determining whether the circuit breaker is open.

6.2.6.13 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual start				
_:22171:1	Manual start:Mode		• off • on	off
_:22171:102	Manual start:Transfer sequence		• parallel • simultaneous • sequential	parallel
Fault start				
_:22141:1	Fault start:Mode		• off • on	off
Fault detect.				
_:24811:1	Fault detect.:Mode		• off • on	on

Addr.	Parameter	C	Setting Options	Default Setting
_:24811:101	Fault detect.:3ph bus.volt. threshold		5.00 % to 20.00 %	10.00 %
_:24811:102	Fault detect.:V0> threshold		5.00 % to 20.00 %	8.00 %
_:24811:103	Fault detect.:V2> threshold		5.00 % to 20.00 %	8.00 %
_:24811:104	Fault detect.:V2/V1 > threshold		2.00 % to 100.00 %	10.00 %
V< start				
_:101	V< start:Mode		• off • on	off
_:102	V< start:Transfer sequence		• simultaneous • sequential	simultaneous
_:103	V< start:3ph bus.volt. threshold		25.0 % to 95.0 %	85.0 %
_:104	V< start:Start delay		0.00 s to 5.00 s	0.00 s
f< start				
_:101	f< start:Mode		• off • on	off
_:102	f< start:Transfer sequence		• simultaneous • sequential	simultaneous
_:103	f< start:Threshold		45.00 Hz to 59.50 Hz	48.50 Hz (f_{rated} = 50 Hz) 57.00 Hz (f_{rated} = 60 Hz)
_:104	f< start:Start delay		0.00 s to 1.00 s	0.00 s
_:105	f< start:Frequency band-width		0.20 Hz to 2.00 Hz	0.50 Hz
_:106	f< start:Alt. freq. health check		• no • yes	no
CB open start				
_:1	CB open start:Mode		• off • on	off
_:102	CB open start:Current check		• no • yes	yes
Add.start seq.				
_:1	Add.start seq.:Mode		• off • on	off
_:102	Add.start seq.:Block by fault detection		• no • yes	no
Add.start sim.				
_:1	Add.start sim.:Mode		• off • on	off
_:102	Add.start sim.:Block by fault detection		• no • yes	no

6.2.6.14 Information List

No.	Information	Data Class (Type)	Type
Start			
_:500	Start:>Manual start	SPS	I
_:501	Start:>Elec. fault start	SPS	I
_:502	Start:>Non-elec. fault start	SPS	I
_:503	Start:>Add. start seq.	SPS	I
_:504	Start:>Add. start sim.	SPS	I
_:505	Start:>Block undervolt. start	SPS	I
_:506	Start:>Block underfreq. start	SPS	I
_:300	Start:Manual start	SPS	O
_:301	Start:Electrical fault start	SPS	O
_:302	Start:Non-electric. fault start	SPS	O
_:303	Start:Undervoltage start	SPS	O
_:309	Start:Underfrequency start	SPS	O
_:306	Start:Add. start sequent.	SPS	O
_:308	Start:Add. start simultan.	SPS	O
_:311	Start:CB inadvert. open start	SPS	O
_:315	Start:Fault detect blk. start	SPS	O
_:316	Start:Alt freq. blk. f< start	SPS	O

6.2.7 Transfer Sequence

6.2.7.1 Overview

The transfer sequence has a large impact on a transfer. The transfer sequence means the operating sequence of CBs (circuit breakers to be closed and to be opened) for one transfer direction. The function block **Transfer sequence** executes the defined operating sequence in the function group **HSBT**.

A function block **Transfer sequence** provides 3 applicable sequence types.

Table 6-5 Operating Sequences for the 3 Sequence Types

Sequence Type	Operating Sequence of CBs
Parallel	After the function receives a start signal, the function sends a close command to the CB to be closed. After the CB closure, the function sends an open command to the CB to be opened.
Simultaneous	After the function receives a start signal, the function sends an open command to the CB to be opened. Meanwhile, if the specific criteria are fulfilled, the function sends a close command to the CB to be closed without the position check of the CB to be opened.
Sequential	After the function receives a start signal, the function sends an open command to the CB to be opened. If the specific criteria are fulfilled after the CB is opened, the function sends a close command to the CB to be closed.

Different sequence types collaborate with different start conditions. The following table shows the collaboration status between the start conditions and the sequence types. In the table, **Yes** means that the specific start condition and sequence type can collaborate.

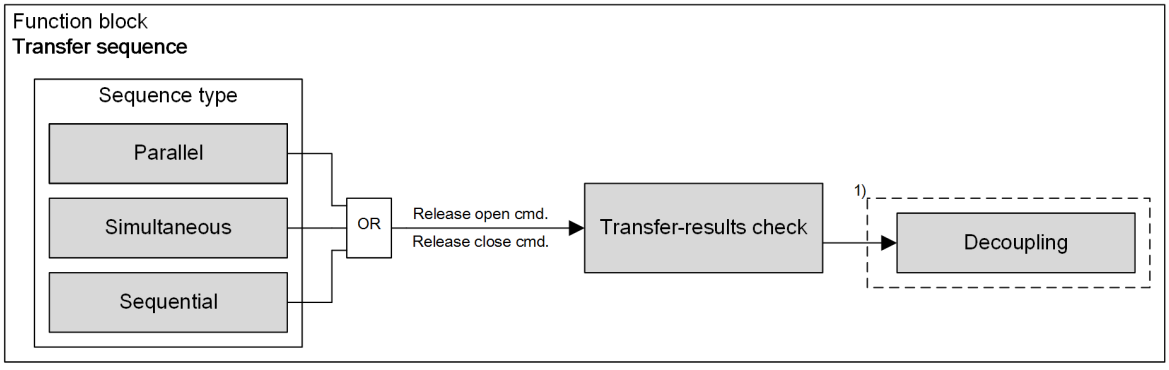
Start Condition	Sequence Type		
	Parallel	Simultaneous	Sequential
Manual start	Yes	Yes	Yes
Electrical fault start	–	–	Yes
Non-electrical fault start	–	Yes	–
Undervoltage start	–	Yes	Yes
Underfrequency start	–	Yes	Yes
Additional start – sequential	–	–	Yes
Additional start – simultaneous	–	Yes	–

6.2.7.2 Structure

The function block **Transfer sequence** contains the following functionalities:

- Sequence types (parallel, simultaneous, and sequential)
- Transfer-results check
- Decoupling

After a transfer direction is started, one of the 3 sequence types is applied. An open command and a close command are released according to the sequence type, and the transfer result is also checked. If necessary, the decoupling is used for the sequence type **Parallel** or **Simultaneous**.
The individual functionalities are described in the following chapters.



[dw_sequence_structure, 1, en_US]

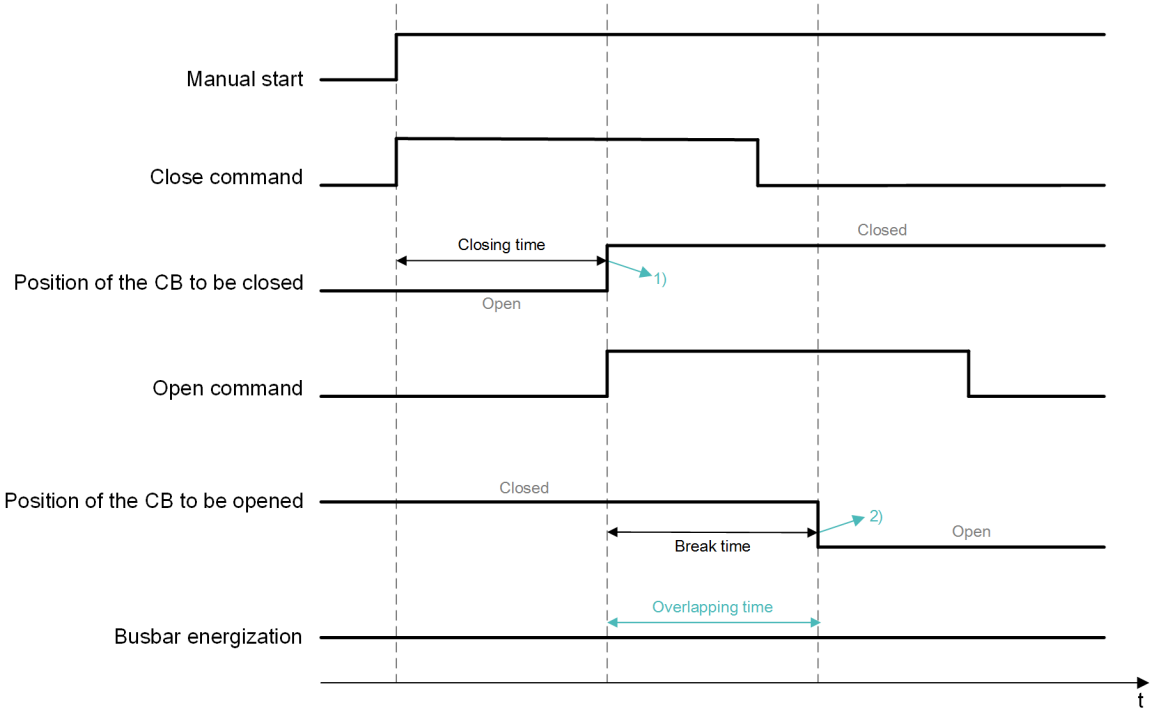
Figure 6-25 Structure of the Function Block **Transfer Sequence**

(1) For the sequence type **Parallel** or **Simultaneous** only

6.2.7.3 Sequence Type Parallel

If 2 incomers are allowed to work in parallel shortly to energize the busbar, the sequence type **Parallel** can be used for a transfer. If a transfer is executed via the sequence type **Parallel**, the busbar is energized continuously.

Timing Diagram



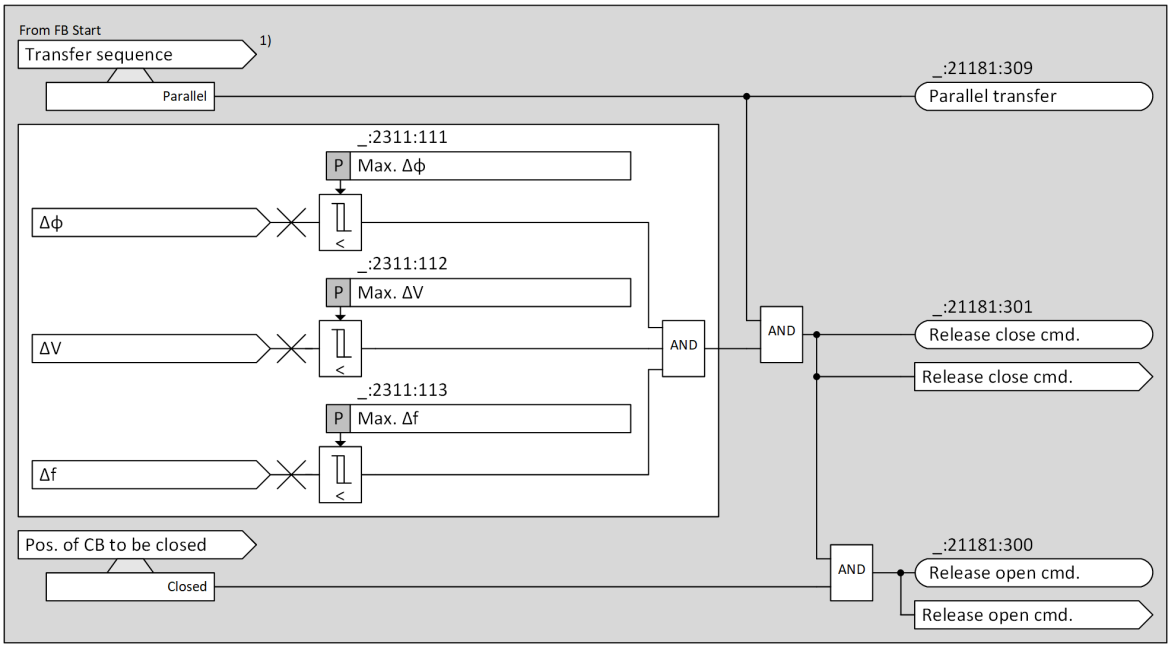
[dw_parallel_timing, 2, en_US]

Figure 6-26 Timing Diagram of the Sequence Type **Parallel**

1) Instant at which the CB is closed
2) Instant at which the CB is opened

For the sequence type **Parallel**, there is a time interval between the instant at which the CB to be closed is closed and the instant at which the CB to be opened is opened. This time interval is called the overlapping time. During the overlapping time, both incomers work in parallel to energize the busbar.

Logic



[lo_parallel, 3, en_US]

Figure 6-27 Logic Diagram of the Sequence Type **Parallel**

(1) The sequence type **Parallel** is activated after the functionality **Manual start** is executed successfully and the corresponding parameter **`Transfer sequence`** is set to ***`parallel`***.

Checking the Synchronization Status of 2 Incomers

For the sequence type **Parallel**, 2 incomers work in parallel during the overlapping time. To ensure the stability of the incomer, 2 incomers must be synchronized. The synchronization status of 2 incomers is checked via the following conditions:

- Δφ must be smaller than the threshold value **`Max. Δφ`**.
- ΔV must be smaller than the threshold value **`Max. ΔV`**.
- Δf must be smaller than the threshold value **`Max. Δf`**.

For more information about the measured values Δφ, ΔV, and Δf, refer to *Functional Measured Values, Page 409*.

Closing the CB to Be Closed

If all the following conditions are fulfilled, the function sends a close command ***`Release close cmd.`*** to the CB to be closed:

- Sequence type **Parallel** is applied
- Condition of the manual start is fulfilled
- 2 incomers are synchronized

The close command ***`Release close cmd.`*** lasts for 100 ms.

Opening the CB to Be Opened

If the close command ***`Release close cmd.`*** is released and the position of the CB to be closed is closed, the function sends an open command ***`Release open cmd.`*** to the CB to be opened.

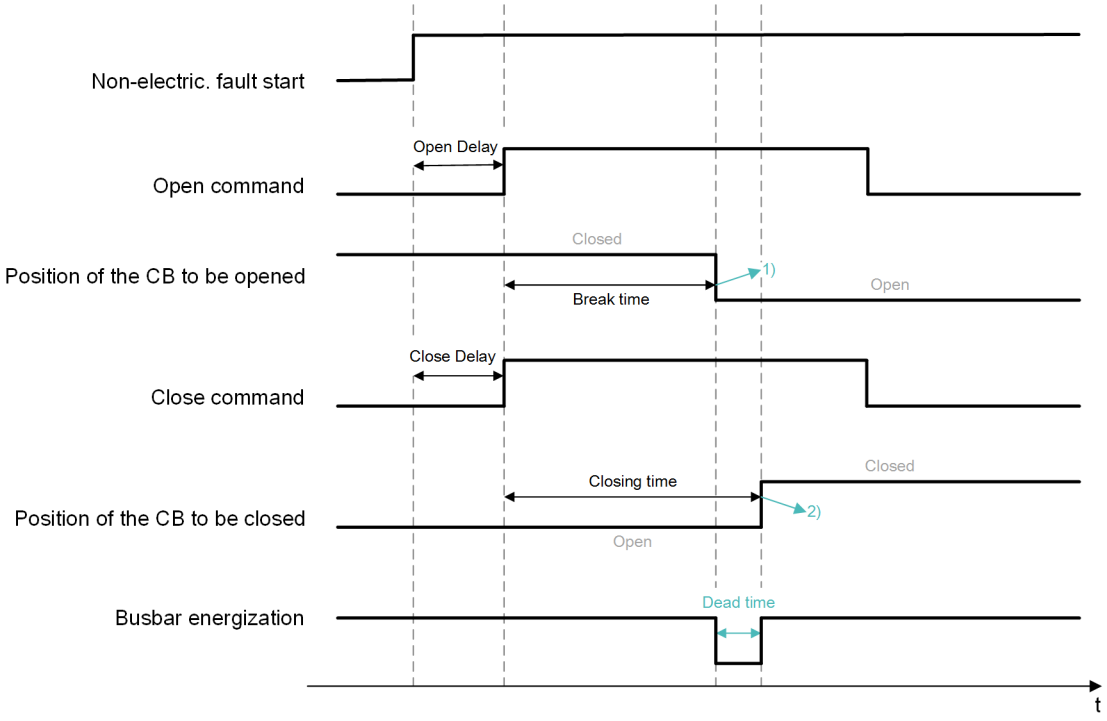
The open command ***`Release open cmd.`*** lasts for 100 ms.

6.2.7.4 Sequence Type Simultaneous

If 2 incomers are not allowed to work in parallel to energize the busbar, the sequence type **Simultaneous** can be used for a transfer. However, if the CB to be opened fails to open, the paralleling of the incomer is still possible.

If a transfer is executed via the sequence type **Simultaneous**, the operating-time difference of the 2 circuit breakers causes a short dead time of the busbar. The open command and the close command are released with separate delays to shorten the dead time.

Timing Diagram



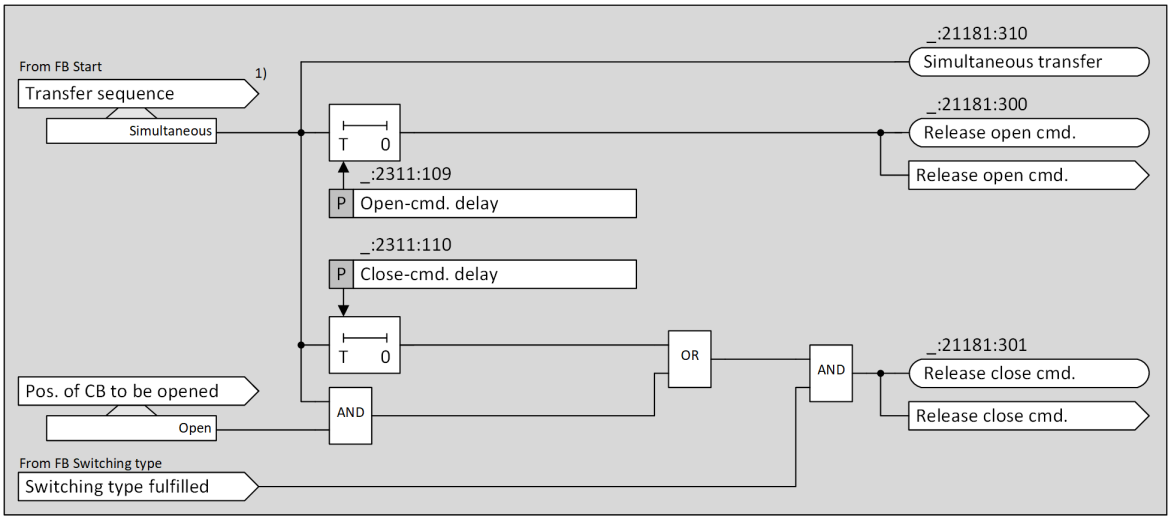
[dw_simultaneous_timing, 2, en_US]

Figure 6-28 Timing Diagram of the Sequence Type **Simultaneous**

1) Instant at which the CB is opened
2) Instant at which the CB is closed

For the sequence type **Simultaneous**, there is a time interval between the instant at which the CB to be opened is opened and the instant at which the CB to be closed is closed. This time interval is called the dead time. During the dead time, the incomers are not connected to the circuit to energize the busbar. The sequence type **Simultaneous** can shorten the dead time by adjusting the open delay and the close delay.

Logic



[lo_simultaneous, 3, en_US]

Figure 6-29 Logic Diagram of the Sequence Type **Simultaneous**

(1) The sequence type **Simultaneous** is activated after one of the available start functionalities is executed successfully and the corresponding parameter **`Transfer sequence`** is set to ***`simultaneous`***.

Opening the CB to Be Opened

If the start conditions are fulfilled and the sequence type **Simultaneous** is applied, the function sends an open command ***`Release open cmd.`*** to the CB to be opened according to the CB open delay (parameter **`Open-cmd. delay`**).

The open command ***`Release open cmd.`*** lasts for 100 ms.

Closing the CB to Be Closed

If the open command ***`Release open cmd.`*** and the close command ***`Release close cmd.`*** are released simultaneously, a dead time of the busbar lasts for a few milliseconds due to the time difference between the break time and the closing time of CBs. In the sequence type **Simultaneous**, you can shorten the dead time via the parameter **`Open-cmd. delay`** or **`Close-cmd. delay`**.

If the start condition is fulfilled and the sequence type **Simultaneous** is selected, the close command is released under one of the following conditions after one of the switching types is fulfilled:

- Delay (parameter **`Close-cmd. delay`**) expires
- CB to be opened is opened

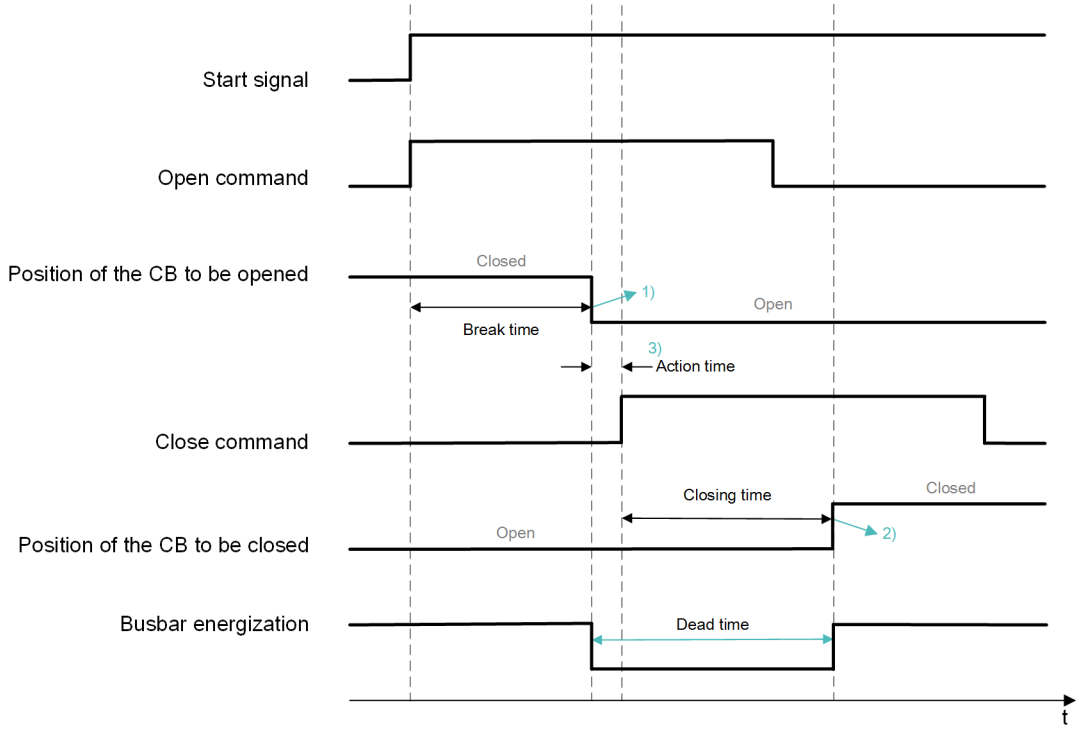
The close command ***`Release close cmd.`*** lasts for 100 ms.

6.2.7.5 Sequence Type Sequential

If 2 incomers are strictly forbidden to work in parallel to energize the busbar, the sequence type **Sequential** can be used for a transfer.

If, for example, an electrical fault occurs on the line transformer, switching onto fault is not allowed during the transfer. The sequence type **Sequential** is used to completely avoid switching onto fault during the transfer.

Timing Diagram



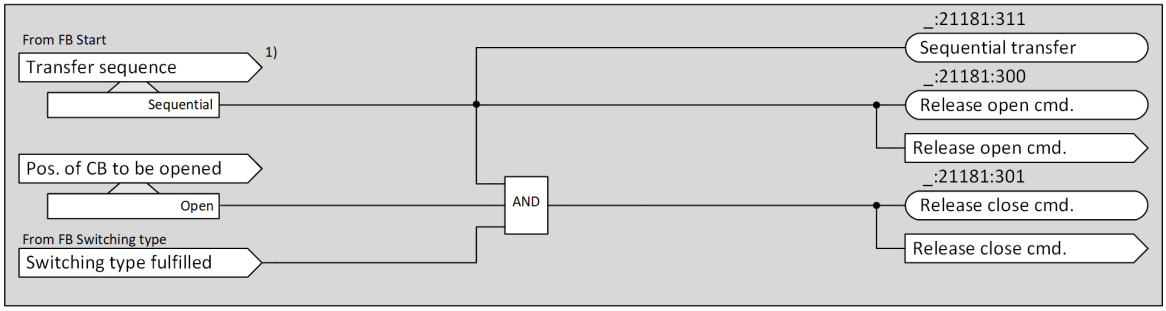
[dw_sequential_timing, 2, en_US]

Figure 6-30 Timing Diagram of the Sequence Type **Sequential**

1) Instant at which the CB is opened
2) Instant at which the CB is closed
3) Time for the functionality **Switching type** to determine the optimal instant to close the CB to be closed.

For the sequence type **Sequential**, there is a time interval between the instant at which the CB to be opened is opened and the instant at which the CB to be closed is closed. This time interval is called the dead time. During the dead time, the incomers are not connected to the circuit to energize the busbar.

Logic



[lo_sequential, 4, en_US]

Figure 6-31 Logic Diagram of the Sequence Type **Sequential**

(1) The sequence type **Sequential** is activated after one of the available start functionalities is executed successfully and the corresponding parameter **`Transfer sequence`** is set to ***`sequential`***.

Opening the CB to Be Opened

If the start conditions are fulfilled and the sequence type **Sequential** is applied, the function sends an open command *Release open cmd.* to the CB to be opened.

The open command *Release open cmd.* lasts for 100 ms.

Closing the CB to Be Closed

If the following conditions are fulfilled, the function sends a close command *Release close cmd.* to the CB to be closed after issuing the open command:

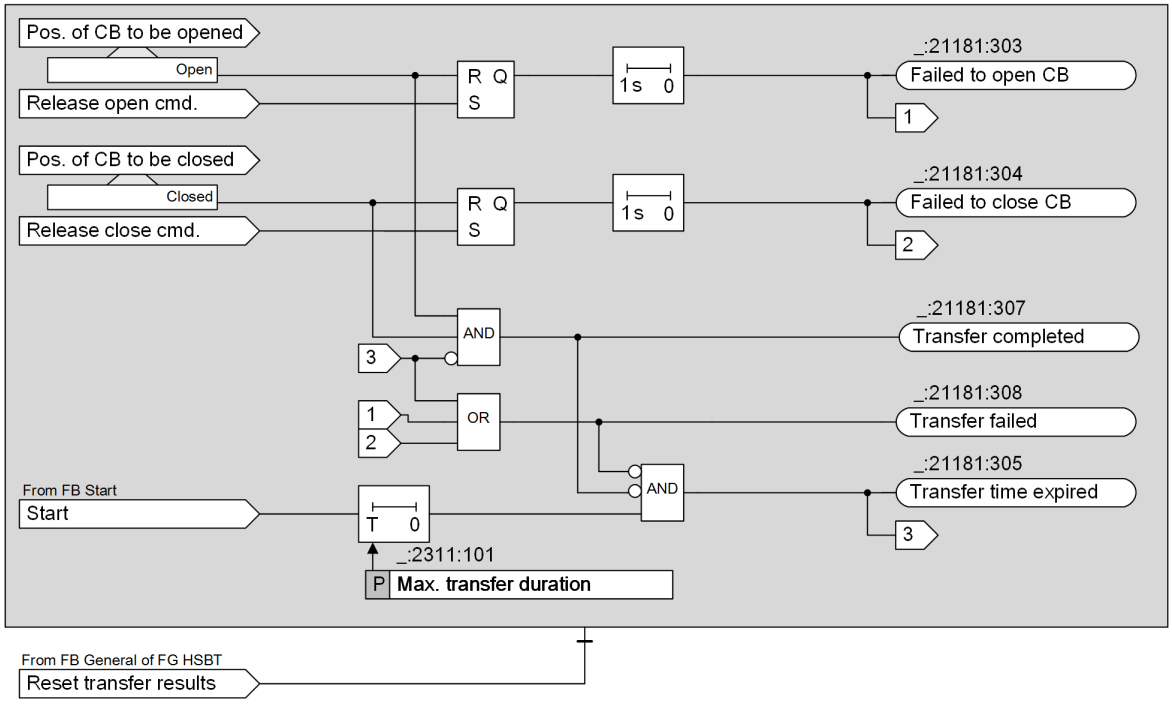
- Criteria of the switching type are fulfilled
  That is, one of the switching types is fulfilled.
- Position of the CB to be opened is open

The close command *Release close cmd.* lasts for 100 ms.

6.2.7.6 Transfer-Results Check

After the commands *Release open cmd.* and *Release close cmd.* are released according to the selected sequence type, the function block **Transfer sequence** checks the transfer results in the transfer-direction level.

Logic



[lo_sequence results, 3, en_US]

Figure 6-32 Logic Diagram of the Transfer-Results Check

Opening or Closing Failure of the Circuit Breaker

If the position of the CB to be opened is not open within 1 s after the open command *Release open cmd.* is released, the CB opening is regarded as failed with the indication *Failed to open CB*.

If the position of the CB to be closed is not closed within 1 s after the close command *Release close cmd.* is released, the CB closing is regarded as failed with the indication *Failed to close CB*.

Transfer Completion

After the commands *Release open cmd.* and *Release close cmd.* are released, if the CB to be opened is open and the CB to be closed is closed within the maximum transfer duration specified by the parameter **Max. transfer duration**, the transfer is completed with the indication *Transfer completed*.

Transfer Failure

A transfer failure is indicated as *Transfer failed* and occurs under one of the following conditions:

- CB to be closed is not closed
- CB to be opened is not open
- Transfer time expires
  The transfer time exceeds the maximum transfer duration specified by the parameter **Max. transfer duration**. The indication *Transfer time expired* is released.

Resetting Transfer Results

After a transfer ends, all transfer results must be reset and the ready check is executed for the next transfer. The internal signal *Reset transfer results* from the FB **General** of the FG **HSBT** is used to reset the following signals that indicate the transfer results:

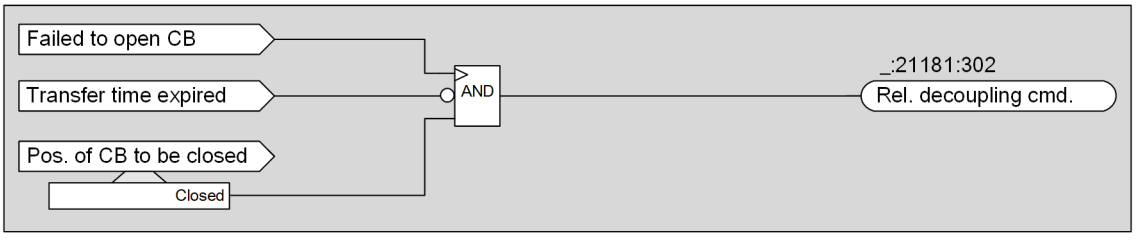
- *Failed to open CB*
- *Failed to close CB*
- *Transfer failed*
- *Transfer completed*
- *Transfer time expired*

For more information, refer to *Resetting All Transfer Results, Page 399*.

6.2.7.7 Decoupling

For the sequence type **Parallel** or **Simultaneous**, there is a possibility that the CB to be opened fails to open after the CB to be closed is closed. To avoid the unwanted paralleling of the incomers under this situation, the closed CB (CB to be closed) must be opened to disconnect the alternative incomer. This action is called decoupling. The command *Rel. decoupling cmd.* indicates the decoupling.

The command *Rel. decoupling cmd.* lasts for 100 ms.



[lo_decoupling, 1, en_US]

Figure 6-33 Logic Diagram of the Decoupling

6.2.7.8 Application and Setting Notes

The following parameters are from the function block **General** of the function group **HSBT**.

Parameter: **Max. transfer duration**

- Default setting **(_:2311:101) Max. transfer duration** = *20.00 s*

With the parameter **Max. transfer duration**, you limit the time for the transfer sequence.

If a transfer is not completed or does not fail before the expiration of the set time, the transfer expires.

Siemens recommends using the default setting.

Parameters for the Sequence Type Parallel: Max. Δφ, Max. ΔV, Max. Δf

- Default setting **(_:2311:111) Max. Δφ** = ***10.0°***

With the parameter **Max. Δφ**, you specify the maximum threshold of the angle difference. To ensure that 2 incomers are synchronized, Δφ must be smaller than the setting value.
Siemens recommends setting the parameter in the range of 10.0° to 15.0°.

- Default setting **(_:2311:112) Max. ΔV** = ***3.5 %***

With the parameter **Max. ΔV**, you specify the maximum threshold of the voltage difference in percentage between the residual voltage and the alternative voltage. To ensure that the voltages of 2 incomers are synchronized, the percentage value of the voltage difference must be smaller than the setting value of the parameter **Max. ΔV**. The percentage value of the voltage difference is calculated based on the primary rated voltage of the CB to be closed.
Siemens recommends setting the parameter in the range of 2.0 % to 5.0 %.

- Default setting **(_:2311:113) Max. Δf** = ***0.10 Hz***

With the parameter **Max. Δf**, you specify the maximum threshold of the frequency difference. To ensure that 2 incomers are synchronized, Δf must be smaller than the setting value.
Siemens recommends setting the parameter in the range of 0.10 Hz to 0.15 Hz.

Parameters for the Sequence Type Simultaneous: Open-cmd. delay, Close-cmd. delay

- Default setting **(_:2311:109) Open-cmd. delay** = ***0.000 s***
- Default setting **(_:2311:110) Close-cmd. delay** = ***0.000 s***

With the parameter **Open-cmd. delay**, you set a time delay to postpone the issuing of the open command.
With the parameter **Close-cmd. delay**, you set a time delay to postpone the issuing of the close command.
The parameters collaborate with each other to shorten the dead time.
Set the parameters according to the mechanical operating time of CB.

6.2.7.9 Settings

Settings from the FB General of the FG HSBT

Addr.	Parameter	C	Setting Options	Default Setting
Simultaneous seq.				
_:2311:109	General:Open-cmd. delay		0.000 s to 0.040 s	0.000 s
_:2311:110	General:Close-cmd. delay		0.000 s to 0.040 s	0.000 s
Parallel sequence				
_:2311:111	General:Max. Δφ		2.0 ° to 80.0 °	10.0 °
_:2311:112	General:Max. ΔV		1.0 % to 70.0 %	3.5 %
_:2311:113	General:Max. Δf		0.02 Hz to 2.00 Hz	0.10 Hz

6.2.7.10 Information List

No.	Information	Data Class (Type)	Type
Transfer seq.			
_:21181:309	Transfer seq.:Parallel transfer	SPS	O
_:21181:310	Transfer seq.:Simultaneous transfer	SPS	O

No.	Information	Data Class (Type)	Type
_:21181:311	Transfer seq.:Sequential transfer	SPS	O
_:21181:300	Transfer seq.:Release open cmd.	SPS	O
_:21181:301	Transfer seq.:Release close cmd.	SPS	O
_:21181:302	Transfer seq.:Rel. decoupling cmd.	SPS	O
_:21181:303	Transfer seq.:Failed to open CB	SPS	O
_:21181:304	Transfer seq.:Failed to close CB	SPS	O
_:21181:307	Transfer seq.:Transfer completed	SPS	O
_:21181:308	Transfer seq.:Transfer failed	SPS	O
_:21181:305	Transfer seq.:Transfer time expired	SPS	O
_:21181:312	Transfer seq.:Load-shedding cmd.	SPS	O

6.2.8 Switching Type

6.2.8.1 Overview

After the power loss of the busbar for the asynchronous motor, the frequency, phase angle, and voltage suddenly change. To ensure a fast and safe transfer, the frequency, phase angle, and voltage are monitored to determine if the current instant is suitable for the closing of the CB to be closed. The function block **Switching type** is used for the determination.

In the function block **Switching type**, the following 5 modes are available:

- Fast mode
- Real-time fast mode
- In-phase mode
- Residual-voltage mode
- Long-time mode

These 5 modes are used to cooperate with the sequence types **Sequential** and **Simultaneous**. For the sequence type **Parallel**, no determination regarding the switching type is necessary, but the synchronization status of the 2 incomers is checked.

The criteria of the 5 modes are checked at the same time. If the criteria of a mode are fulfilled, the close command can be released. It is possible that one or more modes are fulfilled at one instant.

In the function block **Switching type**, only specific criteria are checked. The release of the close command is in the function block **Transfer sequence**. For more information, refer to *6.2.7 Transfer Sequence*.

Basic Principle of the Fast Transfer

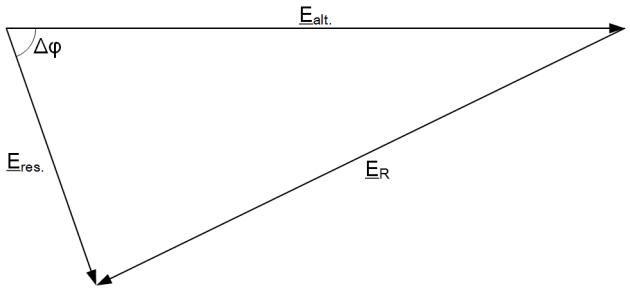
According to the standard ANSI C50.41-2012, it is not practical to calculate the transient impact for all cases. The following simplified guideline is defined for a fast transfer (relative to a slow transfer):

- A fast transfer occurs within a time range of 10 cycles or less.
- The maximum phase angle between $\underline{V}_{res.}/f_{res.}$ and $\underline{V}_{alt.}/f_{alt.}$ does not exceed 90°.

  $\underline{V}_{res.}/f_{res.}$: phasor of the volts per hertz of the residual voltage

  $\underline{V}_{alt.}/f_{alt.}$: phasor of the volts per hertz of the alternative voltage
- At the instant that the transfer is completed, the resultant volts per hertz between $\underline{V}_{res.}/f_{res.}$ and $\underline{V}_{alt.}/f_{alt.}$ does not exceed 1.33 per unit V/f based on the motor rated voltage and frequency.

The following figure illustrates the fast transfer defined in the standard ANSI C50.41-2012.



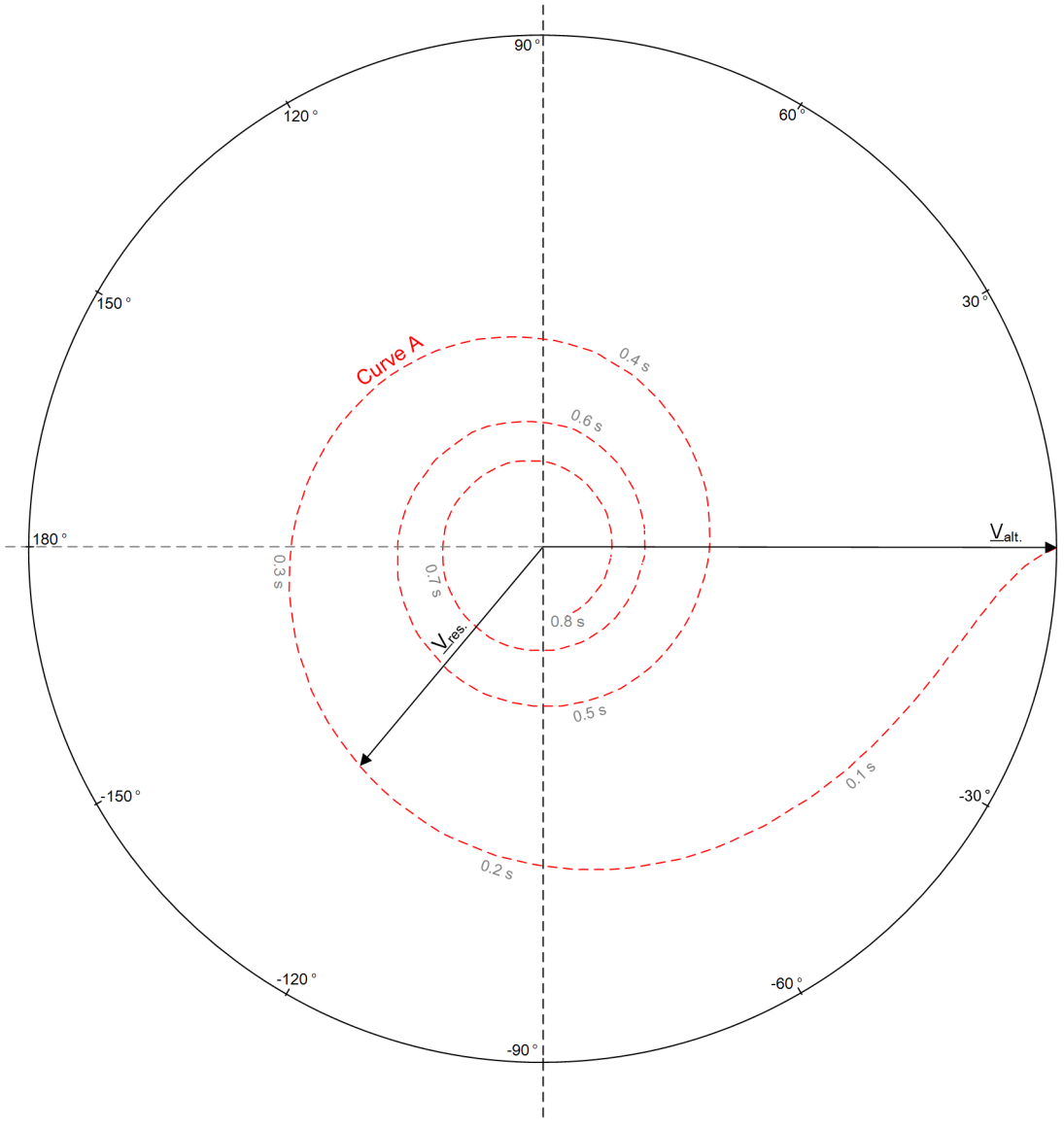
[dw_impact_motor in ANSI, 1, en_US]

Figure 6-34 Phasor Diagram

Table 6-6 Definitions and Details of the Measured Quantities in the Phasor Diagram

Measured Quantity	Definition	Detail
$\underline{E}_{alt.}$	Phasor $\underline{V}_{alt.}/f_{alt.}$ in per unit based on the rated voltage and rated frequency of the circuit breaker	$\underline{E}_{alt.} = \frac{\underline{V}_{alt.}/V_{rated}}{f_{alt.}/f_{rated}}$ Magnitude of $\underline{E}_{alt.} \approx 1.00$ p.u. $\underline{V}_{alt.}$: Voltage phasor of the alternative incomer $V_{alt.}$ is taken as the reference voltage. $f_{alt.}$: Frequency of the alternative incomer
$\underline{E}_{res.}$	Phasor $\underline{V}_{res.}/f_{res.}$ in per unit based on the rated voltage and rated frequency of the circuit breaker	$\underline{E}_{res.} = \frac{\underline{V}_{res.}/V_{rated}}{f_{res.}/f_{rated}}$ $\underline{V}_{res.}$: Voltage phasor of the motor residual voltage on the busbar to be transferred $f_{res.}$: Frequency of the busbar to be transferred
Δφ	Phase-angle difference between $\underline{E}_{alt.}$ and $\underline{E}_{res.}$	$\Delta\varphi = \varphi_{res.} - \varphi_{alt.}$ Maximum $\lvert\Delta\varphi\rvert \leq 90°$ $\varphi_{res.}$: Phase angle of $\underline{E}_{res.}$ $\varphi_{alt.}$: Phase angle of $\underline{E}_{alt.}$
$\underline{E}_R$	Phasor of the resultant volts per hertz in per unit between $\underline{E}_{alt.}$ and $\underline{E}_{res.}$	$\underline{E}_R = \underline{E}_{res.} - \underline{E}_{alt.}$ Magnitude of $\underline{E}_R \leq 1.33$ p.u.

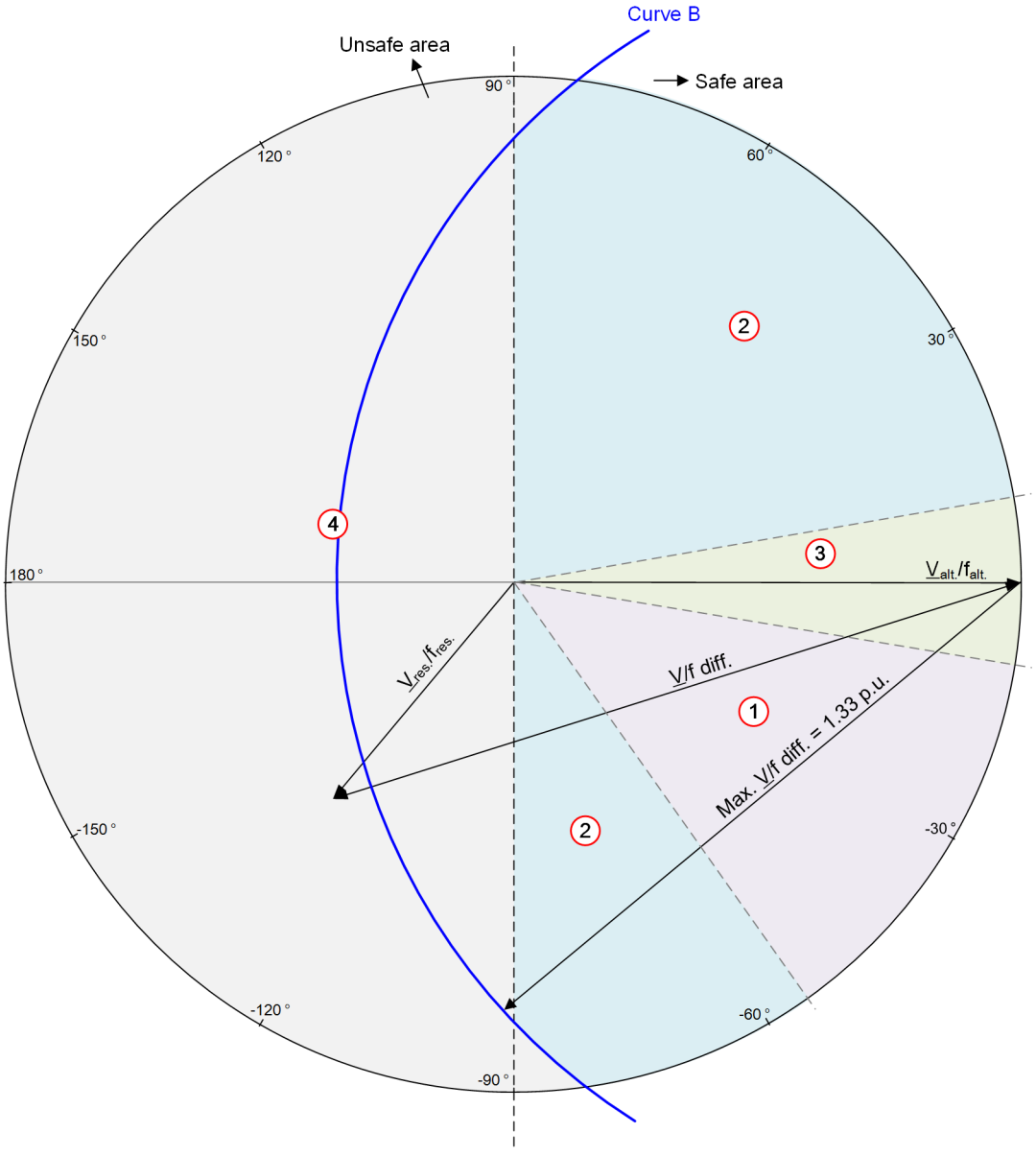
After the power loss, the amplitude of $\underline{V}_{res.}$ gradually decays as shown in *Figure 6-35*. The phase-angle difference between $\underline{V}_{res.}$ and $\underline{V}_{alt.}$ changes. Based on the phase-angle difference, the plane is divided into several areas as shown in *Figure 6-36*. The working areas of the fast mode and the real-time fast mode meet the criteria for the fast transfer defined in the standard ANSI C50.41-2012.



[dw_mode_residual voltage characteristic, 1, en_US]

Figure 6-35 Trajectory of $\underline{V}_{res.}$ in the Polar Coordinate Plane

Curve A Trajectory of $\underline{V}_{res.}$



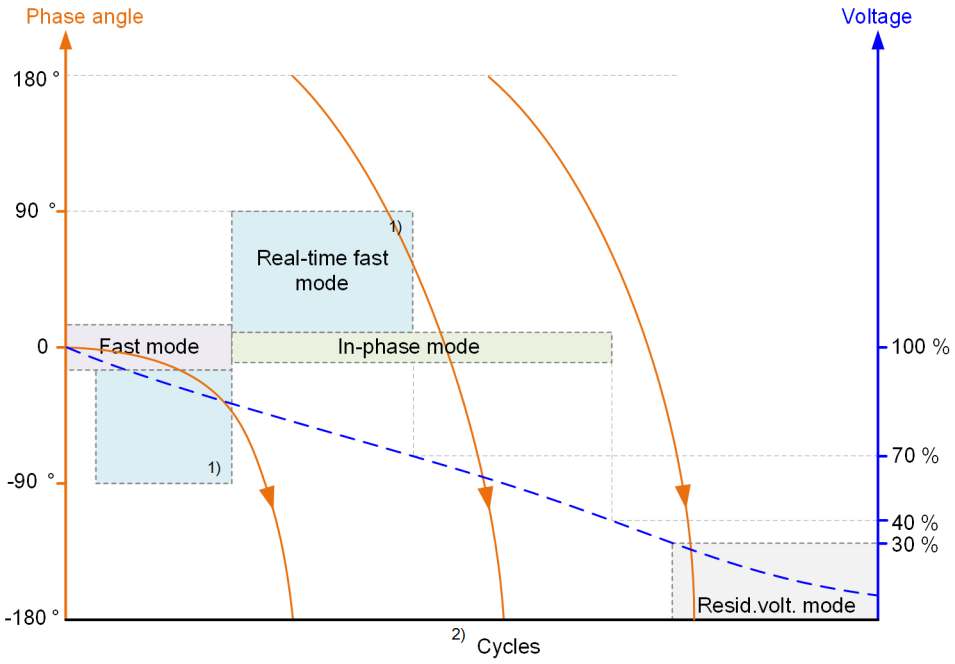
[dw_mode trajectory, 2, en_US]

Figure 6-36 Transformation of V/f into the Polar Coordinate Plane

(1) Working area fast mode
(2) Working area real-time fast mode
(3) Working area in-phase mode
(4) Unsafe area

V/f diff. Phasor of the resultant volts per hertz in per unit between the phasor $\underline{V}_{res.}/f_{res.}$ in per unit and the phasor $\underline{V}_{alt.}/f_{alt.}$ in per unit

Curve B Trajectory of max. V/f diff.



[dw_angle_voltage, 1, en_US]

Figure 6-37 Phase Angle and Voltage of Different Switching Types

(1) Resultant volts per hertz (V/f diff.) at the closure instant of the CB to be closed does not exceed 1.33 p.u.

(2) Cycles mean the rotating cycles of the angle difference between the residual voltage and the alternative voltage during the transfer time.

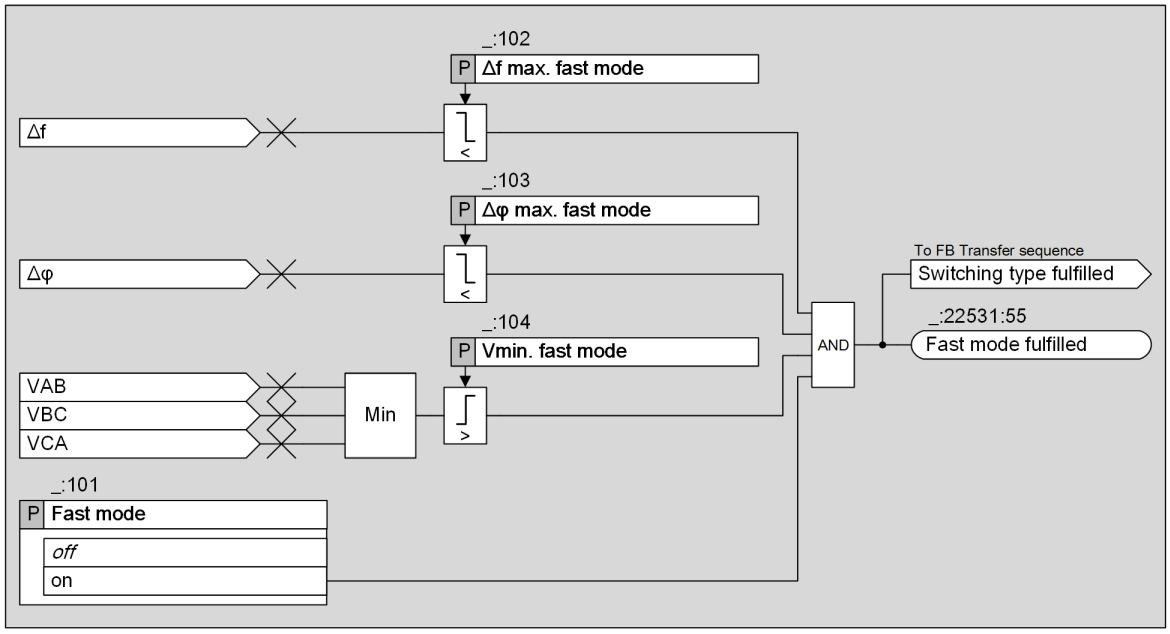
6.2.8.2 Fast Mode

In most cases, the typical values of Δf, Δφ, and ΔV are small in tens of milliseconds after the running incomer is de-energized. The shock to motors is also slight. It is good to execute a safe and fast transfer during this short time. The functionality **Fast mode** is used as the switching type to execute a fast transfer in this short time.

The functionality **Fast mode** aims to restrict Δφ to a small value, such as, 60°. Based on *Figure 6-36*, it is obvious that the resultant volts per hertz (V/f diff.) is smaller than or equal to 1.00 when Δφ is 60°.

You can activate the functionality **Fast mode** using the parameter **`Fast mode`**.

Logic



[lo_fast mode, 1, en_US]

Figure 6-38 Logic Diagram of the Fast Mode

Measurands

Value	Description
Δf	Real-time frequency difference between both sides of the CB to be closed
Δφ	Real-time phase-angle difference between both sides of the CB to be closed
V_{AB} V_{BC} V_{CA}	Real-time phase-to-phase voltages of the busbar

Criteria of the Fast Mode

To reduce the impact caused by the sudden changes (f, φ, and V) and to determine whether the current instant is suitable for the closing of the CB to be closed, the following criteria are checked:

- Δf must be smaller than the threshold value specified via the parameter **`Δf max. fast mode`**.
- Δφ must be smaller than the threshold value specified via the parameter **`Δφ max. fast mode`**.
- All phase-to-phase voltages (V_{AB}, V_{BC}, and V_{CA}) of the busbar must be greater than the threshold value specified via the parameter **`Vmin. fast mode`**.

Termination of the Fast Mode

The fast mode ends at 120 ms after the start conditions are fulfilled and the position of the CB to be opened is open.

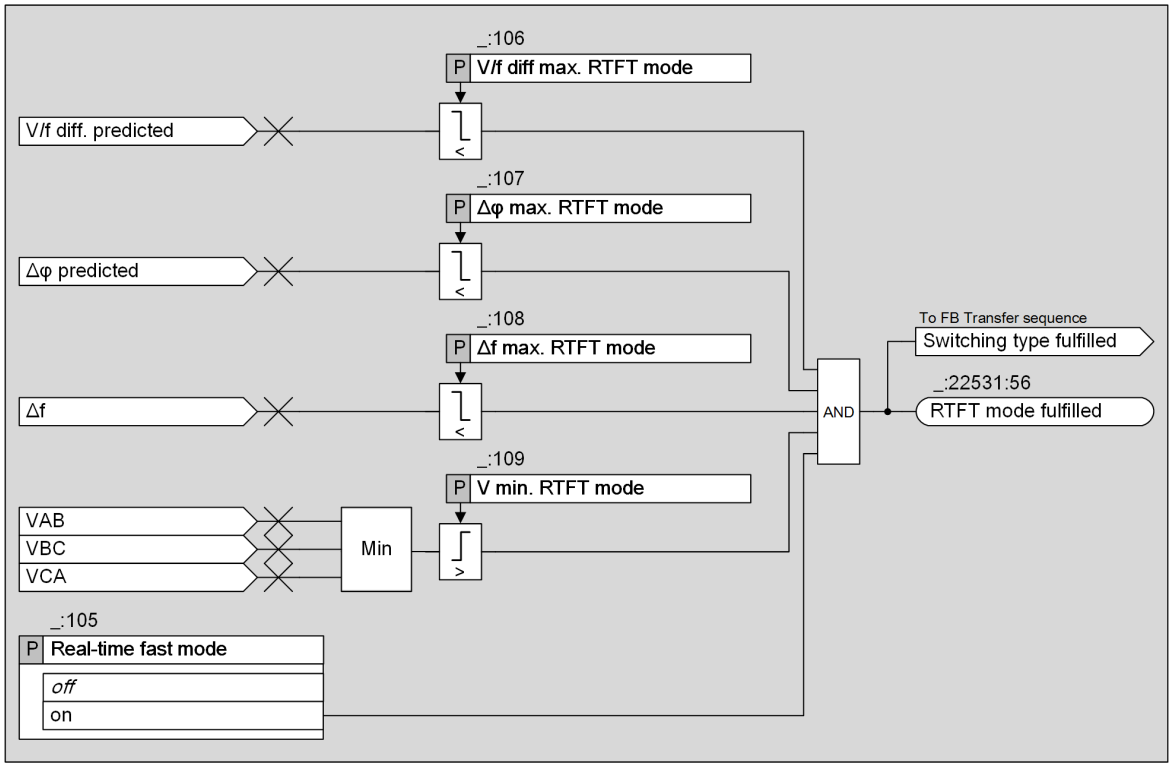
6.2.8.3 Real-Time Fast Mode

The functionality **Real-time fast mode** realizes the following features according to the standard ANSI C50.41-2012:

- Δφ at the closure instant of the circuit breaker to be closed is less than 90°.
- The resultant volts per hertz (V/f diff.) at the closure instant of the circuit breaker to be closed does not exceed 1.33 p.u. based on the motor rated voltage and frequency.

You can activate the functionality **Real-time fast mode** using the parameter **`Real-time fast mode`**.

Logic



[lo_RTFT mode, 2, en_US]

Figure 6-39 Logic Diagram Real-Time Fast Mode

Measurands

Value	Description
V/f diff. predicted	Phasor of the predicted resultant volts per hertz in per unit between $\underline{E}_{alt.}$ and $\underline{E}_{res.}$ at the closure instant of the circuit-breaker to be closed: • $\underline{E}_{alt.}$ is the phasor $\underline{V}_{alt.}/f_{alt.}$ in per unit based on the rated voltage and rated frequency of the circuit breaker. • $\underline{E}_{res.}$ is the phasor $\underline{V}_{res.}/f_{res.}$ in per unit based on the rated voltage and rated frequency of the circuit breaker.
Δφ predicted	Predicted phase-angle difference between $\underline{E}_{alt.}$ and $\underline{E}_{res.}$ at the closure instant of the circuit breaker to be closed
Δf	Real-time frequency difference between both sides of the circuit breakers to be closed
V_{AB}, V_{BC}, and V_{CA}	Real-time phase-to-phase voltages of the busbar

For the calculation of the predicted values V/f diff. predicted and Δφ predicted, the parameter **`CB make time`** is taken into account. For more information, refer to *Parameter: **`CB make time`**, Page 263*.

Criteria of the Real-Time Fast Mode

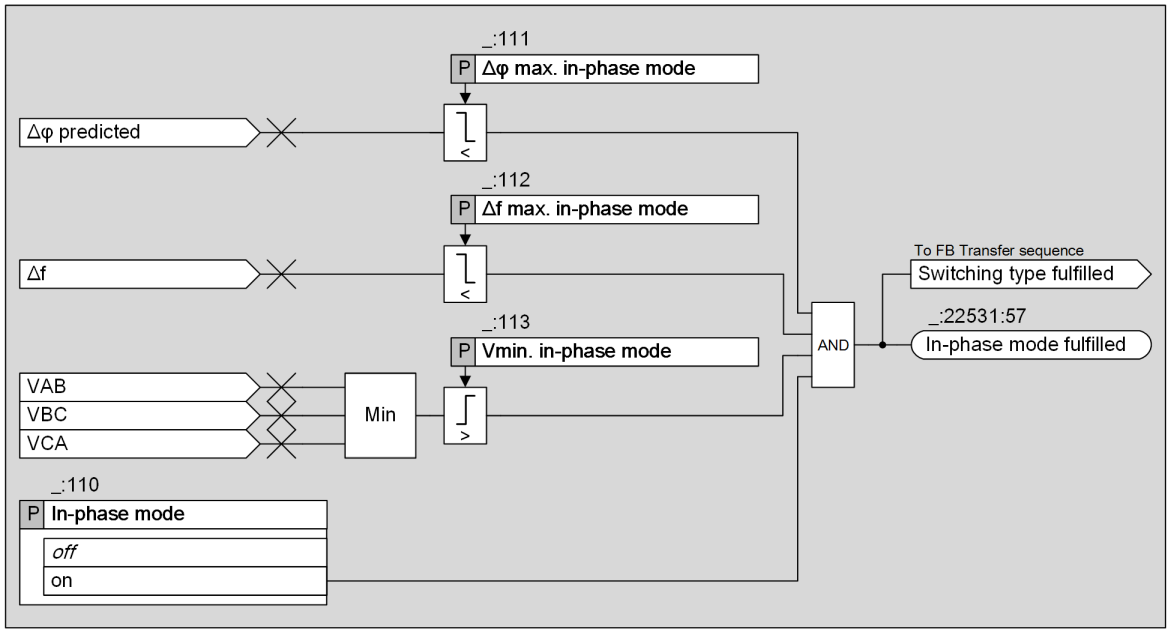
The functionality **Real-time fast mode** predicts Δφ and V/f diff. at the closure instant of the circuit-breaker to be closed. Δφ and V/f diff. predicted are calculated based on the real-time change rate of Δφ and V/f diff. and the settable CB closing time via the exclusive prediction algorithm. In the functionality **Real-time fast mode**, the following criteria are checked:

- V/f diff. predicted must be smaller than the threshold value specified via the parameter **`V/f diff max. RTFT mode`**.
- Δφ predicted must be smaller than the threshold value specified via the parameter **`Δφ max. RTFT mode`**.
- Δf must be smaller than the threshold value specified via the parameter **`Δf max. RTFT mode`**.
- All phase-to-phase voltages (V_{AB}, V_{BC}, and V_{CA}) of the busbar must be greater than the threshold value specified via the parameter **`V min. RTFT mode`**.

6.2.8.4 In-Phase Mode

The functionality **In-phase mode** works only when the phase-angle difference between the residual voltage and the alternative voltage is within a specified range. You can activate the functionality **In-phase mode** using the parameter **`In-phase mode`**.

Logic



[lo_In-phase mode, 1, en_US]

Figure 6-40 Logic Diagram In-Phase Mode

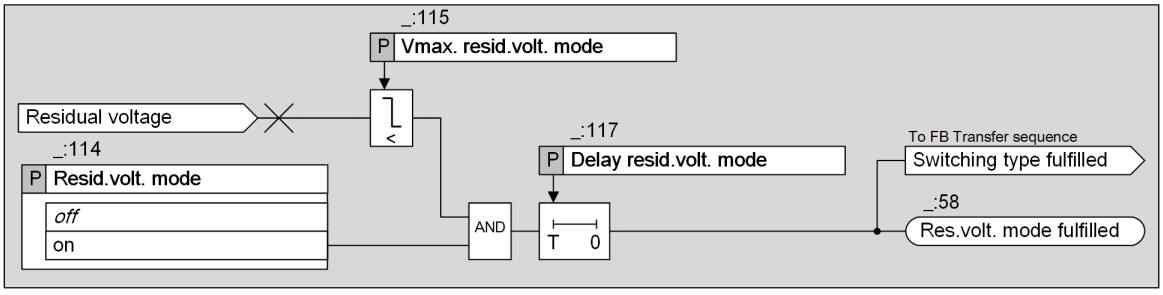
Measurands

Value	Description
Δφ predicted	Predicted phase-angle difference between $\underline{E}_{alt.}$ and $\underline{E}_{res.}$ at the closure instant of the circuit breaker to be closed: • $\underline{E}_{alt.}$ is the phasor $\underline{V}_{alt.}/f_{alt.}$ in per unit based on the rated voltage and rated frequency of the circuit breaker. • $\underline{E}_{res.}$ is the phasor $\underline{V}_{res.}/f_{res.}$ in per unit based on the rated voltage and rated frequency of the circuit breaker. For the calculation of the predicted value Δφ predicted, the parameter **CB make time** is taken into account. For more information, refer to *Parameter: **CB make time**, Page 263*.
Δf	Real-time frequency difference between both sides of the circuit breaker to be closed
V_{AB}, V_{BC}, and V_{CA}	Real-time phase-to-phase voltages of the busbar

6.2.8.5 Residual-Voltage Mode

Once the residual voltage decreases below the threshold value **Vmax. resid.volt. mode**, the mode **Resid.volt. mode** starts to work.

Logic



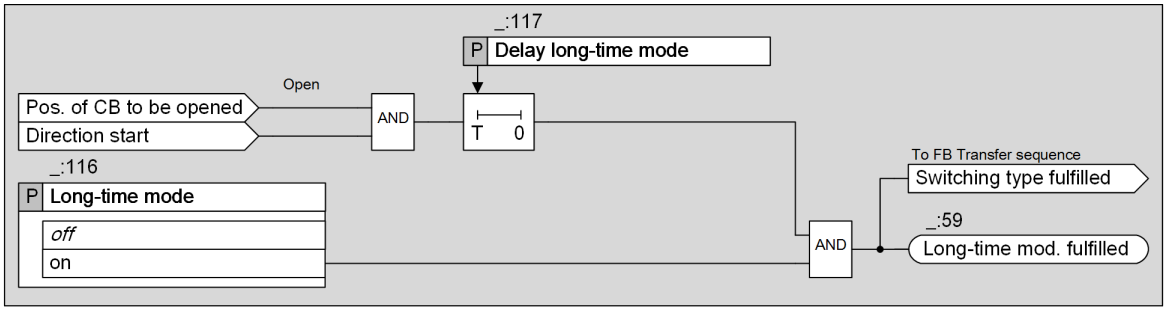
[lo_residual-voltage mode, 1, en_US]

Figure 6-41 Logic Diagram of the Residual-Voltage Mode

6.2.8.6 Long-Time Mode

Once the transfer execution time exceeds the set parameter **Delay long-time mode**, the **Long-time mode** starts to work.

Logic



[lo_long-time mode, 1, en_US]

Figure 6-42 Logic Diagram Long-Time Mode

6.2.8.7 Application and Setting Notes (Fast Mode)

The following parameters must be set according to the residual-voltage characteristic.

Parameter: **Δf max. fast mode**

- Default setting **(_:102) Δf max. fast mode** = ***3.00 Hz***

With the parameter **Δf max. fast mode**, you specify the threshold for the frequency difference between both sides of the circuit breaker to be closed.

Siemens recommends setting the parameter in the range of 3.00 Hz to 5.00 Hz.

Parameter: **Δφ max. fast mode**

- Default setting **(_:103) Δφ max. fast mode** = ***25.0°***

With the parameter **Δφ max. fast mode**, you specify the threshold for the phase-angle difference between both sides of the circuit breaker to be closed.

The default setting of 25.0° is a practical value.

When setting the parameter **Δφ max. fast mode**, consider the closing time of the circuit breaker to be closed.

EXAMPLE

Closing time of the circuit breaker to be closed (vacuum circuit breaker)	60 ms
Phase-angle difference at the closure instant of the circuit breaker to be closed	Restricted to 60°
df/dt of motors during tens of milliseconds after the running incomer is de-energized	1.5 Hz/s

The phase-angle increment from the instant of issuing the close command to the instant of the circuit-breaker closure is calculated as follows:

$$\frac{60\ \text{ms}}{1000} \cdot 360° \cdot 1.5\ \text{Hz} = 32.4°$$

Then, the parameter **Δφ max. fast mode** = 60° - 32.4°= 27.6°.

You can assess and optimize the setting value according to the decay curve of the residual voltage $V_{res.}$ and the closing time of the circuit breaker to be closed (for example, slightly increase the setting value). For the assessment and optimization, a record analysis program like SIGRA can be used.

Parameter: **Vmin. fast mode**

- Default setting **(_:104) Vmin. fast mode** = ***70.0 %***

With the parameter **Vmin. fast mode**, you specify the threshold for the minimum phase-to-phase voltage of the busbar.

Siemens recommends setting the parameter in the range of 50.0 % to 70.0 %.

6.2.8.8 Application and Setting Notes (Real-Time Fast Mode)

Parameter: **V/f diff max. RTFT mode**

- Default setting **(_:106) V/f diff max. RTFT mode** = ***1.33***

With the parameter **V/f diff max. RTFT mode**, you specify the threshold for the predicted resultant volts per hertz in per unit between the phasor $\underline{V}_{res.}/f_{res.}$ in per unit and the phasor $\underline{V}_{alt.}/f_{alt.}$ in per unit at the closure instant of the circuit breaker to be closed.

The default value ***1.33*** is taken from the standard ANSI C50.41-2012. Siemens recommends using the default value.

Parameter: Δφ max. RTFT mode

- Default setting **(_:107) Δφ max. RTFT mode** = ***88.0°***

With the parameter **Δφ max. RTFT mode**, you specify the threshold for the predicted phase-angle difference between the phasor $\underline{V}_{res.}/f_{res.}$ in per unit and the phasor $\underline{V}_{alt.}/f_{alt.}$ in per unit at the closure instant of the circuit breaker to be closed.

The default value is set after considering the accuracy of the predicted phase angle and referring to the standard ANSI C50.41-2012. Siemens recommends using the default value.

The following parameters must be set according to the residual-voltage characteristic.

Parameter: Δf max. RTFT mode

- Default setting **(_:108) Δf max. RTFT mode** = ***6.00 Hz***

With the parameter **Δf max. RTFT mode**, you specify the threshold for the frequency difference between both sides of the circuit breaker to be closed.

Siemens recommends setting the parameter in the range of 3.00 Hz to 6.00 Hz.

Parameter: V min. RTFT mode

- Default setting **(_:109) V min. RTFT mode** = ***70.0 %***

With the parameter **V min. RTFT mode**, you specify the threshold for the minimum phase-to-phase voltage of the busbar.

Siemens recommends setting the parameter in the range of 50.0 % to 70.0 %.

6.2.8.9 Application and Setting Notes (In-Phase Mode)

The following parameters must be set according to the residual-voltage characteristic.

Parameter: Δφ max. in-phase mode

- Default setting **(_:111) Δφ max. in-phase mode** = ***15.0°***

With the parameter **Δφ max. in-phase mode**, you specify the threshold for the predicted phase-angle difference between the phasor of the residual voltage and the phasor of the alternative voltage at the closure instant of the circuit breaker to be closed.

Siemens recommends setting the parameter in the range of 10.0° to 20.0°.

Parameter: Δf max. in-phase mode

- Default setting **(_:112) Δf max. in-phase mode** = ***6.00 Hz***

With the parameter **Δf max. in-phase mode**, you specify the threshold for the frequency difference between both sides of the circuit breaker to be closed.

Siemens recommends setting the parameter in the range of 5.00 Hz to 10.00 Hz.

Parameter: Vmin. in-phase mode

- Default setting **(_:113) Vmin. in-phase mode** = ***40.0 %***

With the parameter **Vmin. in-phase mode**, you specify the threshold for the minimum phase-to-phase voltage of the busbar.

Siemens recommends setting the parameter in the range of 40.0 % to 50.0 %.

6.2.8.10 Application and Setting Notes (Residual-Voltage Mode)

Parameter: Resid.volt. mode

- Default setting **Resid.volt. mode** = ***off***

With the parameter **(_:114) Resid.volt. mode**, you enable or disable the **Resid.volt. mode**.

Parameter: Vmax. resid.volt. mode

- Default setting **(_:115) Vmax. resid.volt. mode** = *30.0 %*

With the parameter **Vmax. resid.volt. mode**, you specify the threshold for the maximum residual voltage of the busbar.

Parameter: Delay resid.volt. mode

- Default setting = *0.00 s*

With the parameter **(_:118) Delay resid.volt. mode**, you specify the time delay for the **Resid.volt. mode**.

6.2.8.11 Application and Setting Notes (Long-Time Mode)

Parameter: Long-time mode

- Default setting **(_:116) Long-time mode** = *off*

With the parameter **Long-time mode**, you enable or disable the **Long-time mode**.

Parameter: Delay long-time mode

- Default setting = *3.00 s*

With the parameter **(_:117) Delay long-time mode**, you specify the time delay for the **Long-time mode**.

6.2.8.12 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fast mode				
_:101	Switch. types:Fast mode		• off • on	off
_:102	Switch. types:Δf max. fast mode		0.50 Hz to 5.00 Hz	3.00 Hz
_:103	Switch. types:Δφ max. fast mode		10.0 ° to 50.0 °	25.0 °
_:104	Switch. types:Vmin. fast mode		50.0 % to 90.0 %	70.0 %
RTFT mode				
_:105	Switch. types:Real-time fast mode		• off • on	off
_:106	Switch. types:V/f diff max. RTFT mode		1.00 to 1.33	1.33
_:107	Switch. types:Δφ max. RTFT mode		70.0 ° to 90.0 °	88.0°
_:108	Switch. types:Δf max. RTFT mode		1.00 Hz to 15.00 Hz	6.00 Hz
_:109	Switch. types:V min. RTFT mode		50.0 % to 90.0 %	70.0 %
In-phase mode				
_:110	Switch. types:In-phase mode		• off • on	off

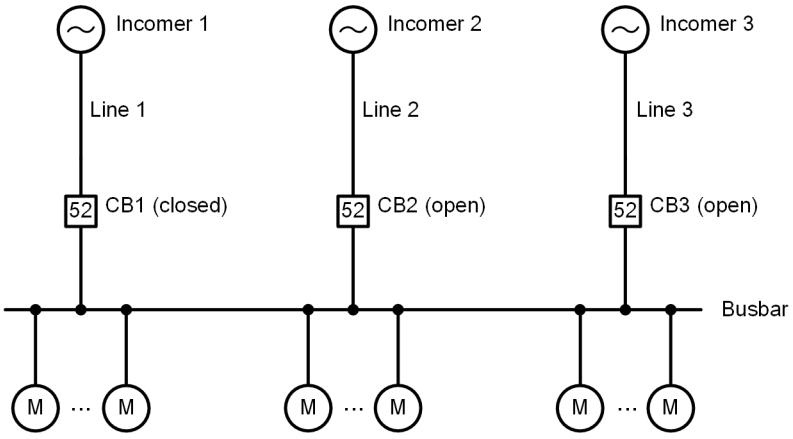
Addr.	Parameter	C	Setting Options	Default Setting
_:111	Switch. types:Δφ max. in-phase mode		0.5 ° to 30.0 °	15.0 °
_:112	Switch. types:Δf max. in-phase mode		1.00 Hz to 15.00 Hz	6.00 Hz
_:113	Switch. types:Vmin. in-phase mode		30.0 % to 80.0 %	40.0 %
Resid.volt. mode				
_:114	Switch. types:Resid.volt. mode		• off • on	off
_:115	Switch. types:Vmax. resid.volt. mode		20.0 % to 60.0 %	30.0 %
_:118	Switch. types:Delay resid.volt. mode		0.00 s to 10.00 s	0.00 s
Long-time mode				
_:116	Switch. types:Long-time mode		• off • on	off
_:117	Switch. types:Delay long-time mode		0.50 s to 10.00 s	3.00 s

6.2.8.13 Information List

No.	Information	Data Class (Type)	Type
Switch. types			
_:22531:55	Switch. types:Fast mode fulfilled	SPS	O
_:22531:56	Switch. types:RTFT mode fulfilled	SPS	O
_:22531:57	Switch. types:In-phase mode fulfilled	SPS	O
_:22531:58	Switch. types:Res.volt. mode fulfilled	SPS	O
_:22531:59	Switch. types:Long-time mod. fulfilled	SPS	O

6.3 Transfer-Priority Group

6.3.1 Overview



[dw_example_1BB_3L, 1, en_US]

Figure 6-43 Application Example

In the preceding application, incomer 1 energizes the busbar. If a fault occurs on Line 1, a transfer is needed. In this situation, there are 2 alternative incomers, incomer 2 and incomer 3. Both of the transfer directions **Incomer 1 to incomer 2** and **Incomer 1 to incomer 3** can be started when they are ready at the same time. However, it is not allowed to start 2 transfer directions at the same time. For this case, you can set the priority according to the actual transfer demand to determine which transfer direction is to be started. The function block **Transfer-priority group** is used to deal with this kind of cases.

For a complicated HSBT application, there are multiple applicable transfer directions. If there is more than one transfer option, you must group and prioritize these transfer directions to make sure that only 1 transfer direction is started at a time. The transfer directions in the same transfer-priority group must fulfill the following conditions:

- They must have the same running incomer with the circuit breaker to be opened.
- They must have different alternative incomers with the circuit breakers to be closed which must be prioritized.
- The incomer is transferred for the same busbar.

The function block **Transfer-priority group** is used to group and prioritize these transfer directions.

A transfer-priority group has the following properties:

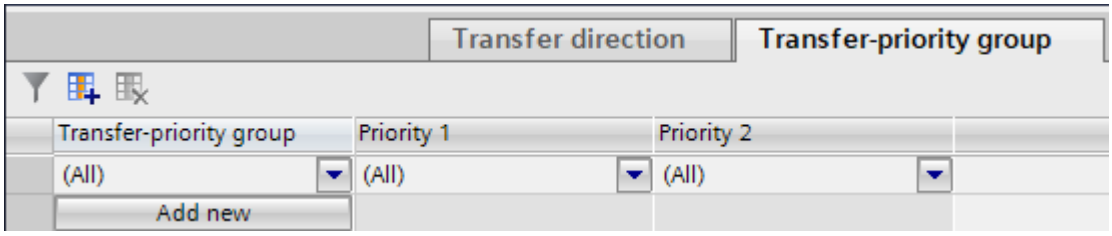
- A function group must contain at least 2 transfer directions to realize the priorities.
  The priorities are determined only within transfer directions that are in one transfer-priority group.
- **Priority 1** is the highest priority in a transfer-priority group.

A transfer direction can be added into only one transfer-priority group at a time.

In a function group **HSBT**, you can instantiate multiple function blocks **Transfer-priority group** as required. Each function block **Transfer-priority group** works independently.

6.3.2 Description

The groups and priorities of the transfer directions are performed in the tab **Transfer-priority group**. You can find the tab **Transfer-priority group** in DIGSI 5 under **Project tree** > **Name of the device** > **Settings** > **HSBT** > **Transfer routing**.



[sc_transfer group, 2, en_US]

Figure 6-44 Tab Transfer-Priority Group

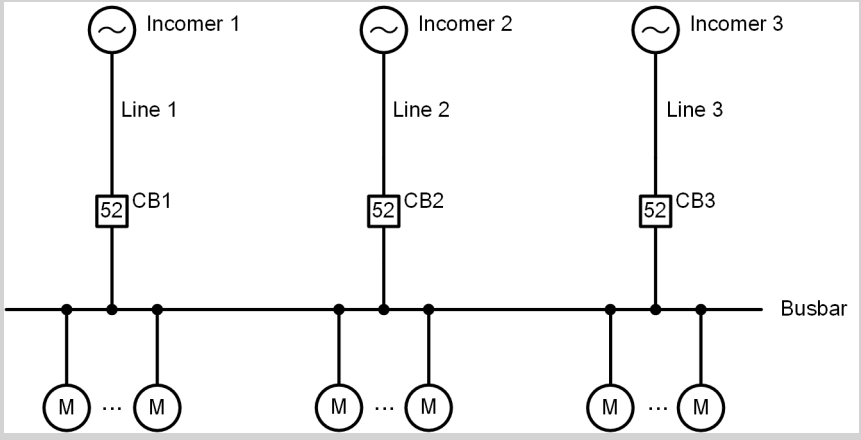
In the tab **Transfer-priority group**, you can perform the following basic operations:

- Transfer-priority group
  - Adding a transfer-priority group
    You can also add a transfer-priority group by instantiating the function block **Transfer-priority group** from the library.
  - Deleting a transfer-priority group
  - Renaming a transfer-priority group
- Priority column
  - Adding a priority column by clicking
    A maximum of 20 priority columns are supported in a function group **HSBT**.
  - Deleting a priority column by clicking
    A tab **Transfer-priority group** has 2 default priority columns that cannot be deleted.
- Transfer-direction prioritization
  You can prioritize a transfer direction by selecting the name of this transfer direction from the list box of a cell in the table.

NOTE

A transfer direction can be added to only one transfer-priority group and one priority column. If you route a transfer direction from one transfer-priority group or one priority column to another, the previous cell displays **Not configured**. The device restarts automatically after the settings are downloaded via DIGSI 5.

Application Example



[dw_1BB_3L_1, en_US]

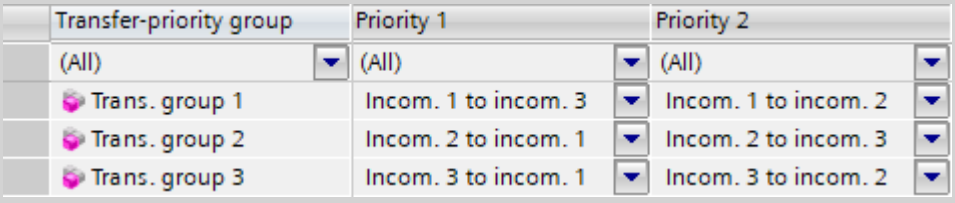
Figure 6-45 Application of a Single Busbar with 3 Incomers

The following table lists the applicable transfer directions in this application. All transfers directions are categorized by the CB to be opened.

Table 6-7 Transfer Directions

CB to be Opened	Transfer Directions	
CB1	Incomer 1 to incomer 2	Incomer 1 to incomer 3
CB2	Incomer 2 to incomer 1	Incomer 2 to incomer 3
CB3	Incomer 3 to incomer 1	Incomer 3 to incomer 2

In this application, all transfer directions must be assigned to 3 transfer-priority groups by the CB to be opened. In each transfer-priority group, set the priorities of transfer directions according to the specific requirements.



[sc_transfer group_setting example_3L_2, en_US]

Figure 6-46 Settings of Groups and Priorities

Taking the transfer-priority group 1 as an example, the transfer direction **Incomer 1 to incomer 3** is set with a higher priority than the transfer direction **Incomer 1 to incomer 2**.

Case 1:

Table 6-8 Transfer-Priority Group 1: Statuses of Transfer Directions in Case 1

Transfer-Priority Group 1	Priorities	Statuses
Incomer 1 to incomer 3	1	Ready
Incomer 1 to incomer 2	2	Ready

In the transfer-priority group 1, if both transfer directions are ready, only the transfer direction **Incomer 1 to incomer 3** can be started according to the priority setting.

Case 2:

Table 6-9 Transfer-Priority Group 1: Statuses of Transfer Directions in Case 2

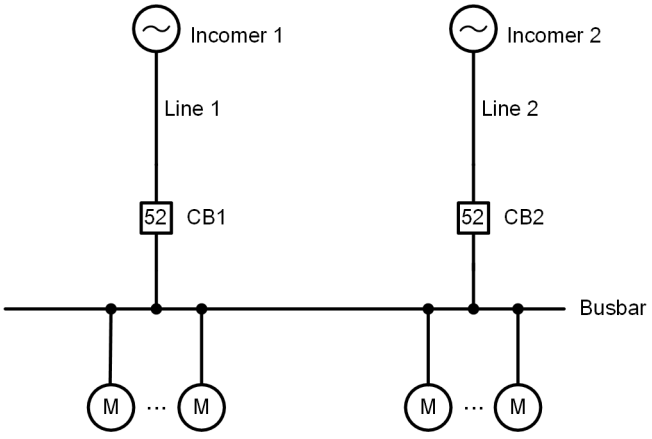
Transfer-Priority Group 1	Priorities	Statuses
Incomer 1 to incomer 3	1	Unready
Incomer 1 to incomer 2	2	Ready

In the transfer-priority group 1, if Line 3 is under maintenance or a fault has occurred on Line 3, the transfer direction **Incomer 1 to incomer 3** is ready. Under this precondition, only the transfer direction **Incomer 1 to incomer 2** can be started according to the priority setting.

6.4 Basic Configurations for the High-Speed Busbar Transfer

To implement a functionality of the high-speed busbar transfer, you must perform several configurations in DIGSI 5. For typical applications, 7VU85 provides 3 application templates with configurations. If you want to adapt the on-site wiring to the templates or use other complex applications, some configurations must be conducted accordingly.

To illustrate the specific configurations, the application of a single busbar with 2 incomers is used as an example as shown in the following figure.

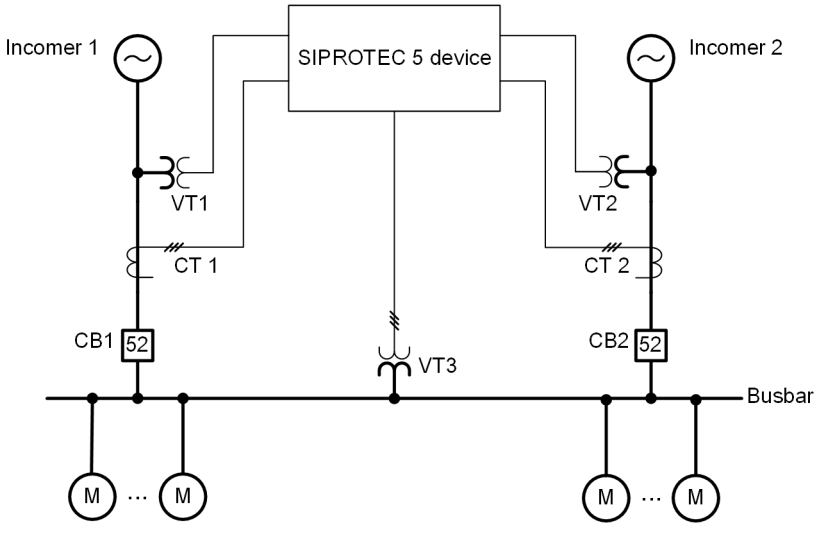


[dw_1BB_2L, 1, en_US]

Figure 6-47 Single Busbar with 2 Incomers

Routing the Measuring Points

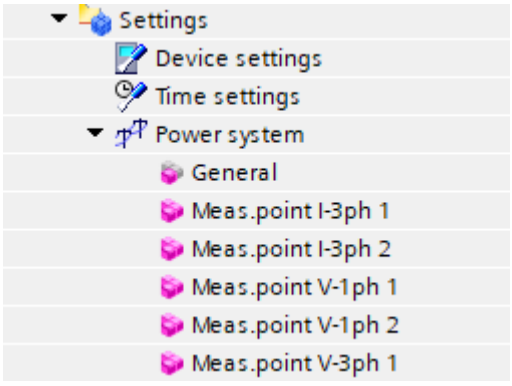
The following figure shows the typical wiring for the application of a single busbar with 2 incomers.



[dw_1B_2L_2CB, 1, en_US]

Figure 6-48 Typical Wiring

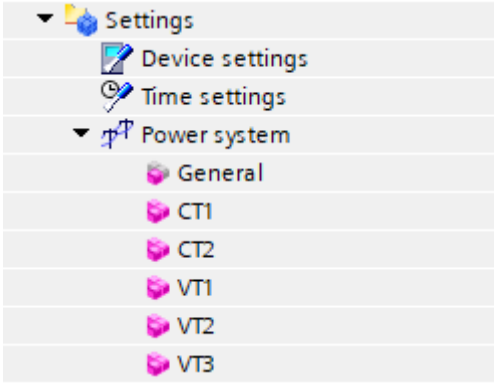
✧ Instantiate the following measuring points according to the typical wiring.
- Two 3-phase current measuring points
- Two 1-phase voltage measuring points
- One 3-phase voltage measuring point



[sc_MP, 1, en_US]

Figure 6-49 Instantiated Measuring Points

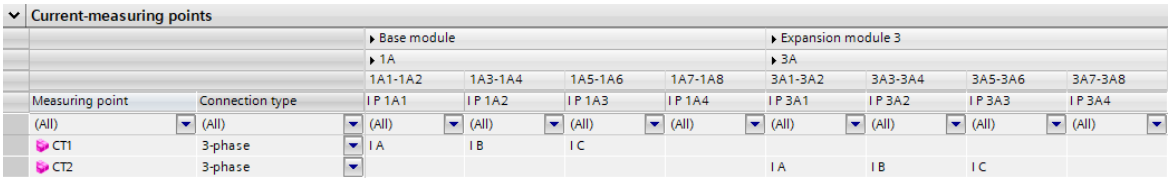
✧ Rename the measuring points.
For direct mapping between the wiring and the assignment of measuring points in DIGSI 5, you can rename the measuring points. In this example, the measuring points are renamed according to the naming in *Figure 6-48*.



[sc_renamed_MP, 1, en_US]

Figure 6-50 Renamed Measuring Points

✧ Route the measuring points according to the connection to the device terminals. The following figures show the routing examples.

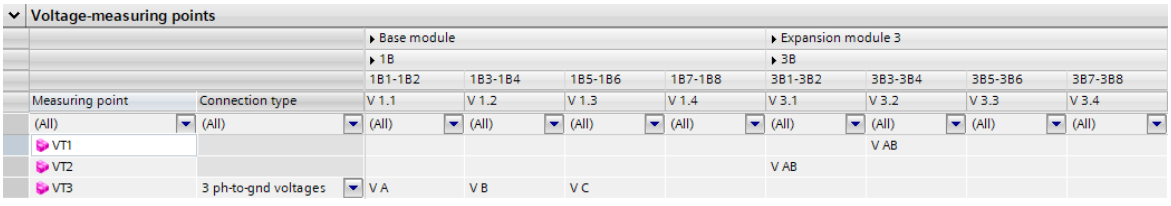


Current-measuring points

		Base module				Expansion module 3			
		1A				3A			
		1A1-1A2	1A3-1A4	1A5-1A6	1A7-1A8	3A1-3A2	3A3-3A4	3A5-3A6	3A7-3A8
Measuring point	Connection type	I P 1A1	I P 1A2	I P 1A3	I P 1A4	I P 3A1	I P 3A2	I P 3A3	I P 3A4
(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)
CT1	3-phase	I A	I B	I C					
CT2	3-phase					I A	I B	I C	

[sc_I_MP_routing, 1, en_US]

Figure 6-51 Routing Example of Current Measuring Points



Voltage-measuring points

		Base module				Expansion module 3			
		1B				3B			
		1B1-1B2	1B3-1B4	1B5-1B6	1B7-1B8	3B1-3B2	3B3-3B4	3B5-3B6	3B7-3B8
Measuring point	Connection type	V 1.1	V 1.2	V 1.3	V 1.4	V 3.1	V 3.2	V 3.3	V 3.4
(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)
VT1							V AB		
VT2						V AB			
VT3	3 ph-to-gnd voltages	V A	V B	V C					

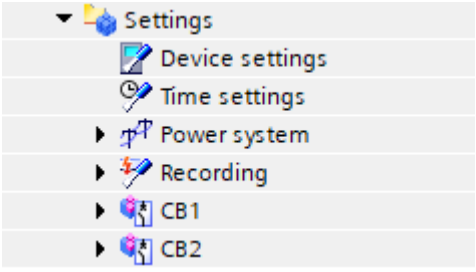
[sc_V_MP_routing, 1, en_US]

Figure 6-52 Routing Example of Voltage Measuring Points

Instantiating the Function Groups Circuit Breaker

✧ Instantiate 2 function groups **Circuit breaker**.

✧ Rename the function groups according to the naming in *Figure 6-48*.



[sc_CB instantiation, 1, en_US]

Figure 6-53 Instantiated and Renamed Function Groups Circuit Breaker

Connecting the Measuring Points to the Function Groups Circuit Breaker

✧ Route the current measuring points to the respective current interface of the circuit breakers according to the wiring.

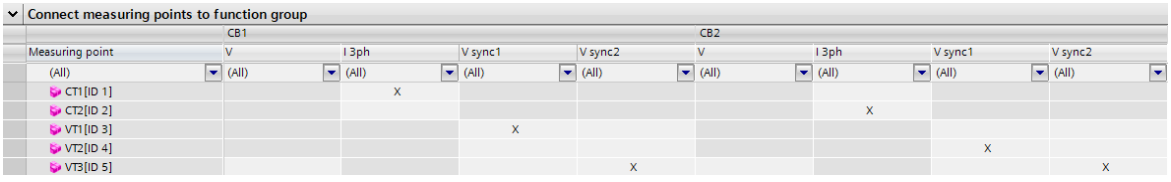
Each current measuring point corresponds to one circuit breaker.

✧ Route the voltage measuring points.

The routing between the voltage measuring points and the function groups **Circuit breaker** for the high-speed busbar transfer does not have a fixed method.

The application of the single busbar with 2 incomers contains 2 circuit breakers of incomers. For the circuit breakers of incomers, the common routing method is as follows:

- Route the voltage measuring points on the incomers to the interfaces V sync1 of the circuit breakers.
- Route the voltage measuring point on the busbar to the interfaces V sync2 of the circuit breakers.



[sc_MP to FG CB, 1, en_US]

Figure 6-54 Connecting the Measuring Points to the Function Groups Circuit Breaker

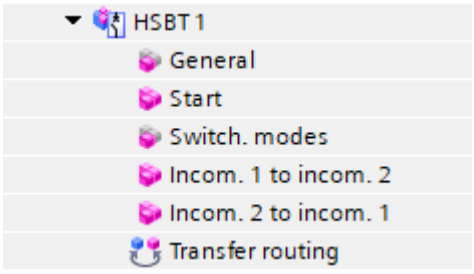
Configuring the High-Speed Busbar Transfer

For the application of the single busbar with 2 incomers, the following 2 transfer directions can be realized:

- **Incomer 1 to incomer 2**
- **Incomer 2 to incomer 1**

✧ To implement the transfer in 2 directions, instantiate 1 function group **HSBT** with 2 functions **Transfer direction**.

✧ Rename the functions according to the naming in *Figure 6-48*.



[sc_transfer directions, 1, en_US]

Figure 6-55 Instantiated Functionalities

Transfer Direction Incomer 1 to Incomer 2

For the transfer direction **Incomer 1 to incomer 2**, the situation is as follows:

Running incomer:	Incomer 1
Alternative incomer:	Incomer 2
Busbar to be transferred:	Busbar

The circuit breakers participating in this transfer must be defined as follows:

CB to be opened:	CB1
CB to be closed:	CB2
Additional open CB:	N/A
Additional closed CB:	N/A

The circuit-breaker routing is as follows:

Transfer direction	CB to be opened	CB to be closed	Additional open CB	Additional closed CB
(All)	(All)	(All)	(All)	(All)
Incom. 1 to incom. 2				
CB1	X			
CB2		X		

[sc_incomer 1 to incomer 2, 1, en_US]

Figure 6-56 Circuit-Breaker Routing

The settings of the following 2 parameters have a decisive impact on the execution of a high-speed busbar transfer. Pay attention to the specific settings. The settings for the transfer direction **Incomer 1 to incomer 2** are as follows:

- Parameter **`Manual start only`**

  If you only want to manually start the transfer direction, set the parameter **`Manual start only`** to ***yes*** which is the default value. If you want to start a transfer direction via all supported start conditions, set the parameter **`Manual start only`** to ***no***.

- Parameter **`Run. busbar volt. source`**

  For this transfer direction, the busbar to be transferred is the whole busbar. In *Figure 6-54*, the voltage measuring point on the busbar is routed to the interface V sync2 of the CB2 (CB to be closed). Then, set the parameter **`Run. busbar volt. source`** to ***V sync2***.

  For more information about the parameter **`Run. busbar volt. source`**, refer to *6.2.4.2 Application and Setting Notes*.

Transfer Direction Incomer 2 to Incomer 1

The configuration process for the transfer direction **Incomer 2 to incomer 1** must follow the configuration process of the transfer direction **Incomer 1 to incomer 2**. The specific configurations must be conducted separately according to the situation.

For the transfer direction **Incomer 2 to incomer 1**, the situation is as follows:

Running incomer:	Incomer 2
Alternative incomer:	Incomer 1
Busbar to be transferred:	Busbar

The circuit breakers participating in this transfer must be defined as follows:

CB to be opened:	CB2
CB to be closed:	CB1
Additional open CB:	N/A
Additional closed CB:	N/A

The circuit-breaker routing is as follows:

Transfer direction	CB to be opened	CB to be closed	Additional open CB	Additional closed CB
(All)	(All)	(All)	(All)	(All)
Incom. 2 to incom. 1				
CB1		X		
CB2	X			

[sc_incomer 2 to incomer 1, 1, en_US]

Figure 6-57 Circuit-Breaker Routing

The settings of the following 2 parameters for the transfer direction **Incomer 2 to incomer 1** is as follows:

- Parameter **`Manual start only`**

  If you only want to manually start the transfer direction, set the parameter **`Manual start only`** to ***yes*** which is the default value. If you want to start a transfer direction via all supported start conditions, set the parameter **`Manual start only`** to ***no***.

- Parameter **`Run. busbar volt. source`**

  For this transfer direction, the busbar to be transferred is the whole busbar. In *Figure 6-54*, the voltage measuring point on the busbar is routed to the interface V sync2 of the CB1 (CB to be closed). Then, set the parameter **`Run. busbar volt. source`** to ***V sync2***.

For more information about the parameter **`Run. busbar volt. source`**, refer to *6.2.4.2 Application and Setting Notes*.

6.5 Primary and Secondary Tests for High-Speed Busbar Transfer

6.5.1 Checking the Measuring-Voltage Circuits

Protection Switches for the Voltage Transformers

If the miniature circuit breaker (MCB) for the VTs is open, the high-speed busbar transfer in the specific direction is blocked automatically. The blocking can be checked along with the voltage circuits.

A prerequisite for this check is that the auxiliary contact of the VT MCB is connected and routed. Proceed as follows:

- ✧ Open one VT MCB.
- ✧ Check in the operational log whether the VT MCB open indication is issued, that is, whether the status of the binary input signal *>Open* from the function **Voltage-Transformer Circuit Breaker** is *on*.
- ✧ Close the VT MCB.
- ✧ Check in the operational log whether the VT MCB close indication is issued, that is, whether the status of the binary input signal *>Open* is *off*.

If one of the indications does not appear, check the connection and allocation of these signals.

If the *on* or *off* status is reversed, check and correct the auxiliary-contact type of the circuit breaker.

Checking the Measurement Chain

The measurement chain for the voltage measurement must be checked. You can check the measurement chain via a primary test or a secondary test:

- Primary test means that the measurands are from the actual power system.
- Secondary test means that the measurands are injected via a test equipment.

The test methods are the same for primary tests and secondary tests:

- ✧ Manually activate the fault recording in DIGSI 5.
- ✧ Check the accuracy of the following measurands:
  – Voltage magnitude
  – Phase sequence
  – Phase information of 1-phase voltage

6.5.2 Measuring the Circuit-Breaker Make Time

General

The switching types **Real-time fast mode** and **In-phase mode** work by checking the predicted analog values at the closure instant of circuit breaker. The precision of the set circuit-breaker make time influences the accuracy of the predicted analog values. The circuit-breaker make time must be measured.

Reading the Make Time from a Fault Record

A simple option for determining the make time involves reading out the time between the close command and the closure of the switch pole via the fault record. The time determined here is the real make time and not the operation time of the circuit breaker. You do not have to add any further time.

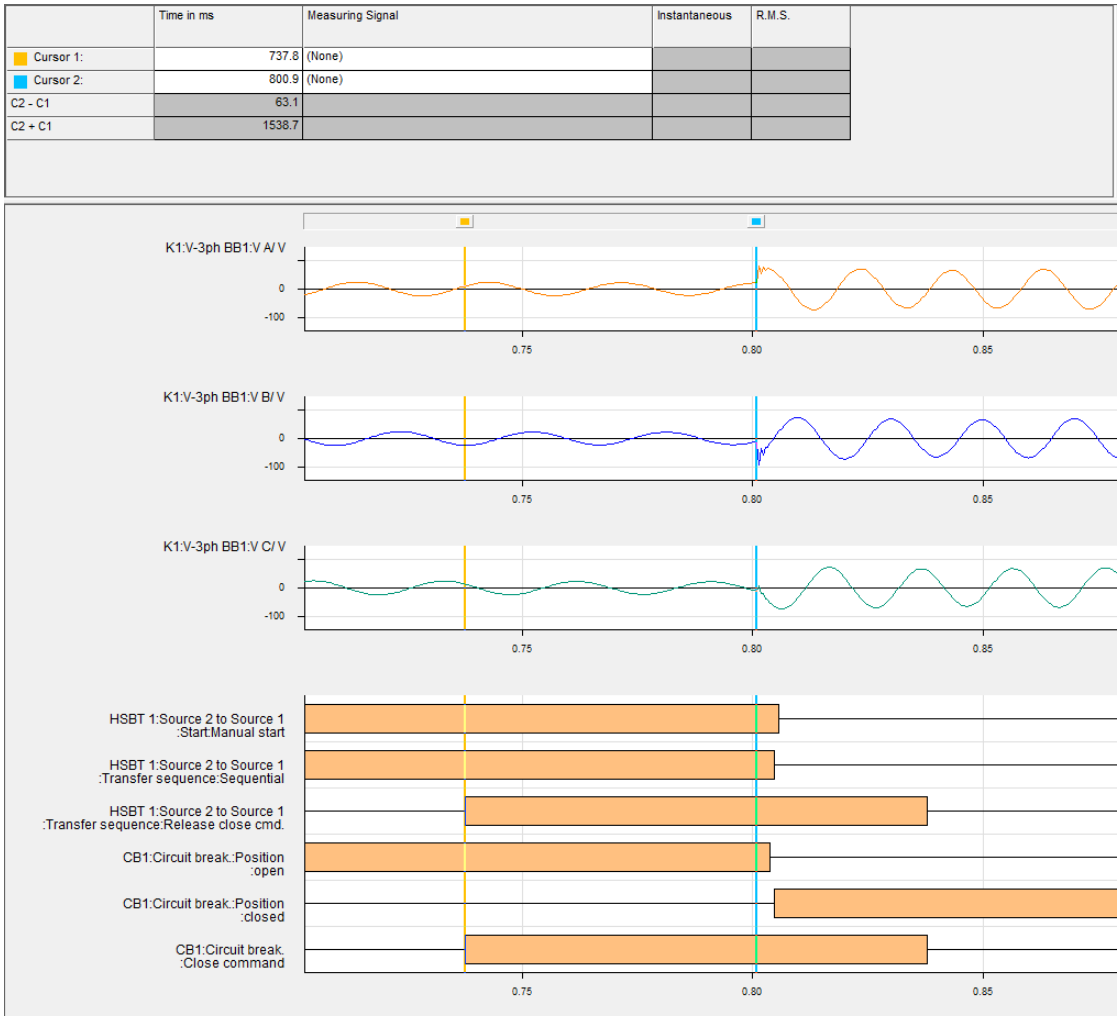
Siemens recommends the following procedure:

- ✧ Enable the functionality **Manual start** (parameter **Mode** = ***on***)
- ✧ Set the sequence type of the manual start to ***sequential*** (parameter **Transfer sequence** = ***sequential***).
- ✧ Enable the functionality **Long-time mode** (parameter **Long-time mode** = ***on***).

✧ Adjust the primary system of the transfer direction to the ready status.
Make sure that the transfer direction is to close the circuit breaker to be tested.

✧ Manually start the transfer direction.

✧ Read the fault record and determine the make time with the 2 cursors and the time-measuring function in SIGRA, as shown in the following figure.
Position cursor 1 at the instant that the close command is issued.
Position cursor 2 at the instant that the busbar voltage recovers to the normal value.



✧ Set the determined time with the parameter **CB make time**.
Proceed in the same way for all other circuit breakers.

✧ Set the parameters (**Mode**, **Transfer sequence**, and **Long-time mode**) back to their former values.

6.5.3 Secondary Test

The secondary test is used for the following purposes:

- Check all transfer directions in a device
- Check all switching types
- Check the connections of the opening and closing circuits

To perform a secondary test, make sure that the on-site environment is suitable.

Prerequisite

Connect a test equipment (for example, Omicron) to the device and keep the connections of the opening and closing circuits.

Performing the Secondary Test

Perform the secondary test as follows:

✧ Adopt a start condition (for example, manual start) to activate a transfer direction. After the transfer, check the following items:

– Check if the transfer is executed as expected.

– Check if the circuit breakers work correctly, that is, the CB to be opened can be opened and the CB to be closed can be closed.

Proceed in the same way for all other transfer directions.

✧ Inject a required voltage via the test equipment to check if a switching type works as expected.

Proceed in the same way for all other switching types.

6.5.4 Primary Test

The primary test is used for the following purposes:

- Check if the setting values meet the residual-voltage characteristic of the busbar.
- Check if the setting values of the CB make time for all circuit breakers are suitable.

To perform a primary test, make sure that the following conditions are fulfilled:

- The connections of measuring circuits are correct.
- The position acquisition of circuit breakers is correct.
- The connections of the opening and closing circuits are correct.

At the same time, it is better for the busbar to energize as many motors as possible.

General Precaution



WARNING

Warning of dangers evolving from improper primary tests

Non-observance of the following measure can result in death, personal injury, or substantial material damage.

✧ The primary test can only be carried out by electrically qualified personnel, who are familiar with the commissioning of the high-speed busbar transfer device and protection systems, the operation of the plant, and the safety rules and regulations (switching, grounding, etc.).

Performing the Primary Test

Perform the primary test as follows:

✧ Activate a transfer direction via one or more start conditions, for example, manual start, undervoltage start, or CB inadvertent opening start.

✧ Read the fault record from the following aspects to verify if the setting values (especially for the switching type) meet the residual-voltage characteristic of the busbar:

– The sequence of the open command and the close command

– The running results of switching types

✧ Check the CB make time of a circuit breaker by comparing the setting value of the parameter **CB make time** with the measured CB make time. For more information about measuring the CB make time, refer to *6.5.2 Measuring the Circuit-Breaker Make Time*.

Proceed in the same way for all other circuit breakers.

7 Control Functions

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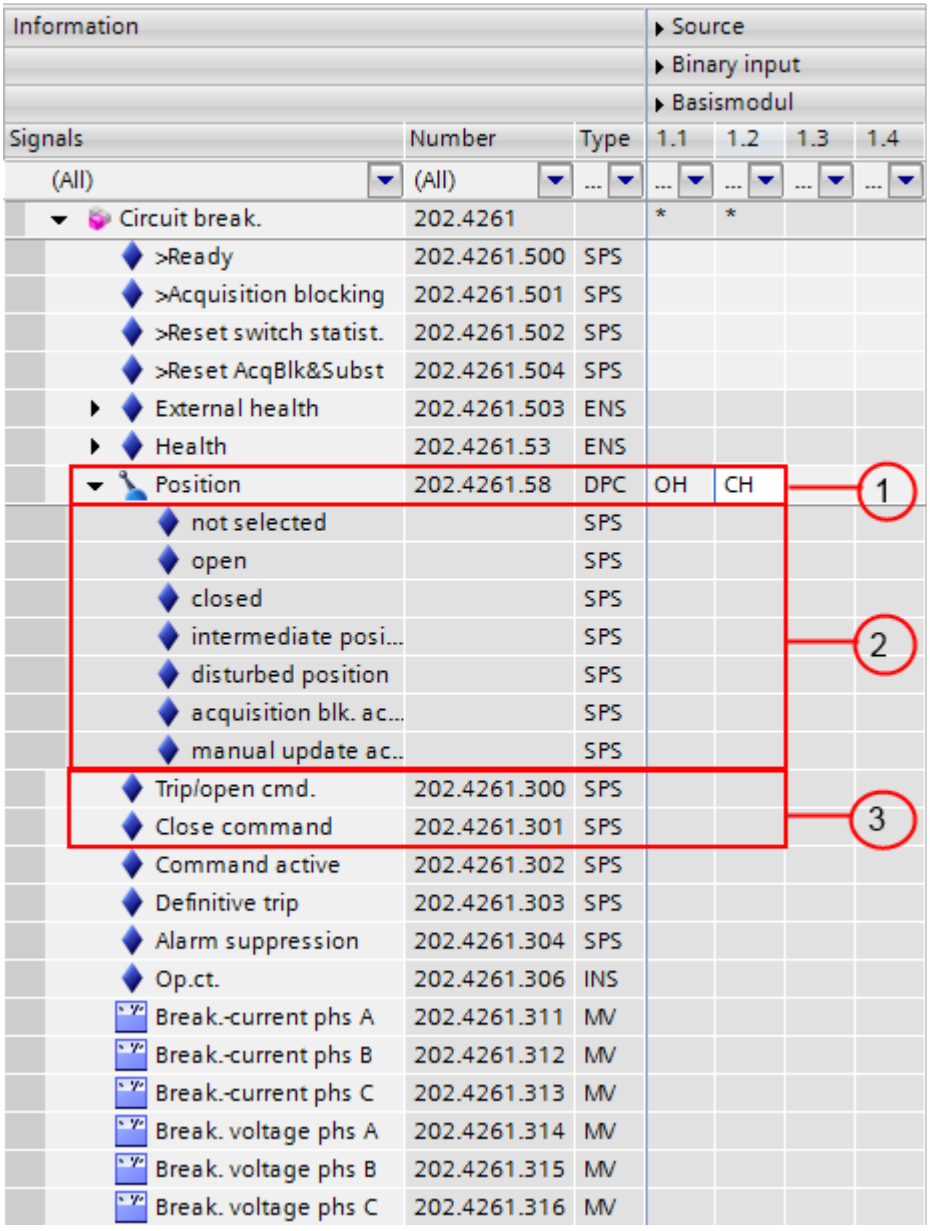
7.1 Introduction

7.1.1 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.

7.1.2 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 circuit breaker, 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).



[sc_control, 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.

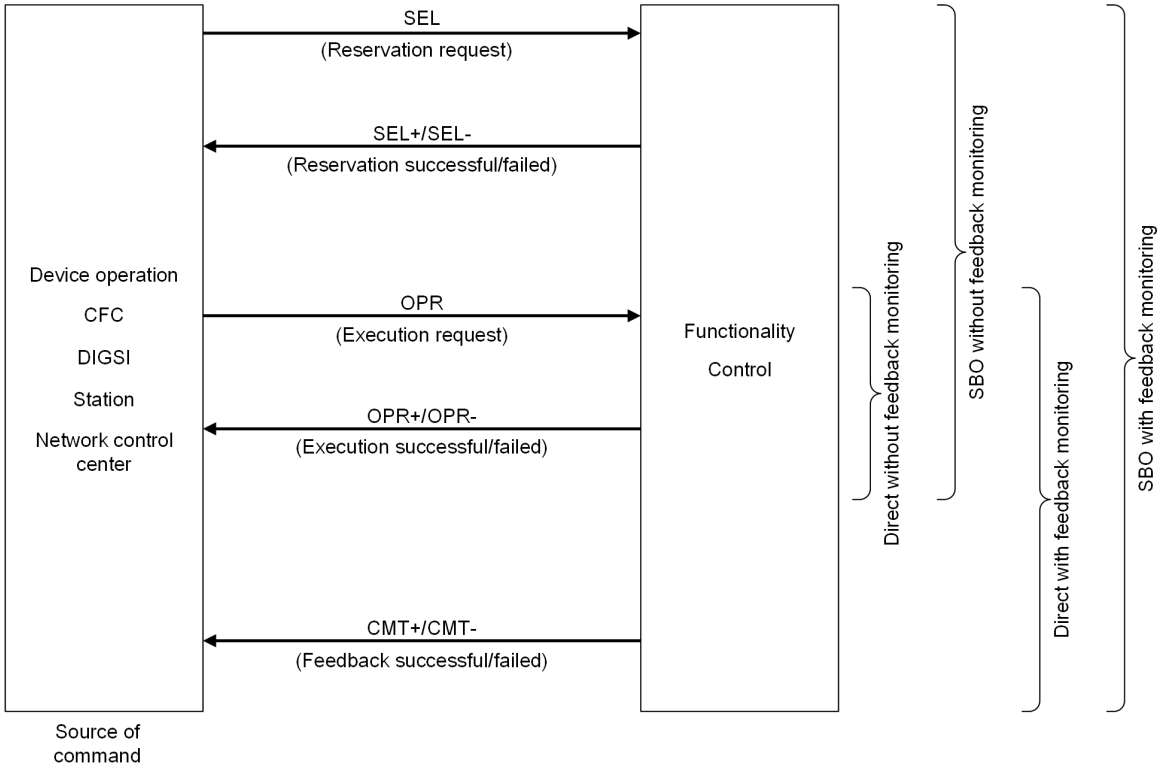
Control Models

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)[29] 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.



[dw_steuer, 2, en_US]

Figure 7-1 Command Sources, Command Types, and Control Models

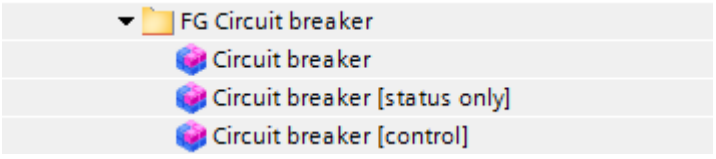
The figure shows the control models (right) with the respective control mechanisms (center). The standard control model for a switching command in an IEC 61850 compliant system is **SBO with feedback monitoring** (**`SBO w. enh. security`**). This control model is the default setting for newly created switching devices.

29 SBO: Select Before Operate

7.2 Switching Devices

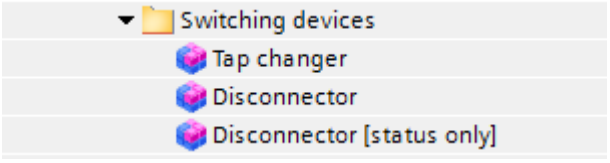
7.2.1 General Overview

You can find the following switching devices in the DIGSI 5 library in the function groups **Circuit breaker** and **Switching devices** (see following figures).



[sc_cb_ausw, 1, en_US]

Figure 7-2 Selecting the Circuit-Breaker Switching Device Using the DIGSI Circuit-Breaker Function Group Menu



[scswausw, 1, en_US]

Figure 7-3 Selecting the Remaining Switching Devices Using the DIGSI Switching-Devices Menu

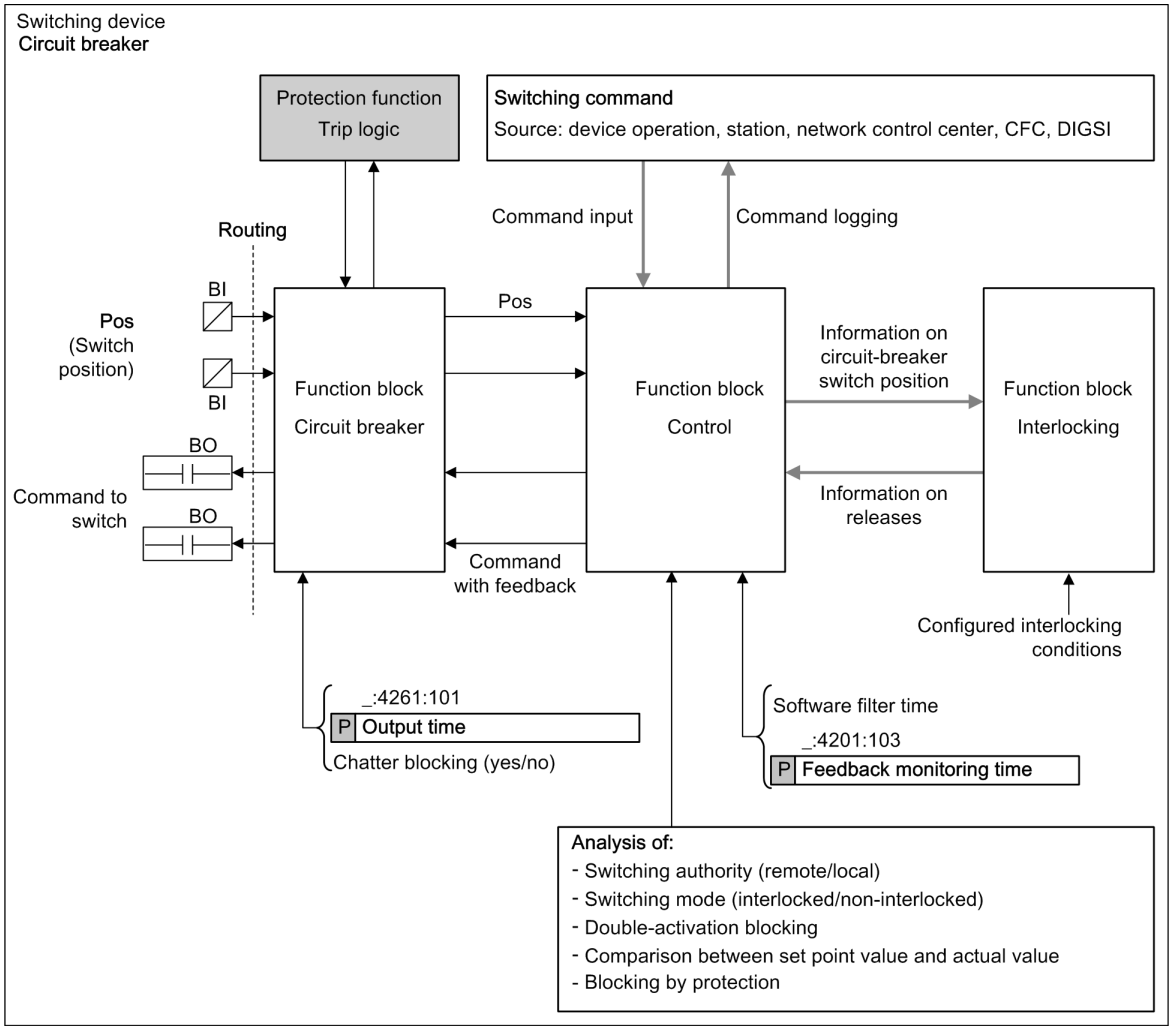
7.2.2 Switching Device Circuit Breaker

7.2.2.1 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 **Trip logic**, or **Manual On function**. However, these are not relevant for the control function. You can find the description of these functions in the chapter *Protection and Automatic Functions*. In addition, other functions can be initialized. You can find the description of these functions in the chapter *Protection Functions*.



[dw_breake, 1, en_US]

Figure 7-4 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.

The **Circuit-breaker** switching device is available in the following types:

- **3-pole circuit breaker**, **Circuit breaker [without current]**, **Circuit-breaker paralleling**
  This switching device contains additional base function blocks for protection functions (for example, **Trip logic**, **Manual closure**, **Circuit-breaker test**).
- **Circuit breaker [status only]**
  This switching device contains only the function block **Circuit breaker**. It is used to acquire the position of a switch, for example, from a neighboring bay. This object type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

Function Blocks of the Circuit Breaker

Table 7-1 Function Blocks of the Circuit-Breaker Function Group

Function Block	Description	Parameter	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 functionality **Interlocking** generates the releases for switchgear interlocking protection.

For the setting values of the parameter, refer to *7.2.2.2 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 7-2 Setting Options of the Controllable **Cmd. with feedback** in the Function Block **Control** of the Circuit Breaker.

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the function block **Control** [30]
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the function block **Control** [30]
Message time before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the function block **Control**[30]
Suppress intermediate position (yes/no)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the function block **Control** [30]

30 First click **Position** and then click the **Details** key in the **Properties** window (below).

Properties	Function	To Be Found in
Treatment of spontaneous position changes (Gen. Software Filt./Spont. Software Filt.)	If you select the ***General software filter*** setting, 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 function block **Control** [30]
Spontaneous software filtering time	Software filtering time for spontaneous position changes	Position of the function block **Control** [30]
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the function block **Control** [30]
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 function block **Control** [30]
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 function block **Control** [30]

Table 7-3 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 function block **Circuit breaker**[30]

Table 7-4 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 function blocks **Circuit breaker** and **Control** are described in the next section (refer to *7.2.2.3 Connection Variants of the Circuit Breaker*).

Interlocking

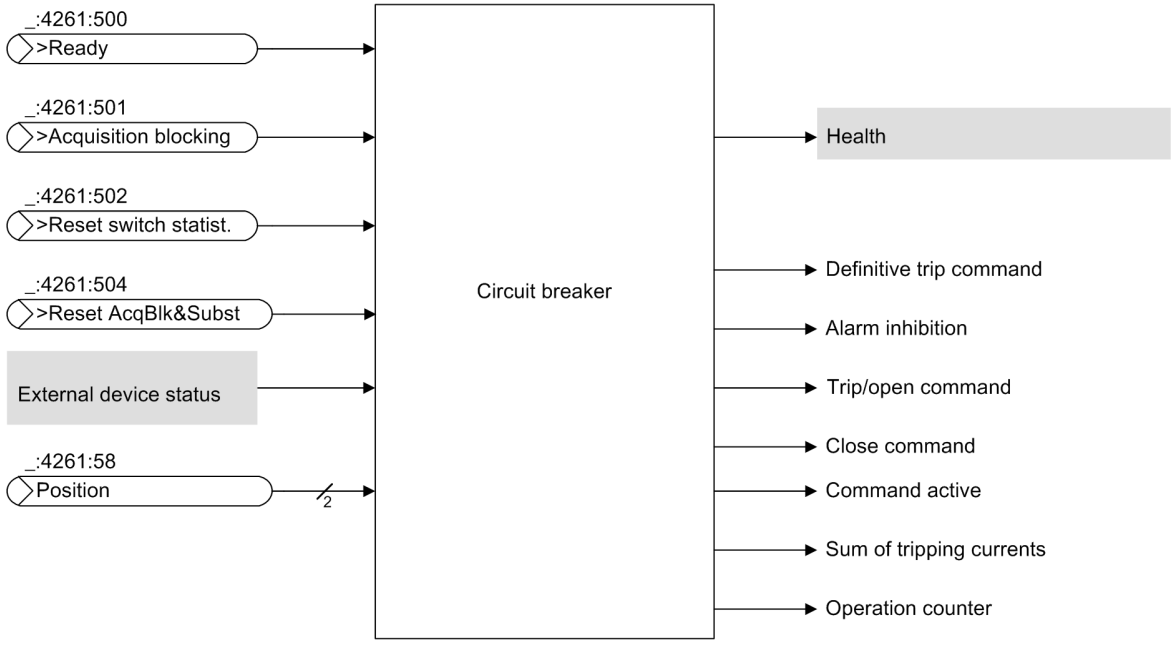
The function block **Interlocking** generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, refer to the general chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*.

7.2.2.2 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.



[dw_func_ls, 2, en_US]

Figure 7-5 Logical Inputs and Outputs of the Circuit-Breaker Function Blocks

Table 7-5 and *Table 7-6* 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 7-5 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***, or ***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 7-6 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 inhibition 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 statistical value counts the hours the circuit breaker is open.	INS
Operating hours	The statistical 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 (see also chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

Through the function SBO (Select Before Operate, reservation[31]), the switching device is reserved 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 2 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).

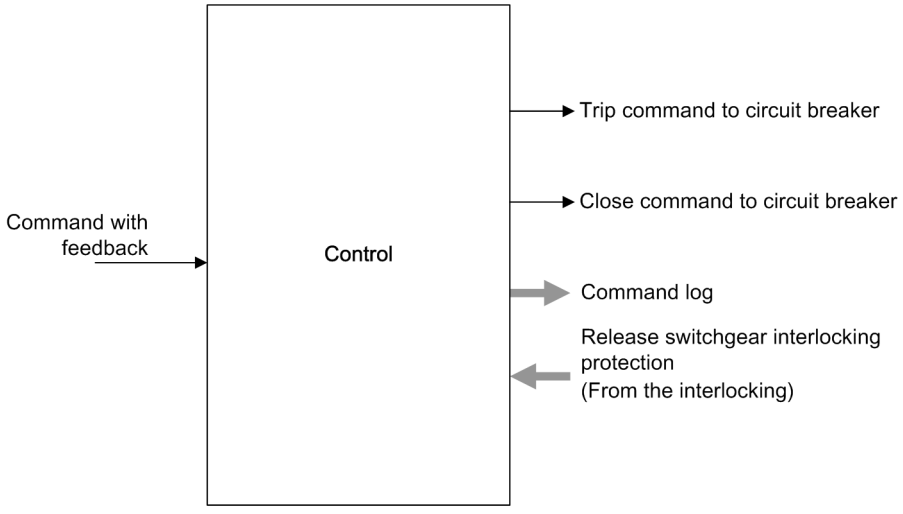
Parameters	Default Setting	Possible Parameter Values
(_:4201:101) Control model	***SBO w. enh. security***[32]	***direct w. normal secur.*** ***SBO w. normal secur.*** ***direct w. enh. security*** ***SBO w. enh. security***
(_:4201:102) SBO time-out	***30.00 s***	0.01 s to 1800 s (Increment: 0.01 s)

31 In the IEC 61850 standard, reservation is described as **Select before Operate (SBO)**.

32 This default setting is the standard control model for a switching command in an IEC 61850-compliant system.

Parameters	Default Setting	Possible Parameter Values
(_:4201:103) Feedback monitoring time	*1.00 s*	0.01 s to 1800 s (Increment: 0.01 s)
(_: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.



[dw_steue1, 1, en_US]

Figure 7-6 Logical Inputs and Outputs of the Control Function Block

Table 7-7 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 issued.	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.

7.2.2.3 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-pole, 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 7-8 Meaning of the Abbreviations of the Connection Variants

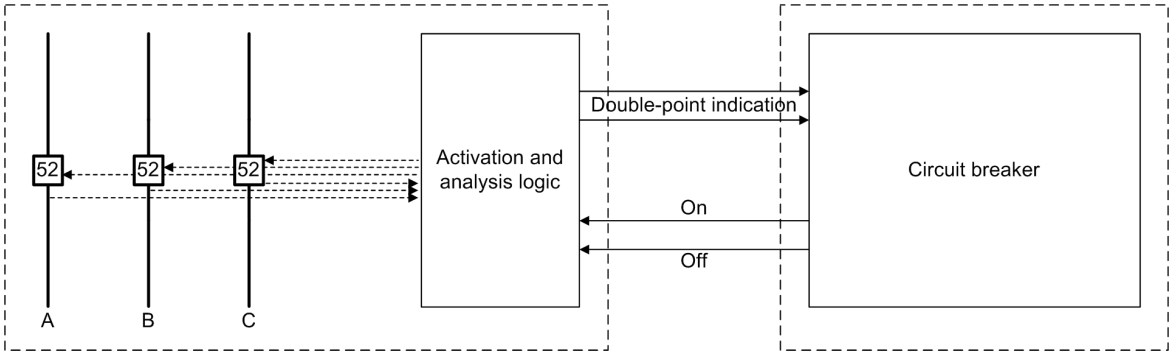
Abbreviation	Meaning of the Abbreviation of the Connection Variants
BO	Binary output
L+; L-	Control voltage
A	Trip command
Gnd	Close command

Table 7-9 Meaning of the Abbreviations in DIGSI

Abbreviation	Description of the Input in DIGSI
V	Unsaved trip command Click the right mouse button and enter **V**.
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 present 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 present at the routed binary input (L). Click the right mouse button and enter **OL**.
CH	The switching-device feedback is in the position **ON**, if there is voltage present 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 present 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

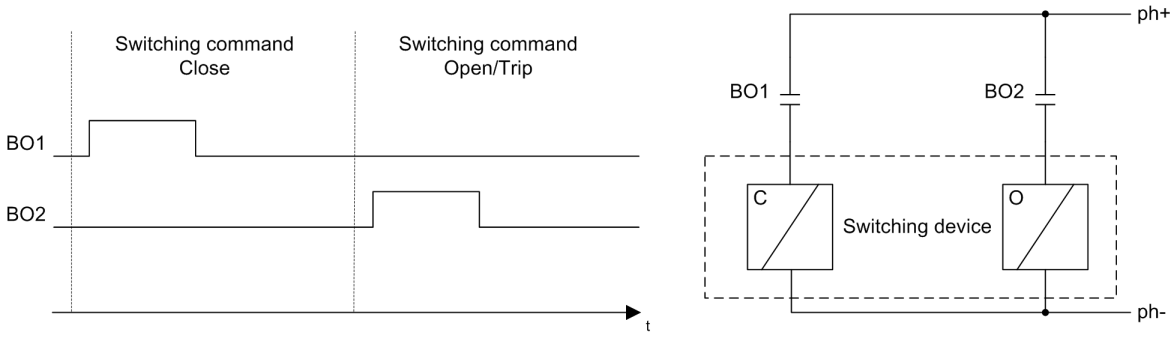
This is the standard type for the control function. All 3 individual poles of the circuit breaker are triggered together by a double command.



[dw_3-pole_ls, 1, en_US]

Figure 7-7 3-Pole Circuit Breaker

1-Pole Triggering



[dw_1-pole, 1, en_US]

Figure 7-8 1-Pole Triggering

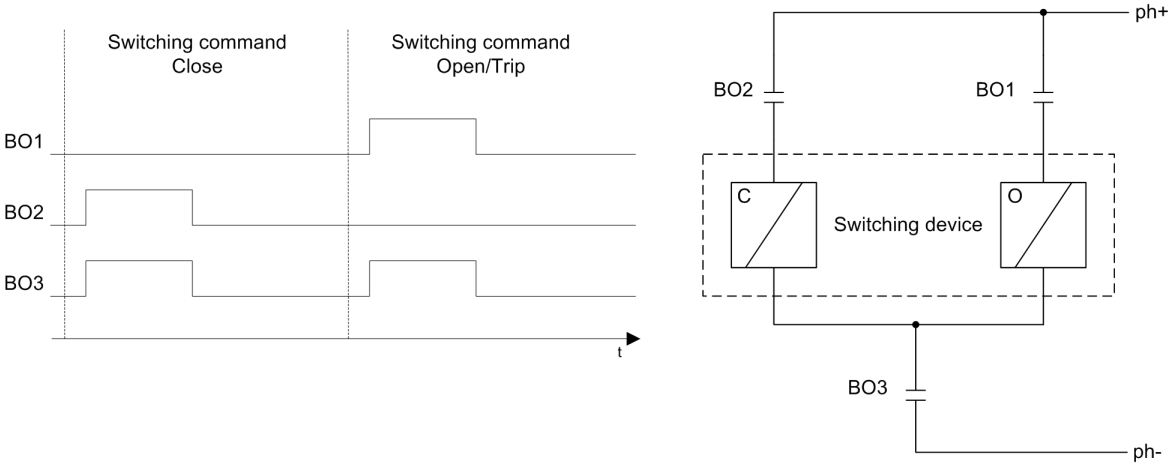
Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*			
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch 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				

[sc_rang1p_cb1p, 1, en_US]

Figure 7-9 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) can be selected.

1.5-Pole Triggering



[dw_5-pole, 1, en_US]

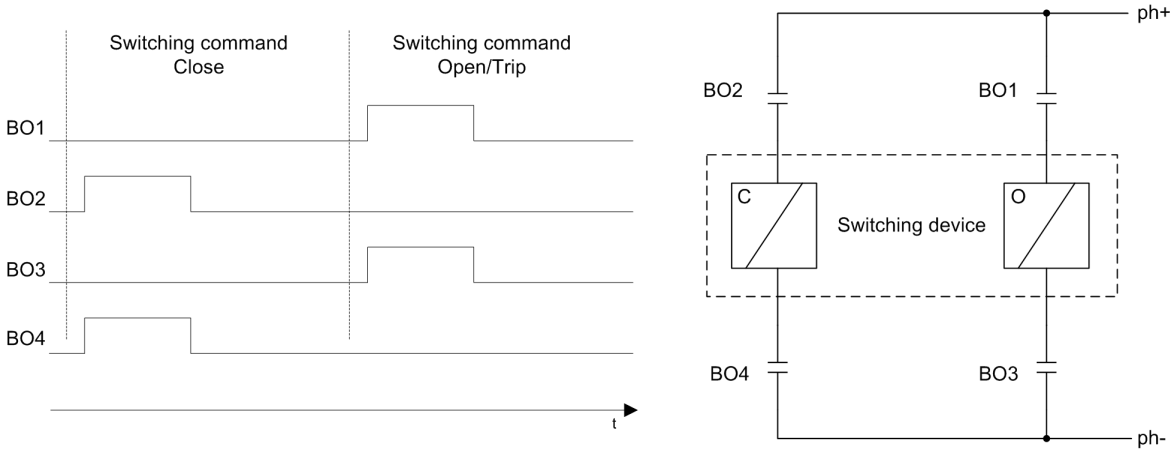
Figure 7-10 1.5-Pole Triggering

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		

[sc_rang_1p_cb15p, 1, en_US]

Figure 7-11 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw_2-pole-open, 1, en_US]

Figure 7-12 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												

[sc_rang_1p_cb13p, 1, en_US]

Figure 7-13 2-Pole Triggering, Routing in DIGSI

Connection Variant: 1-Pole Circuit Breaker

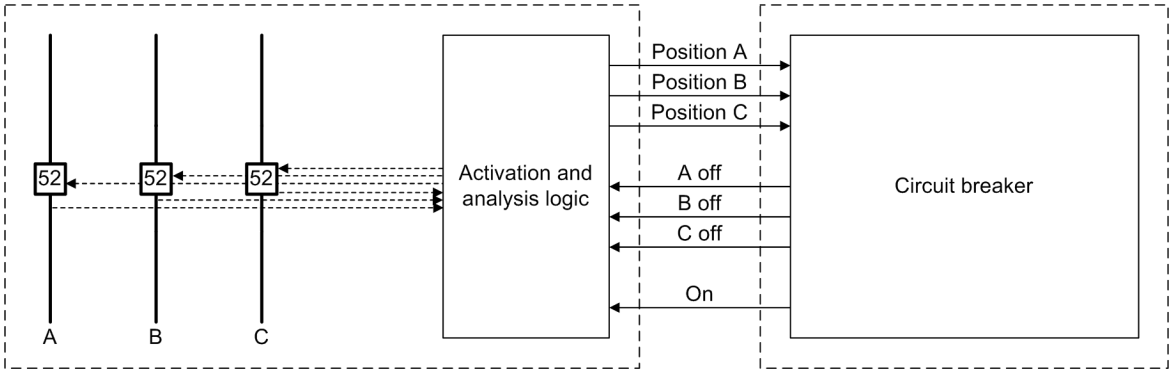
The 1-pole circuit breaker is used for separate activation and acquisition of the individual poles of a circuit breaker. It is intended for joint use by 1-pole protection and control functions.

NOTE

The wiring of the **Circuit-breaker** function group with binary inputs and binary outputs occurs 1 time per device.

The control function in this type switches all 3 poles on or off simultaneously.

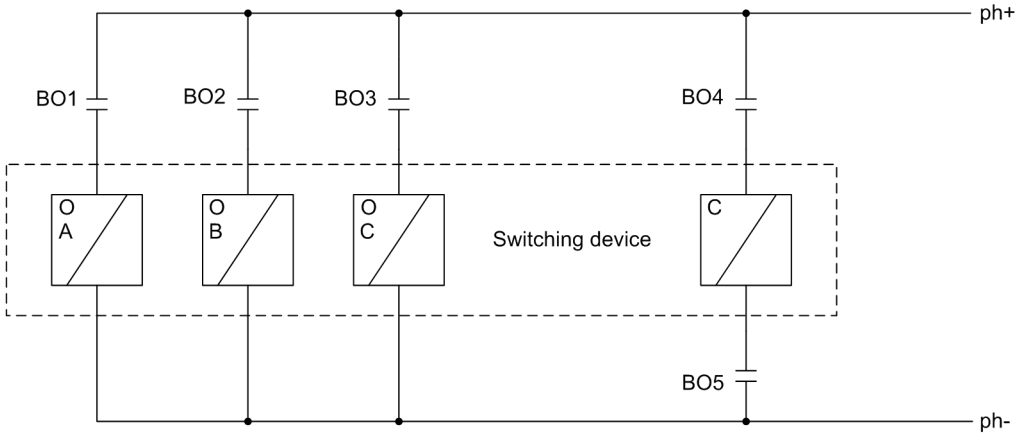
The protection functions can switch off 1-pole. The close command is always 3-pole. Optionally only the open poles are closed.



[dw_1polls, 1, en_US]

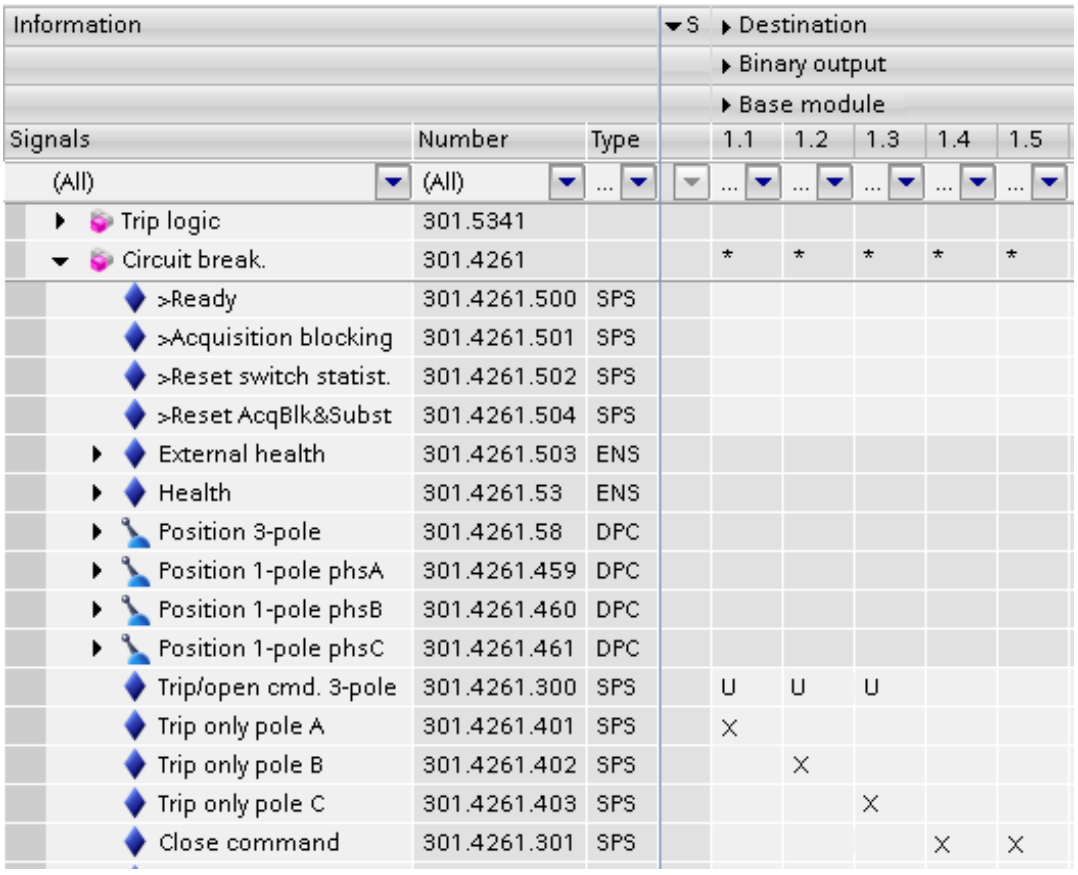
Figure 7-14 Circuit Breaker with 1-Pole Triggering

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).



[dw_1panls, 1, en_US]

Figure 7-15 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

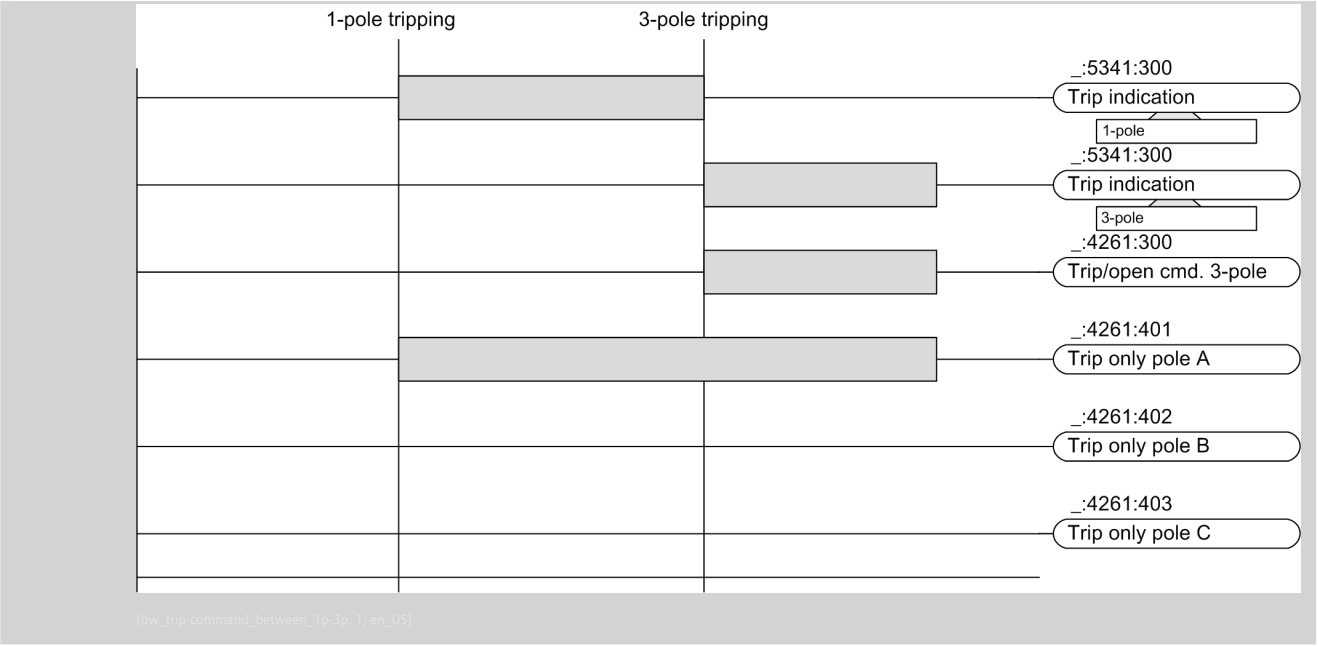
[sc_rang_1p_cb13pz, 1, en_US]

Figure 7-16 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 always switches off the 3 poles of the switch. In addition, the 3 **U** (Unlatched) routings of the trip command and open 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. When, for example informing an external AREC whether it is a 1-pole or 3-pole tripping, you can use the indication *`Trip logic:Trip indication:1-pole`* and *`Trip logic:Trip indication:3-pole`*.



Acquisition of the Circuit-Breaker Position

The binary inputs for feedback of the switch position are routed as shown in the previous figure (see also see *5.1.5.3 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				

[sc_rang_1p_cb_Hk, 1, en_US]

Figure 7-17 Routing of the 1-Pole in DIGSI

You can find the meaning of abbreviations in *Table 7-8* and *Table 7-9*.

The indication **`Command active`** can also be routed to a binary output. This binary output is always active if either a close or trip command is pending, or the switching device was selected by the command control.

7.2.2.4 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		0.10 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
_:4261:105	Circuit break.:Indicat. of breaking values		• with trip • always	always
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
_:6541:102	Manual close:CB open dropout delay		0.00 s to 60.00 s	0.00 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	

Addr.	Parameter	C	Setting Options	Default Setting
_: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
_:6151:102	CB test:Trip only		• 0 • 1	false
_:6151:103	CB test:Consider current criterion		• 0 • 1	false
_:6151:104	CB test:Current 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

7.2.2.5 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	PLC	I
_:4261:501	Circuit break.:>Acquisition blocking	PLC	I
_:4261:502	Circuit break.:>Reset switch statist.	PLC	I
_:4261:504	Circuit break.:>Reset AcqBlk&Subst	PLC	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
_:4261:300	Circuit break.:Trip/open cmd. 3-pole	PLC	O
_:4261:301	Circuit break.:Close command	PLC	O
_:4261:302	Circuit break.:Command active	PLC	O
_:4261:303	Circuit break.:Definitive trip	PLC	O
_:4261:304	Circuit break.:Alarm suppression	PLC	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

No.	Information	Data Class (Type)	Type
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:317	Circuit break.:Break. current 3I0/IN	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	PLC	I
_:6541:500	Manual close:>Input	PLC	I
_:6541:300	Manual close:Detected	PLC	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	PLC	I
_:13381:320	Reset LED Group:LED have been reset	PLC	O
Control			
_:4201:503	Control:>Sw. authority local	PLC	I
_:4201:504	Control:>Sw. authority remote	PLC	I
_:4201:505	Control:>Sw. mode interlocked	PLC	I
_:4201:506	Control:>Sw. mode non-interl.	PLC	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	PLC	I
_:4231:501	Interlocking:>Enable closing	PLC	I
_:4231:502	Interlocking:>Enable opening(fixed)	PLC	I
_:4231:503	Interlocking:>Enable closing (fixed)	PLC	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

7.2.3 Disconnector Switching Device

7.2.3.1 Structure of the Disconnector Switching Device

Like the circuit breaker, the **Disconnector** switching device contains the following 3 function blocks:

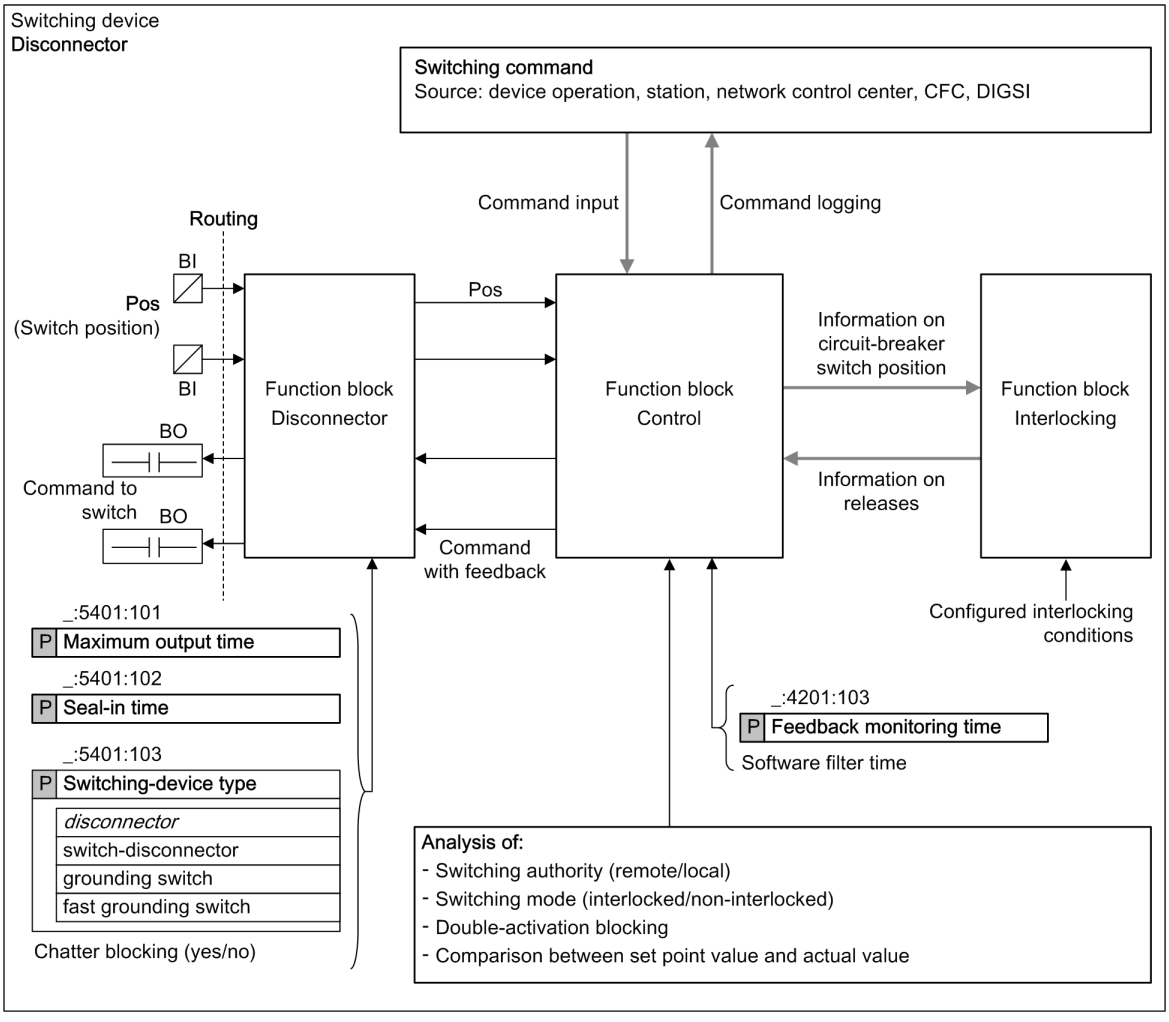
- Function block **Disconnector**
- Function block **Control**
- Function block **Interlocking**

This corresponds to the logical nodes XSWI, CSWI, and 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:



[dw_discon, 2, en_US]

Figure 7-18 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 7-10 Function Blocks of the Disconnector Function Group

Function Block	Description	Parameter	Function
Disconnector	The disconnector represents the physical switch in the SIPROTEC 5 device.	**`Maximum output time`** **`Seal-in 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**
Interlocking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The **Interlocking** functionality generates the releases for switchgear interlocking protection.

You can find the setting values of the parameter in *7.2.3.2 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 7-11 Setting Options of the Controllable **`Command with Feedback`** in the **`Control`** Function Block of the Circuit Breaker

Characteristics	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

Characteristics	Function	To Be Found in
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
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 click the **Details** button in the **Properties** window (below).

Table 7-12 Setting Options of the Controllable **Position** in the Disconnector Function Block (Chatter Blocking)

Characteristics	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 click the **Details** button in the **Properties** window (below).

Table 7-13 Additional Settings in the Device Settings with Effects on the Disconnector

Characteristics	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 *7.2.3.3 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.

You can find more information on this in *7.2.2.2 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 the general chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*.

7.2.3.2 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).

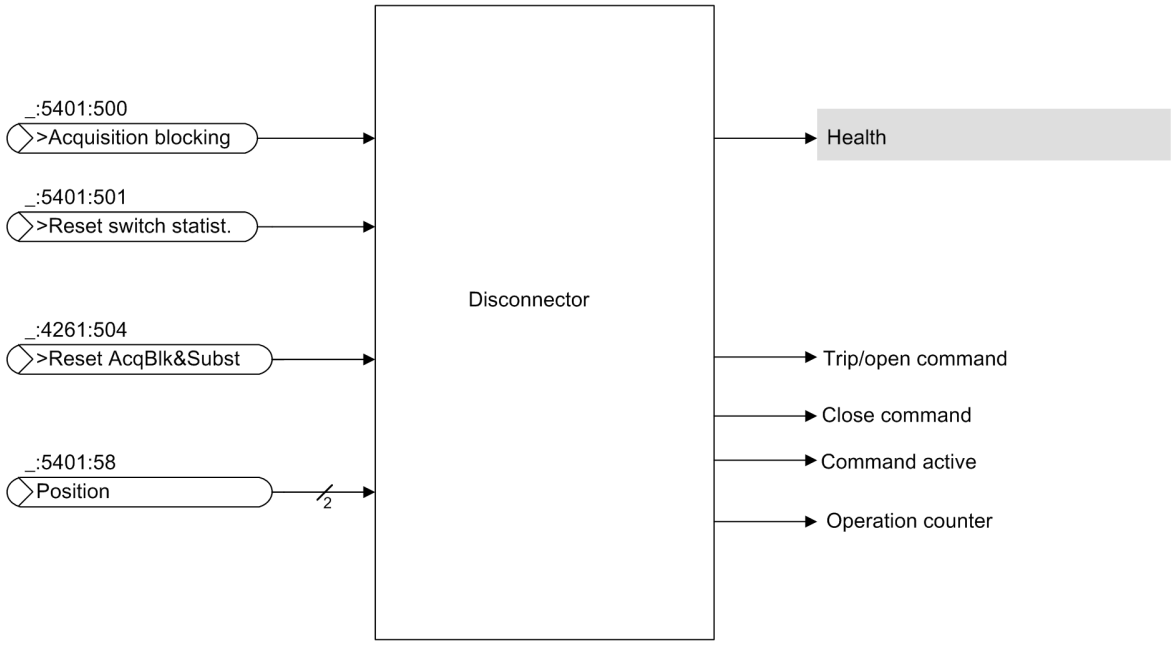
Parameters	Default Setting	Possible Parameter Values
(_:5401:101) Maximum output time The **Maximum output time** specifies the duration of the output pulse created by the switching command.	***10.00 s***	0.02 s to 1800 s (Increment: 0.01 s)
(_:5401:102) Seal-in time If the target actuating position is not yet attained although feedback has already been received, the output time is extended by the **Seal-in time**. The Seal-in time is relevant for equipment that sends feedback before the switching operation is completely performed. The Seal-in time is only considered for control models with feedback monitoring.	***0.00 s***	0 s to 60 s
(_:5401:103) Switching-device type The **Switching-device type** specifies the type of the switching device.	***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 switching device type for communication via IEC 61850. 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.



[dw_out_inp, 2, en_US]

Figure 7-19 Logical Inputs and Outputs of the Disconnector Function Block

Table 7-14 and *Table 7-15* 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.

Table 7-14 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 7-15 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

Signal Name	Description	Type
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 (see also chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

Through the function SBO (Select Before Operate, reservation[33]), the switching device is reserved 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***[34]	***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***	-
(_: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***

7.2.3.3 Trigger Variants of the Disconnector

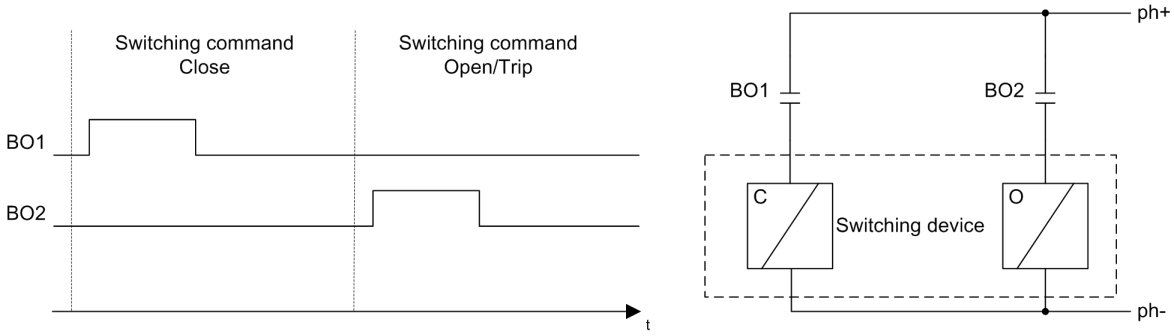
The activation types are identical to those for the circuit breaker. The meaning of abbreviations can be found in *7.2.2.3 Connection Variants of the Circuit Breaker* and *7.2.2.3 Connection Variants of the Circuit Breaker*.

Whether the disconnector is triggered for 1-, 1.5-, or 2-phases depends on the design of the auxiliary and control voltage system.

33 In the IEC 61850 standard, Reservation is described as **Select before Operate (SBO)**.

34 This default setting is the standard control model for a switching command in an IEC 61850-compliant system.

1-Pole Triggering



[dw_1ptren, 1, en_US]

Figure 7-20 1-Pole Triggering

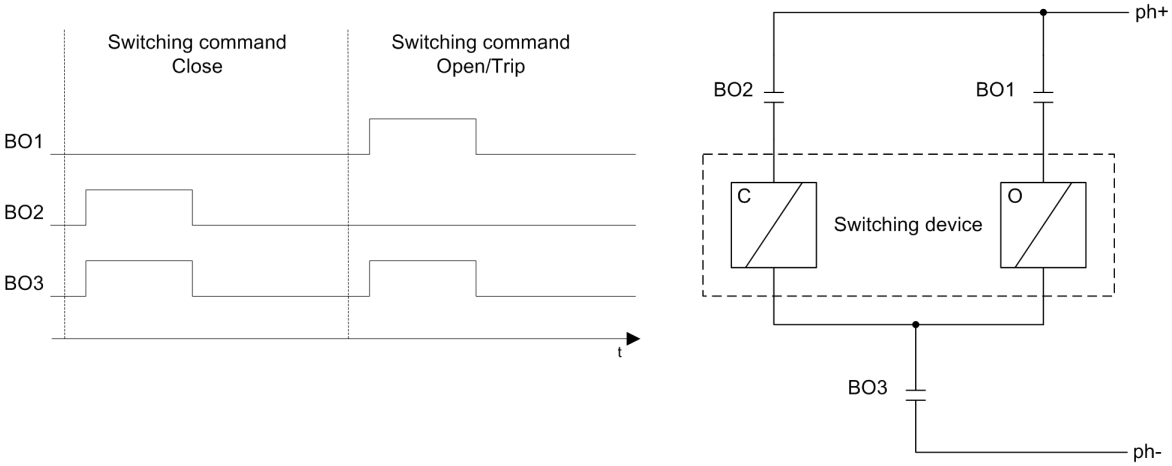
Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*		
Disconnector	601.5401			*	*		
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	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 7-21 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



[dw_5-pole, 1, en_US]

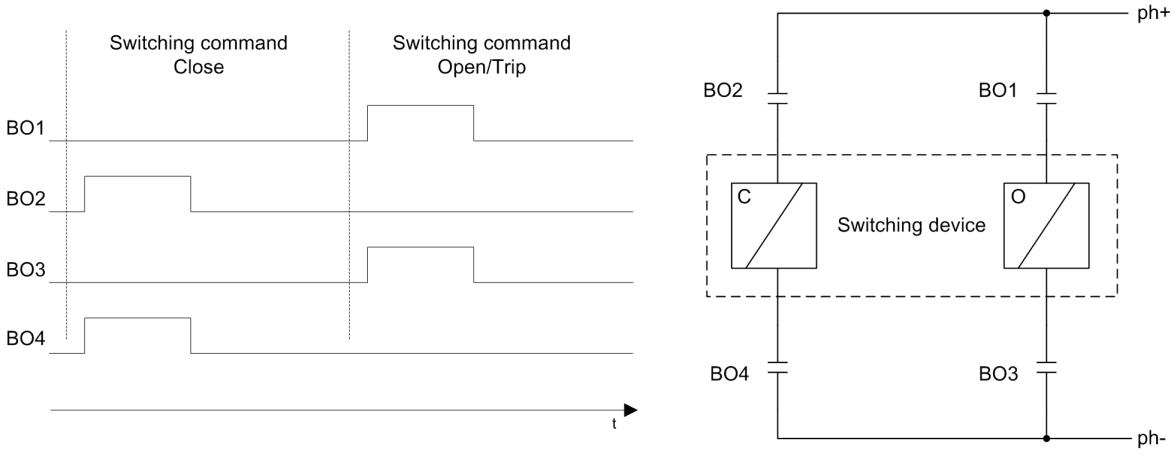
Figure 7-22 1.5-Pole Triggering

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 7-23 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw_2-pole-open, 1, en_US]

Figure 7-24 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 7-25 2-Pole Triggering, Routing in DIGSI

The feedback is routed via the position with the disconnector.

7.2.3.4 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

Addr.	Parameter	C	Setting Options	Default Setting
_:4201:104	Control:Check switching authority		• no • yes	yes
_: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:Seal-in 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

7.2.3.5 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

No.	Information	Data Class (Type)	Type
_:5401:302	Disconnector:Command active	SPS	O
_:5401:305	Disconnector:Op.ct.	INS	O

7.3 Switching Sequences

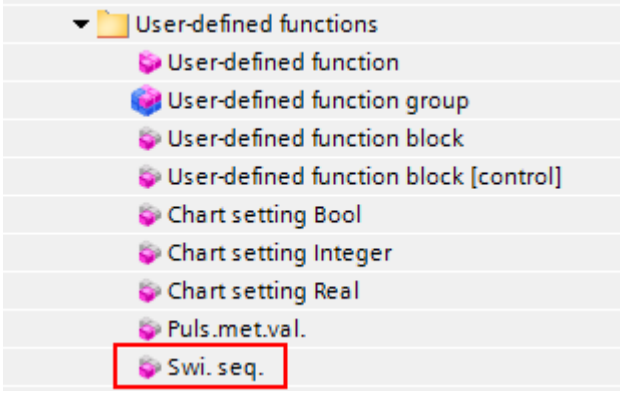
7.3.1 Overview of Functions

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.

7.3.2 Function Description

The function block **Switching sequence** is located in folder **User-defined functions** in the DIGSI 5 Library.

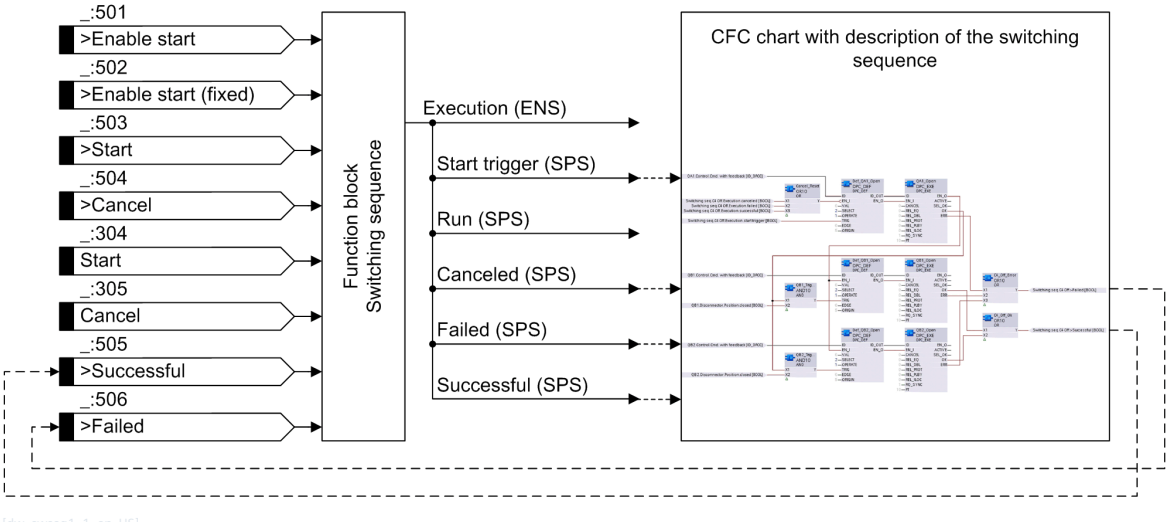


[sc_udeffb, 1, en_US]

Figure 7-26 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 7-27*). 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.



[dw_swseq1, 1, en_US]

Figure 7-27 **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 7-28*, example with 2 switching sequences). You can start or cancel the switching sequences from this menu.

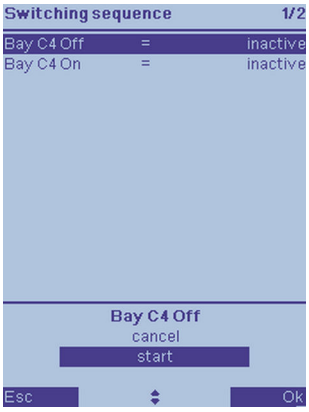
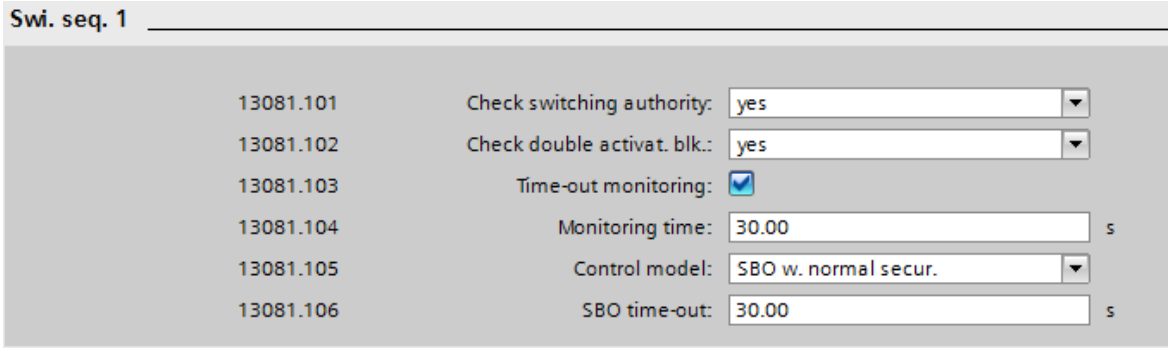


Figure 7-28
Overview of the Switching Sequences on the Device Display

7.3.3 Application and Setting Notes

The function block offers similar settings to the **Control** function block of a circuit breaker or disconnector (see chapter *7.2.1 General Overview*).



[sc_ccs4pa, 1, en_US]

Figure 7-29 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 active, 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

[sc_infof1, 1, en_US]

Figure 7-30 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.

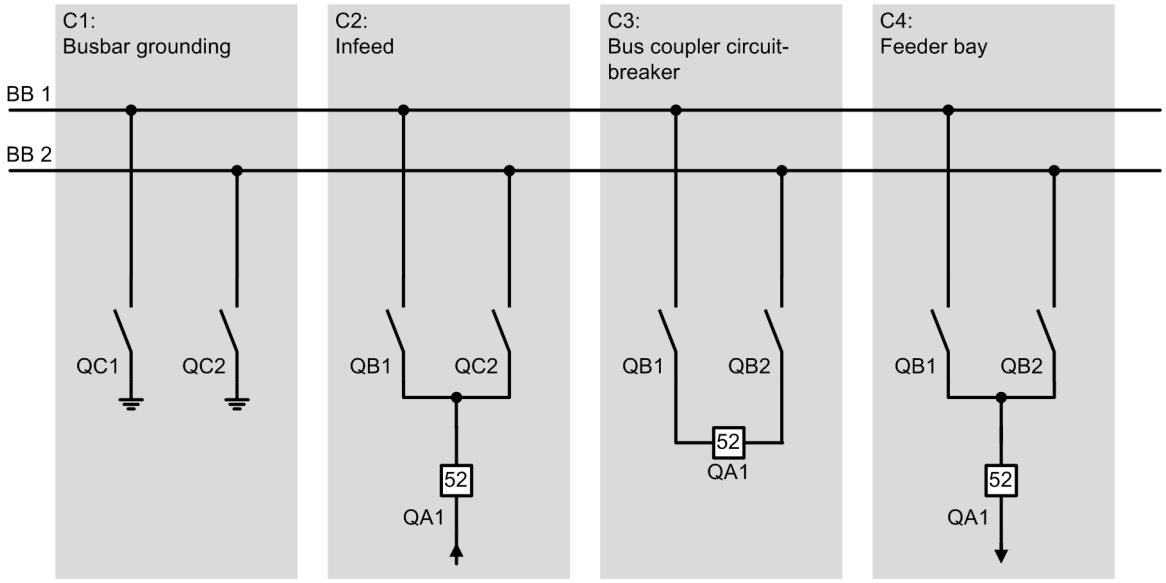
If the time-out monitoring is activated (parameter **`Time-out monitoring`**), the process feedback must take place via the inputs *`>Successful`* and *`>Failed`*. If the last switching command of the switching sequence was executed successfully, the input *`>Successful`* usually is set. To do this, 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 state 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

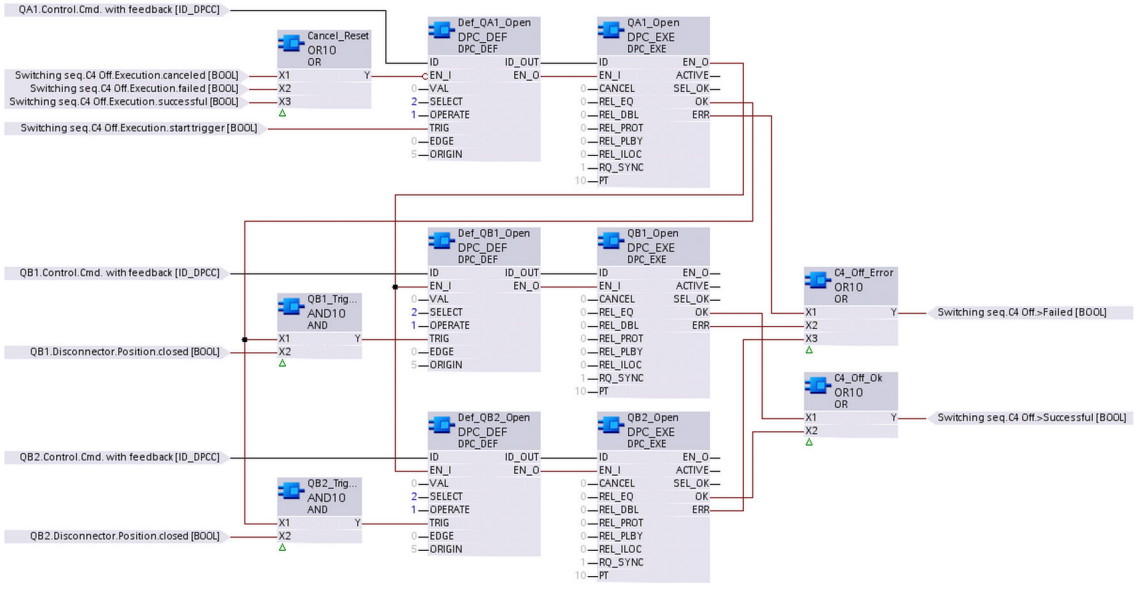
The following figure shows a single-line diagram for a substation with 4 bays: Busbar grounding, infeed, bus-coupler circuit-breaker, and feeder bay.



[dw_bspunt, 1, en_US]

Figure 7-31 Example of a Substation

The switching sequence **C4 Off** (*Figure 7-32*) should switch off feeder bay C4. The circuit breaker is opened; followed by opening of one of the 2 busbar disconnectors.



[sc_ssc4as, 1, en_US]

Figure 7-32 CFC Switching Sequence **C4 Off**

Command Execution

As described in section *Starting and Canceling a Switching Sequence, Page 501*, 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.

7.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Swi. seq. #				
_:101	Swi. seq. #:Check switching authority		• no • yes • advanced	yes
_: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

7.3.5 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

7.4 Control Functionality

7.4.1 Command Checks and Switchgear Interlocking Protection

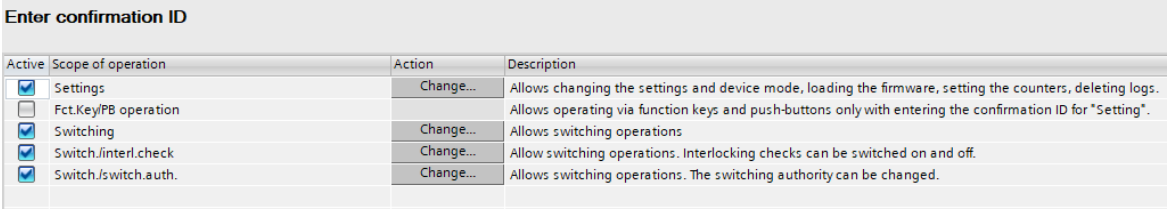
Before switching commands can be issued by the SIPROTEC 5 device, several steps are used to check the command:

- 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 (with Inactive RBAC)

SIPROTEC 5 devices can operate using role-based access control (RBAC). If RBAC is active in the device, the authorizations to execute various actions are linked directly to the role concept.

If RBAC is inactive in the device, various actions are secured using the **confirmation IDs**. The following **confirmation IDs** from the **Safety** menu apply to the control functions:



[sc_conf, 2, en_US]

Figure 7-33 Confirmation IDs in DIGSI 5: Settings Menu

The following table identifies the meanings of the confirmation IDs:

Table 7-16 Relevant Confirmation IDs for Controls

Confirmation ID	Meaning	Description
Setting	Changing settings	The confirmation ID is requested before the device parameters can be changed.
Operation (function keys)	Process data access via function buttons	Access to process data is possible with the help of push-buttons and function buttons. The confirmation ID of **Set/operation** is requested.
Switching	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.

Confirmation ID	Meaning	Description
Switch./interl.check	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.
Switch./switch.auth.	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:

- Setting 222222
- Switching 333333
- Switch./interl.check 444444
- Switch./switch.auth. 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 input of a confirmation ID). You can also set the switching mode for switching commands from the sources DIGSI, station or remote.



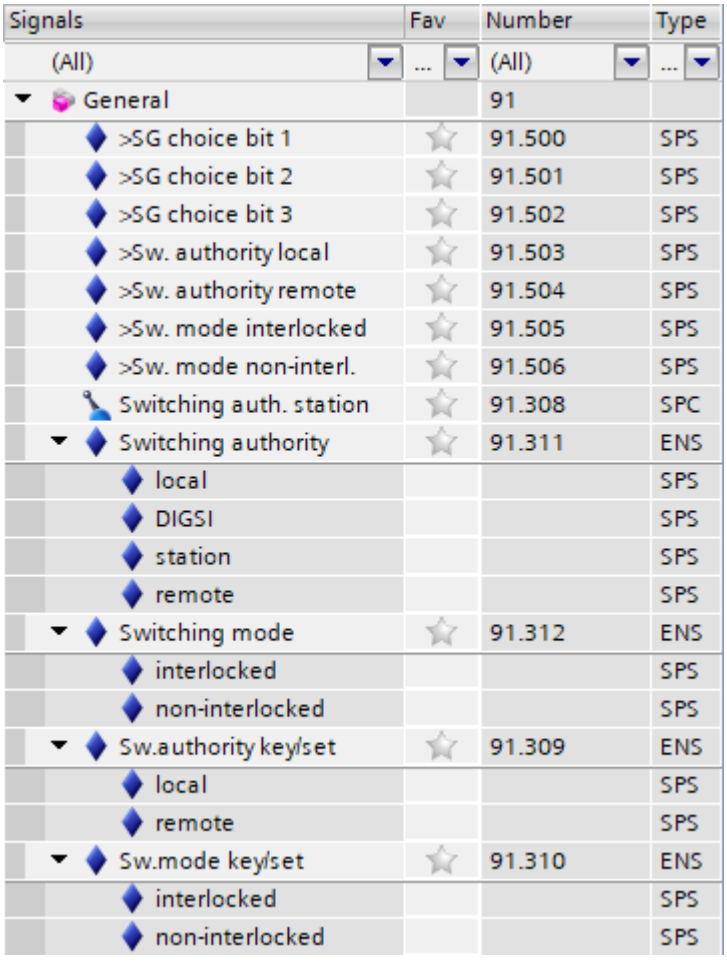
DANGER

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).



[sc_moscha, 1, en_US]

Figure 7-34 Switching Mode in Function Block General

The following table shows the effects of changing the switching mode to use command checks.

Table 7-17 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 **Local**) is possible only if the switching authority is set to **Local** and the device is capable of on-site 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.

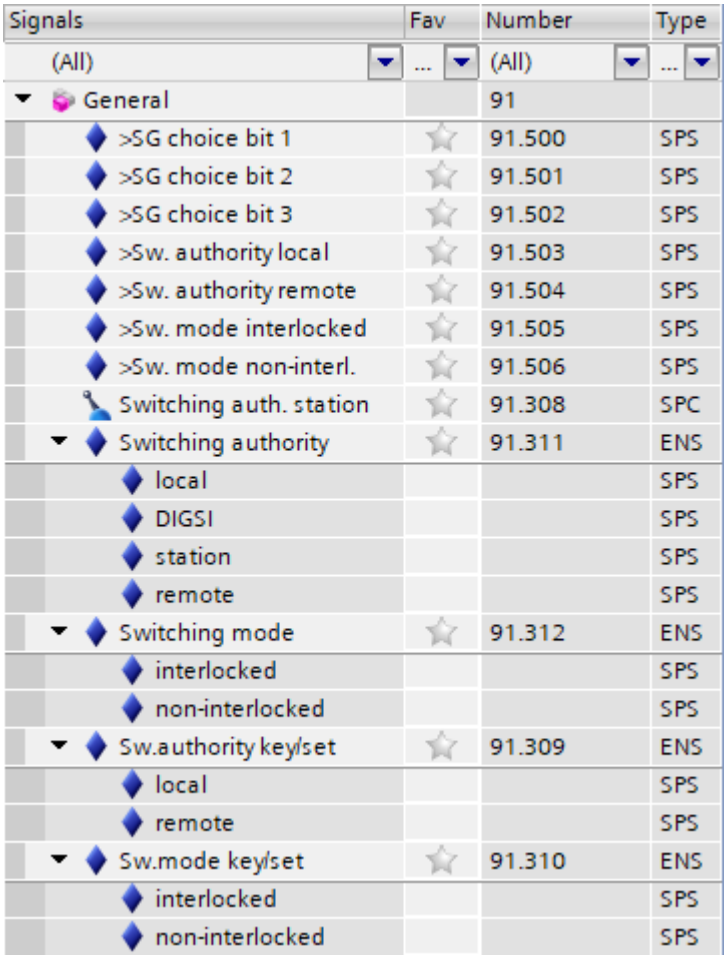
- **Station**:

  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 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.



Signals	Fav	Number	Type
(All)	...	(All)	...
General		91	
>SG choice bit 1		91.500	SPS
>SG choice bit 2		91.501	SPS
>SG choice bit 3		91.502	SPS
>Sw. authority local		91.503	SPS
>Sw. authority remote		91.504	SPS
>Sw. mode interlocked		91.505	SPS
>Sw. mode non-interl.		91.506	SPS
Switching auth. station		91.308	SPC
Switching authority		91.311	ENS
local			SPS
DIGSI			SPS
station			SPS
remote			SPS
Switching mode		91.312	ENS
interlocked			SPS
non-interlocked			SPS
Sw.authority key/set		91.309	ENS
local			SPS
remote			SPS
Sw.mode key/set		91.310	ENS
interlocked			SPS
non-interlocked			SPS

[sc_moscha, 1, en_US]

Figure 7-35 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 ***non-interlocked***.

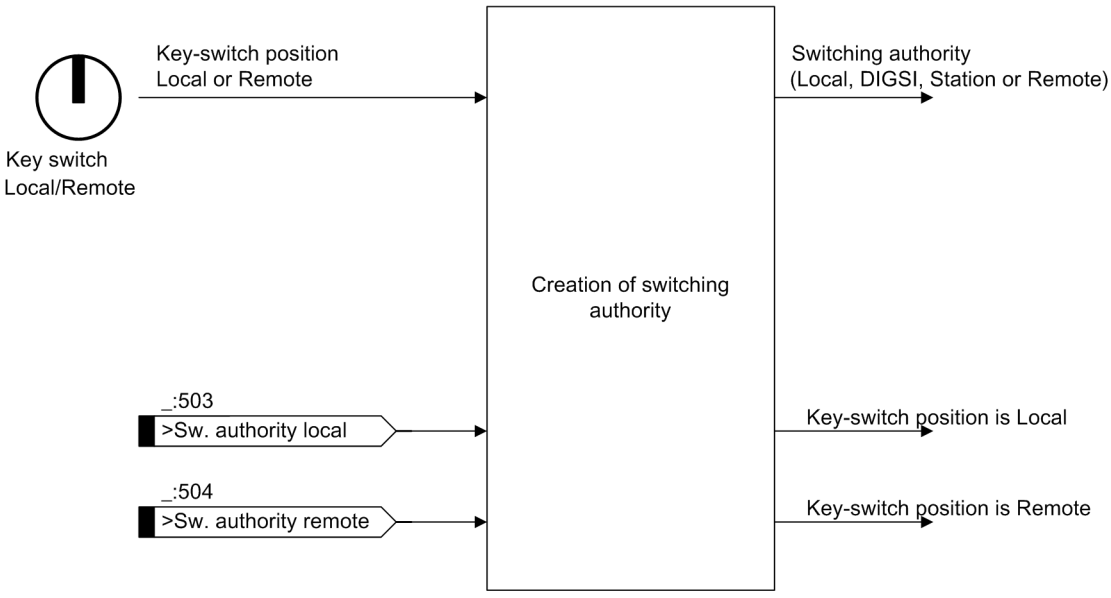
The following table shows the dependency of the switching mode on the key-switch position and the switching authority. In the case of switching commands from **Remote**, the information on whether switching is to be made to locked or unlocked is also sent. For this reason, the position of the key switch 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 7-18 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
Not interlocked	Non-interlocked	Interlocked	Interlocked

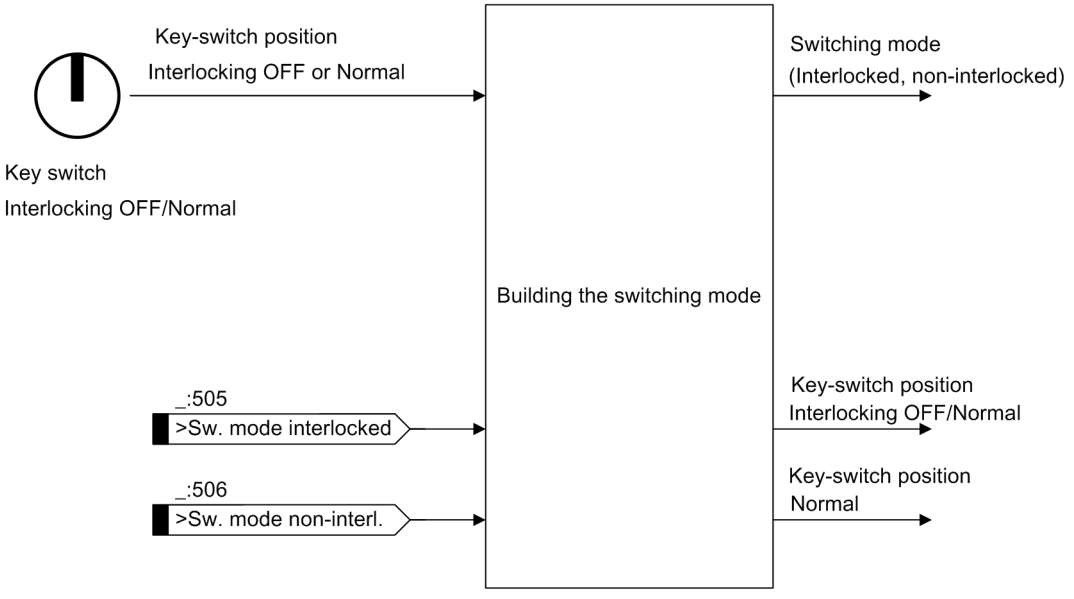
The signals shown in *Figure 7-35* in DIGSI 5 information routing have the following relationship:

- 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 7-36* and *Figure 7-37*).



[dw_authority, 1, en_US]

Figure 7-36 Establishing Switching Authority



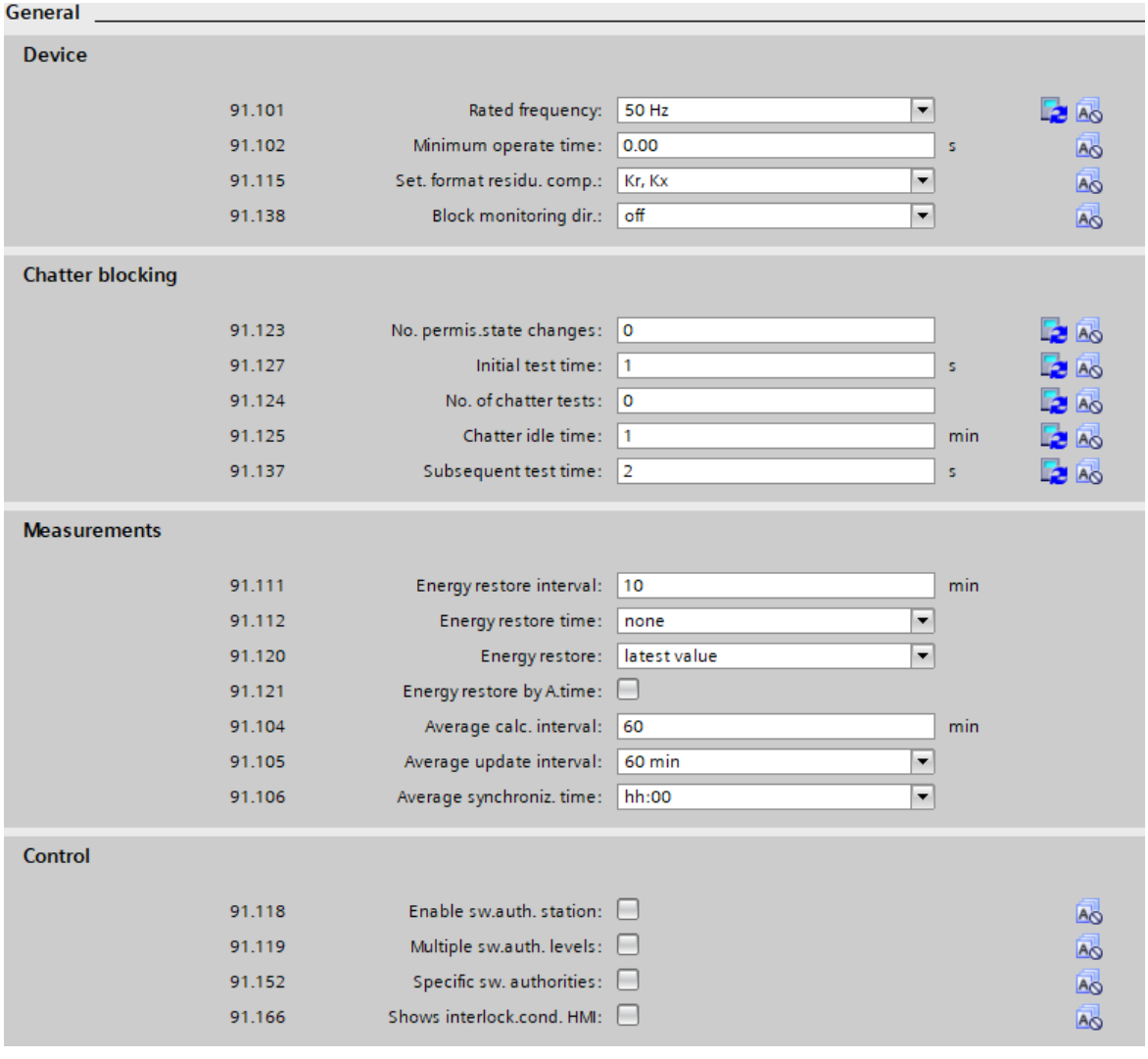
[dw_modsch, 1, en_US]

Figure 7-37 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:

- **`Enable sw.auth. station`** (defined in IEC 61850 Edition 2):
  If you would like to use this switching authority, set the check mark **General/Control**.
- **`Multiple sw.auth. 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 *Specific Switching Authority, Page 514*. By default, these are not used.
- **`Shows interlock.cond. HMI`**:
  You can activate the parameter to show the status of interlocking conditions in the device. For additional information refer to *Specific Switching Authority, Page 514*. By default, this parameter is inactive.



[sc_akt_hoh, 2, en_US]

Figure 7-38 How to Activate the Station Switching Authority and to Enable Several Switching-Authority Levels

Table 7-19 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

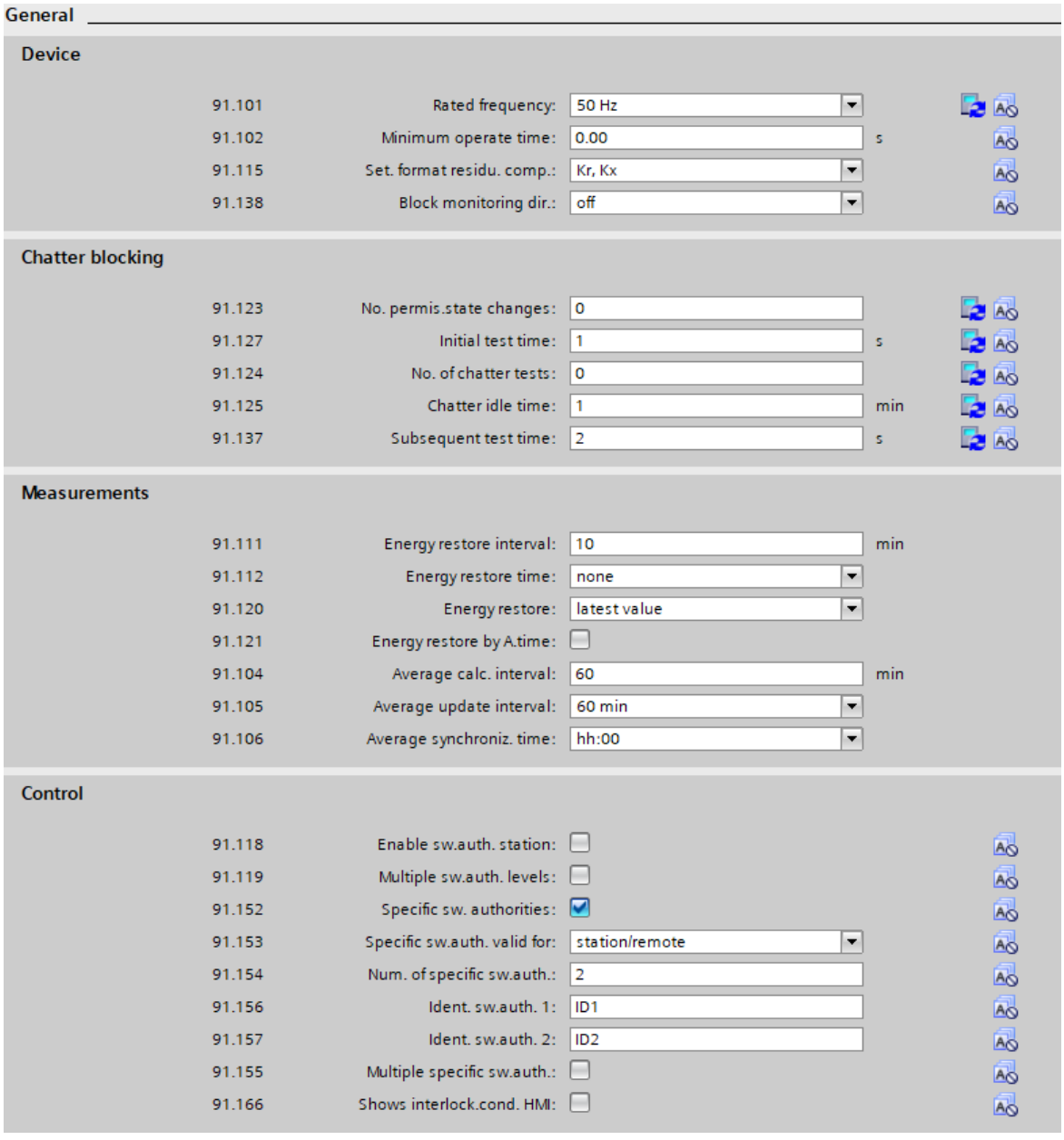
The following table shows the result of the switching-authority check, based on the set switching authority and the cause of the command. This overview represents a simplified normal case (no multiple command sources when using Station and Remote).

Table 7-20 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 authority 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 7-40*). 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, 4, en_US]

Figure 7-39 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 7-21 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

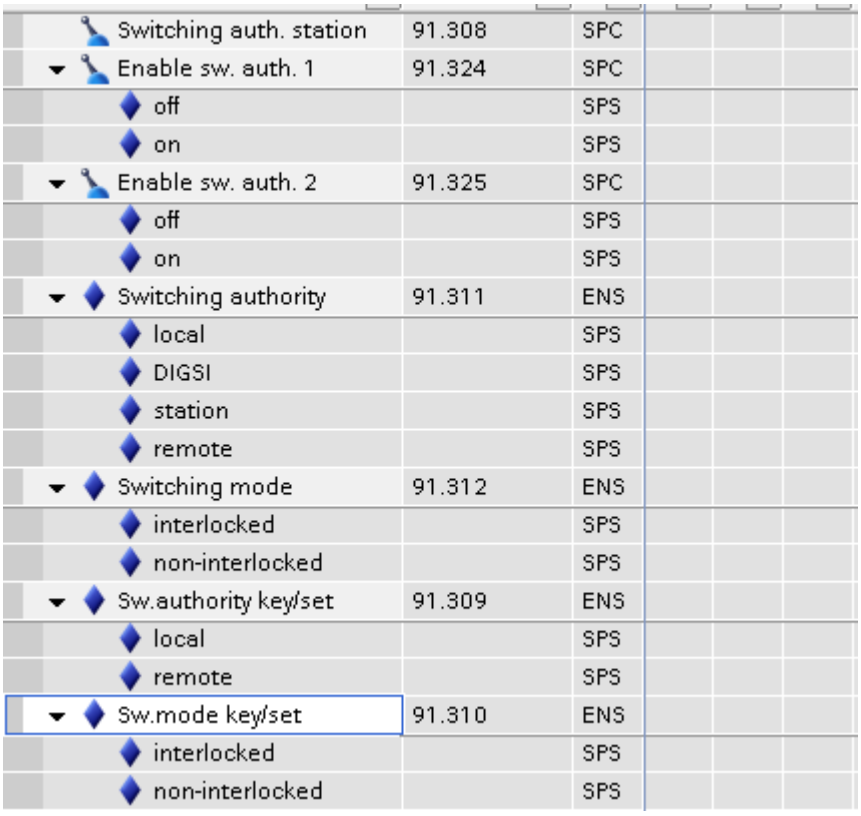
Command Source	Specific sw.auth. valid for		
	station	*station/remote*	*remote*
Remote, remote automatic	No check	Check	Check
DIGSI	No check	No check	No check

- **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 7-22 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 7-40 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

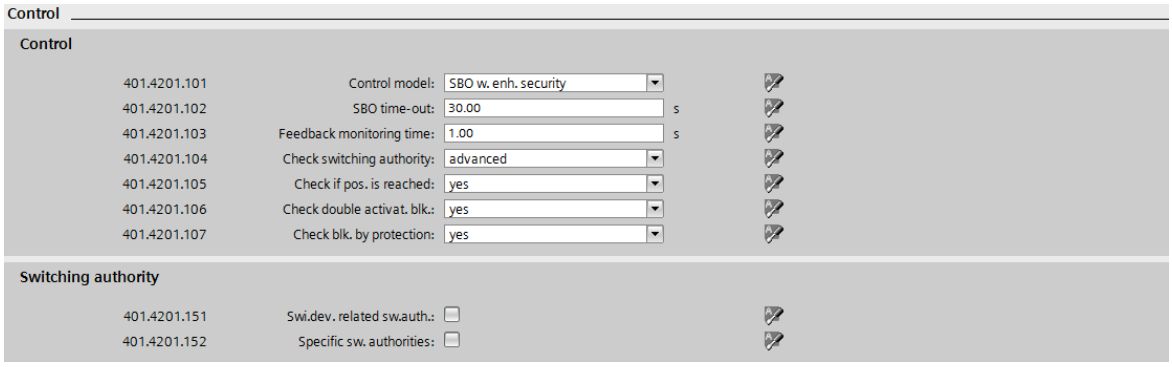
In a standard case, the functionalities switching authority, switching mode, and specific switching authority as described in the previous sections, are applicable to the entire bay unit and, therefore, are valid for all switching devices that are controlled by this bay unit. In addition, you can configure 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.

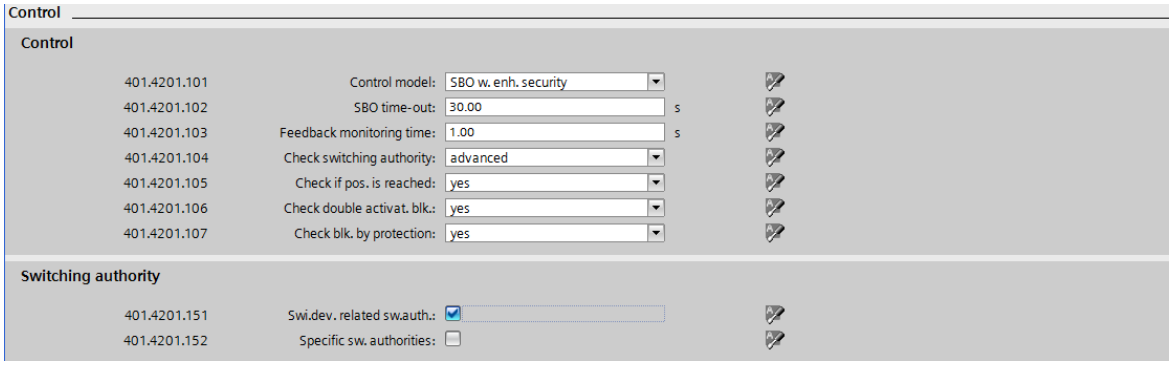
In order to activate this option, go to the function block **Control** of a switching device and set the parameter **`Check switching authority`** to ***`advanced`***. An additional table containing initially 2 parameters is displayed.



[sc_add parameters sw authority sw device, 1, en_US]

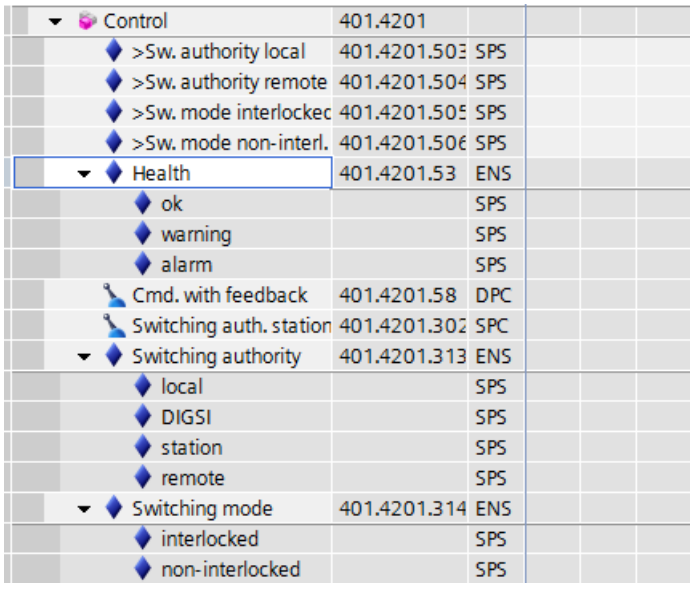
Figure 7-41 Additional Parameters for Switching Authorities in the Parameters of a Switching Device

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 7-42 Expanded Parameters for the Switching Authority in the Switching Device



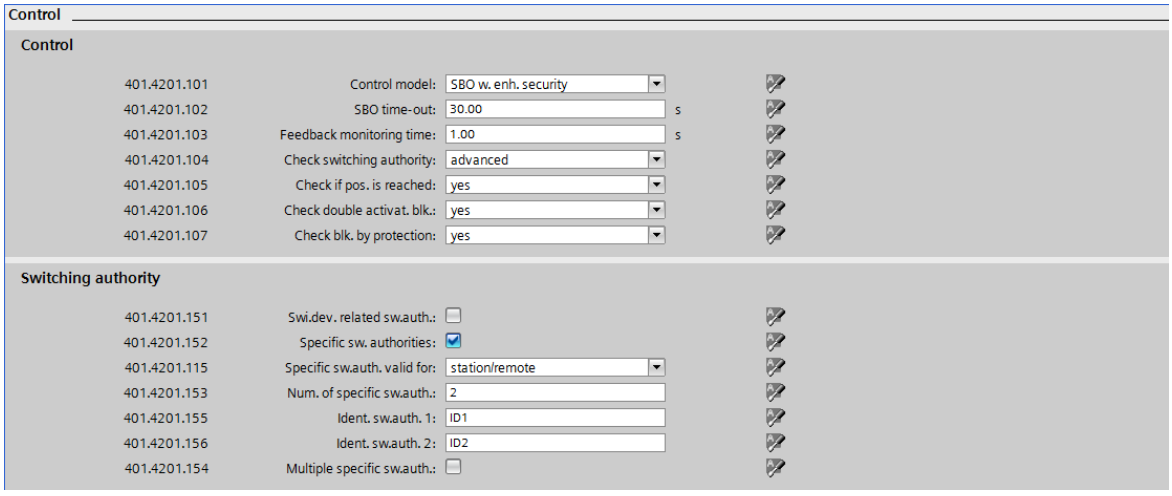
[sc_switching auth sw mode changeable, 1, en_US]

Figure 7-43 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.

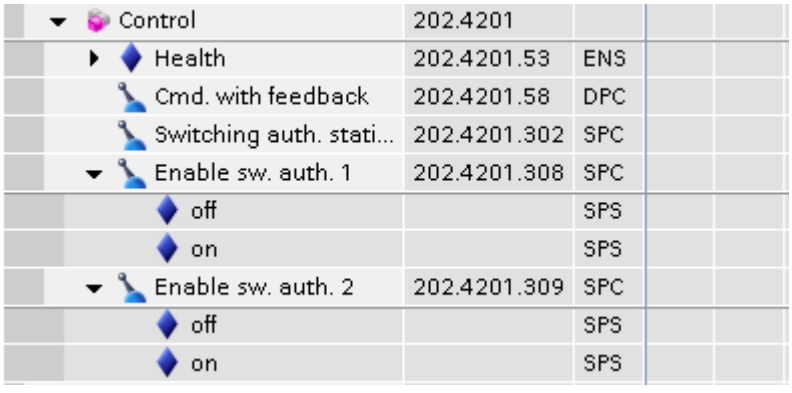
When activating **Specific sw. authorities**, an individual specific switching authority for this switching device is configured. Additional parameters are displayed.



[sc_parameters FB control all additional options, 1, en_US]

Figure 7-44 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 7-45 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.

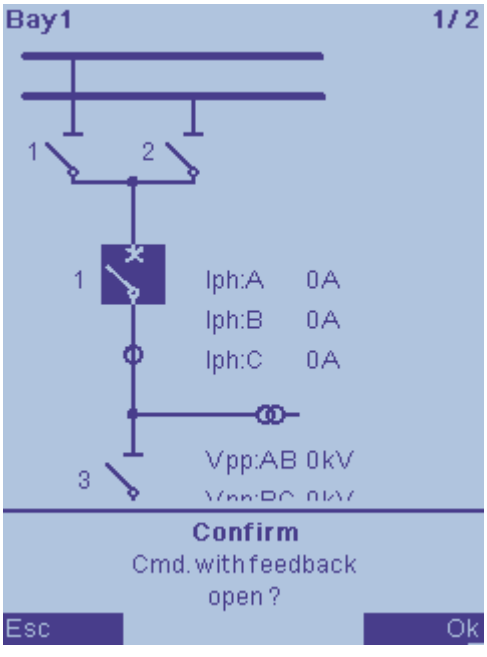
Each of the 2 categories has 2 release signals (for the ***On*** and ***Off*** switching directions) that represent the result of the interlocking plan, so that interlocking is in effect during the command check (see the figure below). The default setting for all release signals is ***TRUE***, so that 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								

[sc_verrie, 1, en_US]

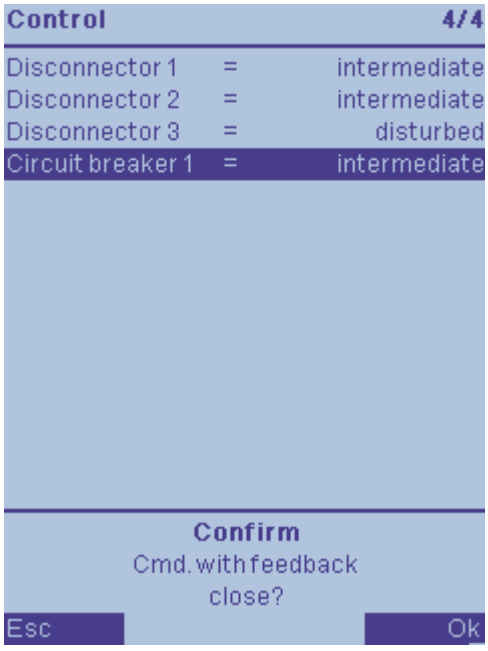
Figure 7-46 Interlocking Signals in Function Block Interlocking

By default, the status of interlocking conditions is not visible in the device, see the following figure.



[sc_HMI_WO_Position, 1, en_US]

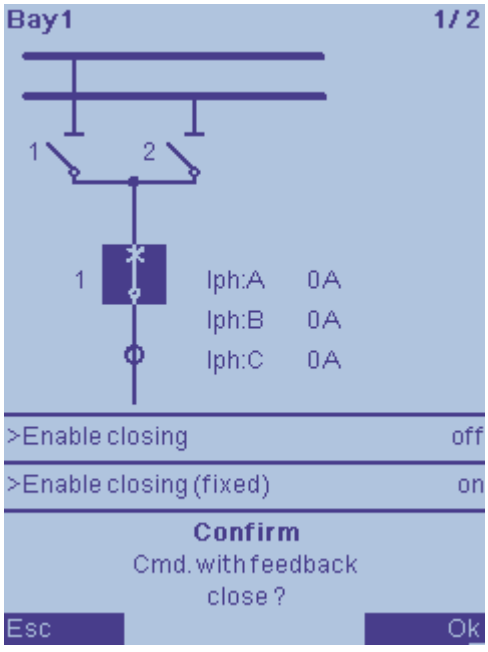
Figure 7-47 The Status of Interlocking Conditions is not Visible in the Control Display



[sc_HMI_WO_Position2, 1, en_US]

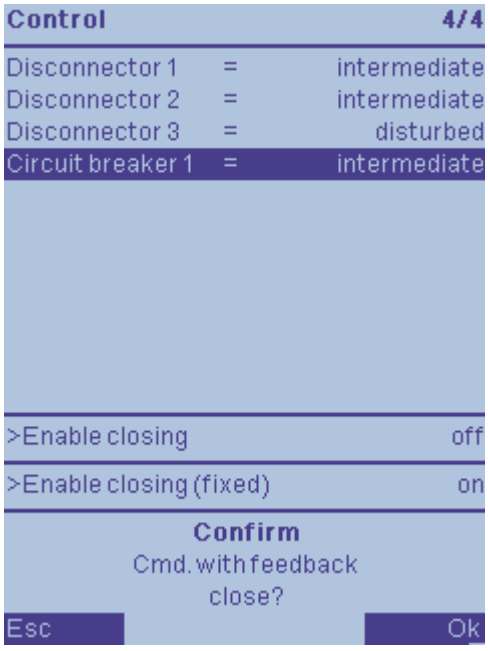
Figure 7-48 The Status of Interlocking Conditions is not Visible in the Control Menu

But, if you activate the parameter **`Shows interlock.cond. HMI`** by navigating to **Settings** > **Device settings** > **General** > **Control** in DIGSI 5, you can get the status of interlocking conditions in the device.



[sc_HMI_W_Position, 1, en_US]

Figure 7-49 The Status of Interlocking Conditions is Visible in the Control Display



[sc_HMI_W_Position2, 1, en_US]

Figure 7-50 The Status of Interlocking Conditions is Visible in the Control Menu

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.

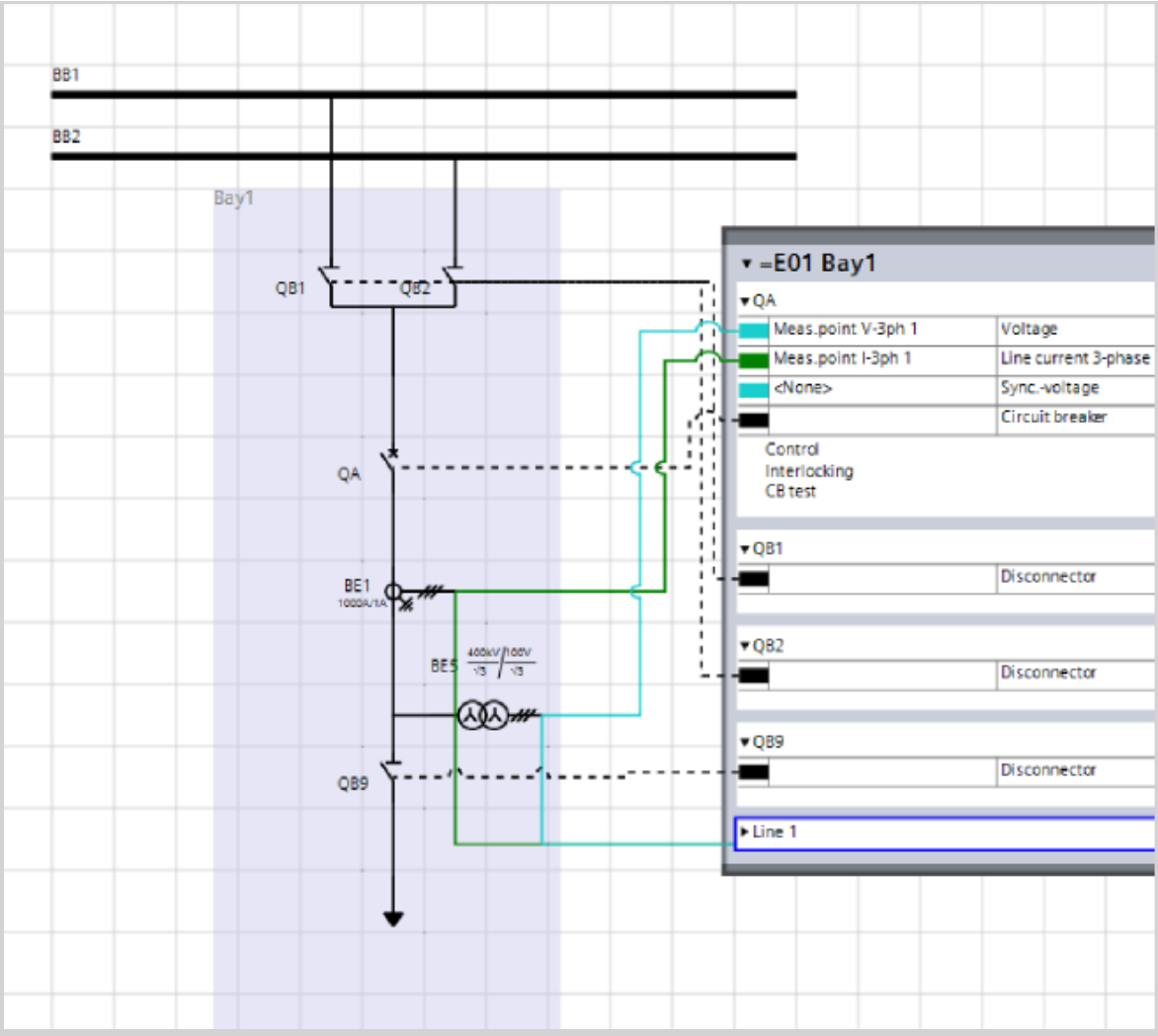


Figure 7-51 Feeder Bay for a Double Busbar System

The CFC chart that is required to implement the interlocking equation is shown in the next figure.

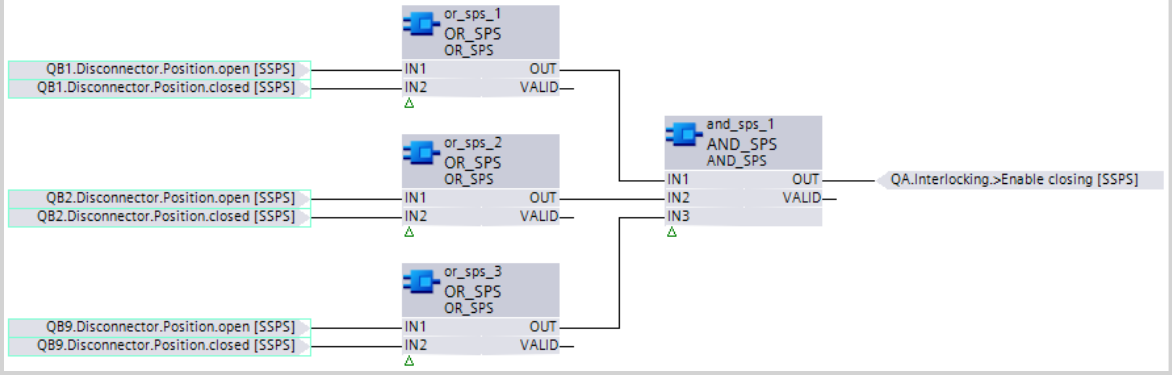


Figure 7-52 Interlocking Chart for Bay Interlocking

Since the **Disconnector** function block provides the defined position ***On*** or ***Off***, the exclusive OR gate XOR is not necessary for the linkage. 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 7-52*).

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).

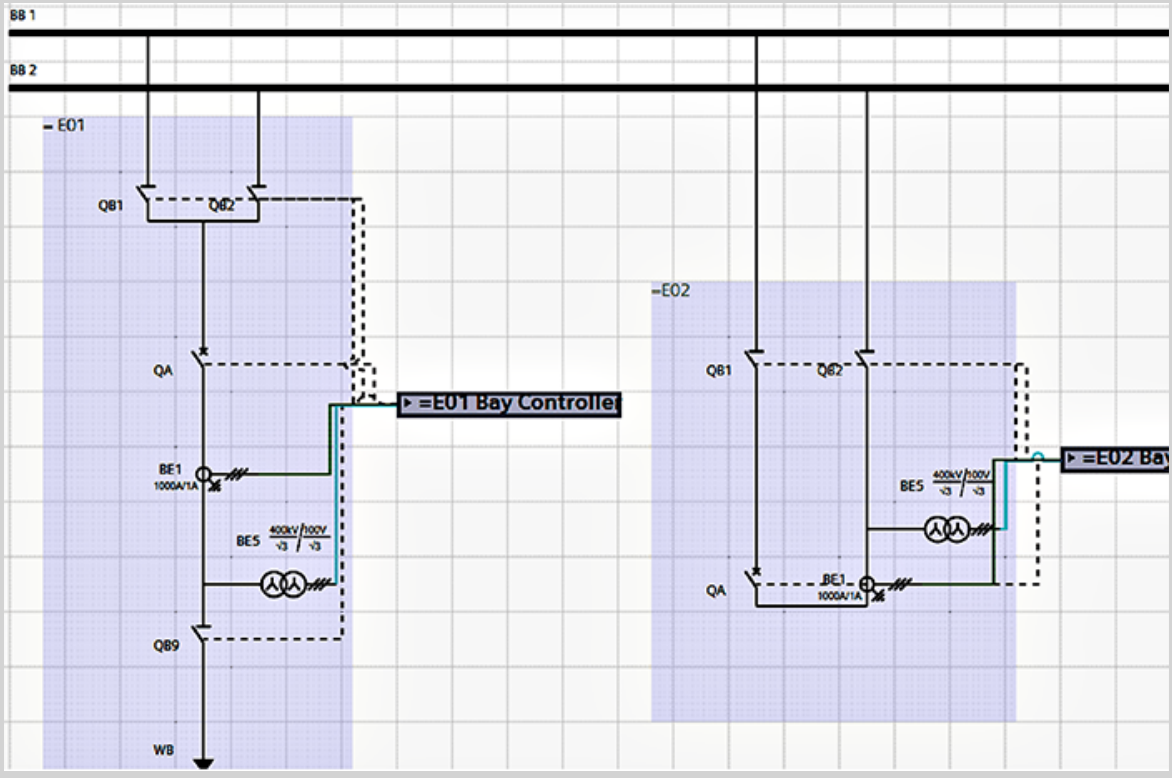


Figure 7-53 System with Feeder and Coupler Bays

The circuit breaker QA in coupler bay = E02 will be considered next. As the multibay interlocking condition, you must provide the bus-coupler circuit-breaker 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 bus coupler device = E02, you must create the following CFC chart (see the figure below).

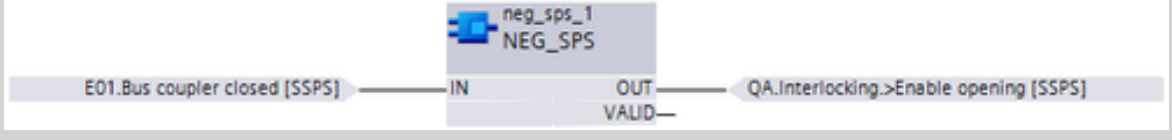
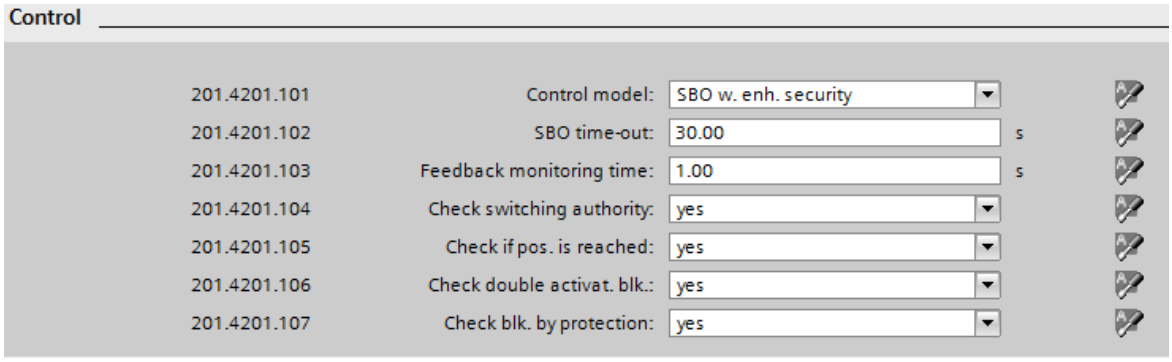


Figure 7-54 Interlocking Chart for System Interlocking

1-Out-of-n Check (Double-Activation Blocking)

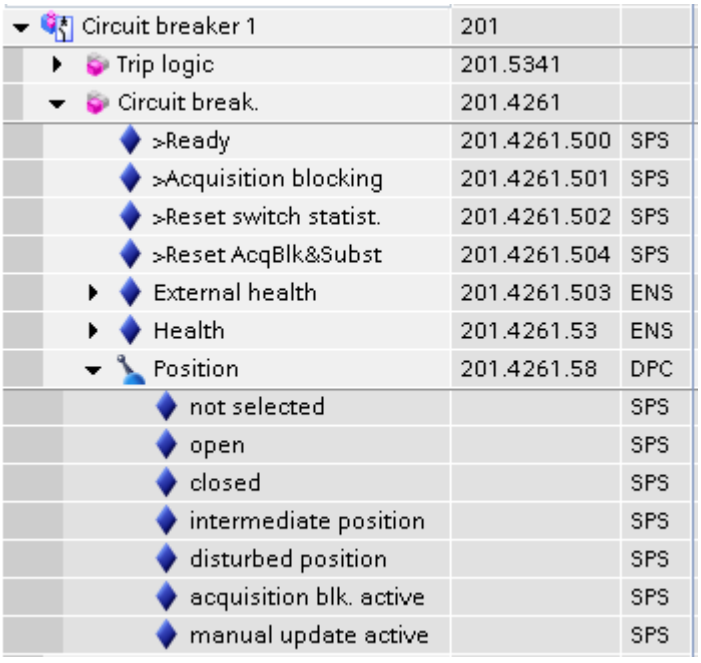
The double-activation blocking prevents 2 commands from being executed in the device simultaneously. You can set the device-internal check for each switching device as a parameter in the **Control** function block.
The default setting is ***Yes***, that is, double-activation blocking is active (see the figure below).



[sc_double, 1, en_US]

Figure 7-55 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).



[sc_notselected, 1, en_US]

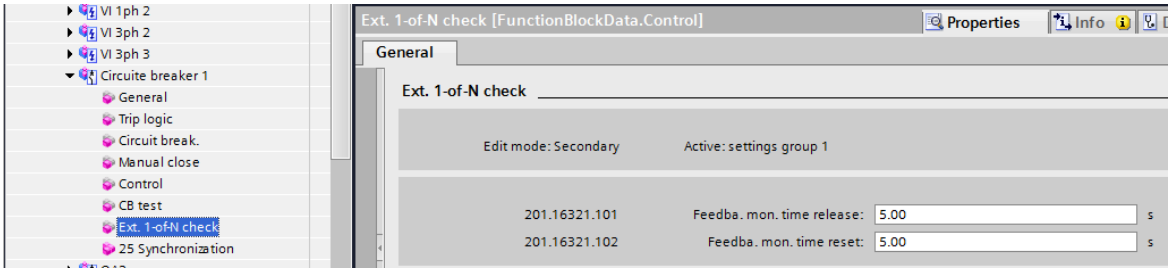
Figure 7-56 Signal *`not selected`* in the Circuit-Breaker Function Block

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.

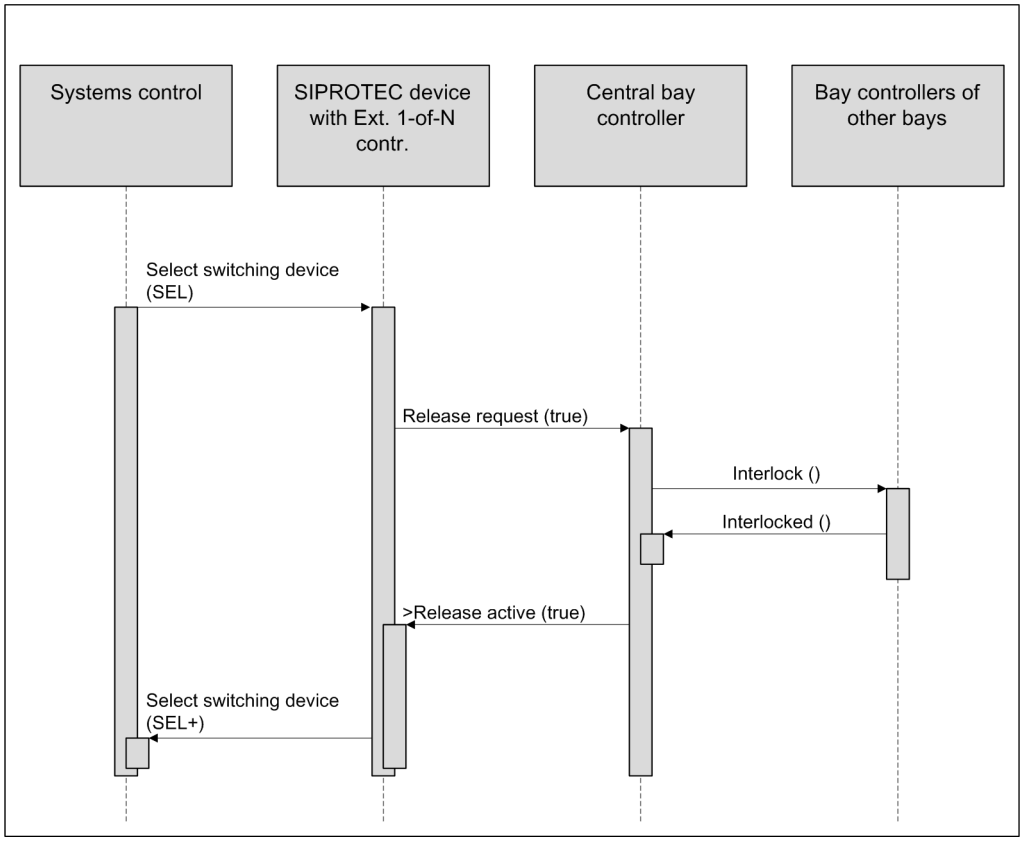
You can use the function block **Ext. 1-of-N check** in the **Circuit breaker** and **Disconnector** function groups. In order to use the function, a control model **with feedback monitoring** must be configured in the circuit-breaker control.



[sc_library properties info routing ext 1-out-of-n control, 1, en_US]

Figure 7-57 Command Execution

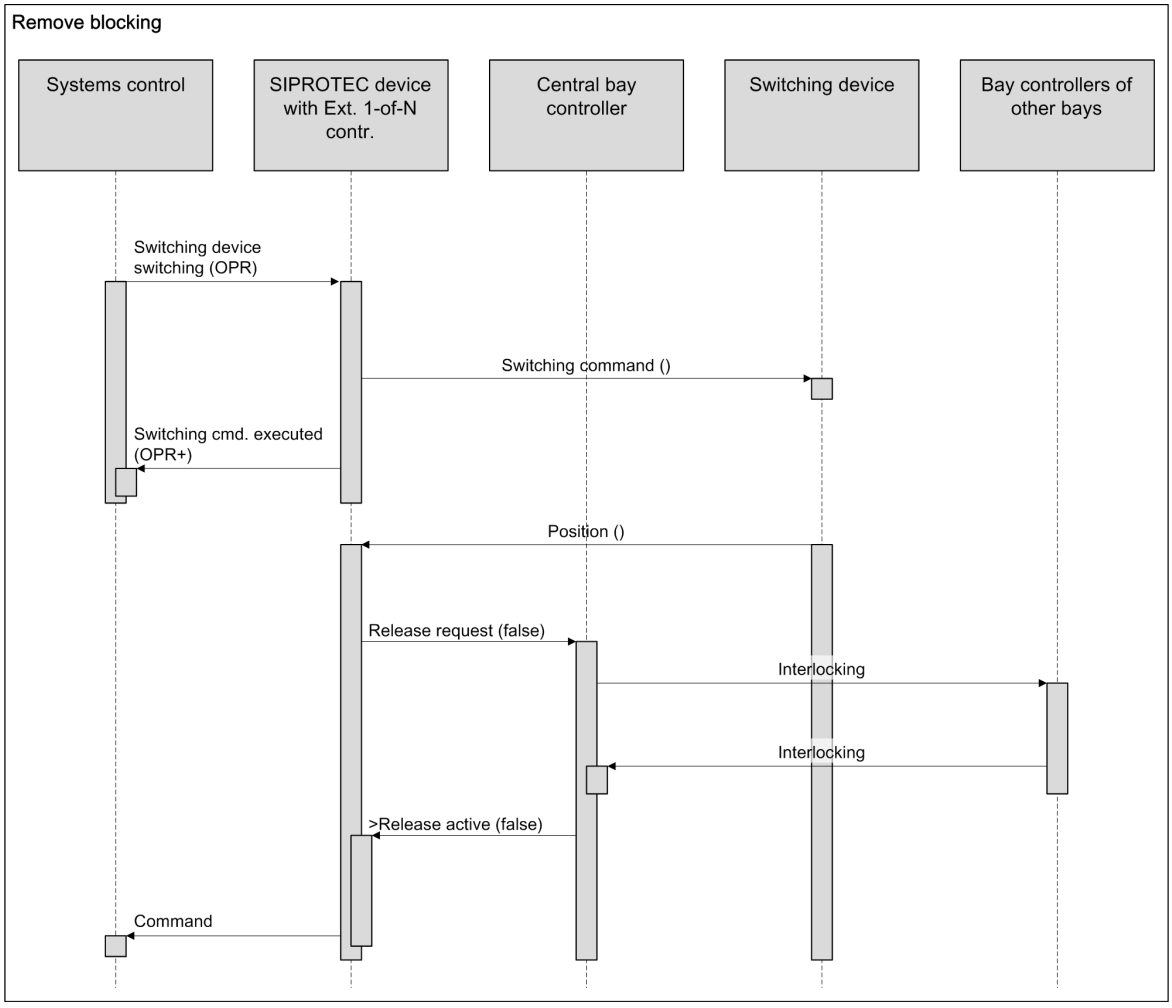
If the external 1-of-N check is instantiated, the output ***Release request*** prompts a central bay controller before executing a switching command. This bay controller must permit the switching operation (see the following figure). If the allocated switching devices were locked in another bay, the release is issued. Only when the release was issued via the input ***>Release active*** is the allocation (**`Control model`**: ***`SBO w. enh. security`***) or the switching command (**`Control model`**: ***`direct w. enh. security`***) executed and confirmed. The central bay controller is parameterized to reject a 2nd switching request.



[dw_set blocking, 1, en_US]

Figure 7-58 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_remove blocking, 2, en_US]

Figure 7-59 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.

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 7-55*).

NOTE

Remember, for instance, that pickup of the thermal overload protection can create a fault as well and thus prevent switching commands.

NOTE

The command check **Blocking by protection function** is only available for controlling circuit breakers, because in this case a unique relationship with protection functions 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 **VI 3-phase, VI 1-phase** or **V 3-phase**)
- Circuit-breaker failure protection: **`Pickup`** (**Circuit-breaker failure protection**)

7.4.2 Command Logging

All commands in the sequence are logged. The command log contains:

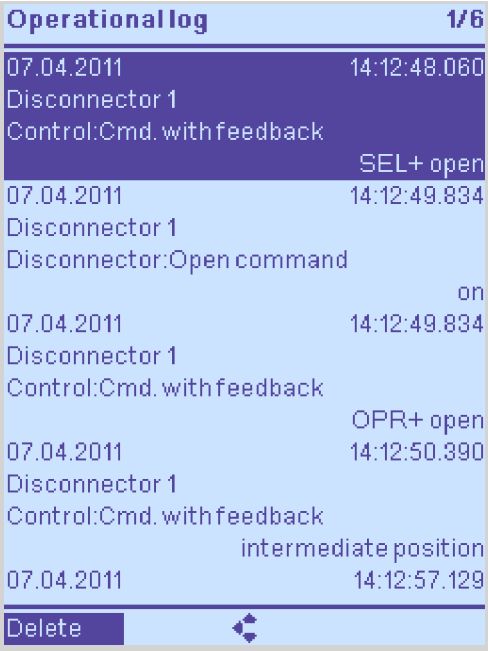
- Date and time
- Name of the switching device (or function group)
- Reason for the transmission (SEL = Selected, OPR = Operate, CMT = Command execution end, SPN = Spontaneous)
- Status or switching direction

EXAMPLE

The following example illustrates control of a disconnector QB1 for various cases.

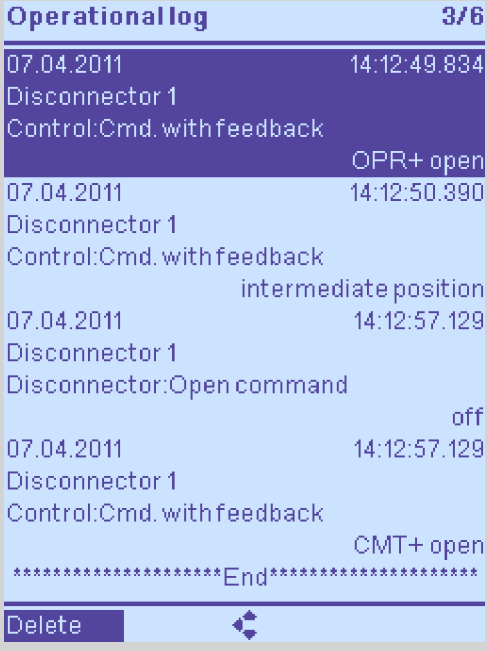
- Successful command output
- Interrupted command
- Command interrupted by switchgear interlocking
- Command ended due to missing feedback
- Spontaneous change of switch position without command output

Figure 7-60 to *Figure 7-66* indicate command logging for various scenarios of the standard control model SBO with feedback monitoring.



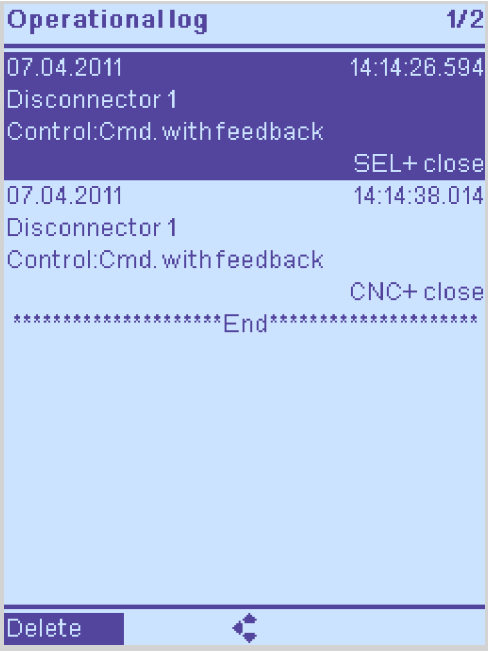
[sc_poscas, 1, en_US]

Figure 7-60 Positive Case (Display 1)



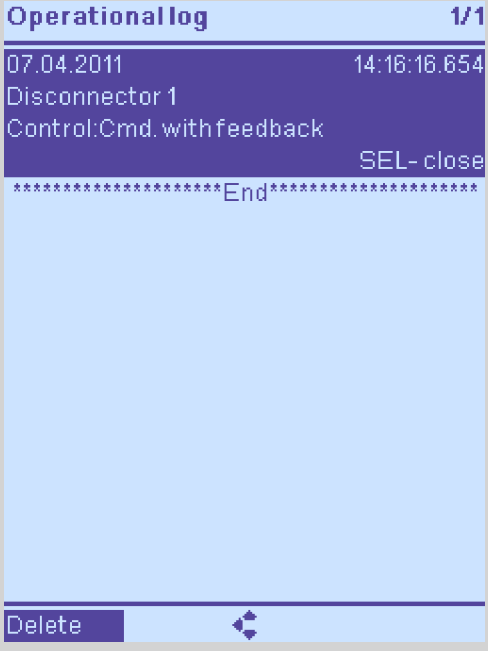
[sc_posca2, 1, en_US]

Figure 7-61 Positive Case (Display 2)



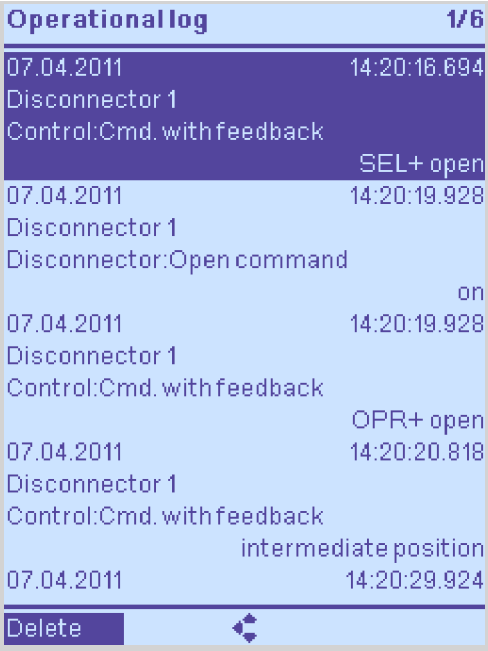
[sc_poscan, 1, en_US]

Figure 7-62 Positive Case with Command Cancellation



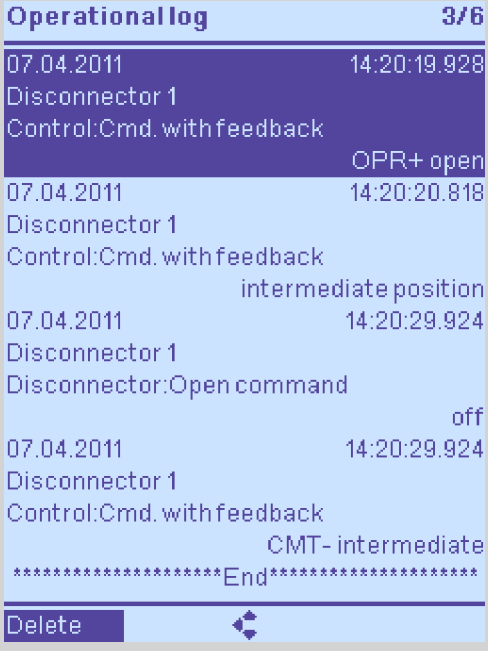
[sc_negint, 1, en_US]

Figure 7-63 Negative Case (Blocked by Switchgear Interlocking)



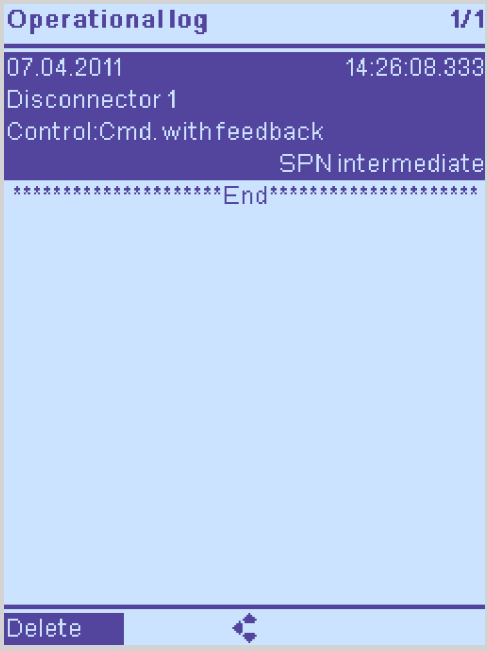
[sc_negtim, 1, en_US]

Figure 7-64 Negative Case (Expiration of Feedback Supervision Time) (Display 1)



[sc_negti2, 1, en_US]

Figure 7-65 Negative Case (Expiration of Feedback Supervision Time) (Display 2)



[sc_sponta, 1, en_US]

Figure 7-66 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 7-23 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

7.4.3 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

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Control:Check if pos. is reached		• no • yes	yes
_:106	Control:Check double activat. blk.		• no • yes	yes
_:107	Control:Check blk. by protection		• no • yes	yes

7.4.4 Information List

No.	Information	Data Class (Type)	Type
Control			
_:53	Control:Health	ENS	O
_:58	Control:Cmd. with feedback	DPC	C

7.5 Paralleling Function

7.5.1 Overview of Functions

The **Paralleling** function realizes the 2-channel paralleling. These 2 channels, which are independent in the measurement procedure and in the processing logic, are of redundant design.
With this function, you achieve a high degree of safety and reliability for one of the following 2 items:

- Paralleling the generator with the power system
- Paralleling 2 power systems

The following operating modes are covered:

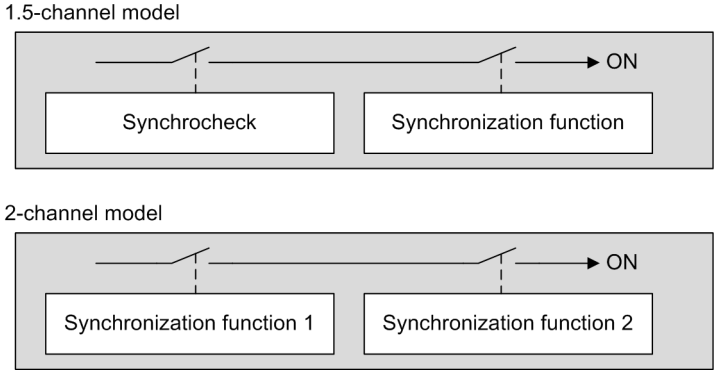
- Switching synchronous systems
- Switching asynchronous systems
- Switching to dead line or dead busbar
- Direct close command
- Balancing voltage
- Balancing frequency

NOTE

Siemens recommends the following applications of the **Paralleling** function:

- Apply the 1.5-channel paralleling function for a system with a capacity < 100 MVA
  The 1.5-channel paralleling function achieves high reliability with a **2-out-of-2 decision**. With this application, only one channel determines the paralleling operation.
- Apply the 2-channel paralleling function for a system with a capacity ≥ 100 MVA
  The 2-channel paralleling function achieves maximum reliability with a **2-out-of-2 decision**. With this application, both channels determine the paralleling operation.

Multichannel Design



[dw_1.5ch & 2ch models, 2, en_US]

Figure 7-67 Multichannel-Redundancy Models

To distinguish between the 1.5-channel model and the 2-channel model, the paralleling with 1.5 channels or with 2 channels is implemented.

Paralleling with 1.5 Channels

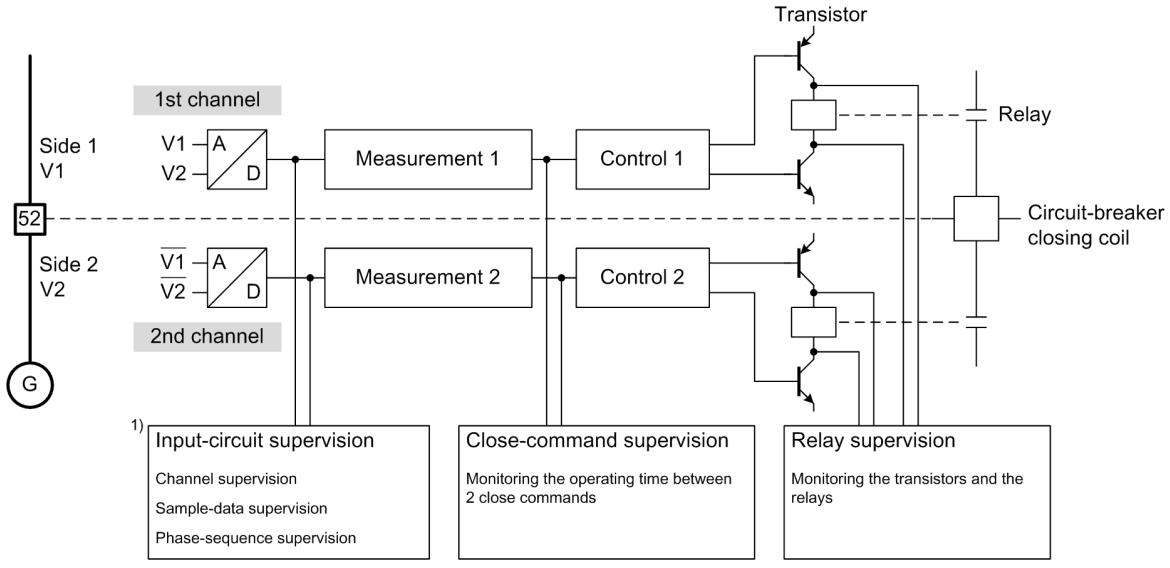
In the paralleling with 1.5 channels, the synchrocheck function and the synchronization function work together. The synchrocheck function operates as a release criterion. It is set roughly in the monitoring limits.

Compared with the paralleling with 2 channels, the paralleling with 1.5 channels has a narrow operating range due to the dependence among the following items:

- Setting values of the release angle
- Permissible frequency difference
- CB make time

Paralleling with 2 Channels

In the paralleling with 2 channels, 2 independent synchronization functions operate in parallel. The close command is issued if both functions decide to release.



[dw_multichannel redundancy, 1, en_US]

Figure 7-68 2-Channel Design

(1) You can find more information about the supervision functionalities in chapter *7.6 Supervision of the Paralleling Function*

Multichannel Redundancy

To ensure high safety and reliability, the software is developed in diverse forms, and the essential hardware components are duplicated. In accordance with *Figure 7-68*, the voltage inputs (V1, V2, $\overline{V1}$, and $\overline{V2}$) are duplicated and are fed to 2 analog-digital converters. The measurement procedure 1 operates with the voltages V1 and V2, and the measurement procedure 2 operates with the inverse voltages $\overline{V1}$ and $\overline{V2}$.
For the 1.5-channel model, the synchrocheck function is applied to the measurement procedure 1 and the synchronization function is applied to the measurement procedure 2. For the 2-channel model, 2 different synchronization functions are applied to the 2 measurement procedures separately.

The closing of the whole system is controlled by the circuit-breaker closing coil which is determined by 2 close-command relays in series. Each close-command relay is controlled by 2 transistors to avoid the overfunction of the transistor.

Measurement Methods

To conform to multichannel redundancy, 2 diverse measuring algorithms are used. This avoids the overfunction caused by the systematic errors. At the same time, the different measurement procedures are used and processed independently with different memory parts.

Different kinds of FIR filters use the central function which is characterized by the following items:

- A defined impulse response
- A linear phase
- High stability

The filters are designed in such way that DC components and higher frequency-disturbance signals are effectively suppressed. The frequency-disturbance signals differ from the rated frequency. In addition, the decimation filter incorporated in the analog-digital converter is helpful for the suppression of the frequency-disturbance signals.

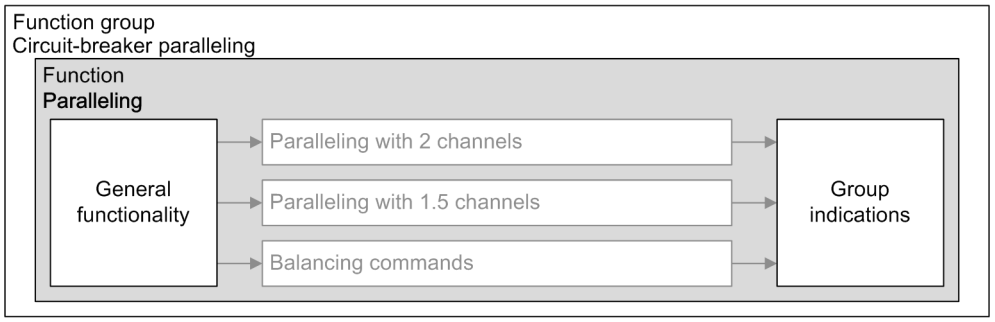
Table 7-24 Overview of the 2 Measurement Procedures

	Measurement Procedure 1	Measurement Procedure 2
Voltage measurement	With the FIR filters whose window length is 1 cycle, the real and imaginary parts of the voltage vector are calculated and are corrected by the frequency. This produces the amplitude of the fundamental component.	With the FIR filters whose window length is 1.25 cycles, the real and imaginary parts of the voltage vector are calculated and are corrected by the frequency. This produces the amplitude of the fundamental component.
Frequency measurement	The frequency is calculated by a special 60-orders bandpass filter (window length = 3 cycles).	The frequency is calculated by an angle difference method.
Angle measurement	The angle is calculated via the frequency-corrected vectors of the previous voltage measurement in the measurement procedure 1.	The angle is calculated via the frequency-corrected vectors of the previous voltage measurement in the measurement procedure 2.
Connection to the asynchronous power system	The connection condition is the angle. With the measured Δf, the CB make time of the circuit breaker is converted to a CB angle. If the measured Δα fulfills the condition of the CB angle, the close command is generated.	The connection condition is the time. With the measured Δf, the measured Δα is converted to a time. If this time fulfills the condition of the CB make time, the close command is generated.

7.5.2 Structure of the Function

The **Paralleling** function is used in the **Circuit-breaker paralleling** function group.
The following stages can be operated within the function:

- 1 stage **Paralleling with 2 channels**
- 1 stage **Paralleling with 1.5 channels**
  Either the **Paralleling with 2 channels** stage or the **Paralleling with 1.5 channels** stage must be instantiated. The stages cannot be instantiated simultaneously. For example, if you want to instantiate the **Paralleling with 1.5 channels** stage, delete the instantiated **Paralleling with 2 channels** stage first.
- 1 stage **Balancing command**



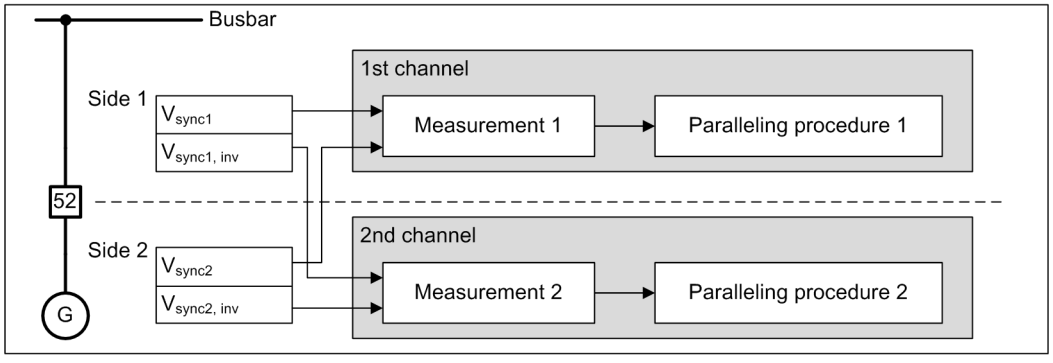
[dw_RSYN_Structure, 1, en_US]

Figure 7-69 Structure/Embedding of the Function

7.5.3 Voltage Connections

The following 4 figures are the common voltage connections for the function **Paralleling**.
Each figure has 2 sides:

- Side 1 is the reference side, for example, which is connected with the busbar side.
  The voltages V_{sync1} and $V_{sync1, inv}$ are derived from side 1.
- Side 2 is the side to be paralleled, for example, which is connected with the generator side.
  The voltages V_{sync2} and $V_{sync2, inv}$ are derived from side 2.



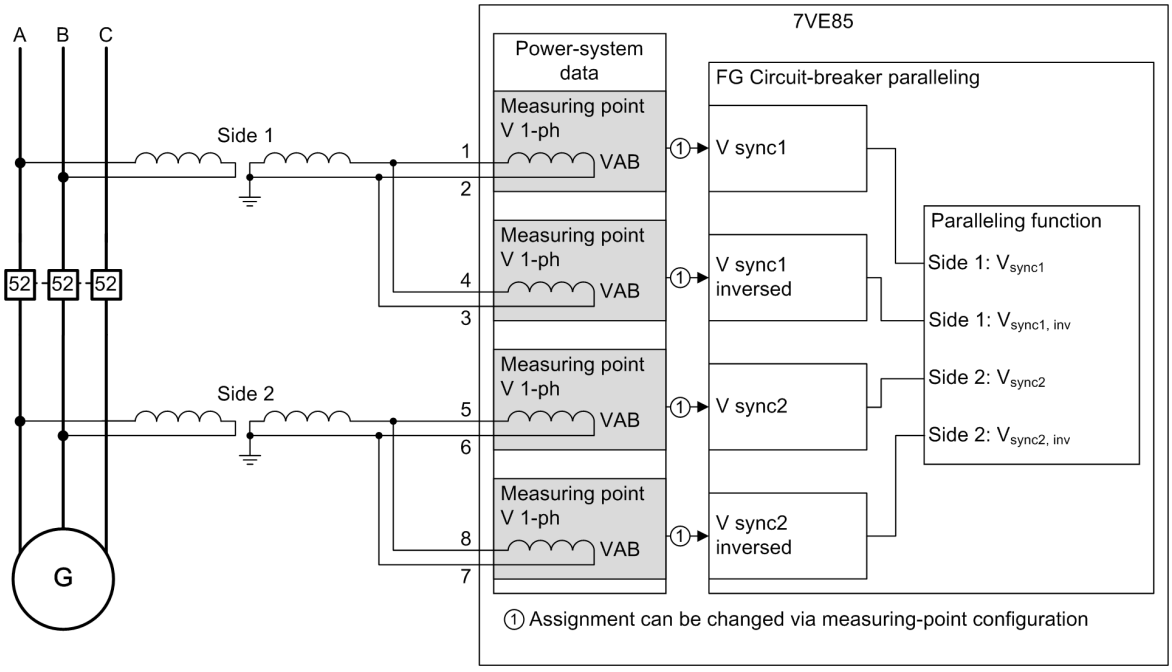
[dw_definition of 2 sides and 2 channels, 1, en_US]

Figure 7-70 Example for the Definition of 2 Sides

The voltage $V_{sync, inv}$ is the opposite vector of the voltage V_{sync}. You can get the voltage $V_{sync, inv}$ by inversing the polarity of the voltage V_{sync}. The voltages V_{sync} and $V_{sync, inv}$ are used for different synchronization channels separately.

Voltage Connection 1

The following figure shows the connection with 2-phase isolated voltage transformers on both sides. In this case, the function **Voltage phase-rotation supervision** is inactive. When connecting to a dead busbar system, be aware of the reliability restrictions caused by shortage of the function **Voltage phase-rotation supervision**. This connection can fully ensure the 2-channel redundancy of the function **Paralleling**.



[dw_typical scenario 001, 1, en_US]

Figure 7-71 Connection with 2-Phase Isolated Voltage Transformers (Ungrounded Voltage Transformers)

Voltage-measuring points

		Base module			
		1B			
		1B1-1B2	1B3-1B4	1B5-1B6	1B7-1B8
Measuring point	Connection type	V 1.1	V 1.2	V 1.3	V 1.4
(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-1ph 1		V AB			
Meas.point V-1ph 2			V AB		
Meas.point V-1ph 3				V AB	
Meas.point V-1ph 4					V AB

[sc_V-MP assignment 001, 1, en_US]

Figure 7-72 Assignment of Voltage-Measuring Points

NOTE

In this voltage connection, the base module offers the voltage inputs of side 1 and side 2. The specific interface numbers for the voltage inputs change according to the actually used I/O modules.

Connect measuring points to function group

	CB Paralleling 1				
Measuring point	I 3ph	V sync1	V sync2	V sync1 inversed	V sync2 inversed
(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]	X				
Meas.point V-1ph 1[ID 2]		X			
Meas.point V-1ph 2[ID 3]				X	
Meas.point V-1ph 3[ID 4]			X		
Meas.point V-1ph 4[ID 5]					X

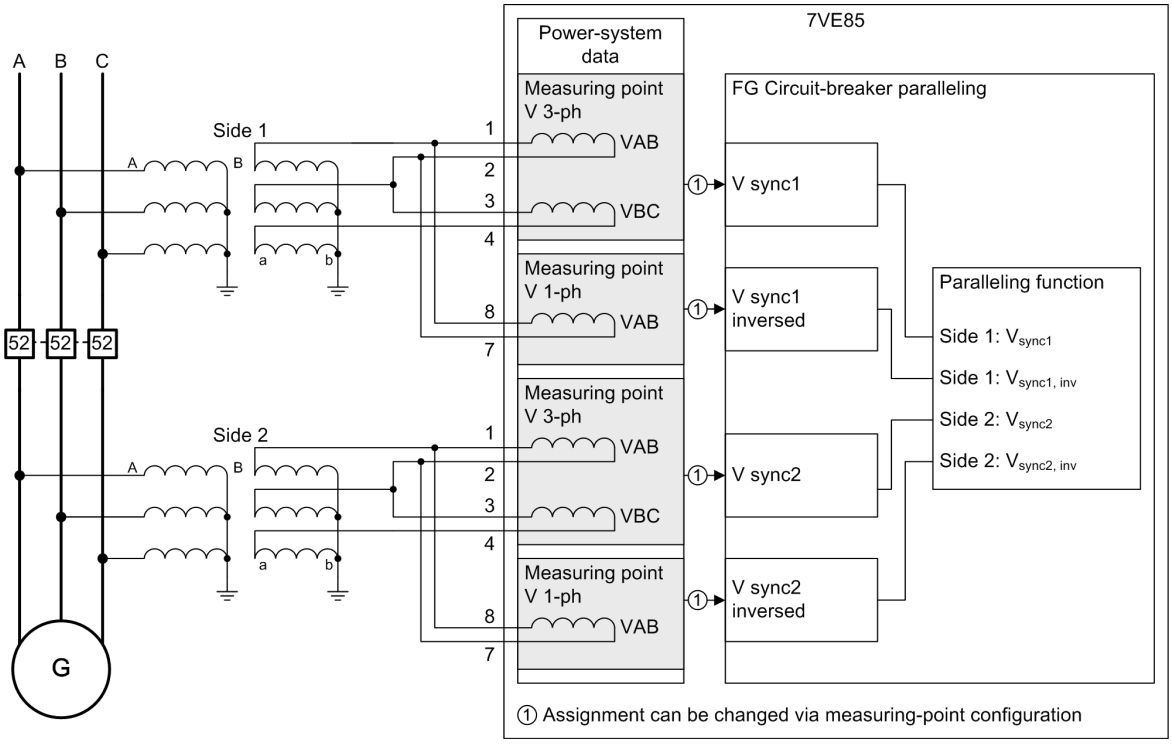
[sc_MP to FG CB paralleling 001, 1, en_US]

Figure 7-73 Connecting Measuring Points to Function Group

Voltage Connection 2

If the 3 star-connected voltage transformers are available, Siemens recommends the following connection. It is a standard connection. It offers higher reliability than other connections for the function **Paralleling**. In this

case, the function **Voltage phase-rotation supervision** is active. With this procedure, a voltage-connection error does not lead to an undesired operation.



[dw_typical scenario 002, 1, en_US]

Figure 7-74 Connection with the 3 Star-Connected Voltage Transformers

Voltage-measuring points

		Base module				Expansion module 3			
		1B				3B			
		1B1-1B2	1B3-1B4	1B5-1B6	1B7-1B8	3B1-3B2	3B3-3B4	3B5-3B6	3B7-3B8
Measuring point	Connection type	V 1.1	V 1.2	V 1.3	V 1.4	V 3.1	V 3.2	V 3.3	V 3.4
(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-3ph 1	2 ph-to-ph voltages	V AB	V BC						
Meas.point V-1ph 1					V AB				
Meas.point V-3ph 2	2 ph-to-ph voltages					V AB	V BC		
Meas.point V-1ph 2									V AB

[sc_V-MP assignment 002, 1, en_US]

Figure 7-75 Assignment of Voltage-Measuring Points

NOTE

In this voltage connection, the base module and the expansion module 3 offer the voltage inputs of side 1 and side 2 separately. The specific interface numbers for the voltage inputs change according to the actually used I/O modules.

Connect measuring points to function group

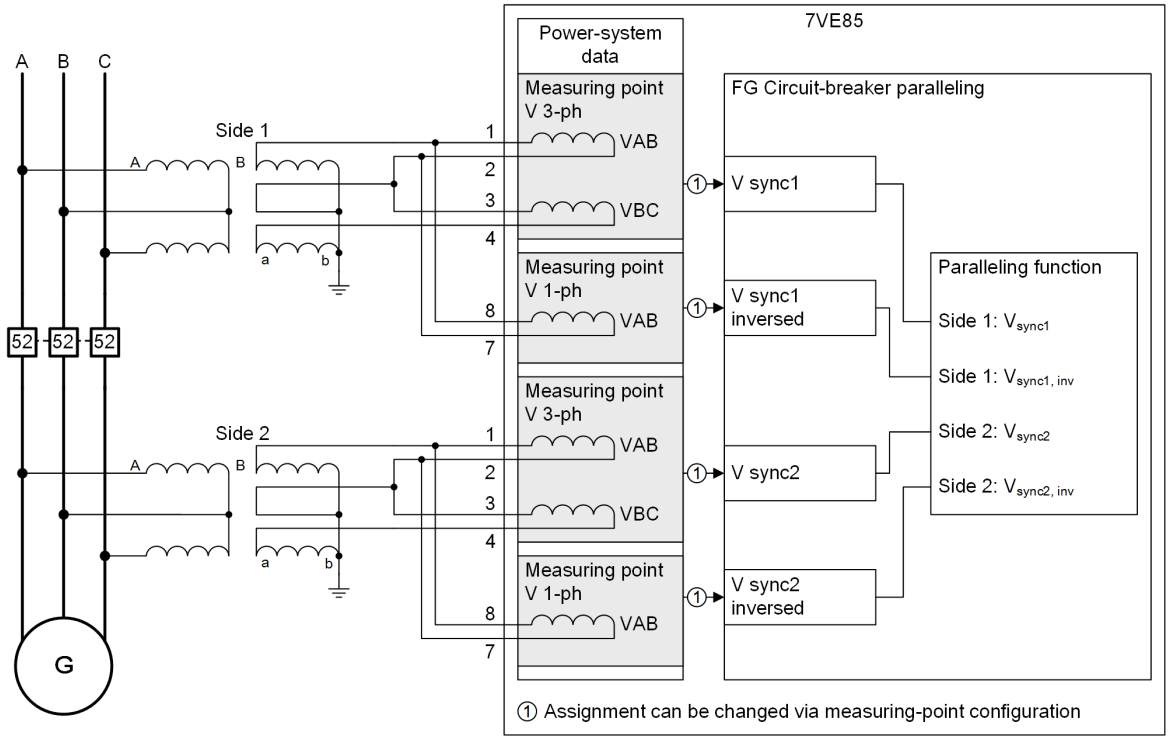
	CB Paralleling 1					
Measuring point	V	I 3ph	V sync1	V sync2	V sync1 inversed	V sync2 inversed
(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]		X				
Meas.point V-3ph 1[ID 2]			X			
Meas.point V-1ph 1[ID 3]					X	
Meas.point V-3ph 2[ID 4]				X		
Meas.point V-1ph 2[ID 5]						X

[sc_MP to FG CB paralleling 002, 1, en_US]

Figure 7-76 Connecting Measuring Points to Function Group

Voltage Connection 3

If the V-connected voltage transformers are available, Siemens recommends the following connection. On the basis of electricity, the following connection has no difference from the connection with the 3 star-connected voltage transformers for the function **Paralleling**. It is also available to connect with a 3-phase voltage transformer on one side and to connect with a V-connected voltage transformer on the other side.



[dw_typical scenario 003, 2, en_US]

Figure 7-77 Connection with the V-Connected Voltage Transformers

Voltage-measuring points

		Base module				Expansion module 3			
		1B				3B			
		1B1-1B2	1B3-1B4	1B5-1B6	1B7-1B8	3B1-3B2	3B3-3B4	3B5-3B6	3B7-3B8
Measuring point	Connection type	V 1.1	V 1.2	V 1.3	V 1.4	V 3.1	V 3.2	V 3.3	V 3.4
(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-3ph 1	2 ph-to-ph voltages	V AB	V BC						
Meas.point V-1ph 1					V AB				
Meas.point V-3ph 2	2 ph-to-ph voltages					V AB	V BC		
Meas.point V-1ph 2									V AB

[sc_V-MP assignment 002, 1, en_US]

Figure 7-78 Assignment of Voltage-Measuring Points

NOTE

In this voltage connection, the base module and the expansion module 3 offer the voltage inputs of side 1 and side 2 separately. The specific interface numbers for the voltage inputs change according to the actually used I/O modules.

Connect measuring points to function group

	CB Paralleling 1					
Measuring point	V	I 3ph	V sync1	V sync2	V sync1 inversed	V sync2 inversed
(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-1ph 1[ID 3]					X	
Meas.point V-3ph 2[ID 4]				X		
Meas.point V-1ph 2[ID 5]						X

[sc_MP to FG CB paralleling 002, 1, en_US]

Figure 7-79 Connecting Measuring Points to Function Group

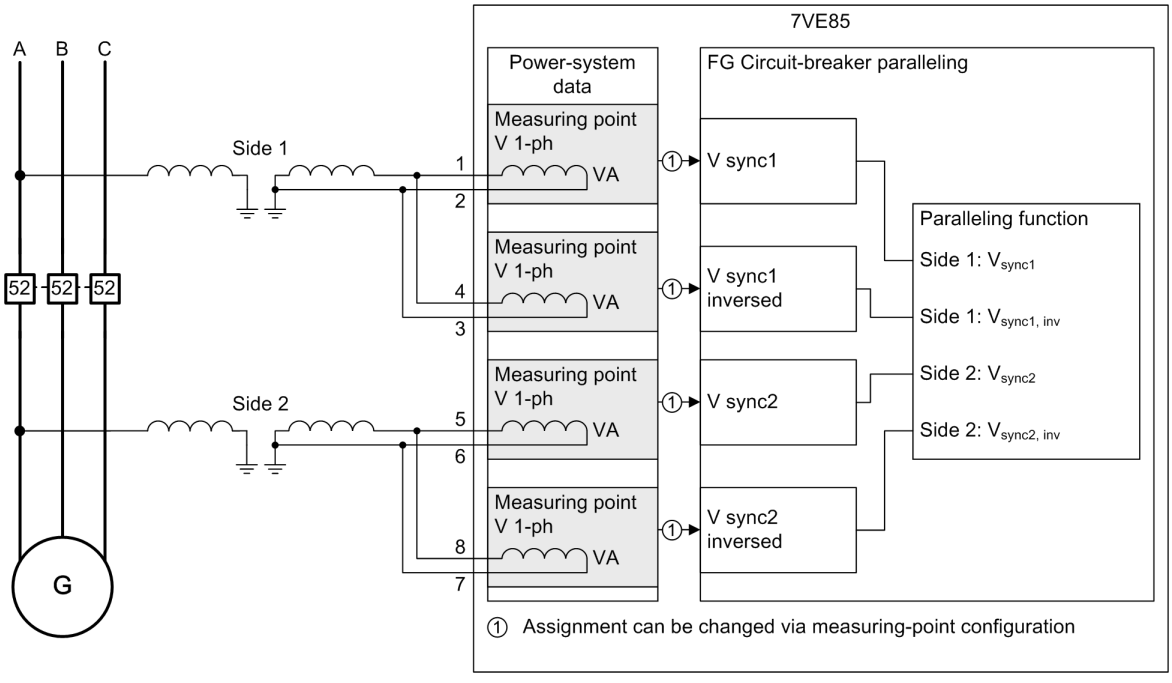
Voltage Connection 4

NOTE

The connection with the 1-phase isolated voltage transformers is not recommended.

The function **Paralleling** can be implemented under the connection with the 1-phase isolated voltage transformers. However, if a phase-to-ground fault occurs, you must consider that the function **Paralleling** cannot distinguish between a ground fault and a dead line or a dead busbar. The following situations must be checked:

- If the mode *V1< & V2>* is allowed, the busbar is recognized as dead. In this case, there is a high risk of wrong paralleling. You can find more information on *V1< & V2>* in section *Switching to Dead Line or Dead Busbar, Page 558*.
- If the healthy phases are used, the device synchronizes with a large angle error because the healthy phases have the phase displacement of 30°.



[dw_typical scenario 004, 1, en_US]

Figure 7-80 Connection with the 1-phase Isolated Voltage Transformers

Voltage-measuring points

		Base module			
		1B			
		1B1-1B2	1B3-1B4	1B5-1B6	1B7-1B8
Measuring point	Connection type	V 1.1	V 1.2	V 1.3	V 1.4
(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-1ph 1		V A			
Meas.point V-1ph 2			V A		
Meas.point V-1ph 3				V A	
Meas.point V-1ph 4					V A

[sc_V-MP assignment 003, 1, en_US]

Figure 7-81 Assignment of Voltage-Measuring Points

NOTE

In this voltage connection, the base module offers the voltage inputs of side 1 and side 2. The specific interface numbers for the voltage inputs change according to the actually used I/O modules.

Connect measuring points to function group

	CB Paralleling 1				
Measuring point	I 3ph	V sync1	V sync2	V sync1 inversed	V sync2 inversed
(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]	X				
Meas.point V-1ph 1[ID 2]		X			
Meas.point V-1ph 2[ID 3]				X	
Meas.point V-1ph 3[ID 4]			X		
Meas.point V-1ph 4[ID 5]					X

[sc_MP to FG CB paralleling 001, 1, en_US]

Figure 7-82 Connecting Measuring Points to Function Group

7.5.4 General Functionality

7.5.4.1 Description

The general functionality of the **Paralleling** function consists of **FB General** and **FB Inv. Voltage**. It provides the measurements for the paralleling stages.

The **FB General** gets the voltages V_{sync1} and V_{sync2}, then calculates the functional measured values of the 1st channel.

The **FB Inv. Voltage** gets the voltages $V_{sync1, inv}$ and $V_{sync2, inv}$, then calculates the functional measured values of the 2nd channel.

Definition of the Variables

The definition of the variables is important for understanding the following implementation.

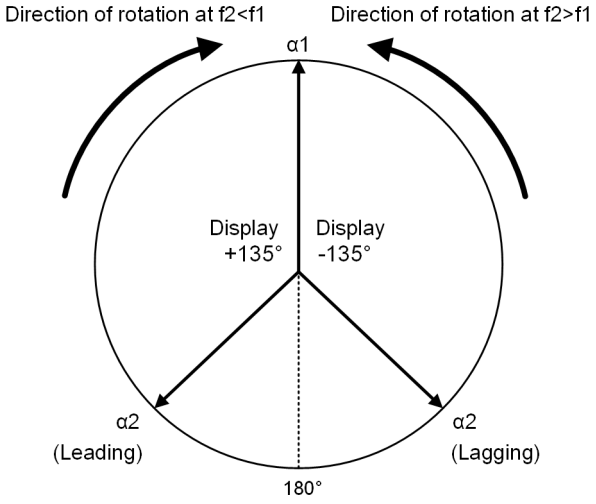
- The reference values voltage V1, frequency f1, and phase angle α1 are all from side 1.
- The electrical values voltage V2, frequency f2, and phase angle α2 are all from side 2.

With different measuring points, the voltages V1 and V2 have the following 3 situations:

- If both of the 2 sides are connected to the 3-phase measuring points, the voltages V1 and V2 are the phase-to-phase voltage V_{AB} of each side.
- If one side is connected to a 3-phase measuring point and the other side is connected to a 1-phase measuring point, the voltages V1 and V2 are the 1-phase voltage of each side.
- If both of the 2 sides are connected to the 1-phase measuring points, the phase angles and magnitude factors of V1 and V2 are considered during the calculation process.

The differential variables are all defined as the absolute measured deviation (Δx = measured value - real value). The following differential variables are calculated:

- **Voltage difference dV = V2 - V1**
  A positive result means that the voltage V2 is greater than the voltage V1. Otherwise, the result is negative.
- **Frequency difference df = f2 - f1**
  A positive result means that the frequency f2 is greater than the frequency f1. For example, the generator frequency is greater than the power frequency. This is the oversynchronous case. If undersynchronous conditions prevail, the result of the frequency difference is negative.
- **Angle difference dα = α2 - α1**
  The angle difference is limited to ±180°. A positive result means that α2 **leads** by a maximum of 180°. A negative result means α2 **lags** by a maximum of 180°. *Figure 7-83* 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 7-83*, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.



[dw_synp_04, 2, en_US]

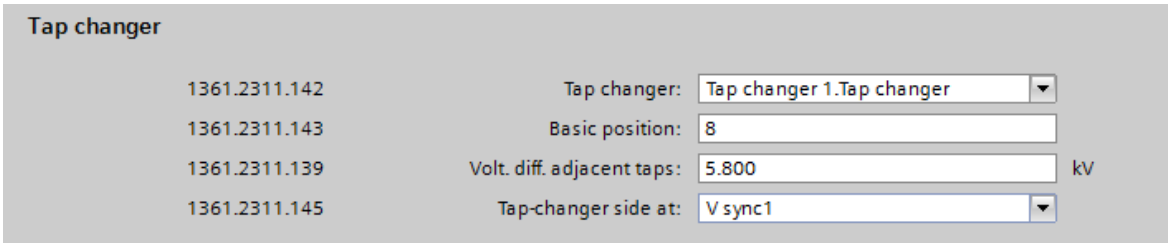
Figure 7-83 Phase-Angle Difference Representation dα

Only positive values are permissible for the parameter settings. In this function, inequalities are used to characterize the parameter settings clearly. Take the voltage difference as an example. 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 frequency difference and angle difference.

Synchronization-Voltage Adaptation According to the Tap-Changer Position

If a tap changer is assigned to a transformer side, the voltage V2 to be paralleled in the **Paralleling** function is adapted to the current tap-changer position. To use the tap-changer functionality, set the following parameters in the **Circuit-breaker paralleling** function group:

- **`Tap changer`**
- **`Basic position`**
- **`Volt. diff. adjacent taps`**
- **`Tap-changer side at`**



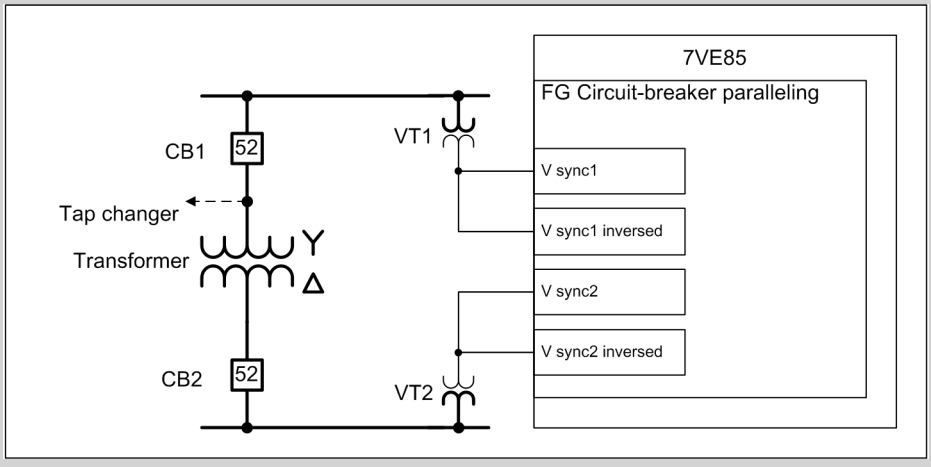
[sc_Settings in DIGSI, 2, en_US]

Figure 7-84 Settings in DIGSI

You can find more information about these parameters in chapter *7.5.4.2 Application and Setting Notes*.

Application Example 1

In the following figure, CB1 is the circuit breaker to be paralleled in the electrical power system. The measuring point from VT1 is routed to the interface $\mathbf{V_{sync1}}$. The measuring point from VT2 is routed to the interface $\mathbf{V_{sync2}}$. Under these conditions, set the parameter **`Tap-changer side at`** to V_{sync1}.



[dw_Tap changer_example 1, 1, en_US]

Figure 7-85 Application Example 1

In this application, to adapt V2 to the tap-changer position, an adjustment factor K_{tap} is calculated. The setting of the parameter **`Highest tap position`** in the **Tap changer** function group influences the calculation of K_{tap}.

Table 7-25 Different K_{tap} According to the Setting of the Parameter **`Highest tap position`**

Setting of the Parameter **`Highest tap position`**	K_{tap}
Highest voltage tap	$K_{tap} = 1 + \frac{(Pos1 - BasePos) \cdot \Delta V}{V1_{rated}}$
Lowest voltage tap	$K_{tap} = 1 - \frac{(Pos1 - BasePos) \cdot \Delta V}{V1_{rated}}$

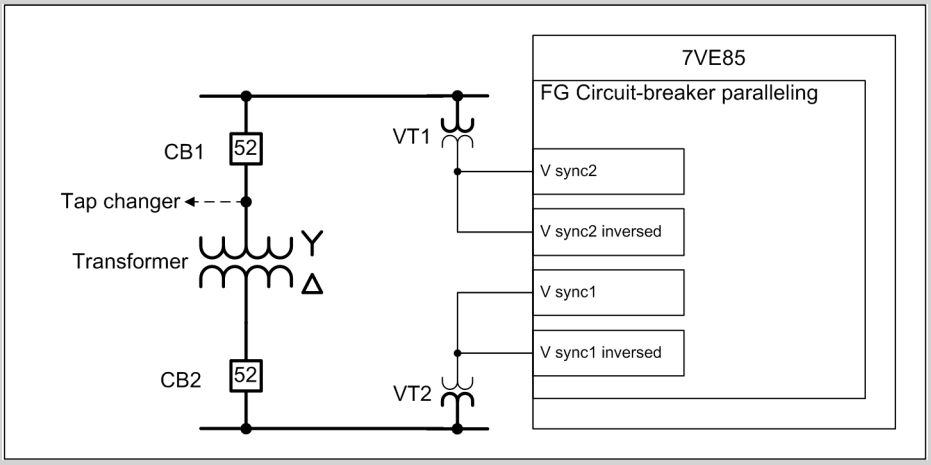
Where:

Pos1	New position of the tap changer
BasePos	Basic position of the tap changer

ΔV	Voltage difference of a stage
$V1_{rated}$	Rated value of the reference voltage V1

Application Example 2

In the following figure, CB2 is the circuit breaker to be paralleled in the electrical power system. The measuring point from VT2 is routed to the interface $\mathbf{V_{sync1}}$. The measuring point from VT1 is routed to the interface $\mathbf{V_{sync2}}$. Under these conditions, set the parameter **`Tap-changer side at`** to V_{sync2}.



[dw_Tap changer_example 2, 1, en_US]

Figure 7-86 Application Example 2

In this application, to adapt V2 to the tap-changer position, an adjustment factor K_{tap} is calculated. The setting of the parameter **`Highest tap position`** in the **Tap changer** function group influences the calculation of K_{tap}.

Table 7-26 Different K_{tap} According to the Setting of the Parameter **`Highest tap position`**

Setting of the Parameter **`Highest tap position`**	K_{tap}
Highest voltage tap	$K_{tap} = \frac{V2_{rated}}{(Pos1 - BasePos) \cdot \Delta V + V2_{rated}}$
Lowest voltage tap	$K_{tap} = \frac{V2_{rated}}{(BasePos - Pos1) \cdot \Delta V + V2_{rated}}$

Where:

Pos1	New position of the tap changer
BasePos	Basic position of the tap changer
ΔV	Voltage difference of a stage
$V2_{rated}$	Rated value of the voltage V2 to be paralleled

Functional Measured Values

The functional measured values for the **Paralleling** function are displayed in their own primary, secondary, and percentage measured-value windows. Voltage measurements are always displayed as phase-to-phase voltages, even if the associated measuring point records phase-to-ground voltages. The functional measured values are determined and displayed once the device is working. The difference values are calculated as soon as the stage is activated.

Table 7-27 Measured Values of the Paralleling Function

Values		Primary	Secondary	% Referenced to
V1	Reference voltage V1	kV	V	Rated operating voltage of the primary values
V2	Voltage to be paralleled V2	kV	V	Rated operating voltage of the primary values
f1	Frequency of the voltage V1	Hz	Hz	Rated frequency
f2	Frequency of the voltage V2	Hz	Hz	Rated frequency
dV	Voltage difference V2 - V1	kV	V	Rated operating voltage of V1
df	Frequency difference f2 - f1	Hz	Hz	Rated frequency
dα	Angle difference α2 - α1	°		–

If the **Tap changer** function is used, the synchronization voltage V2 is displayed and calculated in HMI as follows:

$$V2 = K_{tap} \cdot V2_{Measured}$$

[fo_Calculated V2, 1, en_US]

Statistical Values

The **Paralleling** function counts the maximum value and the minimum value of V1, V2, f1, f2, dV, df, and dα during the paralleling process:

- Once the **Paralleling** function starts, the statistical process starts.
- Once the **Paralleling** function stops, the statistical process stops. Meanwhile, all the statistical values are maintained. The maintained values can be reset via the restart of the function or via the binary input signal *>Reset min./max.*

All the statistical values are absolute values. They are displayed in their own primary, secondary, and percentage measured-value windows. Voltage measurements are always displayed as phase-to-phase voltages, even if the associated measuring point records phase-to-ground voltages.

7.5.4.2 Application and Setting Notes

Parameter: Voltage adjustment

- Default setting **(_:126) Voltage adjustment** = *1.00*

You can find this parameter in the stage **Paralleling with 1.5 channels** or in the stage **Paralleling with 2 channels**.

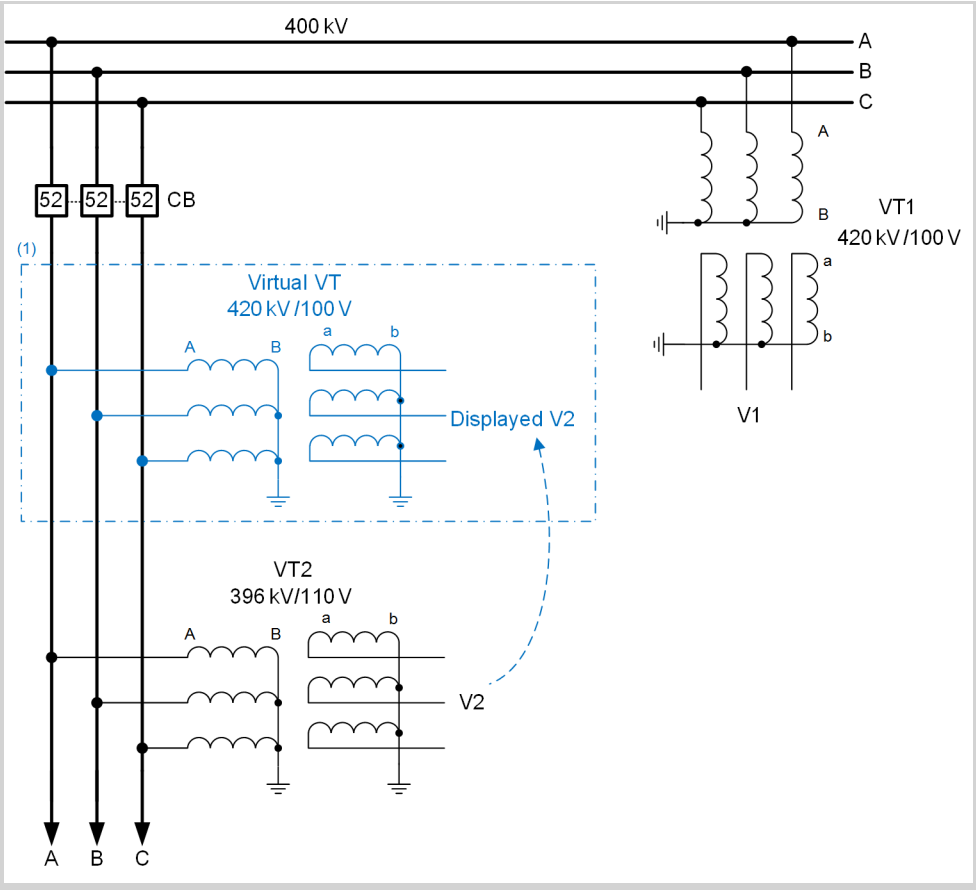
The **Voltage adjustment** parameter can be used to correct amplitude errors, for example, due to indirect measurement (for example, as a result of a tap changer in the system).

To apply a power transformer between the voltage measuring points, it is not necessary to consider the transformer ratio. When setting the **Voltage adjustment** parameter, the transformer ratio is taken into account automatically.

In the following, you can find 2 examples about setting the **Voltage adjustment** parameter:

Example 1:

In the electrical power system, no power transformer exists between the voltage measuring points of the circuit breaker to be synchronized. The rated primary voltages of 2 sides of the electrical power system are different.



[dw_example w.o. power transformer, 1, en_US]

Figure 7-87 Example: the Electrical Power System without a Power Transformer

(1) The virtual VT does not exist in the primary voltage system. It is just a virtual voltage transformer to show the displayed V2 on the device display. The virtual VT has the same transformer ratio as VT1.

The displayed V2 is a processed voltage from VT2.

$$\text{Voltage adjustment} = \frac{V2_{\text{rated prim.}}}{V1_{\text{rated prim.}}} = \frac{396\ \text{kV}}{420\ \text{kV}} \approx 0.94$$

[fo_ex1_V adjustment, 1, en_US]

With:

$V2_{\text{rated prim.}}$	Rated primary voltage of VT2
$V1_{\text{rated prim.}}$	Rated primary voltage of VT1

For this example, the displayed voltage V2 on the device display is from the virtual VT, not from VT2.

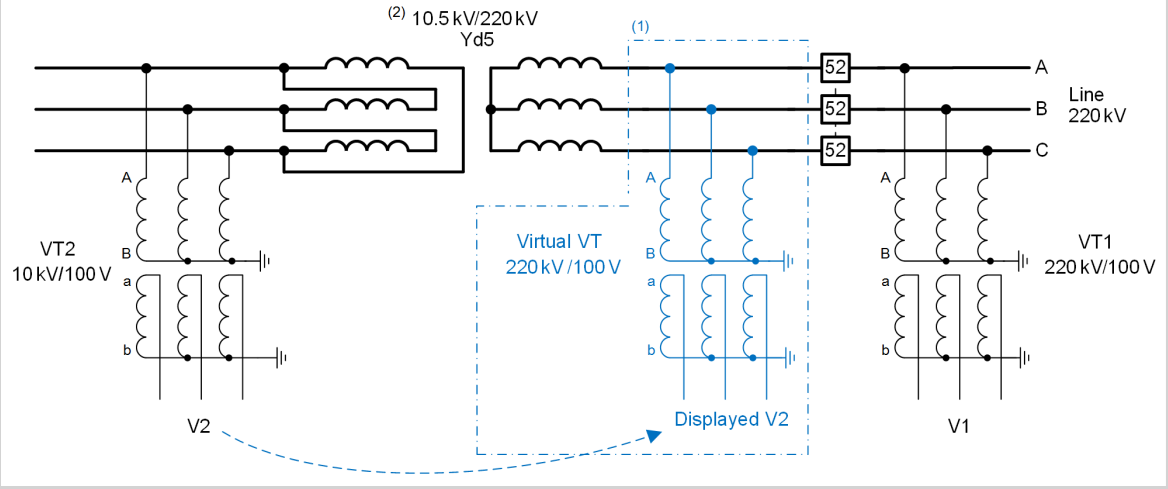
The primary voltages, secondary voltages, and percentage values of the measured values are shown in the following table.

Table 7-28 Primary Voltage, Secondary Voltage, and Percentage Value

Measured Value	Primary Voltage	Secondary Voltage	Percentage Value
V1	400 kV	$\frac{400\,\text{kV}}{420\,\text{kV}/100\,\text{V}} \approx 95.238\,\text{V}$	$\frac{400\,\text{kV}}{420\,\text{kV}} \cdot 100\,\% \approx 95.238\,\%$
V2	400 kV	$\frac{400\,\text{kV}}{396\,\text{kV}/110\,\text{V}} \approx 111.111\,\text{V}$	$\frac{400\,\text{kV}}{396\,\text{kV}} \cdot 100\,\% \approx 101.01\,\%$
Displayed V2	400 kV	$\frac{400\,\text{kV}}{420\,\text{kV}/100\,\text{V}} \approx 95.238\,\text{V}$	$\frac{400\,\text{kV}}{420\,\text{kV}} \cdot 100\,\% \approx 95.238\,\%$

Example 2:

In the electrical power system, a power transformer is located between the voltage measuring points of the circuit breaker to be synchronized. The power transformer ratio differs from the ratio between the rated primary voltages of the voltage transformers of 2 sides of the electrical power system.



[dw_example w. power transformer, 1, en_US]

Figure 7-88 Example: the Electrical Power System with a Power Transformer

(1) The virtual VT does not exist in the primary voltage system. It is just a virtual voltage transformer to show the displayed V2 on the device display. The virtual VT has the same transformer ratio as VT1.

The displayed V2 is a processed voltage from VT2.

(2) This ratio is not the rated transformer ratio on the transformer name plate. This ratio is an actual ratio which considers the tap-changer scenarios when the **Tap changer** function is not used in the device. The rated transformer ratio is 220 kV/10 kV.

$$\text{Voltage adjustment} = \frac{V2_{\text{rated prim.}}}{V1_{\text{rated prim.}}} \cdot R_{PT} = \frac{10\,\text{kV}}{220\,\text{kV}} \cdot \frac{220\,\text{kV}}{10.5\,\text{kV}} \approx 0.95$$

[fo_ex2_V adjustment, 1, en_US]

With:

$V2_{\text{rated prim.}}$	Rated primary voltage of VT2
$V1_{\text{rated prim.}}$	Rated primary voltage of VT1
R_{PT}	Transformer ratio of the power transformer

For this example, the displayed voltage V2 on the device display is from the virtual VT, not from VT2.

The primary voltages, secondary voltages, and percentage values of the measured values are shown in the following table.

Table 7-29 Primary Voltage, Secondary Voltage, and Percentage Value

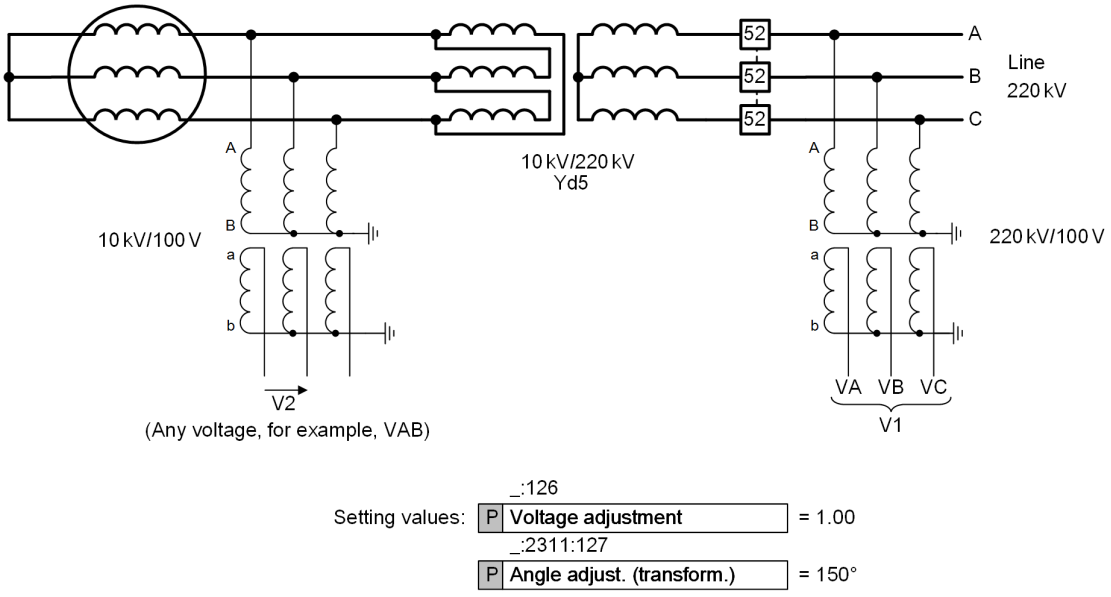
Measured Value	Primary Voltage	Secondary Voltage	Percentage Value
V1	220 kV	$\frac{220\,\text{kV}}{220\,\text{kV}/110\,\text{V}} = 110\,\text{V}$	$\frac{220\,\text{kV}}{220\,\text{kV}} \cdot 100\,\% = 100\,\%$
V2	10.5 kV	$\frac{10.5\,\text{kV}}{10\,\text{kV}/100\,\text{V}} = 105\,\text{V}$	$\frac{10.5\,\text{kV}}{10\,\text{kV}} \cdot 100\,\% = 105\,\%$
Displayed V2	220 kV	$\frac{220\,\text{kV}}{220\,\text{kV}/110\,\text{V}} = 110\,\text{V}$	$\frac{220\,\text{kV}}{220\,\text{kV}} \cdot 100\,\% = 100\,\%$

Parameter: **`Angle adjust. (transform.)`**

- Default setting **`(_:2311:127) Angle adjust. (transform.)`** = ***0°***

The parameter can be applied under the following conditions:

- Phase-angle rotation by power transformer between the measuring points



[dw_transformer between the measuring points, 2, en_US]

Figure 7-89 Transformer Between the Measuring Points

If there is a power transformer between the voltage transformers of the circuit breaker to be paralleled, you then have to correct the phase-angle rotation for a vector group deviating from 0. *Figure 7-89* shows such an application. The **`Angle adjust. (transform.)`** parameter is used to adjust the phase-angle rotation.

The vector group of the transformer is defined by the upper voltage side and the lower voltage side. If the reference voltage transformer V1 is connected to the upper voltage side of the transformer (as in *Figure 7-89*), enter the rotation angle directly according to the vector group. A vector-group numeral 5, for example, means an angle rotation of 5 · 30° = 150°. Then, set the **`Angle adjust. (transform.)`** parameter to 150°.

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 numeral 5 yields an angle adjustment of 360° - (5 · 30°) = 210°.

- Correction of phase-angle errors

  Additionally, you can correct a phase-angle error between the voltage transformers in increments. Considering the different application scenarios, you can ascertain a possible correction value during the commissioning.

Parameters for the Synchronization-Voltage Adaptation According to the Tap-Changer Position

To adapt the synchronization voltage according to the tap-changer position, set the following parameters in the **Circuit-breaker paralleling** function group:

Parameter: `Tap changer`

- Default setting **`(_:142) Tap changer`** = ***`None`***

With the **`Tap changer`** parameter, you assign a tap changer to the transformer side. The other tap-changer related parameters are visible only when a tap changer is assigned.

Parameter: `Basic position`

- Default setting **`(_:143) Basic position`** = ***`8`***

With the **`Basic position`** parameter, you specify the position at which the voltage matches the rated voltage of the transformer side.

Parameter: `Volt. diff. adjacent taps`

- Default setting **`(_:139) Volt. diff. adjacent taps`** = ***`5.800 kV`***

With the **`Volt. diff. adjacent taps`** parameter, you set the voltage difference between 2 adjacent taps under no-load conditions.

Parameter: `Tap-changer side at`

- Default setting **`(_:145) Tap-changer side at`** = V_{sync1}

With the **`Tap-changer side at`** parameter, you specify the transformer side which the tap changer is assigned to.

Parameter Value	Description
V_{sync1}	The tap changer is assigned to the transformer side which is close to the reference side as shown in *Figure 7-85*.
V_{sync2}	The tap changer is assigned to the transformer side which is close to the side to be paralleled as shown in *Figure 7-86*.

7.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:127	General:Angle adjust. (transform.)		-179.0° to 180.0°	0.0°

Tap-Changer Related Parameters in the Circuit-Breaker Paralleling Function Group

Addr.	Parameter	C	Setting Options	Default Setting
`Tap changer`				
_:143	General:Basic position		-128 to 127	8
_:139	General:Volt. diff. adjacent taps		0.000 kV to 800.000 kV	5.800 kV
_:145	General:Tap-changer side at		• V sync1 • V sync2	V sync1
_:142	General:Tap changer		Setting options depend on configuration	

7.5.4.4 Information List

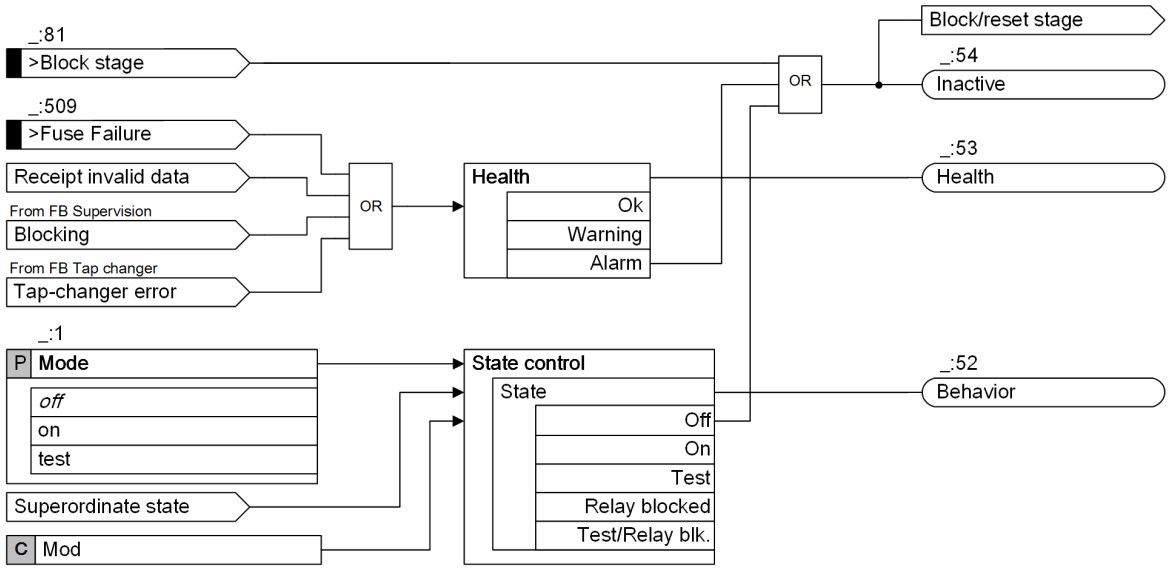
No.	Information	Data Class (Type)	Type
General			
_:2311:85	General:>Reset min./max.	SPS	I
_:2311:304	General:Blocked no V selected	SPS	O
_:2311:329	General:V1	MV	O
_:2311:330	General:f1	MV	O
_:2311:331	General:V2	MV	O
_:2311:332	General:f2	MV	O
_:2311:300	General:dV	MV	O
_:2311:301	General:df	MV	O
_:2311:302	General:dα	MV	O
_:2311:332	General:V1 max	BCR	O
_:2311:333	General:V1 min	BCR	O
_:2311:334	General:V2 max	BCR	O
_:2311:335	General:V2 min	BCR	O
_:2311:336	General:f1 max	BCR	O
_:2311:337	General:f1 min	BCR	O
_:2311:338	General:f2 max	BCR	O
_:2311:339	General:f2 min	BCR	O
_:2311:340	General:dV max	BCR	O
_:2311:341	General:dV min	BCR	O
_:2311:342	General:df max	BCR	O
_:2311:343	General:df min	BCR	O
_:2311:344	General:dα max	BCR	O
_:2311:345	General:dα min	BCR	O
Inv. Voltage			
_:20041:304	Inv. Voltage:Blocked no V selected	SPS	O
_:20041:329	Inv. Voltage:V1	MV	O
_:20041:330	Inv. Voltage:f1	MV	O
_:20041:331	Inv. Voltage:V2	MV	O
_:20041:332	Inv. Voltage:f2	MV	O
_:20041:300	Inv. Voltage:dV	MV	O
_:20041:301	Inv. Voltage:df	MV	O
_:20041:302	Inv. Voltage:dα	MV	O

7.5.5 Stage Paralleling with 2 Channels

7.5.5.1 Description

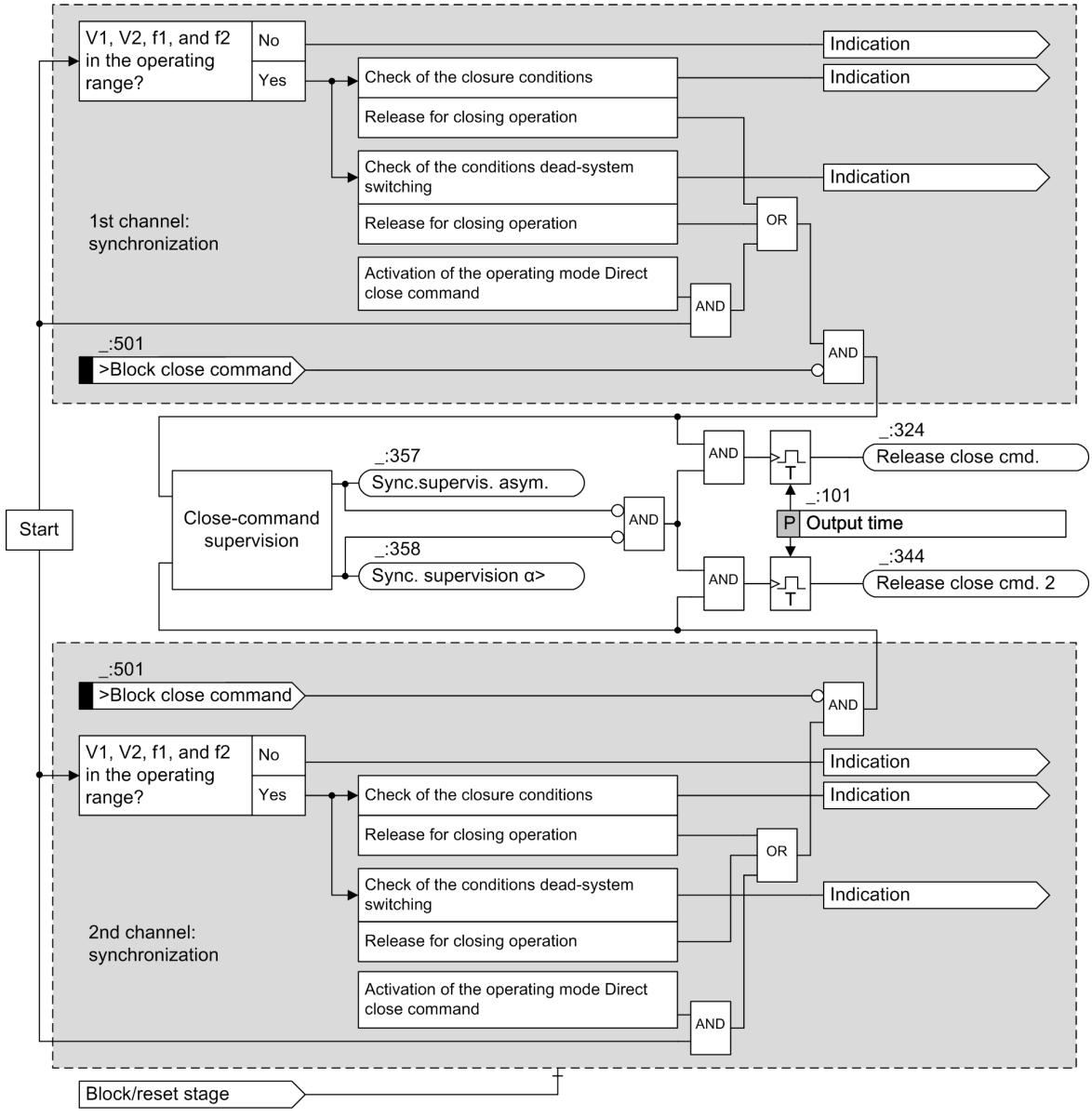
The stage **Paralleling with 2 channels** provides 2 independent procedures which are operated in parallel. These 2 procedures check the closing conditions and generate the close commands separately. If both procedures decide to issue a close command, the close command is issued.

Logic



[lo_paralleling_stage ctrl, 4, en_US]

Figure 7-90 Logic Diagram of the Stage Control

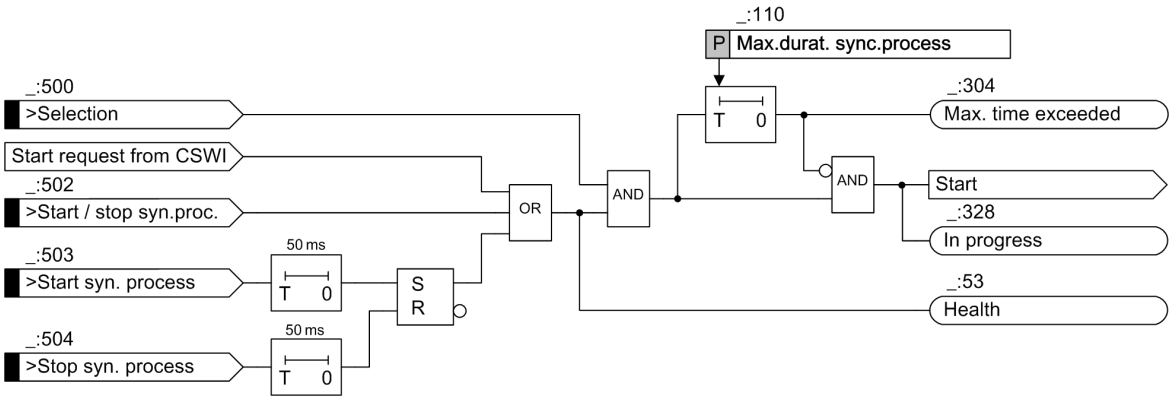


[lo_paralleling_2 ch, 1, en_US]

Figure 7-91 Logic Diagram of the Stage Paralleling with 2 Channels

Start and Stop

The stage **Paralleling with 2 channels** must be started to check the closing conditions.



[lo_start/stop, 1, en_US]

Figure 7-92 Logic of the Start

The stage **Paralleling with 2 channels** can be started by one of the following 3 options:

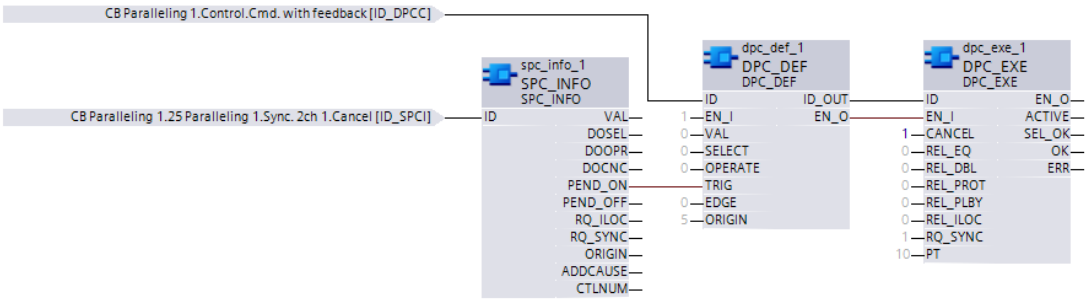
- Via the binary input signal *>Start syn. process* which is a pulse signal
  The binary input signal *>Stop syn. process* is the corresponding stop signal of the signal *>Start syn. process*.
- Via the binary input signal *>Start/stop syn.proc.* when this input signal is active
- Via the start request from CSWI

After a successful start, the indication *In progress* is issued. Meanwhile, the supervision time **Max.durat. sync.process** for the maximum duration of the paralleling process starts.

The stage **Paralleling with 2 channels** can be stopped by one of the following options:

- Via one of the following binary input signals:
  - *>Stop syn. process*
  - *>Start/stop syn.proc.*
  - *>Fuse Failure*
- Via the voltage transformer miniature circuit breaker
  If the voltage transformer miniature circuit breaker is open, the health state of the stage **Paralleling with 2 channels** changes to *Warning* and the stage stops.
- Via the supervision time **Max.durat. sync.process**
  If the supervision time **Max.durat. sync.process** expires, the stage **Paralleling with 2 channels** stops.
- Via the release close commands from 2 channels
  When the 2 indications *Release close cmd.* and *Release close cmd. 2* are generated simultaneously, the stage **Paralleling with 2 channels** stops.
- Via the blocking signal from the function block **Supervision**
  You can find more information in *Table 7-30*

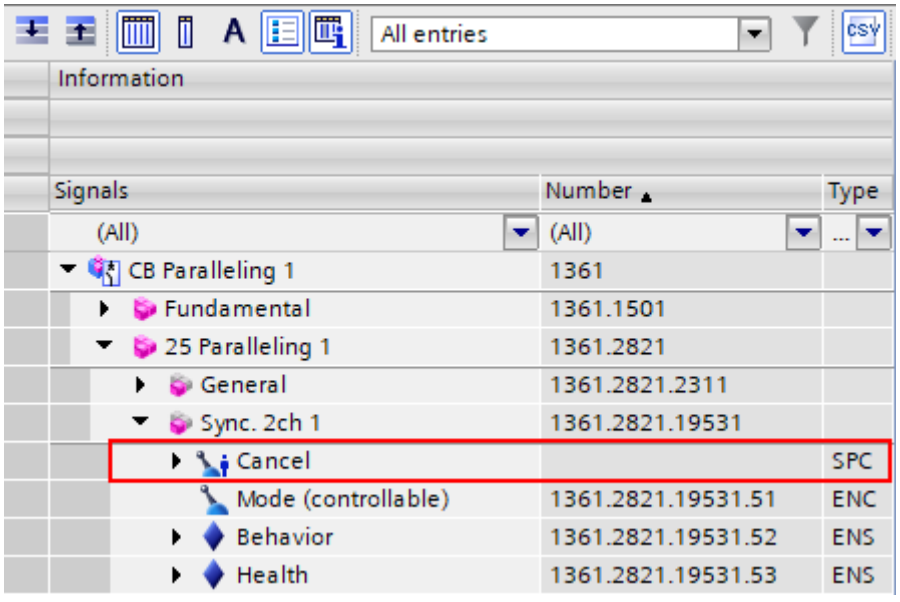
- Via CFC when the stage is started via the start request from CSWI
  If you start the stage via the start request from CSWI, you can stop the stage via the following user-defined CFC chart:



[sc_CFC_cancel_cmd, 1, en_US]

Figure 7-93 User-Defined CFC Chart

In the preceding CFC chart, the input signal **Cancel** of the CFC block **SPC_INFO** is a user-defined SPC signal. You can add it to the stage **Paralleling with 2 channels** in the **Information routing** editor.



[sc_user-defined SPC, 1, en_US]

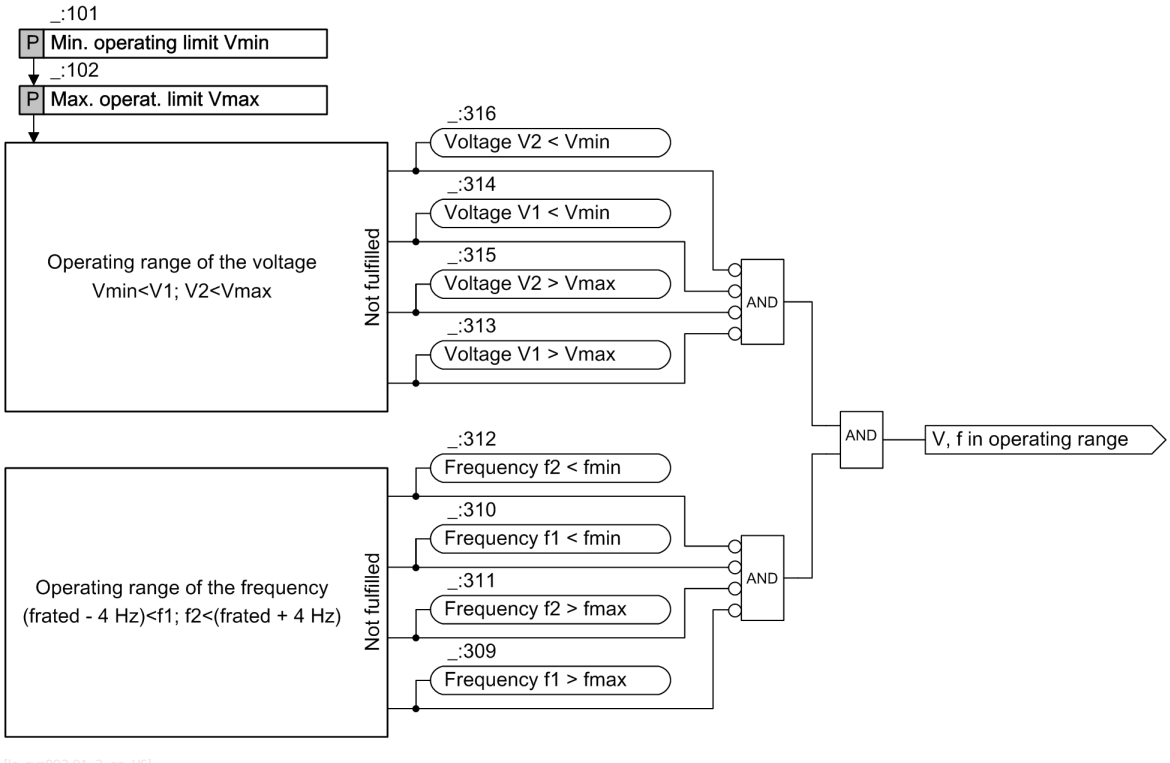
Figure 7-94 User-Defined SPC Signal

If you want to restart the stage **Paralleling with 2 channels**, activate the binary input signal *>Start syn. process* or *>Start/stop syn.proc.* manually.

NOTE

If the input signal *>Selection* is routed to a binary input, the stage **Paralleling with 2 channels** must be selected by this binary input before the starting of the stage. If the stage is not selected, the stage cannot be started.

Operating Range



[lo_syn002-01, 2, en_US]

Figure 7-95 Logic of the Operating Range

The operating range of the stage **Paralleling with 2 channels** is defined by the parameters **`Min. operating limit Vmin`** and **`Max. operat. limit Vmax`** as well as by the specified frequency band f_{rated} ± 4 Hz.

If one of the following 2 conditions is met when the measuring is started, the closing conditions are not checked:

- One or both voltages are out of the permitted operating range.
- One or both frequencies are out of the permitted operating range.

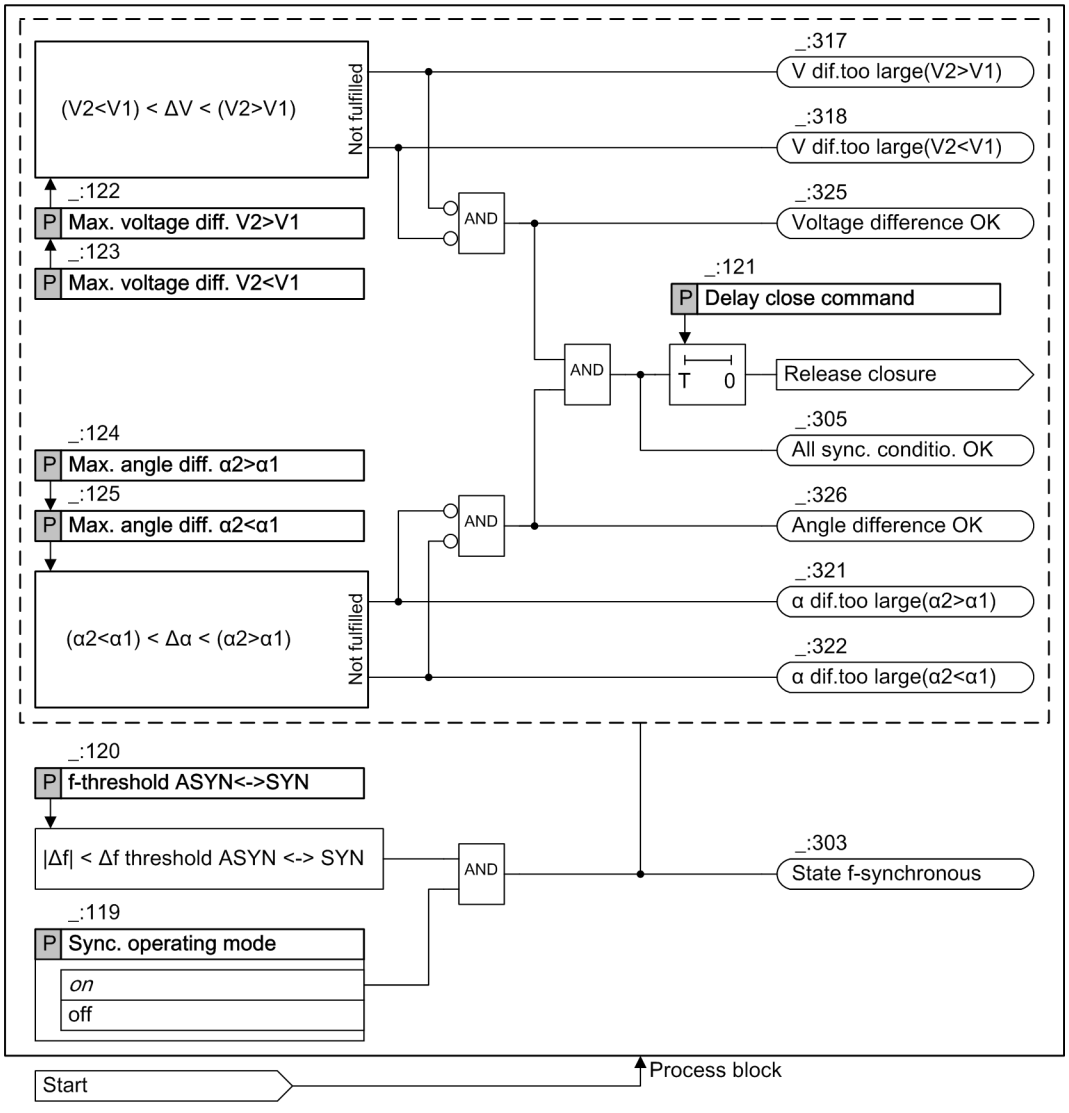
If the voltages or the frequencies are out of the permitted operating range, the corresponding indications are issued, such as **`Voltage V1 < Vmin`** or **`Frequency f1 > fmax`**.



NOTE

When connecting this function to a 3-phase measuring point, make sure that the voltages from 3 phases are all in the permitted operating range.

Checking the Closing Conditions in Synchronous Systems



[lo_sync. system, 2, en_US]

Figure 7-96 Closing Conditions when Switching Synchronous Systems

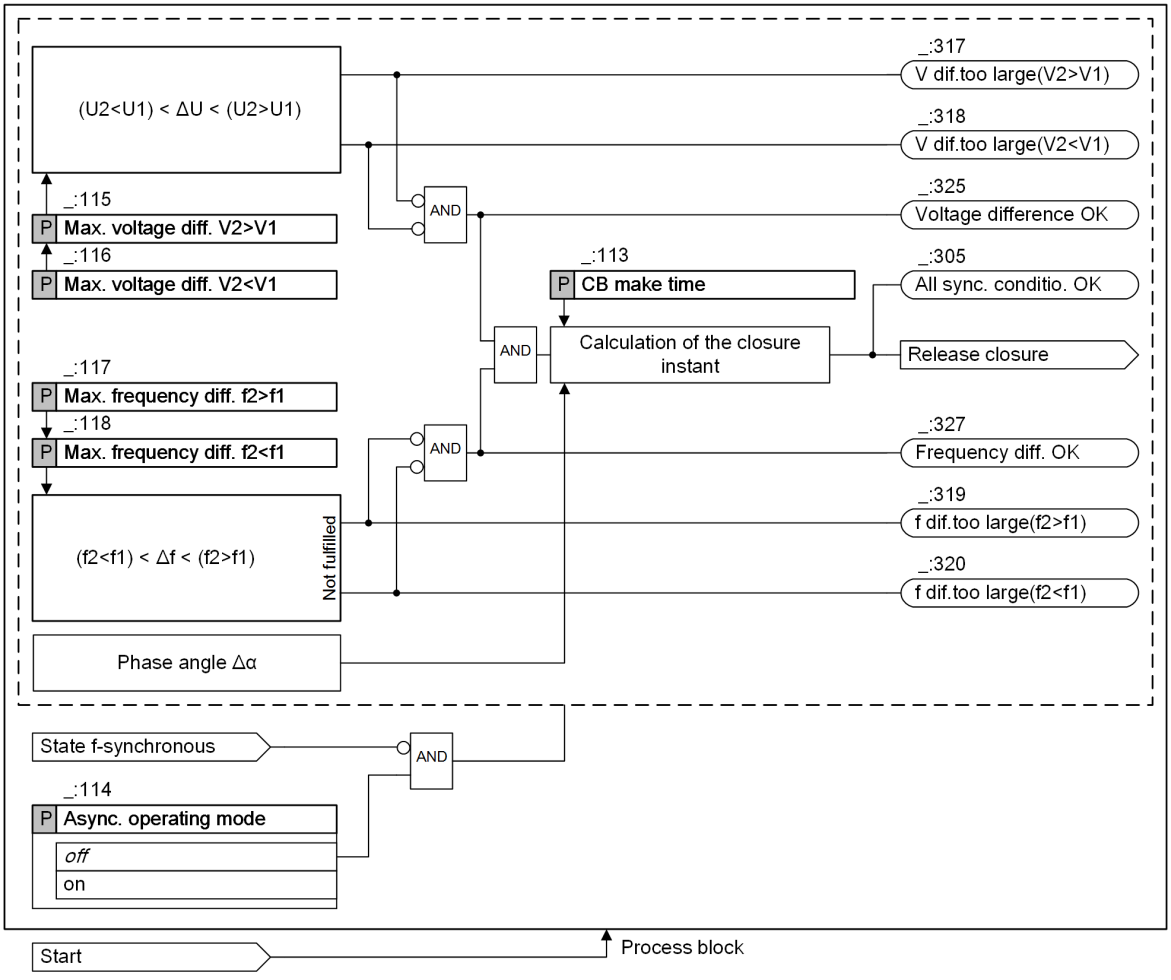
In this operating mode, the frequency difference is low. It is smaller than the threshold value **f-threshold ASYN<->SYN**. The status is signaled via the **State f-synchronous** indication.

The values ΔV and Δα are checked for releasing. The indication **All sync. conditio. OK** indicates that both setting values (conditions) are fulfilled. If the conditions remain fulfilled within the set time delay (parameter **Delay close command**), the closure release is generated.

Every fulfilled condition is indicated individually via the indications **Voltage difference OK** and **Angle difference OK**.

If one of the conditions is not fulfilled, detailed information is provided via indications. For example, if the voltage difference is outside the setting limits, 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 paralleling.

Checking the Closing Conditions in Asynchronous Systems



[lo_async. system, 2, en_US]

Figure 7-97 Closing Conditions when Switching Asynchronous Systems

In this operating mode, the values ΔV and Δf are checked separately. The function calculates the time criterion of the close command considering the angle difference Δα and the make time of the circuit breaker. This calculation process can make sure that all the voltage phasors are equal at the moment of the closing by the circuit breaker (ΔV ≈ 0, Δα ≈ 0).

For this functionality, the frequency difference must be small. If the frequency difference is too large, the fast-changing voltage difference causes the system instability.

Switching to Dead Line or Dead Busbar

If operating modes for switching to dead parts of an electrical power system are configured, the associated conditions are also checked after the stage is started. The fulfilled conditions are indicated. An adjustable **`Supervision time`** is started after the closing conditions are fulfilled. If the conditions are fulfilled during the supervision time, the function generates the closure release.

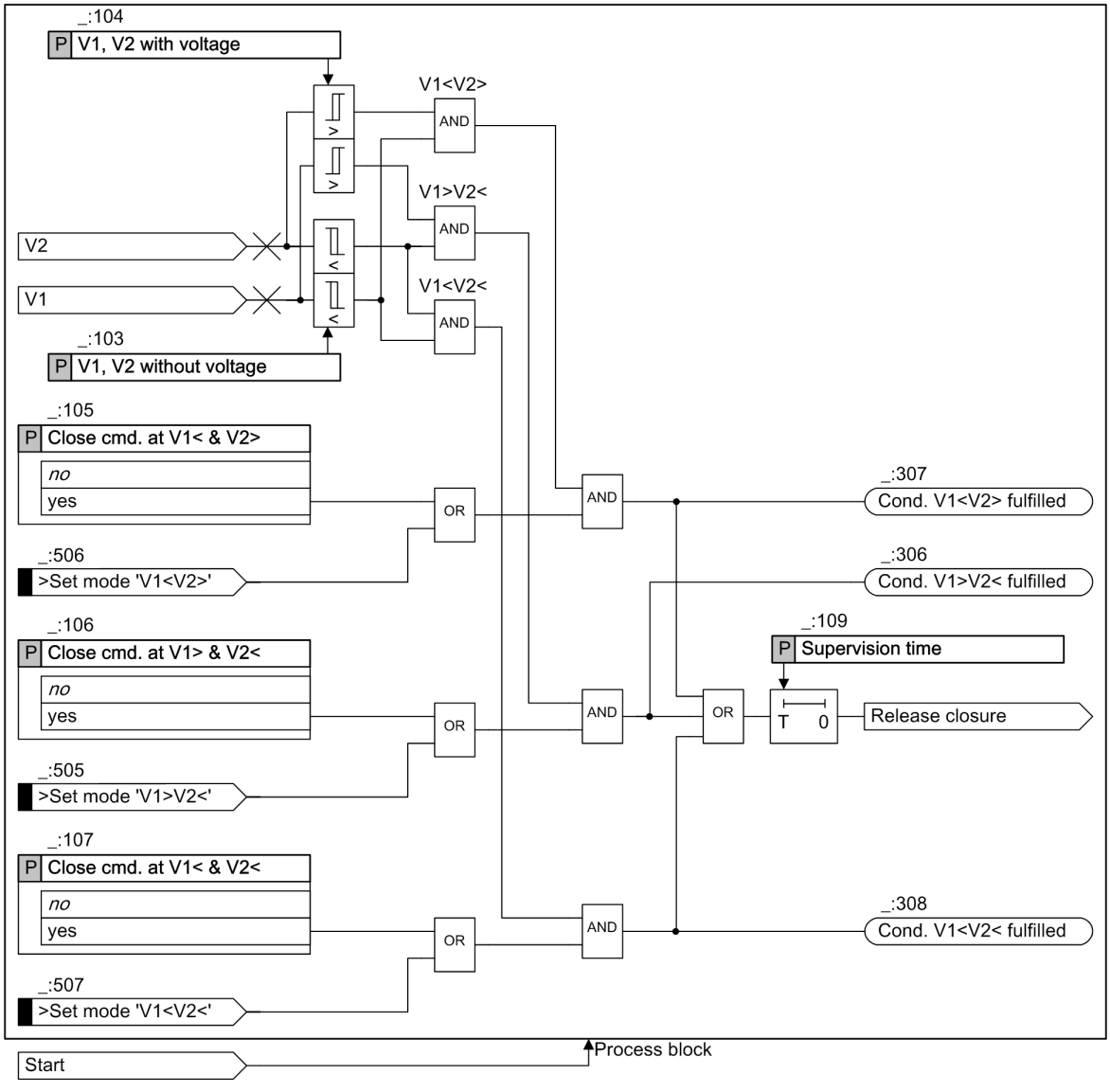
If one side is dead, the measured voltage of this side is less than the threshold **`V1, V2 without voltage`**. In this case, all voltages are compared to the parameter **`V1, V2 without voltage`**.

If one side is energized, all the voltages and frequencies must be in the permitted operating ranges (see section *Operating Range, Page 556*), and all voltages must exceed the threshold **`V1, V2 with voltage`**.

If at least one of the 2 sides of an electrical power system is dead, the 2 sides of the electrical power system can be connected together via the following modes.

Mode	Description
Close cmd. at V1> & V2<	Closure release under the condition that part V_1 of the power system is energized and part V_2 of the electrical power system is dead
Close cmd. at V1< & V2>	Closure release under the condition that part V_1 of the power system is dead and part V_2 of the electrical power system is energized
Close cmd. at V1< & V2<	Closure release under the condition V_1 and V_2 are dead

Each of these modes can function individually via parameters or binary inputs. You can also set 2 or 3 parameters at one time, for example, a closure release is generated if **Close cmd. at V1> & V2<** or **Close cmd. at V1< & V2>** is fulfilled.



[lo_syn003-01, 2, en_US]

Figure 7-98 Release Conditions for Switching to Dead Line or Dead Busbar

NOTE

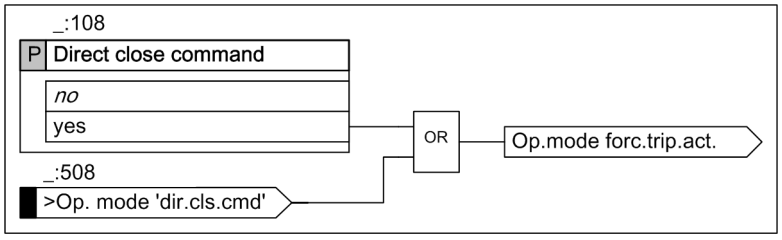
When connecting to a 3-phase measuring point, make sure that the voltages from the 3 phases all fulfill the threshold value **V1, V2 with voltage** or the threshold value **V1, V2 without voltage** in the previous figure.

The indications **Cond. V1>V2< fulfilled**, **Cond. V1<V2> fulfilled**, and **Cond. V1<V2< fulfilled** indicate that the relevant conditions are fulfilled.

For dead-system switching, you can use the **Supervision time** parameter to set a monitoring time during which the preceding fulfilled conditions must be maintained at least.

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'**.



[lo_direct close command, 1, en_US]

Figure 7-99 Activation of the Operating Mode Direct Close Command

The **Direct close command** functionality initiates a closure release without any testing upon starting of the stage **Paralleling with 2 channels**. The closure occurs immediately.

NOTE

The combination of **Direct close command** with other operating modes is not recommended, as the other operating data is bypassed.

Close-Command Monitoring

The following 2 items can be checked during the close-command monitoring:

- Check whether the 2 close commands of the 2 channels are generated under the same condition
  If the conditions of the 2 channels are different, for example, the 1st channel is in the synchronous condition and the 2nd channel is in the asynchronous condition, the close command is blocked. Meanwhile, the indication *Sync.supervis. asym.* is issued. If the difference of the 2 conditions lasts for 1 min, the **Paralleling** function stops and all signals are reset.
- Check whether the 2 close commands of the 2 channels are generated simultaneously
  If the 2 close commands of the 2 channels are not generated simultaneously, the close command is blocked. Meanwhile, the indication *Sync. supervision α>* is issued.

Blocking the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the started stage will be reset.

7.5.5.2 Application and Setting Notes

Parameter: **Min. operating limit Vmin**, **Max. operat. limit Vmax**

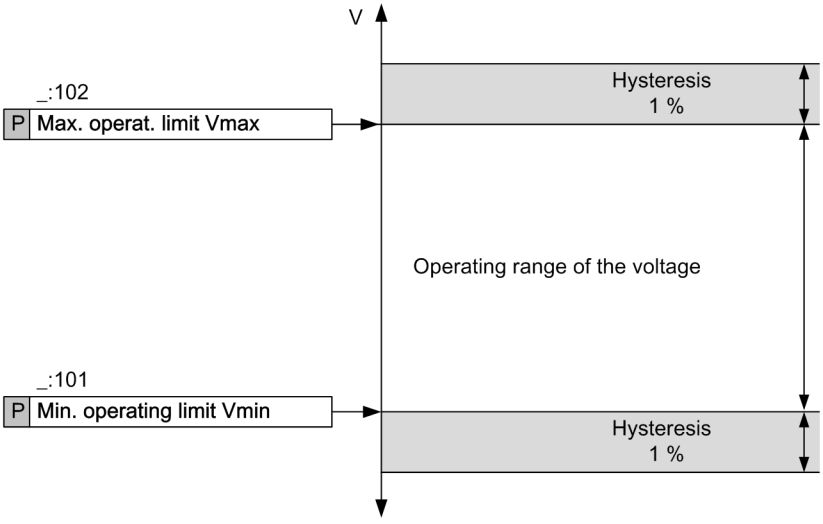
- Default setting **(_:101) Min. operating limit Vmin** = *90.000 V*
- Default setting **(_:102) Max. operat. limit Vmax** = *110.000 V*

These values define the voltage operating range of the paralleling stage. A normal setting is approx. ±10 % of the rated voltage.

NOTE

All voltages connected according to the measuring-point connection type are subjected to the appropriate V_{min}/V_{max} test.

Make sure that these parameters for voltage-range setting are set as phase-to-phase voltages.



[lo_operating range, 1, en_US]

Figure 7-100 Operating Range of the Voltage

If the stage **Paralleling with 2 channels** is started within the area of 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 following 2 conditions are fulfilled in sequence, the switching can occur in the area of the hysteresis:

- The stage is started within the voltage operating range.
- The voltage exceeds the minimum or maximum operating limit during the paralleling process.

Parameter: **`Max.durat. sync.process`**

- Default setting **`(_:110) Max.durat. sync.process`** = ***`30.00 s`***

The start conditions must be fulfilled within this time. If the conditions are not fulfilled, no further closure release takes place and the paralleling is stopped. If this time is set to ∞, the conditions are always checked until they are all fulfilled.

Observe the operating conditions when defining the time limitation. This time must be defined specifically for each system. If 0 s or 0.01 s is set, all conditions are checked after the start of the stage. Thereafter, the process is stopped immediately.

Parameter: **`Close cmd. at V1< & V2>`**

- Default setting **`(_:105) Close cmd. at V1< & V2>`** = ***`no`***

With the parameter **`Close cmd. at V1< & V2>`**, you determine whether to release the close command or not when the voltage V1 is dead.

Settings	Description
`no`	No closure release is generated via this operating mode.
`yes`	If part V1 of the power system is dead and part V2 of the power system is energized, the closure release is generated upon starting of the stage **Paralleling with 2 channels** after the supervision time has expired. The setting depends on the operational requirements.

Parameter: **Close cmd. at V1> & V2<**

- Default setting **(_:106) Close cmd. at V1> & V2<** = ***no***

With the parameter **Close cmd. at V1> & V2<**, you determine whether to release the close command or not when the voltage V2 is dead.

Settings	Description
no	No closure release is generated via this operating mode.
yes	If part V1 of the power system is energized and part V2 of the power system is dead, the closure release is generated upon starting of the stage **Paralleling with 2 channels** after the supervision time has expired. The setting depends on the operational requirements.

Parameter: **Close cmd. at V1< & V2<**

- Default setting **(_:107) Close cmd. at V1< & V2<** = ***no***

With the parameter **Close cmd. at V1< & V2<**, you determine whether to release the close command or not when the voltages V1 and V2 are both dead.

Settings	Description
no	No closure release is generated via this operating mode.
yes	If the parts V1 and V2 of the power system are dead, the closure release is generated upon starting of the stage **Paralleling with 2 channels** after the supervision time has expired. The setting depends on the operational requirements.

Parameter: **V1, V2 without voltage**

- Default setting **(_:103) V1, V2 without voltage** = ***2.000 V***

The **V1, V2 without voltage** parameter indicates the voltage threshold of the dead system. If the measured voltage is smaller than the setting value, the system is dead.

Siemens recommends a setting value of approx. 5 % of the rated voltage for this parameter. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate V_{min}/V_{max} test.

Parameter: **V1, V2 with voltage**

- Default setting **(_:104) V1, V2 with voltage** = ***80.000 V***

The **V1, V2 with voltage** parameter indicates the voltage threshold of the energized system. If the measured voltage is larger than the setting value, the system is energized.

Siemens recommends a setting value of approx. 80 % of the rated voltage for this parameter. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate V_{min}/V_{max} test.

Parameter: **Supervision time**

- Default setting **(_:109) Supervision time** = ***0.10 s***

In the dead system, before the closure release, all the closing conditions must be fulfilled during the supervision time.

In order to include transient phenomena, Siemens recommends using the default value of ***0.10 s***.

Parameter: **Synchronous operating mode, Asynchronous operating mode**

- Default setting **(_:119) Sync. operating mode** = ***off***
- Default setting **(_:114) Async. operating mode** = ***off***

The operating modes of the paralleling stage 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 smaller than the threshold value **f-threshold ASYN<->SYN**, the operating mode **synchronous** is active. Otherwise, the operating mode **asynchronous** is active. If connecting to the galvanically isolated systems, you can select this operating mode.
off	***on***	Regardless of the frequency difference and the threshold value **f-threshold ASYN<->SYN**, only the operating mode **asynchronous** can be activated. The make time of the circuit breaker is always taken into account for determining the connecting point. Select this operating mode if you need to activate machines, for example, generators or asynchronous motors. However, if the synchronous conditions are fulfilled with a small Δf, a close command without a kick pulse is generated in this operating mode.
on	***off***	Use this operating mode for galvanically connected systems. Closure is only possible with synchronous systems (with a small Δf).
off	***off***	Both operating modes are deactivated. No closure release can be generated. This configuration is only recommended for special applications. Select this operating mode if you only want to switch, for example, dead parts of the power system.

Parameter for Synchronous System: Maximum difference of voltage and angle

- Default setting **(_:122) Max. voltage diff. V2>V1** = ***2.000 V***
- Default setting **(_:123) Max. voltage diff. V2<V1** = ***2.000 V***
- Default setting **(_:124) Max. angle diff. α2>α1** = ***10°***
- Default setting **(_:125) Max. angle diff. α2<α1** = ***10°***

Each differential value of voltage and angle has 2 parameters. You can use these parameters to set the unbalanced closing ranges.

The permissible differential values ensure that no damage occurs in the system due to the compensation processes (circulating current) and the power swings. The settings in the side to be paralleled must not be set too small so that the necessary closures are not blocked.

The default settings are the typical values. For different systems, check and adjust the settings correspondingly.

Parameter for Asynchronous System: Maximum difference of voltage and frequency

- Default setting **(_:115) Max. voltage diff. V2>V1** = ***2.000 V***
- Default setting **(_:116) Max. voltage diff. V2<V1** = ***2.000 V***
- Default setting **(_:117) Max. frequency diff. f2>f1** = ***0.100 Hz***
- Default setting **(_:118) Max. frequency diff. f2<f1** = ***0.100 Hz***

Each differential value of voltage and frequency has 2 parameters. You can use these parameters to set the unbalanced closing ranges.

The permissible differential values ensure that no damage occurs in the system due to the compensation processes (circulating current) and the power swings. The settings in the side to be paralleled must not be set too small so that the necessary closures are not blocked.

The default settings are the typical values. For different systems, check and adjust the settings correspondingly.

Parameter: **f-threshold ASYN<->SYN**

- Default setting **(_:120) f-threshold ASYN<->SYN** = ***0.010 Hz***

With the **f-threshold ASYN<->SYN** parameter, you set the frequency difference for switching over between the synchronous system and the asynchronous system.

Siemens recommends using the default setting of ***0.010 Hz***.

Parameter: **Direct close command**

- Default setting **(_:108) Direct close command** = ***no***

In this operating mode, the function initiates a closure release without any testing upon starting of the stage **Paralleling with 2 channels**. 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'**. This method avoids the incorrect switching caused by the wrong activation of the operating mode **Direct close command**.

Parameter: **CB make time**

- Default setting **(_:113) CB make time** = ***0.060 s***

When checking the closing condition in asynchronous system, the make time of the circuit breaker must be taken into account. The device uses this time to calculate the time of the close command. This method can make sure that all the voltage phasors are equal at the moment of the closing by the circuit breaker ($\Delta V \approx 0$, $\Delta\alpha \approx 0$). In addition to the operating time of the switch, the **CB make time** also includes the pickup time of an auxiliary relay that is upstream.

Parameter: **Delay close command**

- Default setting **(_:121) Delay close command** = ***0.00 s***

The **Delay close command** parameter indicates the time delay before the closure release. During this time, all the closing conditions in a synchronous system must be maintained.

Parameter: **Output time**

- Default setting **(_:101) Output time** = ***0.10 s***

With the parameter **Output time**, you can release the close command in a stable way. For more information about this parameter, refer to chapter *5.3.5.6 Application and Setting Notes*.

Input signal: *>Selection*

With the input signal *>Selection*, you determine whether to select the stage **Paralleling with 2 channels**:

- If the input signal *>Selection* is routed to a binary input, the stage **Paralleling with 2 channels** must be selected by the binary input before the starting of the stage. If the stage is not selected, the stage cannot be started.
- If the input signal *>Selection* is not routed to any binary input, the stage **Paralleling with 2 channels** is selected by default.

If multiple stages **Paralleling with 2 channels** are instantiated in multiple function groups **Circuit-breaker paralleling**, make sure that only one stage **Paralleling with 2 channels** is selected each time.

7.5.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Sync. 2ch #:Mode		• off • on • test	off
_:101	Sync. 2ch #:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:102	Sync. 2ch #:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:110	Sync. 2ch #:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:108	Sync. 2ch #:Direct close command		• no • yes	no
_:126	Sync. 2ch #:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:105	Sync. 2ch #:Close cmd. at V1< & V2>		• no • yes	no
_:106	Sync. 2ch #:Close cmd. at V1> & V2<		• no • yes	no
_:107	Sync. 2ch #:Close cmd. at V1< & V2<		• no • yes	no
_:103	Sync. 2ch #:V1, V2 without voltage		0.300 V to 170.000 V	2.000 V
_:104	Sync. 2ch #:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:109	Sync. 2ch #:Supervision time		0.00 s to 60.00 s	0.10 s
Asynchr. op.mode				
_:114	Sync. 2ch #:Async. operating mode		• off • on	off
_:113	Sync. 2ch #:CB make time		0.010 s to 0.600 s	0.060 s
_:115	Sync. 2ch #:Max. voltage diff. V2>V1		0.000 V to 170.000 V	2.000 V
_:116	Sync. 2ch #:Max. voltage diff. V2<V1		0.000 V to 170.000 V	2.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:117	Sync. 2ch #:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:118	Sync. 2ch #:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:119	Sync. 2ch #:Sync. operating mode		• off • on	off
_:120	Sync. 2ch #:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	0.010 Hz
_:122	Sync. 2ch #:Max. voltage diff. V2>V1		0.000 V to 170.000 V	2.000 V
_:123	Sync. 2ch #:Max. voltage diff. V2<V1		0.000 V to 170.000 V	2.000 V
_:124	Sync. 2ch #:Max. angle diff. α2>α1		0° to 90°	10°
_:125	Sync. 2ch #:Max. angle diff. α2<α1		0° to 90°	10°
_:121	Sync. 2ch #:Delay close command		0.00 s to 60.00 s	0.00 s

7.5.5.4 Information List

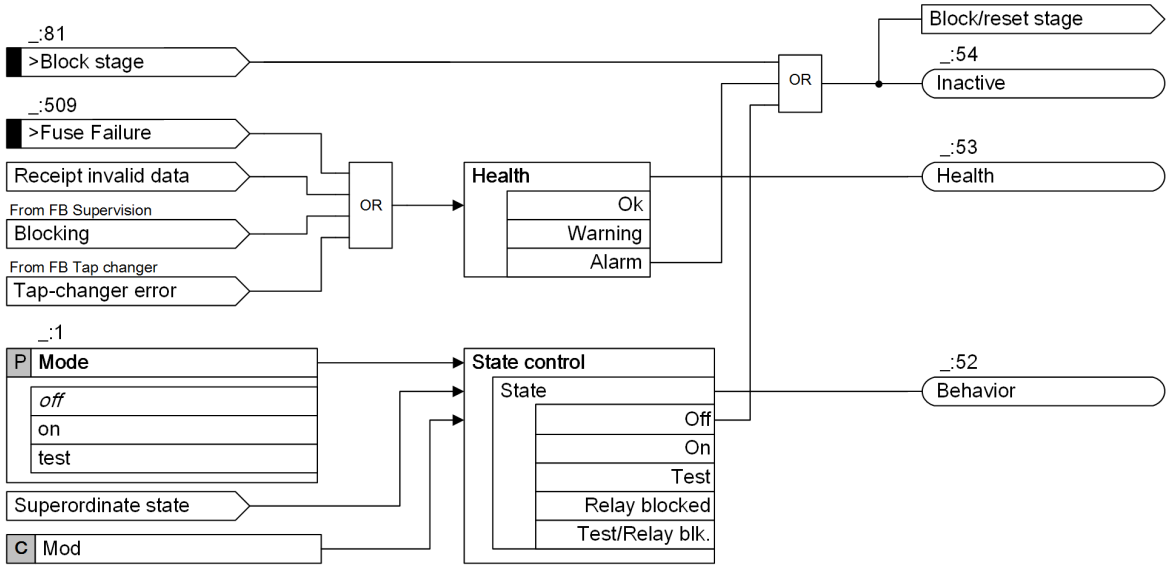
No.	Information	Data Class (Type)	Type
Sync. 2ch #			
_:81	Sync. 2ch #:>Block stage	SPS	I
_:509	Sync. 2ch #:>Fuse Failure	SPS	I
_:500	Sync. 2ch #:>Selection	SPS	I
_:502	Sync. 2ch #:>Start/stop syn.proc.	SPS	I
_:503	Sync. 2ch #:>Start syn. process	SPS	I
_:504	Sync. 2ch #:>Stop syn. process	SPS	I
_:506	Sync. 2ch #:>Op. mode 'V1<V2>'	SPS	I
_:505	Sync. 2ch #:>Op. mode 'V1>V2<'	SPS	I
_:507	Sync. 2ch #:>Op. mode 'V1<V2<'	SPS	I
_:508	Sync. 2ch #:>Op. mode 'dir.cls.cmd'	SPS	I
_:501	Sync. 2ch #:>Block close command	SPS	I
_:54	Sync. 2ch #:Inactive	SPS	O
_:52	Sync. 2ch #:Behavior	ENS	O
_:53	Sync. 2ch #:Health	ENS	O
_:328	Sync. 2ch #:In progress	SPS	O
_:343	Sync. 2ch #:In progress 2	SPS	O
_:324	Sync. 2ch #:Release close cmd.	SPS	O
_:344	Sync. 2ch #:Release close cmd. 2	SPS	O
_:305	Sync. 2ch #:All sync. conditio. OK	SPS	O
_:346	Sync. 2ch #:All sync. conditio. OK 2	SPS	O
_:303	Sync. 2ch #:State f-synchronous	SPS	O
_:325	Sync. 2ch #:Voltage difference OK	SPS	O
_:326	Sync. 2ch #:Angle difference OK	SPS	O
_:327	Sync. 2ch #:Frequency diff. OK	SPS	O

No.	Information	Data Class (Type)	Type
_:356	Sync. 2ch #:Voltage diff. OK 2	SPS	O
_:334	Sync. 2ch #:Angle difference OK 2	SPS	O
_:341	Sync. 2ch #:Frequency diff. OK 2	SPS	O
_:307	Sync. 2ch #:Cond. V1<V2> fulfilled	SPS	O
_:306	Sync. 2ch #:Cond. V1>V2< fulfilled	SPS	O
_:308	Sync. 2ch #:Cond. V1<V2< fulfilled	SPS	O
_:309	Sync. 2ch #:Frequency f1 > fmax	SPS	O
_:310	Sync. 2ch #:Frequency f1 < fmin	SPS	O
_:311	Sync. 2ch #:Frequency f2 > fmax	SPS	O
_:312	Sync. 2ch #:Frequency f2 < fmin	SPS	O
_:313	Sync. 2ch #:Voltage V1 > Vmax	SPS	O
_:314	Sync. 2ch #:Voltage V1 < Vmin	SPS	O
_:315	Sync. 2ch #:Voltage V2 > Vmax	SPS	O
_:316	Sync. 2ch #:Voltage V2 < Vmin	SPS	O
_:317	Sync. 2ch #:V dif.too large(V2>V1)	SPS	O
_:318	Sync. 2ch #:V dif.too large(V2<V1)	SPS	O
_:319	Sync. 2ch #:f dif.too large(f2>f1)	SPS	O
_:320	Sync. 2ch #:f dif.too large(f2<f1)	SPS	O
_:321	Sync. 2ch #:α dif.too large(α2>α1)	SPS	O
_:322	Sync. 2ch #:α dif.too large(α2<α1)	SPS	O
_:304	Sync. 2ch #:Max. time exceeded	SPS	O
_:323	Sync. 2ch #:Setting error	SPS	O
_:358	Sync. 2ch #:Sync. supervision α>	SPS	O
_:357	Sync. 2ch #:Sync.supervis. asym.	SPS	O

7.5.6 Stage Paralleling with 1.5 Channels

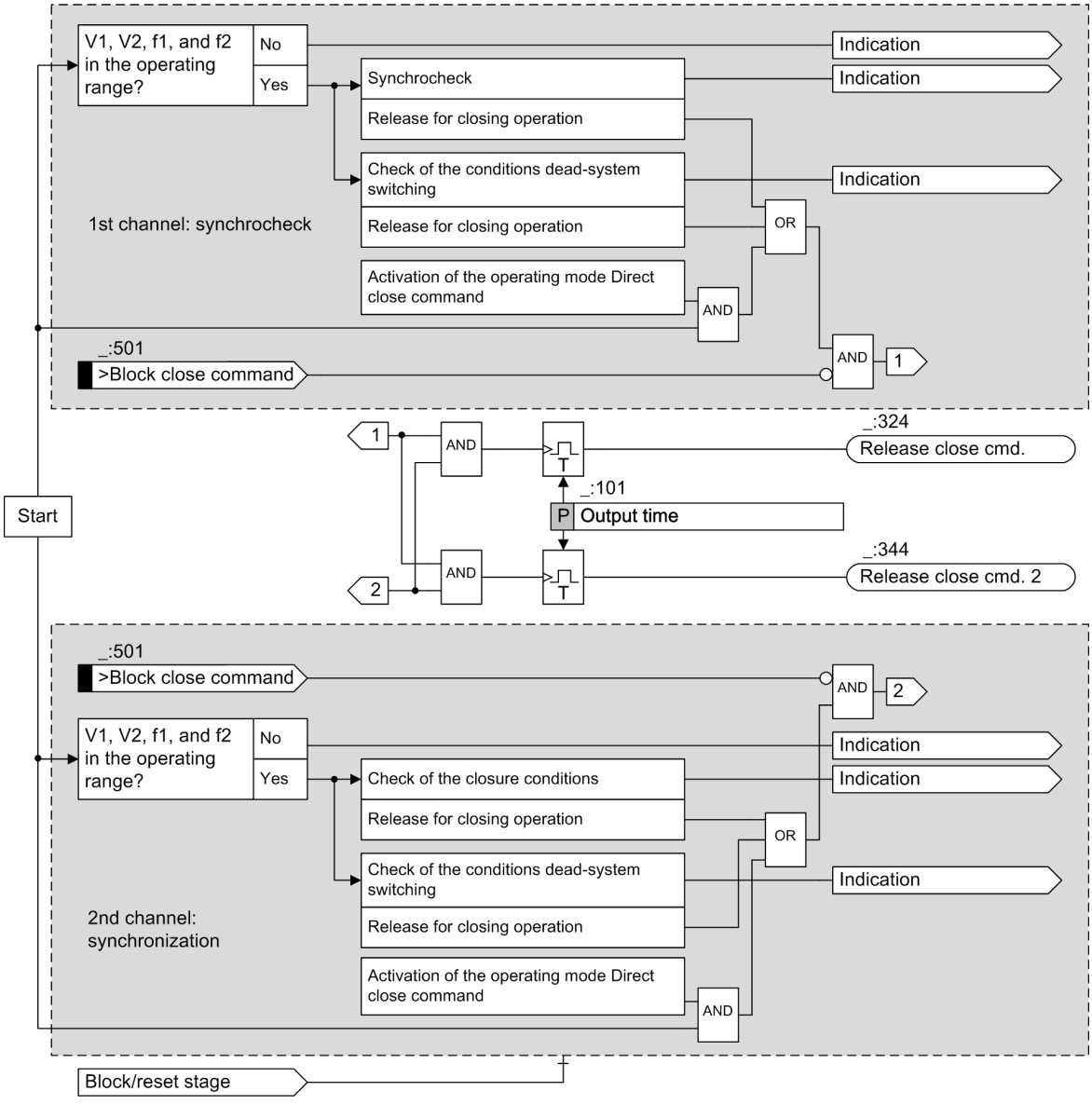
7.5.6.1 Description

Logic



[lo_paralleling_stage ctrl, 4, en_US]

Figure 7-101 Logic Diagram of the Stage Control



[lo_paralleling_1.5 ch, 1, en_US]

Figure 7-102 Logic Diagram of the Stage Paralleling with 1.5 Channels

The stage **Paralleling with 1.5 channels** contains 2 channels:

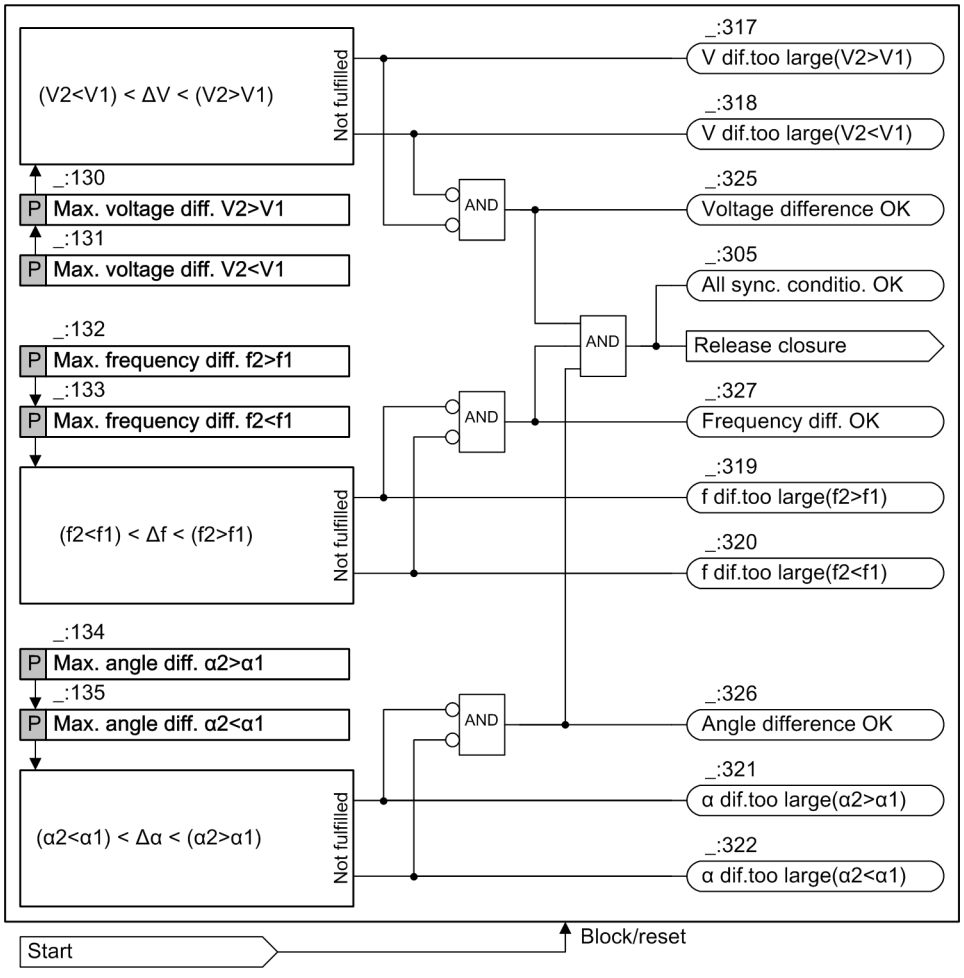
- The 1st channel is the synchrocheck channel which is taken as a 0.5 channel. It gives a release criterion for the close command.
- The 2nd channel is the synchronization channel. It detects the closing condition automatically, and can be paralleled on different closing conditions.

The following functionalities are the same as the ones in the stage **Paralleling with 2 channels**. You can find the detailed information about them in chapter *7.5.5.1 Description*:

- Start and stop
- Operating range
- Checking the closing conditions in synchronous systems
- Checking the closing conditions in asynchronous systems

- Switching to dead line or dead busbar
- Direct close command

Checking the Closing Conditions in the Synchrocheck Functionality



[lo_synchrocheck, 2, en_US]

Figure 7-103 Closing Conditions for the Synchrocheck Functionality

In this operating mode, the values ΔV, Δf, and Δα are checked separately before connecting to the 2 sides of the electrical power system. The indication **`All sync. conditio. OK`** indicates that the setting values (conditions) are fulfilled.

Every fulfilled condition is indicated 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. For example, if the voltage difference is outside the setting limits, 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 paralleling.

Blocking the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the started stage will be reset.

7.5.6.2 Application and Setting Notes

Except the following setting notes for the synchrocheck functionality, the application and setting notes of the stage **Paralleling with 1.5 channels** is the same as that of the stage **Paralleling with 2 channels**. You can find more information in the chapter *7.5.5.2 Application and Setting Notes*.

Parameter for Synchrocheck Functionality: Maximum difference of voltage, frequency, and angle

- Default setting **(_:130) Max. voltage diff. V2>V1** = ***5.000 V***
- Default setting **(_:131) Max. voltage diff. V2<V1** = ***5.000 V***
- Default setting **(_:132) Max. frequency diff. f2>f1** = ***0.100 Hz***
- Default setting **(_:133) Max. frequency diff. f2<f1** = ***0.100 Hz***
- Default setting **(_:134) Max. angle diff. α2>α1** = ***10°***
- Default setting **(_:135) Max. angle diff. α2<α1** = ***10°***

Each of the differential values voltage, frequency, and angle has 2 parameters. You can use these parameters to set the unbalanced closing ranges.

The permissible differential values ensure that no damage occurs in the system due to the compensation processes (circulating current) and the power swings. The settings in the side to be paralleled must not be set too small so that the necessary closures are not blocked.

The default settings are the typical values. For different systems, check and adjust the settings correspondingly.

7.5.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Sync. 1.5ch #:Mode		• off • on • test	off
_:101	Sync. 1.5ch #:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:102	Sync. 1.5ch #:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:110	Sync. 1.5ch #:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:108	Sync. 1.5ch #:Direct close command		• no • yes	no
_:126	Sync. 1.5ch #:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:105	Sync. 1.5ch #:Close cmd. at V1< & V2>		• no • yes	no
_:106	Sync. 1.5ch #:Close cmd. at V1> & V2<		• no • yes	no
_:107	Sync. 1.5ch #:Close cmd. at V1< & V2<		• no • yes	no
_:103	Sync. 1.5ch #:V1, V2 without voltage		0.300 V to 170.000 V	2.000 V
_:104	Sync. 1.5ch #:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:109	Sync. 1.5ch #:Supervision time		0.00 s to 60.00 s	0.10 s
Synchr. conditions				
_:130	Sync. 1.5ch #:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:131	Sync. 1.5ch #:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:132	Sync. 1.5ch #:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:133	Sync. 1.5ch #:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:134	Sync. 1.5ch #:Max. angle diff. α2>α1		0° to 90°	10°
_:135	Sync. 1.5ch #:Max. angle diff. α2<α1		0° to 90°	10°
Asynchr. op.mode				
_:114	Sync. 1.5ch #:Async. operating mode		• off • on	off
_:113	Sync. 1.5ch #:CB make time		0.010 s to 0.600 s	0.060 s
_:115	Sync. 1.5ch #:Max. voltage diff. V2>V1		0.000 V to 170.000 V	2.000 V
_:116	Sync. 1.5ch #:Max. voltage diff. V2<V1		0.000 V to 170.000 V	2.000 V
_:117	Sync. 1.5ch #:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:118	Sync. 1.5ch #:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:119	Sync. 1.5ch #:Sync. operating mode		• off • on	off
_:120	Sync. 1.5ch #:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	0.010 Hz
_:122	Sync. 1.5ch #:Max. voltage diff. V2>V1		0.000 V to 170.000 V	2.000 V
_:123	Sync. 1.5ch #:Max. voltage diff. V2<V1		0.000 V to 170.000 V	2.000 V
_:124	Sync. 1.5ch #:Max. angle diff. α2>α1		0° to 90°	10°
_:125	Sync. 1.5ch #:Max. angle diff. α2<α1		0° to 90°	10°
_:121	Sync. 1.5ch #:Delay close command		0.00 s to 60.00 s	0.00 s

7.5.6.4 Information List

No.	Information	Data Class (Type)	Type
Sync. 1.5ch #			
_:81	Sync. 1.5ch #:>Block stage	SPS	I
_:509	Sync. 1.5ch #:>Fuse Failure	SPS	I

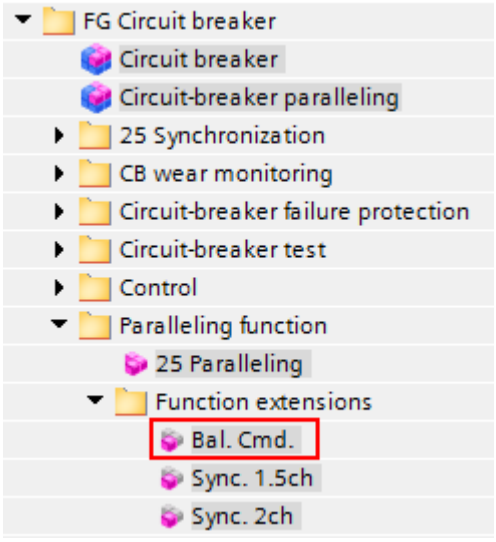
No.	Information	Data Class (Type)	Type
_:500	Sync. 1.5ch #:>Selection	SPS	I
_:502	Sync. 1.5ch #:>Start/stop syn.proc.	SPS	I
_:503	Sync. 1.5ch #:>Start syn. process	SPS	I
_:504	Sync. 1.5ch #:>Stop syn. process	SPS	I
_:506	Sync. 1.5ch #:>Op. mode 'V1<V2>'	SPS	I
_:505	Sync. 1.5ch #:>Op. mode 'V1>V2<'	SPS	I
_:507	Sync. 1.5ch #:>Op. mode 'V1<V2<'	SPS	I
_:508	Sync. 1.5ch #:>Op. mode 'dir.cls.cmd'	SPS	I
_:501	Sync. 1.5ch #:>Block close command	SPS	I
_:54	Sync. 1.5ch #:Inactive	SPS	O
_:52	Sync. 1.5ch #:Behavior	ENS	O
_:53	Sync. 1.5ch #:Health	ENS	O
_:328	Sync. 1.5ch #:In progress	SPS	O
_:343	Sync. 1.5ch #:In progress 2	SPS	O
_:324	Sync. 1.5ch #:Release close cmd.	SPS	O
_:344	Sync. 1.5ch #:Release close cmd. 2	SPS	O
_:305	Sync. 1.5ch #:All sync. conditio. OK	SPS	O
_:346	Sync. 1.5ch #:All sync. conditio. OK 2	SPS	O
_:325	Sync. 1.5ch #:Voltage difference OK	SPS	O
_:326	Sync. 1.5ch #:Angle difference OK	SPS	O
_:327	Sync. 1.5ch #:Frequency diff. OK	SPS	O
_:356	Sync. 1.5ch #:Voltage diff. OK 2	SPS	O
_:334	Sync. 1.5ch #:Angle difference OK 2	SPS	O
_:341	Sync. 1.5ch #:Frequency diff. OK 2	SPS	O
_:307	Sync. 1.5ch #:Cond. V1<V2> fulfilled	SPS	O
_:306	Sync. 1.5ch #:Cond. V1>V2< fulfilled	SPS	O
_:308	Sync. 1.5ch #:Cond. V1<V2< fulfilled	SPS	O
_:309	Sync. 1.5ch #:Frequency f1 > fmax	SPS	O
_:310	Sync. 1.5ch #:Frequency f1 < fmin	SPS	O
_:311	Sync. 1.5ch #:Frequency f2 > fmax	SPS	O
_:312	Sync. 1.5ch #:Frequency f2 < fmin	SPS	O
_:313	Sync. 1.5ch #:Voltage V1 > Vmax	SPS	O
_:314	Sync. 1.5ch #:Voltage V1 < Vmin	SPS	O
_:315	Sync. 1.5ch #:Voltage V2 > Vmax	SPS	O
_:316	Sync. 1.5ch #:Voltage V2 < Vmin	SPS	O
_:317	Sync. 1.5ch #:V dif.too large(V2>V1)	SPS	O
_:318	Sync. 1.5ch #:V dif.too large(V2<V1)	SPS	O
_:319	Sync. 1.5ch #:f dif.too large(f2>f1)	SPS	O
_:320	Sync. 1.5ch #:f dif.too large(f2<f1)	SPS	O
_:321	Sync. 1.5ch #:α dif.too large(α2>α1)	SPS	O
_:322	Sync. 1.5ch #:α dif.too large(α2<α1)	SPS	O
_:304	Sync. 1.5ch #:Max. time exceeded	SPS	O
_:323	Sync. 1.5ch #:Setting error	SPS	O
_:342	Sync. 1.5ch #:State f-synchronous	SPS	O

7.5.7 Stage Balancing Commands

7.5.7.1 Description

The stage **Balancing commands** works with the stage **Paralleling with 1.5 channels** or the stage **Paralleling with 2 channels** to realize the automatic paralleling of the generators. It cannot be used individually. The **Balancing commands** functionality works with the voltages $V_{sync1, inv}$ and $V_{sync2, inv}$ of the 2nd channel.

You can find the stage **Balancing commands** in the Global DIGSI 5 Library under **FG Circuit breaker** → **Paralleling function** → **Function extensions**.



[sc_balancing command, 1, en_US]

Figure 7-104 Stage Balancing Commands in DIGSI Library

Balancing Commands for the Voltage and the Frequency

The stage has 2 separate blocks, split according to balancing commands for the voltage or for the frequency. The balancing pulses for increasing or decreasing the voltage and the frequency are generated in each block.

The following values affect the pulse width of the balancing command:

- The current measured values of the differential voltage
- The current measured values of the differential frequency
- The setting values of dV/dt and df/dt

In addition, the minimum pulse duration (**`T V pulse min`**, **`T f pulse min`**) and the maximum pulse duration (**`T V pulse max`**, **`T f pulse max`**) are defined. The minimum pulse duration allows a safe reaction of the controllers while the maximum pulse duration prevents an overreaction. With the parameter **`T pause f`**, you can set a dead time to attenuate the transient states.

The balancing commands are active once the **Paralleling** function is started.

Balancing Command for the Voltage

The parameters **`Max. voltage diff. V2>V1`** and **`Max. voltage diff. V2<V1`** are used to determine the voltage range that defines the admissible voltage difference for asynchronous parallel switching. The median value of the voltage range is defined as the set point value for the balancing command.

The parameters **`T V pulse min`** and **`T V pulse max`** define the minimum and maximum duration of the balancing pulse.

The parameter **`dV per second`** defines the voltage-changing speed of the side to be paralleled. The functionality uses the measured voltage difference and the setting value of the parameter **`dV per second`** to determine the actuating time. The following equation applies:

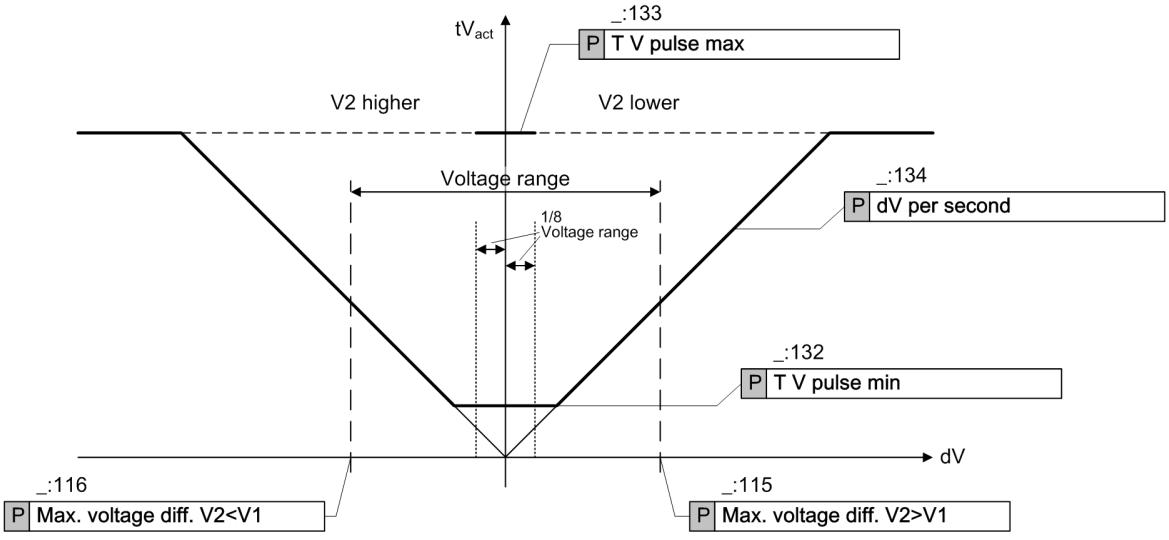
$$tV_{act} = \frac{dV_{MV}}{dV/dt}$$

[fo_voltage adujstment, 1, en_US]

with:

tV_{act}	Pulse duration
dV_{MV}	Measured voltage difference
dV/dt	The setting value of the parameter **dV per second** for defining the voltage-changing speed of the side to be paralleled

The following figure shows the effect of the functionality. When the voltage range falls below approximately 1/8 of the voltage range, the stage no longer generates any voltage balancing command.



[dw_voltage balancing command, 1, en_US]

Figure 7-105 Generation of the Voltage Balancing Command

Balancing Command for the Frequency

The parameters **Max. frequency diff. f2>f1** and **Max. frequency diff. f2<f1** are used to determine the frequency band that defines the admissible frequency difference for asynchronous parallel switching. The set point value for the balancing command is not the median value of the frequency band, but the value defined with the parameter **Δf set point for balancing**. If you specify a positive value, the generators are oversynchronously switched in parallel to the power system and the active power can be transmitted to the power system immediately.

The parameters **T f pulse min** and **T f pulse max** define the minimum and maximum duration of the balancing pulse. The parameter **df/dt of the controller** defines the frequency-changing speed of the side to be paralleled. The functionality uses the measured frequency difference and the setting value of the parameter **df/dt of the controller** to determine the actuating time. The following equation applies:

$$tf_{act} = \frac{df_{MV} - \Delta f_{set\ point\ value}}{df/dt}$$

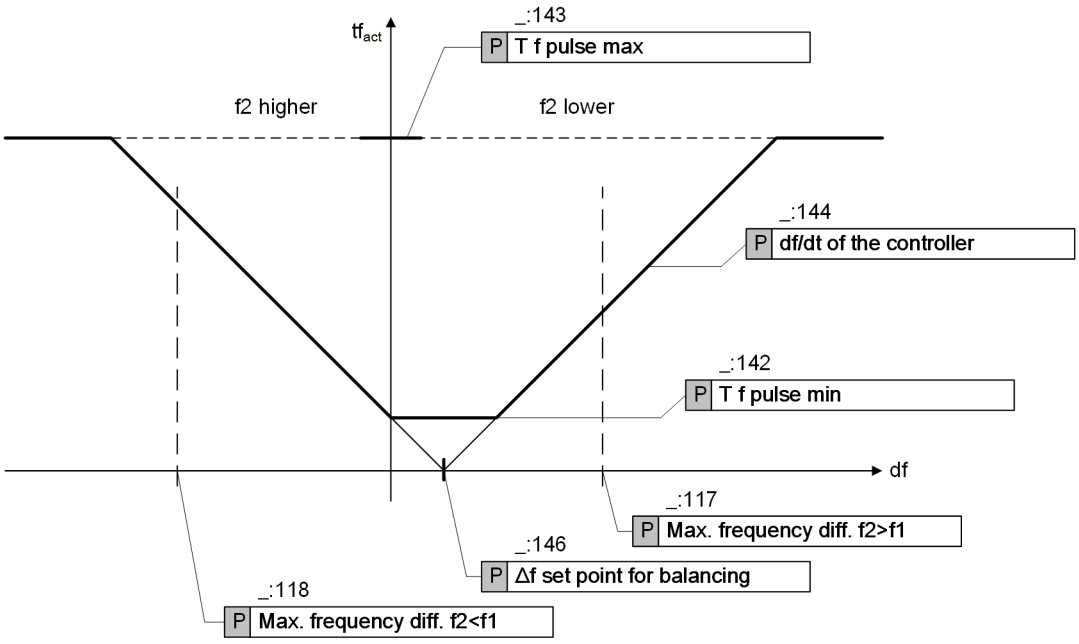
[fo_frequency adujstment, 1, en_US]

with:

tf_{act}	Pulse duration
df_{MV}	Measured frequency difference

$\Delta f_{\text{set point value}}$	The setting value of the parameter **Δf set point for balancing** for specifying the set point value for the frequency balancing command
df/dt	The setting value of the parameter **df/dt of the controller** for defining the frequency-changing speed of the side to be paralleled

The following figure shows the effect of the functionality.



[dw_build_frequency-adjusting-com, 2, en_US]

Figure 7-106 Generation of the Frequency Balancing Command

If the frequency difference df ≈ 0, the voltage phasors of V1 and V2 are practically standing still. In this case, the angle difference does not allow any switching. A certain frequency difference is required for safe switching. A kick pulse is emitted to attain this state. With the parameter **Release for the kick pulse**, you can control the generation of a kick pulse. A kick pulse is only emitted if the frequency difference falls below the setting value for the parameter **f-threshold ASYN<->SYN**. You can find the parameter **f-threshold ASYN<->SYN** in the entry block **Synchr. op.mode**. The actuating time of the kick pulse is defined with the parameter **Δf for the kick pulse**. The following equation applies:

$$tf_{act} = \frac{\Delta f_{\text{kick pulse}}}{df/dt}$$

[fo_frequency adujstment_01, 1, en_US]

with:

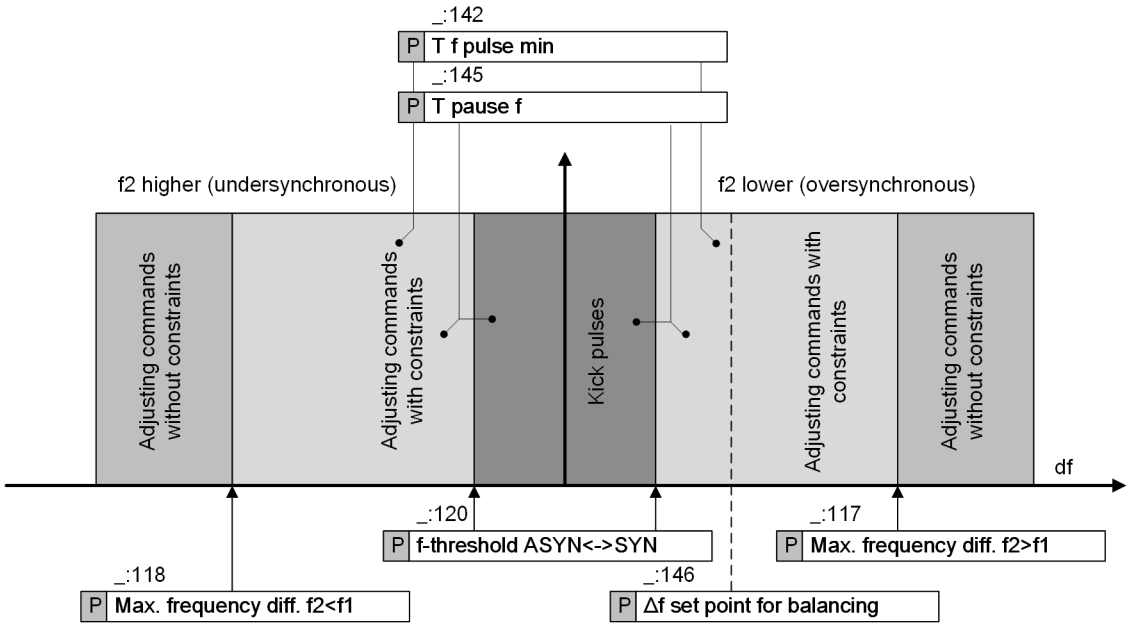
tf_{act}	Pulse duration
$\Delta f_{\text{kick pulse}}$	The setting value of the parameter **Δf for the kick pulse** for the default set point value for the kick pulse
df/dt	The setting value of the parameter **df/dt of the controller** for adapting the balancing command to the controller

NOTE

A kick pulse can be issued no matter if the operating mode is synchronous or asynchronous. The parameter **f-threshold ASYN<->SYN** defines the issuing of a kick pulse (see *Figure 7-107*):

- If the absolute value of the frequency difference is smaller than the setting value of the parameter **f-threshold ASYN<->SYN**, a kick pulse is issued.
- If the absolute value of the frequency difference is larger than or equal to the setting value of the parameter **f-threshold ASYN<->SYN**, no kick pulse is issued. In this case, the standard adjusting commands are issued according to the actual conditions.

The following figure shows the overall effect of the balancing commands:



[dw_kick-pulse_freq-adj-com, 2, en_US]

Figure 7-107 Kick Pulse and Frequency Adjustment Ranges

Stabilization and Supervision Actions

With the parameter **Smoothing**, you set the smoothing of the relevant measured values (dV and df) via a recursive filter. If the measured values have strong fluctuation, the smoothing of the measured values prevents the wrong balancing commands. The smoothing has a low-pass behavior corresponding to a delay element of the 1st order (for PT1 behavior, see also *Figure 7-109*).

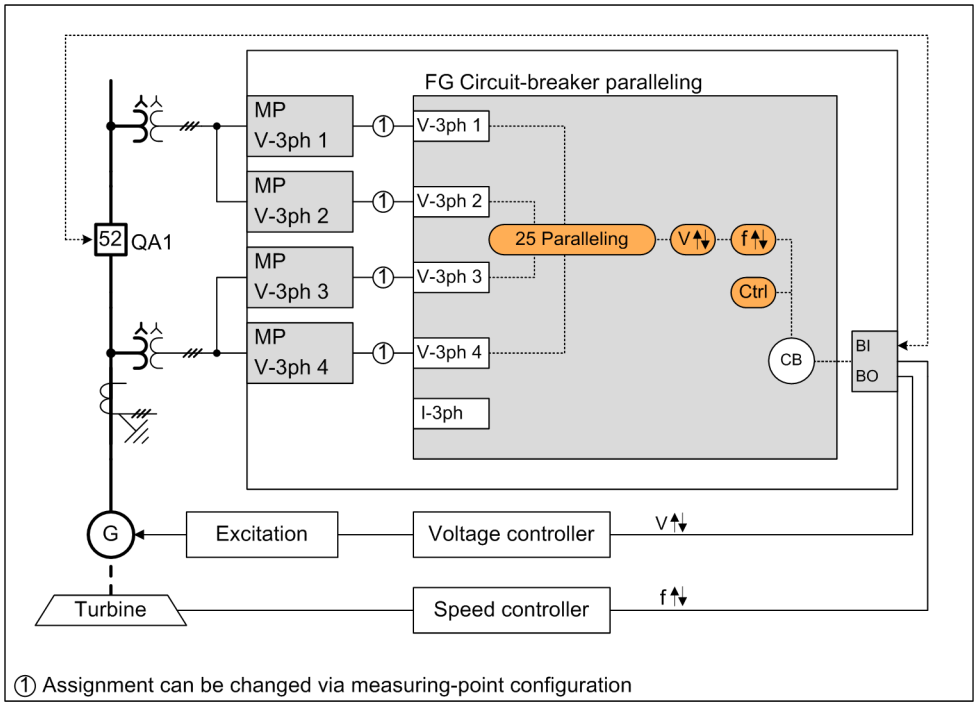
When the voltage and the frequency are adjusted simultaneously, make sure that the admissible overexcitation limit for the generator is not exceeded. The overexcitation is determined by monitoring the $(V/V_{rated})/(f/f_{rated})$ ratio and is compared to the admissible threshold value (parameter **(V/Vrated) / (f/frated)**). When the threshold value is exceeded, a voltage balancing command is issued. In this way, the generator returns to the admissible operating range. The maximum admissible threshold value ($V2_{max}$) for V2 is determined by the parameter **(V/Vrated) / (f/frated)** and the $f2/f_{rated}$ ratio.

A generator can only be paralleled with a system when there is a certain amount of slip. The frequency difference is a measure for the slip within the functionality. A practically constant frequency difference is assumed when determining the switching point. When adjusting the frequency, make sure that no frequency balancing command is issued near a potential switching point. When the frequency is in the admissible band (parameters **Max. frequency diff. f2>f1** and **Max. frequency diff. f2<f1**, see also *Figure 7-107*), the currently determined angle difference dα of the voltage is used to calculate the angle-changing speed dα/dt. The value dα/dt can be used to calculate the remaining time up to the paralleled point (dα → 0) continuously.

If the determined time reaches the setting value of the parameter **T close without balancing** or falls below it, the frequency balancing command is stopped and the active frequency adjustment is discontinued.

7.5.7.2 Application and Setting Notes

The following figure shows an example of the connection with the voltage transformers.



[dw_balancing_3ph-voltage-trans, 1, en_US]

Figure 7-108 Connection with 3-Phase Voltage Transformers

Parameter: f-threshold ASYN<->SYN

- Default setting **(_:120) f-threshold ASYN<->SYN** = ***0.010 Hz***

With the **f-threshold ASYN<->SYN** parameter, you set the frequency difference for switching over between the synchronous system and the asynchronous system. You can find the parameter **f-threshold ASYN<->SYN** in the entry block **Synchr. op.mode** of the stage **Paralleling with 1.5 channels** or the stage **Paralleling with 2 channels**.
Siemens recommends using the default setting of ***0.010 Hz***.

Parameters for Balancing the Voltage

For balancing commands, the following parameters are used to control the voltage:

- **(_:131) Balancing voltage V2**
- **(_:132) T V pulse min**
- **(_:133) T V pulse max**
- **(_:134) dV per second**
- **(_:135) T pause V**
- **(_:136) Smoothing**
- **(_:137) (V/Vrated)/(f/frated)**

Parameter: Balancing voltage V2

- Default setting **(_:131) Balancing voltage V2** = ***off***

With the parameter **Balancing voltage V2**, you specify whether you want to issue the balancing command for the inverse voltages ($V_{sync1, inv}$ and $V_{sync2, inv}$) on the generator side or not. If you want to issue the balancing command for the voltages, 3 options are available for voltage control.

Parameter Value	Description
off	If you select this setting value, no balancing command is issued for the inverse voltages on the generator side.
transformer tap	If you select this setting value, the balancing command is issued to the voltage controller. The balancing command controls the voltage via the tap changer on the transformer with the pulse duration **T V pulse max**.
balancing pulses	If you select this setting value, the balancing command is issued for the inverse voltages to the voltage controller of the generator.

Parameter: T V pulse min

- Default setting **(_:132) T V pulse min** = ***0.10 s***

With the parameter **T V pulse min**, you set the minimum time of the control pulse. This time corresponds to the minimum responding time of the voltage controller. Set the parameter **T V pulse min** to the minimum responding time. The default setting is a practicable value.

Parameter: T V pulse max

- Default setting **(_:133) T V pulse max** = ***1.00 s***

With the parameter **T V pulse max**, you set the maximum time of the control pulse. With this time, you can avoid the overadjustment of the voltage. The default setting is a practicable value.

Parameter: dV per second

- Default setting **(_:134) dV per second** = ***2.00 V/s***

With the parameter **dV per second**, you adjust the balancing command to the controller. You can thus correctly define the set point value. The duration of the control pulse is derived from the measured voltage difference and from the setting value of the parameter **dV per second**. The default setting is a practicable value. Use the following equation to calculate the actuating time:

$$tV_{act} = \frac{dV_{MV}}{dV/dt}$$

[fo_voltage adjustment, 1, en_US]

with:

tV_{act}	Pulse duration
dV_{MV}	Measured voltage difference
dV/dt	The setting value of the parameter **dV per second** for defining the voltage-changing speed of the side to be paralleled

EXAMPLE:

The following values apply to the example:

Measured voltage difference	dV = 4 V
Parameter setting value	**dV per second** = ***2 V/s***

Use the following equation to calculate the duration of the balancing pulse:

$$tV_{act} = \frac{dV_{MV}}{dV/dt} = \frac{4\ V}{2\ V/s} = 2\ s$$

[fo_voltage adjustment_01, 1, en_US]

The calculated duration of the setting pulse is 2 s. The setting value of the parameter **(_:133) T V pulse max** limits the maximum duration of the setting pulse to 1 s. In this case, the pulse duration is 1 s.

Parameter: T pause V

- Default setting **(_:135) T pause V** = ***5.00 s***

With the parameter **T pause V**, you set the dead time between 2 balancing commands. This allows the controller or generator to respond to the control pulse. Considering the different application scenarios, you can determine the final setting value during the commissioning.

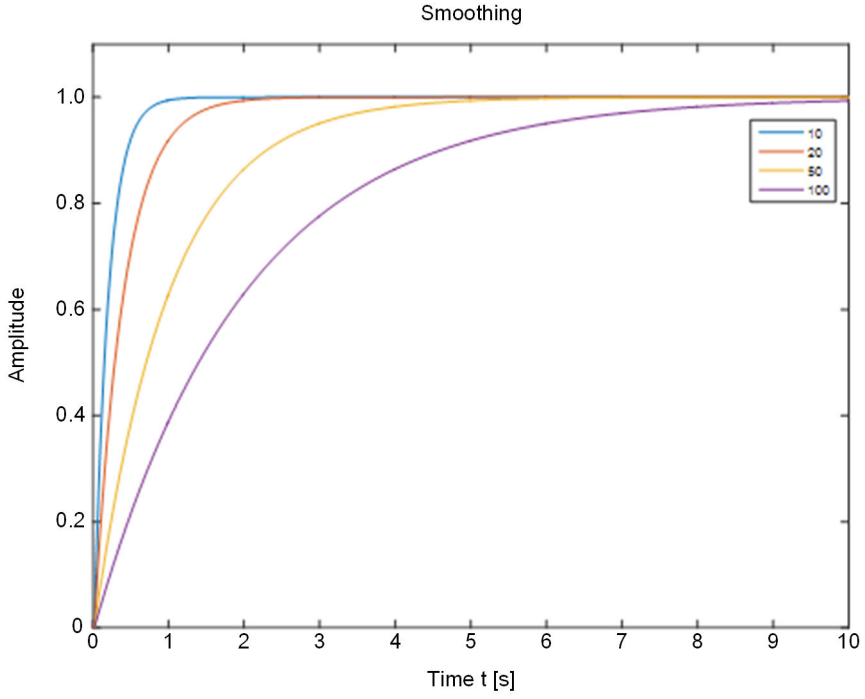
Parameter: Smoothing

- Default setting **(_:136) Smoothing** = ***1***

With the parameter **Smoothing**, you set the smoothing of the measured voltage difference *dV*.

If the measured voltage difference *dV* fluctuates during commissioning, increase the default setting. The smoothing has the low-pass behavior (PT1 behavior).

The following figure allows you to estimate the effect of the setting value of the parameter **Smoothing**. The following figure also shows the step response. The longer the delay is, the greater the smoothing effects.



[dw_characteristic-adjusting-com, 2, en_US]

Figure 7-109 Effect of Smoothing Depending on the Set Parameter

Parameter: (V/Vrated)/(f/frated)

- Default setting **(_:137) (V/Vrated) / (f/frated)** = ***1.10***

With the parameter **(V/Vrated) / (f/frated)**, you specify the overexcitation threshold.

The default setting is a typical value. The threshold refers to the primary voltage. You can also calculate the setting value of this parameter with the secondary values, as the voltage transformers are usually adjusted to the rated voltage of the plant. In case of deviations, you must correct the default setting.

EXAMPLE:

Permissible value $(V/V_{rated})/(f/f_{rated})$	1.1
Primary rated voltage of the generator	V_{prim} = 10.5 kV
Primary voltage of the voltage transformer	$V_{prim, trans.}$ = 10 kV

This results in the following secondary setting value:

$$(V/V_{rated})/(f/f_{rated}) = \frac{V}{f} \cdot \frac{V_{prim}}{V_{prim, trans.}} = 1.1 \frac{10.5\ kV}{10\ kV} = 1.15$$

[fo_v-rated of the generator, 1, en_US]

Parameters for Balancing the Frequency

For balancing commands, the following parameters are used to control the frequency:

- **Balancing frequency f2**
- **T f pulse min**
- **T f pulse max**
- **df/dt of the controller**
- **T pause f**
- **Δf set point for balancing**
- **Smoothing**
- **T close without balancing**
- **Release for the kick pulse**
- **Δf for the kick pulse**
- **Stabilization**

Parameter: Balancing frequency f2

- Default setting **(_:141) Balancing frequency f2** = ***off***

With the parameter **Balancing frequency f2**, you specify whether you want to issue the balancing command for the frequencies (f1 and f2) on the generator side or not.

Parameter Value	Description
off	If you select this setting value, no balancing command is issued for the frequency on the generator side.
balancing pulses	If you select this setting value, the balancing command is issued for the frequency on the generator side.

Parameter: T f pulse min

- Default setting **(_:142) T f pulse min** = ***0.10 s***

With the parameter **T f pulse min**, you set the minimum time of the control pulse. This time corresponds to the minimum responding time of the frequency controller. Set the parameter **T f pulse min** to the minimum responding time. The default setting is a practicable value.

Parameter: T f pulse max

- Default setting **(_:143) T f pulse max** = ***1.00 s***

With the parameter **T f pulse max**, you set the maximum time of the control pulse. With this time, you can avoid the overadjustment of the frequency. The default setting is a practicable value.

Parameter: df/dt of the controller

- Default setting **(_:144) df/dt of the controller** = ***1.000 Hz/s***

With the parameter **df/dt of the controller**, you adjust the balancing command to the controller and correctly define the set point value. The control pulse is derived from the measured frequency difference, the setting value of the parameter **df/dt of the controller**, and the set point value **Δf set point for balancing**. The default setting is a practicable value.

Use the following equation to calculate the actuating time:

$$tf_{act} = \frac{df_{MV} - \Delta f_{set\ point\ value}}{df/dt}$$

[fo_frequency adujstment, 1, en_US]

with:

tf_{act}	Pulse duration
df_{MV}	Measured frequency difference
$\Delta f_{set\ point\ value}$	The setting value of the parameter **Δf set point for balancing** for specifying the set point value for the frequency balancing command
df/dt	The setting value of the parameter **df/dt of the controller** for defining the frequency-changing speed of the side to be paralleled

Parameter: T pause f

- Default setting **(_:145) T pause f** = ***10.00 s***

With the parameter **T pause f**, you set the dead time between 2 balancing commands. This allows the controller and the generator to respond to the control pulse. Considering the different application scenarios, you can determine the final setting value during the commissioning.

Parameter: Δf set point for balancing

- Default setting **(_:146) Δf set point for balancing** = ***0.04 Hz***

With the parameter **Δf set point for balancing**, you define the set point value for the frequency adjustment. The default setting is a practicable value.

EXAMPLE:

Measured frequency difference	df = 0.5 Hz
Parameter setting value	**df/dt of the controller** = 1 Hz/s
Set point value	**Δf set point for balancing** = 0.04 Hz

Use the following equation to calculate the actuating time:

$$tf_{act} = \frac{df_{MV} - \Delta f_{set\ point\ value}}{df/dt} = \frac{0.5\ \text{Hz} - 0.04\ \text{Hz}}{1\ \text{Hz/s}} = 0.46\ \text{s}$$

[fo_frequency adjustment_02, 1, en_US]

Parameter: Smoothing

- Default setting **(_:147) Smoothing** = ***1***

With the parameter **Smoothing**, you set the smoothing of the measured frequency difference df.

If the measured frequency difference df fluctuates during commissioning, increase the default setting. For hydropower plants, in particular, the generator speed may fluctuate, necessitating corresponding adjustment.

The smoothing has the low-pass behavior (PT1 behavior). *Figure 7-109* allows you to estimate the effect of the setting value of the parameter **Smoothing**.

Parameter: T close without balancing

- Default setting **(_:148) T close without balancing** = ***5.00 s***

With the parameter **T close without balancing**, you set the time within which no balancing command is issued. This avoids the frequency change at the moment of switching. The time is the remaining duration up to an available switching. The parameter **T close without balancing** is active if the frequency difference is within the set band (see *Figure 7-107*).

Use the set frequency difference to calculate the time which is set with this parameter. The 2 frequencies are in the phase opposition after half of this time. Do not adjust the frequency within the angle-difference range which is from approximately 120° to a maximum of 180° before switching.

EXAMPLE:

Frequency difference: df = 0.1 Hz

The period duration is as follows:

$$T_{df} = \frac{1}{df} = \frac{1}{0.1\ Hz} = 10\ s$$

[fo_time duration tdf, 1, en_US]

Assuming that the angle difference dα changes by 360° in 10 s, you can calculate the minimum dead time as follows:

360° = 10 s

120° = t_{min}

$$t_{min} = \frac{120° \cdot 10\ s}{360°} = 3.33\ s$$

[fo_frequenzband, 2, en_US]

In a practical case, set the parameter **T close without balancing** to a higher value because the frequency difference is less than 0.1 Hz.

If a frequency difference is 0.04 Hz, a 360° rotation takes 25 s. Then, the minimum dead time is approximate 8 s.

The example shows that the default setting of 5.00 s is a practicable value.

Parameter: Release for the kick pulse

- Default setting **(_:149) Release for the kick pulse** = ***off***

With the parameter **Release for the kick pulse**, you can activate the kick pulse.

If you need a kick pulse for your application, set the parameter **Release for the kick pulse** to ***on***.

Parameter: Δf for the kick pulse

- Default setting **(_:150) Δf for the kick pulse** = ***0.04 Hz***

With the parameter **Δf for the kick pulse**, you define the set point value for the kick pulse. The pulse duration is derived from this value.

Set the parameter **Δf for the kick pulse** to the same value as the parameter **Δf set point for balancing**.

The setting value of 0.04 Hz leads to the following duration for the kick pulse:

$$tf_{act} = \frac{\Delta f_{kick\ pulse}}{df/dt} = \frac{0.04\ Hz}{1\ Hz/s} = 0.04\ s$$

[fo_frequency adjustment_03, 1, en_US]

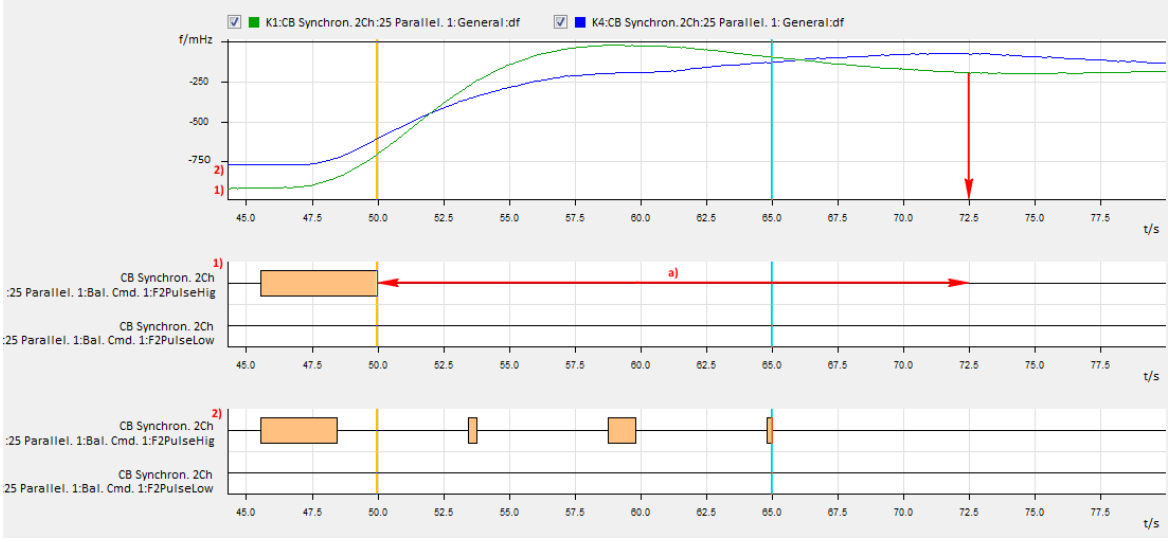
If the controller does not respond to this brief pulse (tf_{act} < t pulse min), the minimum pulse **T f pulse min** applies.

Parameter: Stabilization

- Default setting **(_:151) Stabilization** = ***no***

If the dead time is too short, the parameter **Stabilization** results in a faster compensation of the speed controller.

Parameter Value	Description
no	The default setting ***no*** is a practicable value for typical paralleling applications.
yes	Without the stabilization function, a sufficient dead time must be set to make sure that the transient response can be completed. For example, the dead time of the signal 2) in the following figure is close to 22.5 s after the execution of the pulse signal. If the dead time is too short, there is a risk of overshoot or fluctuation around its set point value, and a stable synchronization condition cannot be reached. If you set the parameter **Stabilization** = ***yes***, the dead time can be set to a smaller value. The behavior of the transient response is taken into account by canceling the control pulse or by issuing a control pulse in the reverse direction. The following figure shows this behavior. The stabilization function leads to an adaption of the frequency pulses, for example, with a dead time of 5.0 s. This adaption results in a change of the frequency pulses as the signal 1) in the following figure, which has no overshoot compared to the signal without stabilization as the signal 2) in the following figure. Due to many different factors, the selected setting for the dead time must be checked during commissioning and primary testing. Siemens recommends starting the **Paralleling** function with measuring the dead time, but without activating the stabilization function, by setting a defined frequency pulse and waiting for the inherent time of the system. The duration between the pulse and the completed transient response is the dead time. Afterwards, the stabilization function can be activated and the dead time can be reduced gradually as long as the frequency change is stable without overshoot and fluctuation. Siemens only recommends this setting value if you want to achieve the fast paralleling within short dead times or for special applications.



[sc_stabilization, 1, en_US]

Figure 7-110 Comparison of the Frequency Balancing with or without Stabilizer

a Dead time

7.5.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Bal. Cmd. #:Mode		• off • on • test	off
Balancing V				
_:131	Bal. Cmd. #:Balancing voltage V2		• off • transformer tap • balancing pulses	off
_:132	Bal. Cmd. #:T V pulse min		0.01 s to 1.00 s	0.10 s
_:133	Bal. Cmd. #:T V pulse max		0.01 s to 60.00 s	1.00 s
_:134	Bal. Cmd. #:dV per second		0.100 V to 50.000 V	2.000 V
_:135	Bal. Cmd. #:T pause V		0.10 s to 60.00 s	5.00 s
_:136	Bal. Cmd. #:Smoothing		1 to 100	1
_:137	Bal. Cmd. #:(V/Vrated)/(f/frated)		1.00 to 1.40	1.10
Balancing f				
_:141	Bal. Cmd. #:Balancing frequency f2		• off • balancing pulses	off
_:142	Bal. Cmd. #:T f pulse min		0.01 s to 1.00 s	0.10 s
_:143	Bal. Cmd. #:T f pulse max		0.01 s to 60.00 s	1.00 s
_:144	Bal. Cmd. #:df/dt of the controller		0.050 Hz/s to 5.000 Hz/s	1.000 Hz/s
_:145	Bal. Cmd. #:T pause f		0.10 s to 60.00 s	10.00 s
_:146	Bal. Cmd. #:Δf set point for balancing		-1.00 Hz to 1.00 Hz	0.04 Hz
_:147	Bal. Cmd. #:Smoothing		1 to 100	1
_:148	Bal. Cmd. #:T close without balancing		1.00 s to 100.00 s	5.00 s
_:149	Bal. Cmd. #:Release for the kick pulse		• off • on	off
_:150	Bal. Cmd. #:Δf for the kick pulse		-1.00 Hz to 1.00 Hz	0.04 Hz
_:151	Bal. Cmd. #:Stabilization		• no • yes	no

7.5.7.4 Information List

No.	Information	Data Class (Type)	Type
Bal. Cmd. #			
_:511	Bal. Cmd. #:>Block balancing	SPS	I
_:513	Bal. Cmd. #:>Block V2 balancing	SPS	I

No.	Information	Data Class (Type)	Type
_:514	Bal. Cmd. #:>Block f2 balancing	SPS	I
_:54	Bal. Cmd. #:Inactive	SPS	O
_:52	Bal. Cmd. #:Behavior	ENS	O
_:53	Bal. Cmd. #:Health	ENS	O
_:332	Bal. Cmd. #:V2 control pulse higher	SPS	O
_:331	Bal. Cmd. #:V2 control pulse lower	SPS	O
_:334	Bal. Cmd. #:f2 control pulse higher	SPS	O
_:333	Bal. Cmd. #:f2 control pulse lower	SPS	O
_:347	Bal. Cmd. #:Release sig. from syn.	SPS	O
_:348	Bal. Cmd. #:Release sig. from syn.2	SPS	O

7.6 Supervision of the Paralleling Function

7.6.1 Overview

The **Paralleling** function incorporates comprehensive supervision functions. The supervision functions cover both hardware and software. The measured values are continuously checked for plausibility, so that the voltage transformer circuits are also included in the monitoring system to a large extent. The supervision of the **Paralleling** function is used to ensure a high safety.

The **Paralleling** function provides the following supervision functions:

- Channel supervision
- Sample-data monitoring
  - Sample-state check
  - Sample-continuity check
- Phase-sequence check
- Close-command monitoring
  - Closure-condition check
  - Close-command simultaneous check
- Parameter plausibility check
- Relay supervision

Depending on the detected error, the device takes different actions as follows:

- An indication is sent.
- The **Paralleling** function is blocked.
- The device turns to the fallback mode.

The following table summarizes the supervision functions and the error responses of the device.

Table 7-30 Responses of the Supervision Functions

Supervision		Possible Causes	Indication	Response
Channel supervision		Internal (hardware) External (connection)	*Sync Fail Ch V1* *Sync Fail Ch V2*	The synchronization is stopped.
Sample-data monitoring	Sample-state check	Internal (hardware)	*Sync Fail Sampling*	The synchronization is stopped.
	Sample-continuity check	Internal (hardware)	*Sync Fail Data Continu.*	The close command is blocked.
Phase-sequence check		External (power system or connection)	*Failure*	The synchronization is stopped.
Close-command monitoring	Closure-condition check	External (power system or connection)	*Sync.supervis. asym.*	The close command is blocked. If the error lasts for more than 1 min, the synchronization is stopped.
	Close-command simultaneous check	External (power system or connection)	*Sync. supervision α>*	The close command is blocked.

Supervision	Possible Causes	Indication	Response
Parameter plausibility check	Configuration errors, parameterization errors	Inconsistency-check information (no indication)	The synchronization is stopped.
Relay supervision	Internal (hardware)	Internal diagnosis indication (no indication)	The device turns to the fallback mode.

You can find more information on the supervision mechanisms and their error responses in chapter *7.6.2 Function Description*.

7.6.2 Function Description

Channel Supervision

The **Channel supervision** function checks the consistency of sampled values based on instantaneous values between the voltage input and the inverse voltage input.

By numerical check of instantaneous values and summation formation (normally approximately 0), the input transformers, analog-digital converters, sampling, and the ring buffer are checked.

In the operating mode of the paralleling device, the **Channel supervision** function monitors the following entries which can lead to permanent faults:

- Analog channels
- A/D conversion
- Sampled values
- External connection

If the **Channel supervision** function detects an error: the *Sync Fail Ch V1* or *Sync Fail Ch V2* indication is generated and the synchronization is stopped.

Sample-Data Monitoring

The **Sample-data monitoring** function includes the following functions:

- **Sample-state check** function

  The **Sample-state check** function monitors the sampling buffer of voltage input to detect the sampling interval error. Additionally, the **Sample-state check** function checks whether the sampling is stopped or not.

  With the **Sample-state check** function, the sample data validity and sampling time stamp are checked for the data in the sampling buffer.

  In a ring buffer, the measured voltages are continually entered as numerical values. For each of the measured values, a corresponding sequence of numerical scan values exists in the ring buffer. The sequence reflects the chronological course of the analog values. An internal counter queries the sampled values and monitors their progress to ensure that current values are available. Additionally, all channels used for paralleling are checked.

  The sample-state error is a serious error. If the **Sample-state check** function detects a sample-state error, the started synchronization is stopped immediately, the *Sync Fail Sampling* indication is issued.

  The error of the device is caused by inconsistencies in the sampled values and must be excluded.

- **Sample-continuity check** function

  The **Sample-continuity check** function is intended to detect a fluctuation of measuring voltage. The fluctuation can generate a large sampled value by mistake and lead to amplitude errors and angle-measuring errors. The possible causes are analog-digital converter errors, memory errors, or induced disturbances (EMC). The **Sample-continuity check** function evaluates the difference of consecutive sampled values for each sampling point to detect an unsteady voltage.

  The sampled values are checked to avoid the unsteady changes. The unsteady changes cause the calculation errors of the frequency and of the angle which can lead to faulty connections.

  The **Sample-continuity check** function checks all phases of each voltage input and detects errors of the difference between 2 consecutive sampled values.

  In a defined time range, if the function detects an unsteady state in any phase of these voltage measuring points, the *Sync Fail Data Continu.* indication is issued and the synchronization is stopped for a defined time.

  During a signal disturbance, for example, EMC disturbance, the synchronization is not stopped but the close command is blocked. As long as the *Sync Fail Data Continu.* indication exists, close command cannot be issued. After the disturbance is eliminated, the synchronization can work normally.

Phase-Sequence Check

The **Phase-sequence check** function checks the consistency of the phase sequence.

You can define the phase sequence of the electrical power system with the **Phase sequence** parameter in DIGSI 5. The time difference between the zero transitions of the individual phases establishes the phase sequence. The phase sequence is checked by supervising the phase sequence of the voltages. If the **Phase-sequence check** function detects an inconsistency of the phase sequence, the *Failure* indication is issued and the synchronization is stopped.

Close-Command Monitoring

The **Close-Command Monitoring** function monitors the close-command signal issued by the 2 channels of the 1.5-channel synchronization or 2-channel synchronization.

You can find more information in chapter *Close-Command Monitoring, Page 560*.

Parameter Plausibility Check

The **Parameter plausibility check** function checks the parameterization and the plausibility of the **Paralleling** function. The **Parameter plausibility check** function is finished on startup of the device and has no inputs, outputs, and indications.

If plausibility errors are detected in the parameterization of the **Paralleling** function, the *Setting error* indication is issued and the **Paralleling** function is blocked.

If you update parameters of the **Paralleling** function, the **Paralleling** function cannot be started.

If you change the parameters after the **Paralleling** function is activated, the synchronization is automatically stopped.

Relay Supervision

The **Relay supervision** function only monitors the fast type relays (type F). Siemens recommends to use the relay type F for the 2-channel close command.

The **Relay supervision** function can detect open circuits and short circuits in the relay. If such errors are detected, the device goes to fallback mode.

7.7 Voltage Measuring-Point Selection for Paralleling

7.7.1 Overview of Functions

In the **Paralleling** function, the function blocks **Paralleling with 1.5 channels** and **Paralleling with 2 channels** both use 2 synchronization voltages and their inverse voltages. If you want to implement the voltage measuring-point selection for these 2 function blocks, use the function block **Voltage measuring-point selection for paralleling**.

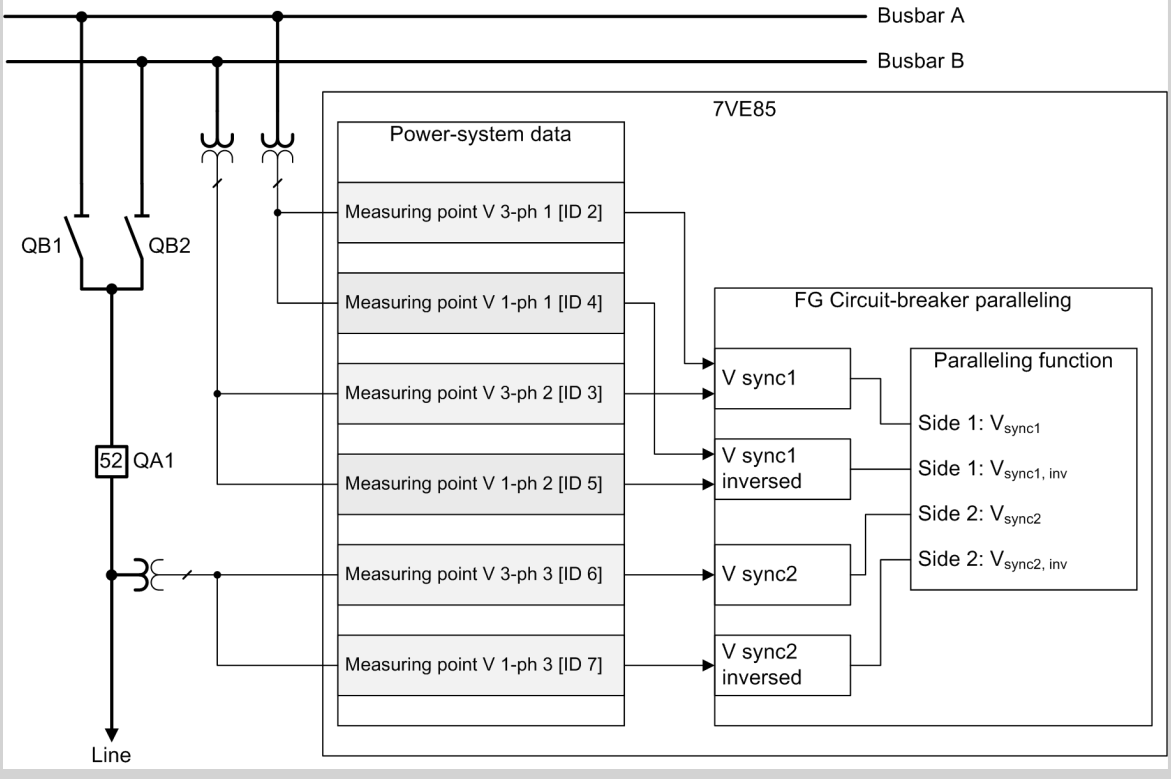
If multiple voltage measuring points are routed to the same voltage interface of the function group **Circuit-breaker paralleling**, you select the correct voltage measuring points with the function block **Voltage measuring-point selection for paralleling**.

7.7.2 Function Description

The function block **Voltage measuring-point selection for paralleling** implements the voltage measuring-point selection via a Continuous Function Chart (CFC).

Example

The following figure shows an example of the voltage measuring-point selection for the **Paralleling** function in a double-busbar arrangement. The correct measuring points are selected depending on the switch positions of the disconnectors QB1 and QB2.



[dw_2 busbars to the line, 1, en_US]

Figure 7-111 Voltage Measuring-Point Selection in a Double-Busbar Arrangement

The system voltage in the previous figure varies according to the following situations:

- If the disconnector QB1 is closed and the disconnector QB2 is open, the system voltage is derived from the busbar A.
- If the disconnector QB1 is open and the disconnector QB2 is closed, the system voltage is derived from the busbar B.
- If the disconnectors QB1 and QB2 are both closed, the system voltage can be derived from the busbar A or the busbar B depending on the CFC logic.
- If the disconnectors QB1 and QB2 are both open, the system voltage cannot be detected.

Connecting Measuring Points to the Function Group Circuit-Breaker Paralleling

The following figure shows the connection of the function group **Circuit-breaker paralleling** with 7 measuring points in DIGSI. The ID of each measuring point appears in the bracket after the name. Based on the given example in *Figure 7-111*, the voltage measuring points ID 2 and ID 4 are connected to the busbar A, ID 3 and ID 5 are connected to the busbar B.

Connect measuring points to function group

	CB Paralleling 1					
Measuring point	V	I 3ph	V sync1	V sync2	V sync1 inversed	V sync2 inversed
(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	
Meas.point V-1ph 2[ID 5]					X	
Meas.point V-3ph 3[ID 6]				X		
Meas.point V-1ph 3[ID 7]						X

[sc_connect MPs to FG CB Paralle., 1, en_US]

Figure 7-112 Connecting Measuring Points to the Function Group Circuit-Breaker Paralleling

There are several consistency checks that validate the connections of the voltage measuring points to the function group in DIGSI 5. If one of the following items is not fulfilled, DIGSI 5 reports an inconsistency:

- Multiple 3-phase voltage measuring points and 1-phase voltage measuring points can be routed to the same voltage interface at the same time. For example, you can route three 3-phase voltage measuring points and two 1-phase voltage measuring points to the interface V_{sync1} at the same time. The preconditions are as follows:
  - All connection types of 3-phase voltage measuring points must be identical.
  - All set phases of 1-phase voltage measuring points must be identical.
- If one of the measuring points routed to the interface V_{sync1} is a 1-phase voltage measuring point, none of the measuring points routed to the interface $V_{sync1\ inversed}$ can be a 3-phase voltage measuring point. The interfaces V_{sync2} and $V_{sync2\ inversed}$ follow the same rule.
- The number of measuring points routed to the interfaces V_{sync1} and $V_{sync1\ inversed}$ must be identical. The interfaces V_{sync2} and $V_{sync2\ inversed}$ follow the same rule.

Besides, if both of the following conditions are met, the voltage types for all the measuring points must be identical:

- Multiple 3-phase voltage measuring points are routed to the same voltage interface.
- The connection types of these 3-phase voltage measuring points are *2 ph-to-ph voltages*.

Example:

Three 3-phase voltage measuring points are routed to the same voltage interface V_{sync1}.

Connect measuring points to function group

	CB Paralleling 1					
Measuring point	V	I 3ph	V sync1	V sync2	V sync1 inversed	V sync2 inversed
(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-3ph 1[ID 1]			X			
Meas.point V-3ph 2[ID 2]			X			
Meas.point V-3ph 3[ID 3]			X			
Meas.point I-3ph 1[ID 4]		X				

[MP routed to the same voltage interface, 1, en_US]

The connection types of these 3-phase voltage measuring points are 2 phase-to-phase voltages. Therefore, the voltage types are identical, that is, V_{AB} and V_{BC} as shown in the following figure.

Voltage-measuring points

		Base module				Expansion module 3			
		1B				3B			
		1B1-1B2	1B3-1B4	1B5-1B6	1B7-1B8	3B1-3B2	3B3-3B4	3B5-3B6	3B7-3B8
Measuring point	Connection type	V 1.1	V 1.2	V 1.3	V 1.4	V 3.1	V 3.2	V 3.3	V 3.4
(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-3ph 1	2 ph-to-ph voltages	V AB	V BC						
Meas.point V-3ph 2	2 ph-to-ph voltages			V AB	V BC				
Meas.point V-3ph 3	2 ph-to-ph voltages					V AB	V BC		

[Identical voltage type, 1, en_US]

7.7.3 Application and Setting Notes

CFC Control

If more than one measuring point is routed to one of the following interfaces of the function group **Circuit-breaker paralleling**, an instantiated function block **Voltage measuring-point selection for paralleling** and a CFC logic are required for the voltage selection:

- V_{sync1}
- V_{sync2}
- $V_{sync1\ inversed}$
- $V_{sync2\ inversed}$

The CFC logic selects the measuring-point IDs for all the preceding interfaces to ensure the correct measuring-point connection.

The following figure shows the measuring-point selection for the voltage interfaces V_{sync1} and $V_{sync1\ inversed}$ based on the given example in *Figure 7-111*:

- If the disconnector 1 (QB1) is closed, the values 2 and 4 are the outputs of the 2 CFC blocks **MUX_D** independently of the position of the disconnector 2 (QB2). That is, the voltages V_{sync1} and $V_{sync1,\ inv}$ are derived from the voltage measuring points with the IDs 2 and 4 separately.
- If QB2 is closed and QB1 is open, the values 3 and 5 are the outputs of the 2 CFC blocks **MUX_D** separately. That is, the voltages V_{sync1} and $V_{sync1,\ inv}$ are derived from the voltage measuring points with the IDs 3 and 5 separately.
- If QB2 and QB1 are both open, no measuring point is selected.

Table 7-31 Selection Result of the Voltage Measuring Points

QB1	QB2	ID in mux_d_1	ID in mux_d_2	Measuring Point Connected to V_{sync1}	Measuring Point Connected to $V_{sync1\ inversed}$
Closed	Closed	2	4	Measuring point V 3-ph 1 [ID 2]	Measuring point V 1-ph 1 [ID 4]
Closed	Open				
Open	**Closed**	3	5	Measuring point V 3-ph 2 [ID 3]	Measuring point V 1-ph 2 [ID 5]
Open	Open	0	0	–	–

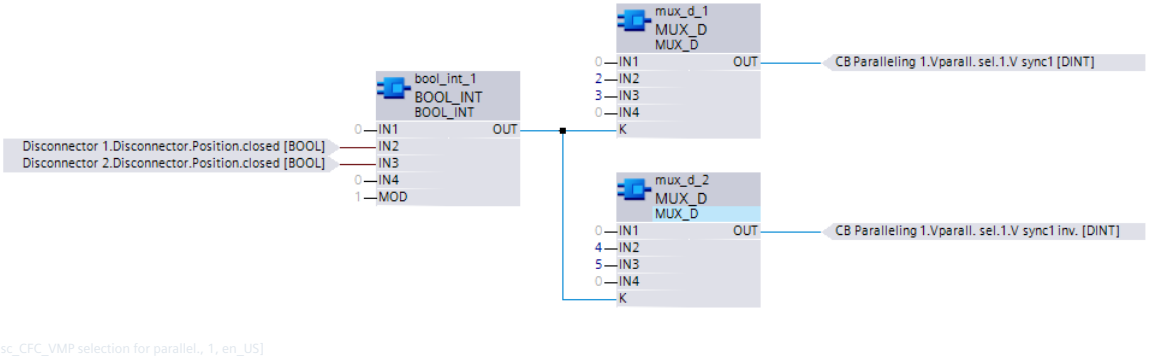


Figure 7-113 CFC Logic: Voltage Selection Using Measuring Point ID

NOTE

In the preceding figure, the mode in the CFC block **BOOL_INT** is set to 1. With this setting, the priority of the input value decreases from input IN1 to IN4. Because IN2 is smaller than IN3, the position information of the disconnector 1 in IN2 is processed if the disconnectors are both closed.

When the disconnectors are both open, the value 0 is used as the ID for the voltage measuring-point selection. ID 0 is a right case in this function. If ID 0 is selected, no voltage is selected. That is, there is no voltage input for the function block **Paralleling with 1.5 channels** or **Paralleling with 2 channels**, and the **Paralleling** function is blocked.

NOTE

An invalid measuring-point selection (ID < 0 or an ID of an unconnected measuring point) for the voltage input (V_{sync1}, V_{sync2}, $V_{sync1\ inversed}$ or $V_{sync2\ inversed}$) of the **Paralleling** function results in the following states:

- The voltage measured values are displayed as **---**.
- The validity of the voltage measured values is set to **invalid**.
- The indication *Health* of the function block **Voltage measuring-point selection for paralleling** is set to ***Alarm***.
- One of the following indications is issued:
  - *Sel. V sync1 invalid*
  - *Sel. V sync2 invalid*
  - *Sel.Vsync1 inv.invalid*
  - *Sel.Vsync2 inv.invalid*

Example

The following 2 figures show an example of the voltage measuring-point selection for the voltage interfaces V_{sync1} and $V_{sync1\ inversed}$. These 2 interfaces are routed to 6 voltage measuring points separately.

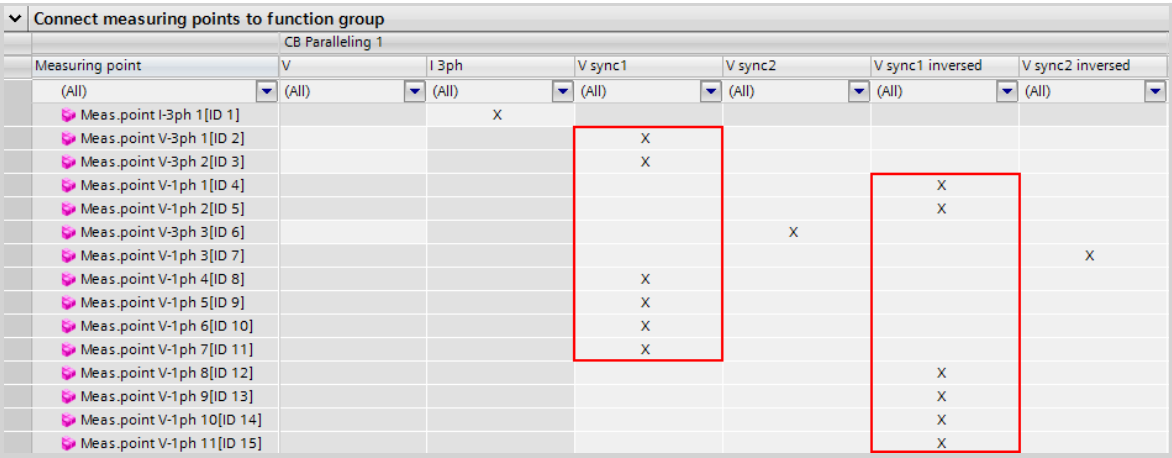


Figure 7-114 Connecting Measuring Points to the Function Group Circuit-Breaker Paralleling

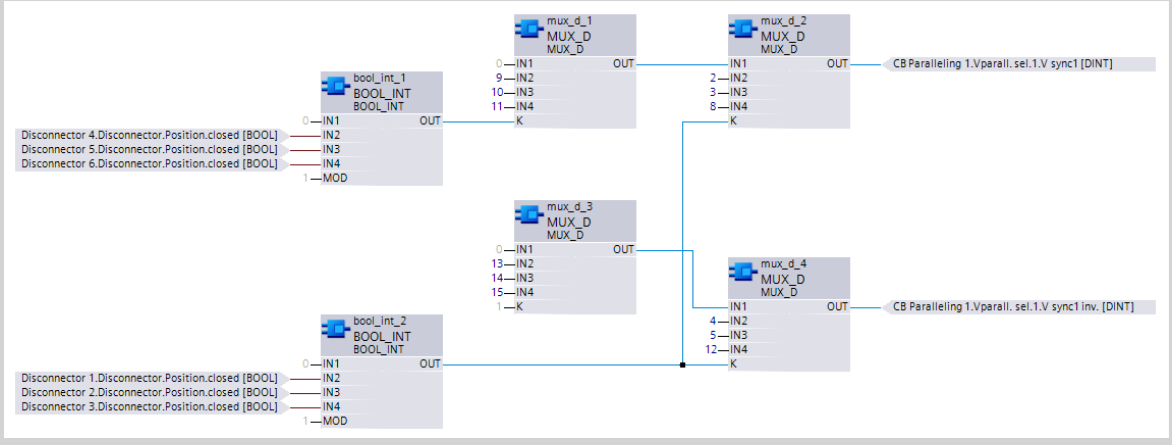


Figure 7-115 CFC Logic: Voltage Selection Using Measuring Point ID

Table 7-32 Selection Result of the Voltage Measuring Points

Disconnector						ID of Measuring Point Connected to V_{sync1}	ID of Measuring Point Connected to $V_{sync1\ inversed}$
1	2	3	4	5	6		
Open	Open	Open	Open	Open	Open	–	–
Closed	Closed	Closed	Closed	Closed	Closed	2	4
Closed	Open/ closed	Open/ closed	Open/ closed	Open/ closed	Open/ closed		
Open	**Closed**	Open/ closed	Open/ closed	Open/ closed	Open/ closed	3	5
Open	Open	**Closed**	Open/ closed	Open/ closed	Open/ closed	8	12
Open	Open	Open	**Closed**	Open/ closed	Open/ closed	9	13
Open	Open	Open	Open	**Closed**	Open/ closed	10	14
Open	Open	Open	Open	Open	**Closed**	11	15

7.7.4 Information List

No.	Information	Data Class (Type)	Type
Vparall. sel.#			
_:500	Vparall. sel.#:V sync1	INS	I
_:501	Vparall. sel.#:V sync2	INS	I
_:502	Vparall. sel.#:V sync1 inv.	INS	I
_:503	Vparall. sel.#:V sync2 inv.	INS	I
_:53	Vparall. sel.#:Health	ENS	O
_:300	Vparall. sel.#:Sel. V sync1 invalid	SPS	O
_:301	Vparall. sel.#:Sel. V sync2 invalid	SPS	O
_:302	Vparall. sel.#:Sel.Vsync1 inv.invalid	SPS	O
_:303	Vparall. sel.#:Sel.Vsync2 inv.invalid	SPS	O

7.8 Synchronization Function

7.8.1 Overview of Functions

The 1-channel **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 as follows:

- Synchronization of a line and a busbar
- Synchronization of 2 busbars via a cross-coupling
- Synchronization of a generator and a busbar

A power transformer between the 2 measuring points can also be taken into consideration.

7.8.2 Structure of the Function

The **Synchronization** function is used in the **Circuit-breaker** function group.

The **Synchrocheck** stage type is preconfigured at the factory.

7.8.3 Connection and Definition

Connection

You can find examples for the synchronization of line and busbar in the following 2 figures. *Figure 7-118* 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[35].

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[35]. 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 *2.1 Embedding of Functions 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 7-116* and *Figure 7-118*):

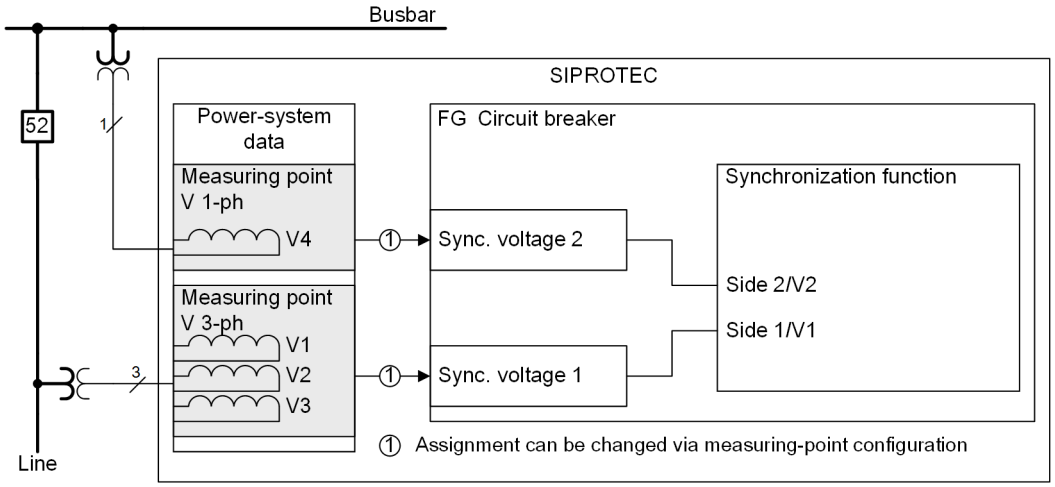
  The voltage connected to the 1-phase measuring point is definitive here. If. for example, this is the phase-to-ground voltage V_A, the voltage V_A is also used by the other side of the 3-phase measuring point.

- Connection of the primary system via 6 voltage inputs and hence use of two 3-phase measuring points (*Figure 7-117*):

  The phase-to-phase voltage V_{AB} of both sides is always used for the test.

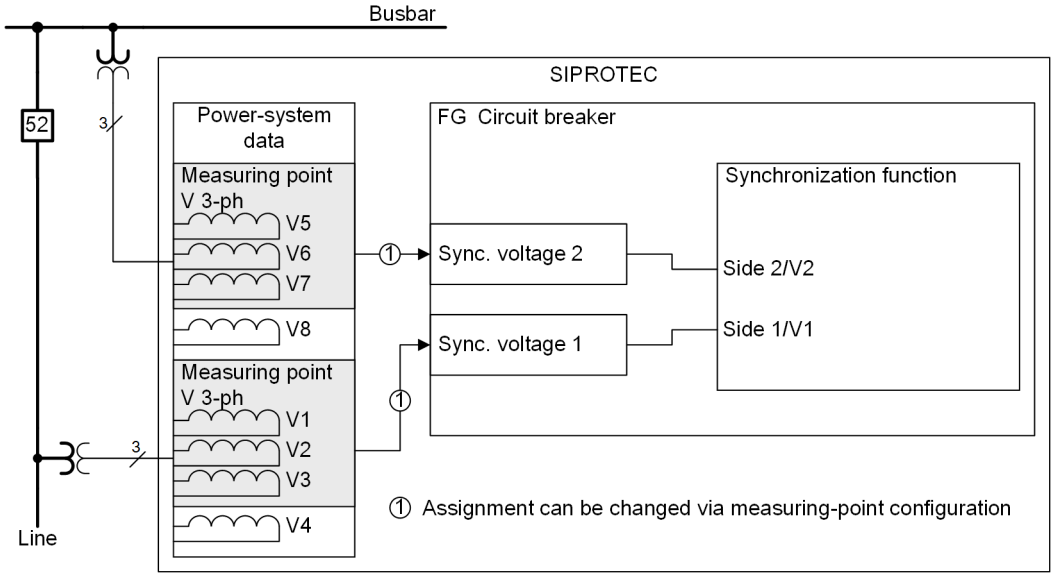
You can connect both the phase-to-ground voltages and the phase-to-phase voltages to the device. The possible interface connections are listed in the Appendix.

35 Do not confuse the designations V1 and V2 with the numbering of the voltage inputs V1 to V4 (*Figure 7-116*) and V1 to V8 (*Figure 7-117*).



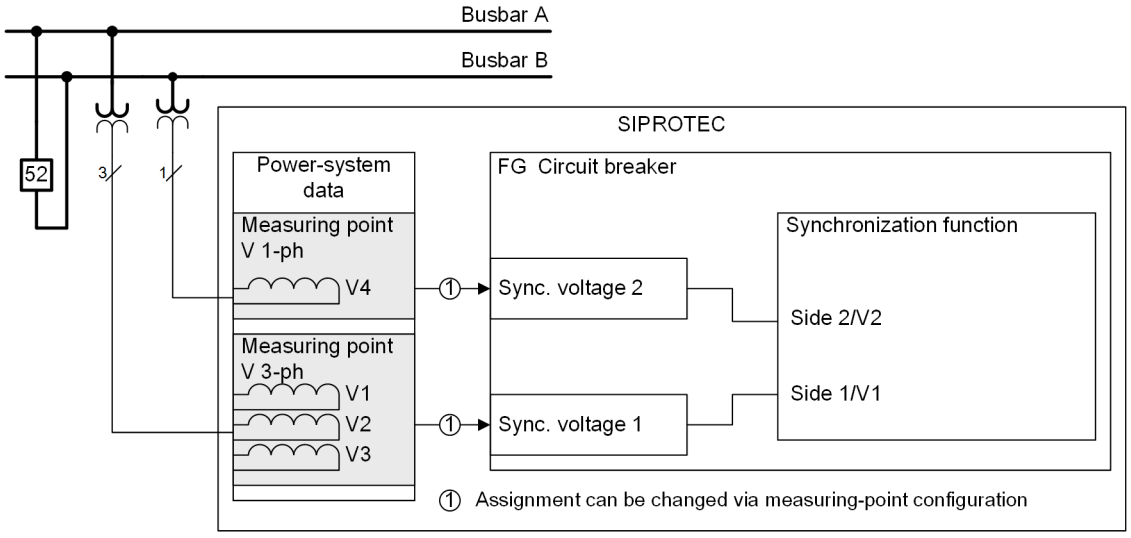
[dw_syns01-01, 2, en_US]

Figure 7-116 Synchronization of Line and Busbar, Connection via 4 Voltage Inputs



[dw_syns02-01, 2, en_US]

Figure 7-117 Synchronization of Line and Busbar, Connection via 6 Voltage Inputs



[dw_syns03-01, 2, en_US]

Figure 7-118 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.

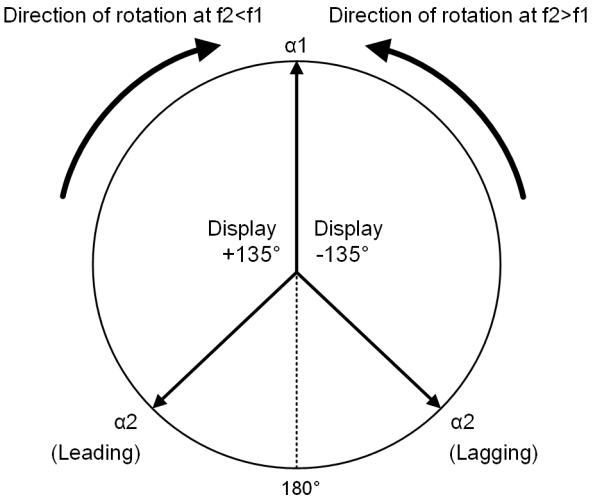
Differential frequency df = f2 – f1

A positive result means that according to the example from *Figure 7-116* 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 7-119* 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 7-119*, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.



[dw_synp_04, 2, en_US]

Figure 7-119 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.

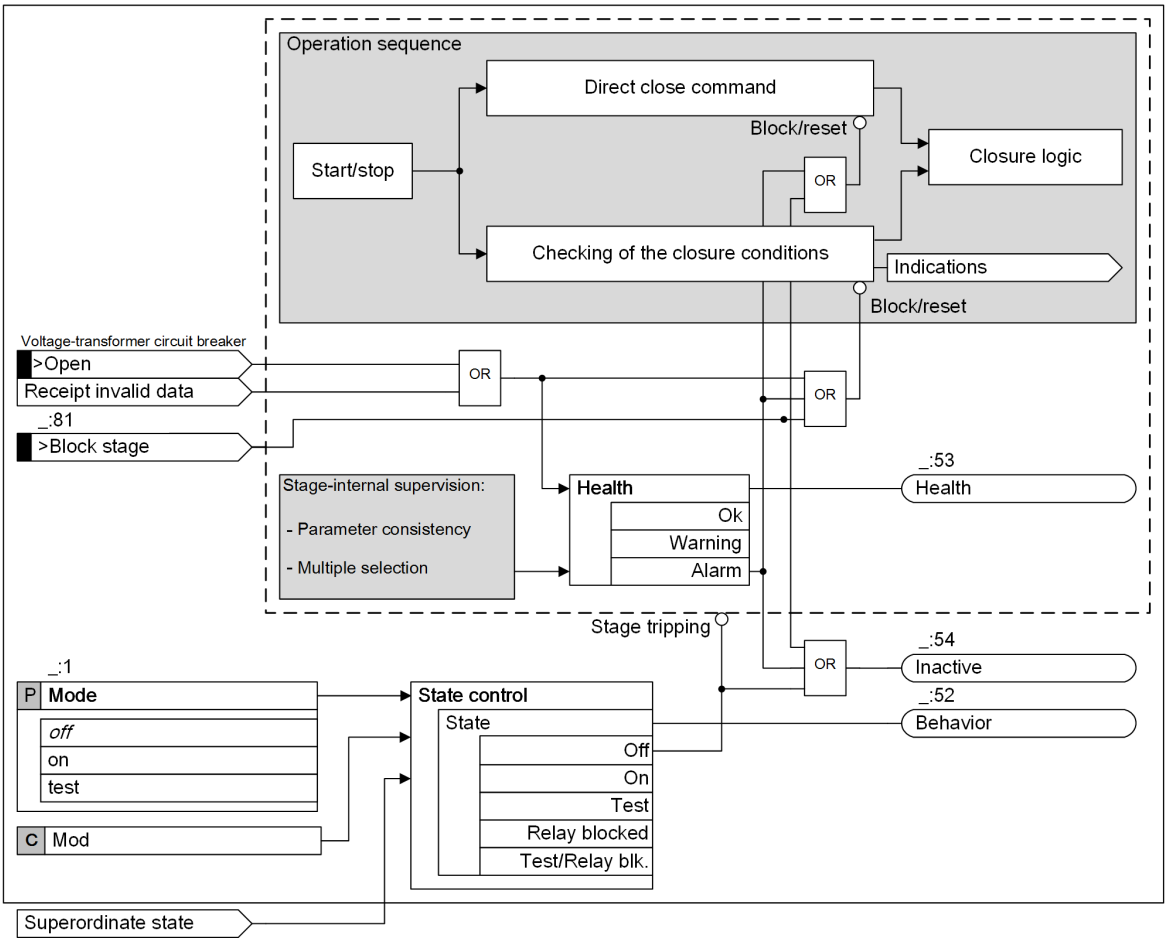
7.8.4 General Functionality

7.8.4.1 Description

Overview of a Synchronization Stage (Sync Stage)

A synchronization stage can be integrated in the following blocks (see *Figure 7-120*):

- 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 *7.8.6 Sequence of Functions*)



[lo_syn001-01, 5, en_US]

Figure 7-120 Overview of the Stage Logic

Stage Control

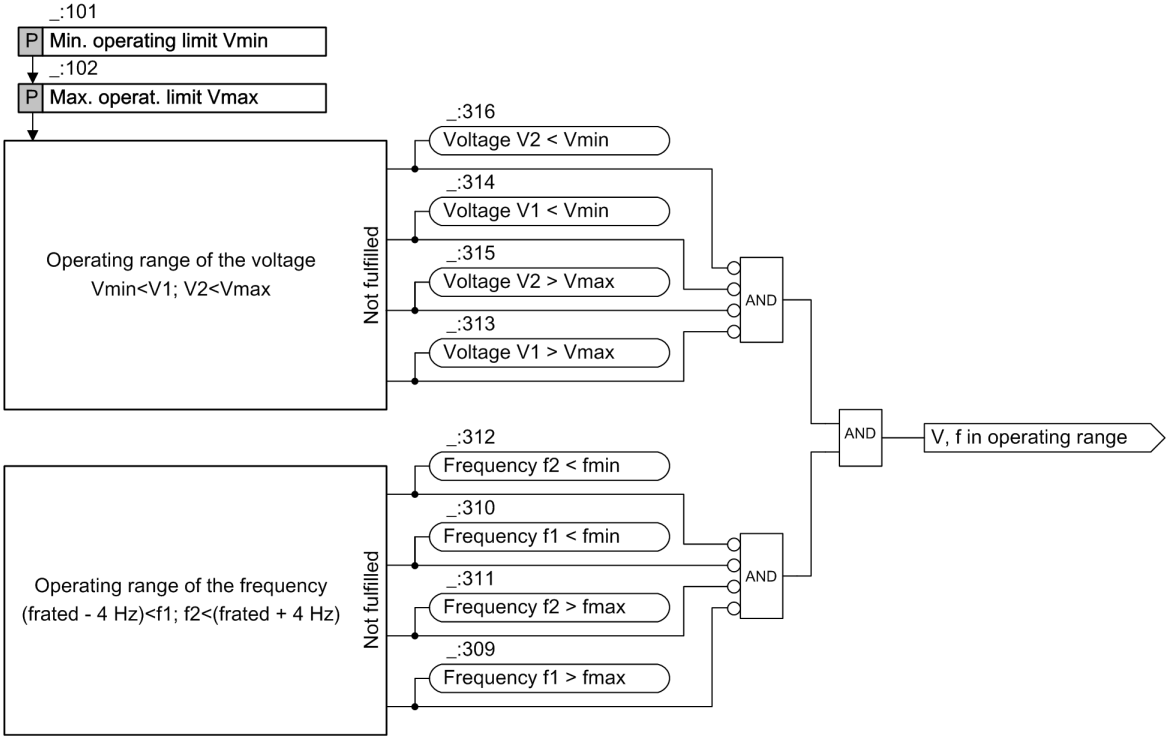
The normal stage control is used for a synchronization stage (see *Figure 7-120*).

Note the following special features:

- For control via IEC 61850, a parameterized function Synchrocheck is only executed if the service parameter **Synchrocheck** is set to ***true***. The function control also provides the service parameter **Interlock-Check**. If the service parameter **Synchrocheck** is set to ***false***, switching is not synchronized. Siemens recommends checking the desired behavior for control from remote via IEC 61850 before the commissioning.
- 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 a 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.

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



[lo_syn002-01, 2, en_US]

Figure 7-121 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 supervision for the synchronization function checks the definite threshold-value settings after a parameter change. If there is an inconsistency, the error message **Setting error** is issued. The supervision is executed in a function-specific manner. If the supervision picks up, the indication ***Health*** goes to ***Warning***. The stage is indicated as **Inactive**. A closing release or direct close command is not possible in this case.

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 conditions of the synchronization stage are no longer tested. This means that 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.

Functional Measured Values

The functional 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 functional 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 7-33 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 Voltage-Transformer Ratios from Both Sides of the Electrical Power System

The synchronization function automatically takes different transformation ratios of the voltage measuring points into account on both sides of the power system. Set the parameter **`Voltage adjustment`** in the synchronization function for the following cases:

- Without a power transformer between the voltage measuring points of the circuit breaker to be synchronized, if the rated primary voltages are different on both sides of the electrical power system.
- With a power transformer between the voltage measuring points of the circuit breaker to be synchronized, if the transfer ratios of the rated primary voltages on the voltage transformer are different on both sides of the electrical power system.

For more information about the parameter **`Voltage adjustment`**, refer to *7.8.4.2 Application and Setting Notes*, *Parameter: **`Voltage adjustment`**, Page 605*.

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 rated primary voltages of the power transformer from 2 sides of the electrical power system. A phase displacement must be taken into account based on the transformer vector group via the parameter **`Angle adjust. (transform.)`**.

The parameter is defined as -Δα = –(α2 – α1).

To calculate the delta variables Δα and ΔU, the voltage of side 2 is converted to that of side 1 using the settings of the 2 parameters **`Angle adjust. (transform.)`** and **`Voltage adjustment`**.

The displayed voltage V2 in the device display is the voltage from the power-transformer side, which is close to the point to be synchronized, and not the measured voltage of the voltage transformer of side 2.

For more information, refer to *7.8.4.2 Application and Setting Notes*.

Different Connection Types on Both Sides

If both the measuring points used by the synchronization functions record different voltages of the 3-phase system, the calculation of the phase-angle difference is automatically considered.

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.

7.8.4.2 Application and Setting Notes

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 *7.8.3 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 *7.8.3 Connection and Definition*.

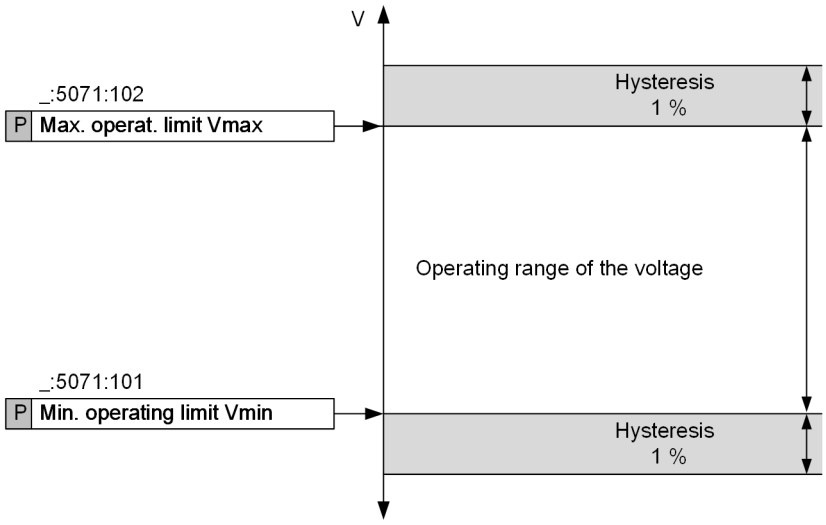
Parameter: `Min. operating limit Vmin`, `Max. operat. limit Vmax`

- 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, since the threshold values must be set with reference to the rated voltage (phase-to-phase voltage).



[lo_hyster-01, 2, 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***

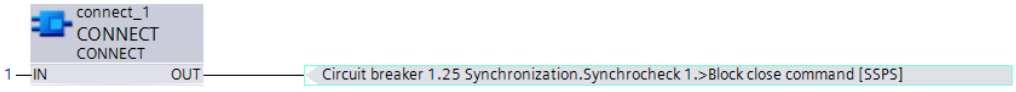
The parameterized conditions must be fulfilled within this time. If the conditions are not fulfilled, no further closing release takes place and the synchronization stage is stopped. If this time is set to ∞, conditions are checked until they are fulfilled. This is also the default setting. Observe the 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. Thereafter the process is stopped immediately.

If the closure release is assigned, the synchronization is terminated. If the synchrocheck is to continuously display the switching conditions, without issuing a direct close command at synchronization, proceed as follows:

EXAMPLE:

For Continuous Checking of the Switching Conditions without Issuing a Direct Close Command

With the aid of the following CFC chart you can set the input ***>Block stage*** of the corresponding synchrocheck stage permanently:



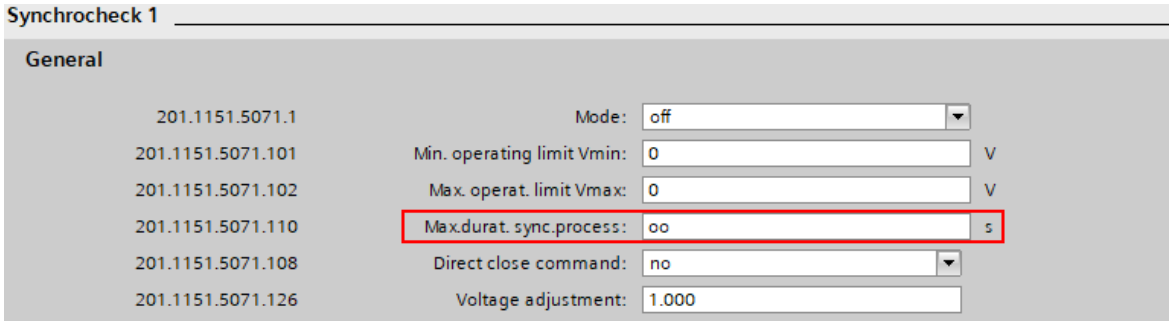
[sc_sync_CFC, 3, en_US]

If you route the indication ***All sync. conditio. OK*** to the corresponding binary output, you receive a separate release of the closure for an external synchronization unit.

Information			Sc ▸ Destination					
			▸ Binary output					
			▸ Base module					
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6
(All)	(All)	(All)	...	...	...	...	...	...
Mode (controllable)	201.1151.5071.51	ENC						
Inactive	201.1151.5071.54	SPS						
Behavior	201.1151.5071.52	ENS						
Health	201.1151.5071.53	ENS						
In progress	201.1151.5071....	SPS						
Release close cmd.	201.1151.5071....	SPS						
All sync. conditio. OK	201.1151.5071....	SPS	U					
Voltage difference OK	201.1151.5071....	SPS						
Angle difference OK	201.1151.5071....	SPS						
Frequency diff. OK	201.1151.5071....	SPS						
Cond. V1<V2> fulfilled	201.1151.5071....	SPS						

[sc_sync_routing, 2, en_US]

If you wish to permanently report each occasion on which synchronization conditions are reached following the start of synchronization, you set the parameter **`Max.durat. sync.process`** to ∞.



[sc_sync_setting, 2, en_US]

Parameter: `Voltage adjustment`

- Default setting **`(_:5071:126) Voltage adjustment`** = ***1.00***

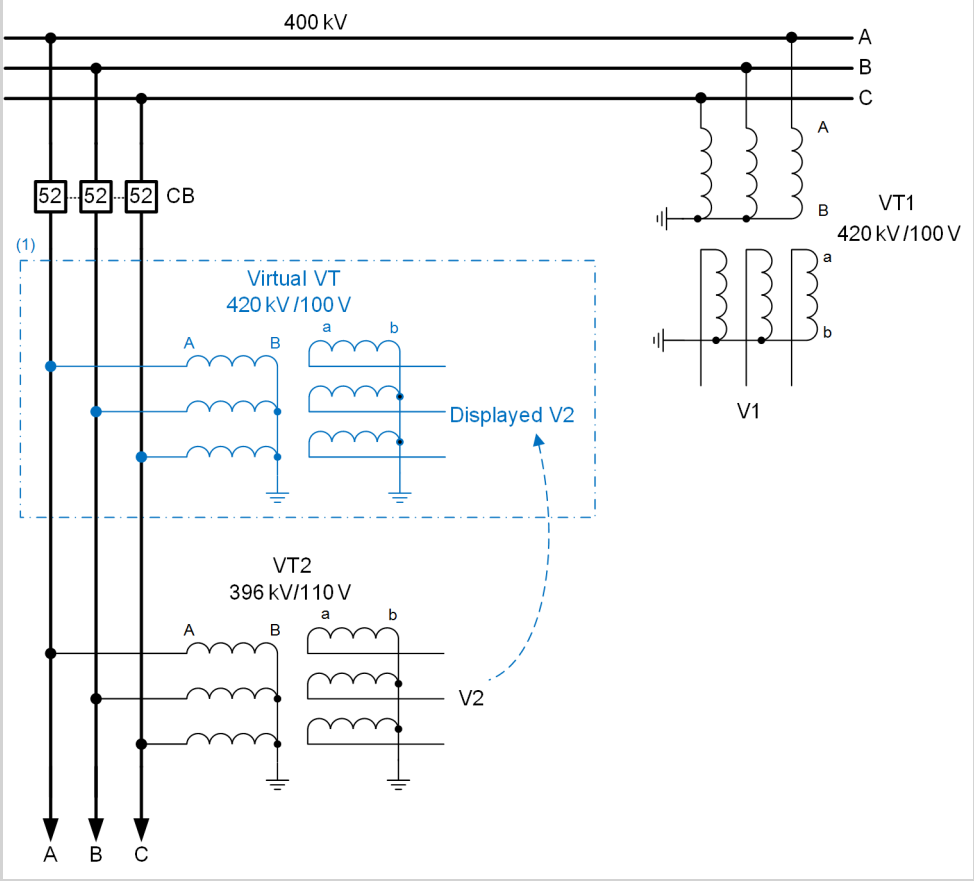
The parameter can be used for correction of amplitude errors, for example, due to indirect measurement (for example, transformer tap changer).

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.

To apply a transformer between the voltage measuring points, the transformer ratio does not have to be taken into account. When you set the parameter **`Voltage adjustment`**, the transformer ratio is automatically taken into account. In the following, you can find 2 examples for the setting of the parameter **`Voltage adjustment`**:

Example 1:

In the electrical power system, no power transformer exists between the voltage measuring points of the circuit breaker to be synchronized. The rated primary voltages of 2 sides of the electrical power system are different.



[dw_example w.o. power transformer, 1, en_US]

Figure 7-122 Example: the Electrical Power System without a Power Transformer

(1) The virtual VT does not exist in the primary voltage system. It is just a virtual voltage transformer to show the displayed V2 on the device display. The virtual VT has the same transformer ratio as VT1.

The displayed V2 is a processed voltage from VT2.

$$\text{Voltage adjustment} = \frac{V2_{\text{rated prim.}}}{V1_{\text{rated prim.}}} = \frac{396\ \text{kV}}{420\ \text{kV}} \approx 0.94$$

[fo_ex1_V adjustment, 1, en_US]

With:

$V2_{\text{rated prim.}}$	Rated primary voltage of VT2
$V1_{\text{rated prim.}}$	Rated primary voltage of VT1

For this example, the displayed voltage V2 on the device display is from the virtual VT, not from VT2.

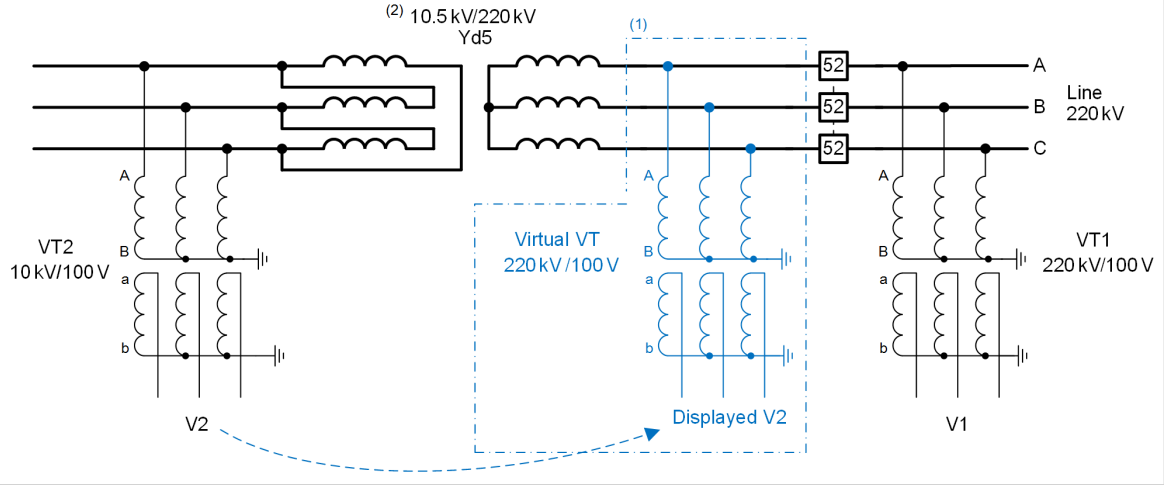
The primary voltages, secondary voltages, and percentage values of the measured values are shown in the following table.

Table 7-34 Primary Voltage, Secondary Voltage, and Percentage Value

Measured Value	Primary Voltage	Secondary Voltage	Percentage Value
V1	400 kV	$\frac{400\,\text{kV}}{420\,\text{kV}/100\,\text{V}} \approx 95.238\,\text{V}$	$\frac{400\,\text{kV}}{420\,\text{kV}} \cdot 100\,\% \approx 95.238\,\%$
V2	400 kV	$\frac{400\,\text{kV}}{396\,\text{kV}/110\,\text{V}} \approx 111.111\,\text{V}$	$\frac{400\,\text{kV}}{396\,\text{kV}} \cdot 100\,\% \approx 101.01\,\%$
Displayed V2	400 kV	$\frac{400\,\text{kV}}{420\,\text{kV}/100\,\text{V}} \approx 95.238\,\text{V}$	$\frac{400\,\text{kV}}{420\,\text{kV}} \cdot 100\,\% \approx 95.238\,\%$

Example 2:

In the electrical power system, a power transformer is located between the voltage measuring points of the circuit breaker to be synchronized. The power transformer ratio differs from the ratio between the rated primary voltages of the voltage transformers of 2 sides of the electrical power system.



[dw_example w. power transformer, 1, en_US]

Figure 7-123 Example: the Electrical Power System with a Power Transformer

(1) The virtual VT does not exist in the primary voltage system. It is just a virtual voltage transformer to show the displayed V2 on the device display. The virtual VT has the same transformer ratio as VT1.

The displayed V2 is a processed voltage from VT2.

(2) This ratio is not the rated transformer ratio on the transformer name plate. This ratio is an actual ratio which considers the tap-changer scenarios when the **Tap changer** function is not used in the device. The rated transformer ratio is 220 kV/10 kV.

$$\text{Voltage adjustment} = \frac{V2_{\text{rated prim.}}}{V1_{\text{rated prim.}}} \cdot R_{PT} = \frac{10\,\text{kV}}{220\,\text{kV}} \cdot \frac{220\,\text{kV}}{10.5\,\text{kV}} \approx 0.95$$

[fo_ex2_V adjustment, 1, en_US]

With:

$V2_{\text{rated prim.}}$	Rated primary voltage of VT2
$V1_{\text{rated prim.}}$	Rated primary voltage of VT1
R_{PT}	Transformer ratio of the power transformer

For this example, the displayed voltage V2 on the device display is from the virtual VT, not from VT2.

The primary voltages, secondary voltages, and percentage values of the measured values are shown in the following table.

Table 7-35 Primary Voltage, Secondary Voltage, and Percentage Value

Measured Value	Primary Voltage	Secondary Voltage	Percentage Value
V1	220 kV	$\frac{220\,\text{kV}}{220\,\text{kV}/110\,\text{V}} = 110\,\text{V}$	$\frac{220\,\text{kV}}{220\,\text{kV}} \cdot 100\,\% = 100\,\%$
V2	10.5 kV	$\frac{10.5\,\text{kV}}{10\,\text{kV}/100\,\text{V}} = 105\,\text{V}$	$\frac{10.5\,\text{kV}}{10\,\text{kV}} \cdot 100\,\% = 105\,\%$
Displayed V2	220 kV	$\frac{220\,\text{kV}}{220\,\text{kV}/110\,\text{V}} = 110\,\text{V}$	$\frac{220\,\text{kV}}{220\,\text{kV}} \cdot 100\,\% = 100\,\%$

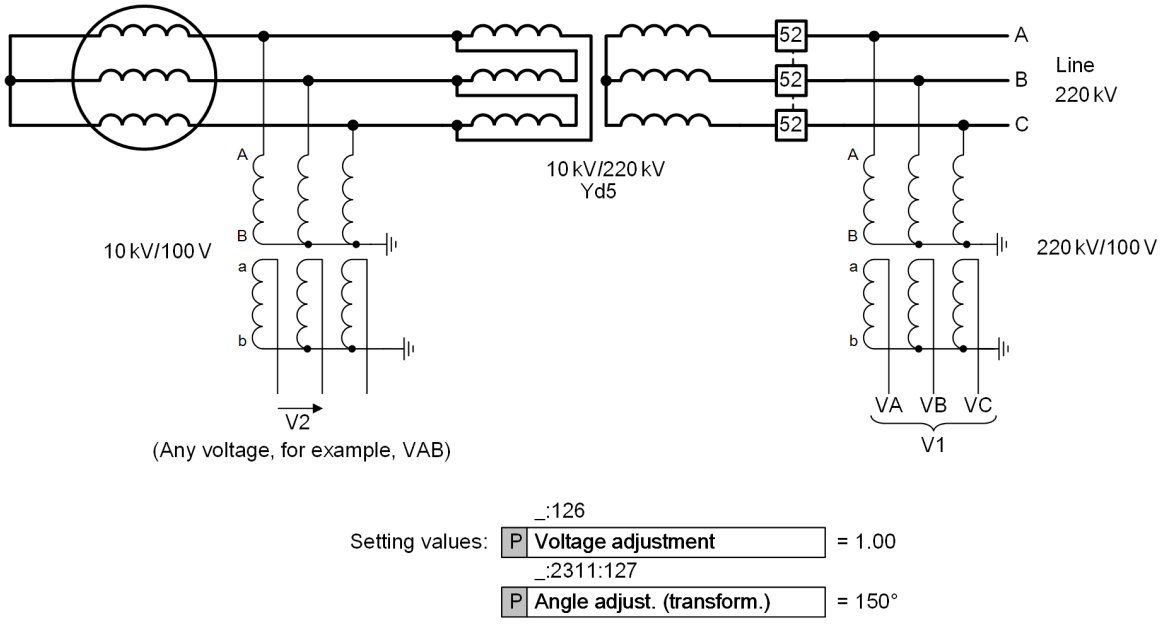
Parameter: **`Angle adjust. (transform.)`**

- 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:



[dw_transformer between the measuring points, 2, en_US]

Figure 7-124 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 7-124* shows such an application. The **`Angle adjust. (transform.)`** parameter is used to save the phase-angle rotation.

The transformer vector group is defined from the upper-voltage side to the undervoltage side. If the reference voltage transformer V1 is connected on the upper-voltage side of the transformer (as in *Figure 7-124*), 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 undervoltage 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.

7.8.4.3 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

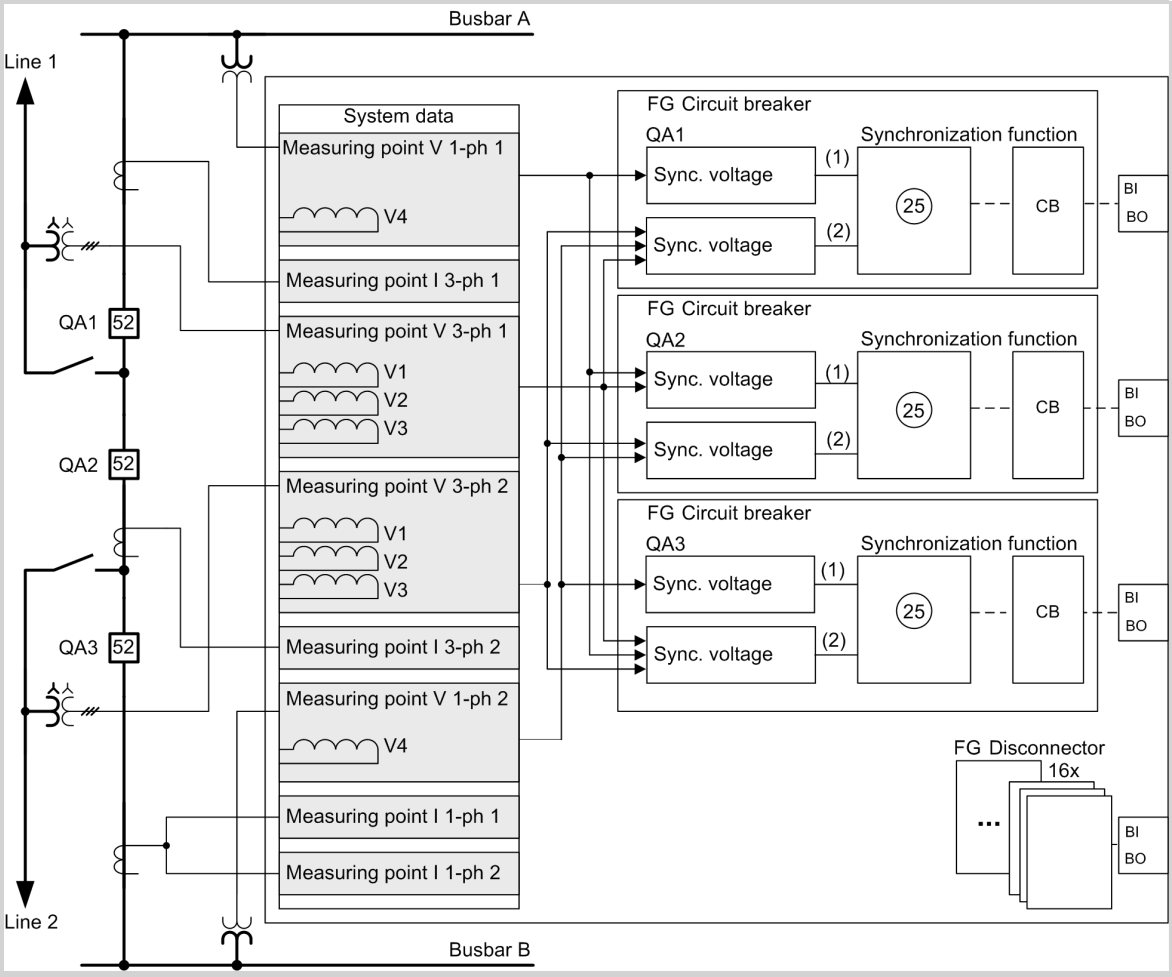
7.8.5 Dynamic Measuring-Point Switching

Dynamic measuring-point switching provides the capability to connect the voltages used in the Synchrocheck 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 function group **Circuit breaker**.

Selection of the desired voltage measuring points (*V sync1* and *V sync2*) for the function group **Circuit breaker** is controlled via Continuous Function Chart.

Example

Figure 7-125 shows an example of a synchrocheck in a breaker-and-a-half arrangement. If circuit breaker QA2 is to be closed, the reference voltages must be selected from several possible measuring points. This selection of measuring points is dependent on the switch positions of all circuit breakers and disconnectors.



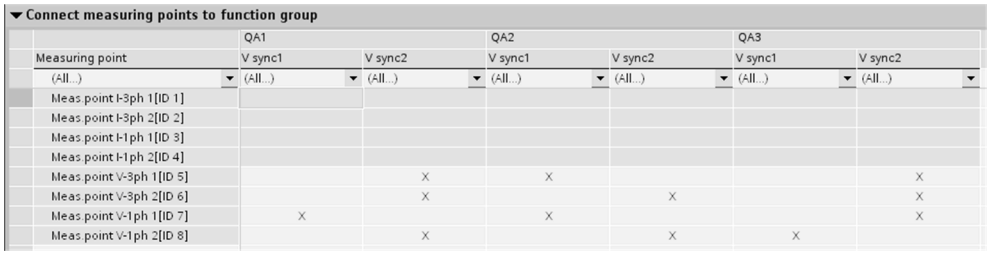
[dwdynmsu-140212-01.tif, 1, en_US]

Figure 7-125 Synchronization in a Breaker-and-a-Half Arrangement

Each synchronization function requires 2 comparison voltages. For the circuit breaker QA2 located in the middle, there are 2 options for each side (V_{sync1} and V_{sync2}). The selection of synchronization voltages for each side depends on the position of the circuit breaker and the disconnectors.
For circuit breakers QA1 and QA3, the busbar voltage (V_{sync1}) is available for one side, and 3 voltages (V_{sync2}) are available for the other side.

Connecting Measuring Points to Circuit-Breaker Function Group

The following figure shows the connection of the function group **Circuit breaker** 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]

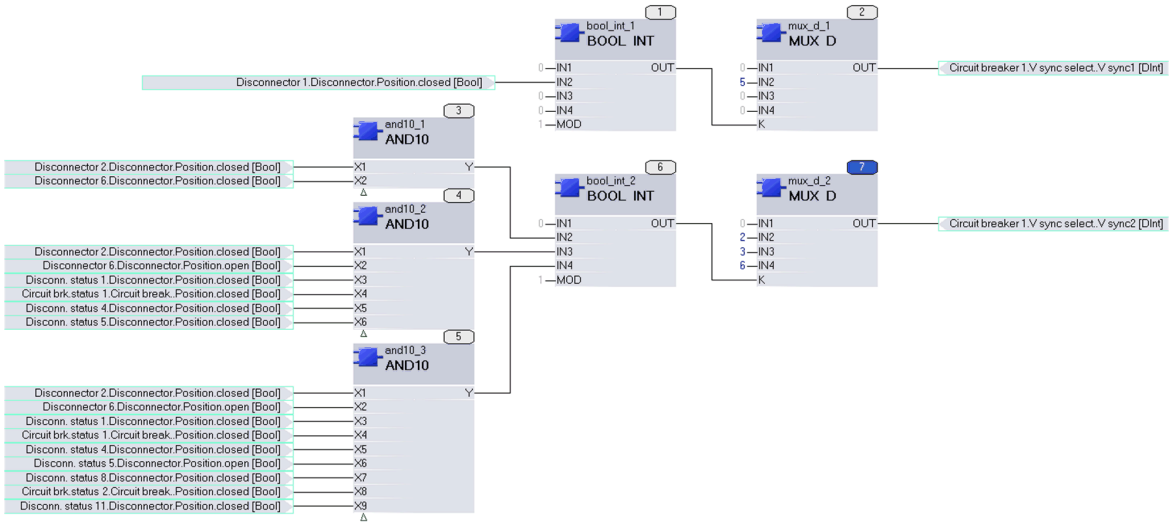
Figure 7-126 Connecting the Measuring Points with the Function Group Circuit-Breaker

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 function group **Circuit breaker**, the function block **V sync select.** has to be removed from the library in the function group **Circuit breaker**. 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.

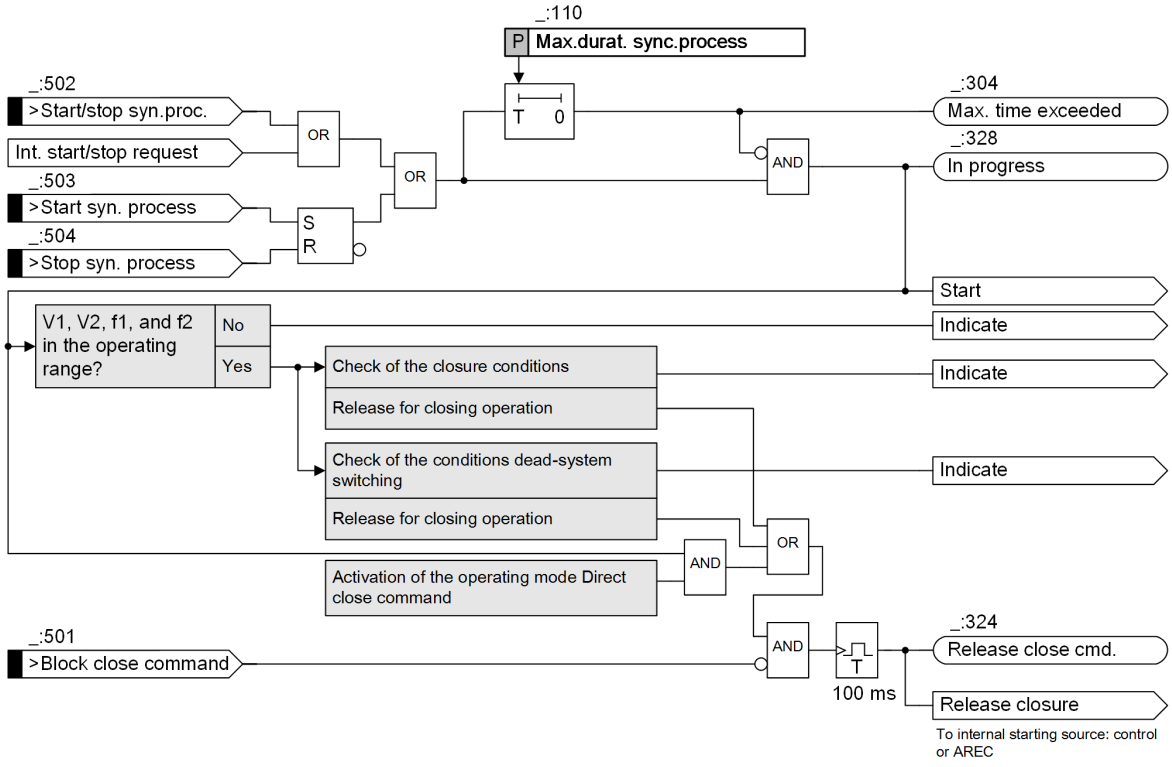


[scdynmsx-160212-01.tif, 1, en_US]

Figure 7-127 CFC Logic: Voltage Selection Using Measuring Point ID

If (defined by the switch or disconnector positions) no measuring point can be selected, 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.

7.8.6 Sequence of Functions



[lo_syn_w.o. mutliple selection, 1, en_US]

Figure 7-128 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 control or externally via binary input signals (see *7.8.10 Interaction with Control and External Triggering*).

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 *7.8.4.1 Description*). If this is not the case, the closing conditions are not checked.



NOTE

The synchronization function does not support multiple synchronization stages. Therefore, it is unnecessary to activate the binary signal **`>Selection`**.

Checking the Closing Conditions, Closure

After starting, the parameterized closing conditions are checked, depending on the selected operating mode. 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 chapter *7.8.7.1 Description*). The release is signaled via the **`Release close cmd.`** indication. This indication is active for 100 ms. With an internal start, the control performs the actual closure, depending on the internal 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 *7.8.8.1 Description*). The fulfilled conditions are signaled. An adjustable supervision time starts after the closure conditions are fulfilled (parameter **Supervision time**). If the conditions remain valid until expiry of the time, the function gives the release for closure after expiry of the time.

Direct Close Command

If the **Direct close command** operation is active, the function instantaneously initiates the release for closure after the successful start (see chapter *7.8.9 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 control , 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.

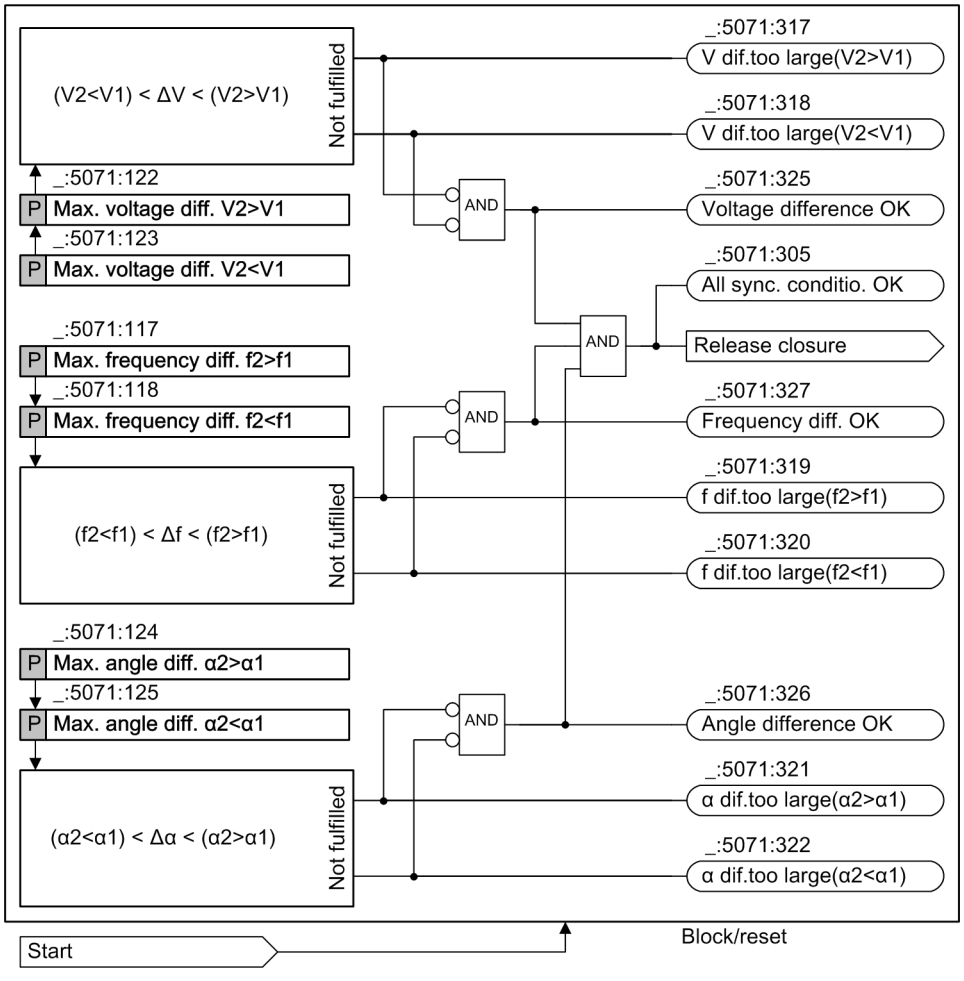
Blocking Closure

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.

7.8.7 Stage Synchrocheck

7.8.7.1 Description

Checking Closing Conditions



[lo_synche-01, 2, en_US]

Figure 7-129 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 section **Checking the Closing Conditions, Closure** in chapter *7.8.6 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.

Continuous Supervision

With the parameter **`Continuous supervision`** selected, even if there is no trigger for the signal *`start`*, the device can continuously monitor the voltage difference, frequency difference, and angle difference of the circuit breaker. Meanwhile, the indications *`in progress`*, *`release close command`*, and *`max. duration time expired`* are not issued.

If you want to release the close command, a trigger for the signal *start* is necessary.

If you keep the default setting, then the stage **Synchrocheck** runs as normal.

7.8.7.2 Application and Setting Notes

Parameter: Sync. operating mode

- Default setting **Sync. operating mode** = ***on***

With the parameter **Sync. operating mode**, you can switch the operating mode of the synchronization condition ***on*** or ***off***. The operating mode is activated in the default setting.

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.

7.8.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:5071:1	Synchrocheck 1:Mode		• off • on • test	off
_:5071:113	Synchrocheck 1:Continuous supervision		• 0 • 1	false
_: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

Addr.	Parameter	C	Setting Options	Default Setting
_:5071:106	Synchrocheck 1:Close cmd. at V1> & V2<		• no • yes	no
_:5071:107	Synchrocheck 1:Close cmd. at V1< & V2<		• no • yes	no
_: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	0.10 s
Synchr. conditions				
_:5071:115	Synchrocheck 1:Sync. operating mode		• off • on	on
_: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 Hz to 2.000 Hz	0.100 Hz
_:5071:118	Synchrocheck 1:Max. frequency diff. f2<f1		0.000 Hz to 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 °

7.8.7.4 Information List

No.	Information	Data Class (Type)	Type
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

No.	Information	Data Class (Type)	Type
_: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

7.8.8 Closing at De-Energized Line/Busbar

7.8.8.1 Description

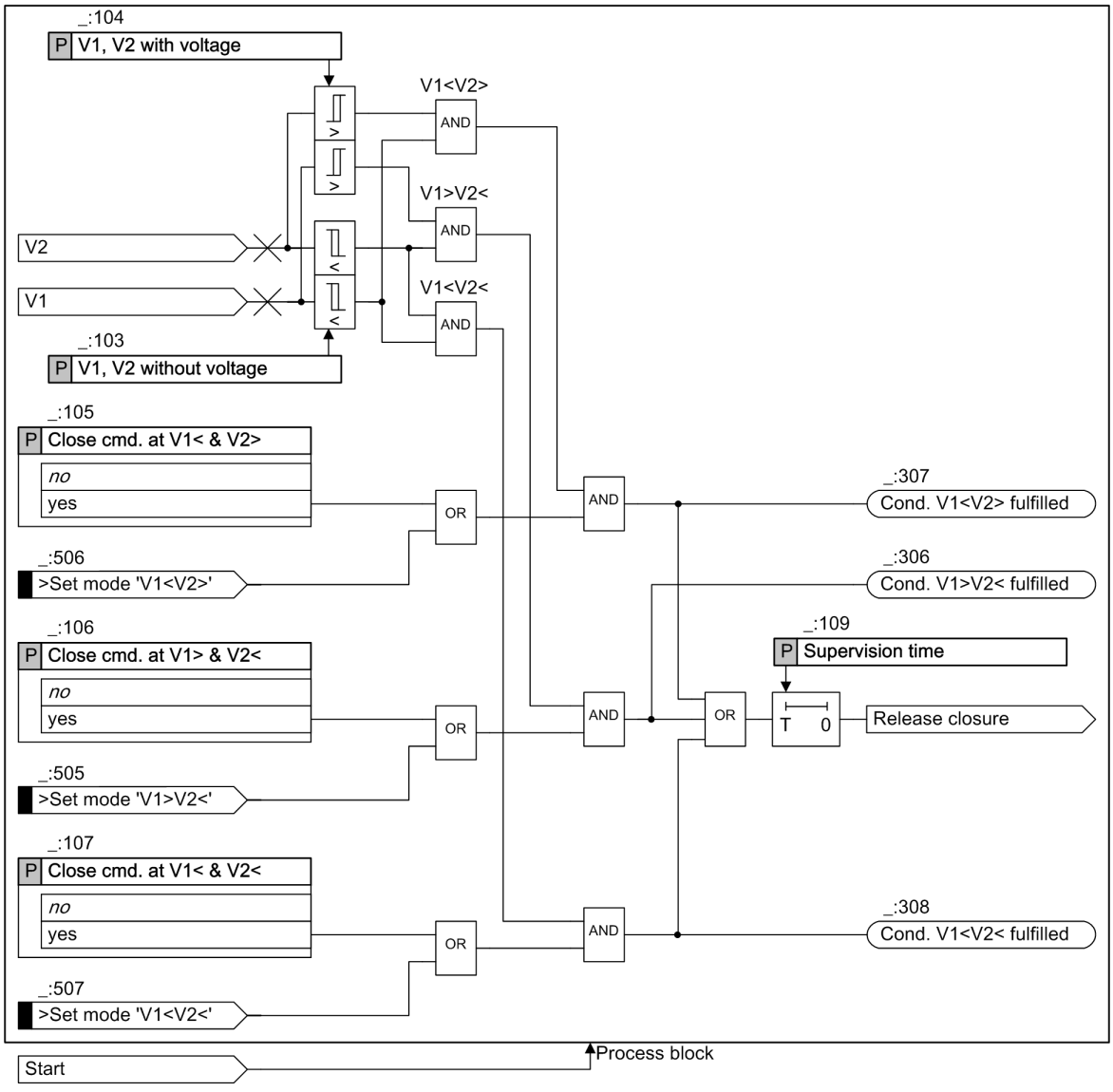
If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes.

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 *7.8.4.1 Description*) 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.
`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.



[lo_syn003-01, 2, en_US]

Figure 7-130 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.

If the following 2 conditions are met, these indications refresh automatically:

- You set the parameter **Sync. operating mode** to ***on***.
- You select the parameter **Continuous supervision**.

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.

7.8.8.2 Application and Setting Notes

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 7-130*). 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 V1of 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 V1of 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`***

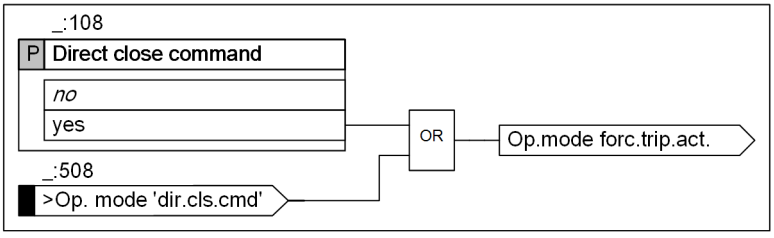
In this operating mode, the function initiates a closing release without any testing upon start of the synchronization stage. The closure occurs immediately.

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 7-132*). This prevents this operating mode from being incorrectly activated statically thereby resulting in an incorrect switching.

7.8.9 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 7-131*).



[lo_syndir_01, 2, en_US]

Figure 7-131 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 mode 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 *7.8.4.1 Description*).

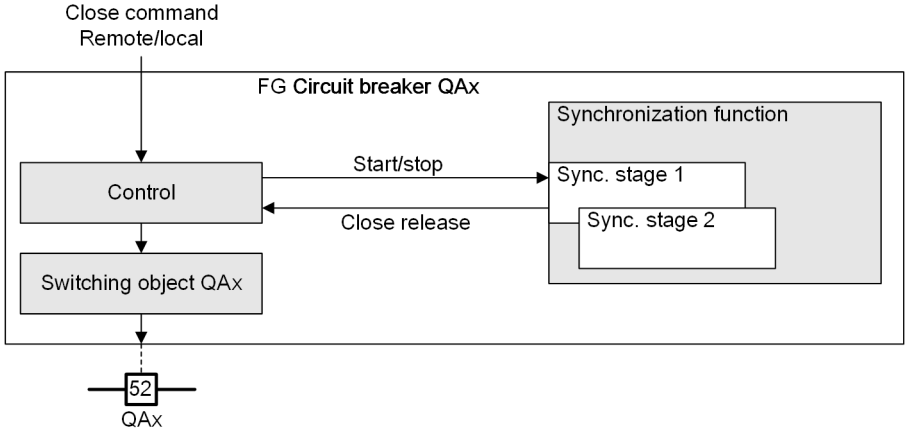
7.8.10 Interaction with Control and External Triggering

With Control

The control and synchronization functions are always located in a **Circuit-breaker** function group. 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 **Circuit-breaker** function group, 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 *7.8.6 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.



[lo_synaw1-01, 3, en_US]

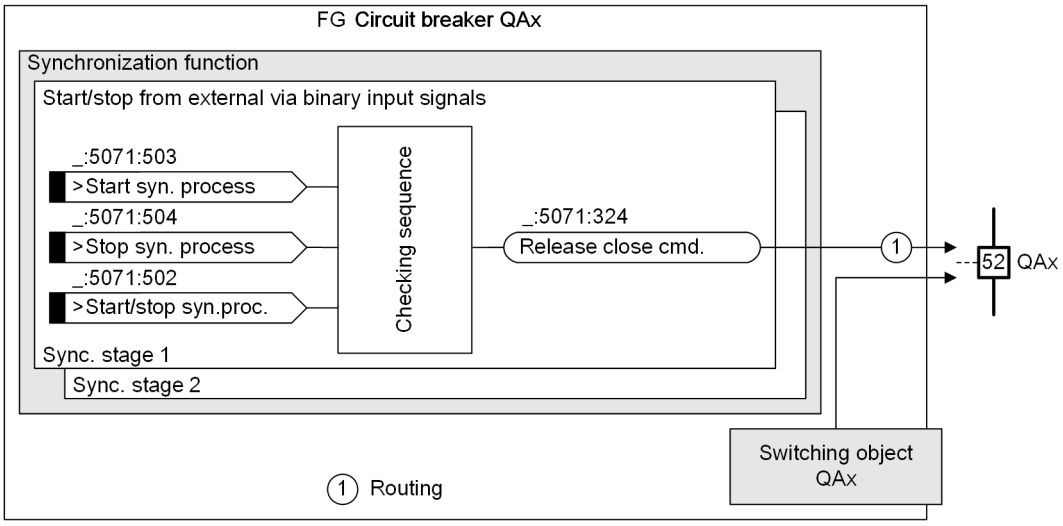
Figure 7-132 Interaction of the Control with the Synchronization Function

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 *7.8.6 Sequence of Functions*).

The start is followed by the functional sequence (see *7.8.6 Sequence of Functions*). If the conditions are fulfilled, the output signal **Release close cmd.** is output. The switched object QAx of the function group **Circuit breaker** is not closed. The output signal **Release close cmd.** must be explicitly routed to the binary output in order to close the circuit breaker.



[lo_synaw3-01, 3, en_US]

Figure 7-133 Interaction of the Synchronization Function with External Control

7.8.11 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
_:5071:113	Synchrocheck 1:Contin-uous supervision		• 0 • 1	false
_: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	0.10 s
Synchr. conditions				
_:5071:115	Synchrocheck 1:Sync. operating mode		• off • on	on
_: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 Hz to 2.000 Hz	0.100 Hz
_:5071:118	Synchrocheck 1:Max. frequency diff. f2<f1		0.000 Hz to 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 °

7.8.12 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
_: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

No.	Information	Data Class (Type)	Type
_: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

7.9 User-Defined Function Block [Control]

7.9.1 Overview of Functions

The **User-defined function block [control]** allows the switching-authority check of a control command, the check of whether the position has been reached, a double-activation blocking, and the definition of interlocking conditions for user-defined controllables.

7.9.2 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 and the interlocking conditions for the user-defined control commands instantiated within it. For these control commands, the function block checks whether the required switch position is equal to the current switch position (actual/set point comparison).
If you activate the double-activation blocking, commands from switching objects and user-defined control signals will be rejected as long as a command is still being performed for one of the other switching objects for which double-activation blocking has also been set.

With the binary release signals, you can determine a switchgear interlocking protection for all the user-defined control signals instantiated in the function block. Unlike the switching devices (circuit breaker, disconnector), there is only one release input here, since there is only one switching direction for the signal types INC and APC. The signal types DPC, SPC, and BSC have 2 switching directions, but still only one release input. This release input can be operated based on the result of a logic created in the CFC, or can be directly connected to a binary input or a variable. If the input **>Enable** is activated, the switching command can be performed. If it is not activated, the switching command is rejected, with the reason *Interlocking violation*.

This applies in a similar way to the input **>Enable (fixed)**, although with this input, the interlocking cannot be revoked by key switch S1 or an *unlocked* switching authority.

The following table shows the reaction of the function to the assignment of its inputs.

Input >Enable	Input >Enable (fixed)	Effect on control command
1	0	Rejected
0	1	Successful if device mode = *unlocked* Rejected if device mode = *locked*
1	1	Successful
0	0	Rejected



NOTE

The default setting for the state of the inputs is **1**, that is, the switching commands are not locked.

You can instantiate every user-defined signal (for example, SPS, DPC, INC) in the function block and route the corresponding indications (see following figure).

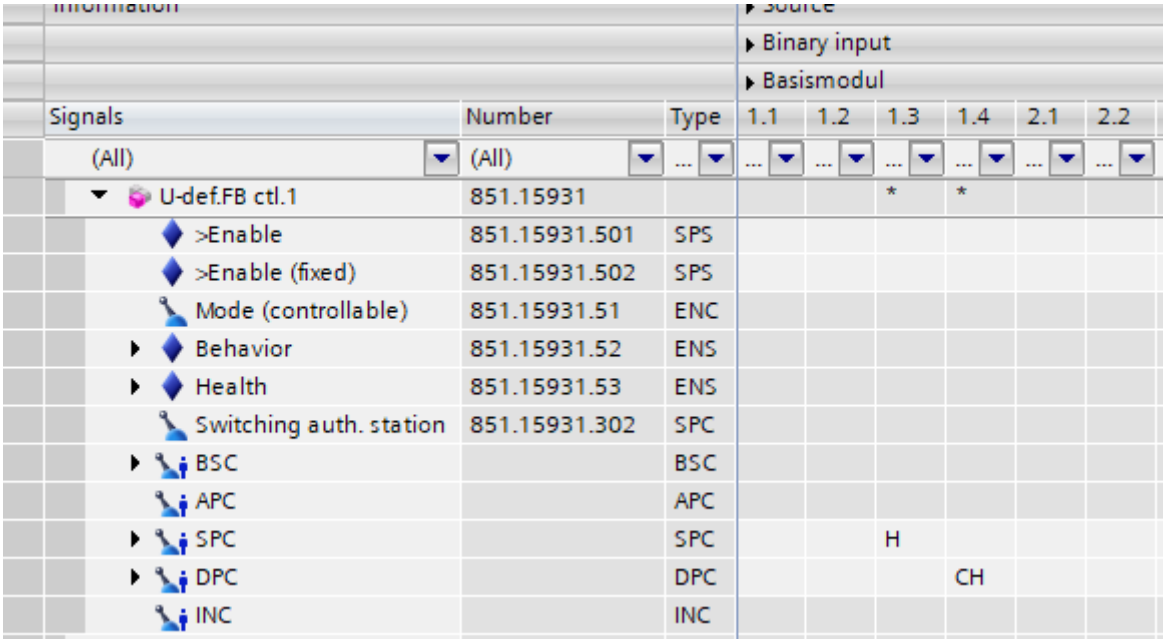
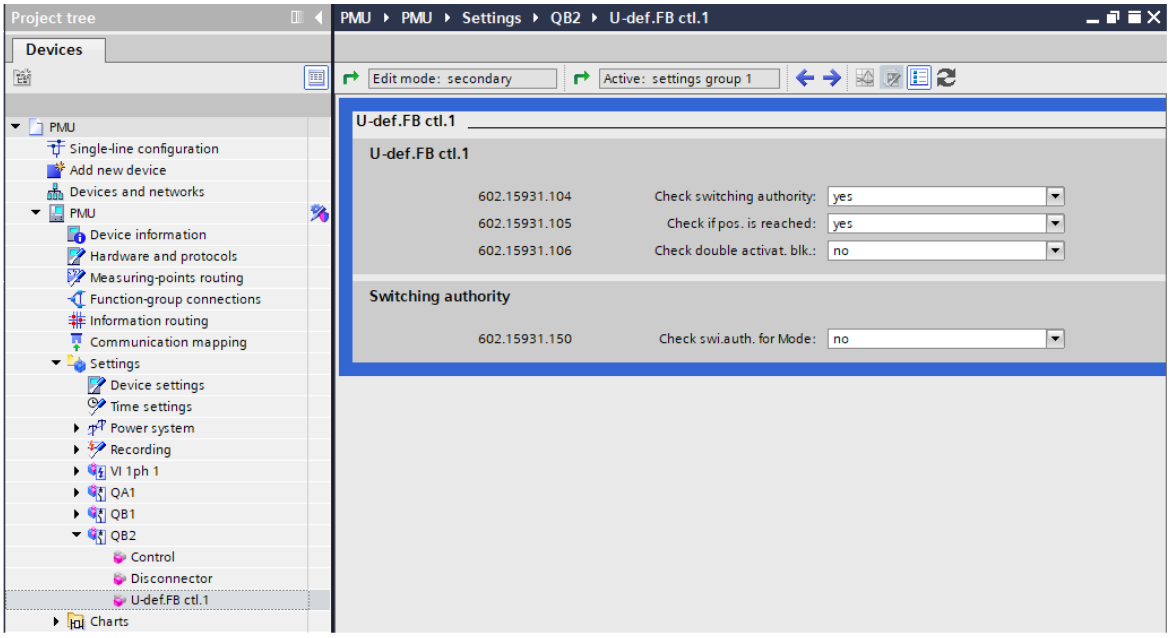


Figure 7-134 Information Routing with Inserted User-Defined Function Block [Control]: Process Indications and Some Single-Point Indications

7.9.3 Application and Setting Notes

The function block contains the parameters **(_:104) Check switching authority**, **(_:105) Check if pos. is reached**, **(_:106) Check double activat. blk.**, and **(_:150) Check swi.auth. for Mode**. The parameter settings **Check switching authority** and **Check if pos. is reached** affect all controllables instantiated **in the** function block. Other signal types are not affected by these parameters and objects.

On the other hand, the parameter setting **Check swi.auth. for Mode** affects the controllable **Mode (controllable)** of the function block.



[sc_user_02, 1, en_US]

Figure 7-135 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 *7.4.1 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.

Parameter: **`Check double activat. blk.`**

- Default setting **`(_:106) Check double activat. blk.`** = ***`no`***

With the **`Check double activat. blk.`** parameter, you check whether commands from switching objects and user-defined control signals should be rejected, as long as a command is still being executed for one of the other objects.

Parameter: **`Check swi.auth. for Mode`**

- Default setting **`(_:150) Check swi.auth. for Mode`** = ***`no`***

With the **`Check swi.auth. for Mode`** parameter, you specify whether the switching authority for the command source must be checked when switching the controllable **`Mode (controllable)`** to the mode ***`On`***, ***`Off`***, or ***`Test`***. If you set the parameter **`Check swi.auth. for Mode`** to ***`yes`***, the switching command is only executed with the appropriate switching authority (see chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

7.9.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
U-def.FB ctl.#				
_:104	U-def.FB ctl.#:Check switching authority		• no • yes • advanced	yes
_:105	U-def.FB ctl.#:Check if pos. is reached		• no • yes	yes
_:106	U-def.FB ctl.#:Check double activat. blk.		• no • yes	no
Switching authority				
_:150	U-def.FB ctl.#:Check swi.auth. for Mode		• no • yes	no
_:151	U-def.FB ctl.#:Swi.dev. related sw.auth.		• 0 • 1	false
_:152	U-def.FB ctl.#:Specific sw. authorities		• 0 • 1	true
_:115	U-def.FB ctl.#:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:153	U-def.FB ctl.#:Num. of specific sw.auth.		2 to 5	2
_:155	U-def.FB ctl.#:Ident. sw.auth. 1		Freely editable text	
_:156	U-def.FB ctl.#:Ident. sw.auth. 2		Freely editable text	
_:157	U-def.FB ctl.#:Ident. sw.auth. 3		Freely editable text	
_:158	U-def.FB ctl.#:Ident. sw.auth. 4		Freely editable text	
_:159	U-def.FB ctl.#:Ident. sw.auth. 5		Freely editable text	
_:154	U-def.FB ctl.#:Multiple specific sw.auth.		• 0 • 1	false

7.9.5 Information List

No.	Information	Data Class (Type)	Type
U-def.FB ctl.#			
_:501	U-def.FB ctl.#:>Enable	SPS	I
_:502	U-def.FB ctl.#:>Enable (fixed)	SPS	I
_:503	U-def.FB ctl.#:>Sw. authority local	SPS	I
_:504	U-def.FB ctl.#:>Sw. authority remote	SPS	I
_:505	U-def.FB ctl.#:>Sw. mode interlocked	SPS	I
_:506	U-def.FB ctl.#:>Sw. mode non-interl.	SPS	I
_:51	U-def.FB ctl.#:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:52	U-def.FB ctl.#:Behavior	ENS	O
_:53	U-def.FB ctl.#:Health	ENS	O
_:302	U-def.FB ctl.#:Switching auth. station	SPC	C
_:308	U-def.FB ctl.#:Enable sw. auth. 1	SPC	C
_:309	U-def.FB ctl.#:Enable sw. auth. 2	SPC	C
_:310	U-def.FB ctl.#:Enable sw. auth. 3	SPC	C
_:311	U-def.FB ctl.#:Enable sw. auth. 4	SPC	C
_:312	U-def.FB ctl.#:Enable sw. auth. 5	SPC	C
_:313	U-def.FB ctl.#:Switching authority	ENS	O
_:314	U-def.FB ctl.#:Switching mode	ENS	O

7.10 CFC-Chart Settings

7.10.1 Overview of Functions

If you want to process a parameter in a CFC chart and this parameter is to be changeable during runtime using DIGSI or HMI, you can use the function blocks **CFC chart of Boolean parameters**, the **CFC chart of integer parameters** and the **CFC chart of floating-point parameters**. Instantiate the appropriate function block depending on the parameter value needed (logical, integer, or floating point). In this way, the current value of the parameter can then be used in the CFC chart at runtime.

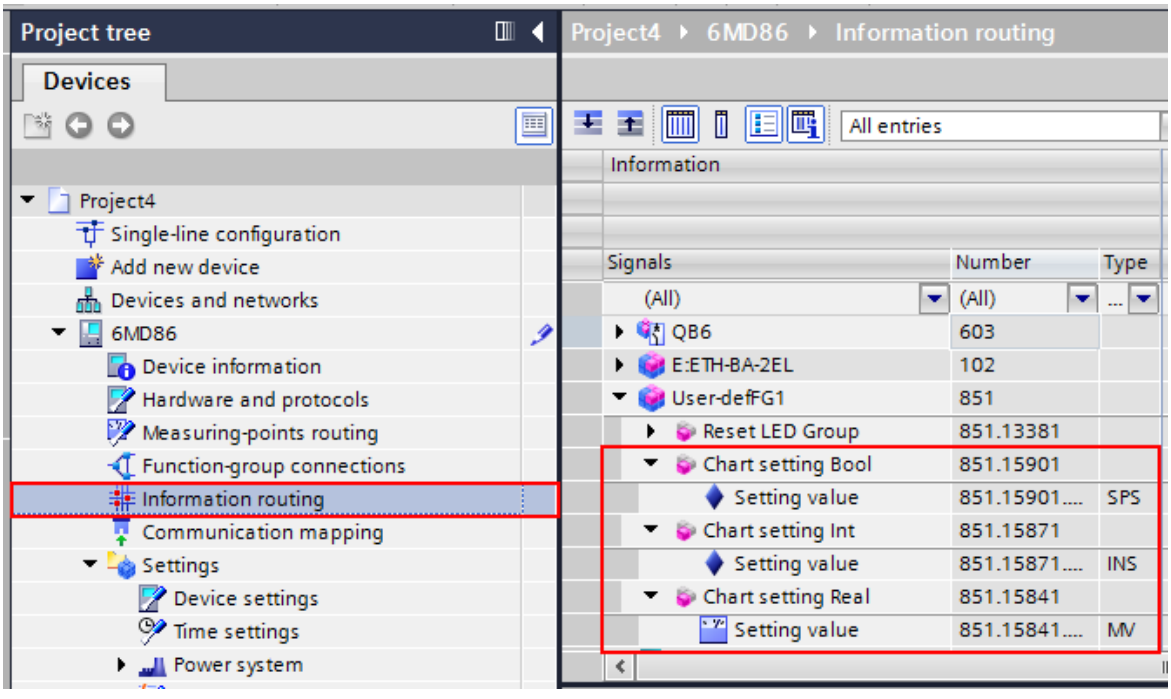
7.10.2 Function Description

You can find the CFC-chart parameters **`Chrt sett.Bool`**, **`Chart setting Int`**, and **`Chrt sett.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.

With **Exp. options**, you define the range and the unit of the value. This prevents users from entering incorrect setting values.

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.



[sc_cfc_param, 1, en_US]

Figure 7-136 CFC-Chart Parameters within Information Routing

7.10.3 Application and Setting Notes

Parameter: **Chrt sett.Bool**

- Default setting **Chrt sett.Bool** = ***False***

You can use the parameter **Chrt sett.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: **Chrt sett.real**

- Default setting **Chrt sett.real** = ***100.000***

You can use the parameter **Chrt sett.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.

7.10.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Chrt sett.Bool				
_:105	Chrt sett.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
Chrt sett.real				
_:105	Chrt sett.real:Value		-10000000000.000 % to 10000000000.000 %	100.000 %

7.10.5 Information List

No.	Information	Data Class (Type)	Type
Chrt sett.Bool			
_:305	Chrt sett.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
Chrt sett.real			
_:305	Chrt sett.real:Setting value	MV	O

7.11 Tap Changers

7.11.1 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 and monitoring functions. The supervision and monitoring functions are used to check the voltage and supply information about the tap position for adaptive matching of the paralleling function.

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 7-137 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.

For more information, refer to *7.11.2 Application and Setting Notes*.

The **Position** Controllable also contains parameters. 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 1

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.

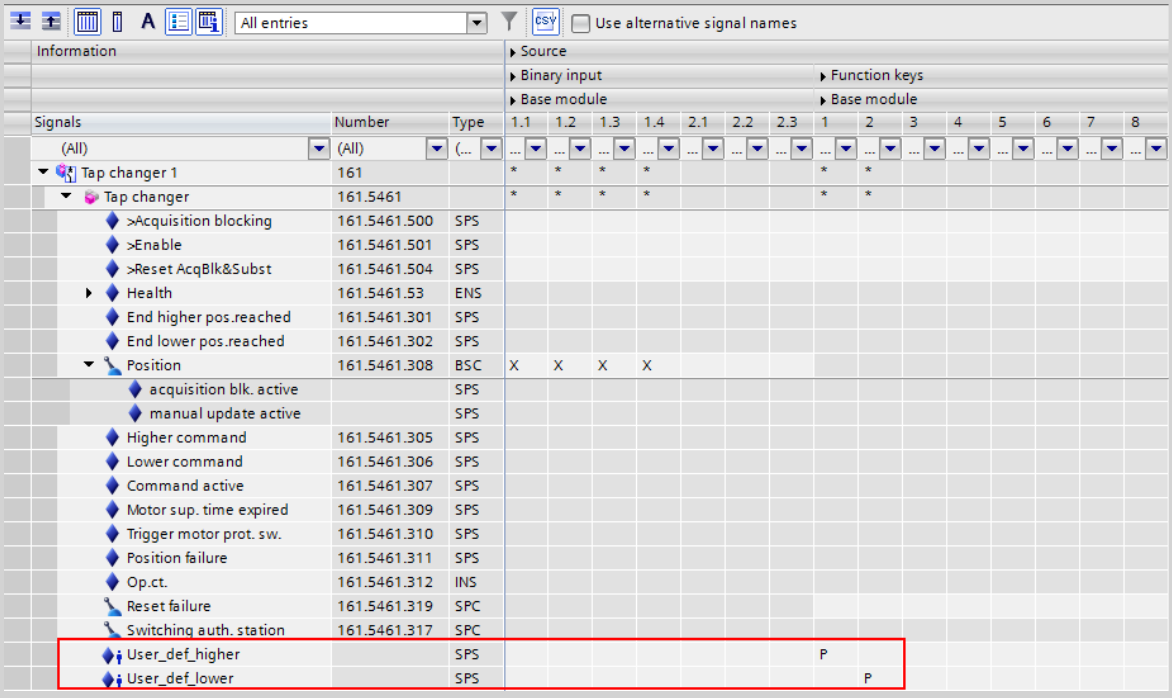


Figure 7-138 Routing of the Function Keys and CFC Signals

To use the function keys, you create 2 user-defined single-point indications (SPS). These are used for the function keys and as the input signals for the appropriate CFC blocks. For example, <F1> as Higher function key and <F2> as Lower function key.

The **Higher command** or **Lower command** must not be connected as an output in the CFC. The CFC block **BSC_DEF** connects them automatically.

You can select the control direction using the following values at the **Val** input of the **BSC_DEF** building block:

- 1 means **step up**
- 0 means **step down**

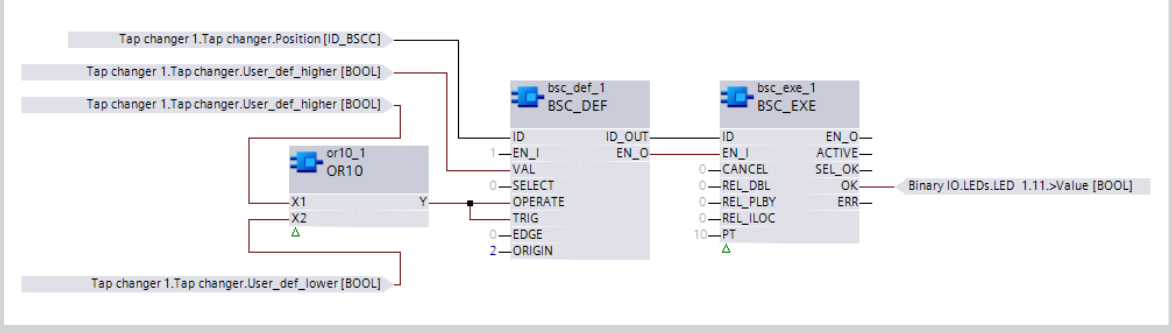
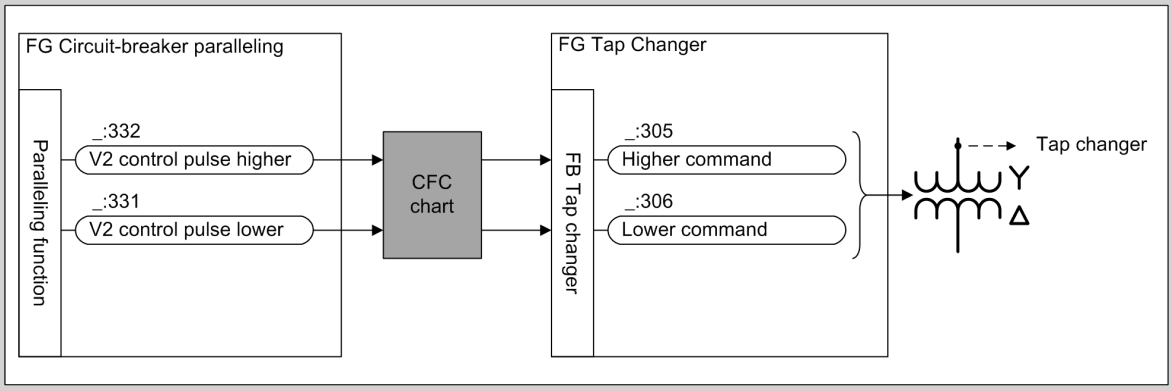


Figure 7-139 CFC Chart

With this CFC chart, you can step up or step down the tap position by pressing the function keys.

Example 2

With a CFC chart, the paralleling function can control the tap changer automatically.

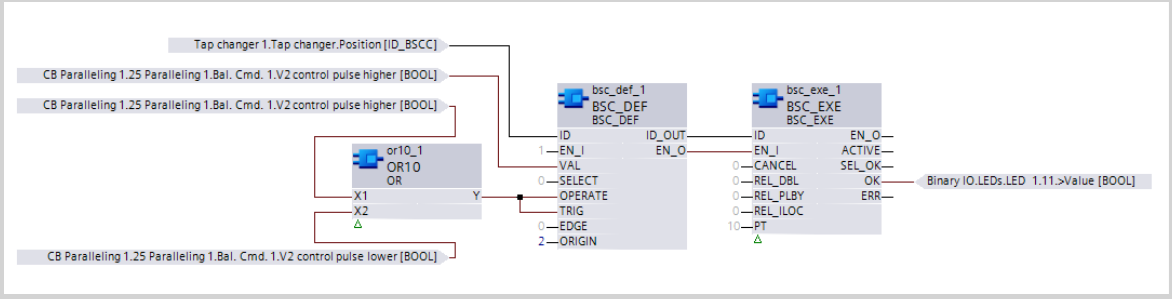


[dw_tap-changer control with CFC, 1, en_US]

Figure 7-140 Tap-Changer Control with the Paralleling Function

The following 2 figures show CFC charts as examples of the automatic tap-changer control:

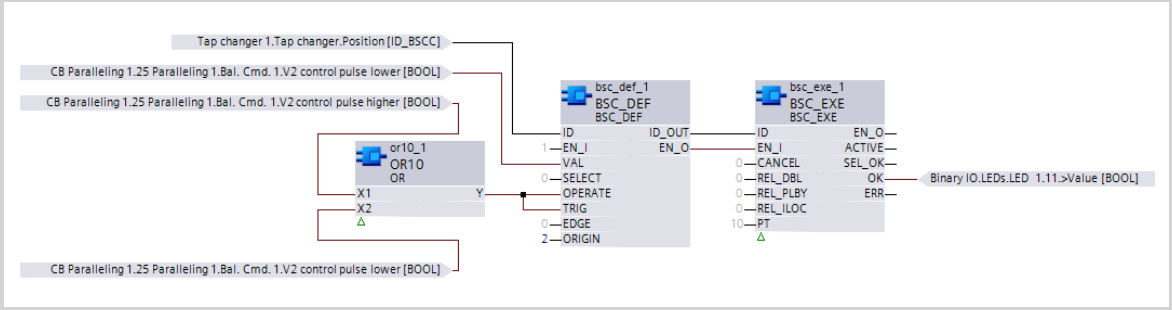
- If you wish to increase the voltage V2 with the **Higher command**, use the following CFC chart:



[sc_CFC_H, 1, en_US]

Figure 7-141 CFC Chart for the Tap Changer with the **Higher Command**

- If you wish to increase the voltage V2 with the **Lower command**, use the following CFC chart:



[sc_CFC_L, 1, en_US]

Figure 7-142 CFC Chart for the Tap Changer with the **Lower Command**

Motor Supervision Time

The runtime of the motor-drive mechanism can be monitored from the device. This function is used to identify failures of the motor-drive mechanism during the switching procedure and to trip actions if necessary. To use the **`Motor supervision time`**, you must route the motor sliding contact (most significant 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 for a duration of 1.5 s.

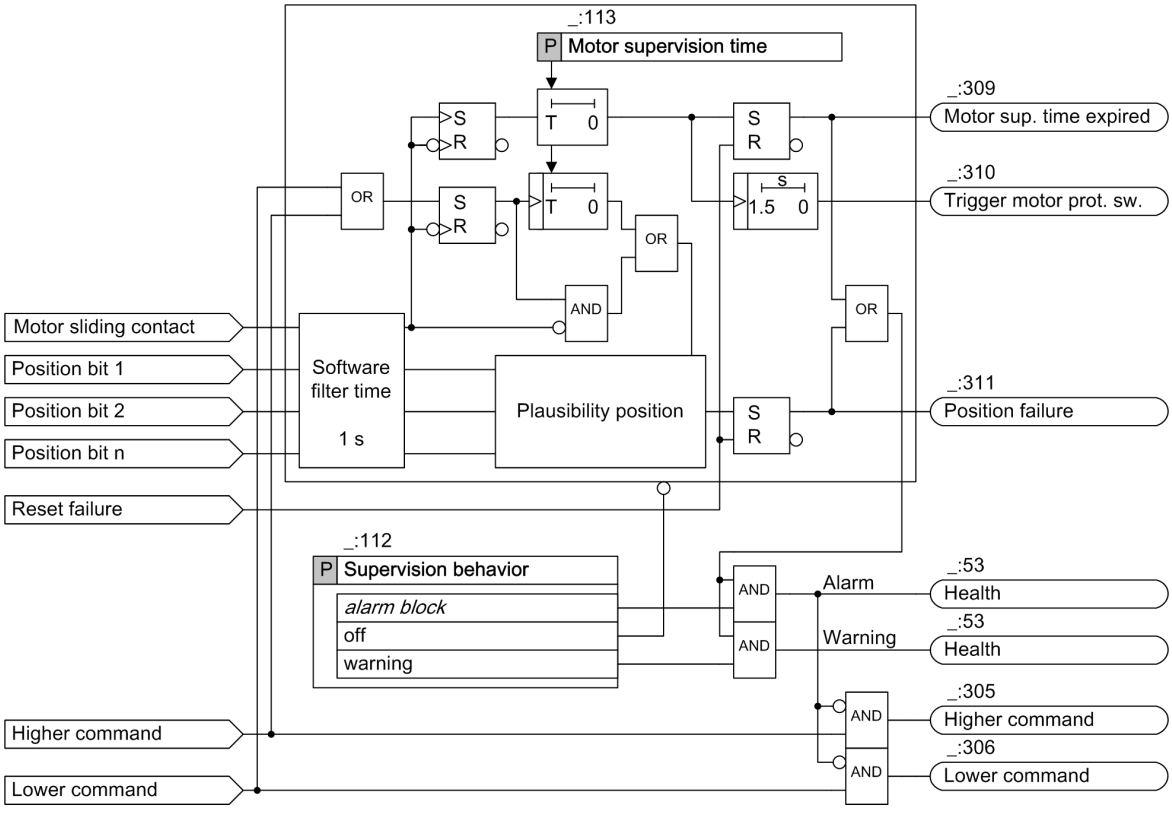
Adjusting-Command Supervision

Adjusting-command supervision 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 tap 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 calculated tap position could not be received within the parameterized time **Motor supervision time**, the error message *Position failure* is output.

The following position errors of the tap changer are taken into consideration during this:

- Invalid tap position: The tap position is outside the predefined range of **minimum value** and **maximum value**
- Adjusting command in the wrong direction (for example, if a higher tap was commanded and the tap changer responds with a lower position and 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 in the **Position** controllable only as an invalid tap position.



[lo_tcmoue, 3, en_US]

Figure 7-143 Position and Motor Supervision Logic

The user-defined signals **Higher command** and **Lower command** are provided via a CFC chart (refer to *Figure 7-139*).

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 parameter **Supervision behavior** 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 manually reset the health state of ***alarm block*** or ***warning*** 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.

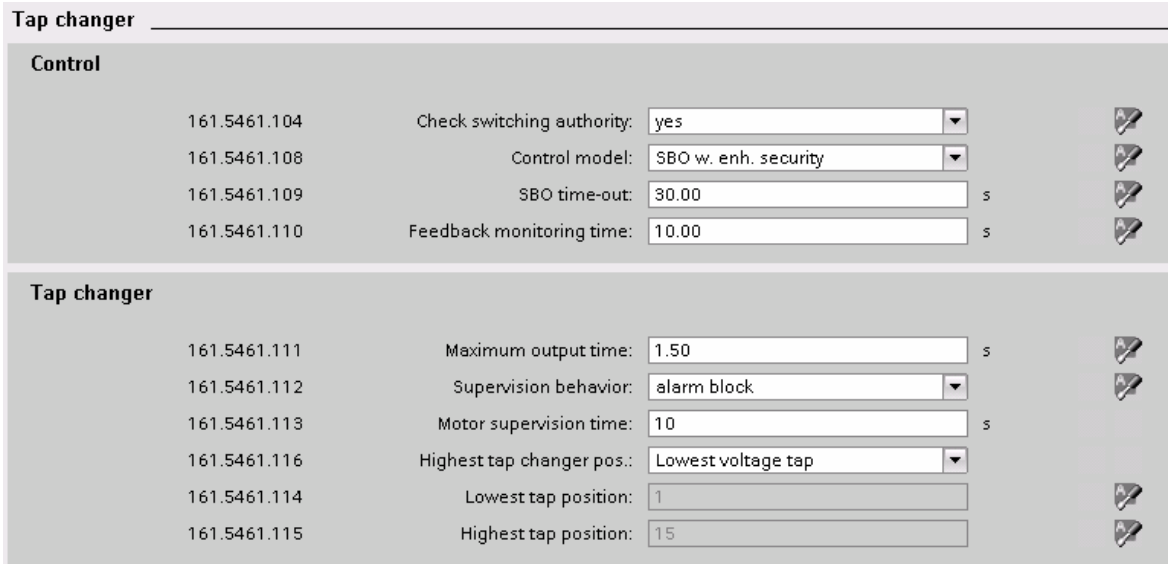
Operating Counter

The device counts the number of successfully completed adjusting commands with the ***Op.ct.*** switching cycle counting value. The counting and memory levels are protected against an auxiliary-voltage failure. The switching cycle counting value can be set 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.

7.11.2 Application and Setting Notes

Parameters of the Tap Changer Function Group



[scstuslt-100713-01.tif, 2, en_US]

Figure 7-144 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 of the motor sliding contact.

Parameter: `Check switching authority`

- Default setting **`(_:104) Check switching authority`** = ***`yes`***

With the **`Check switching authority`** parameter, you specify whether the switching authority (on site, remote) is checked in the case of an adjusting command (see also chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

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. You can find additional information in section *Motor Supervision Time, Page 634*. The range of values extends from 5 s to 100 s.

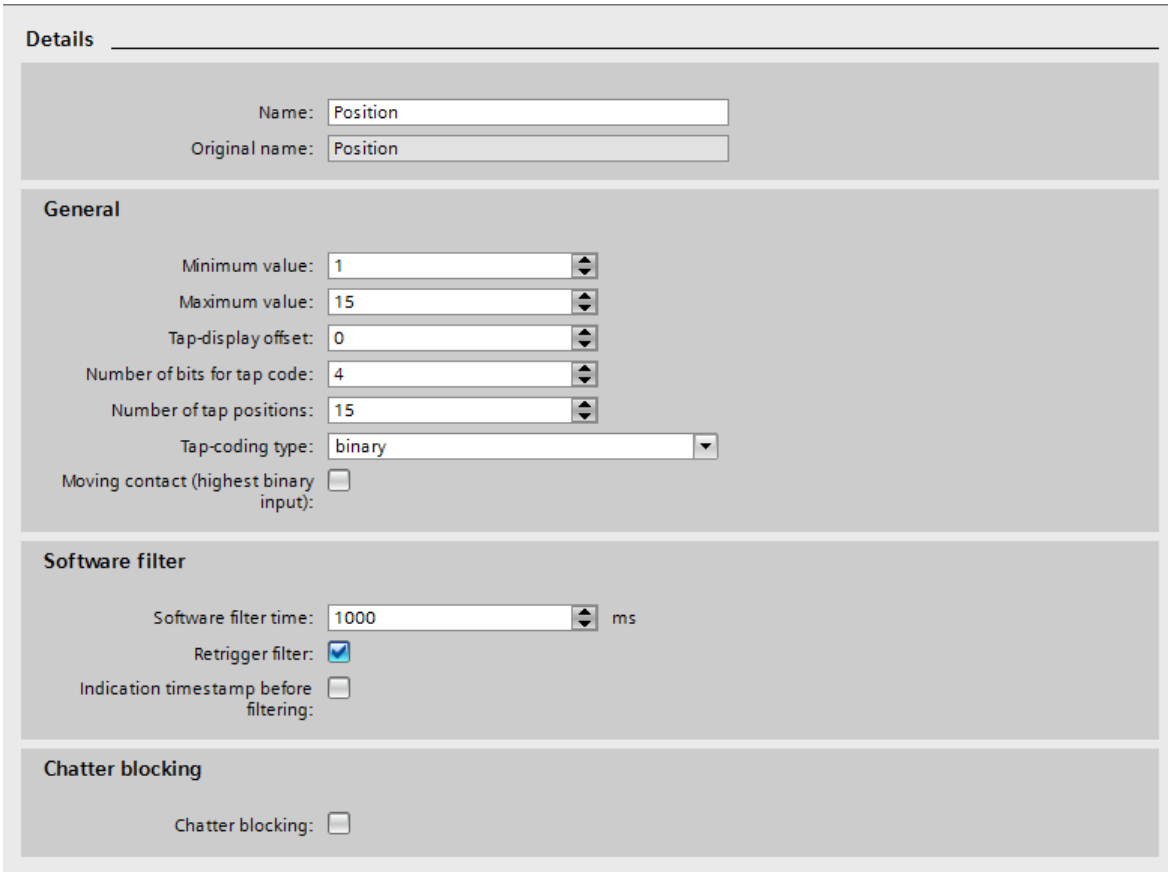
Parameter: **`Highest tap changer pos.`**

- Default setting **`(_:116) Highest tap changer pos.`** = ***`Lowest voltage tap`***

With the **`Highest tap changer pos.`** parameter, you specify 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.



[sc_deegts, 1, en_US]

Figure 7-145 Properties Dialog

Parameter: **`Minimum value`**

- Default setting **`Minimum value`** = ***`1`***

Parameter: **`Maximum value`**

- Default setting **`Maximum value`** = ***`15`***

The parameters **Minimum value** and **Maximum value** are initially calculated by DIGSI 5 on the basis of 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 **Number of tap positions** and **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, you set the number of bits you need for encoding 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 **Tap-display offset** parameter so that the output of 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*

The tap changer position can also be routed via a GOOSE signal (BSC) or a 20-mA measuring transducer input.

You can find more information on this in the document **Measuring the transformer tap changer using an analog measuring transducer input in SIPROTEC 5** in the Download area under *SIPROTEC 5 and DIGSI 5 downloads* → *SIPROTEC 5 General* → *Application Notes* → *Control*.

A selection of tap-coding types is described in greater detail using examples in the following text.

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 7-36 Routing of the Binary Inputs (Tap-Coding Type binary)

	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	X	–	–
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 metered value 3. You must configure the information properties as follows for the example:

Tap-coding type:	binary
Number of tap positions:	7
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)

The following table shows the routing of 6 binary inputs (BI 1 to BI 6) with 39 transformer tap positions designated 1 to 39. The encoding is in ***BCD***. BI 7 is the moving contact.

Table 7-37 Routing of the Binary Inputs (Tap-Coding Type BCD)

	Example						
	BI1	BI2	BI3	BI4	BI5	BI6	BI7
Tap changer	X	X	X	X	X	X	X
Meaning	BCD 1	BCD 2	BCD 4	BCD 8	BCD 10	BCD 20	Moving contact
Tap = 21	1	0	0	0	0	1	–

With 6 binary inputs, a maximum of 39 tap positions can be mapped with the tap-coding type of BCD. This yields the number of tap positions from 1 to 39. If all routed binary inputs indicate 0, this is detected as tap 0. The 7 binary inputs must be numbered sequentially, for example, BI 1, BI 2, BI 3, BI 4, BI 5, BI 6, and BI 7 for the moving contact.

Tap-coding type:	BCD
Number of tap positions:	39
Number of bits f. tap code:	7
Tap-display offset:	0
Moving contact (highest binary input):	Yes

Individual Tap-Coding Type (table)

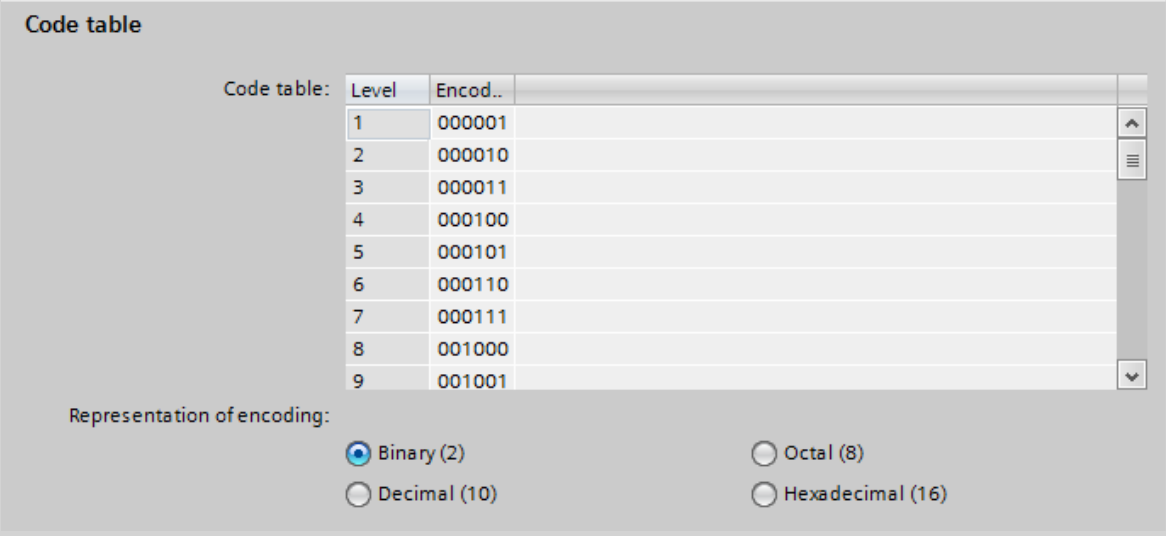
With the ***table*** parameter setting, you can specify an individual **Tap-coding type**.

In the **Representation of encoding** section, select the number 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 **Tap-coding type** list box.



[sc_cotabi, 1, en_US]

Figure 7-146 Code Table for the Tap-Coding Type table

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**, exception BCD signed, see *Routing of the Binary Inputs (Tap-Coding Type BCD signed), Page 641*.

Enter the encoding for the tap in the **Encoding** column in the **Code table**. Enter the value according to the number 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 BCD signed)

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 signed***.

Table 7-38 Routing of the Binary Inputs (Tap-Coding Type BCD signed)

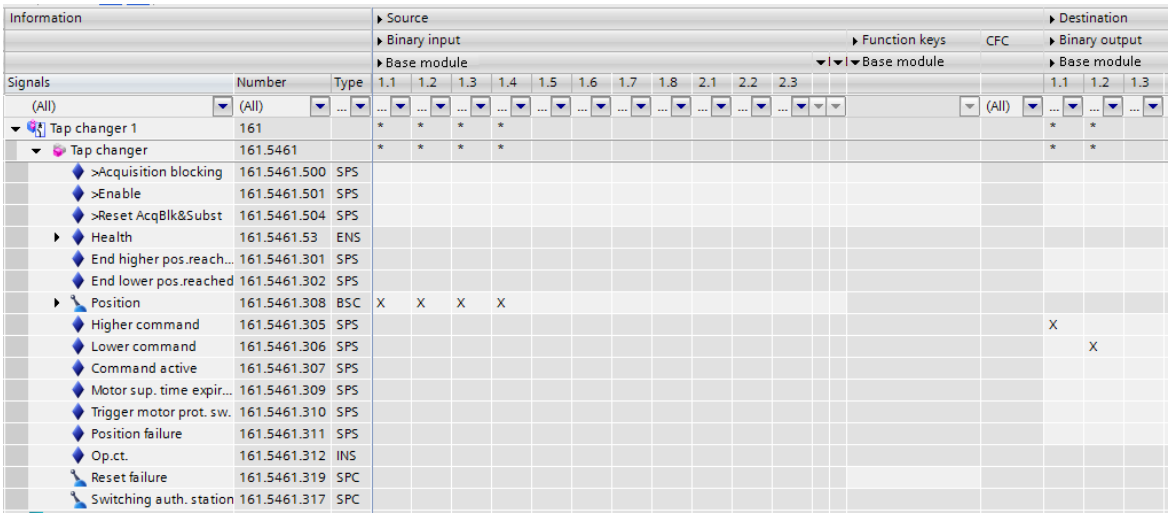
	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	–	–	–
Meaning	BCD 1	BCD 2	Sign	–	–	–
Tap = 1	1	0	1	–	–	–

Using 3 binary inputs, a maximum of 7 tap positions can be mapped with the tap coding type of BCD signed. 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 signed
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 7-147 Routing the Tap Setting Commands

Parameter: **`Moving contact (highest binary input)`**

- Default setting **`Moving contact (highest binary input)`** = ***no***

If the tap position is only to be recognized as valid and implemented when 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 position is only labeled with an * when the moving contact drops out.

Parameter: **`Software filter time`**

- Default setting **`Software filter time`** = ***1000 ms***

With this parameter, you set the **`Software filter time`** for capturing the tap position. The range of values extends from 0 ms to 100 000 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.

7.11.3 Settings (Properties Dialog)

The settings listed here can only be reached and changed by way of the **Properties** dialog of the **Position** Controllable.

Addr.	Parameter	C	Range of Values	Default Setting
`General Information`				
-	Minimum value		Calculated	-
-	Maximum value		Calculated	-
-	Tap-display offset		–63 to +63	0
-	Number of bits f. tap code		2 to 32	4
-	Number of tap positions		2 to 63	15
-	Tap-coding type		• binary • 1-of-n • BCD • table • BCD signed • gray	binary
`Software filter`				
-	Software filter time		0 ms to 100 000 ms	1000 ms

7.11.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Control`				
_:104	Tap changer:Check switching authority		• no • yes • advanced	yes
_: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

Addr.	Parameter	C	Setting Options	Default Setting
_:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:114	Tap changer:Lowest tap position		-64 to 64	1
_:115	Tap changer:Highest tap position		-64 to 64	15
Switching authority				
_:117	Tap changer:Swi.dev. related sw.auth.		• 0 • 1	false
_:118	Tap changer:Specific sw. authorities		• 0 • 1	true
_:119	Tap changer:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:120	Tap changer:Num. of specific sw.auth.		2 to 5	2
_:121	Tap changer:Multiple specific sw.auth.		• 0 • 1	false

7.11.5 Information List

No.	Information	Data Class (Type)	Type
Tap changer			
_:500	Tap changer:>Acquisition blocking	SPS	I
_:501	Tap changer:>Enable	SPS	I
_:507	Tap changer:>Sw. authority local	SPS	I
_:508	Tap changer:>Sw. authority remote	SPS	I
_:509	Tap changer:>Sw. mode interlocked	SPS	I
_:510	Tap changer:>Sw. mode non-interl.	SPS	I
_:504	Tap changer:>Reset AcqBlk&Subst	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

No.	Information	Data Class (Type)	Type
_:313	Tap changer:Switching authority	ENS	O
_:314	Tap changer:Switching mode	ENS	O
_:319	Tap changer:Reset failure	SPC	C
_:317	Tap changer:Switching auth. station	SPC	C
_:320	Tap changer:Enable sw. auth. 1	SPC	C
_:321	Tap changer:Enable sw. auth. 2	SPC	C
_:322	Tap changer:Enable sw. auth. 3	SPC	C
_:323	Tap changer:Enable sw. auth. 4	SPC	C
_:324	Tap changer:Enable sw. auth. 5	SPC	C

8 Protection and Automation Functions

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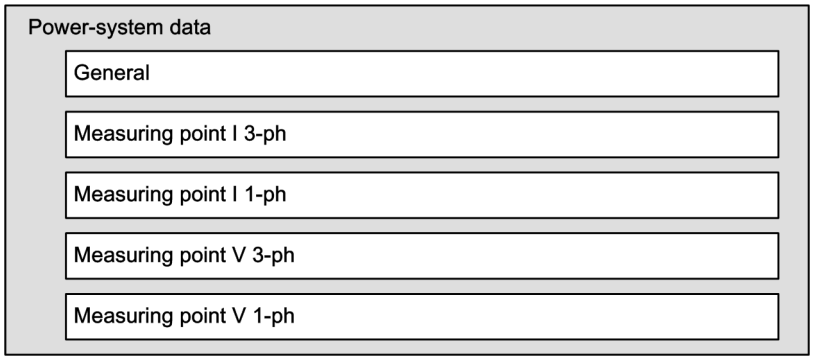
8.1 Power-System Data

8.1.1 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**.

8.1.2 Structure of the Power-System Data

The **Power-system data** contains the block **General** and the **Measuring points** of the device. The following figure shows the structure of the **Power-system data**:



[dw_system data, 2, en_US]

Figure 8-1 Structure of the Power-System Data

In order to adjust its functions to the application, the device requires some data about the power system and the system. The necessary settings can be found in the power-system data under **General** as well as in the **Measuring points**.

NOTE

You will find further information on the settings of the supervision functions in chapter *10.3 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 following function groups, which need the voltage and/or current measured values of the power system.
The measuring points have interfaces to the following function groups:

- Transformer
- Auto transformer
- Circuit breaker

8.1.3 Application and Setting Instructions - 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.

You can find detailed information about phase-rotation reversal in chapter *8.23 Phase-Sequence Switchover*.

8.1.4 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). The **V-1ph measuring point** has only a subset of the parameters described here. The description of the parameter is also valid for the **V-1ph measuring point**.

Parameter: Rated primary voltage

- Default setting **(_:8911:101) Rated primary voltage** = ***400 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 ratio of the voltage transformers is the cause for the deviation (see *Figure 8-2*).

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

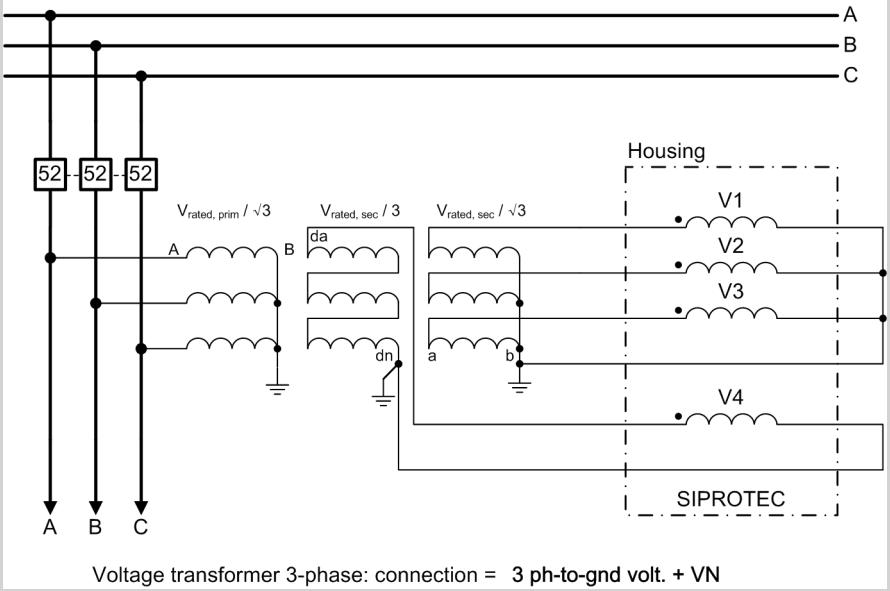
The zero-sequence voltage is calculated as phase-to-ground voltages. The residual voltage is measured on the broken-delta winding of the voltage transformer. For 1-phase voltage transformers the residual voltage is measured in the generator or the transformer neutral point.

NOTE

The measured 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 8-2 3-Phase Voltage Transformer: Connection = 3 Phase-to-Ground Voltage + VN

When the type of connection for 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 8-2*, 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 broken-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:

$$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0\ sec}}{V_{N\ sec}} = \frac{3 \cdot \frac{V_{rated\ \ sec}}{\sqrt{3}}}{3 \cdot \frac{V_{rated\ \ sec}}{3}} = \frac{3}{\sqrt{3}} = \sqrt{3} = 1.73$$

[fo_example_1, 2, 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 broken-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 broken-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:

$$\text{Matching ratio } \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\,\text{sec}}}{V_{\text{N sec}}} = \frac{3 \cdot \frac{V_{\text{rated sec}}}{\sqrt{3}}}{3 \cdot \frac{V_{\text{rated sec}}}{3}} = \frac{3 \cdot \frac{100\ \text{V}}{\sqrt{3}}}{3 \cdot \frac{200\ \text{V}}{3}} = \frac{3}{2 \cdot \sqrt{3}} = \frac{\sqrt{3}}{2} = 0.866$$

[fo_example_2, 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 matching 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_conversion2, 2, en_US]

NOTE

During the ground-fault test, the set matching 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 of the device:

- Overvoltage protection with zero-sequence/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** → **Parameter** → **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 point routing** → **Voltage measuring points**, select the desired connection type under **Connection type**. The following types of connections are possible:

- ***3 ph-to-gnd voltages***
- ***3 ph-to-ph voltages***
- ***2 ph-to-ph 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 chapter *A.7 Connection Examples of Voltage Transformers for Modular Devices*. 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 *8.23 Phase-Sequence Switchover*). This default setting can 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:** Note that, during sampling-frequency tracking, the entire device is set to the determined sampling frequency. That is to say, all of the measuring point channels work with the determined main sampling frequency. Please keep this in mind when working with the device.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, select the setting value ***inactive***.

Parameter: Magnitude correction

- Default setting **(_:3811:103) Magnitude correction** = ***1.000***

With the **Magnitude correction** parameter, you adjust the amplitude (magnitude correction) for the voltage input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction can 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.

8.1.5 Application and Setting Notes for Measuring Point Voltage 1-Phase (V-1ph)

If you insert a **Measuring point V 1-ph** in DIGSI 5, you must route a voltage to the measuring point under **Name of the device** → **Measuring point routing** → **Voltage measuring points**.

You can route the following voltages:

- ***V A***
- ***V B***
- ***V C***
- ***V AB***
- ***V BC***
- ***V CA***

- ***VN***[36]
- ***Vx***
- ***VN broken-delta***[37]

Parameter: Rated primary voltage

- Default setting **(_:2311:101) 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 **(_:2311:102) 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 **(_:2311:108) 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.
For more detailed information, refer to *8.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)*.



NOTE

The **Matching ratio Vph / VN** parameter is only visible in the **Measuring point V-1ph** if the voltage ***VN broken-delta*** has been routed.

Parameter: Tracking

- Default setting **(_:2311:103) Tracking** = ***inactive***

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. The 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 the voltage channel if a voltage channel is valid again.

36 If you route this voltage, the protection functions operate with the neutral-point displacement voltage.
37 If you route this voltage, the protection functions operate with the voltage measured directly at the broken-delta winding of the voltage transformer.

Parameter Value	Description
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, select the setting value ***inactive***.
active	If the parameter **Tracking** = ***active*** has been set, the measuring point will be included when determining the sampling frequency. **Note:** If the parameter is **Tracking** = ***active***, the determined sampling frequency applies to all functions in the device not using fixed sampling rates. Starting from platform version V07.80, you can merge measuring points into **Frequency tracking groups** in SIPROTEC 5 devices. In this case, every frequency tracking group specifies its own sampling frequency. For further information, refer to *3.3 Sampling-Frequency Tracking and Frequency Tracking Groups*.

Parameter: Measuring-point ID

- Default setting **(_:2311:130) Measuring-point ID** = ***1***

The parameter **Measuring-point ID** is write-protected and displays the ID of the measuring point. If you are using several measuring points, the **Measuring-point ID** is continuously incremented.

Starting from platform version V07.80, you can merge measuring points into **Frequency tracking groups** in SIPROTEC 5 devices. In this case, every frequency tracking group specifies its own sampling frequency. For further information, refer to *3.3 Sampling-Frequency Tracking and Frequency Tracking Groups*.

Parameter: Magnitude correction

- Default setting **(_:3811:103) Magnitude correction** = ***1.000***

When using the **Magnitude correction** parameter, you adjust the magnitude (magnitude correction) 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 high-precision 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.

8.1.6 Application and Setting Notes for Measuring-Point Current 3-Phase (I-3ph)

The following example describes the settings for the current measuring points **Measuring point I-3ph** (Current 3-phase). The **I-1ph measuring point** has only a subset of the parameters described here. The description of the parameter is also valid for the **I-1ph measuring point**.

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** → **Parameter** → **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***

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.6 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 manual updating function of the sampling frequency.

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:** During the manual updating of the sampling frequency, the entire device adjusts itself to different sampling frequencies corresponding to the frequency tracking groups. That is to say, the channels of the measuring points work with the determined sampling frequency of the frequency tracking groups. Keep this in mind when working with the device.
`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, you set the active rated primary current of the current transformer.

Parameter: Rated secondary current

- Default setting **`(_:8881:102) Rated secondary current`** = ***`1 A`***

With the **`Rated secondary current`** parameter, you set the active rated secondary current of the current transformer.

Parameter: Current range

- Default setting **`(_:8881:117) Current range`** = ***`100 x IR`***

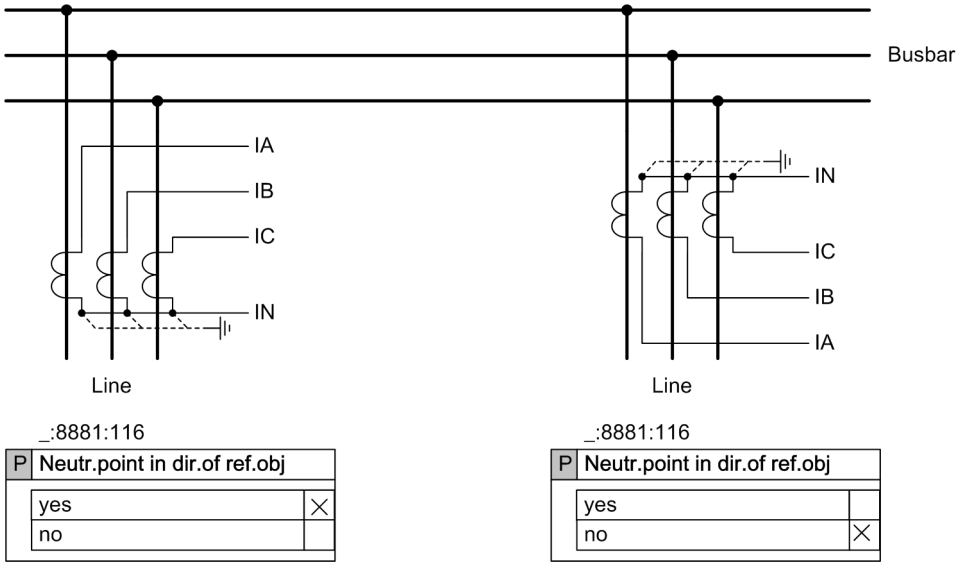
The **`Current range`** parameter allows you to set the dynamic range for the current input. Retain the default setting for power-system protection applications. The setting value for the sensitive current input and the measuring current input is 1.6 x I_{rated}.

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 the 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 changed device-internally.



[dw_polstromwdl, 1, en_US]

Figure 8-3 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-storage hydropower plants (see chapter *8.23 Phase-Sequence Switchover*). This default setting can be retained for power-system protection applications.

Parameter: CT error changeover

- Default setting **(_:8881:107) CT error changeover** = ***1.00***

The **CT error changeover** parameter is only relevant for the Line differential protection function. The **CT error changeover** parameter defines the transition range of the transformer fault from low to higher currents.

Parameter: CT error A

- Default setting **(_:8881:108) CT error A** = ***5.0***

The **CT error A** parameter considers the transformer fault at rated current plus a safety margin.

Parameter: CT error B

- Default setting **(_:8881:109) CT error B** = ***15.0***

The **CT error B** parameter considers the transformer fault at rated overcurrent factor plus a safety margin. It is the number preceding the letter P of the transformer data.

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 Information

Indications for the current rotating field and the information pertaining to the manual updating 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 90 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.

8.1.7 Application and Setting Notes for Measuring Point Current 1-Phase (I-1ph)

If you insert a **Measuring point I 1-ph** in DIGSI 5, you must route a current to the measuring point under **Name of the device** → **Measuring-point routing** → **Current measuring points**.

You can only route the current ***Ix***.

Parameter: Rated primary current

- Default setting **(_:2311:101) Rated primary current** = ***1000 A***

With the parameter **Rated primary current**, you set the active rated primary current of the current transformer.

Parameter: Rated secondary current

- Default setting **(_:2311:102) Rated secondary current** = ***1 A***

With the parameter **Rated secondary current**, you set the active rated secondary current of the current transformer.

Parameter: Current range

- Default setting **(_:2311:103) Current range** = ***100 x IR***

The parameter **Current range** allows you to set the dynamic range for the current input. Retain the default setting for power-system protection applications.

Parameter: Term. 1,3,5,7 in dir. of obj.

- Default setting **(_:2311:116) Term. 1,3,5,7 in dir. of obj.** = ***yes***

With the parameter **Term. 1,3,5,7 in dir. of obj.**, you define the direction of the current. If you set the parameter **Term. 1,3,5,7 in dir. of obj.** = ***yes***, the direction of the current to the protected object is defined as *forward*.

Parameter: Tracking

- Default setting **(_:2311:105) 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** is ***active*** has been set, the measuring point will be included when determining the sampling frequency. **Note:** If the parameter **Tracking** is ***active***, the determined sampling frequency applies to all functions in the device not using fixed sampling rates. With platform version V07.80 and higher, you can merge measuring points into **Frequency tracking groups** in SIPROTEC 5 devices. In this case, every frequency tracking group specifies its own sampling frequency. You can find more information on this in *3.3 Sampling-Frequency Tracking and Frequency Tracking Groups*.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, select the setting value ***inactive***.

Parameter: Measuring-point ID

- Default setting **(_:2311:130) Measuring-point ID** = ***1***

The parameter **Measuring-point ID** is write-protected and displays the ID of the measuring point. If you are using several measuring points, the **Measuring-point ID** is continuously incremented.

With platform version V07.80 and higher, you can merge measuring points into **Frequency tracking groups** in SIPROTEC 5 devices. In this case, every frequency tracking group specifies its own sampling frequency. You can find more information on this in *3.3 Sampling-Frequency Tracking and Frequency Tracking Groups*.

Parameter: Magnitude correction

- Default setting **(_:3841:103) Magnitude correction** = ***1.000***

With the parameter **Magnitude correction**, you set 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 can be required for high-precision 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.

8.1.8 Disconnection of Measuring Points

8.1.8.1 Overview

Maintenance work or specific operating and switching states of the power system can require disconnection of measuring point. Therefore, it is sometimes necessary to take individual measuring points out of processing, for example, to prevent an unwanted tripping of the Differential protection. With the **Disconnection of measuring points** functionality, you can disconnect the connection of the **Measuring point I-3ph** to a protection function group.

If the measuring point has been disconnected, you can carry out any work without influencing the work of the protection functions that are assigned to the measuring point. Once the measuring point has been disconnected, the Differential protection, for example, does not take the measured values of this measuring point into account anymore for calculating the differential current.

An exception applies for the following protection functions of the FG **Line**:

- Distance Protection with Classic Method
- Distance Protection with Reactance Method (RMD)
- Power-Swing Blocking
- Ground-Fault Protection for High-Resistance Ground Faults in Grounded Systems (67N)
- Measuring-voltage failure detection

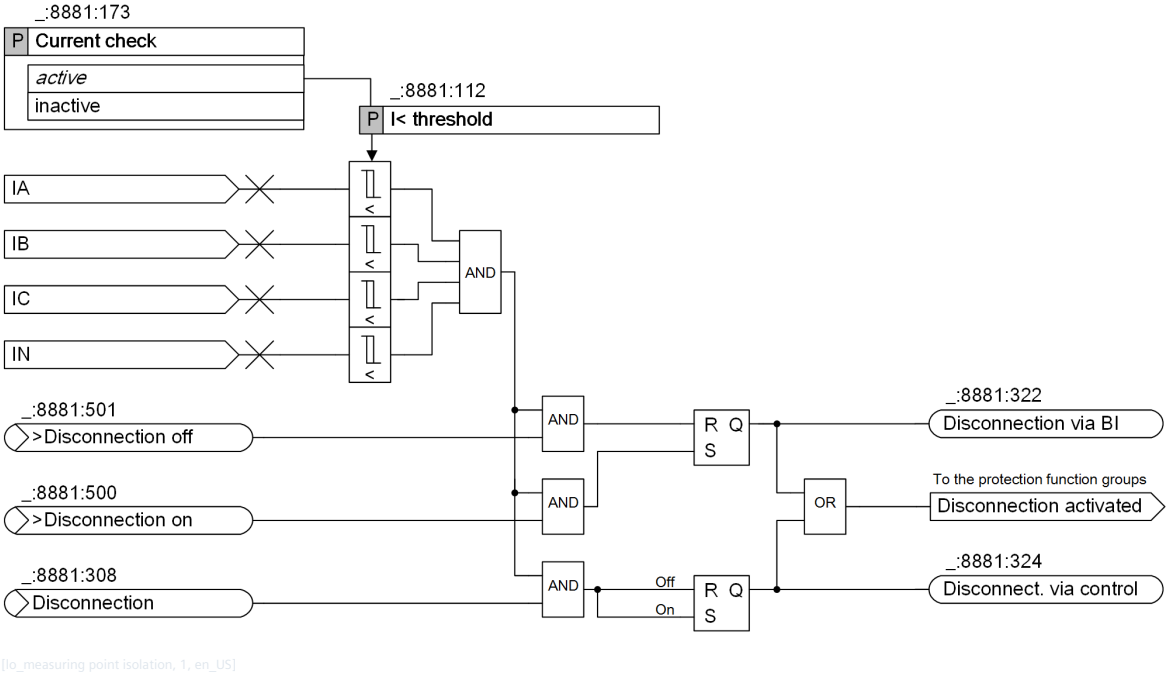
NOTE

If one of the current measuring points is disconnected, the mentioned protection functions of the FG **Line** switch to the *Alarm* state and are not active.

There is another exception for the disconnection of measuring points for the FG **Circuit breaker**: If the FG **Circuit breaker** is connected to a disconnected measuring point, the functional measured values are indicated as usual and used by the functions in the FG **Circuit breaker**. That is, the disconnection does not set the functional measured values to 0. If a circuit-breaker failure detection is instantiated in the FG **Circuit breaker**, Siemens recommends blocking the function for current tests.

8.1.8.2 Description

Logic



[lo_measuring point isolation, 1, en_US]

Figure 8-4 Logic of the Disconnection of Measuring Point

You can find the signals for the **Disconnection of measuring points** in the Information routing matrix in DIGSI under **Settings** → **Power system**→ **Meas.point I-3ph**.

The following signals are available for activating the **Measuring point I-3ph**:

- The binary inputs *(_:8881:500) >Disconnection on* and *(_:8881:501) >Disconnection off*
- The controllable *(_:8881:308) Disconnection*

You can control whether the **Measuring point I-3ph** may only be disconnected if the measured currents fall below the set threshold value. The measuring point can also be disconnected without checking the threshold

value. If you want to disconnect the measuring point without threshold-value check, consider that no currents are flowing anymore in the primary plant.

Disconnection messages are also available after a restart of the device. The device stores the disconnection efficacy in NVRAM[38] The last information on disconnection remains available, even if the auxiliary voltage fails. When the auxiliary voltage returns, the device compares the stored state with that of the binary inputs.

8.1.8.3 Application and Setting Notes

Parameter: Current check

- Default setting **(_:8881:173) Current check** = ***active***

With the **Current check** parameter, you can set whether you want to compare the RMS values of the phase currents IA, IB, IC and of the measured zero-sequence current IN with a threshold value.

Parameter Value	Description
active	The RMS values of the phase currents IA, IB, IC and of the measured zero-sequence current IN are compared to the setting value of the parameter **I< threshold**. The **Measuring point I-3ph** can only be activated if the current measured values fall below the threshold value.
inactive	The RMS values of the phase currents IA, IB, IC and of the measured zero-sequence current IN are not compared to the setting value of the parameter **I< threshold**.

Parameter: I< threshold

- Default setting **(_:8881:112) I< threshold** = ***0.100 A***

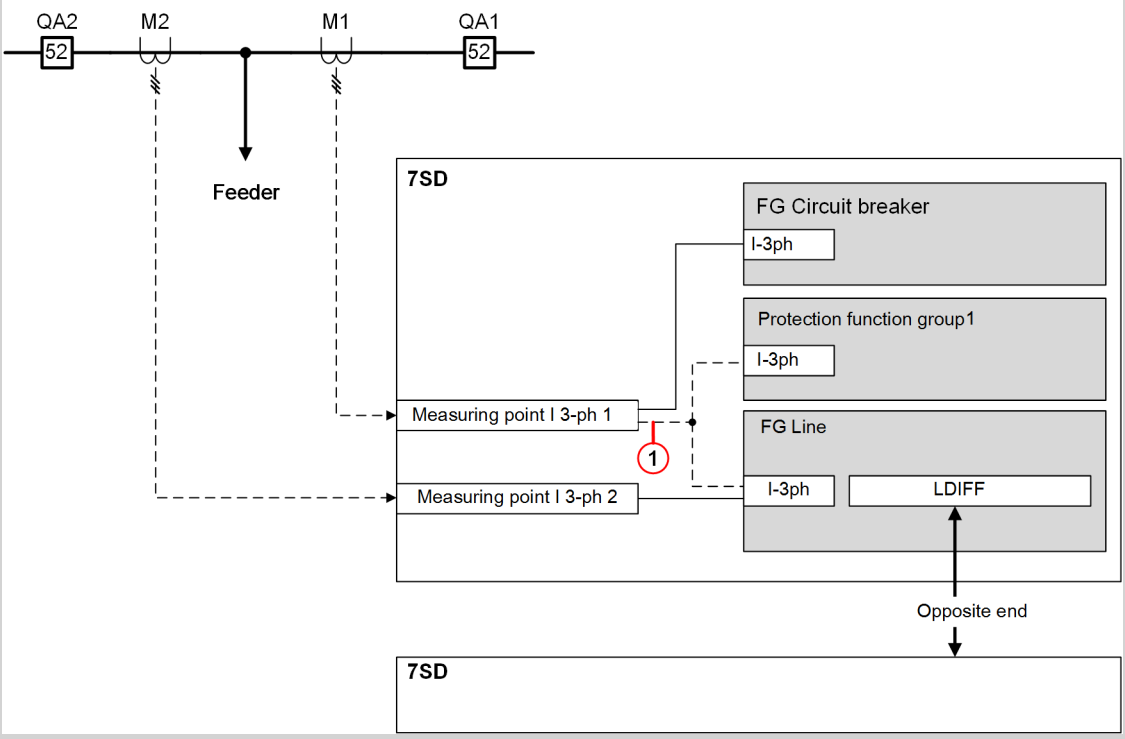
With the **I< threshold** parameter, you set the threshold for disconnection of a measuring point. If the current measured values fall below the threshold value, the **Measuring point I-3ph** can be activated.

Set the **I< threshold** parameter so that the measured current will certainly fall below the parameterized value, for example, if the circuit-breaker pole is open. If parasitic currents, for example, due to induction, are not possible with the line/feeder deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to 0.050 A for example. If no special requirements exist, Siemens recommends retaining the setting value of 0.100 A for secondary purposes.

38 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

EXAMPLE

Temporary Disconnection of a Connection of a Current Measuring Point to a Protection Function Group, Using the Example of a Line Differential Protection



[dw_similar-application_7SD_with_2-MU, 1, en_US]

Figure 8-5 Possible Disconnection of Measuring Point for the Line Differential Protection

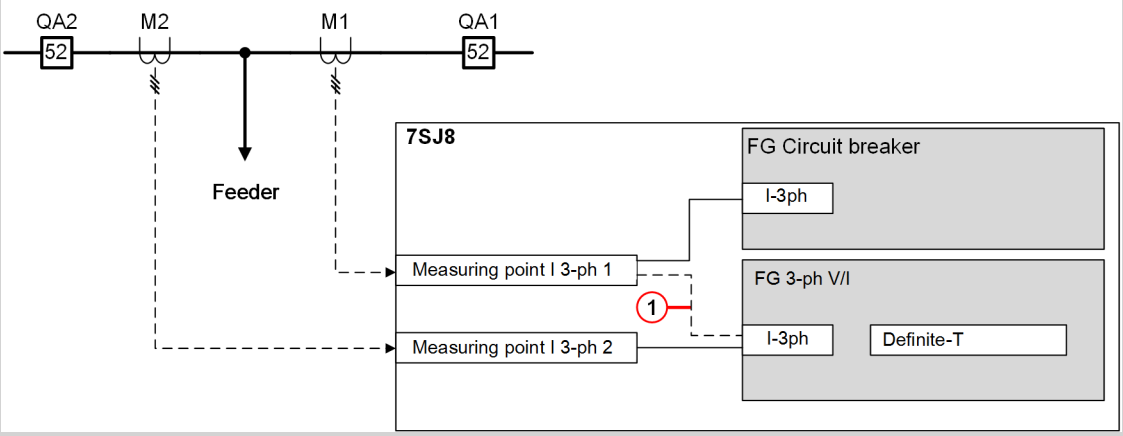
(1) Temporary disconnection of the connection to the **Measuring point I-3ph 1** for the FG **Line** and to the Protection Function Group 1

NOTE

If you disconnect the **Measuring point I-3ph 1**, you must make sure that no currents flows into the feeder via **M1**. Otherwise, this leads to an unwanted tripping of the **Line differential protection** function.

EXAMPLE

Temporary Disconnection of a Connection of a Current Measuring Point to the Protection Function Group 3-ph Voltage/Current



[dw_similar-application_7SJ8_with_2-MU, 1, en_US]

Figure 8-6 Possible Disconnection of Measuring Point for the Feeder Protection

(1) Temporary disconnection of the connection of the **Measuring point I-3ph 1** to the FG **3-ph voltage/current**

8.1.8.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP disconnection				
_:8881:173	CT 3-phase:Current check		• inactive • active	active
_:8881:112	CT 3-phase: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

8.1.8.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:8881:500	CT 3-phase:>Disconnection on	SPS	I
_:8881:501	CT 3-phase:>Disconnection off	SPS	I
_:8881:308	CT 3-phase:Disconnection	SPC	C
_:8881:322	CT 3-phase:Disconnection via BI	SPS	O
_:8881:324	CT 3-phase:Disconnect. via control	SPS	O
_: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

8.1.9 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Phase sequence		• ABC • ACB	ABC
General				
_:8911:101	VT 3-phase:Rated primary voltage		0.10 kV to 1200.00 kV	400.00 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	
VT 2				
_:3812:103	VT 2:Magnitude correction		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_:3812:108	VT 2:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx	
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	
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	
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
_:2521:6	Supv. balan. V:Operate delay		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

Addr.	Parameter	C	Setting Options	Default Setting
_:2581:6	Supv. ph.seq.V:Operate delay		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	43.300 V
_:2461:6	Supv. sum V:Operate delay		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
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	3-phase + IN-separate
_: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	100 x IR
_:8881:118	CT 3-phase:Internal CT type		• CT protection • CT measurement	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
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		• 100 x IR	100 x IR

Addr.	Parameter	C	Setting Options	Default Setting
_:8881:120	CT 3-phase:Internal CT type		• CT protection • CT measurement	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	
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 90.000 A	0.500 A
		5 A @ 100 Irated	0.150 A to 450.000 A	2.500 A
		1 A @ 50 Irated	0.030 A to 45.000 A	0.500 A
		5 A @ 50 Irated	0.150 A to 225.000 A	2.500 A
		1 A @ 1.6 Irated	0.001 A to 1.440 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 7.200 A	2.500 A
_:2491:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:2491:6	Supv. balan. I:Operate delay		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:Operate delay		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	0.150 A to 50.000 A	0.500 A
		1 A @ 50 Irated	0.030 A to 5.000 A	0.100 A
		5 A @ 50 Irated	0.150 A to 25.000 A	0.500 A
		1 A @ 1.6 Irated	0.001 A to 0.160 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 0.800 A	0.500 A
_:2431:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:2431:6	Supv. sum I:Operate delay		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

8.1.10 Information List

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

No.	Information	Data Class (Type)	Type
_:2311:323	General:f track	MV	O
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
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
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

No.	Information	Data Class (Type)	Type
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

8.2 Overvoltage Protection with 3-Phase Voltage

8.2.1 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

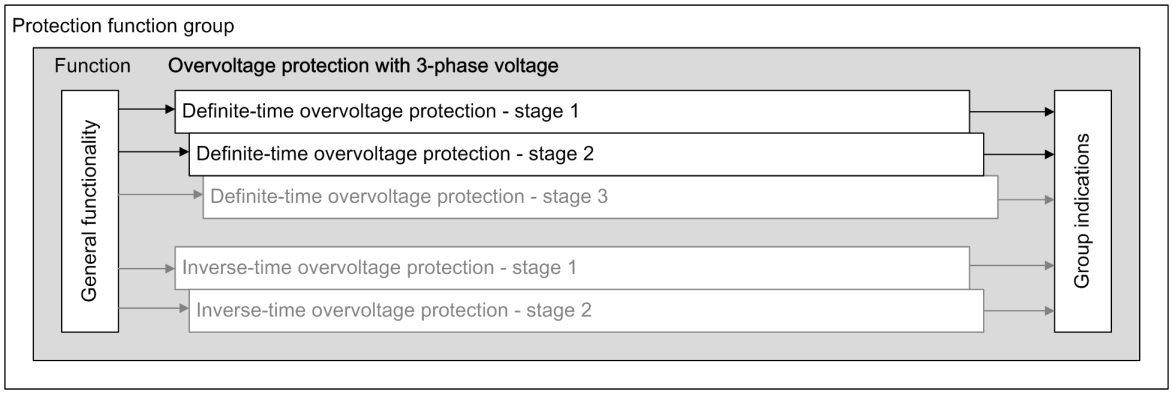
8.2.2 Structure of the Function

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 comes factory-set 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.

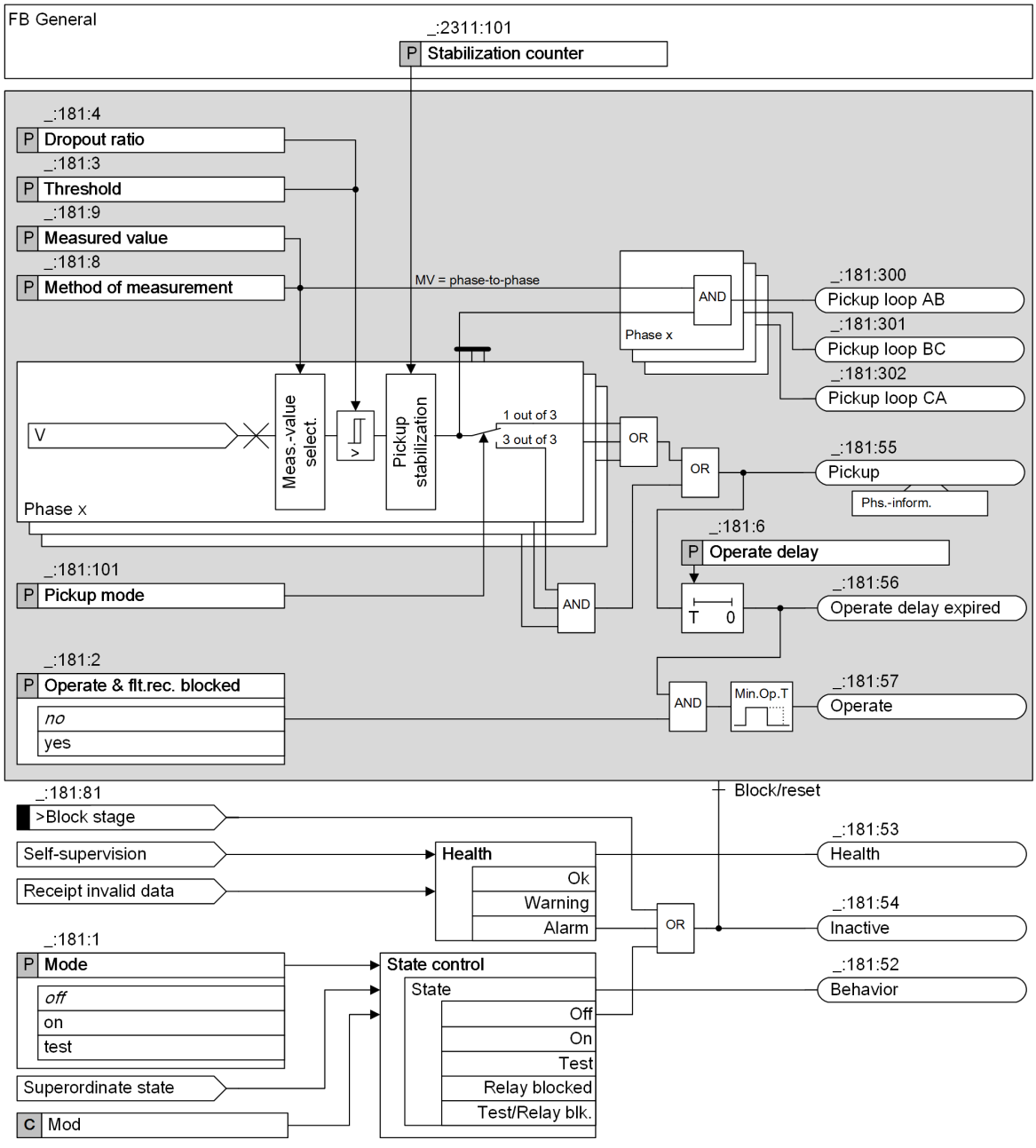


[dw_3-phase_ovp, 5, en_US]

Figure 8-7 Structure/Embedding of the Function

8.2.3 Description

Logic of the Stage



[lo_3phas_j, 5, en_US]

Figure 8-8 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 Stabilization

To enable the pickup stabilization, you set the **Stabilization counter** parameter to a value other than zero. Then, if the input voltage keeps exceeding the **Threshold** for a specified number (1 + **Stabilization counter** value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 10 ms.

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued immediately after the input voltage exceeds the **Threshold**.

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*.

8.2.4 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 **`(_:182:3) 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 overvoltage protection is used to protect machines against inadmissible high insulation stressing. The default setting already takes this application into account.

Specify the **`Threshold`** (pickup threshold) for the specific application.

Parameter: `Stabilization counter`

- Default setting **`(_:2311:101) Stabilization counter`** = ***`0`***

You can configure the **`Stabilization counter`** parameter in the function block **General**.

For special applications, it could be desirable that a short exceeding of the input voltage above the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the **`Stabilization counter`** parameter to a value other than zero.

For example, if you set this parameter to ***`1`***, the pickup signal is issued when the voltage keeps exceeding the **`Threshold`** for 2 successive measuring cycles. For 50 Hz, the measuring cycle time is 10 ms.

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

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 slightly above the permissible voltage range. A typical setting is 1.10 to 1.15 times the generator voltage. Siemens recommends selecting the setting in DIGSI with primary values or by unit values, because the conversion into secondary values is done automatically. A transformer mismatch is automatically taken into account.

  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:

  Voltage transformer: 1.10 V_{rated}

  $V_{threshold, sec} = 1.1\ V_{rated, sec} = 1.1 \cdot 100\ V = 110\ V$

  This requires that the primary rated voltages of protected object and voltage transformer are identical. If the primary rated voltages are different, adjust the pickup value.

  The **Operate delay** depends on the speed of the voltage controller. You can start from a voltage controller speed of approx. 1.5 s to 5 s. The presetting of 3 s is a practicable value that you have to verify during the primary testing.

- 2. Stage:

  The second overvoltage-protection stage is intended for high overvoltages with short duration. This overvoltage occurs when there is a full-load rejection of a generator as a transient voltage and is then reduced to the rated value by the voltage controller. Therefore, set the stage in such a way that the transient voltage operation does not result in tripping.

  Typical settings:

  – Pickup value: approx. 1.30 V_{rated}

  – Tripping delay: approx. 0.5 s

Stage	Setting Values	
	Threshold value	Time delay
1	1.1 V_{rated}	3 s
2	1.3 V_{rated}	approx. 0.5 s

8.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Stabilization counter		0 to 10	0
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

Addr.	Parameter	C	Setting Options	Default Setting
_: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

8.2.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
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
_: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

No.	Information	Data Class (Type)	Type
_: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

8.3 Overvoltage Protection with Any Voltage

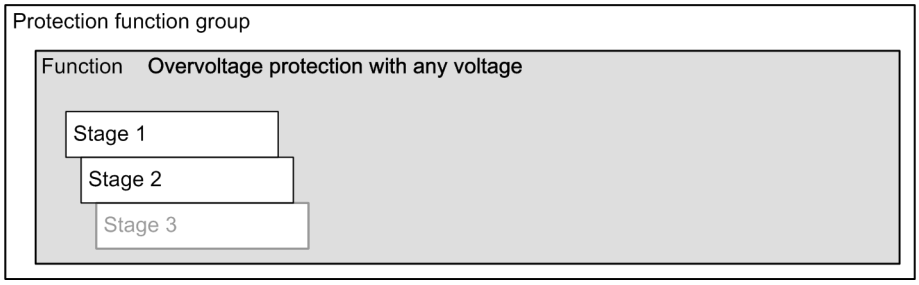
8.3.1 Overview of Functions

The function **Overvoltage protection with any voltage** (ANSI 59) detects any 1-phase overvoltages and is intended for special applications.

8.3.2 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 factory-set with 2 stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

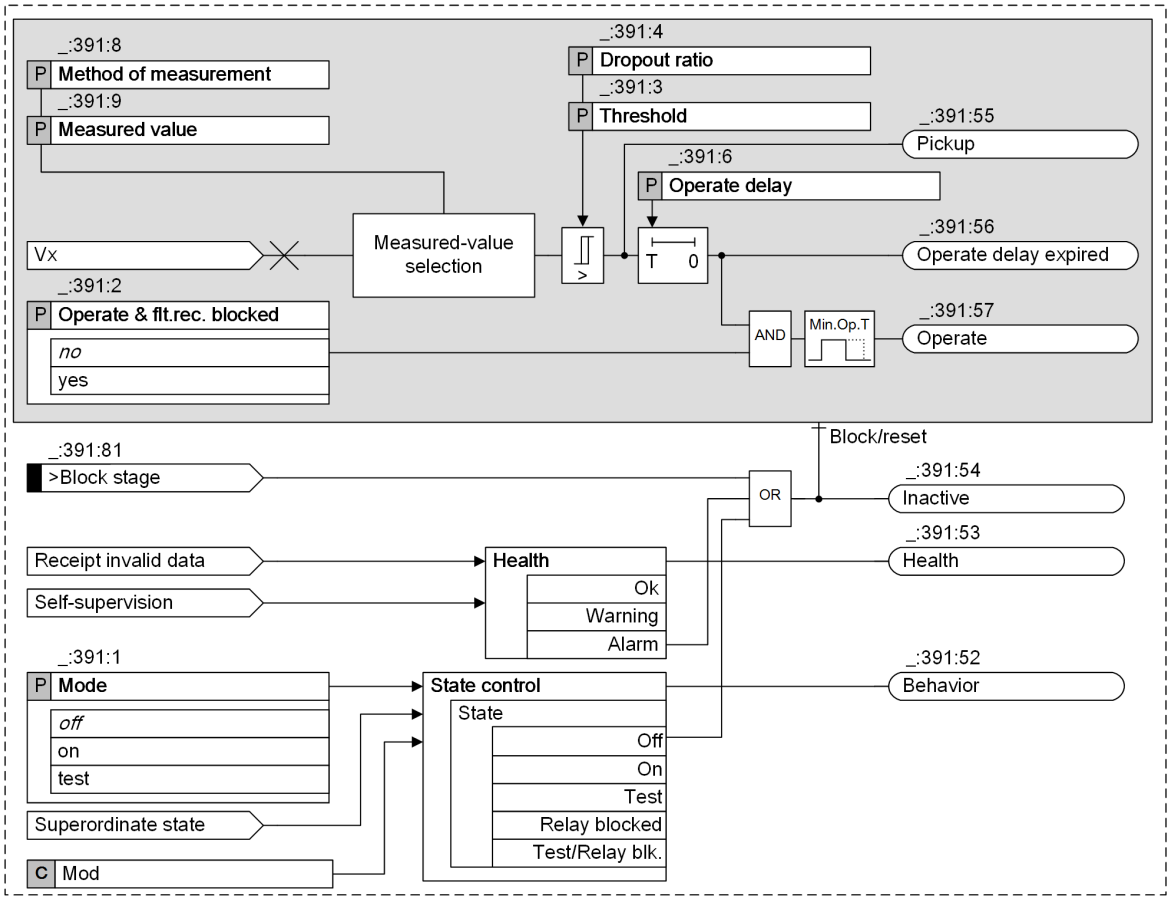


[dw_ovp_uxs, 1, en_US]

Figure 8-9 Structure/Embedding of the Function

8.3.3 Stage Description

Logic of a Stage



[lo_ovp_Vx_any-volt, 2, en_US]

Figure 8-10 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*.

8.3.4 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

From V7.30 on, the value ***VN measured*** is no longer provided. If you have selected this value in earlier versions, you can use either the following methods instead after upgrading the configuration to V7.30 or a later version:

- Select the value ***V0 calculated*** for the **Measured value** parameter in the function **Overvoltage protection with any voltage**.
- Use the function **Overvoltage protection with zero-sequence voltage/residual voltage**.

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.

8.3.5 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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
_: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

8.3.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
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

No.	Information	Data Class (Type)	Type
_: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

8.4 Undervoltage Protection with 3-Phase Voltage

8.4.1 Overview of Functions

The function **Undervoltage protection with 3-phase voltage** (ANSI 27):

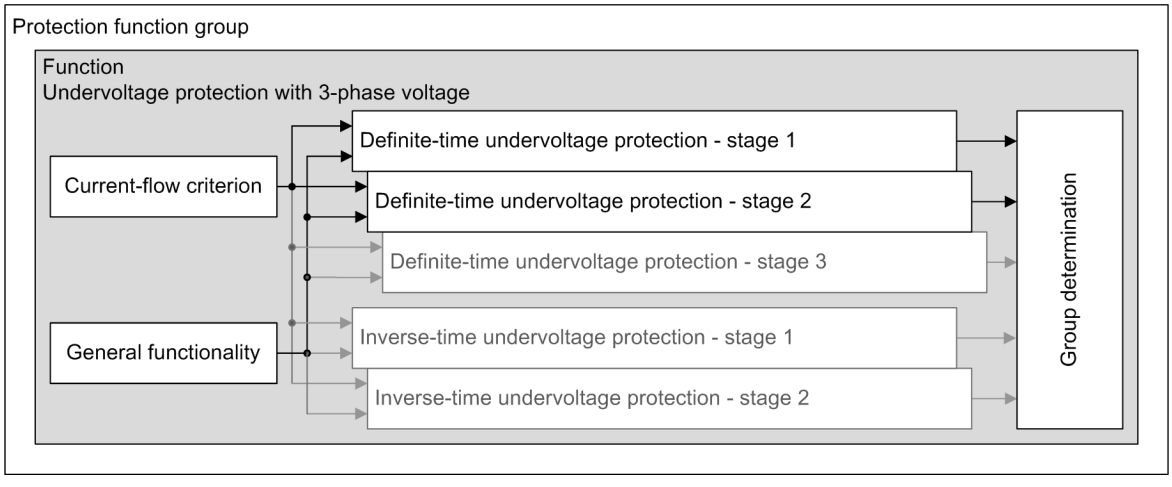
- Monitors the permissible voltage range
- Protects equipment (for example, plant components and machines) against damages caused by undervoltage
- Handles disconnection or load shedding tasks in a system

8.4.2 Structure of the Function

The function **Undervoltage protection with 3-phase voltage** is used in protection function groups with voltage measurement.
The function **Undervoltage protection with 3-phase voltage** comes factory-set 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 8-11*). 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.



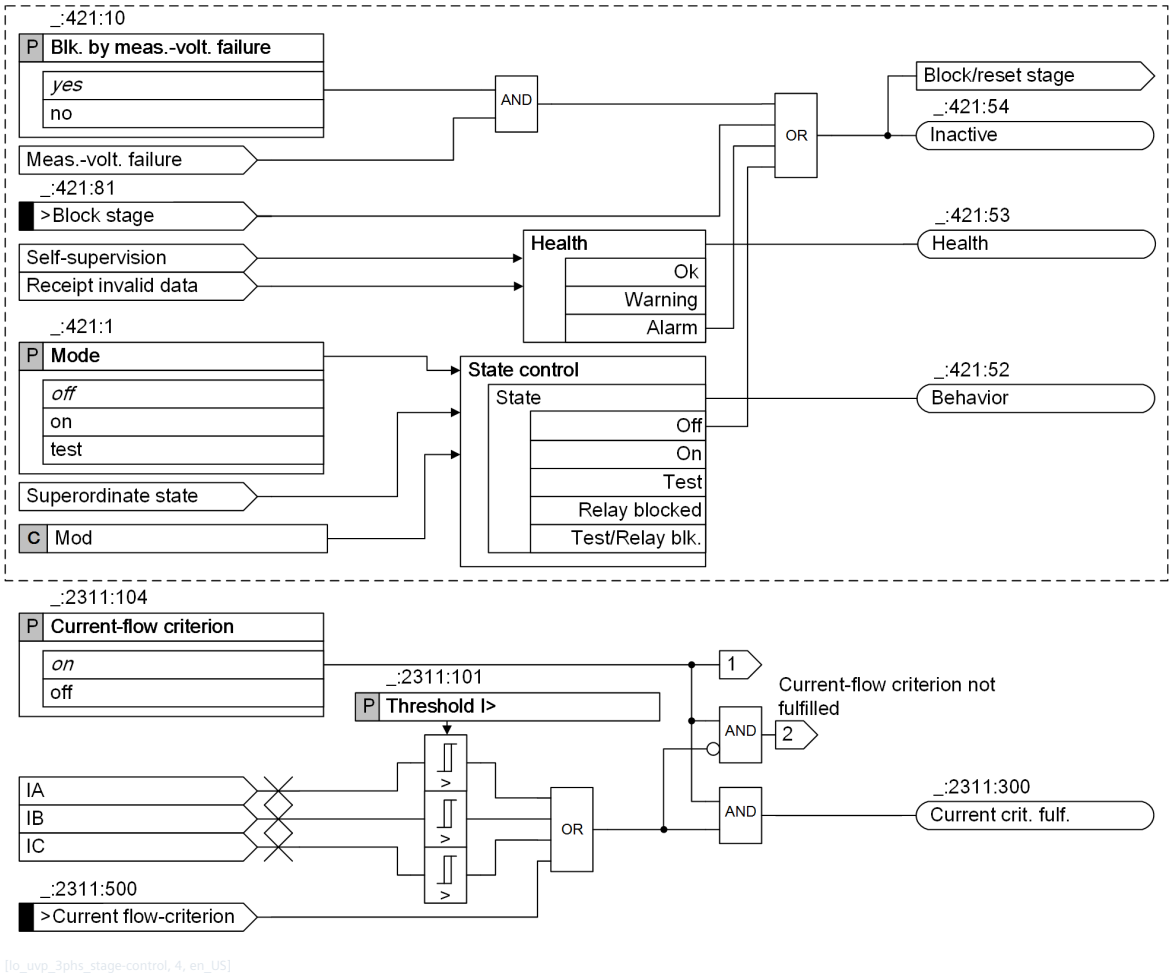
[dw_stru_3p, 5, en_US]

Figure 8-11 Structure/Embedding of the Function

8.4.3 Stage with Definite-Time Characteristic Curve

8.4.3.1 Description

Logic of the Stage



[lo_uvp_3phs_stage-control, 4, en_US]

Figure 8-12 Logic Diagram Stage Control

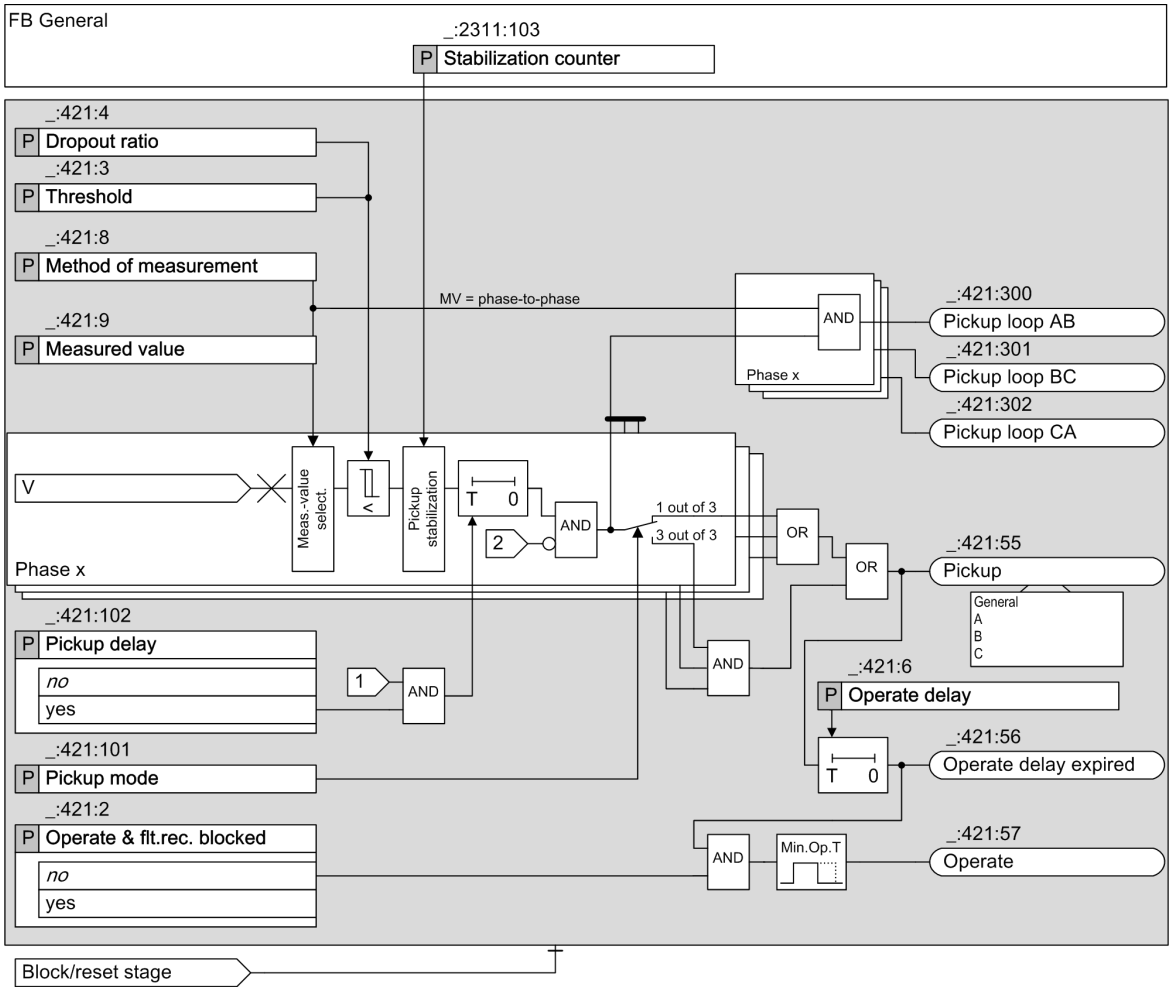


Figure 8-13 Logic Diagram of the Definite-Time Undervoltage Protection with 3-Phase Voltage

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 Stabilization

To enable the pickup stabilization, you set the **Stabilization counter** parameter to a value other than 0. Then, if the input voltage keeps being below the **Threshold** for a specified number (1 + **Stabilization**

counter value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 10 ms.

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued after the input voltage falls below the threshold value.

Pickup Mode

With the **Pickup mode** parameter, 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 the 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 8-13 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 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.

8.4.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:421:8) 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 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***

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

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:

$$V_{Threshold\ value,\ sec} = \frac{0.8 \cdot V_{rated,obj.}}{Ratio_V} = \frac{0.8 \cdot 10\ kV \cdot 100\ V}{10\ kV} = 80\ V$$

[fo_schw_lw, 2, en_US]

Parameter: Stabilization counter

- Default setting **(_:2311:103) Stabilization counter** = ***0***

You can configure the **Stabilization counter** parameter in the function block **General**.

For special applications, it could be desirable that a short falling of the input voltage below the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the **Stabilization counter** parameter to a value other than zero.

For example, if you set this parameter to ***1***, the pickup signal is issued when the voltage keeps being below the **Threshold** for 2 successive measuring cycles. For 50 Hz, the measuring cycle time is 10 ms.

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 **Pickup delay** parameter, 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.

When applied in parallel, the pickup delay and the delay through pickup stabilization add up.

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 setting 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***

With the **Blk. by meas.-volt. failure** parameter, you 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 *10.3.3.1 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 on either 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 still exists.
- If they are located on the junction side, the voltage does not exist.

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 drops out when the current falls below a minimum value (parameter **Threshold I>**).
off	In the case of undervoltage, 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 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.

8.4.3.3 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

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:103	General:Stabilization counter		0 to 10	0
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
_: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 300.00 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 300.00 s	0.50 s

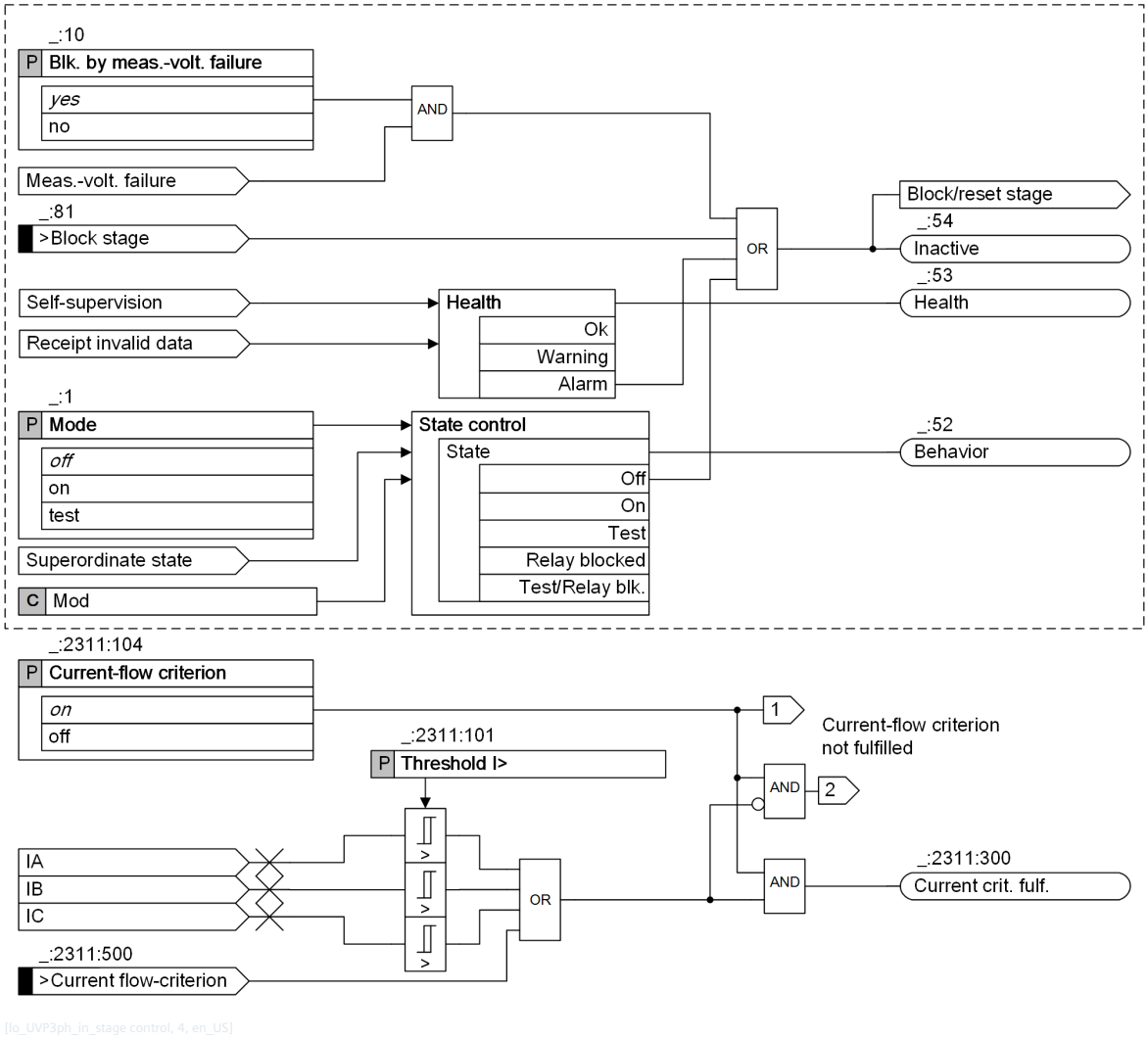
8.4.3.4 Information List

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
_: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

8.4.4 Stage with Inverse-Time Characteristic Curve

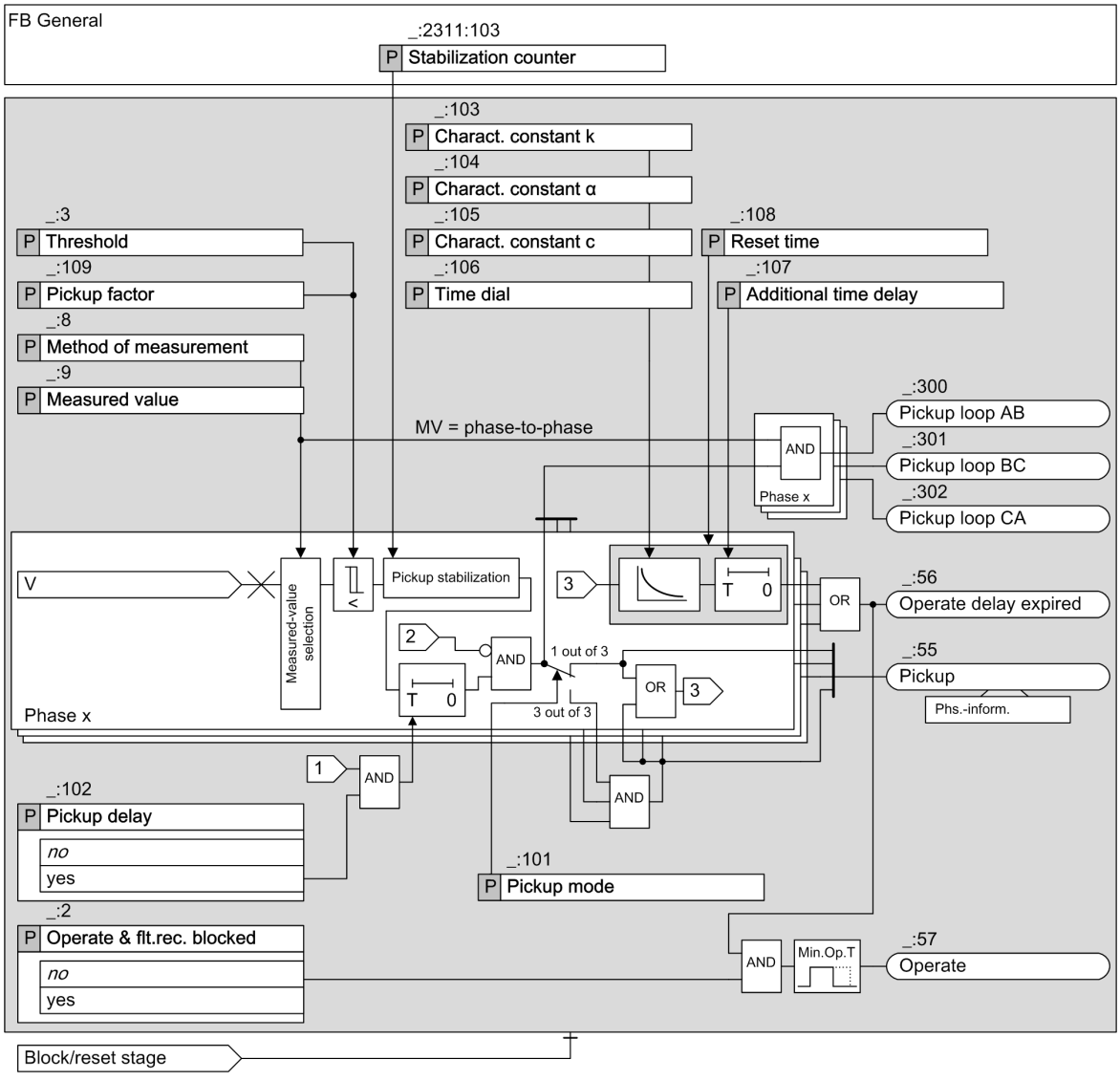
8.4.4.1 Description

Logic of the Stage



[lo_UVP3ph_in_stage control, 4, en_US]

Figure 8-14 Logic Diagram of the Stage Control



[lo_UVP3ph_In, 5, en_US]

Figure 8-15 Logic Diagram of the Inverse-Time Undervoltage Protection with 3-Phase Voltage

Method of Measurement

With the **Method of measurement** parameter, you 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

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 Stabilization

To enable the pickup stabilization, you set the **Stabilization counter** parameter to a value other than zero. Then, if the input voltage keeps being below the pickup value for a specified number (1 + **Stabilization counter** value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 10 ms.

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued after the input voltage falls below the pickup value.

Pickup Mode

With the **Pickup mode** parameter, 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 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:

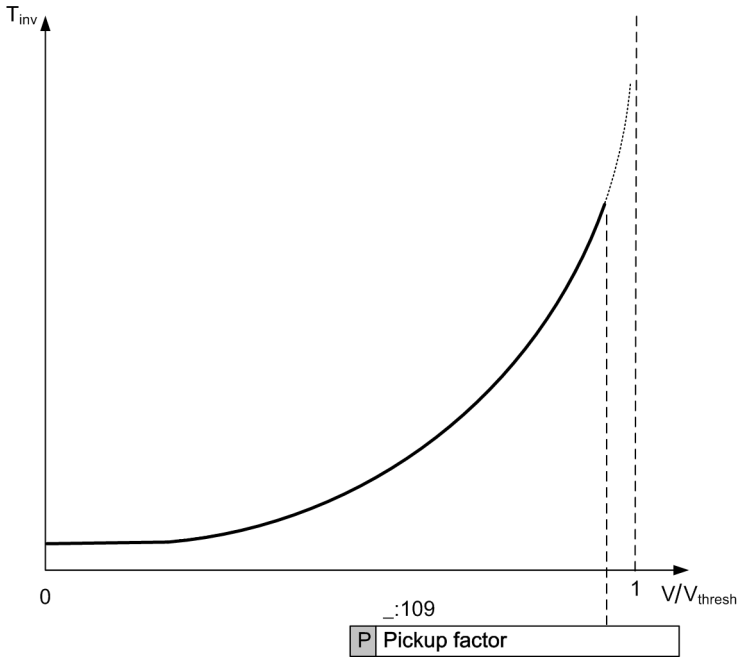
$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_uvp_3ph_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:



[dw_uvp_3ph_inverse, 1, en_US]

Figure 8-16 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 the 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 8-15 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 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.

8.4.4.2 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 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***

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 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** parameter, 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: Stabilization counter

- Default setting **(_:2311:103) Stabilization counter** = ***0***

You can configure the **Stabilization counter** parameter in the function block **General**.

For special applications, it could be desirable that a short falling of the input voltage below the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the **Stabilization counter** parameter to a value other than zero.

For example, if you set this parameter to ***1***, the pickup signal is issued when the voltage keeps being below the pickup value for 2 successive measuring cycles. For 50 Hz, the measuring cycle time is 10 ms.

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 **Pickup delay** parameter, 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.

When applied in parallel, the pickup delay and the delay through pickup stabilization add up.

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 trip-ping, 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 keeping 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 **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: Blk. by meas.-volt. failure

- Default setting **(_:10) Blk. by meas.-volt. failure** = *yes*

With the **Blk. by meas.-volt. failure** parameter, you 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 switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see *10.3.3.1 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 on either 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 still exists.
- If they are located on the junction side, the voltage does not exist.

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 drops out when the current falls below a minimum value (parameter **`Threshold I>`**).
off	In the case of undervoltage, the pickup of the undervoltage protection stage persists when the current-flow criterion is not used.

8.4.4.3 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

8.4.4.4 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

No.	Information	Data Class (Type)	Type
_: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

8.5 Undervoltage Protection with Any Voltage

8.5.1 Overview of Functions

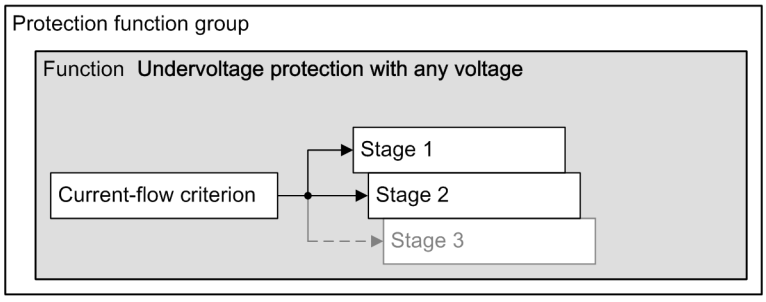
The function **Undervoltage protection with any voltage** (ANSI 27) detects any 1-phase undervoltage and is intended for special applications.

8.5.2 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 factory-set with 2 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 8-17*).

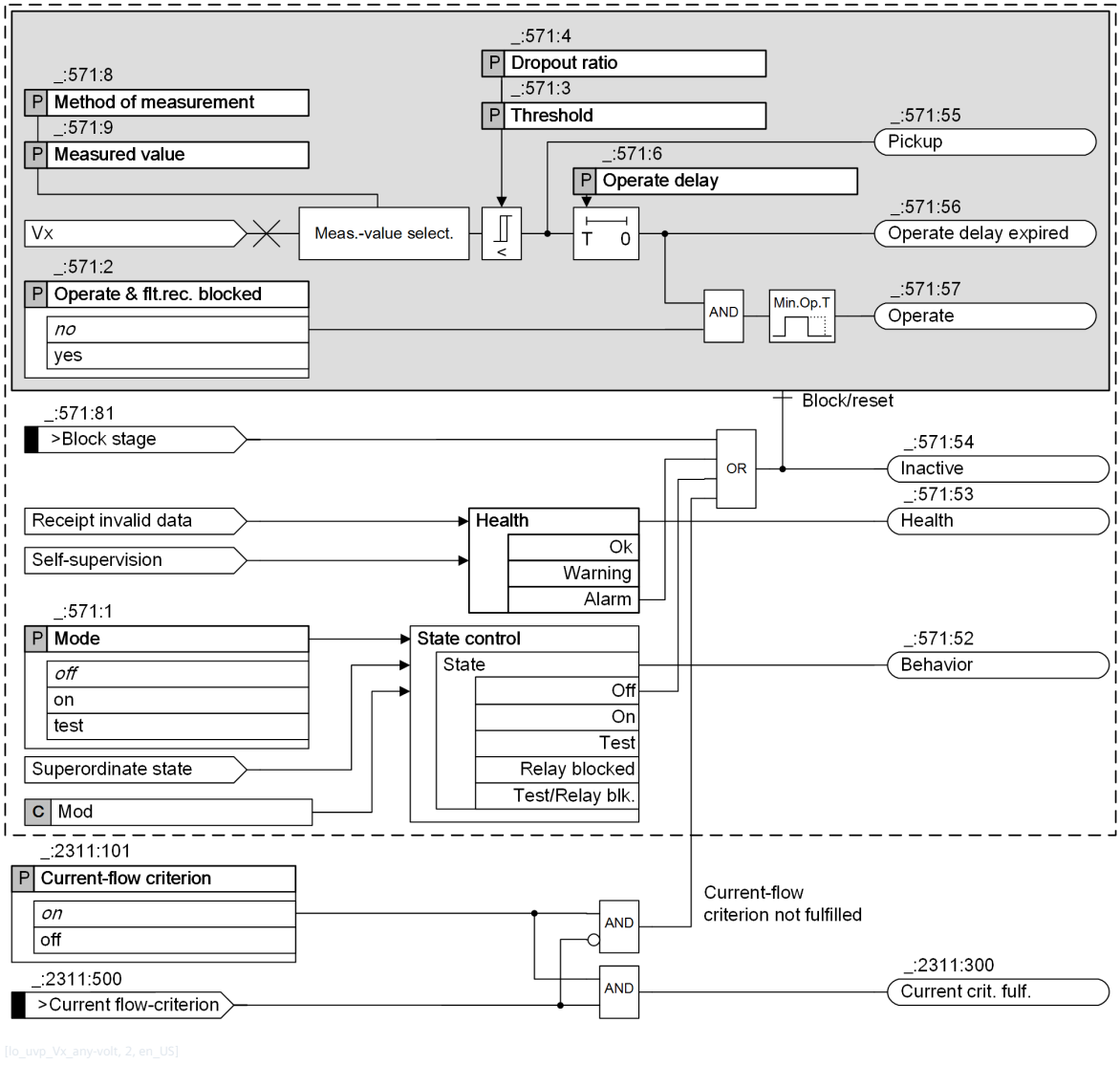


[dw_stuvux, 1, en_US]

Figure 8-17 Structure/Embedding of the Function

8.5.3 Stage Description

Logic of a Stage



[lo_uvp_Vx_any-volt, 2, en_US]

Figure 8-18 Logic Diagram of a Stage: Undervoltage Protection with Any Voltage

NOTE

If the function **Undervoltage 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 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 **Undervoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

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 8-18 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*.

8.5.4 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

From V7.30 on, the value ***VN measured*** is no longer provided. If you have selected this value in earlier versions, you can select the value ***V0 calculated*** instead after upgrading the configuration to V7.30 or a later version.

If the function **Undervoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

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.

8.5.5 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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

8.5.6 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

8.6 Rate-of-Voltage-Change Protection

8.6.1 Overview of Functions

In a power system, in addition to short circuits, there are other situations which also cause voltage changes. For example, too high loads can reduce the voltage level at the end of the line, or too high power production can cause a voltage-level increase.

The function **Rate-of-voltage-change protection** can be used to:

- Prevent the system from not secure states caused by unbalance between the generated and consumed active power
- Detect a network island state
- Advanced load-shedding applications
- Detect a rather fast voltage change related to a fault in the power system

8.6.2 Structure of the Function

The function **Rate-of-voltage-change protection** can be used in protection function groups with 3-phase voltage measurement.

2 stage types are available:

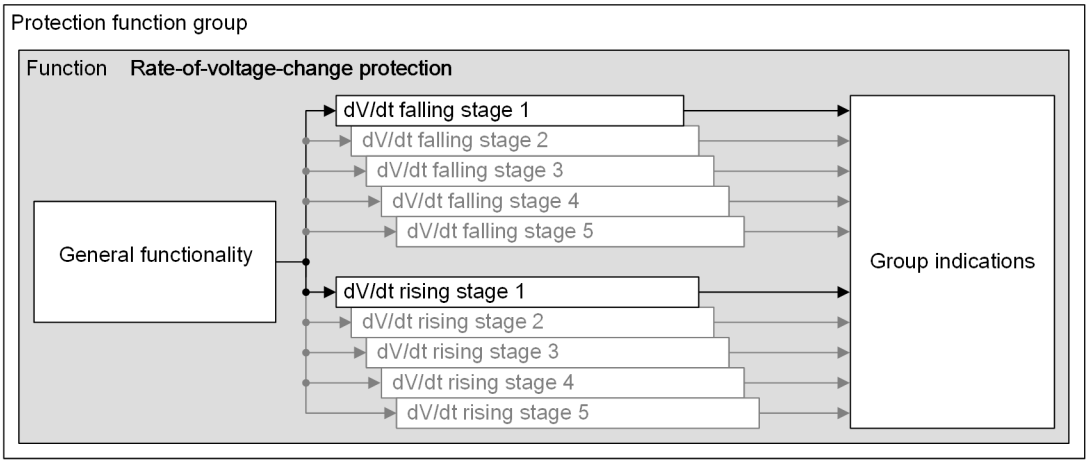
- **dV/dt rising**
- **dV/dt falling**

The function **Rate-of-voltage-change protection** comes factory-set with 1 **dV/dt rising** stage and 1 **dV/dt falling** stage. A maximum of 5 **dV/dt rising** stages and 5 **dV/dt falling** stages can be operated simultaneously within the function. Both stage types are similar in structure.

The general functionality works across stages on the function level.

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_dVdt structure, 1, en_US]

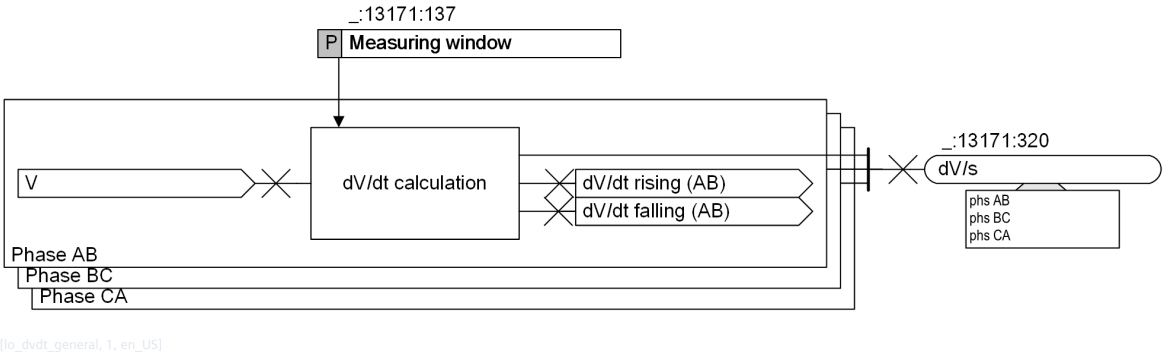
Figure 8-19 Structure/Embedding of the Function

8.6.3 General Functionality

8.6.3.1 Description

Logic

The following figure shows the dV/dt calculation logic. It applies to all configured stages.



[lo_dvdt_general, 1, en_US]

Figure 8-20 Logic Diagram of the General Functionality

dV/dt Calculation

The measured phase-to-phase voltages are used for calculating the rate of voltage change.

The measuring-window interval is used for calculating the dV/dt mean value for further processing. A larger measuring window increases the accuracy of the dV/dt mean value while simultaneously increasing the pickup time.

The ratio between the voltage difference and the time difference reflects the voltage change which can be positive or negative.

Functional Measured Value

Value	Description
dV/s	Calculated mean voltage change per second

8.6.3.2 Application and Setting Notes

Parameter: `Measuring window`

- Default setting **`(_:13171:137) Measuring window`** = ***`5 periods`***

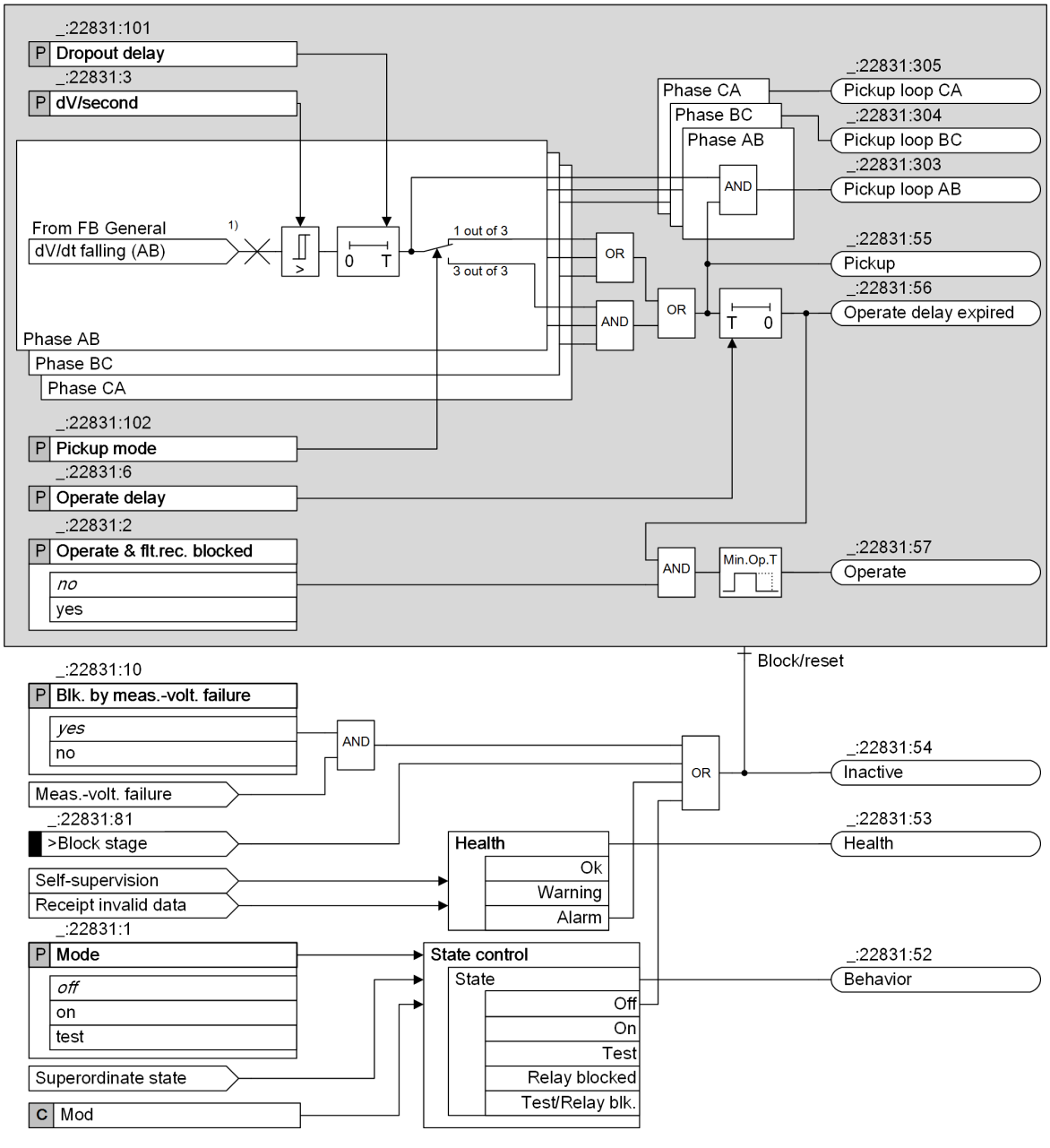
With the **`Measuring window`** parameter, you optimize the measuring accuracy or the pickup time of the function. If the measuring window increases, the measuring accuracy increases while the pickup time increases as well. You can find more information about the pickup time and measuring accuracy in the technical data in chapter *13.12 Rate-of-Voltage-Change Protection*.

If you do not have specific requirements for an especially short pickup time, Siemens recommends using the default setting. The default setting is a reasonable compromise between the measuring accuracy and the pickup time. If the measuring window is smaller than 5 periods, the accuracy of the calculated dV/dt value is affected.

8.6.4 Stage Description

8.6.4.1 Description

Logic of the Stage



[lo_dvdt_stage, 1, en_US]

Figure 8-21 Logic Diagram of the dV/dt Falling Stage

(1) For the stage type **dV/dt rising**, the value **dV/dt rising (AB)** is used.

Voltage Change

The stage **dV/dt falling** is used to detect a system-voltage decrease and the stage **dV/dt rising** is used to detect a system-voltage increase.

You set the threshold value **dV/second** as the absolute voltage change per second. You define the voltage-change direction via the stage type.

Pickup Mode

The **Pickup mode** parameter defines whether the stage picks up if all 3 measuring elements detect the voltage-change condition (***3 out of 3***) or if only 1 measuring element detects the voltage-change condition (***1 out of 3***).

Dropout Delay

If the dV/dt value falls below the dropout threshold, the dropout of the stage 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.

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.

8.6.4.2 Application and Setting Notes

Parameter: dV/second

- Default setting **(_:22831:3) dV/second** = ***20.000 V***

With the **dV/second** parameter, you determine the pickup value of the stage. The pickup value depends on the application.

For the load-shedding application, it is necessary to detect faster rates of voltage change in the range from 20 V to 30 V per second.

For an island-state detection of the network, the pickup value can be set much lower in the range of 1 V per second or less.

Parameter: Dropout delay

- Default setting **(_:22831:101) Dropout delay** = ***0.00 s***

The **Dropout delay** parameter maintains the pickup even if the measured value drops temporarily below the threshold value. A delay is required for very low pickup values to prevent a chattering of the function.

Parameter: Operate delay

- Default setting **(_:22831:6) Operate delay** = ***3.00 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 immediately, set the **Operate delay** to 0.00 s.

Parameter: Pickup mode

- Default setting **(_:22831:102) 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 voltage falling/rising condition (***3 out of 3***) or if only 1 measuring element detects the voltage falling/rising condition (***1 out of 3***).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. This setting reflects how the function operated in previous generations (SIPROTEC 4).
3 out of 3	Select this setting when using the stage to disconnect from the power system (for example in the case of wind farms).

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.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:22831:10) 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.

8.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13171:137	General:Measuring window		2 periods to 50 periods	5 periods
dV/dt falling1				
_:22831:1	dV/dt falling1:Mode		• off • on • test	off
_:22831:2	dV/dt falling1:Operate & flt.rec. blocked		• no • yes	no
_:22831:10	dV/dt falling1:Blk. by meas.-volt. failure		• no • yes	yes
_:22831:102	dV/dt falling1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:22831:3	dV/dt falling1:dV/second		0.500 V to 200.000 V	20.000 V
_:22831:6	dV/dt falling1:Operate delay		0.00 s to 60.00 s	3.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:22831:101	dV/dt falling1:Dropout delay		0.00 s to 60.00 s	0.00 s
dV/dt rising 1				
_:22801:1	dV/dt rising 1:Mode		• off • on • test	off
_:22801:2	dV/dt rising 1:Operate & flt.rec. blocked		• no • yes	no
_:22801:10	dV/dt rising 1:Blk. by meas.-volt. failure		• no • yes	yes
_:22801:102	dV/dt rising 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:22801:3	dV/dt rising 1:dV/second		0.500 V to 200.000 V	20.000 V
_:22801:6	dV/dt rising 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:22801:101	dV/dt rising 1:Dropout delay		0.00 s to 60.00 s	0.00 s

8.6.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:13171:320	General:dV/s	DEL	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
dV/dt falling1			
_:22831:81	dV/dt falling1:>Block stage	SPS	I
_:22831:51	dV/dt falling1:Mode (controllable)	ENC	C
_:22831:54	dV/dt falling1:Inactive	SPS	O
_:22831:52	dV/dt falling1:Behavior	ENS	O
_:22831:53	dV/dt falling1:Health	ENS	O
_:22831:55	dV/dt falling1:Pickup	ACD	O
_:22831:303	dV/dt falling1:Pickup loop AB	SPS	O
_:22831:304	dV/dt falling1:Pickup loop BC	SPS	O
_:22831:305	dV/dt falling1:Pickup loop CA	SPS	O
_:22831:56	dV/dt falling1:Operate delay expired	ACT	O
_:22831:57	dV/dt falling1:Operate	ACT	O
dV/dt rising 1			
_:22801:81	dV/dt rising 1:>Block stage	SPS	I
_:22801:51	dV/dt rising 1:Mode (controllable)	ENC	C
_:22801:54	dV/dt rising 1:Inactive	SPS	O
_:22801:52	dV/dt rising 1:Behavior	ENS	O
_:22801:53	dV/dt rising 1:Health	ENS	O
_:22801:55	dV/dt rising 1:Pickup	ACD	O
_:22801:303	dV/dt rising 1:Pickup loop AB	SPS	O

No.	Information	Data Class (Type)	Type
_:22801:304	dV/dt rising 1:Pickup loop BC	SPS	O
_:22801:305	dV/dt rising 1:Pickup loop CA	SPS	O
_:22801:56	dV/dt rising 1:Operate delay expired	ACT	O
_:22801:57	dV/dt rising 1:Operate	ACT	O

8.7 Overcurrent Protection, Phases

8.7.1 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

8.7.2 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**
- 1 stage **Inverse-time overcurrent protection – advanced**
- 1 stage **User-defined overcurrent protection characteristic curve**

In the **Overcurrent protection, phases – basic** function type, the following stages can be operated simultaneously:

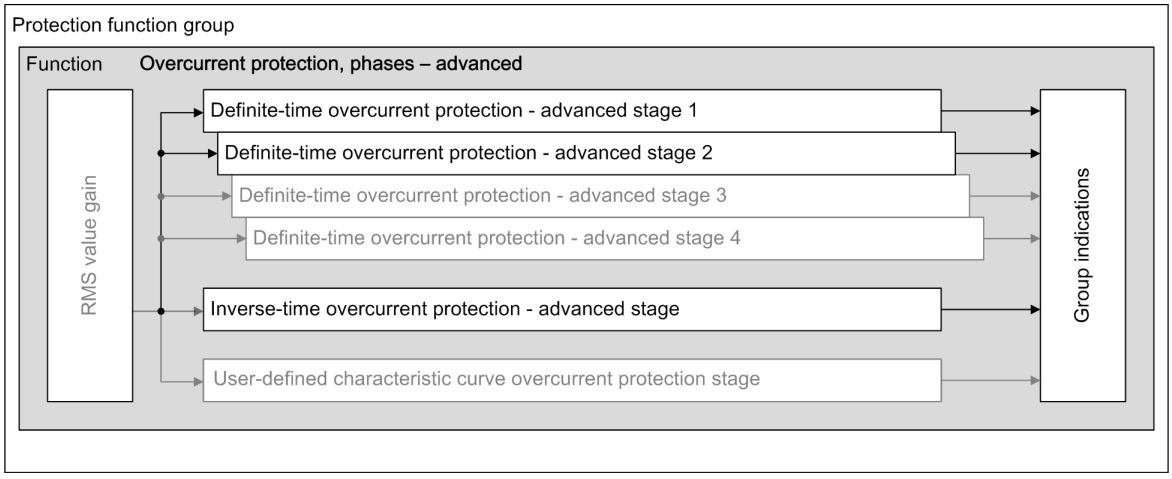
- Maximum of 4 stages **Definite-time overcurrent protection – basic**
- 1 stage **Inverse-time overcurrent protection – basic**

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.

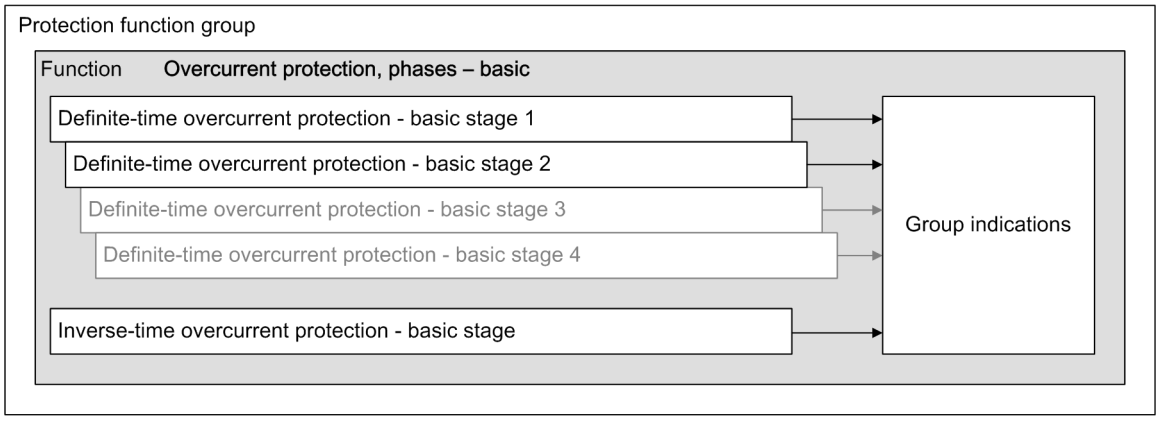
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_ocp_ad with filter2, 1, en_US]

Figure 8-22 Structure/Embedding of the Function Overcurrent Protection, Phases – Advanced



[dw_ocp_bp_1, 3, en_US]

Figure 8-23 Structure/Embedding of 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).

8.7.3 Filter for RMS Value Gain

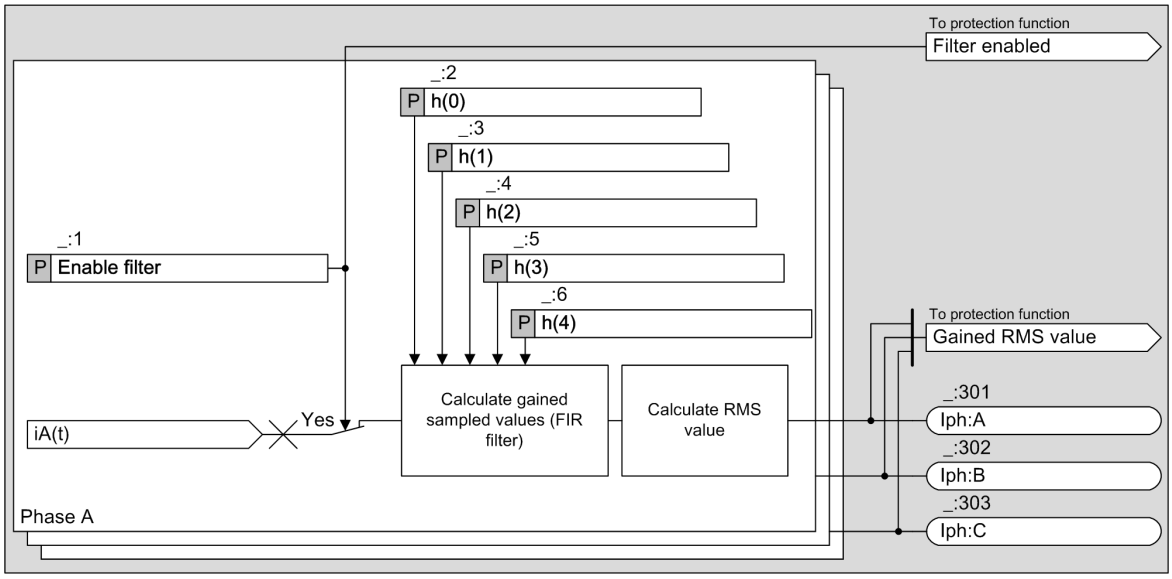
8.7.3.1 Description

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_filter_stage, 1, en_US]

Figure 8-24 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`**
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 ---.

8.7.3.2 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

8.7.3.3 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

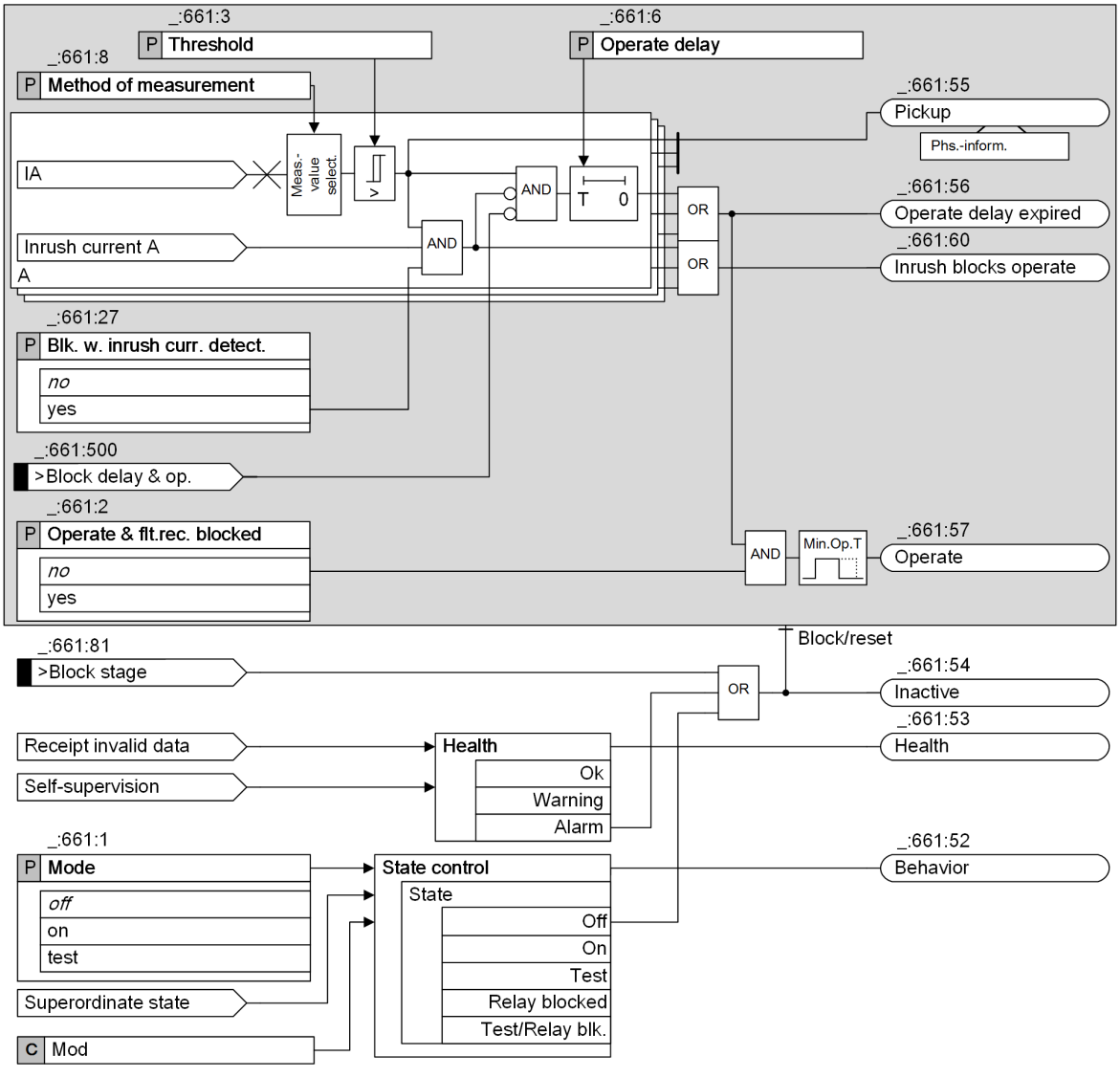
8.7.3.4 Information List

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

8.7.4 Stage with Definite-Time Characteristic Curve

8.7.4.1 Description

Logic of the Basic Stage



[lo_ocp_3b1, 4, en_US]

Figure 8-25 Logic Diagram of the Definite-Time Overcurrent Protection (Phases) – Basic

Method of measurement

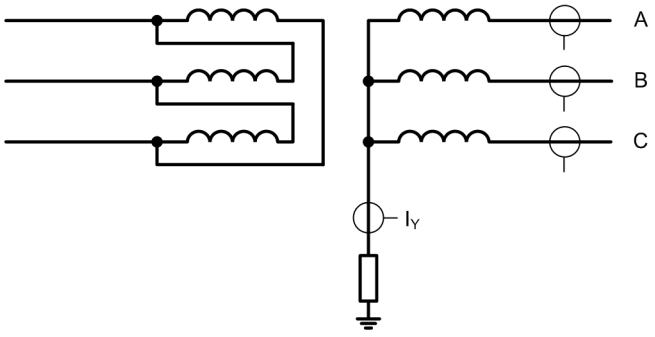
You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- 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.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the 2-phase short circuit 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.



[dw_sgaocp, 1, en_US]

Figure 8-26 I0 Elimination Principle

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 $\underline{I}_{phx\text{-elim.}}$ 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.

Blocking of the Stage

The following blocking resets the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source

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.

8.7.4.2 Application and Setting Notes

If the main protection fails or the external faults are not switched off, the overcurrent protection is the short-circuit protection for small generators and as backup protection for larger power-plant units. In order to ensure short-circuit protection during the startup operation (generator circuit breaker is open), the protection function must be operated on the current transformers in the generator neutral point.

Parameter: `Method of measurement`

- Default setting **`(_:661:8) Method of measurement`** = ***`fundamental comp.`***

With the **`Method of measurement`** parameter, you 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). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **`threshold value`** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: `Threshold`, `Operate delay`

- Default setting **`(_:661:3) Threshold`** = ***`1.35 A`*** (for the 1st stage)
- Default setting **`(_:661:6) Operate delay`** = ***`1.50 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):

For generator protection applications, the threshold value will be set to the maximum permissible operating current and typically ranges from 1.2 times to 1.5 times of $I_{N,\ generator}$. The **`Operate delay`** parameter must be set in coordination with line protection. In the following example, the value of the **`Operate delay`** parameter is 1.50 s.

Determination of the Secondary Pickup Value:

Pickup value 1.4 • $I_{N,\ mach}$	
Rated current $I_{N,\ mach}$	483 A
Rated current $I_{N,\ transf.,\ prim}$	500 A
Rated current $I_{N,\ sec}$	1 A

This results in the following secondary setting values:

$$I> = \frac{1.4 \cdot I_{rated,machine}}{I_{rated\ transf.,\ prim}} \cdot I_{rated,\ sec} = \frac{1.4 \cdot 483\ A}{500\ A} \cdot 1\ A = 1.35\ A$$

[fo_ocp_7um, 1, en_US]

2nd Stage (High-Current Stage):

This stage can be used for a quick tripping during the startup procedure. This function must only be active if the generator circuit breaker is open. In order to eliminate the overfunction, Siemens recommends a

closed-circuit system for the binary input control. Thus, a wire break results in a permanent blocking of the stage. A tripping delay of 0.1 s is recommended. Select a pickup value between the stationary and the transient short-circuit current.

Determination of the Secondary Pickup Value:

Pickup value 1.4 • $I_{N, mach}$	
Rated current $I_{N, Mach}$	483 A
Rated current $I_{N, Transf., prim}$	500 A
Rated current $I_{N, sec}$	1 A

This results in the following secondary setting values:

$$I> = \frac{1.4 \cdot I_{rated,machine}}{I_{rated\ transf., prim}} \cdot I_{rated, sec} = \frac{1.4 \cdot 483\ A}{500\ A} \cdot 1\ A = 1.35\ A$$

[fo_ocp_7um, 1, 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 2-phase short circuit 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.

8.7.4.3 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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
_: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 100.00 s	0.30 s
_:661:7	Definite-T 1:Operate delay mode		• Running dur. DO-delay • Frozen dur. DO-delay	Running dur. DO-delay
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 100.00 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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 100.00 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
_: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 100.00 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 100.00 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 100.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
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 100.00 s	0.30 s

8.7.4.4 Information List

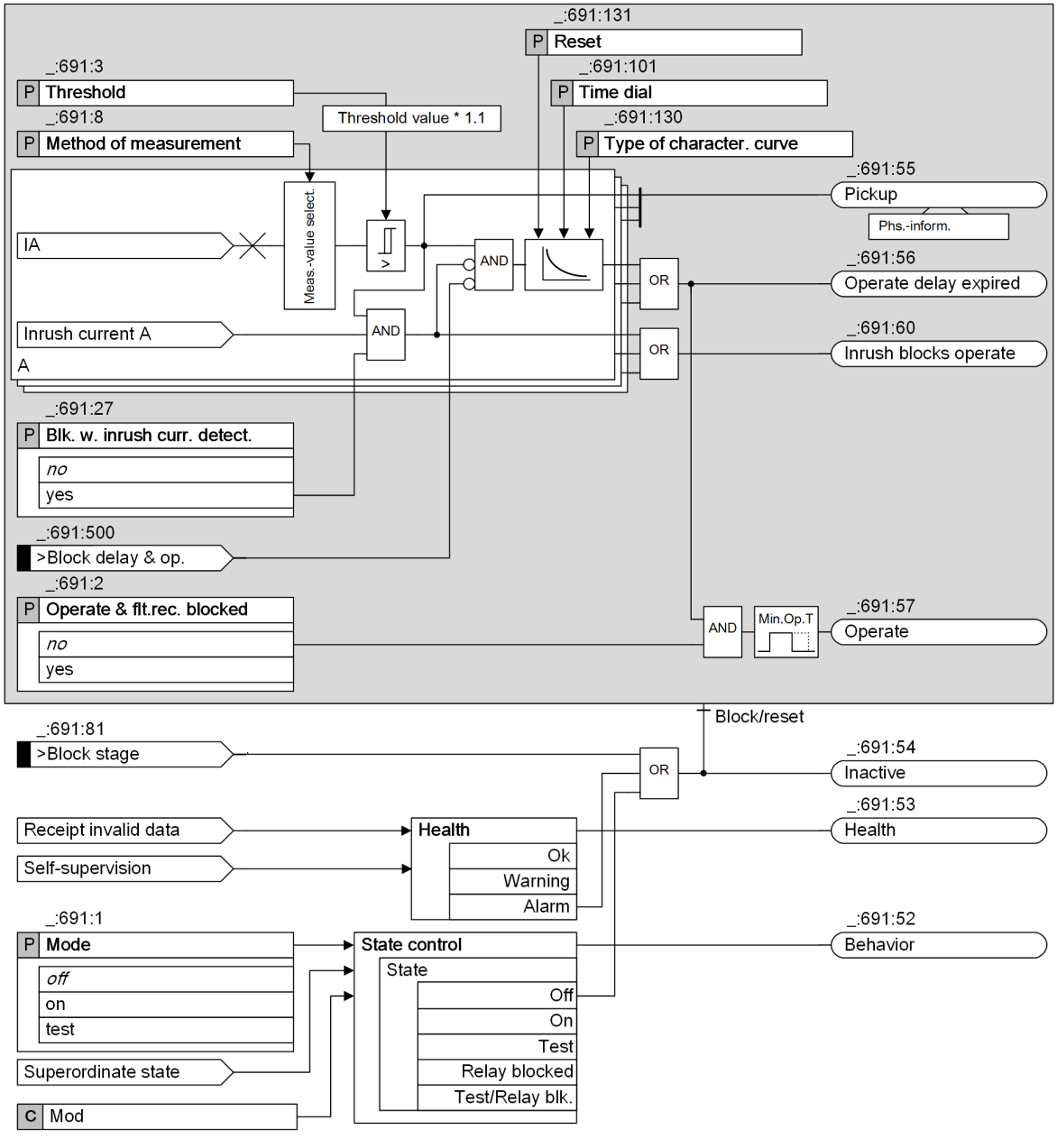
No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:661:81	Definite-T 1:>Block stage	SPS	I
_:661:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:661:500	Definite-T 1:>Block delay & op.	SPS	I
_:661:54	Definite-T 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
Definite-T 2			
_:662:81	Definite-T 2:>Block stage	SPS	I
_:662:84	Definite-T 2:>Activ. dyn. settings	SPS	I
_:662:500	Definite-T 2:>Block delay & op.	SPS	I
_:662:54	Definite-T 2:Inactive	SPS	O
_:662:52	Definite-T 2:Behavior	ENS	O
_:662:53	Definite-T 2:Health	ENS	O
_:662:60	Definite-T 2:Inrush blocks operate	ACT	O

No.	Information	Data Class (Type)	Type
_:662:62	Definite-T 2:Dyn.set. AR cycle1act.	SPS	O
_:662:63	Definite-T 2:Dyn.set. AR cycle2act.	SPS	O
_:662:64	Definite-T 2:Dyn.set. AR cycle3act.	SPS	O
_:662:65	Definite-T 2:Dyn.set. ARcycl.>3act	SPS	O
_:662:66	Definite-T 2:Dyn.set. CLP active	SPS	O
_:662:67	Definite-T 2:Dyn.set. BI active	SPS	O
_:662:68	Definite-T 2:Dyn. set. blks. pickup	SPS	O
_:662:55	Definite-T 2:Pickup	ACD	O
_:662:56	Definite-T 2:Operate delay expired	ACT	O
_:662:57	Definite-T 2:Operate	ACT	O
_:662:302	Definite-T 2:I0el.Iph	WYE	O

8.7.5 Stage with Inverse-Time Characteristic Curve

8.7.5.1 Description

Logic of the Basic Stage



[lo_ocp3b2, 3, en_US]

Figure 8-27 Logic Diagram Inverse-Time Overcurrent Protection (Phases) – Basic

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve according to IEC and ANSI

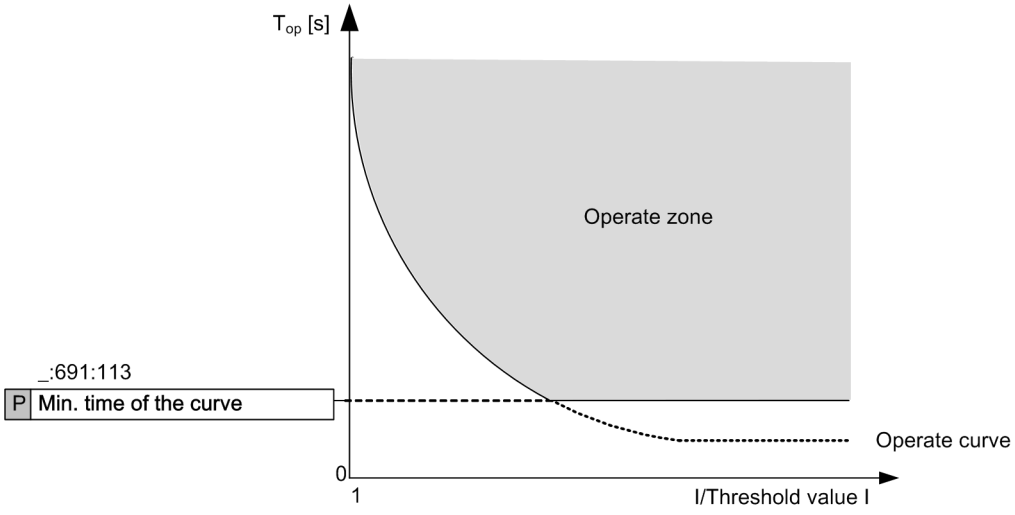
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present 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 · 1.1 · 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.



[dw_ocp_3_mi, 1, en_US]

Figure 8-28 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

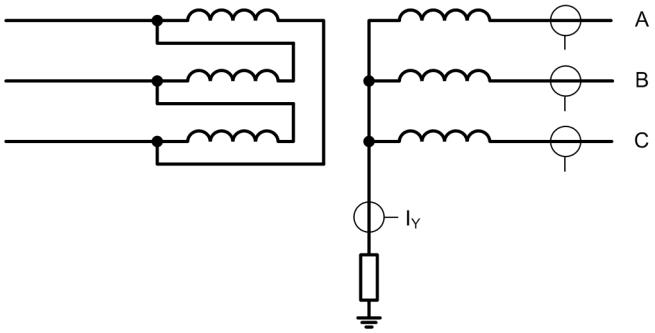
You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- 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 2-phase short circuit 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.



[dw_sgaocp, 1, en_US]

Figure 8-29 I0 Elimination Principle

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

The following blocking resets the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source

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.

8.7.5.2 Application and Setting Notes

In order to derive the setting values for the generator protection application, refer to the implementations for the independent stages (see *8.7.4.2 Application and Setting Notes*). Coordinate the characteristic curve that must be set with the characteristic curve type of the protection system. As pickup value, 1.3 $I_{N,generator}$ may be selected. The time multiplier derives from the time-grading schedule.

General information pertaining to the settings will be provided below. These examples refer to power-system protection applications.

Parameter: Method of measurement

- Recommended setting value **(_:691:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you 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). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

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 *13.13.2 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 **Min. time of the curve** parameter, 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 **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, 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 measurands result in the setting values:

Threshold value I> (primary) = 630 A

$$\text{Threshold value I> (secondary)} = \frac{630\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 5.25\ \text{A}$$

[fo_ocp_005, 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 2-phase short circuit 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***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.
The set value for the **Time dial** parameter 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 parameter **Time dial** at ***1*** (default setting).

Parameter: `Reset`

- Default setting **`(_:691:131) Reset`** = ***`disk emulation`***

With the **`Reset`** parameter, 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`	Select this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

8.7.5.3 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
_: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

Addr.	Parameter	C	Setting Options	Default Setting
_: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
_: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

Addr.	Parameter	C	Setting Options	Default Setting
_: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
_: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

8.7.5.4 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
_:691:84	Inverse-T 1:>Activ. dyn. settings	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

No.	Information	Data Class (Type)	Type
_:691:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:691:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:691:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:691:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:691:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:691:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:691:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	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
_:691:302	Inverse-T 1:I0el.Iph	WYE	O

8.7.6 Stage with User-Defined Characteristic Curve

8.7.6.1 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 *8.7.5.1 Description*). The only differences are as follows:

- You can define the characteristic curve as desired.
- The pickup and dropout behaviors of this stage are determined by the standard parameter **`Threshold`** and, if necessary, by an additional parameter **`Threshold (absolute)`**.

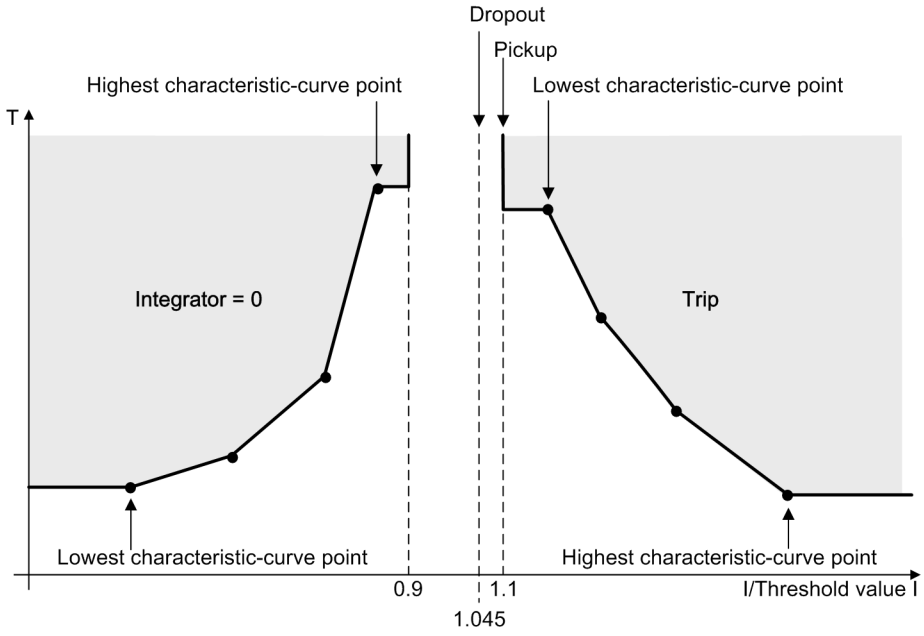
User-Defined Characteristic Curve

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 Behaviors 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.



[dw_ocp_ken_02, 2, en_US]

Figure 8-30 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.

If you want to change the pickup threshold of the stage without changing all points of the characteristic curve, you can use the additional **`Threshold (absolute)`** parameter.

You can set the **`Threshold (absolute)`** parameter to be greater than 1.1 times the **`Threshold`** value. Then the stage behaviors are as follows:

- The stage picks up when the measured current value exceeds the **`Threshold (absolute)`** value.
- The stage starts dropout when the measured current value falls short of the **`Threshold (absolute)`** value by 0.95 times.
- For measured current values lower than the **`Threshold (absolute)`** value, no pickup takes place and consequently the characteristic curve is not processed.

If you set the **`Threshold (absolute)`** parameter to be less than 1.1 times the **`Threshold`** value, the pickup and dropout behaviors are not affected by the **`Threshold (absolute)`** parameter.

8.7.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse-time overcurrent protection – advanced** stage. The only differences are described in chapter *8.7.6.1 Description* . This chapter provides only the application and setting notes for setting characteristic curves and for setting the **`Threshold (absolute)`** parameter. You can find more information on the other parameters of the stage in chapter *8.7.5.2 Application and Setting Notes* .

Parameter: `Current/time value pairs` (from the operate curve)

With these settings, you 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***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter 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***.

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

With the **Reset** parameter, 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	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	Select 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)

With these settings, you 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 trip logic of the **Circuit-breaker** function group) is always 3-pole because the device does not support phase-selective tripping.

Parameter: `Threshold (absolute)`

- Default setting **`(_:113) Threshold (absolute)`** = ***`0.000 A`***

With the **`Threshold (absolute)`** parameter, you define and change the absolute pickup threshold of the stage without changing all points of the characteristic curve.

The parameter is only used for special applications. With the default setting, this functionality is disabled.

You can find more information in *Pickup and Dropout Behaviors with the User-Defined Characteristic Curve , Page 734*.

8.7.6.3 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
_: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
_:113	User curve #:Threshold (absolute)	1 A @ 100 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 100 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 50 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 50 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.000 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.000 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
_:115	User curve #: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				
_: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
_: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

Addr.	Parameter	C	Setting Options	Default Setting
_: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

8.7.6.4 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

No.	Information	Data Class (Type)	Type
_: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

8.8 Overcurrent Protection, Ground

8.8.1 Overview of Functions

The **Overcurrent protection, ground** function (ANSI 50N/51N):

- Detects short circuits in electrical equipment
- Can be used as backup or emergency overcurrent protection in addition to the main protection

8.8.2 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:

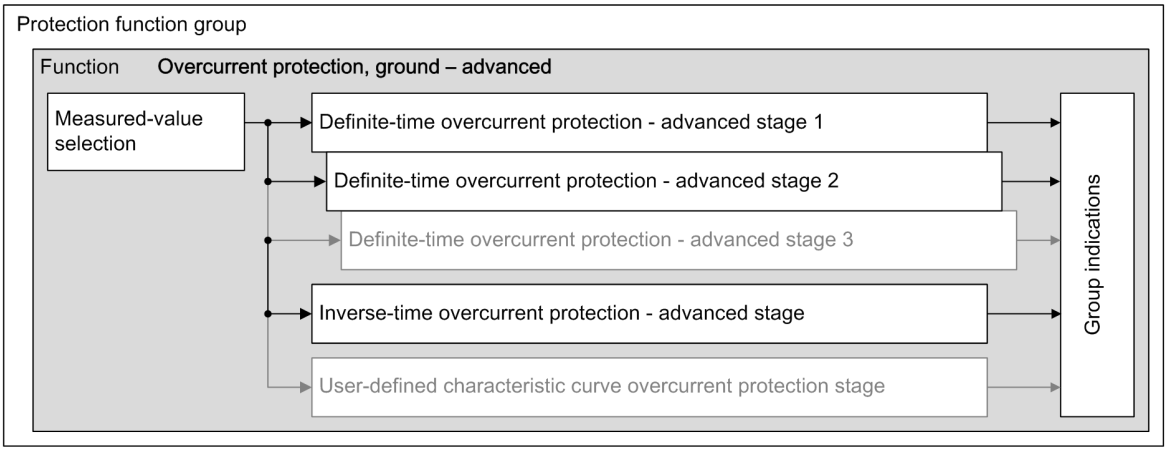
- Maximum of 3 stages **Definite-time overcurrent protection – basic**
- 1 stage **Inverse-time overcurrent protection – basic**

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 8-31* and *8.8.3.1 Description*). This ensures that all stages of the function receive the same measured current value.

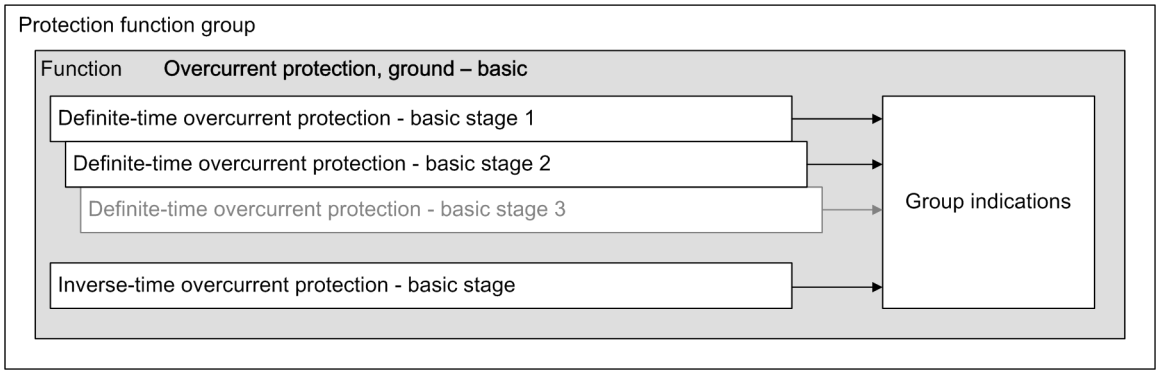
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_ocp_ga2, 5, en_US]

Figure 8-31 Structure/Embedding of the Function Overcurrent Protection, Ground – Advanced



[dw_ocp_gb1, 4, en_US]

Figure 8-32 Structure/Embedding of 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).

8.8.3 General Functionality

8.8.3.1 Description

Measured-Value Selection

The function provides the option to select between the values ***IN measured*** or ***3I0 calculated***.

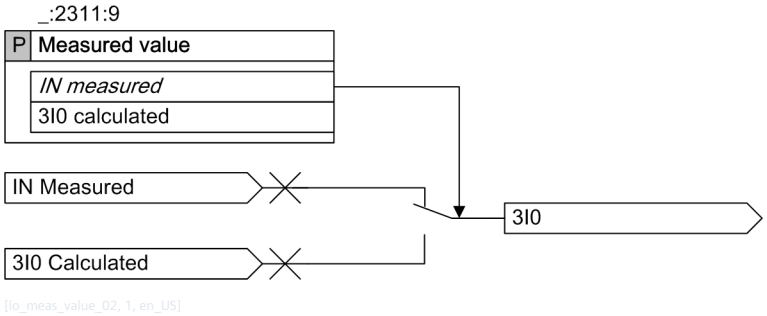


Figure 8-33 Logic Diagram of Measured-Value Selection

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 8-1 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	0.010 A to 35.000 A	N/A	N/A	0.050 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.002 A to 8.000 A
	IN measured	4 * Protection	0.010 A to 35.000 A	N/A	N/A	0.050 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.002 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.010 A to 35.000 A	0.010 A to 35.000 A	0.050 A to 175.00 A	0.050 A to 175.00 A
		3 * Protection, 1 * sen.	0.010 A to 35.000 A	0.010 A to 35.000 A	0.050 A to 175.00 A	0.050 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.002 A to 8.000 A	0.002 A to 8.000 A
	IN measured	4 * Protection	0.010 A to 35.000 A	0.050 A to 175.00 A	0.010 A to 35.000 A	0.050 A to 175.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.002 A to 8.000 A	0.001 A to 1.600 A	0.002 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.002 A to 8.000 A	0.001 A to 1.600 A	0.002 A to 8.000 A

8.8.3.2 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.

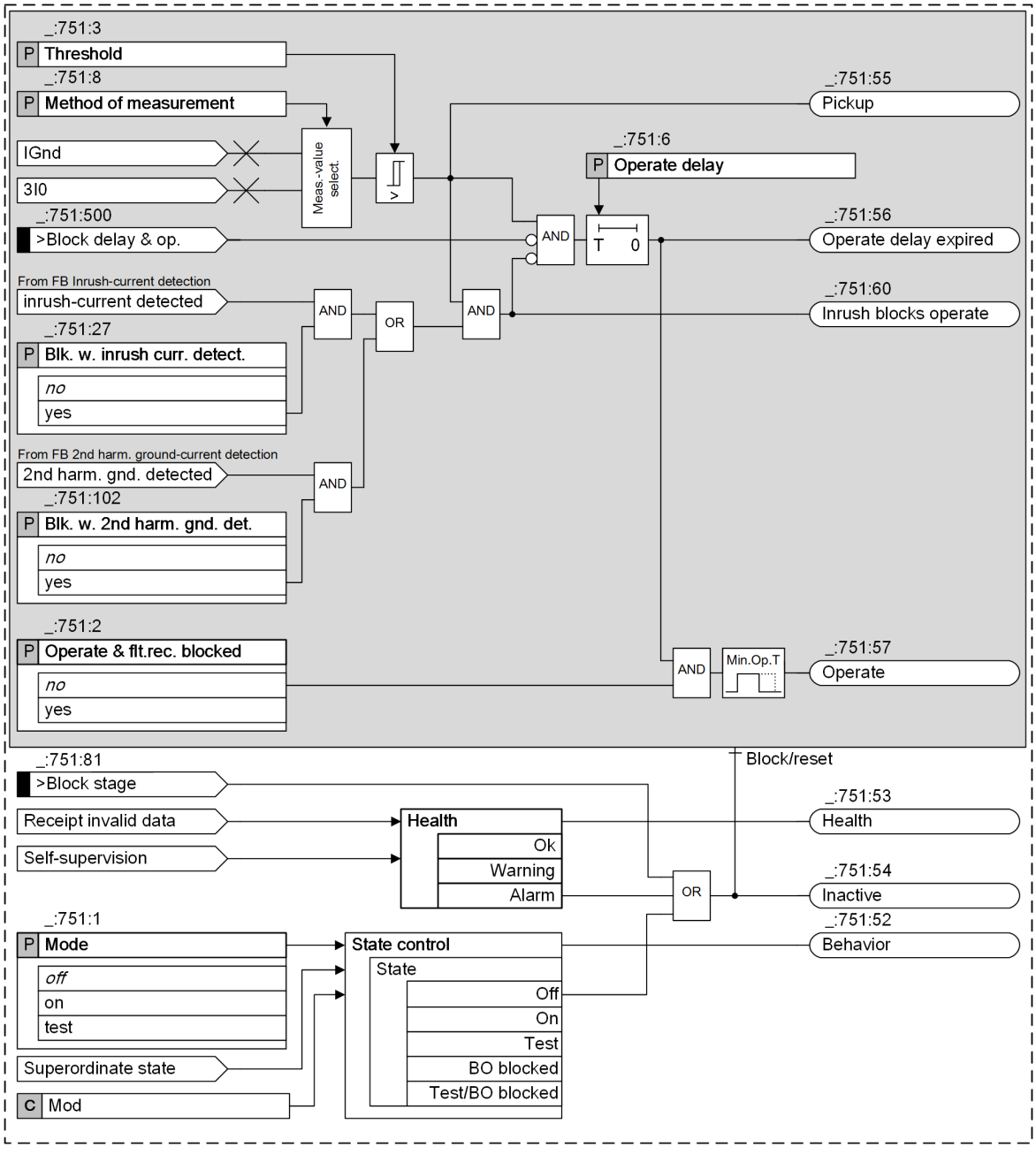
8.8.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

8.8.4 Stage with Definite-Time Characteristic Curve

8.8.4.1 Description

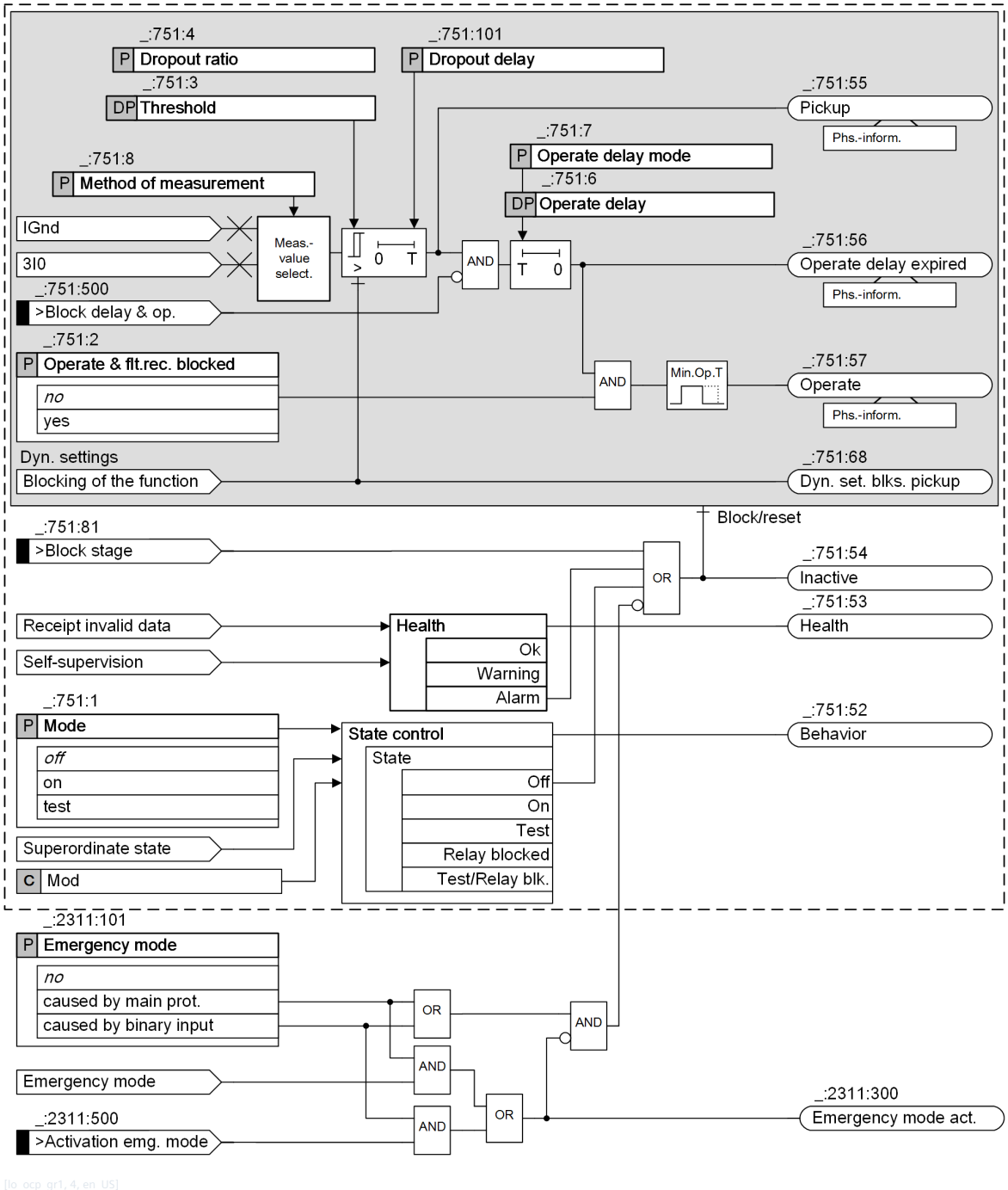
Logic of the Basic Stage



[lo_ocp_gb1, 4, en_US]

Figure 8-34 Logic Diagram Definite-Time Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[lo_ocp_gr1, 4, en_US]

Figure 8-35 Logic Diagram Definite-Time Overcurrent Protection (Ground) – Advanced

Emergency mode (Advanced Stage)

You use the **Emergency mode** parameter to define whether the stage operates as emergency overcurrent protection or as backup overcurrent protection. With the setting **Emergency mode** = ***caused by main prot.***, emergency overcurrent protection starts automatically when the main protection fails. This happens, for example, in the case of distance protection when a short circuit occurs in the voltage-transformer secondary circuit, when the voltage-transformer secondary circuit is disconnected or in the case of line differential protection where protection communication is disconnected. This means that the emergency mode replaces

the main protection as short-circuit protection. With the appropriate parameterization (**Emergency mode** = **caused by binary input**), the emergency mode can also be activated from an external source.

If the overcurrent protection is set as backup overcurrent protection (parameter **Emergency mode** = ***no***), it operates independently of the main protection and thus in parallel. Backup overcurrent protection can also serve as sole short-circuit protection when, for example, no voltage transformers are available for an initial startup.

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 current falls below the dropout threshold, the dropout can be delayed for the time specified by the parameter **Dropout delay**. During the dropout delay, the pickup is maintained. Meanwhile, the operate delay continues to run (parameter **Operate delay mode** = ***Running dur. DO-delay***) or is frozen (parameter **Operate delay mode** = ***Frozen dur. DO-delay***). If the operate delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage

The following blocking resets the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source

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.

8.8.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:751:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you 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). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: **Operate delay mode**

- Default setting **(_:661:7) Operate delay mode** = ***Running dur. DO-delay***

This parameter is not visible in the basic stage.

With the parameter **Operate delay mode**, you specify whether the operate delay continues to run or is frozen during the dropout delay.

This setting is only valid if the parameter **Dropout delay** is not ***0***.

Parameter Value	Description
Running dur. DO-delay	During the dropout delay, the operate delay continues to run.
Frozen dur. DO-delay	During the dropout delay, the operate delay is frozen. If the current exceeds the threshold value again, the operate delay continues to run.

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.

For very small ground-fault currents, Siemens recommends using the **Ground-fault protection against high-resistance ground faults in grounded systems** function.

The **Operate delay** to be set is derived from the time-grading schedule that has been prepared for the system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

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_ocp_002, 1, en_US]

$$Z_P = \frac{110\ \mathrm{kV}^2}{2500\ \mathrm{MVA}} = 4.84\ \Omega$$

[fo_ocp_003, 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_ocp_005, 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 · 1133 A = 1246.3 A

Threshold value 2nd stage (secondary) = $1.1 \cdot \frac{1133\ \mathrm{A}}{600\ \mathrm{A}} \cdot 5\ \mathrm{A} = 10.39\ \mathrm{A}$

[fo_ocp_gr4, 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 using 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 stage.

8.8.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Emergency mode		• no • caused by main prot. • caused by binary input	no
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
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
_:751:102	Definite-T 1:Blk. w. 2nd harm. gnd. det.		• 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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
_:751:7	Definite-T 1:Operate delay mode		• Running dur. DO-delay • Frozen dur. DO-delay	Running dur. DO-delay
Dyn.s: AR off/n.rdy				
_:751:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:35	Definite-T 1:Stage blocked		• no • yes	no
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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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
General				
_:752:1	Definite-T 2:Mode		• off • on • test	off
_:752:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:752:26	Definite-T 2:Dynamic settings		• no • yes	no
_:752:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:752:102	Definite-T 2:Blk. w. 2nd harm. gnd. det.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:752:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:752:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:752:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:752:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:752:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
_:752:7	Definite-T 2:Operate delay mode		• Running dur. DO-delay • Frozen dur. DO-delay	Running dur. DO-delay
Dyn.s: AR off/n.rdy				
_:752:28	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:752:35	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:752:29	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:752:36	Definite-T 2:Stage blocked		• no • yes	no
_:752:14	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:752:20	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:752:30	Definite-T 2:Effected by AR cycle 2		• no • yes	no
_:752:37	Definite-T 2:Stage blocked		• no • yes	no
_:752:15	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:752:21	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 3				
_:752:31	Definite-T 2:Effected by AR cycle 3		• no • yes	no
_:752:38	Definite-T 2:Stage blocked		• no • yes	no
_:752:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:752:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:752:32	Definite-T 2:Effected by AR cycle gr. 3		• no • yes	no
_:752:39	Definite-T 2:Stage blocked		• no • yes	no
_:752:17	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:752:23	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:752:33	Definite-T 2:Effect. b. cold-load pickup		• no • yes	no
_:752:40	Definite-T 2:Stage blocked		• no • yes	no
_:752:18	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:752:24	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:752:34	Definite-T 2:Effected by binary input		• no • yes	no
_:752:41	Definite-T 2:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:752:19	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:752:25	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s

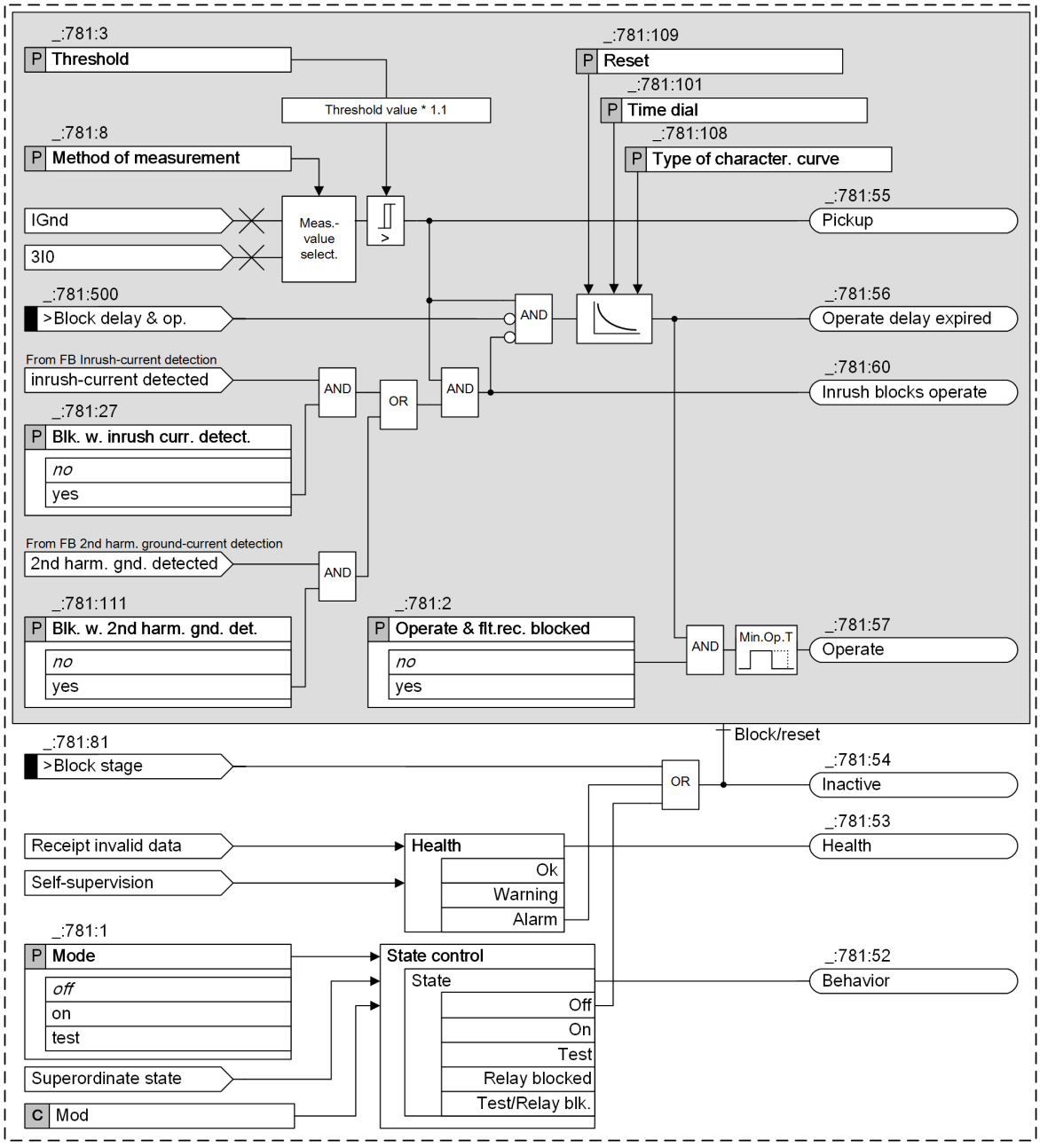
8.8.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
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
_:751:60	Definite-T 1:Inrush blocks operate	ACT	O
_:751:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:751:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:751:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:751:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:751:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:751:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:751:68	Definite-T 1:Dyn. set. blks. pickup	SPS	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

8.8.5 Stage with Inverse-Time Characteristic Curve

8.8.5.1 Description

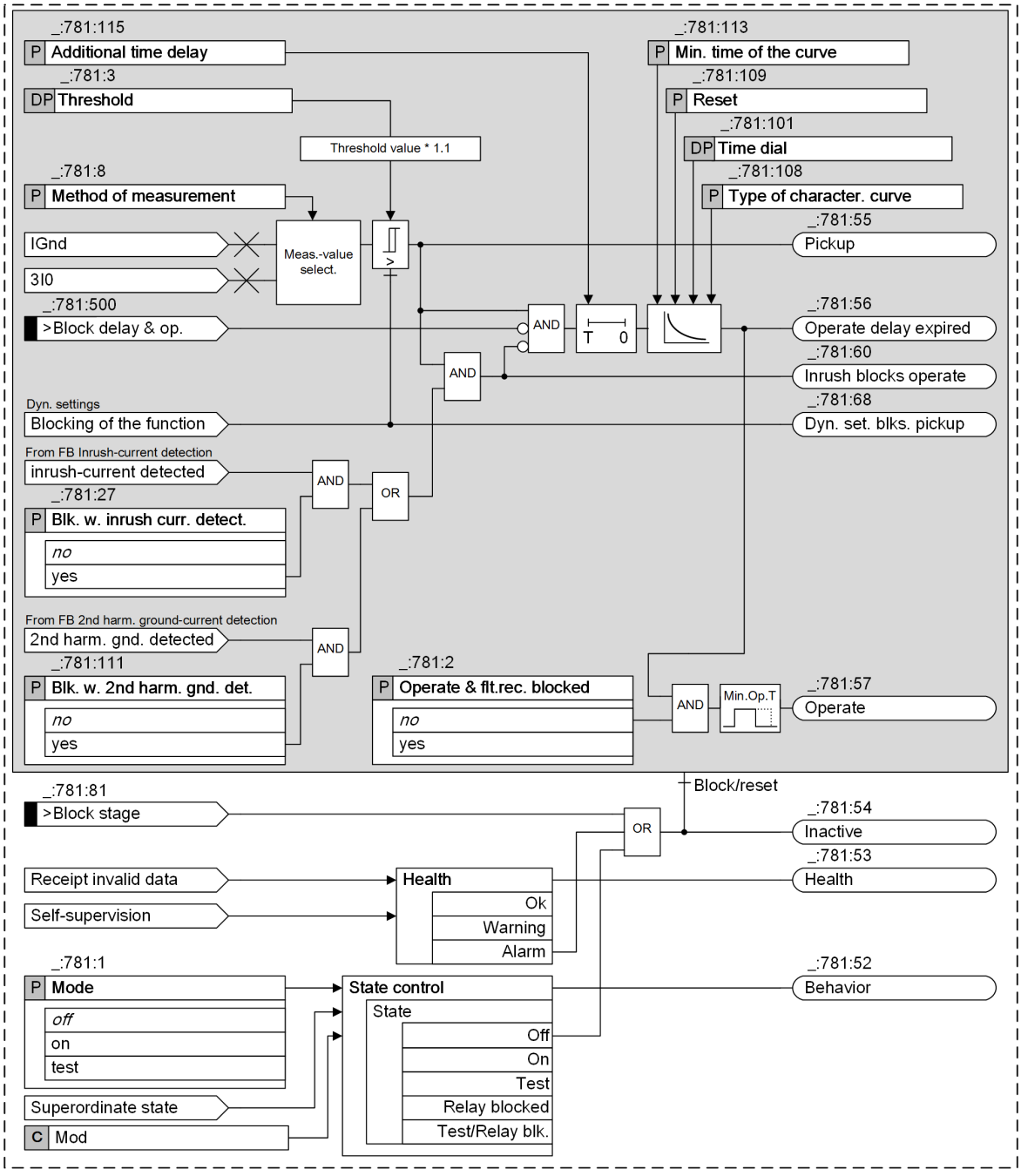
Logic of the Basic Stage



[lo_ocp_gr2_6, en_US]

Figure 8-36 Logic Diagram Inverse-Time Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[lo_ocp_gn2, 5, en_US]

Figure 8-37 Logic Diagram Inverse-Time Overcurrent Protection (Ground) – Advanced

Emergency mode (Advanced Stage)

You use the **Emergency mode** parameter to define whether the stage operates as emergency overcurrent protection or as backup overcurrent protection. With the setting **Emergency mode** = ***caused by main prot.***, emergency overcurrent protection starts automatically when the main protection fails. This happens, for example, in the case of distance protection when a short circuit occurs in the voltage-transformer secondary circuit, when the voltage-transformer secondary circuit is disconnected or in the case of line differential protection where protection communication is disconnected. This means that the emergency mode replaces

the main protection as short-circuit protection. With the appropriate parameterization (**Emergency mode** = ***caused by binary input***), the emergency mode can also be activated from an external source.

If the overcurrent protection is set as backup overcurrent protection (parameter **Emergency mode** = ***no***), it operates independently of the main protection and thus in parallel. Backup overcurrent protection can also serve as sole short-circuit protection when, for example, no voltage transformers are available for an initial startup.

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

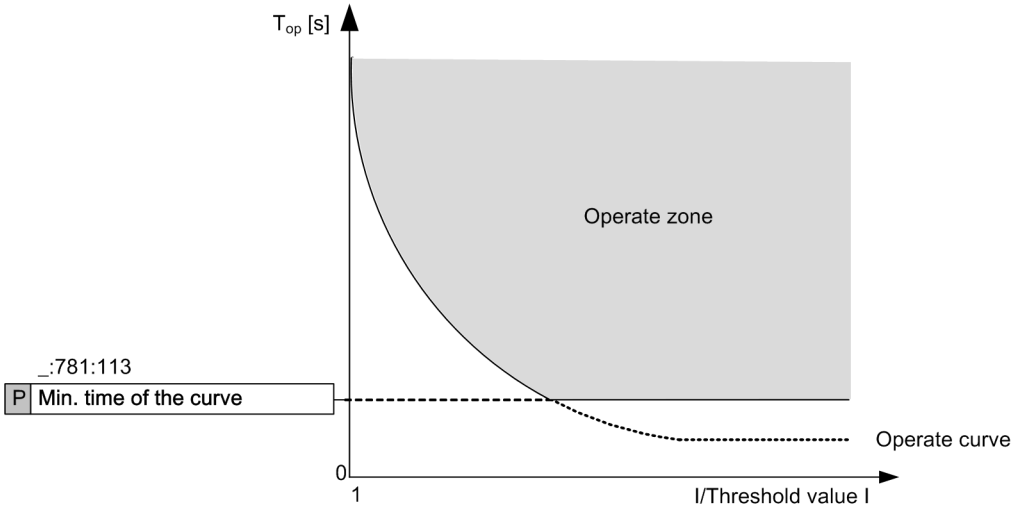
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present 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 · 1.1 · 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.



[dw_ocp_gr3_mi, 1, en_US]

Figure 8-38 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

The following blocking resets the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source

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.

8.8.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:781:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you 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). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

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*13.14.2 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 **Min. time of the curve** parameter, 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 **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, 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***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading schedule that has been prepared for the electrical power system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

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***

With the **Reset** parameter, 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	Select this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

8.8.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Emergency mode		• no • caused by main prot. • caused by binary input	no
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
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
_:781:111	Inverse-T 1:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:781:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:781:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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

Addr.	Parameter	C	Setting Options	Default Setting
_:781:36	Inverse-T 1:Stage blocked		• no • yes	no
_:781:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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
_:781:38	Inverse-T 1:Stage blocked		• no • yes	no
_:781:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:781:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:781:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

8.8.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
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
_:781:84	Inverse-T 1:>Activ. dyn. settings	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
_:781:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:781:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:781:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:781:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O

No.	Information	Data Class (Type)	Type
_:781:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:781:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:781:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	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

8.8.6 Stage with User-Defined Characteristic Curve

8.8.6.1 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 *8.8.5.1 Description*). The only differences are as follows:

- You can define the characteristic curve as desired.
- The pickup and dropout behaviors of this stage are determined by the standard parameter **`Threshold`** and, if necessary, by an additional parameter **`Threshold (absolute)`**.

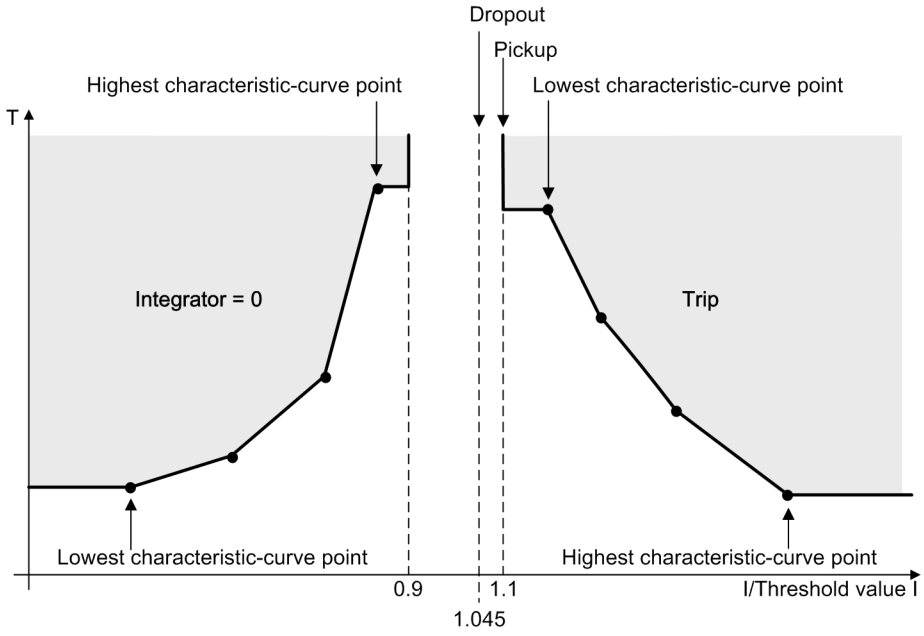
User-Defined Characteristic Curve

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 Behaviors 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.



[dw_ocp_ken_02, 2, en_US]

Figure 8-39 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.

If you want to change the pickup threshold of the stage without changing all points of the characteristic curve, you can use the additional **`Threshold (absolute)`** parameter.

You can set the **`Threshold (absolute)`** parameter to be greater than 1.1 times the **`Threshold`** value. Then the stage behaviors are as follows:

- The stage picks up when the measured current value exceeds the **`Threshold (absolute)`** value.
- The stage starts dropout when the measured current value falls short of the **`Threshold (absolute)`** value by 0.95 times.
- For measured current values lower than the **`Threshold (absolute)`** value, no pickup takes place and consequently the characteristic curve is not processed.

If you set the **`Threshold (absolute)`** parameter to be less than 1.1 times the **`Threshold`** value, the pickup and dropout behaviors are not affected by the **`Threshold (absolute)`** parameter.

8.8.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse-time overcurrent protection – advanced** stage. The only differences are described in chapter *8.8.6.1 Description* . This chapter provides only the application and setting notes for setting characteristic curves and for setting the **`Threshold (absolute)`** parameter. You can find more information on the other parameters of the stage in chapter *8.8.5.2 Application and Setting Notes* .

Parameter: `Current/time value pairs` (from the operate curve)

With these settings, you 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***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter 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***.

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

With the **Reset** parameter, 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	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	Select 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)

With these settings, you 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: Threshold (absolute)

- Default setting **(_:113) Threshold (absolute)** = ***0.000 A***

With the **Threshold (absolute)** parameter, you define and change the absolute pickup threshold of the stage without changing all points of the characteristic curve.

The parameter is only used for special applications. With the default setting, this functionality is disabled. You can find more information in *Pickup and Dropout Behaviors with the User-Defined Characteristic Curve , Page 764*.

8.8.6.3 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
_:111	User curve #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:113	User curve #:Threshold (absolute)	1 A @ 100 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 100 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 50 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 50 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.000 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
_:115	User curve #:Additional time delay		0.00 s to 60.00 s	0.00 s
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

Addr.	Parameter	C	Setting Options	Default Setting
_:14	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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

Addr.	Parameter	C	Setting Options	Default Setting
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 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	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 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	0.002 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

8.8.6.4 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

8.9 Group Indications of Overcurrent Protection Functions

8.9.1 Description

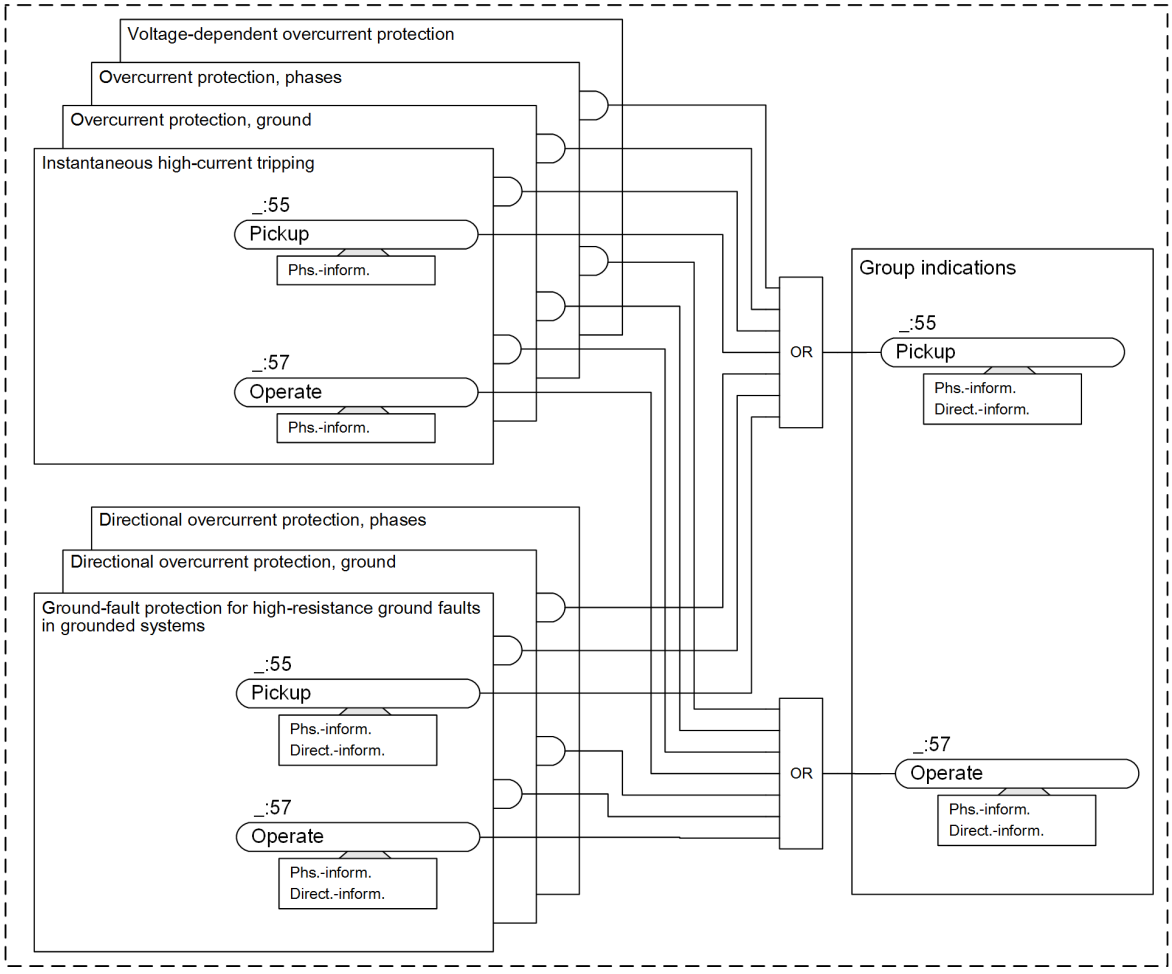
The function block **Group indications of the overcurrent protection functions** uses the pickup and operate indications of the following functions:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Voltage-dependent overcurrent protection
- Directional overcurrent protection, phases
- Directional overcurrent protection, ground
- Ground-fault protection for high-impedance ground faults in grounded systems
- 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 8-40*):

- **`Pickup`**
- **`Operate`**

The pickup and operate indications are output, where present, with direction information.



[lo_oc_grin, 4, en_US]

Figure 8-40 Logic Diagram of the Overcurrent Protection Group Indications

8.10 External Trip Initiation 3-Pole

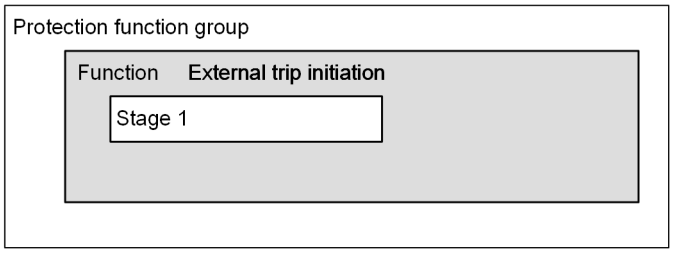
8.10.1 Overview of Functions

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

8.10.2 Structure of the Function

The function **External trip initiation** includes one stage. You can instantiate the **External trip initiation** function in DIGSI 5 multiple times.

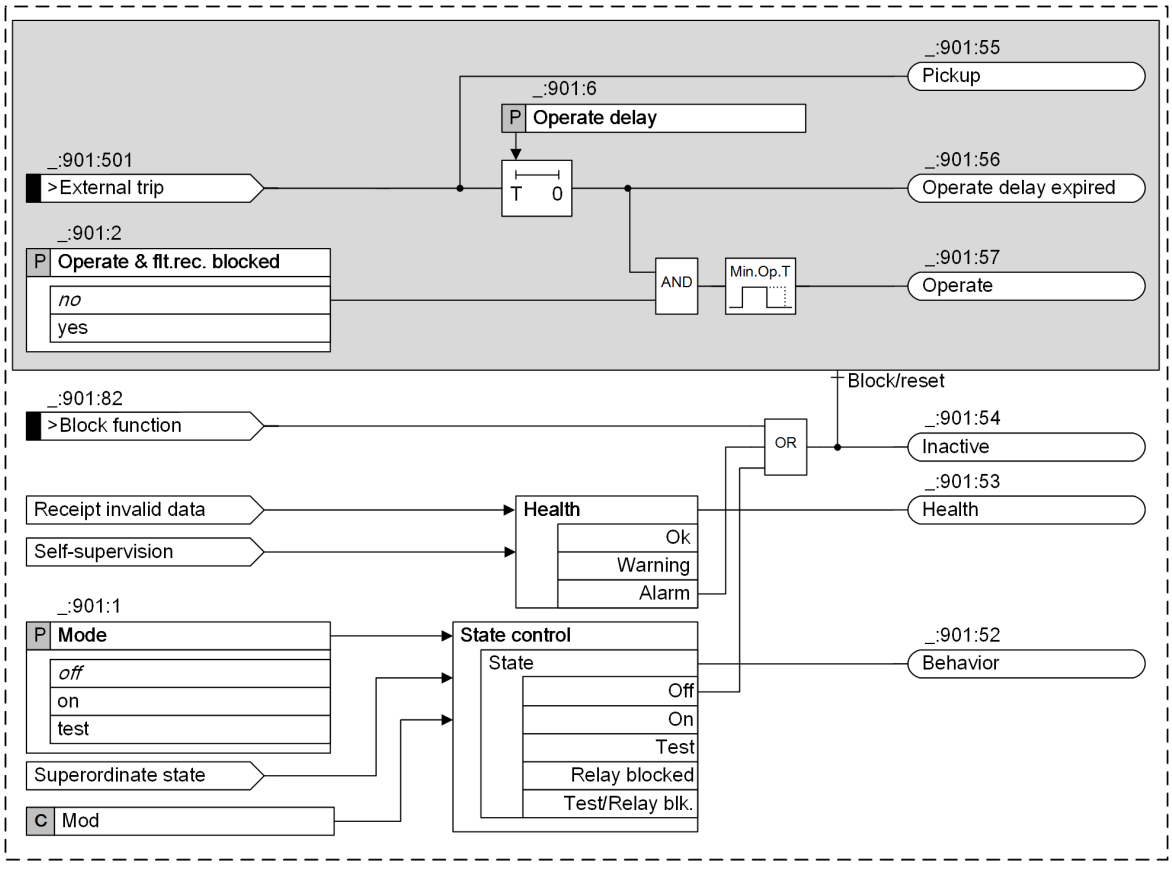


[dw_strext, 2, en_US]

Figure 8-41 Structure/Embedding of the Function

8.10.3 Stage Description

Logic of the Stage



[lo_ext-trip-initiation, 3, en_US]

Figure 8-42 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**.

8.10.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:901:6) Operate delay** = ***0.00 s***

The **Operate delay** parameter must be set for the specific application. After expiry of the **Operate delay** the time-out 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**.

8.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	on
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s

8.10.6 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

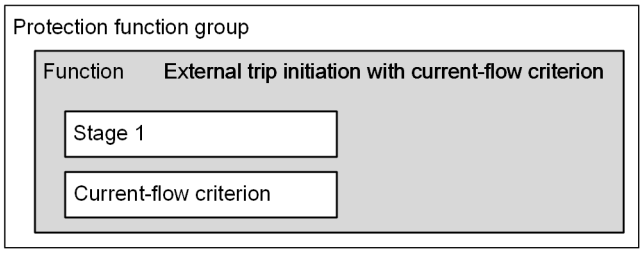
8.11 External Trip Initiation with Current-Flow Criterion 3-Pole

8.11.1 Overview of Functions

The **External trip initiation with current-flow criterion** function enables the use of a current-flow criterion. Otherwise, the function operates as the **External trip initiation** (see *8.10.1 Overview of Functions*).

8.11.2 Structure of the Function

The **External trip initiation with current-flow criterion** function contains 2 fixed steps. You can instantiate the **External trip initiation with current-flow criterion** function in DIGSI 5 multiple times.

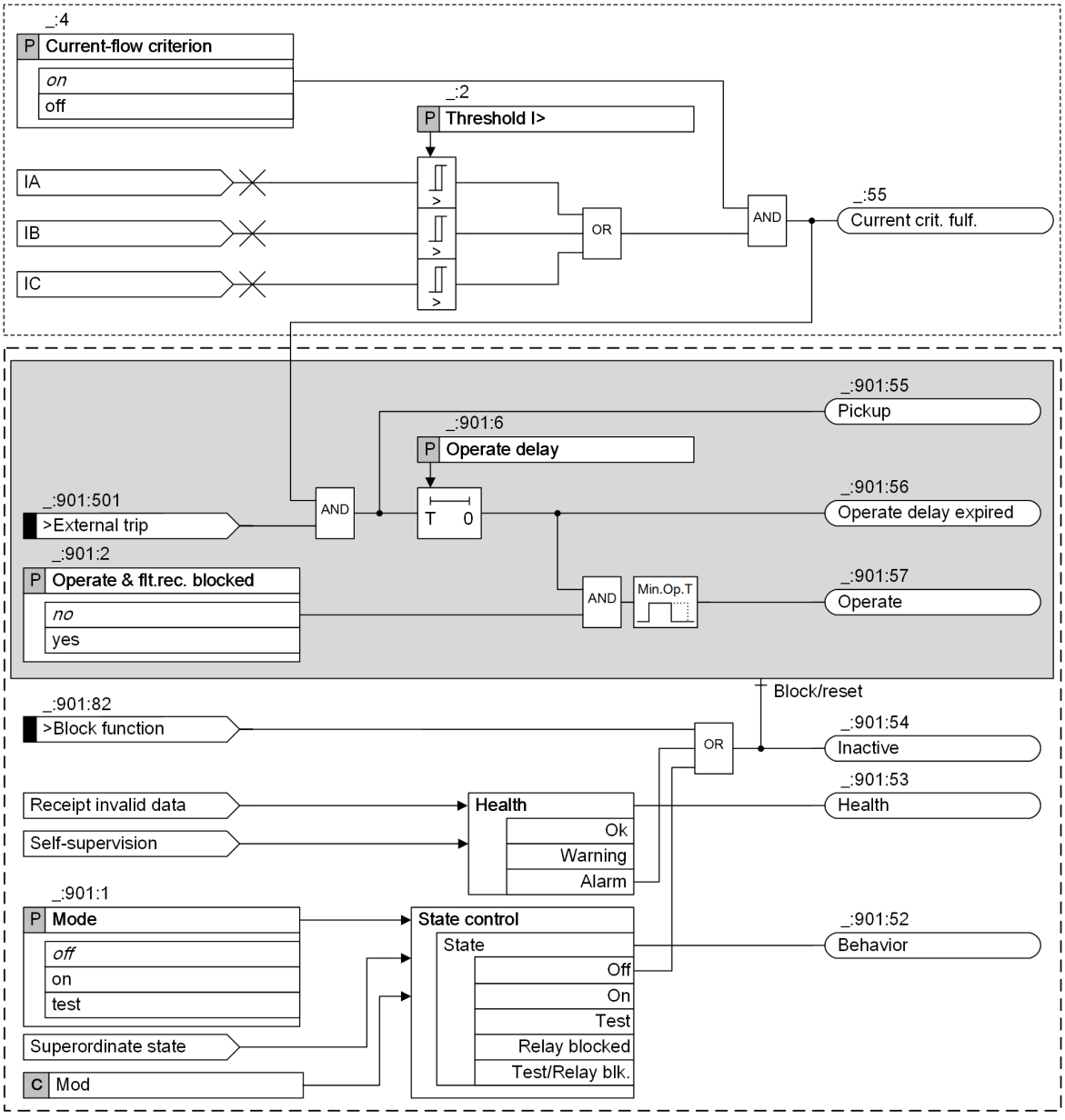


[dw_strext_CIC-051021, 1, en_US]

Figure 8-43 Structure/Embedding of the Function

8.11.3 Stage Description

Stage Logic



[lo_ext-trip-initiation_CfC, 1, en_US]

Figure 8-44 Logic Diagram of the Stage External Trip Initiation with Threshold Value I>

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 activate state at the time of blocking, it will be immediately reset. However, the operate indication remains for the minimum operating time **(_:102) Minimum operate time**.

8.11.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:901:6) Operate delay** = *0.00 s*

The **Operate delay** parameter must be set for the specific application. After the expiry of the **Operate delay**, the time-out and tripping are signaled. The duration of the initiation signal and the adjustable minimum command time determine the signal duration of the **Operate**.

Parameter: Current-flow criterion

- Recommended setting value **(_:4) Current-flow criterion** = *on*

With the parameter **Current-flow criterion**, you can switch off the stage. When switched off, the external trip initiation can work without current criterion.

Parameter: Threshold I>

- Recommended setting value **(_:2) Threshold I>** = *0.05 A*

The **Threshold I>** parameter must be set for the specific application. The tripping is only output if the current exceeds the **threshold value I>**. This is also signaled by *(_:55) Current crit. fulf.*.

8.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	on
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s
Curr.criterion				
_:4	Curr.criterion:Current-flow criterion		• off • on	on
_:2	Curr.criterion: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

8.11.6 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
_:901:51	Stage 1:Mode (controllable)	ENC	C
_:901:54	Stage 1:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_: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
Curr.criterion			
_:51	Curr.criterion:Mode (controllable)	ENC	C
_:52	Curr.criterion:Behavior	ENS	O
_:53	Curr.criterion:Health	ENS	O
_:55	Curr.criterion:Current crit. fulf.	SPS	O

8.12 Inrush-Current and 2nd Harmonic Detection

8.12.1 Inrush-Current Detection

8.12.1.1 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

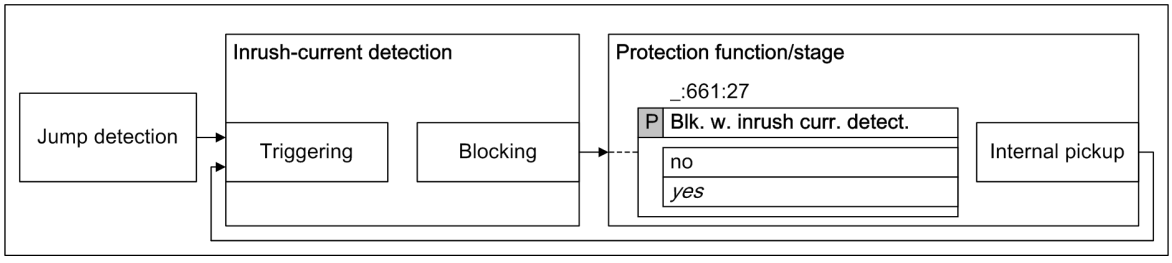
8.12.1.2 Structure of the Function

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.



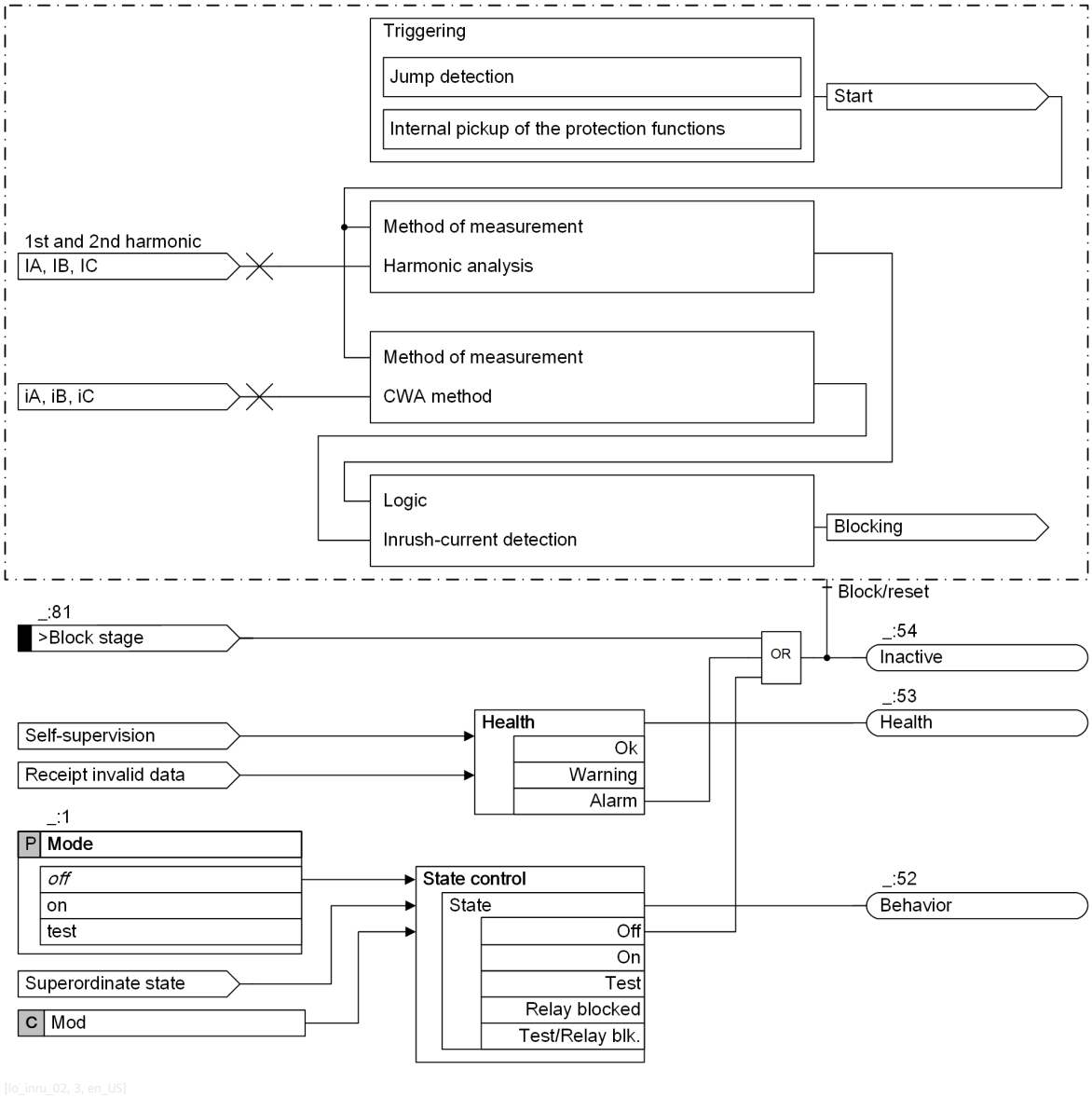
[dw_irsh01, 1, en_US]

Figure 8-45 Structure/Embedding of the Function

8.12.1.3 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 methods of measurement **Harmonic Analysis** and the **CWA method** (current wave shape analysis). Both methods work in parallel and link the results with 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`** .



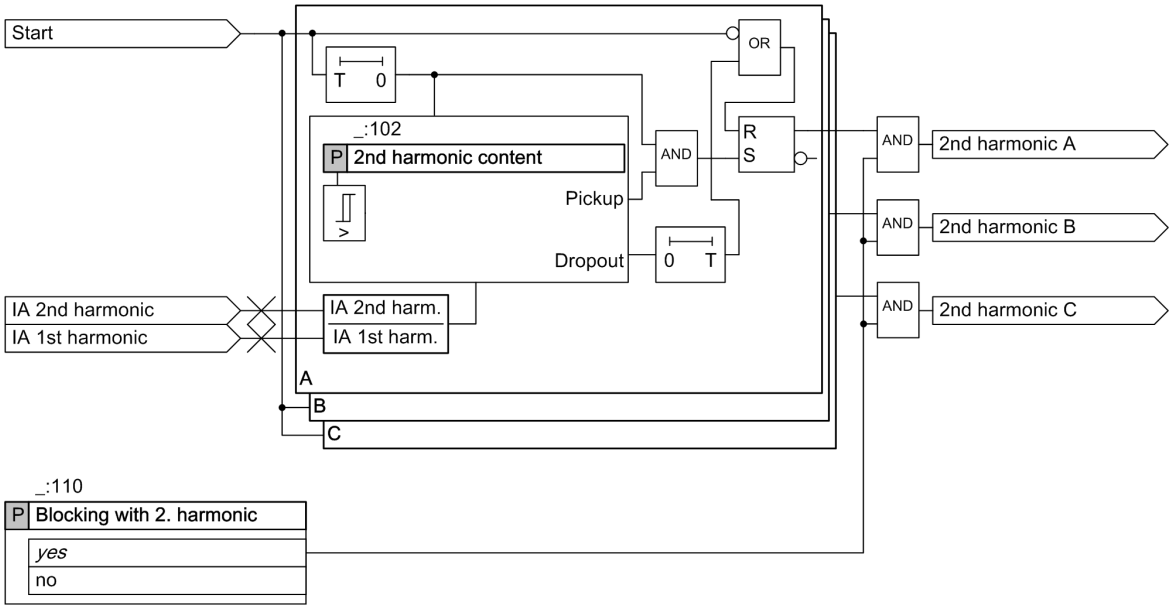
[lo_inru_02, 3, en_US]

Figure 8-46 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 75 % of the set threshold value is exceeded, this leads to a pickup reset (dropout ratio = 0.75).

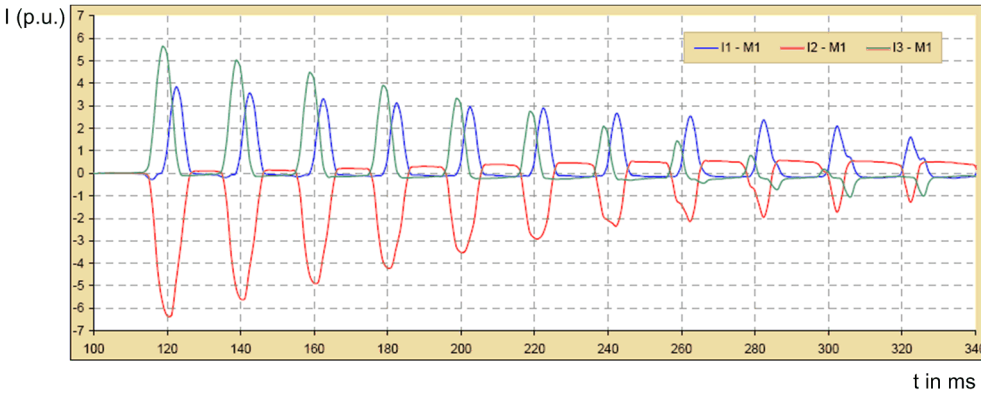


[lo_inrush_10, 1, en_US]

Figure 8-47 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.

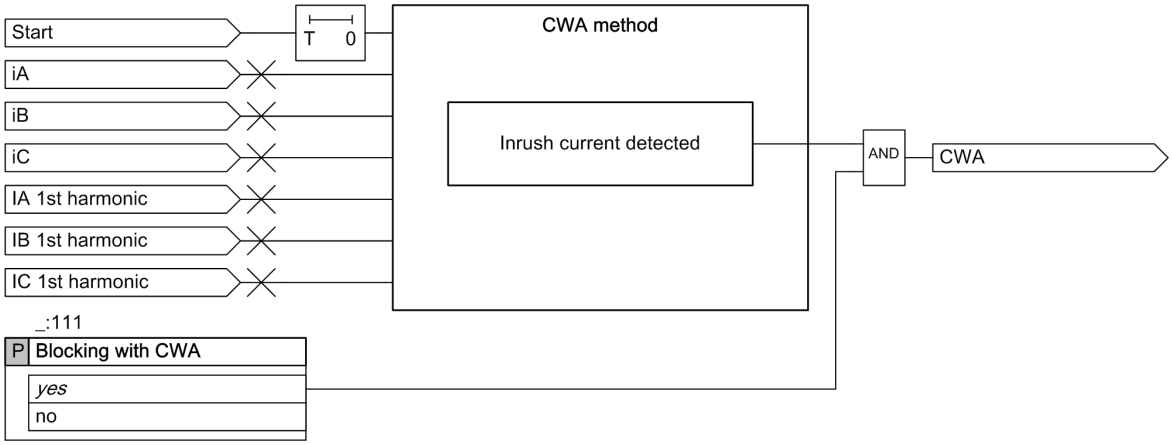


[dw_inrush_03, 1, en_US]

Figure 8-48 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.



[lo_inrush_05, 1, en_US]

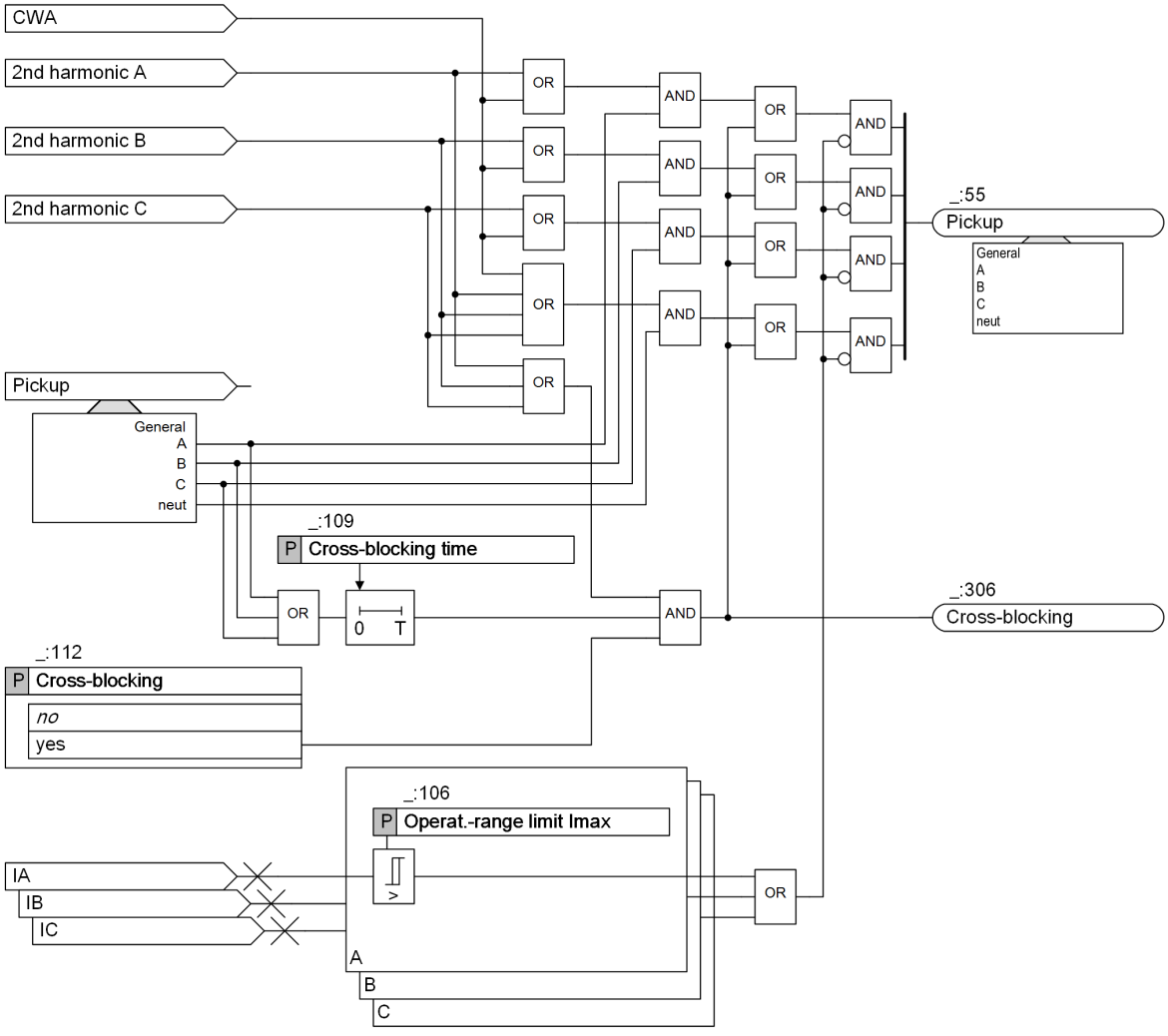
Figure 8-49 Logic of the CWA-Method Function (T = 1 Period)

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 a blocking indication in the event of threshold-value violation 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 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.



[lo_inrush_12, 2, en_US]

Figure 8-50 Logic Diagram of the Inrush-Current Detection

8.12.1.4 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. Set the value to be greater than the RMS value of 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.

8.12.1.5 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

8.12.1.6 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

8.12.2 2nd Harmonic Ground Detection

8.12.2.1 Overview of Functions

The **2nd harmonic to ground detection** function:

- Detects the content of 2nd harmonics in the neutral-point phase current **IN** or in the calculated zero-sequence current **3I0**.
- Generates a blocking signal for protection functions that use the neutral-point phase current **IN** or the calculated zero-sequence current **3I0** as a measured value
- Allows a sensitive setting of the protection functions

The following protection functions analyze the blocking signal:

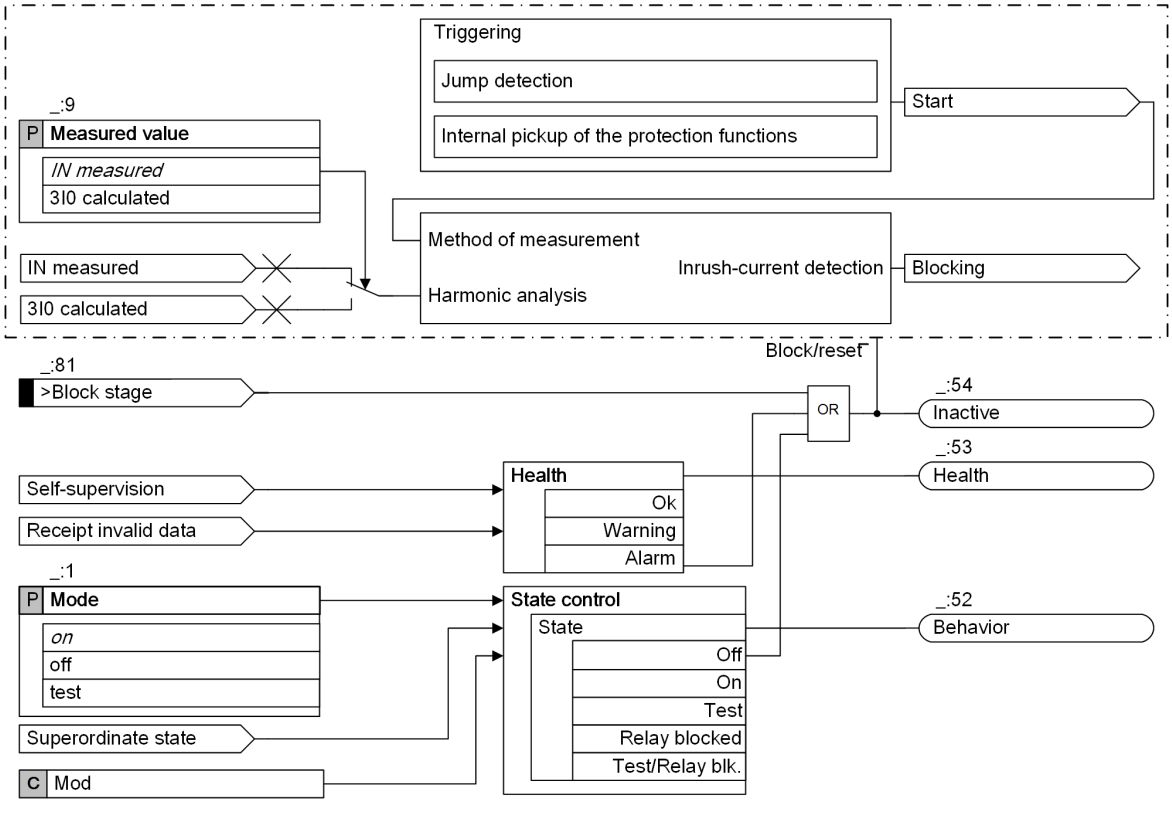
- Overcurrent protection, ground
- Directional sensitive ground-fault detection
- Non-directional sensitive ground-fault detection

8.12.2.2 Structure of the Function

The **2nd harmonic ground detection** function is not an autonomous protection function. In the connection process of a transformer, it sends a blocking signal to other protection functions. For this reason, the **2nd harmonic ground detection** function must be in the same function group as the functions that are to be blocked.

8.12.2.3 Function Description

Logic



[lo_2harm_detec_gnd, 2, en_US]

Figure 8-51 Logic of 2nd Harmonic Detection Ground

Harmonic Analysis

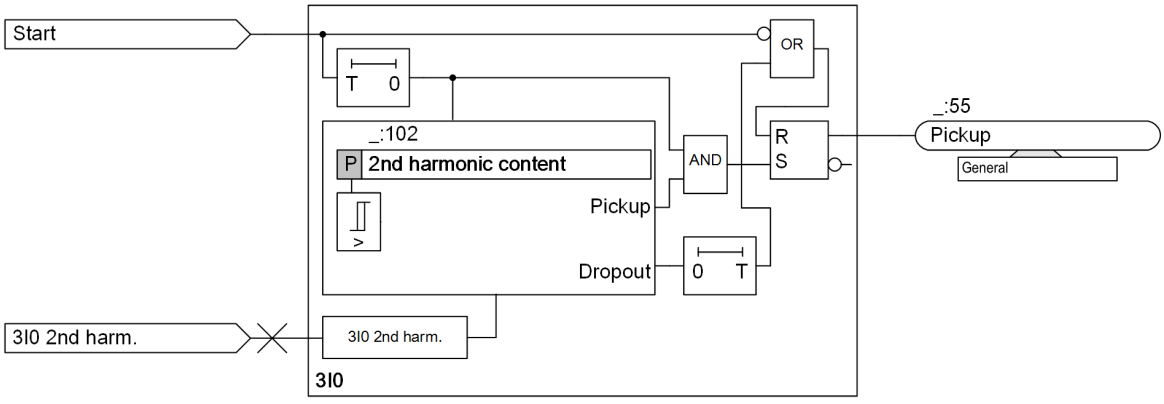
For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) is determined for the neutral-point phase current **IN** or the calculated zero-sequence current **3I0** and the quotient $I_{2nd\ harm}/I_{1st\ harm}$ is formed from this. If this quotient exceeds the set threshold value, a blocking signal is issued.

NOTE

During a transformer saturation, the high content of the 2nd harmonic in the ground current must not lead to a pickup of the function.

NOTE

If the ground current is measured in case of a sensitive transformer and the measured value exceeds the saturation threshold of 1.6 · IN, the function switches to the calculated 3I0 value.



[lo_harmon-analyse, 1, en_US]

Figure 8-52 Logic of the Harmonic Analysis Function

8.12.2.4 Application and Setting Notes

Parameter: Measured value

- Default setting = **(_:9) Measured value** = ***IN measured***

Parameter Value	Description
IN measured	The function evaluates the measured neutral-point phase current **IN**.
3I0 calculated	The function evaluates the calculated zero-sequence current **3I0**.

Parameter: 2nd harmonic content

- Default setting **(_:102) 2nd harmonic content** = ***15 %***

With the parameter **2nd harmonic content**, you can specify the percentage content of the 2nd harmonic in ***IN measured*** or in ***3I0 calculated*** at which the inrush-current detection is blocked internally.

8.12.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2.hrm.det. gnd				
_:1	2.hrm.det. gnd:Mode		• off • on • test	on
_:9	2.hrm.det. gnd:Measured value		• 3I0 calculated • IN measured	IN measured
_:102	2.hrm.det. gnd:2nd harmonic content		10 % to 45 %	15 %

8.12.2.6 Information List

No.	Information	Data Class (Type)	Type
2.hrm.det. gnd			
_:81	2.hrm.det. gnd:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:51	2.hrm.det. gnd:Mode (controllable)	ENC	C
_:54	2.hrm.det. gnd:Inactive	SPS	O
_:52	2.hrm.det. gnd:Behavior	ENS	O
_:53	2.hrm.det. gnd:Health	ENS	O
_:55	2.hrm.det. gnd:Pickup	ACD	O

8.13 Instantaneous High-Current Tripping

8.13.1 Overview of Functions

The function **Instantaneous high-current tripping** (ANSI 50) has the following tasks:

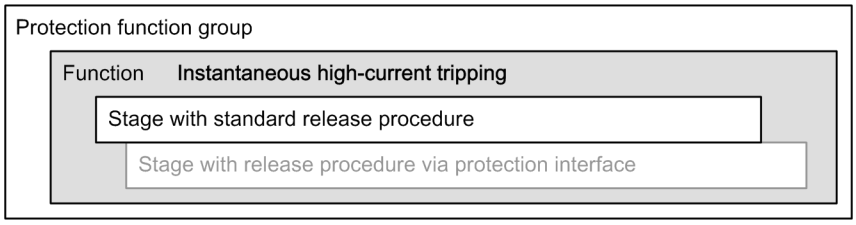
- Instantaneous tripping when switching onto an existing fault, for example, if a grounding switch is closed.
- Instantaneous disconnection of high currents above the highest overcurrent-protection stage.
- The function works independently of other functions.

8.13.2 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.

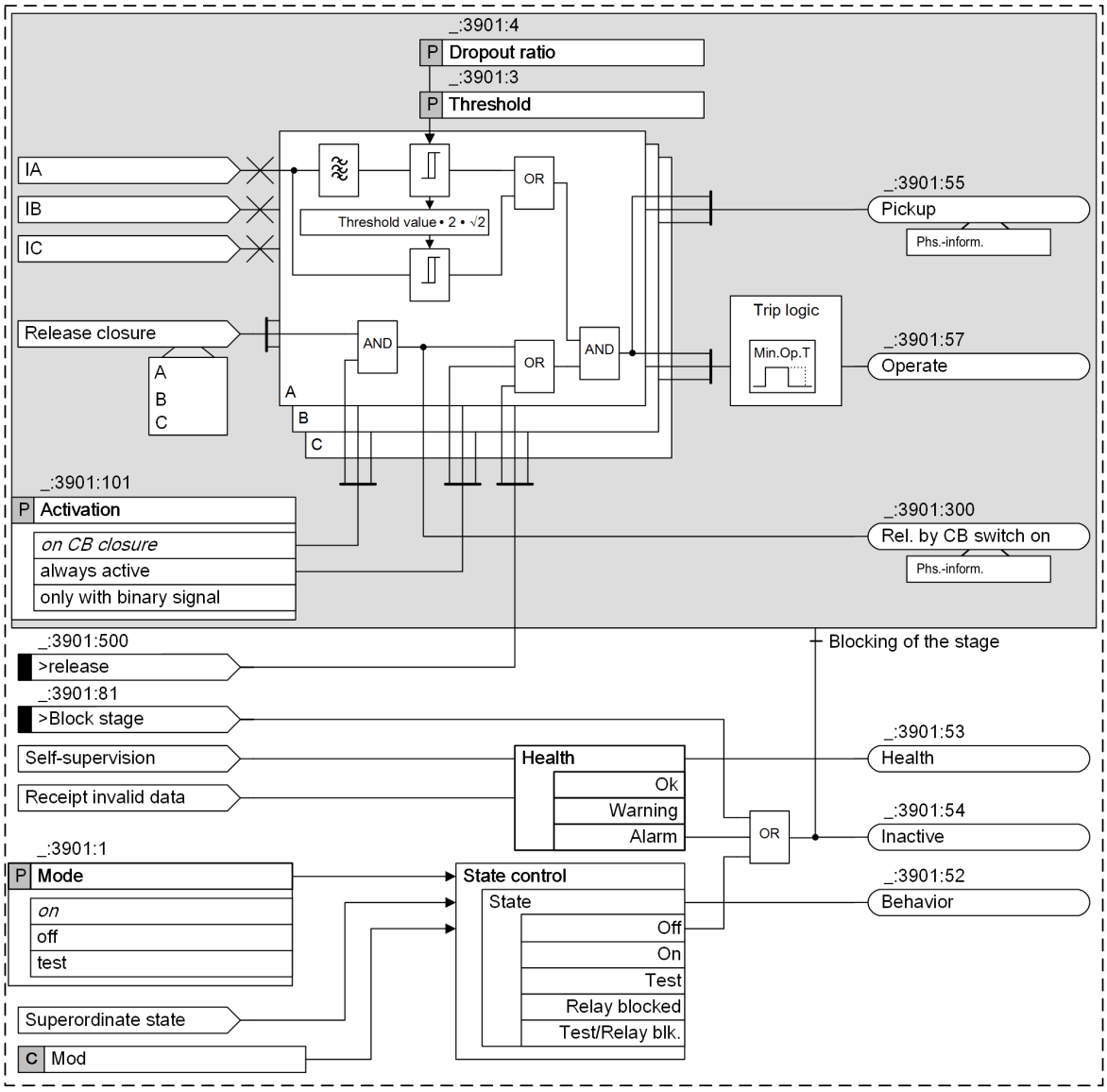


[dw_ihc_str, 1, en_US]

Figure 8-53 Structure/Embedding of the Function

8.13.3 Standard Release Procedure

Logic



[lo_hlore3, 3, en_US]

Figure 8-54 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 the binary input signal *>release* is active. The way the ***Rel. by CB switch on*** signal is generated is described in chapter *5.1.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

- ***always active***

  The stage is always released and is thus independent of the 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 value.
- Evaluation of the unfiltered measurand:
  The stage also works with unfiltered sampled values. Thus, very short operate times are possible. The current sampling values are compared with the threshold value of $2 \cdot \sqrt{2}$ of the preset threshold value.

8.13.4 Application and Setting Notes

Parameter: Activation

- Default setting **(_:3901:101) Activation** = ***on CB closure***

With 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:

$$Z_1/s = \sqrt{0.21^2 + 0.43^2}\ \Omega/km = 0.479\ \Omega/km$$

$$Z_L = 0.479\ \Omega/km \cdot 100\ km = 47.9\ \Omega$$

$$Z_S = \frac{110\ kV^2}{3500\ MVA} = 3.46\ \Omega$$

[fo_glchzv, 1, en_US]

The maximum 3-phase short-circuit current I''_{sc} flowing through is (at a source voltage of 1.1 V_N):

$$I''_{sc} = \frac{1.1 \cdot V_{net}}{\sqrt{3} \cdot (Z_S + Z_L)} + \frac{1.1 \cdot 110\,kV}{\sqrt{3} \cdot (3.46\,\Omega + 47.9\,\Omega)} = 1360\,A$$

[fo_glchik, 1, en_US]

With a safety margin of 10 %, the following setting value results:

- **Threshold value** (primary) = 1.1 · 1360 A = 1496 A
- **Threshold value** (secondary) = $1.1 \cdot \frac{1360\,A}{600\,A} \cdot 5\,A = 12.5\,A$

[fo_glnste, 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.

8.13.5 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.

8.13.6 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

8.13.7 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_: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

8.14 Vector-Jump Protection

8.14.1 Overview of Functions

The **Vector-jump protection** function:

- Is used for network decoupling of the power generating unit in case of a load loss
- Evaluates the phase-angle jump of the voltage phasors

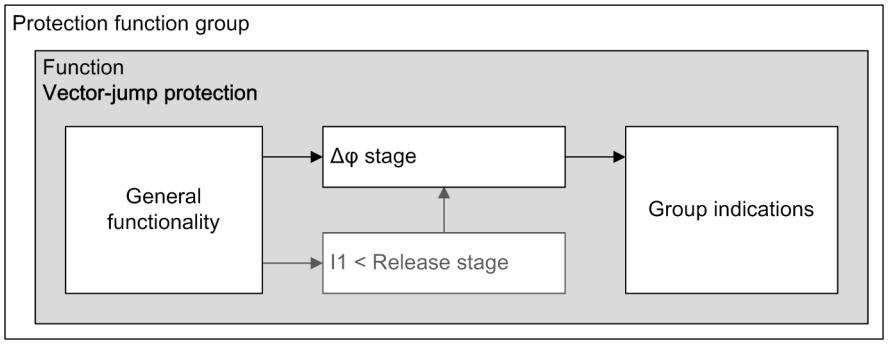
8.14.2 Structure of the Function

The **Vector-jump protection** function can be used in the following function groups:

- Voltage-current 3-phase
- Voltage 3-phase

The **Vector-jump protection** function comes factory-set with a **Δφ** stage.
The following stages can operate simultaneously within the function:

- 1 **Δφ** stage
- 1 **I1 < Release** stage



[dw_VJP_structure, 1, en_US]

Figure 8-55 Structure/Embedding of the Function

8.14.3 General Functionality

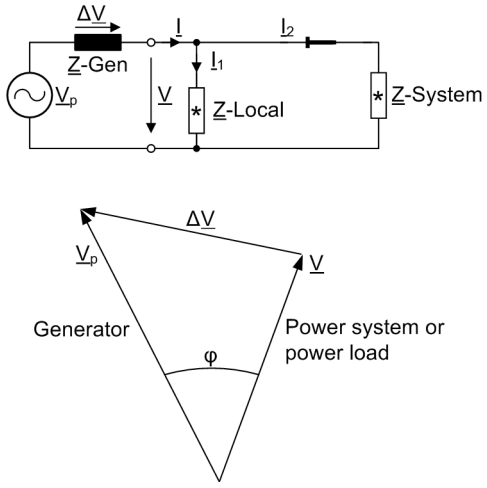
8.14.3.1 Description

Basic Principle of Vector-Jump Protection

The following 2 figures show the basic principle of the **Vector-jump protection** function.
The following figure shows the voltage vector of the steady state condition. The load current causes a voltage drop between the internal voltage V_p and the generator terminal voltage V.

If the load is switched off, the following situations occur:

- The current is reduced.
- A smaller voltage drop is caused.



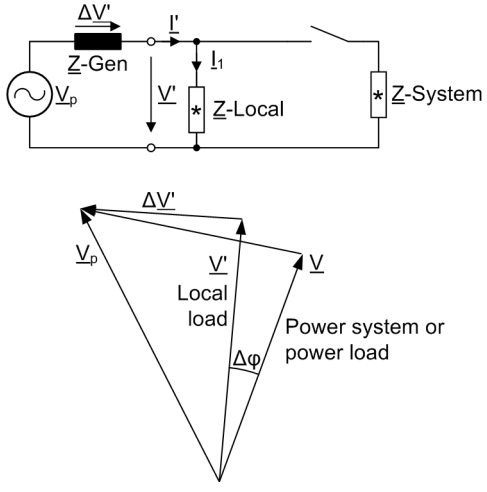
[dw_load loss, 1, en_US]

Figure 8-56 Voltage Vector of the Steady State

The following figure shows the situations after the load is switched off:

- The terminal voltage V changes to V'.
- An additional phase-angle jump occurs.

A phase-angle jump occurs with load loss and is the evaluation criterion for the **Vector-jump protection** function. If the phase-angle differential exceeds a set threshold, the generator circuit breaker or the circuit breaker of the system switch opens. Therefore, the generator unit can be protected against unacceptable stress.



[dw_vector change, 1, en_US]

Figure 8-57 Vector Change after the Load Shedding

Table 8-2 Vector Description

Vector	Description
$\underline{V}_p$	Vector of the generator internal voltage (rotor voltage)
$\underline{V}$	Vector of the generator terminal voltage
$\Delta\underline{V}$	Vector of the voltage differential
$\underline{V}'$	Vector of the terminal voltage after the load shedding
$\Delta\underline{V}'$	Vector of the voltage differential after the load shedding

The following measures are applied to avoid unwanted tripping:

- Correction of steady-state deviations from rated frequency
- Frequency operating range limited to f_{rated} ± 3 Hz
- High measuring accuracy by using frequency-tracked measured values and evaluation of the positive-sequence phasor
- Enabling the minimum voltage for the **Vector-jump protection** function
- Blocking the function when the primary voltage is switched on or off as switching can lead to a phase-angle jump

Logic

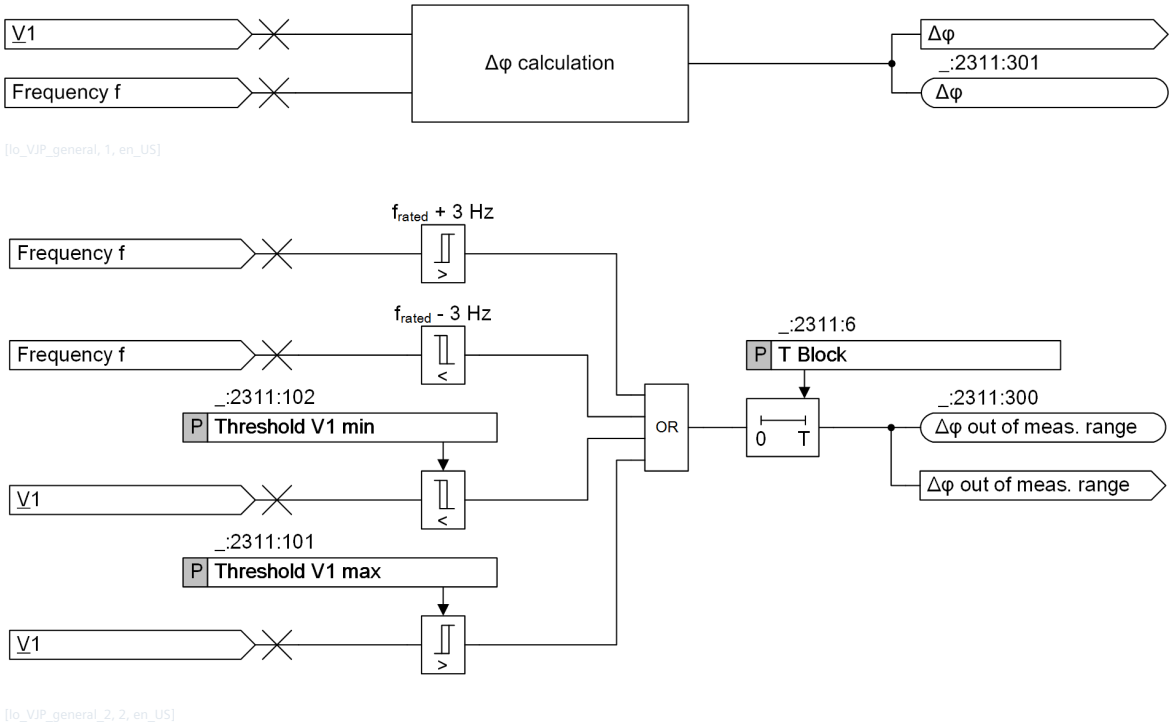


Figure 8-58 Logic Diagram of the General Functionality

Phase-Angle Calculation

The phase-angle differential is calculated at different time intervals (t-T, t-2T, t-3T) from the vector of the positive-sequence voltage via a delta-interval measurement. With the current measured power frequency, the measuring errors of the angle measurement caused by frequency deviations are compensated.

Range

If the measured frequency or voltage is below the set threshold, the **Vector-jump protection** is blocked.
The voltage and frequency bands have the following limits:

- The threshold of the voltage band is configurable.
- The frequency band ranges is fixed from f_{rated} - 3 Hz to f_{rated} + 3 Hz.

Measurand

The general functionality calculates the phase-angle displacement Δφ and sends it to the **Δφ** stage. Δφ is used for comparison with the parameter **`Threshold Δφ`**. Δφ is displayed in the functional measured value and can be routed in a fault record and displayed in the fault log.

The functional measured values of Δφ in HMI are displayed differently in the following situations:

- If the **Vector-jump protection** function is inactive, the function value of Δφ is displayed as "---"
- If the **Vector-jump protection** function is active and has not picked up, the functional measured value of Δφ is displayed as 0.0°
- If the **Vector-jump protection** function is active and has picked up, the functional measured value of Δφ is displayed as a calculated value (for example, 12.0°) and remains unchanged until the next pickup of the **Vector-jump protection** function.

8.14.3.2 Application and Setting Notes

Parameter: `Threshold V1 min`

- Default setting **`(_:2311:102) Threshold V1 min`** = ***`46.189 V`***

With the parameter **`Threshold V1 min`**, you can define the minimum threshold of the voltage band.
The setting value is closed to the allowed lower limit of the voltage band. The default setting is 80 % of the rated positive-sequence voltage. The value of the rated positive-sequence voltage is 100 V/√3.

Parameter: `Threshold V1 max`

- Default setting **`(_:2311:101) Threshold V1 max`** = ***`75.058 V`***

With the parameter **`Threshold V1 max`**, you can define the maximum threshold of the voltage band.
The setting value is closed to the allowed higher limit of the voltage band. The default setting is 130 % of the rated positive-sequence voltage. The value of the rated positive-sequence voltage is 100 V/√3.

Parameter: `T Block`

- Default setting **`(_:2311:6) T Block`** = ***`0.10 s`***

With the parameter **`T Block`**, you set the dropout delay of the **Δφ** stage.
When voltages are connected or disconnected, the overfunction can be avoided with the timer **`T Block`**.
Siemens recommends to use the default setting of the parameter **`T Block`**. Keep in mind that the parameter **`T Block`** has always to be set to 2 cycles more than the measuring window for vector-jump measurement.

8.14.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:102	General:Threshold V1 min		0.300 V to 175.000 V	46.189 V
_:2311:101	General:Threshold V1 max		0.300 V to 175.000 V	75.058 V
_:2311:6	General:T Block		0.00 s to 60.00 s	0.10 s

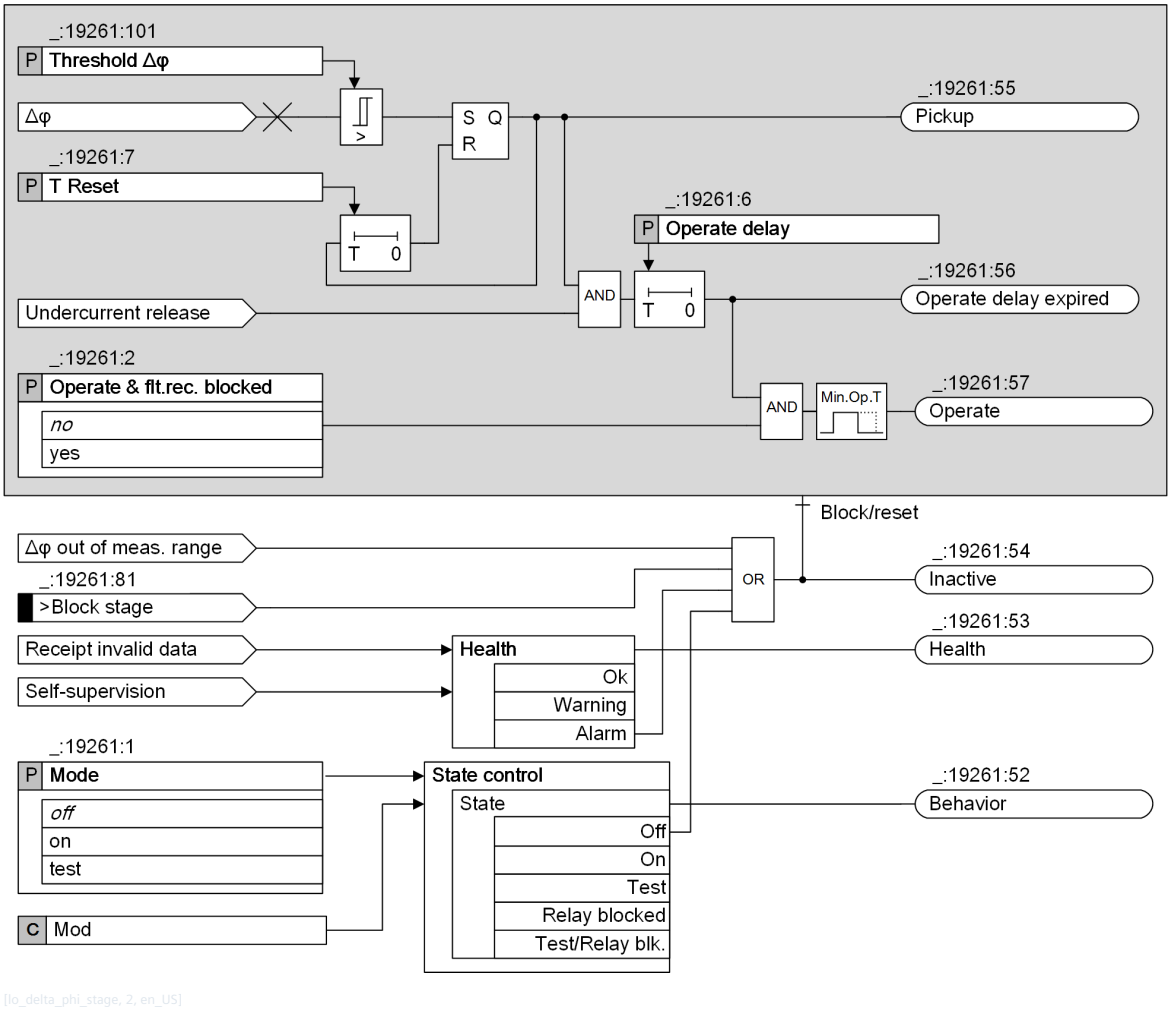
8.14.3.4 Information List

No.	Information	Data Class (Type)	Type
`General`			
_:2311:301	General:Δφ	MV	O
_:2311:300	General:Δφ out of meas. range	SPS	O

8.14.4 Δφ Stage

8.14.4.1 Description

Logic



[lo_delta_phi_stage, 2, en_US]

Figure 8-59 Logic Diagram of the Δφ Stage

In the logic diagram, the **I1 < Release** stage is instantiated. You can find more information in chapter *8.14.5.1 Description*.

If the **I1 < Release** stage is not instantiated, the AND operation has no influence. The *Operate* indication is issued under the following conditions:

- The parameter **Operate & flt.rec. blocked** is set to ***no***.
- The operate delay expires.
- The phase-angle differential exceeds the parameter **Threshold Δφ**.

Measurand

The **Δφ** stage gets the measured value $\Delta\phi$ from the general functionality.

Pickup

The **Δφ** stage compares the value of the vector jump $\Delta\phi$ with the **Threshold Δφ**.

If the value of the **Threshold Δφ** is exceeded, the pickup delay starts.

The vector jump *Δϕ* is stored in an RS flip-flop. Trippings can be delayed by the associated time delay.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- The parameter **Mode** is in the state ***off***.
- The binary input signal *>Block stage* is active.
- The signal *Δϕ out of meas. range* is active.

8.14.4.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:19261:2) 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. If you want the stage to have a warning indication only, set the parameter **Operate & flt.rec. blocked** to ***yes***.

Parameter: **Threshold Δφ**

- Default setting **(_:19261:101) Threshold Δφ** = ***10°***

With the parameter **Threshold Δφ**, you can set the pickup value of the **Δφ** stage.

The parameter value to be set for the vector jump depends on the supply and load conditions. Load changes cause a jump of the voltage vector. The value to be set must be established in accordance with the particular power system. An estimation can be done based on the system equivalent circuit in *Figure 8-57*. A network calculation considering the relevant source and load situations will be more precise.

If the setting for the parameter **Threshold Δφ** is too sensitive, every time loads are connected or disconnected, the protection function performs a network decoupling. Therefore, If no other calculated value is applicable to the setting of this parameter, Siemens recommends using the default setting.

Parameter: **Operate delay**

- Default setting **(_:19261:6) Operate delay** = ***0.00 s***

With the parameter **Operate delay**, you can set the operate delay of the **Δφ** stage. For the tripping stage, set the operate delay between ***0.00 s*** and ***60.00 s***.

Siemens recommends the default setting.

The following requirements can necessitate a change of the parameter **Operate delay** with respect to the default setting:

- The operate indication should be transmitted with delay to a programmable logic.
- There shall be enough time for an external blocking to take effect.

Parameter: **T Reset**

- Default setting **T Reset** = ***5.00 s***

With the parameter **T Reset**, you can set the reset time for the *Pickup* indication stored in the RS flip-flop. When the timer **T Reset** expires, the protection function is reset automatically.

The reset time meets the following conditions:

- The reset time depends on the decoupling requirements
- The reset time must expire before the circuit breaker is reclosed

8.14.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage Δφ 1				
_:19261:1	Stage Δφ 1:Mode		• off • on • test	off
_:19261:2	Stage Δφ 1:Operate & flt.rec. blocked		• no • yes	no
_:19261:101	Stage Δφ 1:Threshold Δφ		2.0° to 30.0°	10.0°
_:19261:6	Stage Δφ 1:Operate delay		0.00 s to 60.00 s	0.00 s
_:19261:7	Stage Δφ 1:T Reset		0.00 s to 60.00 s	5.00 s

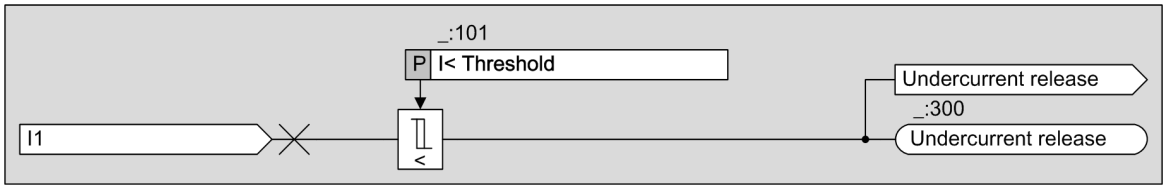
8.14.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage Δφ 1			
_:19261:81	Stage Δφ 1:>Block stage	SPS	I
_:19261:54	Stage Δφ 1:Inactive	SPS	O
_:19261:52	Stage Δφ 1:Behavior	ENS	O
_:19261:53	Stage Δφ 1:Health	ENS	O
_:19261:55	Stage Δφ 1:Pickup	ACD	O
_:19261:56	Stage Δφ 1:Operate delay expired	ACT	O
_:19261:57	Stage Δφ 1:Operate	ACT	O

8.14.5 I1 < Release Stage

8.14.5.1 Description

Logic



[fo_undercurrent_release_stage, 1, en_US]

Figure 8-60 Logic Diagram of the I1 < Release Stage

The **I1 < Release** stage is an optional stage and is used to reduce the risk of overfunction.

The indication ***Undercurrent release*** is an additional safety criterion to avoid an unexpected trip. It indicates a load loss of the connected line to the system and the phase-angle criterion is released. If any load in the network is switched on or off, an unexpected trip can occur.

If the **I1 < Release** stage is not instantiated, the **Δφ** stage works without current-flow criterion. You can find more information in chapter *8.14.4.1 Description*.

If the positive-sequence current falls below the parameter **I< Threshold**, the message ***Undercurrent release*** is issued and is forwarded to the **Δφ** stage.

8.14.5.2 Application and Setting Notes

Parameter: `I< Threshold`

- Default setting **`(_:101) I< Threshold`** = ***`0.100 A`***

With the parameter **`I< Threshold`**, you can set the pickup value of the **I < Release** stage corresponding to the specific application. Consider that the current measuring point must be on the line side. The parameter **`I< Threshold`** depends on the load situation.

8.14.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I1 < Release #`				
_:101	I1 < Release #:I< 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

8.14.5.4 Information List

No.	Information	Data Class (Type)	Type
`I1 < Release #`			
_:300	I1 < Release #:Undercurrent release	SPS	O

8.15 Overfrequency Protection

8.15.1 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.

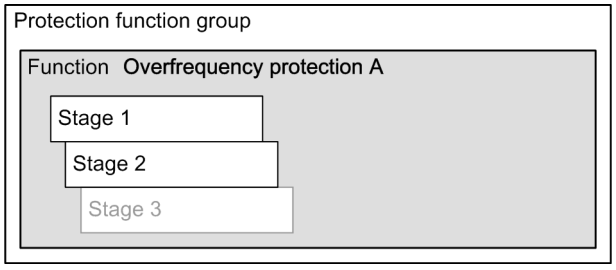
Overfrequency protection is available in two functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

8.15.2 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.

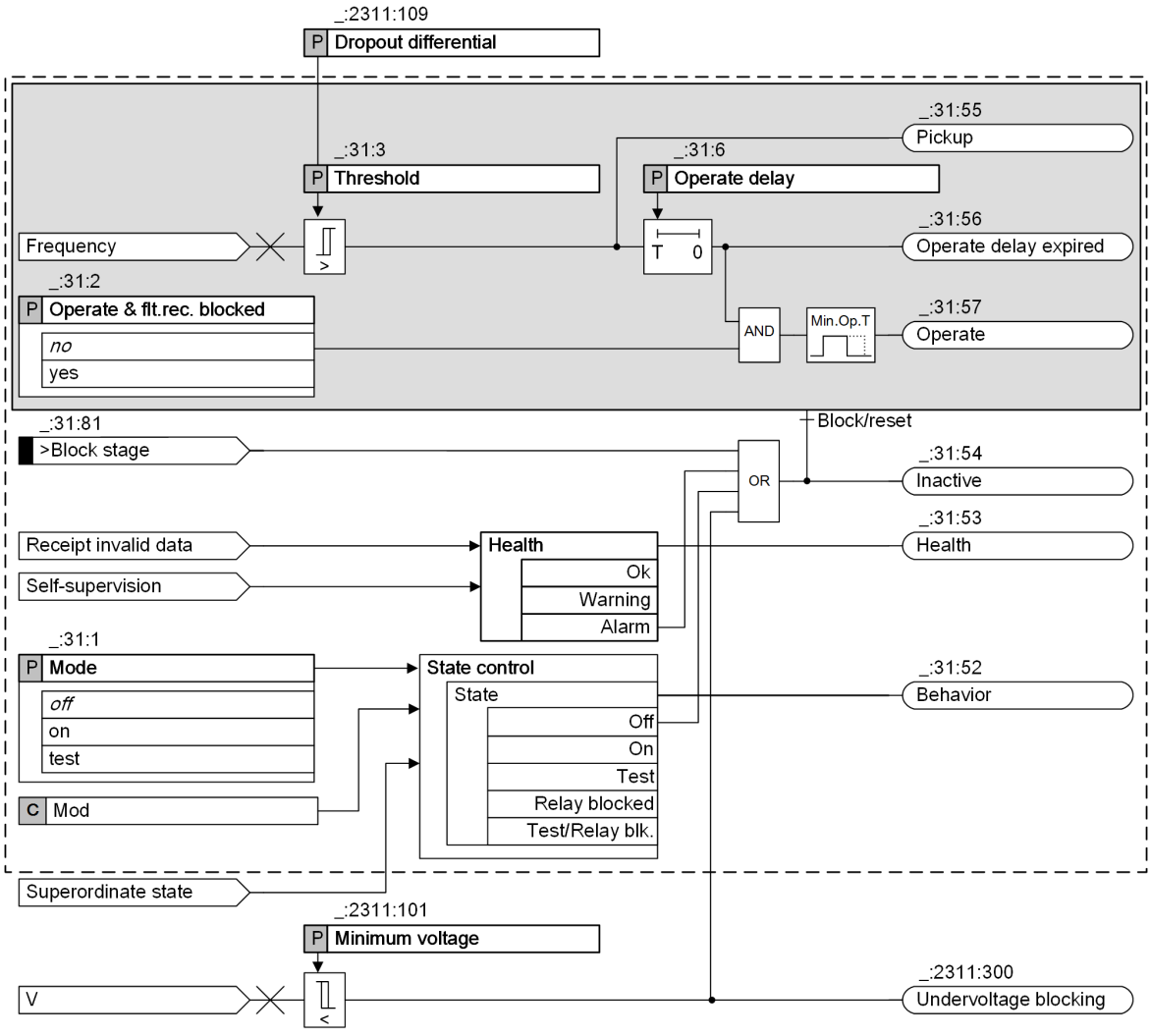


[dw_stofqp, 1, en_US]

Figure 8-61 Structure/Embedding of the Function

8.15.3 Overfrequency-Protection Stage

Logic of a Stage



[lo_stofqp, 2, en_US]

Figure 8-62 Logic Diagram of the Overfrequency-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.



NOTE

The angle difference method (method A) requires the sampling-frequency tracking.

If you use the angle difference method as method of measurement, ensure that sampling-frequency tracking is active (see *3.3.2 Sampling-Frequency Tracking*).

Functional Measured Value

The angle-difference method provides the following measured value:

Measured Value	Description
f	Frequency calculated with the angle-difference method

Behavior on Leaving the Operating Range

The sampling-frequency tracking makes a wide 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

In the event of blocking, a picked-up stage will be reset. 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**

8.15.4 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** = ***51.50 Hz*** for f_{rated} = 50 Hz

With the parameter **Threshold**, you define the pickup threshold of the overfrequency protection stage in dependence of the application. 51.50 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value **(_:31:6) Operate delay** = ***10 s***

With the parameter **Operate delay**, you 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**, Siemens recommends 65 % of the rated voltage of the protected object as the setting value.

Calculate the secondary or primary setting value with the phase-to-ground voltage, that is, $V_{rated}/\sqrt{3}$.

For V_{rated} = 100 V secondary, the setting value of the **Minimum voltage** is calculated as follows:

$$\text{Minimum voltage} = 0.65 \cdot V_{rated} = 0.65 \cdot \frac{100\ \text{V}}{\sqrt{3}} = 37.500\ \text{V}$$

[fo_minimal voltage A, 1, en_US]

In the angle-difference method, the setting value relates to the positive-sequence system.

NOTE

If in DIGSI you switch over the settings view of the parameters to ***Percent***, the phase-to-phase value of the rated voltage is the reference value for the **Minimum voltage** in both methods of measurement.

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. For a later dropout of the stage, increase the setting value of the dropout differential. For example, if the pickup value (parameter **Threshold**) of the stage is set to 51.5 Hz and the **Dropout differential** to 100 mHz, the stage will drop out at 51.4 Hz.

Setting example for the overfrequency protection for generators

If the overspeed limiter does not function properly, the overfrequency protection issues an additional alarm indication. Overspeeding can be caused by load shedding or by a disturbance of the speed limiter (for example, in an island network).

One possible frequency limit could be 1.03 f_{rated}. If the machine does not recover, it can be shut down with a 2nd stage of, for example, 1.08 f_{rated}. To avoid overfunctions, you can set a sufficient time delay for the warning indication or tripping.

For this application, 2 stages of the overfrequency protection are 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 or disconnection	51.50 Hz	61.80 Hz	20.00 s
f2>	Shutdown	54.00 Hz	64.80 Hz	5.00 s

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

8.15.5 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	Overfrequency A	40.00 Hz to 90.00 Hz	51.50 Hz
		Overfrequency B	40.00 Hz to 70.00 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	Overfrequency A	40.00 Hz to 90.00 Hz	54.00 Hz
		Overfrequency B	40.00 Hz to 70.00 Hz	
_:32:6	Stage 2:Operate delay		0.00 s to 600.00 s	5.00 s

8.15.6 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

No.	Information	Data Class (Type)	Type
_: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

8.16 Underfrequency Protection

8.16.1 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.

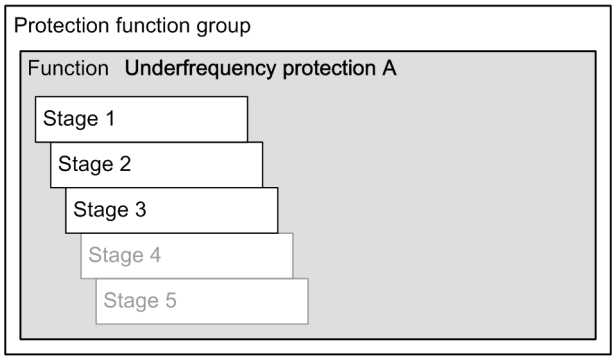
Underfrequency protection is available in 2 functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

8.16.2 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.

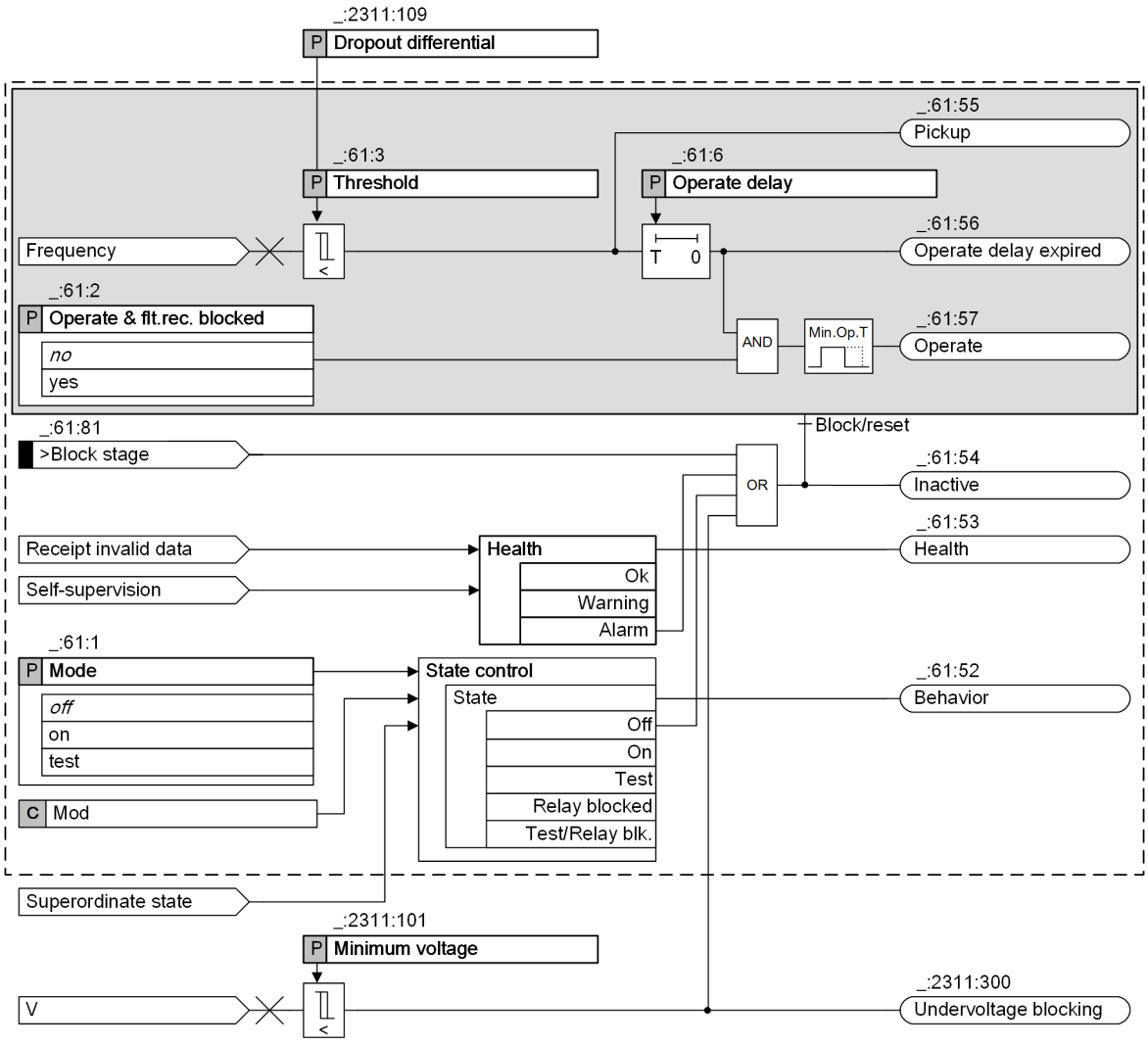


[dw_stufqp, 1, en_US]

Figure 8-63 Structure/Embedding of the Function

8.16.3 Underfrequency-Protection Stage

Logic of a Stage



[lo_stuf_gp, 3, en_US]

Figure 8-64 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.



NOTE

The angle difference method (method A) requires the sampling-frequency tracking.

If you use the angle difference method as method of measurement, ensure that sampling-frequency tracking is active (see *3.3.2 Sampling-Frequency Tracking*).

Behavior on Leaving the Operating Range

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

In the event of blocking, a 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
- Internally when the voltage drops below the **Minimum voltage**

8.16.4 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 security 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

With the parameter **Threshold**, you 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***

With the parameter **Operate delay**, you 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**, Siemens recommends 65 % of the rated voltage of the protected object as the setting value.

Calculate the secondary or primary setting value with the phase-to-ground voltage, that is, $V_{rated}/\sqrt{3}$.

For V_{rated} = 100 V secondary, the setting value of the **Minimum voltage** is calculated as follows:

$$\text{Minimum voltage} = 0.65 \cdot V_{rated} = 0.65 \cdot \frac{100\ \text{V}}{\sqrt{3}} = 37.500\ \text{V}$$

[fo_minimal voltage A, 1, en_US]

In the angle-difference method, the setting value relates to the positive-sequence system.

NOTE

If in DIGSI you switch over the settings view of the parameters to ***Percent***, the phase-to-phase value of the rated voltage is the reference value for the **Minimum voltage** in both methods of measurement.

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 example, 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.

Setting Example of Underfrequency Protection for Generators

Underfrequency protection provides an additional protection for the turbine. It has the task of ensuring the demand of a power plant by a timely decoupling from the electrical power system. After the decoupling from the electrical power system, the turbo set controller sets the generator unit to the rated speed, so that the demand can continue to be supplied with rated frequency.

Turbo-generators can operate permanently at as little as 95 % of the rated frequency. This requires the apparent power to be reduced by the same factor. A decrease of the frequency leads not only to a higher current consumption by the inductive loads but is also a hazard to stable operation.

The decoupling from the electrical power system is initiated with a delay at 0.95 f_{rated}. After the decoupling, the power-plant unit has to recover. If it does not, the turbine is stopped for its own protection. In the turbine, underfrequency can lead to resonances and inadmissible strains of the turbine blades. You can delay the tripping in order to give the speed controllers sufficient time for a response.

The frequency value to be set depends on the specifications of the power plant operator or the turbine manufacturer (speed monitoring). It is approx. 0.94 f_{rated}.

For this application, 3 stages of the underfrequency protection are used. The following table shows a possible setting suggestion. However, if you select the same frequency value for the network disconnection, you have to set a clearly greater delay (for example 47.5 Hz and 40 s).

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 s
f2<	Decoupling from power system	47.50 Hz	57.00 Hz	10.00 s
f3<	Shutdown	47.00 Hz	56.40 Hz	20.00 s

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application and the turbine. Note the requirements in the grid code.

8.16.5 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		30.00 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
_:62:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:62:3	Stage 2:Threshold		30.00 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		30.00 Hz to 70.00 Hz	47.00 Hz
_:63:6	Stage 3:Operate delay		0.00 s to 600.00 s	10.00 s

8.16.6 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

No.	Information	Data Class (Type)	Type
_: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

8.17 Rate of Frequency Change Protection

8.17.1 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

8.17.2 Structure of the Function

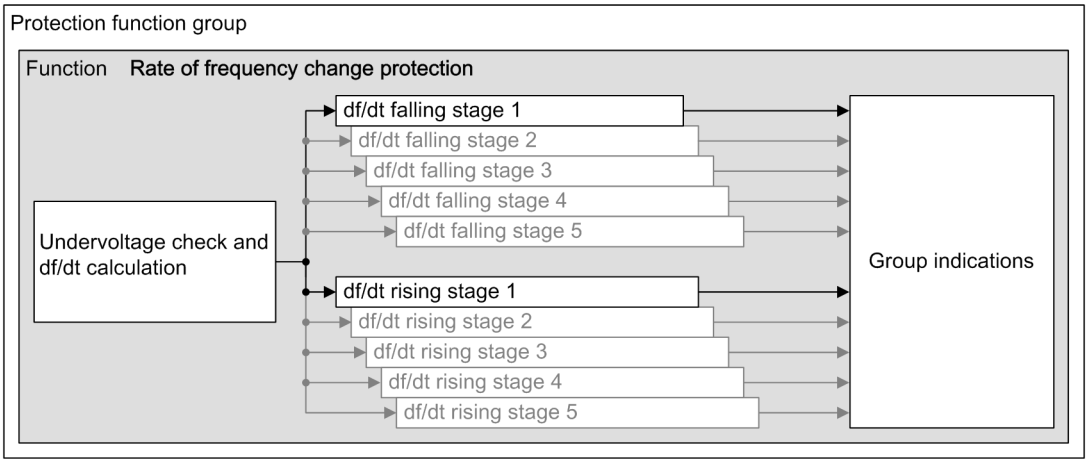
The function **Rate of frequency change protection** can be used in protection function groups containing a 3-phase voltage measurement.

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.



[dw_dfdt 01, 1, en_US]

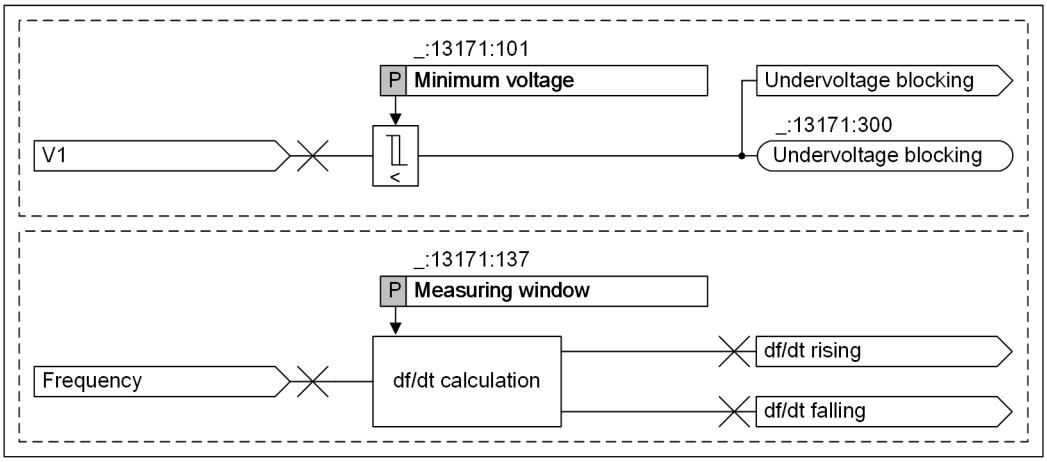
Figure 8-65 Structure/Embedding of the Function

8.17.3 General Functions (Undervoltage Test, df/dt Calculation)

8.17.3.1 Description

Logic

The following figure represents the logic of undervoltage check and df/dt calculation. It applies to all types of stages.



[lo_dfdtgf, 2, en_US]

Figure 8-66 Logic Diagram of General Functionality

Measurand

This function uses the frequency calculated via the angle difference algorithm.

For more information, refer to chapter *8.15.3 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

8.17.3.2 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.

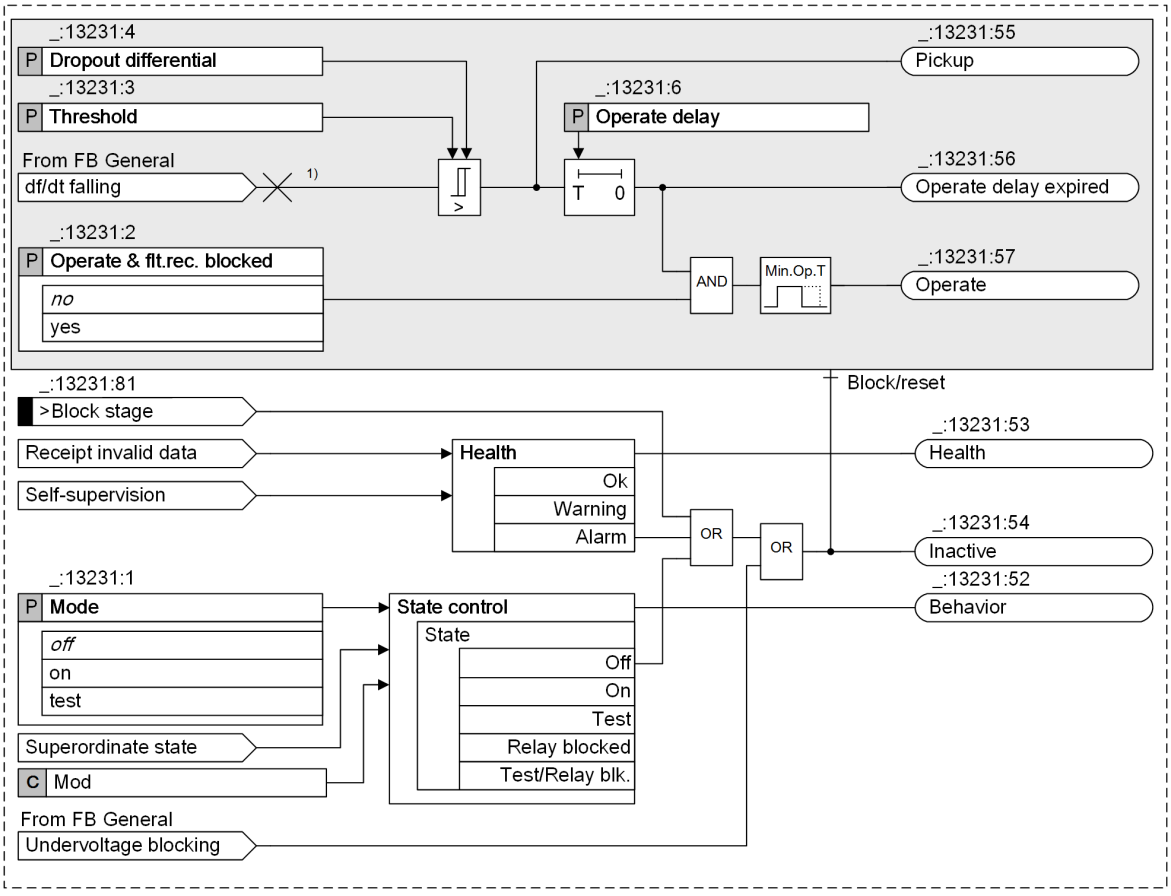
The default setting provides maximum measuring accuracy. If you do not have specific requirements for a decreased pickup time, Siemens recommends using the default setting.

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.

8.17.4 Stage Description

8.17.4.1 Description

Logic of the Stage



[lo_dfdt_st, 2, en_US]

Figure 8-67 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`**

8.17.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:13231:3) Threshold** = ***3.000 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.

8.17.4.3 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		0.100 Hz/s to 20.000 Hz/s	3.000 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		0.100 Hz/s to 20.000 Hz/s	3.000 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

8.17.4.4 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

No.	Information	Data Class (Type)	Type
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
_: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

8.18 Power Protection (P,Q), 3-Phase

8.18.1 Overview of Functions

The **3-phase power protection (P, Q)** function (ANSI 32) is used to:

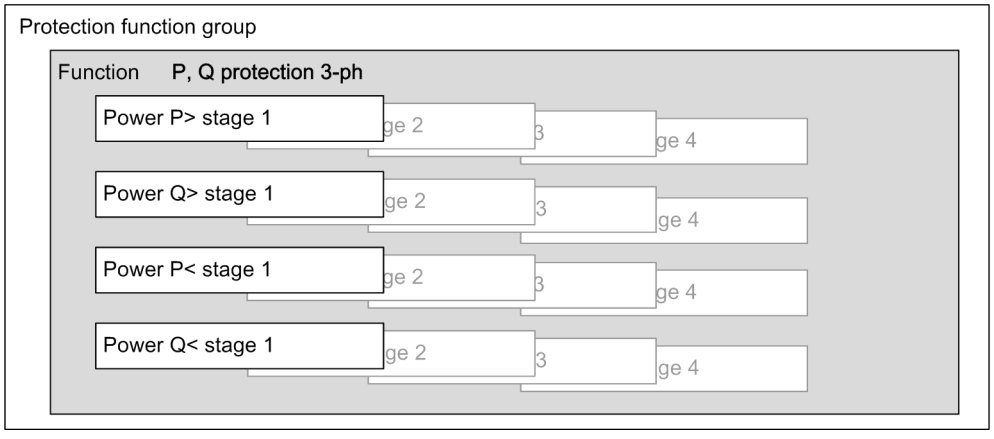
- Detect whether the active or reactive power rises above or drops below a set threshold
- Monitor agreed power limits and output warning indications
- Detect both active and reactive power feedback in the power systems or on electric machines
- Detect machines (motors, generators) running without load 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)

8.18.2 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.

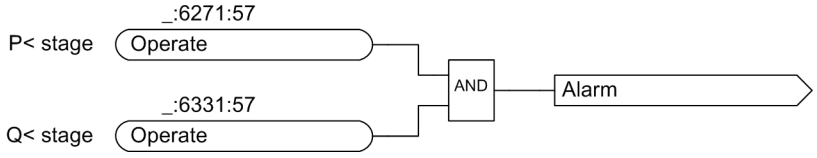


[dw_GPP 3-phase structure, 2, en_US]

Figure 8-68 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.

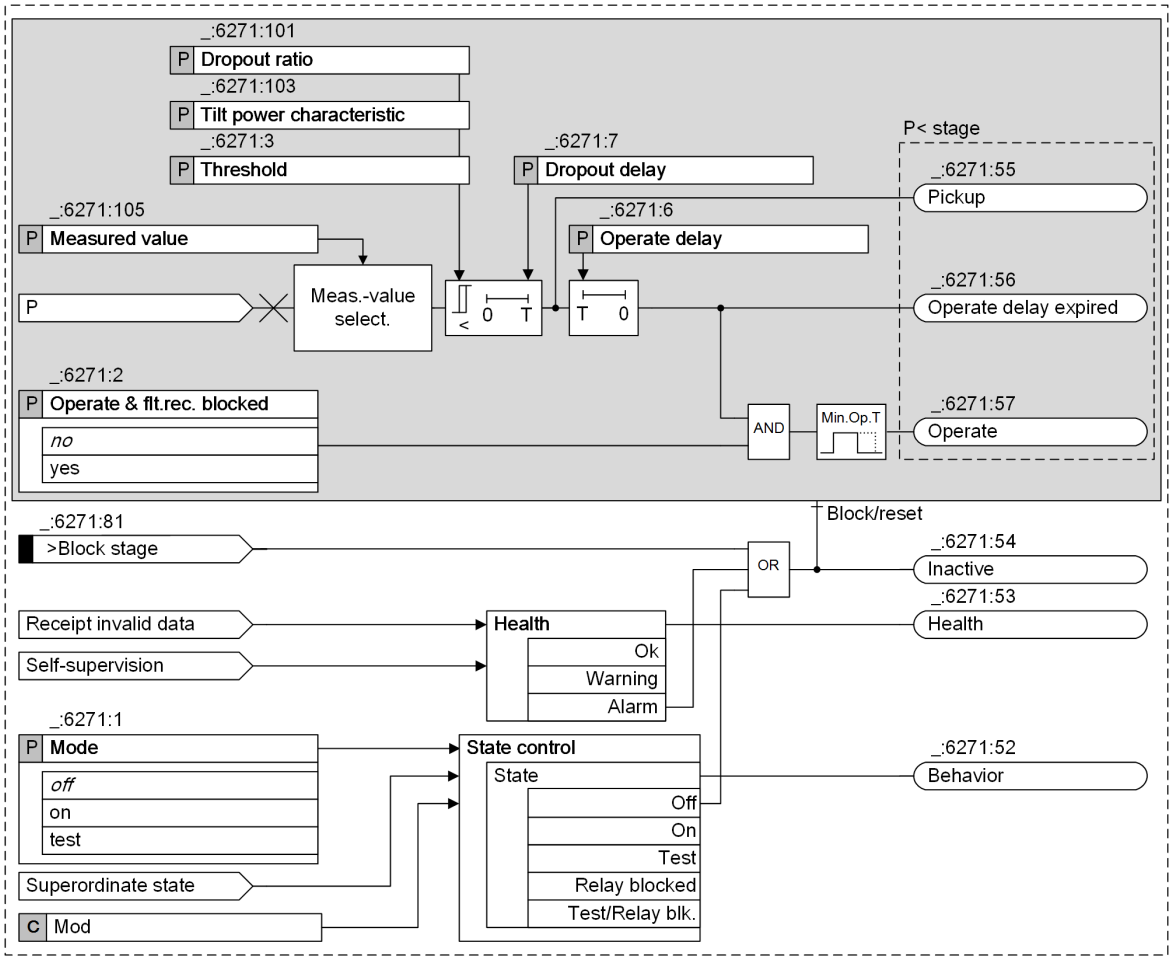


[lo_GPP operate indication logical comb, 2, en_US]

Figure 8-69 Logical Combination of Operate Indications in CFC

8.18.3 Active Power Stage

Logic of a Stage



[lo_3-phase active power, 3, en_US]

Figure 8-70 Logic Diagram of the Active Power Stage (Stage Type: Power P<)

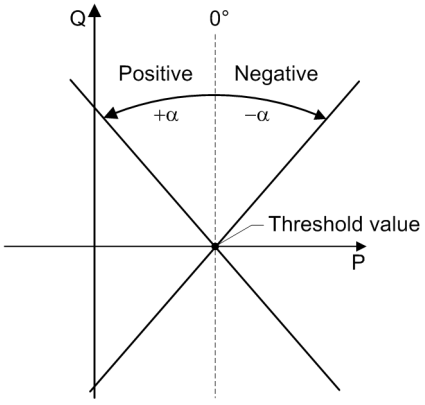
Measured Value

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.



[dw_tilt-power active power, 2, en_US]

Figure 8-71 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.

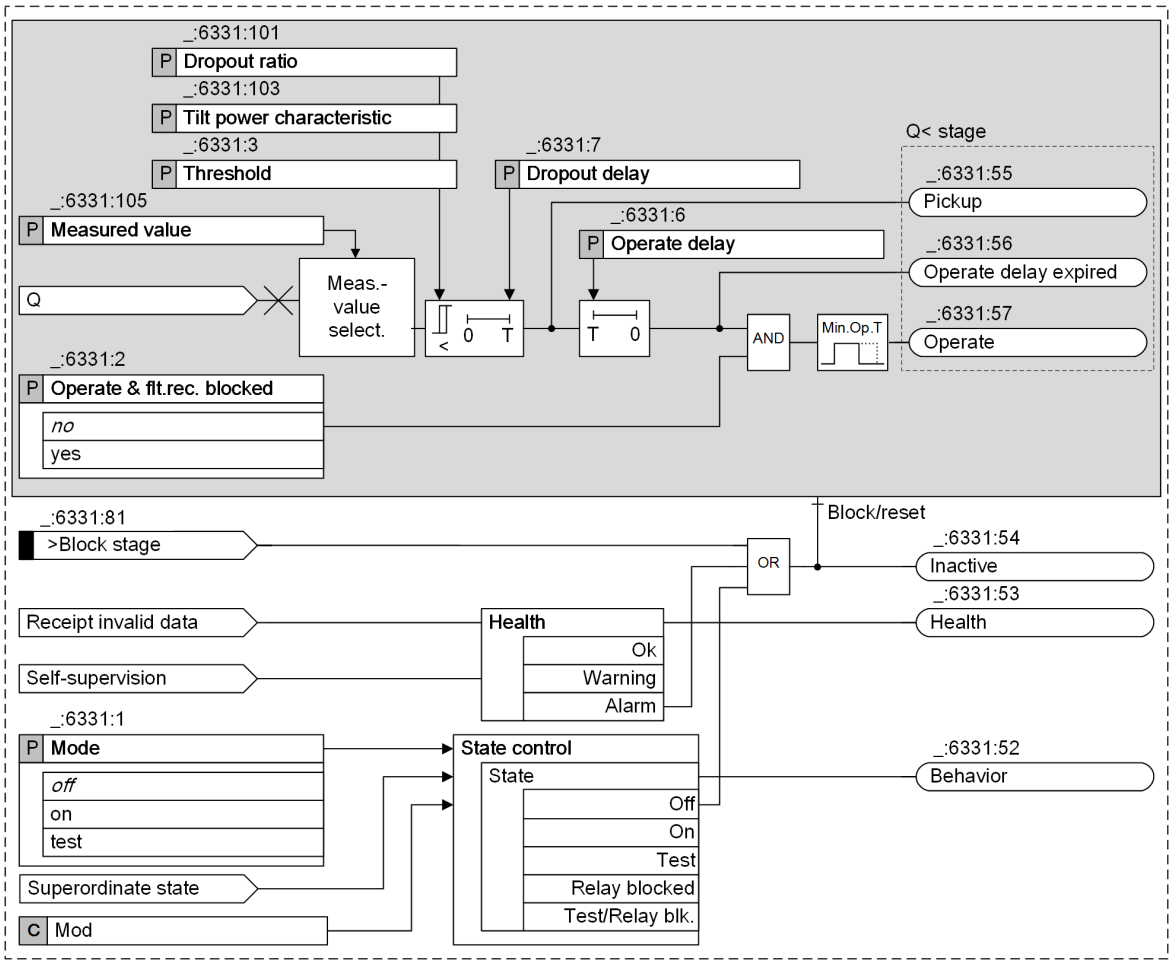
Blocking the Stage

In the event of blocking, a picked-up stage is reset. The following blocking options are available for the stage:

- Internally or externally via the binary input signal *>Block stage*
- The frequency is less than or equal to 10 Hz.

8.18.4 Reactive Power Stage

Logic of a Stage



[lo_3phase reactive power, 3, en_US]

Figure 8-72 Logic Diagram of the Reactive Power Stage (Stage Type: Power Q<)

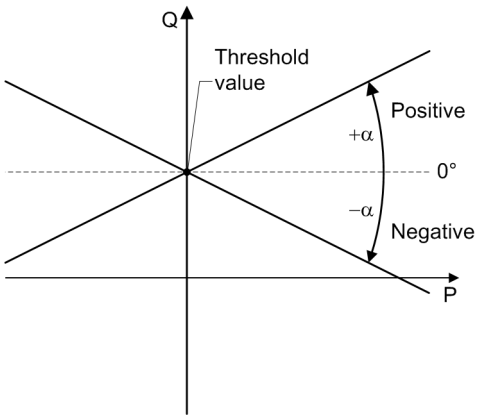
Measured Value

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.



[dw_tilt-power reactive power, 2, en_US]

Figure 8-73 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

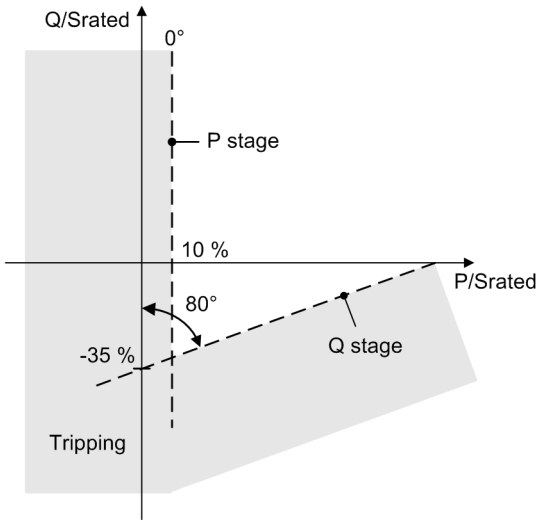
A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter **Operate delay**) continues to run. Once the **Operate delay** has elapsed, the stage trips.

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*.

8.18.5 Application Example

The setting of the function will be explained using a generating unit as an example. When the active power stage drops below a minimum forward power, an alarm indication is generated. The reactive power stage is set to the threshold for the underexcitation limitation and also generates an alarm indication. The underexcitation limitation comes before the static stability limit. The function used is 3-phase power measurement. *Figure 8-74* shows the threshold values and the location of the characteristics in the PQ diagram.



[dw_GPP PQ diagram 7UM, 2, en_US]

Figure 8-74 Pickup Values and Characteristic Curves

8.18.6 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** = ***10 %***

The **Threshold** parameter is used to define the pickup threshold of the active power stage. In the example, 10 % of the apparent generator power have been selected.



NOTE

If you use several settings groups, consider the following:

- The threshold of a stage must have the same sign in all settings groups.
- Switching from a positive threshold to a negative threshold or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the threshold 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** = ***0°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In this example, no inclination is required. The setting value is therefore ***0°***.

Parameter: Dropout delay

- Recommended setting value **(_:6271:7) Dropout delay** = ***0.00 s***

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. You should determine the setting value during the commissioning.

Parameter: Operate delay

- Recommended setting value **(_:6271:6) Operate delay** = ***1.00 s***

The time delay must be tailored to the specific application. The example uses a setting value of 1.00 s.

8.18.7 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<**. Ensure that the characteristic curve is located on the negative Q axis.

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** = ***-35 %***

The **Threshold** parameter is used to define the pickup threshold of the reactive power stage. In the example, -35 % of the apparent generator power have been selected. Adjust the underexcitation limitation to the controller setting. The underexcitation limitation comes before the static stability limit.



NOTE

If you use several settings groups, consider the following:

- The threshold value of a stage must have the same sign in all settings groups.
- Switching from a positive threshold value to a negative threshold value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the threshold 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** = ***+10°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In the application example (see *Figure 8-74*), the power straight line is tilted 10° (90° - 80° = 10°). Set the **Tilt power characteristic** parameter to ***+10°*** (for a definition of the sign, see *Figure 8-73*).

Parameter: Dropout delay

- Recommended setting value **(_:6331:7) Dropout delay** = ***0.00 s***

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. Determine the setting value during the commissioning.

Parameter: Operate delay

- Recommended setting value **(_:6331:6) Operate delay** = ***1.00 s***

The time delay must be tailored to the specific application. The example uses a setting value of 1.00 s.

8.18.8 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 -1.0 % 1.0 % 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

Addr.	Parameter	C	Setting Options	Default Setting
_:6271:3	Power P< 1:Threshold		-200.0 % to -1.0 % 1.0 % 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 °
_: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 -1.0 % 1.0 % 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 -1.0 % 1.0 % 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 °
_:6331:7	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

8.18.9 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
_: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

8.19 Power-Plant Disconnection Protection

8.19.1 Overview of Functions

The **Power-plant disconnection protection** function (ANSI 37 (-dP)):

- Detects external short circuits in the vicinity of the power plant (line, busbar) and opens the high-voltage circuit breaker if the fault duration is long.
- Prevents an impermissible stress on the shaft assembly due to high mechanical stress as a result of an abrupt active-power unloading.
- Prevents power swings of the power-plant unit with the electrical power system as a result of excessively long fault-clearing times.
- Protects the stator winding from excessively long short-circuit current stress.

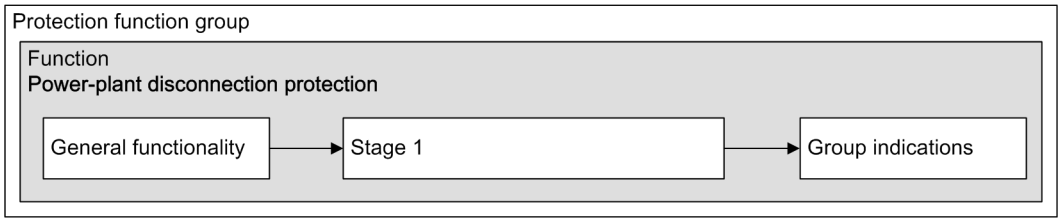
8.19.2 Structure of the Function

The **Power-plant disconnection protection** function is used in the **Generator stator** protection function group. It can also run in the **3-phase voltage-current** function group.

You can copy the function during engineering into the appropriate function group.

The **Power-plant disconnection protection** function consists of 1 stage, which contains the necessary function blocks.

The function processes the 3-phase voltage of the main generator lead and the current of the **Generator stator** function group. The following figure shows the basic structure of the function.



[dw_PPD_structure, 2, en_US]

Figure 8-75 Structure/Embedding of the Function

8.19.3 Function Description

Basic Principle of Power-Plant Disconnection Protection

In the event of system incidents, the sudden change of the electric torque of the generator leads to torsional vibrations in the shaft assemblies of power-plant units. These lead to increased mechanical stress and, in the extreme case, to the destruction of the shaft assembly.

In the event of an external, 3-phase short circuit, there is an abrupt active-power unloading in the power-plant unit, which causes a change of the electric torque. Due to the relief of torque, the angular velocity of the rotor increases and the rotor angle increases. The rotor angle describes the torsional state of the shaft. The rotor angle is the angle difference between the angle of the synchronous generated voltage of the generator and the power-system voltage (reference point in the power system).

NOTE

The rotor angle, which is shown among the functional measured values in the **Generator stator** function group, relates to the terminal voltage of the generator and is somewhat smaller.

The equations presented below show, in simplified form, basic relationships of the resulting stress.

$$\omega_L = \frac{1}{\Theta} \cdot \Delta T t_F + \omega_0;\ \Delta T = T_{mech} - T_{el}$$

[fo_powerplant_stress_01, 2, en_US]

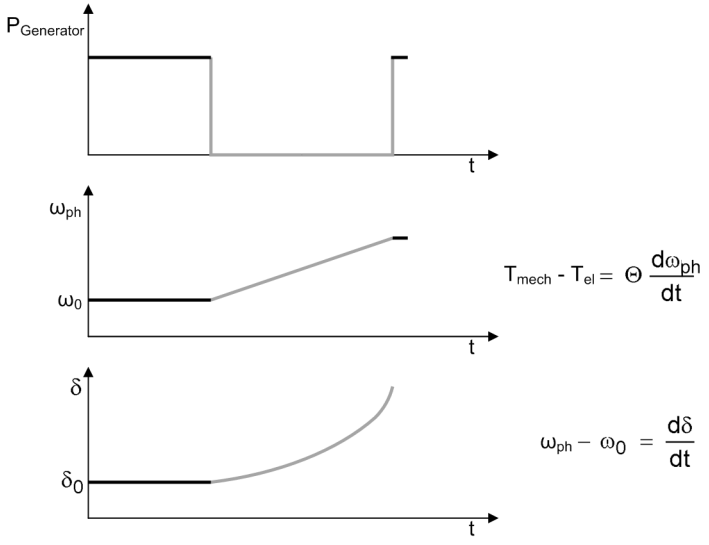
$$\delta = \frac{1}{\Theta} \cdot \Delta T (t_F)^2 + \delta_0$$

[fo_powerplant_stress_02, 2, en_US]

with

T_{mech}	Mechanical torque (turbine torque)
T_{el}	Electric torque (air gap torque)
Θ	Mass moment of inertia of the shaft
ω_L	Angular velocity of the rotor
ω_0	Synchronous angular velocity (constant: $\omega_0 = 2\pi f$)
t_F	Fault-clearing time
δ	Rotor angle of the generator
δ_0	Rotor angle before fault inception

The following figure schematically shows the effect of the sudden active-power jump.



[dw_PPD_rotor-angle, 2, en_US]

Figure 8-76 History of the Rotor Angle for Short Circuit near the Power Plant

As the electric torque changes, the angular velocity of the rotor changes linearly with the fault duration. The rotor angle increases quadratically with the fault duration. The rotor angle at the time when the fault is cleared has a considerable influence on the mechanical stress on the shaft assembly.

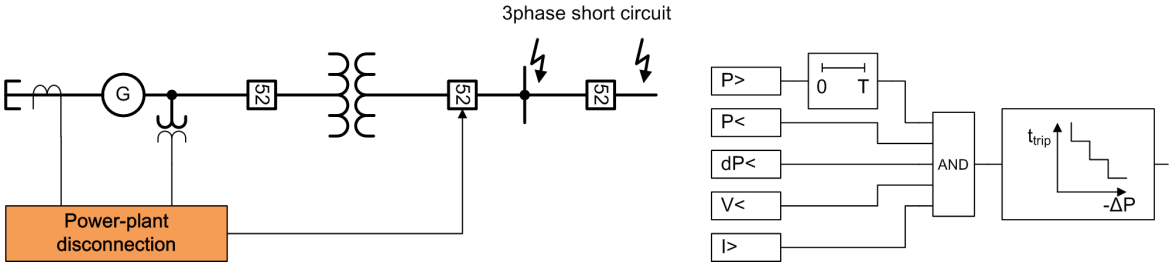
If the voltage does not collapse at the interconnection point, active power can still be output into the power system during the fault. Thereby the change of electric torque is smaller and the stress on the shaft assembly is lower. This means that a longer fault duration is permissible.

Power-plant disconnection avoids an impermissible stress on the shaft assembly. The evaluation of multiple criteria ensures safe functionality:

- Overcurrent — Criterion for detecting short circuits
- Undervoltage — Criterion for detecting undervoltage
- Active power P< — Criterion for detecting active-power decrease

- Active-power release P> — Criterion that the generator has output sufficient active power to the electrical power system before fault inception
- Active-power change dP< — Decisive criterion for determining the stress on the shaft assembly. A multi-stage characteristic curve is possible→ $t_{out} = f(\Delta P)$.

The following figure shows the basic structure. You can find detailed information regarding the implementation under *Logic of the Function, Page 832* and in chapter *8.19.4 Application and Setting Notes*.



[dw_PPD_power-plant-coupler, 2, en_US]

Figure 8-77 Basic Structure of Power-Plant Disconnection

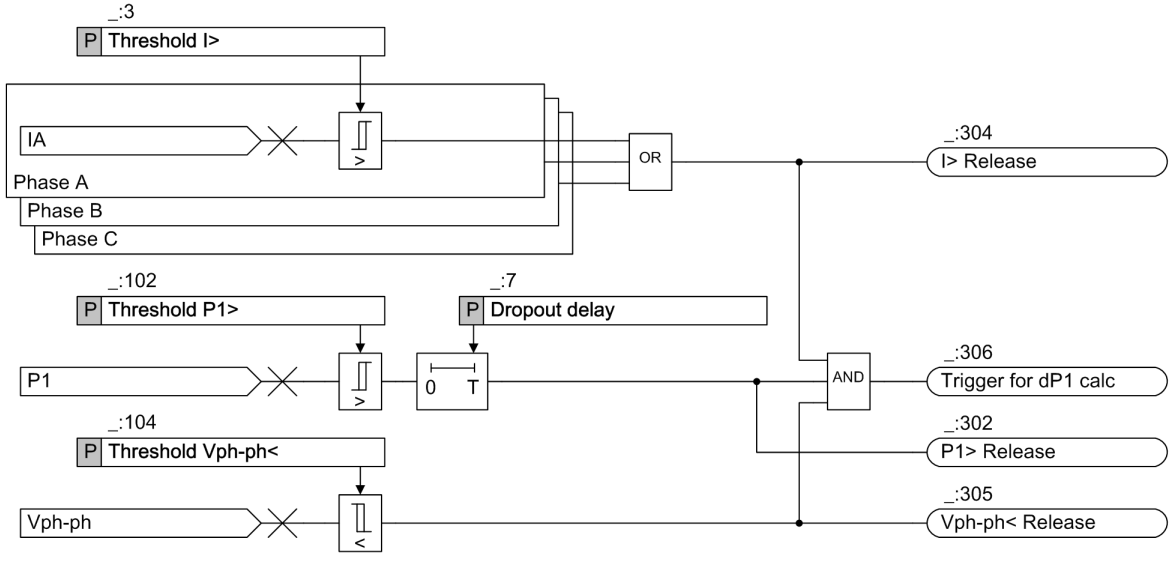
Logic of the Function

The **Power-plant disconnection protection** function includes multiple different criteria. *Figure 8-78* shows the logic for enabling active-power change measurement (dP measurement).

If the following criteria are satisfied, the indication *Trigger for dP1 calc.* is output and the calculation of the active-power difference begins:

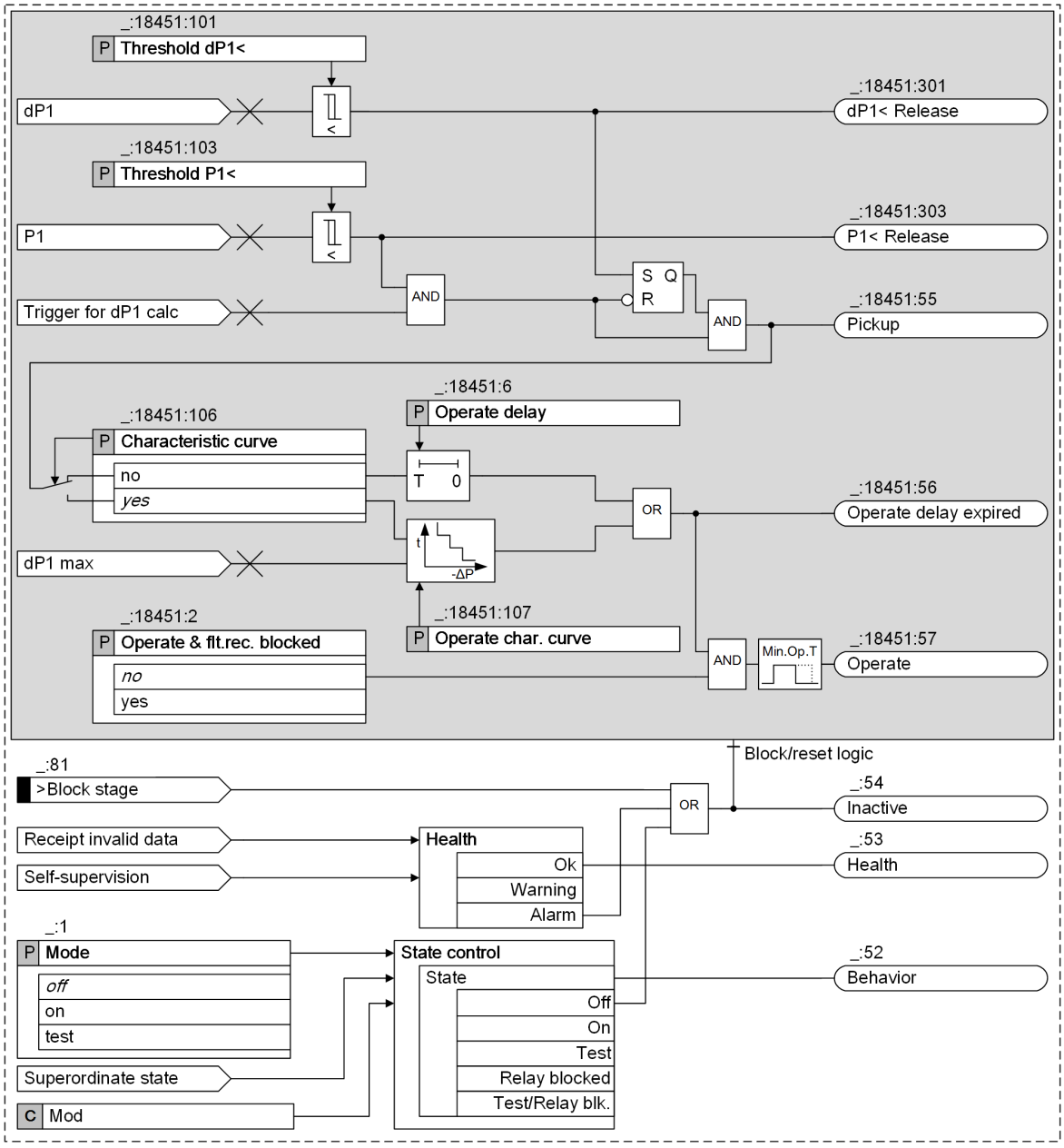
- Overcurrent pickup
- Undervoltage pickup
- Infeed of an appropriate active power from the power-plant unit into the power system

The indication *Trigger for dP1 calc.* describes the calculation time, starting from which the active power before fault inception, P1(t_{prior}) is stored internally. In order to avoid an incorrect measurement during transition processes, the active power is not measured at the time of the trigger; instead the value of approx. 2 cycles before the trigger time is used.



[lo_PPD_db_measurement, 2, en_US]

Figure 8-78 Logic Diagram for Release of dP Measurement



[lo_PPD_function, 3, en_US]

Figure 8-79 Logic Diagram of the Function

Figure 8-79 gives an overview of the implementation and the effect of the individual criteria. The measurands are evaluated every 1/4 cycle so that the function can respond quickly to changes in the power and can – if necessary – quickly fall back. The evaluation of the tracked voltage and current signals at the sampling frequency ensures the high level of measuring accuracy over a wide frequency range.

The measured active power is evaluated solely in percent related to the generator apparent power. It is therefore always less than 100 % and the maximum value is determined under rated conditions by cos φ (power factor). The percentage value for the phase currents is related to the generator rated current; the percentage value for the phase-to-phase voltage is related to the generator rated voltage.

Table 8-3 Implementation and Effect of the Individual Criteria

Criterion	Method of Measurement/Description
I>	Phase-segregated calculation of the fundamental component RMS value • The overcurrent criterion detects the short circuit. The currents are detected on a phase-segregated basis. The vector group of the generator transformer leads only to 2-phase or 3-phase fault currents on the generator side (also see the **Impedance protection** function).
V_{PP}<	Phase-to-phase voltage of the fundamental phasor • The undervoltage criterion detects an external short circuit. In case of a fault, the voltage must be below the threshold value. The undervoltage criterion also makes it possible for the function to drop out if the fault is cleared by the line protection.
P1>	Positive-sequence system active power P1 • If a power plant is operated in the partial-load range, a relatively low load on the shaft assembly can be expected. For this reason, it is checked whether the power-plant unit is feeding in a minimum demand. The criterion is dropout-delayed (parameter: **Dropout delay**), since the threshold value will be undershot in case of a fault.
P1<	Positive-sequence system active power P1 • Falling below an active-power threshold is an additional criterion for fault detection. In the event of a fault, the measured active power must be less than the threshold value.
dP1	$dP1(t) = P1(t_{prior}) - P1(t)$ • This calculates the change of active power starting from fault inception. When a short circuit is detected, the calculation of the power difference begins. The criterion calculates the power difference from the active power before fault inception and the actual active power at the calculation time. For fault detection, the 1st active-power jump is detected and stored in the RS flip-flop. If the preceding conditions are fulfilled and the dP threshold value (query of a negative jump) has been fallen below, the function picks up and the timer is started. If only a fixed time stage (**Characteristic curve** = ***no***) is active, there is tripping after expiration of the time, presuming that all the above conditions are still fulfilled.
dP1max	$dP1(t)max = Max (P1(t_{prior}) - P1(t))$ • If the characteristic curve for protection tripping is to be used, the active-power difference is measured continuously from the trigger time. In contrast to the dP measurement, the maximum active-power difference detected during the pickup is used as a variable in the characteristic curve. This characteristic curve offers the benefit that you can respond according to the level of the active-power change.

By using a multi-stage characteristic curve, you can assign a permissible tripping time to the maximum active-power difference. You can define the number of stages from 2 to 5 and thus optimally adapt the function to the system conditions. Longer tripping times are permitted for small active-power differences.
You can also select only 1 stage. Select between the stagewise operate curve or the defined time.

Functional Measured Values

Functional measured values are available to you so that you can better evaluate the behavior of the function. You can collect these functional measured values in a fault record for example.

Measured Value	Description
P1(t)	Positive-sequence system active power, which is evaluated by the function. The measured value is calculated every 1/4 cycle.
dP1(t)	Continuous representation of the active-power change, starting from the trigger time. With this, you can evaluate the change of the active-power difference at the prefault instant (t_{prior}).
dP1(t)max	This measured value flows into the characteristic curve. It represents the maximum active power during the duration of the fault.

Blocking the Function

You can completely reset the function by using the binary input signal **> Blocking stage**.

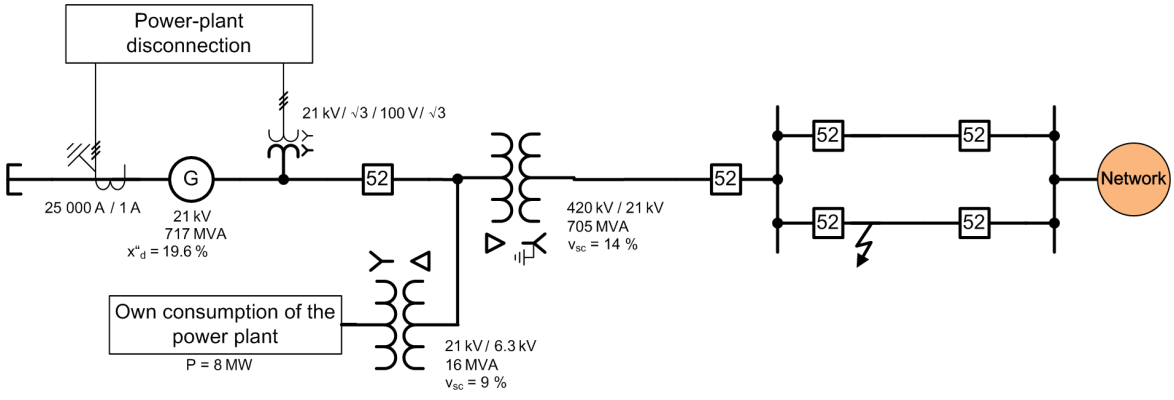
If internal supervision picks up, for example, by interrupting the voltage measuring circuit, the function is blocked.

8.19.4 Application and Setting Notes

For a typical application for a power-plant unit, Siemens recommends the following basic settings. A setting tailored to the power-plant unit, particularly regarding active-power difference and the permissible time delay, is possible only with a power-system study with the specific plant parameter settings. *Figure 8-80* and *Figure 8-81* show typical system configurations and also contain relevant technical data. Preferably load the function into the **Generator stator** or **Voltage-current, 3-phase** function group.

Generator-Stator Function Group

If the function is loaded into the **Generator-stator** function group (see the connection example in *Figure 8-80*), the function must be blocked with the generator circuit breaker open. In the event of a fault in the generator, a fault current still flows for a short time after fault clearing, that is, with an open generator circuit breaker, and therefore there is a risk of an overfunction. Power-plant disconnection remains picked up and opens the high-voltage circuit breaker. This means that you lose the generator transformer and the infeed for internal demand.



[dw_PPD_connection-examples, 2, en_US]

Figure 8-80 Connection Example for the Generator-Stator Function Group

Make the following settings in the **Generator-stator** function group. If calculating with per-unit values, these settings are necessary for scaling the quantities.

NOTE

Make sure that you set the correct generator data in the power-system data.

Parameters: `Rated apparent power`

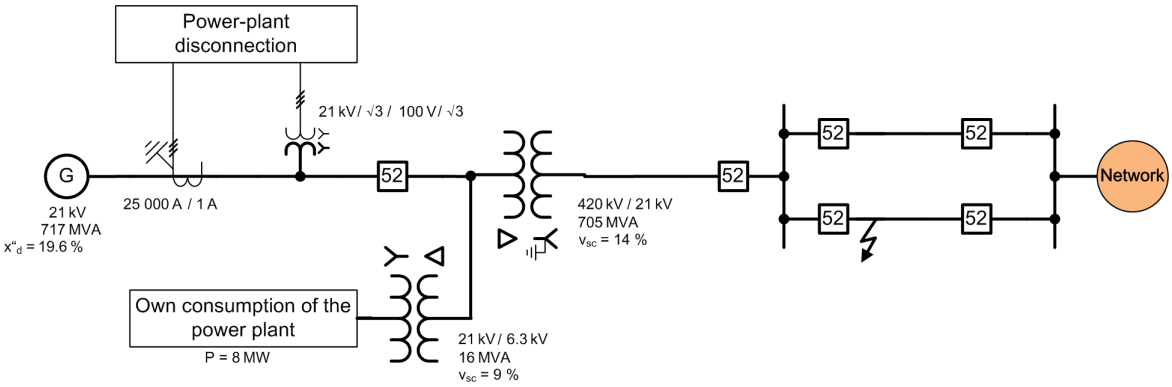
With the parameter **`(_:14671:103) Rated apparent power`**, you set the rated apparent power for the generator to be protected. In the connection example (*Figure 8-80*), that is 717 MVA.

Parameters: `Rated voltage`

With the parameter **`(_:14671:102) Rated voltage`**, you set the rated voltage for the generator to be protected. In the connection example (*Figure 8-80*), that is 21 kV.

The settings for **`Rated apparent power`** and **`Rated voltage`** yield a **`Rated current`** of 717 MVA / (√3 · 21 kV) = 19 712 A.

Load into the Voltage-Current 3-Phase Function Group



[dw_PPD_connection-example 2, 1, en_US]

Figure 8-81 Connection Example for the Voltage-Current 3-Phase Function Group

Make the following settings in the **Voltage-current 3-phase** function group. If calculating with per-unit values, these settings are necessary for scaling the quantities.

NOTE

Make sure that you set the correct generator data in the power-system data.

NOTE

If the current transformer is grounded towards the generator (see *Figure 8-81*), set the parameter **`Neutr.point in dir.of ref.obj`** to ***no***. The parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Settings** → **Power system** → **Measuring point I 3-phase**.

Parameters: `Rated current`

With the parameter **`(_:9451:101) Rated current`**, you set the rated current for the generator to be protected. In the connection example (*Figure 8-81*), that is 19 712 A.

Parameters: `Rated voltage`

With the parameter **`(_:9451:102) Rated voltage`**, you set the rated voltage for the generator to be protected. In the connection example (*Figure 8-81*), that is 21 kV.

The settings for **`Rated current`** and **`Rated voltage`** yield a **`Rated apparent power`** of $\sqrt{3} \cdot 21\ \text{kV} \cdot 19\,712\ \text{A} = 717\ \text{MVA}$.

NOTE

The default settings of the following threshold values are given in percent. In DIGSI 5, you can show the **Percent** mode in the path **Project** → **Device** → **Settings** → **Device settings** → **Edit mode**. You can find more information about the mode in *3.10 General Notes for Setting the Threshold Value*.

Parameter: `Threshold P1>`

- Default setting **`(_:18451:102) Threshold P1>`** = ***60 %***

With the **`Threshold P1>`** parameter, you can set the active power that a generator must feed into the power system before a short circuit occurs. If the active power fed in is lower than the set value, power-plant disconnection does not pick up.

A typical cos φ value of 0.8 to 0.9 yields a percentage of 80 % to 90 % active power (reference power is the apparent power). Therefore the setting value is more than half the maximum active power. Siemens recommends a value of > 50 % ($P1/S_{rated,Gen}$).

Parameter: `Dropout delay`

- Default setting **`(_:18451:7) Dropout delay`** = ***`0.5 s`***

You must set the parameter **`Dropout delay`** to be longer than the maximum tripping delay. Also take into account the setting values of the characteristic curve (see *Table 8-4*). After expiration of this time, the storage of the active power before fault inception $P1(t_{prior})$ will be canceled. The determined active-power change relates to $P1(t_{prior})$. The **`Dropout delay`** is an additional safety criterion for avoiding faulty calculation of the active-power difference.

The default setting is a practicable value. If necessary, you must increase the time somewhat.

Parameter: `Threshold P1<`

- Default setting **`(_:18451:103) Threshold P1<`** = ***`30 %`***

With this parameter, you can set the active power that must be undershot in the case of a short circuit. If the active power is less than the set power, a release signal will be issued. The setting value must be smaller than the **`Threshold P1>`** setting value. To enable a pickup at residual voltage, you must not set the parameter **`Threshold P1<`** too low.

The default setting is a practicable value.

Parameter: `Threshold Vph-ph<`

- Default setting **`(_:18451:104) Threshold Vph-ph<`** = ***`70 %`***

To guarantee a reliable pickup, the terminal voltage of the generator during the short circuit close to the power plant must certainly be below the parameter **`Threshold Vph-ph<`**. This means that you must not set the parameter **`Threshold Vph-ph<`** too low. On the other hand, you must take the defined voltage range into consideration (typically: +/- 5 % or 7.5 %). It must also be ensured that the voltage safely drops out after fault clearing.

If there are unbalanced short circuits in the power system, unbalanced phase-to-phase voltages will also be measured on the generator side. If there is a 1-phase short circuit on the high-voltage side, only 1 phase-to-phase voltage will dip on the generator side. The voltage threshold is also a criterion for determining the time for the active power before fault inception.

A typical setting range is between 50 % and 75 %. The default setting is a practicable value.



NOTE

When determining the **`Threshold Vph-ph<`** parameter, note that the fault current leads to a voltage drop across the generator transformer. You must additionally take into account the short-circuit impedance of the transformer (in simplified form, the short-circuit voltage v_{sc}) in this case.

The possible generator-side terminal voltage can be estimated as follows:

$$V\,[\%] \approx v_{sc}\,[\%] \cdot \frac{I''_{3-phase}}{I_{rated,Gen}}$$

[fo_generator terminal voltage, 2, en_US]

Example

$v_{sc} = 14\ \%$

$I''_{3\text{-phase}} = 3I_{rated,Gen}$

$$V\,[\%] \approx v_{sc}\,[\%] \cdot \frac{I''_{3-phase}}{I_{rated,Gen}} = 14\,\% \cdot \frac{3I_{rated,Gen}}{I_{rated,Gen}} = 42\,\%$$

[fo_generator terminal voltage, example, 2, en_US]

Parameter: `Threshold I>`

- Default setting **`(_:18451:3) Threshold I>`** = ***`130 %`***

In order to detect an external short circuit, define the current pickup value with the **`Threshold I>`** parameter. The default setting is a practicable value.

You can estimate the initial short-circuit alternating current with the subtransient reactance of the generator x''_d and the short-circuit voltage v_{sc} of the transformer:

$$I''_{3-phase} = \frac{I_{rated\ ,Gen}}{x''_d + v_{sc}}$$

[fo_shortcircit AC current, 2, en_US]

For the numerical example:

$$I''_{3-phase} \approx \frac{I_{rated,Gen} \cdot 100\,\%}{19.6\,\% + 14\,\%} \approx 3I_{rated,Gen}$$

[fo_shortcircit AC current, example, 2, en_US]

The default setting is a practicable value.

Parameter: `Threshold dP1<`

- Default setting **`(_:18451:101) Threshold dP1<`** = ***`-70 %`***

With the **`Threshold dP1<`** parameter, you set the value that leads to pickup of the **Power-plant disconnection** function. The prerequisite is that the above-mentioned conditions have been satisfied. The level of the threshold value is determined, among other things, by the following settings. If you want only 1 fixed stage with a defined tripping time (parameter **`Characteristic curve`** = ***`no`***), you must set a larger negative threshold value for the active-power change. Assume a 3-phase close-up short circuit without residual voltage. If cos φ = 0.8 and full-load operation is assumed, then the ***`ideal`*** active-power change is approx. -80 % (at full load, the active power is 80 % $P/S_{rated,Gen}$ and in the fault case 0 %); this ***`ideal`*** state cannot be achieved.

The default setting is a practicable value. The turbo-generator set manufacturer must supply the final value or you determine the value from the dynamic calculations.

If you want to use the characteristic curve (parameter **`Characteristic curve`** = ***`yes`***), set the parameter **`Threshold dP1<`** to the lowest threshold value of the characteristic curve (see *Table 8-4*).

Parameter: `Operate delay`

- Default setting **`(_:18451:6) Operate delay`** = ***`0.15 s`***

You must set the **`Operate delay`** parameter on the basis of the application. The turbo-generator set manufacturer will specify the time. Take account of the ***`Fault Ride Through`*** capability (FRT capability) from the requirements of the ***`Grid Code`*** (grid and system rules of the power-system operator). The FRT capability means that the power-plant unit must remain stable on the power system in the event of a 3-phase short circuit and must not lose synchronism after a fault clearing (asynchronous active-power swing with the power system). A typical FRT time is 0.15 s, which is also the default time delay. Assume an additional pickup delay of approx. 25 ms. The dropout delay is on the same order of the magnitude. 20 ms is used for the estimation.

The **`Operate delay`** can be estimated as follows:

$$t_{pickup\ -ind.} \geq t_{fault} - t_{pickup} + t_{dropout}$$

[fo_pickupInd.Time, 1, en_US]

$$\text{Operate delay} > t_{\text{pickup -ind.}} + \text{Safety time}$$

[fo_op.DelayTime, 1, en_US]

With:

$t_{\text{pickup-ind.}}$	Pickup indication time
t_{fault}	Maximum permissible fault-clearing time
t_{pickup}	Pickup delay
t_{dropout}	Dropout delay

EXAMPLE

$t_{\text{fault}} = 140$ ms

$t_{\text{pickup}} = 25$ ms

$t_{\text{dropout}} = 20$ ms

$$t_{\text{pickup -ind.}} \geq t_{\text{fault}} - t_{\text{pickup}} + t_{\text{dropout}} = 140\text{ ms} - 25\text{ ms} + 20\text{ ms} = 135\text{ ms}$$

[fo_pickupInd.Time with data, 1, en_US]

$$\text{Operate delay} > t_{\text{pickup -ind.}} + \text{Safety time} = 135\text{ ms} + 10\text{ ms} = 145\text{ ms}$$

[fo_op.DelayTime with data, 1, en_US]

The parameter **Operate delay** is set to 150 ms (0.15 s).

Parameter: Characteristic curve

- Default setting **(_:18451:106) Characteristic curve** = ***yes***

With the **Characteristic curve** parameter, you specify whether you want to use the characteristic curve or a fixed tripping delay (**Characteristic curve** = ***no***). Siemens recommends the default setting, because you can act with different delays on different active-power changes with the characteristic curve. In that way, you increase the security of supply and avoid an excessively fast power-system disconnection if there are small active-power changes.

Parameters: Operate char. curve

If you use the characteristic curve, you can set the number of desired stages. The number of table values is visible, depending on the setting. 3 stages is a pragmatic approach.

Small active-power changes lead to a smaller stress. For this reason, longer tripping times are permissible. You must request the final values from the turbo-generator set manufacturer or determine them with a dynamic system calculation program that takes account of the system parameter settings.

NOTE

In DIGSI, set the active-power jump of the operate curve in the descending order.

The following table shows an example of a rough estimation of the operate curve setting.

Table 8-4 Operate-Curve Settings of the 3 Stages

Negative Active-Power Jump	Permissible Time Delay
-40 %	0.30 s
-50 %	0.20 s
-65 %	0.15 s

NOTE

Set the **Threshold dP1<** parameter to the smallest value of the characteristic curve.

8.19.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:18451:1	Stage 1:Mode		• off • on • test	off
_:18451:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:18451:101	Stage 1:Threshold dP1<		-100.00 % to -30.00 %	-70.00 %
_:18451:102	Stage 1:Threshold P1>		50.00 % to 100.00 %	60.00 %
_:18451:7	Stage 1:Dropout delay		0.00 s to 60.00 s	0.50 s
_:18451:103	Stage 1:Threshold P1<		0.00 % to 60.00 %	30.00 %
_:18451:3	Stage 1:Threshold I>	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
_:18451:104	Stage 1:Threshold Vph-ph<		0.300 V to 175.000 V	70.000 V
_:18451:106	Stage 1:Characteristic curve		• no • yes	yes
_:18451:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.15 s

8.19.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:15781:301	General:P1	MV	O
_:15781:302	General:dP1	MV	O
_:15781:303	General:dP1max	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:18451:81	Stage 1:>Block stage	SPS	I
_:18451:54	Stage 1:Inactive	SPS	O
_:18451:52	Stage 1:Behavior	ENS	O
_:18451:53	Stage 1:Health	ENS	O
_:18451:301	Stage 1:dP1< Release	SPS	O
_:18451:302	Stage 1:P1> Release	SPS	O

No.	Information	Data Class (Type)	Type
_:18451:303	Stage 1:P1< Release	SPS	O
_:18451:304	Stage 1:I> Release	SPS	O
_:18451:305	Stage 1:Vph-ph< Release	SPS	O
_:18451:306	Stage 1:Trigger for dP1 calc	SPS	O
_:18451:55	Stage 1:Pickup	ACD	O
_:18451:56	Stage 1:Operate delay expired	ACT	O
_:18451:57	Stage 1:Operate	ACT	O

8.20 Circuit-Breaker Failure Protection

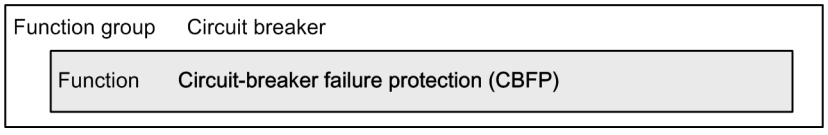
8.20.1 Overview of Functions

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.

Starting with version V7.50, the previous function **CB failure** has been replaced with the new Circuit-breaker failure protection with an adaptive algorithm **Adaptive CB failure protection**. In this way, you achieve a faster, more reliable detection of the opening of the circuit breaker in the event of complex signal histories. The 2 functions are identical, with the exception of a slightly increased processor load, in terms of setting options, logic and indications. Siemens recommends using the adaptive circuit-breaker failure protection and avoiding mixing the protection types in one device. You can find additional information on the processor load in DIGSI for each device under **Device information** in the **Resource consumption** tab.

8.20.2 Structure of the Function

The function **Circuit-breaker failure protection** (CBFP) can be used in the **Circuit-breaker** function group.



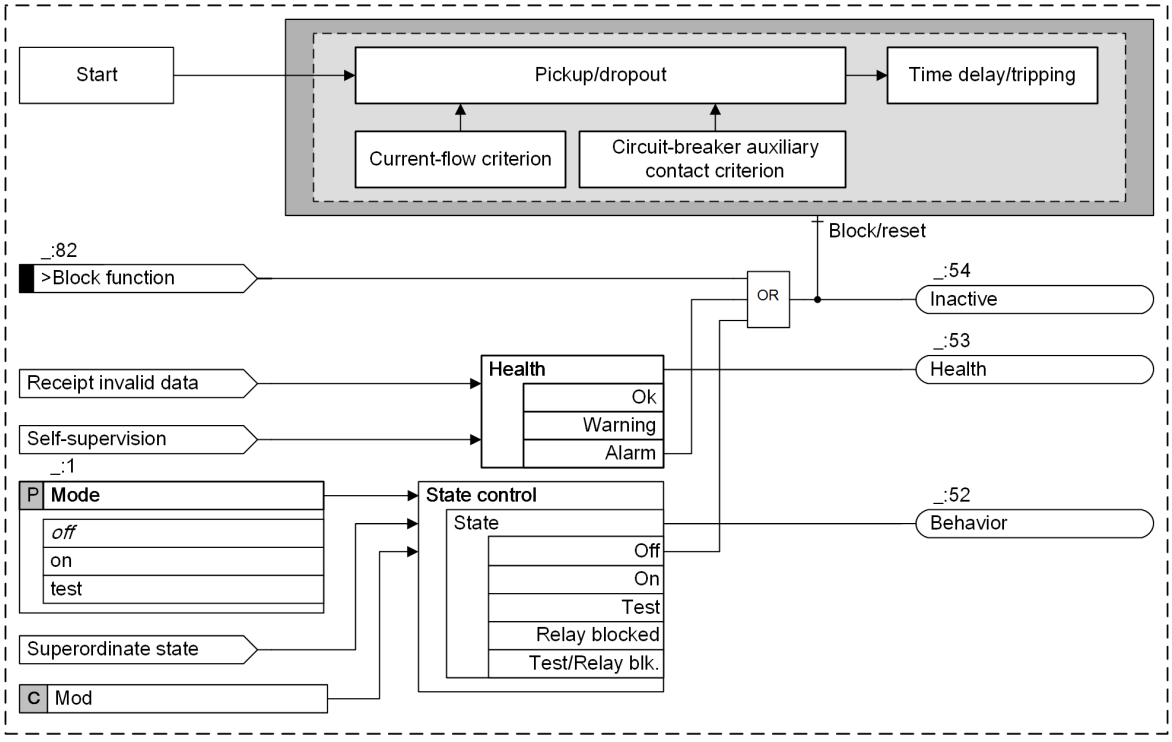
[dw_strbfp, 1, en_US]

Figure 8-82 Structure/Embedding of the Function

Figure 8-83 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 continuously checks 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.



[lo_svs_bfp, 3, en_US]

Figure 8-83 Function Logic Overview

8.20.3 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 8-84* and *Figure 8-85* show the functionality.

Internal Start

By default, each device-internal protection stage that 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 8-84*) is held when the pickup signal has a falling edge or with protection function tripping. The Circuit-breaker failure protection function can in this case only drop out 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).

You can use routing to determine whether individual protection stages or protection functions are used as a starting source or whether the start is only supposed to be external.

The internal starting sources are routed in the protection function groups via the **Circuit-breaker interaction** entry (for this, see*2.1 Embedding of Functions in the Device*.).

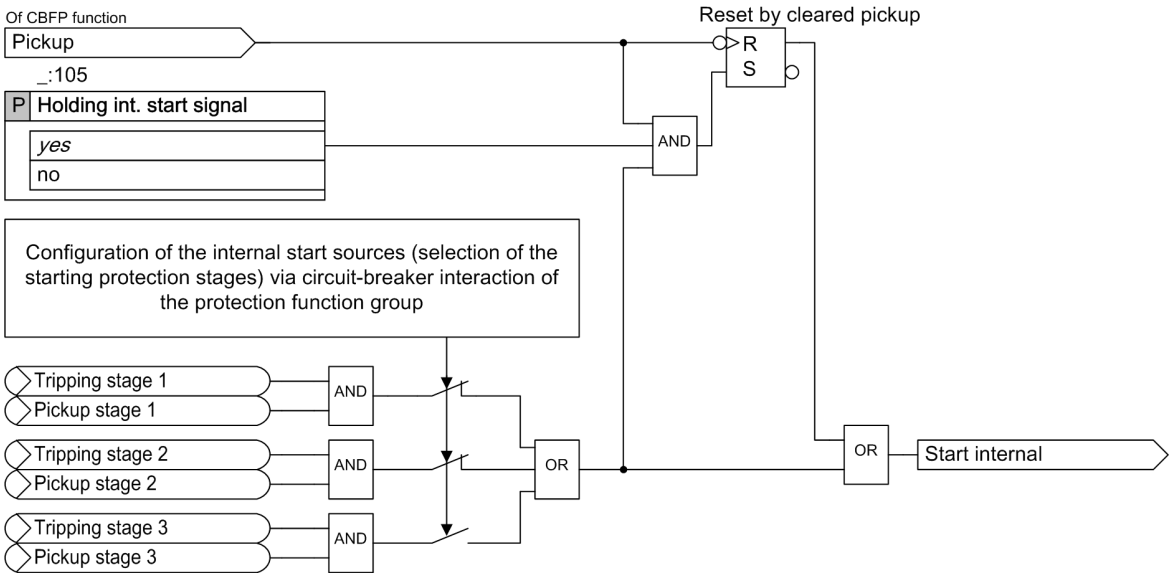


Figure 8-84 Internal Start of the Circuit-Breaker Failure Protection Function

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*.

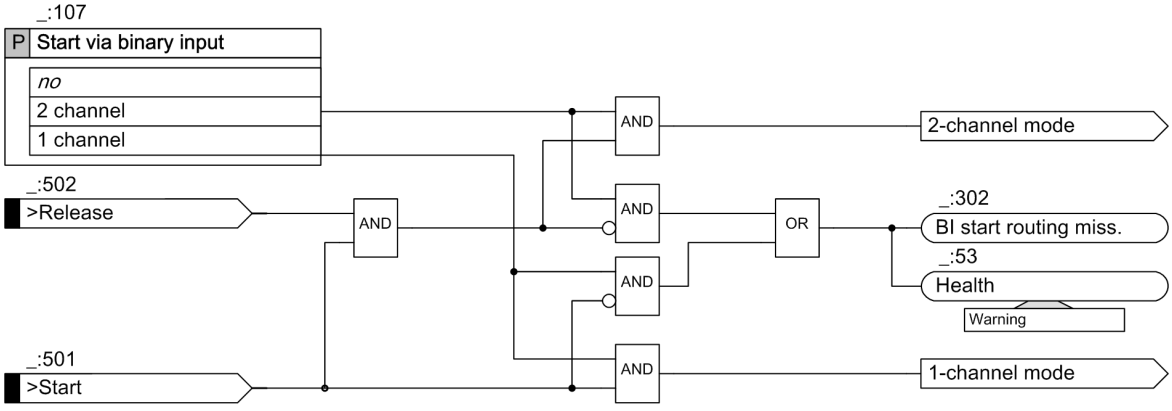


Figure 8-85 Configuration of the External Start of the Circuit-Breaker Failure Protection Function

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 8-86*). 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.

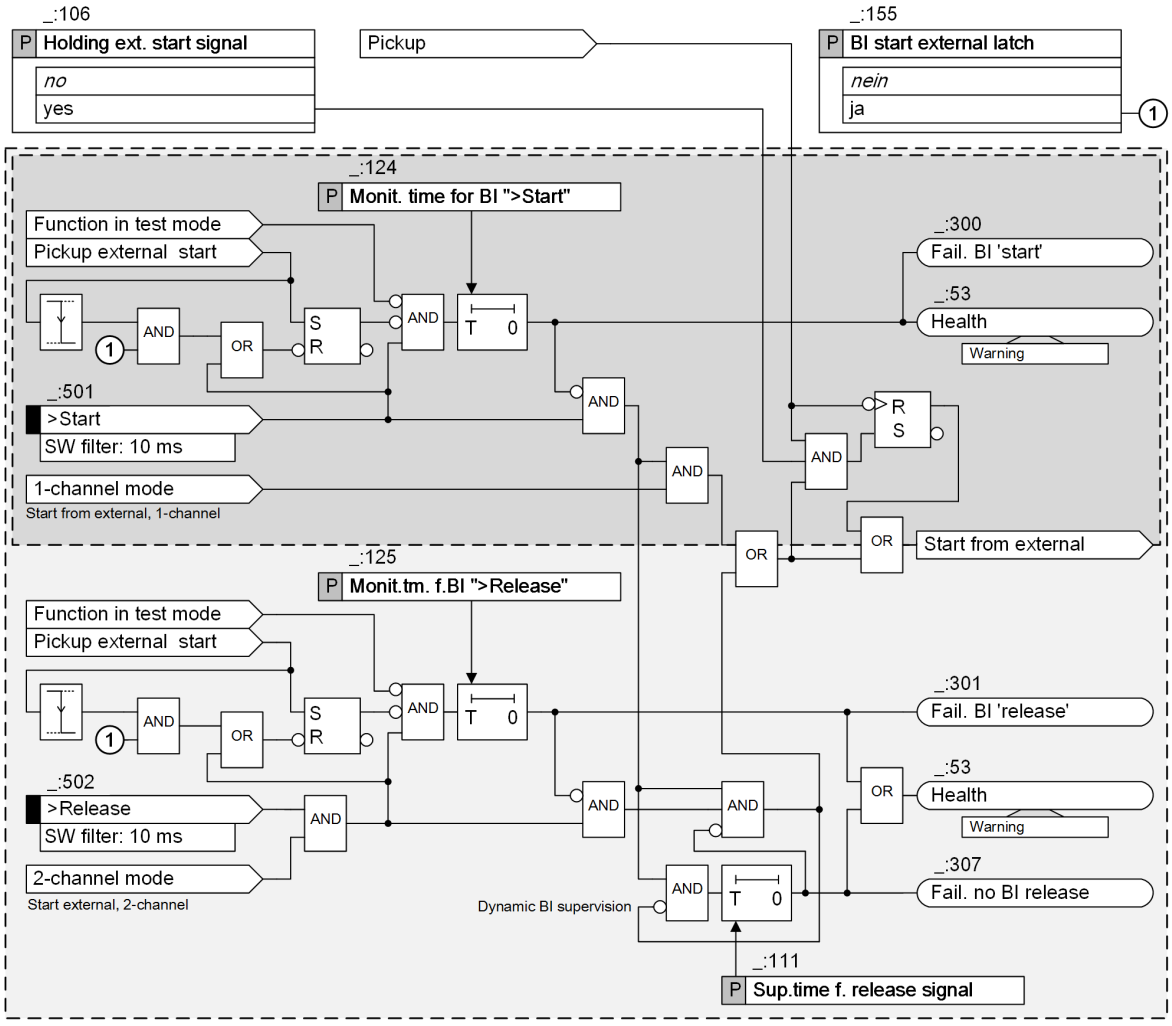
If either of the signals **>Start** or **>Release** is active for more than the set supervision time of the corresponding signal without the function being picked up, an error in the binary input circuit is assumed. The corresponding signal is blocked to exclude an external pickup of the function. An 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, supervision is enabled 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 and no release signal is present after elapse of a settable supervision time for the starting signal, 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 8-86*).



[lo_ext, 3, en_US]

Figure 8-86 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 switch 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 a criterion.

If you are using the transformer connection type **3-phase, 2prim.trans.**, the ground current is neither measured nor calculated. The plausibility check via the ground current is therefore not possible. The setting ***Direct release*** via the ground current does not lead to a pickup of the circuit-breaker failure protection.

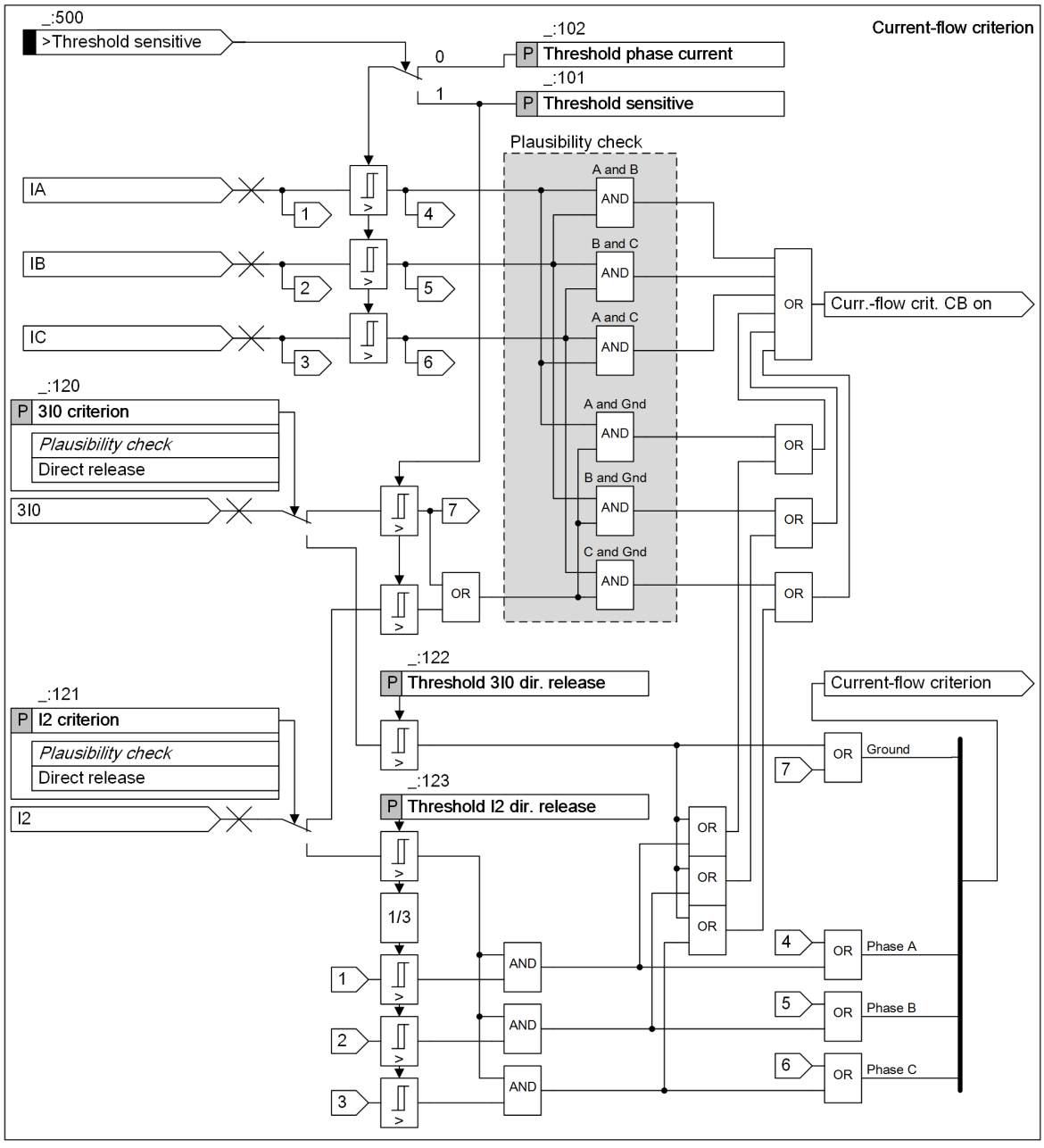
In the case of ground faults, the sensitive threshold value can be dynamically applied to the phase currents as well. The current-flow criterion is in this case fulfilled when the currents exceed the sensitive threshold value. The phase-current threshold value is then ineffective. The binary signal **>Threshold sensitive** is used for the switchover.

If you set the parameter **3I0 criterion** to ***Direct release***, you block the plausibility check of the zero-sequence current. In this way a pickup can only be achieved by way of this current. The **Threshold 3I0 dir. release** parameter is used to set the threshold value to be exceeded.

If you set the parameter **I2 criterion** to ***Direct release***, you also switch off the plausibility check of the negative-sequence current. The **Threshold I2 dir. release** parameter is used to set the threshold value to be exceeded.

If you set the parameter **I2 criterion** 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.



[lo_current1, 4, en_US]

Figure 8-87 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 switch position.

The double-point indication **`3-pole position`** (from the function block **Circuit-breaker**) 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).

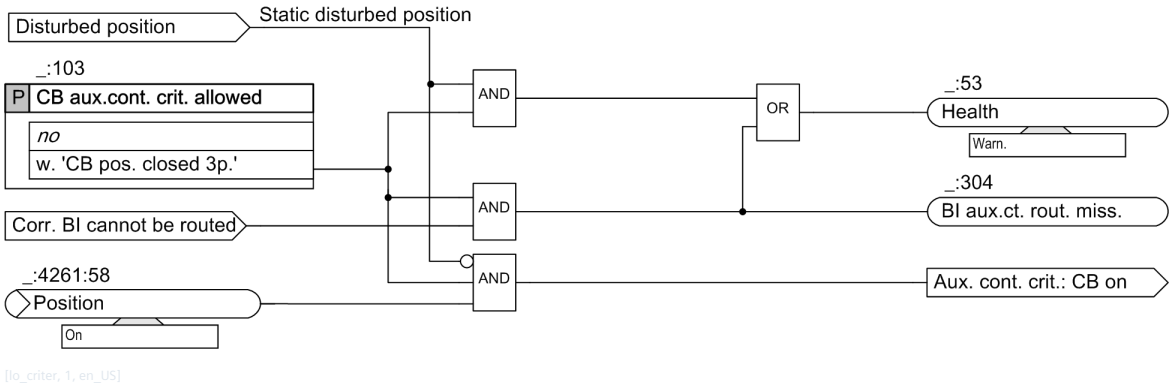


Figure 8-88 Circuit-Breaker Auxiliary Contact Criterion

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.

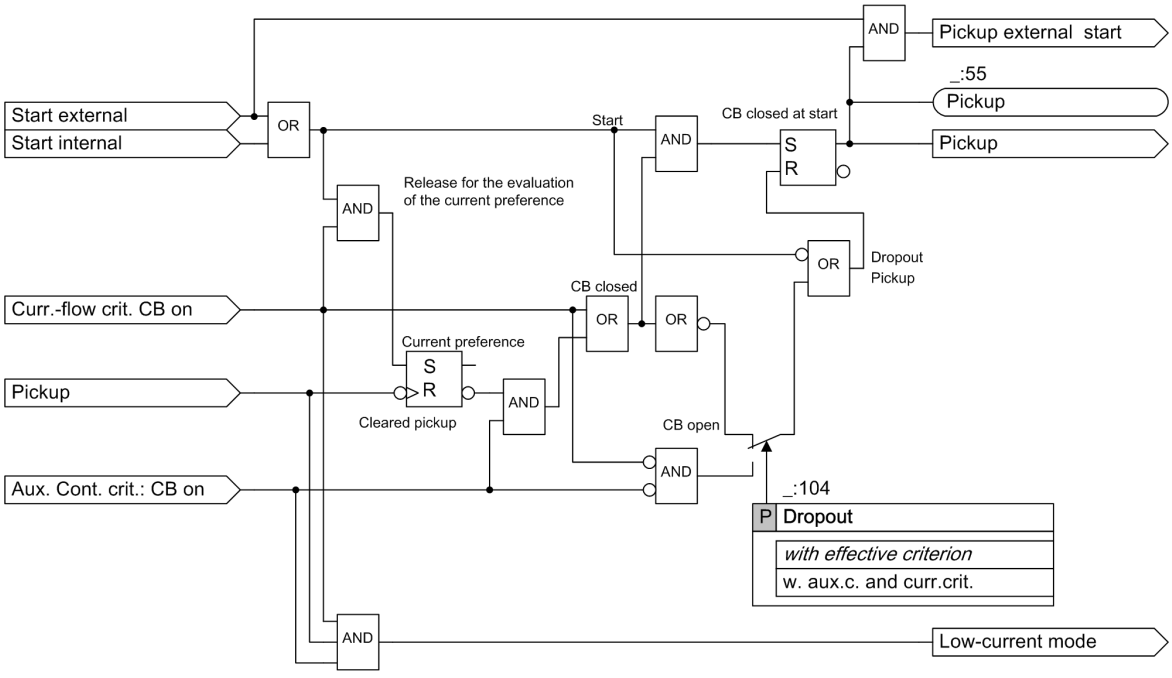
If no current is flowing at the start time, the function can only pick up on the basis of the circuit-breaker auxiliary contact criterion. For this purpose, the circuit-breaker auxiliary contacts must be permitted as criterion. When the current begins to flow after the start, the function switches over to the current-flow criterion.

If the circuit breaker is detected as closed and the starting condition is present, 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 8-84* and *Figure 8-86*). This means that dropout is controlled solely by the current 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.



[lo_pickup1, 4, en_US]

Figure 8-89 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.

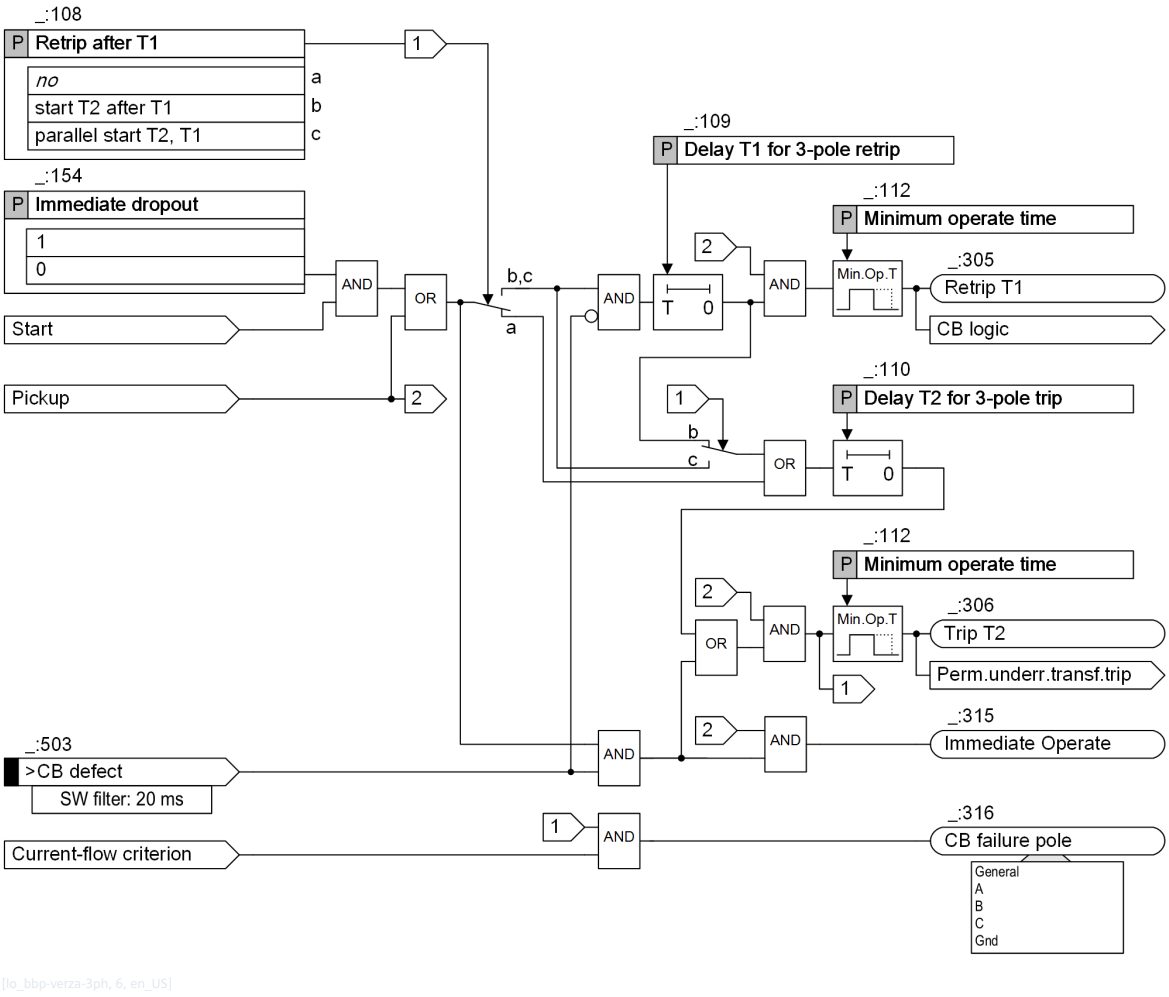
Time delay T2 (backup tripping) can commence in parallel either with the start of time T1 or after expiration of time T1.

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.

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**.



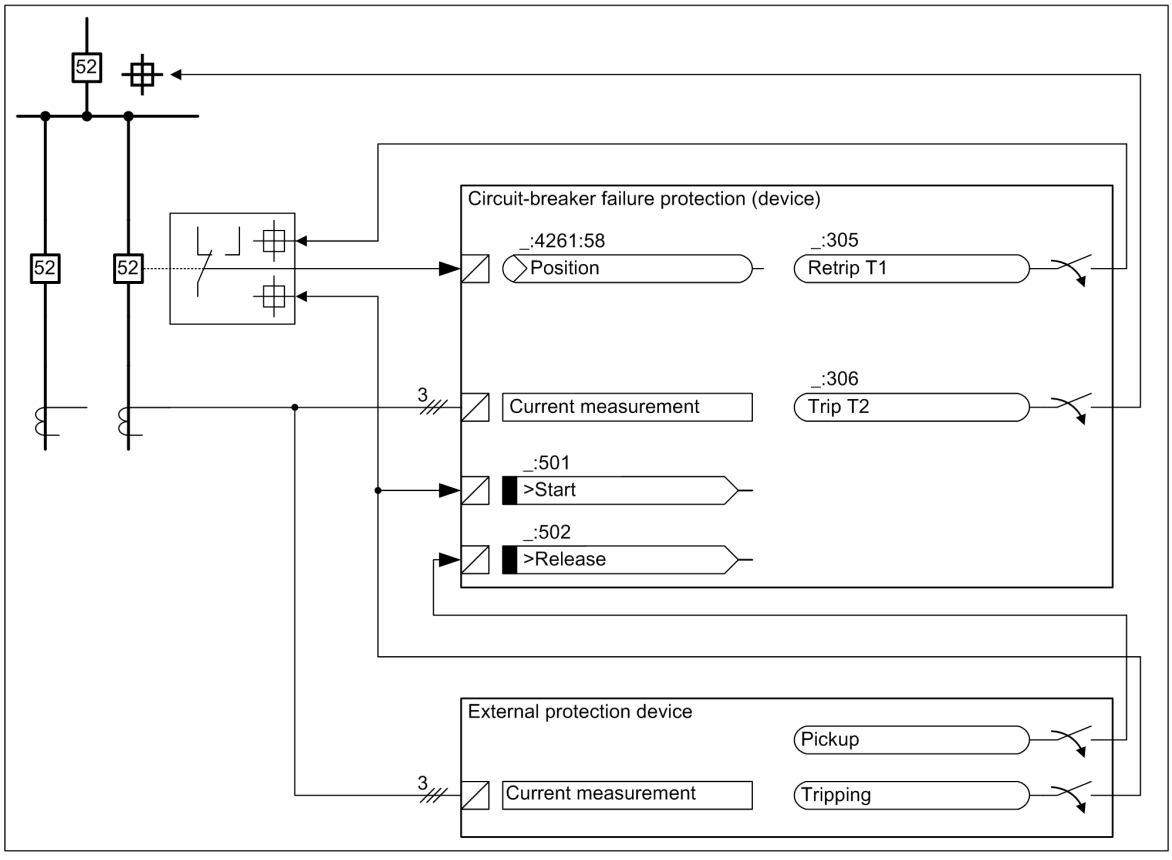
[lo_bbp-verza-3ph, 6, en_US]

Figure 8-90 Delay/Tripping of the Circuit-Breaker Failure Protection Function

With the **`Immediate dropout`** parameter, you determine whether the circuit-breaker switch position is checked continuously or on expiration of the T1 and T2 time delays. If the circuit-breaker switch position is checked once the time delays have expired, the function picks up using Start.

8.20.4 Application and Setting Notes

Figure 8-91 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.



[lo_extpol, 2, en_US]

Figure 8-91 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 (*2.1 Embedding of Functions in the Device*).

By default, the function can be started by any tripping of the internal protection functions that 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 may 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***.
2 channel	2-channel start is used if there is a danger 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 (*Figure 8-91*).
>Release	The release input signal is normally linked with the pickup of the external protection device (*Figure 8-91*). Another common configuration is the parallel wiring of the external trip initiation to both binary inputs (start and release).

Parameter: Supervision time f. release signal

- Default setting **(_:111) Sup.time f. release signal** = ***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 start signal, the time can be set to 0.

Parameter: Holding internal start signal

- Recommended setting value **(_:105) Holding int. start signal** = ***yes***

Parameter Value	Description
yes	In the case of an internal start, the start signal is hold. The dropout of the CBFP depends exclusively on the determination of the circuit-breaker 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 start signal can be disabled if it is ensured by the application that the CB has reliably opened when the start signal has a falling edge, or if the CBFP is explicitly required to drop out when the start signal has a falling edge.

EXAMPLE

Holding Internal Start 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 external start signal

- Recommended setting value **(_:106) Holding ext. start signal** = ***no***

Parameter Value	Description
no	The CBFP drops out when the external start 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 start signal if it is not ensured that the circuit breaker is open when the external start signal has a falling edge.

EXAMPLE

Holding External Start 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.

Parameters: 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 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.
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 is only used to check the plausibility of the phase currents. The value set under the parameter **Threshold sensitive** is used as the threshold for the ground current.
Direct release	The current-flow criterion can be fulfilled only by the ground current without the phase currents exceeding their set threshold value. The value set under the parameter **Threshold 3I0 dir. release** is used in this case as the threshold for the ground current.

If you have set the **Threshold phase current** to be larger than the maximum load current, overfunction because of a false start is impossible. To ensure **Circuit-breaker failure protection** for smaller ground faults even with this setting, you can select **3I0 criterion** to be ***Direct release*** and **Threshold 3I0 dir. release** to be appropriately smaller than **Threshold phase current**.

Parameter: I2 criterion

- Recommended setting value (_:121) **I2 criterion** = ***Plausibility check***

Parameter Value	Description
Plausibility check	The negative-sequence current is only used to check the plausibility of the phase currents. The value set under the parameter **Threshold sensitive** is used as the threshold for the negative-sequence current.
Direct release	If a phase current exceeds 1/3 of the **Threshold I2 dir. release**, the current-flow criterion can be fulfilled only 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.

If you have set the **Threshold phase current** to be larger than the maximum load current, overfunction because of a false start is impossible. To have Circuit-breaker failure protection function for smaller unbalanced faults even with this setting, you can select **I2 criterion** to be ***Direct release*** and **Threshold 3I0 dir. release** to be appropriately smaller than **Threshold phase current**.

Parameter: Threshold 3I0 dir. release

Recommended setting value **(_:122) Threshold 3I0 dir. release** = ***approx. 0.5 Isc***$_{min}$

This parameter is effective only if the **3I0 criterion**parameter is set to ***Direct release***. Siemens recommends setting the threshold to half the minimum short-circuit current (Isc_{min}) to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly.

Parameter: `Threshold I2 dir. release`

Recommended setting value **`(_:123) Threshold I2 dir. release`** = ***`approx. 0.5 I2`***$_{min}$

This parameter is effective only if the **`I2 criterion`**parameter is set to ***`Direct release`***. Siemens recommends setting the parameter to half the permissible negative-sequence current ($I2_{min}$) to achieve a fast fault clearing in the event of an undesired negative-sequence system component.

Parameters: `Monit. time for BI ">Start"`/`Monit.tm. f.BI ">Release"`

- Default setting **`(_:124) Monit. time for BI ">Start"`** = ***`15 s`***
- Default setting **`(_:125) Monit.tm. f.BI ">Release"`** = ***`15 s`***

With these parameters, you set the monitoring time of the binary inputs **`>Start`**/**`>Release`**. If the **Circuit-breaker failure protection** does not pick up during this monitoring time, a failure in the binary-input circuit is assumed. Siemens recommends retaining the default setting of 15 s.

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 a current measurement in combination with voltage or frequency protection functions
- Injection of the tripping signal from Buchholz protection

Parameter: Circuit-Breaker Auxiliary-Contact Criterion Allowed for Machine Protection

- Recommended setting value **`(_:103) CB aux.cont. crit. allowed`** = ***`w. 'CB pos. closed 3p.'`***

Parameter Value	Description
`w. 'CB pos. closed 3p.'`	The auxiliary contacts must be permitted as a further criterion in applications (see the preceding examples) where the current is no reliable criterion for determining the circuit-breaker switch position.
`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: 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-clearing 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 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 after T1, 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 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

Too short setting times for the minimum tripping duration

If you set a time that is too short for tripping, there is a risk (dropout of the function without the current-flow criterion) that the device contacts will interrupt the control loop. If this happens, the device contacts will burn out.

✧ Set a minimum time period that is long enough to ensure that the circuit breaker reliably reaches the end position **Open** 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 1 control circuit is available for the local circuit breaker, the output signal does not necessarily have to be routed because the signal also controls the circuit-breaker trip logic.

If a 2nd control circuit is present, the **Retrip T1** output signal must be routed to the associated binary output.

Output Signal: Trip T2

For operational handling of 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 opposite end).

Parameter: Immediate dropout

- Recommended setting (_:154) **Immediate dropout** = ☑

Parameter Value	Description
☑	The criteria are checked continuously and the circuit-breaker failure protection drops out immediately once the criteria have no longer been met. Siemens recommends keeping this setting.
☐	This setting is used to take alternating load cases into account in the event of a fault, for example when using a breaker-and-a-half layout. The time delays and function pickup are actuated separately using a starter. The criteria for determining a closed circuit breaker are only checked once the time delays have expired. Select the monitoring times for the binary inputs *>Start* and *>Release* in such a way that supervision for these inputs does not respond prior to achieving the current or circuit-breaker auxiliary-contact criterion.

Parameter: BI start external latch

- Default setting (_:155) **BI start external latch** = ☑

Parameter Value	Description
☑	In the case of buffered sources (for example lock-out mechanism after tripping) the start binary signal is latched externally after the protection trip. This means that the binary-input supervision remains inactive until the binary-input source has been reset. Supervision is only activated after this has taken place.
☐	In the case of sources that are not buffered for an external start, the expectation is that they will drop out once the circuit-breaker failure protection has picked up. If this is not the case, the binary input may fail. This is why this setting results in binary-input supervision being reactivated once the Circuit-breaker failure protection function drops out.

8.20.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
50BF Ad.CBF #				
_:1	50BF Ad.CBF #:Mode		• off • on • test	on
_:105	50BF Ad.CBF #:Holding int. start signal		• no • yes	yes
_:107	50BF Ad.CBF #:Start via binary input		• no • 2 channel • 1 channel	no
_:106	50BF Ad.CBF #:Holding ext. start signal		• no • yes	no
_:111	50BF Ad.CBF #:Sup.time f. release signal		0.00 s to 1.00 s	0.06 s

Addr.	Parameter	C	Setting Options	Default Setting
_:103	50BF Ad.CBF #:CB aux.cont. crit. allowed		• no • w. 'CB pos. closed 3p.'	no
_:104	50BF Ad.CBF #:Dropout		• with effective criterion • w. aux.c. and curr.crit.	with effective criterion
_:108	50BF Ad.CBF #:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	no
_:102	50BF Ad.CBF #: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 Ad.CBF #: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 Ad.CBF #:Delay T1 for 3-pole retrip		0.000 s to 60.000 s	0.050 s
_:110	50BF Ad.CBF #:Delay T2 for 3-pole trip		0.050 s to 60.000 s	0.130 s
_:112	50BF Ad.CBF #:Minimum operate time		0.00 s to 60.00 s	0.10 s
_:120	50BF Ad.CBF #:3I0 criterion		• Direct release • Plausibility check	Plausibility check
_:121	50BF Ad.CBF #:I2 criterion		• Direct release • Plausibility check	Plausibility check
_:122	50BF Ad.CBF #: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
_:123	50BF Ad.CBF #: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 Ad.CBF #:Monit. time for BI ">Start"		0.05 s to 60.00 s	15.00 s
_:125	50BF Ad.CBF #:Monit.tm. f.BI ">Release"		0.05 s to 60.00 s	15.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:154	50BF Ad.CBF #:Immediate dropout		• 0 • 1	true
_:155	50BF Ad.CBF #:BI start external latch		• 0 • 1	true

8.20.6 Information List

No.	Information	Data Class (Type)	Type
50BF Ad.CBF #			
_:501	50BF Ad.CBF #:>Start	SPS	I
_:502	50BF Ad.CBF #:>Release	SPS	I
_:82	50BF Ad.CBF #:>Block function	SPS	I
_:503	50BF Ad.CBF #:>CB defect	SPS	I
_:500	50BF Ad.CBF #:>Threshold sensitive	SPS	I
_:54	50BF Ad.CBF #:Inactive	SPS	O
_:52	50BF Ad.CBF #:Behavior	ENS	O
_:53	50BF Ad.CBF #:Health	ENS	O
_:55	50BF Ad.CBF #:Pickup	ACD	O
_:305	50BF Ad.CBF #:Retrip T1	ACT	O
_:306	50BF Ad.CBF #:Trip T2	ACT	O
_:302	50BF Ad.CBF #:BI start routing miss.	SPS	O
_:304	50BF Ad.CBF #:BI aux.ct. rout. miss.	SPS	O
_:300	50BF Ad.CBF #:Fail. BI 'start'	SPS	O
_:307	50BF Ad.CBF #:Fail. no BI release	SPS	O
_:301	50BF Ad.CBF #:Fail. BI 'release'	SPS	O
_:315	50BF Ad.CBF #:Immediate Operate	SPS	O
_:316	50BF Ad.CBF #:CB failure pole	ACD	O

8.21 Circuit-Breaker Restrike Protection

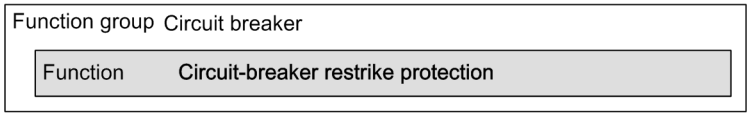
8.21.1 Overview of Function

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

8.21.2 Structure of the Function

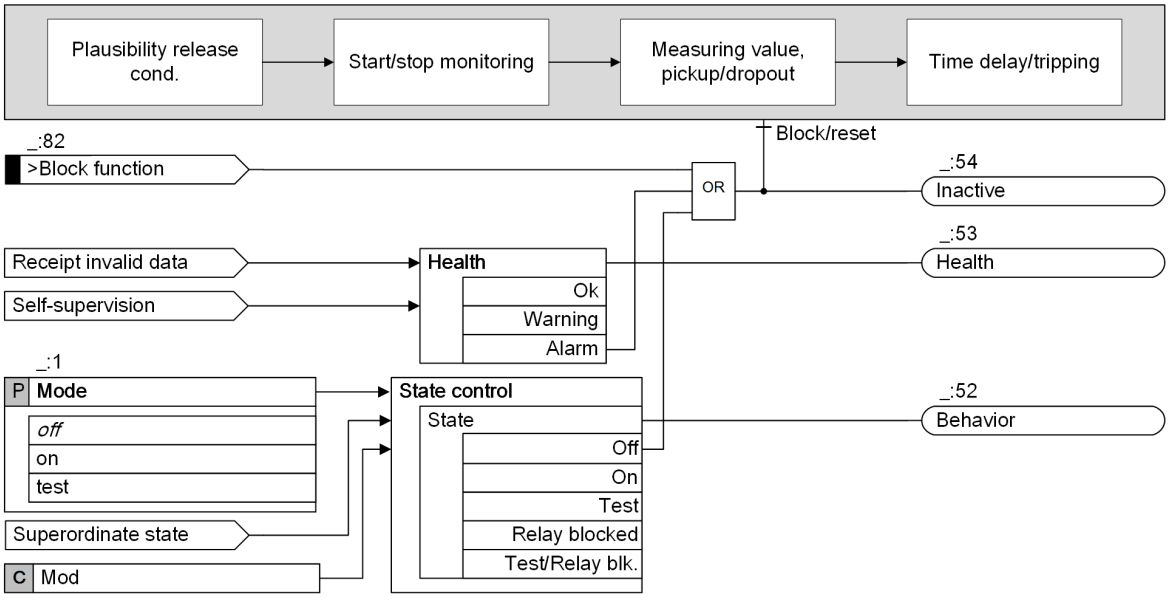
The **Circuit-breaker restrike protection** function is used in the **Circuit-breaker** function group. A maximum of 2 functions can operate simultaneously within the function group.



[lo_strrestrike, 2, en_US]

Figure 8-92 Structure/Embedding of the Function

The function logic is grouped into the parts shown in *Figure 8-93*. In the following chapter, these logic parts are described in detail.



[lo_respro, 2, en_US]

Figure 8-93 Logic Overview of the Function

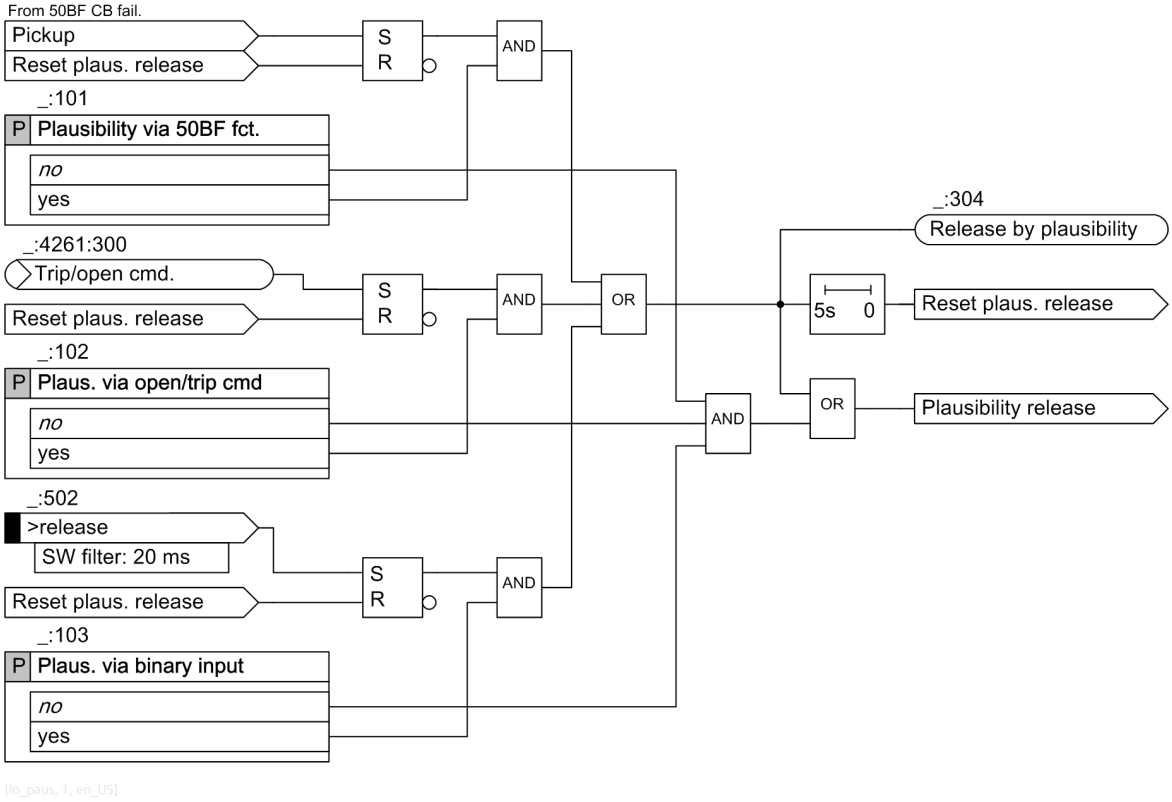
8.21.3 Function Description

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.



[lo_paus, 1, en_US]

Figure 8-94 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.

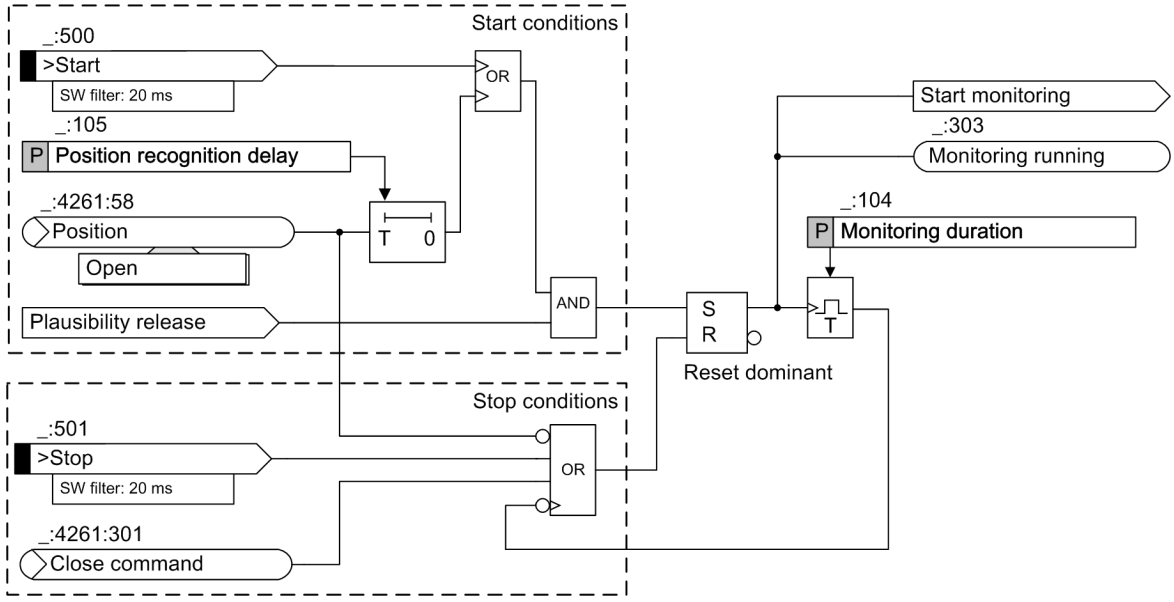
If one of the conditions is fulfilled, the plausibility release is given for 5 s. The 5-s timer ensures that the release criterion and start condition relate to the same circuit-breaker opening/tripping process.

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, 2, en_US]

Figure 8-95 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 861*) 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

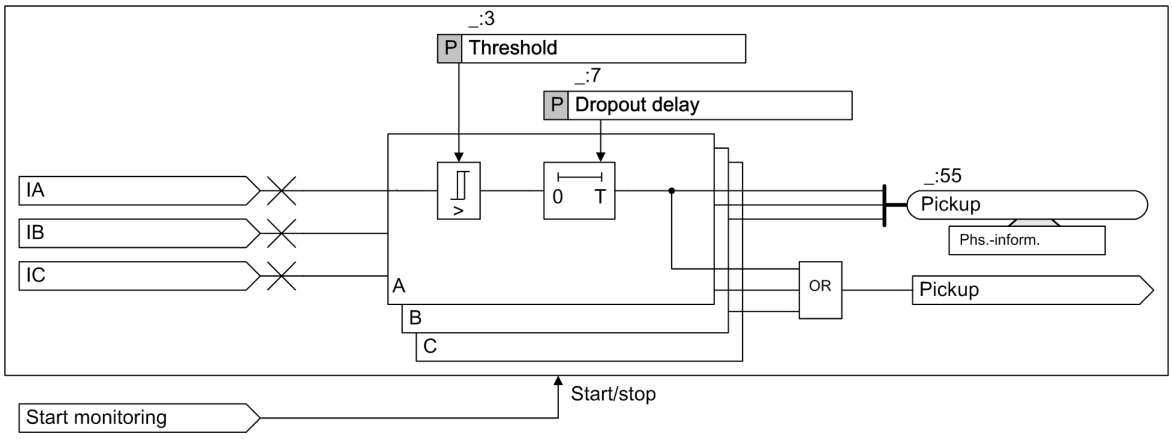
During the **`Monitoring duration`**, the current signal is monitored phase-selectively regarding restriking.

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 864*.



[lo_pickdrop, 1, en_US]

Figure 8-96 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

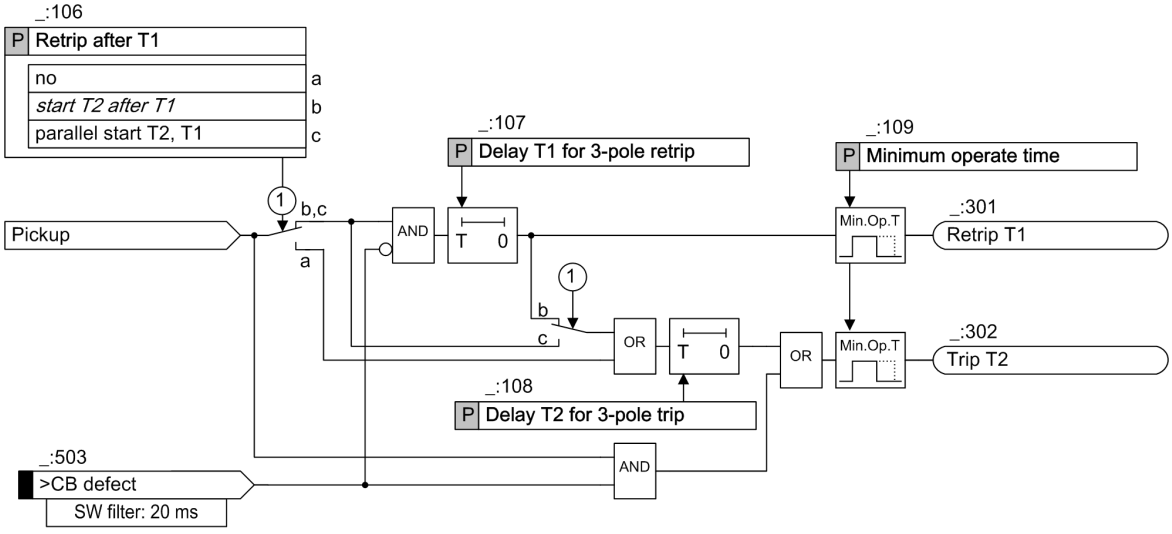
In the first step, tripping of the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. The retrip on the local circuit breaker is as a safety mechanism as well. In the event of a wrong start and pickup, only the local circuit breaker is opened instead 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_del_trip, 2, en_US]

Figure 8-97 Logic Diagram for Delay/Tripping of the Circuit-Breaker Restrike Protection

8.21.4 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 865*.
>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 865*.

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.

8.21.5 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

8.21.6 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

8.22 Instantaneous Tripping at Switch onto Fault

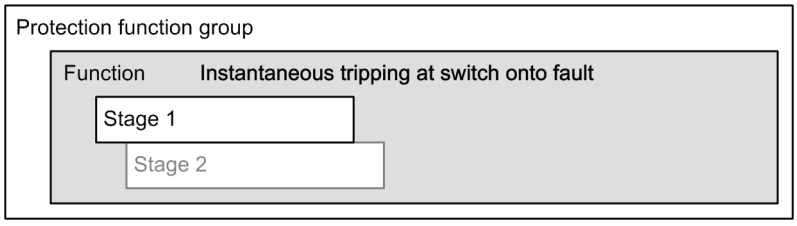
8.22.1 Overview of Functions

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).

8.22.2 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 1 stage. A maximum of 2 tripping stages can be operated simultaneously within the function. The tripping stages have an identical structure.

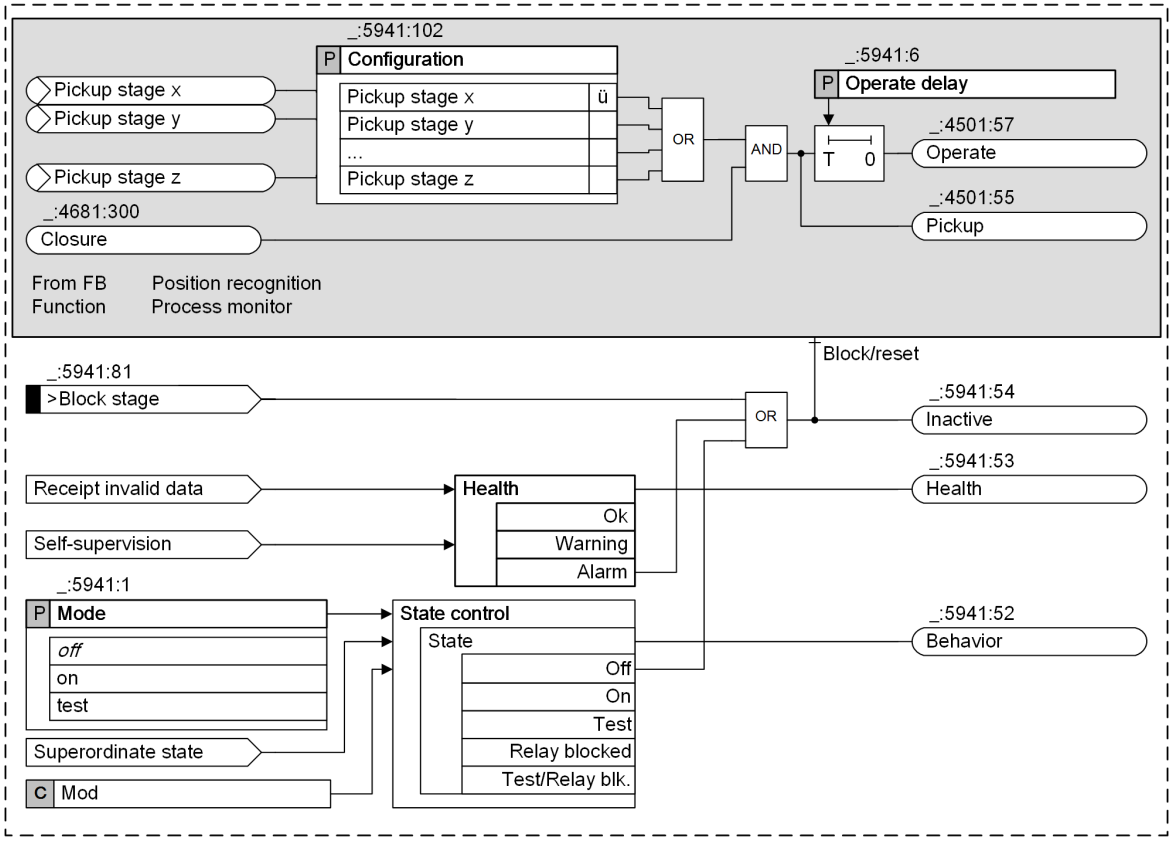


[dw_strsto, 1, en_US]

Figure 8-98 Structure/Embedding of the Function

8.22.3 Stage Description

Logic of the Stage



[lo_gisotf, 2, en_US]

Figure 8-99 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 (refer to *8.7 Overcurrent Protection, Phases*).

8.22.4 Application and Setting Notes

Parameter: Configuration

- Default setting **(_:5941:102) Configuration** = ***no stage***

The **Configuration** parameter is used to define the pickup of a protection function or protection stage that the **Instantaneous tripping at switch onto fault** function uses to respond.

Normally, the pickups of protection functions and stages with high fault current are selected:

- Distance protection
- Overcurrent protection (phase and ground)
- Directional overcurrent protection (phase and ground)
- Ground-fault protection for grounded systems

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.

8.22.5 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	

8.22.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
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

8.23 Phase-Sequence Switchover

8.23.1 Overview of Functions

The **Phase-sequence reversal** function enables correct execution of the protection of the device and supervision functions, independently of the phase sequence of the phases in a system or system section.

The phase sequence is set via parameters. You can select between the phase sequences ***ABC*** or ***ACB***.

Binary inputs also provide the option of switching over the phase sequence with respect to the parameter setting. For example, in pumped-storage hydropower plants with motor or motor/generator operation you temporarily change the direction of rotation by changing over the phase sequence.

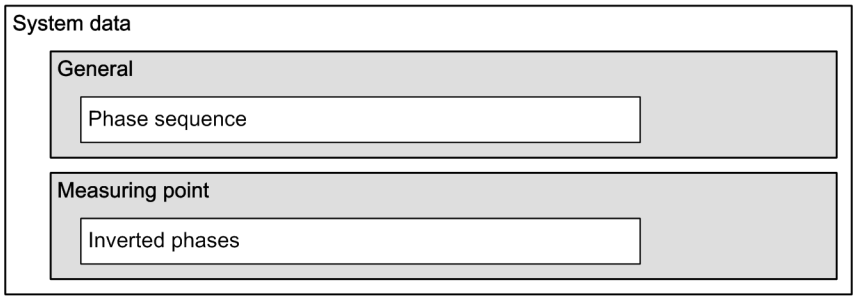
The phase sequence has an effect on calculation of the positive-sequence system and negative-sequence system values and on calculation of phase-to-phase values. A phase-rotation reversal therefore has an effect on all protection and supervision functions that use these values.

You can change the phase sequence in 2 ways via binary inputs.

- Change over the phase sequence for the entire device.
  In doing so, all 3-phase measuring points are switched over. All analog inputs are therefore affected (for example current and voltage inputs simultaneously).
- Change over the phase sequence per measuring point.
  In doing so, only the activated measuring points are switched over. The other measuring points remain unaffected.

8.23.2 Structure of the Function

The **Phase-sequence switchover** function is integrated in the **Power-system data**. You will find the signals in the DIGSI 5 project tree under **Name of the device** → **Settings**. There you will find the parameter for setting the phase sequence and the binary inputs via which you can influence a change in the phase sequence.



[dw_ph_rein, 1, en_US]

Figure 8-100 Structure/Embedding of the Function

8.23.3 Function Description

General

The phase sequence of the system is set in the device via the **Phase sequence** parameter. You will find the signals in the DIGSI 5 project tree under **Name of the device** → **Settings** → **Power-system data** → **General**. There are 3 methods to change the phase sequence for different operational requirements.

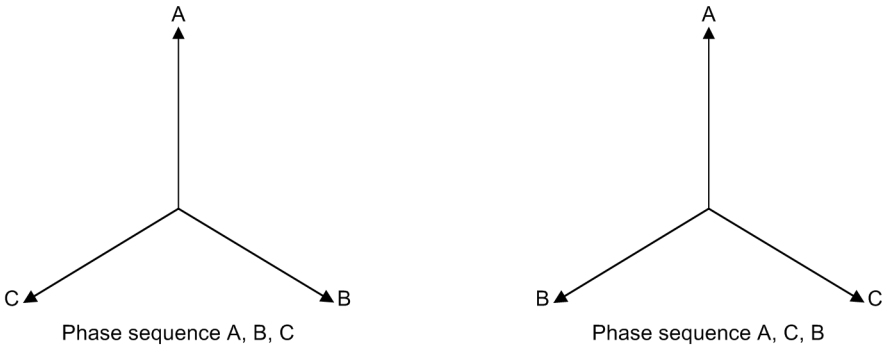
- Changing the phase sequence via the setting parameter.
  - **Note**: With version V7.50 and higher, this setting parameter is a reset parameter. If the parameter is changed and transmitted to the device, the device performs a startup. The parameter change affects all 3-phase measuring points. If the device is in operation and if measurands are present at the measuring points, perform a parameter change carefully since this affects all measuring points.

- With the binary signal *>Phs-rotation reversal*, you change over the phase sequence of all measuring points.
- With the binary signal *>Invert Phases*, you change over the phase sequence per measuring point.
  The **Inverted phases** parameter available for each measuring point is used to set which phases at the measuring point must be swapped. The parameter can be found at each 3-phase measuring point.

The 2 binary-signal mechanisms are explained separately below.

Switchover of the Phase Sequence of All Measuring Points

The direction of rotation of the currents and voltages depends on the phase sequence. The following drawing shows the vector definitions for the 2 phase sequences.



[dw_ph_rdrf, 1, en_US]

Figure 8-101 Vector with Different Phase Sequences

The phase sequence of a system or a system section is defined when parameterizing via the **Phase sequence** parameter. The setting parameter acts on all measuring points.

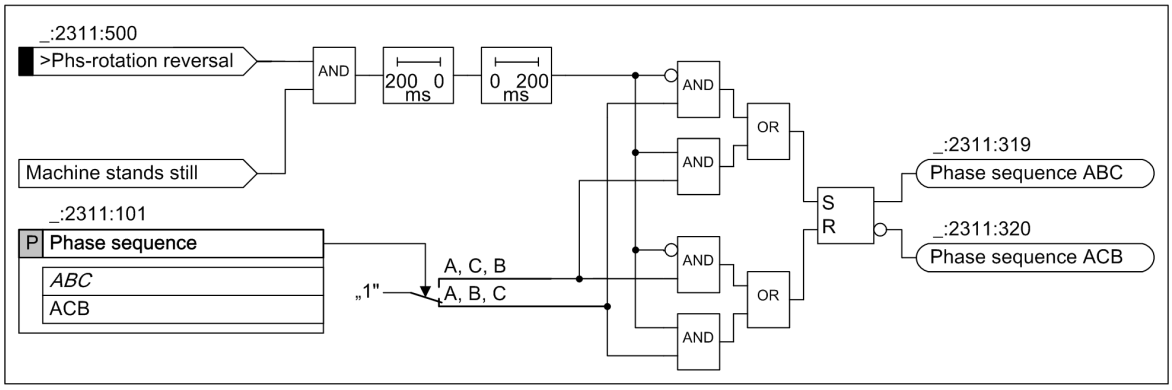
The operationally induced switchover between the phase sequence ***ABC*** and the phase sequence ***ACB*** is initiated via the binary input *>Phs-rotation reversal*. This switches over the phase sequence simultaneously at all 3-phase measuring points.

The following image shows a logic diagram for determining the current phase assignment and switchover. The indications shown on the right show the present phase sequence. If the phase sequence is set via the **Phase sequence** parameter to ***ABC***, activation of the binary input will result in a switchover to the phase sequence ***ACB***.

NOTE

The switchover of the phase sequence is only authorized for a time at which no measured values are pending. The switchover command must be present for at least 200 ms. The change of phase sequence is only permissible when the machine is at standstill. If the current and voltage values of all 3-phase measuring points are below 5 % of the rated variables, this is recognized as machine standstill.

A renewed machine standstill must be detected for a resetting of the phase sequence to the set preferred position.



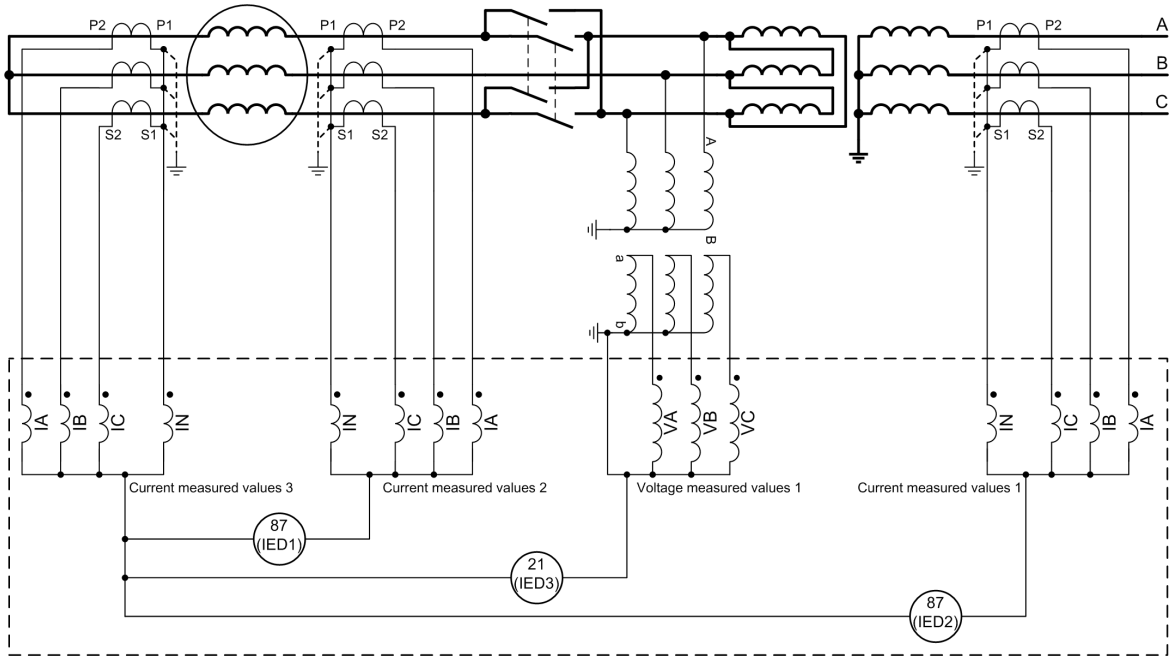
[dw_phrpsys1, 2, en_US]

Figure 8-102 Phase Sequence Switchover

Changing Over the Phase Sequence per Measuring Point

A switchover of the phase sequence per measuring point can also be necessary for operational reasons. This switchover enables proper behavior of the protection equipment, for example at the transition from generator operation to motor operation (pump operation).

The following example shows an application in a pumped storage plant. The switchover of the phase sequence (change in rotational direction) realizes the transition there from generator operation to motor operation. Which phases and measuring points are changed over depends on the conditions in the system.



[dw_phrapp, 2, en_US]

Figure 8-103 Application Example for Phase-Rotation Reversal in a Pump Station

The example shows 2 differential protection devices (IED1 and IED2) and an impedance protection (IED3) with the connected measuring points.

The phase sequence is insignificant for the differential protection of IED1, as the protected object is not affected by the switchover option of the phase sequence.

The phase sequence is also relevant to the differential protection of IED2, as the protected object extends beyond the switchover option.

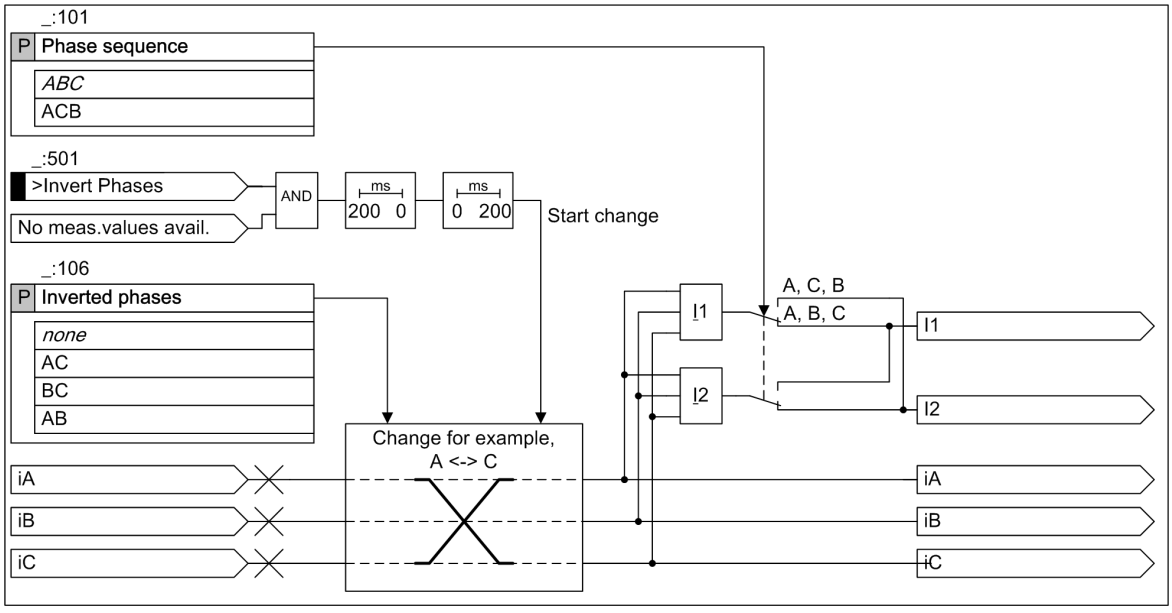
The phase sequence is also relevant to the impedance protection (IED3). Depending on the switch position, the voltage measured values 1 and the current measured values 3 have a different phase sequence.

The phase sequence of the system is set in the device via the **Phase sequence** parameter for generator operation. The **Inverted phases** parameter is used to set which phase is swapped for the relevant measuring point. The swap is communicated to the measuring point via the binary input signal *>Invert Phases*. The changed phase sequence is then included for calculation of the measurands at the measuring point.

In accordance with *Figure 8-103* the phase sequence is set to ***ABC***. A is swapped with C in motor operation. The **Inverted phases** parameter must be set to ***AC*** for the measuring points of current measured values 2 and current measured values 3. As a result, the phase assignment for the differential protection IED2 and the impedance protection IED3 is correct. The positive-sequence and negative-sequence current is calculated correctly.

The following logic diagram shows the principle for determining the present phase assignment and measured variables with the example of currents.

The switchover of the phase sequence is only authorized for a time at which no measured values are pending at the selected measuring points. The switchover command must be present for at least 200 ms. The change in the phase sequence is only implemented if the measurands at the measuring points that are to be switched are under 5 % of the rated variables. If the currents of the measuring points of current measured values 2 and current measured values 3 of the example fall below 5 % of their rated variables, the switchover is released and the set phases are switched with active binary input.



[lo_phrgph, 1, en_US]

Figure 8-104 Measured Values for Changed-Over Phases

8.23.4 Application and Setting Notes

Parameter: Phase sequence

- Default setting **(_:101) Phase sequence** = ***ABC***

ABC	Phase sequence A, B, C
ACB	Phase sequence A, B, C

Parameter: Inverted phases

- Default setting **(_:106) Inverted phases** = ***none***

none	No phase exchange
AC	Phase A changed over with phase C

BC	Phase B changed over with phase C
AB	Phase C changed over with phase B

NOTE

If you change the setting value of the parameter **Inverted phases**, consider the following:

The device can take the new setting value only if the binary input signal *>Invert Phases* is not active.

Input signal: *>Phs-rotation reversal*

The *>Phs-rotation reversal* binary input is used to switch between the ***ABC*** phase sequence and the ***ACB*** phase sequence. The switchover direction depends on the setting of the **Phase sequence** parameter. In doing so, the phase sequence of all 3-phase measuring points is changed. Changing of the phase-rotation reversal via the binary input is only possible if no measurands (< 5 % of the rated variables) are present at all 3-phase measuring points.

Input signal: *>Invert Phases*

The binary input *>Invert Phases* is used to activate the setting of the parameter **Inverted phases**. In doing so, the phase sequence of the selected measuring point is changed. Changing of the phase sequence via the binary input is only possible if no measurand (< 5 % of the rated variables) is present at the respective 3-phase measuring point.

8.23.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Phase sequence		• ABC • ACB	ABC
General				
_:101	VT 3-phase:Rated primary voltage		0.10 kV to 1200.00 kV	400.00 kV
_:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:104	VT 3-phase:VT connection		• 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:111	VT 3-phase:Tracking		• inactive • active	active
_:107	VT 3-phase:Measuring-point ID		0 to 100	0

8.23.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>Phs-rotation reversal	SPS	I
_:501	General:>Invert Phases	SPS	I
General			
_:319	General:Phase sequence ABC	SPS	O
_:320	General:Phase sequence ACB	SPS	O
_:321	General:Freq.out of oper.range	SPS	O
_:322	General:f sys	MV	O
_:323	General:f track	MV	O
General			
_:315	VT 3-phase:Phases AB inverted	SPS	O
_:316	VT 3-phase:Phases BC inverted	SPS	O
_:317	VT 3-phase:Phases AC inverted	SPS	O

8.24 Voltage Measuring-Point Selection

8.24.1 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.

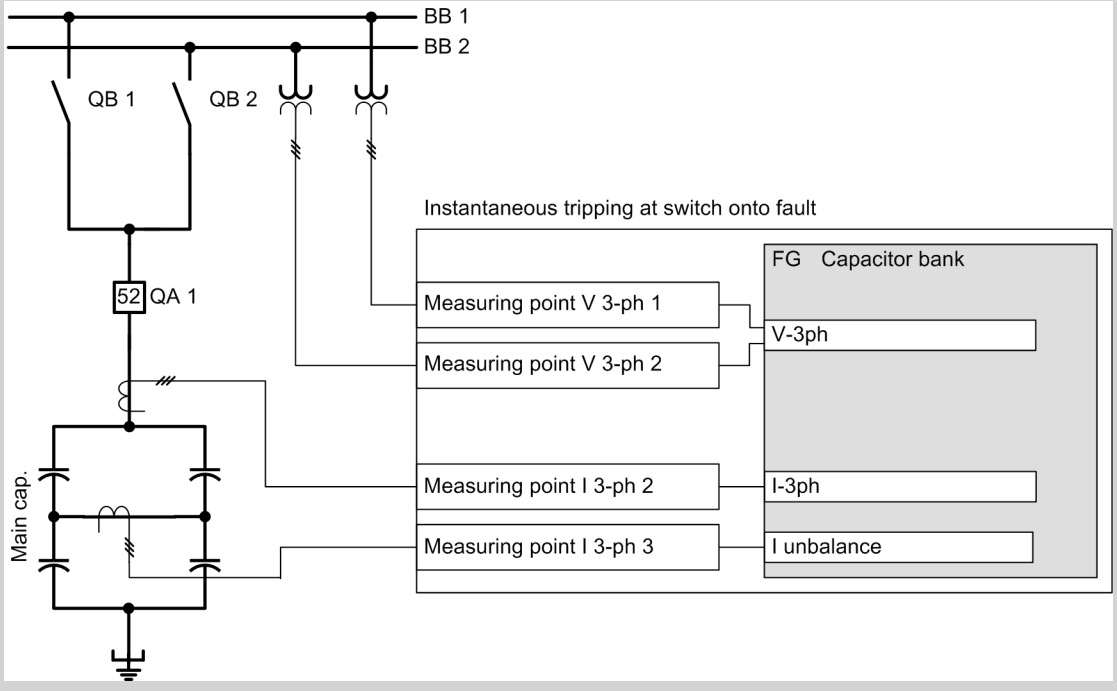
The **Voltage measuring-point selection** is a common functionality for the function groups of the protected objects.

8.24.2 Function Description

The **Voltage measuring-point selection** function block realizes the selection of 1-phase voltage measuring points or of 3-phase 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 8-105 shows an example of voltage measuring points selection for the function group **Capacitor bank** in a double busbar application.



[dw_busbar_double_2, en_US]

Figure 8-105 Double Busbar with Capacitor Bank

Connecting Measuring Points to Capacitor Bank Function Group

Figure 8-106 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.

Connect measuring points to function group

	Circuit breaker 1	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 I-1ph 1[ID 4]					X	

[sc_connection, 1, en_US]

Figure 8-106 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.

8.24.3 Application and Setting Notes

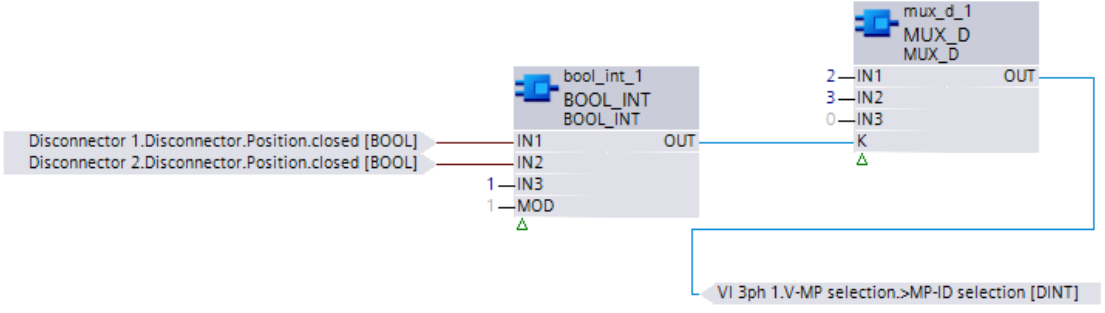
CFC Control

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 8-105*.

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.



[sc_lo-cfcVP, 1, en_US]

Figure 8-107 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.

8.24.4 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

8.25 Arc Protection

8.25.1 Overview of Function

The function **Arc protection**:

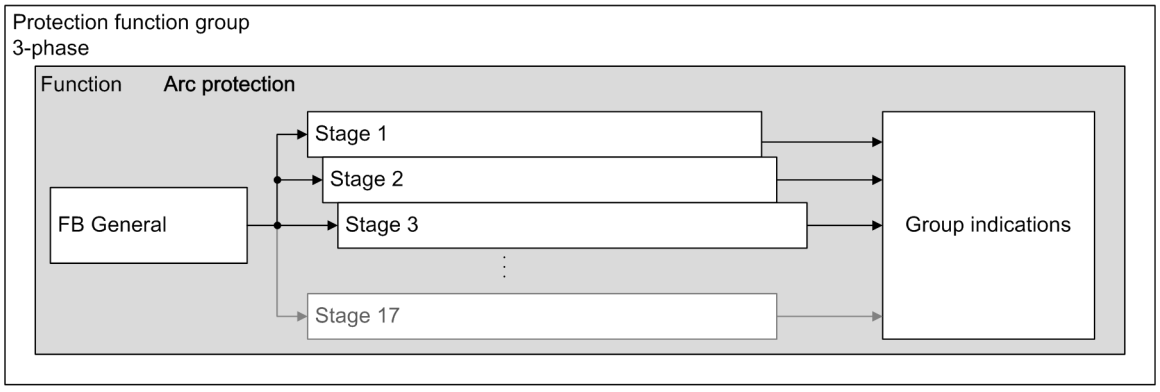
- Detects arcs in air-insulated switchgear parts without delay and in a fail-safe way
- Limits system damage through instantaneous high-speed tripping
- Protect systems from thermal overload
- Increases safety of personnel
- Trips in a 3-pole way
- Is suitable for use in all voltage levels

8.25.2 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.

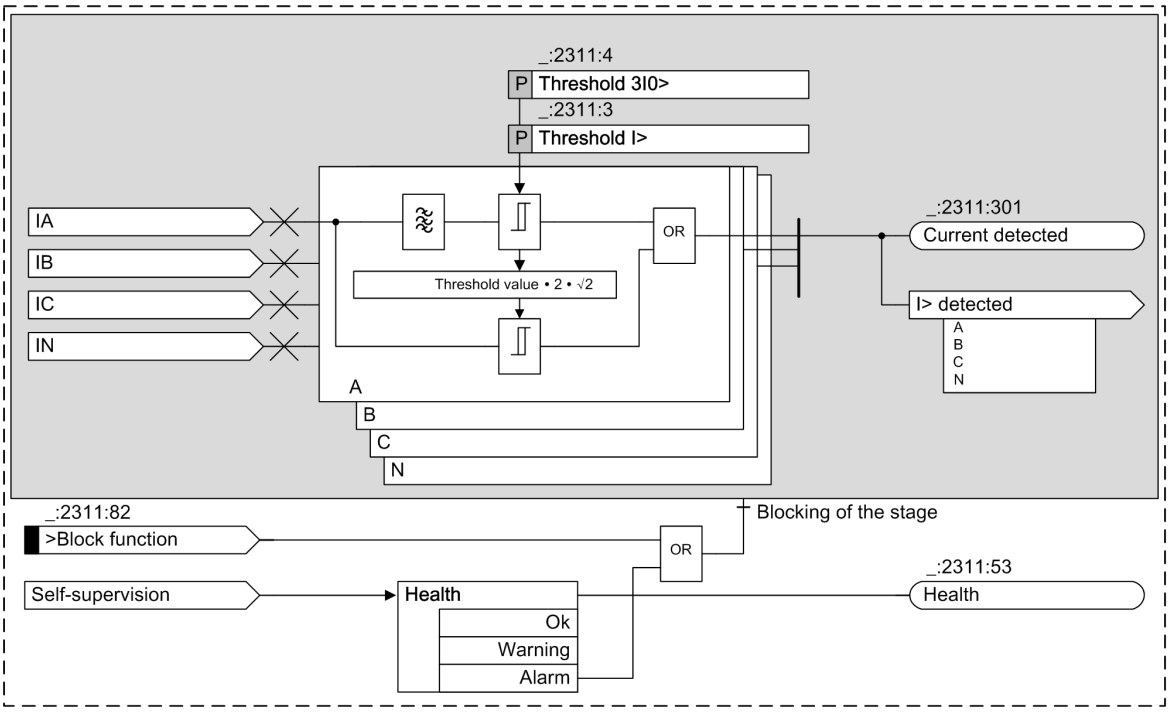


[dw_structure_arcprot, 2, en_US]

Figure 8-108 Structure/Embedding of the Arc Protection Function

8.25.3 Function Description

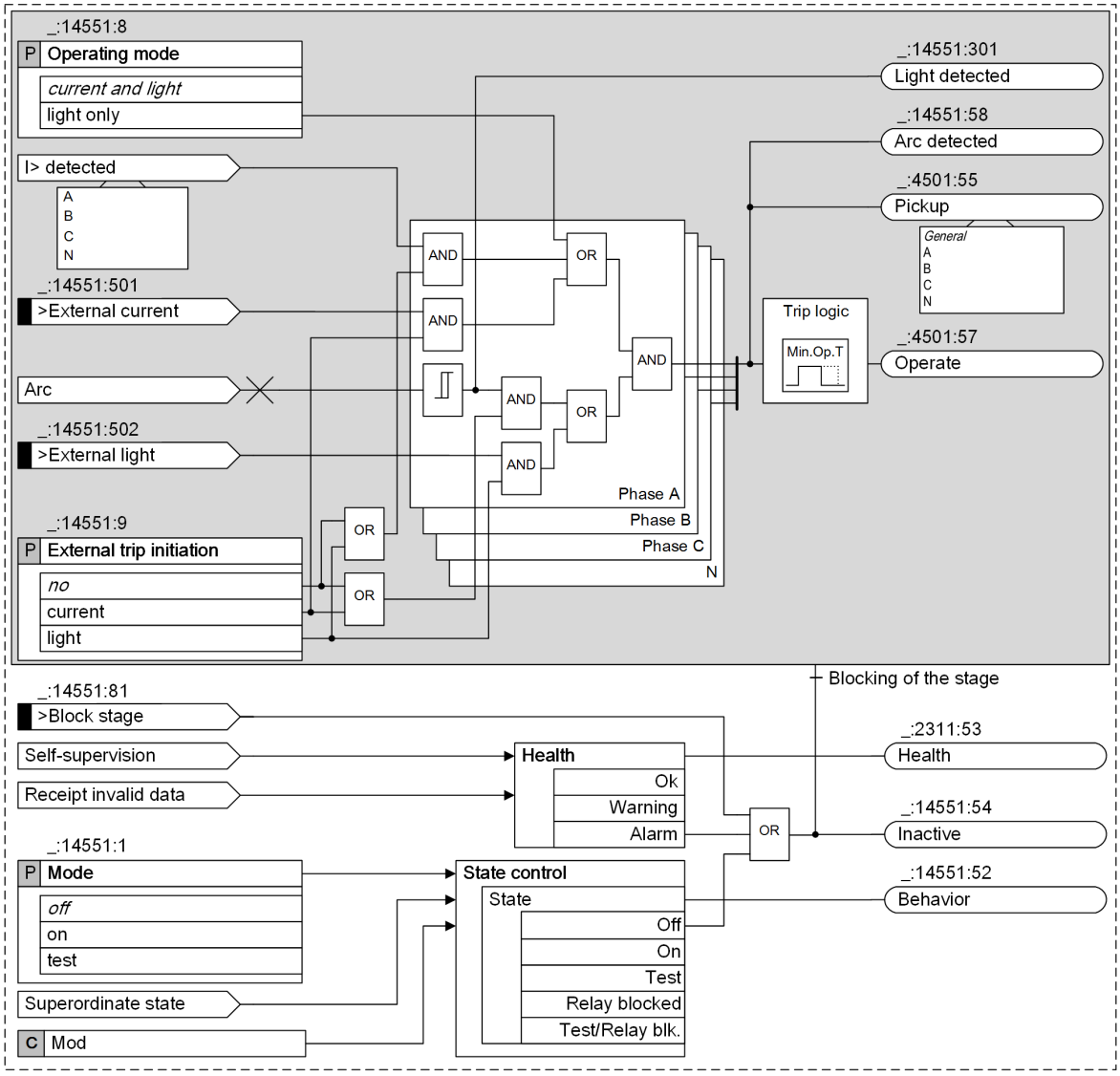
General Logic of the Function Block



[lo_fb0_arcprot, 3, en_US]

Figure 8-109 General Logic Diagram of the Function Block

Logic of the Stage



[lo_stage_arcprotection, 2, en_US]

Figure 8-110 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 value.
- Evaluation of the unfiltered measurand:
  If the current exceeds the threshold value set by the current ≥ 2 ·√2 · 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.

8.25.4 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: Sensor supervision

- Default setting **(_:2311:2) Sensor supervision** = ***yes***

With the parameter **Sensor supervision**, you set whether you want to monitor the arc sensors or not.

Parameter: Threshold I>

- Default setting **(_:2311:3) Threshold I>** = ***2.000 A***

With the parameter **Threshold I>**, you define the trigger threshold of the phase currents. The **Threshold I>** is relevant for the current-flow criterion of the function **Arc protection**.

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 *8.7.4.2 Application and Setting Notes*.

Parameter: Threshold 3I0>

- Default setting **(_:2311:4) Threshold 3I0>** = ***1.000 A***

With the parameter **Threshold 3I0>**, you determine the tripping threshold for the zero-sequence current. The **Threshold 3I0>** is relevant for the current-flow criterion of the function **Arc protection**.

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 *8.8.4.2 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.

If you set the parameter **CT connection** = ***3-phase + IN*** for the **3-phase current measuring point**, the function works with the measured current IN.

If you set the parameter **CT connection** = ***3-phase + IN-separate*** for the **3-phase current measuring point**, the function works with the calculated current 3I0.

8.25.5 Application and Setting Notes for the Stage

Parameter: External trip initiation

- Default setting **(_:14551:9) External trip initiation** = ***no***

With the **External trip initiation** parameter, you 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.
current	The stage operates with an external input signal. If the stage operates with an external input signal, the binary input signal *>External current* must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal *>External current* is only visible in the DIGSI 5 information routing
light	The stage operates with an external input signal. If the stage operates with an external input signal, the binary input signal *>External light* must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal *>External light* is only visible in the DIGSI 5 information routing **Note**: When working with the ***light*** external trip initiation, do not select a channel. If an additional channel is selected with this setting value, the DIGSI 5 will signal an inconsistency.

Parameter: Operating mode

- Default setting **(_:14551:8) Operating mode** = ***current and light***

With the **Operating mode** parameter, you 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 value.
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***

With the **Sensor** parameter, you 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***

With the **Threshold light** parameter, you set the light sensitivity. If you set **Threshold light** to a smaller value, the sensitivity increases. If you set **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***

With the **Channel**parameter, you 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.

8.25.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	on
_:2311:2	General:Sensor supervision		• no • yes	yes
_: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

Addr.	Parameter	C	Setting Options	Default Setting
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 • light • current	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	
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 • light • current	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 • light • current	no
_:14553:8	Stage 3:Operating mode		• light only • current and light	current and light

Addr.	Parameter	C	Setting Options	Default Setting
_: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	

8.25.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:51	General:Mode (controllable)	ENC	C
_:2311:53	General:Health	ENS	O
_:2311:301	General:Current detected	SPS	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 light	SPS	I
_:14551:501	Stage 1:>External current	SPS	I
_:14551:51	Stage 1:Mode (controllable)	ENC	C
_:14551:54	Stage 1:Inactive	SPS	O
_:14551:52	Stage 1:Behavior	ENS	O
_:14551:53	Stage 1:Health	ENS	O
_:14551:318	Stage 1:Fault arc counter	INC	C
_:14551:58	Stage 1:Arc detected	SPS	O
_:14551:301	Stage 1:Light detected	SPS	O
_: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 light	SPS	I
_:14552:501	Stage 2:>External current	SPS	I
_:14552:51	Stage 2:Mode (controllable)	ENC	C
_:14552:54	Stage 2:Inactive	SPS	O
_:14552:52	Stage 2:Behavior	ENS	O
_:14552:53	Stage 2:Health	ENS	O
_:14552:318	Stage 2:Fault arc counter	INC	C
_:14552:58	Stage 2:Arc detected	SPS	O
_:14552:301	Stage 2:Light 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

No.	Information	Data Class (Type)	Type
_:14553:82	Stage 3:>External light	SPS	I
_:14553:501	Stage 3:>External current	SPS	I
_:14553:51	Stage 3:Mode (controllable)	ENC	C
_:14553:54	Stage 3:Inactive	SPS	O
_:14553:52	Stage 3:Behavior	ENS	O
_:14553:53	Stage 3:Health	ENS	O
_:14553:318	Stage 3:Fault arc counter	INC	C
_:14553:58	Stage 3:Arc detected	SPS	O
_:14553:301	Stage 3:Light detected	SPS	O
_:14553:55	Stage 3:Pickup	ACD	O
_:14553:57	Stage 3:Operate	ACT	O

Information about the self-monitoring function of the arc protection module

No.	Information	Data Class (Type)	Type
channel #			
_:307	channel #:Sensor failure	SPS	O

8.25.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only

8.25.8.1 Description

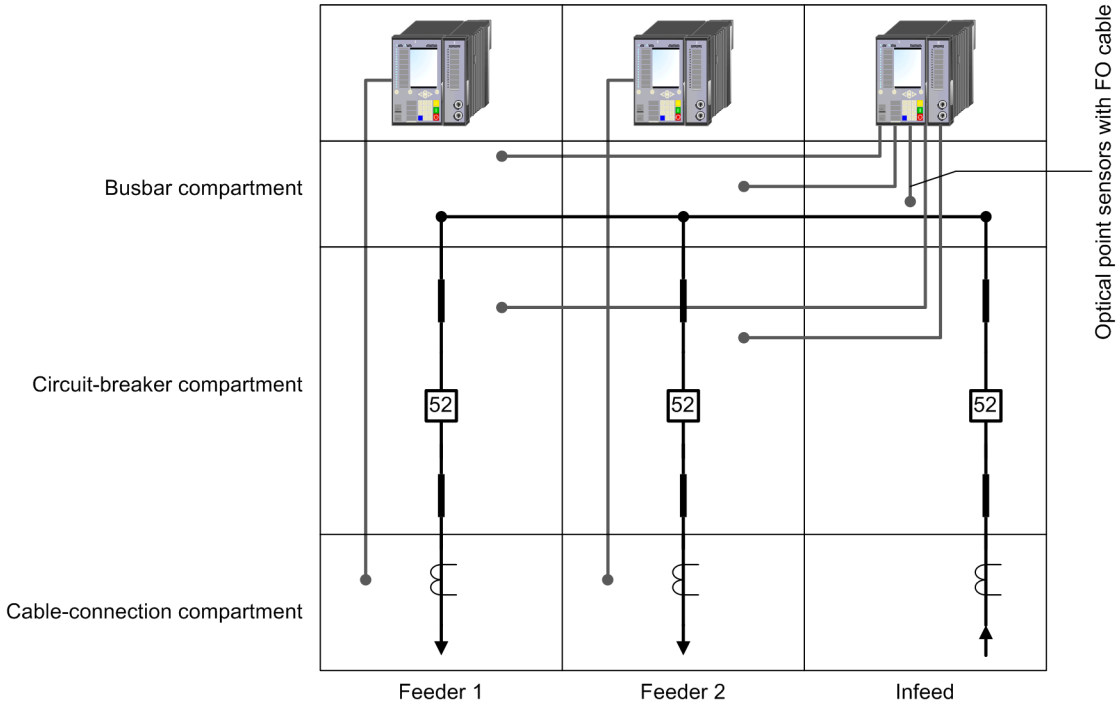
Overview

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 8-111 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.

8.25.8.2 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***.

8.25.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current

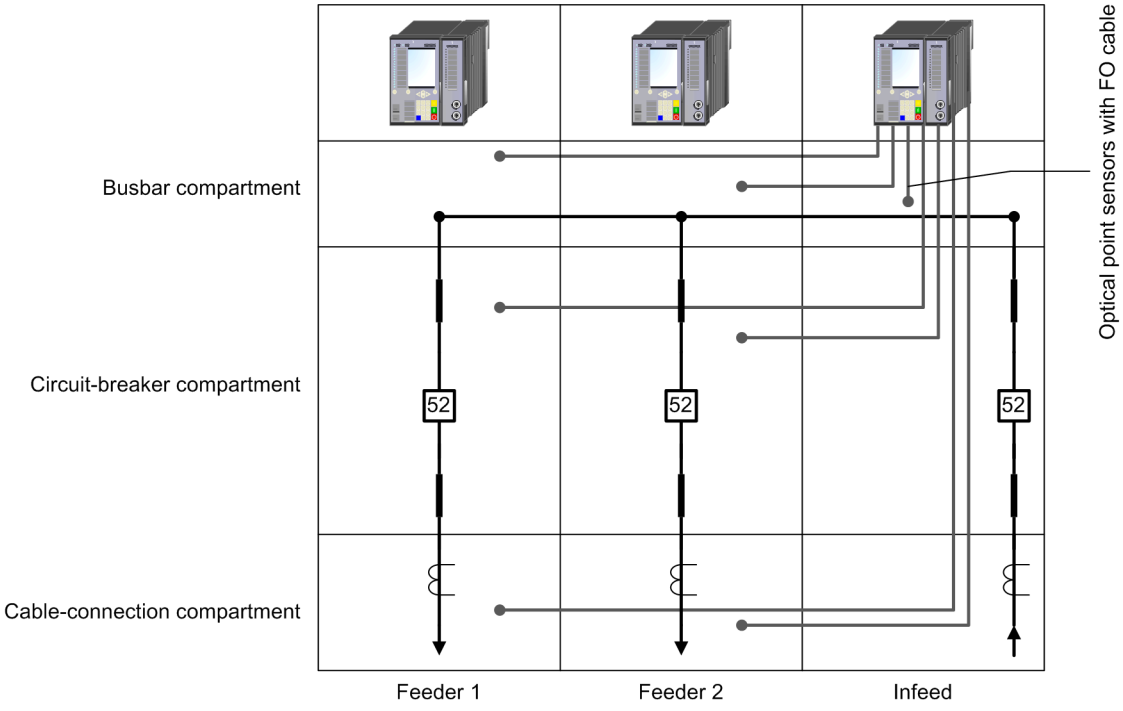
8.25.9.1 Description

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 8-112 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.

8.25.9.2 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 *8.25.4 Application and Setting Notes – General Settings*.

8.25.10 Application Example for Arc Protection with Point Sensors via External Trip Initiation

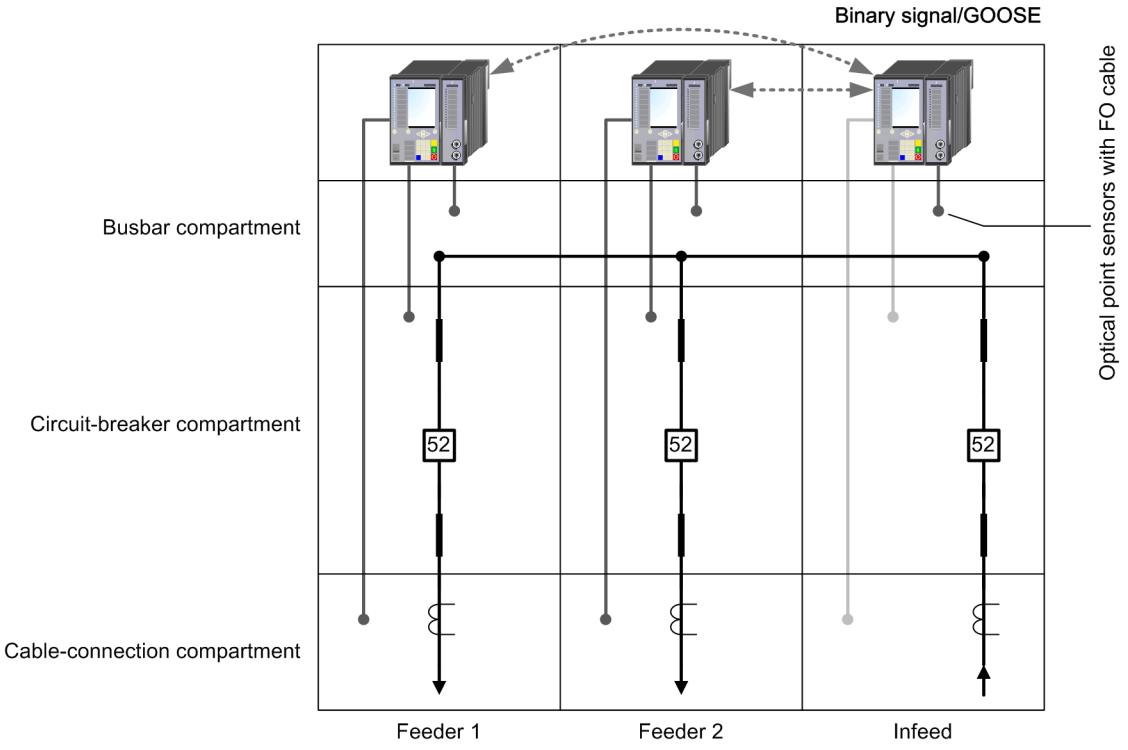
8.25.10.1 Description

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, 3, en_US]

Figure 8-113 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 or the circuit-breaker compartment of the feeders, the ***Light 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 switches off the malfunction.

  You can find detailed information in chapter *8.25.10.2 Application and Setting Notes*
- Arcs in the cable-connection compartment of the feeders can also be switched off selectively by the protection device of the affected feeder. To do this, the ***Current detected*** pickup indication from the infeed unit must be sent 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 number of GOOSE messages is not limited. Therefore, the number of feeders is not limited, and the protection of complex systems is feasible.

8.25.10.2 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 and the circuit-breaker compartment of the feeders must be switched off by the protection device in the infeed. To do this, the protection devices in the feeder device must send the indication *Light 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 **Threshold I>** and/or **Threshold 3I0>** threshold values, the protection device in the infeed switches off faults on the busbar and the circuit-breaker compartment of the feeders.

  Connect the signals over 4 stages, using the external trip initiation or a CFC chart.
- Arcs in the cable-connection compartment of the feeders are switched off locally. The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values **Threshold I>** and/or **Threshold 3I0>**, the *Current detected* indication is sent to the protection devices in the feeders. If, at the same time, an optical sensor in a cable-connection compartment detects light, the protection device trips in the corresponding feeder.

Setting Notes for the Protection Device in Feeder 1

The **Arc protection** function operates with **3** stages.

Stage 1 and 2 (supervision of busbar compartment and circuit-breaker compartment):

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***light only***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Operate & flt.rec. blocked** = ***yes***
- 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

Stage 3 (supervision of cable-connection compartment):

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***current and light***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***current***

  The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed returns the indication *Current detected* to the protection device in the feeder.

  Only if the indication in the feeder device *Current detected* is connected with the signal *>External current* an external trip initiation for this stage is effective.
- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 3***

Setting Notes for the Protection Device in Feeder 2

The **Arc protection** function operates with **3** stages.

Stage 1 and 2 (supervision of busbar compartment and circuit-breaker compartment):

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***light only***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Operate & flt.rec. blocked** = ***yes***
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (stage 1) → busbar-compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (stage 2) → circuit-breaker compartment supervision in feeder 2

Stage 3 (supervision of cable-connection compartment):

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***current and light***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***current***

  The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed returns the indication *Current detected* to the protection device in the feeder.

  Only if the indication in the feeder device *Current detected* is connected with the signal *>External current* an external trip initiation for this stage is effective.
- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 3***

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **7** 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>** and/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 8-113*), a pickup indication is generated immediately. The arc is switched off 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 8-113*), a pickup indication is generated immediately. The arc is switched off 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 7 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **External trip initiation** = ***light***
  If an arc is detected in the busbar compartment or the circuit-breaker compartment of the feeder, the feeder device sends the *Light detected* indication to the infeed device. Only if the indication in the infeed device *Light detected* is connected with the signal *>External light*, 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 switches off the arc.

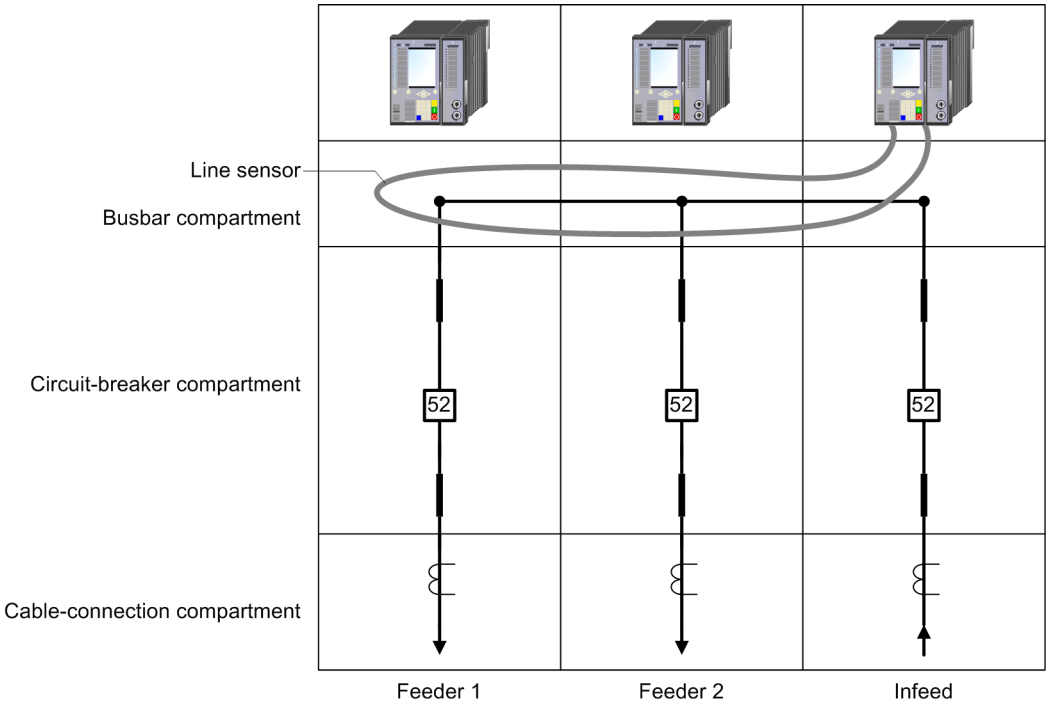
8.25.11 Application Example for Arc Protection with a Line Sensor in Operating Mode: Light and Current

8.25.11.1 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_line sensor, 1, en_US]

Figure 8-114 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 8-114* 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 *8.25.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only* and *8.25.9 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.

8.25.11.2 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 *8.25.4 Application and Setting Notes – General Settings*.

9 Measured Values, Energy Values, and Supervision of the Primary System

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9.2	Structure of the Function	905
9.3	Operational Measured Values	906
9.4	Fundamental and Symmetrical Components	907
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9.10	Statistical Values of the Primary System	945
9.11	Circuit-Breaker Monitoring	946
9.12	Disconnector-Switch Monitoring	988

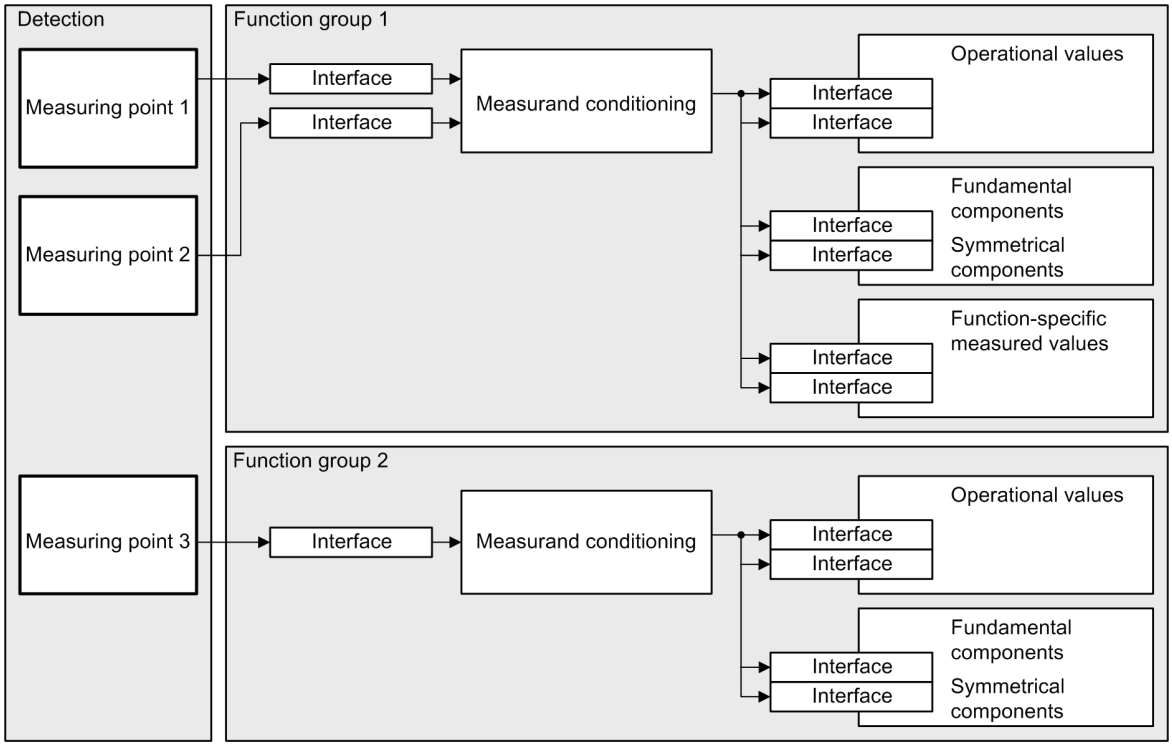
9.1 Overview of Functions

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.

You can find basic instructions for recording and editing process data in *2.1 Embedding of Functions in the Device*.



[dw_om_verf, 1, en_US]

Figure 9-1 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:

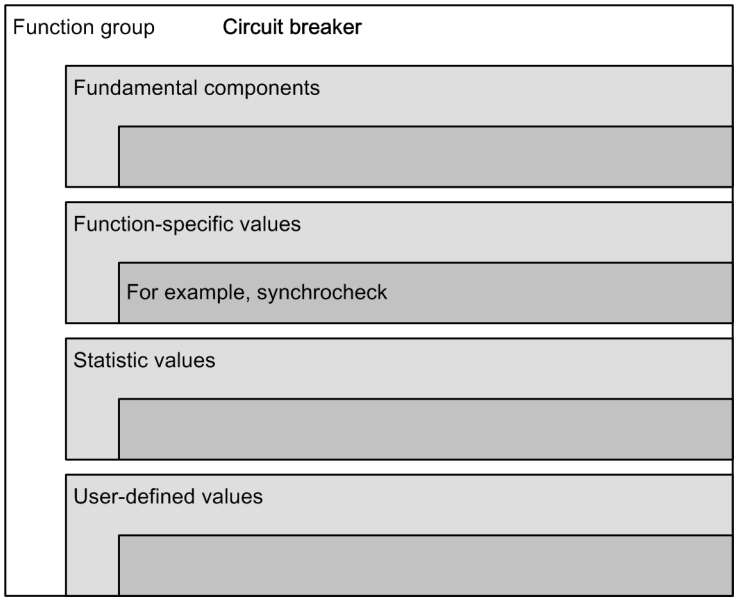
- Operational measured values
- Fundamental and symmetrical components
- Function-specific measured values
- Minimum values, maximum values, average values
- Energy metered values
- User-defined measured and metered values
- Statistical values

9.2 Structure of the Function

Depending on the interconnection of the function groups, these can contain different measured-value groups. 2 typical function groups are displayed below.

Circuit-Breaker Function Group

The **Circuit-breaker** function group may contain the following measured values:



[dw_om_vls1, 1, en_US]

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 used measuring points be correctly set (see also parameter **(_:8881:116) Neutr.point in dir.of ref.obj** 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 consumption (from the line to the busbar) is displayed positively. Then set the option ***reversed*** in the affected function groups at the parameter **P, Q sign**. With the setting ***not reversed*** (default setting), the positive direction for the powers etc. corresponds to the "forward" direction for the protection functions.

The affected values are given in detail in the chapters *9.3 Operational Measured Values* - *9.10 Statistical Values of the Primary System*.

9.3 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. They are updated every 180 ms.

The frequency is calculated using the filter algorithm, which is derived from the voltage or current. The voltage input has higher priority than the current input. If no voltage or current is present, the value contains the last valid frequency. **–** is displayed on the user interface.

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 (per phase)

$$P_{phsx} = \frac{1}{T}\int_{t}^{t+T} v_{phsx}(t) \cdot i_{phsx}(t)\,dt$$

With x = 1 to 3

$v_{phsx}(t)$ – Instantaneous value of the phase voltage, that is, v_A, v_B, v_C

$i_{phsx}(t)$ – Instantaneous value of the phase current, that is, i_A, i_B, i_C

Active power (total)

$$\mathrm{P_{total}} = \sum_{\mathrm{x=1}}^{3} \mathrm{P_{phsx}}$$

Apparent power (per phase)

$$S_{phsx} = V_{phsx} \cdot I_{phsx}$$

With V_{phsx} – RMS value of the phase-to-ground voltage (true RMS):

$$V_{phsx} = \frac{V}{\sqrt{3}}$$

With x = A to C

I_{phsx} – RMS value of the phase current (true RMS); with x = A to C

Apparent power (total)

$$S_{total} = \sum_{x=1}^{3} \mathrm{S}_{phsx}$$

Reactive power (per phase)

$$\mathrm{Q}_{phsx} = \sum_{\mathrm{n}} \mathrm{V_n} \cdot \mathrm{I_n} \cdot \sin(\varphi_\mathrm{n})$$

With:

n – Harmonic order (up to n = 50)

φ_n – Angle difference between voltage and current of the nth harmonic

Reactive power (total)

$$Q_{total} = \sum_{x=1}^{3} \mathrm{Q}_{phsx}$$

Power factor

$$\lambda = \frac{|\mathrm{P}|}{\mathrm{S}}$$

Active factor

$$\cos\varphi = \frac{\mathrm{P}}{\mathrm{S}}$$

9.4 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 9-1 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 9-2 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

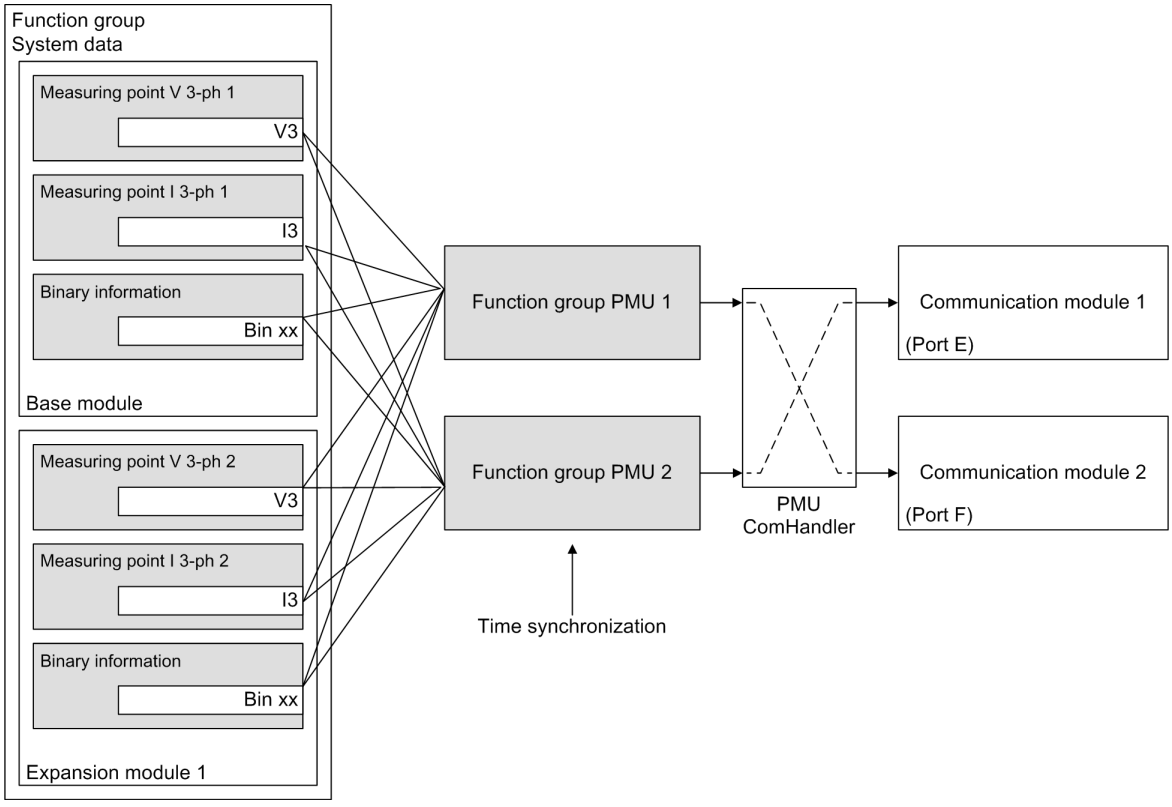
9.5 Phasor Measurement Unit (PMU)

9.5.1 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.

9.5.2 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).



[dw_strpmu, 2, en_US]

Figure 9-2 Structure/Embedding of the Function

9.5.3 Function Description

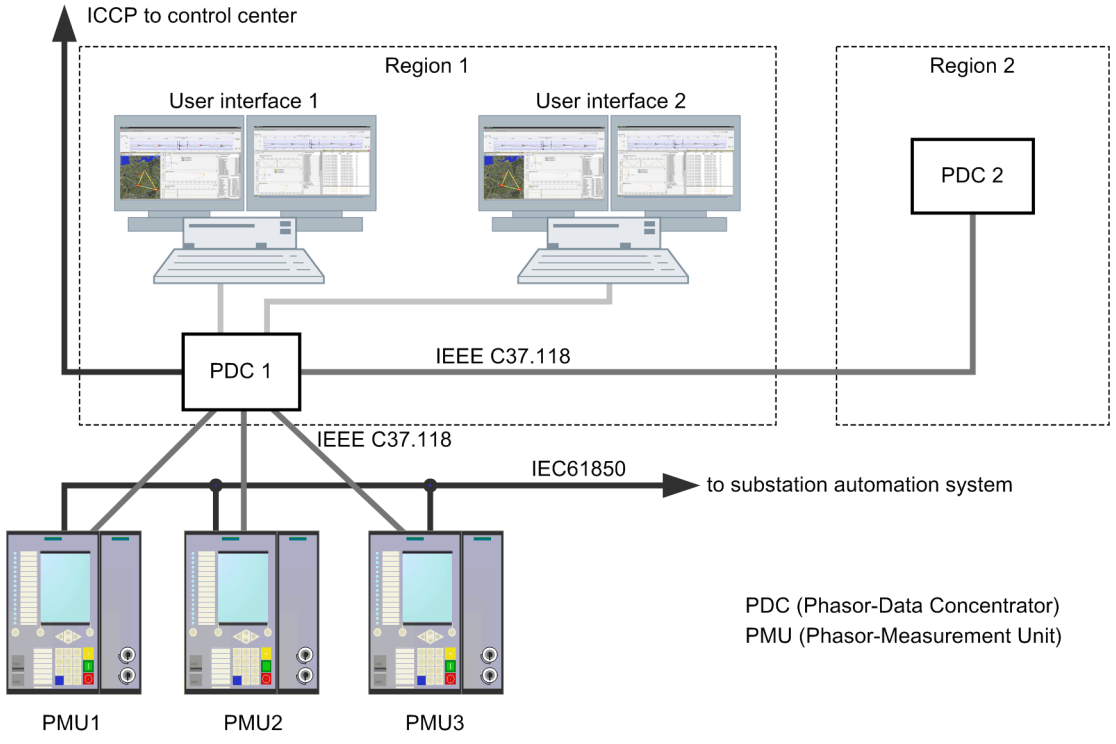
The synchrophasors, sent from the **PMU** in a continuous data stream to a PDC, are provided with time stamps and thus are comparable with the measured values of other PMUs. The power frequency, the power frequency change rate and optional binary information are also transmitted as time-stamped measured 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 9-3 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.



[dw_strwam, 1, en_US]

Figure 9-3 Structure of a Wide-Area Monitoring System with Phasor Measurement Units

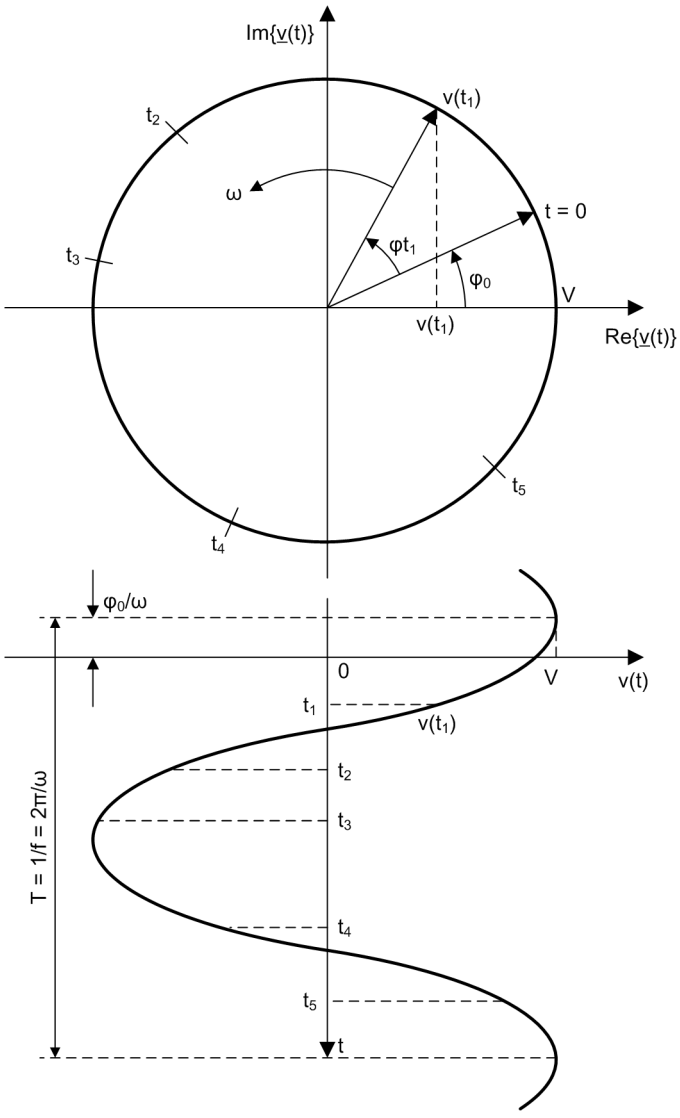
The phasor measurement units each have 2 communication interfaces: an Ethernet module for synchrophasor communication via IEEE C37.118 and another module for communication with the substation automation technology, for example, through the IEC 61850 protocol. If you use an ETH-BD-2FO communication module, you can activate IEEE C37.118 and IEC 61850-8-1 on the same module.

The central evaluation system, for example 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 center 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.

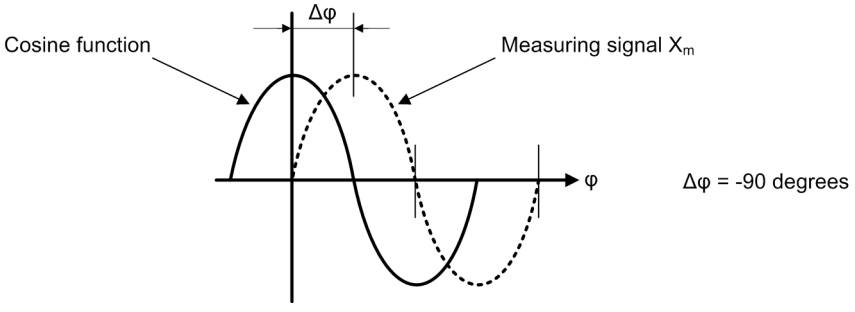


[dw_geopdc, 1, en_US]

Figure 9-4 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 9-5*).



[dw_utcphi, 1, en_US]

Figure 9-5 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 via GPS.

Reporting Rate

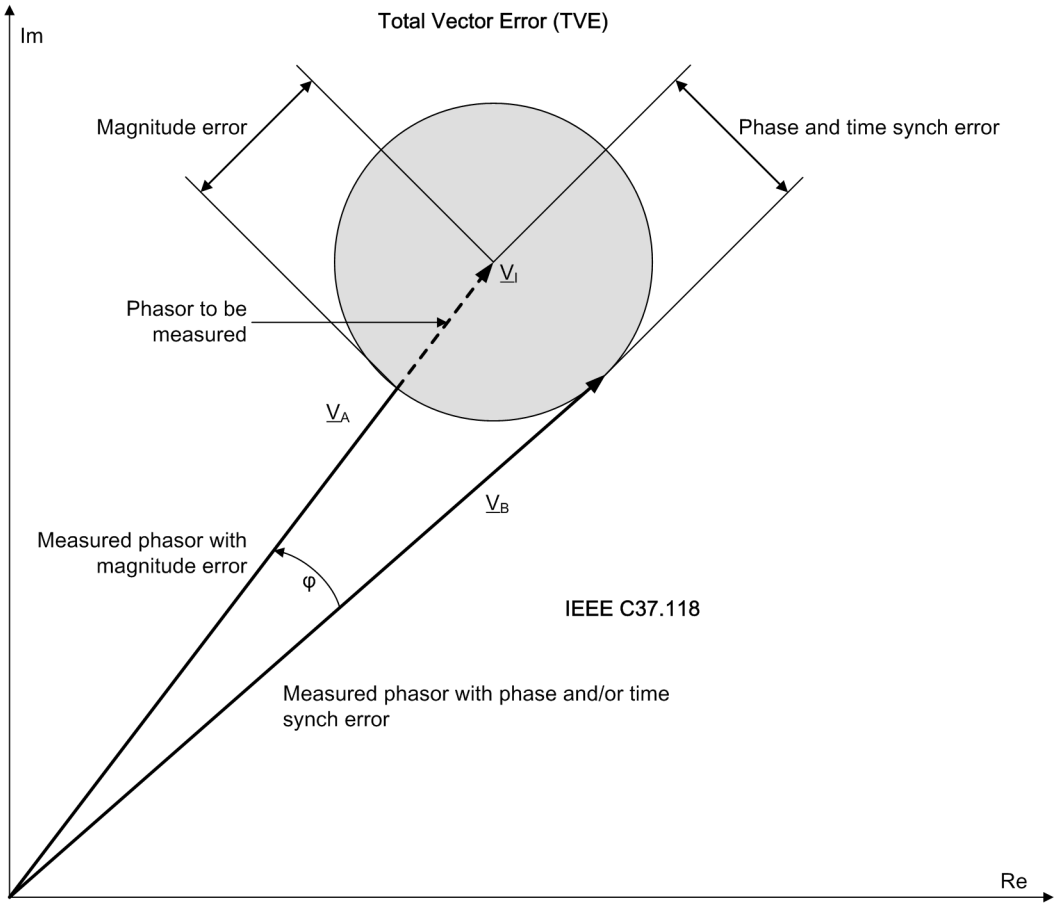
You use the configurable reporting rate (parameter **(_:10621:102) Reporting rate**) to specify the number of telegrams that are generated and sent to the PDC per second. It is adjustable, depending on the rated frequency, and applies to all currents and voltages of the relevant **PMU** function group. 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.



[dw_klatve, 1, en_US]

Figure 9-6 Representation of the Total Vector Error

The TVE is defined as follows:

$$TVE = \sqrt{\frac{\left(X_{r(n)} - X_r\right)^2 + \left(X_{i(n)} - X_i\right)^2}{X_r^2 + X_i^2}}$$

[fo_utcphi_new, 1, en_US]

Where:

- $X_{r(n)}$ = Real part of measured signal
- $X_{i(n)}$ = Imaginary part of measured signal
- X_r = Real part, input signal
- X_i = Imaginary part, 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 mounting arrangement of the GPS antenna.

9.5.4 Transmitted Data

The following data is transmitted from the PMU to the PDC:

- Current and voltage phasors
- Frequency
- Frequency rate of change
- Analog-channel data (active/reactive power)
- 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. You can instantiate the analog-channel data from the Global DIGSI 5 library in the **PMU** function group.

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
2nd 1-phase voltage measuring points
3rd 3-phase current measuring points
4th 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 or in addition to 3 individual sychrophasors. You can make the selection using the **(_:10621:103) Positive sequence** parameter, see *9.5.8 Application and Setting Notes*, *Parameter: Positive sequence, Page 930*.

9.5.5 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. If you use the method of spontaneous data transmission via UDP, data output starts immediately after the device boots without a close command to the PMU.

The values and names for the values are transmitted for the phasors, binary information, and analog channels. The names for the phasors and binary information are automatically generated by the respective PMU function groups. You must enter the analog-channel names yourself.

If necessary, you can edit the names for the phasors, binary information, and analog-channel data and assign your own designations for them. For more information, see chapter *9.5.6 Parameterizing the PMU with DIGSI*.

As an example, the names (generated) for measuring points or binary information may be as follows:

Table 9-4 Possible Measuring-Points 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 V-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 MP-V3ph VN ID01
Measuring point I-3ph 1[ID 2]	MP-I3ph IA ID02 MP-I3ph IB ID02 MP-I3ph IC ID02 MP-I3ph I1 ID02 MP-I3ph IN ID02
Measuring point I-1ph 1[ID 3]	MP-I1ph ID03
Measuring point V-1ph 1[ID 4]	MP-V1ph ID04

Table 9-5 Possible Binary-Information Names

Path Displayed in DIGSI 5 (Can Be Edited)	Name Transferred to the PDC
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 trip 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 by default:

- TCP: Port 4712
- UDP: Port 4713

You can configure the ports anyway you wish in a range of 1 to 65535 using the **`TCP port`** and **`UDP port`** parameters.



NOTE

When configuring the ports, do not set any ports already being used by other communication protocols. Configuring ports used elsewhere prevents communication with the PMU. In this case, data packets from the PDC cannot be received, and inquiries from the PMU cannot be transmitted.

If you are using the UDP protocol for communication between the PMU and the PDC, you can set either ***`command mode`*** or ***`asynchronous response mode`*** as the **`communication mode`**. In ***`asynchronous response mode`***, data can be transmitted continuously to preset PDC destination addresses in IEEE C37.118

format without a PDC having to request transmission of the synchrophasor data via a close command to the PMU.

Up to 4 different PDCs can be connected to one device PMU at the same time. The IP addresses of the maximum 4 PDCs are set in the **PMU** function group. If 4 device PMUs are configured, this enables support for up to 16 PDCs.

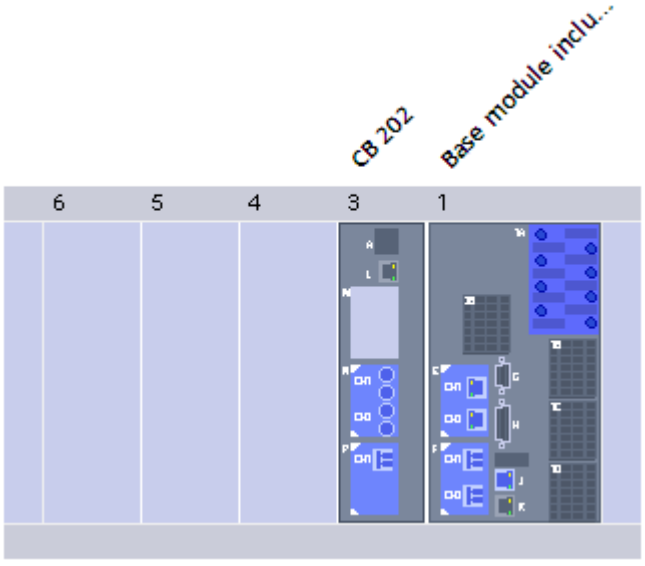
9.5.6 Parameterizing the PMU with DIGSI

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)
- ETH-BD-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 9-7*. You can view the selected port in the **`(_:10621:104) Port`**. This parameter is automatically managed by DIGSI and cannot be changed.



[sc_commod, 1, en_US]

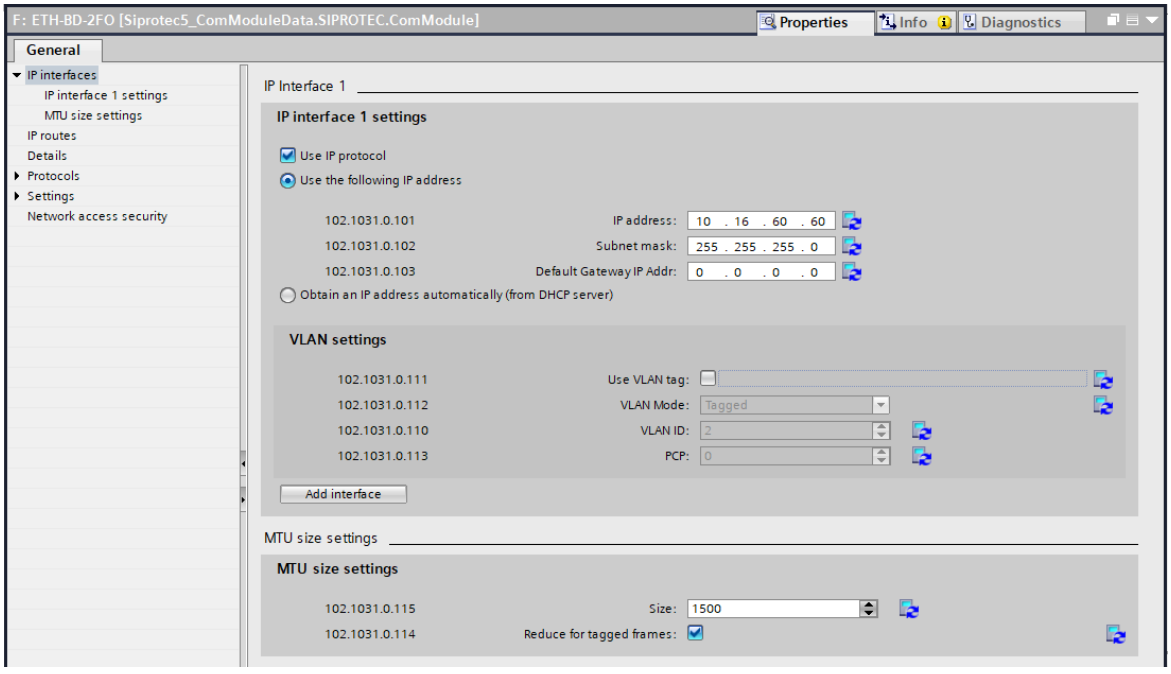
Figure 9-7 Placement of Communication Modules

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

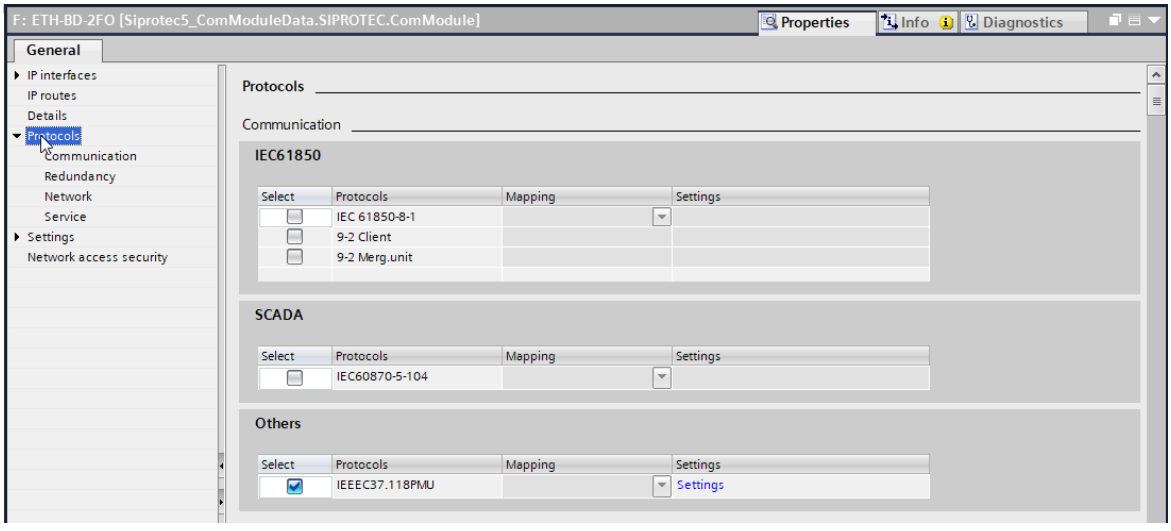
You must configure the respective Ethernet address (IP address, subnet mask, etc.) for each communication module in DIGSI. This is done in the DIGSI **General settings** properties dialog of the communication module in item **Ethernet addresses** and so forms the IP address for the respective PMU.



[sc_ethern, 2, en_US]

Figure 9-8 Ethernet-Address Configuration

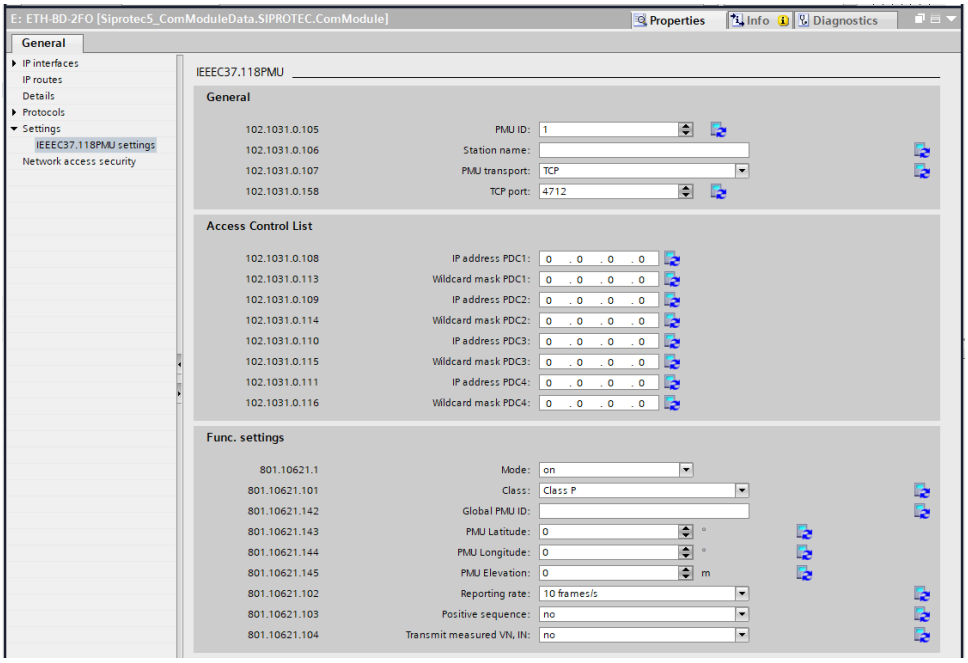
In the *Protocols – Communication* menu, select the synchrophasor protocol; see the following figure.



[sc_protoc, 2, en_US]

Figure 9-9 Protocol Selection

After you have selected the synchrophasor protocol for the communication module, a settings dialog for PMU-specific configuration opens in *Settings*; see the following figure.



[sc_wildcard, 3, en_US]

Figure 9-10 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 networks administered.

Configurable placeholders are allowed for every PDC/IP address with the ***TCP*** PMU transmission protocol in general and with ***UDP*** in the **Communication mode *Commanded operation***. 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 network 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 network, 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 the 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

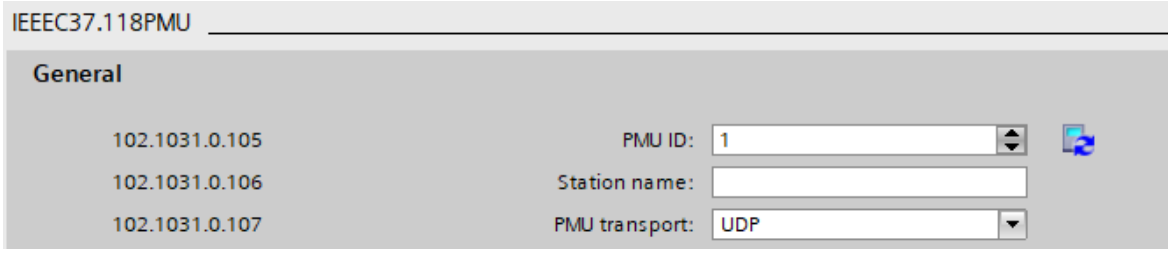
You must have configured at least one IP address to establish a connection between the device and the PDC.

If you set ***UDP*** as the transmission protocol, you can transmit PMU data to groups of PDCs using IP multicast.

Using multicast, considerably more PDCs can be reached via one communication module than when every PDC connects in unicast mode. Usually, the address range from 224.0.0.0 to 239.255.255.255 is used.

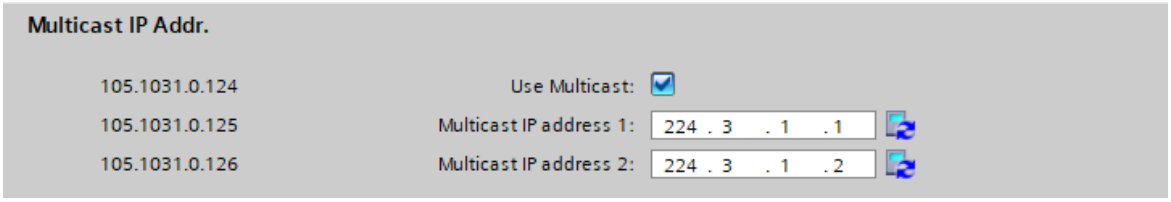
NOTE

The router used must support the **IGMP** (Internet Group Management Protocol) V3 protocol.



[sc_PMU_multicast01, 1, en_US]

Make a checkmark at the ***Use multicast*** parameter. If ***Use multicast*** is checked, you can set up to 2 multicast IP addresses. If you do not put the checkmark in place, the settings for the multicast IP addresses are not displayed.



[sc_PMU_multicast03, 1, en_US]

NOTE

DIGSI does not check the validity of the set multicast IP address. A multicast IP address of 0.0.0.0 is ignored.

You can set the settings for the multicast IP addresses and the PDC IP addresses in the Access Control List. If ***Use multicast*** is active, all data packages of the PMU are transmitted to the parameterized multicast IP addresses, but not to the PDC IP addresses. Commands from PDCs in the Access Control List are processed as if operating without multicast. Responses are only transmitted by way of the multicast IP addresses. In the ***Command mode*** UDP communication mode, you need at least one additional PDC IP address in the Access Control List to start PMU data transmission (see *Figure 9-11*).

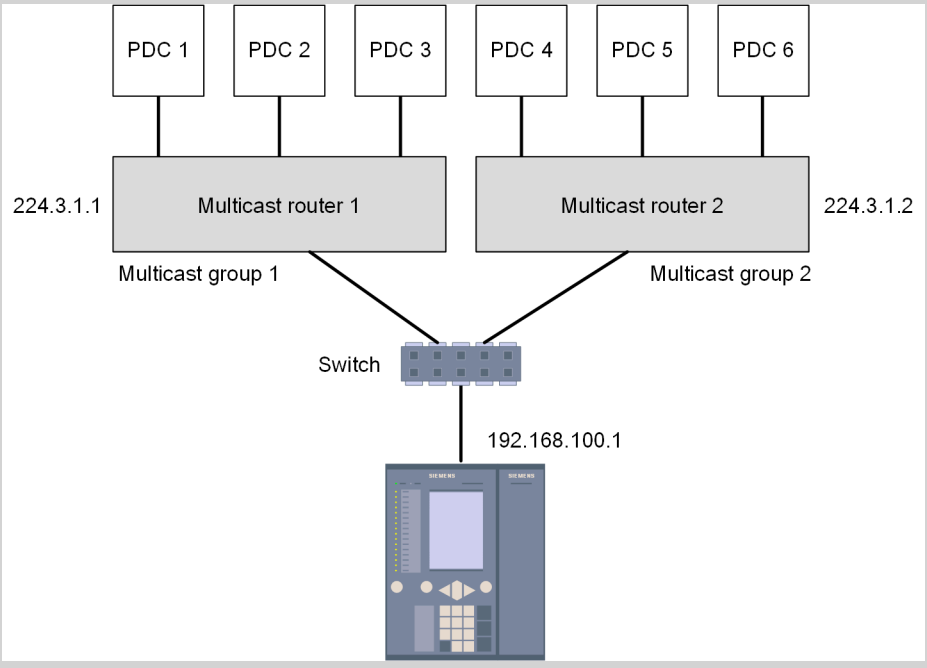


[sc_PMU_Multicast_Access, 1, en_US]

Figure 9-11 Access Control List

EXAMPLE

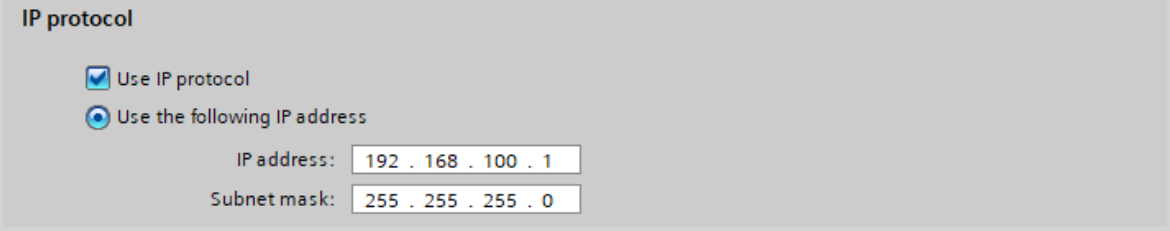
Multicast Operation



[dw_PMU_multicast_config_with_whitellist_PDC, 1, en_US]

Figure 9-12 PMU Multicast Configuration in Asynchronous Response Mode

Select the communication module in the **Hardware and protocols** menu in DIGSI. Set the IP address of the PMU (**192.168.100.1**) under **Properties** → **Ethernet addresses**.



[sc_IP_comm-mode_de, 1, en_US]

After you have selected the synchrophasor protocol for the communication module, a settings dialog for PMU-specific configuration opens in ***Settings***; see the following figure. Set the communication mode to ***Asynchronous response mode***.

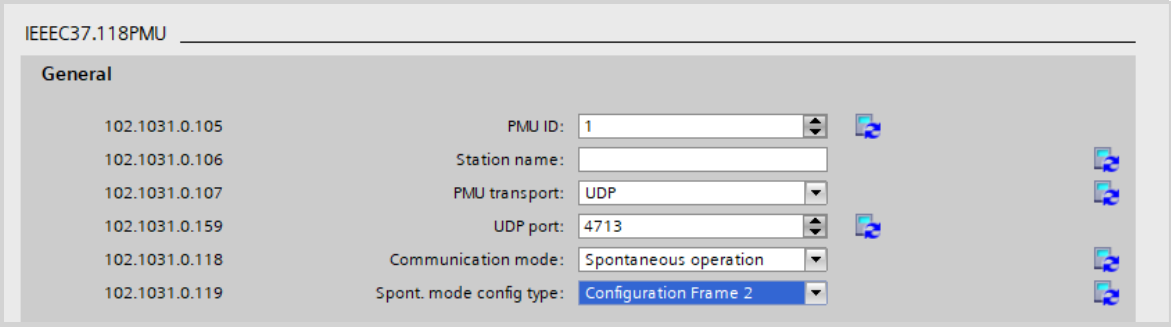


Figure 9-13 PMU Settings

In the following dialog, you set the IP addresses of the multicast routers:

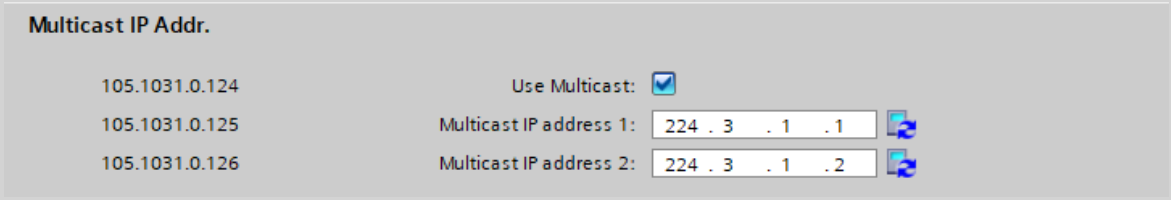


Figure 9-14 Additional Multicast IP Addresses During PMU Transport: UDP and Multicast

If you are using the **asynchronous data transmission method**, set the **`PMU transport`** parameter to ***`UDP`*** and the **`Communication mode`** parameter to ***`Spontaneous operation`***. The PMU data are then sent cyclically via UDP to every PDC/IP address permanently configured in DIGSI. You may not configure placeholders for PDC/IP address ranges in this communication mode.

Data output starts immediately after the device has booted. In this way, a starting signal from the PDC is not necessary to start data transmission.

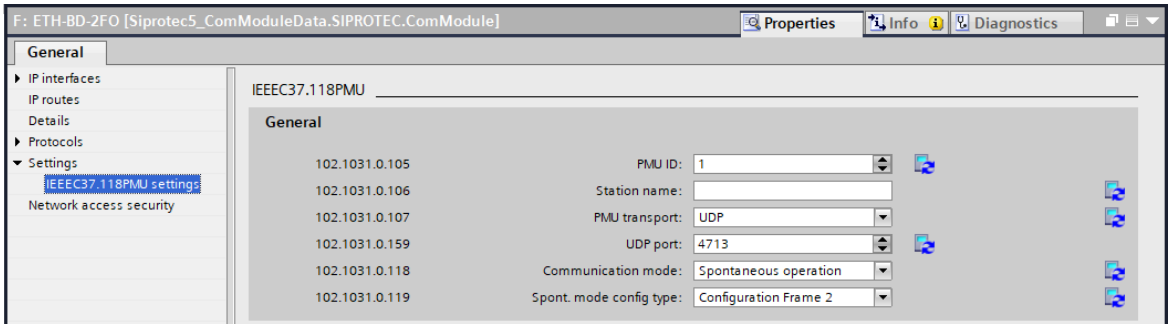


Figure 9-15 PMU Configuration for Spontaneous Transmission

The configuration dataset is transmitted 1x per minute. With the **`Spont. mode config type`** parameter, you select the type for the configuration data record. With the **`Reporting rate`** parameter, you configure the number of cyclic repetitions of the data packages. As UDP is a connectionless protocol, a preconfigured destination device with its PDC/IP address is not required to be physically present and/or connected. This allows uninterrupted provision of the data without bidirectional communication.

NOTE

If you have not configured valid PDC/IP addresses and still activate option for spontaneous data transmission, no cyclic data telegrams are sent.

NOTE

It is possible to configure IP addresses for various PDCs that are not present in the same subnetwork as the COM module. Such configurations are considered valid and can be loaded into the device. However, if the device transmits spontaneous data and configuration packages to these IP addresses, the PDC cannot be reached with the deviating subnetwork destination addresses.

NOTE

Commands or requests from an invalid PMU IP address are ignored.

EXAMPLE

COM-Module Address Configuration

- IP address: **192**.168.100.1
- Subnet mask: **255**.255.255.0

PDC Address Configuration

- IP address for PDC1: **192**.168.100.160
- IP address for PDC2: **86**.168.100.161

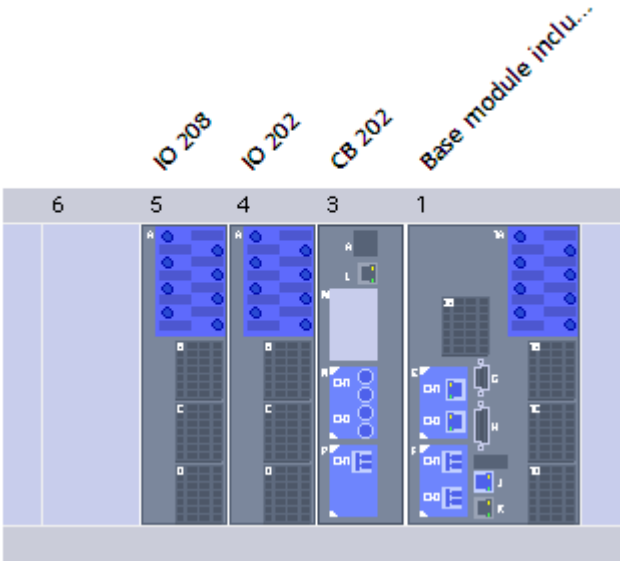
Only PDC1 receives the data because the IP address is in the same subnetwork as the COM module.

PDC2 cannot be reached because the subnetwork address (**86**.x) differs from the subnetwork address of the COM module (**192**.x). The PMU cannot transmit data to this address.

In addition to the PDCs IP addresses, the port can also be configured, which ensures the communication between the PMU and PDC. You can find the TCP or UDP port parameter in place for this purpose, depending on the configured transmission protocol. With the parameters, you can configure the port in a range of 1 to 65 535. The setting for these parameters is stored, even when the parameter is not visible due to the configuration of the transmission protocol. If, for example, TCP has been configured as a transmission protocol, the TCP port is not visible, but the setting has been stored in the background in DIGSI and is still available for use later on.

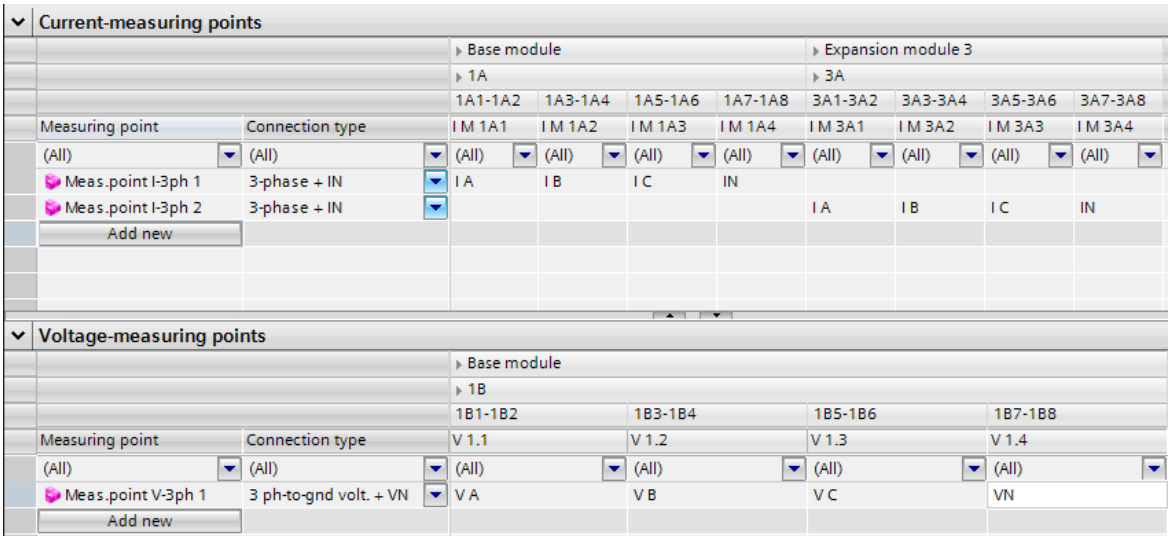
Measuring-Point Assignment

After adding measuring points to the device, you can assign these measuring points to each configured PMU. *Figure 9-16* shows an example of how the device configuration can be supplemented with 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 9-17*.



[sc_addios, 1, en_US]

Figure 9-16 Adding Additional Input/Output Modules



[sc_routin, 1, en_US]

Figure 9-17 Assignment of the Current and Voltage Inputs of the Added Input/Output Modules on Measuring Points

NOTE

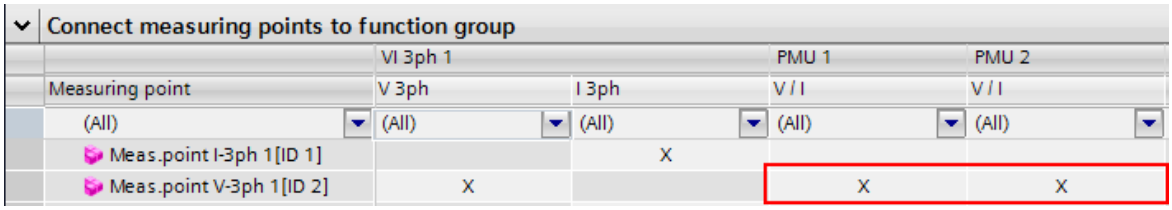
Consider that the maximum amount of measuring points that can be routed is limited by the device.

The maximum numbers of measuring points that can be routed for one PMU are:

- 20 x 3-phase voltage measuring points
- 20 x 3-phase current measuring points
- 40 x 1-phase voltage measuring points
- 40 x 1-phase current measuring points

You can assign all supported measuring points to any PMU, see the following figure. Each PMU must be connected to at least one measuring point, and the total number of phasors (a 3-phase measuring point = 4

phasors) must not exceed 80 per PMU. The limitation of the load model must also be considered, depending on the device configuration.



[sc_fgconn, 1, en_US]

Figure 9-18 Connecting Measuring Points to the Configured PMU Function Groups

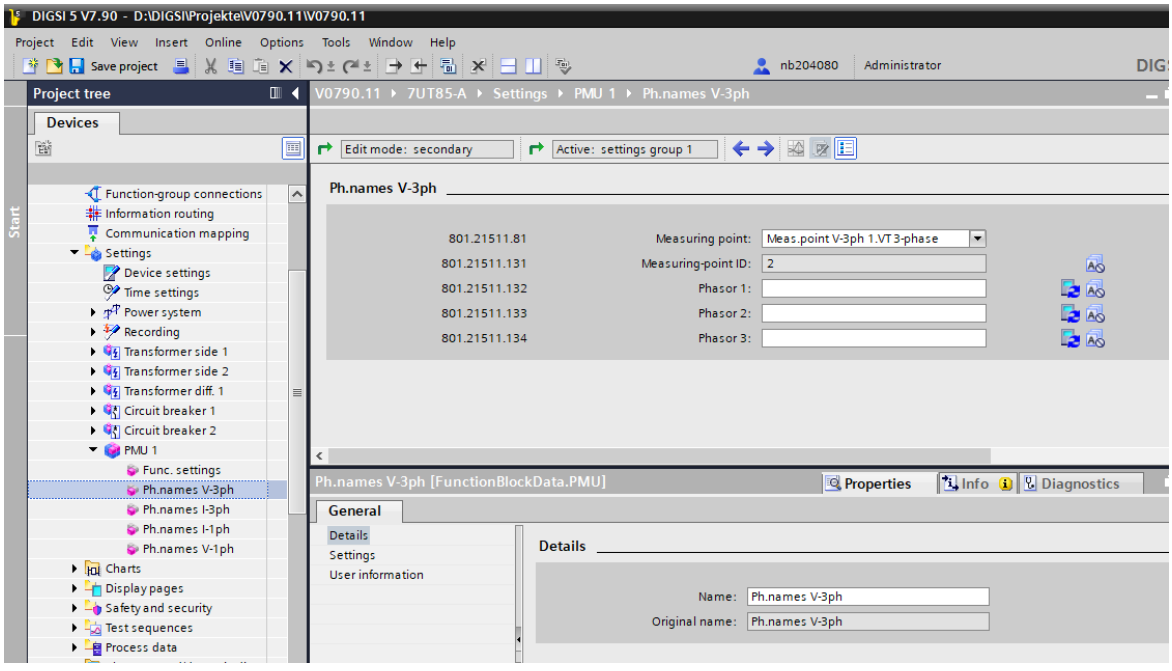
When these setting steps have been completed, the PMUs are fully configured. The **PMU** is a function group that functions independently of all the other function groups instantiated in the device.

Changing the Channel Names of Phasors

You can edit the names of the individual phasor channels for voltages and currents in DIGSI. Clearly structured channel designations support the testing and commissioning of 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. Due to the protocol, the designation length is limited to 255 ASCII characters per channel for CFG3, and to 16 ASCII characters per channel for CFG2.

In order to define your own channel names, firstly instantiate the required number of **Phasor names** function blocks in the **PMU** function group. Assignment to the corresponding measuring points is performed by the *Measuring point* selection. For this purpose, DIGSI shows all measuring points routed to the PMU in the function group connections (see following figure).



[sc_phasor_edit, 1, en_US]

Figure 9-19 Options for Editing the Names of the Individual Phasors

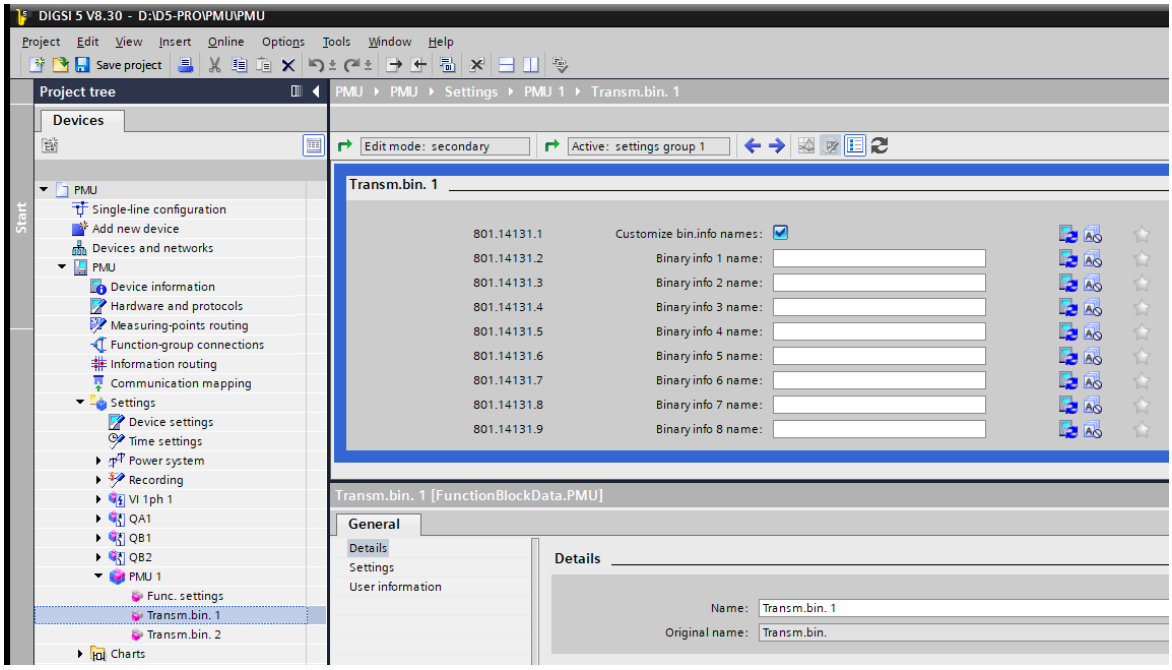
NOTE

You can only rename each individual phasor when you set the parameter **`Positive sequence`** to ***`no`*** or ***`additionally`*** in the function settings. Otherwise you will only be offered one single phasor for each 3-phase measuring point for renaming.

Changing the Channel Names of Binary Channels

You can edit the names of the binary channels in DIGSI. Clearly structured channel designations support the testing and commissioning of PMU systems. You can edit the names of the binary channels visible in the IEEE C37.118 interface in DIGSI. To do this, tick the **`My binary info names`** check box in the **Binary info transmission** function block (see *Figure 9-20*).

The IEEE C37.118 defines the ASCII character set for changing the channel names. Due to the protocol, the designation length is limited to 255 ASCII characters per channel for CFG3, and to 16 ASCII characters per channel for CFG2.

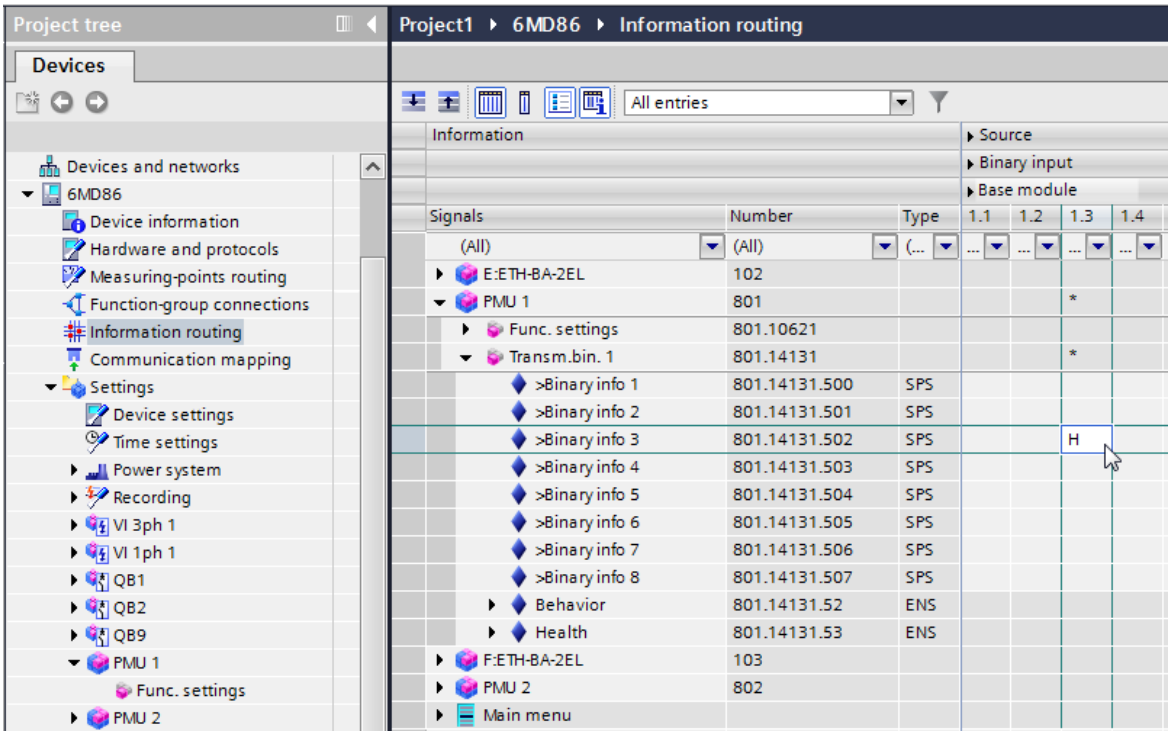


[sc_PMU_bin_info_edit, 1, en_US]

Figure 9-20 Options for Editing the Names of the Individual Binary Channels

Routing Binary Signals

You can connect binary inputs via DIGSI information routing to binary channels of the PMU. As an alternative, you can also route the binary inputs via a function chart (CFC). 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.



[sc_pmu_bif, 1, en_US]

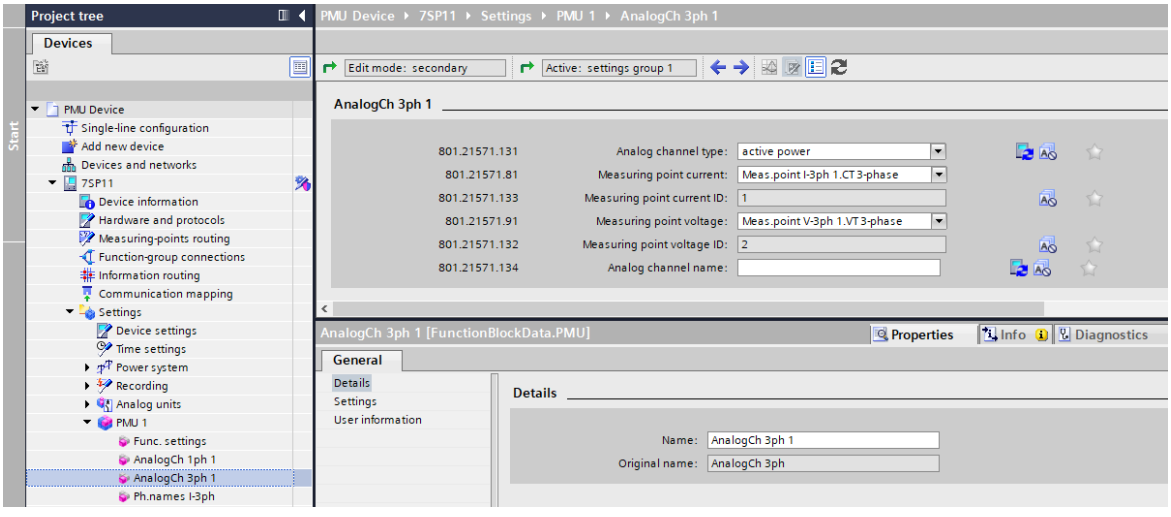
Figure 9-21 Information Routing in DIGSI 5

Routing Analog-Channel Data

In a **PMU** function group, you can instantiate the analog-channel data using the FBs **AnalogCh 1ph** or **AnalogCh 3ph**. In this case, a maximum of 30 instances per function-block type can be used.

With the parameters of the FBs **AnalogCh 1ph** or **AnalogCh 3ph**, you can assign the measuring points. You can only use the measuring points that have previously been assigned to the **PMU** function group.

You can also adjust whether the active or reactive power must be transmitted and assign a name to the analog channel. Due to the protocol, the designation length is limited to 255 ASCII characters for CFG3 and to 16 ASCII characters for CFG2.



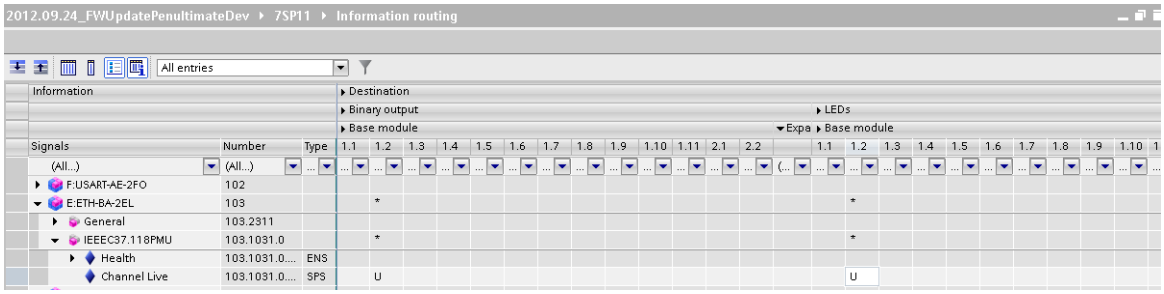
[sc_analog_channel, 1, en_US]

Figure 9-22 Routing Analog-Channel Data

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.

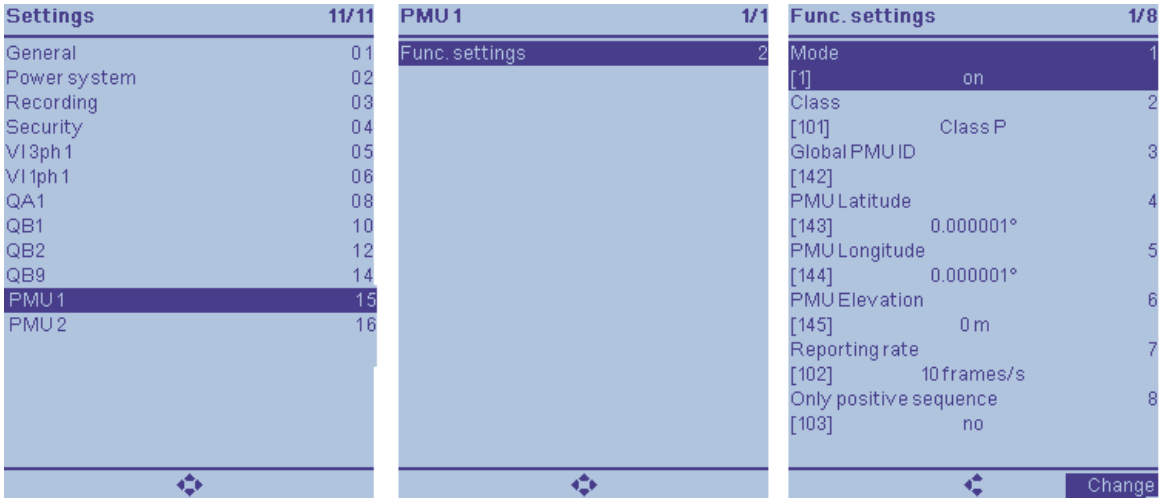


[sc_parami, 1, en_US]

Figure 9-23 Log Indication for Display of the PMU/PDC Connection

9.5.7 Parameterizing the PMU on the Device

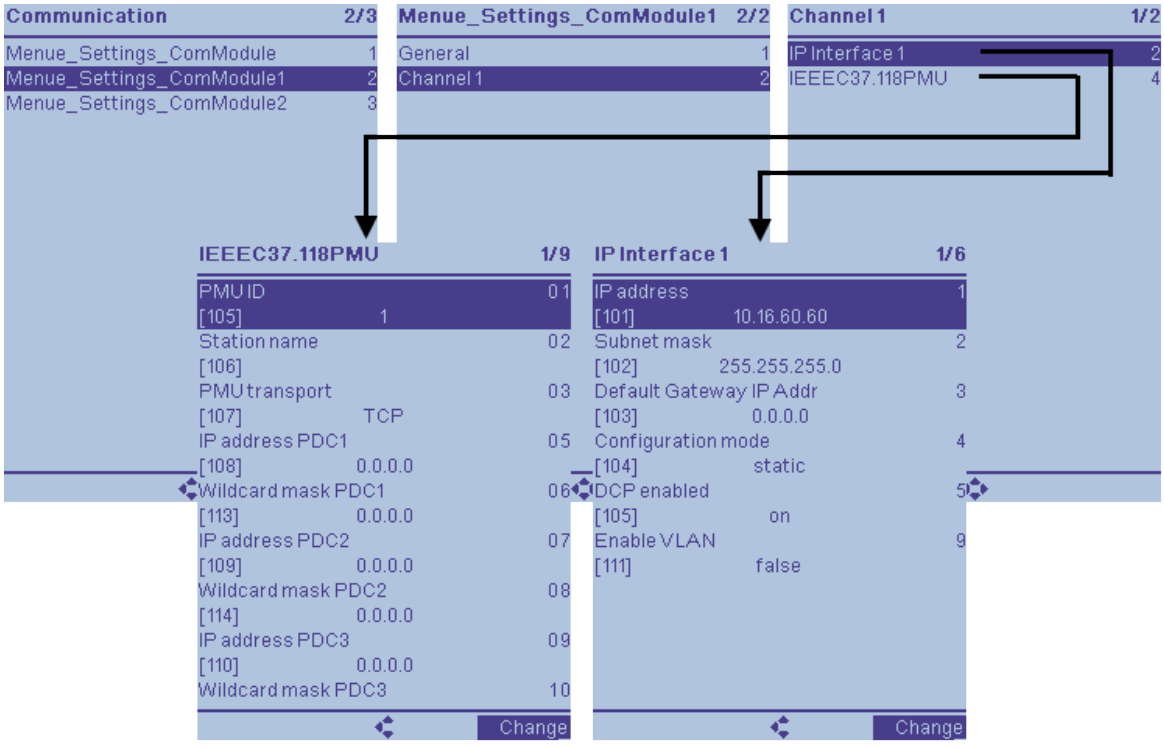
You can also change the PMU settings directly on the device. To do this, select the desired PMU instance on the device display. By selecting menu item **Settings** you then access the editable setting values (see *Figure 9-24*). Note that the parameter **Port** cannot be changed, because this corresponds to the physical slot position of the communication module in question.



[sc_devpmu, 2, en_US]

Figure 9-24 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 9-25*).



[sc_compmu, 2, en_US]

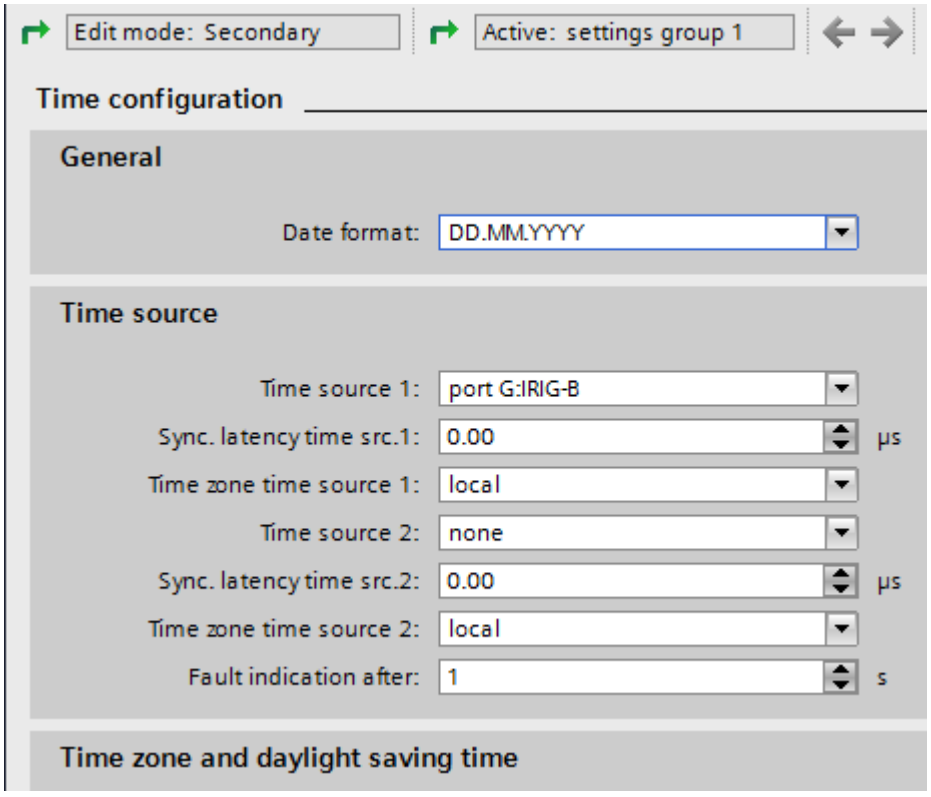
Figure 9-25 Changing the Communication Setting Values via the Device Display

9.5.8 Application and Setting Notes

Time Synchronization

In order to ensure the time accuracy of the PMU, you must select **IRIG-B** as the protocol for the GPS clock (*Figure 9-26*) or, if an ETH-BD-2FO communication module is present, IEEE 1588 (*Figure 9-27*). With other settings, the **PMU function** function group indicates that it is not time synchronized.

Setting Time Synchronization – IRIG-B



[sc_setting time source, 1, en_US]

Figure 9-26 Setting Time Synchronization – IRIG-B

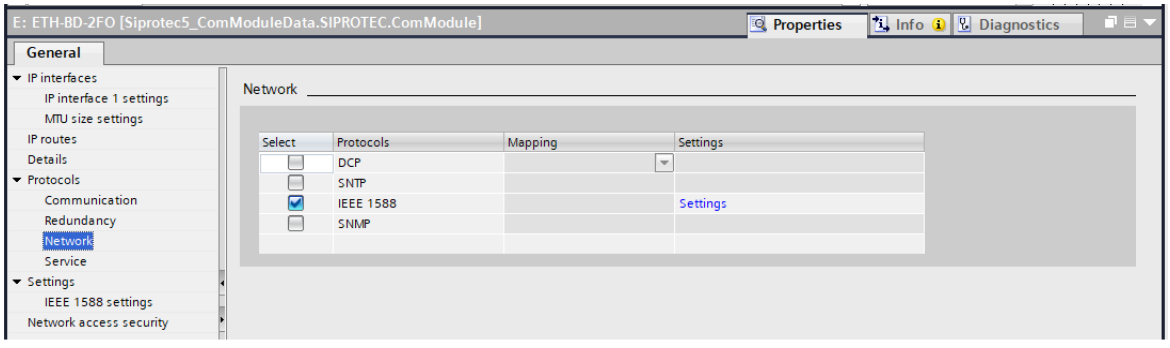
To detect a lack of synchronization quickly, also set the waiting time for the failure indication of the loss of time synchronization to the smallest possible value, thus to 1 s.

Setting Time Synchronization – IEEE 1588 (Precision Time Protocol (PTP))

Activate IEEE 1588 on the ETH-BD-2FO communication module.

NOTE

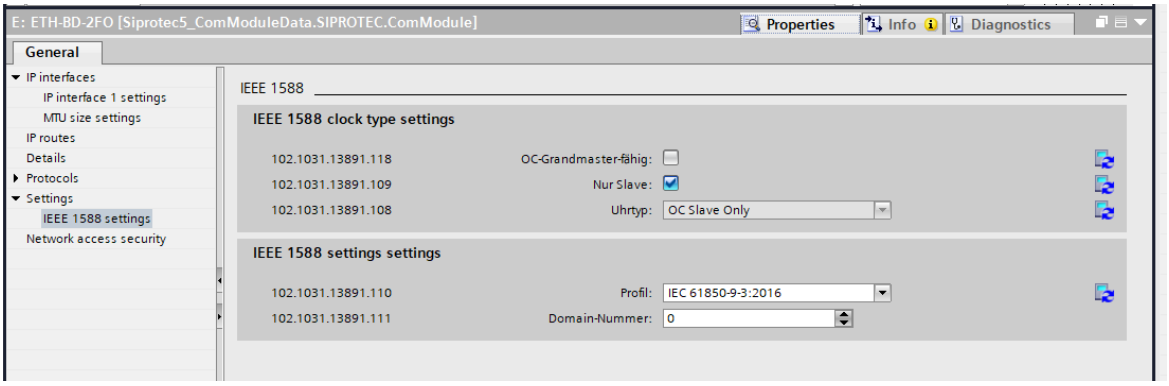
For PMU applications, use the IEEE 1588 protocol on the ETH-BD-2FO communication module, because the IEEE 1588 protocol that can be activated on the ETH-BA-2EL and ETH-BB-2FO modules does not deliver the required accuracy.



[sc_activate_ieee_1588, 1, en_US]

Figure 9-27 IEEE 1588 Activation for the ETH-BD-2FO Module

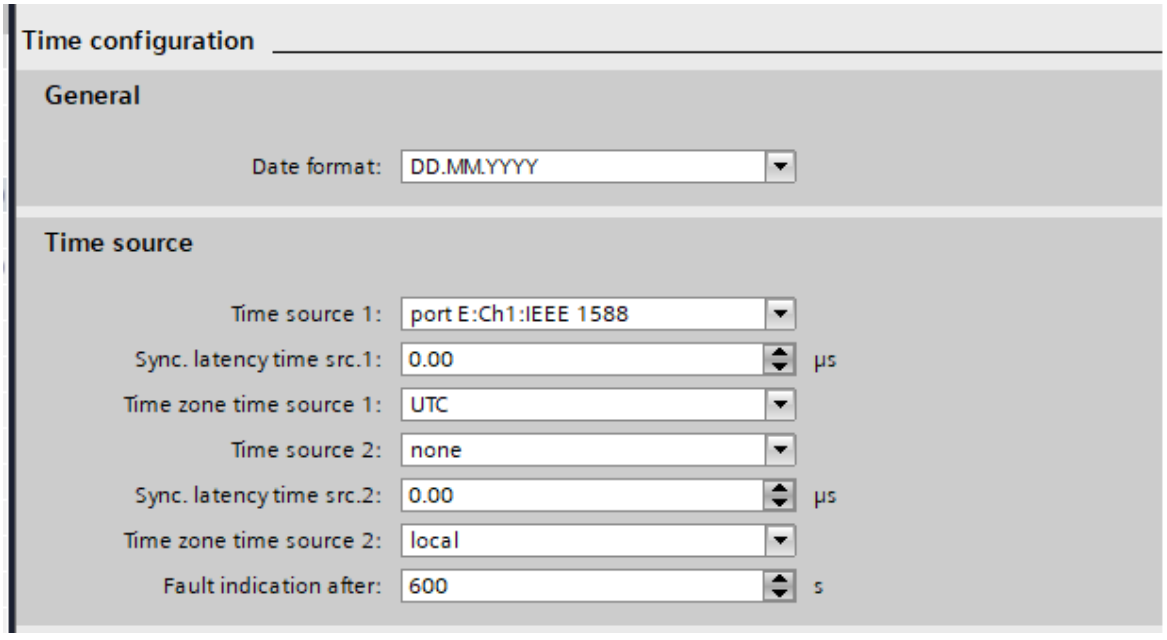
Ensure that the domain number in the IEEE 1588 settings matches that of the switch used.



[sc_para_ieee_1588, 1, en_US]

Figure 9-28 IEEE 1588 settings on the ETH-BD-2FO module

Select IEEE 1588 as the time source in the time configuration.



[sc_choose_of_time, 1, en_US]

Figure 9-29 Selection of Time Source

When selecting the switch used, make sure it supports the PTP standard IEEE 1588. Siemens recommends the RUGGEDCOM RSG2488.

Parameter: Mode

- Default setting **(_:10621:1) Mode** = ***on***

With the parameter **Mode**, you activate or deactivate the PMU, or you switch it to test 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. You can set a reporting rate of 200 frames/s (50 Hz) or 240 frames/s (60 Hz) only when using an ETH-BD-2FO module.

Parameter: Positive sequence

- Default setting **(_:10621:103) Positive sequence** = ***no***

With the parameter **Positive sequence**, you can set whether the PMU transmits the positive-sequence system. The following setting values can be used:

Parameter Value	Meaning
no	The PMU only transmits the 3 individual synchrophasors for the 3-phase measuring points.
only	The PMU only transmits the positive-sequence system instead of the 3 individual synchrophasors for the 3-phase measuring points.
additionally	The PMU transmits the positive-sequence system in addition to the 3 individual synchrophasors for the 3-phase measuring points.

The setting you make here is then valid for all PMUs with 3-phase measuring points.

Parameter: Transmit measured VN, IN

- Default setting **(_:10621:104) Transmit measured VN, IN** = ***no***

This parameter is only visible if you route the **Measuring point V-3ph** or the **Measuring point I-3ph** with VN or IN to the **PMU** in DIGSI 5. The routing option is in the DIGSI 5 project tree in **Device Name** → **Function-group connections** in the **Measuring points** ↔ **Function group** settings sheet.

With this parameter, you define whether or not the **PMU** transmits VN and IN.

Parameter: Class

- Default setting **(_:10621:101) Class** = ***Class P***

With the parameter **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 provide a short response time and that are therefore suitable for recording dynamic processes. ***Class M*** is intended for applications that are unfavorably affected by alias effects and in which short response times are not relevant.

Parameter: Global PMU ID

- Default setting **(_:10621:142) Global PMU ID** = ***Freely editable text***

With the parameter **Global PMU ID**, you enter a global ID for the PMU, which can contain up to 16 characters.

Parameter: PMU Latitude

- Default setting **(_:10621:143) PMU Latitude** = ***0.00000000*** **°**

With the parameter **PMU Latitude**, you set the latitude to a value between -90,00000000 ° and +90,00000000 °.

Parameter: PMU Longitude

- Default setting **(_:10621:144) PMU Longitude** = ***0.00000000*** **°**

With the parameter **PMU Longitude**, you set the current longitude to a value between -180,00000000 ° and +180,00000000 °.

Parameter: PMU Elevation

- Default setting **(_:10621:145) PMU Elevation** = ***0.00 m***

With the parameter **PMU Elevation**, you set the current height above sea level to a value between -50 000.00 m and +50 000.00 m.

Parameter: Port

This parameter cannot be set, because the **Port** results from the physical position where the corresponding communication module is inserted.

9.5.9 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
_:10621:142	Func. settings:Global PMU ID		Freely editable text	
_:10621:143	Func. settings:PMU Latitude		-90.000000 ° to 90.000000 °	0.000000 °
_:10621:144	Func. settings:PMU Longitude		-180.000000 ° to 180.000000 °	0.000000 °
_:10621:145	Func. settings:PMU Elevation		-50000.00 m to 50000.00 m	0.00 m
_: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 • 200 frames/s • 240 frames/s	10 frames/s
_:10621:103	Func. settings:Positive sequence		• no • only • additionally	no
_:10621:105	Func. settings:Transmit measured VN, IN		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:10621:104	Func. settings:Port		• port F • port E • port P • port N	port F
_:10621:141	Func. settings:Freq tracking group ID		1 to 100	1

9.5.10 Information List

No.	Information	Data Class (Type)	Type
General			
_:10621:52	Func. settings:Behavior	ENS	O
_:10621:53	Func. settings:Health	ENS	O

9.6 Average Values

9.6.1 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 *9.2 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

9.6.2 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.

9.7 Minimum/Maximum Values

9.7.1 Function Description of Minimum/Maximum Values

Minimum and maximum values can be formed based on different measured or calculated measurands:

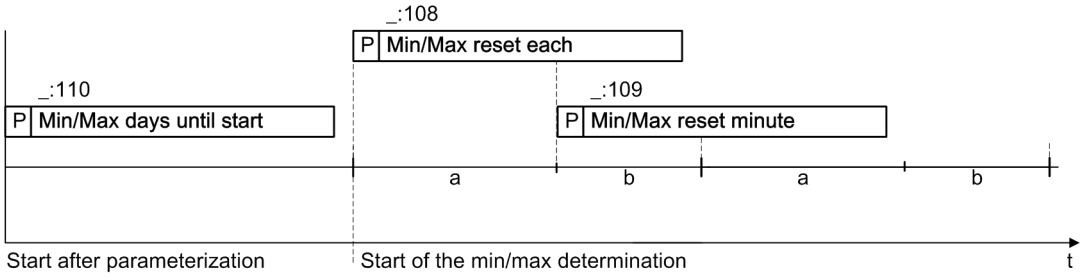
- Operational measured values
- Symmetrical components
- Selected values

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.



[dw_min_max, 1, en_US]

Figure 9-30 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 *9.2 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

9.7.2 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 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)

9.8 Energy Values

9.8.1 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:

$$\text{Energy metered value} = \frac{\text{Energy value}}{S_{N,obj.}} \cdot 60000 \frac{\text{Pulses}}{\text{h}}$$

[fo_omverg, 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 be deactivated automatically.

- 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 counter status
- **Resetting** the counter status 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 *9.2 Structure of the Function*, section on the Inversion of Output-Related Measured and Statistical Values):

- Active energy, output: Wp+
- Active energy, input: Wp-
- Reactive energy, output: Wq+
- Reactive energy, input: Wq-

9.8.2 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** = ***none***

Parameter Value	Description
none	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** = ***false***

Parameter Value	Description
False	Restoring deactivated
True	The cyclic restoring after the set time of the parameter **(_:111) Energy restore interval**will also be synchronized with the system time. 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: When 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. There, 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.

9.9 User-Defined Metered Values

9.9.1 Function Description of Pulse-Metered Values



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 9-31*). Select the metered value and enter the settings under **Properties**.

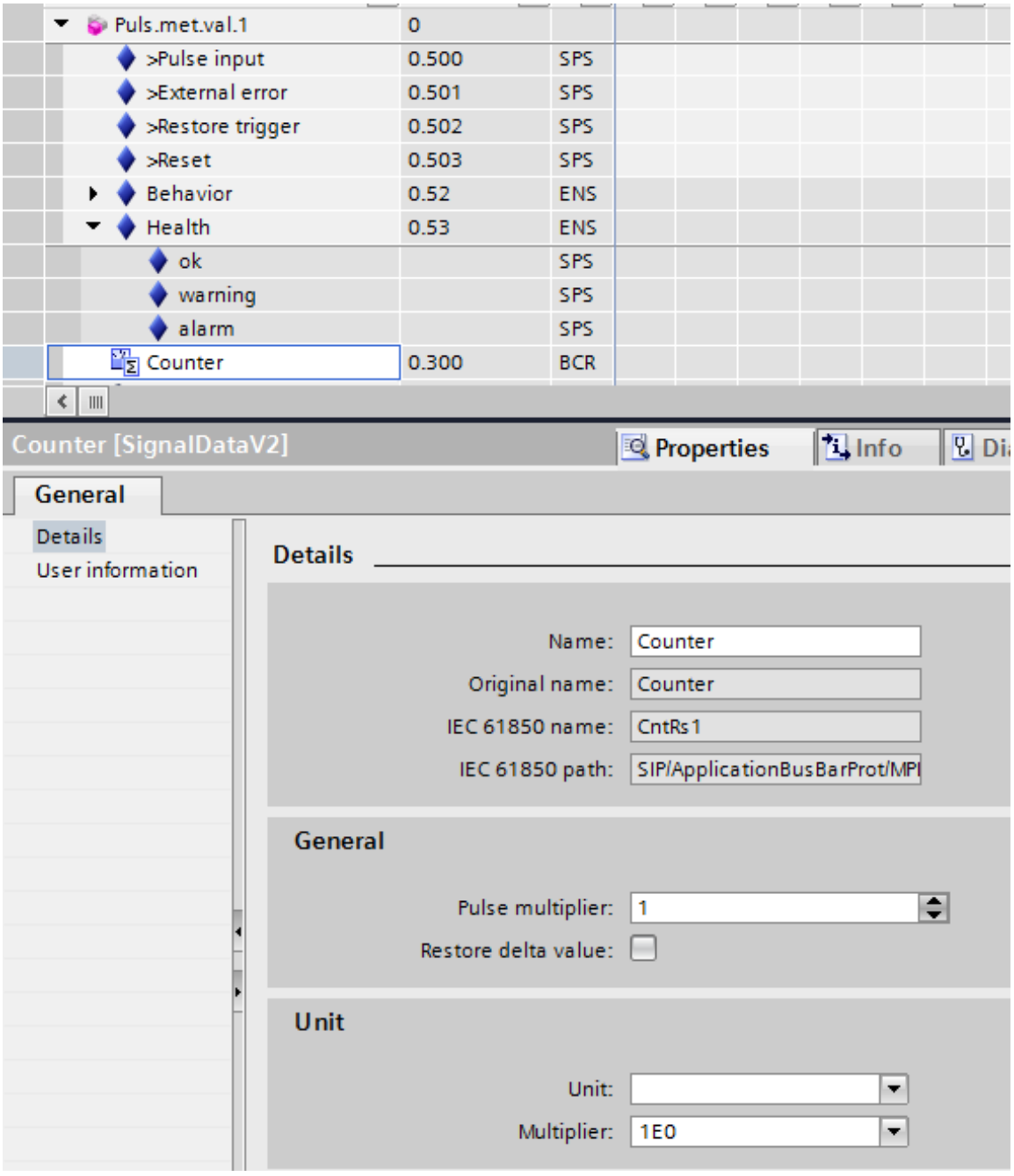


Figure 9-31 Setting with DIGSI, General Settings, Pulse-Metered Values

9.9.2 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**. The maximum repetition rate when detecting the pulse-metered values is 50 Hz.

For pulse-metered values, the following described settings and binary inputs are available.

Parameter: `Restore time`

- Default setting **`(_:101) Restore time`** = ***`none`***

Parameter Value	Description
none	Deactivated
`hh:00`	Transfer on the full hour
`hh:15`	Transfer 15 minutes after the full hour
`hh:30`	Transfer 30 minutes after the full hour
`hh:45`	Transfer 45 minutes after the full hour

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.

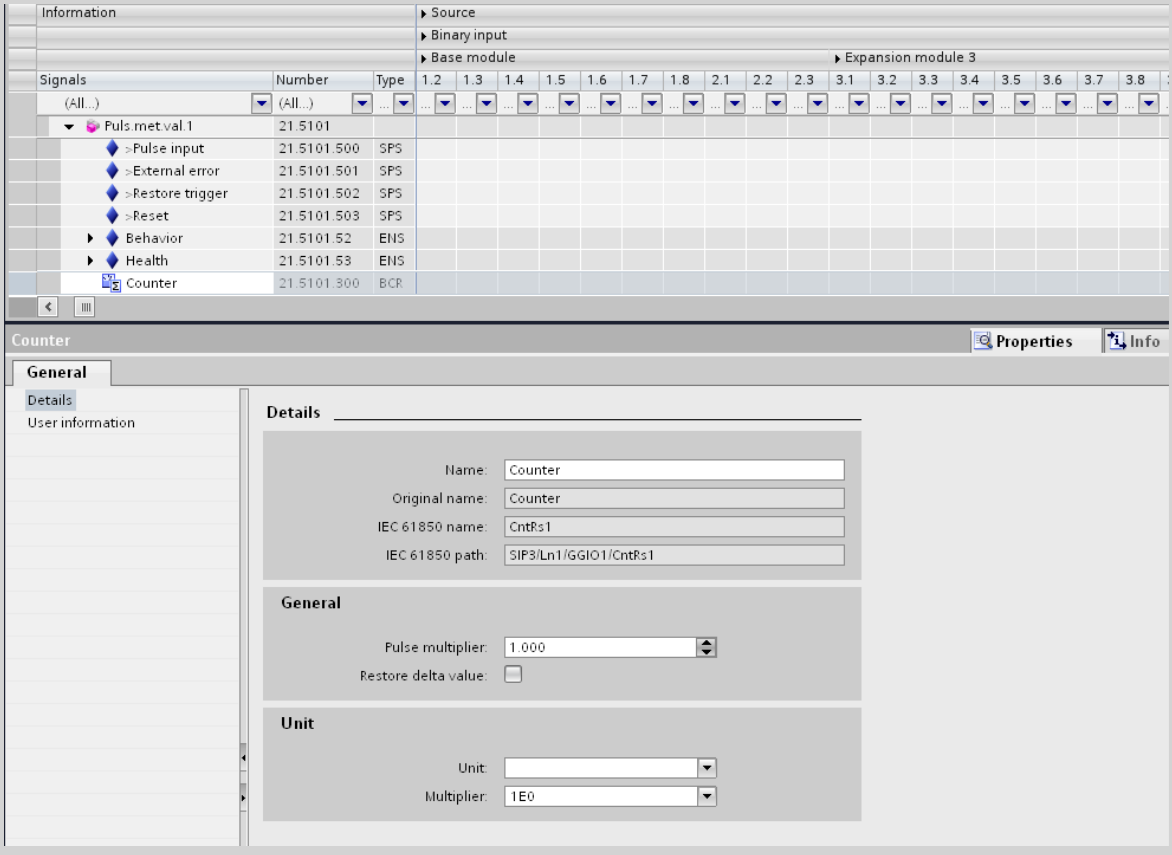
If the check box **Restore delta value** is activated, the differential value is transferred at the restore time set via the communication interface. The difference value is formed by subtracting the counter content of the last restoring operation from the current counter content.

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**.



[sc_impzwe, 1, en_US]

Figure 9-32 Setting with DIGSI

9.10 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)

9.11 Circuit-Breaker Monitoring

9.11.1 Overview of Functions

The **Circuit-breaker monitoring** function:

- Detects the abrasion of the circuit breakers phase-selectively
- Allows an adaptation of maintenance intervals for switching contacts of the circuit breakers according to the real abrasion
- Sends a warning signal when the abrasion of the circuit breaker reaches a certain degree
- Allows the supervision of the circuit-breaker make time
- Allows the supervision of the circuit-breaker break time

One of the main advantages of this function is the reduction of maintenance and service costs.

9.11.2 Structure of the Function

The function **Circuit-breaker monitoring** can be used in the function group **Circuit-breaker**.
The function offers 9 independent operating methods with different methods of measurement:

- **ΣI^x-method**
  Sum of the breaking-current potentials
- **2P-method**
  2 points method for calculating the remaining switching cycles
- **I^2t-method**
  Sum of all breaking-current square integrals
- **Make time**
  Monitoring of the circuit-breaker make time
- **Break time**
  Monitoring of the circuit-breaker break time
- **Pole scatter time open**
  Supervision of the difference in the switch-off times of the individual phases
- **Pole scatter time close**
  Supervision of the difference in the switch-on times of the individual phases
- **Mechanical switching time open**
  Supervision of the switching time open detected via the feedback contacts
- **Mechanical switching time close**
  Supervision of the switching time close detected via the feedback contacts

9.11.3 General Functionality

9.11.3.1 Description

Start Criterion for the Function Circuit-Breaker Monitoring

The methods **ΣI^x**, **2P** and **I^{2}t** are started if one of the following criteria is met:

- The circuit breaker is opened via a command or a protection tripping.
- The binary input signal *>Start calc. for open* is initiated, for example, via an external signal.
- The signal for the closed position of the circuit breaker is going. This signal is built via the circuit-breaker auxiliary-contacts. Thus, a manual opening of the circuit breaker is detected.

The methods **Make time**, **Mechanical switching time close** are started if one of the following criteria is met:

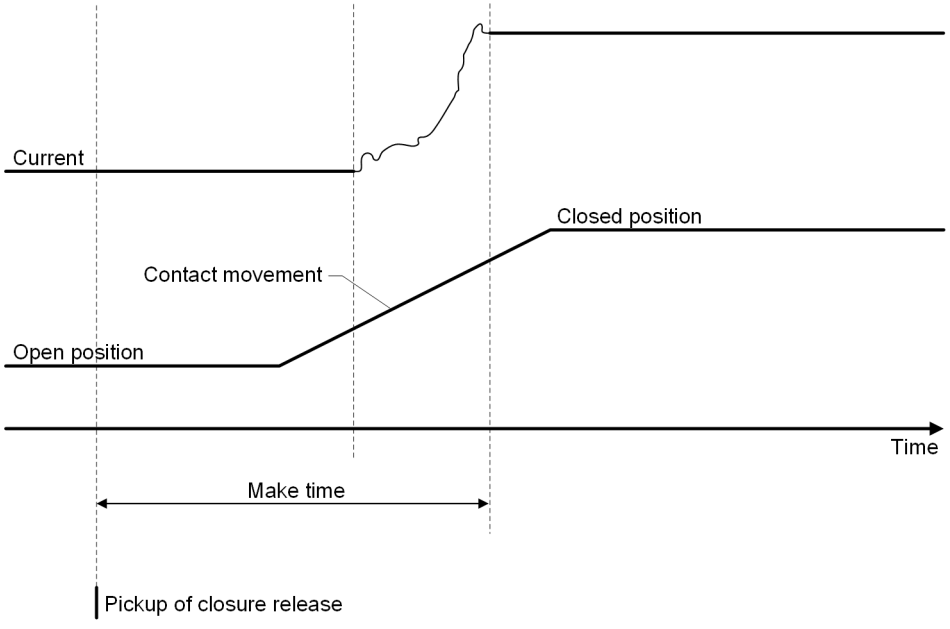
- The circuit breaker is closed via a command.
- The binary input signal *>Start calc. for close* is initiated, for example, via an external signal.

The methods **Break time**, **Mechanical switching time open** and **Pole scatter time open** are started if one of the following criteria is met:

- The circuit breaker is opened via a command.
- The circuit breaker is opened via a protection tripping.
- The binary input signal *>Start calc. for open* is initiated, for example, via an external signal.

Definition of the Times when Opening and Closing the Circuit Breaker

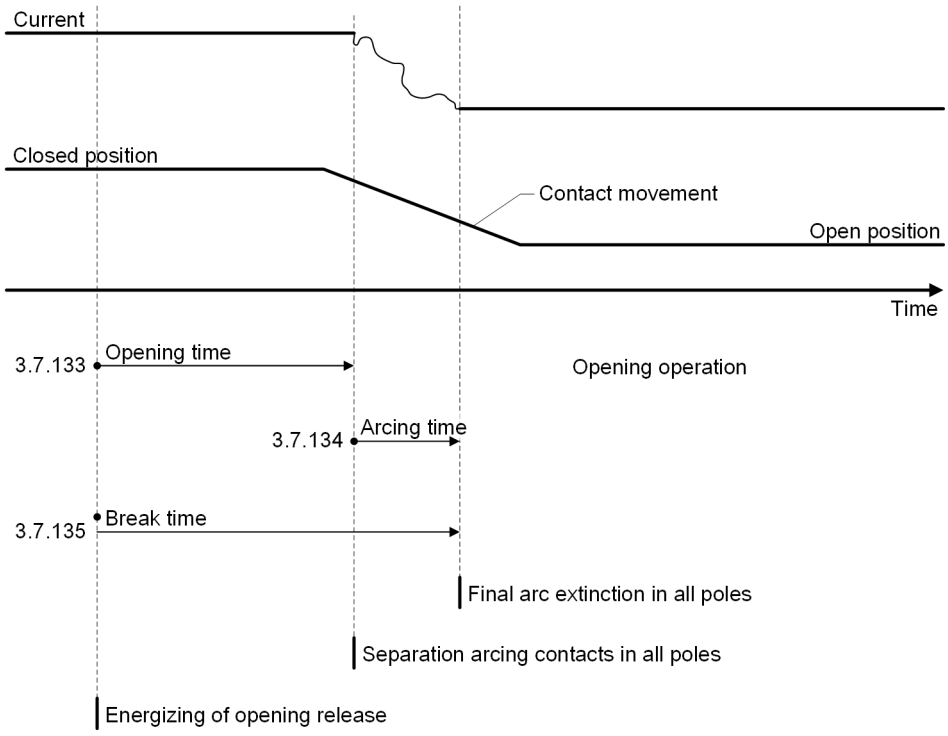
With the paramter **Make time**, you define the point in time when the circuit-breaker poles are closed and the current has reached a constant value.



[dw_maketime, 1, en_US]

Figure 9-33 Definition of Make Time

With the parameter **Opening time**, you define the point in time when the circuit-breaker poles begin to open. With the parameter **Break time**, you define the point in time when the circuit-breaker poles are separated and the arc is extinct. The following graphic shows the relation between these 2 points in time of the circuit breaker.



[dw_breaktime, 1, en_US]

Figure 9-34 Circuit-Breaker Times

9.11.3.2 Application and Setting Notes

Parameter: **Apply PhaseA config to all**

- Default setting **(_:2311:1) Apply PhaseA config to all** = ***inactive***

If the parameter **Apply PhaseA config to all** is activated, all settings of phase A are adopted for phases B and C.

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: **Opening time**

- Default setting **(_:23971:101) Opening time** = ***65 ms***

With the parameter **Opening time**, you define the interval between the activation of the shunt release for the circuit breaker and the moment, when the circuit-breaker poles open.

For information on the setting value, refer to the technical data of the used circuit breaker. For futher information, refer to *Figure 9-34*.

Parameter: **Break time**

- Default setting **(_:23971:102) Break time** = ***80 ms***

With the parameter **Break time**, you define the interval between the activation of the shunt release for the circuit breaker and the moment, when the arc extincts (and the circuit-breaker poles are open).

For information on the setting value, refer to the technical data of the used circuit breaker. For further information, refer to *Figure 9-34*.

Parameter: `Make time`

- Default setting **`(_:23971:103) Make time`** = ***`80 ms`***

With the parameter **`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.
For information on the setting value, refer to the technical data of the used circuit breaker.

9.11.3.3 Settings

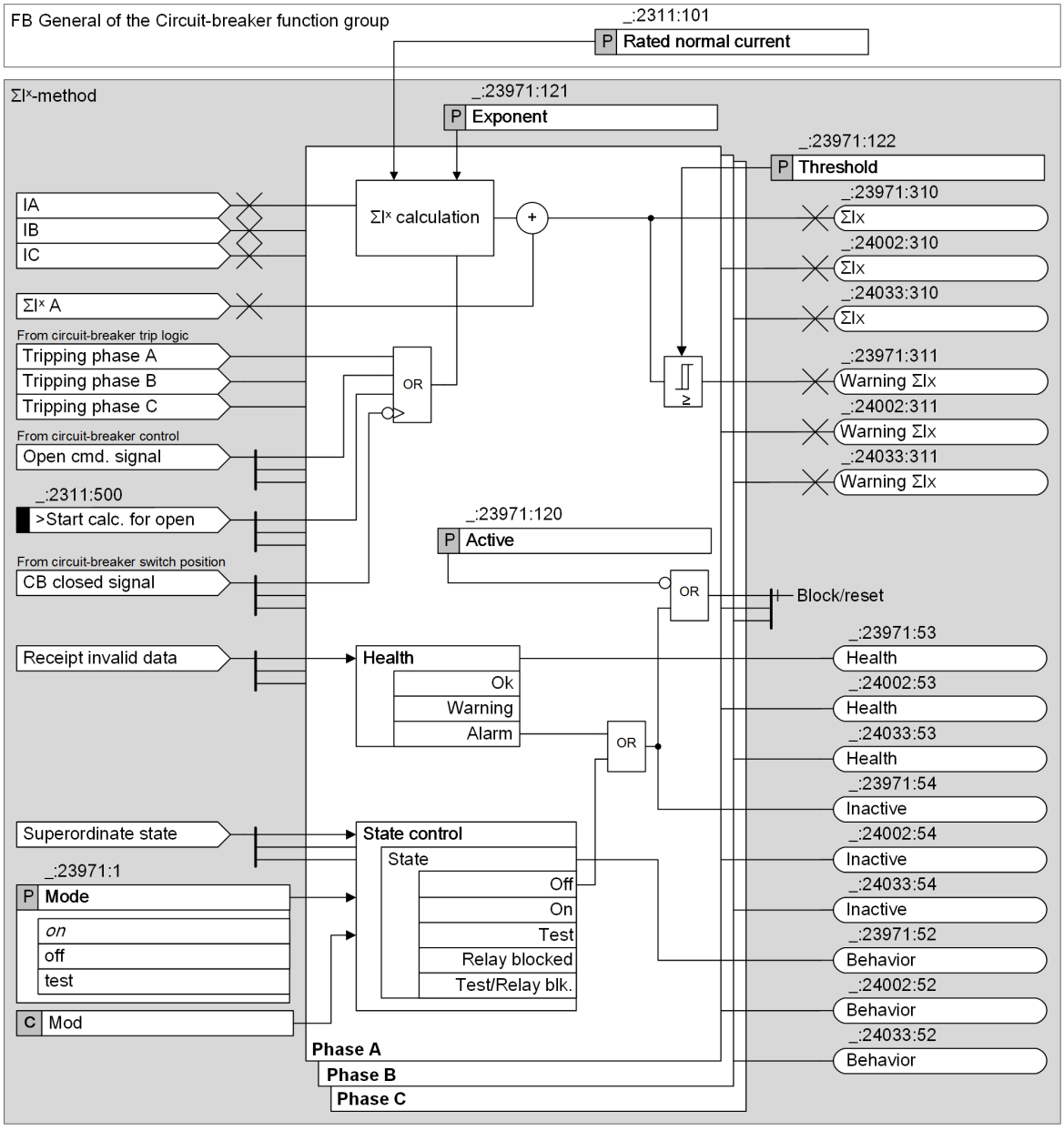
Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Apply PhaseA config to all		• 0 • 1	False
General				
_:23971:1	Phase A:Mode		• off • on • test	on
_:23971:101	Phase A:Opening time		1 ms to 500 ms	65 ms
_:23971:102	Phase A:Break time		1 ms to 600 ms	80 ms
_:23971:103	Phase A:Make time		1 ms to 600 ms	80 ms
General				
_:24002:1	Phase B:Mode		• off • on • test	on
_:24002:101	Phase B:Opening time		1 ms to 500 ms	65 ms
_:24002:102	Phase B:Break time		1 ms to 600 ms	80 ms
_:24002:103	Phase B:Make time		1 ms to 600 ms	80 ms
General				
_:24033:1	Phase C:Mode		• off • on • test	on
_:24033:101	Phase C:Opening time		1 ms to 500 ms	65 ms
_:24033:102	Phase C:Break time		1 ms to 600 ms	80 ms
_:24033:103	Phase C:Make time		1 ms to 600 ms	80 ms

9.11.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calc. for open	SPS	I
_:2311:501	General:>Start calc. for close	SPS	I

9.11.4 ΣIx Method

9.11.4.1 Description



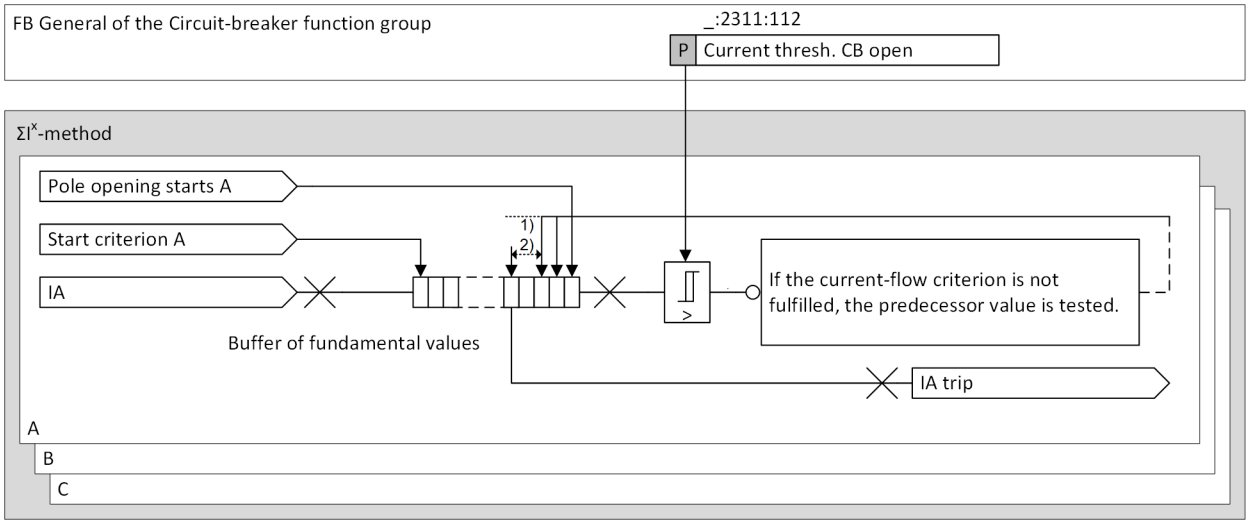
[lo_Ix-calc_1, en_US]

Figure 9-35 Logic of the ΣIˣ Method

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 one period 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.



[lo_cb_wixf, 3, en_US]

Figure 9-36 Logic of the Determination of the Tripping Current Value

(1) Current-flow criterion fulfilled

(2) 1 period 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.

$$\sum I_A^x = \frac{1}{I_{rated}^x} \sum_{q=1}^{m} I_{A\,trip,q}^x$$

[fo_CB-WI-xA, 1, en_US]

Mit:

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.

9.11.4.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: `Active`

- Default setting **`(_:23971:120) Active`** = ***`inactive`***

With the parameter **`Active`**, you switch on the method.

Parameter: `Exponent`

- Default setting **`(_:23971:121) Exponent`** = ***`2.0`***

With the parameter **`Exponent`**, you 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 **`(_:23971:122) Threshold`** = ***`10 000.00`***

With the parameter **`Threshold`**, you 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.

9.11.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
ΣIx-method				
_:23971:120	Phase A:Active		• 0 • 1	False
_:23971:121	Phase A:Exponent		1.0 to 3.0	2.0
_:23971:122	Phase A:Threshold		0 to 10000000	10000
ΣIx-method				
_:24002:120	Phase B:Active		• 0 • 1	False
_:24002:121	Phase B:Exponent		1.0 to 3.0	2.0
_:24002:122	Phase B:Threshold		0 to 10000000	10000
ΣIx-method				
_:24033:120	Phase C:Active		• 0 • 1	False
_:24033:121	Phase C:Exponent		1.0 to 3.0	2.0
_:24033:122	Phase C:Threshold		0 to 10000000	10000

9.11.4.4 Information List

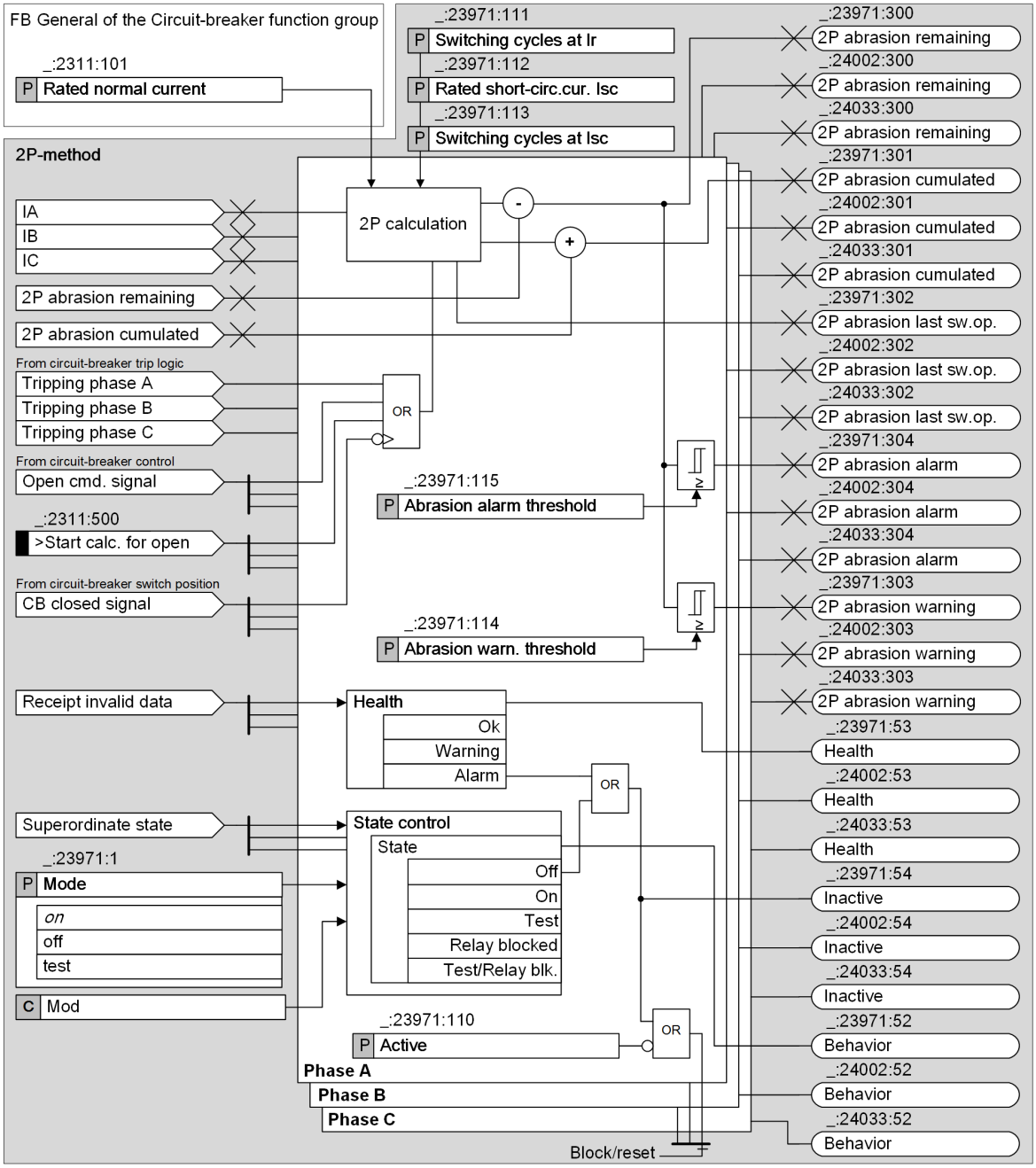
No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O

9.11.5 2P Method

9.11.5.1 Description

Logic of the Stage



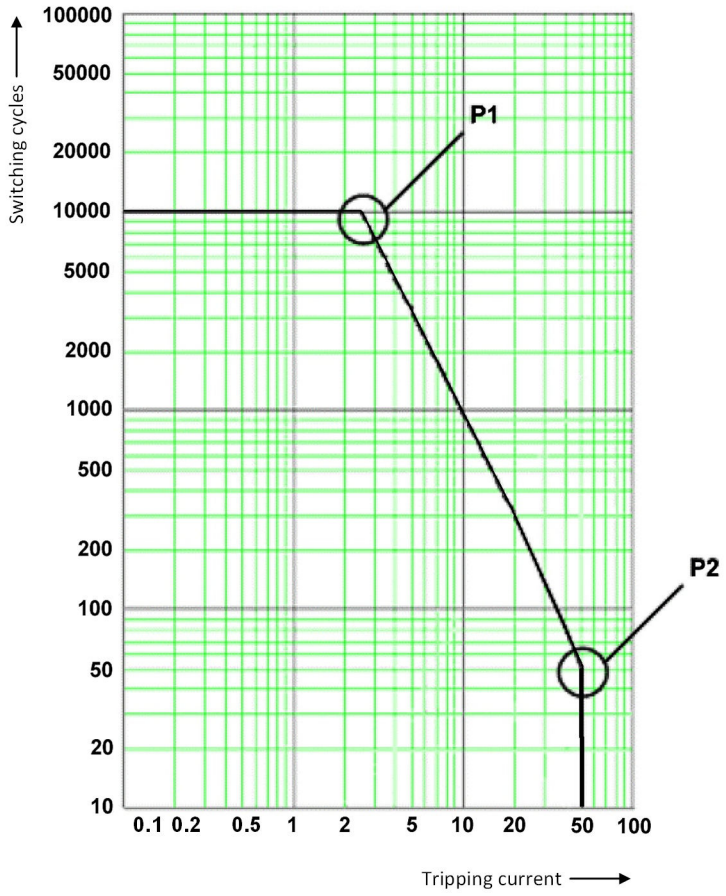
[lo_2P-calc, 1, en_US]

Figure 9-37 Logic 2P Method

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 determined 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**.



[dw_CB_WOpC, 2, en_US]

Figure 9-38 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:

$$n = b\left(\frac{I_{rated}}{I_{trip}}\right)^{m}$$

[fo_CB-W2-P1, 2, en_US]

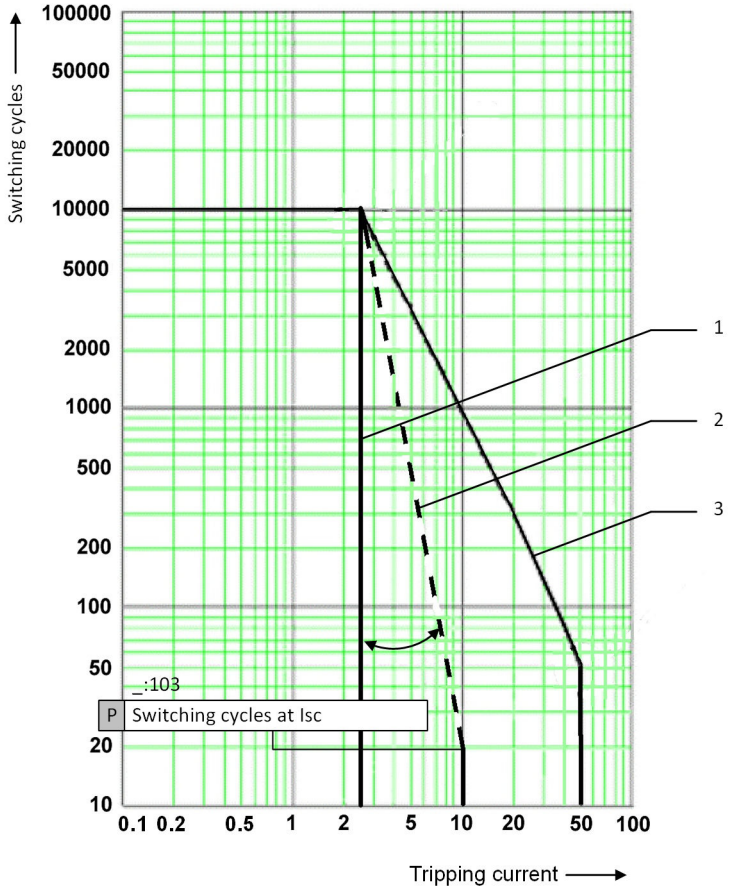
Where:

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.



[dw_CB_WSlo, 2, en_US]

Figure 9-39 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:

$$2\text{p wear rest}_{i} = 2\text{p wear rest}_{i-1} - \frac{n_{rated}}{n_{trip}}$$

[fo_CB-2P-wear-rest_01, 2, en_US]

Where:

i	No. of latest circuit-breaker switching cycle
2p wear rest$_i$	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:

$$\text{2p wear rest} = n_{rated} - \left(100\frac{n_{rated}}{n_{2.5\ kA}}\right) - \left(2\frac{n_{rated}}{n_{50\ kA}}\right) - \left(3\frac{n_{rated}}{n_{10\ kA}}\right)$$

$$= 10\,000 - \left(100\frac{10\,000}{10\,000}\right) - \left(2\frac{10\,000}{50}\right) - \left(3\frac{10\,000}{861}\right) = 9465$$

[fo_CB-2P-wear-rest_02, 2, en_US]

There are still 9465 possible break operations at rated normal current.

Cumulated Abrasion and Abrasion of the Last Switching Operation

In addition to the remaining switching cycles, the cumulated wear and the wear of the last switching operation is calculated. These are available as percentage values ***2P abrasion cumulated*** and ***2P abrasion last sw.op.***.

Circuit-Breaker Maintenance Warning and Alarm

If the adjustable threshold values are undershot, phase-selective warnings and alarms are generated.

9.11.5.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: `Active`

- Default setting **`(_:23971:110) Active`** = ***inactive***

With the parameter **`Active`**, you switch on the method.

Parameter: `Switching cycles at Ir`

- Default setting **`(_:23971:111) Switching cycles at Ir`** = ***10 000***

With the parameter **`Switching cycles at Ir`**, you 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 **(_:23971:112) Rated short-circ.cur. Isc** = ***25 000 A***

With the parameter **Rated short-circ.cur. Isc**, you 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 **(_:23971:113) Switching cycles at Isc** = ***50***

With the parameter **Switching cycles at Isc**, you 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: **Abrasion warn. threshold**

- Default setting **(_:23971:114) Abrasion warn. threshold** = ***1000***

With the parameter **Abrasion warn. threshold**, you define the threshold value for the remaining switching cycles with rated operating current. If the statistical value is below the threshold value, a warning signal is generated.

Parameter: **Abrasion alarm threshold**

- Default setting **(_:23971:115) Abrasion alarm threshold** = ***500***

With the parameter **Abrasion alarm threshold**, you define the threshold value for the remaining switching cycles with rated operating current. If the statistical value is below the threshold value, an alarm signal is generated.

Example

Here is an example that shows you how to set the threshold parameters. 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:

$$3 \cdot \frac{n_{rated}}{n_{50\,kA}} = 3 \cdot \frac{10000}{50} = 600$$

[fo_CB-W2-P4, 2, en_US]

9.11.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2P-method				
_:23971:110	Phase A:Active		• 0 • 1	False
_:23971:111	Phase A:Switching cycles at Ir		100 to 10000000	10000
_:23971:112	Phase A:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:23971:113	Phase A:Switching cycles at Isc		1 to 1000	50
_:23971:114	Phase A:Abrasion warn. threshold		0 to 10000000	100

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:115	Phase A:Abrasion alarm threshold		0 to 10000000	50
2P-method				
_:24002:110	Phase B:Active		• 0 • 1	False
_:24002:111	Phase B:Switching cycles at Ir		100 to 10000000	10000
_:24002:112	Phase B:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:24002:113	Phase B:Switching cycles at Isc		1 to 1000	50
_:24002:114	Phase B:Abrasion warn. threshold		0 to 10000000	100
_:24002:115	Phase B:Abrasion alarm threshold		0 to 10000000	50
2P-method				
_:24033:110	Phase C:Active		• 0 • 1	False
_:24033:111	Phase C:Switching cycles at Ir		100 to 10000000	10000
_:24033:112	Phase C:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:24033:113	Phase C:Switching cycles at Isc		1 to 1000	50
_:24033:114	Phase C:Abrasion warn. threshold		0 to 10000000	100
_:24033:115	Phase C:Abrasion alarm threshold		0 to 10000000	50

9.11.5.4 Information List

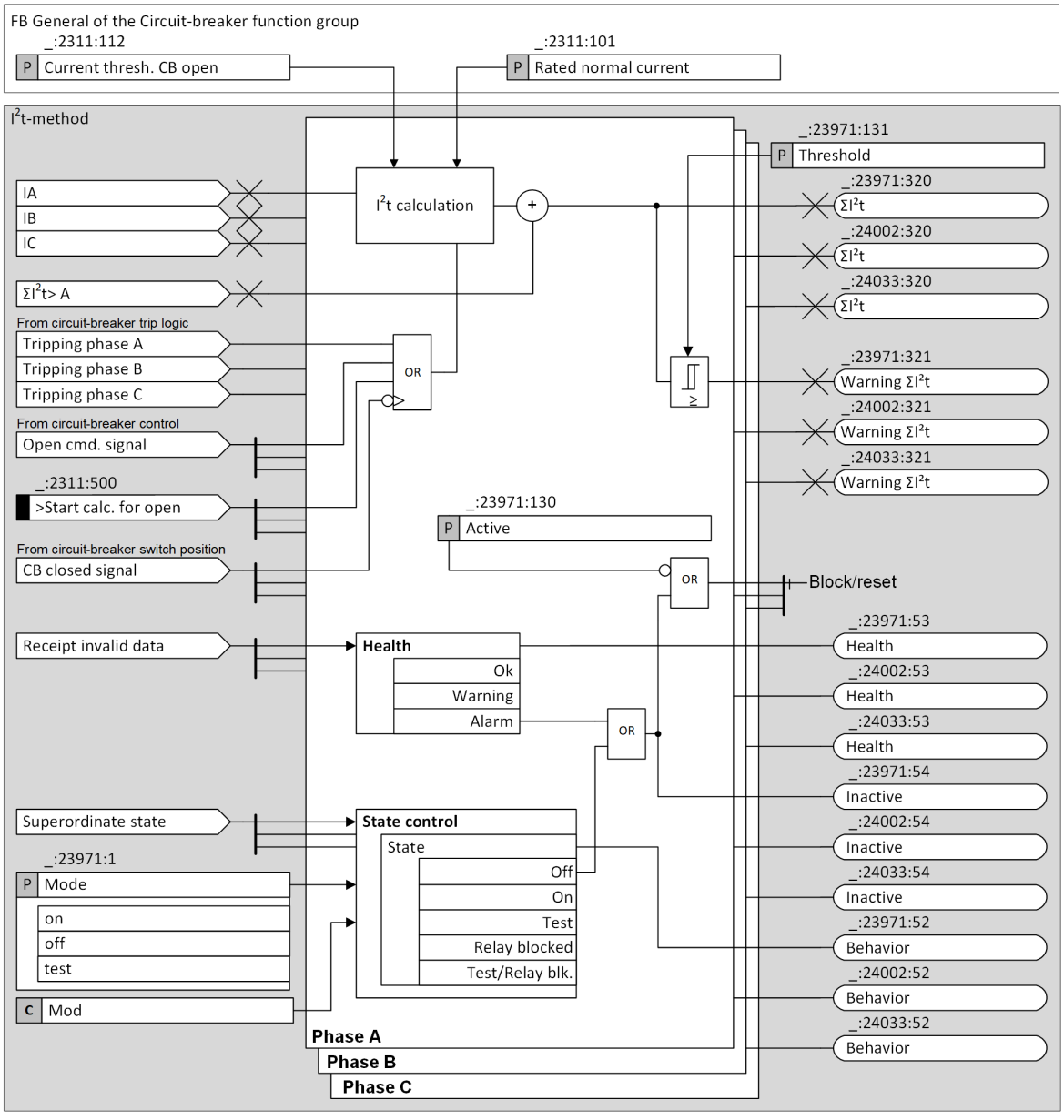
No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O

No.	Information	Data Class (Type)	Type
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O

9.11.6 I2t Method

9.11.6.1 Description

Logic of the Stage



[lo_I2t-calc_2, en_US]

Figure 9-40 Logic of the I²t Method

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 **`Break time`** and **`Opening time`** (see also *Start Criterion for the Function Circuit-Breaker Monitoring, Page 947*). 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.

$$I^2t_{L1} \cdot \frac{1}{I^2_{rated}} = \int_{\text{Start arc time}}^{\text{End arc time}} i^2_{L1}(t)\,dt$$

[fo_CB-WI-2T, 2, 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.

9.11.6.2 Application and Setting Notes

Parameter: `Active`

- Default setting **`(_:23971:130) Active`** = ***`inactive`***

With the parameter **`Active`**, you switch on the method.

Parameter: `Threshold`

- Default setting **`(_:24033:131) Threshold`** = ***`10 000.00 I/Ir*s`***

With the parameter **`Threshold`**, you specify the maximum permitted integral of squared sampled measured values of the phase currents. The same applies to the threshold values of the other phases.

9.11.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I2t-method`				
_:23971:130	Phase A:Active		• 0 • 1	False
_:23971:131	Phase A:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s
`I2t-method`				
_:24002:130	Phase B:Active		• 0 • 1	False
_:24002:131	Phase B:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s
`I2t-method`				
_:24033:130	Phase C:Active		• 0 • 1	False
_:24033:131	Phase C:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s

9.11.6.4 Information List

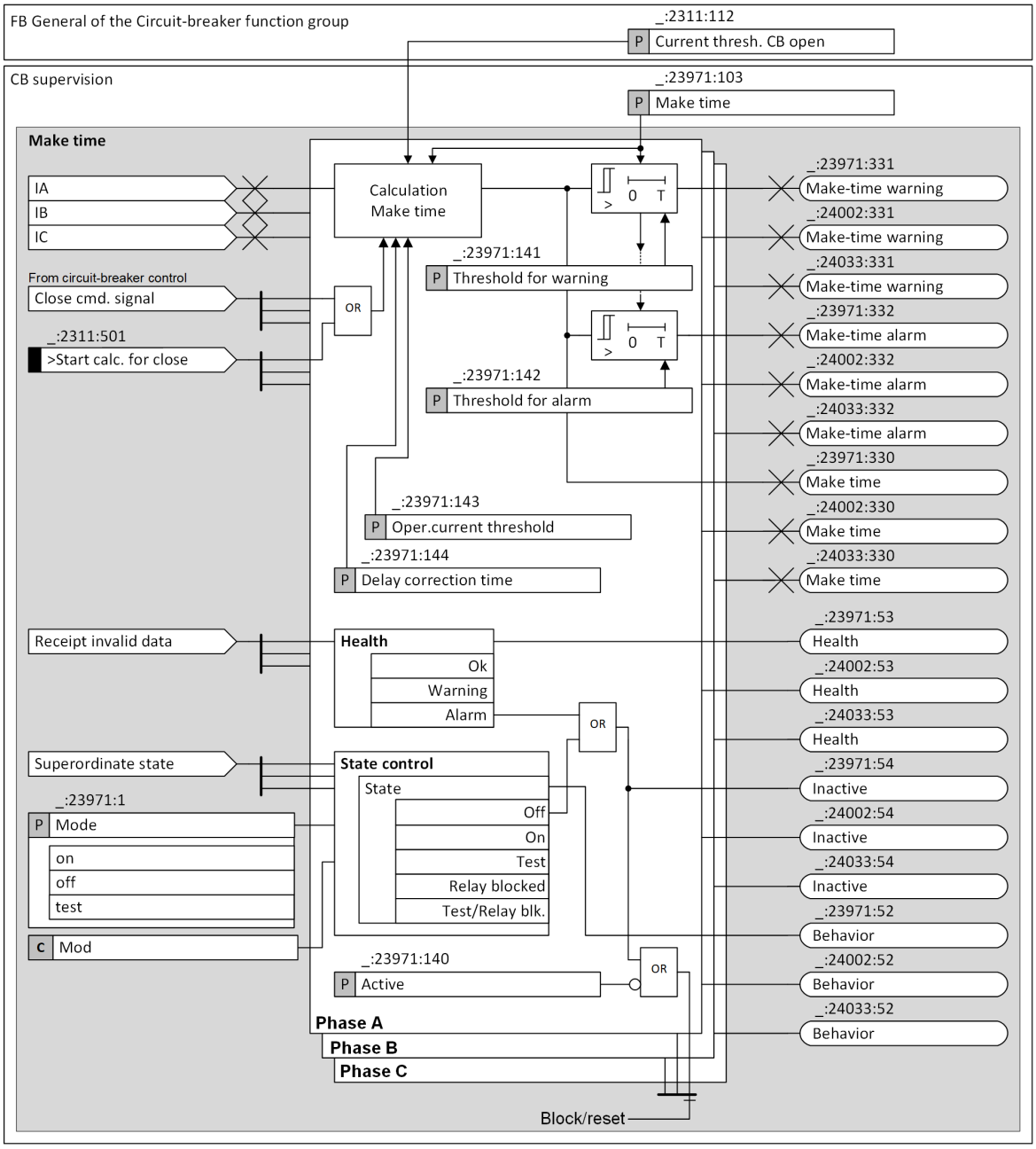
No.	Information	Data Class (Type)	Type
`Phase A`			
_:23971:51	Phase A:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O

9.11.7 Make Time

9.11.7.1 Description

Logic of the Stage



[lo_LS-Überwachung_Einschaltzeit, 2, en_US]

Figure 9-41 Logic of the Make Time

Operating Mode

The stage for the monitoring of the circuit-breaker make time calculates phase-selectively the time between the circuit-breaker closing command and the point in time when the current exceeds the **Oper.current threshold**. If this threshold has not been exceeded after 2.5 times the value of the parameter **Make time**, the measurement is canceled and the output value *Make time* is set to 0 and marked with the quality invalid.

If 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 monitoring of the measured make time. When these thresholds are exceeded or undershot, the corresponding outputs *Make-time warning* and *Make-time alarm* are activated for 100 ms. These can be routed in the log.

9.11.7.2 Application and Setting Notes



NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: Active

- Default setting **(_:23971:140) Active** = ***inactive***

With the parameter **Active**, you switch on the method.

Parameter: Threshold for warning

- Default setting **(_:23971:141) Threshold for warning** = ***5 %***

With the parameter **Threshold for warning**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Make time** at the output *Make time*, before the output *Make-time warning* is set. The output *Make-time warning* then drops out after 100 ms.

Parameter: Threshold for alarm

- Default setting **(_:23971:142) Threshold for alarm** = ***10 %***

With the parameter **Threshold for alarm**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Make time** at the output *Make time*, before the output *Make-time alarm* is set. The output *Make-time alarm* then drops out after 100 ms.

Parameter: Oper.current threshold

- Default setting **(_:23971:143) 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 **(_:23971:144) 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.

9.11.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Make time				
_:23971:140	Phase A:Active		• 0 • 1	False
_:23971:141	Phase A:Threshold for warning		1 % to 100 %	5 %

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:142	Phase A:Threshold for alarm		1 % to 100 %	10 %
_:23971:143	Phase A: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
_:23971:144	Phase A:Delay correction time		-50 ms to 50 ms	0 ms
Make time				
_:24002:140	Phase B:Active		• 0 • 1	False
_:24002:141	Phase B:Threshold for warning		1 % to 100 %	5 %
_:24002:142	Phase B:Threshold for alarm		1 % to 100 %	10 %
_:24002:143	Phase B: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
_:24002:144	Phase B:Delay correction time		-50 ms to 50 ms	0 ms
Make time				
_:24033:140	Phase C:Active		• 0 • 1	False
_:24033:141	Phase C:Threshold for warning		1 % to 100 %	5 %
_:24033:142	Phase C:Threshold for alarm		1 % to 100 %	10 %
_:24033:143	Phase C: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
_:24033:144	Phase C:Delay correction time		-50 ms to 50 ms	0 ms

9.11.7.4 Information List

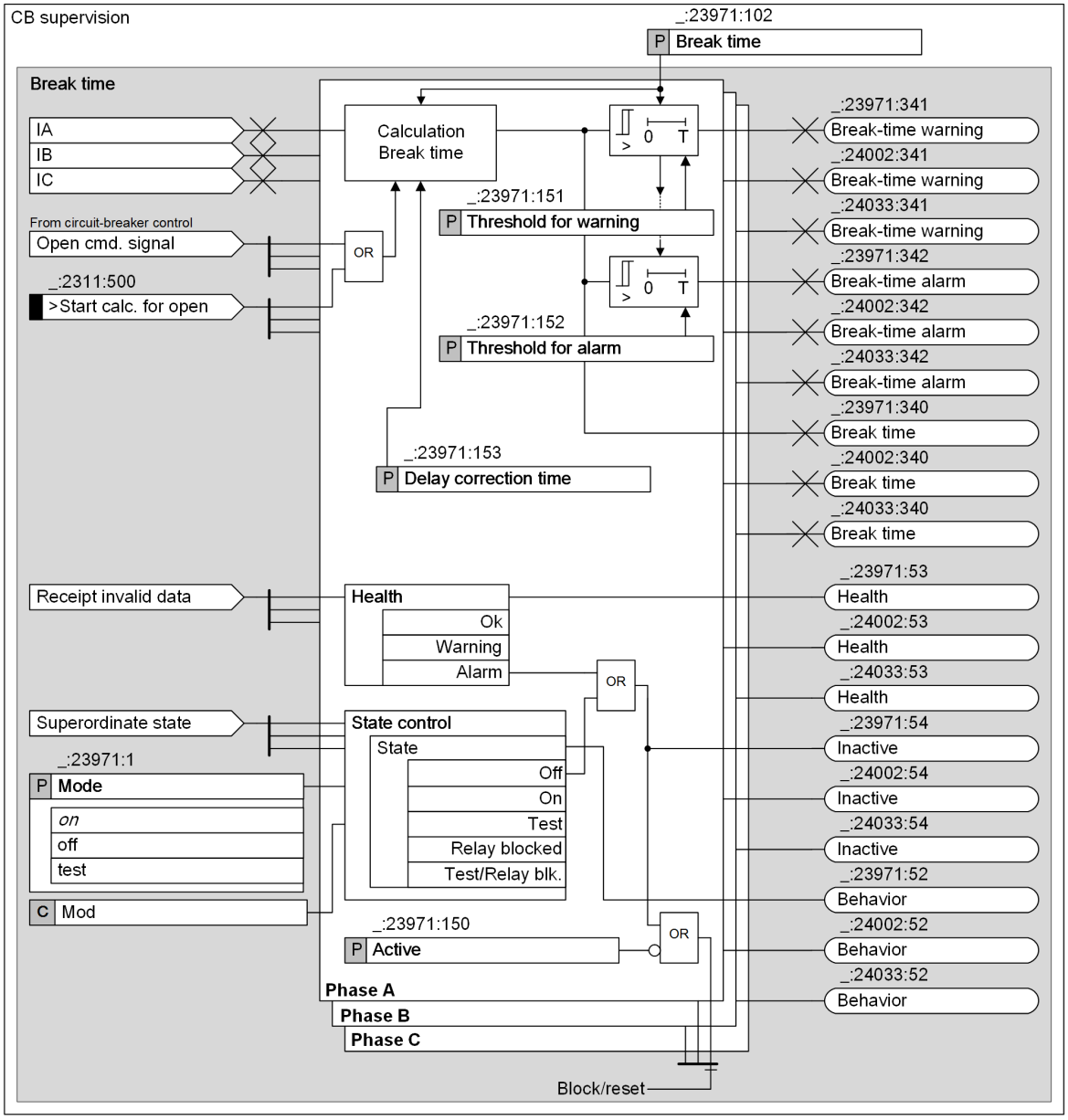
No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:23971:53	Phase A:Health	ENS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O

9.11.8 Break Time

9.11.8.1 Description

Logic of the Stage



[lo_LS-Überwachung_Ausschaltzeit, 1, en_US]

Figure 9-42 Logic of the Break Time

Operating Mode

The stage for the monitoring of the circuit-breaker break time calculates phase-selective the time between the circuit-breaker opening command and the point to which no load current flows. In the event of a restrike after the current was lost, the measurement of the break time is extended accordingly. If a current is still measured after 2.5 times of the value parameter **Break time**, the measurement is canceled and the output value *Break time* is set to 0 and marked with the quality invalid.

If no load current is measured at the time of the break time command, the measurement for the relevant phase is canceled and the output value *Break time* is marked with the quality invalid.

You can define 2 independent thresholds for the monitoring of the measured break time. When these thresholds are exceeded or undershot, the corresponding outputs ***Break-time warning*** and ***Break-time alarm*** are activated for 100 ms. These can be routed in the log.

9.11.8.2 Application and Setting Notes



NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: **Active**

- Default setting **(_:23971:150) Active** = ***inactive***

With the parameter **Active**, you switch on the method.

Parameter: **Threshold for warning**

- Default setting **(_:23971:151) Threshold for warning** = ***5 %***

With the parameter **Threshold for warning**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Break time** at the output ***Break time***, before the output ***Break-time warning*** is set. The output ***Break-time warning*** then drops out after 100 ms.

Parameter: **Threshold for alarm**

- Default setting **(_:23971:152) Threshold for alarm** = ***10 %***

With the parameter **Threshold for alarm**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Break time** at the output ***Break time***, before the output ***Break-time alarm*** is set. The output ***Break-time alarm*** then drops out after 100 ms.

Parameter: **Delay correction time**

- Default setting **(_:23971:153) Delay correction time** = ***0.000 s***

With the parameter **Delay correction time**, you define a correction value which will be subtracted from the ***Break time*** during calculation. This allows you to compensate delays caused by the system, for example, relay residual times, if necessary.

9.11.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Break time				
_:23971:150	Phase A:Active		• 0 • 1	False
_:23971:151	Phase A:Threshold for warning		1 % to 100 %	5 %
_:23971:152	Phase A:Threshold for alarm		1 % to 100 %	10 %
_:23971:153	Phase A:Delay correction time		-50 ms to 50 ms	0 ms
Break time				
_:24002:150	Phase B:Active		• 0 • 1	False
_:24002:151	Phase B:Threshold for warning		1 % to 100 %	5 %

Addr.	Parameter	C	Setting Options	Default Setting
_:24002:152	Phase B:Threshold for alarm		1 % to 100 %	10 %
_:24002:153	Phase B:Delay correction time		-50 ms to 50 ms	0 ms
Break time				
_:24033:150	Phase C:Active		• 0 • 1	False
_:24033:151	Phase C:Threshold for warning		1 % to 100 %	5 %
_:24033:152	Phase C:Threshold for alarm		1 % to 100 %	10 %
_:24033:153	Phase C:Delay correction time		-50 ms to 50 ms	0 ms

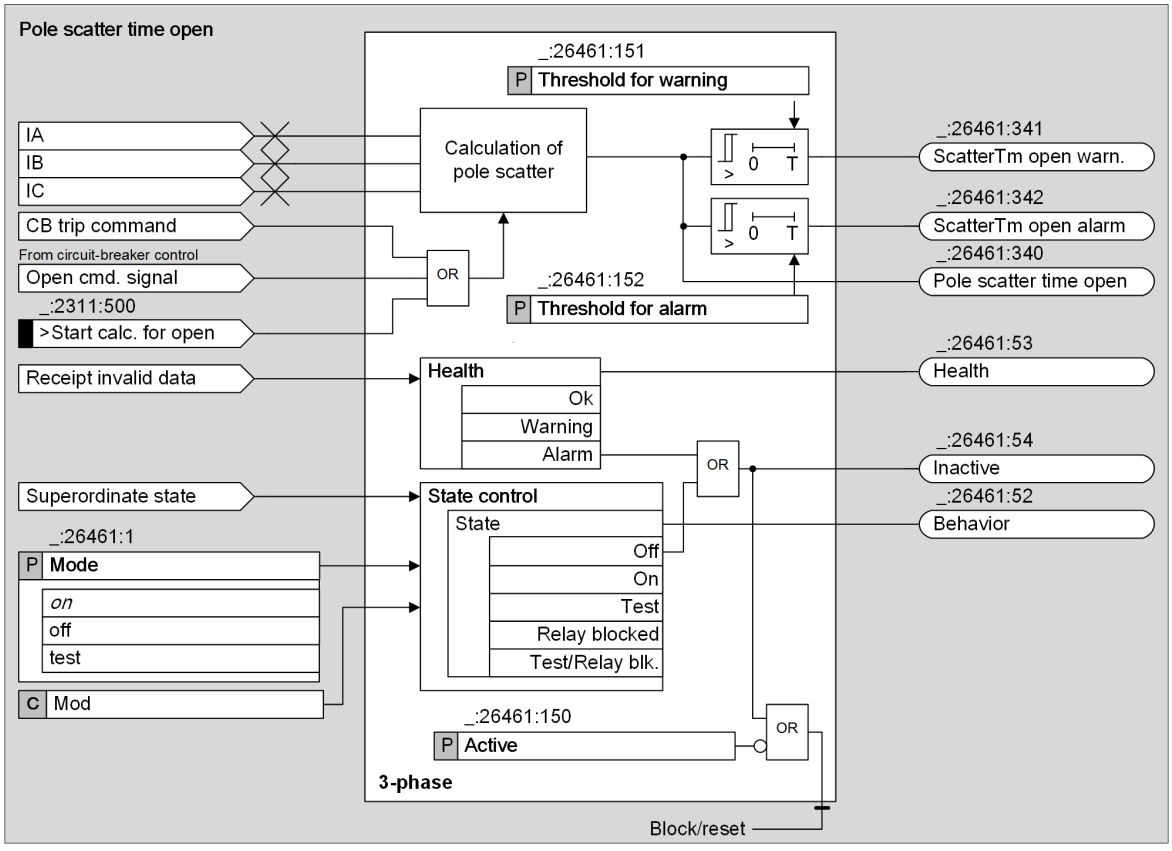
9.11.8.4 Information List

No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O

9.11.9 Pole Scatter Time Open

9.11.9.1 Description

Logic of the Stage

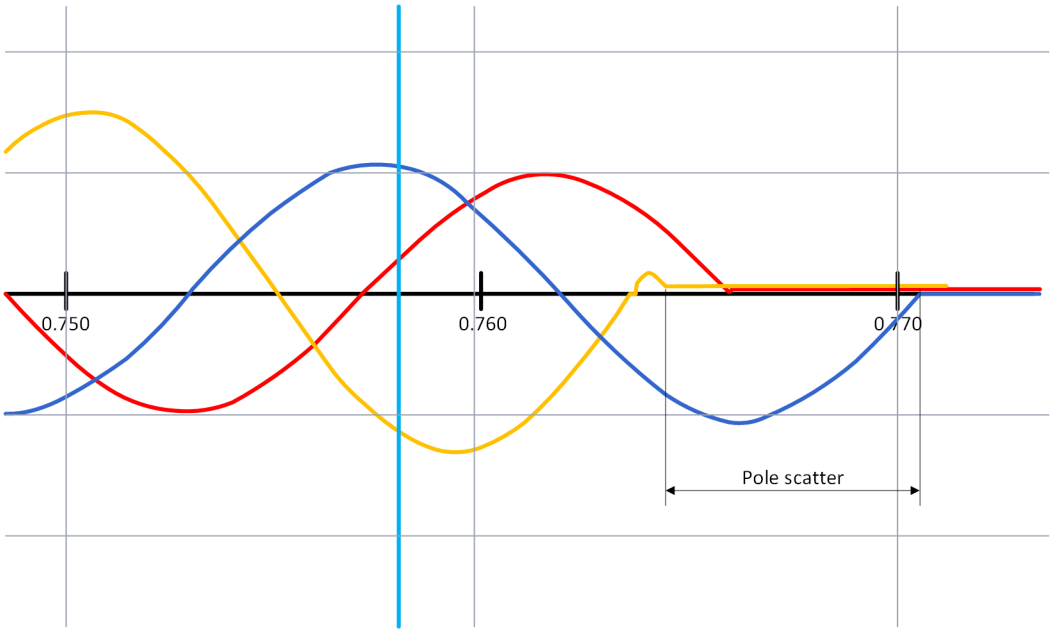


[lo_stage_pole-scatter_open, 1, en_US]

Figure 9-43 Logic of the Stage Pole Scatter Time Open

Operating Mode

The time between the extinction of the current of the first phase until the extinction of the last phase current when opening the circuit breaker is the pole scatter time. A greater time difference can lead to conclusions on the circuit-breaker abrasion.



[dw_charact_pole-scatter, 2, en_US]

Figure 9-44 Pole Scatter Time

The start criterion can be either the trip command of the circuit breaker or the input signal *>Start calc. for open*. You can set 2 independent threshold values for the supervision of the measured pole scatter time. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms.

9.11.9.2 Application and Setting Notes

Parameter: `Threshold for warning`

- Default setting **`(_:26461:151) Threshold for warning`** = ***5 ms***

With the parameter **`Threshold for warning`** , you define from which measured pole scatter time the output *ScatterTm open warn.* is set. The output *ScatterTm open warn.* drops out after 100 ms.

Parameter: `Threshold for alarm`

- Default setting **`(_:26461:152) Threshold for alarm`** = ***10 ms***

With the parameter **`Threshold for alarm`**, you define from which measured pole scatter time the output *ScatterTm open alarm* is set. The output *ScatterTm open alarm* drops out after 100 ms.

9.11.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Pole scatter time open				
_:26461:150	3-Phase:Active		• 0 • 1	unwahr
_:26461:151	3-Phase:Threshold for warning		1 ms to 100 ms	5 ms
_:26461:152	3-Phase:Threshold for alarm		1 ms to 100 ms	10 ms

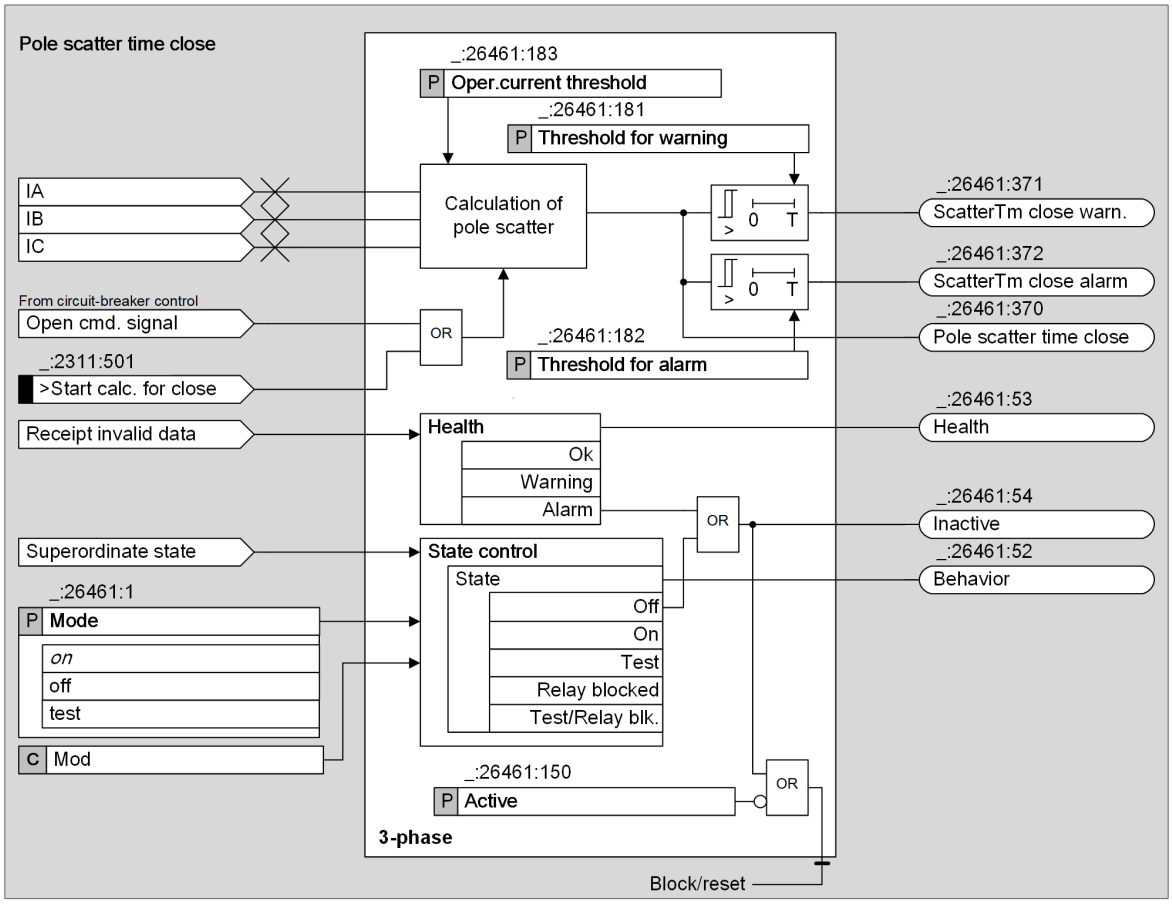
9.11.9.4 Information List

No.	Information	Data Class (Type)	Type
3-Phase			
_:26461:51	3-Phase:Mode (controllable)	ENC	C
_:26461:54	3-Phase:Inactive	SPS	O
_:26461:52	3-Phase:Behavior	ENS	O
_:26461:53	3-Phase:Health	ENS	O
_:26461:340	3-Phase:Pole scatter time open	MV	O
_:26461:341	3-Phase:ScatterTm open warn.	SPS	O
_:26461:342	3-Phase:ScatterTm open alarm	SPS	O

9.11.10 Pole Scatter Time Close

9.11.10.1 Description

Logic of the Stage



[lo_stage_pole-scatter_close, 1, en_US]

Figure 9-45 Logic of the Stage Pole Scatter Time Close

Operating Mode

The time between reaching the operating current threshold of the first phase and reaching the operating current threshold of the last phase when closing the circuit breaker is the pole scatter time. A change of the time difference can lead to conclusions on the wear condition of the circuit breaker.

The start criterion can be either the close command of the circuit breaker or the input signal *>Start calc. for close*. You can set 2 independent threshold values for monitoring the measured pole scatter time. If a threshold value is exceeded, the corresponding output *Warning/alarm* is activated for 100 ms.

If the calculation is not finished after one second, it is canceled and the output signal *Pole scatter time close* is set to 0 and marked with the quality *invalid*.

9.11.10.2 Application and Setting Notes

Parameter: Threshold for warning

- Default setting **(_:26461:181) Threshold for warning** = ***5 ms***

With the parameter **Threshold for warning**, you define from which measured pole scatter time the output *ScatterTm close warn.* is set. The output *ScatterTm close warn.* drops out after 100 ms.

Parameter: Threshold for alarm

- Default setting **(_:26461:182) Threshold for alarm** = ***10 ms***

With the parameter **Threshold for alarm**, you define from which measured pole scatter time the output *ScatterTm close alarm* is set. The output *ScatterTm close alarm* drops out after 100 ms.

Parameter: Oper.current threshold

- Default setting **(_:26461:183) Oper.current threshold** = ***0.1 A***

With the parameter **Oper.current threshold**, you define from which measured current the poles of the circuit breaker are considered to be closed. The pole scattering time is determined from the time span between exceeding the threshold of the 1st phase and exceeding the threshold of the last phase.

9.11.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Pole scatter time close				
_:26461:180	3-Phase: Active		• 0 • 1	false
_:26461:181	3-Phase: Threshold for warning		1 ms to 100 ms	5 ms
_:26461:182	3-Phase: Threshold for alarm		1 ms to 100 ms	10 ms
_:26461:183	3-Phase: 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

9.11.10.4 Information List

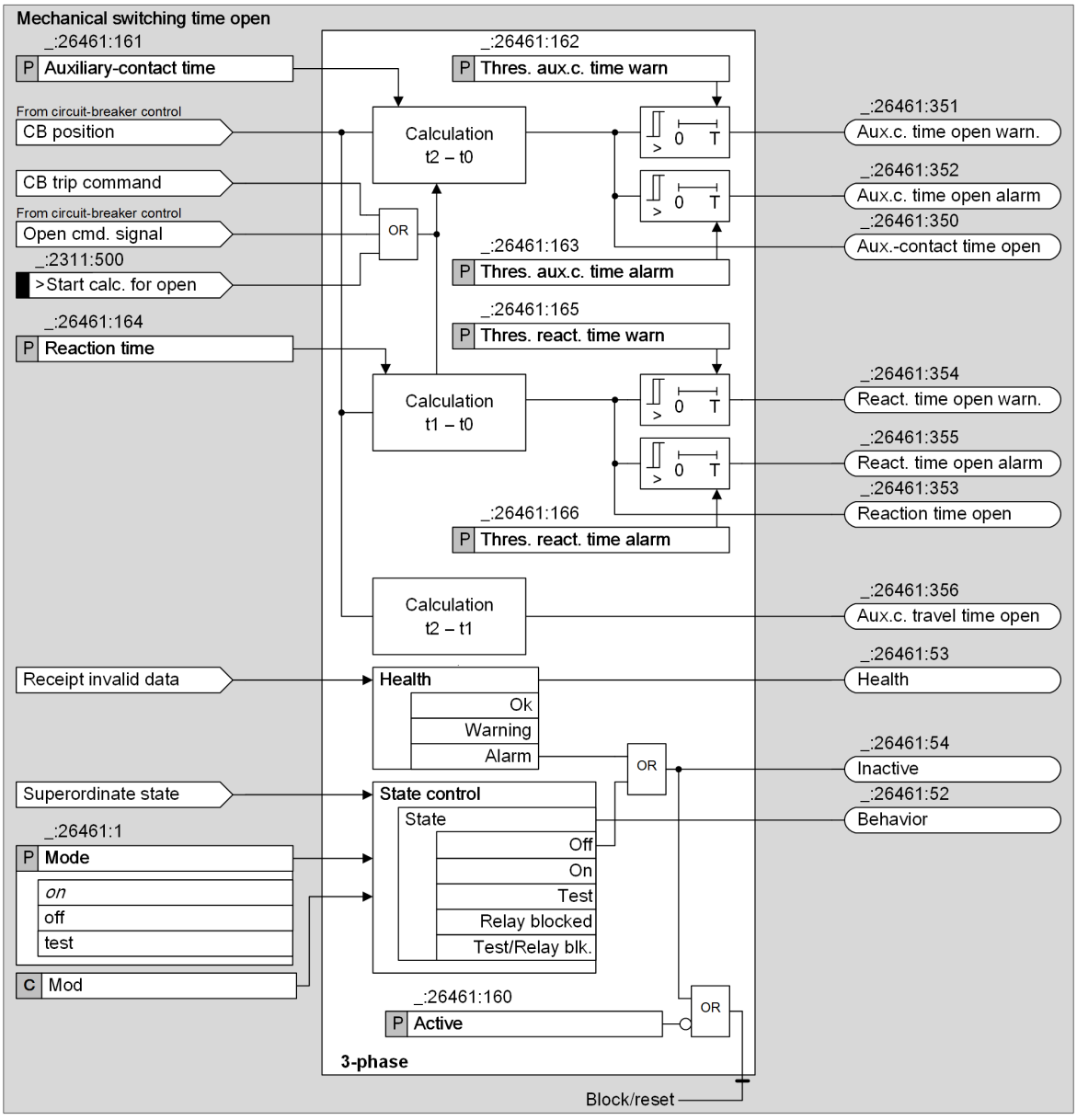
No.	Information	Data Class (Type)	Type
3-Phase			
_:26461:51	3-Phase: Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:26461:54	3-Phase: Inactive	SPS	O
_:26461:52	3-Phase: Behavior	ENS	O
_:26461:53	3-Phase: Health	ENS	O
_:26461:370	3-Phase: Pole scatter time close	MV	O
_:26461:371	3-Phase: ScatterTm close warn.	SPS	O
_:26461:372	3-Phase: ScatterTm close alarm	SPS	O

9.11.11 Mechanical Switching Time Open

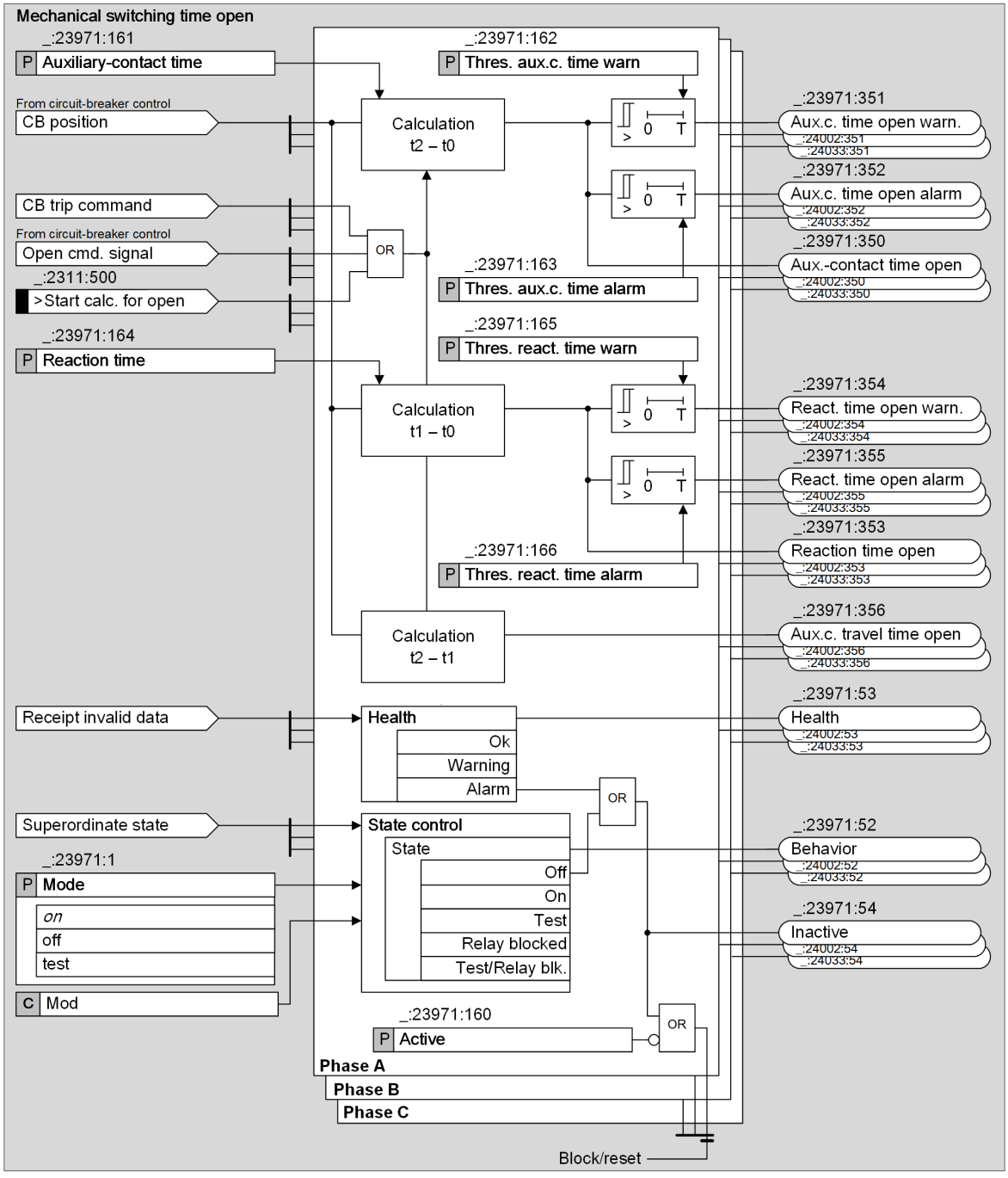
9.11.11.1 Description

Logic of the Stage



[lo_mechanical_Break-time_3phs, 1, en_US]

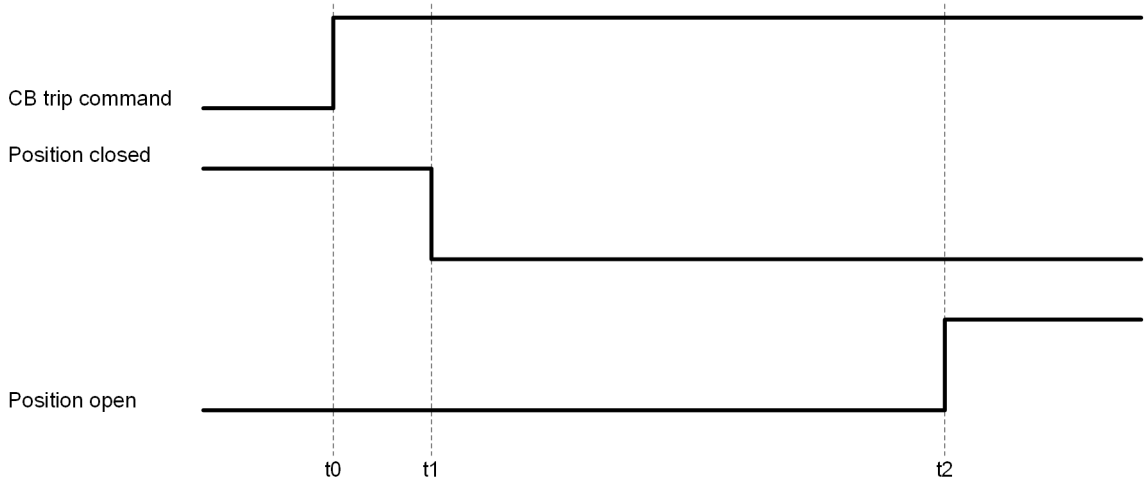
Figure 9-46 Logic of the Stage Mechanical Switching Time Open for Circuit Breakers 3-Pole



[lo_mechanical_Break-time_1phs, 1, en_US]

Figure 9-47 Logic of the Stage Mechanical Switching Time Open for Circuit Breakers 1-Pole

Operating Mode



[dw_charact_cb-breaktime, 1, en_US]

t2 - t0: Auxiliary-contact time opening

t1 - t0: Response time opening

t2 - t1: Auxiliary-contact moving time opening

The stage for supervision of the mechanical switching time opening of the circuit breaker measures the time between the starting criterion (t0) and the point in time when the position of the circuit breaker switches to **Intermediate position** (t1). The stage measures the time between the starting criterion (t0) and the point in time when the position of the circuit breaker switches to **Open** (t2). Additionally, it calculates the auxiliary-contact moving time from the intermediate position (t1) until reaching the position **Open** (t2).

The starting criterion can be either the opening command of the circuit breaker, trip from a protection function or the input signal *>Start calc. for open*.

You can set 2 independent threshold values for the supervision of the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can set 2 independent threshold values for the supervision of the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, only the calculated time is to be indicated. There is no warning or alarm threshold.

If you use a 1-pole circuit breaker, the settings and indications are phase-selective. For 3-pole circuit breakers times cannot be determined phase selective. The settings are done in the section **3-phase**.

A precondition for the monitoring of the mechanical switching times is the routing of the open and closed circuit-breaker position in the function group **Circuit breaker**. If you route only one or no circuit-breaker feedbacks, the function **Mechanical switching time open** cannot work and indicates the status *Warning*.

9.11.11.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: **Auxiliary-contact time**

- Default setting **(_:24002:161) Auxiliary-contact time** = ***35 ms***

With the parameter **Auxiliary-contact time**, you define the time period from the circuit-breaker open command until the feedback contacts of the CB indicate **Open**.

Parameter: **Thres. aux.c. time warn**

- Default setting **(_:24002:162) Thres. aux.c. time warn** = ***5 ms***

With the parameter **Thres. aux.c. time warn**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output *Aux.c. time open warn.* is set. The output *Aux.c. time open warn.* drops out after 100 ms.

Parameter: **Thres. aux.c. time alarm**

- Default setting **(_:24002:163) Thres. aux.c. time alarm** = *10 ms*

With the parameter **Thres. aux.c. time alarm**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output *Aux.c. time open alarm* is set. The output *Aux.c. time open alarm* drops out after 100 ms.

Parameter: **Reaction time**

- Default setting **(_:24002:164) Reaction time** = *15 ms*

With the parameter **Reaction time**, you define the time between the circuit-breaker opening command and the indication **Intermediate position** by the feedback contacts of the CB.

Parameter: **Thres. react. time warn**

- Default setting **(_:24002:165) Thres. react. time warn** = *3 ms*

With the parameter **Thres. react. time warn**, you define by how many ms the reaction time can be exceeded or undershot before the output *React. time open warn.* is set. The output *React. time open warn.* drops out after 100 ms.

Parameter: **Thres. react. time alarm**

- Default setting **(_:24002:166) Thres. react. time alarm(_:24033:166) Thres. react. time alarm** = *5 ms*

With the parameter **Thres. react. time alarm**, you define by how many ms the reaction time can be exceeded or undershot before the output *React. time open alarm* is set. The *React. time open alarm* drops out after 100 ms.

9.11.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time open				
_:26461:160	3-Phase:Active		• 0 • 1	unwahr
_:26461:161	3-Phase:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:26461:162	3-Phase:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:26461:163	3-Phase:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:26461:164	3-Phase:Reaction time		1 ms to 1000 ms	15 ms
_:26461:165	3-Phase:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:26461:166	3-Phase:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time open				
_:23971:160	Phase A:Active		• 0 • 1	unwahr
_:23971:161	Phase A:Auxiliary-contact time		1 ms to 1000 ms	35 ms

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:162	Phase A:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:23971:163	Phase A:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:23971:164	Phase A:Reaction time		1 ms to 1000 ms	15 ms
_:23971:165	Phase A:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:23971:166	Phase A:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time open				
_:24002:160	Phase B:Active		• 0 • 1	unwahr
_:24002:161	Phase B:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24002:162	Phase B:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24002:163	Phase B:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24002:164	Phase B:Reaction time		1 ms to 1000 ms	15 ms
_:24002:165	Phase B:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24002:166	Phase B:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time open				
_:24033:160	Phase C:Active		• 0 • 1	unwahr
_:24033:161	Phase C:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24033:162	Phase C:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24033:163	Phase C:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24033:164	Phase C:Reaction time		1 ms to 1000 ms	15 ms
_:24033:165	Phase C:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24033:166	Phase C:Thres. react. time alarm		1 ms to 1000 ms	5 ms

9.11.11.4 Information List

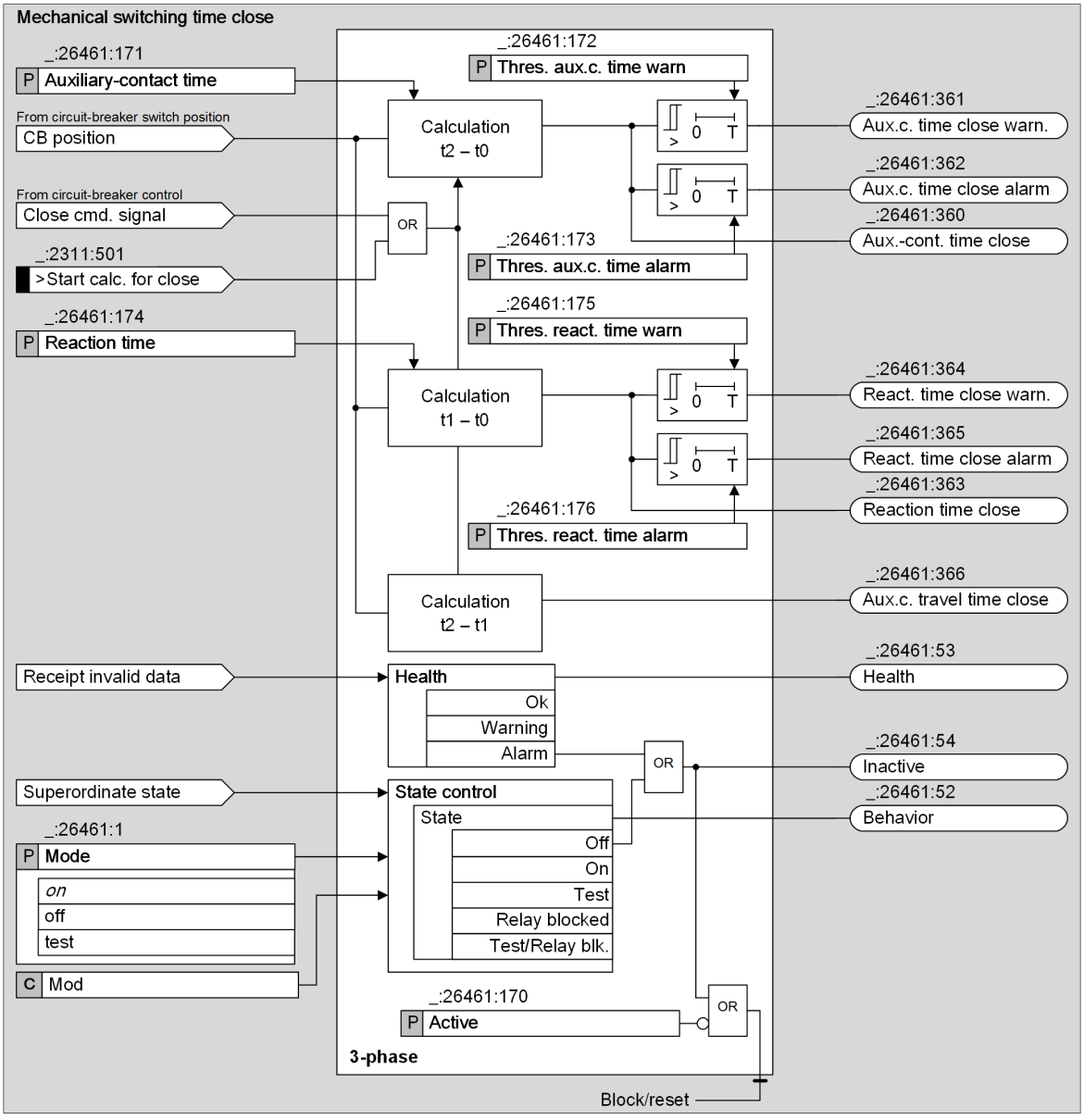
No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calc. for open	SPS	I
3-Phase			
_:26461:350	3-Phase:Aux.-contact time open	MV	O
_:26461:351	3-Phase:Aux.c. time open warn.	SPS	O
_:26461:352	3-Phase:Aux.c. time open alarm	SPS	O
_:26461:353	3-Phase:Reaction time open	MV	O
_:26461:354	3-Phase:React. time open warn.	SPS	O

No.	Information	Data Class (Type)	Type
_:26461:355	3-Phase:React. time open alarm	SPS	O
_:26461:356	3-Phase:Aux.c. travel time open	MV	O
Phase A			
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
Phase B			
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
Phase C			
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O

9.11.12 Mechanical Switching Time Close

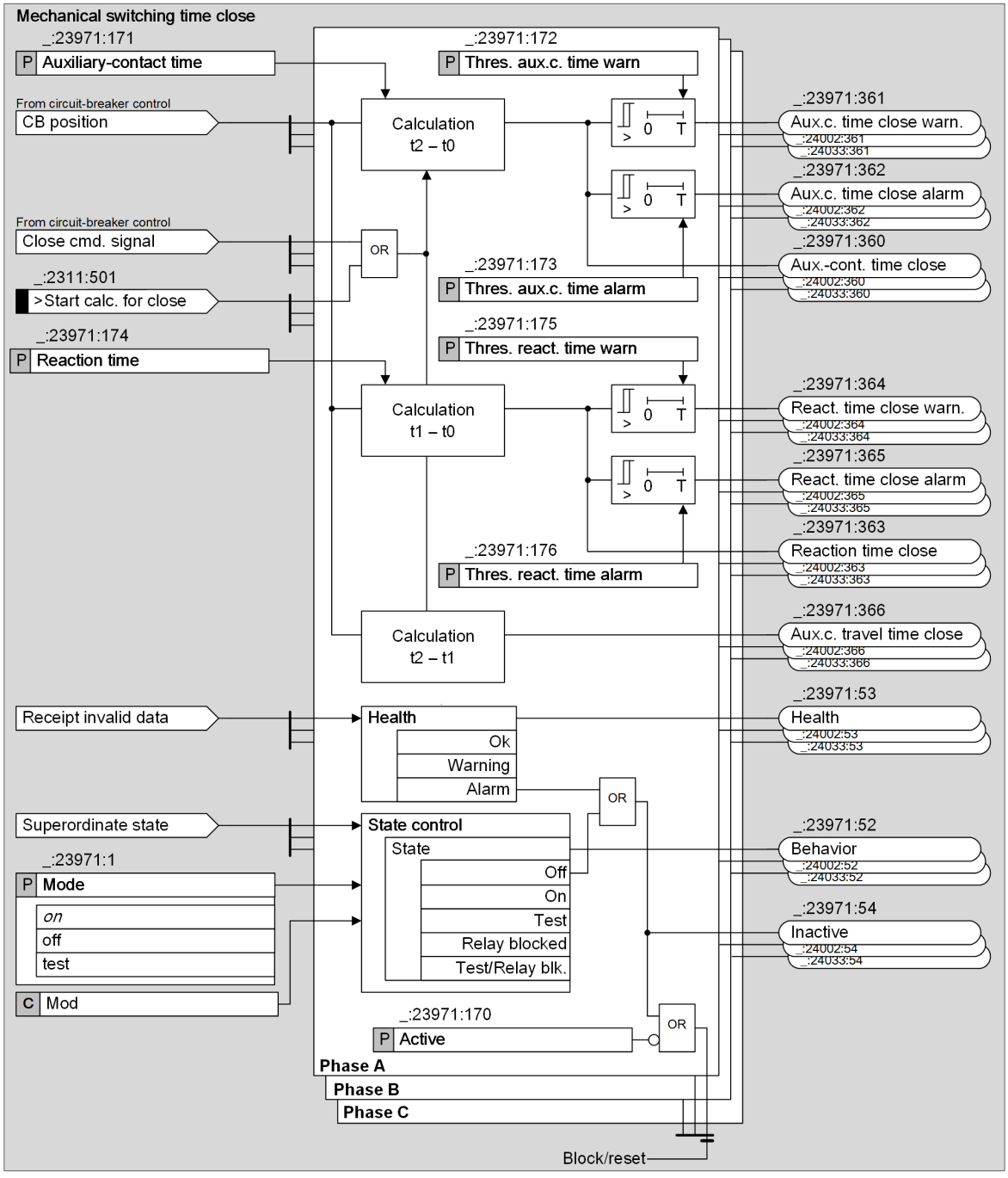
9.11.12.1 Description

Logic of the Stage



[lo_mechanical_Make-time_3phs, 1, en_US]

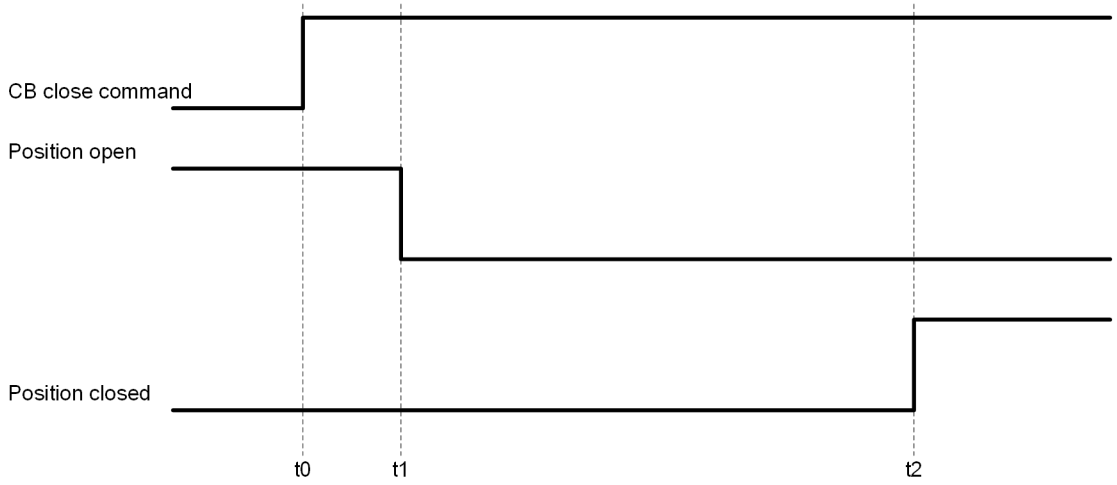
Figure 9-48 Logic of the Stage Mechanical Switching Time Close for Circuit Breakers 3-Pole



[lo_mechanical_Make-time_1phs, 1, en_US]

Figure 9-49 Logic of the Stage Mechanical Switching Time Close for Circuit Breakers 1-Pole

Operating Mode



[dw_charact_cb-maketime, 1, en_US]

t2 - t0: Auxiliary-contact time closing

t1 - t0: Response time closing

t2 - t1: Auxiliary-contact moving time closing

The stage for supervision of the mechanical switching time closing of the circuit breaker measures the time between the closing command of the circuit breaker (t0) and the point in time when the position of the circuit breaker switches to **Intermediate position** (t1). The stage measures the time between the close command of the circuit breaker (t0) and the point in time when the position of the circuit breaker switches to **Close** (t2). Additionally, it calculates the auxiliary-contact moving time from the intermediate position (t1) until reaching the position **Close** (t2).

The starting criterion can be either the closing command of the circuit breaker or the input signal *>Start calc. for close*.

You can set 2 independent threshold values for the supervision of the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can set 2 independent threshold values for the supervision of the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, only the calculated time is to be indicated. There is no warning or alarm threshold.

If you use a 1-pole circuit breaker, the settings and indications are phase-selective. For 3-pole circuit breakers times cannot be determined phase selective. The settings are done in the section **3-phase**.

A precondition for the monitoring of the mechanical switching times is the routing of the open and closed circuit-breaker position in the function group **Circuit breaker**. If you route only one or no circuit-breaker feedbacks, the function **Mechanical switching time close** cannot work and indicates the status *Warning*.

9.11.12.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: **Auxiliary-contact time**

- Default setting **(_:23971:171) Auxiliary-contact time** = *35 ms*

With the parameter **Auxiliary-contact time**, you define the time period from the circuit-breaker close command until the feedback contacts of the CB indicate **Closed**.

Parameter: **Thres. aux.c. time warn**

- Default setting **(_:23971:172) Thres. aux.c. time warn** = ***5 ms***

With the parameter **Thres. aux.c. time warn**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output ***Aux.c. time close warn.*** is set. The output ***Aux.c. time close warn.*** drops out after 100 ms.

Parameter: **Thres. aux.c. time alarm**

- Default setting **(_:23971:173) Thres. aux.c. time alarm** = ***10 ms***

With the parameter **Thres. aux.c. time alarm**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output ***Aux.c. time close alarm*** is set. The output ***Aux.c. time close alarm*** drops out after 100 ms.

Parameter: **Reaction time**

- Default setting **(_:23971:174) Reaction time** = ***15 ms***

With the parameter **Reaction time**, you define the time between the circuit-breaker closing command and the indication **Intermediate position** by the feedback contacts of the CB.

Parameter: **Thres. react. time warn**

- Default setting **(_:23971:175) Thres. react. time warn** = ***3 ms***

With the parameter **Thres. react. time warn**, you define by how many ms the reaction time can be exceeded or undershot before the output ***React. time close warn.*** is set. The output ***React. time close warn.*** drops out after 100 ms.

Parameter: **Thres. react. time alarm**

- Default setting **(_:23971:176) Thres. react. time alarm** = ***5 ms***

With the parameter **Thres. react. time alarm**, you define by how many ms the reaction time can be exceeded or undershot before the output ***React. time close alarm*** is set. The ***React. time close alarm*** drops out after 100 ms.

9.11.12.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time close				
_:26461:170	3-Phase:Active		• 0 • 1	unwahr
_:26461:171	3-Phase:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:26461:172	3-Phase:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:26461:173	3-Phase:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:26461:174	3-Phase:Reaction time		1 ms to 1000 ms	15 ms
_:26461:175	3-Phase:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:26461:176	3-Phase:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time close				
_:23971:170	Phase A:Active		• 0 • 1	unwahr

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:171	Phase A:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:23971:172	Phase A:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:23971:173	Phase A:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:23971:174	Phase A:Reaction time		1 ms to 1000 ms	15 ms
_:23971:175	Phase A:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:23971:176	Phase A:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time close				
_:24002:170	Phase B:Active		• 0 • 1	unwahr
_:24002:171	Phase B:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24002:172	Phase B:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24002:173	Phase B:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24002:174	Phase B:Reaction time		1 ms to 1000 ms	15 ms
_:24002:175	Phase B:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24002:176	Phase B:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time close				
_:24033:170	Phase C:Active		• 0 • 1	unwahr
_:24033:171	Phase C:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24033:172	Phase C:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24033:173	Phase C:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24033:174	Phase C:Reaction time		1 ms to 1000 ms	15 ms
_:24033:175	Phase C:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24033:176	Phase C:Thres. react. time alarm		1 ms to 1000 ms	5 ms

9.11.12.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Start calc. for close	SPS	I
3-Phase			
_:26461:360	3-Phase:Aux.-cont. time close	MV	O
_:26461:361	3-Phase:Aux.c. time close warn.	SPS	O
_:26461:362	3-Phase:Aux.c. time close alarm	SPS	O

No.	Information	Data Class (Type)	Type
_:26461:363	3-Phase:Reaction time close	MV	O
_:26461:364	3-Phase:React. time close warn.	SPS	O
_:26461:365	3-Phase:React. time close alarm	SPS	O
_:26461:366	3-Phase:Aux.c. travel time close	MV	O
Phase A			
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12 Disconnector-Switch Monitoring

9.12.1 Overview of Functions

The function **Disconnector supervision**:

- Detects and reports temporal changes in the switching procedure of disconnectors

9.12.2 Structure of the Function

The function **Disconnector supervision** can be used in the function group **Disconnector**.
The function consists of 2 independent operating procedures:

- **Mechanical switching time open**
  Monitoring of the mechanical switching time for the opening operation, detected via the feedback contacts
- **Mechanical switching time close**
  Monitoring of the mechanical switching time for the closing operation, detected via the feedback contacts

9.12.3 General Functionality

9.12.3.1 Description

Start Criterion for the Function Disconnector Supervision

The operating procedure **Mechanical switching time close** is started if one of the following criteria is met:

- The disconnector is closed via a command.
- The binary input signal *>Start calc. for close* is initiated, for example, via an external signal.

The operating procedure **Mechanical switching time open** is started if one of the following criteria is met:

- The disconnector is opened via a command.
- The binary input signal *>Start calc. for open* is initiated, for example, via an external signal.

9.12.3.2 Application and Setting Notes

Parameter: Mode

- Default setting **(_:26671:1) Mode** = ***on***

With the parameter **Mode**, you can switch the disconnector supervision ***on***, ***off***, or in ***test*** mode.

9.12.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:26671:1	Discon. monit.:Mode		• off • on • test	on

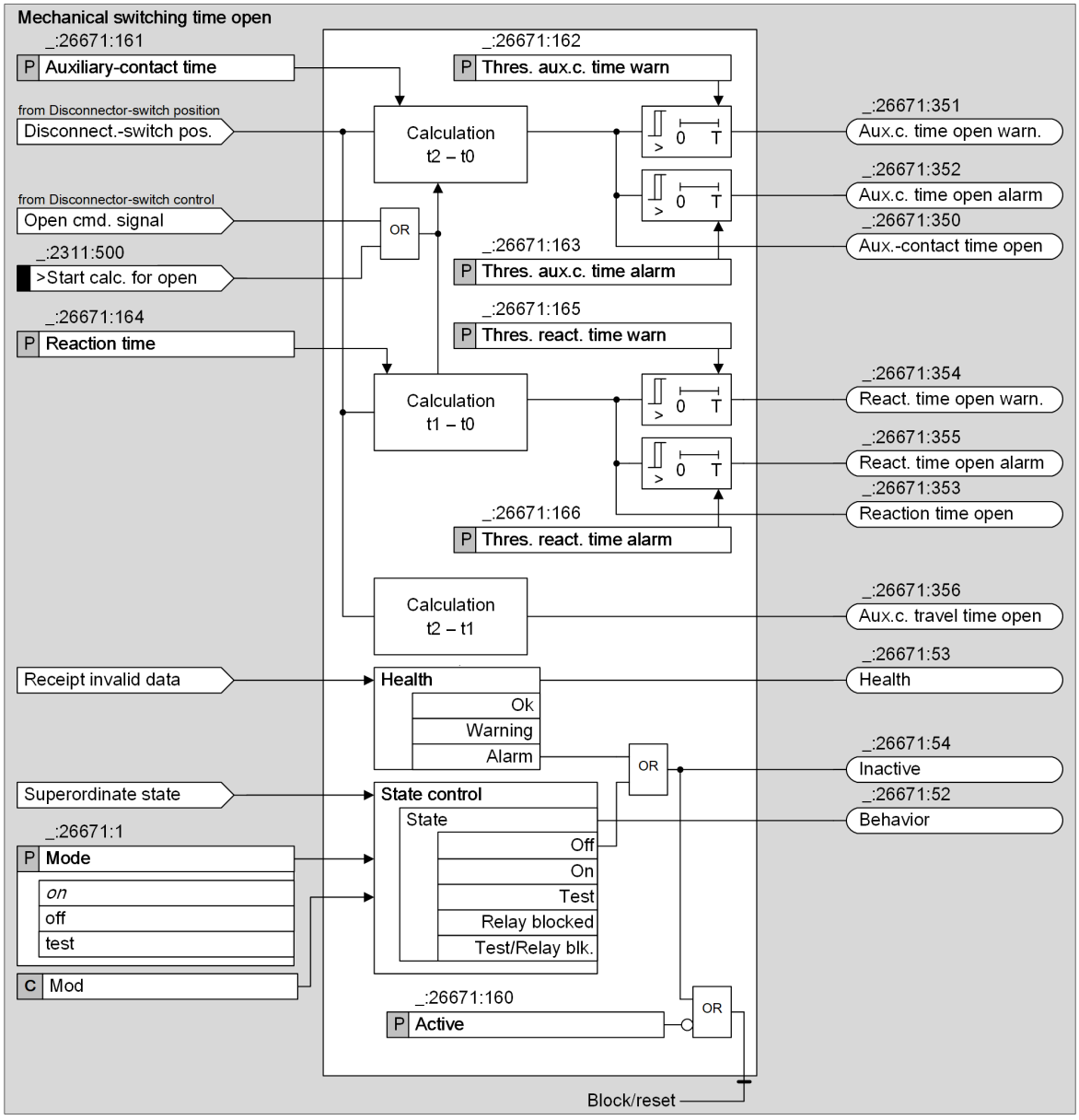
9.12.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calc. for open	SPS	I
_:2311:501	General:>Start calc. for close	SPS	I

9.12.4 Mechanical Switching Time Open

9.12.4.1 Description

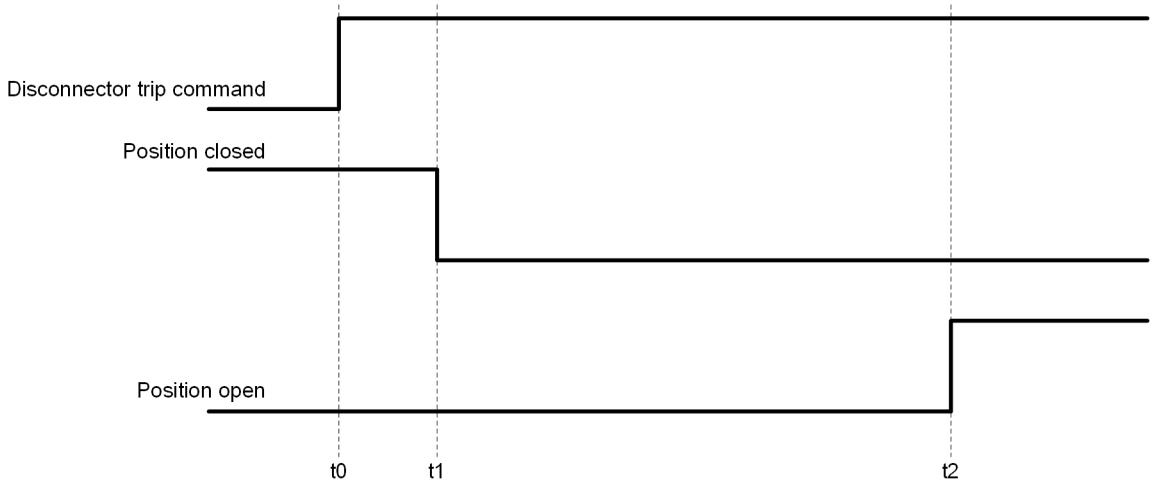
Logic of the Stage



{lo_mechanical_make-time_open, 1, en_US}

Figure 9-50 Logic of the Stage Mechanical Switching Time for Disconnector

Method of Operation



[dw_charact_dcs-maketime_op, 1, en_US]

1) t2 - t0: Auxiliary contact time open operation
2) t1 - t0: Reaction time open operation
3) t2 - t1: Auxiliary contact dead time open operation

The stage for monitoring the **mechanical switching time open** of the disconnector calculates the time between the start criterion (t0) and the time when the disconnector-switch position changes to the **intermediate position** (t1). The stage measures the time between the start criterion (t0) and the time when the disconnector-switch position changes to **open** (t2). Additionally, the stage calculates the time of the auxiliary contacts between the **intermediate position** (t1) until the **open** position is reached (t2).

The start criterion can be either the switching command **open** of the disconnector or the input signal *>Start calc. for open*.

You can define 2 independent threshold values for monitoring the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can define 2 independent threshold values for monitoring the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, the calculated time must be displayed. There is no warning or alarm threshold.

For monitoring the mechanical switching times, you must route the open and closed disconnector-switch position in the function group **Disconnector**. If you route only one or no disconnector feedback, the function **Mechanical switching time open** cannot work and issues the state *Warning*.

9.12.4.2 Application and Setting Notes

Parameter: **Auxiliary-contact time**

- Default setting **(_:26671:161) Auxiliary-contact time** = *10 s*

With the parameter **Auxiliary-contact time**, you to define the duration between the disconnector trip command and the feedback contacts signaling the **open** position.

Parameter: **Thres. aux.c. time warn**

- Default setting **(_:26671:162) Thres. aux.c. time warn** = *12 s*

With the parameter **Thres. aux.c. time warn**, you define by how many seconds the auxiliary-contact time may be undercut or exceeded for the output *Aux.c. time open warn.* to be set. The output *Aux.c. time open warn.* drops out after 100 ms.

Parameter: **Thres. aux.c. time alarm**

- Default setting **(_:26671:163) Thres. aux.c. time alarm** = *14 s*

With the parameter **Thres. aux.c. time alarm**, you define by how many seconds the auxiliary-contact time may be undercut or exceeded for the output *Aux.c. time open alarm* to be set. The output *Aux.c. time open alarm* drops out after 100 ms.

Parameter: Reaction time

- Default setting **(_:26671:164) Reaction time** = *2 s*

With the parameter **Reaction time**, you define the duration between the disconnector trip command and the feedback contacts signaling the **intermediate position**.

Parameter: Thres. react. time warn

- Default setting **(_:26671:165) Thres. react. time warn** = *2.4 s*

With the parameter **Thres. react. time warn**, you define by how many seconds the reaction time may be undercut or exceeded for the output *React. time open warn.* to be set. The output *React. time open warn.* drops out after 100 ms.

Parameter: Thres. react. time alarm

- Default setting **(_:26671:166) Thres. react. time alarm** = *2.8 s*

With the parameter **Thres. react. time alarm**, you define by how many seconds the reaction time may be undercut or exceeded for the output *React. time open alarm* to be set. The output *React. time open alarm* drops out after 100 ms.

9.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time open				
_:26671:160	Discon. monit.:Active		• 0 • 1	false
_:26671:161	Discon. monit.:Auxiliary-contact time		0.02 s to 1800.00 s	10.00 s
_:26671:162	Discon. monit.:Thres. aux.c. time warn		0.02 s to 1800.00 s	12.00 s
_:26671:163	Discon. monit.:Thres. aux.c. time alarm		0.02 s to 1800.00 s	14.00 s
_:26671:164	Discon. monit.:Reaction time		0.02 s to 1800.00 s	2.00 s
_:26671:165	Discon. monit.:Thres. react. time warn		0.02 s to 1800.00 s	2.40 s
_:26671:166	Discon. monit.:Thres. react. time alarm		0.02 s to 1800.00 s	2.80 s

9.12.4.4 Information List

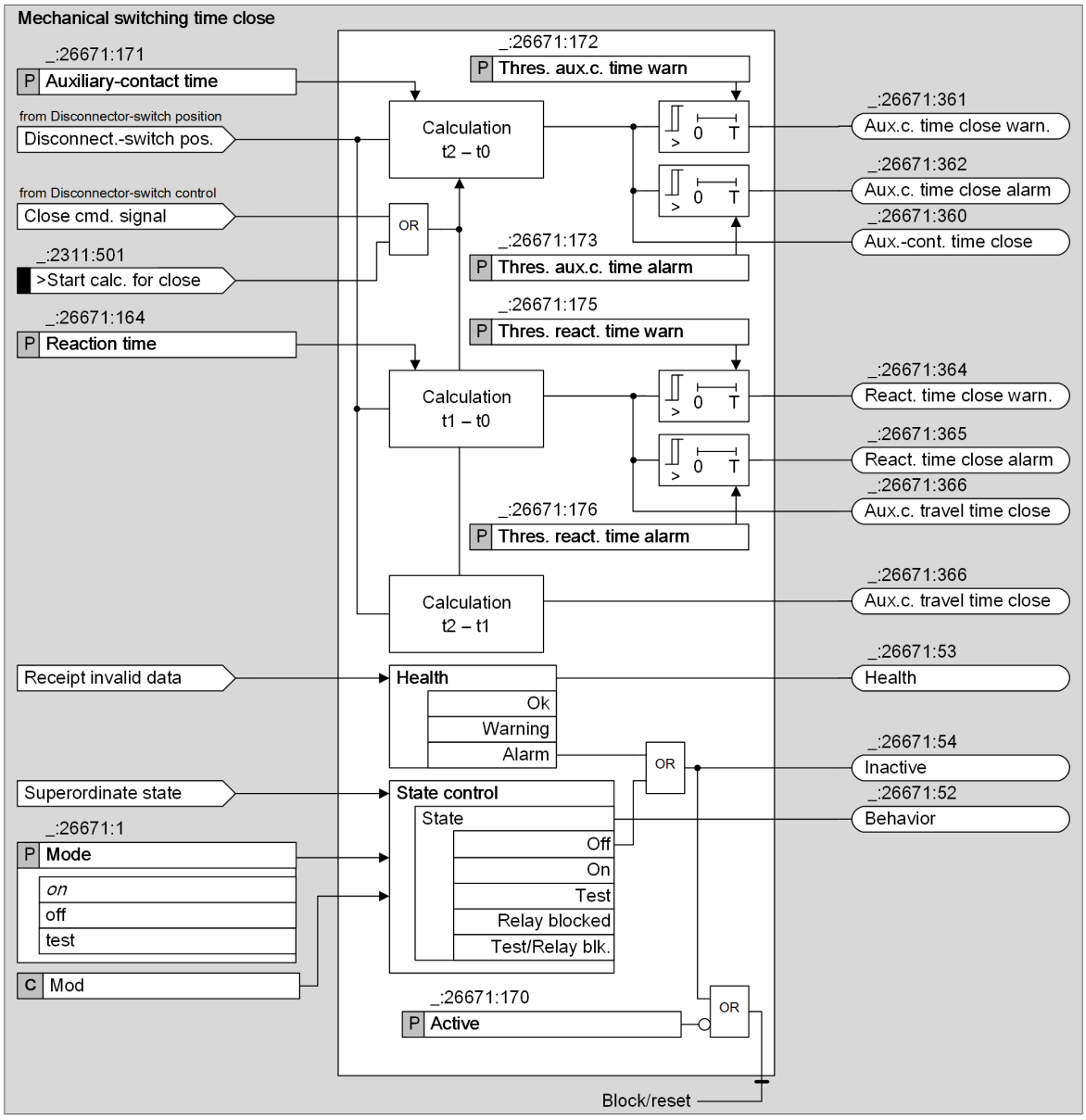
No.	Information	Data Class (Type)	Type
Discon. monit.			
_:26671:51	Discon. monit.:Mode (controllable)	ENC	C
_:26671:54	Discon. monit.:Inactive	SPS	O
_:26671:52	Discon. monit.:Behavior	ENS	O
_:26671:53	Discon. monit.:Health	ENS	O
_:26671:350	Discon. monit.:Aux.-contact time open	MV	O
_:26671:351	Discon. monit.:Aux.c. time open warn.	SPS	O

No.	Information	Data Class (Type)	Type
_:26671:352	Discon. monit.:Aux.c. time open alarm	SPS	O
_:26671:353	Discon. monit.:Reaction time open	MV	O
_:26671:354	Discon. monit.:React. time open warn.	SPS	O
_:26671:355	Discon. monit.:React. time open alarm	SPS	O
_:26671:356	Discon. monit.:Aux.c. travel time open	MV	O

9.12.5 Mechanical Switching Time Close

9.12.5.1 Description

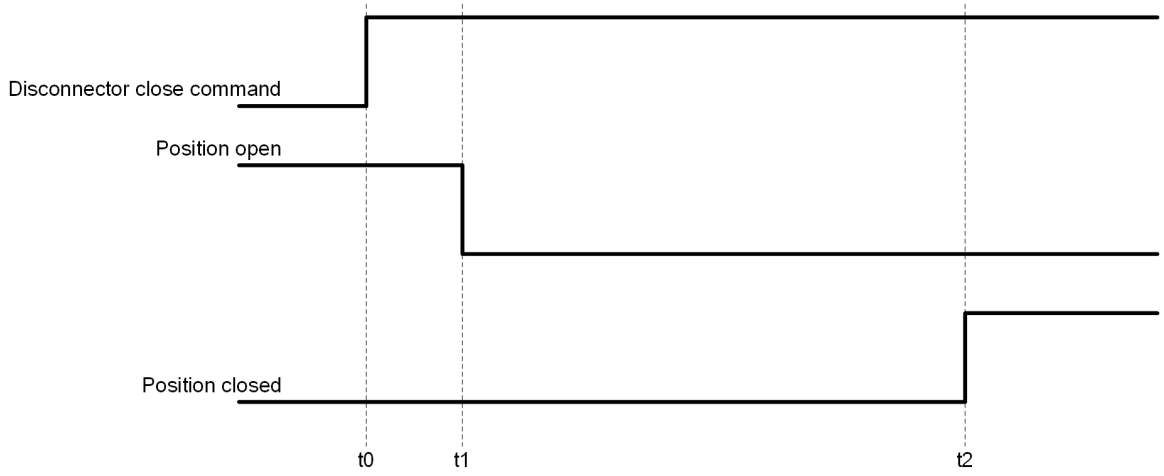
Logic of the Stage



[lo_mechanical_break-time_clo, 1, en_US]

Figure 9-51 Logic of the Stage Mechanical Switching Time Close for Disconnector

Method of Operation



[dw_charact_dcs-breaktime_clo, 1, en_US]

1) t2 - t0: Auxiliary contact time close operation
2) t1 - t0: Reaction time close operation
3) t2 - t1: Auxiliary contact dead time close operation

The stage for monitoring the **mechanical switching time close** of the disconnector measures the time between the disconnector close command (t0) and the time when the disconnector-switch position changes to the **intermediate position**. The stage measures the time between the disconnector close command (t0) and the time when the disconnector-switch position changes to **closed** (t2). Additionally, the stage calculates the time of the auxiliary contacts between the **intermediate position** (t1) until the **closed** position is reached (t2).

The start criterion can be either the disconnector close command or the input signal *>Start calc. for close*.

You can define 2 independent threshold values for monitoring the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can define 2 independent threshold values for monitoring the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, only the measured time must be reported. There is no warning or alarm threshold.

For monitoring the mechanical switching times, you must route the open and closed disconnector-switch position in the function group **Disconnector**. If you route only one or no disconnector feedback, the function **Mechanical switching time close** cannot work and issues the state *Warning*.

9.12.5.2 Application and Setting Notes

Parameter: Auxiliary-contact time

- Default setting **(_:26671:171) Auxiliary-contact time** = *10 s*

With the parameter **Auxiliary-contact time**, you define the duration between the disconnector close command and the feedback contacts signaling the **closed** position.

Parameter: Thres. aux.c. time warn

- Default setting **(_:26671:172) Thres. aux.c. time warn** = *12 s*

With the parameter **Thres. aux.c. time warn**, you define by how many seconds the auxiliary contact time may be undercut or exceeded for the output *Aux.c. time close warn.* to be set. The output *Aux.c. time close warn.* drops out after 100 ms.

Parameter: **Thres. aux.c. time alarm**

- Default setting **(_:26671:173) Thres. aux.c. time alarm** = ***14 s***

With the parameter **Thres. aux.c. time alarm**, you define by how many seconds the auxiliary contact time may be undercut or exceeded for the output ***Aux.c. time close alarm*** to be set. The output ***Aux.c. time close alarm*** drops out after 100 ms.

Parameter: **Reaction time**

- Default setting **(_:26671:174) Reaction time** = ***2 s***

With the parameter **Reaction time**, you define the duration between the disconnector close command and the feedback contacts signaling the **intermediate position**.

Parameter: **Thres. react. time warn**

- Default setting **(_:26671:175) Thres. react. time warn** = ***2.4 s***

With the parameter **Thres. react. time warn**, you define by how many seconds the reaction time may be undercut or exceeded for the output ***React. time close warn.*** to be set. The output ***React. time close warn.*** drops out after 100 ms.

Parameter: **Thres. react. time alarm**

- Default setting **(_:26671:176) Thres. react. time alarm** = ***2.8 s***

With the parameter **Thres. react. time alarm**, you define by how many seconds the reaction time may be undercut or exceeded for the output ***React. time close alarm*** to be set. The output ***React. time close alarm*** drops out after 100 ms.

9.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time close				
_:26671:170	Discon. monit.:Active		• 0 • 1	false
_:26671:171	Discon. monit.:Auxiliary-contact time		0.02 s to 1800.00 s	10.00 s
_:26671:172	Discon. monit.:Thres. aux.c. time warn		0.02 s to 1800.00 s	12.00 s
_:26671:173	Discon. monit.:Thres. aux.c. time alarm		0.02 s to 1800.00 s	14.00 s
_:26671:174	Discon. monit.:Reaction time		0.02 s to 1800.00 s	2.00 s
_:26671:175	Discon. monit.:Thres. react. time warn		0.02 s to 1800.00 s	2.40 s
_:26671:176	Discon. monit.:Thres. react. time alarm		0.02 s to 1800.00 s	2.80 s

9.12.5.4 Information List

No.	Information	Data Class (Type)	Type
Discon. monit.			
_:26671:51	Discon. monit.:Mode (controllable)	ENC	C
_:26671:54	Discon. monit.:Inactive	SPS	O
_:26671:52	Discon. monit.:Behavior	ENS	O
_:26671:53	Discon. monit.:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:26671:360	Discon. monit.:Aux.-cont. time close	MV	O
_:26671:361	Discon. monit.:Aux.c. time close warn.	SPS	O
_:26671:362	Discon. monit.:Aux.c. time close alarm	SPS	O
_:26671:363	Discon. monit.:Reaction time close	MV	O
_:26671:364	Discon. monit.:React. time close warn.	SPS	O
_:26671:365	Discon. monit.:React. time close alarm	SPS	O
_:26671:366	Discon. monit.:Aux.c. travel time close	MV	O

10 Supervision Functions

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10.1 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, including the external auxiliary power supply
- 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.

10.2 Resource-Consumption Supervision

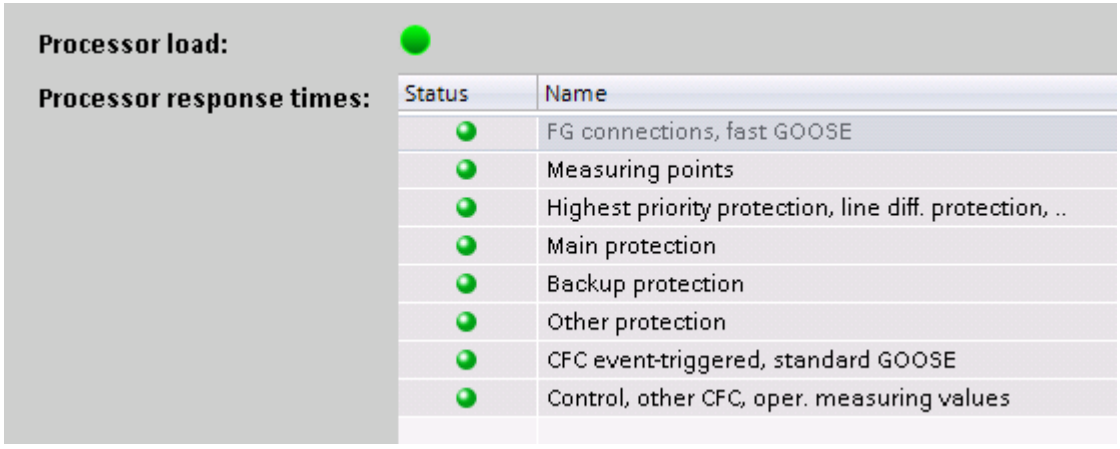
10.2.1 Load Model

SIPROTEC 5devices 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:



[sc_lastmo_01, 1, en_US]

Figure 10-1 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. A green display in front of an area (see *Figure 10-1*) indicates that the response times of the functions grouped in this area can be maintained. A red exclamation mark indicates that functions may have longer response times than 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:

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 can 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 stage 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.

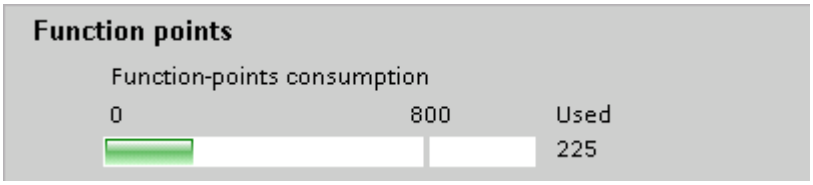
Use the general **Circuit-breaker** function group only in the following cases:

- Interaction with a protection-function group is essential.
  That is to say, 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.

10.2.2 Function Points

When you order a SIPROTEC 5device, 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.



[sc_fpunkt, 1, en_US]
Figure 10-2 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. Alternatively, you order the device with 0 function points and create the license file with the required point credits ad hoc using the SIPROTEC function point manager (see *2.2 Application Templates/Adaptation of Functional Scope*).

10.2.3 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:

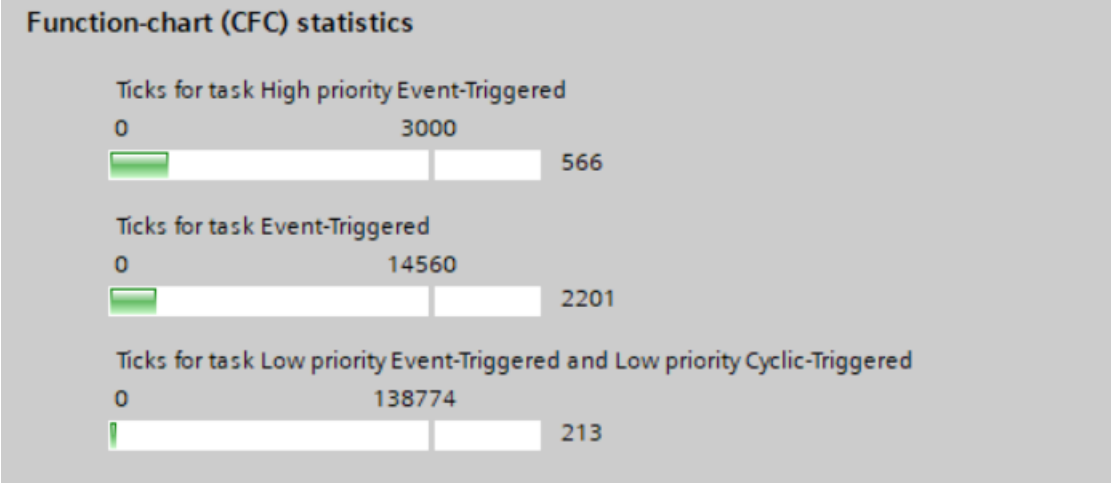
Task Level	Description
High priority Event-triggered	Use the ***High priority Event-triggered*** task level for time-critical tasks, for example, if a signal should block a protection function within 2 ms to 3 ms. Functions on this task level are processed in an event-triggered way with the highest priority. 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 ***High priority 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.
Low priority Cyclic-triggered	Use the ***Low priority Cyclic-triggered*** task level for processing measured values. Functions on this task level are processed cyclically every 500 ms.
Low priority Event-triggered	Use the ***Low priority Event-triggered*** 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 ***Low priority Event-triggered*** 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, 2, en_US]

Figure 10-3 CFC Statistics

NOTE

High priority 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.

10.3 Supervision of the Secondary System

10.3.1 Overview

The secondary circuits establish a connection to the power system from the point of view of the device. The measuring-input circuits (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

When the supervisions listed in the previous section 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 respective function descriptions.

External Auxiliary Voltage

The supervision of the external auxiliary voltage is described in Error Responses and Corrective Measures starting with *10.8.1 Overview*.

10.3.2 Measuring-Voltage Failure

10.3.2.1 Overview of Functions

The **Measuring-voltage failure detection** function monitors the voltage transformer secondary circuits:

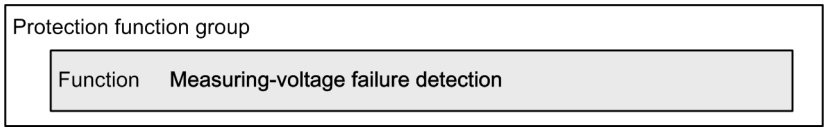
- Non-connected transformers
- Pickup of the voltage transformer circuit breaker (in the event of short circuits in the secondary circuit)
- Broken conductor in one or more measuring loops

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 protection function **Undervoltage protection with 3-phase voltage**, the response (block/do not block) to a measuring-voltage failure can be set within the function.

10.3.2.2 Structure of the Function

The function is part of protection function groups which are connected with a 3-phase voltage and current measuring point.

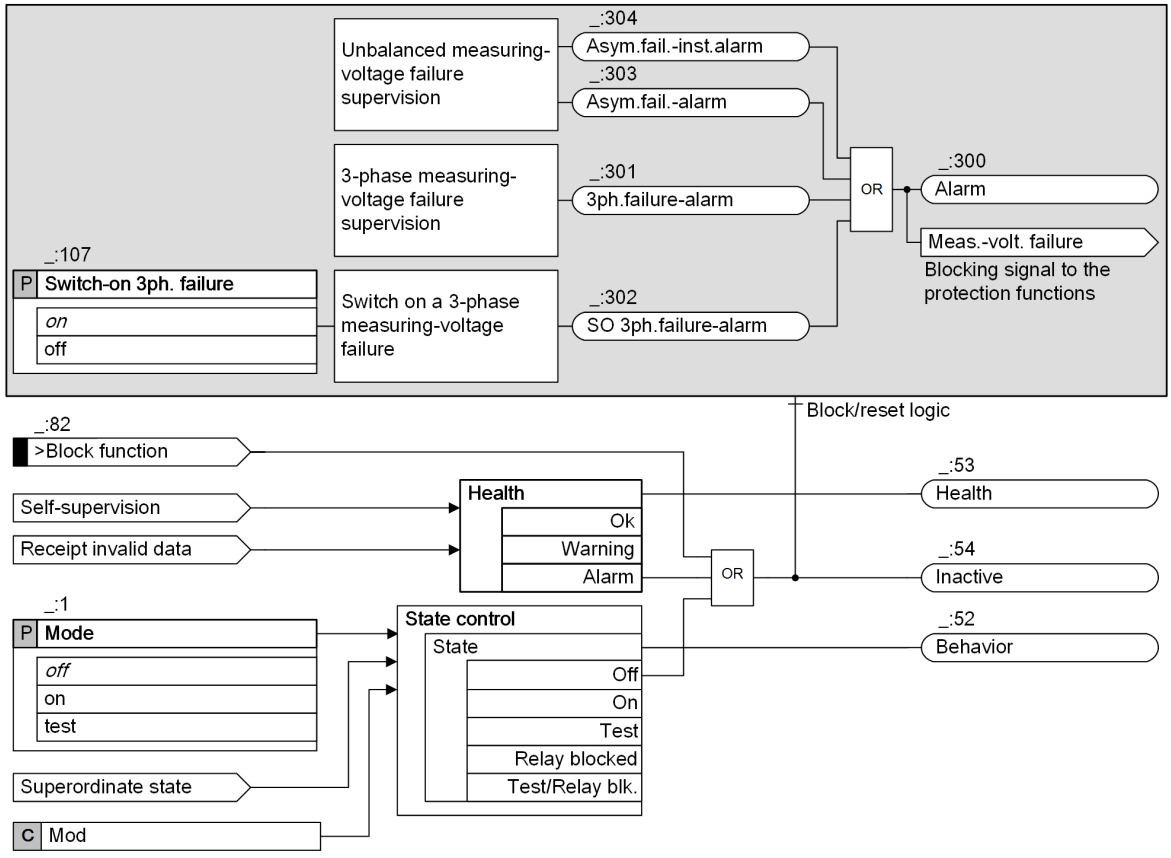


[dw_strffm, 1, en_US]

Figure 10-4 Structure/Embedding of the Function

The function is broken down into 3 subfunctions (see *Figure 10-5*):

- Supervision for unbalanced measuring-voltage failure
- Supervision for 3-phase measuring-voltage failure
- Supervision for switching onto a 3-phase measuring-voltage failure



[lo_ffm-3p_zusamm, 3, en_US]

Figure 10-5 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.

10.3.2.3 Unbalanced Measuring-Voltage Failure

Logic

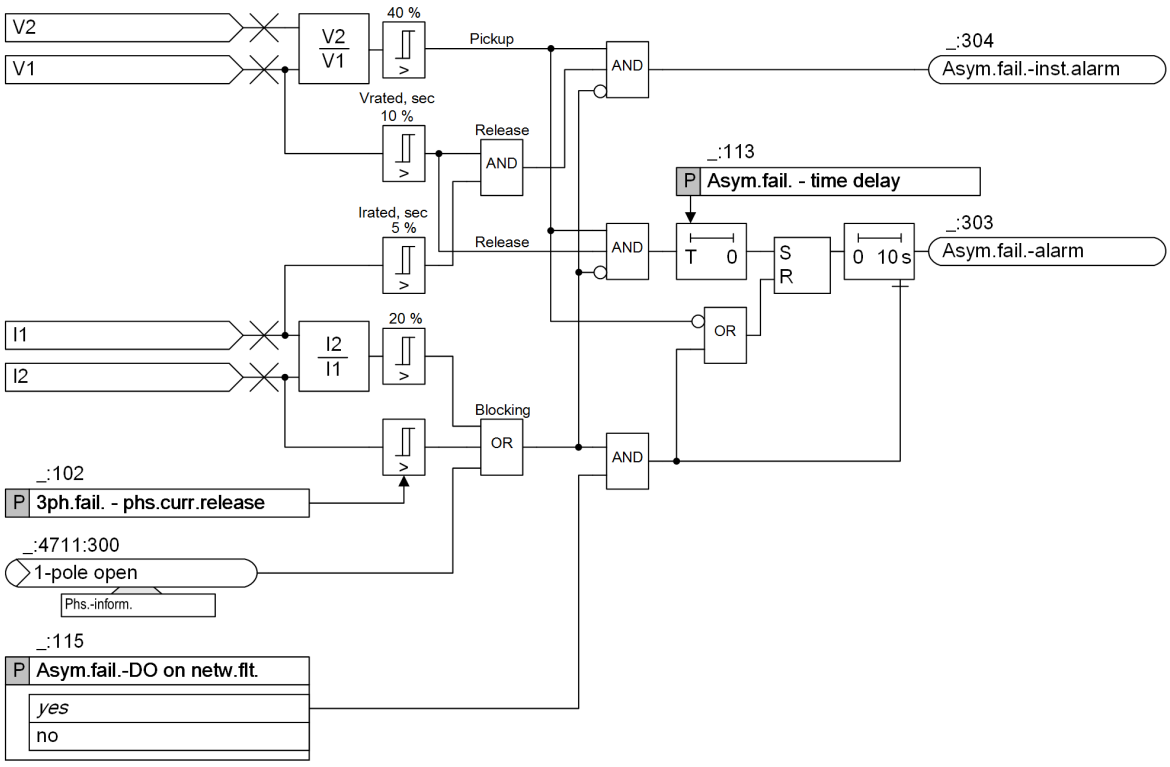


Figure 10-6 Logic Diagram Unbalanced Measuring-Voltage Failure Detection

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 exceeded and the monitoring is released and not blocked, the monitoring picks up (see *Figure 10-6*). 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.

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, monitoring can be delayed using the parameter **Asym.fail. - time delay**.

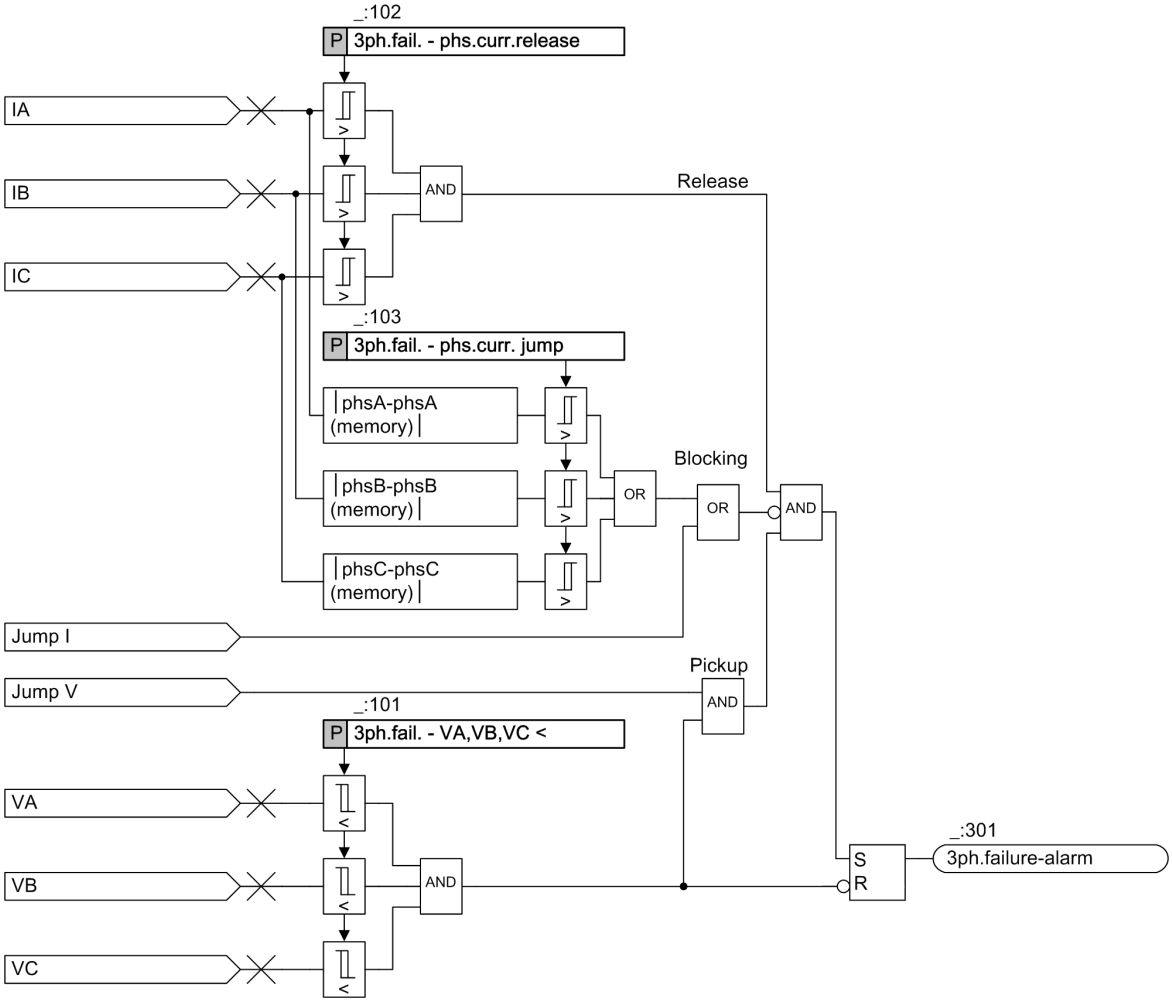
If a system incident is detected during the time delay, the supervision drops off. This is because the function assumes that the unbalance - and consequently the pickup of the supervision - is due to the system incident.

After the time delay has elapsed, it definitely assumes a measuring-voltage failure. 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.

10.3.2.4 3-Phase Measuring-Voltage Failure

Logic



[lo_symmet, 1, en_US]

Figure 10-7 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.

If the device incorporates the distance-protection function, the device checks the input threshold value **3ph.fail. - phs.curr.release** against the minimum current setting of the distance protection for plausibility. The threshold value **3ph.fail. - phs.curr.release** must be set to less than or equal to the release current of the distance protection.

Blocking in the Case of a System Incident

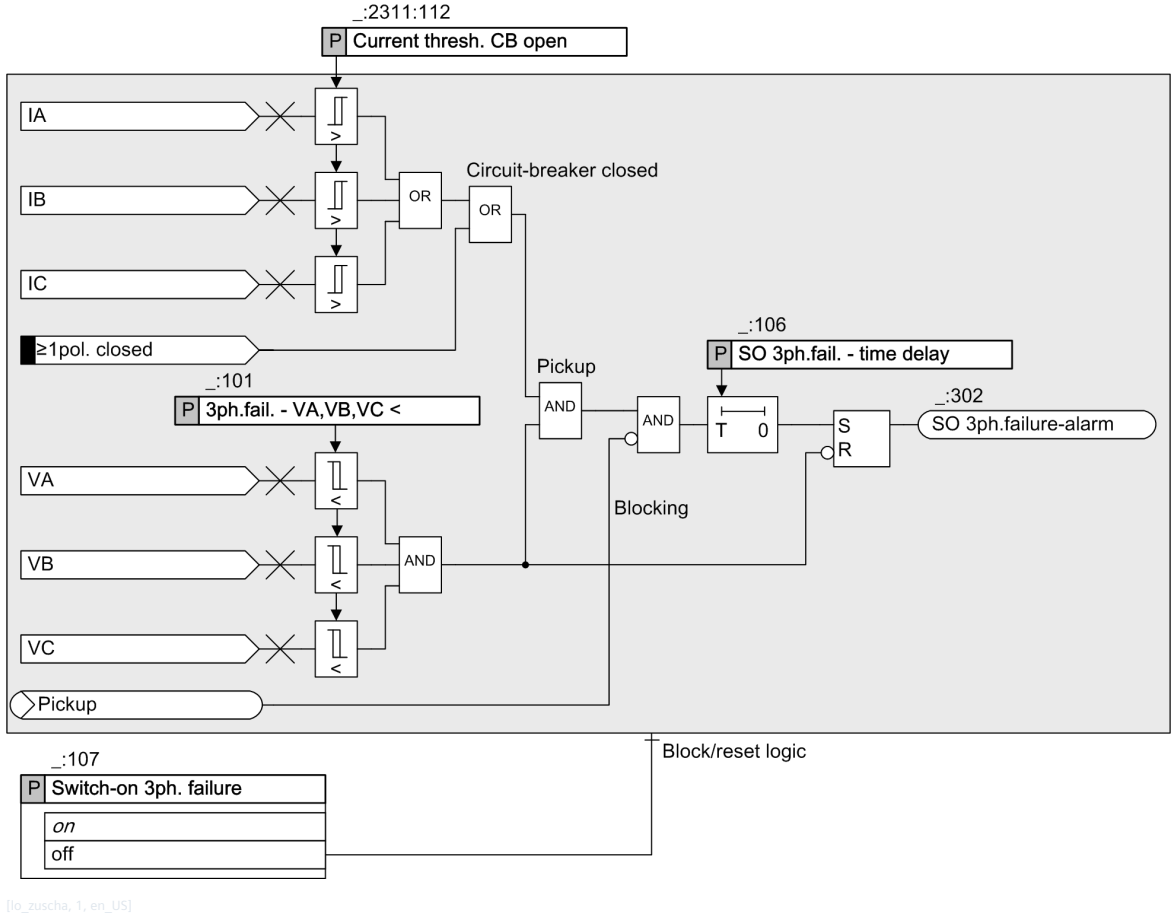
In the case of a 3-phase system incident, supervision must be blocked. The device detects a 3-phase system incident with a jump in the current. This change is detected via the internal signal **`Jump I`** or when the change in current of a phase current exceeds the threshold value **`3ph.fail. - phs.curr. 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 *10.3.3.1 Overview of Functions*).

10.3.2.5 Switching onto a 3-Phase Measuring-Voltage Failure, Low Load

Logic



[lo_zuscha, 1, en_US]

Figure 10-8 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 <`**.

A voltage jump – such as in a 3-phase measuring-voltage failure with closed circuit breaker (refer to *10.3.2.4 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 position is also determined from the circuit-breaker auxiliary contacts. The subfunction for detecting a 3-phase measuring-voltage failure (refer to *10.3.2.4 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.

10.3.2.6 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 switching that subfunction on.
off	With the setting ***off*** the subfunction **Switching to a 3-phase measuring-voltage failure** is not active.

10.3.2.7 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
_:114	Mes.v.fail.det:Asym.fail.-dropout delay		10.00 s to 10.00 s	10.00 s

10.3.2.8 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

10.3.3 Voltage-Transformer Circuit Breaker

10.3.3.1 Overview of Functions

The function **Voltage-transformer circuit breaker** 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 impacts the quality of the recorded measured-value data (refer to *3.4 Processing Quality Attributes*).

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:

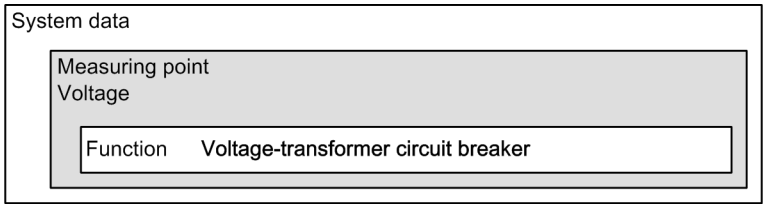
- Overvoltage protection with 3-phase voltage
- Overvoltage protection with any voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with any voltage

NOTE

If the voltage signal is generated using the optional Merging unit function, the quality of the voltage signal is sent as ***invalid*** in the sampled value stream, depending on the status of the voltage-transformer circuit breaker. For more information about configuring the voltage-transformer circuit breaker function for devices with merging unit and process-bus client, refer to the *Process Bus manual*.

10.3.3.2 Structure of the Function

The *Figure 10-9* shows the position of the function in the device. Every voltage measuring point contains the **Voltage-transformer circuit breaker** function.



[dw_mcbstr, 1, en_US]

Figure 10-9 Structure/Embedding of the Function

10.3.3.3 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 *10.3.3.1 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.

10.3.3.4 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.

10.3.3.5 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

10.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Definite-T #			
_:500	VT miniatureCB:>Open	SPS	I

10.3.4 Signaling-Voltage Supervision

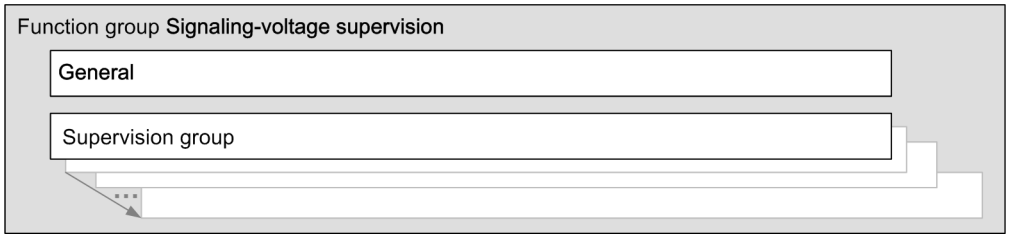
10.3.4.1 Overview of Functions

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.

10.3.4.2 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.

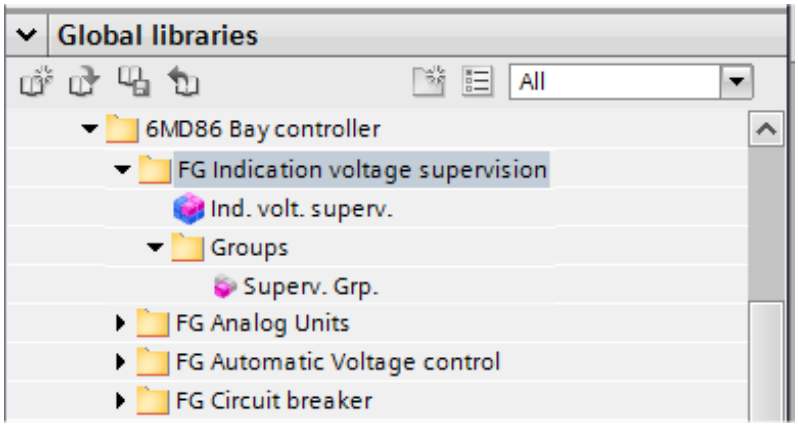


[dw_ivsstr, 1, en_US]

Figure 10-10 Structure/Embedding of the Function Group

10.3.4.3 Function Description

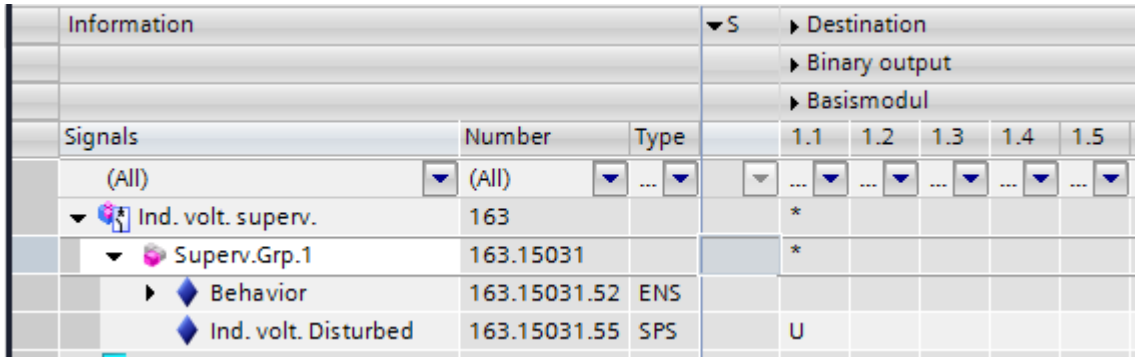
You can instantiate the **Signaling-voltage supervision** function group in the Global DIGSI 5 library. It contains 1 pre-instantiated **Superv.Grp.** function block (see the following figure). You can instantiate a maximum of 25 supervision groups.



[sc_ivslib, 1, en_US]

Figure 10-11 Entry in the Global Library

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.

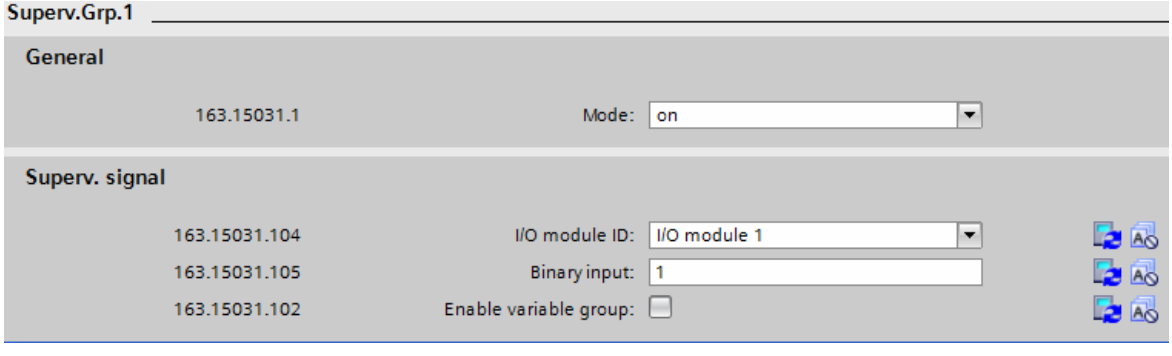


[sc_ivsrou, 1, en_US]

Figure 10-12 Information Routing

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***.



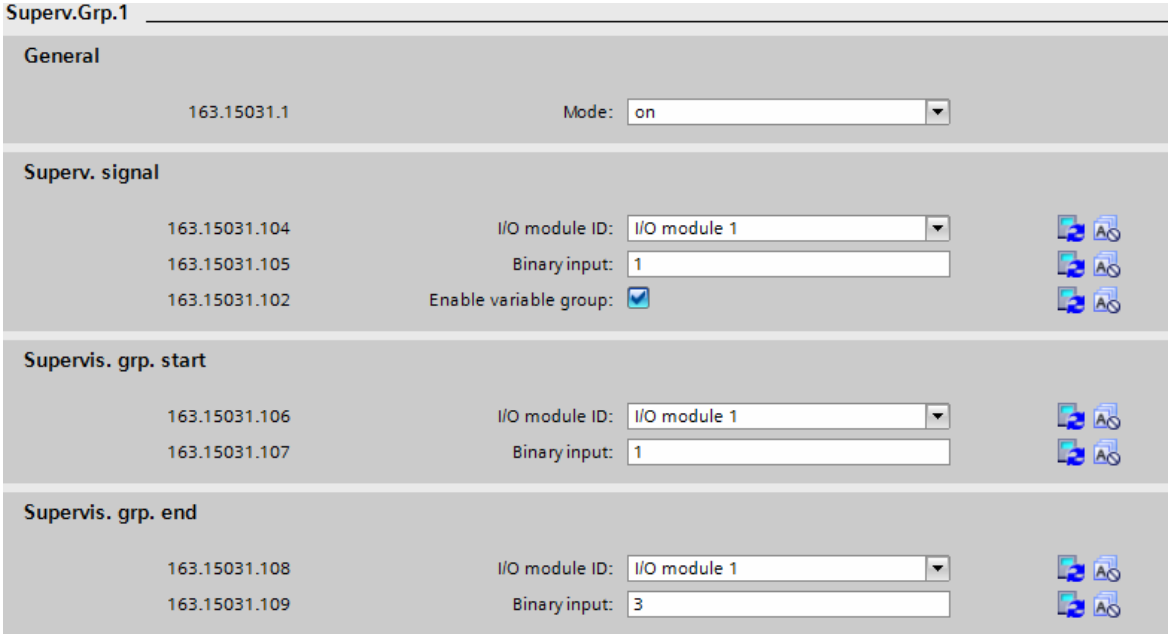
[sc_ivsgrp, 2, en_US]

Figure 10-13 Parameterization Menu of the Supervision Group (I)

NOTE

Each status change of the monitored binary inputs is delayed by 3 ms.

You can also combine binary inputs across modules in one **Superv.Grp.** function block and define any binary input within this group for 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 parameterization menu by the sections **Supervis. grp. start** and **Supervis. grp. end** (see the following figure).



[sc_gruppe_de, 2, en_US]

Figure 10-14 Parameterization Menu of the Supervision Group (II)

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 and 2 or 2 and 3, but no binary inputs on modules 1 and 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 **Superv.Grp.** 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.

Error parameters are displayed to you by inconsistency indications in DIGSI.

Example

There are 4 input/output modules available.

Binary inputs of input/output modules 1 and 2 are already combined in supervision group 1. The 2 last binary inputs on module 2 are not included in the grouping.

In supervision group 2, only these 2 binary inputs of the input/output module 2 not used in supervision group 1 as well as further consecutive binary inputs of the input/output modules 3 and 4 can be combined.

10.3.4.4 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.

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 supervision of the signaling voltage. 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) on 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 teh 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 checkmark. 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.

10.3.4.5 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

Addr.	Parameter	C	Setting Options	Default Setting
_:107	Superv.Grp.#:Binary input		1 to 256	1
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

10.3.4.6 Information List

No.	Information	Data Class (Type)	Type
Superv.Grp.#			
_:52	Superv.Grp.#:Behavior	ENS	O
_:55	Superv.Grp.#:Sig. volt. disturbed	SPS	O

10.3.5 Voltage-Balance Supervision

10.3.5.1 Overview of Functions

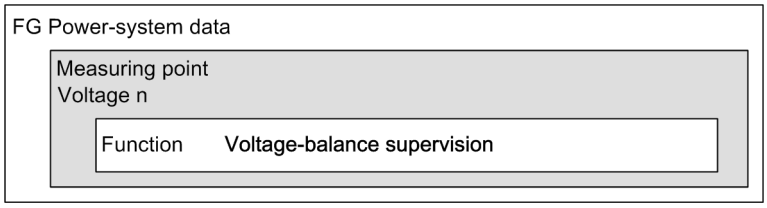
In healthy system operation, a certain balance between voltages can be assumed.
The **Voltage-balance supervision** function detects the following errors:

- 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.

10.3.5.2 Structure of the Function

The **Voltage-balance supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.



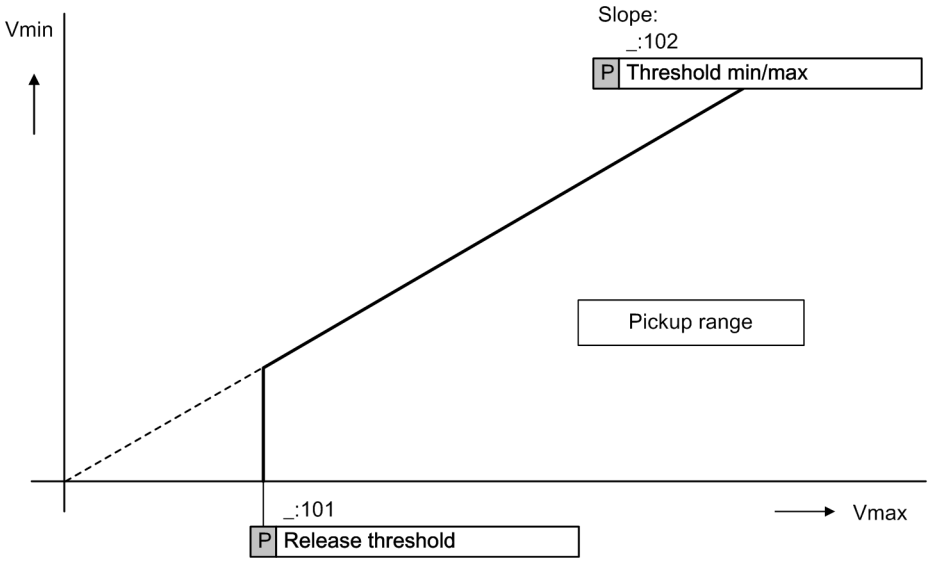
[dw_strusy, 2, en_US]

Figure 10-15 Structure/Embedding of the Function

10.3.5.3 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-to-phase voltage. Unbalance is detected if

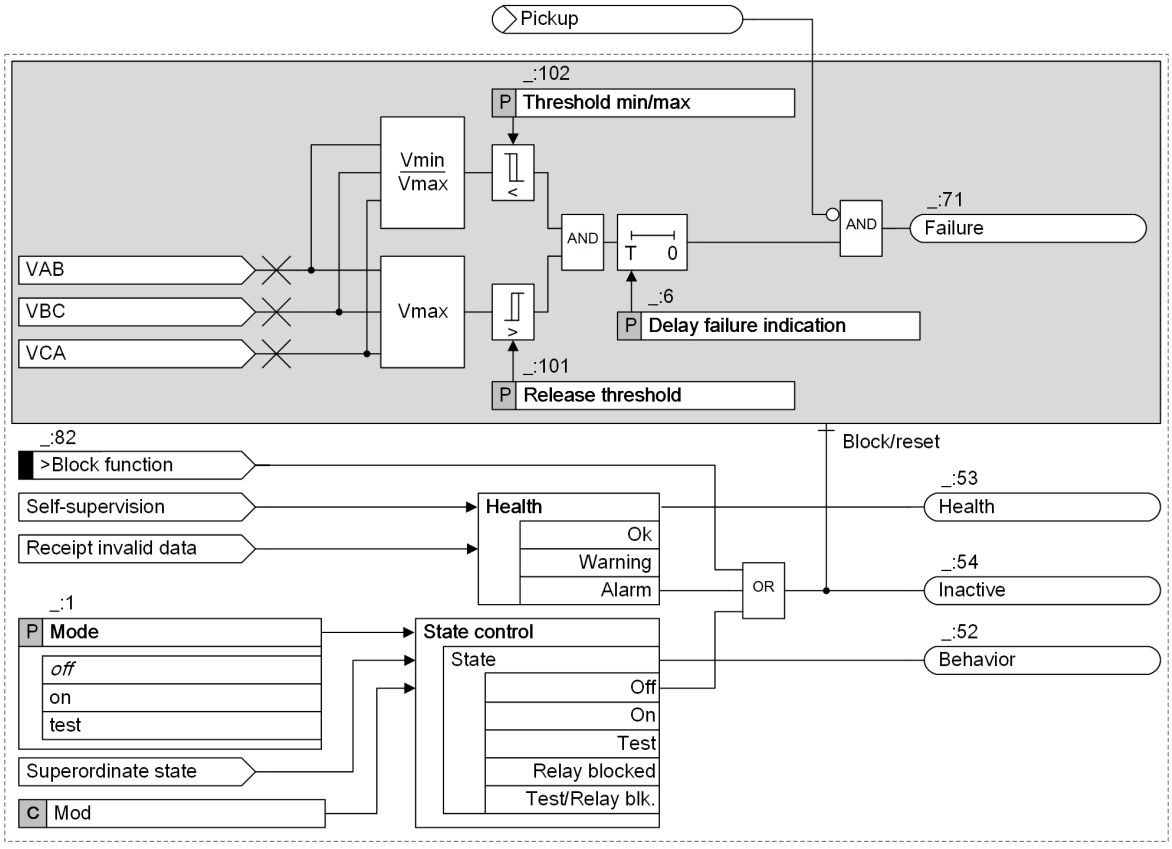
|Vmin| / |Vmax| < **`Threshold min/max`**, as long as Vmax > **`Release threshold`**



[lo_kenuns, 1, en_US]

Figure 10-16 Characteristic of the Voltage-Balance Supervision

Logic



[lo_sp_asym, 5, en_US]

Figure 10-17 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.

Delay failure indication

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 delay of the failure indication (parameter: **Delay failure indication**) starts. If both conditions persist during this time, the indication **Failure** is generated.

Blocking the Function

The following blockings reset the picked up function completely:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the *Failure* indication.

10.3.5.4 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: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

10.3.5.5 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 failure indication		0.00 sto 100.00 s	5.00 s

10.3.5.6 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

10.3.6 Voltage-Sum Supervision

10.3.6.1 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.

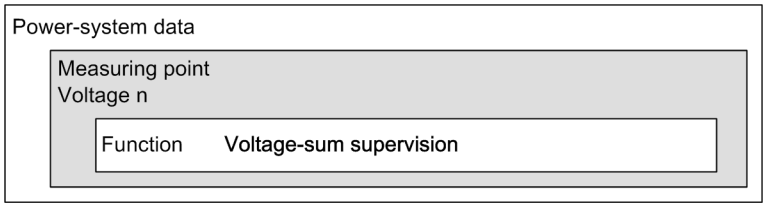
NOTE

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.

10.3.6.2 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.

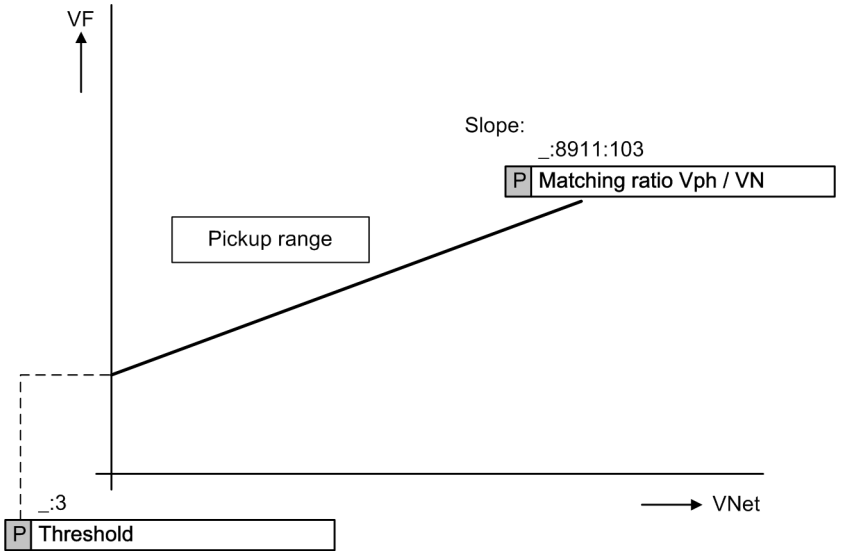


[dw_strvss, 2, en_US]

Figure 10-18 Structure/Embedding of the Function

10.3.6.3 Function Description

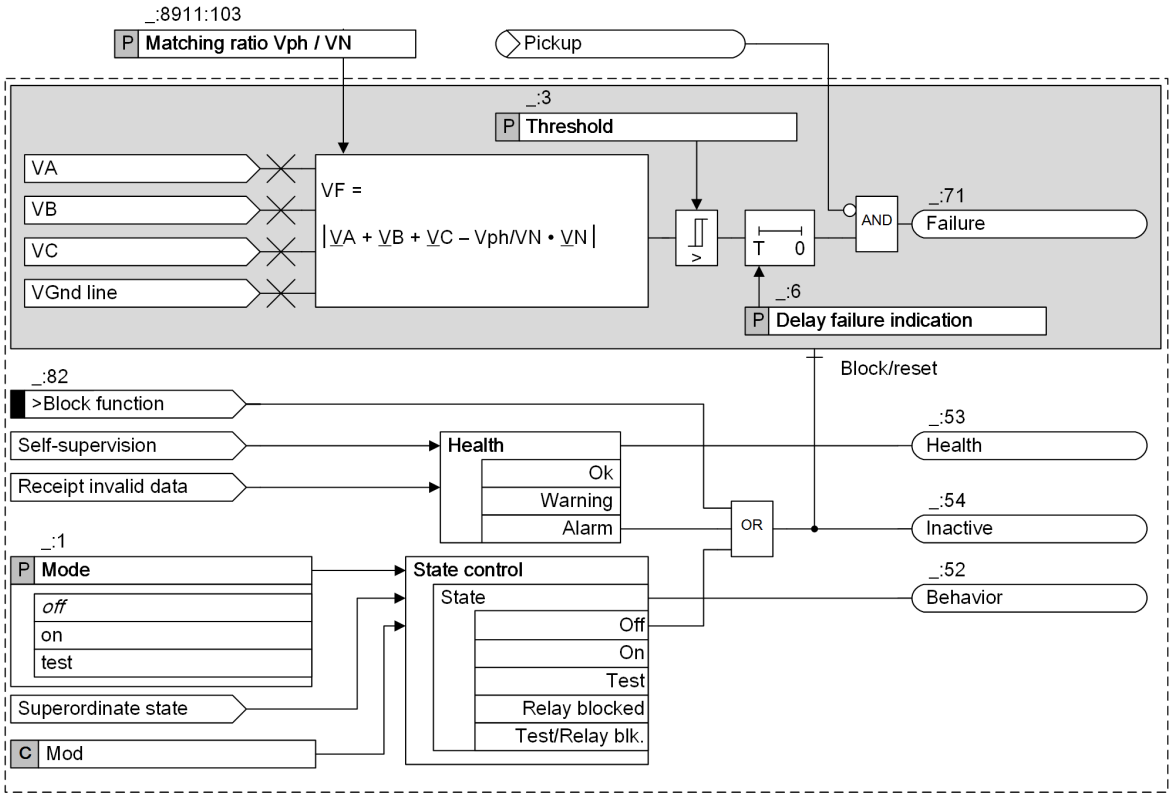
The voltage sum is generated by addition of the voltage phasors. Errors in the voltage circuits are detected if VF = |$\underline{V}$A + $\underline{V}$B + $\underline{V}$C - Vph/VN • $\underline{V}$N| > **`Threshold`**, where Vph/VN forms the **`Matching ratio Vph / VN`** parameter.



[lo_kenvss-01.tif, 1, en_US]

Figure 10-19 Characteristic of the Voltage-Sum Supervision

Logic



[lo_volt-sum-supervision, 5, en_US]

Figure 10-20 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 **Delay failure indication** triggers the indication **Failure**.

The device calculates the fault voltage (V_F) with the formula:

VF = |VA + VB + VC - Vph/UN • UN|, 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.

You can find more information in this respect in chapter *10.3.6.1 Overview of Functions*).

Delay failure indication

When the threshold value for the delay of the failure indication (parameter: **Delay failure indication**) is exceeded, the indication **Failure** is generated.

Blocking the Function

The following blockings reset the picked up function completely:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the *Failure* indication.

10.3.6.4 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: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

10.3.6.5 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 failure indication		0.00 sto 100.00 s	5.00 s

10.3.6.6 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

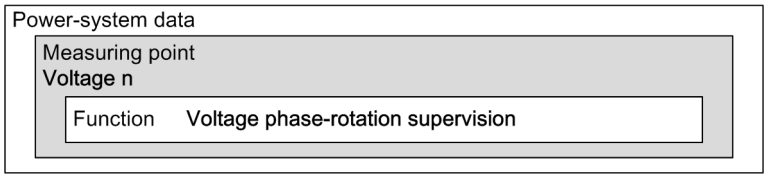
10.3.7 Voltage Phase-Rotation Supervision

10.3.7.1 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.

10.3.7.2 Structure of the Function

The **Voltage phase-rotation supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.

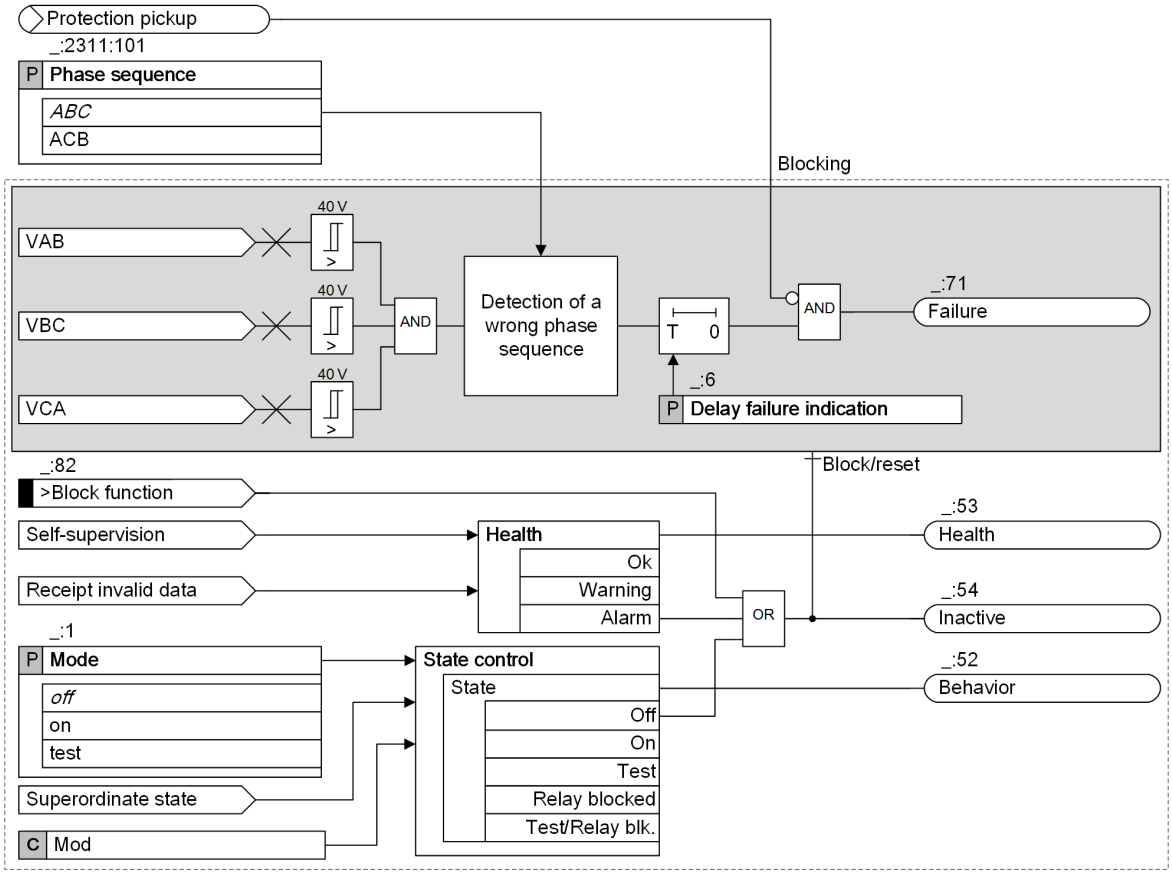


[dw_strvrs, 3, en_US]

Figure 10-21 Structure/Embedding of the Function

10.3.7.3 Function Description

Logic



[lo_volt-phs-rotation-supervision, 5, en_US]

Figure 10-22 Logic Diagram of the Voltage Phase-Rotation Supervision

The phase rotation is important for protection functions which process phase, loop, and directional information. You can set the phase sequence with the **Phase sequence** parameter in the function block **General** of the power-system data (see chapter *8.1 Power-System Data*).

To supervise the phase rotation, the device compares the measured phase sequence with the set phase sequence. For abnormal phase sequences, the indication *Failure* is generated.

The connection of the voltages to the device does not depend on the selected phase sequence. The connection diagrams are shown in chapter *A Appendix*.

Release Condition

The supervision of the voltage phase rotation is carried out when all measured phase-to-phase voltages are greater than 40 V.

Blocking of the Function

The following blockings reset the function completely:

- Via the binary input signal *>Block function* from an external or internal source
- Via a protection pickup
  The pickup signal from a protection function blocks the indication *Failure*.

Delay failure indication

When the device detects an inverted phase-rotation direction for the duration of the **Delay failure indication**, the indication *Failure* is generated.

10.3.7.4 Application and Setting Notes

Parameter: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = *5.00 s*

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

10.3.7.5 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 failure indication		0.00 s to 100.00 s	5.00 s

10.3.7.6 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

10.3.8 Voltage-Comparison Supervision

10.3.8.1 Overview of Functions

The **Voltage-comparison supervision** function (ANSI 60):

- Monitors the voltage-transformer circuits by comparing the voltages from 2 voltage transformers
  If failures in the voltage circuits are detected, voltage-related protection functions can be blocked.
- Requires the connection of 2 voltage measuring points to the voltage interface of the function group
  You can take one of the voltages as the reference voltage and then the other becomes the main voltage. The reference voltage is used for comparison.

NOTE

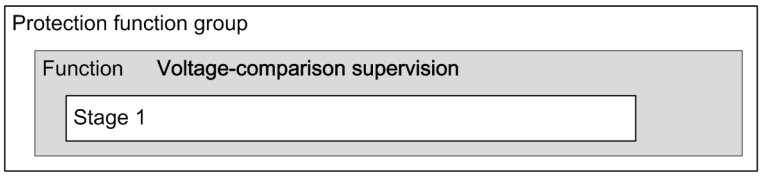
The voltage selection for the protection function in the FGs works independent of the status of the **Voltage-comparison supervision** function.

10.3.8.2 Structure of the Function

The **Voltage-comparison supervision** function can be used in the following function groups:

- Generator stator
- Generator side
- Voltage-current 3-phase (VI 3ph)
- Transformer side
- Auto transformer autoside (Auto trf. autoside)

The **Voltage-comparison supervision** function supports only 1 stage. The stage is preconfigured at the factory.



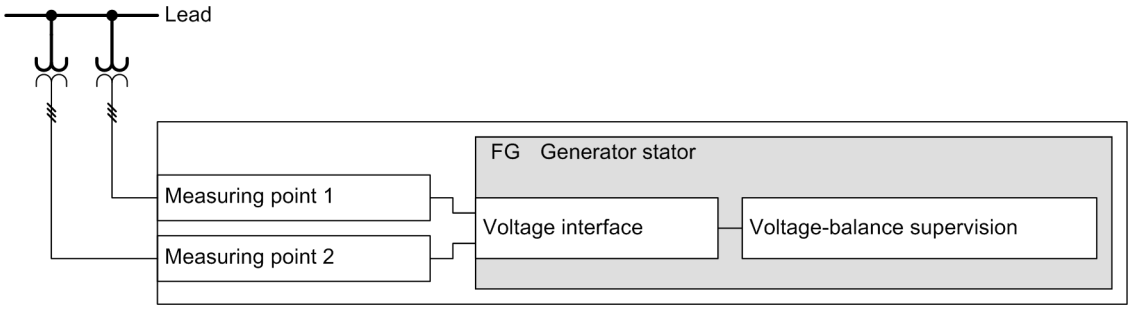
[dw_structure_VBP, 1, en_US]

Figure 10-23 Structure/Embedding of the Function

10.3.8.3 Description

Function Application

The following figure shows an application example.

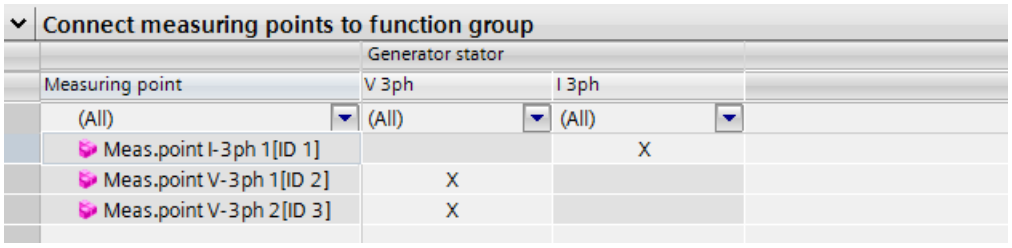


[dw_VBP application, 1, en_US]

Figure 10-24 Application Example

Connecting Measuring Points to a Function Group

The following figure shows the connection of the function group **Generator stator** with several measuring points in DIGSI. The ID of each measuring point appears in the brackets after the name.



[sc_VBStoFG, 1, en_US]

Figure 10-25 Connecting the Measuring Points to the Generator Stator 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.
- 2 voltage measuring points must be connected to one voltage interface.
- Either the **Voltage-comparison supervision** function or the **Voltage measuring-point selection** function must be instantiated. They must not be instantiated at the same time.

  About the **Voltage measuring-point selection** function, you can find more information in chapter *8.24 Voltage Measuring-Point Selection*.

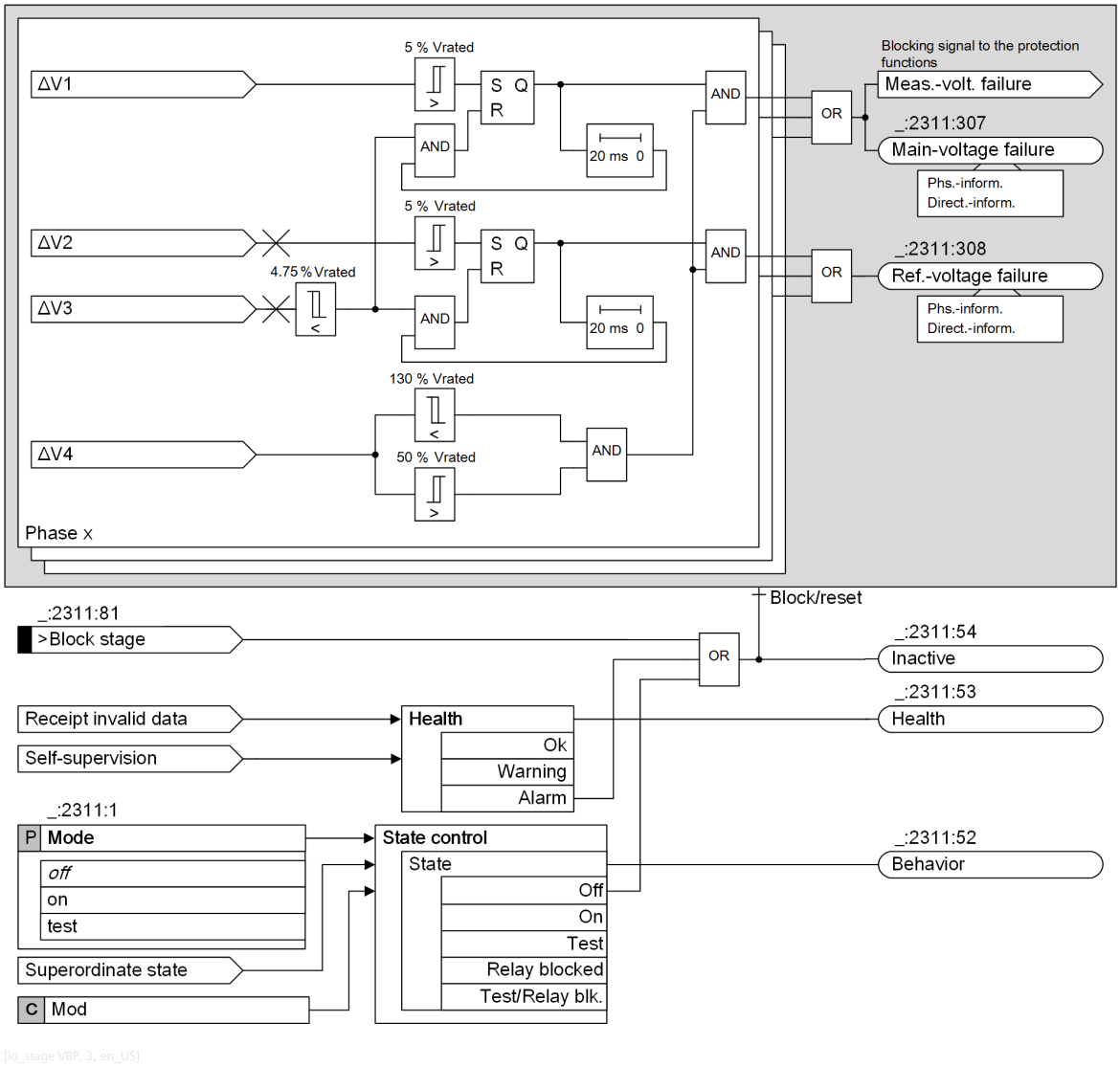
Voltage Selection

2 voltage measuring points are connected to a voltage interface of a function group. In the **Voltage-comparison supervision** function, you can set one of the voltages as the reference voltage via the parameter **`Reference voltage`**, and the other voltage becomes the main voltage.

- The reference voltage is used for voltage comparison.
- The main voltage is used for all voltage-related functions in the FGs that contain the **Voltage-comparison supervision** function.

  If the main voltage transformer is disconnected, the **Voltage-comparison supervision** function issues the blocking signal *`Meas.-volt failure`*. The signal is transmitted to all voltage-related protection functions which are used in the same FGs as the **Voltage-comparison supervision**.

Logic of the Stage



[lo_stage VBP, 3, en_US]

Figure 10-26 Logic Diagram of the Supervision Stage

The voltage inputs in the preceding figure are calculated with the following equations:

$\Delta V1 = |v(n)_{ref.}| - |v(n)_{main}|$

$\Delta V2 = |v(n)_{main}| - |v(n)_{ref.}|$

$\Delta V3 = |V_{ref.} - V_{main}|$

$\Delta V4 = \text{Max.}\ (V1_{ref.}, V1_{main})$

The following table shows the description of the voltages.

Table 10-1 Voltage Description

Voltages	Description
$v(n)_{ref.}$	Sampled value of the reference voltage
$v(n)_{main}$	Sampled value of the main voltage
$V_{ref.}$	Fundamental value of the reference voltage
V_{main}	Fundamental value of the main voltage

Voltages	Description
$V1_{ref.}$	Positive-sequence value of the reference voltage
$V1_{main}$	Positive-sequence value of the main voltage

Pickup

If the voltage difference between each 2 of 3 continuous sampling points is over 8 % Vrated of the plant, the supervision stage picks up.

Voltage Supervision

For the **Voltage-comparison supervision** function, the following 2 connection types are allowed:

- Phase-to-ground
  The phase-to-ground voltages are used for the voltage-difference comparison.
- Phase-to-phase
  The phase-to-phase voltages are used for the voltage-difference comparison.



NOTE

The **2 ph-to-ph volt. + VN** and **2 ph-to-ph voltages** connection types are not allowed.

Voltage-Failure Indication

For different connection types, the indications are different.

- Phase-to-ground
  You can get the voltage-failure information from the output signals *Main-voltage failure* and *Ref.-voltage failure*.
- Phase-to-phase
  - If one phase is influenced, the phase information is indicated.
  - If more than one phase is influenced, the phase-to-phase information is indicated.
    Take the main voltage transformer for example. You can determine the faulty phase with the following table.

Determination Criteria	Calculated Result		
(|vAB(n)ref.| - |vAB(n)main|) - 8 % Vrated	> 0	> 0	< 0
(|vBC(n)ref.| - |vBC(n)main|) - 8 % Vrated	< 0	> 0	> 0
(|vAC(n)ref.| - |vAC(n)main|) - 8 % Vrated	> 0	< 0	> 0
Failure Information	**Phase A is failed.**	**Phase B is failed.**	**Phase C is failed.**

Release Voltage

If the main positive-sequence voltage or the reference positive-sequence voltage is between 50 % Vrated and 130 % Vrated, the function is released.

Selection Invalid

An invalid measuring-point 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.

Blocking of the Stage

In the event of blocking, the picked up function is reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

10.3.8.4 Application and Setting Notes

Parameter: `Reference voltage`

- Default setting **`Reference voltage`** = ***None***

With the parameter **`Reference voltage`**, you can set a measured voltage as the reference voltage.

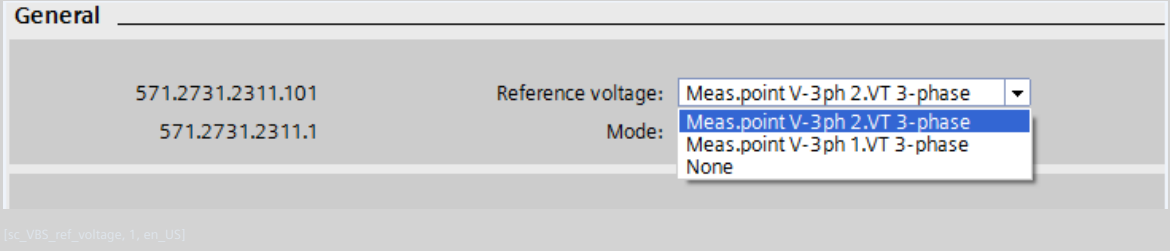


NOTE

You must assign a voltage measuring point to the parameter **`Reference voltage`**. The assignment influences the voltage-related protection functions which are used in the same FGs as the **Voltage-comparison supervision** function. These voltage-related protection functions use the unassigned voltage measuring point, which is defined as the main voltage in the **Voltage-comparison supervision** function. You can find more information in section *Voltage Selection, Page 1027*.

EXAMPLE

Meas.point V-3ph 1 and **Meas.point V-3ph 2** are connected to the **Voltage-comparison supervision** function. Then you have 2 more setting options, as shown in the following figure. You must select one of these setting options for the parameter **`Reference voltage`**.



Parameter: `Mode`

- Default setting **`(_:2311:1) Mode`** = ***off***

With the parameter **`Mode`**, you can activate and deactivate the **Voltage-comparison supervision** function. If you switch to ***test*** mode, the **Voltage-comparison supervision** function is marked as invalid.

10.3.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
VolCmpSup 1				
_:2311:1	General:Mode		• off • on • test	off
_:2311:101	General:Reference voltage		Setting options depend on configuration	None

10.3.8.6 Information List

No.	Information	Data Class (Type)	Type
VolCmpSup 1			
_:2311:81	General:>Block stage	SPS	I
_:2311:501	General:>MP-ID selection	INS	I
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:307	General:Main-voltage failure	ACD	O
_:2311:308	General:Ref.-voltage failure	ACD	O
_:2311:309	General:Selection invalid	SPS	O

10.3.9 Auxiliary Direct-Voltage Supervision

10.3.9.1 Overview of Functions

The function **Auxiliary direct-voltage supervision**:

- Measures the auxiliary direct-voltage of a substation battery system
- Provides sampled values for fault recording
- Monitors the battery direct-voltage by checking whether the measured voltage is greater or smaller than the specified threshold

The direct-voltage input is located on the plug-in module type ANAI-CE-2EL (1 input per module).

Once you have configured the plug-in module ANAI-CE-2EL, the function **Auxiliary direct-voltage supervision** is visible under the function group **Analog units**. You can find the function group **Analog units** in the **Settings** folder of the device in the DIGSI 5 project tree.

10.3.9.2 Structure of the Function

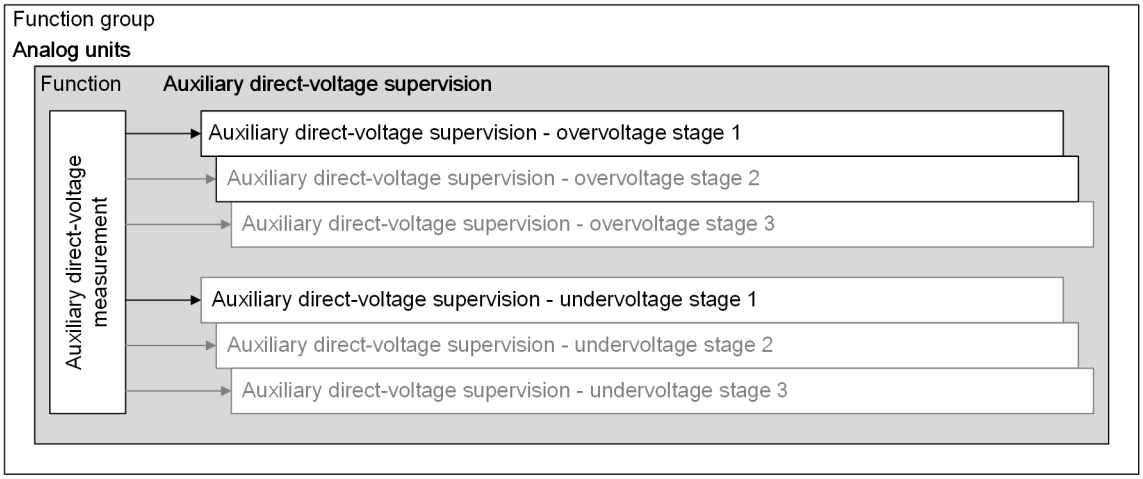
The function **Auxiliary direct-voltage supervision** can work only in the function group **Analog units**.

The function comes factory-set with 1 fixed function block **Auxiliary direct-voltage measurement**, 1 stage **Auxiliary direct-voltage supervision - overvoltage**, and 1 stage **Auxiliary direct-voltage supervision - undervoltage**.

The following stages can be operated simultaneously within the function:

- 3 stages **Auxiliary direct-voltage supervision - overvoltage**
- 3 stages **Auxiliary direct-voltage supervision - undervoltage**

Stages that are not preconfigured are shown in gray in the following figure. The stages are identical in structure.

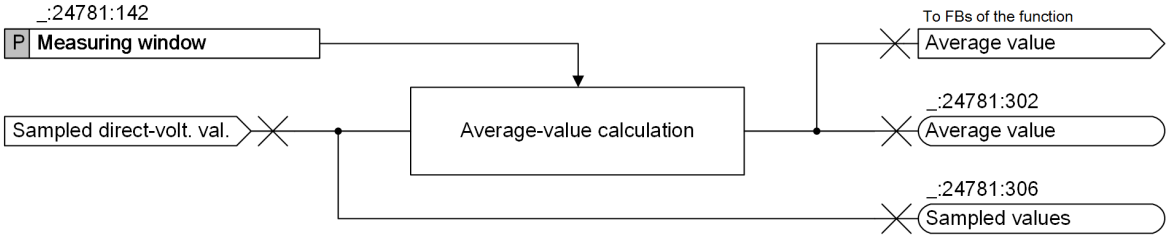


[dw_DC supervision_Structure, 1, en_US]

Figure 10-27 Structure/Embedding of the Function

10.3.9.3 Auxiliary Direct-Voltage Measurement

Logic



[lo_DC voltage measurement, 1, en_US]

Figure 10-28 Logic Diagram of the Function Block Auxiliary Direct-Voltage Measurement

Calculation of Average Direct-Voltage Values

The FB **Auxiliary direct-voltage measurement** receives the sampled direct-voltage values from the interface of the plug-in module ANAI-CE-2EL and calculates an average value by a settable time interval (via the parameter **`Measuring window`**).

The calculation formula is:

$$V_{avg} = \frac{1}{m}\sum_{n=1}^{m} V_n$$

[fo_DC_volt_supervision, 1, en_US]

Where

V_{avg}	Average direct-voltage value
V_n	Sampled direct-voltage value in a measuring window
m	Number of sampled values in a measuring window

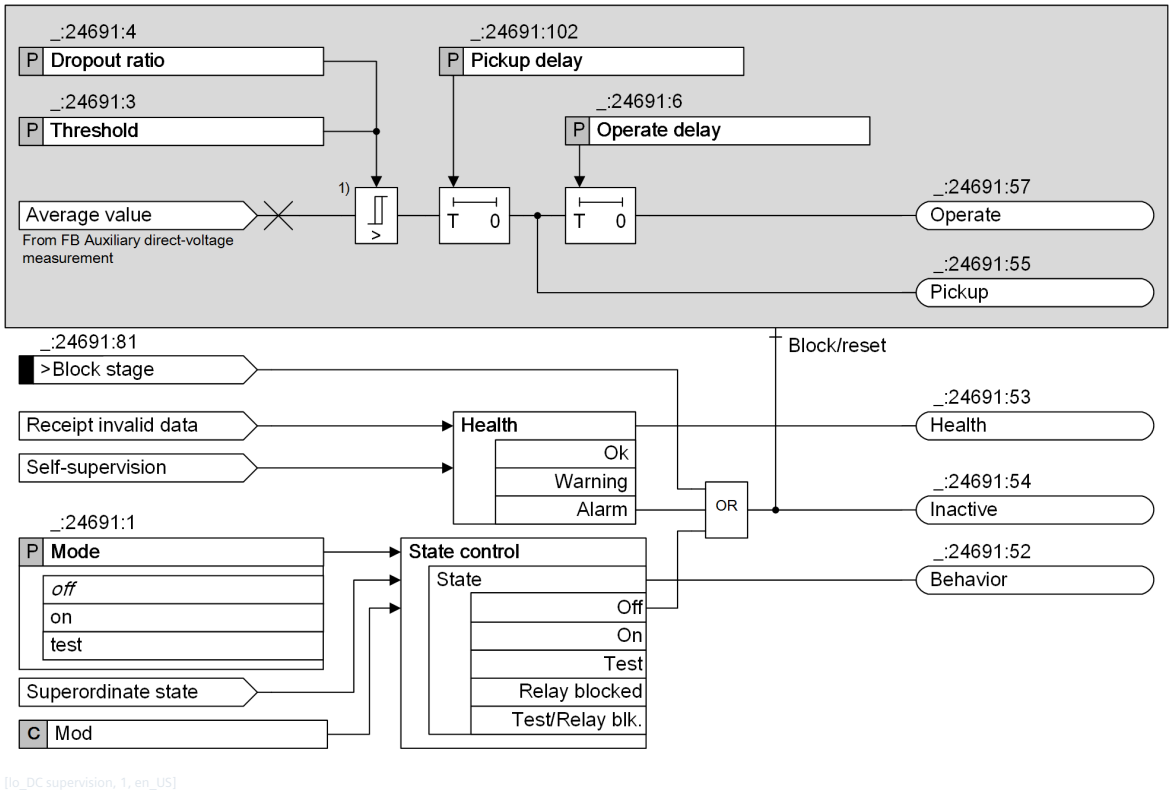
Functional Measured Value

Value	Description
`Average value`	Average value calculated from the sampled direct-voltage values

10.3.9.4 Stage Description

Logic

The logic of the stage **Auxiliary direct-voltage supervision - overvoltage** is the same as that of the stage **Auxiliary direct-voltage supervision - undervoltage**. The following figure shows the logic of the stage **Auxiliary direct-voltage supervision - overrvoltage** as an example.



[lo_DC supervision, 1, en_US]

Figure 10-29 Logic Diagram of the Stage Auxiliary Direct-Voltage Supervision - Overvoltage

(1) For the stage **Auxiliary direct-voltage supervision - undervoltage**, the symbol is:



Measurand

The stage obtains the average direct-voltage value from the FB **Auxiliary direct-voltage measurement**.

Pickup, Operate, Dropout

The stage compares the average direct-voltage value with the **Threshold**:

- **Overvoltage** stage
  If the average direct-voltage value exceeds the **Threshold**, the pickup delay (specified by the parameter **Pickup delay**) starts. If the value keeps exceeding the **Threshold** during the pickup delay, the pickup signal is issued.
- **Undervoltage** stage
  If the average direct-voltage value falls below the **Threshold**, the pickup delay (specified by the parameter **Pickup delay**) starts. If the value stays below the **Threshold** during the pickup delay, the pickup signal is issued.

Once the pickup signal is issued, the operate delay (specified by the parameter **Operate delay**) starts. After the expiration of the operate delay, the operate signal is issued.

With the parameter **Dropout ratio**, you can define the ratio of the dropout threshold to the **Threshold**.

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.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal **>Block stage**. In the event of blocking, the picked up stage is reset.

10.3.9.5 Application and Setting Notes

Recording of Sampled Direct-Voltage Values

The recording of sampled direct-voltage values cannot be started via the pickup of stages. If you want to record the sampled direct-voltage values, you could use other starting methods. For more information about the methods, refer to *3.5 Fault Recording*.

Parameter: Measuring window

- Default setting **(_:24781:142) Measuring window** = ***20 ms***

With the parameter **Measuring window**, you set the measuring window that is used to determine the average value from the sampled values. If this parameter is set to ***20 ms***, the average value is calculated from the sampled values in the measuring window of 20 ms.

Extending the measuring window can improve the measurement accuracy but will increase the pickup time. If there are no specific requirements, Siemens recommends using the default setting of 20 ms.

Parameter: Threshold

- Default setting **(_:24691:3) Threshold** = ***264.0 V*** (for the **Overvoltage** stage)
- Default setting **(_:24721:3) Threshold** = ***176.0 V*** (for the **Undervoltage** stage)

Set the parameter **Threshold** for the specific application.

Parameter: Dropout ratio

- Default setting **(_:24691:4) Dropout ratio** = ***0.95*** (for the **Overvoltage** stage)
- Default setting **(_:24721:4) Dropout ratio** = ***1.05*** (for the **Undervoltage** stage)

For the **Overvoltage** stage, the recommended setting value of ***0.95*** is appropriate for most applications. To achieve high-precision measurements, the **Dropout ratio** can be reduced, for example, to ***0.98***.

For the **Undervoltage** stage, the recommended setting value of ***1.05*** is appropriate for most applications. To achieve high-precision measurements, the **Dropout ratio** can be reduced, for example, to ***1.02***.

Parameter: Pickup delay

- Default setting **(_:24691:102) Pickup delay** = ***0.00 s***

With the parameter **Pickup delay**, you define a time interval during which a pickup is not generated if the voltage exceeds the threshold (for the **Overvoltage** stage) or falls below the threshold (for the **Undervoltage** stage).

With the pickup delay, you can achieve that a short auxiliary-voltage disturbance will not be reported. If you want to detect all disturbances, use the default value of ***0.00 s***.

Parameter: Operate delay

- Default setting **(_:24691:6) Operate delay** = ***1.00 s***

The parameter **Operate delay** determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.



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.

10.3.9.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-DC measurem.				
_:24781:142	V-DC measurem.:Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	20 ms
Aux.V sup. V>1				
_:24691:1	Aux.V sup. V>1:Mode		• off • on • test	off
_:24691:3	Aux.V sup. V>1:Threshold		10.0 V to 295.0 V	264.0 V
_:24691:4	Aux.V sup. V>1:Dropout ratio		0.90 to 0.99	0.95
_:24691:102	Aux.V sup. V>1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:24691:6	Aux.V sup. V>1:Operate delay		0.00 s to 60.00 s	1.00 s
Aux.V sup. V<1				
_:24721:1	Aux.V sup. V<1:Mode		• off • on • test	off
_:24721:3	Aux.V sup. V<1:Threshold		10.0 V to 295.0 V	176.0 V
_:24721:4	Aux.V sup. V<1:Dropout ratio		1.01 to 1.10	1.05
_:24721:102	Aux.V sup. V<1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:24721:6	Aux.V sup. V<1:Operate delay		0.00 s to 60.00 s	1.00 s

10.3.9.7 Information List

No.	Information	Data Class (Type)	Type
V-DC measurem.			
_:24781:302	V-DC measurem.:Average value	MV	O
_:24781:306	V-DC measurem.:Sampled values	SAV	O

No.	Information	Data Class (Type)	Type
Aux.V sup. V>1			
_:24691:81	Aux.V sup. V>1:>Block stage	SPS	I
_:24691:51	Aux.V sup. V>1:Mode (controllable)	ENC	C
_:24691:54	Aux.V sup. V>1:Inactive	SPS	O
_:24691:52	Aux.V sup. V>1:Behavior	ENS	O
_:24691:53	Aux.V sup. V>1:Health	ENS	O
_:24691:55	Aux.V sup. V>1:Pickup	ACD	O
_:24691:57	Aux.V sup. V>1:Operate	ACT	O
Aux.V sup. V<1			
_:24721:81	Aux.V sup. V<1:>Block stage	SPS	I
_:24721:51	Aux.V sup. V<1:Mode (controllable)	ENC	C
_:24721:54	Aux.V sup. V<1:Inactive	SPS	O
_:24721:52	Aux.V sup. V<1:Behavior	ENS	O
_:24721:53	Aux.V sup. V<1:Health	ENS	O
_:24721:55	Aux.V sup. V<1:Pickup	ACD	O
_:24721:57	Aux.V sup. V<1:Operate	ACT	O

10.3.10 Broken-Wire Detection

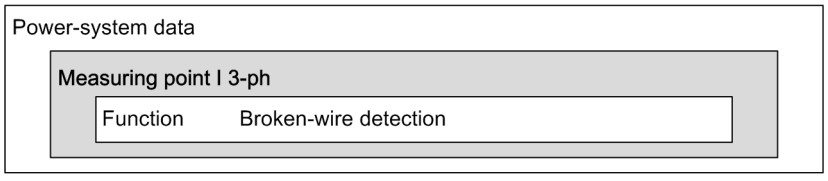
10.3.10.1 Overview of Functions

The purpose of the **Broken-wire detection** is to detect interruptions in the secondary circuit of the current transformers during steady-state operation. In addition jeopardizing the secondary circuit due to high voltages, such interruptions can mimic the presence of differential currents for the differential protection, as caused by short circuits in the protected object. To prevent overfunctions due to faulty current values, the affected protection functions are blocked, for example the Line differential protection and the Distance protection.

The function **Broken-wire detection** works only if at least one function group (for example, the function group **Voltage-current 3-phase**) is instantiated.

10.3.10.2 Structure of the Function

The **Broken-wire detection** function is structurally anchored in the power-system data as well and in various protection function groups.



[dw_bwsjsk, 3, en_US]

Figure 10-30 Structure/Embedding of the Function

The **Broken-wire detection** function consists of several stages.

1. Broken wire suspected

- The instantaneous values of all current measuring points are checked on a phase-selective basis for implausible values.
- The affected phases are marked with Broken wire suspected and the following indications are generated: *(_:301) Phs A BW suspected*, *(_:302) Phs B BW suspected* and/or *(_:303) Phs C BW suspected* and *(_:307) Broken wire suspected*.

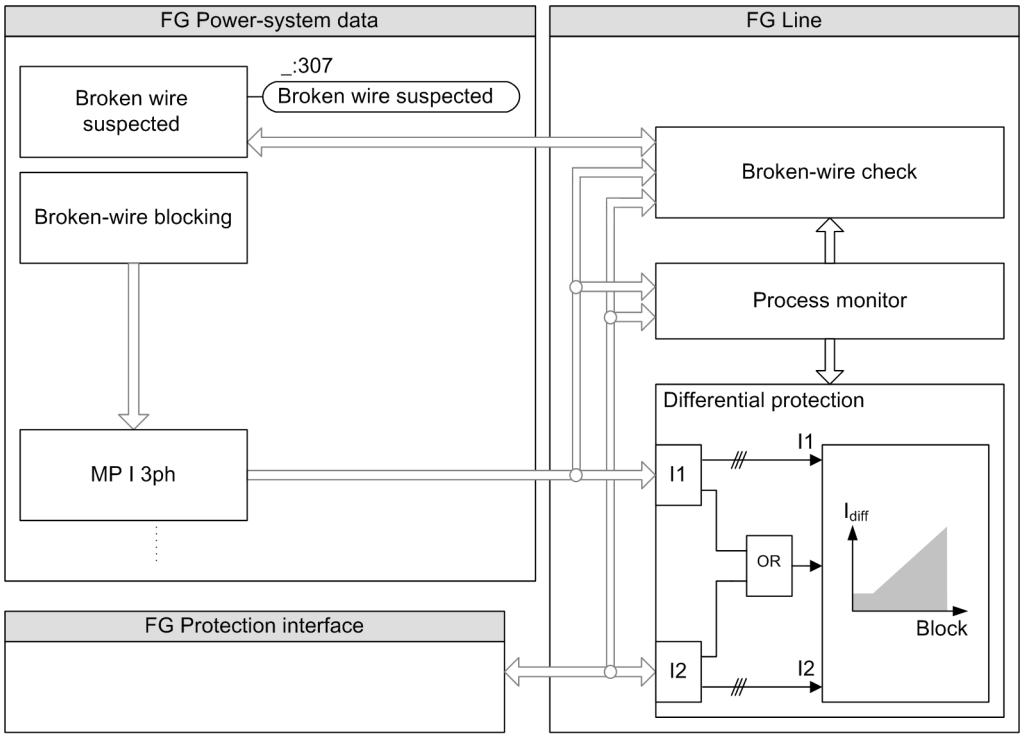
- Depending on the supervision mode, you can add a marker for blocking protection functions for the affected phases.
- After 10 ms of broken-wire check, a detected wire break is signaled with the following indications: *(_:304) Phase A broken wire*, *(_:305) Phase B broken wire* and/or *(_:306) Phase C broken wire* and *(_:308) Broken wire confirmed*).

2. Broken-wire check

- Current phases suspected to have a broken wire are tested for plausibility using exclusion criteria.
- A valid exclusion criterion resets the broken-wire suspicion and cancels any existing blocking of protection functions.

3. Blocking the protection

- The **Broken-wire blocking** marker immediately leads to blocking of some protection functions.



[lo_bw_str1, 2, en_US]

Figure 10-31 Stages of the Broken-Wire Detection Function Using the Example of Differential Protection

10.3.10.3 Function Description

Broken Wire Suspected

The function **Broken-wire detection** 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.

NOTE

If the secondary circuits of the current transformers are accidentally opened while the broken-wire detection is on, functions like the differential protection are blocked phase-segregated and no longer initiate tripping. Hazardous overvoltages can be generated at the open circuit of the current transformer in this condition which are not eliminated because the differential protection is blocked.

The detection of the local broken wire suspected is performed on each 3-phase current measuring point of the device selectively for each phase. Depending on the protected object, the detection is based on permanent (line differential protection) or frequency-adjusted instantaneous values (transformer differential protection).

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 , by a reset criterion of the broken-wire check or by a binary input signal. Binary resetting can be useful during laboratory tests among other applications.

Indication

If the broken-wire detection by the broken-wire check has not been reset within 10 ms, it will be indicated. The indication is held stable for the duration of at least 3 periods.

Broken-Wire Check

To prevent unwanted pickup of this monitoring function caused by special operating conditions, for example fault, maintenance, test, etc., a local broken wire suspected must be confirmed by additional other criteria. These criteria are checked on the level of the protection functions (Protection function group).

If at least one of the following criteria contradicting wire break is satisfied, the locally set broken wire suspected is reset including any associated protection blocking.

Local resetting criteria:

- At least one protection function has picked up.
- An assigned circuit breaker is open.
- A wire break is simultaneously detected at a different local current channel.
- Jump detection on a local voltage channel (if voltage transformers exist)
- Jump detection of the associated zero-sequence current
  This reset criterion applies only for **CT connection** = ***3-phase + IN-separate***.
- Jump detection on a different local current channel of the same phase without broken wire suspected
- Local overcurrent, that is, for at least one phase applies $I_{ph} > 2 \cdot I_{rated}$

Reset criteria at the opposite end:

For the line differential protection, there are additional criteria of the opposite end that can contradict a local broken wire suspected and cause resetting. The request to reset is transmitted via the protection interface.

- A wire break is simultaneously detected at a current channel of the opposite end.
- Jump detection on a voltage channel of the opposite end (if voltage transformers exist)
- Jump detection on a current channel of the opposite end
- Local overcurrent at the opposite end, that is true for at least one phase $I_{ph} > 2 \cdot I_{rated}$

Blocking the Protection

The decision to block the protection and the determination of the local broken wire suspected is performed phase-segregated for each 3-phase current measuring point of the device. A central mode parameter of the broken-wire detection (**Mode**) in the power-system data decides the blocking behavior.

- No blocking
  - Wire break is only signaled
- Blocking
  - Each broken wire suspected must cause the affected protection functions to be blocked. Affected phases are marked with “protection blocked”.
- Automatic blocking
  - In addition to broken wire suspected, you can make the blocking dependent on the criterion that the maximum differential current of all phases does not exceed a settable threshold value **Delta value for autoblock** for the differential protection. The phases to be blocked are marked.

Differential protection functions and protection functions that pick up on unbalanced currents are blocked. Each individual protection function is responsible for the actual blocking and is described there, too.

10.3.10.4 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***.

Parameter: Mode of blocking

- Recommended setting value **(_:101) Mode of blocking** = ***blocking***

The **Mode of blocking** parameter enables you to define the blocking condition (see Blocking the protection). Siemens recommends using the default setting. The setting options are ***blocking***, ***auto blocking*** and ***not blocking***.

Parameter: Delta value for autoblock

- Recommended setting value **(_:102) Delta value for autoblock** = ***1.00 I/IN***

With the **Delta value for autoblock** parameter you can make the blocking decision for protection functions dependent on the amount of the differential current.

10.3.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Brk.wire det.				
_:1	Brk.wire det.:Mode		• off • on • test	off
_:101	Brk.wire det.:Mode of blocking		• blocking • auto blocking • not blocking	blocking
_:102	Brk.wire det.:Delta value for autoblock		0.004 to 5.000	1.000

10.3.10.6 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

No.	Information	Data Class (Type)	Type
_: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
_:307	Brk.wire det.:Broken wire suspected	SPS	O
_:308	Brk.wire det.:Broken wire confirmed	SPS	O

10.3.11 Current-Balance Supervision

10.3.11.1 Overview of Functions

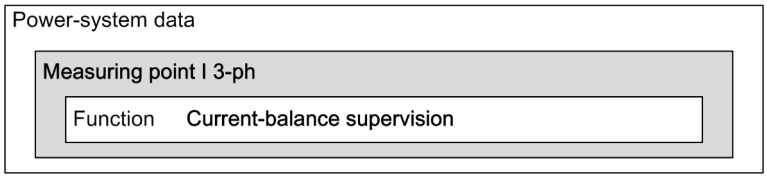
In healthy network operation, a certain balance between currents can be assumed.
The **Current-balance supervision** function detects the following errors:

- 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.

10.3.11.2 Structure of the Function

The **Current-balance supervision** function is located in the **Power-system data** of each 3-phase current measuring point.



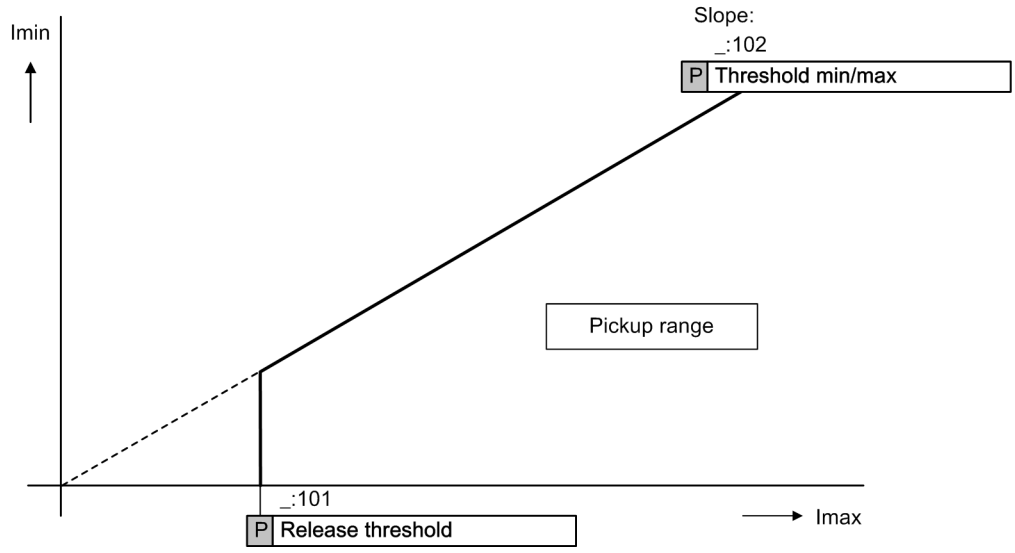
[dw_str_sym, 3, en_US]

Figure 10-32 Structure/Embedding of the Function

10.3.11.3 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

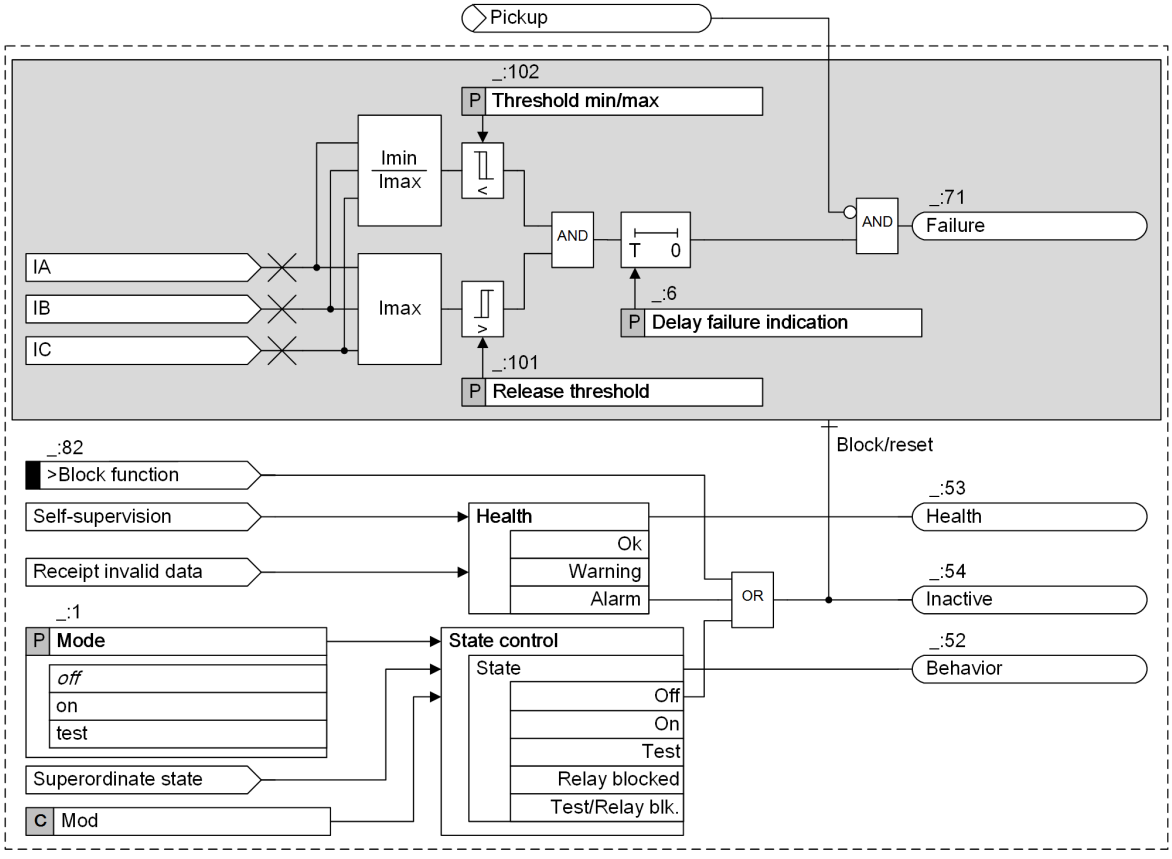
|Imin| / |Imax| < **`Threshold min/max`**, as long as Imax > **`Release threshold`**.



[lo_symmke, 1, en_US]

Figure 10-33 Characteristic of the Current-Balance Supervision

Logic



[lo_cb_symm, 4, en_US]

Figure 10-34 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.

Delay failure indication

If it falls below the balance factor **Threshold min/max** at the same time as the maximum phase current exceeds the **Release threshold**, the operate delay of the failure indication (parameter **Delay failure indication**) starts. If both conditions persist during this time, the indication **Failure** is generated.

Blocking the Function

The following blockings completely reset the picked up function:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the indication *Failure*.

10.3.11.4 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: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = *5.00 s*

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

10.3.11.5 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 failure indication		0.00 s to 100.00 s	5.00 s

10.3.11.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. I			
_:82	Supv. balan. I:>Block function	SPS	I
_:54	Supv. balan. I:Inactive	SPS	O
_:52	Supv. balan. I:Behavior	ENS	O
_:53	Supv. balan. I:Health	ENS	O
_:71	Supv. balan. I:Failure	SPS	O

10.3.12 Current-Sum Supervision

10.3.12.1 Overview of Functions

In healthy system operation, the sum of all currents at one measuring point must be approximately 0. The **Current-sum supervision** function 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. Select the following connection variant:

- Current-transformer connections connected to 3 current transformers and the neutral point (see *Figure A-7* in the *Attachment*)

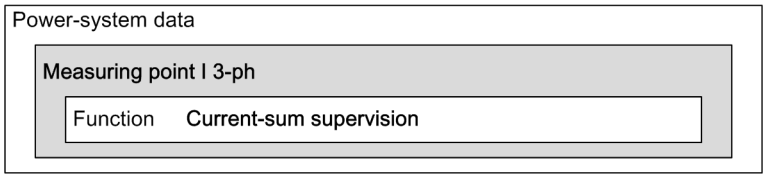


NOTE

For current-sum supervision, the ground current of the line to be protected must be connected to the 4th current measurement input (I_N).

10.3.12.2 Structure of the Function

The **Current-sum supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

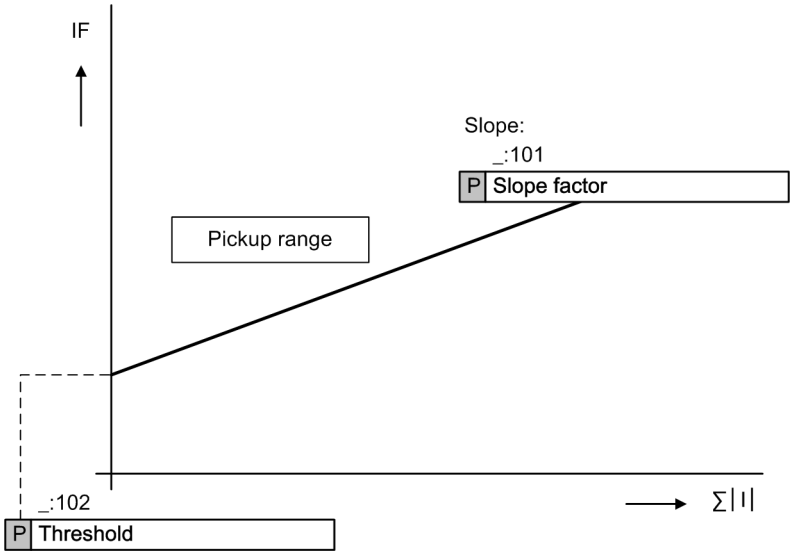


[dw_str_css, 3, en_US]

Figure 10-35 Structure/Embedding of the Function

10.3.12.3 Function Description

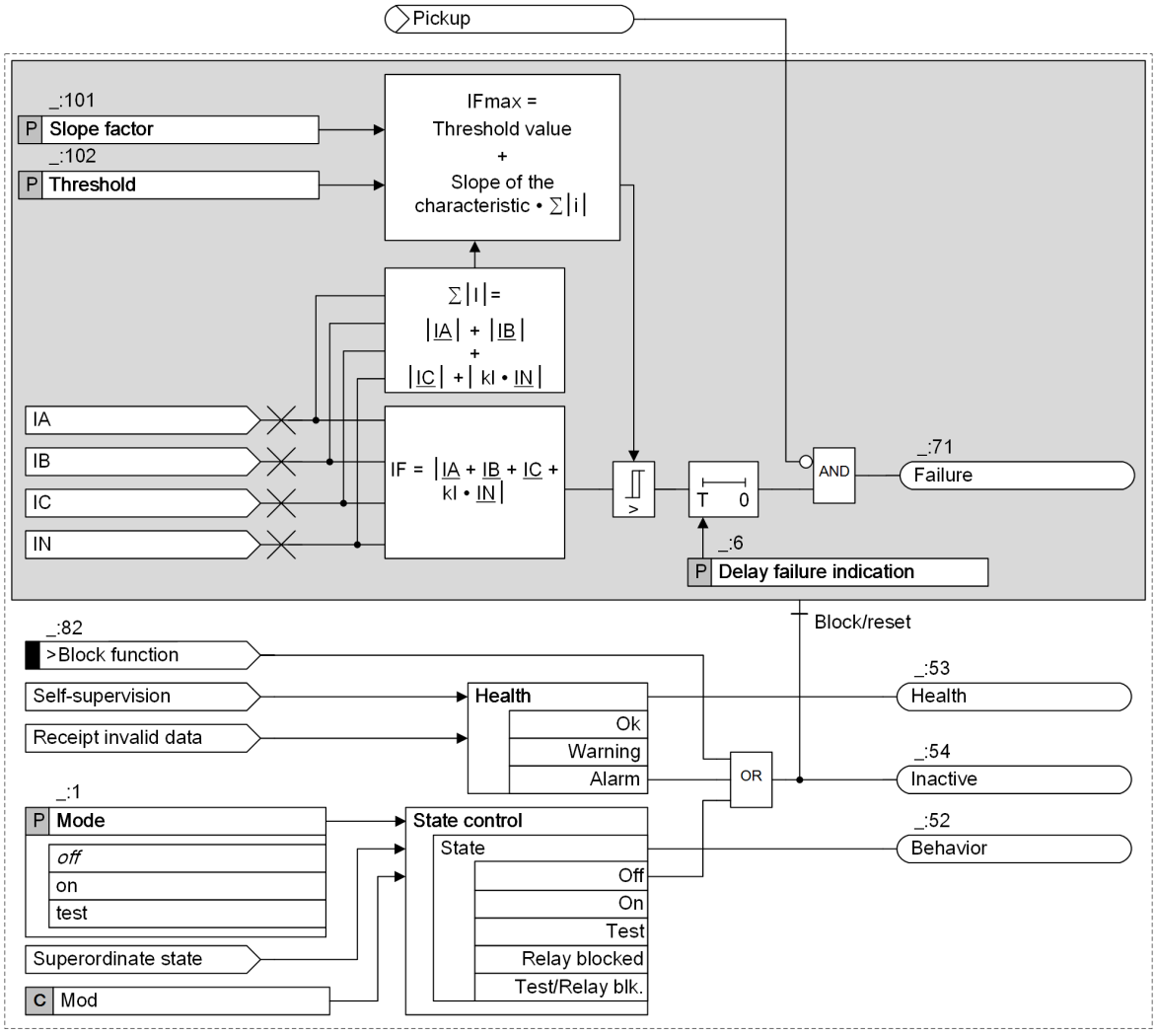
The current sum is generated by addition of the current phasors. Errors in the current circuits are detected if IF = |IA + IB + IC + kI• IN| > **Threshold** + **Slope factor** •Σ | I |.



[lo_kensum, 1, en_US]

Figure 10-36 Characteristic of the Current-Sum Supervision

Logic



[lo_cs_summ, 4, en_US]

Figure 10-37 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 zero-sequence current converter: $Ratio_N$
- Transformation ratio of phase-current converter: $Ratio_{ph}$

$$k_I = \frac{Ratio_N}{Ratio_{ph}}$$

[fo_glchki, 1, en_US]

Threshold

The **Threshold** parameter is the lower limit of the operating range of the **Current-sum supervision** function.

Delay failure indication

When the calculated fault current (I_F) exceeds the calculated fault current limit (I_{Fmax}), the delay of the failure indication (parameter: **Delay failure indication**) starts. If the threshold-value violation persists for that time, the **Failure** indication is generated.

Blocking the Function

The following blockings reset the picked up function completely:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the *Failure* indication.

10.3.12.4 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: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = *5.00 s*

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

10.3.12.5 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

Addr.	Parameter	C	Setting Options	Default Setting
_:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:6	Supv. sum I:Delay failure indication		0.00 s to 100.00 s	5.00 s

10.3.12.6 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

10.3.13 Current Phase-Rotation Supervision

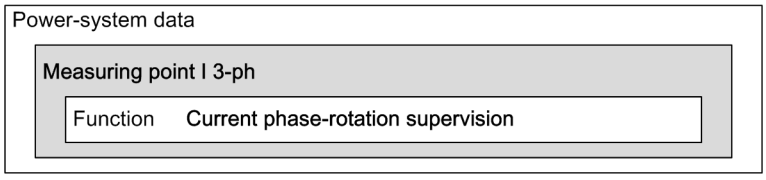
10.3.13.1 Overview of Functions

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.

10.3.13.2 Structure of the Function

The **Current phase-rotation supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

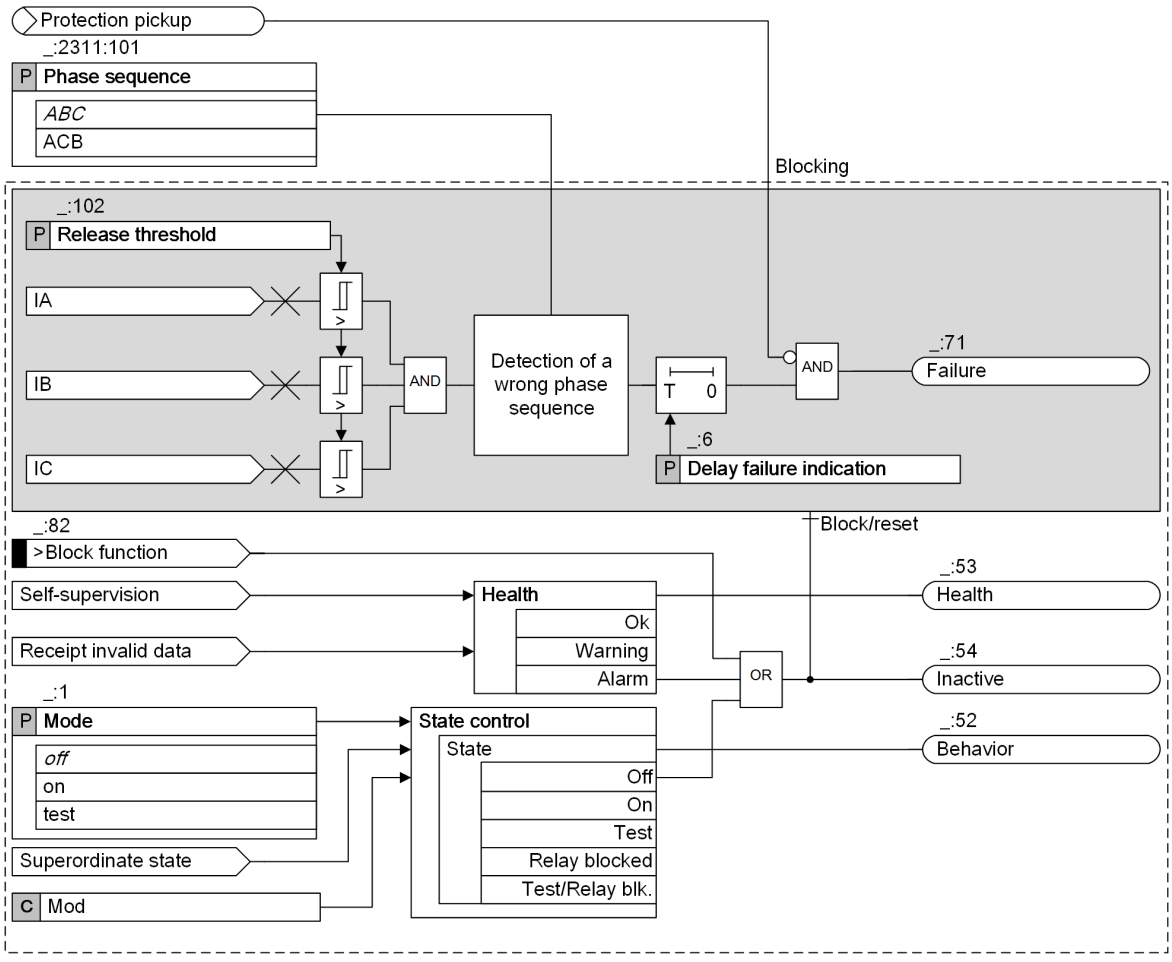


[dw_str_crs, 4, en_US]

Figure 10-38 Structure/Embedding of the Function

10.3.13.3 Function Description

Logic



[lo_cr_symm, 6, en_US]

Figure 10-39 Logic Diagram of the Current Phase-Rotation Supervision

The phase rotation is important for protection functions which process phase, loop, and directional information. You can set the phase sequence with the **`Phase sequence`** parameter in the function block **General** of the power-system data (see *8.1 Power-System Data*).

To supervise the phase rotation, the device compares the measured phase sequence with the set phase sequence. For abnormal phase sequences, the indication *`Failure`* is generated.

The connection of the currents to the device does not depend on the selected phase sequence. For connection diagrams see *A Appendix*.

Release Condition

The supervision of the current phase rotation is carried out when all measured phase currents are greater than the value of the **`Release threshold`** parameter.

Blocking of the Function

The following blockings reset the function completely:

- Via the binary input signal *`>Block function`* from an external or internal source
- Via a protection pickup
  The pickup signal from a protection function blocks the indication *`Failure`*.

Delay failure indication

When the device detects an inverted phase sequence for the duration of the **Delay failure indication**, the indication *Failure* is generated.

10.3.13.4 Application and Setting Notes

Parameter: Release threshold

- Default setting **(_:102) Release threshold** = ***0.500 A*** for I_{rated} = 1 A or ***2.50 A*** for I_{rated} = 5 A

With the **Release threshold** parameter, you specify the lower limit of the phase current for phase-rotation supervision.

Parameter: Delay failure indication

- Default setting **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

10.3.13.5 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 failure indication		0.00 s to 100.00 s	5.00 s
_:102	Supv. ph.seq.I:Release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 50.00 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

10.3.13.6 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

10.3.14 Saturation Detection

10.3.14.1 Overview of Functions

The **Saturation detection** function evaluates the profile of the current signals and determines whether the current transformer is saturated.

Protection functions such as the **Line differential protection** require this information for their selective function.

10.3.14.2 Structure of the Function

10.3.14.3 Function Description

If current-transformer saturation occurs, this leads to an erroneous representation of the primary-current history. With this, typical signal distortions of the current-signal profile occur.

The **Saturation detection** function searches for these typical signal distortions in the current signals of the 3 phases. If the **Saturation detection** function detects the typical signal distortions, it transmits corresponding internal information to the protection functions. The protection functions evaluate this information and react if saturation is detected.

The **Saturation detection** does not operate until a configurable minimum current (parameter: **CT saturation threshold**) is exceeded.

10.3.14.4 Application and Setting Notes

Parameter: CT saturation threshold

- Default setting **(_:17731:101) CT saturation threshold** = ***8.0 A***

The **CT saturation threshold** parameter is in the **Saturat. det.** block and is only visible if the **I-DIFF fast 2** stage is instantiated in the **Line differential protection** function or if the **S-DIFF fast 2** stage is instantiated in the **Stub-differential protection** function.

With the **CT saturation threshold** parameter, you set the current threshold for the saturation detection. If the set value is exceeded, the saturation detection becomes active.

Calculate the setting value for the parameter **CT saturation threshold** according to the following formula:

$$I_{saturation\ >} = \frac{n'}{k_{CT}} \cdot I_{rated}$$

[fo_sup isaet, 1, en_US]

where:

k_{CT}	Minimum current factor
n'	Effective accuracy limiting factor

The effective accuracy limiting factor n´ is calculated as follows:

$$n' = n \cdot \frac{S_{rated} + S_i}{S' + S_i}$$

[fo_saet n, 1, en_US]

where:

n	Rated overcurrent factor
S_{rated}	Rated burden of the current transformers [VA]
S_i	Inherent burden of the current transformers [VA]
S'	Actually connected burden (protection device + secondary lines)

The minimum current factor k_{CT} establishes the relationship between the different classes of conventional primary current transformers and the expected minimum current that can result in saturation of the transformer.

Closed iron core transformers such as **X**, **P**, **PX**, **PS** and **TPS** are combined in the current-transformer class **TPX**. These transformers have a large amount of remanence and a large secondary time constant.

Conventional current transformers with an anti-remanence gap such as the **TPY** and the **PR** limit the maximum possible remanence to 10 %. The minimum expected current that can result in saturation of the transformer is greater for this current-transformer class.

Due to its linear characteristic curve, the current-transformer class of the linear transformers **TPZ** transforms the alternating-current component of the primary current very well. The direct-current component of the current is greatly reduced. Depending on the connected burden, saturation occurs just below the operational overcurrent.

The following table shows the minimum current factor k_{CT} for the different current-transformer classes:

Current-Transformer Class	TPX	TPY	TPZ
k_{CT}	5	3	1.5

10.3.14.5 Settings

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
Saturat. det.				
_:17731:101	Saturat. det.:CT saturation threshold	1 A @ 100 Irated	1.200 A to 100.000 A	8.000 A
		5 A @ 100 Irated	6.00 A to 500.00 A	40.00 A
		1 A @ 50 Irated	1.200 A to 50.000 A	8.000 A
		5 A @ 50 Irated	6.00 A to 250.00 A	40.00 A

10.3.15 Trip-Circuit Supervision

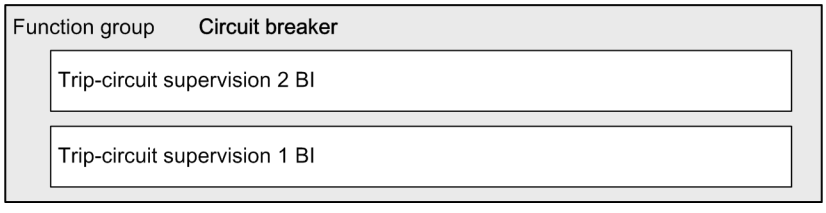
10.3.15.1 Overview of Functions

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.

10.3.15.2 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.



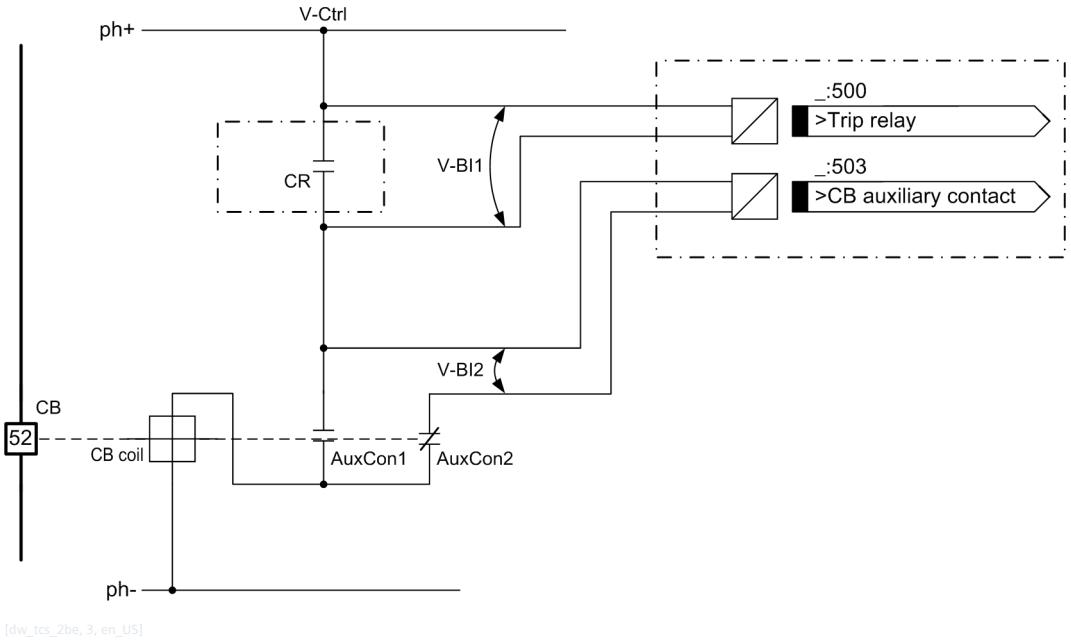
[dw_tcsueb, 1, en_US]

Figure 10-40 Structure/Embedding of the Function

10.3.15.3 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.



[dw_tcs_2be, 3, en_US]

Figure 10-41 Principle of Trip-Circuit Supervision with 2 Binary Inputs

CR	Command relay
CB	Circuit breaker (open)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (make contact)
AuxCon2	Circuit-breaker auxiliary contact (break contact)
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.

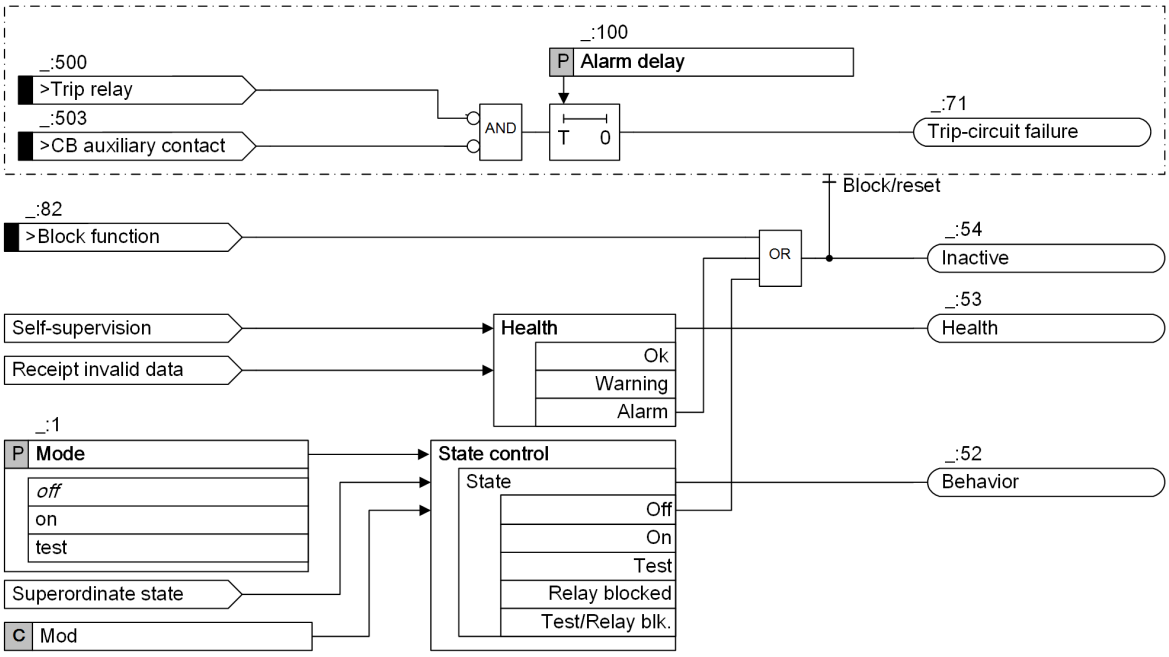
Depending on the switch position of the command relay and circuit breaker, the binary inputs are either activated (**H**) or not (**L**). If both binary inputs are not activated, there is a fault. The fault can be a disruption or a short circuit in the trip circuit, an outage of the battery voltage or 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 ineffective.

The following figure shows the logic diagram of the trip-circuit supervision with 2 binary inputs.



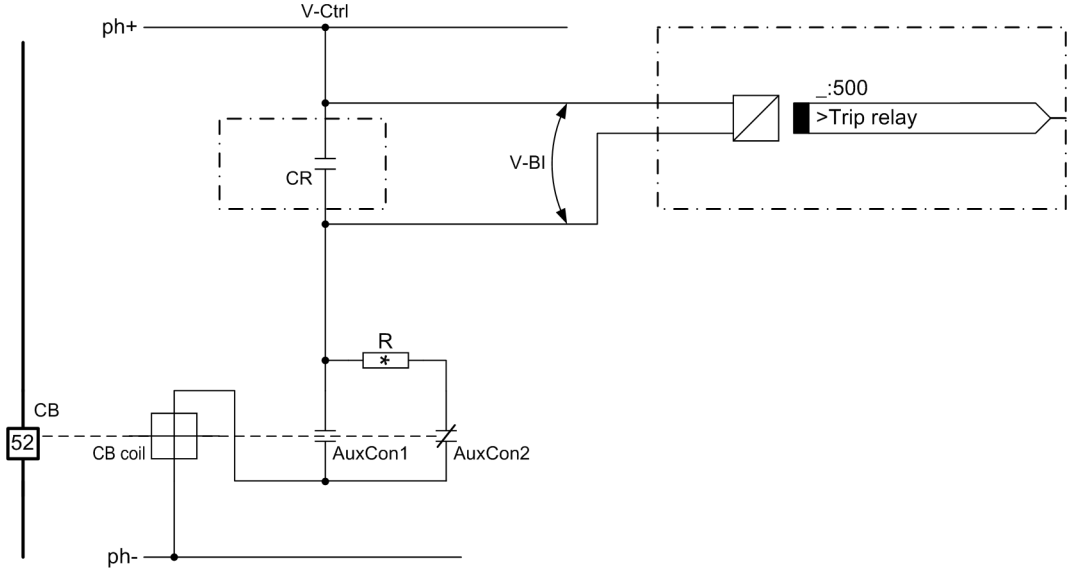
[lo_tcs_2be, 2, en_US]

Figure 10-42 Logic Diagram of Trip-Circuit Supervision with 2 Binary Inputs

10.3.15.4 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.



[dw_tcs_1be, 3, en_US]

Figure 10-43 Principle of Trip-Circuit Supervision with 1 Binary Input

CR	Command relay
CB	Circuit breaker (open)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (make contact)
AuxCon2	Circuit-breaker auxiliary contact (break contact)
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 outage 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:

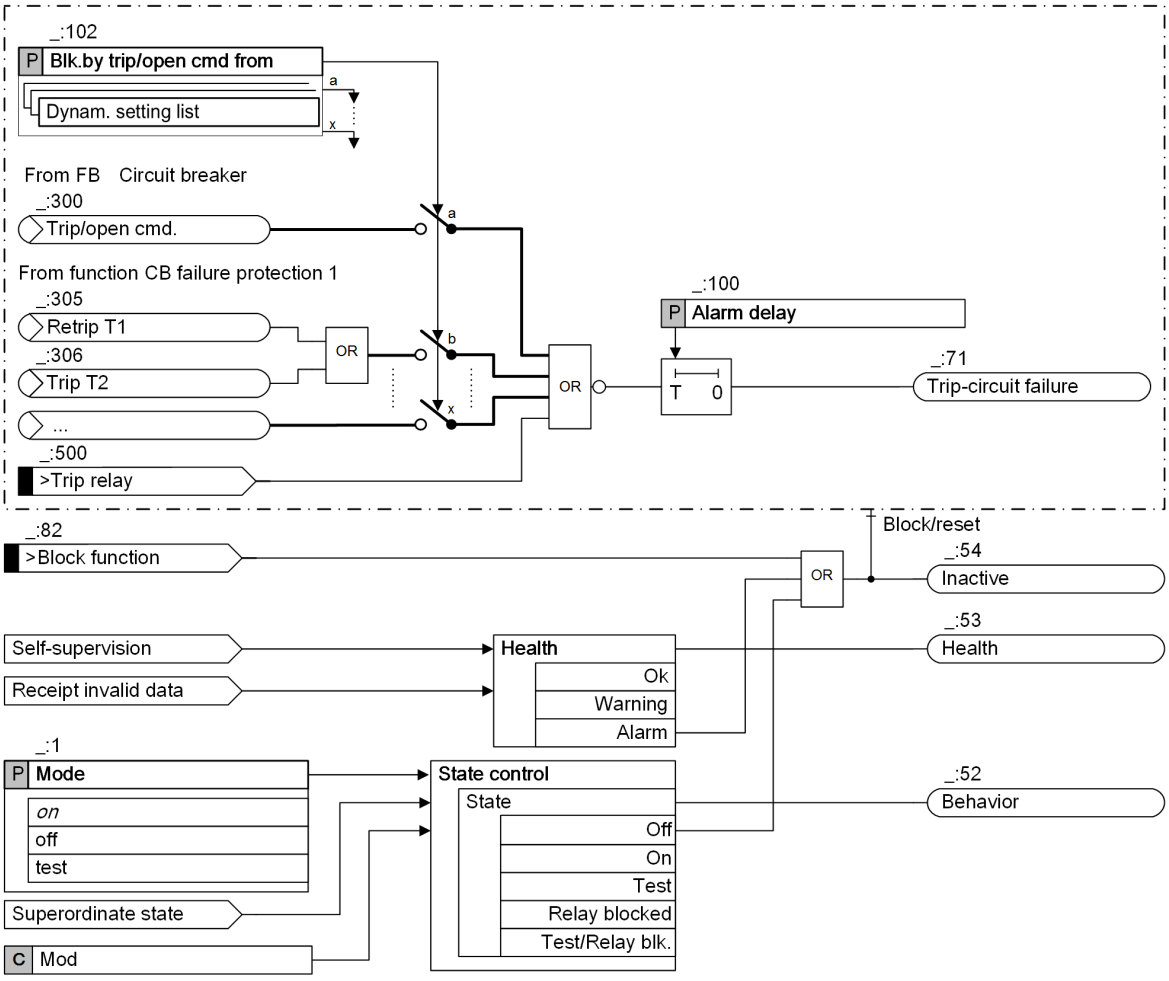
- The *Trip/open cmd.* of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.

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 the **Trip-circuit supervision** function is not in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 1 binary input.



[lo_tcs_1be, 2, en_US]

Figure 10-44 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:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BI\,min}}{I_{BI(High)}} \right) - R_{CBC}$$

[fo_r_max, 1, en_US]

So that the circuit-breaker coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC(Low\ max)}}{V_{CBC(Low\ max)}} \right)$$

[fo_r_min, 1, en_US]

with:

V_{Ctrlst}	Control voltage for the trip circuit
$V_{BI\,min}$	Minimum activate voltage for BI

R_{CBC}	Ohm's resistance of the CB coil
$I_{BI(High)}$	Constant current with activated BI
$V_{CBC\ (Low\ max)}$	Maximum voltage at the CB coil that does not lead to a tripping

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

$$R = \frac{R_{max} + R_{min}}{2}$$

[fo_r, 1, en_US]

The following applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R + R_{CBC}}\right)^2 \cdot R$$

[fo_pr, 1, en_US]

10.3.15.5 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.

10.3.15.6 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		0.50 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		0.50 s to 30.00 s	2.00 s

10.3.15.7 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

10.3.16 Closing-Circuit Supervision (General)

10.3.16.1 Overview of Functions

The **Closing-circuit supervision** function detects disruptions in the closed circuit of the circuit breaker.

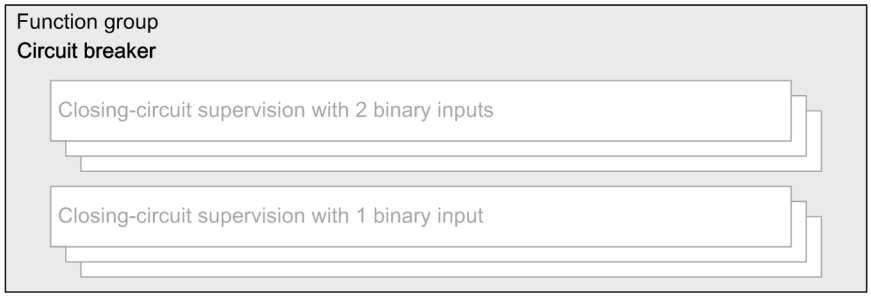
The control voltage for the closed circuit must be greater than the sum of the minimum voltage drops at the binary inputs, that is, $V_{Ctrl} > 2 \cdot V_{BImin}$.

10.3.16.2 Structure of the Function

The **Closing-circuit supervision** function is integrated into the **Circuit-breaker** function group. Depending on the available number of the binary inputs, the function works with 2 binary inputs or with 1 binary input.

The following stages can be operated simultaneously in the **Circuit-breaker** function group:

- Maximum of 3 stages **Closing-circuit supervision with 2 binary inputs**
- Maximum of 3 stages **Closing-circuit supervision with 1 binary input**



[dw_CCS_structure, 1, en_US]

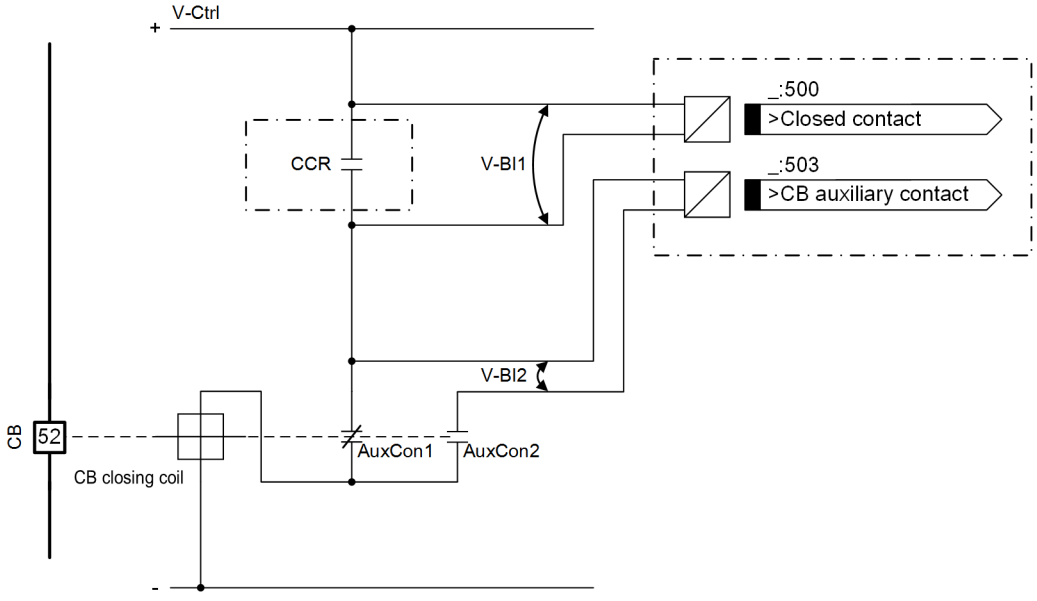
Figure 10-45 Structure/Embedding of the Function

10.3.16.3 Closing-Circuit Supervision with 2 Binary Inputs

Principle

In order to detect disruptions in the closed circuit for each switch position, 2 binary inputs are necessary:

- One binary input is connected in parallel to the close-command relay.
- Another binary input is connected in series with the circuit-breaker auxiliary contact.



[dw_CCS_2BI, 1, en_US]

Figure 10-46 Principle of the Closing-Circuit Supervision with 2 Binary Inputs

CCR	Close-command relay
CB	Circuit breaker
CB closing coil	Circuit-breaker closing coil
AuxCon1	Circuit-breaker auxiliary contact 1 (open if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact 2 (closed if the CB is closed)
V-Ctrl	Control voltage for the closed circuit
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2

The stage **Closing-circuit supervision with 2 binary inputs** detects disruptions in the closed circuit. It also monitors the reaction of the circuit breaker via the position of the circuit-breaker auxiliary contacts.

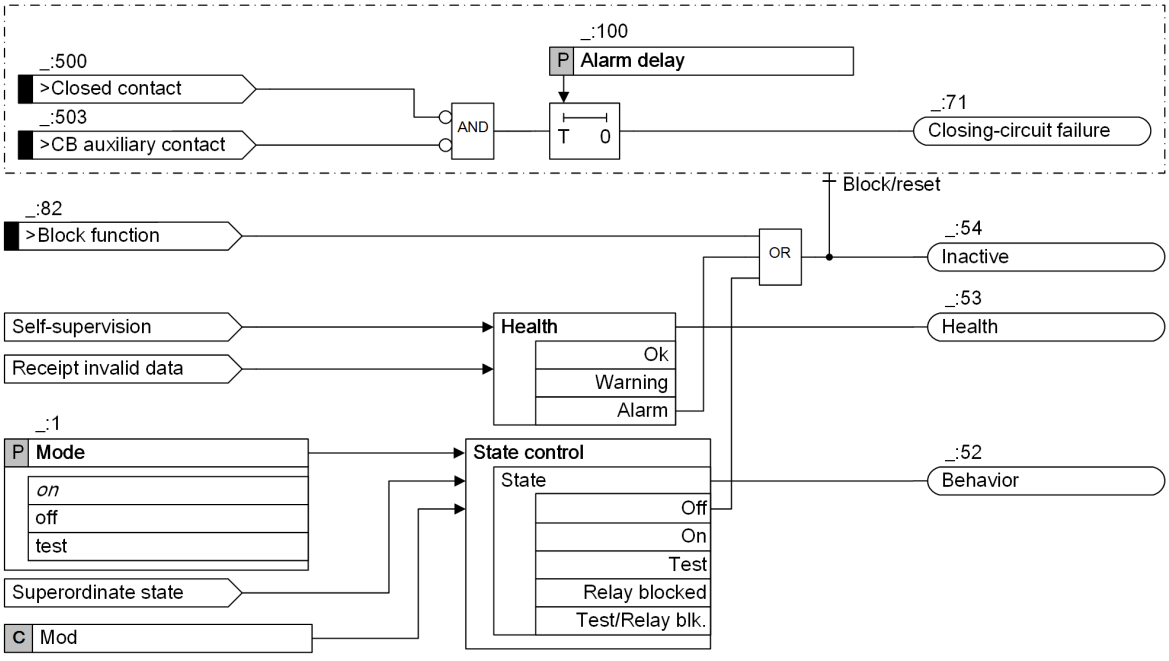
Depending on the switch position of the close-command relay and the circuit breaker, the binary inputs are either activated (H) or deactivated (L). If both binary inputs are deactivated, a fault occurs. The fault can be one of the following conditions:

- A disruption
- An outage of the battery voltage
- An adhesion present on the contact surface of the CCR

The following table shows all the states of the closed circuit:

CCR	CB	AuxCon1	AuxCon2	>Closed contact	>CB auxil-iary contact	Dynamic State	Static State
Open	Open	Closed	Open	H	L	Normal operation with an open circuit breaker	
Open	Closed	Open	Closed	H	H	Normal operation with a closed circuit breaker	
Closed	Open	Closed	Open	L	L	Transient	Fault
Closed	Closed	Open	Closed	L	H	Transient, CCR is activated	

Logic



[lo_CCS_2BI, 2, en_US]

Figure 10-47 Logic Diagram of the Stage Closing-Circuit Supervision with 2 Binary Inputs

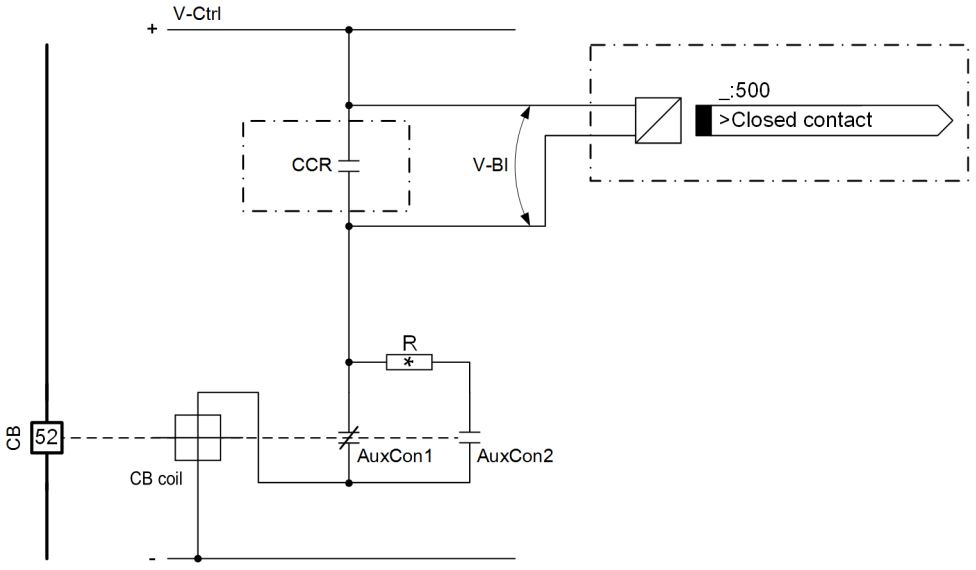
The indication *Closing-circuit failure* is generated when the following 2 conditions are met:

- The binary inputs **>Closed contact** and **>CB auxiliary contact** are both deactivated.
- The **Alarm delay** has elapsed.

10.3.16.4 Closing-Circuit Supervision with 1 Binary Input

Principle

In the stage **Closing-circuit supervision with 1 binary input**, 1 binary input is used to detect the disruption in the closed circuit. The binary input is connected parallel to the close-command relay. The circuit-breaker auxiliary contact is bridged with an equivalent resistance R.



[dw_CCS_1BI, 1, en_US]

Figure 10-48 Principle of the Closing-Circuit Supervision with 1 Binary Input

CCR	Close-command relay
CB	Circuit breaker
CB closing coil	Circuit-breaker closing coil
AuxCon1	Circuit-breaker auxiliary contact 1 (open if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact 2 (closed if the CB is closed)
V-Ctrl	Control voltage for the closed circuit
V-BI	Input voltage for binary input
R	Equivalent resistance

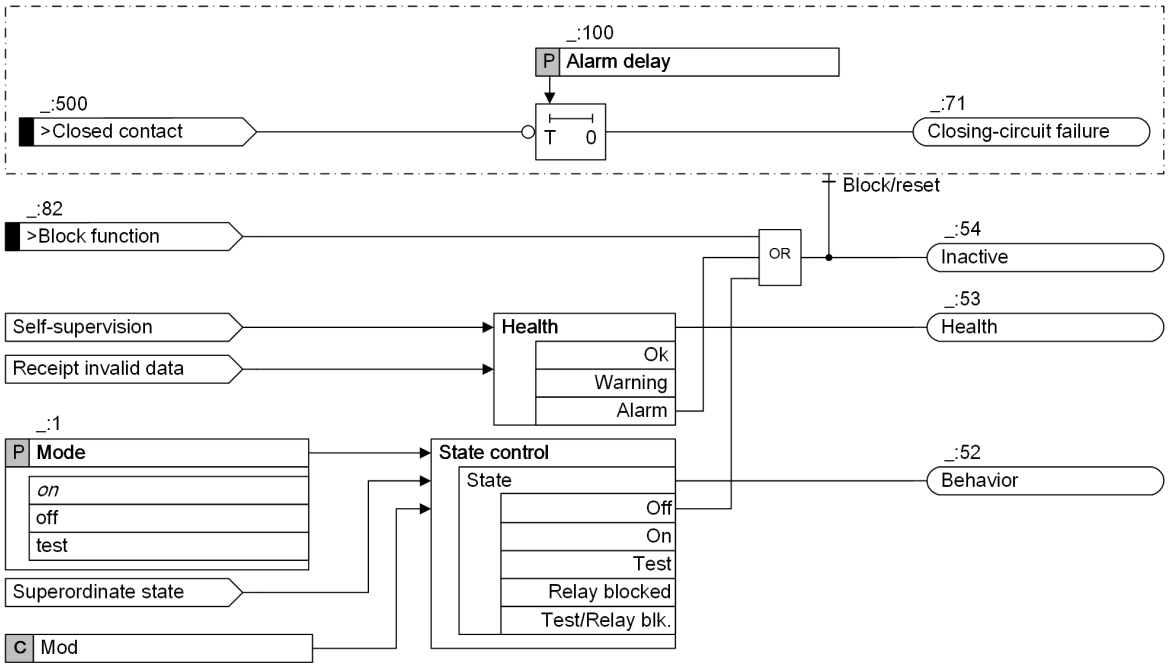
Depending on the switch position of the close-command relay, the binary input is either activated (H) or deactivated (L). If the binary input is deactivated, a fault occurs. The fault can be one of the following conditions:

- A disruption
- An outage of the battery voltage
- An adhesion present on the contact surface of the CCR

The following table shows all the states of the closed circuit:

CCR	CB	AuxCon1	AuxCon2	>Closed contact	Dynamic State	Static State
Open	Open	Closed	Open	H	Normal operation with an open circuit breaker	
Open	Closed	Open	Closed	H	Normal operation with a closed circuit breaker	
Closed	Open	Closed	Open	L	Transient	Fault
Closed	Closed	Open	Closed	L	Transient, CCR is activated	

Logic



[lo_CCS_1BI, 2, en_US]

Figure 10-49 Logic Diagram of the Stage Closing-Circuit Supervision with 1 Binary Input

The indication *Closing-circuit failure* is generated when the following 2 conditions are met:

- The binary input **>Closed contact** is deactivated.
- The **Alarm delay** has elapsed.

Equivalent Resistance R

The equivalent resistance R must be dimensioned such that the circuit-breaker closing 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:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BImin}}{I_{BImax}}\right) - R_{CBC}$$

[fo_CCS_general_Rmax, 1, en_US]

Because the circuit-breaker closing coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC(Lowmax)}}{V_{CBC(Lowmax)}}\right)$$

[fo_CCS_general_Rmin, 1, en_US]

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

$$R = \frac{R_{max} + R_{min}}{2}$$

[fo_CCS_general_R, 1, en_US]

The following equation applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R_{CBC} + R}\right)^2 \cdot R$$

[fo_CCS_general_P, 1, en_US]

With:

V_{Ctrl}	Control voltage for the closed circuit
V_{BImin}	The minimum voltage to activate the binary input
I_{BImax}	The maximum current to activate the binary input
R_{CBC}	The resistance of the circuit-breaker closing coil
$V_{CBC(Lowmax)}$	The maximum voltage flow through the circuit-breaker closing coil, which does not result in the closing of the circuit breaker

10.3.16.5 Application and Setting Notes

Parameter: Alarm delay

- Default setting **(_:100) Alarm delay** = ***2 s*** (Closing-circuit supervision with 2 binary inputs)
- Default setting **(_:100) Alarm delay** = ***300 s*** (Closing-circuit supervision with 1 binary input)

With the parameter **Alarm delay**, you can set the time for the delayed output of the indication *Closing-circuit failure*.

For the stage **Closing-circuit supervision with 2 binary inputs**, set the parameter **Alarm delay** so that the short-term transient states do not cause the function to activate.

For the stage **Closing-circuit supervision with 1 binary input**, set the parameter **Alarm delay** so that the longest duration of a close command is bridged without fail. This setting ensures that the function is activated only when the closed circuit is disrupted.

10.3.16.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
74CC sup.1BI #				
_:1	74CC sup.1BI #:Mode		• off • on • test	on
_:100	74CC sup.1BI #:Alarm delay		0.50 s to 600.00 s	300.00 s
74CC sup.2BI #				
_:1	74CC sup.2BI #:Mode		• off • on • test	on
_:100	74CC sup.2BI #:Alarm delay		0.50 s to 30.00 s	2.00 s

10.3.16.7 Information List

No.	Information	Data Class (Type)	Type
74CC sup.1BI #			
_:82	74CC sup.1BI #:>Block function	SPS	I
_:500	74CC sup.1BI #:>Closed contact	SPS	I

No.	Information	Data Class (Type)	Type
_:54	74CC sup.1BI #:Inactive	SPS	O
_:52	74CC sup.1BI #:Behavior	ENS	O
_:53	74CC sup.1BI #:Health	ENS	O
_:71	74CC sup.1BI #:Closing-circuit failure	SPS	O
74CC sup.2BI #			
_:82	74CC sup.2BI #:>Block function	SPS	I
_:500	74CC sup.2BI #:>Closed contact	SPS	I
_:503	74CC sup.2BI #:>CB auxiliary contact	SPS	I
_:54	74CC sup.2BI #:Inactive	SPS	O
_:52	74CC sup.2BI #:Behavior	ENS	O
_:53	74CC sup.2BI #:Health	ENS	O
_:71	74CC sup.2BI #:Closing-circuit failure	SPS	O

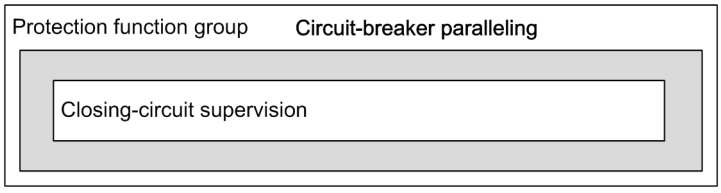
10.3.17 Closing-Circuit Supervision for Paralleling

10.3.17.1 Overview of Functions

The **Closing-circuit supervision** function recognizes disruptions in the closed circuit of the circuit breaker as well as failures in the closed relay and prevents, for example, an inadvertent connection with welded binary contacts.

10.3.17.2 Structure of the Function

The **Closing-circuit supervision** function is integrated into the **Circuit-breaker paralleling** function group.
Depending on the number of available binary inputs, the function works with 2 binary inputs and 1 resistance or with 3 binary inputs.



[dw_CCS_3BI_Structure, 2, en_US]

Figure 10-50 Structure/Embedding of the Function

10.3.17.3 Description

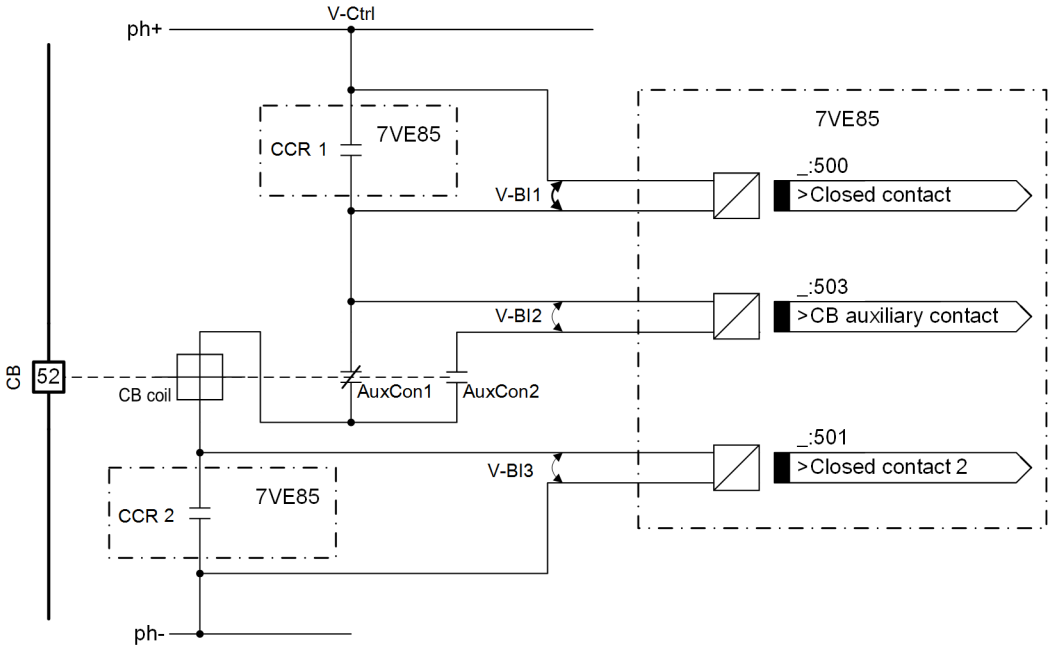
Precondition

To use the **Closing-circuit supervision** function, set the control voltage larger than 3 times the voltage of the binary input ($V_{Ctrl} > 3 \cdot V_{BImin}$).

In the following descriptions, the threshold of the binary input is 19 V.

Closing-Circuit Supervision with 3 Binary Inputs

In order to recognize disruptions in the closed circuit for each switch position, you need 3 binary inputs.
2 inputs are connected parallel to the respective command relays of the protection, another is connected parallel to the circuit-breaker auxiliary contact.



[dw_closed-circuit supervision_3BIs, 1, en_US]

Figure 10-51 Principle of the Closing-Circuit Supervision with 3 Binary Inputs

CCR 1	Closed-command relay 1
CCR 2	Closed-command relay 2
CB	Circuit breaker (closed)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (closed if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact (open if the CB is closed)
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2
V-BI3	Input voltage for binary input 3

The function **Closing-circuit supervision** with 3 binary inputs identifies disruptions in the closed 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.

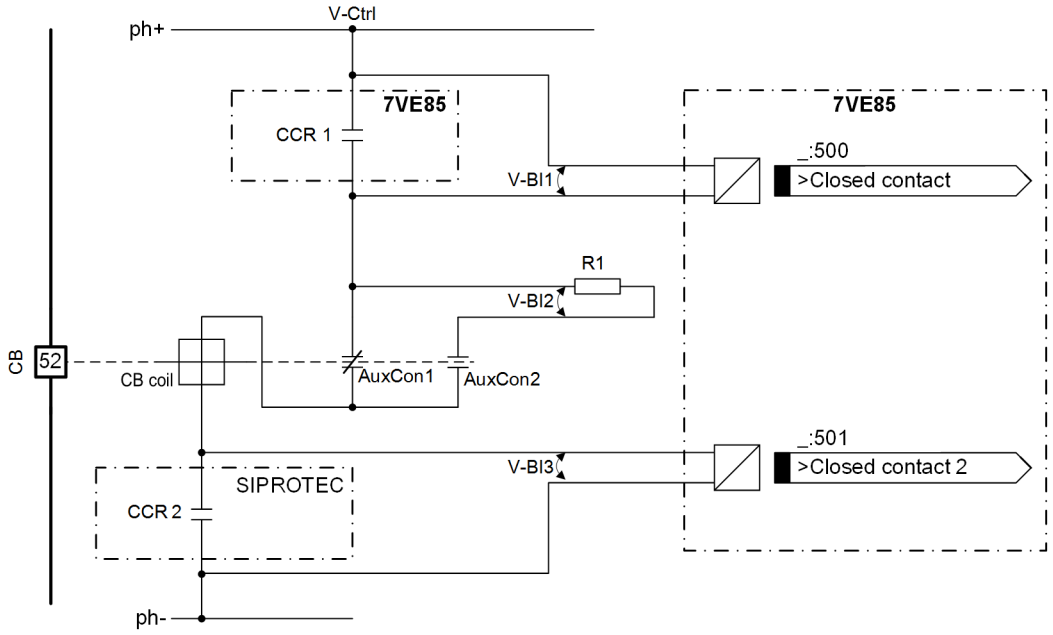
Depending on the switch position of the closed-command relay and the circuit breaker, the binary inputs are either activated (**H**) or deactivated (**L**). If both binary inputs are deactivated, a fault occurs. The fault can be a disruption or a short circuit in the closed circuit, a failure of the voltage of the binary inputs or a fault in the mechanics of the circuit breaker. With intact closed circuits, this state occurs only briefly while the command relay is closed and the circuit breaker is not opened.

Closed Command	CB	AuxCon1	AuxCon2	>Closed contact	>Closed contact 2	State
No	Closed	Closed	Open	H	H	Normal operation with closed circuit breaker
No	Open	Open	Closed	H	H	Normal operation with open circuit breaker
Yes	Open	Open	Closed	L	L	Transient process
Yes	Closed	Closed	Open	L	L	Transient process
No	–	–	–	L	L	Fault

Closed Command	CB	AuxCon1	AuxCon2	>Closed contact	>Closed contact 2	State
No	–	–	–	H	L	Fault
No	–	–	–	L	H	Fault

Closing-Circuit Supervision with 2 Binary Inputs and 1 Resistance

In *Figure 10-51*, when the circuit breaker is closed, the binary input *>CB auxiliary contact* is used to form the complete supervision circuit and limit the inductive current. Therefore the **Closing-circuit supervision** also works with 2 binary inputs and 1 resistance.



[dw_closed-circuit supervision_2BIs, 1, en_US]

Figure 10-52 Principle of the Closing-Circuit Supervision with 2 Binary Inputs and 1 Resistance

CCR 1	Closed-command relay 1
CCR 2	Closed-command relay 2
CB	Circuit breaker (closed)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (closed if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact (open if the CB is closed)
R	Equivalent resistance
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2
V-BI3	Input voltage for binary input 3

Equivalent Resistance R

The equivalent resistance R must be dimensioned in such a way 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:

$$R_{max} = \left(\frac{V_{Ctrl} - 2 \cdot V_{BImin}}{I_{BI(High)}} \right) - R_{CBC}$$

[fo_closed_circuit_supervision_1, 1, en_US]

If there is no closed command, the current flows via the binary inputs. Then the circuit current is limited to 2.5 mA at most. The closed circuit-breaker coil remains activated.

The following formula applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \times R$$

[fo_closed_circuit_supervision_2, 1, en_US]

In the following examples, you can find the calculation of R under different control voltages.

- **The control voltage is 110 V.**

  In the following example, if R_{CBC} is 90 Ω, R_{max} is calculated as follows:

  $$R_{max} = \left(\frac{V_{Ctrl} - 2 \cdot V_{BImin}}{I_{BI(High)}} \right) - R_{CBC} = \frac{110\ V - 2 \cdot 19\ V}{2.5\ mA} - 0.09\ k\Omega = 28.71\ k\Omega$$

  [fo_closed_circuit_supervision_RMax_110V, 1, en_US]

  Siemens recommends the resistance R of 18 kΩ, then the calculated maximum power is 0.11 W.

  $$P_R = I^2 \times R = \frac{2.5\ mA \cdot 2.5\ mA \cdot 18\ k\Omega}{1000} = 0.11\ W$$

  [fo_closed_circuit_supervision_PR_110V, 1, en_US]

  If the closed-command relay is open, the maximum voltage on the circuit-breaker coil and the minimum voltage on each binary input is calculated as follows:

  $$V_{CBCmax} = 1.5 \cdot 0.09\ k\Omega \cdot 2.5\ mA = 0.34\ V$$

  [fo_closed_circuit_supervision_Vmax_110V, 2, en_US]

  The circuit-breaker coil is not activated.

  $$V_{CBCmin} = [0.8 \cdot V_{CTR} - I_{BI(High)} \cdot (1.5 \cdot R_{CBC} + R)] \cdot 0.5 = [0.8 \cdot 110\ V - 2.5\ mA \cdot (1.5 \cdot 0.09\ k\Omega + 18\ k\Omega)] \cdot 0.5 = 21.33\ V$$

  [fo_closed_circuit_supervision_Vmin_110V, 2, en_US]

  The binary input is activated.

- **The control voltage is 220 V.**
  In the following example, if R_{CBC} is 36 Ω, R_{max} is calculated as follows:

$$R_{max} = \left(\frac{V_{Ctrl} - 2 \cdot V_{BImin}}{I_{BI(High)}}\right) - R_{CBC} = \frac{220\ V - 2 \cdot 19\ V}{2.5\ mA} - 0.36\ k\Omega = 72.44\ k\Omega$$

[fo_closed_circuit_supervision_RMax_220V, 1, en_US]

Siemens recommends the resistance R of 51 kΩ, then the calculated maximum power is 0.32 W.

$$P_R = I^2 \times R = \frac{2.5\ mA \cdot 2.5\ mA \cdot 51\ k\Omega}{1000} = 0.32\ W$$

[fo_closed_circuit_supervision_PR_220V, 1, en_US]

If the closed-command relay is open, the maximum voltage on the circuit-breaker coil and the minimum voltage on each binary input is calculated as follows:

$$V_{CBCmax} = 1.5 \cdot 0.36\ k\Omega \cdot 2.5\ mA = 1.35\ V$$

[fo_closed_circuit_supervision_Vmax_220V, 2, en_US]

The circuit-breaker coil is not activated.

$$V_{CBCmin} = \left[0.8 \cdot V_{CTR} - I_{BI(High)} \cdot (1.5 \cdot R_{CBC} + R)\right] \cdot 0.5 = \left[0.8 \cdot 220\ V - 2.5\ mA \cdot (1.5 \cdot 0.36\ k\Omega + 51\ k\Omega)\right] \cdot 0.5 = 23.58\ V$$

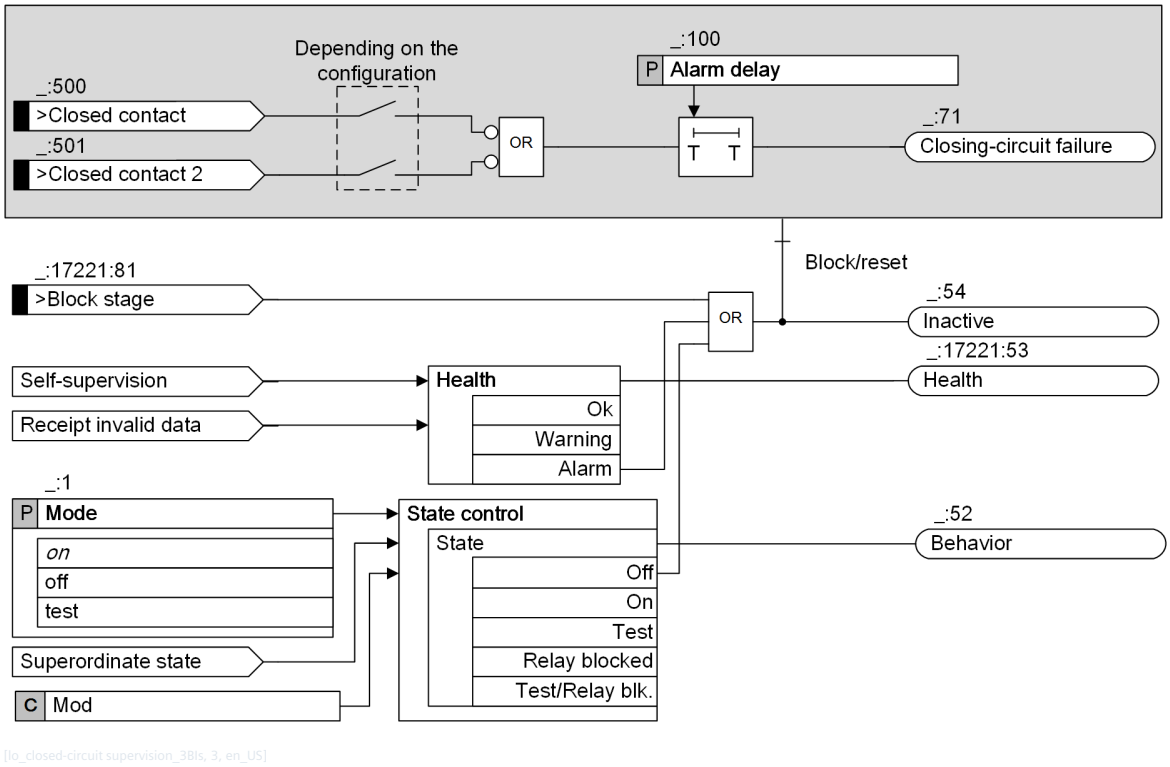
[fo_closed_circuit_supervision_Vmin_220V, 2, en_US]

The binary input is activated.

Logic of the Function Closing-Circuit Supervision

With the **`Alarm delay`** parameter, you can set the time delay. After fixing the faults in the closed circuit, the failure indication automatically expires after the **`Alarm delay`** time.

If the binary input signal *`>Closed contact`* or *`>Closed contact 2`* is not routed to the binary input of the device (**Information routing** in DIGSI 5), the **Closing-circuit supervision** function does not work.



[lo_closed-circuit supervision_3Bls, 3, en_US]

Figure 10-53 Logic Diagram of the Function Closing-Circuit Supervision

The indication is generated when the following 2 conditions are met:

- The binary input signal *>Closed contact* or *>Closed contact 2* is deactivated.
- The **Alarm delay** has elapsed.

The indication disappears only when the following 2 conditions are met:

- If the binary input signals *>Closed contact* and *>Closed contact 2* are activated
- The **Alarm delay** has elapsed.

10.3.17.4 Application and Setting Notes

Parameter: Alarm delay

- Default value **(_:100) Alarm delay** = *2.00 s*

With the parameter **Alarm delay**, you set the time for the delayed output of the indication *Closing-circuit failure*.

10.3.17.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Clsd.Cir.Sup.#				
_:1	Clsd.Cir.Sup.#:Mode		• off • on • test	on
_:100	Clsd.Cir.Sup.#:Alarm delay		0.50 s to 30.00 s	2.00 s

10.3.17.6 Information List

No.	Information	Data Class (Type)	Type
Clsd.Cir.Sup.#			
_:82	Clsd.Cir.Sup.#:>Block function	SPS	I
_:500	Clsd.Cir.Sup.#:>Closed contact	SPS	I
_:503	Clsd.Cir.Sup.#:>CB auxiliary contact	SPS	I
_:501	Clsd.Cir.Sup.#:>Closed contact 2	SPS	I
_:54	Clsd.Cir.Sup.#:Inactive	SPS	O
_:52	Clsd.Cir.Sup.#:Behavior	ENS	O
_:53	Clsd.Cir.Sup.#:Health	ENS	O
_:71	Clsd.Cir.Sup.#:Closing-circuit failure	SPS	O

10.4 Supervision of the Device Hardware

10.4.1 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 error 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 go into a secure state. Such errors are, for example:

- Failure communication module (module x)
- Measuring-transducer module failure (module x)
- USB interface
- Integrated Ethernet interface
- Real-time clock device
- 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
- Defective 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 of the error responses in table form at the end of this chapter. 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.

10.4.2 Analog-Channel Supervision via Fast Current-Sum

10.4.2.1 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 measuring 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).



[ti_phase_2, 4, en_US]

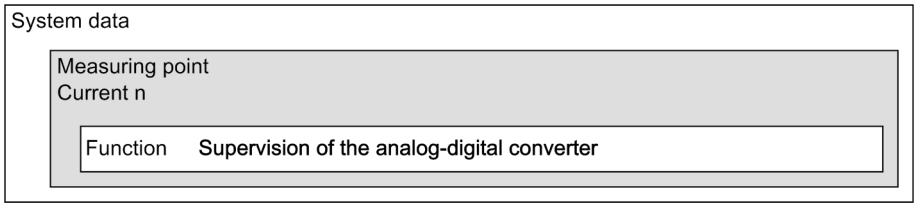
Figure 10-54 Connection to a 3-Phase Current Transformer and Measured Zero-Sequence Current (Current in Common Return Conductor)

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. When using this function, check the correct connection of the neutral conductor/ground current by supplying an asymmetrical current. Otherwise, a 1-pole or 2-pole fault could result in an unwanted blocking of the protection.

10.4.2.2 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.



[dw_schstr, 1, en_US]

Figure 10-55 Structure/Embedding of the Function

10.4.2.3 Function Description

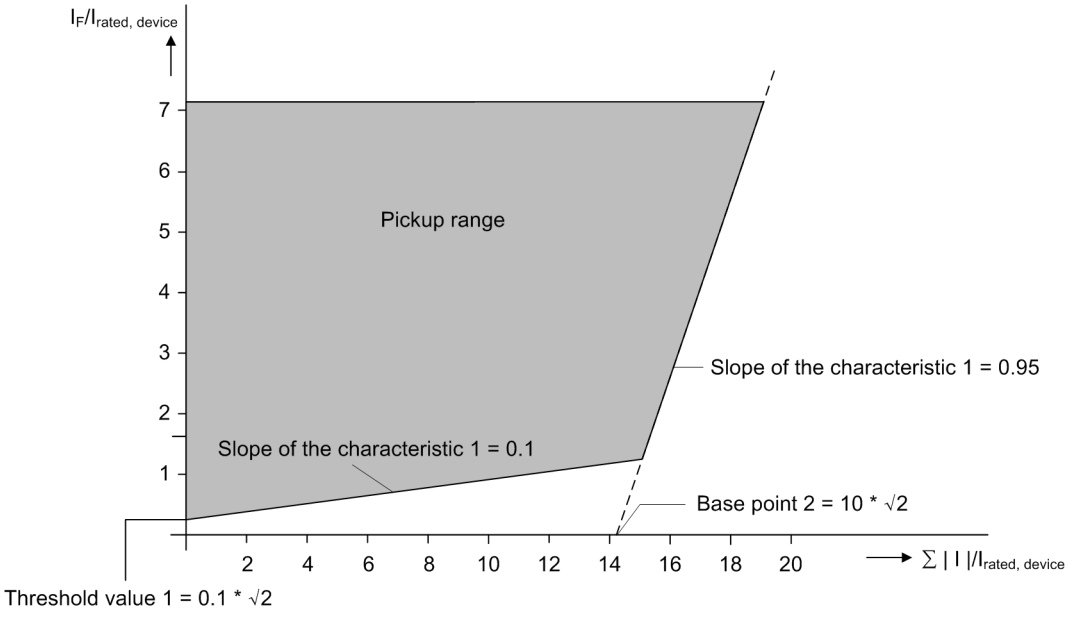
Errors in the current circuits are detected if

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**)

The device uses the current inputs (iA, iB, iC, and iN) to calculate:

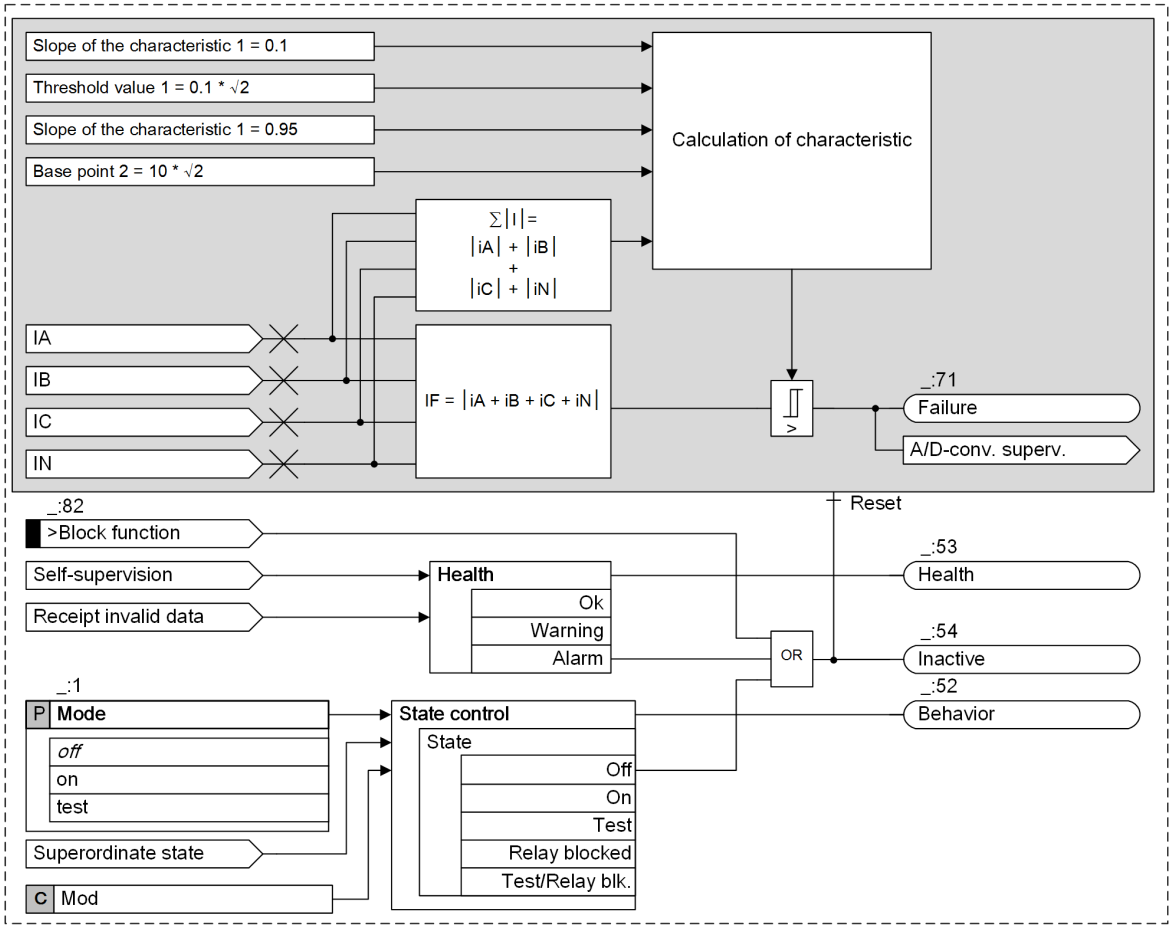
- Fault current I_F = |iA + iB + iC + iN|
- Maximum current Σ| i | = |iA|+|iB|+|iC|+ |iN|



[lo_kenisu, 2, en_US]

Figure 10-56 Characteristic Curve of the Supervision of the Device-Internal Analog-Digital Converters

Logic



[lo_sumsch, 4, en_US]

Figure 10-57 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 *13.27 Analog Channel Supervision via Fast Current Sum*).

NOTE

The parameters are set in the device and cannot be changed.

It is not necessary to change the parameters as a function of 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 permanently set to 10 % of the device rated current.

Slope of the Characteristic 1

The component **Slope of the characteristic 1** • Σ | i | accounts for permissible errors of the current input that can occur in the event of slight overcurrents.

The **Slope of the characteristic 1** is permanently set to 0.1.

Slope of the Characteristic 2

The component **Slope of the characteristic 2** accounts for permissible errors of the current input that can occur in the event of large overcurrents (high short-circuit currents).

The **Slope of the characteristic 2** is permanently set to 0.95. The base point of the **Slope of the characteristic 2** is permanently set to 10.

10.5 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 responses at the end of chapter *10.8 Error Responses and Corrective Measures*. You will find corresponding corrective measures there.

10.6 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 for which 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 the IE-converter configuration (normal/sensitive).

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 of the error responses in table form at the end of this chapter. You will find corresponding corrective measures there. You can resolve configuration errors through another synchronization with DIGSI.

10.7 Supervision of Communication Connections

SIPROTEC 5devices offer extensive communication options via fixed and optional interfaces. Beyond the hardware supervision, 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!
- Additionally, each port is equipped with a separate communication log which displays details of the failures, for example the error rate.

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, analog measured values, and binary information to **invalid**, for example for the 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.

You can correct communication failures by checking the external connections or by replacing the affected communication modules.

For further information on error responses, see to *10.8.4 Defect Severity 3*. Corresponding corrective measures are also be described there.

10.8 Error Responses and Corrective Measures

10.8.1 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 remains 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 cannot be implemented by a restart. 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 remains 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.

Table 10-2 Error Responses

	Group-Warning Indication Group Warning	Indication in Operational Log	Indication in 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	–	–

10.8.2 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.

Life 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.

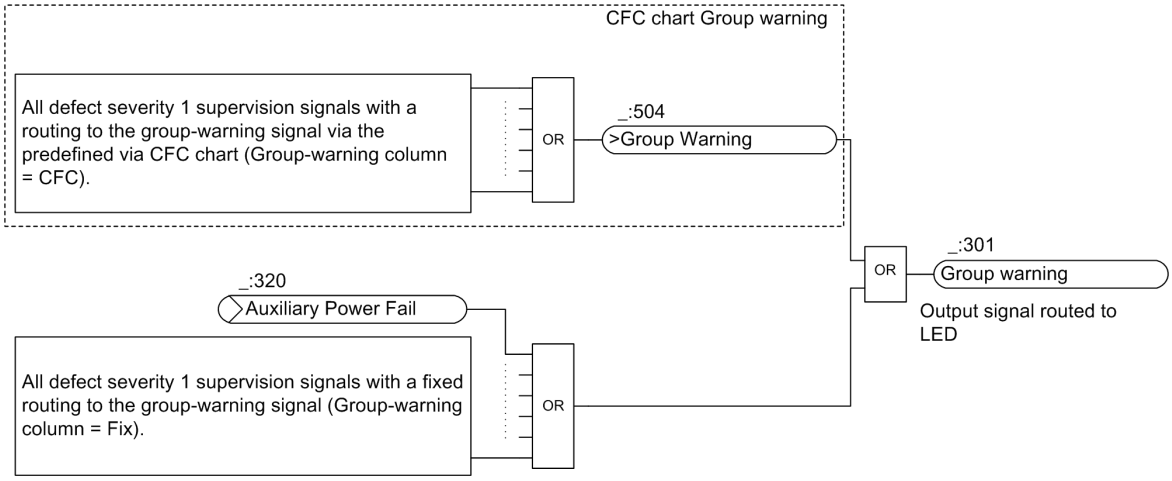
There is further information on handling the logs in *3.1 Indications*.

Group-Warning Indication Group Warning

As delivered, all monitoring 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`** (**Group warning** column = fixed). However, some supervision indications are routed flexibly to the **`Group warning`** via a logic block chart (**Group warning** column = CFC). If necessary, the routings via a CFC chart can be taken from the group indication again.

In delivery condition, the **`Group warning`** is routed to an LED.

The following logic diagram shows the correlation.



[lo_warning_indication, 1, en_US]

Figure 10-58 Forming the Warning Group Indication Group Warning

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 generates up to the general group indication **Health** (_:53) via the associated function group. Check from the operational log from which function or function block the error originates. In the associated function description, there is additional information as to why the Standby of the function or a function block can change.
(_:53) **Health** = ***Warning***	SPS		
(_:53) **Health** = ***Alarm***	SPS		

Indication		Type	Group Warning	Explanation
Device:				
	_:320 **Auxiliary Power Fail**	SPS	Fixed	Fault with the auxiliary power supply: Check the external power supply. This message does not appear if the device has a redundant PS204 power supply module, and is replaced by the messages described below for a device with PS204.
	(_:305) **Battery failure**	SPS		Battery fault: Replace the device battery. To avoid data loss, Siemens recommends replacing the device battery with the device supply voltage switched on. You can find more information on battery disposal in the hardware manual from version V07.80 (order number: C53000-G5040-C002-D).
	_:312 **Compensation error** x	ENS		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 ≈).
	_:314 **Offset error** x	ENS		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 ≈).
	_:306 **Clock fail**	SPS		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 time is marked with the quality attribute of *Clock Failure*.
	(_:319) **Error memory**	SPS		Checksum (cyclic redundancy check) error in monitored memory areas of the device
	Measuring transducer error (x)	ENS		Hardware failure on the measuring-transducer module on plug-in module position E/F/M/N/P: Contact the Customer Support Center.

Indication		Type	Group Warning	Explanation
Device with redundant PS204 power supply module:				
	_:330 **Power sup. Module fail.** x	INS	CFC	Internal device error on the power supply module at position x[39]: • The device remains in operation because it has a redundant power supply module, provided it is intact. • Exchange the defective power supply module so that redundancy is reestablished!
	_:331 **Power sup. Module OK** x	INS		No internal device error in the power supply module at position x[39].
	_:332 **Pow. sup. aux. pow. fail.** x	INS		Error in the external auxiliary power supply module at position x[39]: • The device remains in operation because it has a redundant power supply module, provided it is intact. • Check the auxiliary power supply module.
	_:333 **Power sup.aux.pow.OK** x	INS		The external auxiliary power supply module at position x[39] is OK.
	_:334 **Power sup. Module fail.** x	SPS	Fixed	At least one power supply module has an internal device error
	_:335 **Pow. sup. aux. pow. fail.** x	SPS	Fixed	At least one power supply module does not have an adequate auxiliary power supply
Handling an alarm:				
	(_:504) **>Group Warning**	SPS	Fixed	Input signal for user-defined generation of group warning
Time sync.:				
	(_:305) **Time sync. error**	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 time is marked with the quality attribute of *Clock not synchronized*.
Power-system data:meas. point I-3ph:superv. Bal. I: (_:71) **Failure**		SPS	CFC	Current balance failure (see *10.3.11.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Phsseq.I: (_:71) **Failure**		SPS	CFC	Failure of the current phase-rotation supervision system (see *10.3.13.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Sum I (_:71) **Failure**		SPS	CFC	Failure of the current sum (see *10.3.12.1 Overview of Functions*)

39 x refers to the PCB assembly slot (x =1,2,3,...)

Indication	Type	Group Warning	Explanation
Power-system data:meas. point I-3ph:superv.ADC sum.I: (_:71) **Failure**	SPS	CFC	Failure of the fast current sum (see *10.4.2.1 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 the blocking can be set individually.
Power-system data:meas. point V-3ph: Superv. of Bal. V: (_:71) **Failure**	SPS	CFC	Failure of the voltage balance (see *10.3.5.1 Overview of Functions*)
Power-system data:meas. point V-3ph: Superv. Phsseq.V: (_:71) **Failure**	SPS	CFC	Failure of the voltage phase-rotation supervision (see *10.3.7.1 Overview of Functions*)
Power-system data:meas. point V-3ph: Superv. of Sum V: (_:71) **Failure**	SPS	CFC	Failure of the voltage sum (see *10.3.6.1 Overview of Functions*)
2 devices prot. comm.: Protection interface #:			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.
(_:303) **Connection broken**	SPS	CFunctionC[40]	
(_:316) **Error rate / min exc.**	SPS		
(_:317) **Error rate / hour exc.**	SPS		
(_:318) **Time delay exceeded**	SPS		
(_:320) **Time delay jump**	SPS		
Device: (_:343) SEU happened	SPS		SEU memory fault: Cosmic radiation can result in a Single Event Upset, which can be detected through bit flips (changes in the status of a bit) in the memory blocks. A reset to reinitialize the memory is initiated. You will find additional explanations on the physical background in a special SEU whitepaper.

10.8.3 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

40 The indications are not pre-routed in the logic block chart. The indications must be added to by the user in the logic block chart!

NOTE

If the fault of defect severity 2 has not 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.

For further information on handling the logs, refer to 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.
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.
11160	SEU memory fault (short term): Reset initiated
Miscellaneous	Internal firmware error: If the fault occurs numerous times, contact the Customer Support Center.

10.8.4 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) Physical health* 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 the signal *(:301) Physical health* 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 *3.1 Indications*.

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.
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.

10.8.5 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 *10.9 Group Indications*).

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*.

10.9 Group Indications

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).

Information			Source		
			Binary input		
			Basismodul		
Signals	Number	Type	1.1	1.2	1.3
(All)	(All)	...	...	...	...
General	91				
Device	4171				
Alarm handling	5971				
>Group Alarm	5971.503	SPS			
>Group Warning	5971.504	SPS			
>Group Indication	5971.505	SPS			
Behavior	5971.52	ENS			
Health	5971.53	ENS			
Group alarm	5971.300	SPS			
Group warning	5971.301	SPS			
Group indication	5971.302	SPS			

[sc_grwarn, 1, en_US]

Figure 10-59 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 user-specifically by a binary input signal and not by internal device supervision. Nevertheless, the response of the device is serious, such as blocking all protection and automatic functions (see chapter *10.8.5 Defect Severity 4 (Group Alarm)*).

If the binary input signal *(_:503) >Group Alarm* is set, the group indication *(_:300) Group alarm* becomes active. 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 linked to the signal *(_:301) Group warning*, others are connected flexibly in the device delivery condition via a CFC chart. This assignment is described in chapter *10.8.2 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 exclusively 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* becomes active and is recorded in the operational log. This warning indication does not result in blocking a protection function. If the binary input signal is reset, the signal *(_:302) Group indication* drops out. Using a CFC chart, you can define when the binary input signal *(_:505) >Group indication* is to be set.

11 Power Quality – Basic

11.1	Voltage Variation	1090
11.2	Voltage Unbalance	1106
11.3	THD and Harmonics	1119
11.4	Total Demand Distortion	1128

11.1 Voltage Variation

11.1.1 Overview of Functions

The function **Voltage variation** is used for measuring and monitoring short-duration variations of the voltage in distribution and industrial power systems. The power-quality events such as voltage dips, swells, and interruptions in 3-phase systems are detected.

This measuring function provides the RMS value of the voltage for the minimum value in the event of a voltage dip, the lowest residual voltage in the event of an interruption or the highest swell, as well as the duration of the event.

All events can be logged in operational or user-defined logs. They can enable the fault recorder via binary warning indications, and write their values as tracks.

The values are recorded according to the standard for voltage quality IEC 61000-4-30 class S.

11.1.2 Structure of the Function

The function **Voltage variation** is used in protection function groups with 3-phase voltage measurement.

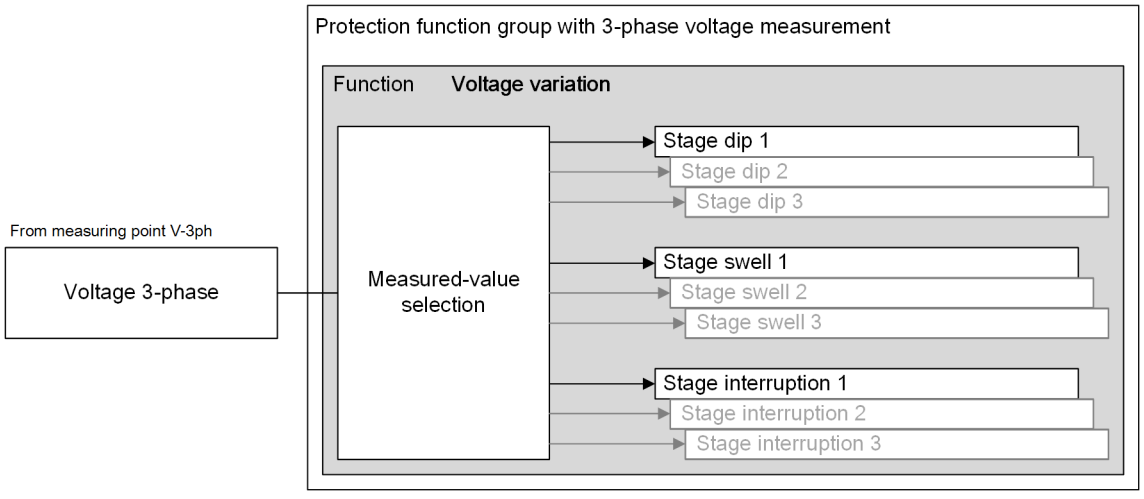
The function comes factory-set with the following stages:

- 1 stage **Dip**
- 1 stage **Swell**
- 1 stage **Interruption**

A maximum of 3 stages **Dip**, 3 stages **Swell**, and 3 stages **Interruption** can be operated simultaneously within the function.

Stages that are not preconfigured are shown in gray in the following figure. The stages are identical in structure.

The measured-value selection is a general functionality and has a uniform effect on the stages (see *Figure 11-1* and *11.1.3.1 Description*). This ensures that all stages of the function receive the same measured values.



[dw_pq_volt_var_structure, 1, en_US]

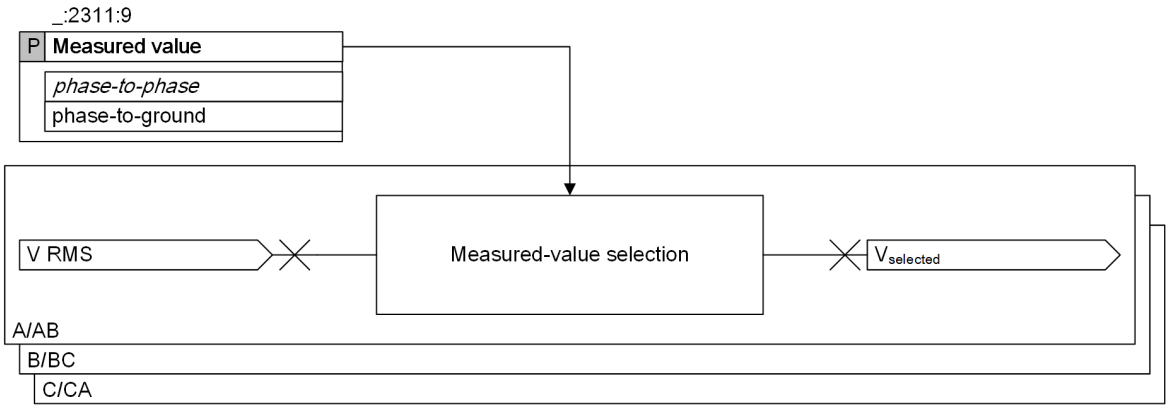
Figure 11-1 Structure/Embedding of the Function

11.1.3 General Functionality

11.1.3.1 Description

Measured-Value Selection

The function provides the option to select between the phase-to-phase and phase-to-ground voltage.



{lo_pq volt_var_general, 1, en_US}

Figure 11-2 Logic Diagram of Measured-Value Selection

The 1-cycle RMS value of the voltage is used in the function.
The setting options of the parameter **Measured value** depend on the connection type of the 3-phase voltage measuring point.

Table 11-1 Setting Options of the Parameter **Measured value**

Connection Type	Setting Options of the Parameter **Measured value**
3 ph-to-gnd voltages 3 ph-to-gnd volt. + VN	• ***phase-to-ground*** • ***phase-to-phase***
3 ph-to-ph voltages 3 ph-to-ph volt. + VN 2 ph-to-ph voltages 2 ph-to-ph volt. + VN	• ***phase-to-phase*** The setting of the parameter is read-only.

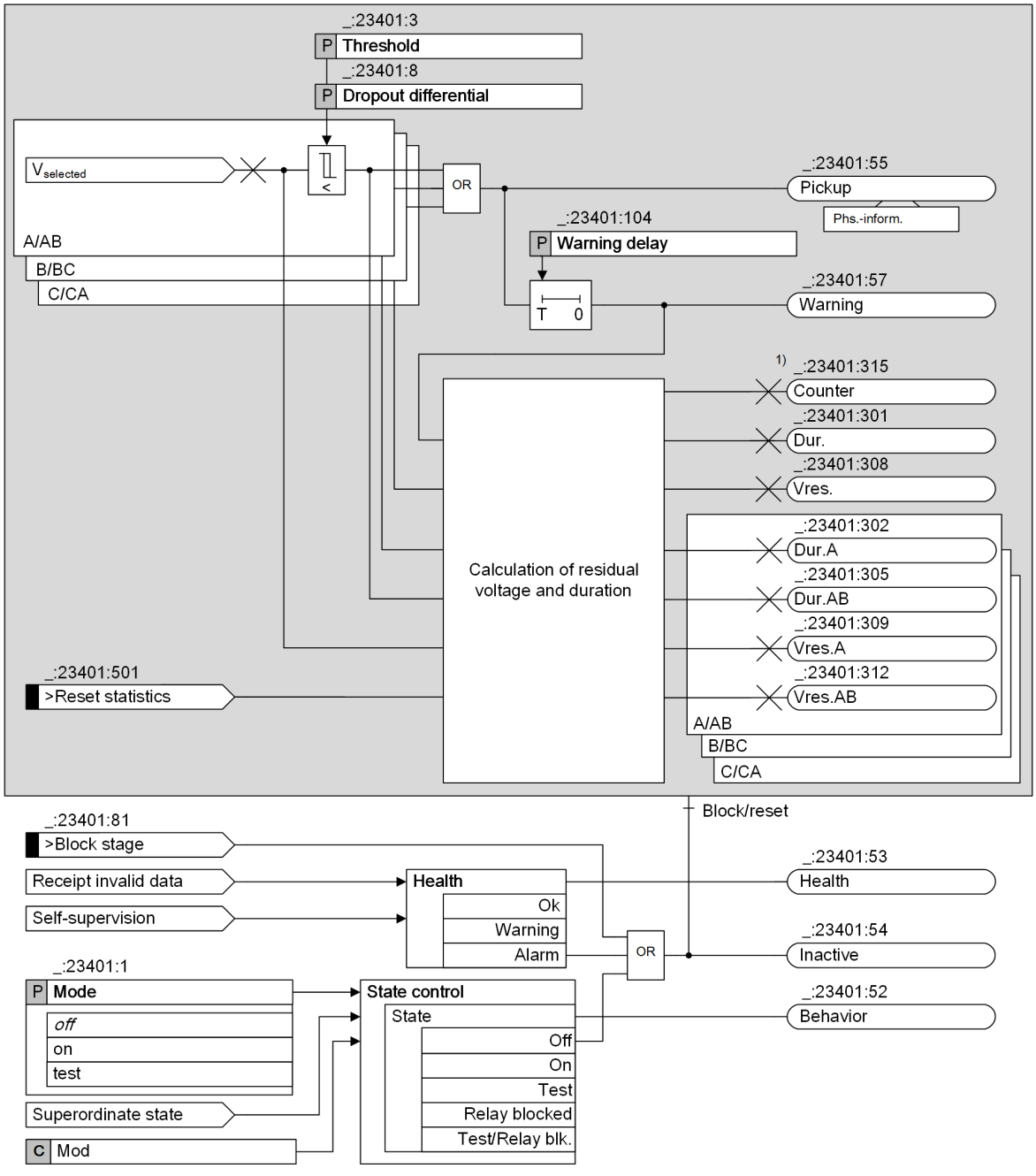
11.1.4 Stage Dip

11.1.4.1 Description

The stage **Dip**:

- Detects a voltage dip in the power system and issues a warning signal for any phase
- Logs the dip duration and the minimum residual voltage for any phase when the voltage-dip event disappears
- Counts the number of voltage-dip events

Logic of the Stage



[lo_pq_dip, 1, en_US]

Figure 11-3 Logic Diagram of the Stage Dip

(1) Counter is a statistical value. It is not reset by the block or reset state of the stage. For more information, refer to *Counter Accumulation, Page 1095*.

Pickup and Warning

If the voltage falls below the threshold value, a signal ***Pickup*** is issued. After expiration of the time specified by the parameter **`Warning delay`**, a signal ***Warning*** is issued.

The phase information of the signal *Pickup* is issued according to the selected measured value:

- The ***phase-to-ground*** voltage is selected as the measured value:
  If a phase-to-ground voltage, for example, VA, falls below the threshold value, the phase information of phase A of the signal *Pickup* is issued.
- The ***phase-to-phase*** voltage is selected as the measured value:
  If a phase-to-phase voltage, for example, VAB, falls below the threshold value, the phase information of phase A and phase B of the signal *Pickup* is issued.

Value Indications

If the signal *Warning* is issued, it is regarded as a voltage-dip event. Once the voltage-dip event disappears (the signal *Warning* drops out), the following value indications are calculated:

- The durations and residual voltages of this event are calculated and can be logged in the operational or user-defined logs if routed.
- The counter of voltage-dip events is increased by 1.

If, after the pickup, the voltage dip disappears during the time delay, the signal *Warning* is not issued and the incident is regarded as a voltage chattering and not as a voltage-dip event. No duration or voltage is calculated and the counter is not increased.

Table 11-2 Value Indications of the Stage Dip

Value	Description	Calculation
Counter	Total number of voltage-dip events This is a statistical value stored in the NVRAM[41].	Refer to *Counter Accumulation, Page 1095*
Dur.	Calculated phase overall duration of a voltage-dip event	Refer to *Duration Calculation, Page 1093*
Dur.A Dur.B Dur.C	Durations of a voltage-dip event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Dur.AB Dur.BC Dur.CA	Durations of a voltage-dip event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	
Vres.	Minimum residual voltage of all phases in a voltage-dip event among the phases A, B, and C or among the phases AB, BC, and CA	These values are percentage values related to the parameter **Rated voltage** (reference voltage) that is set in the function group. Refer to *Residual-Voltage Calculation, Page 1095*.
Vres.A Vres.B Vres.C	Minimum residual voltages in a voltage-dip event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Vres.AB Vres.BC Vres.CA	Minimum residual voltages in a voltage-dip event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	

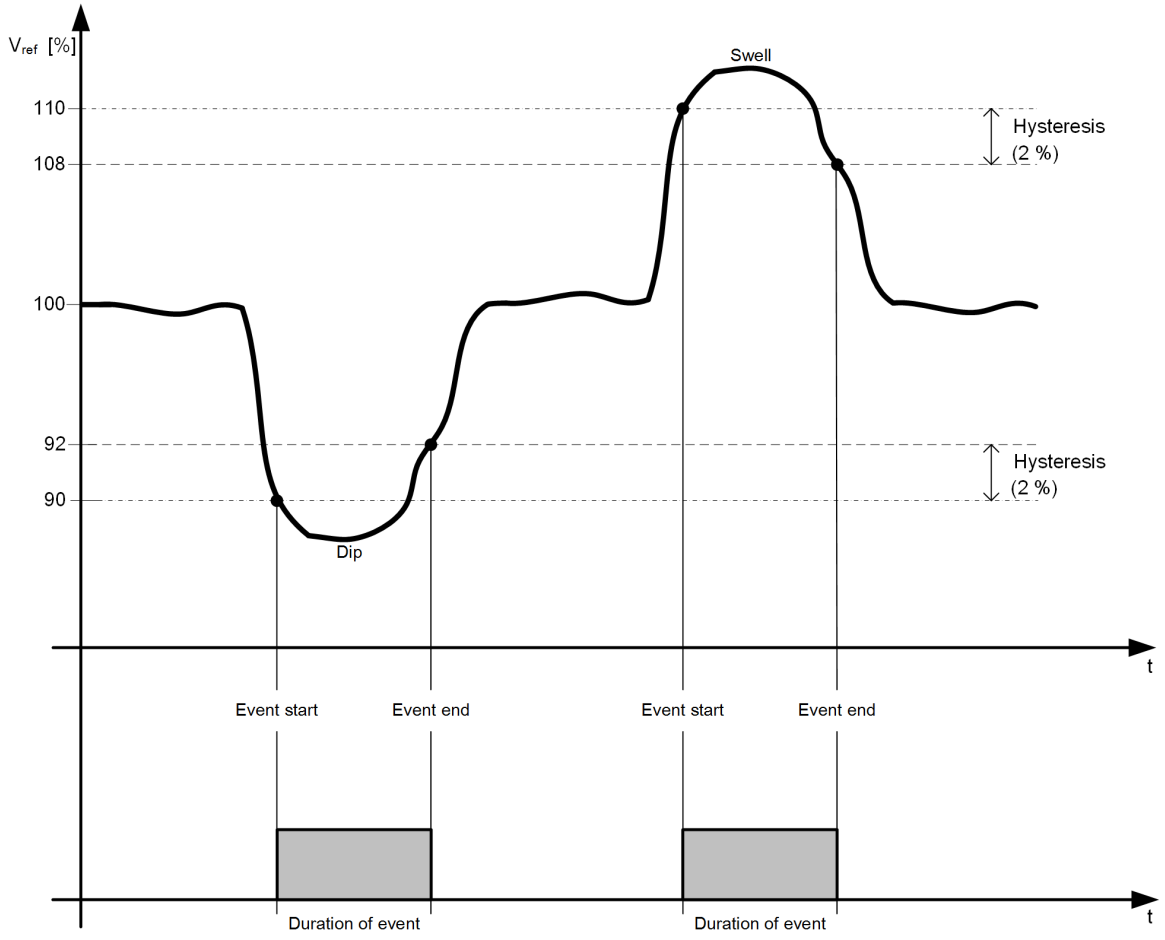
Duration Calculation

The duration of a voltage-dip or voltage-swell event is defined as the duration between the event start and event end, as shown in *Figure 11-4*.

41 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

In the figure, it is assumed as follows:

- The dip threshold is 90 % (specified by the parameter **Threshold** of the stage **Dip**).
- The swell threshold is 110 % (specified by the parameter **Threshold** of the stage **Swell**).
- The hysteresis is 2 % (specified by the parameter **Dropout differential** of the respective stage).
- The warning delay is 0 s (specified by the parameter **Warning delay** of the respective stage).



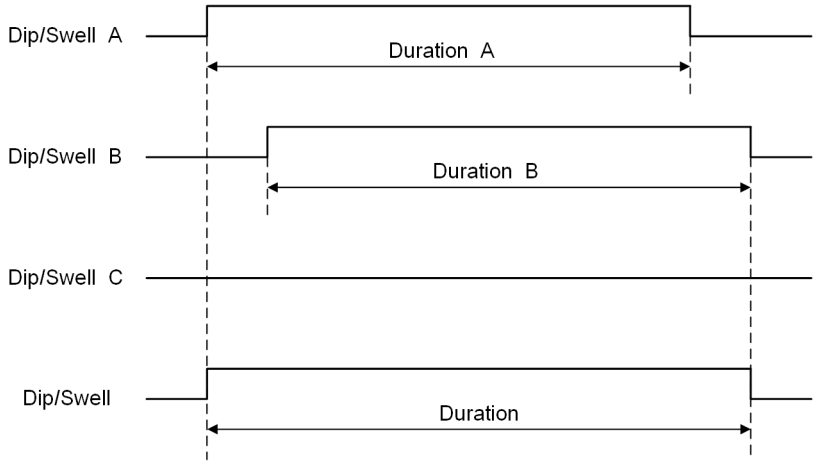
[dw_pq_volt_var_event_duration, 1, en_US]

Figure 11-4 Duration of a Voltage-Dip or Voltage-Swell Event

Where

Event start	The moment when the signal *Pickup* is issued
Event end	The moment when the signal *Pickup* drops out
V_{ref} [%]	The percentage value of the parameter **Rated voltage** (reference voltage) that is set in the function group

Only the durations of picked-up phases as well as the overall duration are calculated and logged. The following figure provides an example of phase-selective duration calculation with the ***phase-to-ground*** voltage selected as the measured value.



[dw_pq_volt_var_phs-selective_dur, 1, en_US]

Figure 11-5 Example of Phase-Selective and Overall Duration Calculation

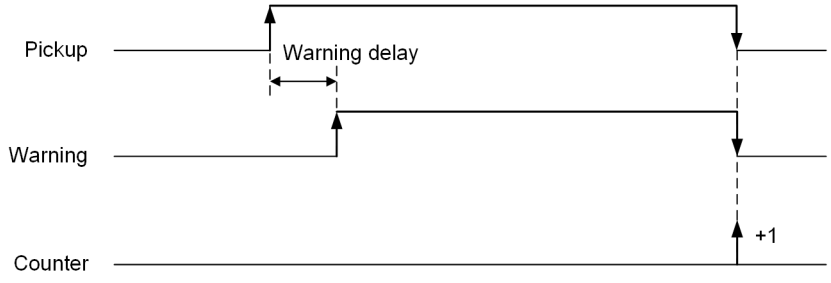
In the preceding example, voltage dips or swells occur only in phases A and B. Therefore, durations of phases A and B and the overall duration are calculated and logged. No duration of phase C is calculated or logged.

Residual-Voltage Calculation

Only picked-up phases calculate the minimum values of the residual voltages. If the values are assigned to a log, they are also logged.

Counter Accumulation

The *Counter* value is increased by 1 when the voltage-variation event disappears, as shown in the following figure.



[dw_pq_counter_accum, 1, en_US]

Figure 11-6 Counter Accumulation

NOTE

The counter is accumulated also when the function is in test mode.

The *Counter* value is retained (not reset) in the following scenarios:

- The parameter **Mode** of the stage is set to *off*.
- The signal *>Block stage* is issued.
- Device restart
- Device power-off and power-on (with battery)

The *Counter* value can be reset based on the following possibilities:

- The signal *>Reset statistics* is issued (in condition that the stage is active).
- HMI reset (in condition that the stage is active)
- DIGSI online reset (in condition that the stage is active)
- Device reset (to factory settings)
- Via protocol (in condition that the stage is active)

Blocking of the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage is reset.

11.1.4.2 Application and Setting Notes

Evaluation Possibilities – Voltage Variation Function Provides Standard-Relevant Values und Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based classifications on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: `Threshold`, `Dropout differential`

- Default setting **`(_:23401:3) Threshold`** = ***`90.0 %`***
- Default setting **`(_:23401:8) Dropout differential`** = ***`2.0 %`***

The parameters **`Threshold`** and **`Dropout differential`** are percentage values related to the parameter **`Rated voltage`** (reference voltage) that is set in the function group.

Set the parameters **`Threshold`** and **`Dropout differential`** for the specific application.

According to the standard IEC 61000-4-30, the dip threshold is typically in the range of 85 % to 90 % for troubleshooting or statistical applications, and the hysteresis (**`Dropout differential`**) is typically equal to 2 %.

Parameter: `Warning delay`

- Default setting **`(_:23401:104) Warning delay`** = ***`0.00 s`***

If you do not want to log a voltage-dip event that lasts shorter than a specific time duration, for example, 20 ms, you can set the parameter **`Warning delay`** to ***`0.02 s`***.

11.1.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
Dip 1				
_:23401:1	Dip 1:Mode		• off • on • test	off
_:23401:3	Dip 1:Threshold		10.0 % to 100.0 %	90.0 %
_:23401:8	Dip 1:Dropout differential		1.0 % to 10.0 %	2.0 %
_:23401:104	Dip 1:Warning delay		0.00 s to 60.00 s	0.00 s

11.1.4.4 Information List

No.	Information	Data Class (Type)	Type
Dip 1			
_:23401:81	Dip 1:>Block stage	SPS	I
_:23401:501	Dip 1:>Reset statistics	SPS	I
_:23401:51	Dip 1:Mode (controllable)	ENC	C
_:23401:54	Dip 1:Inactive	SPS	O
_:23401:52	Dip 1:Behavior	ENS	O
_:23401:53	Dip 1:Health	ENS	O
_:23401:55	Dip 1:Pickup	ACD	O
_:23401:57	Dip 1:Warning	SPS	O
_:23401:301	Dip 1:Dur.	MV	O
_:23401:302	Dip 1:Dur.A	MV	O
_:23401:303	Dip 1:Dur.B	MV	O
_:23401:304	Dip 1:Dur.C	MV	O
_:23401:305	Dip 1:Dur.AB	MV	O
_:23401:306	Dip 1:Dur.BC	MV	O
_:23401:307	Dip 1:Dur.CA	MV	O
_:23401:308	Dip 1:Vres.	MV	O
_:23401:309	Dip 1:Vres.A	MV	O
_:23401:310	Dip 1:Vres.B	MV	O
_:23401:311	Dip 1:Vres.C	MV	O
_:23401:312	Dip 1:Vres.AB	MV	O
_:23401:313	Dip 1:Vres.BC	MV	O
_:23401:314	Dip 1:Vres.CA	MV	O
_:23401:315	Dip 1:Counter	INS	O

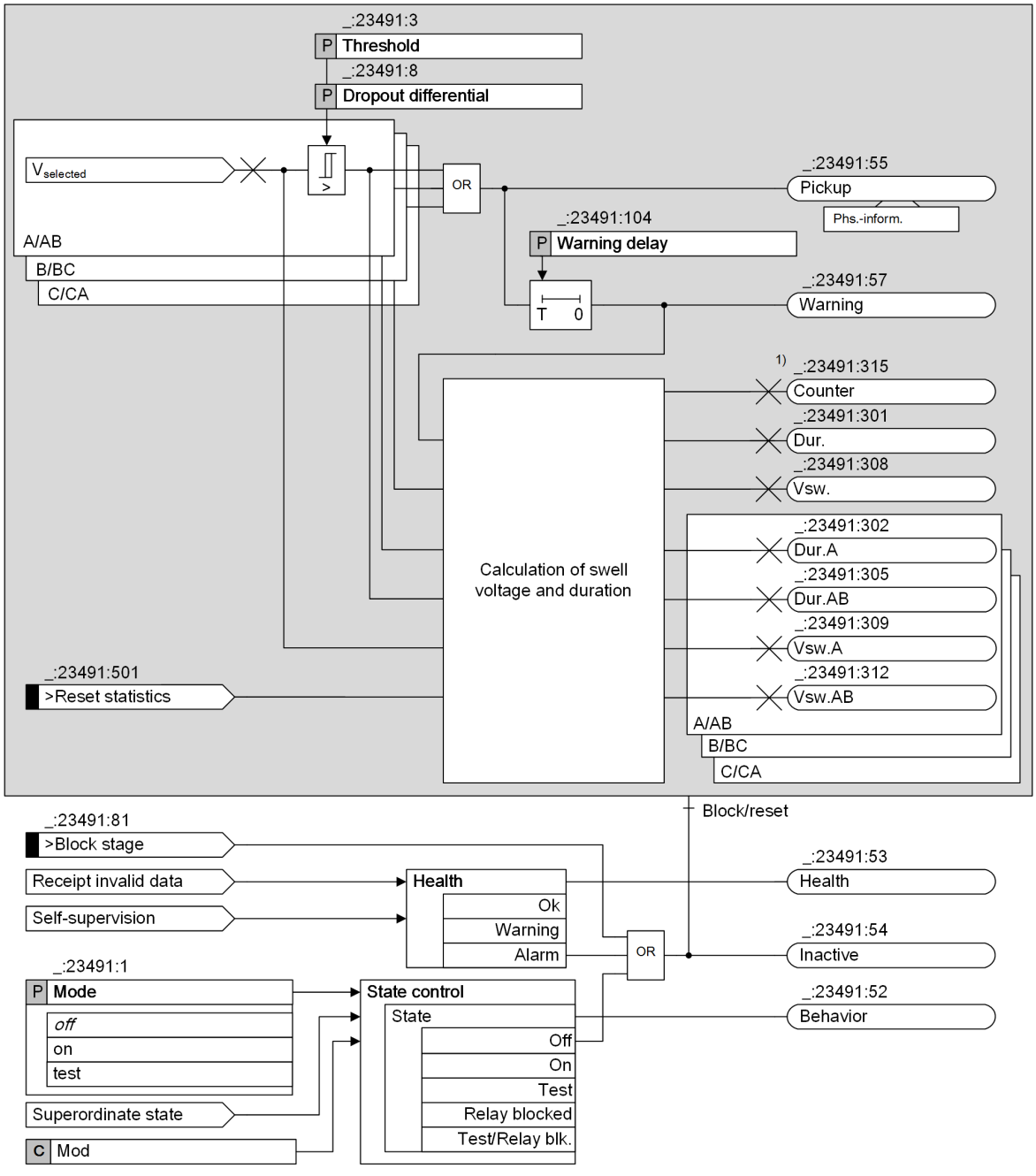
11.1.5 Stage Swell

11.1.5.1 Description

The stage **Swell**:

- Detects a voltage swell in the power system and issues a warning signal for any phase
- Logs the swell duration and the maximum swell voltage for any phase when the voltage-swell event disappears
- Counts the number of voltage-swell events

Logic of the Stage



[lo_pq_swell, 1, en_US]

Figure 11-7 Logic Diagram of the Stage Swell

(1) Counter is a statistical value. It is not reset by the block or reset state of the stage. For more information, refer to *Counter Accumulation, Page 1100*.

Pickup and Warning

If the voltage exceeds the threshold value, a signal *Pickup* is issued. After expiration of the time specified by the parameter **Warning delay**, a signal *Warning* is issued.

The phase information of the signal *Pickup* is issued according to the selected measured value:

- The ***phase-to-ground*** voltage is selected as the measured value:
  If a phase-to-ground voltage, for example, VA, exceeds the threshold value, the phase information of phase A of the signal *Pickup* is issued.
- The ***phase-to-phase*** voltage is selected as the measured value:
  If a phase-to-phase voltage, for example, VAB, exceeds the threshold value, the phase information of phase A and phase B of the signal *Pickup* is issued.

Value Indications

If the signal *Warning* is issued, it is regarded as a voltage-swell event. Once the voltage-swell event disappears (the signal *Warning* drops out), the following value indications are calculated:

- The durations and swell voltages of this event are calculated and can be logged in the operational or user-defined logs if routed.
- The counter of voltage-swell events is increased by 1.

If, after the pickup, the voltage swell disappears during the time delay, the signal *Warning* is not issued and the incident is regarded as a voltage chattering and not as a voltage-swell event. No duration or voltage is calculated and the counter is not increased.

Table 11-3 Value Indications of the Stage Swell

Value	Description	Calculation
Counter	Total number of voltage-swell events This is a statistical value stored in the NVRAM[42].	Similar to the counter accumulation of the stage **Dip**, refer to *Figure 11-6*
Dur.	Calculated phase overall duration of a voltage-swell event	Similar to the duration calculation of the stage **Dip**, refer to *Duration Calculation, Page 1093*
Dur.A Dur.B Dur.C	Durations of a voltage-swell event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Dur.AB Dur.BC Dur.CA	Durations of a voltage-swell event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	
Vsw.	Maximum swell voltage of all phases in a voltage-swell event among the phases A, B, and C or among the phases AB, BC, and CA	These values are percentage values with relation to the parameter **Rated voltage** (reference voltage) that is set in the function group. Refer to *Swell-Voltage Calculation, Page 1100*.
Vsw.A Vsw.B Vsw.C	Maximum swell voltages in a voltage-swell event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Vsw.AB Vsw.BC Vsw.CA	Maximum swell voltages in a voltage-swell event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	

Duration Calculation

For details, refer to *Duration Calculation, Page 1093*.

42 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

Swell-Voltage Calculation

Only picked-up phases calculate the maximum values of the swells. If the values are assigned to a log, they are also logged.

Counter Accumulation

For details, refer to *Counter Accumulation, Page 1095*.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage is reset.

11.1.5.2 Application and Setting Notes

Evaluation Possibilities – Voltage Variation Function Provides Standard-Relevant Values und Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based classifications on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: `Threshold`, `Dropout differential`

- Default setting **`(_:23491:3) Threshold`** = ***`110.0 %`***
- Default setting **`(_:23491:8) Dropout differential`** = ***`2.0 %`***

The parameters **`Threshold`** and **`Dropout differential`** are percentage values related to the parameter **`Rated voltage`** (reference voltage) that is set in the function group.

Set the parameters **`Threshold`** and **`Dropout differential`** for the specific application.

According to the standard IEC 61000-4-30, the swell threshold is typically greater than 110 %, and the hysteresis (**`Dropout differential`**) is typically equal to 2 %.

Parameter: `Warning delay`

- Default setting **`(_:23491:104) Warning delay`** = ***`0.00 s`***

If you do not want to log a voltage-swell event that lasts shorter than a specific time duration, for example, 20 ms, you can set the parameter **`Warning delay`** to ***`0.02 s`***.

11.1.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:9	General:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
`Swell 1`				
_:23491:1	Swell 1:Mode		• off • on • test	off
_:23491:3	Swell 1:Threshold		100.0 % to 140.0 %	110.0 %
_:23491:8	Swell 1:Dropout differential		1.0 % to 10.0 %	2.0 %
_:23491:104	Swell 1:Warning delay		0.00 s to 60.00 s	0.00 s

11.1.5.4 Information List

No.	Information	Data Class (Type)	Type
Swell 1			
_:23491:81	Swell 1:>Block stage	SPS	I
_:23491:501	Swell 1:>Reset statistics	SPS	I
_:23491:51	Swell 1:Mode (controllable)	ENC	C
_:23491:54	Swell 1:Inactive	SPS	O
_:23491:52	Swell 1:Behavior	ENS	O
_:23491:53	Swell 1:Health	ENS	O
_:23491:55	Swell 1:Pickup	ACD	O
_:23491:57	Swell 1:Warning	SPS	O
_:23491:301	Swell 1:Dur.	MV	O
_:23491:302	Swell 1:Dur.A	MV	O
_:23491:303	Swell 1:Dur.B	MV	O
_:23491:304	Swell 1:Dur.C	MV	O
_:23491:305	Swell 1:Dur.AB	MV	O
_:23491:306	Swell 1:Dur.BC	MV	O
_:23491:307	Swell 1:Dur.CA	MV	O
_:23491:308	Swell 1:Vsw.	MV	O
_:23491:309	Swell 1:Vsw.A	MV	O
_:23491:310	Swell 1:Vsw.B	MV	O
_:23491:311	Swell 1:Vsw.C	MV	O
_:23491:312	Swell 1:Vsw.AB	MV	O
_:23491:313	Swell 1:Vsw.BC	MV	O
_:23491:314	Swell 1:Vsw.CA	MV	O
_:23491:315	Swell 1:Counter	INS	O

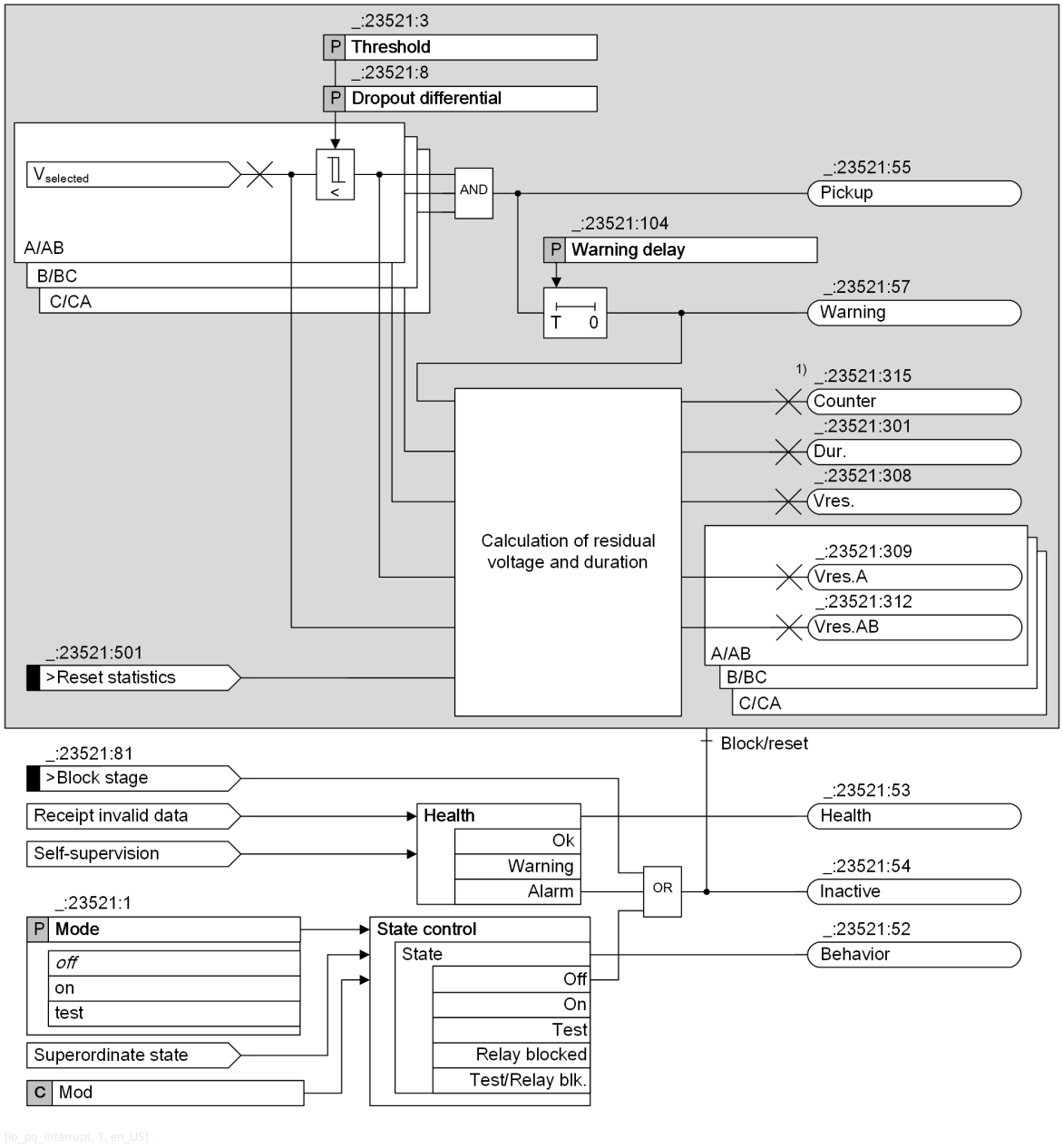
11.1.6 Stage Interruption

11.1.6.1 Description

The stage **Interruption**:

- Detects a voltage interruption in the power system and issues a warning signal
- Logs the interruption duration (not phase-selective) and the minimum residual voltage when the voltage-interruption event disappears
- Counts the number of voltage-interruption events

Logic of the Stage



[lo_pq_interrupt, 1, en_US]

Figure 11-8 Logic Diagram of the Stage Interruption

(1) Counter is a statistical value. It is not reset by the block or reset state of the stage. For more information, refer to *Counter Accumulation, Page 1104*.

Pickup and Warning

If all 3 voltage measured values fall below the threshold value, a signal ***Pickup*** is issued. After expiration of the time specified by the parameter **`Warning delay`**, a signal ***Warning*** is issued. The following measured-value types can be selected:

- The ***phase-to-ground*** voltage is selected as the measured value:

  If all the phase-to-ground voltages VA, VB, and VC fall below the threshold value, the signal ***Pickup*** is issued.

- The ***phase-to-phase*** voltage is selected as the measured value:

  If all the phase-to-phase voltages VAB, VBC, and VCA fall below the threshold value, the signal *Pickup* is issued.

Value Indications

If the signal *Warning* is issued, it is regarded as a voltage-interruption event. Once the voltage-interruption event disappears (the signal *Warning* drops out), the following value indications are calculated:

- The duration and residual voltages of this event are calculated and can be logged in the operational or user-defined logs if routed.
- The counter of voltage-interruption events is increased by 1.

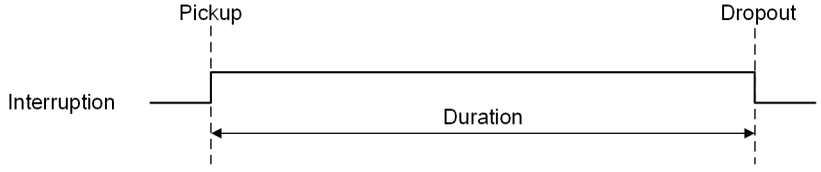
If, after the pickup, the voltage interruption disappears during the time delay, the signal *Warning* is not issued and the incident is regarded as a voltage chattering and not as a voltage-interruption event. No duration or voltage is calculated and the counter is not increased.

Table 11-4 Value Indications of the Stage Interruption

Value	Description	Calculation
Counter	Total number of voltage-interruption events This is a statistical value stored in the NVRAM[43].	Similar to the counter accumulation of the stage **Dip**, refer to *Figure 11-6*
Dur.	Calculated phase overall duration of a voltage-interruption event	Refer to *Duration Calculation, Page 1103*
Vres.	Minimum residual voltage in a voltage-interruption event among the phases A, B, and C or among the phases AB, BC, and CA	These values are percentage values related to the parameter **Rated voltage** (reference voltage) that is set in the function group refer to *Residual-Voltage Calculation, Page 1103*.
Vres.A Vres.B Vres.C	Minimum residual voltages in a voltage-interruption event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Vres.AB Vres.BC Vres.CA	Minimum residual voltages in a voltage-interruption event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	

Duration Calculation

The duration of a voltage-interruption event is defined as the duration between the event start and event end, which is similar to that of a voltage-dip or voltage-swell event. For more details, refer to *Figure 11-4*.



[dw_pq_volt_var_dur_interrupt, 1, en_US]

Figure 11-9 Duration Calculation of the Stage Interruption

Residual-Voltage Calculation

The minimum values of the residual voltages of all phases are calculated. If the values are assigned to a log, they are also logged.

43 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

Counter Accumulation

For details, refer to *Counter Accumulation, Page 1095*.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage is reset.

11.1.6.2 Application and Setting Notes

Evaluation Possibilities – Voltage Variation Function Provides Standard-Relevant Values und Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based classifications on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: `Threshold`, `Dropout differential`

- Default setting **`(_:23521:3) Threshold`** = ***`5.0 %`***
- Default setting **`(_:23521:8) Dropout differential`** = ***`2.0 %`***

The parameters **`Threshold`** and **`Dropout differential`** are percentage values related to the parameter **`Rated voltage`** (reference voltage) that is set in the function group.

Set the parameters **`Threshold`** and **`Dropout differential`** for the specific application.

According to the standard IEC 61000-4-30, the interruption threshold can, for example, be set to 5 % or to 10 %, and the hysteresis (**`Dropout differential`**) is typically equal to 2 %.

Parameter: `Warning delay`

- Default setting **`(_:23521:104) Warning delay`** = ***`0.00 s`***

If you do not want to log a voltage-interruption event that lasts shorter than a specific time duration, for example, 20 ms, you can set the parameter **`Warning delay`** to ***`0.02 s`***.

11.1.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:9	General:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
`Interrup. 1`				
_:23521:1	Interrup. 1:Mode		• off • on • test	off
_:23521:3	Interrup. 1:Threshold		1.0 % to 20.0 %	5.0 %
_:23521:8	Interrup. 1:Dropout differential		1.0 % to 10.0 %	2.0 %
_:23521:104	Interrup. 1:Warning delay		0.00 s to 60.00 s	0.00 s

11.1.6.4 Information List

No.	Information	Data Class (Type)	Type
Interrup. 1			
_:23521:81	Interrup. 1:>Block stage	SPS	I
_:23521:501	Interrup. 1:>Reset statistics	SPS	I
_:23521:51	Interrup. 1:Mode (controllable)	ENC	C
_:23521:54	Interrup. 1:Inactive	SPS	O
_:23521:52	Interrup. 1:Behavior	ENS	O
_:23521:53	Interrup. 1:Health	ENS	O
_:23521:55	Interrup. 1:Pickup	ACD	O
_:23521:57	Interrup. 1:Warning	SPS	O
_:23521:301	Interrup. 1:Dur.	MV	O
_:23521:308	Interrup. 1:Vres.	MV	O
_:23521:309	Interrup. 1:Vres.A	MV	O
_:23521:310	Interrup. 1:Vres.B	MV	O
_:23521:311	Interrup. 1:Vres.C	MV	O
_:23521:312	Interrup. 1:Vres.AB	MV	O
_:23521:313	Interrup. 1:Vres.BC	MV	O
_:23521:314	Interrup. 1:Vres.CA	MV	O
_:23521:315	Interrup. 1:Counter	INS	O

11.2 Voltage Unbalance

11.2.1 Overview of Functions

In a 3-phase power system, the voltages are normally balanced, as well as the connected loads. In some cases, however, the balanced conditions can be disturbed due to various influences.

Voltage unbalances can be caused by various factors:

- Unbalanced load, for example, caused by different consumers in the individual phases
- Phase failure, for example, due to a tripped 1-phase fuse or a broken conductor
- Faults in the primary system, for example, at the transformer

The function **Voltage unbalance**:

- Detects the voltage-unbalance conditions in the distribution and industrial power systems.
- Monitors the voltage-unbalance conditions.

In the function **Voltage unbalance**, the following stage types are available:

- **V2/V1**: ratio of the negative-sequence voltage to the positive-sequence voltage
- **V0/V1**: ratio of the zero-sequence voltage to the positive-sequence voltage

All the measured values are displayed under **Power quality basic** > **Voltage unbalance** of a specific function group in the HMI.

The specific function group in which the function **Voltage unbalance** is instantiated must be connected to the 3-phase voltage measuring point.

The values are recorded according to the standard for voltage quality IEC 61000-4-30 class S.

11.2.2 Structure of the Function

The function **Voltage unbalance** can be used in the protection function groups with 3-phase voltage measurement.

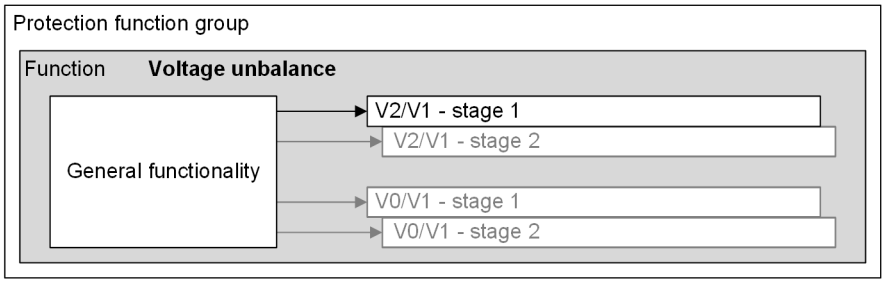
The function **Voltage unbalance** comes factory-set with a stage **V2/V1**.

The following stages can be operated simultaneously within the function:

- 2 stages **V2/V1**
- 2 stages **V0/V1**

The general functionality works across stages on the function level.

The stages are identical in structure. Stages that are not preconfigured are shown in gray in the following figure.



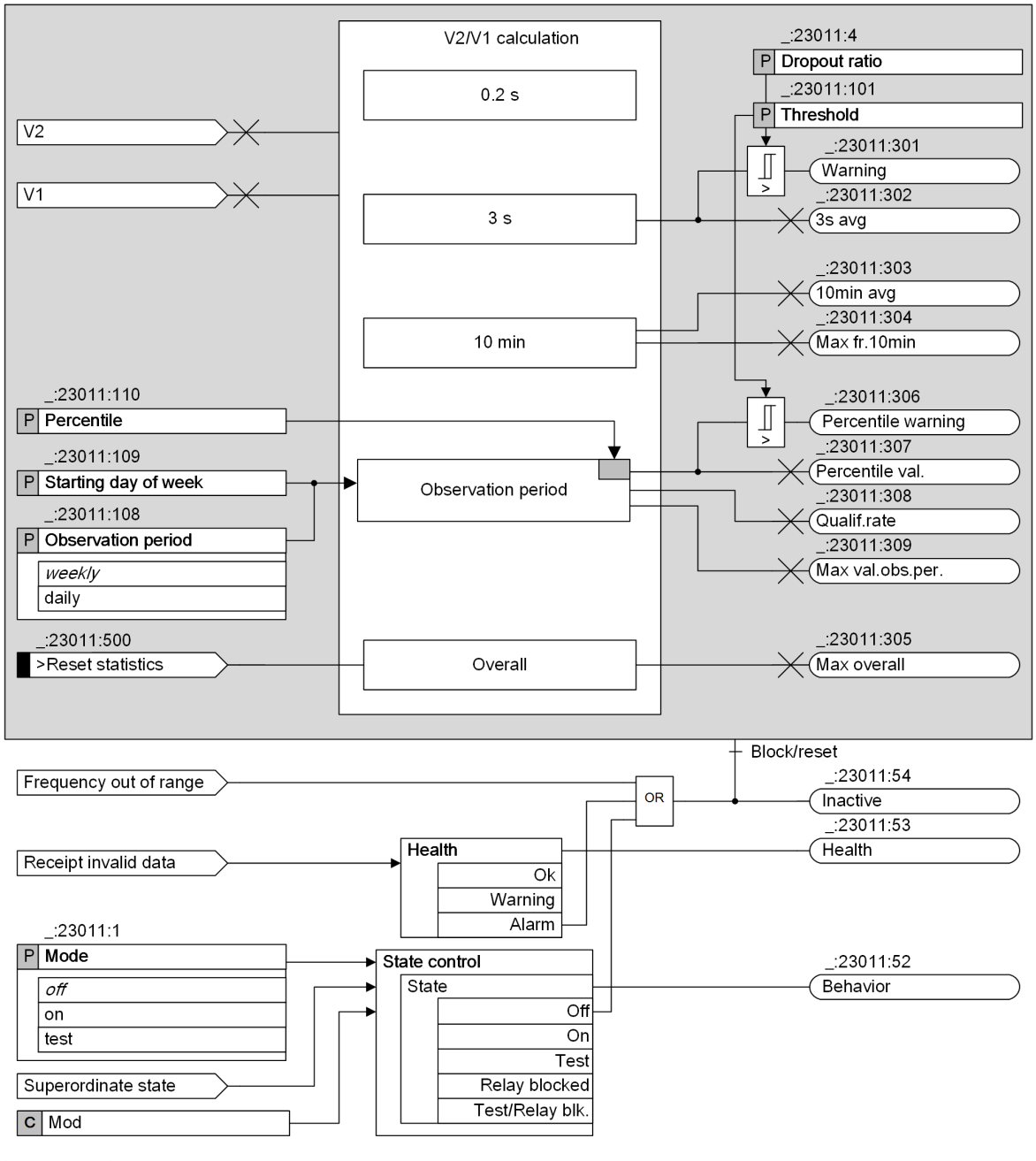
[dw_V_unbalance_structure, 1, en_US]

Figure 11-10 Structure/Embedding of the Function

11.2.3 Stage V2/V1

11.2.3.1 Description

Logic of the Stage



[lo_V2_V1, 2, en_US]

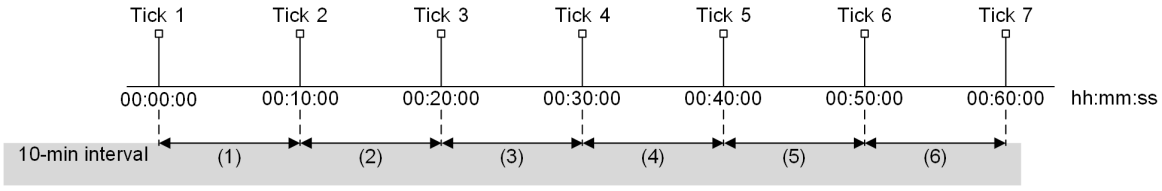
Figure 11-11 Logic Diagram of the Stage **V2/V1**

Measuring Intervals

Measuring Intervals	Description
0.2 s	10 cycles for the 50-Hz system or 12 cycles for the 60-Hz system This interval is the basic measuring interval for this stage. All further measured values are aggregated based on the 0.2-s values.
3 s	150 cycles for the 50-Hz system or 180 cycles for the 60-Hz system This interval is used for the calculation of the 3-s average value.
10 min	The calculation in the 10-min interval is based on the UTC 10-min tick. There is no gap and no overlap between 2 consecutive 10-min intervals. This interval is used for the calculation of the 10-min average value and the maximum 0.2-s value in 10 min.
Observation period	Settable interval of one week or one day
Overall	From the device startup or from the latest reset of statistical values until the current time The maximum value of V2/V1 in overall time is displayed as a statistical value.

Aggregation by the UTC 10-Min Tick

The 10-min average values are aggregated by the UTC 10-min tick according to the standard IEC 61000-4-30. Each 10-min interval begins at a tick.



[dw_tick_interval, 1, en_US]

Figure 11-12 Ticks and 10-Min Intervals in an Hour

Warning of the Voltage Unbalance

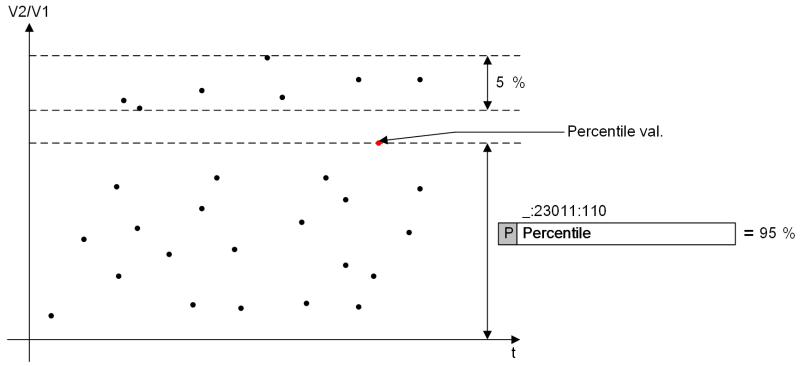
If the 3-s average value exceeds the threshold value, a voltage-unbalance event occurs and the indication *warning* is generated.

If the 3-s average value is smaller than or equal to the result of the threshold value multiplied by the dropout ratio, the indication *warning* for the voltage unbalance disappears.

Observation

A settable observation period of *weekly* or *daily* is provided. In the observation period, the following measured values are observed to determine the voltage-unbalance conditions.

Table 11-5 Observed Values in the Observation Period

Value	Description
Percentile val.	To locate the value *Percentile val.*, you must set the parameter **Percentile**. The following figure shows an example of locating the percentile value: In the figure, all the 10-min average values of V2/V1 in the last observation period are displayed. The parameter **Percentile** is set to 95 %. Then, the value *Percentile val.* is determined as the value that 95 % of the 10-min average values in the last observation period are smaller than or equal to. 
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period

During the observation period, if the value *Percentile val.* of the 10-min average values exceeds the threshold value, a voltage-unbalance event occurs and the indication *Percentile warning* is generated.

Functional Values

Value	Description
Max overall	Maximum 0.2-s value of V2/V1 from the device startup or from the latest reset of statistical values to the current time
3s avg	Average value of V2/V1 in the last 3-s interval, that is, 150 cycles or 180 cycles
10min avg	Average value of V2/V1 in the last 10-min interval
Max fr.10min	Maximum 0.2-s value of V2/V1 in the last 10-min interval
Percentile val.	The value *Percentile val.* is the value that, for example, 95 % (default setting of the parameter **Percentile**) of all 10-min average values in the last observation period are smaller than or equal to. For more information, refer to *Observation, Page 1108*.
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period This value is refreshed at the end of each observation period.

Value Indications

If the indication *Percentile warning* is generated, routed value indications from the table *Table 11-6* can be entered in the log.

Table 11-6 Value Indications

Value	Description
Perc.value abnor.	**Percentile value abnormal** Percentile in case of a warning (percentile is above limiting value) and possible record It is the ame value as *Percentile val.* from the same observation interval.
Qual.rate abnor.	**Quality rate abnormal** Quality rate in case of a warning (percentile is above limiting value) and possible record It is the same value as *Qualif.rate* from the same observation interval.
Max val.obs.per.abnor.	**Maximum value observation period abnormal** Maximum value of the observation period in case of a warning (percentile is above limiting value) and possible record It is the same value as *Max val.obs.per.* from the same observation interval.

The value indications can be routed to the following logs:

- Operational log
- User-defined log 1
- User-defined log 2

Resetting the Statistical Value

The statistical value *Max overall* can be reset via the following methods:

- Via the binary input signal *>Reset statistics*
- Via the **Reset** button for the maximum value of statistic in the operation panel of the device
- Via communication protocols
- Via an online DIGSI connection to the device

Influences Caused by the Change of the Device Time

If the device time is changed, the calculated values in the 10-min intervals and in observation periods are influenced. There are 2 cases:

- After the change, the time is still in the time interval of the calculation.
  The calculation is not influenced and continues. The calculated value is refreshed at the end of the time interval.
- After the change, the time is out of the time interval of the calculation.
  The calculation is influenced and is terminated immediately. Meanwhile, the calculated value is refreshed and the calculation of the next time interval is started.

11.2.3.2 Application and Setting Notes

Evaluation Possibilities – the Stage V2/V1 of the function Voltage Unbalance Provides Standard-Relevant Values and Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based evaluations on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: **Minimum voltage V1**

- Default setting **(_:2311:101) Minimum voltage V1** = ***5.000 V***

You can configure the parameter **Minimum voltage V1** in the function block **General**.

With the parameter **Minimum voltage V1**, you set the minimum value of the positive-sequence voltage V1. The calculation in the stage **V2/V1** or **V0/V1** starts only when V1 exceeds the set **Minimum voltage V1**.

Siemens recommends using the default setting.

Parameter: **Threshold**

- Default setting **(_:23011:101) Threshold** = ***2.00 %***

With the parameter **Threshold**, you set the threshold value to define the degree of voltage unbalance which is not considered as normal any more. If the average value of V2/V1 exceeds the threshold value, a voltage-unbalance event is detected and the indication *warning* is generated.

According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

Parameter: **Dropout ratio**

- Default setting **(_:23011:4) Dropout ratio** = ***0.95***

With the parameter **Dropout ratio**, you set the dropout ratio for the voltage unbalance. If the average value of V2/V1 is smaller than or equal to the result of the threshold value multiplied by the dropout ratio, the indication *warning* for the voltage unbalance disappears.

Siemens recommends using the default setting.

Parameter: **Observation period**

- Default setting **(_:23011:108) Observation period** = ***weekly***

With the parameter **Observation period**, you set the period for the observation.

Parameter Value	Description
weekly	The observation is executed and repeated weekly according to the start day specified by the parameter **Starting day of week**. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the first starting day. Then, the observation is repeated weekly.
daily	The observation is executed and repeated every day. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the next day. Then, the observation is repeated day by day.

Parameter: **Starting day of week**

- Default setting **(_:23011:109) Starting day of week** = ***Sunday***

This parameter is effective only when the parameter **Observation period** is set to ***weekly***.

With the parameter **Starting day of week**, you set the start day of the weekly observation. The start day can be set to any day of the week. For example, it is Tuesday today and the set start day is ***Sunday***, then, the first observation starts from Tuesday to Saturday, and the following observation is executed weekly starting from Sunday.

Parameter: **Percentile**

- Default setting **(_:23011:110) Percentile** = ***95 %***

With the parameter **Percentile**, you define the range of the 10-min average values that is used to locate the percentile value in the last observation period.

The default setting ***95 %*** is taken as an example. 95 % of the 10-min average values are smaller than or equal to the percentile value in the last observation period.

According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

11.2.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V
V2/V1 stage 1				
_:23011:1	V2/V1 stage 1:Mode		• off • on • test	off
_:23011:101	V2/V1 stage 1:Threshold		0.50 % to 10.00 %	2.00 %
_:23011:4	V2/V1 stage 1:Dropout ratio		0.90 to 0.99	0.95
_:23011:108	V2/V1 stage 1:Observation period		• daily • weekly	weekly
_:23011:109	V2/V1 stage 1:Starting day of week		• Sunday • Monday • Tuesday • Wednesday • Thursday • Friday • Saturday	Sunday
_:23011:110	V2/V1 stage 1:Percentile		80 % to 99 %	95 %

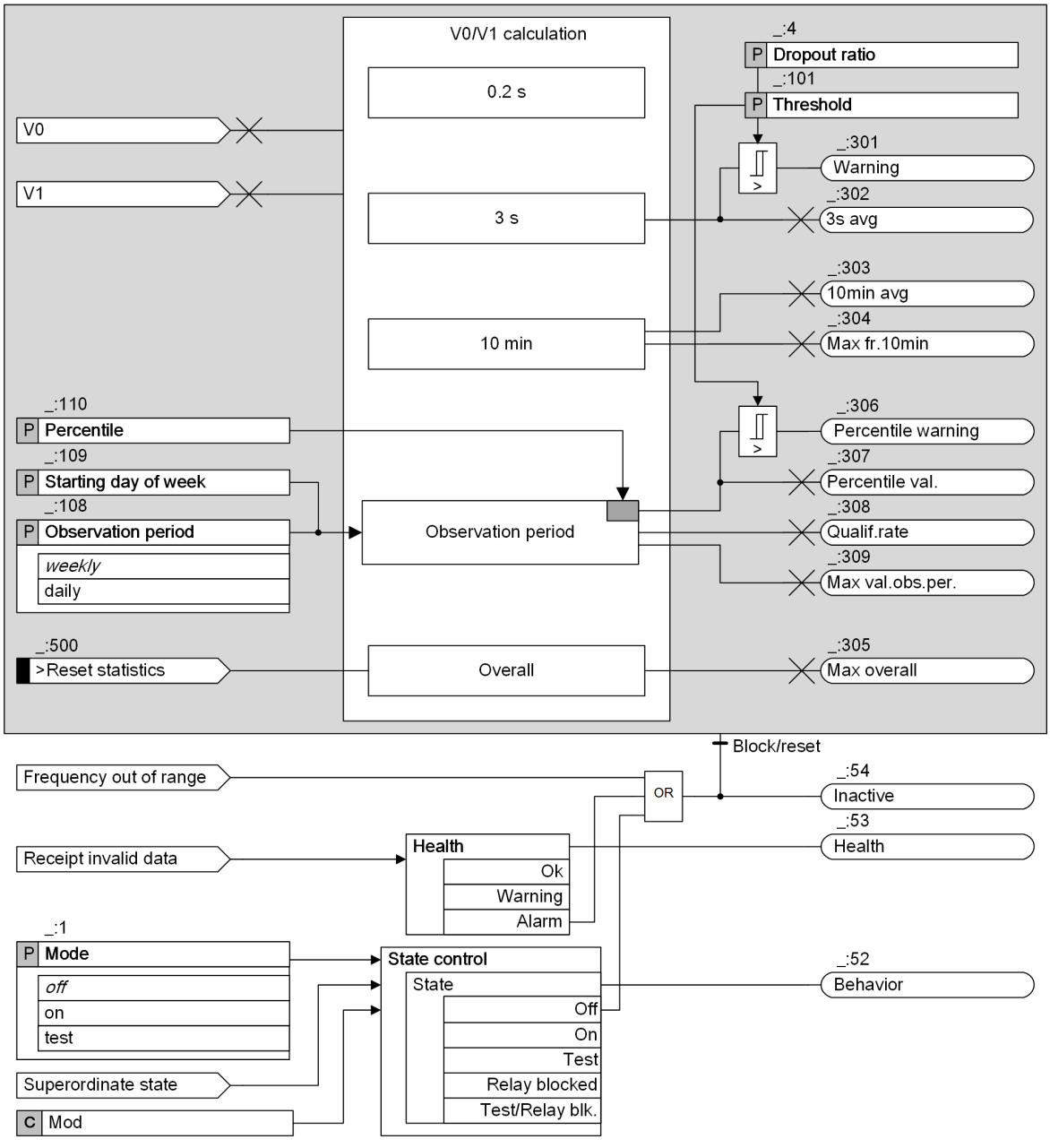
11.2.3.4 Information List

No.	Information	Data Class (Type)	Type
V2/V1 stage 1			
_:23011:500	V2/V1 stage 1:>Reset statistics	SPS	I
_:23011:51	V2/V1 stage 1:Mode (controllable)	ENC	C
_:23011:54	V2/V1 stage 1:Inactive	SPS	O
_:23011:52	V2/V1 stage 1:Behavior	ENS	O
_:23011:53	V2/V1 stage 1:Health	ENS	O
_:23011:301	V2/V1 stage 1:Warning	SPS	O
_:23011:305	V2/V1 stage 1:Max overall	MV	O
_:23011:302	V2/V1 stage 1:3s avg	MV	O
_:23011:303	V2/V1 stage 1:10min avg	MV	O
_:23011:304	V2/V1 stage 1:Max fr.10min	MV	O
_:23011:306	V2/V1 stage 1:Percentile warning	SPS	O
_:23011:307	V2/V1 stage 1:Percentile val.	MV	O
_:23011:308	V2/V1 stage 1:Qualif.rate	MV	O
_:23011:309	V2/V1 stage 1:Max val.obs.per.	MV	O
_:23011:310	V2/V1 stage 1:Perc.value abnor.	MV	O
_:23011:311	V2/V1 stage 1:Qual.rate abnor.	MV	O
_:23011:312	V2/V1 stage 1:Max val.obs.per.abnor.	MV	O

11.2.4 Stage V0/V1

11.2.4.1 Description

Logic of the Stage



[lo_V0_V1, 2, en_US]

Figure 11-13 Logic Diagram of the Stage **V0/V1**

Measuring Intervals

Measuring Intervals	Description
0.2 s	10 cycles for the 50-Hz system or 12 cycles for the 60-Hz system This interval is the basic measuring interval for this stage. All further measured values are aggregated based on the 0.2-s values.
3 s	150 cycles for the 50-Hz system or 180 cycles for the 60-Hz system This interval is used for the calculation of the 3-s average value.
10 min	The calculation in the 10-min interval is based on the UTC 10-min tick. There is no gap and no overlap between 2 consecutive 10-min intervals. This interval is used for the calculation of the 10-min average value and the maximum 0.2-s value in 10 min.
Observation period	Settable interval of one week or one day
Overall	From the device startup or from the latest reset of statistical values to the current time The maximum value of V0/V1 in overall time is displayed as a statistical value.

Aggregation by the UTC 10-Min Tick

For details, refer to *Aggregation by the UTC 10-Min Tick, Page 1108*.

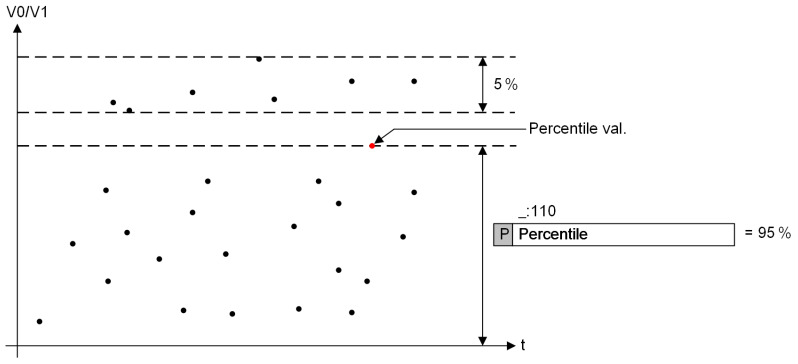
Warning of the Voltage Unbalance

For details, refer to *Warning of the Voltage Unbalance, Page 1108*.

Observation

A settable observation period of *weekly* or *daily* is provided. In the observation period, the following measured values are observed to determine the voltage-unbalance conditions.

Table 11-7 Observed Values in the Observation Period

Value	Description
Percentile val.	To locate the value *Percentile val.*, you must set the parameter **Percentile**. The following figure shows an example of locating the percentile value: In the figure, all the 10-min average values of V0/V1 in the last observation period are displayed. The parameter **Percentile** is set to 95 %. Then, the value *Percentile val.* is determined as the value that 95 % of the 10-min average values in the last observation period are smaller than or equal to. 
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period

During the observation period, if the value *Percentile val.* of the 10-min average values exceeds the threshold value, a voltage-unbalance event occurs and the indication *Percentile warning* is generated.

Functional Values

Value	Description
Max overall	Maximum 0.2-s value of V0/V1 from the device startup or from the latest reset of statistical values to the current time
3s avg	Average value of V0/V1 in the last 3-s interval, that is, 150 cycles or 180 cycles
10min avg	Average value of V0/V1 in the last 10-min interval
Max fr.10min	Maximum 0.2-s value of V0/V1 in the last 10-min interval
Percentile val.	The value *Percentile val.* is the value that, for example, 95 % (default setting of the parameter **Percentile**) of all 10-min average values in the last observation period are smaller than or equal to. For more information, refer to *Observation, Page 1114*.
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period This value is refreshed at the end of each observation period.

Value Indications

For details, refer to *Value Indications, Page 1109*.

Resetting the Statistical Value

For details, refer to *Resetting the Statistical Value, Page 1110*.

Influences Caused by the Change of the Device Time

For details, refer to *Influences Caused by the Change of the Device Time, Page 1110*.

Connection Type

In the stage **V0/V1**, the following connection types of the voltage transformer are available for the 3-phase voltage measuring point:

- *3 ph-to-gnd volt. + VN*
- *3 ph-to-gnd voltages*
- *3 ph-to-ph volt. + VN*
- *2 ph-to-ph volt. + VN*

The following connection types of the voltage transformer are not available for the 3-phase voltage measuring point. If one of the connection types is connected, DIGSI 5 reports an inconsistency:

- *3 ph-to-ph voltages*
- *2 ph-to-ph voltages*

11.2.4.2 Application and Setting Notes

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***`2.00 %`***

With the parameter **`Threshold`**, you set the threshold value to define the degree of voltage unbalance which is not considered as normal any more. If the average value of V0/V1 exceeds the threshold value, a voltage-unbalance event is detected and the indication *`Warning`* is generated.

According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

Parameter: `Dropout ratio`

- Default setting **`(_:4) Dropout ratio`** = ***`0.95`***

With the parameter **`Dropout ratio`**, you set the dropout ratio for the voltage unbalance. If the average value of V0/V1 is smaller than or equal to the result of the threshold value multiplied by the dropout ratio, the indication *`Warning`* for the voltage unbalance disappears.

Siemens recommends using the default setting.

Parameter: `Observation period`

- Default setting **`(_:108) Observation period`** = ***`weekly`***

With the parameter **`Observation period`**, you set the period for the observation.

Parameter Value	Description
weekly	The observation is executed and repeated weekly according to the start day specified by the parameter **`Starting day of week`**. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the first starting day. Then, the observation is repeated weekly.
daily	The observation is executed and repeated every day. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the next day. Then, the observation is repeated day by day.

Parameter: `Starting day of week`

- Default setting **`(_:109) Starting day of week`** = ***`Sunday`***

This parameter is effective only when the parameter **Observation period** is set to ***weekly***.

With the parameter **Starting day of week**, you set the start day of the weekly observation. The start day can be set to any day of the week. For example, it is Tuesday today and the set start day is ***Sunday***, then, the first observation starts from Tuesday to Saturday, and the following observation is executed weekly starting from Sunday.

Parameter: Percentile

- Default setting **(_:110) Percentile** = ***95 %***

With the parameter **Percentile**, you define the range of the 10-min average values that is used to locate the percentile value in the last observation period.

The default setting ***95 %*** is taken as an example. 95 % of the 10-min average values are smaller than or equal to the percentile value in the last observation period.

According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

11.2.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0/V1 stage #				
_:1	V0/V1 stage #:Mode		• off • on • test	off
_:101	V0/V1 stage #:Threshold		0.50 % to 10.00 %	2.00 %
_:4	V0/V1 stage #:Dropout ratio		0.90 to 0.99	0.95
_:108	V0/V1 stage #:Observation period		• daily • weekly	weekly
_:109	V0/V1 stage #:Starting day of week		• Sunday • Monday • Tuesday • Wednesday • Thursday • Friday • Saturday	Sunday
_:110	V0/V1 stage #:Percentile		80 % to 99 %	95 %

11.2.4.4 Information List

No.	Information	Data Class (Type)	Type
V0/V1 stage #			
_:500	V0/V1 stage #:>Reset statistics	SPS	I
_:51	V0/V1 stage #:Mode (controllable)	ENC	C
_:54	V0/V1 stage #:Inactive	SPS	O
_:52	V0/V1 stage #:Behavior	ENS	O
_:53	V0/V1 stage #:Health	ENS	O
_:301	V0/V1 stage #:Warning	SPS	O
_:305	V0/V1 stage #:Max overall	MV	O
_:302	V0/V1 stage #:3s avg	MV	O
_:303	V0/V1 stage #:10min avg	MV	O
_:304	V0/V1 stage #:Max fr.10min	MV	O

No.	Information	Data Class (Type)	Type
_:306	V0/V1 stage #:Percentile warning	SPS	O
_:307	V0/V1 stage #:Percentile val.	MV	O
_:308	V0/V1 stage #:Qualif.rate	MV	O
_:309	V0/V1 stage #:Max val.obs.per.	MV	O
_:310	V0/V1 stage #:Perc.value abnor.	MV	O
_:311	V0/V1 stage #:Qual.rate abnor.	MV	O
_:312	V0/V1 stage #:Max val.obs.per.abnor.	MV	O

11.3 THD and Harmonics

11.3.1 Overview of Functions

At the connection point to the public power system, the allowed total harmonic distortion (THD) is limited according to the power-quality related standards. The function **THD and harmonics** can be used to monitor the THD value.

The function **THD and harmonics** serves for the calculation of the following values:

- THD values of the 3-phase currents and 3-phase voltages
- Aggregated THD values of the 3-phase voltages
  If the aggregated THD value exceeds the threshold, a warning is generated.
- 2nd to 20th harmonics of the 3-phase currents and 3-phase voltages

The calculated THD values and harmonics are displayed under **Power quality basic** > **THD and harmonics** of a specific function group in the HMI or via the DIGSI Online-Editor. If routed, the calculated THD values and harmonics are available in the communication protocols and in the fault record. Abnormal values can be logged in the operational or user-defined log if routed.

11.3.2 Structure of the Function

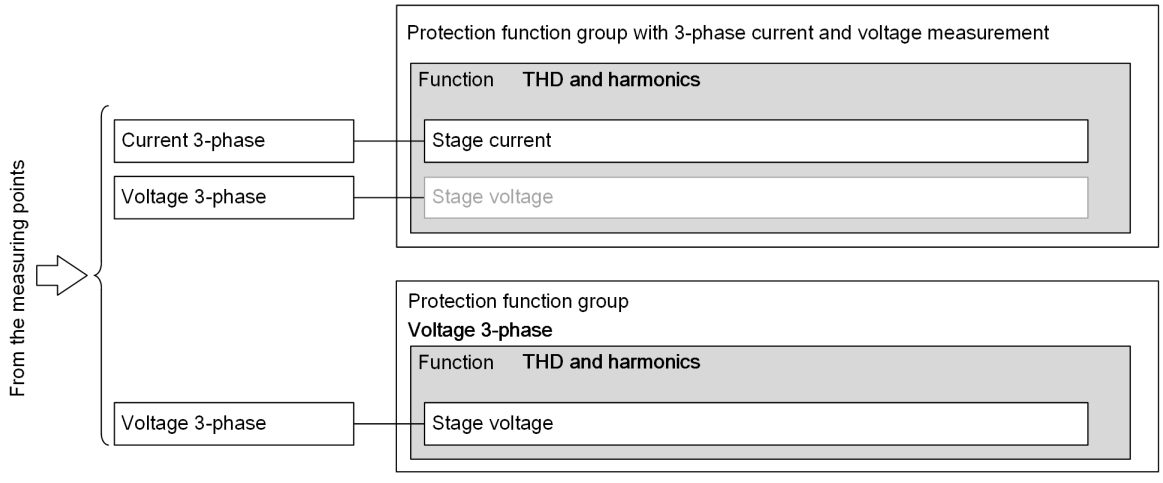
The function **THD and harmonics** can be used in the protection function groups with 3-phase current and voltage measurements and in the protection function group with only 3-phase voltage measurement.

When being used in a function group with 3-phase current and voltage measurements, the function comes factory-set with 1 stage **Current**. The following stages can be operated simultaneously within the function:

- 1 stage **Current**
- 1 stage **Voltage**

When being used in a function group with only 3-phase voltage measurement, the function comes factory-set with 1 stage **Voltage**. Only 1 voltage stage can be operated within the function.

The 2 types of function groups are displayed in the following figure. The stage that is not preconfigured is shown in gray.



[dw_structure_THD harmonic, 3, en_US]

Figure 11-14 Structure/Embedding of the Function

11.3.3 Stage Current

11.3.3.1 Function Description

The stage **Current** calculates and displays the THD values and harmonics for the 3-phase currents.

Calculation of THD Values and Harmonics Values

The THD value of the current is a percentage value calculated as follows:

$$I_{THD} = \frac{\sqrt{\sum_{n=2}^{N} I_n^{\,2}}}{I_s} \cdot 100\ \%$$

[fo_THD value_I, 1, en_US]

Where

N	20 The function supports the THD calculation up to the 20th harmonic.
I_n	Harmonic value of order *n*
I_s	Fundamental-component value

The calculated harmonic values of the current are percentage values that take the fundamental-component value as reference:

$$I_{Harmonic_n} = \frac{I_n}{I_s} \cdot 100\ \%$$

[fo_harmonic ratio_I, 1, en_US]

Functional Measured Values

Table 11-8 Functional Measured Values of the stage **Current**

Value	Description
THD:A THD:B THD:C	THD values of the 3-phase currents for the phases A, B, and C These values are percentage values.
H2:A H2:B H2:C ... H20:A H20:B H20:C	Harmonic values from the 2nd to 20th harmonics of the 3-phase currents for the phases A, B, and C These values are percentage values.

Operating Range

The frequency operating range of the stage **Current** is 0.8 to 1.2 of the rated frequency:

- If the power frequency is in this range, the THD values and harmonics are calculated.
- If the power frequency is out of this range, the THD values and harmonics are shown as "---".

If the fundamental-component value is smaller than 1 % of the rated current, the THD values and harmonics are shown as "---".

11.3.3.2 Information List

No.	Information	Data Class (Type)	Type
Current			
_:22081:52	Current:Behavior	ENS	O
_:22081:53	Current:Health	ENS	O
_:22081:301	Current:THD	WYE	O
_:22081:302	Current:H2	WYE	O
_:22081:303	Current:H3	WYE	O
_:22081:304	Current:H4	WYE	O
_:22081:305	Current:H5	WYE	O
_:22081:306	Current:H6	WYE	O
_:22081:307	Current:H7	WYE	O
_:22081:308	Current:H8	WYE	O
_:22081:309	Current:H9	WYE	O
_:22081:310	Current:H10	WYE	O
_:22081:311	Current:H11	WYE	O
_:22081:312	Current:H12	WYE	O
_:22081:313	Current:H13	WYE	O
_:22081:314	Current:H14	WYE	O
_:22081:315	Current:H15	WYE	O
_:22081:316	Current:H16	WYE	O
_:22081:317	Current:H17	WYE	O
_:22081:318	Current:H18	WYE	O
_:22081:319	Current:H19	WYE	O
_:22081:320	Current:H20	WYE	O

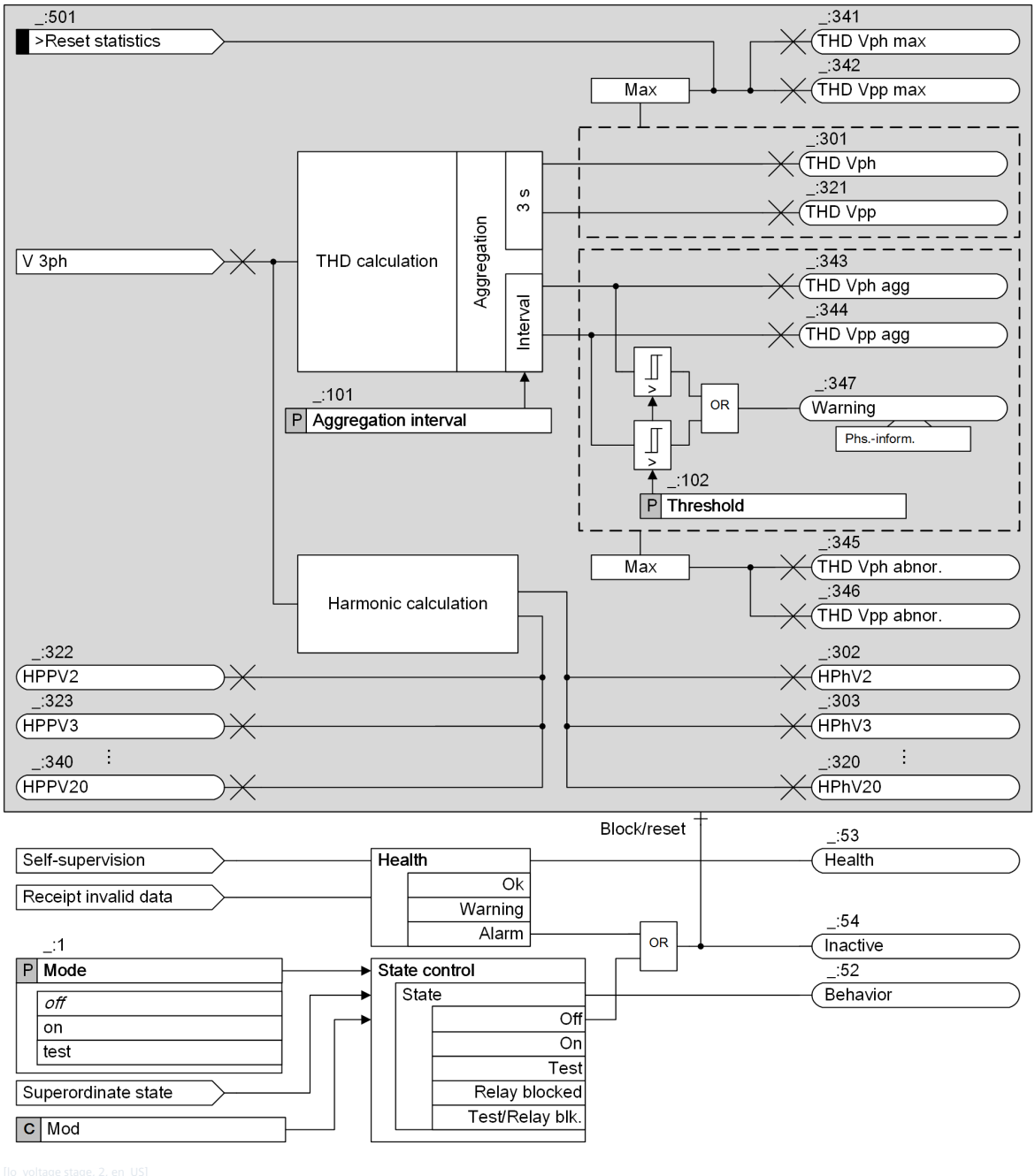
11.3.4 Stage Voltage

11.3.4.1 Function Description

The stage **Voltage**:

- Calculates and displays the THD values and harmonics for the 3-phase voltages.
- Calculates and displays the aggregated THD values for the 3-phase voltages.
- Generates a warning signal if the aggregated THD value exceeds the threshold.

Logic of the Stage



[lo_voltage stage, 2, en_US]

Figure 11-15 Logic Diagram of the stage **Voltage**

Calculation of THD Values and Harmonic Values

The THD value of the voltage is a percentage value. The following table lists the formulas for the calculation of the raw value and the aggregated THD values.

Based on the raw value, the aggregated THD values of the phase-to-phase voltages and the phase-to-ground voltages are calculated.

Table 11-9 Calculation of THD Values

Value	Formula
Raw value	$V_{Raw} = \frac{\sqrt{\sum_{n=2}^{N} V_n^{\,2}}}{V_s} \cdot 100\ \%$ • N: 20 The function supports the THD calculation up to the 20th harmonic. • V_n: Harmonic value of order *n* • V_s: Fundamental-component value
THD Vph THD Vpp	$V_{THD} = \frac{1}{N} \sum_{n=0\ (t=0)}^{N\ (t=3\ s)} V_{Raw}\ (n)$ • N: Total number of the raw values over a 3-s interval
THD Vph max THD Vpp max	$V_{THD,\,max} = MAX\left\{V_{THD,\,1}, V_{THD,\,2}, V_{THD,\,3} \ldots\right\}$
THD Vph agg THD Vpp agg	$V_{THD,\,agg} = \frac{1}{N} \sum_{n=0}^{N} V_{Raw}\ (n)$ • N: Total number of the raw values over the aggregation interval of 1 min or 10 min

The calculated harmonic values of the voltage are percentage values that take the fundamental-component values as reference.

Table 11-10 Calculation of Harmonic Values

Value	Formula
HPhV2 HPhV3 ... HPhV20	$V_{Harmonic_n} = \frac{V_n}{V_s} \cdot 100\ \%$ • V_n: Harmonic value of order *n* • V_s: Fundamental-component value
HPPV2 HPPV3 ... HPPV20	

Functional Values

For the stage **Voltage**, the functional values are divided into 2 submenus:

- Phase-to-ground voltage, as shown in *Table 11-11*.
- Phase-to-phase voltage, as shown in *Table 11-12*.

The functional values are all percentage values. They are calculated using the formulas in the section *Calculation of THD Values and Harmonic Values, Page 1122*.

Table 11-11 Functional Values for the Phase-to-Ground Voltage

Value	Description
THD Vph:A THD Vph:B THD Vph:C	Average THD values of the phase-to-ground voltages for the phases A, B, and C over a 3-s interval
THD Vph max	Maximum 3-s average THD value of the phase-to-ground voltage in the period from the device startup or from the latest reset of this maximum value to the current time
THD Vph agg:A THD Vph agg:B THD Vph agg:C	Average THD values of the phase-to-ground voltages for the phases A, B, and C over the aggregation interval of 1 min or 10 min
HPhV2:A HPhV2:B HPhV2:C ... HPhV20:A HPhV20:B HPhV20:C	Harmonic values from the 2nd to 20th harmonics of the phase-to-ground voltages for the phases A, B, and C

Table 11-12 Functional Values for the Phase-to-Phase Voltage

Value	Description
THD Vpp:AB THD Vpp:BC THD Vpp:CA	Average THD values of the phase-to-phase voltages for the phases AB, BC, and CA over a 3-s intervals
THD Vpp max	Maximum 3-s average THD value of the phase-to-phase voltage in the period from the device startup or from the latest reset of this maximum value to the current time
THD Vpp agg:AB THD Vpp agg:BC THD Vpp agg:CA	Average THD values of the phase-to-phase voltages for the phases AB, BC, and CA over the aggregation interval of 1 min or 10 min
HPPV2:AB HPPV2:BC HPPV2:CA ... HPPV20:AB HPPV20:BC HPPV20:CA	Harmonic values from the 2nd to 20th harmonics of the phase-to-phase voltages for the phases AB, BC, and CA

NOTE

Considering the device resources, do not route non-required harmonic measured values for transmission via communication protocols.

Resetting the Statistical Values

The statistical values *THD Vph max* and *THD Vpp max* can be reset via the following methods:

- Via the binary input signal *>Reset statistics*
- Via the **Reset** button for the maximum value of statistic in the operation panel of the device
- Via communication protocols
- Via an online DIGSI connection to the device

Monitoring of the Aggregation Values

If the aggregated THD value *THD Vph agg* or *THD Vpp agg* exceeds the threshold, a phase-selective indication *warning* is generated. During the period when the indication *warning* is active, the maximum aggregated THD value of the phase-to-phase voltages or the phase-to-ground voltages is logged as an abnormal value. The abnormal value can be routed to the following logs:

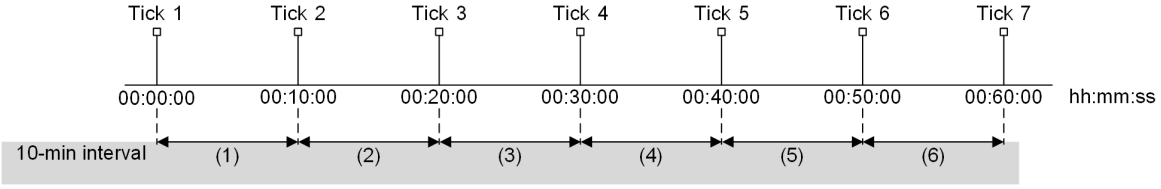
- Operational log
- User-defined log 1
- User-defined log 2

Table 11-13 Abnormal Values

Value	Description
THD Vph abnor.:A THD Vph abnor.:B THD Vph abnor.:C	Abnormal THD values (THD value is above limiting value) of the phase-to-ground voltages for the phases A, B, and C over the aggregation interval of 1 min or 10 min A record is possible.
THD Vpp abnor.:AB THD Vpp abnor.:BC THD Vpp abnor.:CA	Abnormal THD values of the phase-to-phase voltages for the phases AB, BC, and CA over the aggregation interval of 1 min or 10 min A record is possible.

Aggregation by the UTC 10-Min Tick

If the parameter **Aggregation interval** is set to ***10 min***, the THD values are aggregated by the UTC 10-min tick according to the standard IEC 61000-4-30. Each 10-min interval begins at a tick.



[dw_tick_interval, 1, en_US]

Figure 11-16 Ticks and 10-Min Intervals in an Hour

Influences Caused by the Change of the Device Time

If the device time is changed, the calculation of THD values is influenced. There are 2 cases:

- After the change, the time is still in the time interval of the calculation.
  The calculation is not influenced and continues. The calculated value is refreshed at the end of the time interval.
- After the change, the time is out of the time interval of the calculation.
  The calculation is influenced and is terminated immediately. Meanwhile, the calculated value is refreshed and the calculation of the next time interval is started.

Operating Range

The frequency operating range of the stage **Voltage** is 0.8 to 1.2 of the rated frequency:

- If the power frequency is in this range, the THD values and harmonics are calculated.
- If the power frequency is out of this range, the THD values and harmonics are not calculated and are shown as "---". Meanwhile, the function **THD and harmonics** becomes inactive.

If the fundamental-component value is smaller than 5 % of the rated voltage, the THD values and harmonics are shown as "---".

11.3.4.2 Application and Setting Notes

Parameter: `Aggregation interval`

- Default setting **`(_:101) Aggregation interval`** = ***`10 min`***

With the parameter **`Aggregation interval`**, you set the aggregation interval to 1 min or 10 min to determine the THD condition.

According to the standard IEC 61000-4-30, Siemens recommends using the default setting.

Parameter: `Threshold`

- Default setting **`(_:102) Threshold`** = ***`8.0 %`***

With the parameter **`Threshold`**, you set the threshold for the aggregated THD values. If the aggregated THD value exceeds the threshold, the indication ***`Warning`*** is generated. Meanwhile, the maximum aggregated THD value is logged as an abnormal value.

According to the standard IEC TS 62749, for the low-voltage or medium-voltage system, the THD value should be smaller than or equal to 8 %. Siemens recommends using the default setting.

11.3.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Voltage`				
_:1	Voltage:Mode		• off • on • test	on
_:101	Voltage:Aggregation interval		• 1 min • 10 min	10 min
_:102	Voltage:Threshold		1.0 % to 25.0 %	8.0 %

11.3.4.4 Information List

No.	Information	Data Class (Type)	Type
`Voltage`			
_:501	Voltage:>Reset statistics	SPS	I
_:51	Voltage:Mode (controllable)	ENC	C
_:54	Voltage:Inactive	SPS	O
_:52	Voltage:Behavior	ENS	O
_:53	Voltage:Health	ENS	O
_:347	Voltage:Warning	ACT	O
_:301	Voltage:THD Vph	WYE	O
_:341	Voltage:THD Vph max	MV	O
_:343	Voltage:THD Vph agg	WYE	O
_:345	Voltage:THD Vph abnor.	WYE	O
_:321	Voltage:THD Vpp	DEL	O
_:342	Voltage:THD Vpp max	MV	O
_:344	Voltage:THD Vpp agg	DEL	O
_:346	Voltage:THD Vpp abnor.	DEL	O
_:302	Voltage:HPhV2	WYE	O
_:303	Voltage:HPhV3	WYE	O
_:304	Voltage:HPhV4	WYE	O
_:305	Voltage:HPhV5	WYE	O

No.	Information	Data Class (Type)	Type
_:306	Voltage:HPhV6	WYE	O
_:307	Voltage:HPhV7	WYE	O
_:308	Voltage:HPhV8	WYE	O
_:309	Voltage:HPhV9	WYE	O
_:310	Voltage:HPhV10	WYE	O
_:311	Voltage:HPhV11	WYE	O
_:312	Voltage:HPhV12	WYE	O
_:313	Voltage:HPhV13	WYE	O
_:314	Voltage:HPhV14	WYE	O
_:315	Voltage:HPhV15	WYE	O
_:316	Voltage:HPhV16	WYE	O
_:317	Voltage:HPhV17	WYE	O
_:318	Voltage:HPhV18	WYE	O
_:319	Voltage:HPhV19	WYE	O
_:320	Voltage:HPhV20	WYE	O
_:322	Voltage:HPPV2	DEL	O
_:323	Voltage:HPPV3	DEL	O
_:324	Voltage:HPPV4	DEL	O
_:325	Voltage:HPPV5	DEL	O
_:326	Voltage:HPPV6	DEL	O
_:327	Voltage:HPPV7	DEL	O
_:328	Voltage:HPPV8	DEL	O
_:329	Voltage:HPPV9	DEL	O
_:330	Voltage:HPPV10	DEL	O
_:331	Voltage:HPPV11	DEL	O
_:332	Voltage:HPPV12	DEL	O
_:333	Voltage:HPPV13	DEL	O
_:334	Voltage:HPPV14	DEL	O
_:335	Voltage:HPPV15	DEL	O
_:336	Voltage:HPPV16	DEL	O
_:337	Voltage:HPPV17	DEL	O
_:338	Voltage:HPPV18	DEL	O
_:339	Voltage:HPPV19	DEL	O
_:340	Voltage:HPPV20	DEL	O

11.4 Total Demand Distortion

11.4.1 Overview of Functions

At the connection point to the public power system, the allowed total demand distortion (TDD) is limited according to the power-quality related standards. The function **Total demand distortion** can be used to monitor the TDD value.

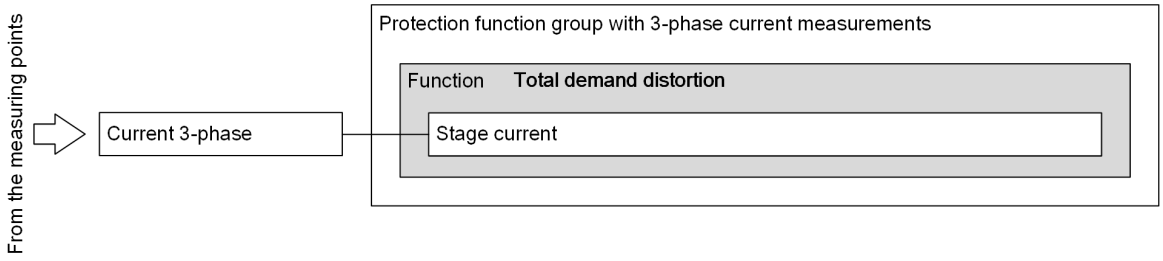
The function **Total demand distortion** serves for calculating the following values of the 3-phase currents:

- 3-s TDD value
- TDD value within an interval
  If the TDD value **`TDD intvl.`** exceeds the threshold value, a warning is generated.

The TDD values are displayed under **Power quality basic** > **TDD** of a specific function group in the HMI or via the DIGSI Online-Editor. If routed, the TDD values are available in the communication protocols and the fault records. Abnormal values can be logged in the operational log or user-defined logs.

11.4.2 Structure of the Function

The function **Total demand distortion** can be used in the protection function groups with 3-phase current measurements. When being used in such a function group, the function comes factory-set with 1 stage **Current**.

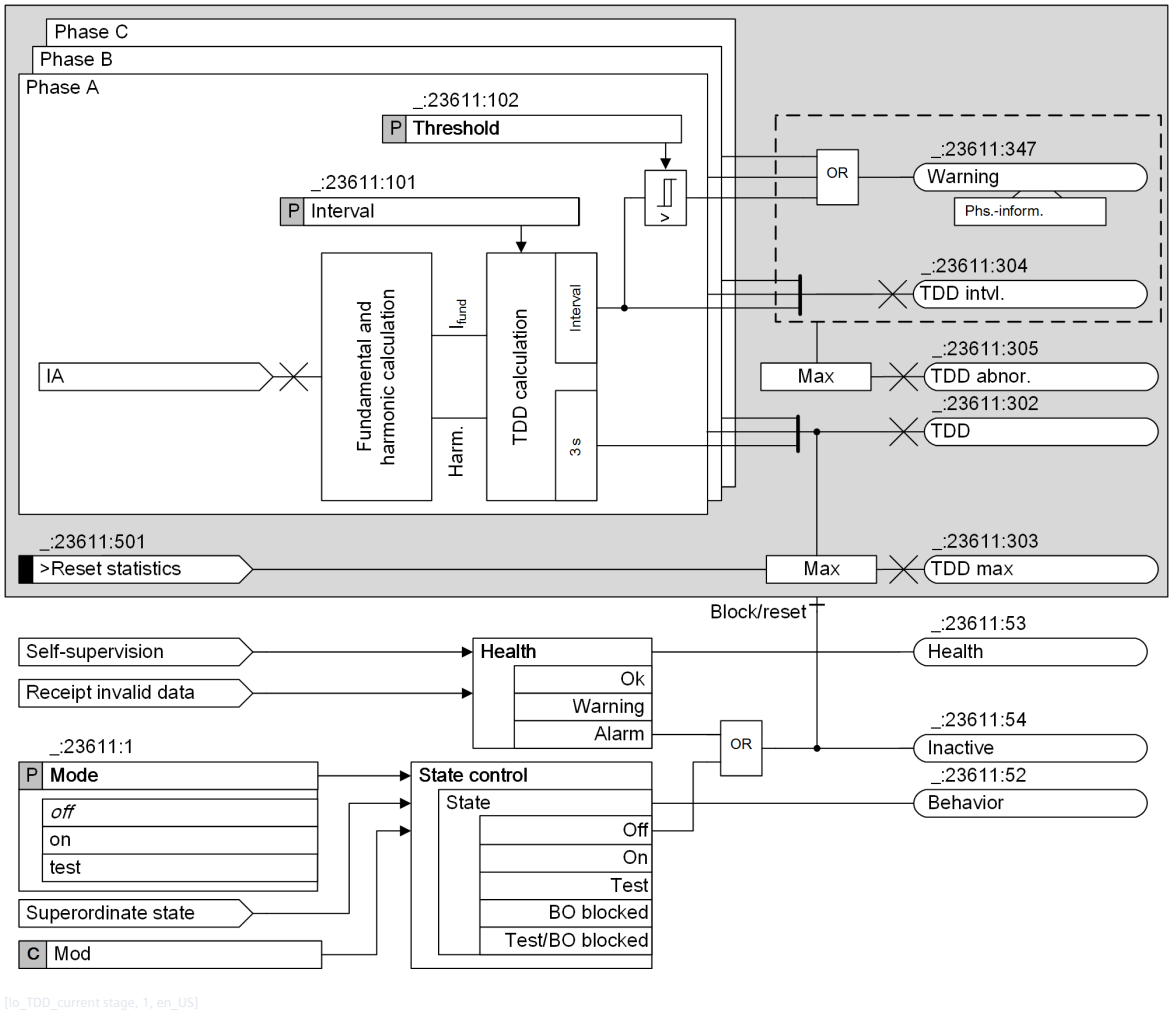


[dw_TDD_structure, 1, en_US]

Figure 11-17 Structure/Embedding of the Function

11.4.3 Stage Current

Logic of the Stage



[lo_TDD_current stage, 1, en_US]

Figure 11-18 Logic Diagram of the Stage Current

Calculation of TDD Values

Both the 3-s TDD value and the TDD value within an intervall are calculated as follows:

$$I_{TDD} = \frac{\sqrt{\sum_{k=2}^{N}[\text{mean}(I_k)]^2}}{I_{lmax}}$$

[fo_TDD_I, 1, en_US]

Where

N	20 The function supports the TDD calculation up to the 20th harmonic.
I_k	Harmonic value of order *k*
I_{lmax}	Maximum fundamental-component value of the demand load current over an interval
mean(I_k)	Arithmetic mean value of each order harmonic component over the whole interval

Functional Values

All functional values are given in percentage.

Table 11-14 Functional Values of the Stage Current

Value	Description
TDD:A TDD:B TDD:C	TDD values for phases A, B, and C over the 3-s intervals
TDD intvl.:A TDD intvl.:B TDD intvl.:C	TDD values for phases A, B, and C over the 15-min or 30-min interval
TDD max	Maximum TDD value in the period from the device startup or from the latest reset of this maximum value to the current time This value is the maximum value of the *TDD* which is calculated over the 3-s intervals.

Resetting the Statistical Values

The statistical value *TDD max* can be reset with the following methods:

- Via the binary input signal *>Reset statistics*
- Via the **Reset** button for the maximum value of the statistic in the operation panel of the device
- Via communication protocols
- Via an online DIGSI connection to the device

Supervision of the TDD Value within an interval

The stage **Current** monitors the TDD value **TDD intvl.** within an interval and generates the phase-selective indication *Warning* if **TDD intvl.** exceeds the threshold.

When the indication *Warning* drops out, the maximum TDD value since the beginning of this indication which contains the maximum value of all phases, is entered as an abnormal value in the log (if the value is routed). You can route the abnormal value to the following logs:

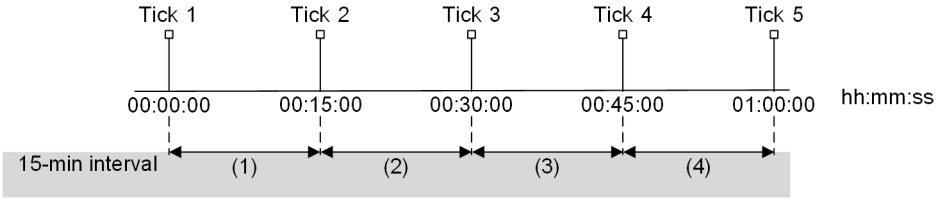
- Operational log
- User-defined log 1
- User-defined log 2

Table 11-15 Abnormal Value

Value	Description
TDD abnor.:A TDD abnor.:B TDD abnor.:C	**TDD abnormal** Maximum TDD value **TDD intvl.** during the event as long as the indication *Warning* indication is active

Aggregation by the UTC 15-Min Tick

Based on the experience in THD values which are aggregated by the UTC 10-min tick according to the IEC 61000-4-30 standard, the parameter **Interval** in TDD is set to ***15 min*** by default. Each 15-min interval begins at a tick. The following figure shows the ticks and the 15-min intervals in an hour.



[dw_TDD_tick_interval, 1, en_US]

Figure 11-19 Ticks and 15-Min Intervals in an Hour

Influences Caused by the Change of the Device Time

If the device time is changed, the calculation of TDD values is influenced. There are 2 cases:

- After the change, the time is still in the time interval of the calculation.
  The calculation is not influenced and continues. The calculated value is refreshed at the end of the time interval.
- After the change, the time is out of the time interval of the calculation.
  The calculation is influenced and is terminated immediately. Meanwhile, the calculated value is refreshed and the calculation of the next time interval is started.

Operating Range

The frequency operating range of the stage **Current** is 0.8 to 1.2 of the rated frequency:

- If the power frequency is in this range, the TDD values are calculated.
- If the power frequency is out of this range, the TDD values are not calculated and are shown as **---**. Meanwhile, the function **Total demand distortion** becomes inactive.

If the fundamental-component value is smaller than 1 % of the rated current, TDD values and harmonics are set to **---**.

11.4.4 Application and Setting Notes

Parameter: _:23611:101 Interval

- Default setting **Interval** = ***15 min***

With the parameter **Interval**, you set the interval to 15 min or 30 min to determine the TDD condition.

Parameter: _:23611:102 Threshold

- Default setting **Threshold** = ***5.0 %***

With the parameter **Threshold**, you set the threshold for the TDD value. If the demand TDD values exceed the threshold value, the indication ***Warning*** is generated. Meanwhile, the maximum TDD value is taken as the abnormal value and is shown in the DIGSI 5 information lists.
Siemens recommends using the default setting.

11.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage				
_:23611:1	Stage:Mode		• off • on • test	off
_:23611:101	Stage:Interval		• 15 min • 30 min	15 min
_:23611:102	Stage:Threshold		1.0 % to 25.0 %	5.0 %

11.4.6 Information List

No.	Information	Data Class (Type)	Type
Stage			
_:23611:501	Stage:>Reset statistics	SPS	I
_:23611:51	Stage:Mode (controllable)	ENC	C
_:23611:54	Stage:Inactive	SPS	O
_:23611:52	Stage:Behavior	ENS	O
_:23611:53	Stage:Health	ENS	O
_:23611:347	Stage:Warning	ACT	O
_:23611:302	Stage:TDD	WYE	O
_:23611:303	Stage:TDD max	MV	O
_:23611:304	Stage:TDD intvl.	WYE	O
_:23611:305	Stage:TDD abnor.	WYE	O

12 Functional Tests

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12.9	Circuit-Breaker Test	1157

12.1 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 can be used to check the setting values.

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.

12.2 Enabling/Disabling the Application/Test Mode for the Entire Device

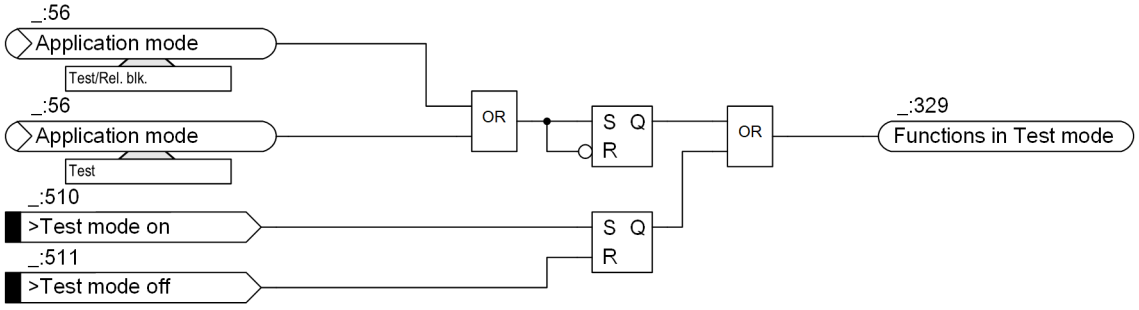
Siemens recommends to enable the test mode for the entire device before you start testing protection functions.

You can enable or disable the test mode for the entire device as follows:

- Via the on-site operation panel under **Device functions > Operating states >** *Application mode* = ***Test*** or ***Test/Relay blk.***
- Via the binary inputs *(_:91:510) General:>Test mode on* and *(_:91:511) General:>Test mode off*
  You can find the binary inputs in the DIGSI information routing under **General**.
- Via communication (IEC 61850) with the controllable *(_:91:56) General:Application mode*
  You can find the controllable in the DIGSI information routing under **General**.

When the test mode for the entire device is enabled, the indication *(_:91:329) Functions in Test mode* is generated.

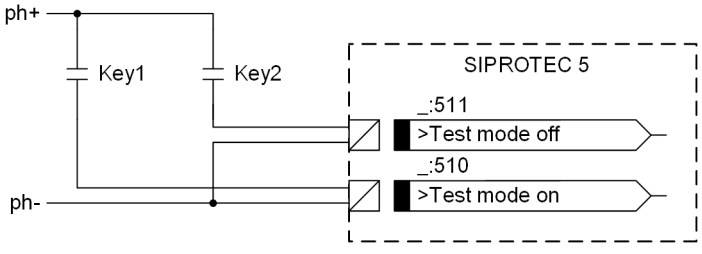
In the test mode of the device all device indications are marked with a test bit. This prevents the circuit breaker from switching unintentionally or protection functions from starting unintended actions. If you enable or disable the test mode for the entire device using the controllable *(_:91:56) General:Application mode*, the device stores the state of the controllable in a voltage-fail-safe memory.



[lo_application_mode_device, 1, en_US]

Figure 12-1 Logic Diagram: Enabling/Disabling the Test Mode for the Entire Device

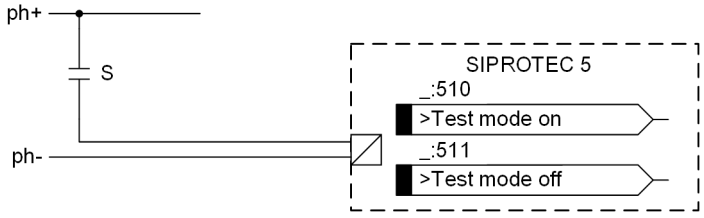
The following figures show possible variants for enabling and disabling the test mode for the entire device using binary inputs. The following figure shows the use of push-buttons **Ta1** and **Ta2**:



[lo_application_mode_device_taster, 1, en_US]

Figure 12-2 External Wiring of Push-Buttons for Enabling/Disabling the Test Mode for the Entire Device

The following figure shows the use of a switch **S**. Route the logical binary input *(_:91:510) General:>Test mode on* as **H** (high-active) and the logical binary input *(_:91:511) General:>Test mode off* as **L** (low-active) to a physical binary input.



[lo_application_mode_device_switch, 1, en_US]

Figure 12-3 External Wiring of Switches for Enabling/Disabling the Test Mode for the Entire Device

12.3 Functional Test Protection Communication

12.3.1 Checking the Protection-Data Communication

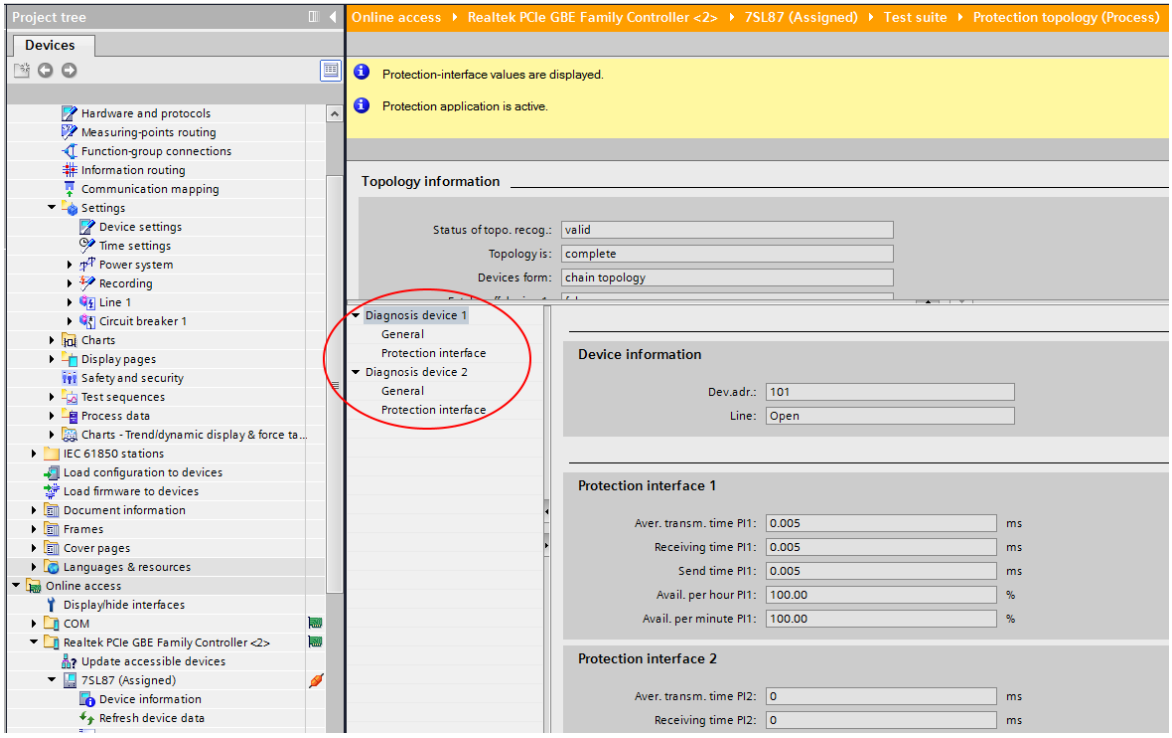
Checking the Protection-Data Communication

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.

The following information is provided via the protection interfaces by the devices in the device combination:

- Address of the device in the device combination
- Circuit-breaker switch position (open/closed/undefined); only for protection interfaces of type 1
- Availability of the protection-interface communication within the last minute, as percentage
  Availability of the protection-interface communication within the last hour, as percentage
- Signal-transit time in the transmission and reception direction of the telegrams between the local device and the neighboring device

You can find this diagnostic data in DIGSI under the following menu structure:



[sc_protec, 1, en_US]

Figure 12-4 Diagnostic Data of the Protection-Interface Channels – Device Address

NOTE

To reset the measured values for the protection interface directly in the device, proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Release measured values**.

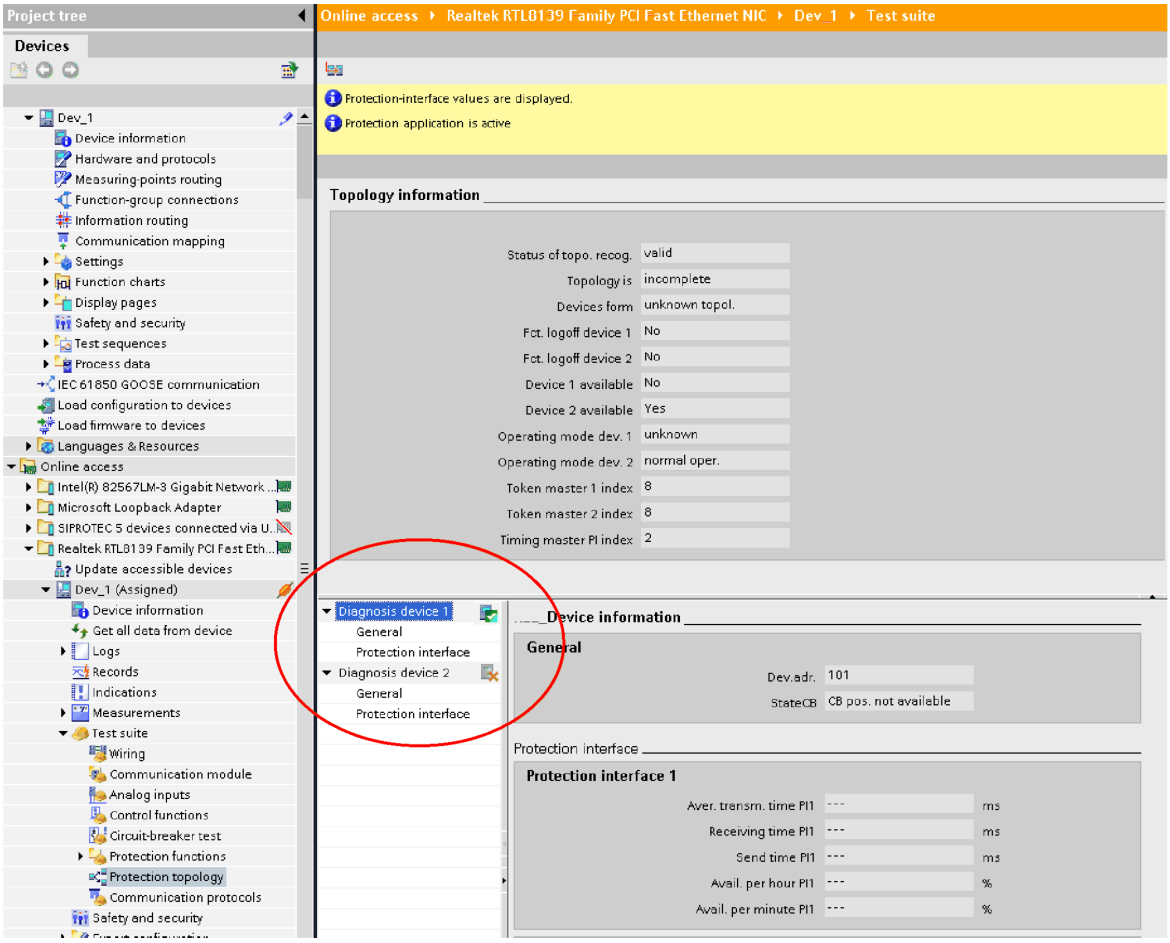
Proper communication of the devices among each other can be supervised during operation.

✧ Check the connections for each protection interface in DIGSI 5.

If a connection is successfully established, the **Status of topo recog.** field shows the indication *valid* in DIGSI 5 (see *Figure 12-4*).

If 2 devices are parameterized incorrectly, the **Status of topo recog.** field shows the indication *invalid* (see *Figure 12-4*).

In *Figure 12-5* 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.



[sc_protcocol, 1, en_US]

Figure 12-5 Protection-Data CommunicationDeactivated

12.3.2 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.

12.4 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.

12.5 Primary and Secondary Tests for the Paralleling Function

12.5.1 Checking the Control Circuits and the Measuring-Voltage Circuits

General

The control circuits and the measuring-voltage circuits are checked to ensure the correct cabling, polarity, phase sequence, transformation ratio of the voltage transformers (VTs), etc.

Preparations

Before checking the circuits, perform the following preparations:

- Set the threshold of the overvoltage protection function to about 110 % of the rated voltage of the generator with trip on excitation.
- Check the unexcited generator with the residual voltages.
- Remove all short-circuit bridges.

Grounding of the Voltage Transformers

When checking the VTs, pay attention to the grounding, especially the broken-delta windings, because these windings are only grounded in one phase.

Control Circuits

When checking the circuit breaker, open the neighboring disconnectors and pay attention to the following items:

- If the synchronizing switch (if it exists) is in the manual position, make sure that the circuit breaker can only be closed by pressing the control button.

  If the synchronizing switch is in the automation position, make sure that the circuit breaker can only be closed by the device.
- If the balancing commands are used for the frequency and voltage functions, the 7VU85 device can check the correct reaction of the voltage controller and of the speed controller on the balancing commands (higher/lower).
- If there are multiple synchronization points, the preceding check must be executed for each synchronization point.

Protection Switches for the Voltage Transformers

If the miniature circuit breaker (MCB) for the VTs is open, the undervoltage protection and the synchronization functions are blocked automatically. The blocking can be checked along with the voltage circuits.

A prerequisite for this check is that the auxiliary contact of the VT MCB is connected and routed. Proceed as follows:

- Open one VT MCB.
- Check in the operational log that the VT MCB open indication is issued, for example, the status of the binary input signal *>Open* is *on*.
- Close the VT MCB.
- Check in the operational log that the VT MCB close indication is issued, for example, the status of the binary input signal *>Open* is *off*.

If one of the indications does not appear, check the connection and allocation of these signals.

If the *on* or *off* status is reversed, check and correct the auxiliary-contact type of the circuit breaker.

Measuring-Voltage Circuits, General

The VT connections are tested with primary quantities.

WARNING

Warning of dangers evolving from improper primary tests

Non-observance of the following measure can result in death, personal injury, or substantial material damage.

✧ The primary test can only be carried out by electrically qualified personnel, who are familiar with the commissioning of the synchronization device and protection systems, the operation of the plant, and the safety rules and regulations (switching, grounding, etc.).

With proper connections of the measuring-voltage circuits, none of the measured-value supervision functions picks up in the device. If a supervision function detects a problem, you can view the causes of the problem in the operational log.

Check the magnitude and the phase sequence of the voltages. They can be read on the front display panel or via DIGSI 5. If the measurements are not reasonable, switch off the line and check and revise the connections. Then repeat the check until all measurements are correct.

Measuring-Voltage Circuits, Synchronization Function

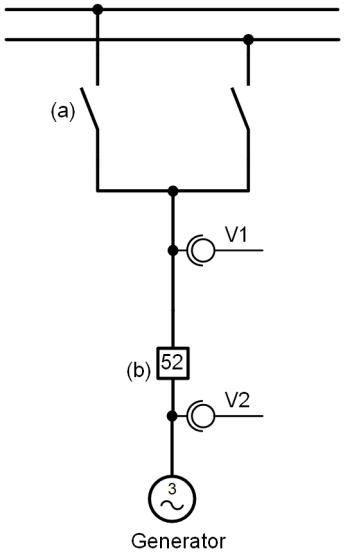
With regard to the synchronization function, the control of the VT via the primary switch is an imperative test to be carried out.

The tests differ depending on the arrangement of the VT. The examples of this chapter describe different typical applications.

- If the generator is not yet ready for operation, the preliminary test can be executed with the system voltage.
- If there are VTs at both sides of the circuit breaker, as shown in the following figure, the test can be simply executed by checking the voltage.

Checking with Side Connection Voltage Transformer

The following figure shows an example of the measuring-voltage circuits.



[dw_VMeasforSyn_1_en_US]

Figure 12-6 Voltage Measurement for Synchronization

Proceed as follows:

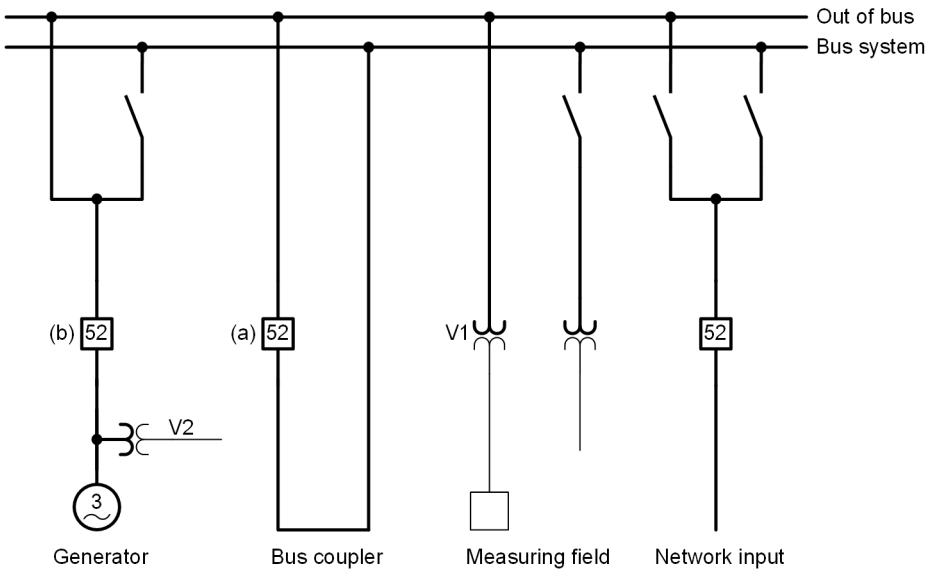
- Open the circuit breaker (b) and close the disconnector (a). The busbar voltage is read out as V1 and compared with the actual voltage.
- If 2 or 3 phase-to-phase voltages are connected to the device, check the phase sequence.
  If the phase sequence is not correct, the corresponding indications are issued and the secondary wiring must be checked.
- Close the circuit breaker (b) and open the disconnector (a).
- After the generator is started, read out the generator voltage as V2 and compare it with the actual voltage.
  Note that the parameter **Voltage adjustment** influences the operational measured value of the voltage V2. Normally, this factor is set to ***1*** and if necessary, when the checking of the secondary voltage circuits is finished, the deviating values can be set.
- Check the phase rotation with the generator voltage.
  If the phase sequence is not correct, the corresponding indications are issued and the secondary wiring must be checked. The phase rotation of the generator voltage must be equal to the phase rotation of the system voltage.
- To ensure that the voltages of the 2 sides are identical after the circuit breaker (b) is closed, test the secondary voltage circuits.
  Read the operational measured values and check the measuring tolerances. To ensure the data correctness, you can test on both channels.
  - V1 = V2
  - f1 = f2
  - dV = 0
  - df = 0
  - dα = 0
- If the secondary voltages are not equal due to different VTs, perform an appropriate correction via the parameter **Voltage adjustment**.
  The same applies for the phase-angle deviation tolerance, which can be adapted via the parameter **Angle adjust. (transform.)**.

During the check, pay attention to the following items:

- For the 3-phase systems, if the phase-rotation checks are executed, the phase rotation of both sides has to be the same.
- If there are multiple synchronization points, the preceding check must be executed for each synchronization point.

Checking with Busbar Voltage Transformer

Check the system voltage as well as the generator voltage in the measuring field with an arrangement as shown in the following figure.



[dw_MVTestExmp1, 1, en_US]

Figure 12-7 Checking the Measuring Voltages in the Measuring Field – Example 1

NOTE

In the example, circuit breaker (a) and circuit breaker (b) cannot be closed at the same time!

To check with the busbar voltage transformer, proceed as follows:

- Open the circuit breaker (b) and close the circuit breaker (a).
- Check the system voltage in the measuring field.
- Open the circuit breaker (a) and close the circuit breaker (b).
- Check the generator voltage.
- Open the circuit breaker (b).
- Read out the system voltage as V1 and compare it with the actual voltage.
- If 2 or 3 phase-to-phase voltages are connected to the device, check the phase sequence.
  If the phase sequence is not correct, the corresponding indications are issued and the secondary wiring must be checked.
- After the generator is started, read out the generator voltage as V2 and compare it with the actual voltage.
- Open the circuit breaker (a) and close the circuit breaker (b) again.
  Consider that the operational measured value of the voltage V2 is influenced by the parameter **`Voltage adjustment`**.
- Check the phase rotation with the generator voltage.
- If the phase sequence is not correct, the corresponding indications are indicated and the secondary wiring must be checked.
  The phase rotation of the generator voltage must be equal to the phase rotation of the system voltage.
- If both VTs receive the identical voltage, perform the final test of the secondary voltage circuits.
  - If the circuit breaker (a) is open, no system voltage is available.
  - If the generator circuit breaker (b) is closed, both side voltages V1 and V2 are identical.

- Read the operational measured values and check the measuring tolerances. To ensure the data correctness, you can test on both channels.
  - V1 = V2
  - f1 = f2
  - dV = 0
  - df = 0
  - dα = 0

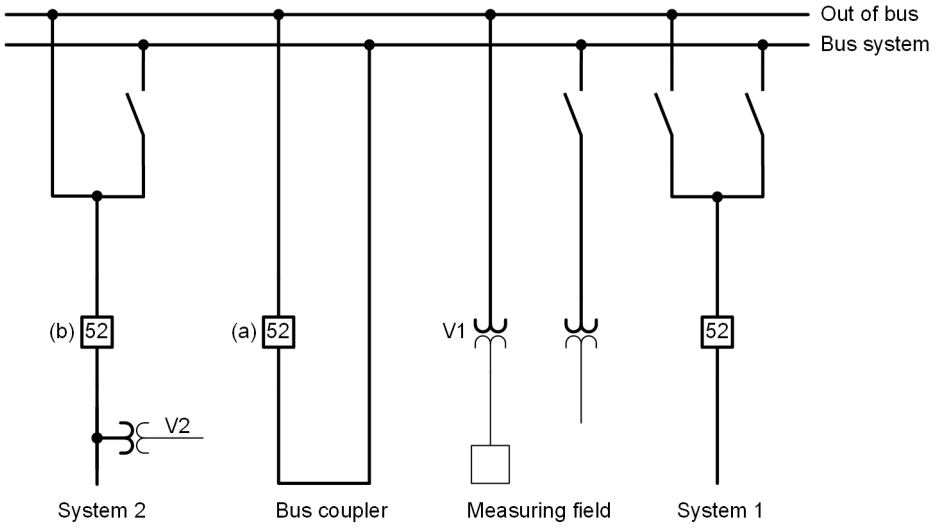
  If the secondary voltages are not equal due to different VT, you can correct them via the parameter **`Voltage adjustment`**. The same applies for the phase-angle deviation tolerance, which can be adapted with the parameter **`Angle adjust. (transform.)`**.

During the check, pay attention to the following items:

- For the 3-phase systems, if the phase-rotation checks are executed, the phase rotation of both sides has to be the same.
- With multiple busbars, each busbar voltage has to be checked.
- If there are multiple synchronization points, the preceding check must be executed for each synchronization point.

Synchronization of Networks

The preceding rules can be applied to the synchronization of networks. The following figure shows a possible switching arrangement. Identical tests are executed. You can find more information in section *Checking with Busbar Voltage Transformer, Page 1142*.



[dw_MVTestExmp2, 1, en_US]

Figure 12-8 Testing the Measuring Voltages in the Measuring Field – Example 2

If there is no transformer between the 2 measuring points, as shown in the preceding example, the parameter **`Angle adjust. (transform.)`** must be set to *0*°.

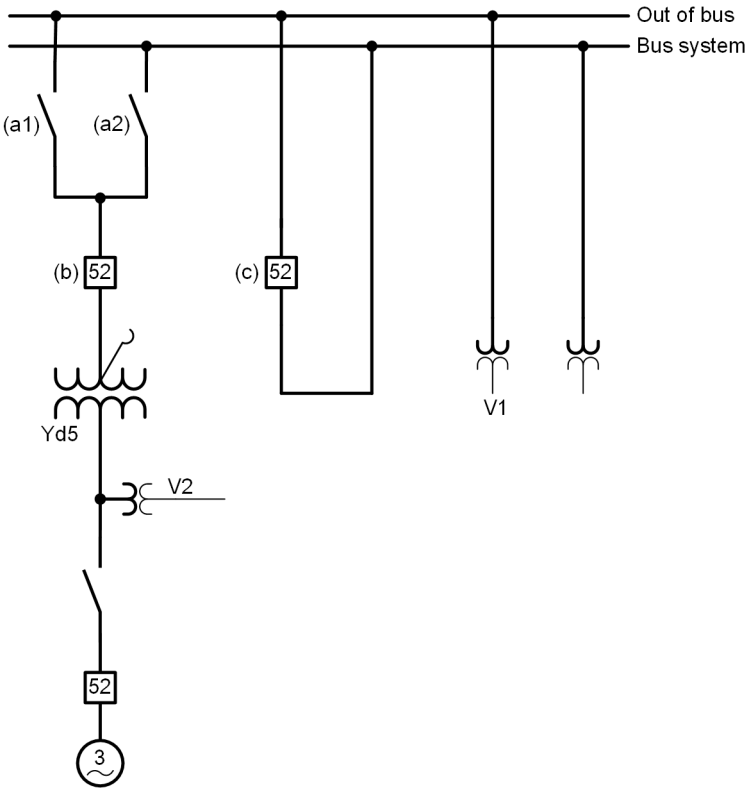
If there is a transformer between the 2 measuring points, the parameter **`Angle adjust. (transform.)`** must be set according to the phase rotation through which the vector group of the transformer rotates the voltage.

Checking with the Power Transformer

NOTE

The tap changers are not supported in the current version.

In the synchronization range, a power transformer with tap changers is included, as shown in the following figure. There are different methods to perform the test. In the following, the method without having the generator in operation is described. To ensure the security, the generator circuit breaker and the disconnector are always open.



[dw_MVSynviaTrsf, 1, en_US]

Figure 12-9 Measuring Voltages with Synchronization via the Transformer

Execute the following checking steps:

- Set the tap changer of the transformer to the position where the voltage is nominal.
- Open the circuit breaker (b) and close the section switch (c).
- Check the measured values V1, f1, and the phase rotation on side V1.
- Check that the transformer differential protection is ready for operation.
- Close the disconnector (a1).
- Close the circuit breaker (b).
- Check the measured values V2, f2, and the phase rotation on side V2.

- Compare the measured values on side 1 and side 2. To ensure the data correctness, you can test on both channels.
  - V1 = V2
  - f1 = f2
  - dV = 0
  - df = 0
  - dα = 0

NOTE

If dV and dα are unequal to 0, then a wiring or setting error exists.
To clear such an error, activate the tap changer and check the measured values again. The measured values of the 2 sides have to remain the same and all differential quantities must be equal to 0.

12.5.2 Measuring the Circuit-Breaker Make Time

General

Under the asynchronous system conditions, the circuit-breaker make time must be measured and set correctly during the commissioning. This achieves an exact parallel switching with a phase angle 0°.

NOTE

If switching occurs only in the synchronous system conditions, measurement of the circuit-breaker make time can be skipped.

The make time can be determined via the following 2 methods:

- By reading from a fault record (recommended method)
- With an external timer

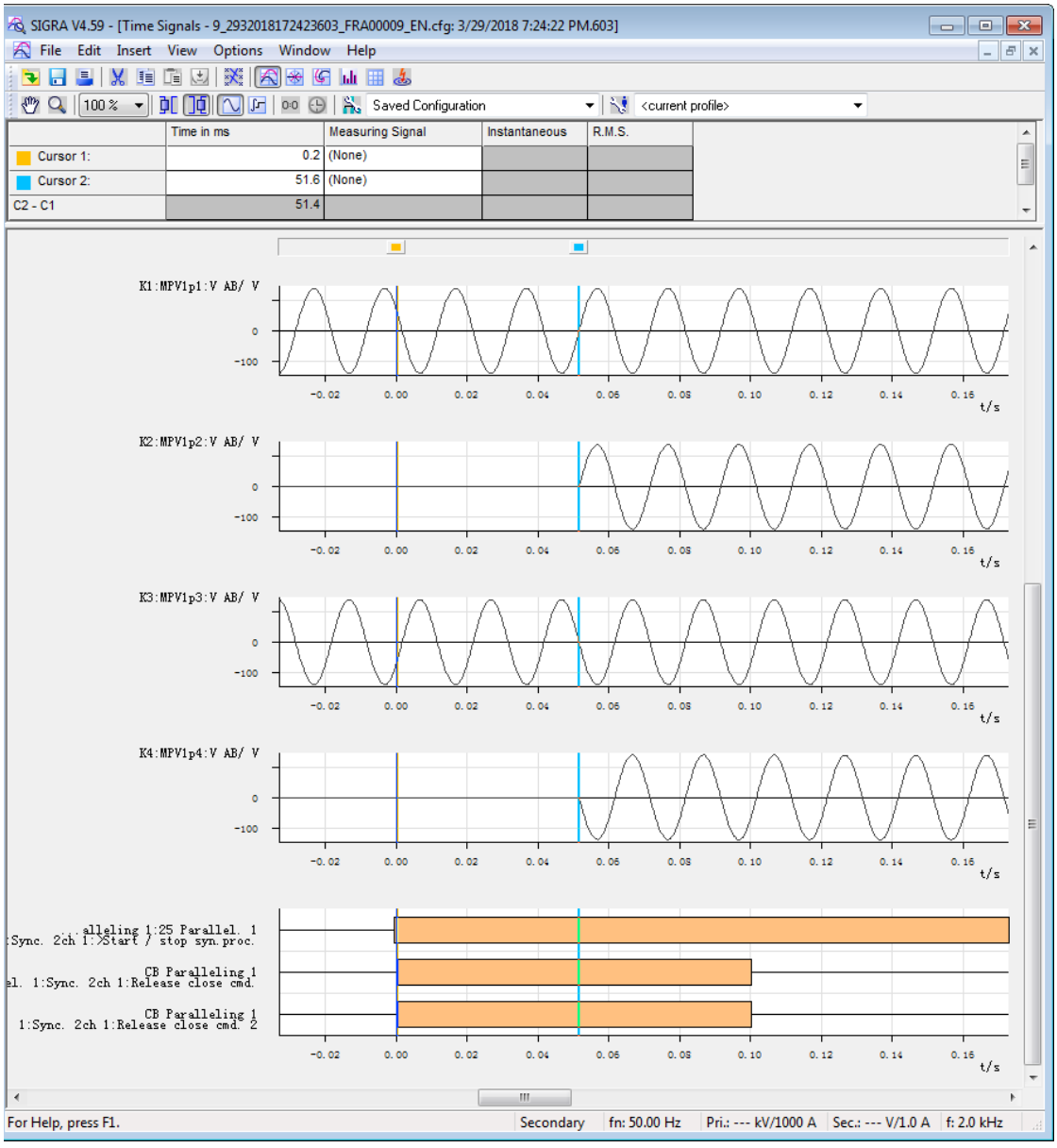
Reading the Make Time from a Fault Record

A simple option for determining the make time involves reading out the time between the close command and the closure of the switch pole via the fault record. The time determined here is the real make time and not the operation time of the circuit breaker. 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 with no danger.
  - If V2 is switched through, activate the operating mode **`Close cmd. at V1< & V2>`** for the paralleling stage[44] by setting it to ***`yes`***.
  - If V1 is switched through, activate the operating mode **`Close cmd. at V1> & V2<`** for the paralleling stage by setting it to ***`yes`***.
- Make sure that the fault recorder is activated. Via a temporary CFC chart, link the signal **`Release close cmd.`** of the active paralleling 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.
- Start the paralleling stage.
  The device is activated immediately.

44 Paralleling stage represents the stage **Paralleling with 2 channels** or **Paralleling with 1.5 channels**.

- Read the fault record and determine the make time via SIGRA, as shown in the following figure.



[sc_CBClosingT, 1, en_US]

Figure 12-10 Measurement of the Circuit-Breaker Make Time

- Read and determine the make time with the 2 cursors and the time-measuring function.
  - Position cursor 1 on the raising close command.
    The occurrence of the 2nd voltage signals the closed power-switching poles.
  - Position cursor 2 on the raising 2nd voltage.
- Set the determined time with the parameter **CB make time**.
- Set the parameter **Close cmd. at V1< & V2>** or **Close cmd. at V1> & V2<** back to its original value.
- Delete the CFC chart.

Determining with the External Timer

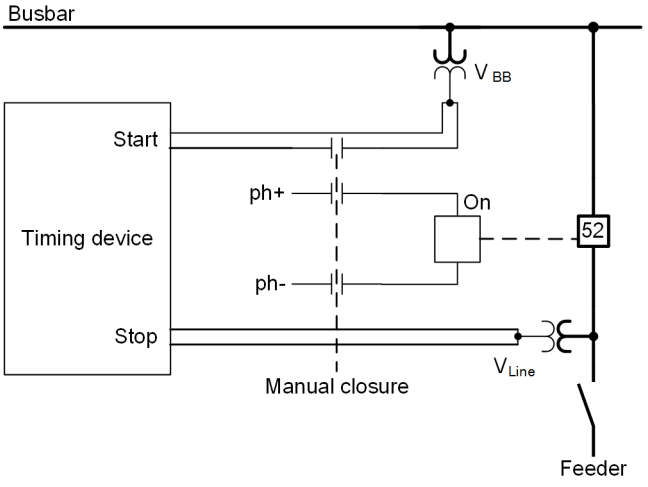
The arrangement shown in *Figure 12-11* is recommended for measuring the circuit-breaker make time with an external timer.

- Set the timer to 1 s or to a resolution of 1 ms.
- Connect the circuit breaker manually.
  The timer is started simultaneously.
- If the poles of the circuit breaker are closed, the voltage V_{Line} appears and the timer stops.
- If the timer does not stop due to an unfavorable closing moment, repeat the attempt.
  Siemens recommends calculating the average value by several (3 to 5) successful switching attempts.

NOTE

Add the OOT (Output Operating Time) of the controlled device to the measured time. The OOT exclusively depends in good approximation on the binary output used for the close command. You can find the OOTs for different binary outputs in *13 Technical Data*. Set the total time with the parameter **`CB make time`**.

Siemens recommends sending the close command via the hard-wired connection. If you use a GOOSE signal to send the close command, consider the time delay caused by the GOOSE communication while setting the parameter **`CB make time`**.



[dw_synae6-01, 2, en_US]

Figure 12-11 Measurement of the Circuit-Breaker Make Time

12.5.3 Blind-Switching Attempts

If the function **Paralleling** is used in the device, the blind-switching attempts must be performed.

Requirements

Before executing the attempts, make sure that all of the following requirements are met:

- You have checked the setting values again.
- The circuit breaker is switched off.
- The close command for the circuit breaker is disconnected.
- If the balancing commands are used, disconnect them.
- The system voltage is switched through for the measurement.

Attempt with the Asynchronous Systems

Proceed as follows:

- Via the 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`**.

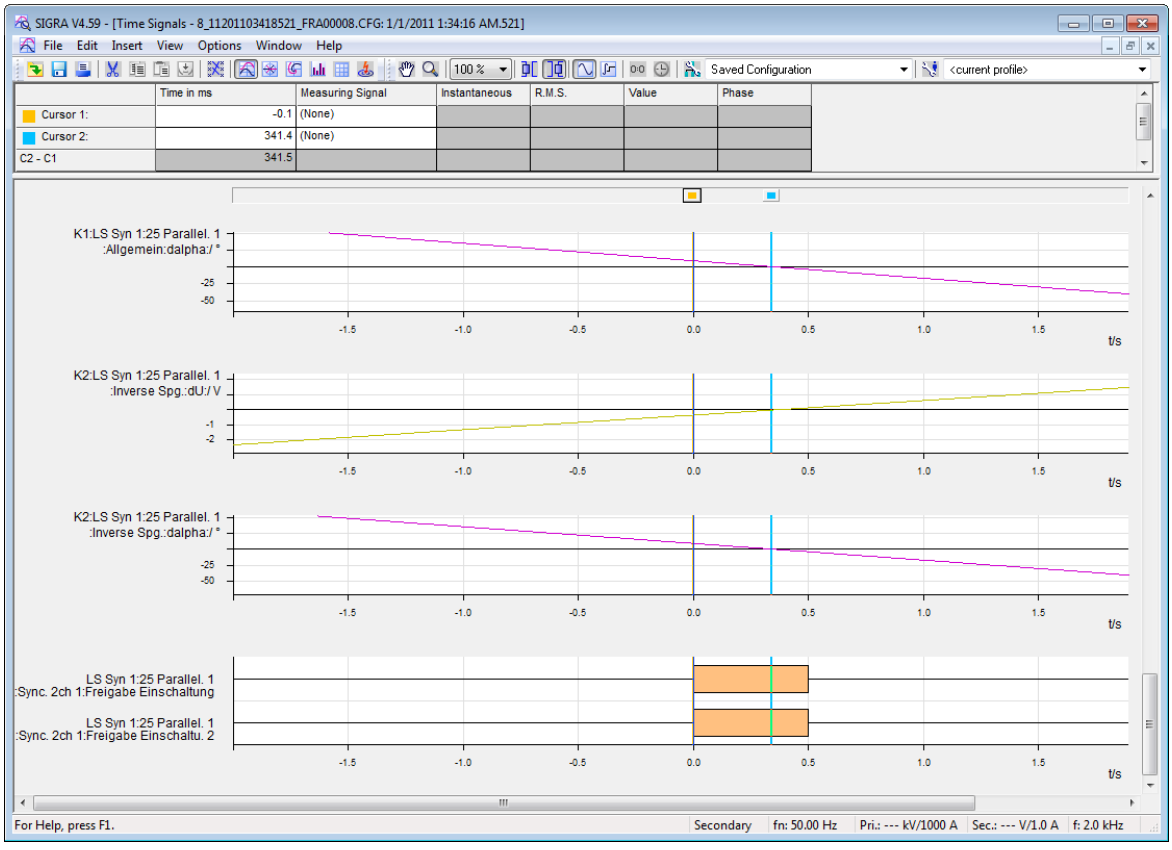
  After the generator is started, you can read out the setting values in the operational measured values.
- Start the paralleling stage, for example, externally with the binary input signal or via the integrated controller.

  You can use a synchroscope to trigger the start at synchronism. 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.
- Perform this attempt several times for the oversynchronous switching and the undersynchronous switching.
- Check the switching performance with an external recorder or the integrated fault-recording function.

  You have to start the fault recording explicitly.

The switching on behavior is checked with an external recorder or with the integrated fault recording function. Additionally both procedures must have issued the close command briefly before the synchronous instant, with offset to the close time of the circuit breaker. The following figure shows an example of an instantaneous value recording. The envelope curve and the synchronous instance are clearly visible as well as the binary tracks traces with the close commands of the 2 measuring procedures. The track with the difference angle Δα is used for the evaluation of the switching on behavior. The distance between the close command and Δα = 0 must correspond to the circuit-breaker make time. The circuit-breaker make time runs in the example to 420 ms. In case of a long time, there was an interlocking switched in between.

You can repeat the blind-switching attempts at the limits of the permissible voltage difference.



[sc_InsVal_EN, 1, en_US]

Figure 12-12 Record of Instantaneous Values from the Function Paralleling (Asynchronous Conditions)

Attempt with the Synchronous Systems

Proceed as follows:

- Start the paralleling stage, for example, externally with the binary input signal or via the integrated controller.
- Check the proper release for activation with the operational 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 the synchronous and asynchronous operations, raise the change-over threshold **`f-threshold ASYN<->SYN`** slightly.

12.6 Primary and Secondary Testing of the Synchronization Function

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.

Prerequisite:

- ✧ 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 synchronoscope to trigger the start at synchronism, that is, at **12 o'clock**. 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 indication log or via the fault record. You have to start the fault recording explicitly.

12.7 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 material 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 *8.20.4 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 *8.20.4 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.

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.

12.8 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**.

12.9 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 or an only-open cycle of the circuit breaker during operation. You can also include a current-flow criterion in the test. The effect of the current-flow criterion is to ensure the circuit-breaker test is only carried out if the current flow across the circuit breaker is below the parametrizable threshold.

NOTE

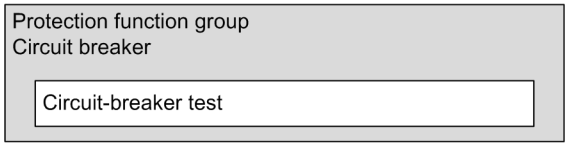
If the circuit-breaker auxiliary contacts are not connected, a circuit breaker that has been opened can be permanently closed.

The following test program is available for you to carry out the circuit-breaker test.

No.	Test Program
1	3-phase open/closed cycle

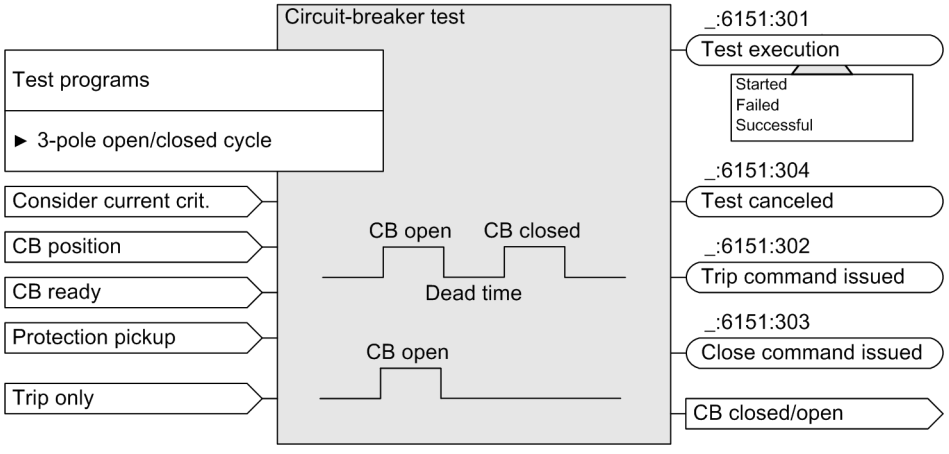
Structure of the Function

The **Circuit-breaker test** function is used in protection function groups for circuit breakers.



[dw_cbch01, 1, en_US]

Figure 12-13 Embedding of the Function



[dw_zecbc3p2, 2, en_US]

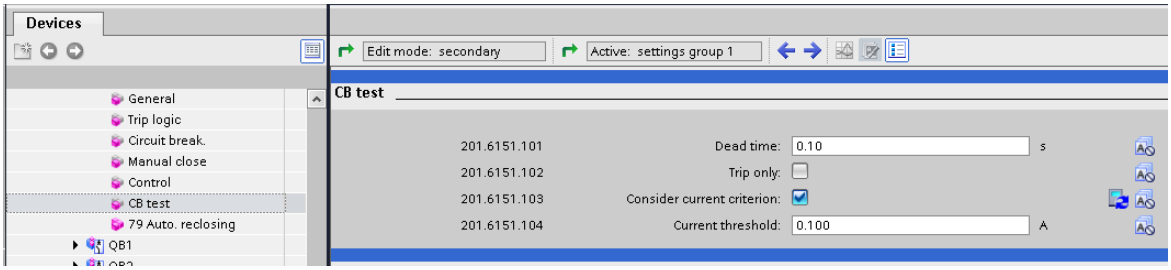
Figure 12-14 Structure of the Function

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 binary inputs of the signal **`Position`**, 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 or only-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.

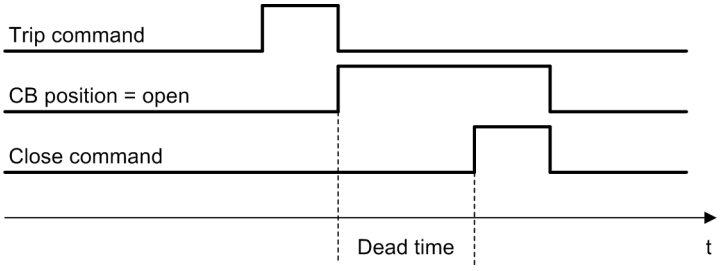


[sc_cbtest3p, 1, en_US]

Figure 12-15 Settings for the Circuit-Breaker Test

Figure 12-16 shows the progression over time of an open-close cycle. If you activated the **(_:6151:102) Trip only** option, the close command will not be executed and the dead time will not be taken into account.

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**) for an open-close cycle. 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.



[dw_cbch03, 1, en_US]

Figure 12-16 Progress over Time of a Circuit-Breaker Test Cycle

Use the **(_:6151:103) Consider current criterion** parameter to ensure the circuit-breaker test is only carried out when the current flowing through the circuit breaker does not exceed a specific current threshold (parameter **(_:6151:104) Current threshold**). Otherwise, the circuit-breaker test is not started.

✧ If the current-flowcriterion is deactivated, the current threshold is not evaluated. The circuit-breaker test is performed irrespective of the current-flow level through the circuit breaker.

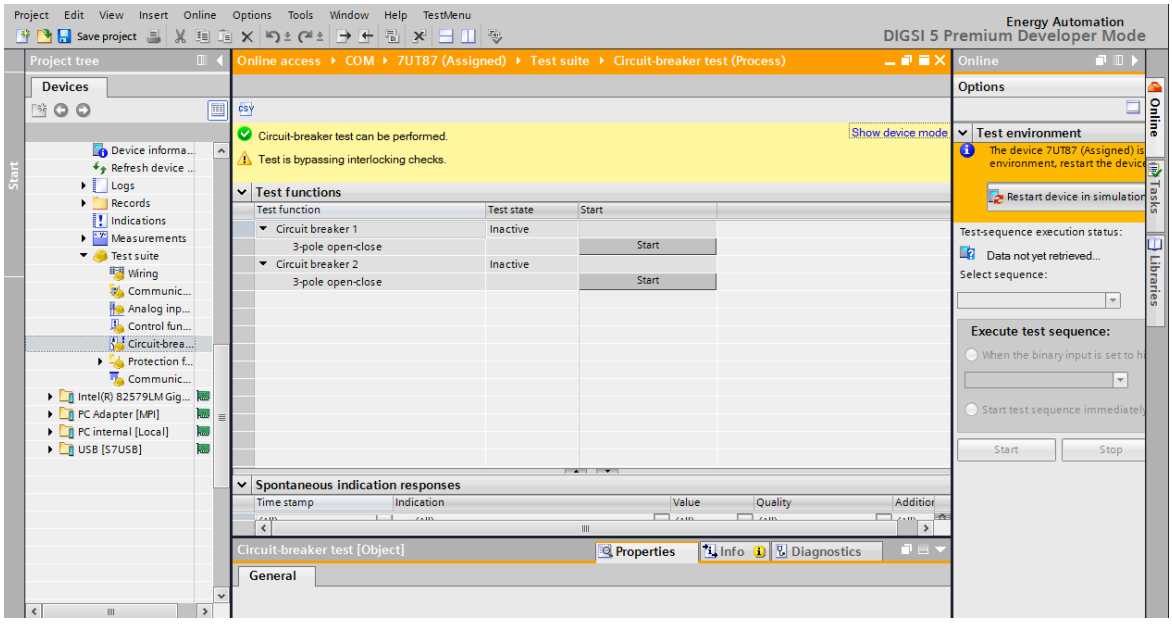
NOTE

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 can 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 communication protocols
- Via control commands, which you can also connect in the CFC

The following figure illustrates operation of the circuit-breaker test in DIGSI.



[sc_cb_3pol, 1, en_US]

Figure 12-17 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 working area.
- ✧ The corresponding feedback is displayed in the bottom portion of the working area. Additional information about the behavior of other functions while the circuit-breaker test is being performed can be read in the operational log.

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13.1 General Device Data

13.1.1 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
	5 A 1 A	0 A to 500 A 0 A to 100 A
Instrument transformers	5 A 1 A	0 A to 8 A 0 A to 1.6 A
Consumption per current input 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	

GIS Low-Power Current Input (via Module IO240)

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
GIS-LPCT input	Primary rated current I_{rated}	Measuring range
	Kr · GIS-LPCT secondary rated value Kr = Transformation ratio of the GIS-LPCT (DIGSI setting) Refer to the GIS manual for the GIS-LPCT secondary rated value.	K_{pcr} = 50 (protection channel) K_{pcr} = 1.6 (measuring channel)
Power consumption per current circuit at rated current	Max. 40 mVA Burden = 9.5 kΩ	
Thermal rating	Max. input voltage = 20 V	
Accuracy	Class 5TPE (protection channel) Class 0.2S (measuring channel)	

Optical Current Input (via Module IO245)

All current, voltage, and power data are specified as RMS values.			
Rated frequency f_{rated}	50 Hz, 60 Hz		
Rated current I_{rated}	Depending on the TOCT design		
Measuring range	Measuring channel	Protection channel	
	1.6 · I_{rated}	100 · I_{rated}	
Accuracy	Measuring channel	Protection channel	
	0.5, 0.2, 0.2S	< 10 kA	> 10 kA
		Comparable to measuring channel	5TPE

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	IO102, IO202, IO208, IO211, IO214	IO215
Measuring range	0 V to 200 V	0 V to 7.07 V
Burden	< 0.1 VA	< 0.01 VA
Thermal rating	230 V continuously	20 V continuously

GIS Low-Power Voltage Input (via Module IO240)

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
GIS-LPVT input	Primary rated voltage V_{rated}	Measuring range
	Kr · GIS-LPVT secondary rated value Kr = Transformation ratio of the GIS-LPVT (DIGSI setting) Refer to the GIS manual for the GIS-LPVT secondary rated value.	$K_{pcr} = 2$
Power consumption per current circuit at rated current	Max. 1 mVA Burden = 50 Ω	
Thermal rating	Max. input current = 4.4 mA	
Accuracy	Class 0.1	

RCVT Voltage Input (via Module IO240 or IO245)

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
RCVT input	Primary rated voltage V_{rated}	Measuring range
	100/√3 V L-N	$2 \cdot V_{rated}$
Burden	2 MΩ/50 pF	
Thermal rating	200 V L-N	
Accuracy	Class 0.1	

Measuring-Transducer Inputs (via Module ANAI-CA-4EL)

Insulation class	PELV (Protective Extra Low Voltage) (according to IEC 60255-27)
Connector type	8-pin terminal spring
Input channels	4 differential current inputs
Measuring range	DC -20 mA to +20 mA
Tolerance	0.5 % of the measuring range
Maximum measuring range	DC -25.6 mA to +25.6 mA
Input impedance	140 Ω
ADC type	16-Bit Delta-Sigma
Permissible potential difference between channels	DC 20 V
Galvanic separation from ground/ housing	AC 500 V, DC 700 V
Permissible overload	DC 100 mA continuously
Sampling rate	5 Hz

Fast Measuring Transducer Inputs, Voltage (via Module ANAI-CE-2EL, Channel 2, and IO218)

Insulation class	HLV (Hazardous Live Voltage) (in accordance with IEC 60255-27)
Input channels	1 DC voltage input, ANAI-CE-2EL, channel 2 (CH2) 3 DC voltage inputs, IO218
Measuring range	DC 0 V to + 300 V
Tolerance	0.2 % of measuring range
Input impedance	260 kΩ
Galvanic separation against ground/housing	DC 4.6 kV
Max. permissible voltage against ground on the measuring inputs	DC 300 V
Sampling rate	16 kHz

Inputs for Optical Sensors for Arc Protection (via Module ARC-CD-3FO)

Connector type	AVAGO AFBR-4526Z
Number of transceivers	3
Fiber type	Plastic 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[45]	Minimal 25 dB
Analog sampling rate	16 kHz
ADC type	10-bit successive approximation
Transmitter	
Type	LED
Wavelength	λ = 650 nm
Transmitter power	Minimum 0 dBm Maximum 2 dBm
Numerical aperture	0.5 [46]
Signal rate connection test	1 pulse per second
Pulse duration connection test	11 µs

Fast Measuring Transducer Inputs, Voltage/Current (via IO210, IO212)



NOTE

Current and voltage must not be connected at the same time to one measuring transducer input. Instead, only connect either current or voltage. For EMC reasons, do not connect a line to an unused input (current or voltage).

Use shielded cables.

45 All values in combination with sensors approved by Siemens.

46 Numerical aperture (NA = sin θ (launch angle))

Table 13-1 Fast Measuring Transducer Inputs, Voltage

Differential voltage input channels	IO210: 4[47] IO212: 8[48]
Measuring range	DC -10 V to +10 V
Fault	< 0.5 % of measuring range
Input impedance	48 kΩ
Max. permissible voltage with respect to ground on the measuring inputs	300 V
Permissible overload	DC 20 V continuously DC 60 V continuously (IO210 MU3 terminal point C9)

Table 13-2 Fast Measuring Transducer Inputs, Current

Differential current input channels	IO210: 4[49] IO212: 8[50]
Measuring range	DC -20 mA to +20 mA
Fault	< 0.5 % of measuring range
Input impedance, current	12 Ω
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation with respect to ground/housing	DC 3.5 kV
Permissible current overload	DC 100 mA continuously

Table 13-3 Combined Data for Fast Measuring Transducer Voltage/Current Inputs

Conversion principle	Delta-sigma (16 bit)
Insulation test voltage between the channels	DC 3.5 kV
Insulation test voltage with respect to ground/housing	DC 3.5 kV
Measured value repetition	62.5 µs
Insulation class IO210	ELV (Extra Low Voltage) (as per IEC 60255-27)
Insulation class IO212	SELV (as per IEC 60255-27)

Table 13-4 Measuring Transducer Inputs, Current (via Module IO218)

Insulation class	PELV (Protective Extra Low Voltage) (acc. to IEC 60255-27)
Input channels	7 current inputs with common ground (MUx inputs and RTD not galvanically separated)
Measuring range	DC 0 mA to +20 mA
Tolerance	0.5 % of measuring range (MU1 to MU3) 1.0 % of measuring range (MU4 to MU7)
Maximum measuring range	DC 0 mA to +24.5 mA
Input impedance	12 Ω
ADC type	12-bit SAR

47 The IO210 has 4 fast measuring transducer inputs. They can be used either as a voltage or current input.
48 The IO212 has 8 fast measuring transducer inputs. They can be used either as a voltage or current input.
49 The IO210 has 4 fast measuring transducer inputs. They can be used either as a voltage or current input.
50 The IO212 has 8 fast measuring transducer inputs. They can be used either as a voltage or current input.

Permissible potential difference between channels	DC 20 V
Galvanic separation against ground/housing	AC 500 V, DC 700 V
Permissible overload	DC 100 mA continuously
Sampling rate	16 kHz (MU1 to MU3) 5 Hz (MU4 to MU7)

Temperature Inputs

Settings	Value	Note
Insulation class	PELV (Protective Extra Low Voltage) (acc. to IEC 60255-27)	With IO218: RTD and MUx inputs not galvanically separated.
Measurement mode	• Pt 100 Ω • Ni 100 Ω • Ni 120 Ω 3-wire connection, shielded cables	–
Temperature measuring range	-65 °C to +710 °C	For PT100
	-50 °C to +250 °C	For NI100
	-50 °C to +250 °C	For NI120

Temperature Inputs (via Module IO240)

Settings	Value
Sensor Type	PT100 (Class F 0.3 EN 60751) 4-wire shielded cable connection
Measurement range	-50 °C to +180 °C
Accuracy	±1 °C

Optical Temperature Input (via Module IO245)

Setting	Value
Sensor type	Optical GaAs (Gallium Arsenide) sensor Single cable with multi-mode fiber optic (OM1)
Measuring range	-50 °C to +150 °C
Accuracy	±2 °C

LPIT Digital Input (via Module IO240)

Shield Cover Input	
Sensor type	Dry contact input
Measurement type	Output voltage of 1 mA current injection @ max. DC 5 V

Insulation of LPIT Digital Input (via Module IO245)

Insulation (All Inputs)	
Configuration	The LPVT inputs are isolated from PE and the operator according to the requirements of IEC 61869-1 (AC 3 kV, 50 Hz, 1 min) and IEC 60255-27 for a rated voltage of 300 V despite the low-level signaling voltages. All channels are protected with differential-mode and common-mode voltage-limiting devices.
Test levels (type test)	AC 3250 V, 50 Hz, 1 min 6000 V 1.2/50 µs peak impulse

13.1.2 Supply Voltage

Integrated Power Supply			
For modular devices, the following modules contain a power supply: PS201 – Power supply of the base module and of the 1st device row PS203 – Power supply of the 2nd device row PS204 – Redundant power supply CB202 – Plug-in module assembly with integrated power supply, for example, to accommodate communication modules			
Permissible voltage ranges (PS201, PS203, PS204, 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, PS204, 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) Only for non-modular devices	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) Only for non-modular devices	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, IEC 61000-4-17	≤ 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 Only for non-modular devices	4 A inert, 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 (to device version xA)	4 A inert, 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, PS204 (Device version xB and higher)	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	3.15 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	

Integrated Power Supply			
Power consumption (life relay active)			
–	DC	AC 230 V/50 Hz	AC 115 V/50 Hz
1/3 module, non-modular Without plug-in modules	7 W	16 VA	12.5 VA
1/3 base module, modular Without plug-in modules	13 W	55 VA	40 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 IEC 61000-4-11 IEC 61000-4-29		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 IEC 61000-4-11 IEC 61000-4-29		For V ≥ DC 24 V ≥ 20 ms For V ≥ DC 60 V ≥ 50 ms For V ≥ AC 115 V ≥ 200 ms	

13.1.3 Binary Inputs

Standard Binary Input

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 modules IO230, IO231, IO232, and IO233.	
Current consumption, picked up	Approx. DC 0.6 mA to 2.5 mA (independent of the control voltage)	
Max. power consumption	0.6 W	
Pickup time	Approx. 3 ms	
Dropout time[51]	Capacitive load (supply-line capacitance)	Dropout time
	< 5 nF	< 4 ms
	< 10 nF	< 6 ms
	< 50 nF	< 10 ms
	< 220 nF	< 35 ms

51 Pay attention to the specified dropout times for time-critical applications with active-low signals. If necessary, provide for active discharge of the binary input (for example, a resistor in parallel with the binary input or using a change-over contact).

Control voltage for all modules with binary inputs, except module IO233	Adapt the binary-input threshold to be set in the device to the control voltage.	
	Range 1 for 24 V, 48 V, and 60 V control voltage	V_{low} ≤ DC 10 V V_{high} ≥ DC 19 V
	Range 2 for 110 V and 125 V control voltage	V_{low} ≤ DC 44 V V_{high} ≥ DC 88 V
	Range 3 for 220 V and 250 V control voltage	V_{low} ≤ DC 88 V V_{high} ≥ DC 176 V
Control voltage for binary inputs of the IO233 module	Range for 125 V control voltage	V_{low} ≤ DC 85 V V_{high} ≥ DC 105 V
Maximum admissible voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. To ensure EMC immunity, use the terminals shown in the terminal diagrams/connection diagrams to root the binary inputs to the common potential.		

Special Binary Input with Maximized Robustness against Electrical Disturbances and Failures (IO216)

Rated voltage range	DC 220 V The special binary inputs of the SIPROTEC 5 with maximized robustness against electrical disturbances and failures are bipolar and available only on the module IO216.	
Input impedance	50 kΩ to 60 kΩ	
Rejection pulse charge	> 200 µC	
Current consumption, excited	Approx. DC 1.2 mA to 2.0 mA (additionally to the current consumption of the input impedance)	
Power consumption, max.	1.5 W at DC 242 V	
Pickup time	Approx. 3 ms	
Dropout time[52]	Capacitive load (supply-line capacitance)	Dropout time
	< 5 nF	< 3 ms
	< 10 nF	< 4 ms
	< 50 nF	< 5 ms
	< 220 nF	< 10 ms
Control voltage for the module IO216	Range for 220 V control voltage	
	Threshold pickup	158 V to 170 V
	Threshold dropout	132 V to 154 V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. To ensure EMC immunity, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

13.1.4 Relay outputs

Standard Relay (Type S)

Rated voltage (AC and DC)	250 V
Rated current (continuous) and total permissible current for contacts connected to common potential	5 A

52 For time-critical applications with low-active signals, consider the specified dropout times. If necessary, provide for active discharge of the binary input (for example, a resistor in parallel to the binary input or using a change-over contact).

Permissible current per contact (switching on and holding)	30 A for 1 s (make contact only)
Short-time current across closed contact	250 A for 30 ms
Breaking capacity	Max. 30 W (L/R = 40 ms) Max. 360 VA (power factor ≥ 0.35, 50 Hz to 60 Hz)
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 8 ms; maximum: 10 ms Break time: typical: 2 ms; maximum: 5 ms
Max. rated data of the output contacts in accordance with UL certification	DC 24 V, 5 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, 1/6 hp AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation

Fast Relay (Type F)

Rated voltage (AC and DC)	250 V
Rated current (continuous) and total permissible current for contacts connected to common potential	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact only)
Short-time current across closed contact	250 A for 30 ms
Breaking capacity	Max. 30 W (L/R = 40 ms) Max. 360 VA (power factor ≥ 0.35, 50 Hz to 60 Hz)
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 4 ms; maximum: 5 ms Break time: typical: 2 ms; maximum: 5 ms
Max. rated data of the output contacts in accordance with UL certification	AC 120 V, 5 A, general purpose AC 250 V, 5 A, general purpose AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation with cyclic testing (make contact only)

High-Speed Relay with Semiconductor Acceleration (Type HS)

Rated voltage	AC 200 V, DC 250 V
Rated current (continuous)	5 A (in accordance with UL approval) 10 A (not UL approved; AWG 14 / 2.5 mm^2copper conductors necessary)
Permissible current per contact (switching on and holding)	30 A for 1 s
Short-time current across closed contact	250 A for 30 ms
Breaking capacity	Max. 2500 W (L/R = 40 ms)

Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 0.2 ms; maximum: 0.2 ms Break time: typical: 9 ms; maximum: 9 ms
Max. rated data of the output contacts in accordance with UL certification	B150 Q300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation

Power Relay (for Direct Control of Motor Switches)

Rated voltage (AC and DC)	250 V
Rated current (continuous) and total permissible current for contacts connected to common potential	5 A
Switching power for permanent and periodic operation In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.	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
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. In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.	100 V/9.0 A 60 V/10.0 A 48 V/10.0 A 24 V/10.0 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
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	≤ 16 ms
Max. rated data of the output contacts in accordance with UL certification	DC 300 V, 4.5 A – 30 s ON, 15 min OFF 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, 10 A, 1/2 hp Motor – 30 s ON, 15 min OFF DC 48 V, 10 A, 1/3 hp Motor – 30 s ON, 15 min OFF DC 24 V, 10 A, 1/6 hp Motor – 30 s ON, 15 min OFF
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation
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.	

13.1.5 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	4.4 kg	7.2 kg	9.9 kg	12.7 kg	15.5 kg

	Device Size Weight of the Modular Devices				
Surface-mounted device with integrated on-site operation panel	7.4 kg	11.7 kg	15.9 kg	20.2 kg	24.5 kg
Surface-mounted device with detached on-site operation panel	4.7 kg	7.8 kg	10.8 kg	13.9 kg	17.0 kg

Devices with IO240 weigh 0.9 kg more.

	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 7xx81, 7xx82
Type of construction	1/3
Flush-mounting device	3.6 kg
Bracket for non-modular surface-mounting version	1.9 kg

Dimensions of the Base and Expansion Modules

Type of Construction		Max. Total Width x Max. Total Height x Max. Total Depth[53], Each Rounded up to the Next Full mm (in Inches)
Flush-mounting device	Base module	150 mm x 266 mm x 231 mm (5.91 x 10.47 x 9.09)
	Base module with IO240	150 mm x 266 mm x 277 mm (5.91 x 10.47 x 10.91)
	Base module with IO111	150 mm x 266 mm x 243 mm (5.91 x 10.47 x 9.57)
	Expansion module	75 mm x 266 mm x 231 mm (2.95 x 10.47 x 9.09)
	Expansion module with IO240, IO218	75 mm x 266 mm x 277 mm (2.95 x 10.47 x 10.91)
	Expansion module with IO111	75 mm x 266 mm x 243 mm (2.95 x 10.47 x 9.57)
Surface-mounted device with integrated on-site operation panel	Base module	150 mm x 315 mm x 341 mm (5.91 x 12.4 x 13.43)
	Expansion module	75 mm x 315 mm x 341 mm (2.95 x 12.4 x 13.43)

53 Including current terminal, excluding USB port cover

Type of Construction		Max. Total Width x Max. Total Height x Max. Total Depth[53], Each Rounded up to the Next Full mm (in Inches)
Surface-mounted device with detached on-site operation panel	Base module	150 mm x 315 mm x 231 mm (5.91 x 12.4 x 9.09)
	Base module with IO240	150 mm x 315 mm x 277 mm (5.91 x 12.4 x 10.91)
	Base module with IO111	150 mm x 315 mm x 243 mm (5.91 x 12.4 x 9.57)
	Expansion module	75 mm x 315 mm x 231 mm (2.95 x 12.4 x 9.09)
	Expansion module with IO240, IO218	75 mm x 315 mm x 277 mm (2.95 x 12.4 x 10.91)
	Expansion module with IO111	75 mm x 315 mm x 243 mm (2.95 x 12.4 x 9.57)

Dimensions of the Device Rows

Type of Construction	Max. Total Width x Max. Total Height x Max. Total Depth[54], Rounded to full mm (in Inches)				
Device width	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	150 mm x 266 mm x 231 mm (5.91 x 10.47 x 9.09)	225 mm x 266 mm x 231 mm (8.86 x 10.47 x 9.09)	300 mm x 266 mm x 231 mm (11.81 x 10.47 x 9.09)	375 mm x 266 mm x 231 mm (14.76 x 10.47 x 9.09)	450 mm x 266 mm x 231 mm (17.72 x 10.47 x 9.09)
Flush-mounting device with IO240, IO218	150 mm x 266 mm x 277 mm (5.91 x 10.47 x 10.91)	225 mm x 266 mm x 277 mm (8.86 x 10.47 x 10.91)	300 mm x 266 mm x 277 mm (11.81 x 10.47 x 10.91)	375 mm x 266 mm x 277 mm (14.76 x 10.47 x 10.91)	450 mm x 266 mm x 277 mm (17.72 x 10.47 x 10.91)
Flush-mounting device with IO111	150 mm x 266 mm x 243 mm (5.91 x 10.47 x 9.57)	225 mm x 266 mm x 243 mm (8.86 x 10.47 x 9.57)	300 mm x 266 mm x 243 mm (11.81 x 10.47 x 9.57)	375 mm x 266 mm x 243 mm (14.76 x 10.47 x 9.57)	450 mm x 266 mm x 243 mm (17.72 x 10.47 x 9.57)
Surface-mounted device with integrated on-site operation panel	150 mm x 315 mm x 341 mm (5.91 x 12.4 x 13.43)	225 mm x 315 mm x 343 mm[55] (8.86 x 12.4 x 13.43)	300 mm x 315 mm x 343 mm[55] (11.81 x 12.4 x 13.43)	375 mm x 315 mm x 343 mm[55] (14.76 x 12.4 x 13.43)	450 mm x 315 mm x 343 mm[55] (17.72 x 12.4 x 13.43)
Surface-mounted device with detached on-site operation panel	150 mm x 315 mm x 231 mm (5.91 x 12.4 x 9.09)	225 mm x 315 mm x 231 mm (8.86 x 12.4 x 9.09)	300 mm x 315 mm x 231 mm (11.81 x 12.4 x 9.09)	375 mm x 315 mm x 231 mm (14.76 x 12.4 x 9.09)	450 mm x 315 mm x 231 mm (17.72 x 12.4 x 9.09)

53 Including current terminal, excluding USB port cover
54 Including current terminal, excluding USB port cover
55 Including connecting rail

Type of Construction	Max. Total Width x Max. Total Height x Max. Total Depth[54], Rounded to full mm (in Inches)				
Surface-mounted device with detached on-site operation panel with IO240, IO218	150 mm x 315 mm x 277 mm (5.91 x 12.4 x 10.91)	225 mm x 315 mm x 277 mm (8.86 x 12.4 x 10.91)	300 mm x 315 mm x 277 mm (11.81 x 12.4 x 10.91)	375 mm x 315 mm x 277 mm (14.76 x 12.4 x 10.91)	450 mm x 315 mm x 277 mm (17.72 x 12.4 x 10.91)
Surface-mounted device with detached on-site operation panel with IO111	150 mm x 315 mm x 243 mm (5.91 x 12.4 x 9.57)	225 mm x 315 mm x 243 mm (8.86 x 12.4 x 9.57)	300 mm x 315 mm x 243 mm (11.81 x 12.4 x 9.57)	375 mm x 315 mm x 243 mm (14.76 x 12.4 x 9.57)	450 mm x 315 mm x 243 mm (17.72 x 12.4 x 9.57)

Plug-In Module Dimensions

Type of Construction	Max. Width x Max. Height x Max. Depth (in Inches)
USART-Ax-xEL, ETH-Bx-xEL	61 mm x 45 mm x 121 mm (2.4 x 1.77 x 4.76)
USART-Ax-xFO, ETH-Bx-xFO (without protective cover)	61 mm x 45 mm x 133 mm (2.4 x 1.77 x 5.24)
ANAI-CA-4EL, ANAI-CE-2EL	61 mm x 45 mm x 120 mm (2.4 x 1.77 x 4.72)
ARC-CD-3FO	61 mm x 45 mm x 121 mm (2.4 x 1.77 x 4.76)

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 According to IEC 60529

For equipment in the surface-mounting housing	IP54[56] for front
For equipment in the flush-mounting housing	IP54[56] for front
For operator protection (back side)	IP2x for current terminal (installed) IP2x for voltage terminal (installed)
Degree of pollution, IEC 60255-27	2
Maximum operating altitude above sea level	2000 m (6561.68 ft)

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.

54 Including current terminal, excluding USB port cover

56 The supplied plug-in strips must be used for expansion modules with LEDs.

Tightening Torques for Terminal Screws

Type of Line	Current Terminal	Voltage Terminal with Spring-Loaded Terminals	Voltage Terminal with Screw Connection
Stranded wires 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	–
Blank stranded wire	Not permitted	1 Nm	0.6 Nm

NOTE

For current and voltage terminals, the maximum speed of the tool must not exceed 640 rpm.

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

13.2 Protection Interface and Protection Topology

Setting Values

Mode	On Off	
Synchronization	External synchron. off Telegr. and ext. synch. Telegr. or ext. synch. External synch. only	
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
Fault indication after	0.05 s to 2.00 s	Increments of 0.01 s
Transm. fail. alarm 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 %

Transmission Rate

Direct connection:	
Transmission rate	2048 kbit/s
Connection via communication networks:	
Supported network interfaces	IP protection communication
	C37.94 at 64 kBit/s or 128 kBit/s or 512 kBit/s
	G703.1 at 64 kBit/s G703-T1 at 1.455 MBit/s G703-E1 at 2.048 MBit/s
	X.21 at 64 kBit/s or 128 kBit/s or 512 kBit/s
	Pilot wires at 128 kbit/s
Transmission rate	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 for Remote Data

Measured with a minimum of 512 kbit/s

Priority 1:		
Response time, total approx.		
For 2 ends	Minimum	3 ms + OOT[57]
	Typical	5 ms + OOT
For 3 ends	Minimum	5 ms + OOT
	Typical	9 ms + OOT
For 6 ends	Minimum	10 ms + OOT
	Typical	13 ms + OOT

57 OOT (Output Operating Time): Additional delay of the output medium used, for example, 1 ms with electronic relays

Dropout times, total approx.		
For 2 ends	Typical	15 ms + OOT
For 3 ends	Typical	15 ms + OOT
For 6 ends	Typical	21 ms + OOT

Priority 2		
Response time, total approx.		
For 2 ends	Minimum	4 ms + OOT
	Typical	11 ms + OOT
For 3 ends	Minimum	7 ms + OOT
	Typical	13 ms + OOT
For 6 ends	Minimum	12 ms + OOT
	Typical	18 ms + OOT
Dropout times, total approx.		
For 2 ends	Typical	19 ms + OOT
For 3 ends	Typical	20 ms + OOT
For 6 ends	Typical	27 ms + OOT

Priority 3[58]		
Response time, total approx.		
For 2 ends	Minimum	
	Typical	95 ms + OOT
For 3 ends	Minimum	
	Typical	145 ms + OOT
For 6 ends	Minimum	
	Typical	195 ms + OOT
Dropout times, total approx.		
For 2 ends	Typical	95 ms + OOT
For 3 ends	Typical	145 ms + OOT
For 6 ends	Typical	195 ms + OOT

58 Times cannot be determined because the signals are transmitted in fragments.

13.3 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) [59] SNTP IEC 60870-5-103 DNP3 IEEE 1588 T104
Time zone 1, time zone 2	Local
	UTC
Fault indication after	0 s to 3600 s
Time zone and daylight saving time	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	0 min to 120 min [15 min. steps]

59 if provided

13.4 Function Group Analog Units

20-mA Inputs, Ethernet Interface 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 to 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, adjustable
Pt 100	-199 °C to 800 °C (-326 °F to 1472 °F)
Ni 100	-54 °C to 278 °C (-65 °F to 532 °F)
Ni 120	-52 °C to 263 °C (-62 °F to 505 °F)
Resolution	1 °C or 1 °F
Tolerance	±0.5 % of the measured value ±1 °C (±0.56 °F)

13.5 High-Speed Busbar Transfer

Setting Values

General		
Max. transfer duration	10.00 s to 60.00 s	Increments of 0.01 s
Min. operating limit Vmin	30.0 % to 100.0 %	Increments of 0.1 %
Ready check		
Ready delay	5.00 s to 60.00 s	Increments of 0.01 s
Unready delay	5.00 s to 60.00 s	Increments of 0.01 s
Simultaneous seq.		
Open-cmd. delay	0.000 s to 0.040 s	Increments of 0.001 s
Close-cmd. delay	0.000 s to 0.040 s	Increments of 0.001 s
Parallel sequence		
Max. Δφ	2.0° to 80.0°	Increments of 0.1°
Max. ΔV	1.0 % to 70.0 %	Increments of 0.1 %
Max. Δf	0.02 Hz to 2.00 Hz	Increments of 0.01 Hz
Fault detection		
3ph bus.volt. threshold	5.00 % to 20.00 %	Increments of 0.01 %
V0> threshold	5.00 % to 20.00 %	Increments of 0.01 %
V2> threshold	5.00 % to 20.00 %	Increments of 0.01 %
V2/V1 > threshold	2.00 % to 100.00 %	Increments of 0.01 %
V< start		
3ph bus.volt. threshold	25.0 % to 95.0 %	Increments of 0.1 %
Start delay	0.00 s to 5.00 s	Increments of 0.01 s
f< start		
Threshold	45.00 Hz to 59.50 Hz	Increments of 0.01 Hz
Start delay	0.00 s to 1.00 s	Increments of 0.01 s
Frequency bandwidth	0.20 Hz to 2.00 Hz	Increments of 0.01 Hz
Fast mode		
Δf max. fast mode	0.50 Hz to 5.00 Hz	Increments of 0.01 Hz
Δφ max. fast mode	10.0° to 50.0°	Increments of 0.1°
Vmin. fast mode	50.0 % to 90.0 %	Increments of 0.1 %
RTFT mode		
V/f diff max. RTFT mode	1.00 to 1.33	Increments of 0.01
Δφ max. RTFT mode	70.0° to 90.0°	Increments of 0.1°
Δf max. RTFT mode	1.00 Hz to 15.00 Hz	Increments of 0.01 Hz
V min. RTFT mode	50.0 % to 90.0 %	Increments of 0.1 %
In-phase mode		
Δφ max. in-phase mode	0.5° to 30.0°	Increments of 0.1°
Δf max. in-phase mode	1.00 Hz to 15.00 Hz	Increments of 0.01 Hz
Vmin. in-phase mode	30.0 % to 80.0 %	Increments of 0.1 %
Resid.volt. mode		
Vmax. resid.volt. mode	20.0 % to 60.0 %	Increments of 0.1 %
Delay resid.volt. mode	0.00 s to 10.00 s	Increments of 0.01 s
Long-time mode		
Delay long-time mode	0.50 s to 10.00 s	Increments of 0.01 s

Measured Values

Voltage difference	
Unit	kV in primary, V in secondary, or % V_{rated}
Range	10 % to 120 % of V_{rated}
Tolerance at rated frequency	≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency difference	
Unit	mHz
Range	0 % to 40 % of f_{rated}
Tolerance at rated frequency	20 mHz
Angle difference	
Unit	°
Range	-180° to +180°
Tolerance at rated frequency	0.2°

Action Time

Fastest action time of fast mode	Approx. 20 ms at 50 Hz Approx. 16.7 ms at 60 Hz
Fastest action time of RTFT mode	Approx. 60 ms at 50 Hz Approx. 50 ms at 60 Hz

Frequency Operating Range

Frequency	< 1.2 f_{rated}

Tolerances

Voltage difference	1 % of the measured value or 0.5 % V_{rated}
Frequency difference	20 mHz
Angle difference	0.2°
Residual voltage	1 % of the setting value or 0.5 V
V0 > threshold V2 > threshold V2/V1 > threshold	0.5 % of the setting value or 0.05 V
Open-cmd delay Close-cmd delay	3 ms
Ready delay Unready delay Start delay Delay resid.volt. mode Delay long-time mode	1 % of the setting value or 10 ms

13.6 Paralleling Function

Operating Modes

Switching synchronous systems
Switching asynchronous systems
Switching to dead line or dead busbar
Direct close command
Balancing voltage
Balancing frequency

Setting Values

Supervision/Delay/Pulse times		
Max.durat. sync.process	0.00 s to 3600.00 s or ∞ (ineffective)	Increments of 0.01 s
Supervision time for dead-system 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
T V pulse min/T f pulse min	0.01 s to 1.00 s	Increments of 0.01 s
T V pulse max/T f pulse max	0.01 s to 60.00 s	Increments of 0.01 s
T pause V/T pause f	0.01 s to 60.00 s	Increments of 0.01 s
T close without balancing	1.00 s to 100.00 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
V1, V2 without voltage	0.300 V to 170.000 V (phase-to-phase)	Increments of 0.001 V
V1, V2 with voltage	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Differential values, changeover thresholds asynchronous/synchronous/balancing		
Voltage difference 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
Angle 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
Δf set point for balancing	-1.00 Hz to 1.00 Hz	Increments of 0.01 Hz
Δf for the kick pulse	-1.00 Hz to 1.00 Hz	Increments of 0.01 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		
Make time of the circuit breaker	0.010 s to 0.600 s	Increments of 0.001 s

Dropout Ratio

Min./max. operating limit	1 % of the setting value
Voltage differential	10 % of the setting value or 0.5 V
Dead/energized	5 % of the setting value
Frequency difference	3 mHz
Angle difference	0.1°

Measured Values

Reference voltage: V1 (always displayed as a phase-to-phase voltage)	
Unit	kV in primary, V in secondary, or % V_{rated}
Range	10 % to 120 % of V_{rated}
Tolerance at rated frequency	≤ 1 % of the measured value or 0.5 % V_{rated}
Voltage to be paralleled: V2 (always displayed as a phase-to-phase voltage)	
Unit	kV in primary, V in secondary, or % V_{rated}
Range	10 % to 120 % of V_{rated}
Tolerance at rated frequency	≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency of the voltage V1: f1	
Unit	Hz
Range	25 Hz ≤ f ≤ 70 Hz
Tolerance at rated frequency	1 mHz
Frequency of the voltage V2: f2	
Unit	Hz
Range	25 Hz ≤ f ≤ 70 Hz
Tolerance at rated frequency	1 mHz
Voltage difference: V2 - V1 (always displayed as a phase-to-phase voltage according to V1)	
Unit	kV in primary, V in secondary, or % V_{rated}
Range	10 % to 120 % of V_{rated}
Tolerance at rated frequency	≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency difference: f2 - f1	
Unit	mHz
Range	f_{rated} ± 10 %
Tolerance at rated frequency	1 mHz
Angle difference: α2 - α1	
Unit	°
Range	-180° to +180°
Tolerance at rated frequency	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

Voltage	2 % of the setting value or 1 V
Voltage difference V2>V1; V2<V1	1 V
Frequency difference f2>f1; f2<f1	10 mHz
Angle difference α2>α1; α2<α1	1°
Pulse time	1 % of the calculated impulse or 10 ms

Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

13.7 Synchronization Function

Operating Modes

Synchrocheck
De-energized switching
Direct closing command

Setting Values

Supervision/Delay times:		
Max.durat. sync.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
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 threshold values asynchronous/synchronous/balancing commands:		
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
Angle difference α2 > α1; α2 < α1	0° to 90°	Increments of 1°
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		
Make time of the circuit breaker	0.010 s to 0.600 s	Increments of 0.001 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
Angle 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
Angle 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
Angle difference α2>α1; α2<α1	1°
Pulse time	1 % of the calculated impulse or 10 ms
Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

13.8 Overvoltage Protection with 3-Phase Voltage

Setting Values for the Function

Stabilization counter	0 to 10	Increments of 1

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[60]	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`**)

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

60 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

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**)

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, typical	Approx. 25 ms + OOT[61] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	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

61 OOT (Output Operating Time): additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

13.9 Overvoltage Protection with Any Voltage

Setting Values

Measured value[62]	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[63]	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, typical	Approx. 25 ms + OOT[64] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

62 If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the measured-value parameter is not visible.

63 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

64 OOT (Output Operating Time): additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

13.10 Undervoltage Protection with 3-Phase Voltage

Setting Values for the Function

Stabilization counter	0 to 10	Increments of 1

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
Threshold value[65]		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 300.00 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

65 If you have selected the **Method of measurement** = **RMS value**, do not set the threshold value under 10 V.

T_{Inv} Inverse-time delay

T_{add} Additional time delay (parameter **Additional time delay**)

$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_uvp_3ph_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

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[66] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 \text{ Hz} \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90 \text{ Hz}$	Slightly expanded tolerances
$f < 10 \text{ Hz}$ $f > 90 \text{ Hz}$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

66 OOT (Output Operating Time): additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

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), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

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), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A), 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

13.11 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	
Threshold value[67]	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, typical	Approx. 25 ms + OOT[68] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

67 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

68 OOT (Output Operating Time): additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

13.12 Rate-of-Voltage-Change Protection

Setting Value for the Function

Measuring window	2 periods to 50 periods	Increments of 1 period

Setting Values for Stage Types

dV/second	0.500 V to 200.000 V	Increments of 0.001 V
Dropout 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 larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:	
Dropout differential derived from `Dropout ratio`	90 % for the **`dV/second`** parameter
Minimum absolute dropout differential	0.15 V per second

Times

Pickup time	• At 50 Hz: Pickup time = Measuring window + 120 ms + OOT[69] Max. 220 ms + OOT with the default measuring window of 5 periods • At 60 Hz: Pickup time = Measuring window + 100 ms + OOT Max. 183.3 ms + OOT with the default measuring window of 5 periods
Dropout time	• At 50 Hz: Dropout time = Measuring window + 120 ms + OOT Max. 220 ms + OOT with the default measuring window of 5 periods • At 60 Hz: Dropout time = Measuring window + 100 ms + OOT Max. 183.3 ms + OOT with the default measuring window of 5 periods

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

69 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *13.1.4 Relay outputs*

Tolerances

Threshold	1 % of the setting value or 0.05 V/s with a measuring window ≥ 5 periods For a measuring window < 5 periods, a slightly expanded tolerance results.
Time delays	1 % of the setting value or 10 ms

Functional Measured Value

Value	Description
dV/s	Calculated voltage change per second

13.13 Overcurrent Protection, Phases

13.13.1 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[70]	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 100.00 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 [71] 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

70 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

71 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
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	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)
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)
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)
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)
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)
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)
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)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[72] (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) [73]
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) [74]
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) [75]
Pickup delay	1 % of the setting value or 10 ms
Dropout delay	1 % of the setting value or 10 ms
Operate delay for the basic stage	1 % of the setting value or 10 ms

72 In case that the filter response exactly matches the user-defined gain factors

73 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

74 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

75 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Operate delay for the advanced stage	Operate delay mode = Running dur. DO-delay	1 % of the setting value or 10 ms
	Operate delay mode = Frozen dur. DO-delay	1 % of the reference value or 10 ms (Reference value = Setting value + Frozen time)

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

13.13.2 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

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)

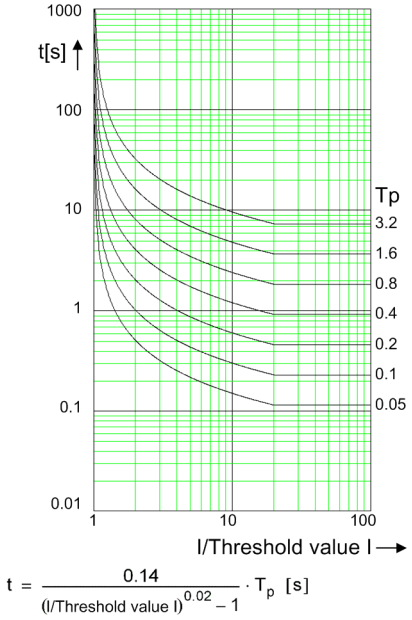
Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

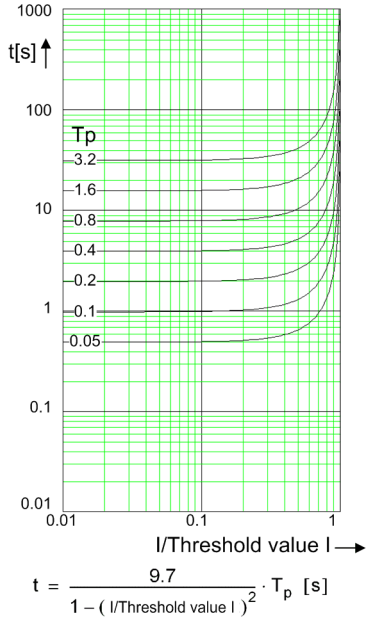
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

NORMAL INVERSE: Type A



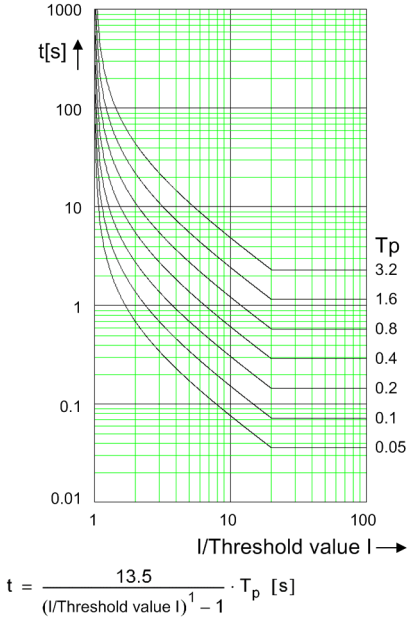
$$t = \frac{0.14}{(I/\text{Threshold value } I)^{0.02} - 1} \cdot T_p \ [s]$$

RESET NORMAL INVERSE: Type A



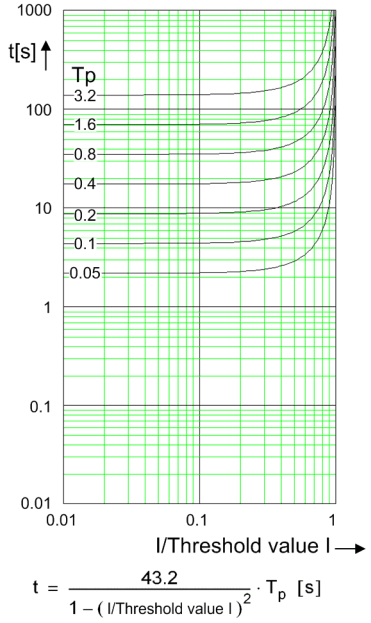
$$t = \frac{9.7}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

VERY INVERSE: Type B



$$t = \frac{13.5}{(I/\text{Threshold value } I)^{1} - 1} \cdot T_p \ [s]$$

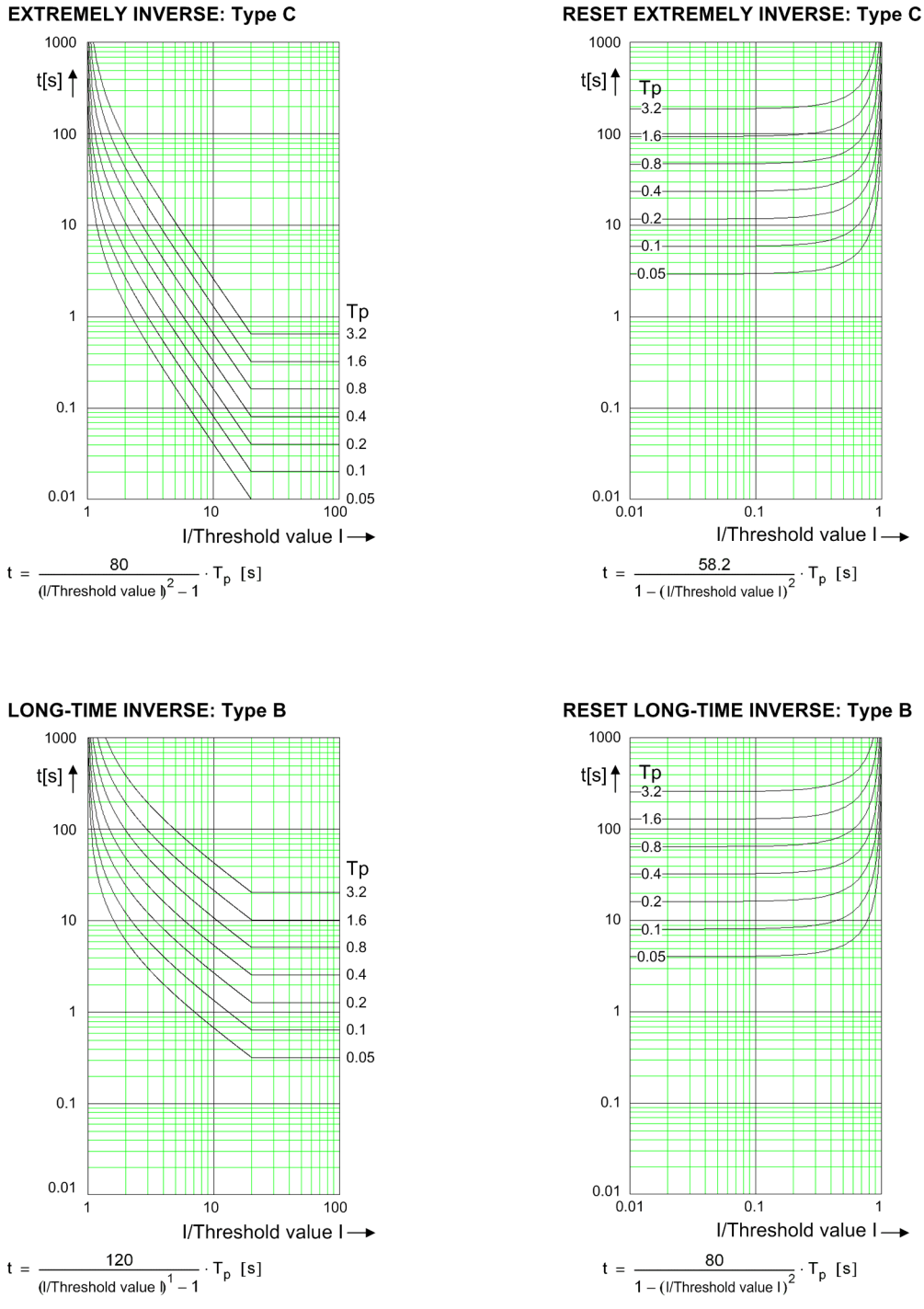
RESET VERY INVERSE: Type B



$$t = \frac{43.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

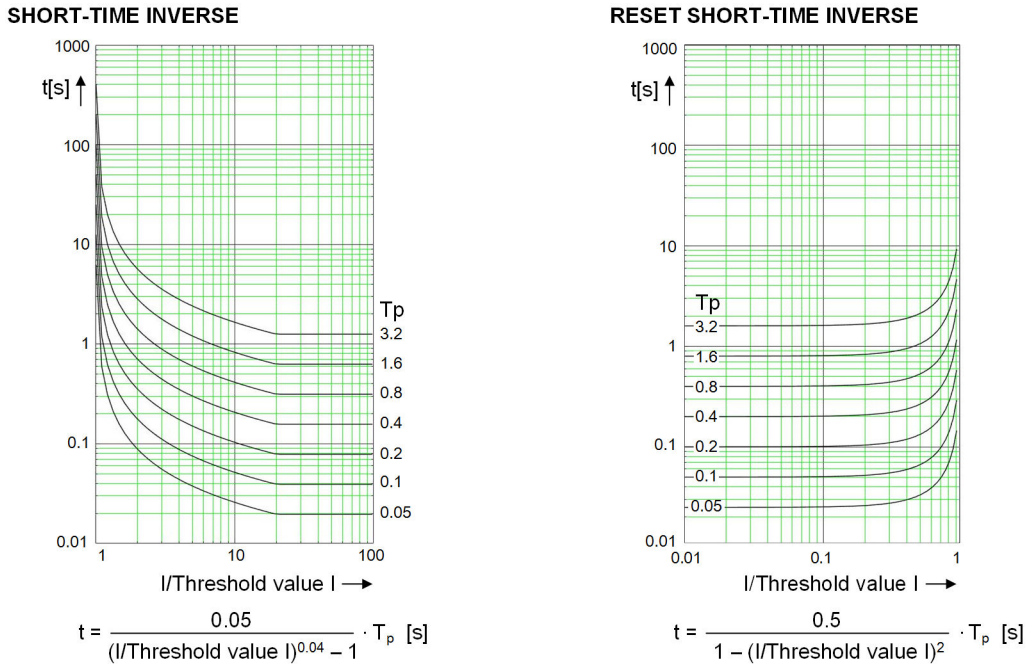
[dw_ocp_ki1, 1, en_US]

Figure 13-1 Operate Curves and Dropout-Time Characteristic Curves According to IEC



[dw_ocp_ki2, 1, en_US]

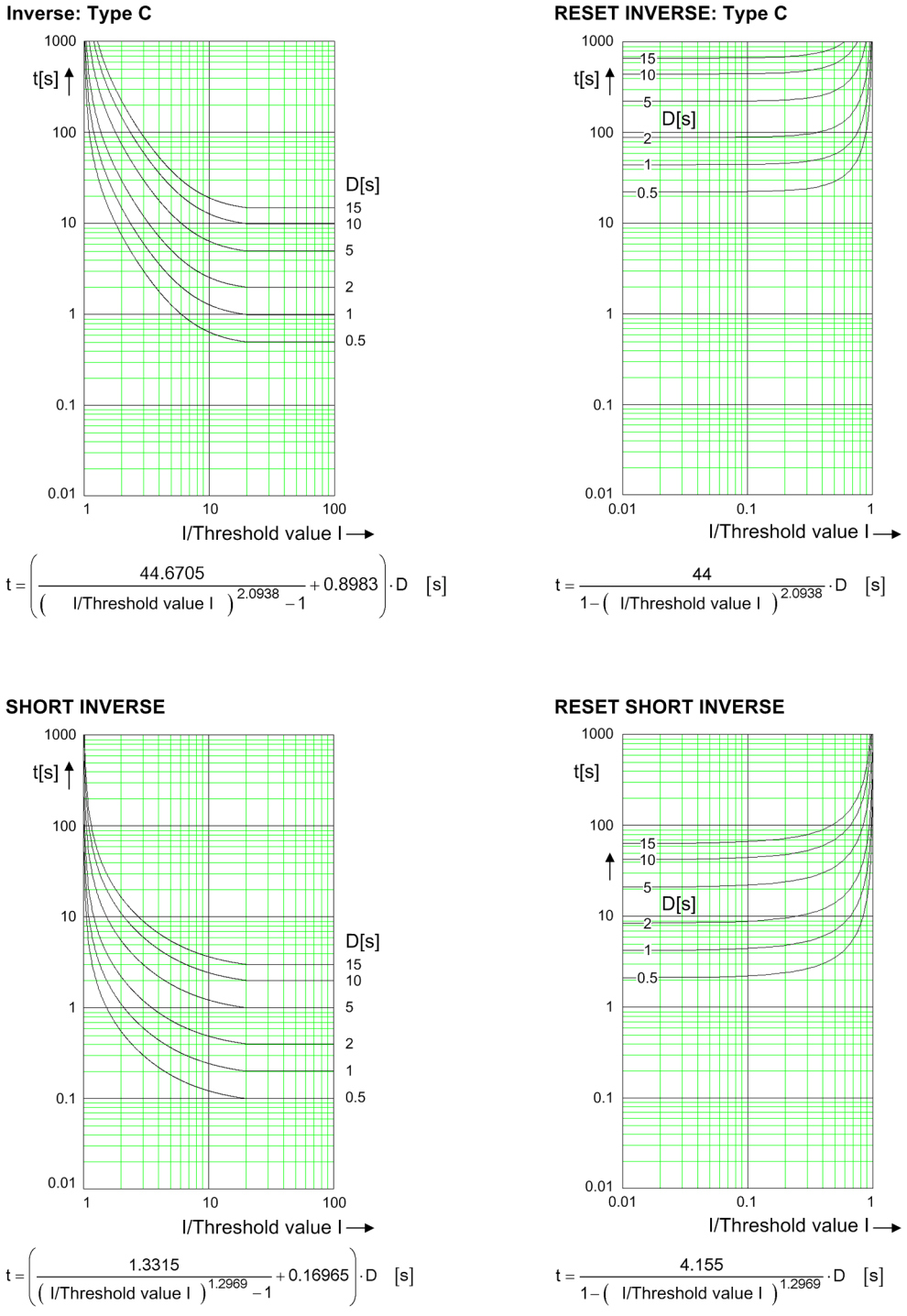
Figure 13-2 Operate Curves and Dropout-Time Characteristic Curves According to IEC



[dw_iec-short-inverse, 1, en_US]

Figure 13-3 Operate Curves and Dropout-Time Characteristic Curves According to IEC (Advanced Stage)

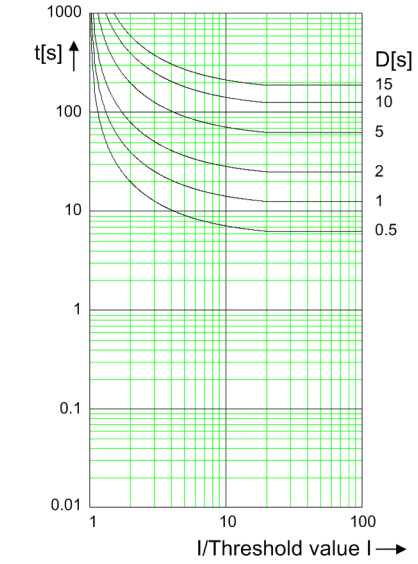
Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



[dw_ocp_ka1, 2, en_US]

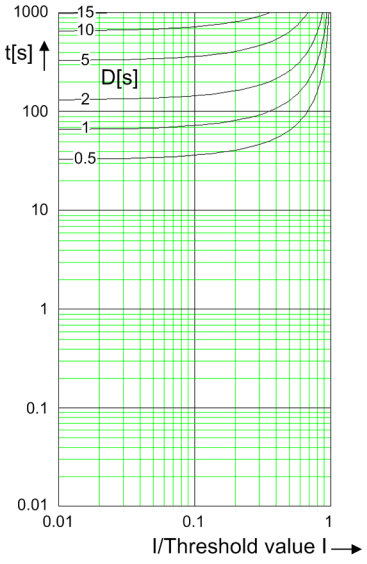
Figure 13-4 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

LONG INVERSE



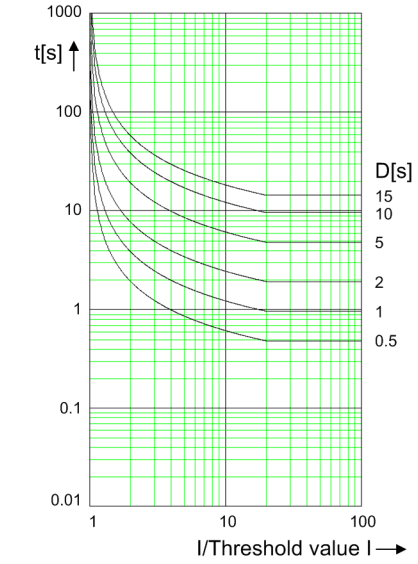
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



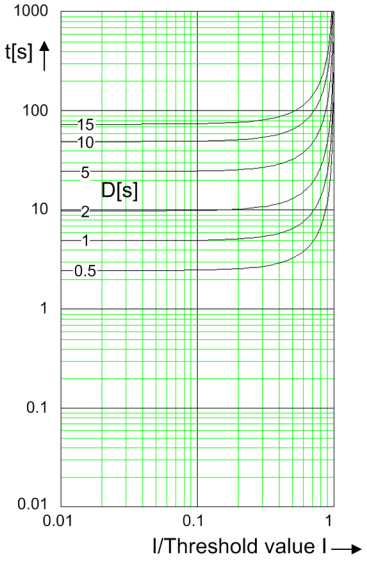
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

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

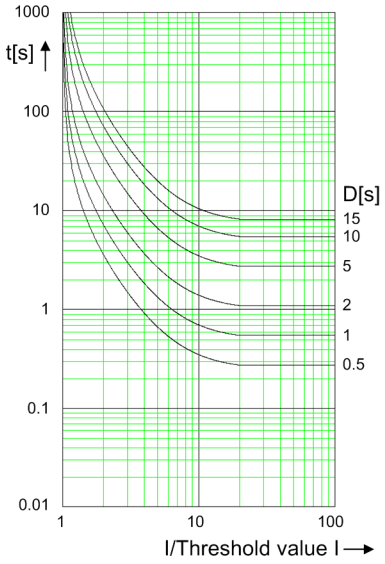


$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

[dw_ocp_ka2, 2, en_US]

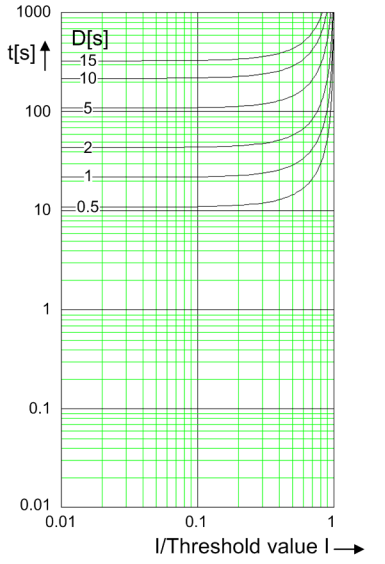
Figure 13-5 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

VERY INVERSE



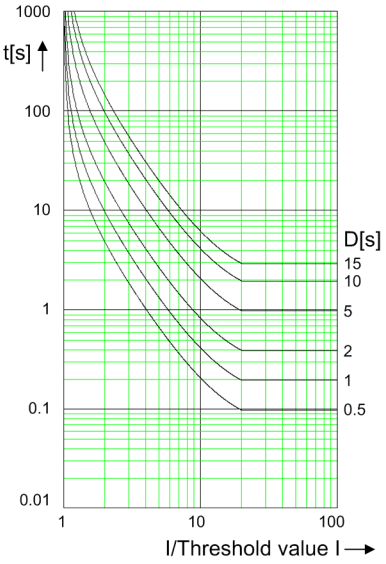
$$t = \left(\frac{19.61}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.491 \right) \cdot D \quad [s]$$

RESET VERY INVERSE



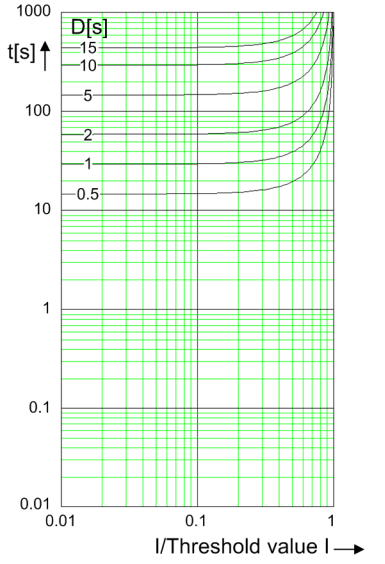
$$t = \frac{21.6}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

EXTREMELY INVERSE



$$t = \left(\frac{28.2}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.1217 \right) \cdot D \quad [s]$$

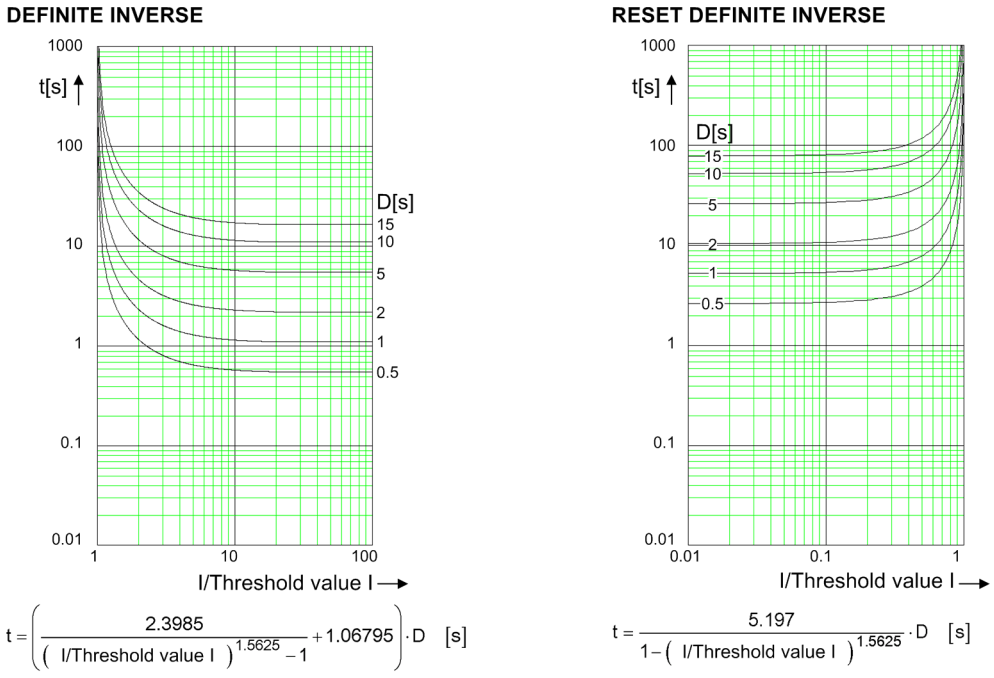
RESET EXTREMELY INVERSE



$$t = \frac{29.1}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

[dw_ocp_ka3, 2, en_US]

Figure 13-6 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dw_ocp_ka4, 2, en_US]

Figure 13-7 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

NOTE

In the preceding operate curves according to IEC and ANSI/IEEE, the inverse-time delays for **I/Threshold value I** > 20 are identical to the inverse-time delay for **I/Threshold value I** = 20.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	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)
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)
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)
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)

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)
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)
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)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[76] (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) [77]
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) [78]
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) [78]
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 Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

13.13.3 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

76 In case that the filter response exactly matches the user-defined gain factors

77 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

78 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

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
Absolute pickup value	1 A @ 50 and 100 Irated	0.000 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 175.00 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
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 20.00 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
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 or 95 % of the absolute pickup 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
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	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)
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)
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)
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)
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)
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)
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)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[79] (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) [80]
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) [81]
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) [82]
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 Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

79 In case that the filter response exactly matches the user-defined gain factors

80 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

81 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

82 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

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

13.14 Overcurrent Protection, Ground

13.14.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[83]	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 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	0.002 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	5 mA sec. (I_{rated} = 1 A) or 25 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[84] 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
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

83 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

84 OOT (Output Operating Time): additional delay of the output medium used, see *13.1.4 Relay outputs*

Tolerances

3I0 measured via I4[85], method of measurement = fundamental component		1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
3I0 measured via I4[86], 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)
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)
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)
Pickup delay		1 % of the setting value or 10 ms
Dropout delay		1 % of the setting value or 10 ms
Operate delay for the basic stage		1 % of the setting value or 10 ms
Operate delay for the advanced stage	Operate delay mode = Running dur. DO-delay	1 % of the setting value or 10 ms
	Operate delay mode = Frozen dur. DO-delay	1 % of the reference value or 10 ms (Reference value = Setting value + Frozen time)

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

13.14.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[87]	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 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	0.002 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:

85 Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

86 Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

87 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	5 mA sec. (I_{rated} = 1 A) or 25 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 *Figure 13-1* in chapter *13.13.2 Stage with Inverse-Time Characteristic Curve*
Very inverse: type B	
Extremely inverse: type C	See *Figure 13-2* in chapter *13.13.2 Stage with Inverse-Time Characteristic Curve*
Long-time inverse: type B	
Short-time inverse (Only in the advanced stage)	See *Figure 13-3* in chapter *13.13.2 Stage with Inverse-Time Characteristic Curve*

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See *Figure 13-4* in chapter *13.13.2 Stage with Inverse-Time Characteristic Curve*
Short inverse	
Long inverse	See *Figure 13-5* in chapter *13.13.2 Stage with Inverse-Time Characteristic Curve*
Moderately inverse	
Very inverse	See *Figure 13-6* in chapter *13.13.2 Stage with Inverse-Time Characteristic Curve*
Extremely inverse	
Definite inverse	See *Figure 13-7* in chapter *13.13.2 Stage with Inverse-Time Characteristic Curve*

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

3I0 measured via I4[88], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
3I0 measured via I4[89], 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)

88 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

89 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

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)
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)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
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 Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

13.14.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 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	0.002 A to 8.000 A	Increments of 0.001 A
Absolute pickup value	1 A @ 50 and 100 Irated	0.000 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 175.00 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
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 20.00 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
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 or 95 % of the absolute pickup value
Minimum absolute dropout differential	
Protection-class current transformer	5 mA sec. (I_{rated} = 1 A) or 25 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
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

3I0 measured via I4[90], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
3I0 measured via I4[91], 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)
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)
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)
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 Threshold Values

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

90 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

91 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

13.15 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[92]

Tolerance

Sequence tolerance for time delays	1 % of the setting value or 10 ms

92 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see Chapter *13.1.4 Relay outputs*

13.16 External Trip Initiation with Current-Flow Criterion

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[93].

Tolerance

Processing tolerance for time delays			1 % of the setting value or 10 ms
Threshold I>	Protection-class current transformers	At I_{rated} = 1 A	1 % of the setting value or 5 mA
		At I_{rated} = 5 A	1 % of the setting value or 25 mA
	Sensitive current transformer	At I_{rated} = 1 A	1 % of the setting value or 0.1 mA
		At I_{rated} = 5 A	1 % of the setting value or 0.5 mA

93 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter *13.1.4 Relay outputs*

13.17 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[94]

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Response tolerance, current	5 % of the setting value or 10 mA at I_{rated} = 1 A 5 % of the setting value or 50 mA at I_{rated} = 5 A
Time delays	1 % of the setting value or 10 ms

94 OOT (Output Operating Time) Additional delay of the output medium used, see *13.1.4 Relay outputs*

13.18 Vector-Jump Protection

Setting Values

Threshold V1 min	0.300 V to 175.000 V	Increments of 0.001 V
Threshold V1 max	0.300 V to 175.000 V	Increments of 0.001 V
Threshold Δφ	2.0° to 30.0°	Increments of 0.1°
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
T Reset	0.00 s to 60.00 s	Increments of 0.01 s
T Block	0.00 s to 60.00 s	Increments of 0.01 s
I< Threshold	0.030 A to 35.000 A at 1 A 0.150 A to 175.000 A at 5 A	Increments of 0.001 A

Times

Pickup times	Approx. 80 ms + OOT[95] at 50 Hz Approx. 66.8 ms + OOT at 60 Hz
Dropout times	Approx. 80 ms + OOT at 50 Hz Approx. 66.8 ms + OOT at 60 Hz

Frequency Operating Range

f_{rated} - 3 Hz ≤ f or f_{rated} ≤ f_{rated} + 3 Hz	According to specified tolerances
f < f_{rated} - 3 Hz or f > f_{rated} + 3 Hz	Inactive

Tolerances

Angle jump	0.5° at V > 0.5 V_{rated}
Voltage blocking	1 % of the setting value or 0.500 V
Undercurrent release	For I_{rated} = 1 A: 1 % of the setting value or 10 mA For I_{rated} = 5 A: 1 % of the setting value or 50 mA
Time delay T	1 % or 10 ms

95 OOT (Output Operating Time): additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

13.19 Overfrequency Protection

Setting Values

Pickup values f>	Angle difference method	
	40.00 Hz to 90.00 Hz	Increments of 0.01 Hz
	Filtering method	
	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[96] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 79 ms + OOT Approx. 65 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 parameter `Dropout ratio` If this parameter is not present, a dropout ratio of 99.97 % applies to the overfrequency protection.	
Minimum absolute dropout differential	5 mHz

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 90 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

96 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *13.1.4 Relay outputs*

13.20 Underfrequency Protection

Setting Values

Pickup values f<	30.00 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[97] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 75 ms + OOT Approx. 64 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 parameter `Dropout ratio` If this parameter is not present, a dropout ratio of 100.03 % applies to the underfrequency protection.	
Minimum absolute dropout differential	5 mHz

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 90 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

97 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *13.1.4 Relay outputs*

13.21 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 value	0.100 Hz/s to 20.000 Hz/s	Increments of 0.025 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

Frequency	Parameterizable dropout differential
Minimum voltage	
The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:	
Dropout differential derived from `Dropout ratio`	105 % for the **Minimum voltage** parameter
Minimum absolute dropout differential	150 mV secondary

Times

Pickup time	Approx. 160 ms + OOT[98] to 220 ms + OOT (depends on measuring window length) at 50 Hz Approx. 140 ms + OOT to 200 ms + OOT (depends on measuring window length) at 60 Hz
Dropout time	Approx. 160 ms + OOT to 220 ms + OOT (depends on measuring window length) at 50 Hz Approx. 140 ms + OOT to 200 ms + OOT (depends on measuring window length) at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Threshold, measuring window > 3 periods	Approx. 3 % or 0.060 Hz/s
Threshold, measuring window ≤ 3 periods	Approx. 5 % or 0.060 Hz/s

98 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *13.1.4 Relay outputs*

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

13.22 Power Protection (P,Q), 3-Phase

Setting Values

Measured value	Positive sequence power Power of phase A Power of phase B Power of phase C	
Threshold	-200.0 % to -1.0 % 1.0 % 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

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio`	
Minimum absolute dropout differential	0.5 % S_{rated}

Times

Pickup times	Approx. 55 ms + OOT[99] 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} or ±2 % of the 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 $0.8 \le V_{aux.}/V_{aux.,rated} \le 1.15$	≤ 1 %
Frequency in the range $0.95 \le f/f_{rated} \le 1.05$	≤ 1 %
Harmonics - Up to 10 % of 3rd harmonics - Up to 10 % of 5th harmonics	≤ 1 % ≤ 1 %

99 OOT (Output Operating Time): additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz < f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f$	Slightly expanded tolerances
$f \leq 10\ Hz$	Inactive

13.23 Power-Plant Disconnection Protection

Setting Values

Threshold P1>		50.00 % to 100.00 %	Increments of 0.01 %
Threshold P1<		0.00 % to 60.00 %	Increments of 0.01 %
Threshold Vph-ph<		0.300 V to 175.000 V	Increments of 0.001 V
Threshold I>	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
Threshold dP1<		-100.00 % to -30.00 %	Increments of 0.01 %
Dropout 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
Operate curve		2 to 5	Increments of 1

Functional Measured Values

Functional measured values are available to you so that you can better evaluate the behavior of the function. You can collect these functional measured values in a fault record for example.

Measured Value	Description
P1(t)	Positive-sequence system active power, which is evaluated by the function. The measured value is calculated every 1/4 cycle.
dP1(t)	Continuous representation of the active-power change, starting from the trigger time. With this, you can evaluate the change of the active-power difference at the prefault instant (t_{prior}).
dP1(t)max	This measured value flows into the characteristic curve. It represents the maximum active power during the duration of the fault.

Times

Pickup times	
Characteristic curve = no	Approx. 28 ms + OOT[100] at 50 Hz Approx. 25 ms + OOT at 60 Hz
Characteristic curve = yes	Approx. 26 ms + OOT at 50 Hz Approx. 24 ms + OOT at 60 Hz
Dropout times	
Characteristic curve = no	Approx. 18 ms + OOT at 50 Hz Approx. 19 ms + OOT at 60 Hz
Characteristic curve = yes	Approx. 22 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

Tolerance

I>	1 % of the dropout value or 0.005 I_{rated}
P1>	0.5 % S_{rated} or ±3 % of the setting value when Q < 0.5 S_{rated}

100 OOT (Output Operating Time): additional delay of the output medium used

Vph-ph<	0.5 % of the dropout value or 0.05 V
dP1<	0.5 % S_{rated} or ±3 % of the setting value when Q < 0.5 S_{rated}
P1<	0.5 % S_{rated} or ±3 % of the setting value when Q < 0.5 S_{rated}

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 90 Hz	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Inactive

13.24 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	3-pole tripping internal or external[101]

Dropout

The greater dropout differential (= **| pickup threshold – dropout threshold |**) 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 to the current threshold values.	
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)

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3-pole CB tripping	One 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).

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[102]	< 5 ms

NOTE

Using the setting ***`Direct release`*** with the parameters **`3I0 criterion`** or **`I2 criterion`** can result in extended dropout times.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

101 Via binary inputs

102 The use of the transformer connection types **2ph, 2p. CT + IN-sep** result in slightly expanded tolerances

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

13.25 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
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	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

13.26 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

13.27 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).

13.28 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 and100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and100 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 and100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and100 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 parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies to the current threshold value and a dropout ratio of 105 % applies to the voltage threshold value.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 10 ms + OOT[103] 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[104] at 50 Hz Approx. 9 ms + OOT at 60 Hz

Use in other function group types	
Pickup time	Approx. 20 ms + OOT[105] at 50 Hz Approx. 18 ms + OOT at 60 Hz

103 OOT (Output Operating Time) Additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

104 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *13.1.4 Relay outputs*

105 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *13.1.4 Relay outputs*

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), ($f_{rated} \pm 10$ %)
Voltages	0.5 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

13.29 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

13.30 Voltage-Balance Supervision

Setting Values

Release threshold	0.300 V to 170.000 V	Increments of 0.001 V
Threshold min/max	0.58 to 0.95	Increments of 0.01
Delay failure indication	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

13.31 Voltage-Sum Supervision

Setting Values

Threshold	0.300 V to 170.000 V	Increments of 0.001 V
Delay failure indication	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

13.32 Voltage 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

13.33 Voltage-Comparison Supervision

Times

Alarm times	Approx. 3 ms to 12 ms + OOT [106]at 50 Hz Approx. 2.5 ms to 10 ms + OOT at 60 Hz
Dropout time	20 ms

Frequency Operating Range

10 Hz ≤ f ≤ 90 Hz	According to specified tolerances
f < 10 Hz	Inactive
f > 90 Hz	

Tolerances

Pickup threshold	
Voltage	0.5 % of the setting value or 0.05 V

106 OOT (Output Operating Time): extra delay of the output medium used

13.34 Auxiliary Direct-Voltage Supervision

Setting Value for the FB Auxiliary Direct-Voltage Measurement

Measuring window	10 ms, 20 ms, 40 ms, 60 ms, 80 ms, 100 ms

Setting Values for the Stages

Threshold	10.0 V to 295.0 V	Increments of 0.1 V
Dropout ratio for the **Overvoltage** stage	0.90 to 0.99	Increments of 0.01
Dropout ratio for the **Undervoltage** stage	1.01 to 1.10	Increments of 0.01
Pickup delay Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

Dropout differential is derived from the parameter **`Dropout ratio`**.

Times

Pickup time	(1 to 2) · **`Measuring window`** + OOT[107] Example for **`Measuring window`** of 20 ms: Pickup time = 20 ms to 40 ms + OOT
Dropout time	(1 to 2) · **`Measuring window`** + OOT Example for **`Measuring window`** of 20 ms: Dropout time = 20 ms to 40 ms + OOT

Tolerances

Direct voltage	0.2 % of the setting value or 50 mV
Operate delay	1 % of the setting value or 10 ms

[107] OOT (Output Operating Time): additional delay of the output medium used, see chapter *13.1.4 Relay outputs*

13.35 Current-Balance Supervision

Setting Values

Release threshold	I_{rated}= 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	I_{rated}= 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Threshold min/max		0.10 to 0.95	Increments of 0.01
Delay failure indication		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overcurrent dropout ratio	Approx. 0.97
Undercurrent dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

13.36 Current-Sum Supervision

Setting Values

Slope factor		0.00 to 0.95	Increments of 0.01
Threshold	1 A @ 50 and100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and100 Irated	0.15 A to 50.00 A	Increments 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 failure indication		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

13.37 Current Phase-Rotation Supervision

Setting Values

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
Delay failure indication		0.00 s to 100.00 s	Increments of 0.01 s
Phase sequence		A B C A C B	

Dropout Ratio

Release-threshold dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

13.38 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

13.39 Closing-Circuit Supervision (General)

Setting Values

Operating mode per circuit	With 1 binary input With 2 binary inputs	
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 30.00 s	Increments of 0.01 s

13.40 Closing-Circuit Supervision for Paralleling

Setting Values

Number of monitored circuits per circuit-breaker paralleling function group	1 to 3	
Operating mode per circuit	With 2 binary inputs and 1 resistance With 3 binary inputs	
Pickup and dropout time	Approx. 1 s to 2 s	
Adjustable indication delay with 2 binary inputs and 1 resistance	1.00 s to 30.00 s	Increments of 0.01 s
Adjustable indication delay with 3 binary inputs	1.00 s to 30.00 s	Increments of 0.01 s

13.41 Arc Protection

Setting Values

Threshold I>	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 @ 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 @ 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 @ 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		no current light	
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 parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 90 % applies to the current threshold values.	
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 [108]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

108 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relay, see chapter *13.1.4 Relay outputs*

13.42 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[109]

Tolerance

Sequence tolerance for time delays	1 % of the setting value or 10 ms

109 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see Chapter *13.1.4 Relay outputs*

13.43 Inrush-Current Detection

Setting Values

Operating limit I_{max}	0.030 A to 35.000 A at I_{rated} = 1 A 0.15 A to 175.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A
Content 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

Operating times	Approx. 29 ms

Pickup

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	Setting value or at least
Protection-class current transformers	$I_{1st\ harm}$ = 10 mA sec. and $I_{2nd\ harm}$ = 10 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 50 mA sec. and $I_{2nd\ harm}$ = 50 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{1st\ harm}$ = 1 mA sec. and $I_{2nd\ harm}$ = 1 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 5 mA sec. and $I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 5 A)

Dropout

The greater dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overcurrent protection and a dropout ratio of 105 % applies for the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	5 mA sec. (I_{rated} = 1 A) or 25 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)
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	0.75
Protection-class current transformers	$I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 25 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{2nd\ harm}$ = 0.5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	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
Time delays	1 % of the setting value or 10 ms

13.44 2nd Harmonic Detection Ground

Setting Values

Measured value	IN measured 3I0 calculated	
2nd harmonic content	10 % to 45 %	Increments of 1 %

Times

Operating times	Approx. 29 ms

Pickup

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	Setting value or at least
Protection-class current transformer	$I_{1st\ harm}$ = 10 mA sec. and $I_{2nd\ harm}$ = 10 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 50 mA sec. and $I_{2nd\ harm}$ = 50 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{1st\ harm}$ = 1 mA sec. and $I_{2nd\ harm}$ = 1 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 5 mA sec. and $I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 5 A)

Dropout

The greater dropout differential (= **`| pickup threshold – dropout threshold |`**) 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 overcurrent protection and a dropout ratio of 105 % applies for the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	5 mA sec. (I_{rated} = 1 A) or 25 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)
Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	0.75 or
Protection-class current transformers	$I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 25 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{2nd\ harm}$ = 0.5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value for setting values $I_{2nd\ harm}/I_{1st\ harm}$

13.45 Operational Measured Values and Statistical Values

The following applies to the tolerances of the currents and voltages:

- The values apply both to the RMS values and the absolute value and phase angle of the fundamental components.
- These values were determined for pure sinusoidal signals – without harmonics.
- All measured values additionally have a tolerance of 1 DIGIT.

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 0.1 V_{rated} 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)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 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 0.1 V_{rated} 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)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
V_1, V_2, V_0 **Voltage range**	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC 0.1 V_{rated} 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	0.25 % of the measured value in the above mentioned measuring range or 0.05 V
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.35 % of the measured value in the above mentioned measuring range or 0.05 V

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 I_{rated} 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 or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}
I_1, I_2, I_0 **Current range**	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 I_{rated} 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	0.2 % of the measured value in the above mentioned measuring range or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.35 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}

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 I_{rated} to 5 I_{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 or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.35 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}
I_1, I_2, I_0 **Current range**	A secondary < 100 I_{rated}

Rated currents Measuring range Frequency range	1 A, 5 A 0.1 I_{rated} to 5 I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.25 % of the measured value in the above mentioned measuring range or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.4 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}

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 I_{rated} 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 or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}

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
Voltage range Current range Frequency range Power factor	0.8 V_{rated} to 1.2 V_{rated} 0.1 I_{rated} to 2 I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz $\lvert\cos\varphi\rvert \geq 0.707$
Tolerance	0.5 % of S_{rated} in the above mentioned measuring range
Reactive power Q	var secondary

Voltage range Current range Frequency range Power factor	0.8 V_{rated} to 1.2 V_{rated} 0.1 I_{rated} to 2 I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz $\lvert\cos\varphi\rvert \leq 0.707$
Tolerance	0.5 % of S_{rated} in the above mentioned measuring range
Apparent power S	VA secondary
Voltage range Current range Frequency range	0.8 V_{rated} to 1.2 V_{rated} 0.01 I_{rated} to 2 I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of S_{rated} in the above mentioned measuring range

Power Factor

Voltage range	0.8 V_{rated} to 1.2 V_{rated}
Current range	0.1 I_{rated} to 2 I_{rated}
Frequency range	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.02 in the above mentioned measuring range

Frequency

Frequency f	Hz
Range	f_{rated} ± 0.20 Hz
Tolerance	± 2 mHz at V = V_{rated} or at I = I_{rated}
Range	f_{rated} ± 3.00 Hz
Tolerance	± 5 mHz at V = V_{rated} or at I = I_{rated}
Range	25 Hz to 80 Hz; operational measured values 10 Hz to 90 Hz; functional measured values, system frequency
Tolerance	± 10 mHz at V = V_{rated} or at I = I_{rated}

Statistical Values of the Device

Device operating hours	h
Range	0 h to 9999999 h
Tolerance	1 h

Statistical Values, Circuit Breaker

Op.cnt. (operation counter)	
Range	0 to 999999999
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 h to 9999999 h
Tolerance	1 h
Circuit breaker open hours	h
Range	0 h to 9999999 h
Tolerance	1 h

Statistical Values, Disconnector

Op.cnt. (operation counter)	
Range	0 to 999999999
Tolerance	None

13.46 Circuit-Breaker Monitoring

Setting Values

Threshold value	ΣI^x-method	0 to 10 000 000	Increments of 1
	2P-method	0 to 10 000 000	Increments of 1
	I^2t-method	0.00 I/Ir*s to 21 400 000.00 I/Ir*s	Increments of 0.01
	Make time	1 % to 100 %	Increments of 1 %
	Break time	1 % to 100 %	Increments of 1 %
	Pole scatter time open	1 ms to 100 ms	Increments of 1 ms
	Pole scatter time close	1 ms to 100 ms	Increments of 1 ms
	Mechanical switching time open	1 ms to 1000 ms	Increments of 1 ms
	Mechanical switching time close	1 ms to 1000 ms	Increments of 1 ms
CB opening time		1 ms to 500 ms	Increments of 1 ms
CB break time		1 ms to 600 ms	Increments of 1 ms
CB make time		1 ms to 600 ms	Increments of 1 ms
Exponent for ΣI^x method		1.0 to 3.0	Increments of 0.1
Switching cycles at I_r		100 to 10 000 000	Increments of 1
Rated short-circuit current I_{sc}		10 A to 100 000 A	Increments of 1 A
Switching cycles at I_{sc}		1 to 1000	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 0.01 A
Delay correction time		-50 ms to 50 ms	Increments of 1 ms
Auxiliary-contact time		1 ms to 1000 ms	Increments of 1 ms
Response time		1 ms to 1000 ms	Increments of 1 ms

Tolerances

Tolerance of the measured value Make time	± 2 ms
Tolerance of the measured value Break time	± 2 ms
Tolerance of the measured value Pole scatter time	± 2 ms
Tolerance of the measured value Aux.-contact time	± 2 ms
Tolerance of the measured value response time	± 2 ms

13.47 Disconnector Supervision

Setting Values

Threshold value	Mechanical switching time open	0.02 s to 1800.00 s	Increments of 0.01 s
	Mechanical switching time close	0.02 s to 1800.00 s	Increments of 0.01 s
Auxiliary contact time		0.02 s to 1800.00 s	Increments of 0.01 s
Reaction time		0.02 s to 1800.00 s	Increments of 0.01 s

Tolerances

Tolerance of the make-time measured value	±2 ms
Tolerance of the break-time measured value	±2 ms
Tolerance of the reaction-time measured value	±2 ms

13.48 Power Quality – Basic

13.48.1 Voltage Variation

The function **Voltage variation** complies with Class S according to IEC 61000-4-30.

Setting Values

Threshold of the **Dip** stage	10.0 % to 100.0 %	Increments of 0.1 %
Threshold of the **Swell** stage	100.0 % to 140.0 %	Increments of 0.1 %
Threshold of the **Interruption** stage	1.0 % to 20.0 %	Increments of 0.1 %
Dropout differential	1.0 % to 10.0 %	Increments of 0.1 %
Warning delay	0.00 s to 60.00 s	Increments of 0.01 s

Tolerances

Threshold value	1 % of the parameter **`Rated voltage`** that is set in the function group Class S according to IEC 61000-4-30
Warning delay	1 % of the setting value or 10 ms
Dip, swell, or interruption duration	2 network cycles Class S according to IEC 61000-4-30 (For the stage **Interruption**, Class S is met when the threshold value of the stage **Interruption** is set to be equal to or greater than 3 %.)
Residual or swell voltage	1 % of the parameter **`Rated voltage`** that is set in the function group Class S according to IEC 61000-4-30

Frequency Operating Range

$0.85\ f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
$10\ Hz \le f < 0.85\ f_{rated}$ $1.15\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

13.48.2 Voltage Unbalance

The function **Voltage Unbalance** complies with Class S according to IEC 61000-4-30.

Setting Value for the Function

Value	Setting Range	Increment
Minimum voltage V1	0.300 V to 60.000 V	0.001 V

Setting Values for the Stages

Value	Setting Range	Increment
Threshold	0.50 % to 10.00 %	0.01 %
Dropout ratio	0.90 to 0.99	0.01
Observation period	• daily • weekly	–

Value	Setting Range	Increment
Starting day of week	• Sunday • Monday • Tuesday • Wednesday • Thursday • Friday • Saturday	–
Percentile	80 % to 99 %	1 %

Tolerance

For all functional values in the measuring interval of 3 s or 10 min	
V2/V1, V0/V1	±0.15 % Class S according to IEC 61000-4-30

Dropout Ratio

Dropout ratio of warning	5 % of the setting value or 0.25

Frequency Operating Range

$0.85\ f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
$10\ Hz \le f < 0.85\ f_{rated}$ $1.15\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

13.48.3 THD and Harmonics

Setting Value for the Stage Voltage

Value	Setting Range	Increment
Threshold	1.0 % to 25.0 %	0.1
Aggregation interval	• 1 min • 10 min	–

Stage Current

Current range (Ia, Ib, Ic)	Sensitive transformer: $0.01\ I_{rated}$ to $1.6\ I_{rated}$ Protection transformer: $0.01\ I_{rated}$ to $2\ I_{rated}$	
Tolerance THD value	$I_{fund.} \ge 0.1\ I_{rated}$	0.5 % in the measured range
	$0.01\ I_{rated} \le I_{fund.} < 0.1\ I_{rated}$	2.0 % in the measured range
Tolerance harmonic value (2nd to 20th)	$I_{fund.} \ge 0.1\ I_{rated}$	0.5 % in the measured range
	$0.01\ I_{rated} \le I_{fund.} < 0.1\ I_{rated}$	2.0 % in the measured range

Stage Voltage

Voltage range (Va, Vb, Vc)	0.1 V_{rated} to 2 V_{rated}
Tolerance THD value	0.5 % in the measured range
Tolerance harmonic value (2nd to 20th)	0.5 % in the measured range

Frequency Operating Range

$0.85\ f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
$0.8\ f_{rated} \le f < 0.85\ f_{rated}$ $1.15\ f_{rated} < f \le 1.2\ f_{rated}$	Slightly expanded tolerances
$f < 0.8\ f_{rated}$ $f > 1.2\ f_{rated}$	Inactive

13.48.4 Total Demand Distortion

Setting Value for the Stage Voltage

Value	Setting Range	Increment
Threshold	1.0 % to 25.0 %	0.1
Interval	• 15 min • 30 min	–

Stage Current

Current range (Ia, Ib, Ic)	Sensitive transformer: 0.01 I_{rated} to 1.6 I_{rated} Protection transformer: 0.01 I_{rated} to 2 I_{rated}	
Tolerance of the TDD value	$I_{fund.} \ge 0.1\ I_{rated}$	0.5 % in the measured range
	$0.01\ I_{rated} \le I_{fund.} < 0.1\ I_{rated}$	2.0 % in the measured range

Frequency Operating Range

$0.85\ f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
$0.8\ f_{rated} \le f < 0.85\ f_{rated}$ $1.15\ f_{rated} < f \le 1.2\ f_{rated}$	Slightly expanded tolerances
$f < 0.8\ f_{rated}$ $f > 1.2\ f_{rated}$	Inactive

13.49 Energy Values

Active energy W_p	kWh, MWh, GWh
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 energy W_q	kvarh, Mvarh, Gvarh
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

Pulse metered values	
Maximum detection speed	50/s

13.50 Phasor Measurement Unit

Accuracy

IEEE Standard for Synchrophasor Measurements
IEEE Std C37.118.1a™-2014

Data Transfer

IEEE Standard for Synchrophasor Data transfer
IEEE Std C37.118.2™-2011

13.51 CFC

Typical response times and maximum number of ticks of the CFC task levels:

Task Level	Time (in ms)	Max. Number of Ticks CP300
High priority Event-triggered	<1	1000
Event-triggered	<5	12 594
Low priority Event-triggered	<5	119 716 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 **Unit connection extended**.

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 the High priority Event-triggered level
104 Ticks in the Event-triggered level
54 Ticks in Measurement level
74 Ticks in the Low priority Event-triggered level

T_{int} Number of internal connections between 2 CFC blocks in one chart

T_{Block} Used ticks per CFC block (see *Table 13-5*)

Table 13-5 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
BSC_DEF	1.3
BSC_EXE	1.1

Element	Ticks
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
ENC_DEF	3.6
ENC_EXE	3.8
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
NL_LZ	3.8
NL_MV	5.6
NL_ZP	2.7
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
TP	2.5
TSHORT	1.9
UINT_DINT	3.0
XOR2	2.6

A Appendix

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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:

- 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 terminal (power supply) Terminal block, 2-pole[110]
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	Terminals for IO110, IO112, IO113[110]
Terminal	Terminals and shielding for IO111[110],[111],[112]
Terminal	Terminal set only for IO23x[110]
Terminal	2-pole cross connector for voltage terminal
Terminal	Cover for current terminal block
Terminal	Cover for voltage terminal block
Terminal	Transport safety, current terminal
Terminal	Transport safety, voltage terminal
Terminal	Terminal set for direct connection to 400 V low voltage
Accessories	USB covers (10 each for CP 100, 150, 200, 300)
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	Cover panel 1/6, 5 pcs
Accessories	Set of angle rails
Accessories	10 x labeling strip, LEDs/function keys
Accessories	5 x labeling strips, push-buttons
Accessories	Set of parts, mounting bracket 1/2
Accessories	Set of parts, mounting bracket 2/3

110 Recommended tightening torque when screwing down the terminal on the rear plate: 0.3 Nm

111 The set consists of terminals and shielding for the IO111 for the terminal positions M and N.

112 Only for non-modular devices 7xx82

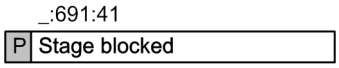
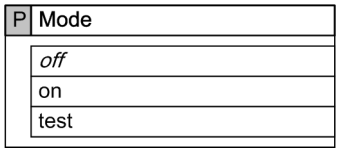
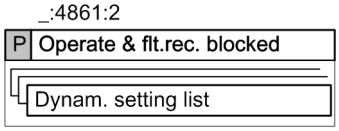
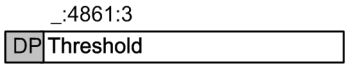
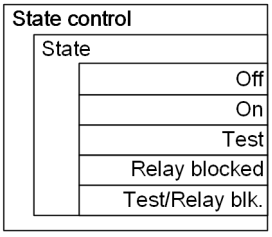
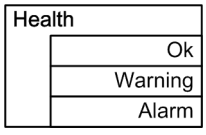
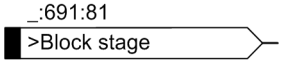
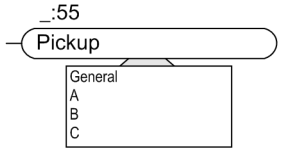
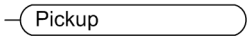
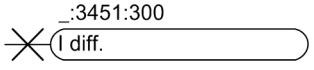
Group	Accessories
Accessories	Set of parts, mounting bracket 5/6
Accessories	Set of parts, mounting bracket 1/1
Accessories	4 x screw cover 1/3, type C11
Accessories	4 x screw cover 1/3, type C22
Accessories	4 x screw cover 1/6, type C21
Accessories	2 x bus termination plate
Accessories	Assembly frame for panel surface mounting for non-modular devices 7xx81 and 7xx82 devices
Accessories	SDHC memory card for 7KE85
Accessories	10 x battery holder
Accessories	Connecting cable for 2nd row
Accessories	DIGSI 5 USB cable 2.0
Accessories	SFP RJ45, 10 units
Accessories	SFP Single-mode, 24 km, 10 units
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 7 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, length 3 m
Sensors for arc protection	Line sensor, length 10 m
Sensors for arc protection	Line sensor, length 20 m
Sensors for arc protection	Line sensor, length 30 m
Sensors for arc protection	Line sensor, length 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

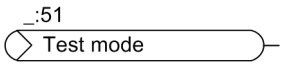
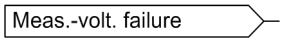
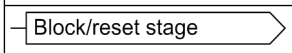
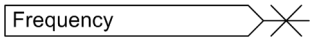
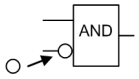
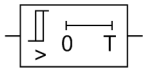
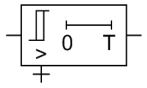
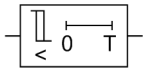
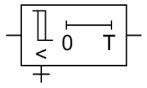
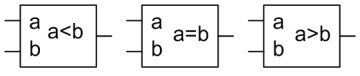
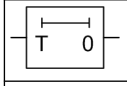
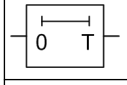
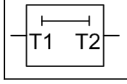
A.3 Typographic and Symbol Conventions

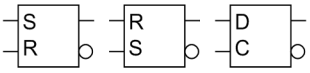
The following typefaces are used to characterize parameters in the text:

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
off	Parameter state

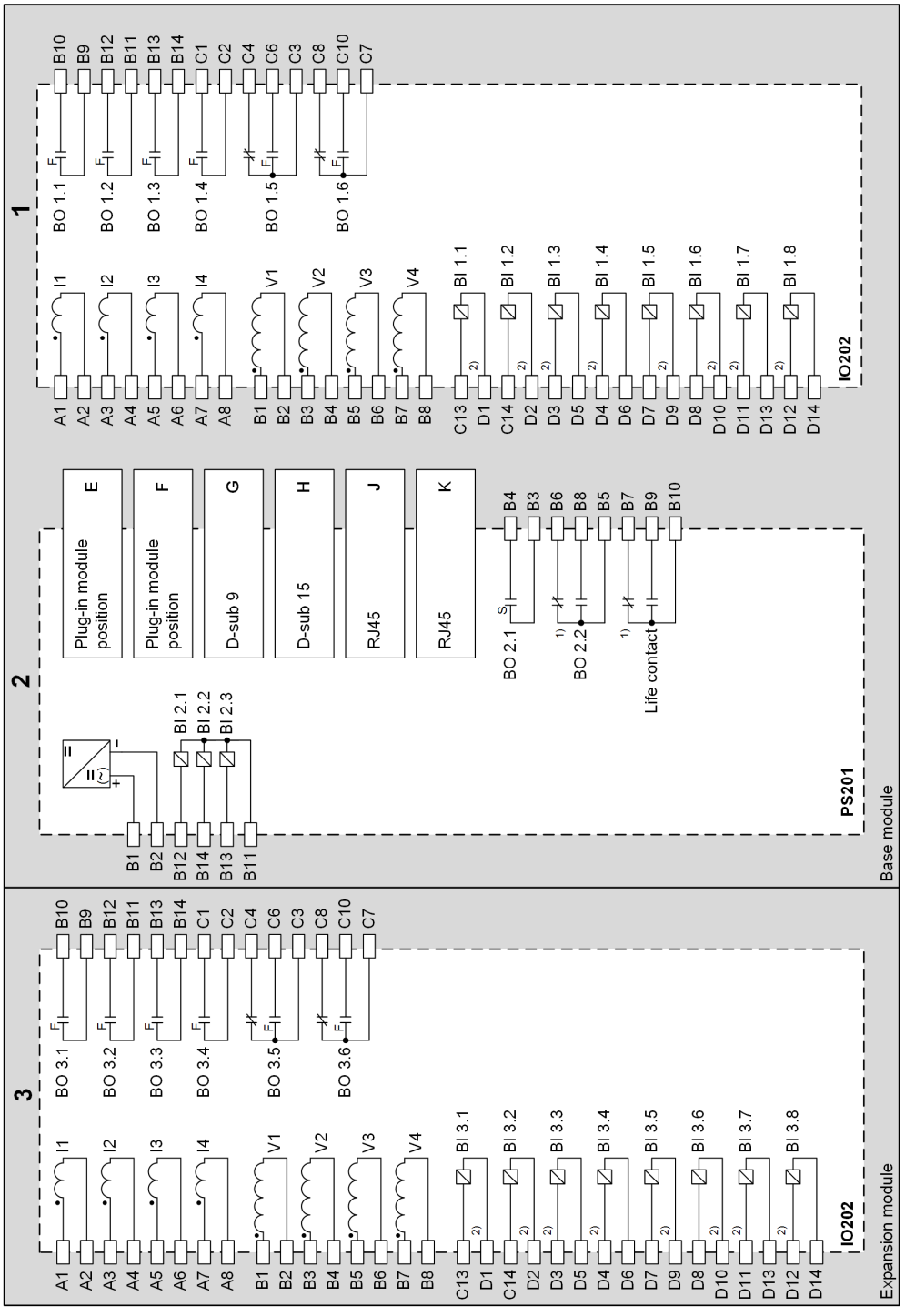
The following symbols are used in drawings:

Icon	Description
	Parameter
	Parameters with setting values The default setting is in the 1st position and is 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

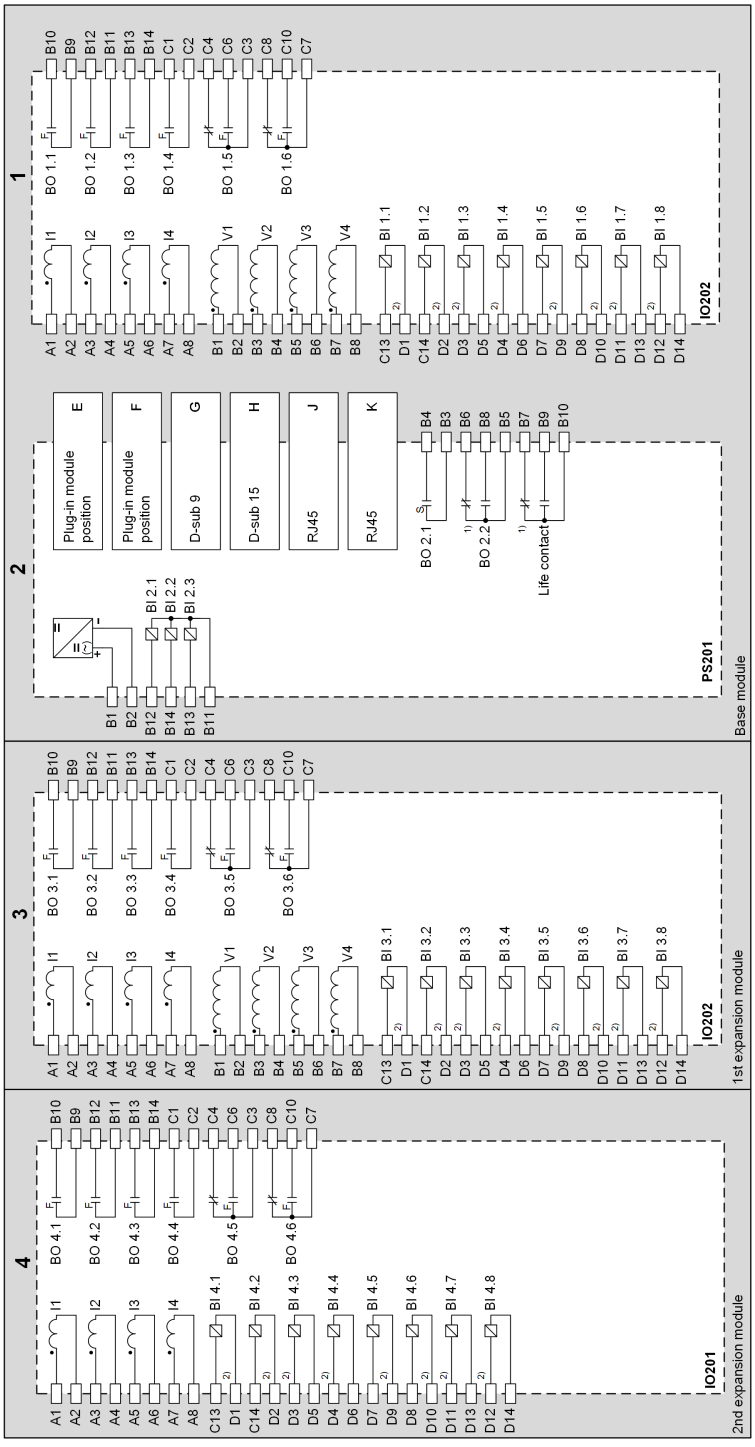
A.4 Standard Variants for 7VU85



[dw_standard_variant_7VU85_1, 1, en_US]

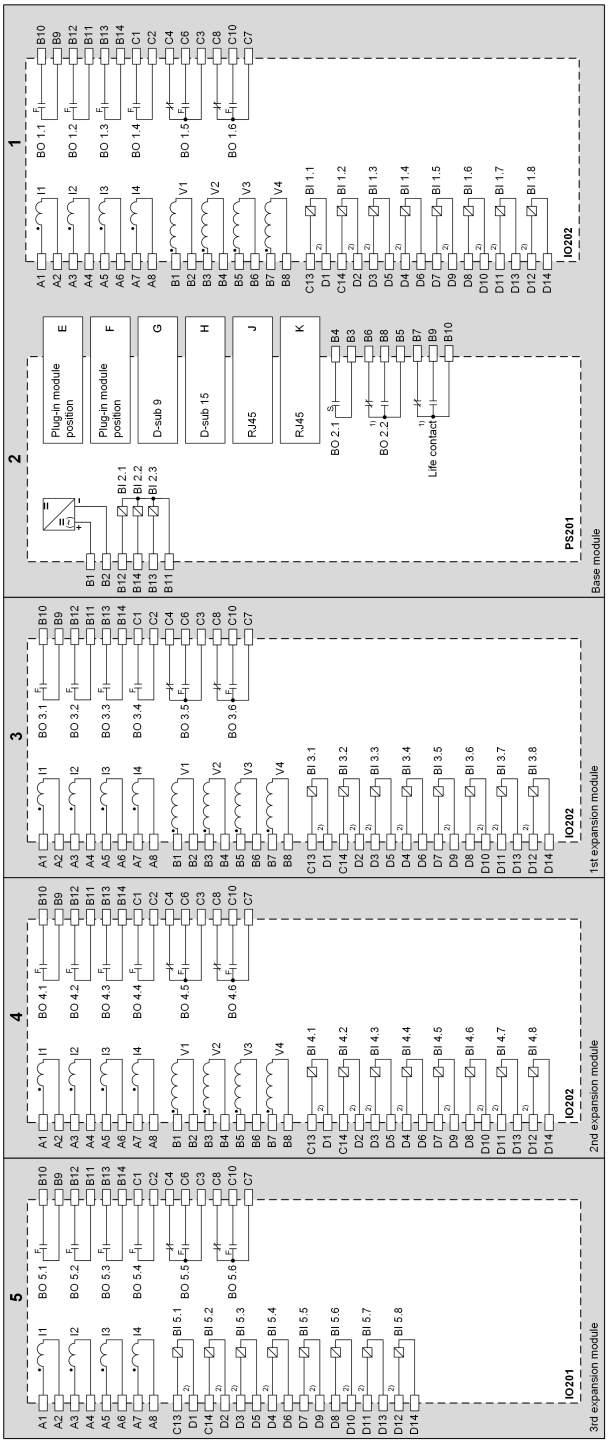
Figure A-1 Standard Variant Type AV1

[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



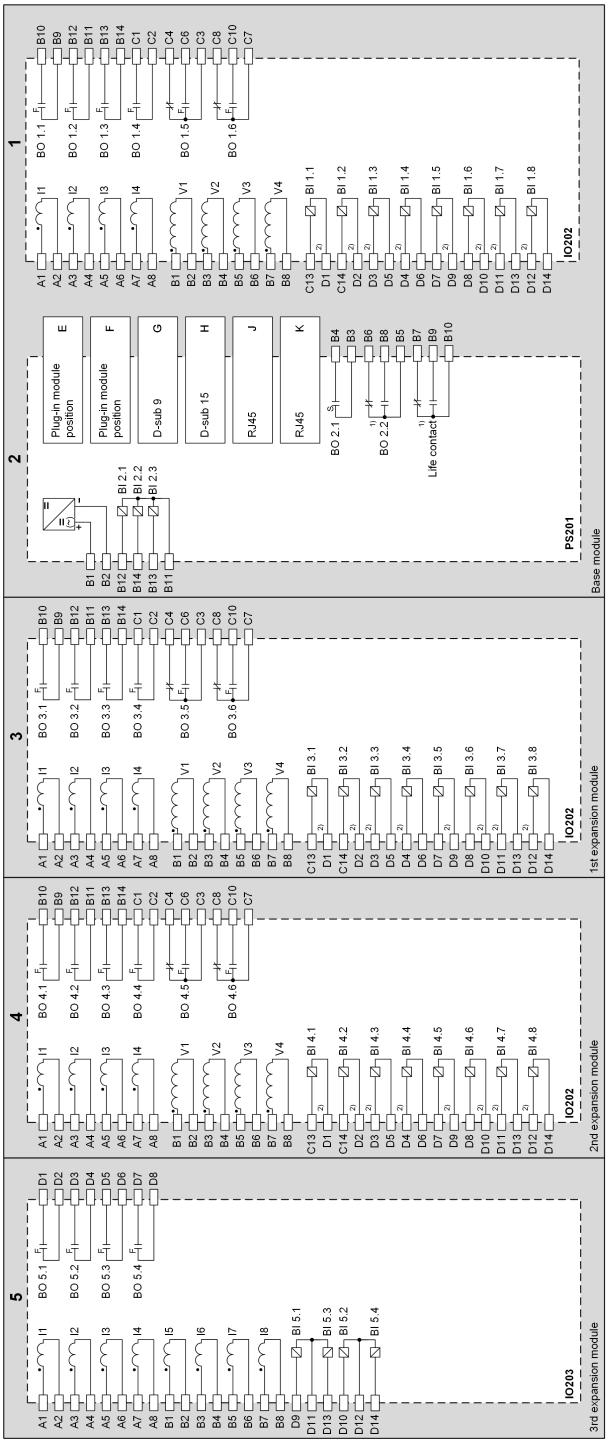
[dw_standard_variant_7VU85_2, 1, en_US]

Figure A-2 Standard Variant Type AV2



[dw_standard_variant_7VU85_3, 1, en_US]

Figure A-3 Standard Variant Type AV3



[dw_standard_variant_7VU85_4, 1, en_US]

Figure A-4 Standard Variant Type AV4

A.5 Requirements for Current Transformers

The protection functions require current transformers that are dimensioned properly. This section describes the characteristics required for the dimensioning of the current transformer. The specified rules pertaining to dimensioning apply the definition of a protection current transformer from IEC 61869-2 (previously IEC 60044-1 and IEC 60044-6) as well as IEC TR 61869-100. Dimensioning according to ANSI C57.13 is also described.

Current Transformers

Parameter	Description
ALF	Accuracy limit factor
ALF'	Operational accuracy limit factor
	The operational accuracy limit factor is derived from the connected burden R_{bc}: $$ALF' \approx ALF \cdot \frac{R_{ct} + R_b}{R_{ct} + R_{bc}}$$
R_{ct}	Secondary winding resistance; corrected to 75 °C or another temperature as per the specification
R_b	Rated resistive burden
R_{bc}	Connected resistive operating burden
S_r	Rated power
K_{SSC}	Rated symmetrical short-circuit current factor $$K_{SSC} = \frac{I_{psc}}{I_{pr}}$$
I_{psc}	Rated primary short-circuit current
I_{pr}	Rated primary current
I_{sr}	Rated secondary current
K_{td}	Transient dimensioning factor
E_k	Rated knee-point EMF
V_{tc}	Current terminal voltage with 20-fold rated current and connected burden R_{bc} (ANSI C57.13)

Protected Object

Parameter	Description
I_{SC}	Symmetrical short-circuit current
$I_{max.\ threshold}$	Maximum primary threshold value for a current stage

Definition of the Requirements for the Dimensioning of the Phase Current Transformer

The requirements for the phase current transformers predominantly arise from the high-current stage setting values for the overcurrent protection system, the high-current stage being the current stage with the max. threshold value. There are also minimum requirements that are derived from empirical values.

IEC Class	Minimum	Requirement
5P, 10P	ALF´ ≥ 20	$ALF' \geq \frac{I_{max,threshold}}{I_{pr}}$
5PR, 10PR	ALF´ ≥ 20	$ALF' \geq \frac{I_{max,threshold}}{I_{pr}}$

IEC Class	Minimum	Requirement
TPX, TPY, TPZ	20 (Burden $R_b \geq R_{bc}$)	$K_{td} \cdot K_{SSC} \geq \frac{I_{max,threshold}}{I_{pr}}$
PX, PXR	$E_k \geq 16 \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$E_k \geq 0{,}8 \cdot \frac{I_{max,threshold}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$
ANSI class C (I_{sr} = 5 A)	$20 \cdot I_{sr} \cdot R_{bc}$	$V_{tc} \geq \frac{I_{max,threshold}}{I_{pr}} \cdot I_{sr} \cdot R_{bc}$

Examples can be found in the sections:

- *Application of Current Transformers Class IEC 5P, 10P, Page 1283*
- *Application of Current Transformers Class IEC TPY , Page 1284*
- *Application of Current Transformers Class ANSI C, Page 1285*

Application of Current Transformers Class IEC 5P, 10P

For this example, a check is carried out to see whether an existing 10P10 current transformer meets the requirements. The high-current stage is used as a fast short-circuit protection system for a transformer.

Parameter	Value	Description
I_{pr}	50 A	Rated primary current of the current transformer
I_{sr}	1 A	Rated secondary current of the current transformer
S_r	5 VA	Rated power
ALF	10	Accuracy limit factor
R_{ct}	0.5 Ω	Secondary winding resistance at 75 °C
l_{Cable}	50 m	Length of the secondary current transformer supply lines
A_{Cable}	4 mm^2	Core cross section of the secondary current transformer supply lines
ρ_{Cu}	0.0213 Ω mm^2/m	Copper cable resistance at 75 °C (the value is 0.0175 Ω mm^2/m at 20 °C)
S_{Device}	0.1 VA	Protection device burden at the rated current

Calculation of the Connected Burden:
The burden R_{bc} that is connected to the terminals of the current transformer is derived from the double supply line resistance (supply and return line) and the device burden as indicated below.

$$R_{Cable} = \frac{2 \cdot \rho_{Cu} \cdot l_{Cable}}{A_{Cable}} = \frac{2 \cdot 0.0213 \frac{\Omega \cdot mm^2}{m} \cdot 50}{4\ mm^2} = 0.5325\ \Omega$$

$$R_{Device} = \frac{S_{Device}}{I_{sr}^2} = \frac{0.1\ VA}{(1\ A)^2} = 0.1\ \Omega$$

$$R_b = \frac{S_r}{I_{sr}^2} = \frac{5\ VA}{(1\ A)^2} = 5\ \Omega$$

$$R_{bc} = R_{Cable} + R_{Device} = 0.5325\ \Omega + 0.1\ \Omega \approx 0.633\ \Omega$$

$$ALF' \approx ALF \cdot \frac{R_{ct} + R_b}{R_{ct} + R_{ba}} = 10 \cdot \frac{0.5\ \Omega + 5\ \Omega}{0.5\ \Omega + 0.633\ \Omega} \approx 49$$

Estimation of the threshold value $I_{max.threshold}$ for a transformer with the following data:

Rated voltages	20 kV/0.4 kV
Rated apparent power	S_r = 1.4 MVA
Vector group	Dyn5
Short-circuit voltage	v_{sc} = 6 %

Rated current:

$$I_{r,20\,kV} = \frac{S_r}{\sqrt{3} \cdot V_{r,20kV}} = \frac{1.4\ MVA}{\sqrt{3} \cdot 20\ kV} = 40.41\ A$$

Symmetrical short-circuit current for a fault on the 0.4 kV side:

$$I_{sc} \approx \frac{I_{r,20\,kV}}{v_{sc}[\%]} \cdot 100\ \% = \frac{40.41\ A}{6\ \%} \cdot 100\ \% = 674\ A$$

Threshold value of the overcurrent-protection stage:

$$I_{max.threshold} = 1.4 \cdot I_{SC} = 1.4 \cdot 674\ A = 944\ A$$

Conditions:

Requirement:

$$ALF' \geq \frac{I_{max.threshold}}{I_{pr}} = \frac{944\ A}{50\ A} = 18.9 \text{ at least } 20$$

Comparison:	ALF´current transformer > ALF´requirement
Result:	49 > 20

The current transformer meets the requirement.

Application of Current Transformers Class IEC TPY

The current transformers are specified by K_{SSC}, K_{td}, and R_b. The current transformer above should be replaced by a current transformer class TPY with the following parameters:

K_{SSC} = 20

K_{td} = 1.5

R_b = 1 Ω

The requirements are compared with the data from the current transformer.

Rated symmetrical short-circuit current factor:

$$K_{SSC} = \frac{I_{psc}}{I_{pr}} = \frac{I_{max.threshold}}{I_{pr}} = \frac{944\ A}{50\ A} = 18.9$$

Required product:

$$K_{td} \cdot K_{SSC} \geq \frac{I_{max.\ threshold}}{I_{pr}} = \frac{944\ A}{50\ A} = 18.9 \text{ at least } 20$$

Current transformer:	$K_{td} \cdot K_{SSC} = 1.5 \cdot 20 = 30$
Result:	30 > 20

The required resistive dimensioning burden R_b of the current transformer must be greater than the connected resistive burden R_{bc} that was previously calculated.

Requirement:	$R_b > R_{bc}$
Result:	1 Ω > 0.663 Ω

The TPY class current transformer meets the requirements.

Application of Current Transformers Class ANSI C

This class is specified with a maximum secondary terminal voltage V_t. In this example, the current transformer uses the following parameters:

Class	C100
Transformer terminal voltage at a rated impedance of 1 Ω	$V_t = 100$ V
Rated secondary current:	$I_{sr} = 5$ A

The rated secondary current of $I_{sr} = 5$ A causes the connected burden to change.

$$R_{Device} = \frac{S_{Device}}{I_{sr}^2} = \frac{0.1\ VA}{(5\ A)^2} = 0.004\ \Omega$$

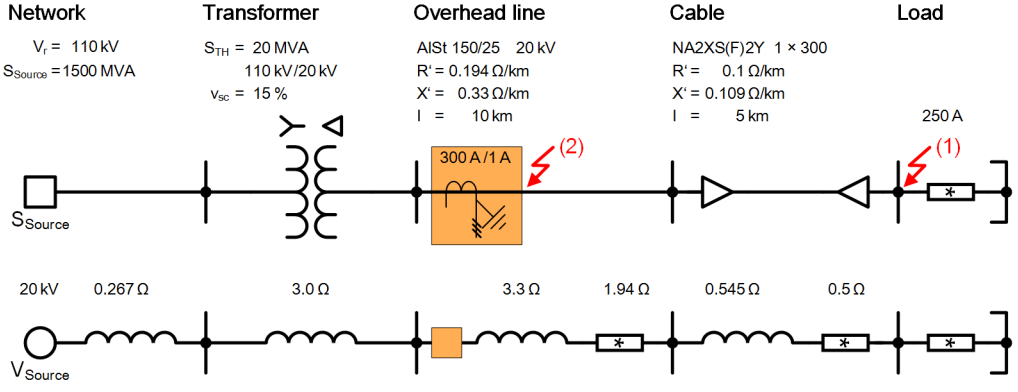
$$R_{bc} = R_{Cable} + R_{Device} = 0.5325\ \Omega + 0.004\ \Omega \approx 0.537\ \Omega$$

Required transformer terminal voltage for the current transformer:	$V_{tc} \geq \frac{I_{max.threshold}}{I_{pr}} \cdot I_{sr} \cdot R_{bc} = \frac{944\ A}{50\ A} \cdot 5\ A \cdot 0.537\ \Omega = 50.69\ V$
Minimum requirement:	$V_{tc} \geq 20 \cdot I_{sr} \cdot R_{bc} = 20 \cdot 5\ A \cdot 0.537\ \Omega = 53.7\ V$
Current transformer terminal voltage:	$V_t = 100$ V
Result:	100 V > 53.7 V

The C100 class current transformer meets the requirements.

Application in the Electrical Power System

The current transformer is selected for the system shown in the example. The primary impedances that have been converted to the 20 kV voltage level are shown in the figure below. These are used to estimate the short-circuit current.



[dw_app-example_for_current-transf_connect-requirements_01, 1, en_US]

Figure A-5 Example for a System Design

The 3-phase short-circuit current is calculated as follows for remote faults:

$$I_{sc(1)} = \frac{1.1 \cdot \frac{V_Q}{\sqrt{3}}}{\sqrt{R_{Sum}^2 + X_{Sum}^2}} = \frac{1.1 \cdot \frac{20\ kV}{\sqrt{3}}}{\sqrt{\left((1.94 + 0.5)\Omega\right)^2 + \left((0.267 + 3 + 3.3 + 0.545)\Omega\right)^2}}$$

$$= \frac{1.1 \cdot \frac{20\ kV}{\sqrt{3}}}{\sqrt{(5.95 + 50.58)\Omega^2}} = 1.69\ kA$$

The 3-phase short-circuit current is calculated as follows for near faults:

$$I_{sc(2)} = \frac{1.1 \cdot \frac{V_Q}{\sqrt{3}}}{\sqrt{X_N^2 + X_{Tr}^2}} = \frac{1.1 \cdot \frac{20\ kV}{\sqrt{3}}}{\sqrt{\left((0.267 + 3.0)\Omega\right)^2}} = \frac{1.1 \cdot \frac{20\ kV}{\sqrt{3}}}{\sqrt{10.67\ \Omega^2}} = 3.89\ kA$$

Estimation of the overcurrent-protection stage pickup value:

$$I_{Threshold\ value} \approx 1.5 \cdot I_{pr} = 1.5 \cdot 300\ A = 450\ A$$

Ratio to the max. short-circuit current:

$$\frac{I_{sc(2)}}{I_{Threshold\ value}} = \frac{3890\ A}{450\ A} \approx 8.64$$

As the threshold value is significantly less than the maximum short-circuit current, protection by measuring the RMS value over a cycle will safely kick in even in the event of current-transformer saturation.

Selected current transformer: **10P10; 2.5 VA** or **5P10; 2.5 VA**

The calculation is based on a connected burden of $R_{bc} < 2\ \Omega$. If a high-current stage is available, for example for reverse interlocking, Siemens recommends power of 5 VA for the current transformer or a current transformer 5P20; 2.5 VA.

A.6 Connection Examples for Current Transformers



Current transformer 3-phase: connection = **3-phase**

[ti_3-phase_1, 4, en_US]

Figure A-6 Connection to 3 Phase Current Transformers (Zero-Sequence Current to be Calculated)



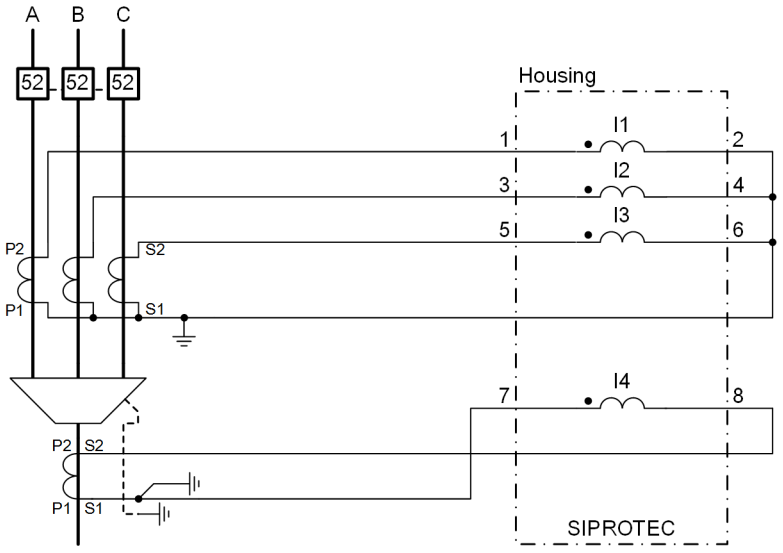
Current transformer 3-phase: connection = **3-phase + IN**

[ti_phase_2, 4, en_US]

Figure A-7 Connection to 3 Phase Current Transformers and a Measured Zero-Sequence Current (Current in Common Return Conductor)

NOTE

The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 (I_N)!



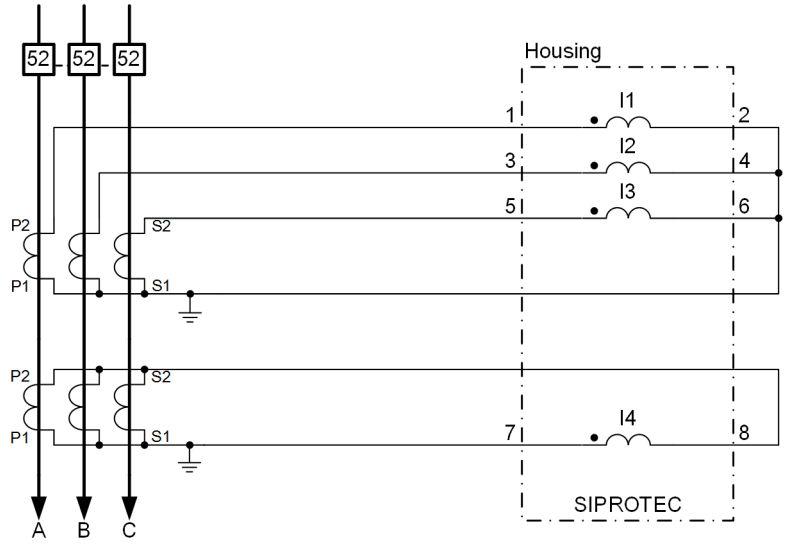
Current transformer 3-phase: connection = **3-phase + IN-separate**

[ti_phase_3, 4, en_US]

Figure A-8 Connection to 3 Phase Current Transformers and a Cable Type Current Transformer for Sensitive Ground-Fault Detection

NOTE

The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



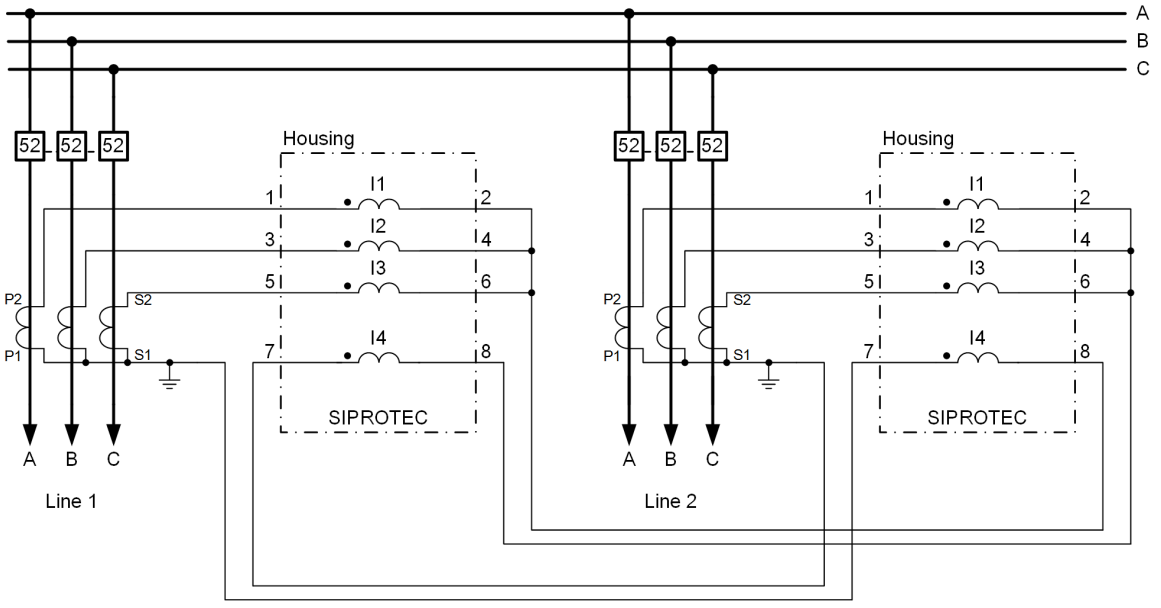
Current transformer 3-phase: connection = **3-phase + IN-separate**

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Figure A-9 Connection to 3 Phase Current Transformers and a Measured Ground Current from a Complete Holmgreen Connection

NOTE

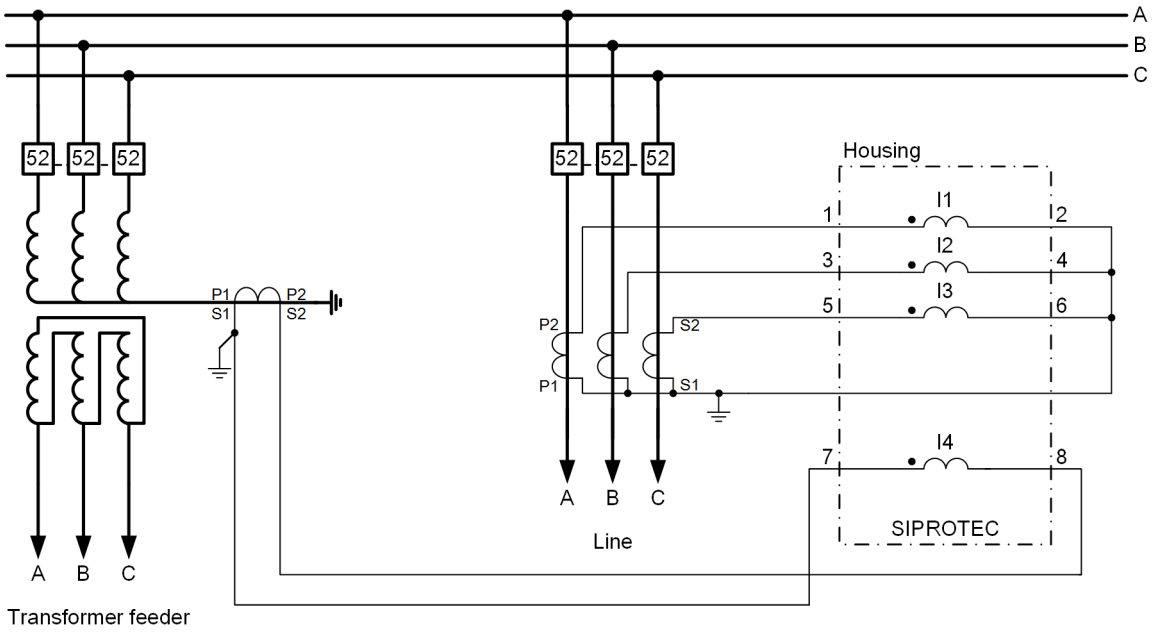
The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



Current transformer 3-phase: connection = **3-phase**
Current transformer 1-phase: connection = **Ix**

[tileite5-060313-01.tif, 4, en_US]

Figure A-10 Connection to 3 Phase Current Transformers and a Measured Residual Current from the Current-Transformer Neutral Point of the Respective Parallel Line (for Parallel-Line Compensation)



Current transformer 3-phase: connection = **3-phase**
Current transformer 1-phase: connection = **Ix**

[tileite6-060313-01.tif, 4, en_US]

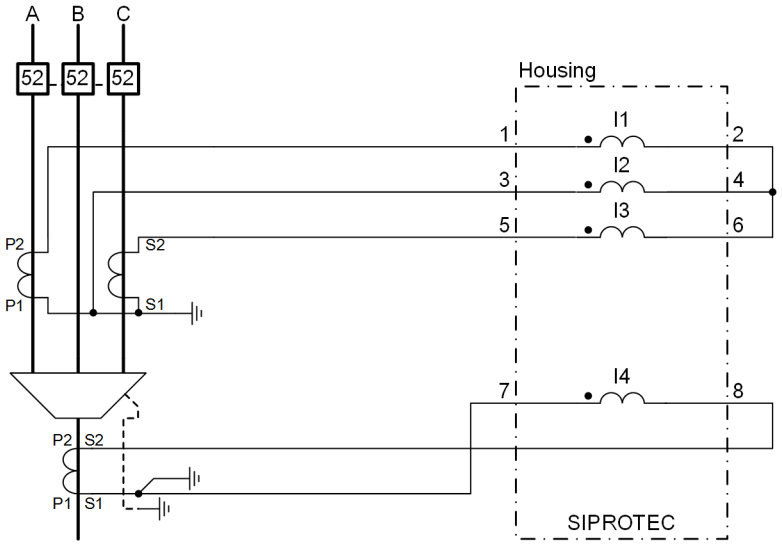
Figure A-11 Connection to 3 Phase Current Transformers and a Measured Ground Current via the Neutral-Point Current Transformer of a Grounded Power Transformer



Current transformer 3-phase: connection = **3-phase, 2 primary CT**

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Figure A-12 Connection to a 2 Phase Current Transformers – for Isolated or Resonant-Grounded Systems Only



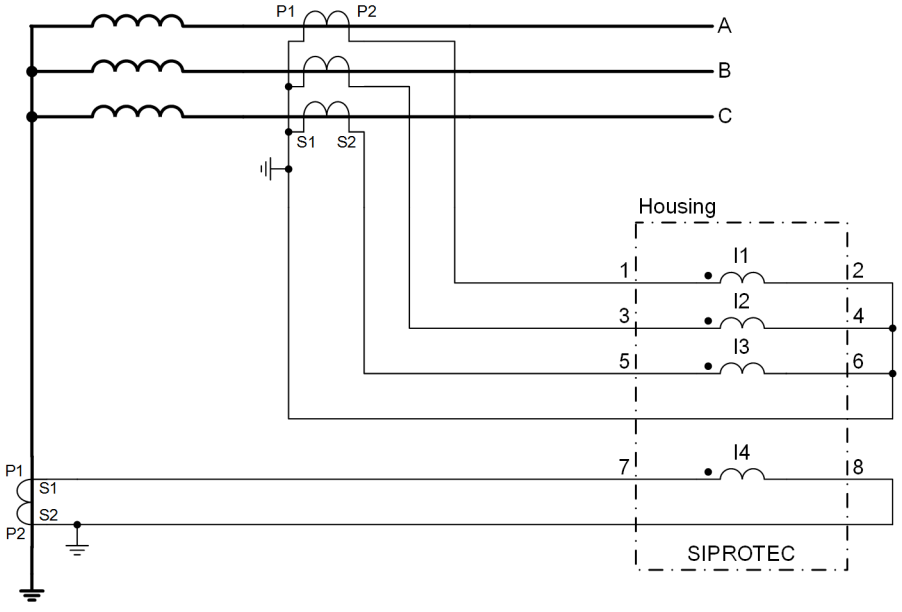
Current transformer 3-phase: connection = **3ph,2prim.CT + IN-sep**

[tileite8-260313-01.tif, 4, en_US]

Figure A-13 Connection to 2 Phase Current Transformers and a Cable Type Current Transformer for Sensitive Ground-Fault Detection – for Isolated or Resonant-Grounded Systems Only

NOTE

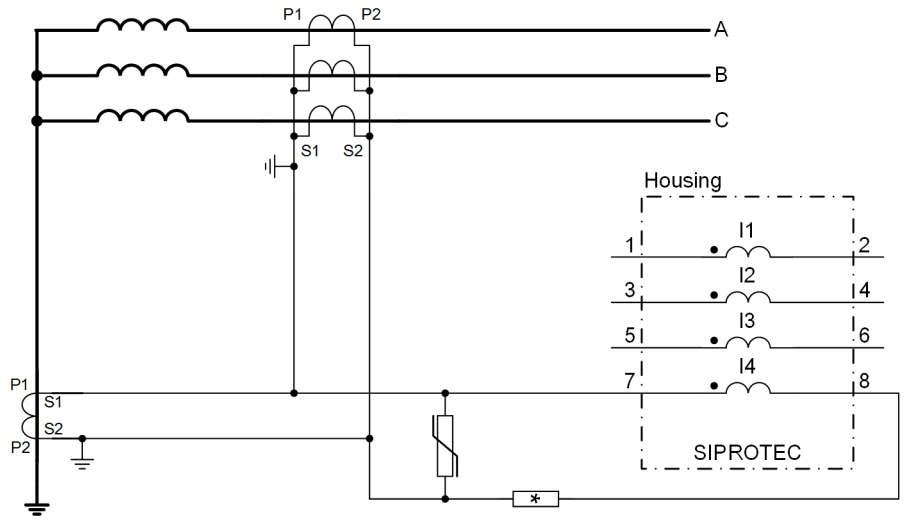
The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



Current transformer 3-phase: connection = **3-phase**
Current transformer 1-phase: connection = **Ix**

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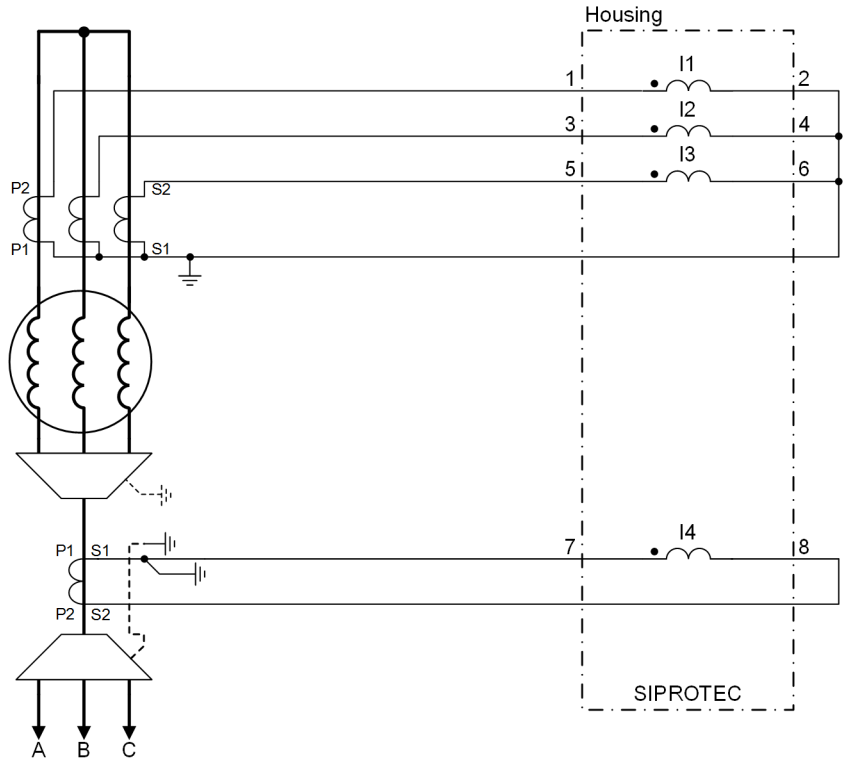
Figure A-14 Connection to 3 Phase Current Transformers and an Additional Current Transformer in the Neutral Point of a Grounded Power Transformer



Current transformer 1-phase: connection = Ix

[ti_phase_10, 5, en_US]

Figure A-15 Current Transformer Connection for High-Impedance Differential Protection (for Example, a Power Transformer, in Preparation)

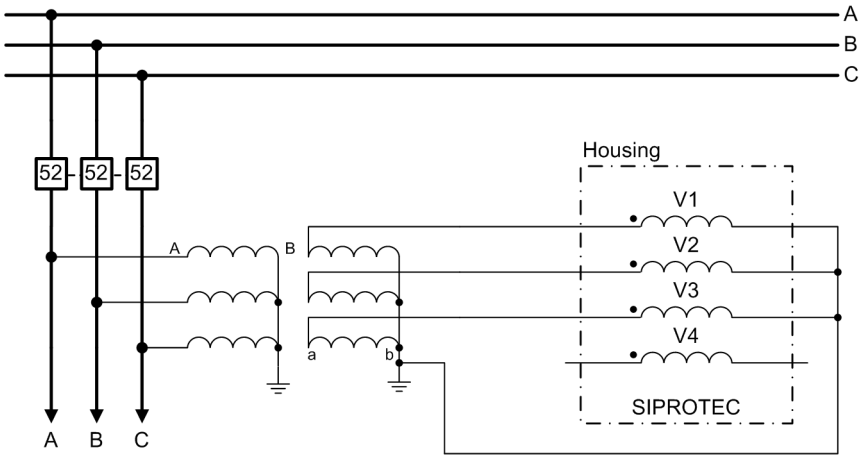


Current transformer 3-phase: connection = 3-phase
Current transformer 1-phase: connection = Ix

[ti_phase_11, 4, en_US]

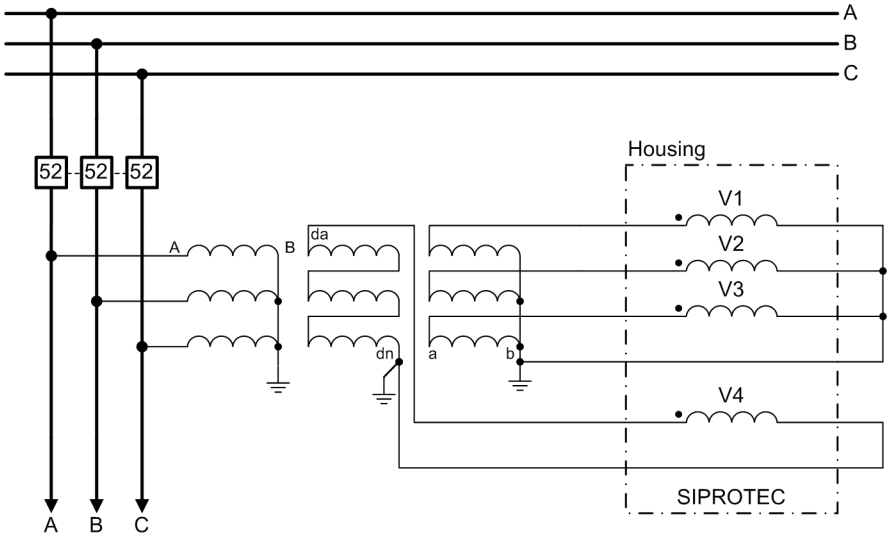
Figure A-16 Connection to 3 Phase Current Transformers in the Neutral Point of a Generator and a Cable Type Current Transformer for Sensitive Ground-Fault Detection of the Line

A.7 Connection Examples of Voltage Transformers for Modular Devices



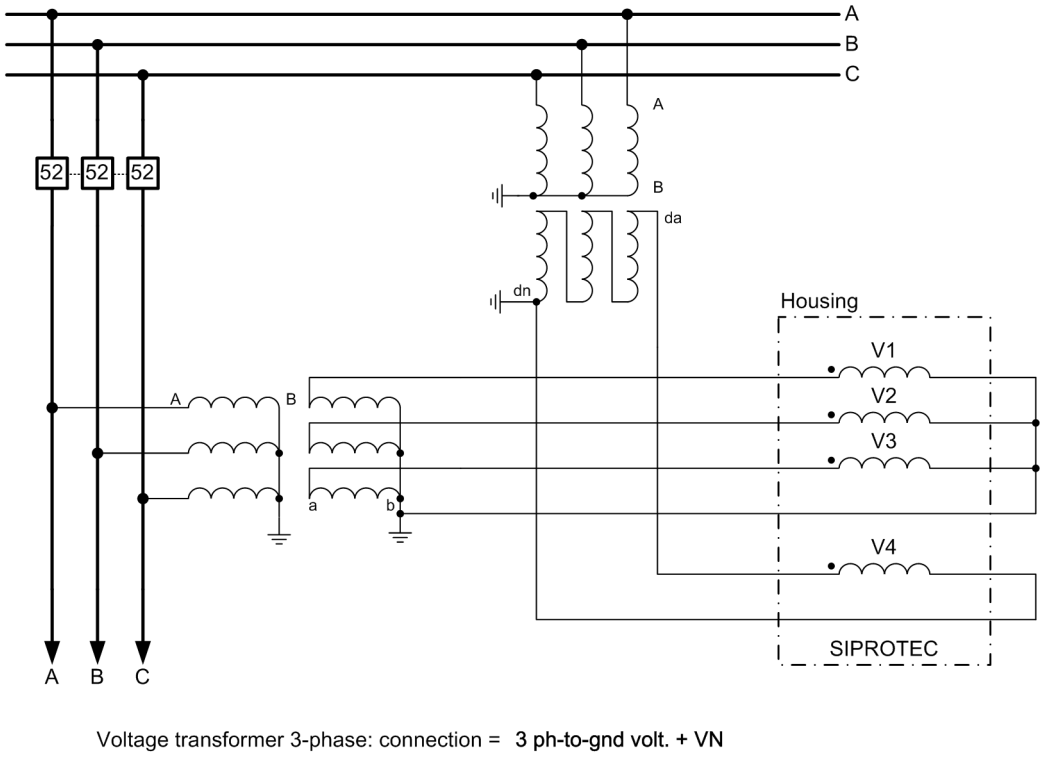
[tvvolta1-260313-01.tif, 1, en_US]

Figure A-17 Connection to 3 Star-Connected Voltage Transformers



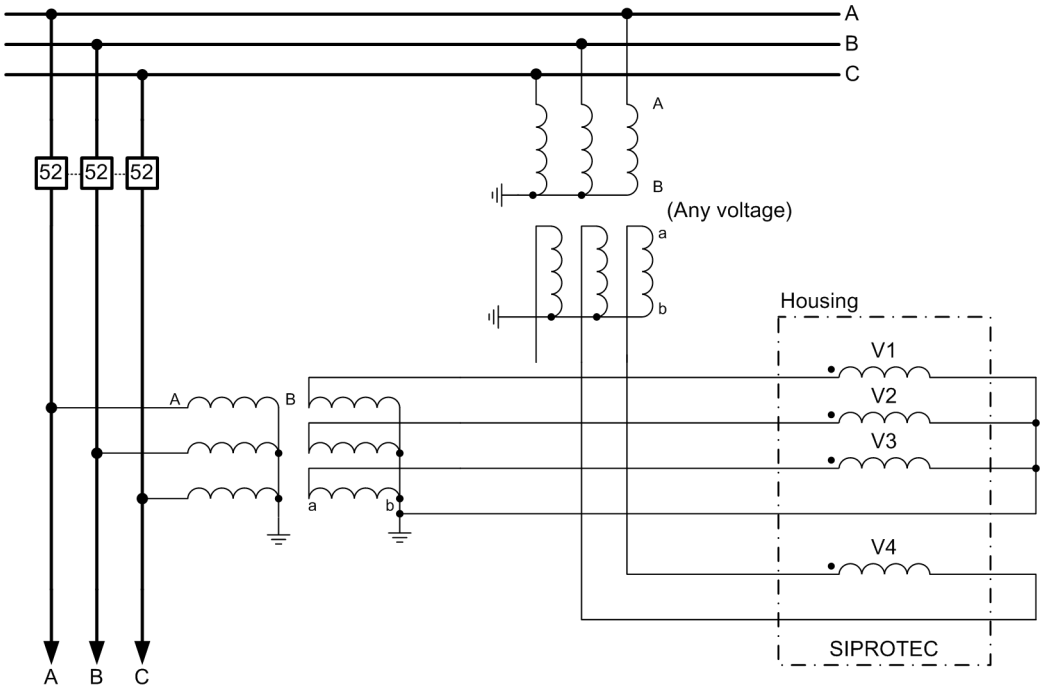
[tvvolta2-260313-01.tif, 1, en_US]

Figure A-18 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding



[tvvolta3-260313-01.tif, 1, en_US]

Figure A-19 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer (for Example Busbar)

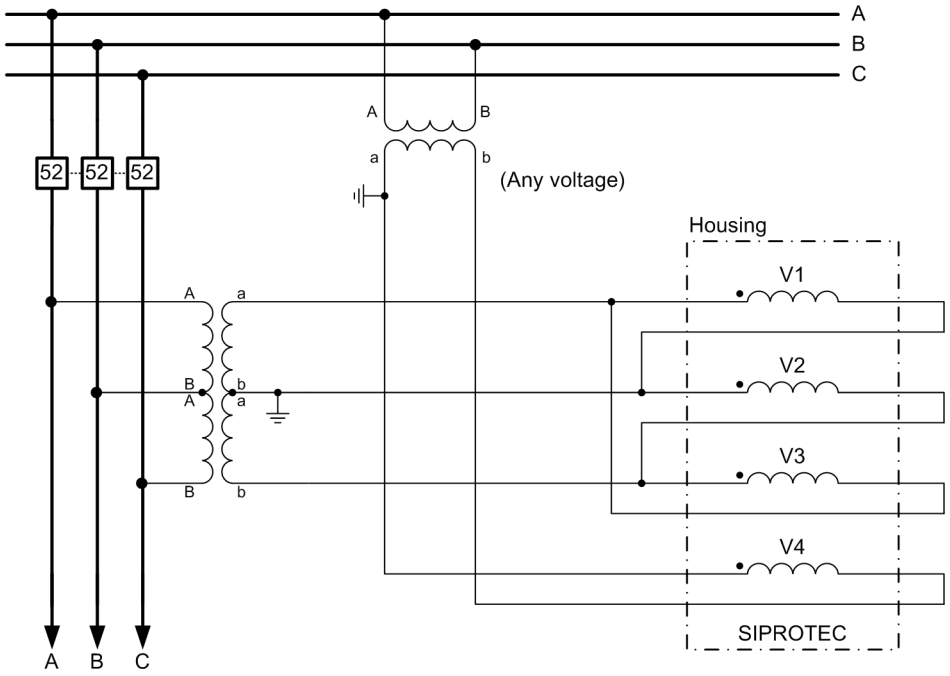


Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

[tvvolta4-260313-01.tif, 2, en_US]

Figure A-20 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example for Synchrocheck Applications)



Voltage transformer 3-phase: connection = **3 ph-to-ph voltages**

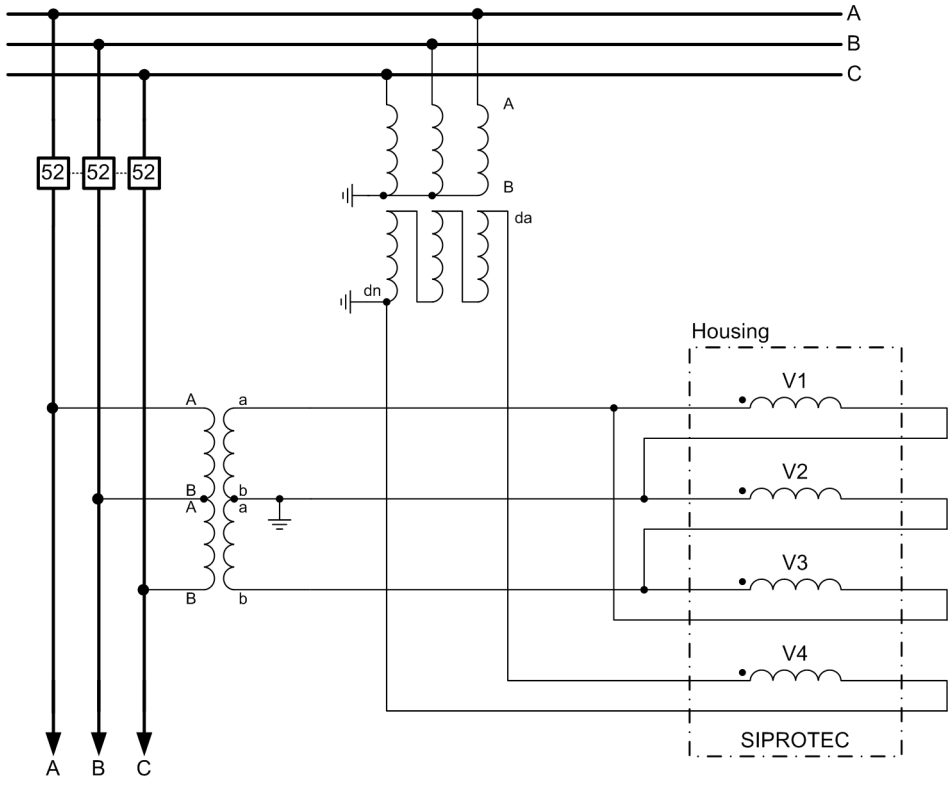
Voltage transformer 1-phase: connection = **VAB**

[tvvolta5-260313-01.tif, 1, en_US]

Figure A-21 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

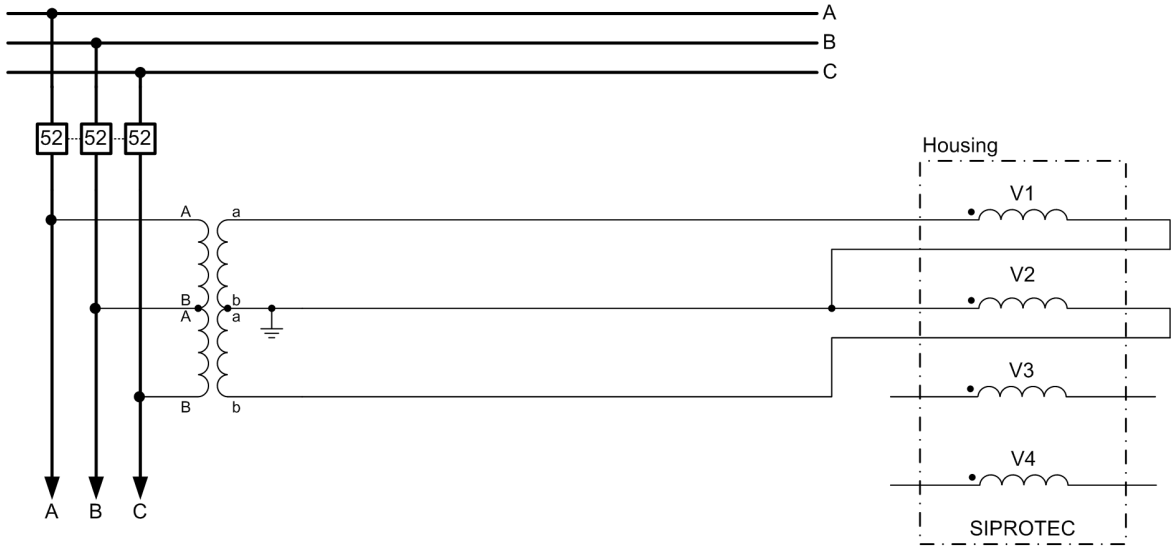
When using the connection type 3-phase-to-phase voltage, the zero-sequence voltage cannot be detected.



Voltage transformer 3-phase: connection = 3 ph-to-ph volt. + VN

[tvvolta6-260313-01.tif, 1, en_US]

Figure A-22 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer

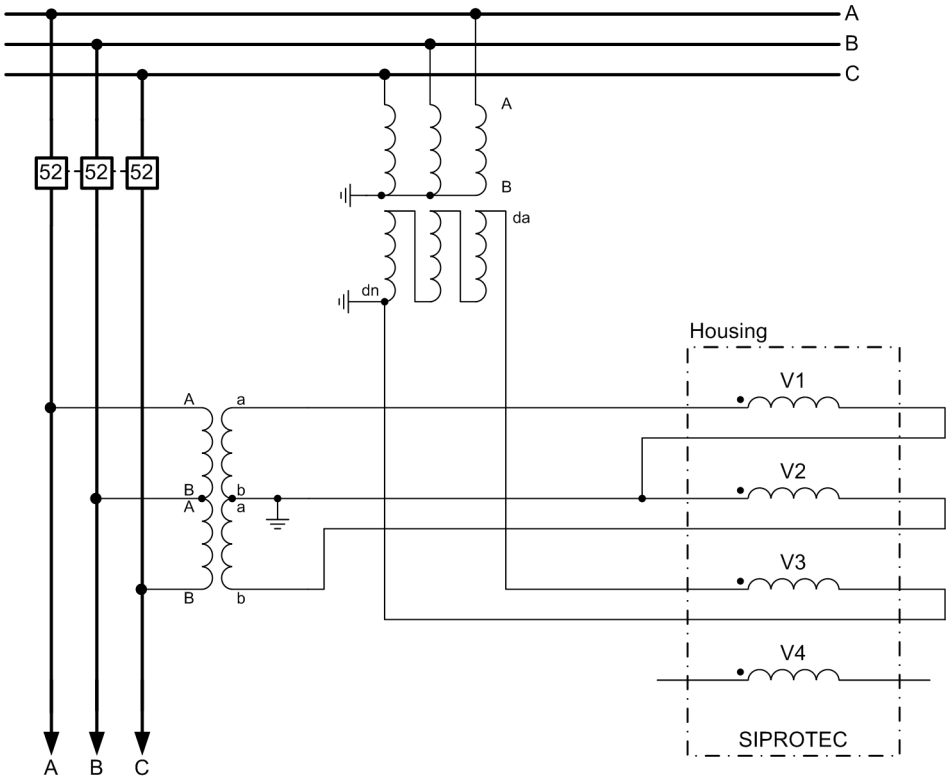


Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

Phase voltages = VAB, VBC

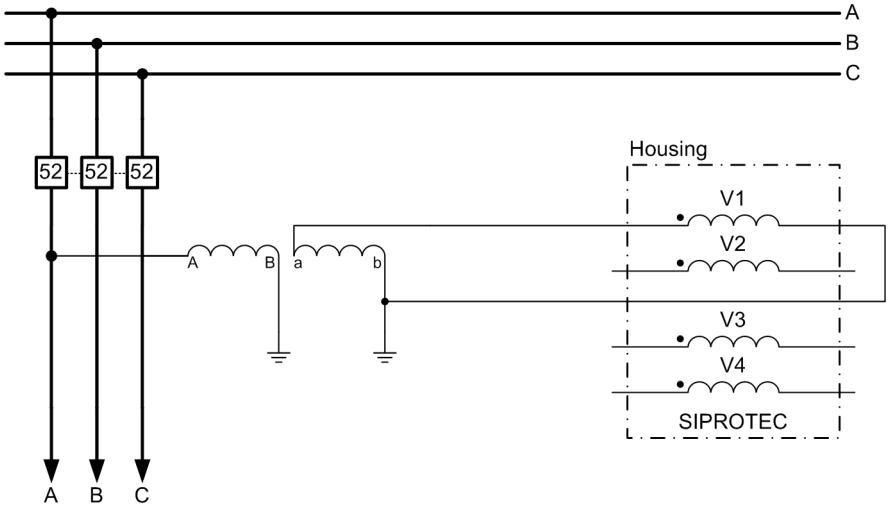
[tvvol2ll-260313-01.tif, 2, en_US]

Figure A-23 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)



[tvl2lluu-260313-01.tif, 2, en_US]

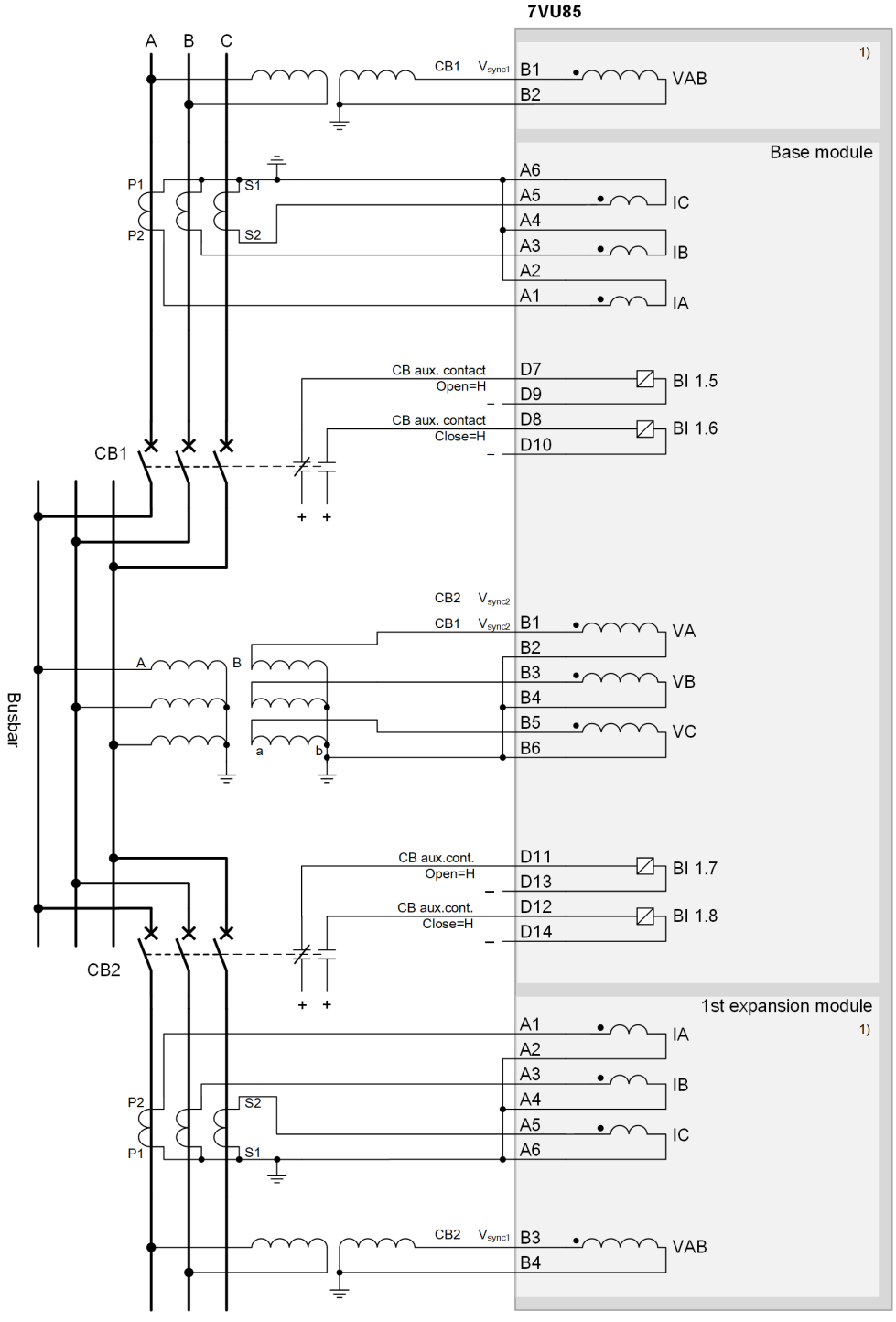
Figure A-24 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



[tvvolta7-260313-01.tif, 1, en_US]

Figure A-25 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

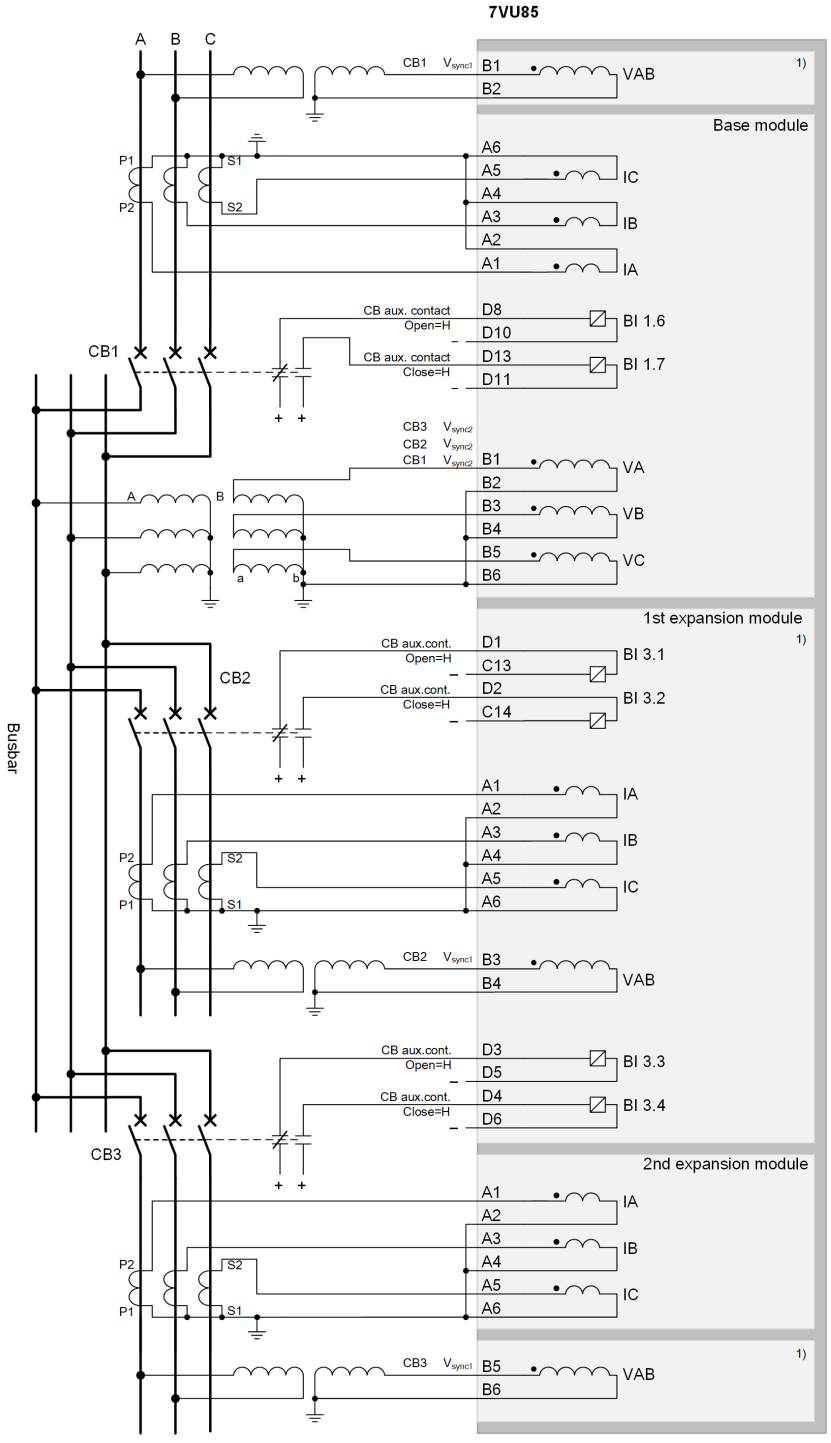
A.8 Connection Examples for the High-Speed Busbar Transfer Device



[dw_connection_example_7VU85_1BB_2S, 1, en_US]

Figure A-26 Connection Example for the Template: Single Busbar with 2 Incomers

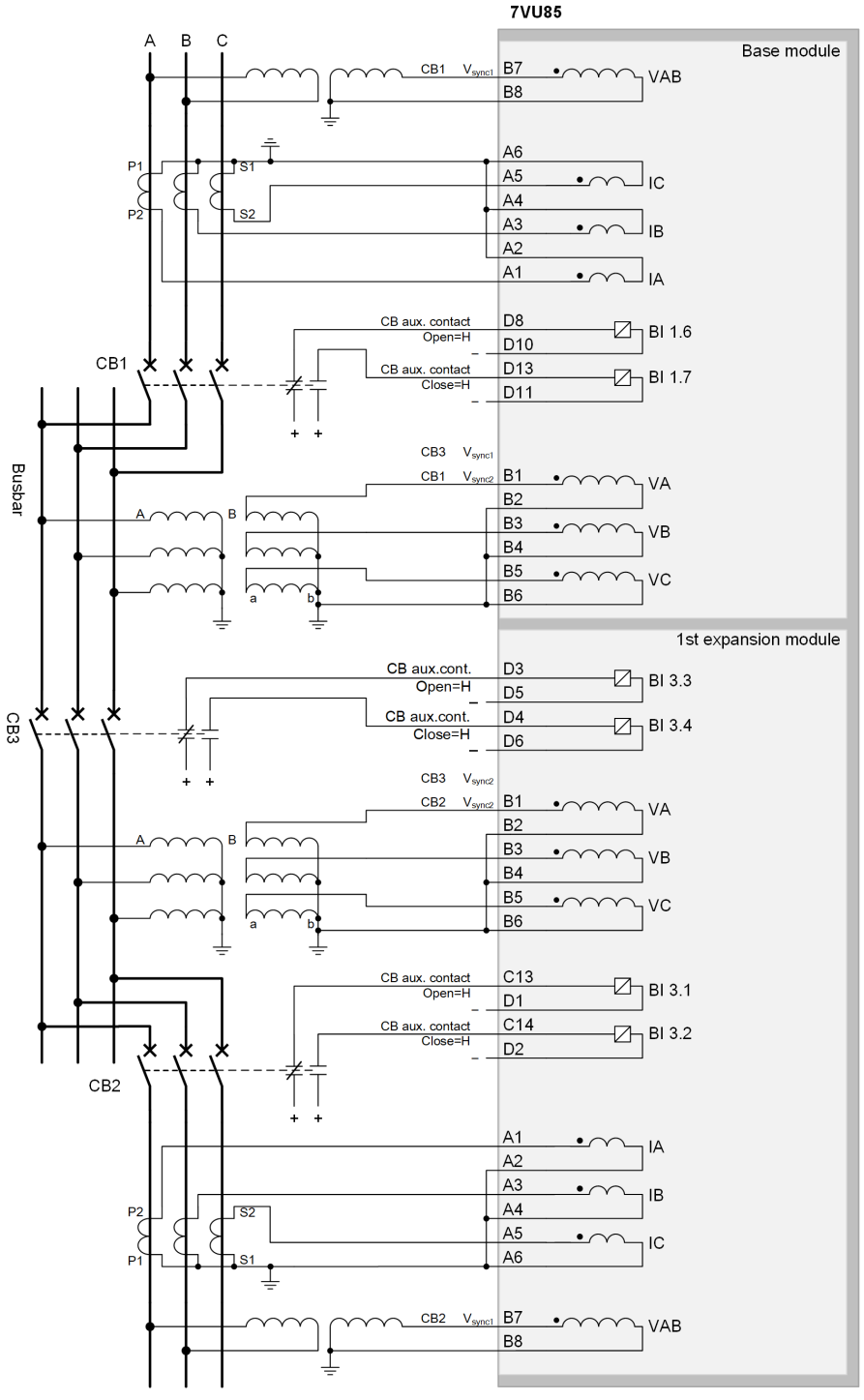
(1) To clearly illustrate the connection, the 1st expansion module is divided into 2 parts in the figure.



[dw_connection_example_7VU85_1BB_3S, 1, en_US]

Figure A-27 Connection Example for the Template: Single Busbar with 3 Incomers

(1) To clearly illustrate the connection, the 1st expansion module is divided into 3 parts in the figure.



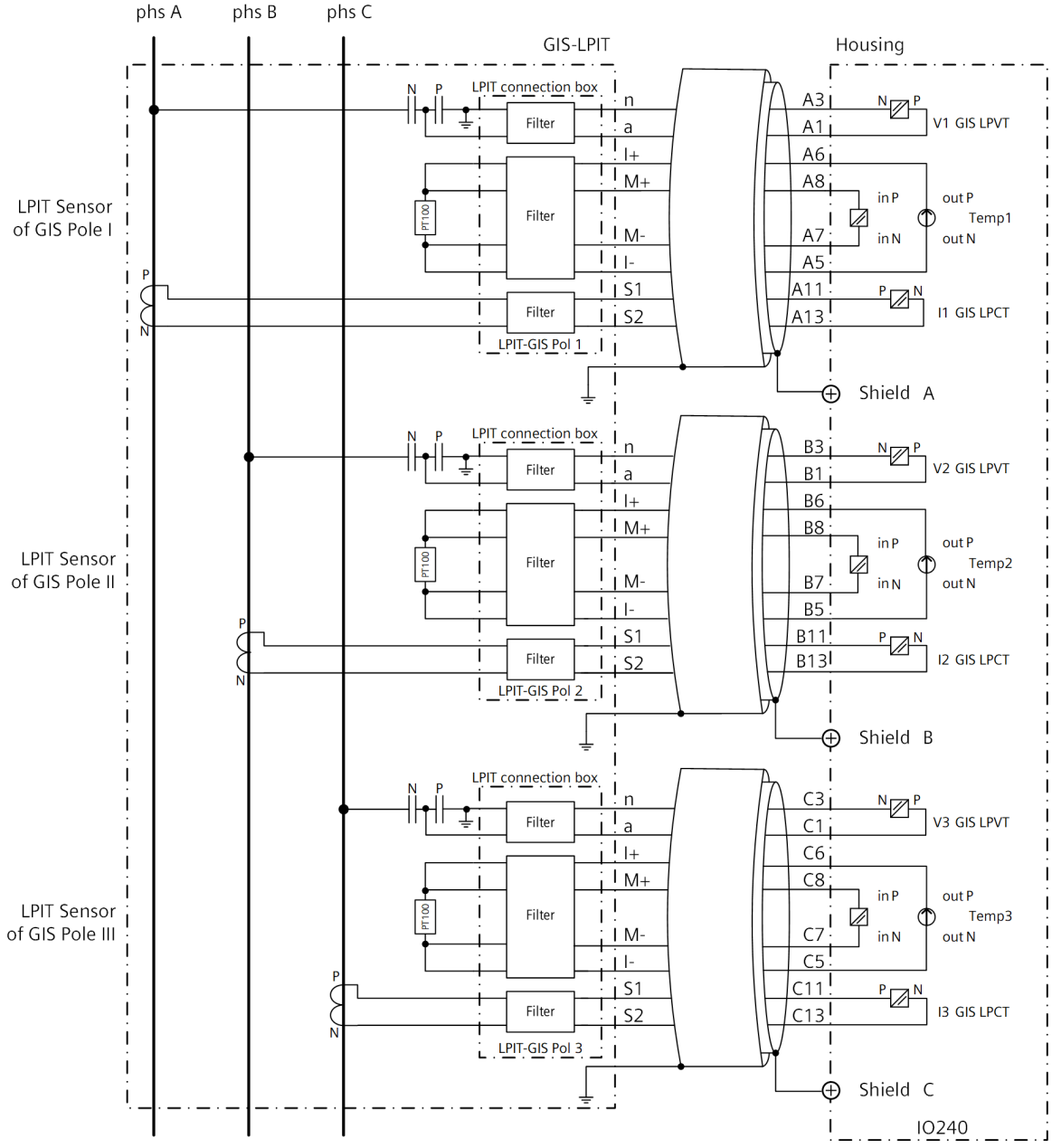
[dw_connection_example_7VU85, 2, en_US]

Figure A-28 Connection Example for the Template: Sectionalized Busbar with 2 Incomers

A.9 Connection Examples for LPIT Module IO240

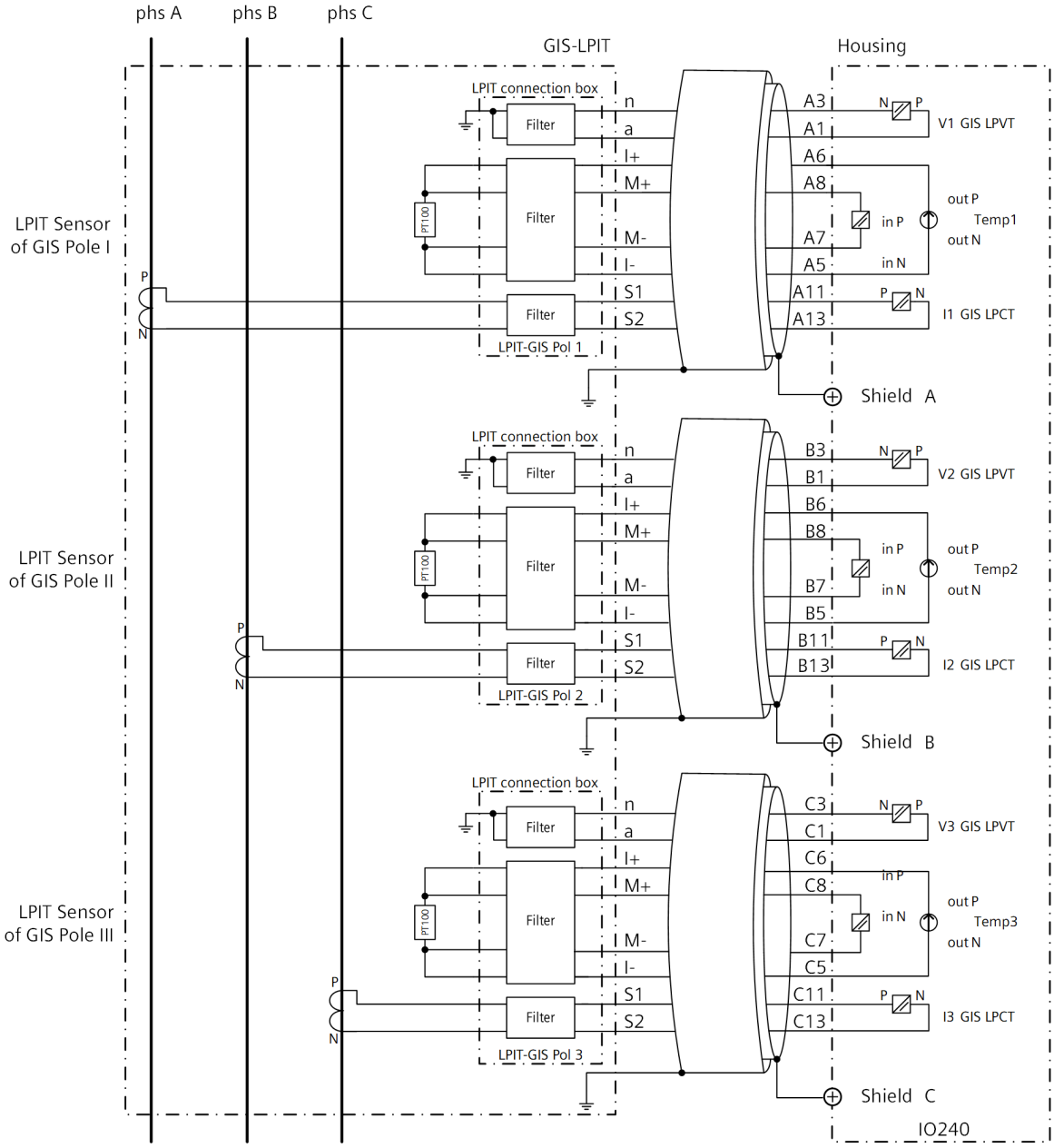
The connection examples show the following case:

- The LPIT sensor of GIS Pole I physically connects to the primary phase A of the LPIT module IO240.
- The LPIT sensor of GIS Pole II physically connects to the primary phase B of the LPIT module IO240.
- The LPIT sensor of GIS Pole III physically connects to the primary phase C of the LPIT module IO240.



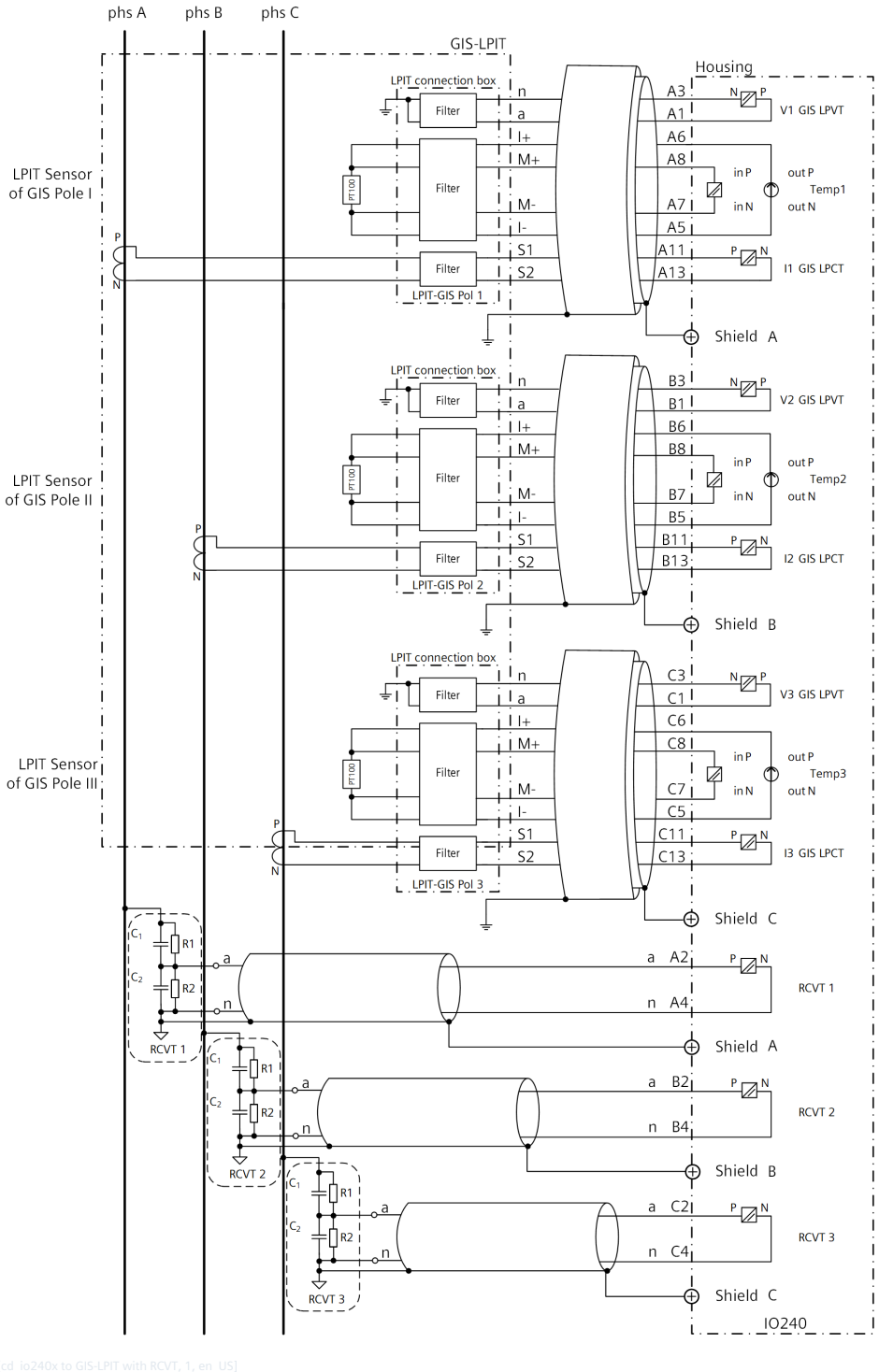
[cd_io240x to GIS-LPIT, 4, en_US]

Figure A-29 Connection of IO240 to the Siemens Energy GIS-LPIT



[cd_io240x to GIS-LPIT without CVS, 4, en_US]

Figure A-30 Connection of IO240 to the Siemens Energy GIS-LPIT without GIS-LPVT



[cd_io240x to GIS-LPIT with RCVT, 1, en_US]

Figure A-31 Connection of IO240 to the Siemens Energy GIS-LPIT and RCVT

NOTE

For the LPIT sensors of the GIS poles, you can set the relationship between the physical connection of LPIT sensors to the respective inputs of the LPIT module IO240 via the parameters **`Primary Phase A`**, **`Primary Phase B`**, and **`Primary Phase C`**.

NOTE

For RCVTs, physically connect primary phase A to the RCVT 1 terminals, primary phase B to the RCVT 2 terminals and primary phase C to the RCVT 3 terminals.

NOTE

The following unused terminal pairs must be individually short-circuited, using the voltage terminal cross-connectors (product code P1Z550):

- A12 and A14
- B12 and B14
- C12 and C14
- D1 and D3
- D2 and D4
- D5 and D7
- D6 and D8
- D11 and D13
- D12 and D14

If RCVT is not used, the following more unused terminal pairs must be individually short-circuited, using the voltage terminal cross-connectors (product code P1Z550):

- A2 and A4
- B2 and B4
- C2 and C4

NOTE

You can only use the LPIT Module IO240 with the LPIT Connection Box (C53207-A9443-B1-3).
You must use the cable L45551-P42-B5 from the LEONI Special Cables GmbH.
The maximum allowed cable length is 100 m.

A.10 Prerouting 7VU85 HSBT Sectionalized Busbar with 2 Incomers

For the meanings of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-2 Default Binary Inputs for HSBT Sectionalized Busbar with 2 Incomers

Binary Input	Signal	Number	Signal Type	Configu-ration
BI1	HSBT 1:General:>Block HSBT	1421.2311.501	SPS	H
BI2	HSBT 1:General:>Manual reset	1421.2311.502	SPS	H
BI3	HSBT 1:Incom. 1 to incom. 2:Start:>Elec. fault start	1421.3251.24511.501	SPS	H
	HSBT 1:Incom. 1 to busbar 2:Start:>Elec. fault start	1421.3252.24511.501	SPS	H
BI4	HSBT 1:Incom. 2 to incom. 1:Start:>Elec. fault start	1421.3253.24511.501	SPS	H
	HSBT 1:Incom. 2 to busbar 1:Start:>Elec. fault start	1421.3254.24511.501	SPS	H
BI6	CB1:Circuit break.:Position	201.4261.58	DPC	OH
BI7	CB1:Circuit break.:Position	201.4261.58	DPC	CH
BI9	HSBT 1:Incom. 1 to incom. 2:Start:>Non-elec. fault start	1421.3251.24511.502	SPS	H
	HSBT 1:Incom. 1 to busbar 2:Start:>Non-elec. fault start	1421.3252.24511.502	SPS	H
BI10	HSBT 1:Incom. 2 to incom. 1:Start:>Non-elec. fault start	1421.3253.24511.502	SPS	H
	HSBT 1:Incom. 2 to busbar 1:Start:>Non-elec. fault start	1421.3254.24511.502	SPS	H
BI12	CB2:Circuit break.:Position	202.4261.58	DPC	OH
BI13	CB2:Circuit break.:Position	202.4261.58	DPC	CH
BI14	CB3:Circuit break.:Position	1501.4261.58	DPC	OH
BI15	CB3:Circuit break.:Position	1501.4261.58	DPC	CH

Binary Outputs

Table A-3 Default Standard Relays for HSBT Sectionalized Busbar with 2 Incomers

Binary Output	Signal	Number	Signal Type	Configu-ration
BO1	HSBT 1:General:Transfer completed	1421.2311.302	SPS	U
BO2	HSBT 1:General:Transfer failed	1421.2311.303	SPS	U
BO3	HSBT 1:General:Transfer ready	1421.2311.300	SPS	U
BO4	CB1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U
BO5	CB1:Circuit break.:Close command	201.4261.301	SPS	X
BO6	CB2:Circuit break.:Trip/open cmd.	202.4261.300	SPS	U
BO7	CB2:Circuit break.:Close command	202.4261.301	SPS	X
BO8	CB3:Circuit break.:Trip/open cmd.	1501.4261.300	SPS	U
BO9	CB3:Circuit break.:Close command	1501.4261.301	SPS	X

Binary Output	Signal	Number	Signal Type	Configu-ration
BO13	HSBT 1:Incom. 1 to incom. 2:Transfer seq.:Load-shedding cmd.	1421.3251.21181.312	SPS	U
	HSBT 1:Incom. 1 to busbar 2:Transfer seq.:Load-shedding cmd.	1421.3252.21181.312	SPS	U
	HSBT 1:Incom. 2 to incom. 1:Transfer seq.:Load-shedding cmd.	1421.3253.21181.312	SPS	U
BO14	HSBT 1:Incom. 1 to incom. 2:Transfer seq.:Load-shedding cmd.	1421.3251.21181.312	SPS	U
	HSBT 1:Incom. 2 to incom. 1:Transfer seq.:Load-shedding cmd.	1421.3253.21181.312	SPS	U
	HSBT 1:Incom. 2 to busbar 1:Transfer seq.:Load-shedding cmd.	1421.3254.21181.312	SPS	U

LEDs

Table A-4 Default LED Display for HSBT Sectionalized Busbar with 2 Incomers

LED	Signal	Number	Signal Type	Configu-ration
LED1	CB1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	L
LED2	CB1:Circuit break.:Close command	201.4261.301	SPS	L
LED3	CB2:Circuit break.:Trip/open cmd.	202.4261.300	SPS	L
LED4	CB2:Circuit break.:Close command	202.4261.301	SPS	L
LED5	CB3:Circuit break.:Trip/open cmd.	1501.4261.300	SPS	L
LED6	CB3:Circuit break.:Close command	1501.4261.301	SPS	L
LED8	HSBT 1:General:Transfer ready	1421.2311.300	SPS	U
LED9	HSBT 1:General:Transfer completed	1421.2311.302	SPS	L
LED10	HSBT 1:General:Transfer failed	1421.2311.303	SPS	L
LED11	HSBT 1:Incom. 1 to incom. 2:Start:Manual start	1421.3251.24511.300	SPS	L
	HSBT 1:Incom. 1 to busbar 2:Start:Manual start	1421.3252.24511.300	SPS	L
	HSBT 1:Incom. 2 to incom. 1:Start:Manual start	1421.3253.24511.300	SPS	L
	HSBT 1:Incom. 2 to busbar 1:Start:Manual start	1421.3254.24511.300	SPS	L
	HSBT 1:Busbar 2 to incom. 1:Start:Manual start	1421.3255.24511.300	SPS	L
	HSBT 1:Busbar 1 to incom. 2:Start:Manual start	1421.3256.24511.300	SPS	L

LED	Signal	Number	Signal Type	Configu-ration
LED12	HSBT 1:Incom. 1 to incom. 2:Start:Under-voltage start	1421.3251.24511.303	SPS	L
	HSBT 1:Incom. 1 to incom. 2:Start:Underfre-quency start	1421.3251.24511.309	SPS	L
	HSBT 1:Incom. 1 to incom. 2:Start:CB inad-vert. open start	1421.3251.24511.311	SPS	L
	HSBT 1:Incom. 1 to busbar 2:Start:Under-voltage start	1421.3252.24511.303	SPS	L
	HSBT 1:Incom. 1 to busbar 2:Start:Underfre-quency start	1421.3252.24511.309	SPS	L
	HSBT 1:Incom. 1 to busbar 2:Start:CB inad-vert. open start	1421.3252.24511.311	SPS	L
	HSBT 1:Incom. 2 to incom. 1:Start:Under-voltage start	1421.3253.24511.303	SPS	L
	HSBT 1:Incom. 2 to incom. 1:Start:Underfre-quency start	1421.3253.24511.309	SPS	L
	HSBT 1:Incom. 2 to incom. 1:Start:CB inad-vert. open start	1421.3253.24511.311	SPS	L
	HSBT 1:Incom. 2 to busbar 1:Start:Under-voltage start	1421.3254.24511.303	SPS	L
	HSBT 1:Incom. 2 to busbar 1:Start:Underfre-quency start	1421.3254.24511.309	SPS	L
	HSBT 1:Incom. 2 to busbar 1:Start:CB inad-vert. open start	1421.3254.24511.311	SPS	L
LED13	HSBT 1:Incom. 1 to incom. 2:Start:Electrical fault start	1421.3251.24511.301	SPS	L
	HSBT 1:Incom. 1 to incom. 2:Start:Non-elec-tric. fault start	1421.3251.24511.302	SPS	L
	HSBT 1:Incom. 1 to busbar 2:Start:Electrical fault start	1421.3252.24511.301	SPS	L
	HSBT 1:Incom. 1 to busbar 2:Start:Non-elec-tric. fault start	1421.3252.24511.302	SPS	L
	HSBT 1:Incom. 2 to incom. 1:Start:Electrical fault start	1421.3253.24511.301	SPS	L
	HSBT 1:Incom. 2 to incom. 1:Start:Non-elec-tric. fault start	1421.3253.24511.302	SPS	L
	HSBT 1:Incom. 2 to busbar 1:Start:Electrical fault start	1421.3254.24511.301	SPS	L
	HSBT 1:Incom. 2 to busbar 1:Start:Non-elec-tric. fault start	1421.3254.24511.302	SPS	L
LED14	HSBT 1:Incom. 1 to incom. 2:Transfer seq.:Load-shedding cmd.	1421.3251.21181.312	SPS	L
	HSBT 1:Incom. 1 to busbar 2:Transfer seq.:Load-shedding cmd.	1421.3252.21181.312	SPS	L
	HSBT 1:Incom. 2 to incom. 1:Transfer seq.:Load-shedding cmd.	1421.3253.21181.312	SPS	L
	HSBT 1:Incom. 2 to busbar 1:Transfer seq.:Load-shedding cmd.	1421.3254.21181.312	SPS	L
LED15	Alarm handling:Group warning	5971.301	SPS	U

LED	Signal	Number	Signal Type	Configu-ration
LED16	General:Functions in Test mode	91.329	SPS	U
	Device:Process mode inactive	-	SPS	U

Function Keys

Table A-5 Default Function Keys for HSBT Sectionalized Busbar with 2 Incomers

Function Key	Signal	Configuration
F-key1	Main menu:Logs:Operational log	X
F-key2	Main menu:Measurements:HSBT 1	X
F-key3	Main menu:Logs:Fault log	X
F-key4	Main menu:Settings:HSBT 1	X

Literature

/1/ Distance Protection, Line Differential Protection, and Overcurrent Protection for 3-Pole Tripping – 7SA82, 7SD82, 7SL82, 7SA84, 7SD84, 7SA86, 7SD86, 7SL86, 7SJ86
C53000-G5040-C010

/2/ Distance and Line Differential Protection, Breaker Management for 1-Pole and 3-Pole Tripping – 7SA87, 7SD87, 7SL87, 7VK87
C53000-G5040-C011

/3/ Overcurrent Protection – 7SJ82/7SJ85
C53000-G5040-C017

/4/ Overcurrent Protection – 7SJ81
C53000-G5040-C079

/5/ Motor Protection – 7SK82/85
C53000-G5040-C024

/6/ Transformer Differential Protection – 7UT82, 7UT85, 7UT86, 7UT87
C53000-G5040-C016

/7/ Generator Protection – 7UM85
C53000-G5040-C027

/8/ Busbar Protection 7SS85
C53000-G5040-C019

/9/ High-Voltage Bay Controller – 6MD85/86
C53000-G5040-C015

/10/ Paralleling Device – 7VE85
C53000-G5040-C071

/11/ Universal Protection – 7SX82/7SX85
C53000-G5040-C607

/12/ Merging Unit 6MU85
C53000-G5040-C074

/13/ Fault Recorder – 7KE85
C53000-G5040-C018

/14/ Compact Class – 7SX800
C53000-G5040-C003

/15/ Hardware Description
C53000-G5040-C002

/16/ Communication Protocols
C53000-L1840-C055

/17/ Process Bus
C53000-H3040-C054

/18/ DIGSI 5 – Software Description
C53000-D5040-C001

/19/ SIPROTEC 5 – Security
C53000-H5040-C081

/20/ PIXIT, PICS, TICS, IEC 61850
C53000-G5040-C013

/21/ Operation
C53000-G5040-C003

/22/ Engineering Guide
C53000-G5040-C004

/23/ High-Speed Busbar Transfer – 7VU85
C53000-G5040-C090

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 – information regarding a controllable analog value

ASDU

ASDU stands for **A**pplication **S**ervice **D**ata **U**nit. 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 1st 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, timers, and counters are held as retentive.

Bay controller

Bay controllers are devices with control and supervision functions without protection functions.

BCR

IEC 61850 data type: **B**inary **C**ounter **R**eading

Best Master Clock Algorithm

A PTP network consists of communicating clocks. The best master clock algorithm (BMCA) is used to determine the device that indicates the most precise time. This device serves as a reference clock and is called the grandmaster. In case of changes to the network topology, the BMC algorithm is performed again for network segments which might be cut off from the grandmaster. If a participating device assumes the role of master and slave at the same time, it is also referred to as a boundary clock.

Big-endian

The terms big-endian and little-endian are used to describe the arrangement of the bytes when saving. In case of big-endian, the upper limiting value byte is saved at the lowest address. Little-endian saves the upper limiting value byte at the highest address.

Binary Controlled Analog Process Value

The data type BAC models a command with or without feedback. The BAC is used to control an arc-suppression coil, for example. The commands **Higher**, **Lower**, and **Stop** can be issued. The process delivers an analog value as feedback.

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

Bit pattern indication is a processing function with which items of digital process information applicable across several inputs can be detected together in parallel and further processed. The bit pattern length can be selected as 1, 2, 3, or 4 bytes.

BMCA

Best **M**aster **C**lock **A**lgorithm

Boundary clock

The PTP protocol recognizes different types of clock: An Ordinary Clock (OC), Boundary Clock (BC), and Transparent Clock (TC). The boundary clock transmits time information beyond a network limit. For example in a router which connects different switched networks. As a slave, the clock of the router receives time information and passes it on as a master.

BRCB

Buffered **R**eport **C**ontrol **B**lock

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

CBFP

Sampled **V**alue **S**upervision

CDC

Common **D**ata **C**lass

CFC

Continuous **F**unction **C**hart

Chatter blocking

A rapidly intermittent input (for example, due to a relay contact fault) is disconnected after a configurable supervision time and can thus not generate any further signal changes. The function prevents overloading of the system when a fault occurs.

CID

Configured **I**ED **D**escription

CIT

Conventional **I**nstrument **T**ransformer

CMV

Complex **m**easured **v**alue

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 the IEC 61850 model.

Communication branch

A communication branch corresponds to the configuration of 1 to n participants that communicate via a common bus.

Configured IED Description

A Configured IED Description (CID) is a file for data exchange between the IED Configuration Tool and the IED itself.

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 common 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 CTRL key. The diagram contains the switching devices to be controlled in the feeder, with status representation. The control display serves for the bushing of the switching operations. Defining this display is part of the project engineering.

Controllable Integer Status

The data type INC can be used to issue a command (to one or more relays, selectable in information routing) which is then monitored via a whole number as feedback.

Controller

The controller initiates the IO data communication.

COT

Cause **o**f **T**ransmission

CRC

Cyclic **r**edundancy **c**heck

DAN

Double **A**ttached **N**ode

DANP

Double **A**ttached **N**ode **P**RP

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 suchlike.

Data unit

Information item with a joint transmission source. Abbreviation: DU – **D**ata **U**nit

Data window

The right section of the project window visualizes the content of the section 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 **C**onfiguration **F**ile

DCF77

The high-precision 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 **C**onfiguration **P**rotocol

DDD

DIGSI 5 **D**evice **D**river – SIPROTEC 5 device driver which must be loaded in DIGSI.

DEL

Phase-to-phase related measurements of a 3-phase system

Device 5 Export Format

DEX5

DEX5

Device 5 **Ex**port Format

You can archive the data from an individual SIPROTEC 5 device in DEX5 format.

DHCP

Dynamic **H**ost **C**onfiguration **P**rotocol

DIGDNP

DIGSI 5 protocol settings for DNP3

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

DIGMOD

DIGSI 5 protocol settings for Modbus TCP

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

DIGSI

Configuration software for SIPROTEC

DIGSI 5 Display Pages

You can archive individual or all display pages from 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 protocol DNP3 is configured for a system interface, you can export the protocol settings in DIGDNP format. The DIGDNP format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 protocol settings for IEC 60870-5-103

If the protocol IEC 60870-5-103 is configured for a system interface, you can export the protocol settings in DIGT103 format. The DIGT103 format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 protocol settings for IEC 60870-5-104

If the protocol IEC 60870-5-104 is configured for a system interface, you can export the protocol settings in DIGT104 format. The DIGT104 format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 protocol settings for Modbus TCP

If the protocol Modbus TCP is configured for a system interface, you can export the protocol settings in DIGMOD format. The DIGMOD format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 Test Sequences

You can archive individual or all test sequences from 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.

DIGT103

DIGSI 5 protocol settings for IEC 60870-5-103

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

DIGT104

DIGSI 5 protocol settings for IEC 60870-5-104

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

Discovery and Basic Configuration Protocol

The DCP protocol is used to detect devices without an IP address and to assign addresses to these devices.

DNP3

DNP3 is a communication standard for telecontrol engineering. DNP3 is used as a general transmission protocol between control systems and substations, as well as between bay devices and the systems controls.

Double command

Double commands (DPC – **D**ouble **P**oint **C**ontrol) are process outputs which represent 4 process states at 2 outputs: 2 defined states (for example ON/OFF) and 2 undefined states (for example disturbed positions).

Double-point indication

A double-point indication (DPS – **D**ouble **P**oint **S**tatus) ia a process information that represents 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: **D**ouble **P**oint **C**ontrol - double command

DPS

IEC 61850 data type: **D**ouble **P**oint **S**tatus - double-point indication

Drag and drop

Copying, moving, and linkin function, used in graphic user interfaces. Objects are selected with the mouse, held and moved from one data area to another.

DSP5

DIGSI 5 Display Pages

DU

Data **U**nit

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 utilized. 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).

In the case of SIPROTEC 5, the device can also be assigned an IP address via DIGSI and 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 electric equipment functions without error in a specified environment. The environment is not influenced in any impermissible way here.

ENC

Enumerated Status **C**ontrollable

ENS

Enumerated **S**tatus

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.

FC

Ferrule **C**onnector

FEFI

Far **E**nd **F**ault **I**ndication

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 of the output voltage that is not connected to ground is generated. Therefore, no current flows through the body to ground in the event of touching.

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.

GaAs

Gallium arsenide

General Interrogation

The state of all process inputs, of the status, and of the fault 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 (GI).

General Station Description Mark-up Language

GSDML is an XML-based data description language for the creation of 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

Global Navigation Satellite System

A global navigation satellite system or GNSS is a system for determining position and for navigation on the ground and in the air. Position is determined by the receipt of signals from navigation satellites and pseudolites.

GNSS

Global **N**avigation **S**atellite **S**ystem

GOOSE

Generic **O**bject-**O**riented **S**ubstation **E**vent

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 measures for grounding.

GSDML

General **S**tation **D**escription **M**ark-up **L**anguage

Hierarchy level

Within a structure with higher-level and lower-level objects a hierarchy level is a level of equivalent 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 indication and discards the 2nd indication (see PRP protocol).

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 indications in the ring that are not directed at it.

In order to avoid circular indications 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-**M**achine **I**nterface (HMI)

HSR

High Availability **S**eamless **R**edundancy Protocol

HV bay description

The HV project description file contains details of bays which exist in a ModPara project. The actual bay information of each bay is stored in a HV field description file. Within the HV project description file, each bay receives an HV field 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. This data is distributed to several files. One file contains details about the fundamental project structure. This also includes, for example, information detailing which bays exist in this project. This file is called a HV project description file.

ICD

IED **C**apability **D**escription

IEC

International **E**lectrotechnical **C**ommission - International Electrotechnical Standardization Body

IEC 60870-5-103

International standard protocol for communication with IEDs (especially protection devices) Many protection devices, bay units, bay controllers, and measured-value acquisition devices use the IEC 60870-5-103 protocol to communicate with SICAM PAS.

IEC 60870-5-104

Standard international telecontrol protocol. Transmission protocol based on IEC 60870-5-101 for connecting the substation control level to the telecontrol center via TCP/IP protocols using a wide area network connection (WAN).

IEC 60870-5-104 is also used for communicating with IEDs.

IEC 61850

IEC 61850 is an international standard for continuous communication in switchgear. It defines the communication between devices in a switchgear and the corresponding system requirements. All automation functions of a switchgear and their engineering are supported this way. IEC 61850 can also be transferred to automation systems in other applications, for example for controlling and monitoring decentralized 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

Intelligent **E**lectronic **D**evice

IED stands for a physical part of a device (hardware, etc.)

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

Institute of **E**lectrical and **E**lectronic **E**ngineers

IEEE 1588

Time-synchronization protocol according to the standard IEEE 1588-2008. Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (IEEE 1588 v2) and the standard IEEE C37.238-2011: IEEE Standard Profile for Use of IEEE 1588 PTP protocol in Power System Applications (Power Profile).

IEEE 1588v2/PTP

PTP has many optional features and often offers more than one way of doing things. Meaning that it is not mandatory for PTP devices to work together. Provided that they are configured with a compatible set of selection options for IEEE 1588 options and settings. The solution for this is profiles. Profiles are rule sets with restrictions for PTP that are designed to be used to meet the requirements for specific applications or a set of similar applications. The IEEE 1588 standard itself only defines 1 profile, which is designated as the **Default profile**. 2 profiles are used in the power industry: IEC 61850-9-3 (Power Utility Profile) and C37.238-2017 (Power Profile).

IID

Instantiated **I**ED **D**escription

INC

Controllable Integer Status

Input data/input direction

Data is sent from the protocol slave to the protocol master.

INS

Integer **S**tatus

Instantiated IED Description

Files in IID format are ICD files adapted for the specific use case in the project. This format is mainly suitable for exchanging data between DIGSI 5 and an external system configurator or a substation automation system such as SICAM PAS. The ICD format uses SCL as the description language for this.

International Electrotechnical Commission

IEC

Internet Protocol

An Internet protocol (IP) enables the connection of participants which are positioned in different networks.

IO

Input-**O**utput

IO Provider Status

The transmitter (provider) of an IO data element uses this to indicate the state (good/bad, including fault location).

IOPS

IO Provider **S**tatus

IP

Internet **P**rotocol

IPv4

Internet-**P**rotocol **V**ersion 4

ISC

Integer **S**tep **C**ontrolled Position Information

LAN

Local **A**rea **N**etwork

Link address

The link address indicates the address of a SIPROTEC device.

Link Layer Discovery Protocol

The Link Layer Discovery Protocol (LLDP) serves as the basis for topology detection and configuration determination.

List view

The right area of the project window displays the names and icons 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 **L**ayer **D**iscovery **P**rotocol

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.

LPIT

Low-**P**ower **I**nstrument **T**ransformer –
AKA **NCIT** – **N**on **C**onventional **I**nstrument **T**ransformer. Examples: Low-power current transformer, C dividers, R dividers, RC dividers, optical sensors

LPVT

Low-**P**ower **V**oltage **T**ransformer

LSB

Least **S**ignificant **B**it

MAC address

The MAC address (Media Access Control) is the hardware address of each individual network adaptor. It serves to identify the devices in the network unambiguously.

Management Information Base

A Management Information Base (MIB) is a database which continuously saves information and statistics concerning each device in a network. 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.

Master Clock

The **M**aster **C**lock (MC) contains a mechanical or electric mechanism and a contact device, which periodically transmits drive pulses to the slave clocks.

MC

Master **C**lock

Measured Value

This data type provides a measured value that can be used as a CFC result, for instance.

Merging Unit

The **M**erging **U**nit (MU) is used (also for IEC 61850 plant) for the field-signal bus interface. The publisher/server of the sampled measured values is designated as the merging unit.

Metered value

Metered values are a processing function, used to determine the total number of discrete similar events (counter pulses), for example, as integral over a time span. In the power utility field, electrical energy is often recorded as a metered value (energy import/delivery, energy transport).

MIB

Management **I**nformation **B**ase

MICS

Model **I**mplementation **C**onformance **S**tatement

MMS

Manufacturing **M**essage **S**pecification

Modbus

The Modbus protocol is a communication protocol. It is based on a master/slave or client/server architecture.

Model Implementation Conformance Statement

MICS

The Model Implementation Conformance Statement describes in detail the standard data object models that are supported by the system or by the device.

Module

Unit of a device. This can either be a physical module or a functional unit of a device.

MSB

Most **S**ignificant **B**it

MU

Merging **U**nit

MV

Data type **M**easured **V**alue

NACK

Negative **ack**nowledgment

Navigation window

The left area of the project window displays the names and icons of all containers of a project in the form of a folder tree structure.

Network Time Protocol

The **N**etwork **T**ime **P**rotocol is an international standard for time synchronization.

NTP

Network **T**ime **P**rotocol

Object

Each element of a project structure is designated as an object in DIGSI 5.

Object property

Each object has properties. These might 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 **S**witch **M**odule

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 switchover, which avoids any downtime 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**) over 2 separate networks, and unambiguously marks both with a sequence number. The receiver 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 relays no indications to the other network. Since the process is realized in the Ethernet layer (same MAC address), it is transparent and usable for all Ethernet user data 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 indications.

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 set parameters for 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 comprises the name of the participant, the national code, the area index and the participant-specific phone number.

PB Client

Process-**B**us client. The sampled measured values subscriber is designated as a process-bus client.

PICS

Protocol **I**mplementation **C**onformance **S**tatement

Precision Time Protocol

The PTP protocol causes the time settings of several devices in a network to synchronize. PTP is defined in IEEE 1588. The focus of PTP is on higher accuracy and networks that are locally restricted. PTP can achieve an accuracy in the range of nanoseconds in a hardware variant, and in the range of a few milliseconds in a software variant.

PROFIBUS

PROcess **FI**eld **BUS**, German process and fieldbus standard (EN 50170). The standard specifies the functional, electrical, and mechanical characteristics for a bit-serial fieldbus.

PROFIBUS address

An unambiguous 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

Together with an API, the Profile_ID unambiguously defines the access and behavior of an application.

PROFINET IO

PROFINET is the open Industrial Ethernet Standard of PROFIBUS for 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 Block

Building blocks are parts of the user program delimited by their function, structure, and intended use.

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, input/output modules (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 engineering.

Project

Content-wise, a project is the image of a real energy supply system. Graphically, a project is represented as a number of objects which are integrated in a hierarchical structure. Physically, a project consists of a number of directories and files containing project data.

Project tree

The project tree contains a representation of the data structure. This data structure represents the content of the project and is created with 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 consideration various criteria, such as fault distance, fault direction, or fault duration, 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 **R**edundancy **P**rotocol

PTP

Precision-**T**ime **P**rotocol

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

Redundancy box

The RedBox is used to connect a device with only one interface redundantly to both PRP networks LAN A and LAN B. The RedBox is a DAN (Double Attached Node) and functions as a proxy server for the devices (VDANs) connected to it. The RedBox has its own IP address for configuration, administration, and monitoring.

Relay Information by OMICRON

You can use files in RIO format to exchange data between test systems from the company OMICRON and any other desired 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 **R**elay **I**nformation by **O**MICRON

RSTP

Rapid-**S**panning **T**ree **P**rotocol

Sampled Measured Value

IEC 61850 is a communication protocol for electrical substation automation systems. The abstract data models defined in IEC 61850 can be mapped with various protocols. At present, there are mappings in the standard for the following protocols:

MMS (Manufacturing Message Specification)

GOOSE (Generic Object Oriented Substation Event)

SMV (Sampled Measured Value)

Web services (coming soon)

These protocols can run with fast-switching Ethernet via TCP/IP networks or substation LANs to achieve the required response times for protection functions of under 4 ms.

Sampled value

Sampling is the registration of measured values for discrete, mostly equidistant periods of time. This can be used to extract a discrete time signal from a continuous time signal.

Sampling rate

In signal processing, sampling is reducing a continuous time signal (for example current and voltages) to a discrete time signal. A common example is converting soundwave (a continuous signal) into a sampling sequence (a discrete time signal).

SAN

Single **A**ttached **N**ode

An SAN is a non-redundant node in a PRP network. It is connected with a single port to a single network (LAN A or LAN B). It can only communicate in the connected network via nodes. Devices with only one connection can be connected to both networks, LAN A and LAN B, redundantly via a RedBox. In order to keep LAN A and LAN B symmetrical, Siemens recommends avoiding SANs and to connect the devices either via a RedBox or in a separate network without PRP support.

SBO

Select **b**efore **o**perate

SC

Single **c**ommand

SCD

Substation **C**onfiguration **D**escription

SCL

Substation **C**onfiguration Description **L**anguage

SED

System **E**xchange **D**escription

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 behavior, 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)

SFP

Small **F**orm-Factor **P**luggable

SICAM SAS

Substation **A**utomation **S**ystem – Modular substation automation system based on the SICAM SC substation controller and the HMI system SICAM WinCC.

SICAM WinCC

The operator control and monitoring system SICAM WinCC graphically displays the state of your network. SICAM WinCC visualizes alarms and indications, 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 simulation-related files of a SIPROTEC 5 device in SIM format. This new functionality in DIGSI 5 makes it possible to export the simulation data and to create a simulation of all devices in the DIGSI 5 project for testing and commissioning purposes. The simulation is achieved by importing the simulation file into a signal processing and automation system, which then simulates the device/devices using the process data like in a real-time system. This feature allows a device to be tested for various real-time conditions.

Single command

Single commands (SPC – **S**ingle **P**oint **C**ontrol) are process outputs which represent 2 process states (for instance on/off) at one output.

Single-line diagram

A single-line diagram (SLD) is a simplified electrical overview diagram of the switchgear. Instead of all 3 phases, only a single line is shown, hence the name single-line.

Single-Line Editor

The Single-Line Editor (SLE) contains the catalog with the topological elements of a single-line diagram. Using the single-line components, the customer can configure the topological part of the plant.

Single-point indication

Single-point indications (**SPS**) are a type of process information which represents 2 process states (for instance on/off) at one output.

SIPROTEC

The registered trademark SIPROTEC designates the product family of Siemens protection devices and fault recorders.

SIPROTEC 5 device

This object type represents a real SIPROTEC device with all the contained setting values and process data.

Slave device

A slave may only exchange data with a master after being prompted to do so by the master. SIPROTEC devices work as slaves. A master computer controls a slave computer. A master computer can also control a peripheral device.

SLD

Single-**L**ine **D**iagram

SLE

Single-**L**ine **E**ditor

SMV

Sampled **M**easured **V**alue

SNMP

Single **N**etwork **M**anagement **P**rotocol

SNTP

Single **N**etwork**T**ime **P**rotocol

SOE

Sequence **o**f **E**vents

SP

Single-point status

SP

Single-**P**oint Indication

SPC

IEC 61850 data type: **S**ingle **P**oint **C**ontrol

SPS

IEC 61850 data type: **S**ingle **P**oint **S**tatus

SPS

Programmable **L**ogic **C**ontroller

SSD

System **S**pecification **D**escription

ST

Structured **T**ext file

Structured Text file

You can import function charts (CFC) from DIGSI 4 in ST format. Before doing so, export your function charts from DIGSI 4.83 or higher.

Substation Configuration Description

A substation configuration description is an IEC 61850-compliant file for data exchange between the system configurator and the IED configurator. The substation configuration description contains information on the network structure of a substation. The substation configuration description contains for example, information on the assignment of the devices to the primary equipment, as well as on the station-internal communication.

Substation Configuration Description Language

Substation Configuration Description Language (SCL) is a description language standardized in IEC 61850 and 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 generally carried out for all SCL formats, not only for SCD imports.

SV Stream

Sampled **V**alue Stream

The SV stream is a set of current and voltage values that are transmitted in a fast and cyclical fashion. Information exchange is based on a publisher/subscriber mechanism. SV transmission is a continuous stream of layer-2 Ethernet telegrams in one direction. The content of an SV stream can be configured in anyway you wish in accordance with IEC 61869-9. IEC 61850-9-2 LE defines a fixed set of 4 voltage and 4 current values for each SV stream.

System Exchange Description

With files in SED format, you can 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 substation automation system including a single-line configuration of the substation. 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 **A**tomique **I**nternational - International atomic time

TC

Tap-position **c**ommand

TCP

Transmission **C**ontrol **P**rotocol

TEA-X

You can archive the data from individual SIPROTEC 5 devices or whole projects 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.

Time stamp

A time stamp is a value in a defined format. The time stamp assigns a point in time to an event, for example, in a log file. Time stamps ensure that events can be found again.

TOCT

Trench **O**ptical **C**urrent **T**ransformer – Optical current transformer manufactures by Trench

Topological view

The Topological View is oriented to the objects of a system (for example, switchgear) and their relationship 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 packets.

Transparent clock

The Precision Time Protocol (PTP) recognizes different types of clocks: a standard clock (referred to as Ordinary Clock, OC for short), a Boundary Clock (BC) and a Transparent Clock (TC). The transparent clock was integrated in the specification retrospectively in 2008 and serves to improve the transmission of time information within a network by receiving PTP messages and modifying (correcting) them before passing them on.

Tree view

The left area of the project window displays the names and icons of all containers of a project in the form of a folder tree structure. This area is called the 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 **D**atagram **P**rotocol

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 **R**eport **C**ontrol **B**lock

USART

Universal **S**ynchronous/**A**synchronous **R**eceiver/**T**ransmitter

User Datagram Protocol

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 **T**ime **C**oordinated

Vendor ID

Manufacturer-specific part of the device labeling for PROFINET.

Virtual device

A virtual device (VD) 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.

VLAN

Virtual **L**ocal **A**rea **N**etwork

WYE

Phase-to-ground related measurements of a 3-phase system

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