SIEMENS

SIPROTEC 4

Differential Protection 7SD610

V4.7

Manual

Vorwort

Table of Contents

Introduction 1

Functions 2

Mounting and Commissioning 3

Technical Data 4

Ordering Information and Accessories A

Terminal Assignments B

Connection Examples C

Default Settings and Protocol-dependent Functions D

Functions, Settings, Information E

Literature

Glossary

Index

C53000-G1176-C145-8



NOTE

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

Disclaimer of liability

We have checked the text of this manual against the hardware and software described. However, deviations from the description cannot be completely ruled out, so that no liability can be accepted for any errors or omissions contained in the information given.

The information given in this document is reviewed regularly and any necessary corrections will be included in subsequent editions. We appreciate any suggestions for improvement.

We reserve the right to make technical improvements without notice

Document Version V04.41.00

Release date 05.2016

Copyright

Copyright © Siemens AG 2016. All rights reserved.

Dissemination or reproduction of this document, or evaluation and communication of its contents, is not authorized except where expressly permitted. Violations are liable for damages. All rights reserved, particularly for the purposes of patent application or trademark registration.

Registered Trademarks

SIPROTEC, SINAUT, SICAM and DIGSI are registered trademarks of Siemens AG. Other designations in this manual might be trademarks whose use by third parties for their own purposes would infringe the rights of the owner.

Vorwort

Purpose of this Manual

This manual describes the functions, operation, installation, and commissioning of devices 7SD610. In particular, one will find:

- Information regarding the configuration of the scope of the device and a description of the device functions and settings → Chapter 2;
- Instructions for Installation and Commissioning → Chapter 3;
- Compilation of the Technical Data → Chapter 4;
- As well as a compilation of the most significant data for advanced users → Appendix A.

General information with regard to design, configuration, and operation of SIPROTEC 4 devices are set out in the SIPROTEC 4 System Description */1/ SIPROTEC 4 System Description*.

Target Audience

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

Applicability of this Manual

This manual applies to: SIPROTEC 4 Differential Protection 7SD610; Firmware-Version V4.7.

Indication of Conformity

CE	This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95 EC). This conformity is proved by tests conducted by Siemens AG in accordance with the Council Directives in agreement with the generic standards EN61000-6-2 and EN 61000-6-4 for the EMC directive, and with the standard EN 60255-27 for the low-voltage directive. The device has been designed and produced for industrial use. The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

Additional Standards IEEE Std C37.90 (see Chapter 4, "Technical Data")

c UL us LISTED IND. CONT. EQ. 69CA

c RU us IND. CONT. EQ.

[ul-schutz-110602-kn, 1, --_--]

Additional Support

For questions about the SIPROTEC 4 system, please contact your Siemens sales partner.
Our Customer Support Center provides a 24-hour service.
Phone: +49 (180) 524-8437
Fax: +49 (180) 524-2471
e-mail: support.ic@siemens.com

Training Courses

Enquiries regarding individual training courses should be addressed to our Training Center:
Siemens AG
Siemens Power Academy TD
Humboldt Street 59 59
90459 Nuremberg
Phone: +49 (911) 433-7415
Fax: +49 (911) 433-5482
Internet: www.siemens.com/energy/power-academy
e-mail: poweracademy.ic-sg@siemens.com

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

GEFAHR bedeutet, dass Tod oder schwere Verletzungen eintreten **werden**, wenn die angegebenen Maßnahmen nicht getroffen werden.

- ✧ Beachten Sie alle Hinweise, um Tod oder schwere Verletzungen zu vermeiden.
- ✧ Danger indicates that death, severe personal injury or substantial material damage will result if proper precautions are not taken.



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.



NOTE

indicates information on the device, handling of the device, or the respective part of the instruction manual which is important to be noted.

Typographic and Symbol Conventions

The following text formats are used when literal information from the device or to the device appear in the text flow:

Parameter Names

Designators of configuration or function parameters which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI), are marked in bold letters in monospace type style. The same applies to titles of menus.

1234A

Parameter addresses have the same character style as parameter names. Parameter addresses contain the suffix **A** in the overview tables if the parameter can only be set in DIGSI via the option **Display additional settings**.

Parameter Options

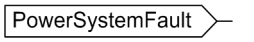
Possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI), are additionally written in italics. The same applies to the options of the menus.

Indications

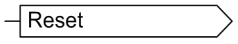
Designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotation marks.

Deviations may be permitted in drawings and tables when the type of designator can be obviously derived from the illustration.

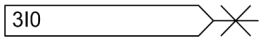
The following symbols are used in drawings:



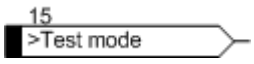
Device-internal logical input signal



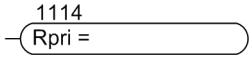
Device-internal logical output signal



Internal input signal of an analog quantity



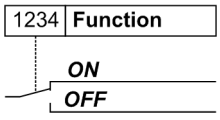
External binary input signal with number (binary input, input indication)



External binary output signal with number (example of a value indication)

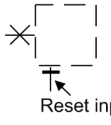


External binary output signal with number (device indication) used as input signal

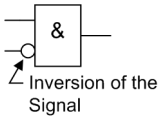


Example of a parameter switch designated **FUNCTION** with address 1234 and the possible settings ***Ein*** and ***Aus***

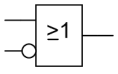
Besides these, graphical symbols are used in accordance with IEC 60617-12 and IEC 60617-13 or similar. Some of the most frequently used are listed below:



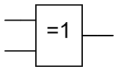
Analog input variable



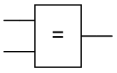
AND-gate operation of input values



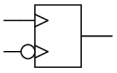
OR-gate operation of input values



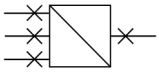
Exclusive OR gate (antivalence): output is active, if only **one** of the inputs is active



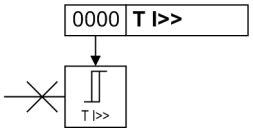
Coincidence gate: output is active, if **both** inputs are active or inactive at the same time



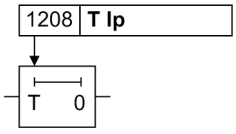
Dynamic inputs (edge-triggered) above with positive, below with negative edge



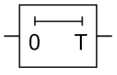
Formation of one analog output signal from a number of analog input signals



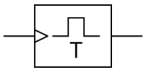
Limit stage with setting address and parameter designator (name)



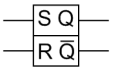
Timer (pickup delay T, example adjustable) with setting address and parameter designator (name)



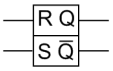
Timer (dropout delay T, example non-adjustable)



Dynamic triggered pulse timer T (monoflop)



Static memory (SR flipflop) with setting input (S), resetting input (R), output (Q) and inverted output ($\overline{Q}$), setting input dominant



Static memory (RS-flipflop) with setting input (S), resetting input (R), output (Q) and inverted output ($\overline{Q}$), resetting input dominant

Table of Contents

Vorwort **3**

1 Introduction **13**

1.1 Gesamtfunktion 14

1.2 Application Scope 17

1.3 Characteristics 19

2 Functions **23**

2.1 General 24

2.1.1 Functional Scope 24
2.1.1.1 Configuration of the Scope of Functions 24
2.1.1.2 Setting Notes 25
2.1.1.3 Settings 26

2.1.2 General Power System Data (Power System Data 1) 27
2.1.2.1 Setting Notes 28
2.1.2.2 Settings 33

2.1.3 Change Group 34
2.1.3.1 Purpose of the Setting Groups 34
2.1.3.2 Setting Notes 34
2.1.3.3 Settings 34
2.1.3.4 Information List 35

2.1.4 General Protection Data (Power System Data 2) 35
2.1.4.1 Setting Notes 35
2.1.4.2 Settings 39
2.1.4.3 Information List 41

2.2 Protection Data Interfaces and Protection Data Topology 43

2.2.1 Functional Description 43
2.2.1.1 Protection Data Topology / Protection Data Communication 43

2.2.2 Operating Modes of the Differential Protection 45
2.2.2.1 Mode: Log Out Device 45
2.2.2.2 Differential Protection Test Mode 47
2.2.2.3 Differential Protection Commissioning Mode 48

2.2.3 Protection Data Interfaces 50
2.2.3.1 Setting Notes 50
2.2.3.2 Settings 52
2.2.3.3 Information List 53

2.2.4 Differential Protection Topology 53
2.2.4.1 Setting Notes 53
2.2.4.2 Settings 54
2.2.4.3 Information List 55

2.3 Differential Protection 56

2.3.1 Functional Description 56

2.3.2 Setting Notes 63

2.3.3 Settings 66

2.3.4 Information List ... 66
2.4 Breaker Intertrip and Remote Tripping ... 68
2.4.1 Functional Description ... 68
2.4.2 Setting Notes ... 69
2.4.3 Settings ... 70
2.4.4 Information List ... 70
2.5 Restricted Earth Fault Protection (optional) ... 71
2.5.1 Application Examples ... 71
2.5.2 Functional Description ... 72
2.5.3 Setting Notes ... 76
2.5.4 Settings ... 77
2.5.5 Information List ... 77
2.6 Direct Local Trip ... 78
2.6.1 Funktional Description ... 78
2.6.2 Setting Notes ... 78
2.6.3 Settings ... 79
2.6.4 Information List ... 79
2.7 Transmission of binary commands and messages ... 80
2.7.1 Functional Description ... 80
2.7.2 Information List ... 80
2.8 Instantaneous High-Current Switch-onto-Fault Protection (SOTF) ... 83
2.8.1 Functional Description ... 83
2.8.2 Setting Notes ... 85
2.8.3 Settings ... 86
2.8.4 Information List ... 87
2.9 Backup Time Overcurrent Protection ... 88
2.9.1 General ... 88
2.9.2 Functional Description ... 88
2.9.3 Setting Notes ... 100
2.9.4 Settings ... 106
2.9.5 Information List ... 109
2.10 Automatic Reclosure Function (optional) ... 111
2.10.1 Functional Description ... 111
2.10.2 Setting Notes ... 125
2.10.3 Settings ... 131
2.10.4 Information List ... 133
2.11 Undervoltage and Overvoltage Protection (optional) ... 136
2.11.1 Overvoltage Protection ... 136
2.11.2 Undervoltage Protection ... 142
2.11.3 Setting Notes ... 146
2.11.4 Settings ... 150
2.11.5 Information List ... 152
2.12 Frequency Protection (optional) ... 155
2.12.1 Functional Description ... 155
2.12.2 Setting Notes ... 157
2.12.3 Settings ... 159

2.12.4 Information List ... 159
2.13 Circuit Breaker Failure Protection ... 161
2.13.1 Functional Description ... 161
2.13.2 Setting Notes ... 171
2.13.3 Settings ... 174
2.13.4 Information List ... 175
2.14 Thermal Overload Protection ... 177
2.14.1 Functional Description ... 177
2.14.2 Setting Notes ... 178
2.14.3 Settings ... 180
2.14.4 Information List ... 180
2.15 Monitoring Functions ... 181
2.15.1 Measurement Supervision ... 181
2.15.1.1 Hardware Monitoring ... 181
2.15.1.2 Software Monitoring ... 183
2.15.1.3 Measurement Circuit Monitoring ... 183
2.15.1.4 Monitoring the Phase Angle of the Positive Sequence Power ... 191
2.15.1.5 Fault Reactions ... 193
2.15.1.6 Setting Notes ... 194
2.15.1.7 Settings ... 196
2.15.1.8 Information List ... 197
2.15.2 Trip Circuit Supervision ... 198
2.15.2.1 Functional Description ... 198
2.15.2.2 Setting Notes ... 201
2.15.2.3 Settings ... 201
2.15.2.4 Information List ... 201
2.16 Function Control and Circuit Breaker Test ... 202
2.16.1 Function Control ... 202
2.16.1.1 Line Energization Recognition ... 202
2.16.1.2 Detection of the Circuit Breaker Position ... 205
2.16.1.3 Open Pole Detector ... 208
2.16.1.4 Pickup Logic of the Entire Device ... 210
2.16.1.5 Tripping Logic of the Entire Device ... 211
2.16.2 Circuit Breaker Test ... 215
2.16.2.1 Functional Description ... 215
2.16.2.2 Information List ... 216
2.16.3 Device ... 216
2.16.3.1 Trip-Dependent Indications ... 216
2.16.3.2 Switching Statistics ... 217
2.16.3.3 Setting Notes ... 218
2.16.3.4 Settings ... 218
2.16.3.5 Information List ... 218
2.16.4 EN100-Modul 1 ... 220
2.16.4.1 Functional Description ... 220
2.16.4.2 Setting Notes ... 220
2.16.4.3 Information List ... 220
2.17 Auxiliary Functions ... 221
2.17.1 Commissioning Aids ... 221
2.17.1.1 Functional Description ... 221
2.17.1.2 Setting Notes ... 223
2.17.2 Processing of Messages ... 223
2.17.2.1 Functional Description ... 223

2.17.3 Statistics....226
2.17.3.1 Functional Description.... 226
2.17.3.2 Information List.... 227
2.17.4 Measurement During Operation....228
2.17.4.1 Function Description.... 228
2.17.4.2 Information List.... 229
2.17.5 Differential Protection Values....230
2.17.5.1 Measured values of differential protection....230
2.17.5.2 Information List.... 231
2.17.6 Measured Values Constellation.... 231
2.17.6.1 Functional Description.... 231
2.17.7 Oscillographic Fault Records.... 232
2.17.7.1 Functional Description 232
2.17.7.2 Setting Notes.... 232
2.17.7.3 Settings.... 233
2.17.7.4 Information List.... 233
2.17.8 Energy....233
2.17.8.1 Energy Metering.... 233
2.17.8.2 Setting Notes.... 234
2.17.8.3 Information List.... 234
2.18 Command Processing 235
2.18.1 Control Authorization.... 235
2.18.1.1 Type of Commands.... 235
2.18.1.2 Sequence in the Command Path....235
2.18.1.3 Interlocking.... 236
2.18.1.4 Information List.... 239
2.18.2 Control Device....239
2.18.2.1 Information List.... 239
2.18.3 Process Data....240
2.18.3.1 Functional Description.... 240
2.18.3.2 Information List.... 240
2.18.4 Protocol....241
2.18.4.1 Information List.... 241

3 Mounting and Commissioning.... 243

3.1 Mounting and Connections.... 244
3.1.1 Configuration Information.... 244
3.1.2 Hardware Modifications....248
3.1.2.1 General....248
3.1.2.2 Demontage....249
3.1.2.3 Switching Elements on Printed Circuit Boards.... 251
3.1.2.4 Interface Modules.... 255
3.1.2.5 Reassembly....258
3.1.3 Mounting.... 258
3.1.3.1 Panel Flush Mounting....258
3.1.3.2 Rack and Cubicle Mounting.... 259
3.1.3.3 Panel Mounting....260
3.2 Checking Connections....261
3.2.1 Checking Data Connections of Serial Interfaces.... 261
3.2.2 Checking the Protection Data Communication....263
3.2.3 Checking the System Connections.... 264
3.3 Commissioning.... 266
3.3.1 Test Mode / Transmission Block....267

3.3.2 Checking the Time Synchronisation Interface ... 267
3.3.3 Checking the System Interface ... 267
3.3.4 Checking the switching states of the binary Inputs/Outputs ... 269
3.3.5 Checking the Protection Data Topology ... 271
3.3.6 Checking for Breaker Failure Protection ... 278
3.3.7 Checking the Instrument Transformer Connections of One Line End ... 280
3.3.8 Checking the Instrument Transformer Connections with Two Line Ends ... 281
3.3.9 Checking the Signal Transmission for Internal and External Remote Tripping ... 287
3.3.10 Checking the User-defined Functions ... 287
3.3.11 Trip and Close Test with the Circuit Breaker ... 287
3.3.12 Switching Test of the Configured Operating Equipment ... 288
3.3.13 Triggering Oscillographic Recording for Test ... 288
3.4 Final Preparation of the Device ... 290

4 Technical Data ... 291

4.1 General ... 292
4.1.1 Analogue Inputs and Outputs ... 292
4.1.2 Auxiliary voltage ... 292
4.1.3 Binary Inputs and Outputs ... 293
4.1.4 Communication Interfaces ... 294
4.1.5 Electrical Tests ... 298
4.1.6 Mechanical Tests ... 299
4.1.7 Climatic Stress Tests ... 300
4.1.8 Deployment Conditions ... 301
4.1.9 Constructive versions ... 301
4.2 Protection Data Interfaces and Differential Protection Topology ... 302
4.3 Differential Protection ... 306
4.4 Restricted Earth Fault Protection ... 308
4.5 Breaker Intertrip and Remote Tripping- Direct Local Trip ... 309
4.6 Transmission of Binary Information (optional) ... 310
4.7 Instantaneous High-Current Switch-onto-Fault Protection (SOTF) ... 311
4.8 Backup Time Overcurrent Protection ... 312
4.9 Automatic Reclosure (optional) ... 319
4.10 Voltage Protection (optional) ... 320
4.11 Frequency Protection (optional) ... 323
4.12 Circuit Breaker Failure Protection (optional) ... 324
4.13 Thermal Overload Protection ... 325
4.14 Monitoring Functions ... 327
4.15 User defined functions (CFC) ... 329
4.16 Additional Functions ... 333
4.17 Dimensions ... 336
4.17.1 Housing for Panel Flush Mounting or Cubicle Installation ... 336
4.17.2 Panel Surface Mounting ... 337

A Ordering Information and Accessories ... 339

A.1 Ordering Information ... 340

A.2 Accessories ... 343

B Terminal Assignments ... 347

B.1 Housing for Panel Flush and Cubicle Mounting ... 348

B.2 Housing for panel surface mounting ... 349

C Connection Examples ... 351

C.1 Current Transformer Connection Examples ... 352

C.2 Voltage Transformer Examples ... 354

D Default Settings and Protocol-dependent Functions ... 355

D.1 LEDs ... 356

D.2 Binary Input ... 357

D.3 Binary Output ... 358

D.4 Function Keys ... 359

D.5 Default Display ... 360

D.6 Pre-defined CFC Charts ... 361

D.7 Protocol-dependent Functions ... 362

E Functions, Settings, Information ... 363

E.1 Functional Scope ... 364

E.2 Settings ... 366

E.3 Information List ... 381

E.4 Group Alarms ... 425

E.5 Measured Values ... 426

Literature ... 431

Glossary ... 433

Index ... 443

1 Introduction

The SIPROTEC 4 7SD610 is introduced in this chapter. The device is presented in its application, characteristics, and functional scope.

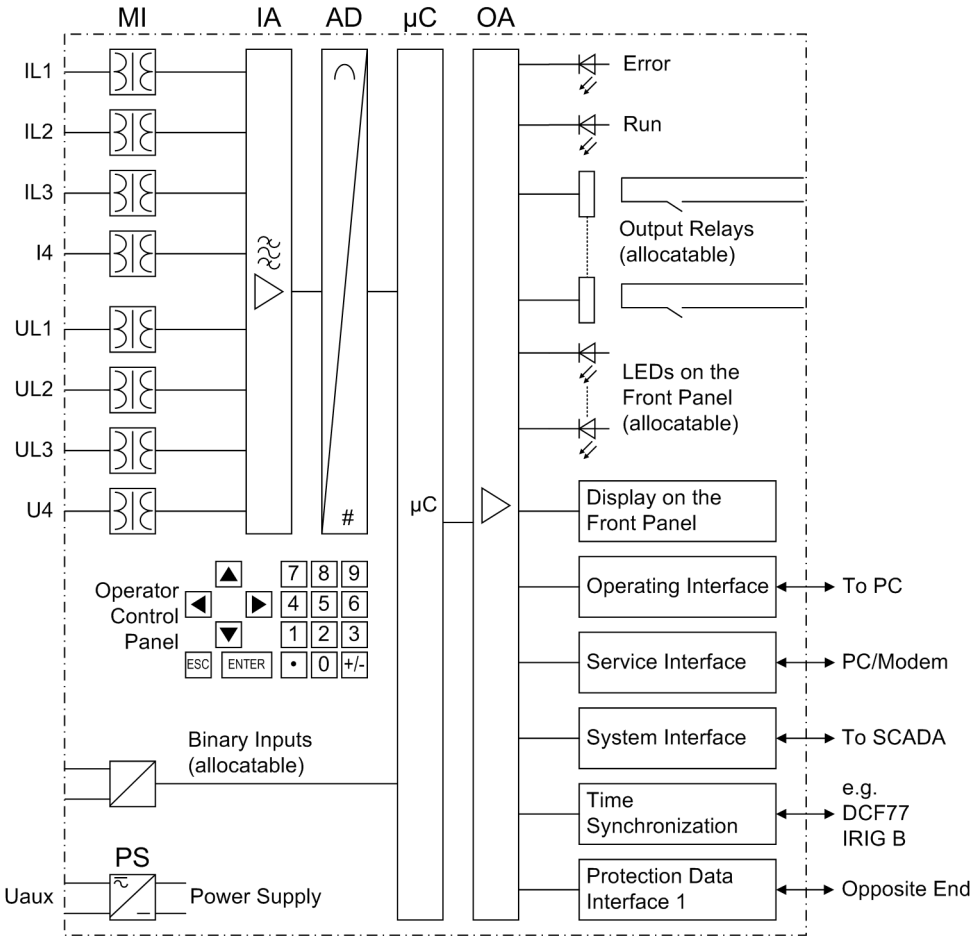
1.1	Gesamtfunktion	14
1.2	Application Scope	17
1.3	Characteristics	19

1.1 Gesamtfunktion

The SIPROTEC 4 7SD610 line protection is equipped with a powerful microprocessor system. This provides fully digital processing of all functions in the device, from the acquisition of the measured values up to the output of commands to the circuit breakers, as well as the exchange of measured data with the other ends of the protected area. *Figure 1-1* shows the basic structure of the device.

Analog Inputs

The measuring inputs (MI) convert the currents and voltages coming from the instrument transformers and adapt them to the level appropriate for the internal processing of the device. The device has 4 current and 4 voltage inputs. Three current inputs are provided for measurement of the phase currents, a further measuring input (I_4) may be used for the earth current (current transformer starpoint or a separate earth current transformer) or the starpoint current of the transformer side to be protected (earth fault differential protection).



[hw-struktur-060406, 1, en_GB]

Figure 1-1 Hardware structure of the differential protection 7SD610

A voltage measuring input is provided for each phase-earth voltage. In principle, the differential protection does not require any measured voltage, however, for the directed overcurrent time protection, the connection of the phase earth voltages U_{L1}, U_{L2} and U_{L3} is definitely required. Additionally, voltages that allow to display voltages and powers and serve to measure the line voltage also for automatic reclosure can be connected to the device. A further voltage input (U_4) may optionally be used to measure either the displacement voltage (e-n voltage), or for any other voltage U_x (for overvoltage protection). The analogue values are transferred further to the IA input amplifier group.

The input amplifier group IA provides high-resistance termination for the analog input quantities. It consists of filters that are optimized for measured value processing with regard to bandwidth and processing speed.

The AD analog-to-digital converter group contains analog/digital converters and memory chips for data transfer to the microcomputer system.

Microcomputer System

Apart from processing the measured values, the microcomputer system µC also executes the actual protection and control functions. This especially includes:

- Filtering and conditioning of the measured signals
- Continuous monitoring of the measured quantities
- Monitoring of the pickup conditions for the individual protection functions
- Formation of the local differential protection values (phasor analysis and charge current computation) and creation of the transmission protocol
- Decoding of the received transmission protocol, synchronisation of the differential protection values and summing up of the differential currents and charge currents
- monitoring of the communication with the other devices of the line protection system
- Monitoring of limit values and time sequences
- Control of signals for logical functions
- Reaching trip and close command decisions
- Recording of messages, fault data and fault values for analysis
- Administration of the operating system and its functions, e.g. data storage, realtime clock, communication, interfaces, etc.

The information is provided via output amplifier OA.

Binary Inputs and Outputs

Binary inputs from and outputs to the computer system are routed via the I/O modules (inputs and outputs). The computer system obtains information from the system (e.g remote resetting) or from the external equipment (e.g. blocking commands). Outputs are commands that are issued to the switching devices and messages for remote signaling of important events and states.

Front Elements

LEDs and an LC display provide information on the function of the device and indicate events, states and measured values.

Integrated control and numeric keys in conjunction with the LCD facilitate local communication with the device. Thus, all information of the device, e.g. configuration and setting parameters, operating and fault messages, and measured values can be retrieved or changed (see also chapter 2 and SIPROTEC 4 System Description).

Devices with control functions also allow control of switchgear from the front panel.

Serial Interfaces

The serial operator interface in the front cover enables communication with a personal computer when using the DIGSI operating program. This allows all device functions to be handled conveniently.

The serial service interface can also be used for communication with a personal computer using DIGSI. This port is especially well suited for a permanent connection of the devices to the PC or for operation via a modem.

All device data can be transmitted to a control center through the serial system interface. Various protocols and physical arrangements are available for this interface to suit a particular application.

An additional interface is provided for time synchronization of the internal clock through external synchronization sources.

Further communication protocols can be realized via additional interface modules.

The operator or service interface allows the communication with the devices at all ends of the protected object during commissioning, checking and also during operation using a standard browser via a communication network This function is supported by a comprehensive “WEB-Monitor” which has been optimised especially for the line protection system.

Protection Data Interface

The protection data interface is a particular case. It is used to transfer the measuring data from each end of the protection area to the opposite end. Further information such as closing the local circuit breaker, pickup of the inrush restraint as well as other external trip commands coupled via binary inputs or binary information can be transmitted to the other end via the protection data interface.

Power Supply

The functional units described are powered by a power supply, PS, with adequate power in the different voltage levels. Brief supply voltage dips which may occur during short circuits in the auxiliary voltage supply of the substation, are usually bridged by a capacitor (see also Technical Data, Section *4.1 General*).

1.2 Application Scope

The digital Differential Protection SIPROTEC 4 7SD610 is a selective short-circuit protection for overhead lines and cables with single- and multi-ended infeeds in radial, ring or any type of meshed systems of any voltage level. Conditioning of the system starpoint is irrelevant, as measuring data are compared separately for each phase.

High sensitivity and the inrush current restraint allow for the application of the 7SD610 even if a power transformer is located within the protected zone (ordering option) whose starpoint(s) might also be isolated, earthed or provided with a Petersen coil.

A major advantage of the differential protection principle is the instantaneous tripping in the event of a short-circuit at any point within the entire protected zone. The current transformers limit the protected zone at the ends towards the remaining system. This rigid delimitation is the reason why the differential protection scheme shows such an ideal selectivity.

The differential protection system requires a 7SD610 device as well as a set of current transformers at either end of the protected zone. Voltage transformers are not required. However, they are available for indicating and processing of measured values (voltages, power, power factor), or when using a directional overcurrent protection stage (ordering variant).

The devices located at the ends of the protected zone exchange measuring information via protection data interfaces using dedicated communication links (usually fibre-optic cables) or a communication network. Using 7SD610, a protected object with two ends can be protected: cable, overhead line or both, even with unit-connected power transformer (ordering option). For each end, a 7SD610 is used.

Since fault-free data transmission is the prerequisite for the proper operation of the protection, it is continuously monitored internally.

Protection Functions

Recognition of short-circuits in the protection zone – even of weak-current or high-resistive shorting – is the basic function of the device. Even complex multiphase faults are precisely detected, as the measured values are evaluated phase-segregated. The protection system is restrained against inrush currents of power transformers. When switching onto a fault at any point of a line, an undelayed trip signal can be emitted.

In the event of a communication failure, the devices can automatically be switched to emergency operation using an integrated time overcurrent protection until communication is restored. This overcurrent time protection has three definite-time overcurrent stages and one inverse-time stage. Furthermore, the device has one directional definite-time overcurrent stage and one directional inverse stage which enables an increased selectivity of the emergency function. For inverse time overcurrent protection stages, several curves of different standards are provided.

Alternatively, the time overcurrent protection can be used as a backup time overcurrent protection, i.e. it operates independent of and parallel to the differential protection at either end.

The communication connection can be used for transmitting further information. Besides measured values, binary commands or other information can be transmitted as well (ordering variant).

Depending on the order variant, the short-circuit protection functions may also trip single-pole, and may work in co-operation with an integrated automatic reclosure (optionally). The automatic reclosure function enables for single-pole, three-pole or single- and three-pole automatic reclosure as well as several interrupt cycles on overhead lines.

Apart from the short-circuit protection functions mentioned, a thermal overload protection has been integrated which protects in particular cables and power transformers from undue heating through overload. Furthermore, multi-step over- and undervoltage as well as frequency protection and restricted earth fault protection can be used (ordering variant). An optional circuit breaker failure protection monitors the circuit breaker response after a trip command (ordering variant).

Control Functions

The device is equipped with control functions which operate, close and open, switchgear devices via control keys, the system interface, binary inputs and a PC with DIGSI software. The status of the primary equipment can be transmitted to the device via auxiliary contacts connected to binary inputs. The present status (or position) of the primary equipment can be displayed on the device, and used for interlocking or plausibility monitoring. The number of the devices to be switched is limited by the binary inputs and outputs available in the

device or the binary inputs and outputs allocated for the switch position feedbacks. Depending on the mode of operation, one binary input (single point indication) or two binary inputs (double point indication) can be used. The capability of switching primary equipment can be restricted by appropriate settings for the switching authority (remote or local), and by the operating mode (interlocked/non-interlocked, with or without password validation). Interlocking conditions for switching (e.g. switchgear interlocking) can be established using the integrated userdefined logic.

Indications and Measured Values; Fault Recording

The operational indications provide information about conditions in the power system and the device. Measurement quantities and values that are calculated can be displayed locally and communicated via the serial interfaces.

Device messages can be assigned to a number of LEDs on the front panel (programmable), can be externally processed via output contacts (programmable), linked with user-definable logic functions and/or issued via serial interfaces (see Communication below).

During a fault (system fault) important events and changes in conditions are saved in fault logs. Instantaneous fault values are also saved in the device and may be analysed at a later time.

The fault values are synchronized between the line terminals via the communication link.

Communication

Serial interfaces are available for the communication with operating, control and memory systems.

A 9-pin DSUB socket on the front panel is used for local communication with a personal computer. By means of the SIPROTEC 4 operating software DIGSI, all operational and evaluation tasks can be executed via this operator interface, such as specifying and modifying configuration parameters and settings, configuring userspecific logic functions, retrieving operational and fault messages and measured values, reading out and displaying fault recordings, inquiring device conditions and measured values, issuing control commands.

To establish an extensive communication with other digital operating, control and memory components the device may be provided with further interfaces depending on the order variant.

The service interface can be operated via the RS232 or RS485 interface and also allows communication via modem. For this reason, remote operation is possible via PC and the DIGSI operating software, e.g. to operate several devices via a central PC.

The system interface is used for central communication between the device and a control center. It can be operated through the RS232, the RS485 or the FO port. Several standardized protocols are available for data transmission. An EN 100 module allows integrating the devices into 100 MBit Ethernet communication networks of the process control and automation system, using IEC 61850 protocols. In parallel to the link with the process control and automation system, this interface can also handle DIGSI communication and interrelay communication using GOOSE messaging.

Another interface is provided for the time synchronization of the internal clock via external synchronization sources (IRIG-B or DCF77).

Other interfaces provide for communication between the devices at the ends of the protected object. These protection data interfaces have been mentioned above in the protection functions.

The operator or service interface allows to operate the device remotely or locally using a standard browser. This is possible during commissioning, checking and also during operation with the devices at all ends of the protected object via a communication network. For this purpose, a “WEB-Monitor” is provided, which has been optimised specially for the differential protection system

1.3 Characteristics

General Features

- Powerful 32-bit microprocessor system
- Complete digital processing of measured values and control, from the sampling of the analog input values, the processing and organization of the communication between devices up to the closing and tripping commands to the circuit breakers
- Complete galvanic separation and interference immunity of the internal processing circuits from the measurement, control, and power supply circuits by analog input transducers, binary inputs and outputs and the DC/DC or AC/DC converters
- Suited for lines with 2 ends, even with transformers in the protected zone (order option)
- Simple device operation using the integrated operator panel or a connected personal computer with operator guidance
- Storage of fault indications and instantaneous values for fault recording

Differential Protection

- Differential protection system for 2 ends with digital protection data transmission
- Protection for all types of short-circuits in systems with any neutral-point treatment conditioning
- Reliable differentiation between load and fault conditions also in high-resistant, current-weak faults by adaptive measuring procedures
- High sensitivity in case of weakly loaded system, extreme stability against load jumps and power swings
- Phase-selective measurement ensures that the pickup sensitivity is independent of the fault type
- Suited for transformers in the protected zone (order variant)
- Detection of high-resistance, weak-current faults due to high sensitivity of the protection functions
- Insensitive to inrush and charging currents – also for transformers in the protected zone – and to higher-frequency transient processes
- High stability also for different current transformer saturation
- Adaptive stabilisation that is automatically derived from the measured quantities and the configured current transformer data
- Fast, phase segregated tripping also on weak or zero infeed ends (breaker intertrip)
- Low dependence on frequency
- Digital protection data transmission; communication between devices via dedicated communication links (in general optical fibre) or a communication system
- Communication possible via a single copper wire pair (typically 8 km, max. up to 30 km, depending on cable type used)
- Synchronization via GPS possible, resulting in automatic correction of transmission time differences thus increasing once more the sensitivity
- Permanent monitoring of the protection data transmission concerning disturbance, failure or transfer time deviations in the transmission network with automatic transfer time correction
- Phase segregated tripping possible (for operation with single-pole or single-and three-pole auto-reclosure) (order variant)

Restricted Earth Fault Protection

- Earth fault protection for earthed transformer windings
- Short tripping time

- High sensitivity for earth faults
- High stability against external earth faults using the magnitude and phase relationship of through-flowing earth current

External Direct and Remote Tripping

- Tripping of the local end by an external device via binary input
- Tripping of the remote end by internal protection functions or by an external device via binary input

Transmission of Information

- Transmission of measured values from the other end of the protected object
- Transmission of up to 4 fast commands to all remote ends (optional)

Time Overcurrent Protection

- Selectable as emergency function during protection data communication failure or as backup function or as both
- Maximal three definite time stages and one inverse time stage each for phase currents and earth current
- One directional definite time stages and one directional inverse time stage, each for phase currents and earth current
- For inverse-time overcurrent protection select from various characteristics based on several standards
- Blocking capability e.g. for reverse interlocking with any stage
- Instantaneous tripping by any stage when switching onto a fault

Instantaneous High-Current Switch-onto-Fault Protection

- Fast tripping for all faults on total line length
- Selectable for manual closure or following each closure of the circuit breaker
- with integrated line energisation detection

Automatic Reclosure Function (optional)

- For reclosure after 1-pole, 3-pole or 1-pole and 3-pole tripping
- Single or multiple reclosure (up to 8 reclosure attempts)
- With separate action time setting for the first 4 reclose attempts, optionally without action times
- With separate dead times after 1-pole and 3-pole tripping, separate for the first four reclosure attempts
- With the option of an adaptive dead time: in this case the one device controls the automatic reclosure cycles whilst at the other line end the automatic reclosure solely depends on the one controlling device. The criteria used are voltage measurement and/or the transmitted CLOSE command (Remote-CLOSE)
- Automatic reclosure controlled optionally by protection start with separate dead times after single, two and three-pole starting

Voltage Protection (optional)

- Overvoltage and undervoltage detection with different stages
- Two overvoltage stages for the phase-earth voltages
- Two overvoltage stages for the phase-phase voltages
- Two overvoltage stages for the positive sequence voltage, optionally with compounding
- Two overvoltage stages for the negative sequence voltage
- Two overvoltage stages for the zero sequence voltage or any other single-phase voltage

- Settable dropout to pickup ratios
- Two undervoltage stages for the phase-earth voltages
- Two undervoltage stages for the phase-phase voltages
- Two undervoltage stages for the positive sequence voltage
- Settable current criterion for undervoltage protection functions

Frequency Protection (optional)

- Monitoring on underfrequency (f<) and/or overfrequency (f>) with 4 frequency limits and delay times that are independently adjustable
- Very insensitive to harmonics and abrupt phase angle changes
- Large frequency range (approx. 25 Hz to 70 Hz)

Circuit Breaker Failure Protection (optional)

- With definite time current stages for monitoring the current flow through every pole of the circuit breaker
- Separate pickup thresholds for phase and earth currents
- Independent timers for single-pole and three-pole tripping
- Start by trip command of every internal protection function
- Start by external trip functions possible
- Single-stage or two-stage
- Short dropout and overshoot times
- End fault protection and pole discrepancy monitoring possible

Thermal Overload Protection (optional)

- Thermal replica of the current heat losses of the protected object
- R.M.S. measurement of all three phase currents
- Settable thermal and current-dependent warning stages

User-defined Logic Functions (CFC)

- Freely programmable combination of internal and external signals for the implementation of user-defined logic functions
- All typical logic functions
- Time delays and limit value inquiries

Commissioning; Operation; Maintenance

- Display of magnitude and phase angle of local and remote measured values
- Indication of the calculated differential and restraint currents
- Display of measured values of the communication link, such as transmission delay and availability

Command Processing

- Switchgear can be switched on and off manually via local control keys, the programmable function keys on the front panel, via the system interface (e.g. by SICAM or LSA), or via the operator interface (using a personal computer and the operating software DIGSI)
- Feedback on switching states via the circuit breaker auxiliary contacts (for commands with feedback)
- Monitoring of the circuit breaker position and of the interlocking conditions for switching operations.

Monitoring Functions

- Increase of the availability of the device by monitoring of the internal measurement circuits, auxiliary power supply, hardware, and software
- Monitoring of the current and voltage transformer secondary circuits by means of summation and symmetry checks
- Monitoring of communication with statistics showing the number of faulty transmission telegrams
- Check of the consistency of protection settings at both line ends: no processor system start-up with inconsistent settings which could lead to a malfunction of the differential protection system
- Trip circuit supervision
- Check of local and remote measured values and comparison of both
- Broken wire supervision for the secondary CT circuits with fast phase-segregated blocking of the differential protection system in order to avoid malfunction
- Supervision of measuring voltage failure using “Fuse Failure Monitor”

Additional Functions

- Battery buffered real-time clock, which may be synchronized via a synchronization signal (e.g. DCF77, IRIG B, GPS via satellite receiver), binary input or system interface
- Automatic time synchronization between the devices at the ends of the protected object via the protection data transmission
- Continuous calculation and display of measured quantities on the front of the device. Indication of measured quantities of the remote end
- Fault event memory (trip log) for the last 8 network faults (faults in the power system), with real time stamps
- Fault recording memory and and transmission of the data for fault recording for a maximum time range of 30 s, synchronized between the devices of the differential protection system
- Switching statistics: Counting of the trip and close commands issued by the device, as well as recording of the fault current data and accumulation of the interrupted fault currents
- Communication with central control and memory components possible via serial interfaces (depending on the options ordered), optionally via RS232, RS485, modem connection or fibre optic cable
- Commissioning aids such as connection and direction checks as well as circuit breaker test functions
- The WEB-Monitor (installed on a PC or a laptop) widely supports the testing and commissioning procedure. The communication topology of the differential protection and communication system, phasor diagrams of all currents and (if applicable) voltages at both ends of the differential system are displayed as a graph

2 Functions

This chapter describes the individual functions of the SIPROTEC 4 device 7SD610. It shows the setting possibilities for each function in maximum configuration. Guidelines for establishing setting values and, where required, formulae are given.

Based on the following information, it can also be determined which of the provided functions should be used.

2.1	General	24
2.2	Protection Data Interfaces and Protection Data Topology	43
2.3	Differential Protection	56
2.4	Breaker Intertrip and Remote Tripping	68
2.5	Restricted Earth Fault Protection (optional)	71
2.6	Direct Local Trip	78
2.7	Transmission of binary commands and messages	80
2.8	Instantaneous High-Current Switch-onto-Fault Protection (SOTF)	83
2.9	Backup Time Overcurrent Protection	88
2.10	Automatic Reclosure Function (optional)	111
2.11	Undervoltage and Overvoltage Protection (optional)	136
2.12	Frequency Protection (optional)	155
2.13	Circuit Breaker Failure Protection	161
2.14	Thermal Overload Protection	177
2.15	Monitoring Functions	181
2.16	Function Control and Circuit Breaker Test	202
2.17	Auxiliary Functions	221
2.18	Command Processing	235

2.1 General

A few seconds after the device is switched on, the default display appears on the LCD. In the 7SD610 the measured values are displayed.

Configuration settings can be entered by using a PC and the DIGSI operating software and transferred via the operator interface on the front panel of the device or via the service interface. The procedure is described in detail in the SIPROTEC 4 System Description. Entry of password no. 7 (parameter set) is required to modify configuration settings. Without the password, the settings may be read, but may not be modified and transmitted to the device.

The function parameters, i.e. function options, threshold values, etc., can be changed via the front panel of the device, or via the operator or service interface from a personal computer using DIGSI. The level 5 password (individual parameters) is required.

This general section describes which device settings reflect the interaction between your substation, its measuring points (current and voltage transformers), the analog device connections and the various protection functions of the device.

In a first step (Subsection *2.1.1 Functional Scope*), you have to specify which protection functions you want to use, because not all of the functions integrated in the device are necessary, useful or even possible for your relevant case of application.

After entering some System Data (frequency), you inform the device (Section 2.1.2) of the properties of the main protected object. This comprises e.g. nominal system data, nominal data of instrument transformers, polarity and connection type of measured values

The above information is sufficient to describe the protected object to the device's main protection function, i.e. the differential protection. For the other protection functions (e.g. overcurrent time protection) you select what measured values will be processed and in which way.

You will be informed how to set the circuit breaker data, and find out about setting groups and how to use them.

Last but not least, you can set general data which are not dependent on any protection functions.

2.1.1 Functional Scope

2.1.1.1 Configuration of the Scope of Functions

The 7SD610 device contains a series of protection and additional functions. The hardware and firmware is designed for this scope of functions. Additionally, the command functions can be matched to the system conditions. Furthermore, individual functions may be enabled or disabled during configuration, or interaction between functions may be adjusted.

Example for the configuration of scope of functions:

7SD610 devices can, on overhead lines, also be used with transformers in the protected area. Overload protection should only be applied on transformers. If the device is used for overhead lines, this function has to be set ***Disabled***, and if used for transformers, it has to be set ***Enabled***.

The available protection functions and additional functions can be configured as ***Enabled*** or ***Disabled***. For some functions, a choice between several options is possible which are described below.

Functions configured as ***Disabled*** are not processed by the 7SD610. There are no indications, and corresponding settings (functions, limit values) are not displayed during setting.



NOTE

The functions and default settings available depend on the device version ordered.

2.1.1.2 Setting Notes

Configuring the functional scope

The scope of functions with the available options is set in the **Functional Scope** dialog box to match plant requirements.

Most settings are self-explanatory. Besonderheiten are described below.

Special Cases

If use of the setting group changeover function is desired, address 103 **Grp Chge OPTION** should be set to ***Enabled***. In this case, up to four different groups of settings may be changed quickly and easily during device operation (see also Section *2.1.3 Change Group*). With the setting ***Disabled*** only one parameter group is available.

Address 110 **Trip mode** is only valid for devices that can trip single-pole or three-pole. Set ***1-/3pole*** to enable also single-pole tripping, i.e. if you want to utilise single-pole or single-pole/three-pole automatic reclosure. This requires that an internal automatic reclosure function exists or that an external reclosing device is used. Furthermore, the circuit breaker must be capable of single-pole tripping.



NOTE

If you have changed address 110, save your changes first via **OK** and reopen the dialog box since the other setting options depend on the selection in address 110.

The differential protection function **DIFF. PROTECTION** (address 112) as a main function of the device should always be ***Enabled***. This also implies the supplementary functions of the differential protection such as breaker intertrip.

The Direct Local Trip (address 122 **DTT Direct Trip**) is a command that is initiated from an external device for tripping the local circuit breaker.

At address 126 **Back-Up O/C** you can set the characteristic group which the time overcurrent protection uses for operation. In addition to the definite-time overcurrent protection (definite time), an inverse-time overcurrent protection can be configured that either operates according to an IEC characteristic (***TOC IEC***) or to an ANSI characteristic (***TOC ANSI***). This selection is independent of whether the time overcurrent protection is intended to operate as emergency protection (only in case of protection communication failure) or as independent backup protection. In device variants with directional time overcurrent protection (MLFB position 14 = R or S), you have an additional directional definite-time overcurrent stage and a directional current dependent inverse time stage available. The characteristic curves for both inverse-time overcurrent stages are identical. The various characteristics are shown in the Technical Data (Section 4.6). You can also disable the time overcurrent protection (***Disabled***).

If the device features an automatic reclosing function, address 133 and 134 are of importance. Automatic reclosure is only permitted for overhead lines. It must not be used in any other case. If the protected object consists of a combination of overhead lines and other equipment (e.g. overhead line in unit with a transformer or overhead line/cable), reclosure is only permissible if it can be ensured that it can only take place in the event of a fault on the overhead line. If no automatic reclosing function is desired for the feeder at which 7SD610 operates, or if an external device is used for reclosure, set address 133 **Auto Reclose** to ***Disabled***.

Otherwise, set the number of desired reclosing attempts there. You can select ***1 AR-cycle*** to ***8 AR-cycles***. You can also set ASP (adaptive dead times); in this case the behaviour of the automatic reclosure function is determined by the cycles of the remote end. However, at one end of the line the number of cycles must be configured. This end must provide a reliable infeed. The other end can then operate with adaptive dead time. See Subsection *2.10 Automatic Reclosure Function (optional)* for detailed information.

The **AR control mode** at address 134 allows a total of four options. On the one hand, it can be determined whether the auto reclose cycles are carried out according to the fault type detected by the **pickup** of the starting protection function(s) (only for three-pole tripping) or according to the type of **trip command**. On the other hand, the automatic reclosure function can be operated **with** or **without** action time.

The setting ***Trip with T-action / Trip without T-action ...*** (default setting = Trip with T-action ...) is preferred if single-pole or single-pole/three-pole auto reclose cycles are provided for and possible. In this case, different dead times (for every AR cycle) are possible after single-pole tripping and after three-

pole tripping. The tripping protection function determines the type of tripping: Single-pole or three-pole. The dead time is controlled in dependence on this.

The setting ***Pickup with T-action / Pickup without T-action ...*** (default setting = Pickup with T-action ...) is only possible and visible if only three-pole tripping is desired. This is the case when either the ordering number of the device model indicates that it is only suited for three-pole tripping, or when only three-pole tripping is configured (address 110 **Trip mode** = ***3pole only***, see above). In this case, different dead times can be set for the auto reclose cycles following 1-, 2- and 3-phase faults. The decisive factor here is the **pickup** situation of the protection functions at the instant the trip command disappears. This operating mode enables making the dead times dependent on the type of fault also for three-pole reclosure cycles. Tripping is always three-pole.

The setting ***Trip with T-action*** with action time) provides an action time for each auto-reclose cycle. The action time is started by a general pickup of all protection functions. If there is no trip command yet when the action time has expired, the corresponding automatic reclosure cycle cannot be executed. Section *2.10 Automatic Reclosure Function (optional)* provides detailed information on this topic. This setting is recommended for time-graded protection. If the protection function which is to operate with automatic reclosure, does not have a general pickup signal for starting the action times, select ***Trip without T-action...*** (without action time).

Address 137 **U/O VOLTAGE** allows activating the voltage protection function with a variety of undervoltage and overvoltage protection stages. In particular, the overvoltage protection with the positive sequence system of the measuring voltages provides the option to calculate the voltage at the other, remote line end via integrated compounding. This is particularly useful for long transmission lines where no-load or low-load conditions prevail and an overvoltage at the other line end (Ferranti effect) is to cause tripping of the local circuit breaker. In this case set address 137 **U/O VOLTAGE** to ***Enabl. w. comp.*** (enabled with compounding). Do not use compounding on lines with series capacitors!

For the trip circuit supervision set at address 140 **Trip Cir. Sup.** the number of trip circuits to be monitored: ***1 trip circuit***, ***2 trip circuits*** or ***3 trip circuits***, unless you omit it(***Disabled***).

If the device is connected to voltage transformers, set this condition in address 144 **V-TRANSFORMER**. The voltage dependent functions, such as the directional time overcurrent stages or the determination of voltage related measuring values can only be activated by the device if voltage transformers are connected.

If a power transformer is located within the protected zone, set this condition in address 143 **TRANSFORMER** order option). The transformer data themselves are then polled when parameterizing the general porotection data (see *2.1.4.1 Setting Notes*).

2.1.1.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip mode	3pole only 1-/3pole	3pole only	Trip mode
112	DIFF.PROTECTION	Enabled Disabled	Enabled	Differential protection
122	DTT Direct Trip	Disabled Enabled	Disabled	DTT Direct Transfer Trip
124	HS/SOTF-O/C	Disabled Enabled	Disabled	Instantaneous HighSpeed/SOTF Overcurrent
126	Back-Up O/C	Disabled TOC IEC TOC ANSI	TOC IEC	Backup overcurrent

Addr.	Parameter	Setting Options	Default Setting	Comments
133	Auto Reclose	1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles ADT Disabled	Disabled	Auto-Reclose Function
134	AR control mode	Pickup w/ Tact Pickup w/o Tact Trip w/ Tact Trip w/o Tact	Trip w/o Tact	Auto-Reclose control mode
136	FREQUENCY Prot.	Disabled Enabled	Disabled	Over / Underfrequency Protection
137	U/O VOLTAGE	Disabled Enabled Enabl. w. comp.	Disabled	Under / Overvoltage Protection
139	BREAKER FAILURE	Disabled Enabled enabled w/ 3I0>	Disabled	Breaker Failure Protection
140	Trip Cir. Sup.	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision
141	REF PROT.	Disabled Enabled	Disabled	Restricted earth fault protection
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
143	TRANSFORMER	NO YES	NO	Transformer inside protection zone
144	V-TRANSFORMER	Not connected connected	connected	Voltage transformers
148	GPS-SYNC.	Enabled Disabled	Disabled	GPS synchronization

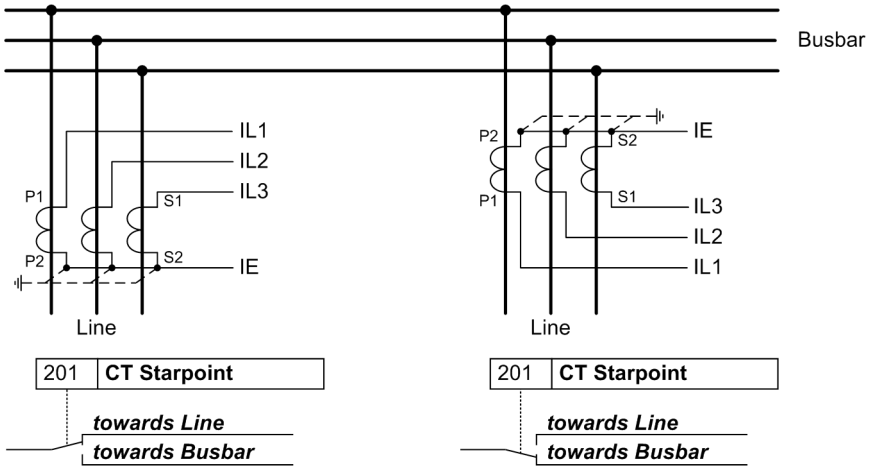
2.1.2 General Power System Data (Power System Data 1)

The device requires some plant and power system data in order to be able to adapt its functions accordingly, depending on the actual application. The data required include for instance rated data of the substation and the measuring transformers, polarity and connection of the measured quantities, if necessary features of the circuit breakers, and others. Furthermore, there are several function parameters associated with several functions rather than one specific protection, control or monitoring function. The Power System Data 1 can only be changed from a PC running DIGSI and are discussed in this section.

2.1.2.1 Setting Notes

Current Transformer Polarity

In address 201 **CT Starpoint**, the polarity of the wye-connected current transformers is specified (the following figure also goes for only two current transformers). The setting determines the measuring direction of the device (forward = line direction). A change in this setting also results in a polarity reversal of the earth current inputs I_E.



[polung-stromwandler-020313-kn, 1, en_GB]

Figure 2-1 Polarity of current transformers

Nominal Values of Transformers

In principle, the differential protection does not require any measured voltage. However, voltages can be connected. These voltages allow to display and log voltages, and to calculate various components of power. If necessary, they can also serve for determining the life line condition in case of automatic reclosure. During configuration of the device functions (Subsection *2.1.1 Functional Scope*), it has been determined whether the device is to work with or without measured voltages.

In addresses 203 **Unom PRIMARY** and 204 **Unom SECONDARY** the device obtains information on the primary and secondary rated voltage (phase-to-phase voltage) of the voltage transformers; in address 205 **CT PRIMARY** und 206 **CT SECONDARY** the primary and secondary rated current transformers are set.

It is important to ensure that the secondary CT nominal current matches the rated current of the device, otherwise the device will be blocked. The nominal current is set with jumpers on the measuring module (see Section *3.1.2 Hardware Modifications*).

Correct entry of the primary data is a prerequisite for the correct computation of operational measured values with primary magnitude. If the settings of the device are performed with primary values using DIGSI, these primary data are an indispensable requirement for the correct function of the device.

Voltage Connection

The device features four voltage measuring inputs, three of which are connected to the set of voltage transformers. Various possibilities exist for the fourth voltage input U_4:

- Connection of the U_4 input to the open delta winding Ue-n of the voltage transformer set:

  Address 210 is then set to: **U4 transformer** = ***Udelta transf.***.

  When connected to the e-n winding of a set of voltage transformers, the voltage transformation ratio of the voltage transformers is usually:

  $$\frac{U_{Nprim}}{\sqrt{3}} / \frac{U_{Nsec}}{\sqrt{3}} / \frac{U_{Nsec}}{3}$$

  The factor Uph/U (secondary voltage, address 211 **Uph / Udelta**) must be set to $3/\sqrt{3} = \sqrt{3} \approx$ ***1.73***. For other transformation ratios, i.e. the formation of the displacement voltage via an interconnected transformer set, the factor must be corrected accordingly. This factor is of importance for the monitoring of the measured values and the scaling of the measurement and disturbance recording signals.

- If the input U_4 is not required, set:

  Address 210 **U4 transformer** = ***Not connected***.

  Factor **Uph / Udelta** (address 211, see above) is also of importance in this case, as it is used for scaling the measured data and fault recording data.

Current Connection

The device features four current measurement inputs, three of which are connected to the set of current transformers. Various possibilities exist for the fourth current input I_4:

- Connection of the I_4 input to the earth current in the starpoint of the set of current transformers on the protected feeder (normal connection):

  Address 220 is then set to: **I4 transformer** = ***In prot. line*** and address 221 **I4/Iph CT** = **1**.

- Connection of the I_4 input to a separate earth current transformer on the protected feeder (e.g. a summation CT or core balance CT):

  Address 220 is then set to: **I4 transformer** = ***In prot. line*** and address 221 **I4/Iph CT** is set:

$$I_4 / I_{ph\,CT} = \frac{\text{Ratio of earth current transformer}}{\text{Ratio of phase current transformers}}$$

[uebersetzung-erd-phase-260702-wlk, 1, en_GB]

Example:
Phase current transformers 500 A / 5 A
Earth current transformer 60 A / 1 A

$$I_4 / I_{ph\,CT} = \frac{60/1}{500/5} = 0.600$$

[formel-strmwdl-parallelschlt-270702-wlk, 1, en_GB]

- Connection of the I_4 input to the starpoint current of a transformer; this connection is always used for the restricted earth fault protection:

  Address 220 is then set to: **I4 transformer** = ***IY starpoint***, and address 221 **I4/Iph CT** is according to transformation ratio of the starpoint transformer to the transformer set of the protected line.

- Wird der I_4-Eingang nicht benötigt, so wird eingestellt:

  Adresse 220 **I4 transformer** = ***Not connected***,

  Adresse 221 **I4/Iph CT** ist dann irrelevant.

  Für die Schutzfunktionen wird in diesem Fall der Nullstrom aus der Summe der Phasenströme berechnet.

Rated frequency

The rated frequency of the power system is set at address 230 **Rated Frequency**. The factory presetting according to the ordering code (MLFB) only needs to be changed if the device is applied in a region different from the one indicated when ordering. You can set ***50 Hz*** or ***60 Hz***

System Starpoint

The manner in which the system starpoint is earthed must be considered for the correct processing of earth faults and double earth faults. Accordingly, set for address 207 **SystemStarpoint** = ***Solid Earthed***, ***Peterson-Coil*** or ***Isolated***. For low-resistant earthed systems set ***Solid Earthed***.

Distance Unit

Address 236 **Distance Unit** allows to define the distance unit (***km*** or ***Miles***). If the compounding function of the voltage protection is used, the overall line capacitance is calculated from the line length and the capacitance per unit length. If compounding is not used, this parameter is of no consequence. Changing the length unit will not result in an automatic conversion of the setting values which depend on this length unit. They have to be re-entered into their corresponding valid addresses.

Trip command duration

In address 240 the minimum trip command duration **TMin TRIP CMD** is set. It applies to all protection and control functions which may issue a trip command. It also determines the duration of the trip pulse when a circuit breaker test is initiated via the device. This parameter can only be altered in DIGSI at **Display Additional Settings**.

In address 241 the maximum close command duration **TMax CLOSE CMD** is set. It applies to all close commands issued by the device. It also determines the length of the close command pulse when a circuit breaker test cycle is issued via the device. It must be long enough to ensure that the circuit breaker has securely closed. There is no risk in setting this time too long, as the close command will in any event be terminated following a new trip command from a protection function. This parameter can only be altered in DIGSI at **Display Additional Settings**.

Circuit breaker test

7SD610 allows a circuit-breaker test during operation using a trip-and-close command entered on the front panel or from DIGSI. The duration of the trip command is set as explained above. Address 242 **T-CBtest-dead** determines the duration from the end of the trip command until the start of the close command for this test. It should not be less than 0.1 s.

Current transformer characteristic

The basic principle of the differential protection assumes that all currents flowing into a healthy protected section add up to zero. If the current transformer sets at the line ends have different transformation errors in the overcurrent range, the total of the secondary currents can reach considerable peaks when a short-circuit current flows through the line. These peaks may feign an internal fault. The measures to prevent errors in case of current transformer saturation included in 7SD610 work completely satisfying if the protection knows the transmission behaviour of the current transformers.

For this, the characteristic data of the current transformers and of their secondary circuits are set (see also *Figure 2-17* in Section *2.3 Differential Protection*). The default setting is adequate in most cases; it considers the data of the worstcase protective current transformers.

The rated accuracy limit factor n of the current transformers and the rated power P_N are usually stated on the rating plate of the current transformers. The information refers to nominal conditions (nominal current, nominal burden). For example (according to VDE 0414 / Part 1 or IEC 60044)

Current transformer 10P10; 30 VA → n = 10; P_N = 30 VA

Current transformer 10P20; 20 VA → n = 20; P_N = 20 VA

The operational accuracy limit factor n' is derived from these rated data and the actual secondary burden P':

$$\frac{n'}{n} = \frac{P_N + P_i}{P' + P_i}$$

[ad1_betruebf-280803-rei, 1, en_GB]

with

n' =	operational accuracy limit factor (effective overcurrent factor)
n =	rated accuracy limit factor of the current transformers (distinctive number behind P)
P_N =	rated burden of the current transformers [VA] at rated current
P_i =	internal burden of the current transformers [VA] at rated current
P' =	actually connected burden (devices + secondary lines) [VA] at rated current

Usually, the internal burden of the current transformers is stated in the test report. If it is unknown, it can be roughly calculated from the DC resistance Ri of the secondary winding.

$P_i \approx R_i \cdot I_N^2$

The ratio between operational accuracy limit factor and rated accuracy limit factor n'/n is set at address 251 **K_ALF/K_ALF_N**.

The CT error at rated current, plus a safety margin, is set at address 253 **E% ALF/ALF_N**. It is equal to the "current measuring deviation for primary nominal current intensity F1" according to VDE 0414 / Teil 1 or IEC 60044. It is

– 3 % for a 5P transformer,

– 5 % for a 10P transformer.

The CT error at rated accuracy limit factor, plus a safety margin, is set at address 254 **E% K_ALF_N**. It is derived from the number preceding the P of the transformer data.

Table 2-1 illustrates some usual protective current transformer types with their characteristic data and the recommended settings.

Table 2-1 Recommended settings for current transformer data

CT class-Wandler-klasse	Standard	Error at rated current		Error at rated accuracy limit factor	Recommended settings		
		Transformation ratio	Angle		Address 251	Address 253	Address 254
5P	IEC 60044-1	1,0 %	± 60 min	≤ 5 %	≤ 1,50 [1)]	3,0 %	10,0 %
10P		3,0 %	—	≤ 10 %	≤ 1,50 [1)]	5,0 %	15,0 %
TPX	IEC 60044-1	0,5 %	± 30 min	ϵ ≤ 10 %	≤ 1,50 [1)]	1,0 %	15,0 %
TPY		1,0 %	± 30 min	ϵ ≤ 10 %	≤ 1,50 [1)]	3,0 %	15,0 %
TPZ		1,0 %	± 180 min ± 18 min	ϵ ≤ 10 % (only I~)	≤ 1,50 [1)]	6,0 %	20,0 %
PX	IEC 60044-1 BS: Class X				≤ 1,50 [1)]	3,0 %	10,0 %
C100 to C800	ANSI				≤ 1,50 [1)]	5,0 %	15,0 %

[1)] If n'/n ≤ 1.50, setting = calculated ratio; if n'/n > 1.50, setting = 1.50

With this data the device establishes an approximate CT error characteristic and calculates the restraint quantity (see also Section *2.3 Differential Protection*).

Calculation example:

Current transformer 5P10; 20 VA

Transformation 600 A / 5 A

Internal burden 2 VA

Secondary lines 4 mm² Cu

Length 20 m

Device 7SD610 , I_N = 5 A

Burden at 5 A, 0.3 VA

The resistance of the secondary lines is (with the resistivity for copper ρ_{Cu} = 0,0175 Ωmm²/m)

$$R_l = 2 \cdot 0.0175 \frac{\Omega mm^2}{m} \cdot \frac{20\ m}{4\ mm^2} = 0.175\ \Omega$$

[ad1_risek-280803-rei, 1, en_GB]

Here, the most unfavourable case is assumed, i.e. the current (as is the case with single-phase faults) flows back and forth via the secondary lines (factor 2). From that the power for nominal current I_N = 5 A is calculated

$P_l = 0.175\ \Omega \cdot (5\ A)^2 = 4.375\ VA$

The entire connected burden consists of the burden of the incoming lines and the burden of the device:

P' = 4.375 VA + 0,3 VA = 4.675 VA

Thus the ratio of the accuracy limit factors is as follows

$$\frac{n'}{n} = \frac{P_N + P_i}{P' + P_i} = \frac{20\ VA + 2\ VA}{4.675\ VA + 2\ VA} = 3.30$$

[ad1_ueifakt-280803-rei, 1, en_GB]

According to the above table, address 251 is to be set to 1.5 if the calculated value is higher than 1.5. This results in the following setting values:

Address 251 **K_ALF/K_ALF_N** = **1.50**

Address 253 **E% ALF/ALF_N** = **3.0**

Address 254 **E% K_ALF_N** = **10.0**

The presettings correspond to current transformers 10P with rated burden.

Of course, only those settings are reasonable where address 253 **E% ALF/ALF_N** is set lower than address 254 **E% K_ALF_N**.

Transformer with voltage control

If a power transformer with voltage control is located in the protected zone, a differential current may occur even during normal operation under steady-state conditions. This differential current depends on the current intensity as well as on the position of the tap changer. Since this is a current-proportional error, the best way is to treat it like an additional current transformer error. Calculate the maximum fault current at the limits of the control range and add it (referred to the mean current of the control range) to the current transformer errors for the addresses 253 and 254). Perform this correction only at the end facing the regulated winding of the power transformer.

Calculation example:

Transformer	YNd5 35 MV 110 kV / 25 kV Y-winding with tap changer ±10 %

This results in the following:

Rated current at rated voltage	I_N = 184 A
Rated current at U_N + 10 %	I_{min} = 167 A
Rated current at U_N – 10 %	I_{max} = 202 A

$$\text{Medium Current } I_{Mid} = \frac{I_{min} + I_{max}}{2} = \frac{167\ A + 202\ A}{2} = 184.5\ A$$

[ad1_bsp1-280803-rei, 1, en_GB]

The maximum deviation from this current is

$$\text{Max. Error } \delta_{Max} = \frac{I_{Max} + I_{Mid}}{I_{Mid}} = \frac{202\ A - 184.5\ A}{184.5\ A} = 0.095 = 9.5\ \%$$

[ad1_bsp2-280803-rei, 1, en_GB]

This maximum deviation δ_{max} [in %] has to be added to the maximum transformer errors 253 **E% ALF/ALF_N** and 254 **E% K_ALF_N** as determined above.

Please consider that this deviation through voltage control is referred to the mean current at rated apparent power and not to the rated current at rated voltage. This requires an adequate correction of the setting values as discussed in Section *2.1.4 General Protection Data (Power System Data 2)* under "Topological Data for Transformers (optional)".

2.1.2.2 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

Addr.	Parameter	Setting Options	Default Setting	Comments
201	CT Starpoint	towards Line towards Busbar	towards Line	CT Starpoint
203	Unom PRIMARY	0.4 .. 1200.0 kV	400.0 kV	Rated Primary Voltage
204	Unom SECONDARY	80 .. 125 V	100 V	Rated Secondary Voltage (Ph-Ph)
205	CT PRIMARY	10 .. 10000 A	1000 A	CT Rated Primary Current
206	CT SECONDARY	1A 5A	1A	CT Rated Secondary Current
207	SystemStarpoint	Solid Earthed Peterson-Coil Isolated	Solid Earthed	System Starpoint is
208A	1-1/2 CB	NO YES	NO	1-1/2 Circuit breaker arrangement
210	U4 transformer	Not connected Udelta transf. Ux transformer	Not connected	U4 voltage transformer is
211	Uph / Udelta	0.10 .. 9.99	1.73	Matching ratio Phase-VT To Open-Delta-VT
220	I4 transformer	Not connected In prot. line IY starpoint	In prot. line	I4 current transformer is
221	I4/Iph CT	0.010 .. 5.000	1.000	Matching ratio I4/Iph for CT's
230	Rated Frequency	50 Hz 60 Hz	50 Hz	Rated Frequency
236	Distance Unit	km Miles	km	Distance measurement unit
240A	TMin TRIP CMD	0.02 .. 30.00 sec	0.10 sec	Minimum TRIP Command Duration
241A	TMax CLOSE CMD	0.01 .. 30.00 sec	1.00 sec	Maximum Close Command Duration

Addr.	Parameter	Setting Options	Default Setting	Comments
242	T-CBtest-dead	0.00 .. 30.00 sec	0.10 sec	Dead Time for CB test-autoreclosure
251	K_ALF/K_ALF_N	1.00 .. 10.00	1.00	k_alf/k_alf nominal
253	E% ALF/ALF_N	0.5 .. 50.0 %	5.0 %	CT Error in % at k_alf/k_alf nominal
254	E% K_ALF_N	0.5 .. 50.0 %	15.0 %	CT Error in % at k_alf nominal

2.1.3 Change Group

2.1.3.1 Purpose of the Setting Groups

Up to four different setting groups can be created for establishing the device's function settings. During operation, the user can locally switch between setting groups using the operator panel, binary inputs (if so configured), the operator and service interface from a personal computer or via the system interface. For reasons of safety, it is not possible to change between setting groups during a power system fault.

A setting group includes the setting values for all functions that have been selected during configuration (Section *2.1.1.2 Setting Notes*) as ***Enabled*** or an other active option. In 7SD610devices, four independent setting groups (A to D) are available. Whereas setting values and options may vary, the selected scope of functions is the same for all groups.

Setting groups enable the user to save the corresponding settings for each application. When they are needed, settings may be loaded quickly. All setting groups are stored in the relay. Only one setting group may be active at a given time.

2.1.3.2 Setting Notes

General

If you do not want to change between several setting groups, then set only setting group A. Then, the rest of this section is not applicable.

If multiple setting groups are desired, the setting group change option must be set to **`Grp Chge OPTION`** = ***Enabled*** (Section *2.1.1.2 Setting Notes*. address 103). Now the 4 setting groups A to D are available. They are configured individually as required in the following. To find out how to proceed, how to copy and to reset settings groups to the delivery state, and how to switch between setting groups during operation, please refer to the SIPROTEC 4 System Description.

Two binary inputs enable changing between the 4 setting groups from an external source.

2.1.3.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
301	ACTIVE GROUP	Group A Group B Group C Group D	Group A	Active Setting Group is
302	CHANGE	Group A Group B Group C Group D Binary Input Protocol	Group A	Change to Another Setting Group

2.1.3.4 Information List

No.	Information	Type of Information	Comments
-	P-GrpA act	IntSP	Setting Group A is active
-	P-GrpB act	IntSP	Setting Group B is active
-	P-GrpC act	IntSP	Setting Group C is active
-	P-GrpD act	IntSP	Setting Group D is active
7	>Set Group Bit0	SP	>Setting Group Select Bit 0
8	>Set Group Bit1	SP	>Setting Group Select Bit 1

2.1.4 General Protection Data (Power System Data 2)

The general protection data (**P.System Data 2**) include settings associated with all functions rather than a specific protection, monitoring or control function. In contrast to the **P.System Data 1** as discussed before, these can be changed over with the setting groups and can be configured via the operator panel of the device.

To ensure uniform conversion factors of measured values for WEB-Monitor and control centres, the setting of all operational rated values of the parameter groups under **P.System Data 2** should be identical.

2.1.4.1 Setting Notes

Rated values of protected lines

The information under this margin heading only apply if no power transformer is located within the protected zone (device version without transformer option or address 143 **TRANSFORMER** set to ***NO***, Section *2.1.1.2 Setting Notes*).

With address 1103 **FullScaleVolt.** you inform the device on the primary rated voltage (phase-to-phase) of the equipment to be protected. This setting influences the displays of the operational measured values in %.

The primary rated current (address 1104 **FullScaleCurr.**) is that of the protected object. For cables the thermal continuous current-loading capacity can be used as a basis. For overhead lines the nominal current is usually not defined. Here it is advisable to select the rated current of the current transformers (as in address 205 **CT PRIMARY**, Section *2.1.2.1 Setting Notes*). If the current transformers have different rated currents at the ends of the protected object, set the highest rated current value for all ends.

This setting will not only have an impact on the displays of the operational measured values in per cent, but **it must also be exactly the same for each end of the protected object** since it is the basis for the current comparison at the ends.

General line data

The directional values (power, power factor, work and related min., max., mean and setpoint values), calculated in the operational measured values, are usually defined with positive direction towards the protected object. This requires that the connection polarity for the entire device was configured accordingly in the **P.System Data 1** (compare also "Polarity of the Current Transformers", address 201). A different setting of the "forward" direction for the protection functions and the positive direction for the power etc. is also possible, e.g., so that the active power flow (from the line to the busbar) is indicated in the positive sense. At address 1107 **P,Q sign** set the option ***reversed***. If the setting is ***not reversed*** (default), the positive direction for the power etc. corresponds to the "forward" direction of the protection functions.

The reactance value X' as well as the capacitance value C' of the protected line are required for compounding in overvoltage protection. Without these functions these parameters are of no consequence. The reactance value X' of the protected line is entered in address 1111 as reference value **x'** in Ω/km if the distance unit was set as kilometer or in Ω/mile if mile was selected as distance unit (address 236, see Section *2.1.2.1 Setting Notes* at "Distance Unit"). The corresponding line length is entered in address 1113 **Line Length** in kilometres or miles. If the distance unit is changed in address 236, the relevant line data of the changed distance unit must be reset in address 1111, address 1112, and in address 1113.

Capacity value C' of the line to be protected is entered in address 1112 as reference value **c'** in µF/km, if km has been specified as length unit, or in µF/mile, if miles have been specified as length unit (address v, see Section *2.1.2.1 Setting Notes* under "Distance Unit"). If the distance unit is changed at address 236, the relevant line data have to be reset for the changed distance unit in address 1112 and in address 1113.

Topologiedaten bei Trafo im Schutzbereich (wahlweise)

The statements under this margin heading refer to protected lines (cables or overhead lines) if a power transformer is situated within the protected zone, i.e. to models with transformer option and if address 143 **TRANSFORMER** has been set to ***YES*** (see Section *2.1.1.2 Setting Notes*). If no transformer is part of the protected zone, this paragraph can be passed over.

The topological data enable to relate all measured quantities to the nominal data of the power transformer.

With address 1103 **FullScaleVolt.** you inform the device on the primary rated voltage (phase-to-phase) of the transformer. The operational rated voltage is also needed for computing the current reference values of the differential protection. Therefore, it is absolutely necessary to **set the correct rated voltage for each end of the protected object even if no voltages are applied to the device**.

In general, select the rated voltage of the transformer winding facing the device. However, if a winding has a voltage control range,do not use the rated voltage of that winding but the voltage that corresponds to the mean value of the currents at the ends of the control range of the tap changer. In this way the fault currents caused by voltage control are minimised.

Calculation example:

Transformer	YNd5 35 MVA 110 kV / 25 kV Y-winding with tap changer ±10 %

For the regulated winding (110 kV) this results in:

Maximum voltage	U_{max} = 121 kV
Minimum voltage	U_{min} = 99 kV

Voltage to be set (address 1103)

$$U_N\text{-Oper Prim} = \frac{2}{\frac{1}{U_{Max}} + \frac{1}{U_{Min}}} = \frac{2}{\frac{1}{121\ kV} + \frac{1}{99\ kV}} = 108.9\ kV$$

[ad2_bsp1-280803-rei, 1, en_GB]

The **OPERATION POWER** (address 1106) is the direct primary rated apparent power for transformers and other machines. For transformers with more than two windings, state the winding with the highest rated apparent power. The **same operation power value must be set for each end of the protected object** since it is the basis for the current comparison at the ends.

The power must always be entered as primary value, even if the device is generally configured in secondary values. The device calculates the primary rated current of the protected device from the reference power.

The **VECTOR GROUP I** (address 1162) is the vector group of the power transformer, always from the device's perspective. The device which is used for the reference end of the transformer, normally the one at the high voltage side, must keep the numerical index **0** (default setting). The relevant vector group index must be stated for the other winding(s).

Example:

Transformer **Yy6d5**

For the **Y** end set: **VECTOR GROUP I** = **0**,

For the **y** end set: **VECTOR GROUP I** = **6**,

For the **d** end set: **VECTOR GROUP I** = **5**.

If a different winding is selected as reference winding, e.g. the d winding, this has to be considered accordingly:

For the **Y** end set: **VECTOR GROUP I** = **7** (12 - 5),

For the **y** end set:**VECTOR GROUP I** = **1** (6 - 5),

For the **d** end set: **VECTOR GROUP I** = **0** (5 - 5 = 0 = Bezugsseite).

Address 1161 **VECTOR GROUP U** is normally set to the same value as address 1162 **VECTOR GROUP I**.

If the vector group of the transformer is adapted with external means, e.g. because there are matching transformers in the measuring circuit that are still used, set **VECTOR GROUP I** = **0** at all ends. In this case the differential protection operates without proper matching computation. However, the measuring voltages beyond the transformer would then not be adapted in the device and therefore not be calculated and displayed correctly. Address 1161 **VECTOR GROUP U** eliminates this deficit. Set the correct vector group of the transformer according to the above-mentioned considerations.

Address 1162 **VECTOR GROUP I** is therefore relevant for the differential protection whereas address 1161 **VECTOR GROUP U** serves as a basis for the calculation of the measured voltages beyond the transformer.

At address 1163 **TRANS STP IS** you can enter whether the power transformer starpoint facing the device is earthed or not. If the starpoint is earthed, the device will eliminate the zero sequence current of the relevant side, since this zero sequence current can otherwise cause a spurious tripping in case of a ground fault outside of the protected zone.

Circuit breaker status

Information regarding the circuit breaker position is required by various protection and supplementary functions to ensure their optimal functionality. The device has a circuit breaker status recognition which processes the status of the circuit breaker auxiliary contacts and contains also a detection based on the measured currents and voltages for opening and closing (see also Section *2.16.1 Function Control*).

In address 1130 the residual current **PoleOpenCurrent** is set, which will definitely not be exceeded when the circuit breaker pole is open. If parasitic currents (e.g. through induction) can be excluded when the circuit breaker is open, this setting may be very sensitive. Otherwise this setting must be increased. Usually the presetting is sufficient. This parameter can only be altered in DIGSI at Display **Additional Settings**.

The switch-on-to-fault activation (seal-in) time **SI Time all Cl.** (address 1132) determines the activation period of the protection functions enabled during each energization of the line (e.g. fast tripping high-current stage). This time is started by the internal circuit breaker switching detection when it recognizes energization of the line or by the circuit breaker auxiliary contacts, if these are connected to the device via binary input to provide information that the circuit breaker has closed. The time should therefore be set longer than the circuit breaker operating time during closing plus the operating time of this protection function plus the circuit breaker operating time during opening. This parameter can only be altered in DIGSI at Display **Additional Settings**.

In address 1134 **Line Closure** the criteria for the internal recognition of line energization are determined. ***only with ManCl*** means that only the manual close signal via binary input or the integrated control is evaluated as closure.

With the following 3 setting options, the manual close signal via binary input or the integrated control are determined as closure always in addition.

I OR U or ManCl means that closure (message *Line closure*, no. 590) is detected if voltages and currents exceed their corresponding pole open thresholds within the time **SI Time all Cl.** (address 1132).

CB OR I or M/C implies that either the currents or the states of the circuit breaker auxiliary contacts are used to determine closure of the circuit breaker. If the voltage transformers are not situated on the line side, the setting ***CB OR I or M/C*** must be used.

In the case of ***I or Man.Close*** only the currents or the manual close signal or the integrated control are used to recognize closing of the circuit breaker.

Before each line energization detection, the breaker must be recognized as open for the settable time 1133 **T DELAY SOTF**.

Address 1135 **Reset Trip CMD** determines under which conditions a trip command is reset. If ***CurrentOpenPole*** is set, the trip command is reset as soon as the current disappears. It is important that the value set in address 1130 **PoleOpenCurrent** (see above) is undershot. If ***Current AND CB*** is set, the circuit breaker auxiliary contact must send a message that the circuit breaker is open. It is a prerequisite for this setting that the position of the auxiliary contacts is allocated via a binary input.

For special applications, in which the device trip command does not always lead to a complete cutoff of the current, the setting ***Pickup Reset*** can be chosen. In this case, the trip command is reset as soon as the pickup of the tripping protection function drops off and - just as with the other setting options- the minimum trip command duration (address 240) has elapsed. The setting ***Pickup Reset*** makes sense, for instance, during the test of the protection equipment, when the system-side load current cannot be cut off and the test current is injected in parallel to the load current.

While the time **SI Time all Cl.** (address 1132, refer above) is activated following each recognition of line energization, **SI Time Man.Cl** (address 1150) is the time following manual closure during which special influence of the protection functions is activated (e.g. increased reach of the distance protection). This parameter can only be altered in DIGSI at Display **Additional Settings**.

NOTE

For CB Test and automatic reclosure the CB auxiliary contact status derived with the binary inputs >CB1 ... (No. 366 to 371, 410 and 411) is relevant to indicate the CB switching status. The other binary inputs >CB ... (No. 351 to 353, 379 and 380) are used for detecting the status of the line (address 1134) and for reset of the trip command (address 1135). Address 1135 is also used by other protection functions, e.g. by the echo function, energization in case of overcurrent etc. For use with one circuit breaker only, both binary input functions, e.g. 366 and 351, can be allocated to the same physical input. For applications with 2 circuit breakers per feeder (1.5 circuit breaker systems or ring bus), the binary inputs >CB1... must be connected to the correct circuit breaker. The binary inputs >CB... then need the correct signals for detecting the line status. In certain cases, an additional CFC logic may be necessary.

Address 1136 **OpenPoleDetect.** defines the criteria for operating the internal open-pole detector (see also Section *2.16.1 Function Control*, Subsection Open-Pole Detector). When using the default setting ***w/ measurement***, all available data are evaluated that indicate single-pole dead time. The internal trip command and pickup indications, the current and voltage measured values and the CB auxiliary contacts are used. To evaluate only the auxiliary contacts including the phase currents, set the address 1136 to ***Current AND CB***. If you do not wish to detect single-pole dead time, set **OpenPoleDetect.** to ***OFF***.

Under address 1151 **SYN.MAN.CL** it can be determined whether a manual closure of the circuit breaker is to be performed via binary input. If manual closing is to be performed without synchronism check, set **SYN.MAN.CL** = ***w/o Sync-check***. To not use the MANUAL CLOSE function of the device, set **SYN.MAN.CL** to ***NO***. This may be reasonable if the close command is output to the circuit breaker without involving the 7SD610, and the relay itself is not desired to issue a close command.

NOTE

If you set the parameter 1151 **SYN.MAN.CL** auf ***w/o Sync-check***, it is recommendable to set the software filter time under DIGSI 4 for the binary input 356 *>Manual Close* to 50 ms.

For commands via the integrated control (on site, DIGSI, serial interface) address 1152 **Man.Clos. Imp.** determines whether a close command via the integrated control regarding the MANUAL CLOSE handling for the protection functions (like instantaneous re-opening when switching onto a fault) is to act like a MANUAL CLOSE command via binary input. This address also informs the device to which switchgear this applies. You can select from the switching devices which are available to the integrated control. Select the circuit breaker which operates for manual closure and, if required, for automatic reclosure (usually Q0). If ***kein*** is set here, a CLOSE command via the control will not generate a MANUAL CLOSE impulse for the protection function.

Three-pole coupling

Three-pole coupling is only relevant if single-pole auto-reclosures are carried out. If not, tripping is always three-pole. The remainder of this margin heading is then irrelevant.

Address 1155 **3pole coupling** determines whether any multi-phase pickup leads to a three-pole tripping command, or whether only multi-pole tripping decisions result in a three-pole tripping command. This setting is only relevant for versions with single-pole and three-pole tripping and is only available there.

It does not have an impact on the differential protection itself since pickup and tripping are equivalent. The time overcurrent protection function, however, can also pick up in the event of a fault occurred outside the protected object, without tripping.

More information on the function is also given in Section *2.16.1 Function Control* Pickup Logic for the Entire Device.

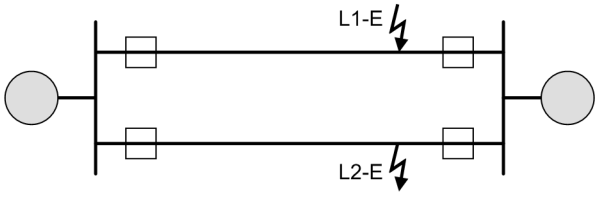
With the setting ***with PICKUP*** every fault detection in more than one phase leads to three-pole coupling of the trip outputs, even if only a single-phase earth fault is situated within the tripping region, and further faults only affect the higher zones, or are located in the reverse direction. Even if a single-phase trip command has already been issued, each further fault detection will lead to three-pole coupling of the trip outputs.

If, on the other hand, this address is set to ***with TRIP***, three-pole coupling of the trip output (three-pole tripping) only occurs when more than one pole is tripped. Therefore, if a single-phase fault occurs within the trip zone and a further fault outside of it, single-pole tripping is possible. A further fault during the single-pole tripping will only lead to a three-pole coupling, if it occurs within the trip zone.

This parameter is valid for all protection functions of 7SD610 which are capable of single-pole tripping.

The difference made by this parameter becomes apparent when multiple faults are cleared, i.e. faults occurring almost simultaneously at different locations in the network.

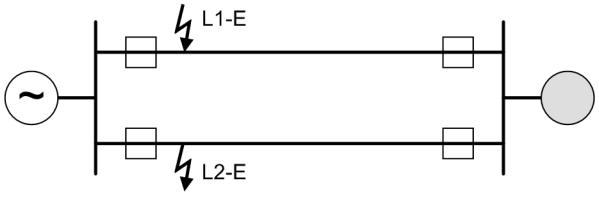
If, for example, two single-phase earth faults occur on different lines — these may also be parallel lines — (*Figure 2-2*), the protection relays detect the fault type on all four line ends L1-L2-E, i.e. the pickup image corresponds to a two-phase earth fault. If single pole tripping and reclosure is employed, it is therefore desirable that each line only trips and recloses single pole. This is possible with setting 1155 **3pole coupling** = ***with TRIP***. Each of the four devices detects a single-pole internal fault and can thus trip single-pole.



[mehrfachfehler-doppelltg-oz-010802, 1, en_GB]

Figure 2-2 Multiple fault on a double-circuit line

In some cases, however, three-pole tripping would be preferable for this fault scenario, for example in the event that the double-circuit line is located in the vicinity of a large generator unit (*Figure 2-3*). This is because the generator considers the two single-phase ground faults as one double-phase ground fault, with correspondingly high dynamic load on the turbine shaft. With the setting 1155 **3pole coupling** = ***with PICKUP***, the two lines are switched off three-pole, since each device picks up as with L1-L2-E, i.e. as with a multi-phase fault.



[generator-mehrfachfehler-doppelltg-oz-010802, 1, en_GB]

Figure 2-3 Multiple fault on a double-circuit line next to a generator

Address 1156 **Trip2phFlt** determines that the short-circuit protection functions perform only a single-pole trip in case of isolated two-phase faults (clear of ground), provided that single-pole tripping is possible and permitted. This allows a single-pole reclose cycle for this kind of fault. You can specify whether the leading phase (***1pole leading Ø***), or the lagging phase (***1pole lagging Ø***) is tripped. The parameter is only available in versions with single-pole and three-pole tripping. This parameter can only be altered using DIGSI at **Additional Settings**. If this possibility is to be used, you have to bear in mind that the phase selection should be the same throughout the entire network and that it must be the same at all ends of one line. More information on the functions is also contained in Section *2.16.1 Function Control* Pickup Logic of the Entire Device. The presetting ***3pole*** is usually used.

2.1.4.2 Settings

Addresses which have an appended “A” can only be changed with DIGSI, under “Additional Settings”.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1103	FullScaleVolt.		0.4 .. 1200.0 kV	400.0 kV	Measurement: Full Scale Voltage (100%)
1104	FullScaleCurr.		10 .. 10000 A	1000 A	Measurement: Full Scale Current (100%)
1105	Line Angle		10 .. 89 °	85 °	Line Angle
1106	OPERATION POWER		0.2 .. 5000.0 MVA	692.8 MVA	Operational power of protection zone
1107	P,Q sign		not reversed reversed	not reversed	P,Q operational measured values sign
1111	x'	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	x' - Line Reactance per length unit
		5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
1111	x'	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	x' - Line Reactance per length unit
		5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
1112	c'	1A	0.000 .. 100.000 µF/km	0.010 µF/km	c' - capacit. per unit line len. µF/km
		5A	0.000 .. 500.000 µF/km	0.050 µF/km	
1112	c'	1A	0.000 .. 160.000 µF/mi	0.016 µF/mi	c' - capacit. per unit line len. µF/mile
		5A	0.000 .. 800.000 µF/mi	0.080 µF/mi	
1113	Line Length		0.1 .. 1000.0 km	100.0 km	Line Length
1113	Line Length		0.1 .. 650.0 Miles	62.1 Miles	Line Length
1130A	PoleOpenCurrent	1A	0.05 .. 1.00 A	0.10 A	Pole Open Current Threshold
		5A	0.25 .. 5.00 A	0.50 A	
1131A	PoleOpenVoltage		2 .. 70 V	30 V	Pole Open Voltage Threshold
1132A	SI Time all Cl.		0.01 .. 30.00 sec	0.10 sec	Seal-in Time after ALL closures
1133A	T DELAY SOTF		0.05 .. 30.00 sec	0.25 sec	minimal time for line open before SOTF
1134	Line Closure		only with ManCl I OR U or ManCl CB OR I or M/C I or Man.Close	I or Man.Close	Recognition of Line Closures with
1135	Reset Trip CMD		CurrentOpenPole Current AND CB Pickup Reset	CurrentOpenPole	RESET of Trip Command
1136	OpenPoleDetect.		OFF Current AND CB w/ measurement	w/ measurement	open pole detector
1150A	SI Time Man.Cl		0.01 .. 30.00 sec	0.30 sec	Seal-in Time after MANUAL closures
1151	SYN.MAN.CL		w/o Sync-check NO	NO	Manual CLOSE COMMAND generation
1152	Man.Clos. Imp.		(Einstellmöglichkeiten anwendungsabhängig)	none	MANUAL Closure Impulse after CONTROL
1155	3pole coupling		with PICKUP with TRIP	with TRIP	3 pole coupling

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1156A	Trip2phFlt		3pole 1pole leading Ø 1pole lagging Ø	3pole	Trip type with 2phase faults
1161	VECTOR GROUP U		0 .. 11	0	Vector group numeral for voltage
1162	VECTOR GROUP I		0 .. 11	0	Vector group numeral for current
1163	TRANS STP IS		Solid Earthed Not Earthed	Solid Earthed	Transformer starpoint is

2.1.4.3 Information List

No.	Information	Type of Information	Comments
301	Pow.Sys.Flt.	OUT	Power System fault
302	Fault Event	OUT	Fault Event
351	>CB Aux. L1	SP	>Circuit breaker aux. contact: Pole L1
352	>CB Aux. L2	SP	>Circuit breaker aux. contact: Pole L2
353	>CB Aux. L3	SP	>Circuit breaker aux. contact: Pole L3
356	>Manual Close	SP	>Manual close signal
357	>Blk Man. Close	SP	>Block manual close cmd. from external
361	>FAIL:Feeder VT	SP	>Failure: Feeder VT (MCB tripped)
366	>CB1 Pole L1	SP	>CB1 Pole L1 (for AR,CB-Test)
367	>CB1 Pole L2	SP	>CB1 Pole L2 (for AR,CB-Test)
368	>CB1 Pole L3	SP	>CB1 Pole L3 (for AR,CB-Test)
371	>CB1 Ready	SP	>CB1 READY (for AR,CB-Test)
378	>CB faulty	SP	>CB faulty
379	>CB 3p Closed	SP	>CB aux. contact 3pole Closed
380	>CB 3p Open	SP	>CB aux. contact 3pole Open
381	>1p Trip Perm	SP	>Single-phase trip permitted from ext.AR
382	>Only 1ph AR	SP	>External AR programmed for 1phase only
383	>Enable ARzones	SP	>Enable all AR Zones / Stages
385	>Lockout SET	SP	>Lockout SET
386	>Lockout RESET	SP	>Lockout RESET
410	>CB1 3p Closed	SP	>CB1 aux. 3p Closed (for AR, CB-Test)
411	>CB1 3p Open	SP	>CB1 aux. 3p Open (for AR, CB-Test)
501	Relay PICKUP	OUT	Relay PICKUP
502	Relay Drop Out	OUT	Relay Drop Out
503	Relay PICKUP L1	OUT	Relay PICKUP Phase L1
504	Relay PICKUP L2	OUT	Relay PICKUP Phase L2
505	Relay PICKUP L3	OUT	Relay PICKUP Phase L3
506	Relay PICKUP E	OUT	Relay PICKUP Earth
507	Relay TRIP L1	OUT	Relay TRIP command Phase L1
508	Relay TRIP L2	OUT	Relay TRIP command Phase L2
509	Relay TRIP L3	OUT	Relay TRIP command Phase L3
510	Relay CLOSE	OUT	Relay GENERAL CLOSE command
511	Relay TRIP	OUT	Relay GENERAL TRIP command

No.	Information	Type of Information	Comments
512	Relay TRIP 1pL1	OUT	Relay TRIP command - Only Phase L1
513	Relay TRIP 1pL2	OUT	Relay TRIP command - Only Phase L2
514	Relay TRIP 1pL3	OUT	Relay TRIP command - Only Phase L3
515	Relay TRIP 3ph.	OUT	Relay TRIP command Phases L123
530	LOCKOUT	IntSP	LOCKOUT is active
533	IL1 =	VI	Primary fault current IL1
534	IL2 =	VI	Primary fault current IL2
535	IL3 =	VI	Primary fault current IL3
536	Definitive TRIP	OUT	Relay Definitive TRIP
545	PU Time	VI	Time from Pickup to drop out
546	TRIP Time	VI	Time from Pickup to TRIP
560	Trip Coupled 3p	OUT	Single-phase trip was coupled 3phase
561	Man.Clos.Detect	OUT	Manual close signal detected
562	Man.Close Cmd	OUT	CB CLOSE command for manual closing
563	CB Alarm Supp	OUT	CB alarm suppressed
590	Line closure	OUT	Line closure detected
591	1pole open L1	OUT	Single pole open detected in L1
592	1pole open L2	OUT	Single pole open detected in L2
593	1pole open L3	OUT	Single pole open detected in L3

2.2 Protection Data Interfaces and Protection Data Topology

Devices protecting an object protected by current transformer sets, must exchange data of the protected object.

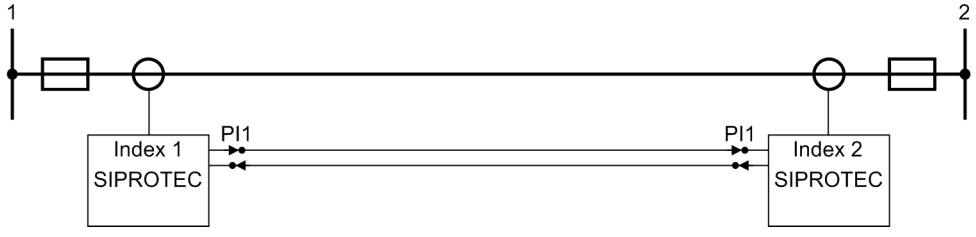
This applies not only to the measured quantities relevant to the actual differential protection, but also to all data which are to be available at the ends. These data include also topological data as well as the intertripping, transfer trip, remote annunciation signals and measured values. The topology of the protected object, the allocation of the devices to the ends of the protected object and the allocation of the ways of communication to the protection data interfaces form the topology of the protection system and its communication. Further details are available in the function description of the differential protection (see Subsection *2.3 Differential Protection*).

2.2.1 Functional Description

2.2.1.1 Protection Data Topology / Protection Data Communication

Protection Data Topology

For a standard layout of lines with two ends, you require one protection data interface (PI1) for each device (see also *Figure 2-4*).



[dis2endenmit2-7sa522je1ws-240402-wlk, 1, en_GB]

Figure 2-4 Differential protection for two ends with two 7SD610 devices, each of them having one protection data interface (transmitter/receiver)

Communication media

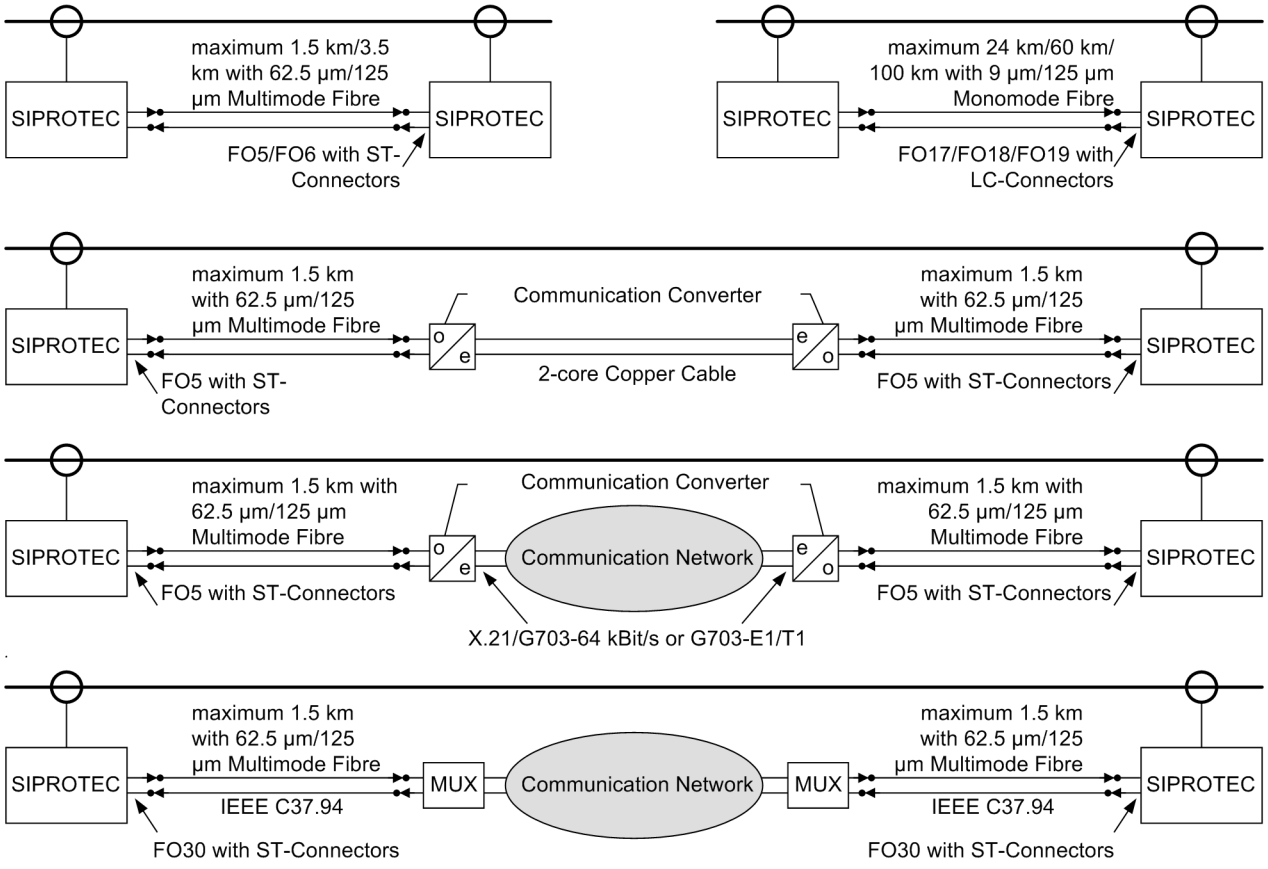
Communication can be effected via different communication connections. Which kind of media is used depends on the distance and on the communication media available. For shorter distances, a direct connection via optical fibres with a transmission rate of 512 kBit/s is possible. Otherwise, we recommend communication converters. A transmission via modems and communication networks can also be realized. Please note, however, that the tripping times of the differential protection devices depend on the transmission quality and that they are prolonged in case of a reduced transmission quality and/or an increased transmission time. *Figure 2-5* shows some examples for communication connections. In case of a direct connection, the bridgeable distance depends on the type of the optical fibre (refer to Chapter 4). Different types of communication modules can be installed in the devices. For ordering information, refer to Appendix, under “Accessories”.

If a communication converter is used, the device and the communication converter are linked with an FO5 module via optical fibres. The converter itself is available in different versions allowing to connect it to communication networks (X.21, G703 64 kBit, G703 E1/T1) or connection via two-wire copper lines. Use the FO30 module to connect the device to the communications converter via IEEE C37.94. For the ordering information, please refer to the Appendix under “Accessories”.



NOTE

If the protection data interfaces of the devices are connected via a communication network, a circuit switched network, e.g. a SDH and/or PDH-network is required. Packet switched networks, e.g. IP-Networks, are not suitable for protection data interface communication. Networks of this type do not have deterministic channel delays as the symmetrical and asymmetrical channel delays vary too much from one telegram to the next. As a result it is not possible to obtain a definite tripping time.



[bsp-kom-verbin-180510-wlk, 1, en_GB]

Figure 2-5 Examples for communication connections

Establishing the protection data communication

When the devices of a differential protection system are linked to each other and switched on, they communicate by themselves. The successful connection is indicated, e.g. with *Rel2 Login*, when device 1 has detected device 2. Each device of a differential protection system informs the other device of the successful protection data communication.

These are helpful features during commissioning and are described, together with further commissioning tools, in the Section “Mounting and Commissioning”. But even during operation, the proper communication of the devices can be checked.

Monitoring the communication

The communication is permanently monitored by the devices.

Single faulty data telegrams are not a direct risk if they occur only occasionally. They are recognized and counted in the device which detects the disturbance and can be read out per unit of time as statistical information (Annunciation → Statistic).

You can define a limit for the permissible rate of faulty data telegrams. When, during operation, this limit is exceeded, an alarm is given (e.g. *PI1 Error*, No. 3258). You may use this alarm to block the differential protection, either via binary output and input, or via logical combination by means of the integrated user-definable logic (CFC).

If several faulty telegrams or no data telegrams at all are received, this is regarded as a communication error as soon as a time delay for data disturbance alarm of 100 ms (default setting, can be altered) is exceeded. A corresponding alarm is output *PI1 Data fault*, No 3229). The differential protection is then out of operation. Both devices are affected by the disturbance, since the formation of differential currents and restraint currents is no longer possible at any of the ends. If the backup overcurrent protection is configured, it will be

the only short-circuit protection still active. As soon as the data communication works fault-free again, the devices will automatically switch back to differential protection operation.

If the communication is interrupted for a permanent period (which is longer than a settable time period), this is regarded as a transmission failure . A corresponding alarm is output (*PI1 Datafailure*, No 3230). Otherwise the same reactions apply as for the data disturbance.

Transmission time jumps that, for example, can occur in case of switchings in the communication network can be recognized (*PI1 jump*, No 3254) and corrected by the device. The differential protection system continues to operate without loss of sensitivity. The transmission times are measured again and updated within less than 2 seconds. If GPS synchronization (with satellite receiver) is used, asymmetric transmission times are recognized and corrected immediately.

The maximum permissible unbalance of the operating times can be set. This has a direct influence on the sensitivity of the differential protection. The automatic self-restraint of the protection adapts the restraint quantities to this tolerance so that a spurious pickup of the differential protection by these influences is excluded. Thus, higher tolerance values reduce the sensitivity of the protection, which may be noticeable in case of very lowcurrent faults. With GPS-synchronization, transmission time differences do **not** affect the sensitivity of the protection as long as GPS-synchronization is intact. When the GPS–synchronization detects that the permissible time difference is exceeded during operation, the message *PI 1 PD unsym.* No 3250 will be issued.

When a transmission time jump exceeds the maximum permissible transmission operating time, this is annunciated. If transmission time jumps occur frequently, the regular operation of the differential protection is no longer ensured. The differential protection can be blocked via a setting parameter (e.g. 4515 **PI1 BLOCK UNSYM**) An alarm is output (*PI1 unsym.*, No 3256). This blocking can only be reset via a binary input *>SYNC PI1 RESET*, No 3252).

2.2.2 Operating Modes of the Differential Protection

2.2.2.1 Mode: Log Out Device

General

The “Log out device” mode (also: Log out device functionally) is used to log the device out of the line protection system with the local circuit breaker being switched off.

The remaining device continues to operate in “Differential protection mode”, the special feature, however, being that only the locally measured currents are included in the logic as differential currents. The behaviour is now comparable to a time overcurrent protection. The set thresholds for the differential current now evaluate the local current.

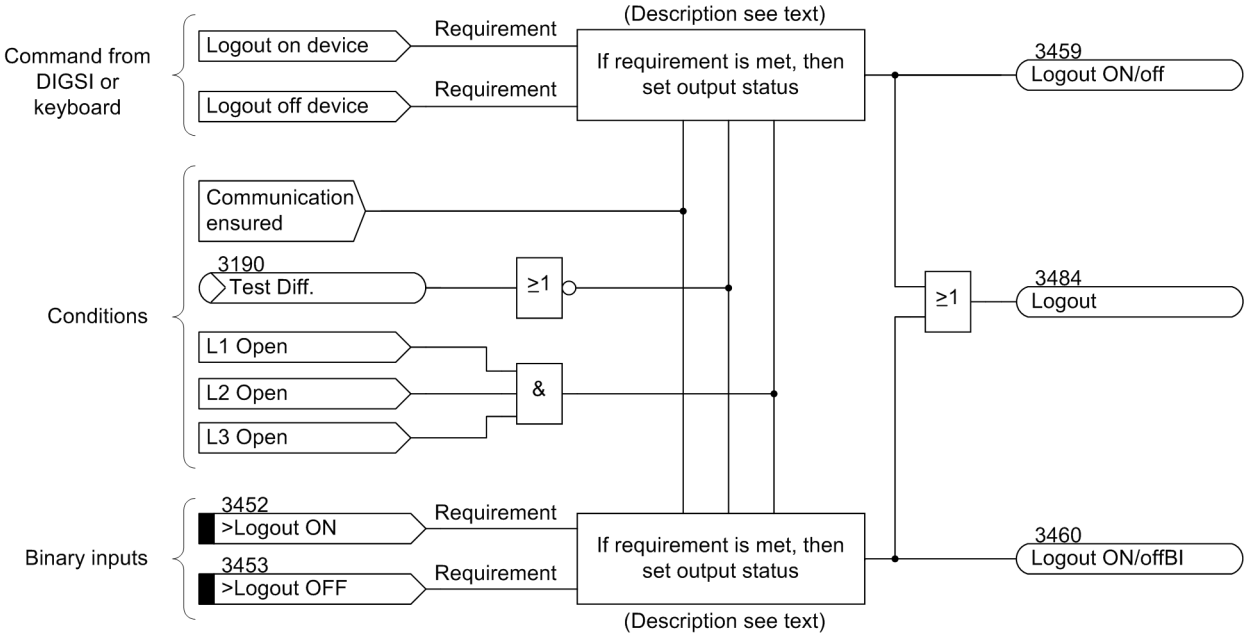
A device can be logged out and on as described below:

- Using the integrated keypad: Menu Control/Taggings/Set: “Logout”
- Via DIGSI: Control / Taggings “Logout local device”
- Via binary inputs (No. 3452 *>Logout ON*, No. 3453 *>Logout OFF*) if this was allocated

In the other device of the line protection system, logging out/on of a device is signalled by the indications *Rel1Logout* or *Rel2Logout* (No. 3475 or No. 3476).

Principle of function

In the following, the logic is shown in a simplified way:



[logik-geraet-abmelden, 1, en_GB]

Figure 2-6 Logic diagram for switching the **Log out device** mode

If a command (from DIGSI or keypad) or a binary input requests the change of the current mode, this request is checked. If *Logout* ON or *>Logout ON* is requested, the following is checked:

- Is the local circuit breaker open?
- Is the communication of the remaining devices ensured?
- Is the device not operating in differential protection test mode?

If all requirements are met, the request is accepted and the indication *Logout* ON (No. 3484) is generated. According to the request source, either the indication *Logout ON/off* ON (No. 3459) or *Logout ON/ offBI* ON (No. 3460) is output. As soon as a requirement is not met, the device is not logged out.

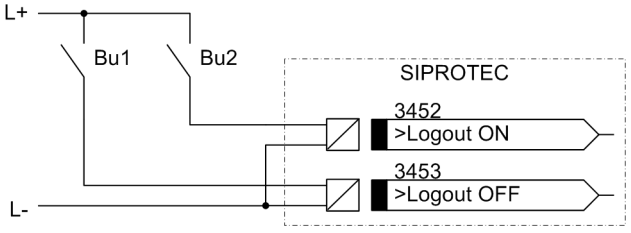
If the device is to be logged on to the line protection system *Logout* off or*>Logout OFF*), the following is checked:

- Is the local circuit breaker open?
- Is the device not operating in differential protection test mode?

If all requirements are met, the request is accepted and the indication *Logout* OFF (No. 3484) is generated. According to the request source, either the indication *Logout ON/off* OFF (No. 3459) or *Logout ON/ offBI* OFF (No. 3460) is output. As soon as a requirement is not met, the device is not logged on.

NOTE

The device can deny the logout if one of the conditions mentioned before is not fulfilled. Please consider this behaviour when requesting the messages via a binary input.



[logik-geraet-abmelden-ext-taster, 1, en_GB]

Figure 2-7 Principle and preferred external button wiring for controlling in the **Log out device** mode

Bu1 Button “Log on device”
BU2 Button “Log out device”

Figure 2-7 shows the preferred variant for changing the “Log out device” mode with the aid of two buttons. The used binary inputs are to be used as NO contacts.

2.2.2.2 Differential Protection Test Mode

General

If differential protection test mode (test mode in the following) is activated, the differential protection is blocked in the entire system.

Depending on the configuration, the overcurrent protection becomes effective as an emergency function.

In the local device, all currents from the other devices are set to zero. The local device only evaluates the locally measured currents, interprets them as differential current but does not send them to the other devices. This enables to measure the thresholds of the differential protection. Moreover, the test mode prevents the generation of an intertrip signal in the local device by tripping of the differential protection.

If the device is still connected to the local CT the measured current can lead to a trip of the device.

If the device was logged out of the line protection system before activating the test mode (see “Log out device” mode), the differential protection remains effective in the other device. The local device can now also be tested.

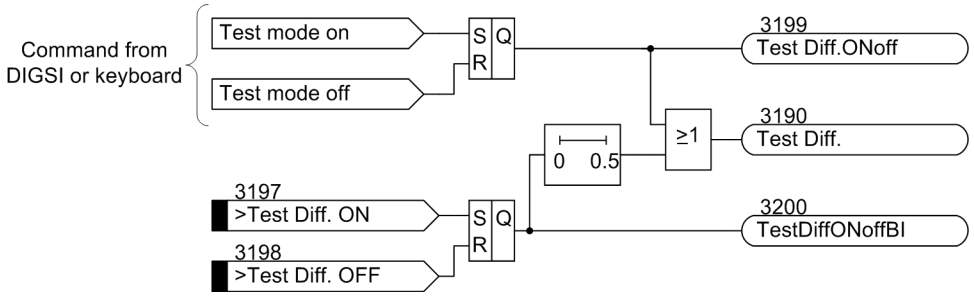
The test mode can be activated/deactivated as follows:

- Using the integrated keypad: Menu Control/Taggings/Set: “Test mode”
- Via binary inputs (No. 3197 *>Test Diff. ON*, No. 3198 *>Test Diff. OFF*) if this was allocated
- In DIGSI with Control/Taggings: “Diff: Test mode”

The test mode status of the other device of the line protection system is indicated on the local device by the indication *TestDiff.remote* (No. 3192).

Principle of function

In the following, the logic is shown in a simplified way:

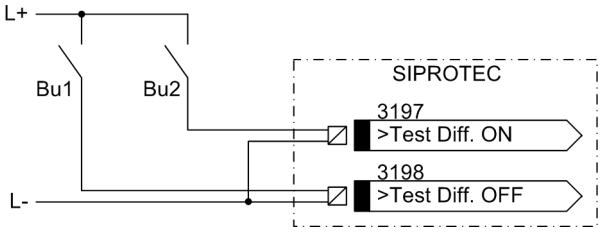


[logik-testmodus, 1, en_GB]

Figure 2-8 Logic diagram of the test mode

Depending on the way used for controlling the test mode, either the indication Depending on the way used for controlling the test mode, either the indication *Test Diff.ONoff* (No. 3199) or *TestDiffONoffBI* (No. 3200) is generated. The way used for deactivating the test mode always has to be identical to the way used for activating it. The indication *Test Diff.* (No. 3190) is generated independently of the selected way. When deactivating the test mode via the binary inputs, a delay time of 500 ms becomes effective.

The following figures show possible variants for controlling the binary inputs. If a switch is used for the control (*Figure 2-10*), it has to be observed that binary input *>Test Diff. ON* (No. 3197) is parameterised as NO contact and that binary input *>Test Diff. OFF* (No. 3198) is parameterised as NC contact.

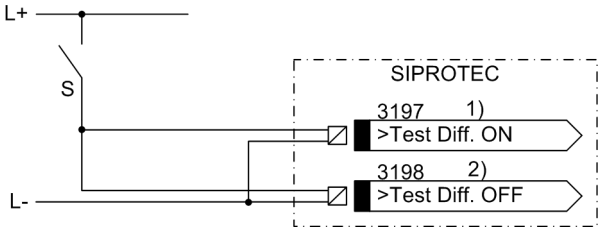


[logik-testmodus-ext-taster, 1, en_GB]

Figure 2-9 Principle for external button wiring for controlling the differential protection test mode

Bu1 Button "Deactivating differential protection test mode"

Bu2 Button "Activating differential protection test mode"



[logik-testmodus-ext-schalter, 1, en_GB]

Figure 2-10 Principle for external switch wiring for controlling the differential protection test mode

S Switch "Activating/deactivating differential protection test mode"

1) Binary input as NO contact

2) Binary input as NC contact

If a test switch is to be used for changing to test mode, we recommed the following procedure:

- Block the differential protection via a binary input
- Use the test switch to activate/deactivate the test mode
- Reset the blocking of the differential protection via the binary input

2.2.2.3 Differential Protection Commissioning Mode

General

In differential protection commissioning mode (commissioning mode in the following), the differential protection does not generate TRIP commands. The commissioning mode is intended to support the commissioning of the differential protection. It can be used to check the differential and restraint currents, to visualise the differential protection characteristic and thus the operating point of the differential protection. By changing parameters, the operating point can be changed without risk up to the generation of a trip.

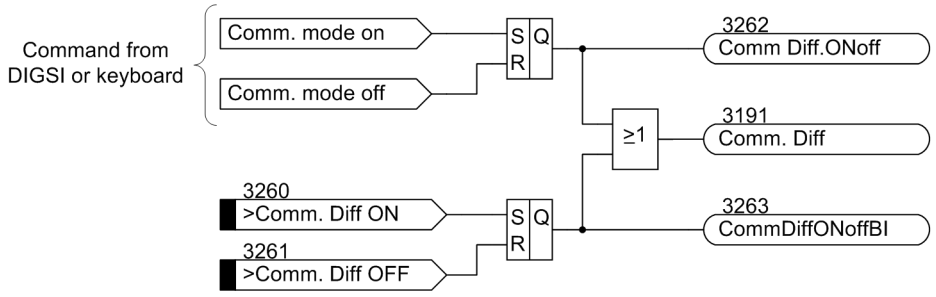
The commissioning mode is activated on one device of the protection device constellation and also affects the other device (indication No. 3193 *Comm.Diff act.*). The commissioning mode has to be deactivated on the device on which it was activated.

The commissioning mode can be activated/deactivated as follows:

- Using the integrated keypad: Menu Control/Taggings/Set: "Commissioning mode"
- Via binary inputs (No. 3260 *>Comm. Diff ON*, No. 3261 *>Comm. Diff OFF*) if this was allocated
- In DIGSI with Control/Taggings: "Diff: Commissioning mode"

Principle of function

In the following, the logic is shown in a simplified way:



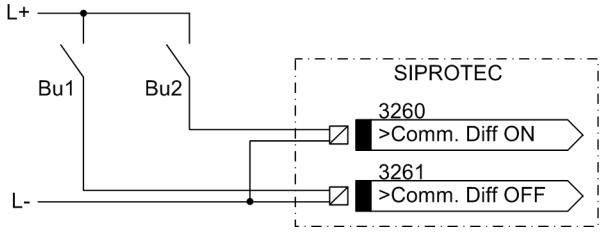
[logik-ibs-modus, 1, en_GB]

Figure 2-11 Logic diagram of the commissioning mode

There are two ways to set the commissioning mode. The first way is to use a command (commissioning mode on / commissioning mode off) which is generated either when operating the integrated keypad or when operating with DIGSI. The second way is to use the binary inputs (No. 3260 *>Comm. Diff ON*, No. 3261 *>Comm. Diff OFF*).

Depending on the way used for controlling the commissioning mode, either the indication *Comm Diff. ONoff* (No. 3262) or *CommDiffONoffBI* (No. 3263) is generated. The way used for deactivating the commissioning mode always has to be identical to the way used for activating. The indication *Comm. Diff* (No. 3191) is generated independently of the chosen way.

The following figures show possible variants for the control of the binary inputs. If a switch is used for the control (*Figure 2-13*), it has to be considered that binary input *>Comm. Diff ON* (No. 3260) must be parameterized as NO contact and that binary input *>Comm. Diff OFF* (No. 3261) must be parameterized as NC contact.

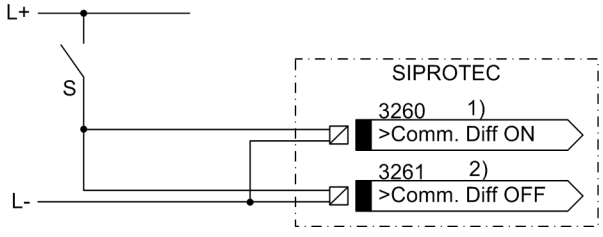


[logik-ibs-modus-ext-taster, 1, en_GB]

Figure 2-12 External button wiring for controlling the differential protection commissioning mode

Bu1 Button “Deactivating differential protection commissioning mode”

BU2 Button “Activating differential protection commissioning mode”



[logik-ibs-modus-ext-schalter, 1, en_GB]

Figure 2-13 Externe Schalter-Verdrahtung zum Steuern des Differentialschutz-IBS-Mode

S Switch “Activating/deactivating differential protection commissioning mode”

1) Binary input as NO contact

2) Binary input as NC contact

2.2.3 Protection Data Interfaces

2.2.3.1 Setting Notes

General Information about Interfaces

The protection data interfaces connect the devices with the communication media. The communication is permanently monitored by the devices. Address 4509 **T-DATA DISTURB** defines after which delay time the user is informed about a faulty or missing telegram. Address 4510 **T-DATAFAIL** is used to set the time after which a transmission failure alarm is output. Address 4512 **Td ResetRemote** determines how long remote signals remain standing after a communication disturbance.

Protection data interface 1

The protection data interface 1 can be turned ***ON*** or ***OFF*** in address 4501 **STATE PROT I 1**. If it is switched ***OFF***, this corresponds to a communication failure. The differential protection and all functions which require the transmission of data, cannot work in this case.

In address 4502 **CONNEC. 1 OVER**, set the transmission media that you want to connect to protection data interface PI 1. The following selection is possible:

F.optic direct, i.e. direct communication by fibre-optic cable with 512 kbit/s;

Com c 64 kBit/s, i.e. via communication converters with 64 kbit/s (G703.1 or X.21);

Com c 128kBit/s, i.e. via communication converters with 128 kbit/s (X.21, copper cable);

Com c 512kBit/s, i.e. via communication converter 512 KBit/s (X.21) or communication converter for 2 MBit/s (G703-E1/T1);

IEEE C37.94, i.e. communication network connection with 1, 2, 4, or 8 slots.

The setting options depend on the parameterization of the functional scope and on the device variant. The data must be identical at both ends of a communication route.

The setting depends on the properties of the communication medium. Generally, the response time of the differential protection system is shorter the higher the transmission rate.

The devices measure and monitor the transmission times. Deviations are corrected as long as they are within the permissible range.

The maximum permissible transmission time (address 4505 **PROT 1 T-DELAY**) is preset to a default value that does not exceed the usual delay of communication networks. This parameter can only be set in DIGSI at **Additional Settings**. If it is exceeded during operation, for example, because of switchover to a different transmission route, the message *PI1 TD alarm* (No. 3239) will be issued. The protection data interface and the differential protection continue being in operation! Increased transmission times only have an impact on the tripping time of the differential protection and therefore on the fault clearance time.

The maximum **transmission time difference** (outgoing signal vs. return signal) can be changed in address 4506 **PROT 1 UNSYM.**. This parameter can only be set in DIGSI at **Additional Settings**. The devices assume symmetrical transfer times after establishing or re-establishing a connection. The maximum runtime difference is considered as the maximum fault of synchronisation when calculating the restraint current.

If transmission time jumps exceeding the parameterized value of the maximum transmission time difference (address 4506) occur in the communication networks, a proper function of the differential protection for high-current faults outside the zone to be protected is not guaranteed. The device is able to record transmission time jumps. At address 4515 **PI1 BLOCK UNSYM** (default ***YES***), you can define whether the protection data interface connection for the differential protection shall be blocked in this case. The protection data interface can be unblocked by means of the message 3256 *PI1 unsym.* or via the binary input 3252 *>SYNC PI1 RESET*. The message 3256 is pre-allocated in DIGSI in the control menu. The unblocking may only be effected if the transmission times are symmetrical.

The following table provides setting hints for the parameters 4506 and 4515 when using different communication media or communication converters:

Table 2-2 Parameters of the protection data interface

Communication medium Communication Converter	**Supported Interface**	**Protection data interface parameters**		
		4502 **CONNEC. 1 OVER**	4506 **PROT 1 UNSYM.**	4515 **PI1 BLOCK UNSYM**
Direct FO (no converter)	Direct FO	***F.optic direct***	0.0 ms	***NO***
Communication network/ communication converter KU-XG (7XV5662–0AA00)	G.703 - 64 kBit/s X.21 - 64 kBit/s X.21 - 64 kBit/s X.21 - 64 kBit/s	***Com c 64 kBit/s*** ***Com c 64 kBit/s*** ***Com c 128kBit/s*** ***Com c 512kBit/s***	0.250 ms bis 0.6 ms[1)]	***YES***[2)]
Communication network/ communication converter KU-KU (7XV5662–0AC00)	Pilot wire twisted and shielded	***Com c 128kBit/s***	0.125 ms	***NO***
Communication network/ communication converter KU-2M (7XV5662–0AD00)	G703 - T1 (1544 MBit/s) G703 - E1 (2048 MBit/s)	***Com c 512kBit/s***	0.250 ms bis 0.6 ms[1)]	***YES***[2)]
Communication network IEEE C37.94, FO30 module	IEEE C37.94 1, 2, 4, 8 Time Slots	C37.94 1 SLOT C37.94 2 SLOTS C37.94 4 SLOTS C37.94 8 SLOTS	0.250 ms bis 0.6 ms[1)]	***YES***[2)]
Direct FO-FO converter(7XV5461–0Bx00)	Direct FO	***F.optic direct***	0.0 ms	***NO***

[1)] Average value (adjust if necessary)

[2)] If the maximum possible transmission time difference in address 4506 or 4606is parameterised, address 4515 or 4615can be set to NO.

If GPS synchronisation is used (order option), the preset value for the maximum transmission time difference is only effective with certain restrictions. Address 4511 **PI1 SYNCMODE** defines the precondition for the activation of the differential protection after re-establishing the communication connection (establishing or re-establishing after a communication failure).

PI1 SYNCMODE = ***GPS SYNC OFF*** means that no GPS synchronisation is available at this protection data interface. This makes sense if no runtime differences are expected (e.g. fibre optic connection). The value parameterized at address 4506 **PROT 1 UNSYM.** is considered by the differential protection when calculating the restraint current.

PI1 SYNCMODE= ***TEL and GPS*** means that the differential protection is only released if the communication line has been synchronized via GPS (both stations must be able to receive GPS signals) or if symmetrical transmission times are signalled via an external operation (binary input). If the operator initiates the synchronisation, the differential protection uses the value set at address 4506 **PROT 1 UNSYM.** until the transmission time difference has been calculated by the GPS synchronisation.

PI1 SYNCMODE = ***TEL or GPS*** means that the differential protection will be enabled immediately once the connection has been re-established (data telegrams are received). The differential protection works with the value paramterized at address 4506 **PROT 1 UNSYM.** until the synchronisation has been completed. As soon as both stations can receive GPS signals and the communication connection has been synchronized via GPS, the differential protection works with increased sensitivity.

In **PI1 SYNCMODE** ***TEL or GPS*** or ***TEL and GPS***, the transmission time can be measured separately for transmit and receive direction. If the measured transmission time difference exceeds the value parameterized at address 4506 **PROT 1 UNSYM.**, the message 3250 ***PI 1 PD unsym.*** will be output.

You can determine a limit value **PROT1 max ERROR** for the permissible rate of faulty protection data telegrams under address 4513. This parameter can only be set in DIGSI at **Additional Settings**. The preset value 1 % means that maximum one faulty telegram per 100 telegrams is permissible.

GPS synchronisation (optional)

For the protection data interface, the synchronisation via GPS can be switched *ON* or *OFF* at address 4801 **GPS-SYNC.**.

GPS synchronisation means the use of a 1-pulse-per-second signal (1 PPS). This signal is generated by an external GPS receiver. The 1 PPS signal is connected to port A of the device (see Chapter *3 Mounting and Commissioning*, Table 3-12). The 1 PPS signal has the property that the leading edge presents a maximum deviation of 10 µs (compared between 2 GPS receivers and under all GPS signal conditions). This feature does not depend on the location. If the deviation of max. 10 µs is no longer ensured due to bad GPS receiving conditions, the 1 PPS signal must be switched off by the GPS receiver.

In addition, these GPS receivers can provide further time signals, e.g. DCF77 or IRIG-B. These time signals can be connected to port A as well. However, they are not suitable for a µs-accurate synchronisation of the protection data interfaces and, consequently, of the differential protection. The edge accuracy of these time signals is often insufficient.

At address 4803 **TD GPS FAILD** you can specify the time after which the indication *GPS loss* (no. 3247) is output.

Other parameters concerning the GPS synchronisation can be set individually for each protection data interface (see above).

2.2.3.2 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

Addr.	Parameter	Setting Options	Default Setting	Comments
4501	STATE PROT I 1	ON OFF	ON	State of protection interface 1
4502	CONNEC. 1 OVER	F.optic direct Com c 64 kBit/s Com c 128kBit/s Com c 512kBit/s C37.94 1 slot C37.94 2 slots C37.94 4 slots C37.94 8 slots	F.optic direct	Connection 1 over
4505A	PROT 1 T-DELAY	0.1 .. 30.0 ms	30.0 ms	Prot 1: Maximal permissible delay time
4506A	PROT 1 UNSYM.	0.000 .. 3.000 ms	0.100 ms	Prot 1: Diff. in send and receive time
4509	T-DATA DISTURB	0.05 .. 2.00 sec	0.10 sec	Time delay for data disturbance alarm
4510	T-DATAFAIL	0.0 .. 60.0 sec	6.0 sec	Time del for transmission failure alarm
4511	PI1 SYNCMODE	TEL and GPS TEL or GPS GPS SYNC OFF	TEL and GPS	PI1 Synchronizationmode
4512	Td ResetRemote	0.00 .. 300.00 sec; ∞	0.00 sec	Remote signal RESET DELAY for comm.fail
4513A	PROT1 max ERROR	0.5 .. 20.0 %	1.0 %	Prot 1: Maximal permissible error rate
4515A	PI1 BLOCK UNSYM	YES NO	YES	Prot.1: Block. due to unsym. delay time

Addr.	Parameter	Setting Options	Default Setting	Comments
4801	GPS-SYNC.	ON OFF	OFF	GPS synchronization
4803A	TD GPS FAILD	0.5 .. 60.0 sec	2.1 sec	Delay time for local GPS-pulse loss

2.2.3.3 Information List

No.	Information	Type of Informa-tion	Comments
3215	Wrong Firmware	OUT	Incompatible Firmware Versions
3217	PI1 Data reflec	OUT	Prot Int 1: Own Datas received
3227	>PI1 light off	SP	>Prot Int 1: Transmitter is switched off
3229	PI1 Data fault	OUT	Prot Int 1: Reception of faulty data
3230	PI1 Datafailure	OUT	Prot Int 1: Total receiption failure
3233	DT inconsistent	OUT	Device table has inconsistent numbers
3234	DT unequal	OUT	Device tables are unequal
3235	Par. different	OUT	Differences between common parameters
3239	PI1 TD alarm	OUT	Prot Int 1: Transmission delay too high
3243	PI1 with	VI	Prot Int 1: Connected with relay ID
3245	>GPS failure	SP	> GPS failure from external
3247	GPS loss	OUT	GPS: local pulse loss
3248	PI 1 GPS sync.	OUT	GPS: Prot Int 1 is GPS sychronized
3250	PI 1 PD unsym.	OUT	GPS:PI1 unsym.propagation delay too high
3252	>SYNC PI1 RESET	SP	> PI1 Synchronization RESET
3254	PI1 jump	OUT	Prot.1: Delay time change recognized
3256	PI1 unsym.	IntSP	Prot.1: Delay time unsymmetry to large
3258	PI1 Error	OUT	ProtInt1:Permissible error rate exceeded
3274	PI1: C37.94 n/a	OUT	PI1: IEEE C37.94 not supported by module

2.2.4 Differential Protection Topology

2.2.4.1 Setting Notes

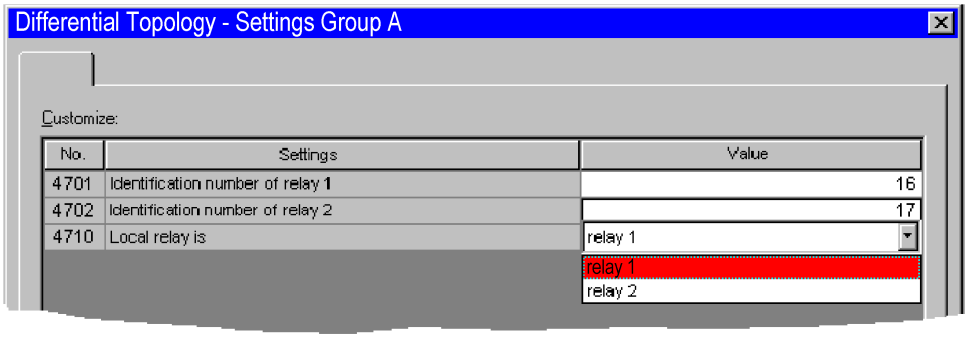
Protection data topology

First of all, define your protection data communication topology: Number the devices consecutively. This numbering is a serial device index that serves for your own overview. It starts for each distance differential protection system (i.e. for each protected object) with 1. For the differential protection system the device with index 1 is always the absolute time master, i.e. the absolute time management of all devices which belong together depends on the absolute time management of this device, if synchronization is set to **Source** or **Timing-Master**. As a result, the time information of all devices is comparable at all times. The **Timing-Master**-Setting has only influence on the absolut time (SCADA-Time). This setting has no impact on the differential protection. The device index thus serves for the unique identification of the devices within a differential protection system (i.e. for one protected object).

In addition, assign an ID number to each device (device-ID). The device ID is used by the communication system to identify each individual device. It must be between 1 and 65534 and must be unique within the communication system. The ID number thus identifies the devices in the communication system (according to a device address) since the exchange of information between several differential protection systems (thus also for several protected objects) can be executed via the same communication system.

If you work with different physical interfaces and communication links, please make sure that every protection data interface corresponds to the projected communication link (direct FO or communication network).

For a protected object with two ends (e.g. a line) the addresses 4701 **ID OF RELAY 1** and 4702 **ID OF RELAY 2** are set, e.g. for device 1 the device-ID **16** and for device 2 the device-ID **17** (*Figure 2-14*). The indices of the devices and the device-IDs do not have to match here, as mentioned above.



[diff-beisp2-260803-rei, 1, en_GB]

Figure 2-14 Differential protection topology for 2 ends with 2 devices — example

In address 4710 **LOCAL RELAY** you indicate the actual local device. One device has index 1, the other index 2.

Make sure that the parameters of the differential protection topology for the differential protection system are conclusive:

- Each device index can only be used once.
- Each device index must be assigned unambiguously to one device ID.
- Each device index must be the index of a local device once.
- The device with index 1 is the source for the absolute time management (timing master).

During startup of the protection system, the above listed conditions are checked. If one of these conditions is not yet fulfilled, the differential protection does not operate.

The device then issues one of the following error messages

- *DT inconsistent* (Device Table contains two or more identical device ident numbers)
- *DT unequal* (Different settings of parameters 4701 to 4702)
- *Equal IDs* (Protection system contains devices with identical settings of parameter 4710)

If the indication *Par. different* ON is displayed, the differential protection is blocked as well. In this case the following parameters, which should have identical settings in the devices, have in fact different settings.

- Address 230 **Rated Frequency**
- Address 143 **TRANSFORMER** in the protected zone
- Address 1104 **FullScaleCurr.**
- Address 1106 **OPERATION POWER** primary address 1106 is only displayed if parameter 143 is set to yes
- Address 112 **DIFF. PROTECTION**exists

2.2.4.2 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4701	ID OF RELAY 1	1 .. 65534	1	Identification number of relay 1
4702	ID OF RELAY 2	1 .. 65534	2	Identification number of relay 2
4710	LOCAL RELAY	relay 1 relay 2	relay 1	Local relay is

2.2.4.3 Information List

No.	Information	Type of Information	Comments
3452	>Logout ON	SP	> Logout state ON
3453	>Logout OFF	SP	> Logout state OFF
3458	Chaintopology	OUT	System operates in a open Chaintopology
3459	Logout ON/off	IntSP	Logout state ON/OFF
3460	Logout ON/offBI	IntSP	Logout state ON/OFF via BI
3464	Topol complete	OUT	Communication topology is complete
3475	Rel1Logout	IntSP	Relay 1 in Logout state
3476	Rel2Logout	IntSP	Relay 2 in Logout state
3484	Logout	IntSP	Local activation of Logout state
3487	Equal IDs	OUT	Equal IDs in constellation
3491	Rel1 Login	OUT	Relay 1 in Login state
3492	Rel2 Login	OUT	Relay 2 in Login state

2.3 Differential Protection

The differential protection is the main function of the device. It is based on current comparison. For this, one device must be installed at each end of the zone to be protected. The devices exchange their measured quantities via communications links and compare the received currents with their own. In case of an internal fault the allocated circuit breaker is tripped.

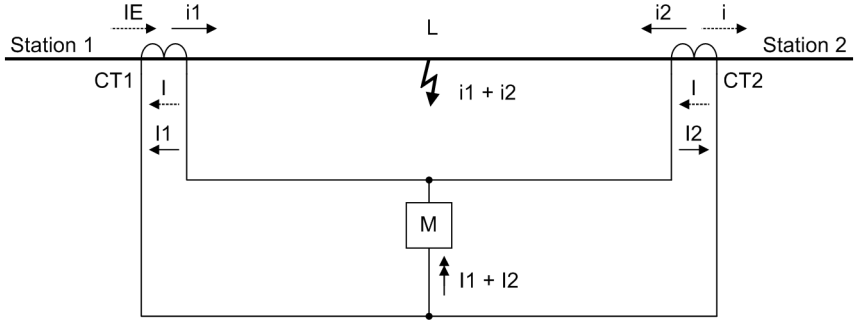
Apart from normal lines, 7SD610 also enables protecting lines with transformers switched en block (order variant). The protected zone is selectively limited by the CTs at its ends.

2.3.1 Functional Description

Basic principle with two ends

The differential protection is based on current comparison. It makes use of the fact that e.g. a line section L (*Figure 2-15*) always carries the same current i (dashed line) at its two ends in healthy operation. This current flows into one side of the considered zone and leaves it again on the other side. A difference in current is a clear indication of a fault within this line section. If the actual current transformation ratios are the same, the secondary windings of the current transformers **CT1** and **CT2** at the line ends can be connected to form a closed electric circuit with a secondary current I; a measuring element **M** which is connected to the electrical balance point remains at zero current in healthy operation.

When a fault occurs in the zone limited by the transformers, a current $i_1 + i_2$ which is proportional to the fault currents $\underline{I}_1 + \underline{I}_2$ flowing in from both sides is fed to the measuring element. As a result, the simple circuit shown in *Figure 2-15* ensures a reliable tripping of the protection if the fault current flowing into the protected zone during a fault is high enough for the measuring element **M** to respond.



[diff-grundprinzip-zwei-enden-290803-st, 1, en_GB]

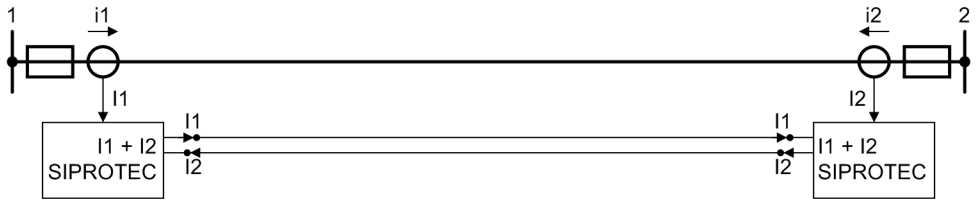
Figure 2-15 Basic principle of the differential protection for a line with two ends

Transmission Measured Value

If the entire protected object is located in one place — as is the case with generators, transformers, busbars — the measured quantities can be processed immediately. This is different for lines where the protected zone spans a certain distance from one substation to the other. To be able to process the measured quantities of all line ends at each line end, these have to be transmitted in a suitable form. In this way, the tripping condition at each line end can be checked and the respective local circuit breaker can be operated if necessary.

Bei 7SD610 transmits the measured quantities as digital telegrams via communication channels. For this, each device is equipped with at least one protection data interface.

the following figure shows this for a line with two ends. Each device measures the local current and sends the information on its intensity and phase relation to the opposite end. The interface for this communication between



[diffschutz-eine-leitung-mit-zwei-enden, 1, en_GB]

Figure 2-16 Differential protection for a line with two ends

You will find detailed information on the topology of device communication in Section *2.2.1 Functional Description*.

Restraint

The precondition for the basic principle of the differential protection is that the total sum of all currents flowing into the protected object is zero in healthy operation. This precondition is only valid for the primary system and even there only if shunt currents of a kind produced by line capacitances or magnetizing currents of transformers and parallel reactors can be neglected.

The secondary currents which are applied to the devices via the current transformers, are subject to measuring errors caused by the response characteristic of the current transformers and the input circuits of the devices. Transmission errors such as signal jitters can also cause deviations of the measured quantities. As a result of all these influences, the total sum of all currents processed in the devices in healthy operation is not exactly zero. Therefore, the differential protection is restrained against these influences.

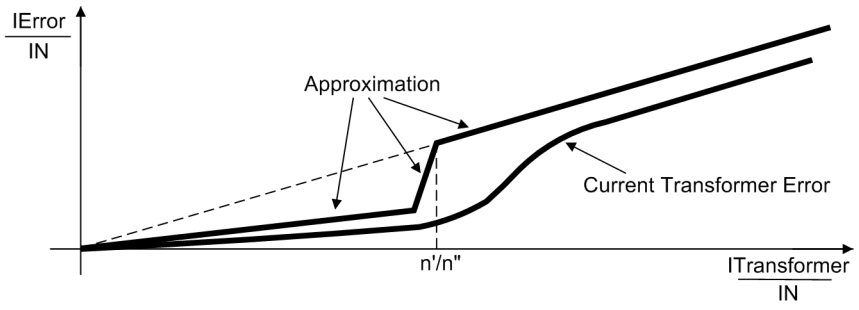
Charging Currents

Due to the capacitances of the three phases against ground and against one another, charging currents are flowing even in healthy operation and cause a difference of currents at the ends of the protected zone. Especially when cables are used, the capacitive charging currents can reach considerable magnitude.

Charging currents do not depend on the intensity of the measured currents. In healthy operation they can be considered as being almost constant under steady-state conditions, since they are only determined by the voltage and the capacitances of the lines. They can therefore be taken into account during the setting of the sensitivity of the differential protection (see also Subsection *2.3.2 Setting Notes* under "Pickup Value of Differential Current"). The same is true for the steady-state magnetizing currents across shunt reactances. The devices have a separate inrush restraint feature for transient inrush currents (see below under the margin heading "Inrush Restraint").

Current transformer errors

To consider the influences of current transformer errors, each device calculates a self-restraining quantity I_{error}. This is calculated by estimating the possible local transformer errors from the data of the local current transformers and the intensity of the locally measured currents (see *Figure 2-17*). The current transformer data have been parameterized in the power system data 1 (Section *2.1.2.1 Setting Notes* Setting Notes under margin heading "Current Transformer Characteristic" and apply to each individual device. Since each device transmits its estimated errors to the other devices, each device is also capable of forming the total sum of possible errors; this sum is used for restraint.



[naehrung-stromwandlerfehler, 1, en_GB]

Figure 2-17 Approximation of the current transformer errors

Further influences

Further measuring errors which may arise in the actual device by hardware tolerances, calculation tolerances, deviations in time or due to the "quality" of the measured quantities such as harmonics and deviations in frequency are also estimated by the device and automatically increase the local self-restraining quantity. Here, the permissible variations in the data transmission and processing periods are also considered.

Deviations in time are caused by residual errors during the synchronization of measured quantities, data transmission and operating time variations, and similar events. When GPS synchronization is used, these influences are eliminated and do not increase the self-restraining quantity.

If an influencing parameter cannot be determined — e.g. the frequency if no sufficient measured quantities are available — the device will assume nominal values by definition. In this example, frequency means that if the frequency cannot be determined because no sufficient measured quantities are available, the device will assume nominal frequency. But since the actual frequency can deviate from the nominal frequency within the permissible range (± 20% of the nominal frequency), the restraint will be increased automatically. As soon as the frequency has been determined (max. 100 ms after reappearance of a suitable measured quantity), the restraint will be decreased correspondingly. This is important during operation if no measured quantities exist in the protected area before a fault occurs, e.g. if a line with the voltage transformers on the line side is switched onto a fault. Since the frequency is not yet known at this time, an increased restraint will be active until the actual frequency is determined. This may delay the tripping, but only close to the pickup threshold, i.e. in case of very low-current faults.

The self-restraining quantities are calculated in each device from the total sum of the possible deviations and transmitted to the other device. In the same way as the total currents (differential currents) are calculated (see "Transmission of measured values" above), each device thus calculates the total sum of the restraining quantities.

It is due to the self-restraint that the differential protection always operates with the maximum possible sensitivity since the restraining quantities automatically adapt to the maximum possible errors. In this way, also highresistance faults, with high load currents at the same time, can be detected effectively. Using GPS synchronisation, the self-restraint when using communication networks is once more minimised since differences in the transmission times are compensated by the precise calculation of the two-way transmission times. A maximum sensitivity of the differential protection consists of an optical-fiber connection.

Inrush restraint

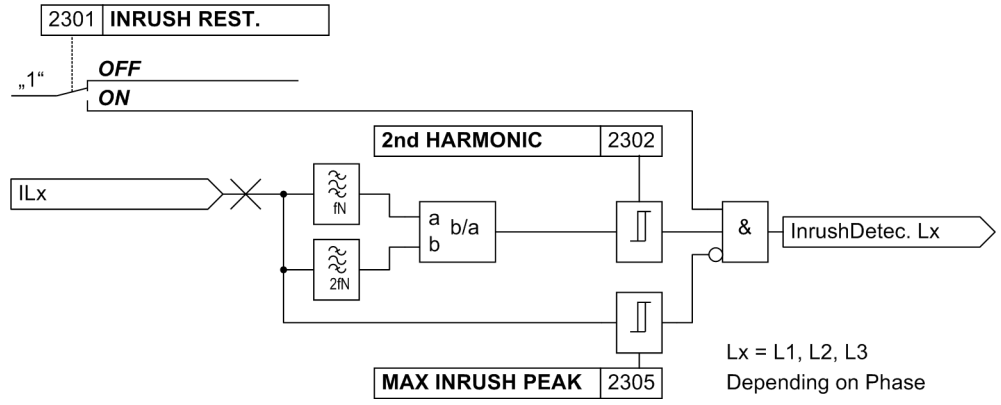
If the protected area includes a power transformer, a high inrush current can be expected when connecting the transformer. This inrush current flows into the protected zone but does not leave it again.

The inrush current can amount to a multiple of the rated current and is characterised by a considerable 2nd harmonic content (double rated frequency) which is practically absent during a short-circuit. If the second harmonic content in the differential current exceeds a selectable threshold, tripping is blocked.

The inrush restraint has an upper limit: if a certain (adjustable) current value is exceeded, it will not be effective any more, since there must be an internal current-intensive short-circuit.

Figure 2-18 shows a simplified logic diagram. The condition for the inrush restraint is examined in each device in which this function has been activated.

The blocking condition is also effective at the other device.

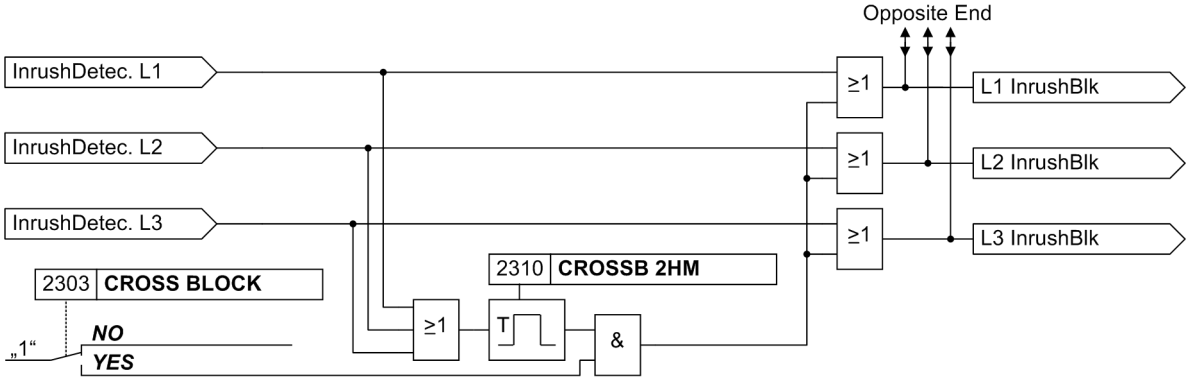


[logikdia-einschaltstabilisierung-290803st, 1, en_GB]

Figure 2-18 Logic diagram of the inrush restraint for one phase

Since the inrush restraint operates individually for each phase, the protection is fully operative when the transformer is switched onto a single-phase fault, where an inrush current may be flowing through one of the undisturbed phases. It is, however, also possible to set the protection in such a way that when the permissible harmonic content in the current of only one single phase is exceeded, not only the phase with the inrush current but also the remaining phases of the differential stage are blocked. This cross-block function can be limited to a selectable duration. the following figure shows the logic diagram.

The cross-block function also affects both devices since it not only extends the inrush restraint to all three phases but also sends it to the other devices via the communication link.



[logik-crossblock-fkt-fuer-1-ende-20110128, 1, en_GB]

Figure 2-19 Logic diagram of the cross-block function for one end

Evaluation of the measured quantities

The evaluation of measured values is performed separately for each phase. Additionally, the residual current is evaluated

Each device calculates a differential current from the total of the current phasors that are calculated at each end of the protected zone and transmitted to the other ends. The differential current value is equal to the value of the fault current that is „seen“ by the differential protection system. In the ideal case it is thus equal to the fault current value. During healthy operation it is small, and in a first approximation, equal to the charging current.

Jedes Gerät berechnet einen Differentialstrom aus der Summe der Stromzeiger, die an jedem Ende des Schutzobjektes berechnet und zu den übrigen Enden übertragen werden. Sein Betrag entspricht dem Fehlerstrom, den das Differentialschutzsystem “sieht”, im Idealfall also dem Kurzschlussstrom. Im fehlerfreien Betrieb ist er klein und entspricht bei Leitungen in erster Näherung dem Ladestrom.

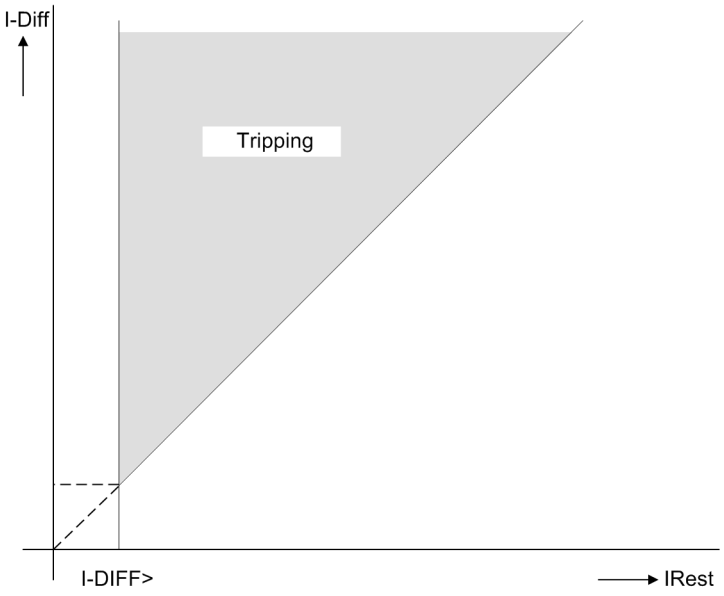
The restraining current counteracts the differential current. It is the total of the maximum measuring errors at the ends of the protected object and is calculated adaptively from the current measured quantities and power system parameters that were set. For this purpose, the maximum error of the current transformers within the nominal range and/or the short-circuit current range is multiplied with the current flowing through each end

of the protected object. Consequently, the restraint current always reflects the maximum possible measuring error of the differential protection system.

The pickup characteristic of the differential protection (see the following Figure) derives from the restraining characteristic $I_{diff} = I_{rest}$ (45°-curve), that is cut below the setting value **I-DIFF>**. It complies with the formula

I_{rest} = **I-DIFF>** + Σ (errors by CT´s and other measuring errors)

If the calculated differential current exceeds the pickup limit and the greatest possible measurement error, the fault must be internal (shaded area in the Figure).



[ansprechkennlinie-diffschutz, 1, en_GB]

Figure 2-20 Differential protection pickup characteristic, I_{diff}> stage

If not only an internal fault is to cause a TRIP command, but if a local current of a specific quantity is to exist additionally, the value of this current can be set at address 1219 **I> RELEASE DIFF**. Zero is preset for this parameter so that this additional criterion does not become effective.

High-speed charge comparison

The charge comparison is a differential protection stage which is superimposed on the current comparison (the actual differential protection). It produces high-speed tripping decisions in the event of high-current faults.

The charge comparison protection function does not sum up the complex current phasors at the ends of the protected object, but the integral of currents calculated according to the following formula:

$$Q = \int_{t_1}^{t_2} i(t)\, dt$$

[diff_ladver-280803-rei, 1, en_GB]

It includes the integration interval of t_1 to t_2, which is selected in the 7SD610 device to period $^1/_4$.

The calculated charge Q is a scalar value which is faster to determine and to transmit than a complex phasor.

The charges of both ends of the protected object are added in the same way as done with the current phasors of the differential protection. Thus the total of the charges is available at all ends of the protected zone.

Immediately after a fault has occurred in the protected zone, a charge difference emerges. For high fault currents which can lead to saturation of current transformers, a decision is thus reached before the saturation begins

The charge difference of external faults is theoretically equal to zero at the beginning. The charge comparison protection function immediately detects the external fault and blocks its own function. If saturation begins in

one or more current transformers which limit the protected zone, the before-mentioned function remains blocked. Thus possible differences resulting from the saturation are excluded. Generally it is assumed that an initial saturation of current transformers only takes place after the expiration of at least one integration interval ($^1/_4$ cycle) that commenced with the occurrence of a fault.

When energizing a line, the pickup value of the charge comparison is automatically doubled for a period of approximately 1.5 s. This is to prevent from malfunction caused by transient currents in the CT secondary circuit due to remanence of the CTs (e.g. during auto-reclosure). This current would simulate a charge value in the primary circuit.

Each phase is subject to the charge comparison. Therefore an internal fault (sequential fault) in a different phase after the external fault occurred is detected immediately. The functional limitation of the charge comparison is reached in the less probable case that an internal fault (sequential fault) appears after the occurrence of an external fault with considerable current transformer saturation in the same phase. This must be detected by the current comparison stage in the differential protection.

Furthermore the charge comparison is influenced by charge currents from lines and shunt currents from transformers (steady-state and transient) that also cause a charge difference. Therefore the charge comparison is, as aforesaid, a function suited to complete the differential protection ensuring a fast tripping for high-current short-circuits. Normally, the charge comparison is set higher than the nominal current.

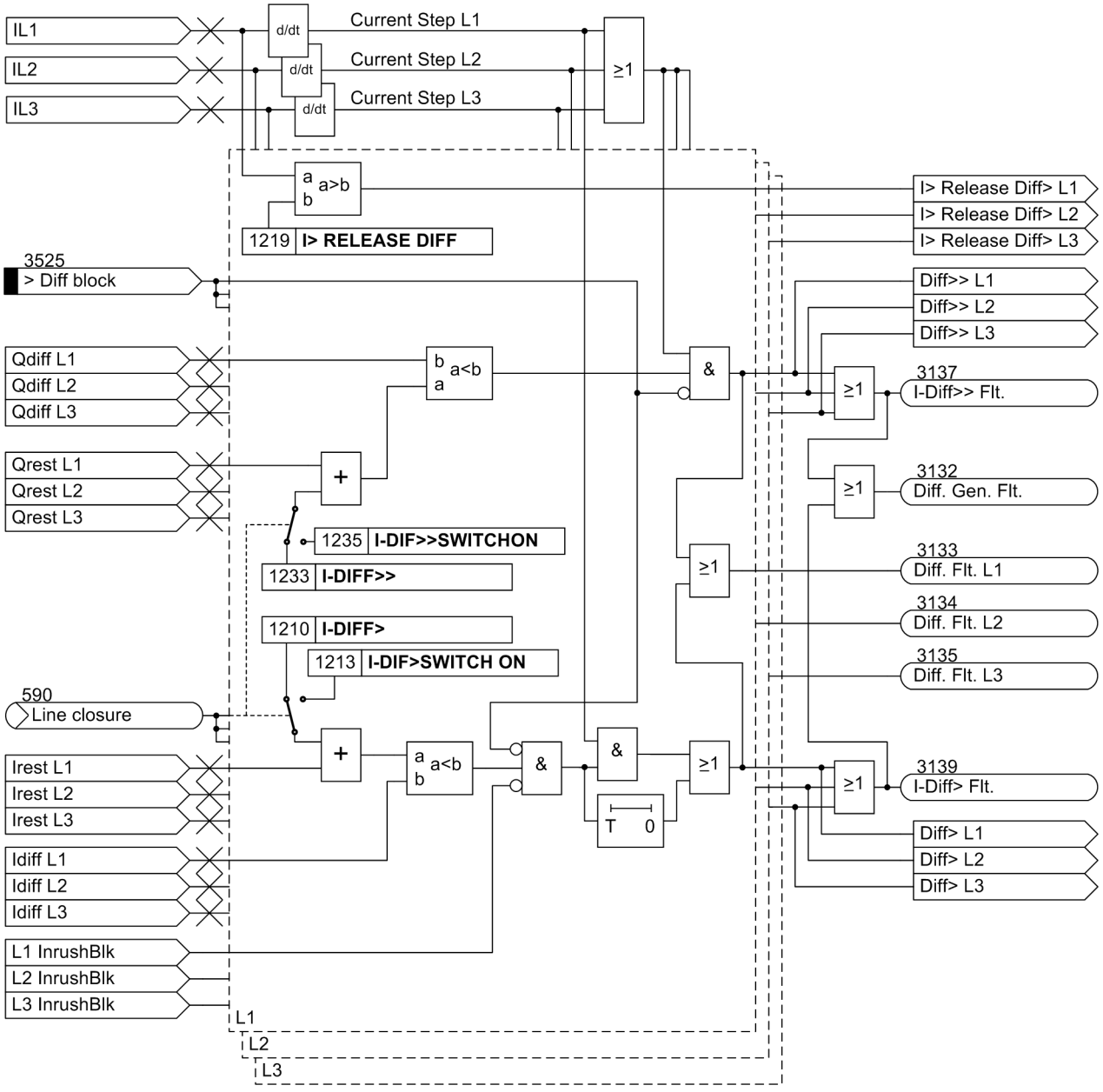
Blocking/interblocking

The differential protection can be blocked via a binary input. The blocking at one end of a protected object affects the other end via the communications link (interblocking). If the overcurrent protection is configured as an emergency function, both devices will automatically switch over to this emergency operation mode.

Please keep in mind that the differential protection is phase-selectively blocked at both ends when a wire break is detected at one end of the protected object. The message “Wire break” appears only on the device in which the wire break has been detected. The other device shows the phase-selective blocking of the differential protection by displaying dashes instead of the differential and restraint current for the failed phase.

Pickup of the differential protection

The folowing figure shows the logic diagram of the differential protection. The phase-selective indications of the stage are summarised to form general phase indications. In addition, the device indicates which stage picked up.



[anregelogik-des-differentialschutzes-010903-off, 1, en_GB]

Figure 2-21 Pickup logic for the differential protection function

As soon as the differential protection function registers a fault within its tripping zone, the signal *Diff. Gen. Flt.* (general device pickup of the differential protection) is issued. For the differential protection function itself, this pickup signal is of no concern since the tripping conditions are available at the same time. This signal, however, is necessary for the initiation of internal or external supplementary functions (e.g. fault recording, automatic reclosure).

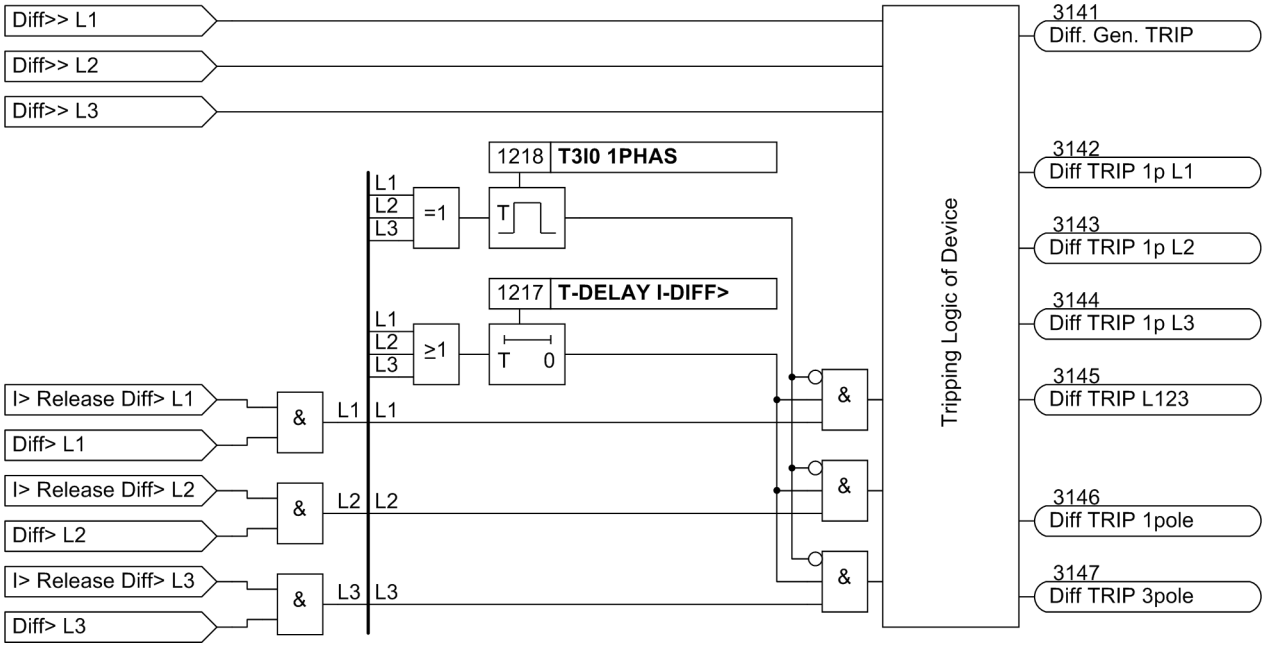
Tripping logic of the differential protection

The tripping logic of the differential protection combines all decisions of the differential stages and forms output signals which are also influenced by the central tripping logic of the entire device (see the following figure)

The pickup signals that identify the concerned stages of the differential protection stages can be delayed via the time stage **T-DELAY I-DIFF>**. Independently of this condition, a single-phase pickup can be blocked for

a short time in order to bridge the transient oscillations on occurrence of a single earth fault in a resonant-tearthed system.

The signals thus processed are linked with the output signals *Diff. Gen. TRIP*, *Diff TRIP 1p L1*, *Diff TRIP 1p L2*, *Diff TRIP 1p L3*, *Diff TRIP L123* in the tripping logic of the device. The single-pole information implies that tripping will actually take place single-pole only. The actual generation of the commands for the tripping (output) relay is executed within the tripping logic of the entire device (see Section *2.16.1 Function Control*).



[ausloeselogik-fuer-differentialschutz, 1, en_GB]

Figure 2-22 Tripping logic of the differential protection

2.3.2 Setting Notes

General

The differential protection can be switched 1201 **STATE OF DIFF.** in address *ON* or *OFF*. If any device is switched off, a calculation of measured values becomes impossible. The entire differential protection system of both ends is then blocked.

Pickup value of differential current

The current sensitivity is set with address 1210 **I-DIFF>**. It is determined by the entire current flowing into a protected zone in case of a short-circuit. This is the total fault current regardless of how it is distributed between the ends of the protected object.

This pickup value must be set to a value that is higher than the total steady-state shunt current of the protected object. For cables and long overhead lines, the charging current is to be considered in particular.

The charging current is calculated from the operational capacitance:

$I_C = 3.63 \cdot 10^{-6} \cdot U_N \cdot f_N \cdot C_B' \cdot s$

with

I_C	Charging current to be calculated in A primary
U_N	Nominal voltage of the network in kV primary
f_N	Nominal frequency of the network in Hz
C_B'	Per unit line length capacitance of the line in nF/km or nF/mile
s	Length of the line in km or miles

Considering the variations of voltage and frequency, the set value should be at least 2 to 3 times higher than the calculated charging current. Moreover, the pickup value should not be less than 15% of the rated operational current. The rated operational current either derives from the nominal apparent power of a transformer in the protected zone (as described in Section *2.1.4.1 Setting Notes* under margin heading "Topological Data for Transformers (optional)", or from the addresses 1104 **FullScaleCurr.** according to Section *2.1.4.1 Setting Notes* under margin heading "Nominal Values of Protected Lines". It must be identical at all ends of the protected object.

If setting is performed from a personal computer using DIGSI, the parameters can be set either as primary or as secondary quantities. If secondary quantities are set, all currents must be converted to the secondary side of the current transformers.

Calculation Example:

110 kV single-conductor oil-filled cable

Cross section = 240 mm^2

Rated frequency f_N = 50 Hz

Length s = 16 km

Capacitance C_B' = 310 nF/km

Current transformer, transformer ratio 600 A/5 A

From that the steady-state charging current is calculated:

$I_C = 3.63 \cdot 10^{-6} \cdot U_N \cdot f_N \cdot C_B' \cdot s = 3.63 \cdot 10^{-6} \cdot 110 \cdot 50 \cdot 310 \cdot 16 = 99$ A

For the setting with primary values at least double the value is to be set, i.e.:

Setting value **I-DIFF>** = 200 A

For the setting with secondary values this value has to be converted to secondary quantity:

$$\text{SettingValue I-DIFF>} = \frac{200\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 1.67\ \text{A}$$

[diff_ewsek-280803-rei, 1, en_GB]

If a power transformer with voltage regulation is installed within the protected zone consider that a differential current may be present even during normal operation, dependent on the position of the tap changer. Please also refer to the notes in chapter *2.1.2.1 Setting Notes* Setting information, Margin heading "Power Transformer with Voltage Regulation".

Pickup value during switch-on

When switching on long, unloaded cables, overhead lines and arc-compensated lines, pronounced higher-frequency transient reactions may take place. These peaks are considerably damped by means of a digital filter in the differential protection. A pickup value **I-DIF>SWITCH ON** (address 1213) can be set to reliably prevent single-sided pickup of the protection. This pickup value is active whenever a device has recognized the connection of a dead line at its end. For the duration of the seal-in time **SI Time all Cl.**. which was set in the general protection data at address 1132 (Section *2.1.4.1 Setting Notes*) all devices are then switched over to this particular pickup sensitivity. A setting to three to four times the steady-state charging current usually ensures the stability of the protection during switch-on of the line. For switch-on of a transformer or shunt reactor, an inrush restraint is incorporated (see below under margin heading "Inrush Restraint").

The pickup thresholds are checked during commissioning. For further information please refer to the chapter Mounting and Commissioning.

Delays

In special cases of application it may be useful to delay the tripping of the differential protection with an additional timer, e.g. in case of reverse interlocking. The delay time **T-DELAY I-DIFF>** (address 1217) is only started upon detection of an internal fault. This parameter can only be altered with DIGSI at **Additional Settings**.

If the differential protection is applied to an isolated or resonant-earthed network, it must be ensured that tripping is avoided due to the transient oscillations of a single earth fault. With address 1218 **T3I0 1PHAS** pickup on a single fault is therefore delayed for 0.04 s (default setting). For large resonant-earthed systems the time delay should be increased. By setting the address to ∞, the single-phase pickup is suppressed entirely.

In an earthed system, **T3I0 1PHAS** shall be set to 0.00 s. This parameter can only be altered in DIGSI at **Additional Settings**.

If it is desired that a TRIP command is generated in the event of an internal fault only if simultaneously the current of the local line end has exceeded a specific quantity, then this current threshold can be set for enabling the differential protection TRIP at address 1219 **I> RELEASE DIFF**. This parameter can only be altered in DIGSI at **Additional Settings**.

Pickup value of charge comparison stage

The pickup threshold of the charge comparison stage is set in address 1233 **I-DIFF>>**. The RMS value of the current is decisive. The conversion into charge value is carried out by the device itself.

In most cases, it is adequate to set the values to approx. 100 % to 200 % of the operational nominal current. Please also consider that the setting is related to the operational nominal values that must be equal on the pimary side at all ends of the protected object.

Since this stage reacts very quickly, a pickup of capacitive charging currents (for lines) and inductive magnetizing currents (for transformers or shunt reactors) must be excluded – also for switching processes. If there are inductances or transformers located in the protected area (between the current transformers of the differential protection), the parameters must be set to a value higher than the max. magnetizing current (rush current) to be expected.

For protected transformers, set the value $I_{N\ Transformer}/u_{k\ Transformer}$.

In resonant-earthed systems, the value of the non-compensated system earth fault current should not be undershot as well. This value derives from the capacitive earth fault current of the entire network without considering the Arc-suppression coil. As the Arc-suppression coil serves to compensate nearly the total earth fault current, its nominal current can be approximately used as a basis.

The pickup thresholds are finally checked during commissioning. Further information can be found in chapter Installation and Commissioning.

Pickup value when switching on the charge comparison

If bushing transformers are used for a transformer in the protected line section, stray fluxes through the bushing transformers may occur when reclosing after an external fault. These stray fluxes may cause a distortion of the secondary current and an overfunction of the charge comparison.

If bushing transformers are used, the setting value of parameter 1235 **I-DIF>>SWITCHON** should be 2 to 3 times the setting value of **I-DIFF>>**. The default setting of **I-DIF>>SWITCHON** corresponds to the default setting of parameter 1233 **I-DIFF>>**. In the default setting, this parameter is therefore ineffective.



NOTE

The setting value of Parameter **I-DIF>> ZUSCH.** must be higher or equal than the setting value of Parameter **I-DIF>> ZUSCH.**.

If the setting value of parameter **I-DIF>> ZUSCH.** is lower than the setting value of parameter **I-DIFF>>**, the setting value is changed automatically to the same setting as parameter **I-DIFF>>**.

Inrush restraint

The inrush restraint of the differential protection is only necessary when the devices are operated on a transformer or on lines which end on transformers. The transformer is located inside the differential protection zone. Inrush restraint can be turned ***ON*** or ***OFF*** at address 2301 **INRUSH REST.**.

It is based on the evaluation of the second harmonic which exists in the inrush current. Ex-works a ratio of **15 %** of the **2nd HARMONIC** I_{2fN}/I_{fN} is set under address 2302, which can normally be taken over. However the component required for restraint can be parameterized. In order to be able to achieve a higher degree of restraint in case of exceptionally unfavourable inrush conditions, you may also set a smaller value.

However, if the local measured current exceeds a value set in address 2305 **MAX INRUSH PEAK**, there will be no inrush restraint. The peak value is decisive. The set value should be higher than the maximum inrush current peak value that can be expected. For transformers, you can set the value above $\sqrt{2}\cdot I_{NTransformator}/u_{kTrans-}$

formator by rule of thumb. If a line ends on a transformer, a smaller value may be selected, considering the damping of the current by the line impedance.

At address 2303 **CROSS BLOCK**, the crossblock function can be activated (***YES***) or deactivated (***NO***). The time after exceeding the current threshold for which this crossblock is to be activated is set at address 2310 **CROSSB 2HM**. With the setting ∞ the crossblock function is always active until the second harmonic content in all phases has dropped below the set value.

2.3.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1201	STATE OF DIFF.		OFF ON	ON	State of differential protection
1210	I-DIFF>	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Pickup value
		5A	0.50 .. 100.00 A	1.50 A	
1213	I-DIF>SWITCH ON	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Value under switch on condition
		5A	0.50 .. 100.00 A	1.50 A	
1217A	T-DELAY I-DIFF>		0.00 .. 60.00 sec; ∞	0.00 sec	I-DIFF>: Trip time delay
1218	T3I0 1PHAS		0.00 .. 0.50 sec; ∞	0.04 sec	Delay 1ph-faults (comp/ isol. star-point)
1219A	I> RELEASE DIFF	1A	0.10 .. 20.00 A; 0	0.00 A	Min. local current to release DIFF-Trip
		5A	0.50 .. 100.00 A; 0	0.00 A	
1233	I-DIFF>>	1A	0.8 .. 100.0 A; ∞	1.2 A	I-DIFF>>: Pickup value
		5A	4.0 .. 500.0 A; ∞	6.0 A	
1235	I-DIF>>SWITCHON	1A	0.8 .. 100.0 A; ∞	1.2 A	I-DIFF>>: Value under switch on cond.
		5A	4.0 .. 500.0 A; ∞	6.0 A	
2301	INRUSH REST.		OFF ON	OFF	Inrush Restraint
2302	2nd HARMONIC		10 .. 45 %	15 %	2nd. harmonic in % of fundamental
2303	CROSS BLOCK		NO YES	NO	Cross Block
2305	MAX INRUSH PEAK	1A	1.1 .. 25.0 A	15.0 A	Maximum inrush-peak value
		5A	5.5 .. 125.0 A	75.0 A	
2310	CROSSB 2HM		0.00 .. 60.00 sec; ∞	0.00 sec	Time for Crossblock with 2nd harmonic

2.3.4 Information List

No.	Information	Type of Information	Comments
3102	2nd Harmonic L1	OUT	Diff: 2nd Harmonic detected in phase L1
3103	2nd Harmonic L2	OUT	Diff: 2nd Harmonic detected in phase L2
3104	2nd Harmonic L3	OUT	Diff: 2nd Harmonic detected in phase L3
3120	Diff active	OUT	Diff: Active
3132	Diff. Gen. Flt.	OUT	Diff: Fault detection

No.	Information	Type of Informa-tion	Comments
3133	Diff. Flt. L1	OUT	Diff: Fault detection in phase L1
3134	Diff. Flt. L2	OUT	Diff: Fault detection in phase L2
3135	Diff. Flt. L3	OUT	Diff: Fault detection in phase L3
3136	Diff. Flt. E	OUT	Diff: Earth fault detection
3137	I-Diff>> Flt.	OUT	Diff: Fault detection of I-Diff>>
3139	I-Diff> Flt.	OUT	Diff: Fault detection of I-Diff>
3141	Diff. Gen. TRIP	OUT	Diff: General TRIP
3142	Diff TRIP 1p L1	OUT	Diff: TRIP - Only L1
3143	Diff TRIP 1p L2	OUT	Diff: TRIP - Only L2
3144	Diff TRIP 1p L3	OUT	Diff: TRIP - Only L3
3145	Diff TRIP L123	OUT	Diff: TRIP L123
3146	Diff TRIP 1pole	OUT	Diff: TRIP 1pole
3147	Diff TRIP 3pole	OUT	Diff: TRIP 3pole
3148	Diff block	OUT	Diff: Differential protection is blocked
3149	Diff OFF	OUT	Diff: Diff. protection is switched off
3176	Diff Flt. 1p.L1	OUT	Diff: Fault detection L1 (only)
3177	Diff Flt. L1E	OUT	Diff: Fault detection L1E
3178	Diff Flt. 1p.L2	OUT	Diff: Fault detection L2 (only)
3179	Diff Flt. L2E	OUT	Diff: Fault detection L2E
3180	Diff Flt. L12	OUT	Diff: Fault detection L12
3181	Diff Flt. L12E	OUT	Diff: Fault detection L12E
3182	Diff Flt. 1p.L3	OUT	Diff: Fault detection L3 (only)
3183	Diff Flt. L3E	OUT	Diff: Fault detection L3E
3184	Diff Flt. L31	OUT	Diff: Fault detection L31
3185	Diff Flt. L31E	OUT	Diff: Fault detection L31E
3186	Diff Flt. L23	OUT	Diff: Fault detection L23
3187	Diff Flt. L23E	OUT	Diff: Fault detection L23E
3188	Diff Flt. L123	OUT	Diff: Fault detection L123
3189	Diff Flt. L123E	OUT	Diff: Fault detection L123E
3190	Test Diff.	IntSP	Diff: Set Teststate of Diff. protection
3191	Comm. Diff	IntSP	Diff: Set Commissioning state of Diff.
3192	TestDiff.remote	OUT	Diff: Remote relay in Teststate
3193	Comm.Diff act.	OUT	Diff: Commissioning state is active
3197	>Test Diff. ON	SP	Diff: >Set Teststate of Diff. protection
3198	>Test Diff. OFF	SP	Diff: >Reset Teststate of Diff. protec.
3199	Test Diff.ONoff	IntSP	Diff: Teststate of Diff. prot. ON/OFF
3200	TestDiffONoffBI	IntSP	Diff: Teststate ON/OFF via BI
3260	>Comm. Diff ON	SP	Diff: >Commissioning state ON
3261	>Comm. Diff OFF	SP	Diff: >Commissioning state OFF
3262	Comm Diff.ONoff	IntSP	Diff: Commissioning state ON/OFF
3263	CommDiffONoffBI	IntSP	Diff: Commissioning state ON/OFF via BI
3525	> Diff block	SP	>Differential protection blocking signal
3526	Diffblk.rec PI1	OUT	Differential blocking received at PI1
3528	Diffblk.sen PI1	OUT	Differential blocking sending via PI1

2.4 Breaker Intertrip and Remote Tripping

7SD610 allows to transmit a tripping command created by the local differential protection to the other end of the protected object (intertripping). Likewise, any desired command of another internal protection function or of an external protection, monitoring or control equipment can be transmitted for remote tripping.

The reaction when receiving such a command can be set individually for each device.

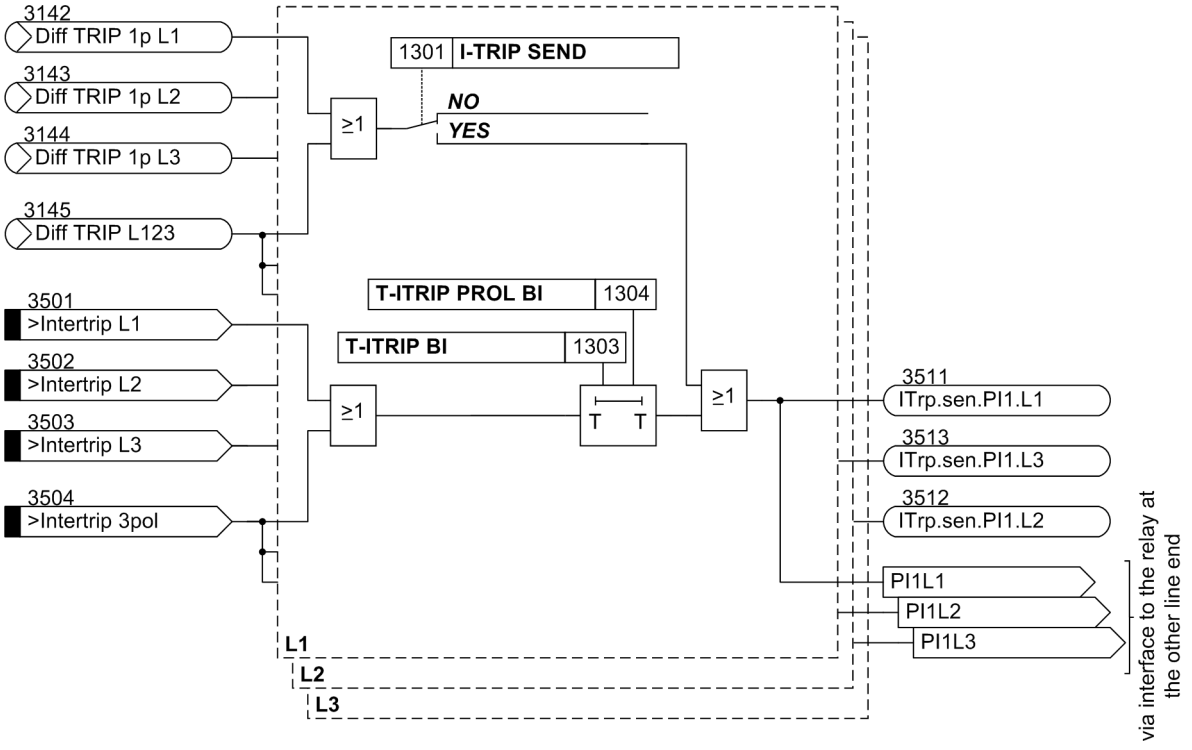
Commands are transmitted separately for each phase, so that a simultaneous single-pole auto-reclosure is always possible, provided that devices and circuit breakers are designed for single-pole tripping.

2.4.1 Functional Description

Transmission Circuit

The transmission signal can originate from two different sources (see logical diagram). If the parameter **I-TRIP SEND** is set to ***YES***, each tripping command of the differential protection is routed immediately to the transmission function "ITrp.sen. L1" to "...L3" (intertrip) and transmitted via the communication link at the protection data interface.

Furthermore, it is possible to trigger the transmission function via binary inputs (remote tripping). This can be done either separately for each phase via the input functions *>Intertrip L1*, *>Intertrip L2* and *>Intertrip L3*, or for all phases together (3-pole) via the binary input function *>Intertrip 3pol*. The transmission signal can be delayed with **T-ITRIP BI** and prolonged with **T-ITRIP PROL BI**.



[mitnahme-sendekreis-060406, 1, en_GB]

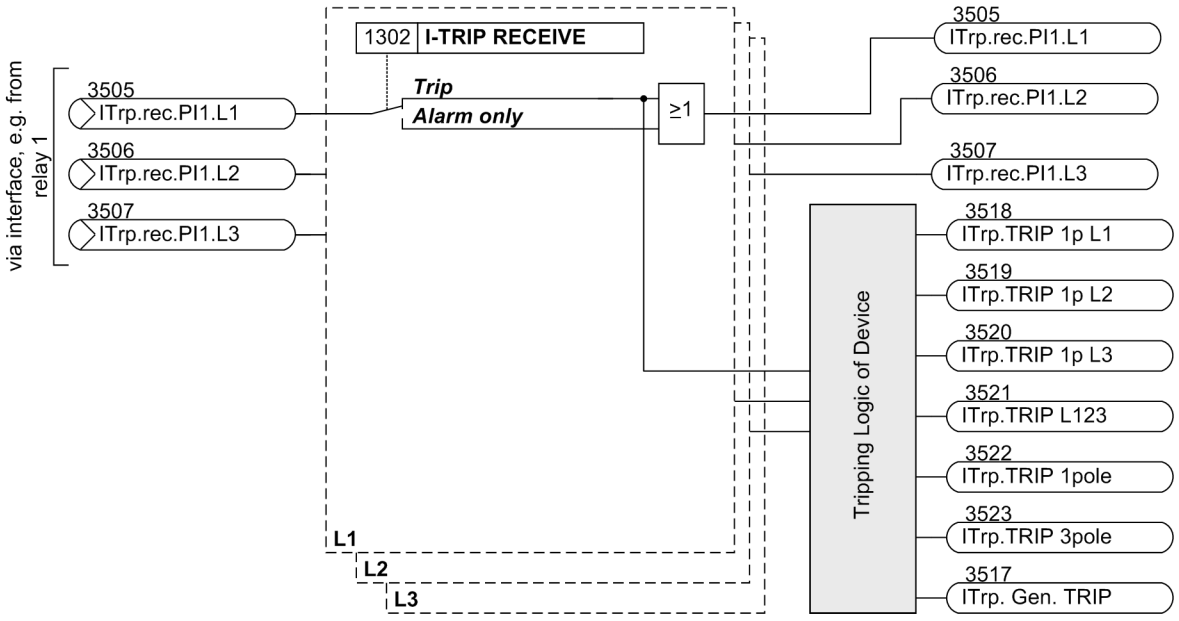
Figure 2-23 Logic diagram of the intertrip — transmission circuit

Receiving circuit

On the receiving end the signal can lead to a trip. Alternatively it can also cause an alarm only.

The following figure shows the logic diagram. If the received signal is to cause the trip, it will be forwarded to the tripping logic. The tripping logic of the device (see also Section *2.16.1 Function Control*) ensures, if necessary, that the conditions for single-pole tripping are met (e.g. single-pole tripping permissible, auto-reclosure function ready).

Once an error in the protection data interface communication has been detected, the time **`Td ResetRemote`** (address 4512) for resetting the inter trip signals is started. This means that in case of communication is interrupted, a present receive signal maintains its last status for the time **`Td ResetRemote`** before it is reset.



[mitnahme-empfangskreis-060406, 1, en_GB]

Figure 2-24 Logic diagram of the intertrip receive circuit

Ancillary functions

Since the signals for remote tripping can be set to cause only an alarm, any other desired signals can be transmitted in this way as well. After the binary input(s) have been activated, the signals which are set to cause an alarm at the receiving end are transmitted. These alarms can in turn execute any desired actions at the receiving end.

It should be noted that for the transmission of remote alarms and remote commands a further 24 transmission channels and, in addition, 4 fast transmission channels are optionally available (see also Section *2.7 Transmission of binary commands and messages*).

2.4.2 Setting Notes

General

The intertrip function for tripping caused by the differential protection can be activated (***`YES`***) or deactivated (***`NO`***) with address 1301 **`I-TRIP SEND`**. Since the differential protection devices theoretically operate with the same measured values at all ends of the protected object, a tripping in the event of an internal fault normally is also carried out at all ends, regardless of the infeed conditions at the ends. In special cases, i.e. if fault currents are to be expected near to the pickup threshold, it may occur that one or more ends do not issue a trip command due to inevitable device tolerances. For these cases **`I-TRIP SEND`** = ***`YES`*** ensures the tripping at all ends of the protected object.

Intertrip/Remote tripping

If the intertrip function is activated, it will automatically start if the differential protection trips on one line end only.

If the relevant binary inputs are allocated and activated by an external source, the intertrip signal is transmitted as well. In this case, the signal to be transmitted can be delayed with address 1303 **`T-ITRIP BI`**. This delay stabilizes the transmission signal against dynamic interferences which may occur on the control cabling. Address 1304 **`T-ITRIP PROL BI`** is used to extend a signal after it has been effectively injected from an external source.

The reaction of a device when receiving an intertrip/remote tripping signal is set at address 1302 **I-TRIP RECEIVE**. If it is supposed to cause tripping, set the value ***Trip***. If the received signal, however, is supposed to cause an alarm only, ***Alarm only*** must be set if this indication is to be further processed externally.

The setting times depend on the individual case of application. A delay is necessary if the external control signal originates from a disturbed source and a restraint seems appropriate. Of course, the control signal has to be longer than the delay for the signal to be effective. If the signal is processed externally at the receiving end, a prolongation time might become necessary for the transmitting end so that the reaction desired at the receiving end can be executed reliably.

2.4.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
1301	I-TRIP SEND	YES NO	NO	State of transmit. the intertrip command
1302	I-TRIP RECEIVE	Alarm only Trip	Trip	Reaction if intertrip command is receiv.
1303	T-ITRIP BI	0.00 .. 30.00 sec	0.02 sec	Delay for intertrip via binary input
1304	T-ITRIP PROL BI	0.00 .. 30.00 sec	0.00 sec	Prolongation for intertrip via bin.input

2.4.4 Information List

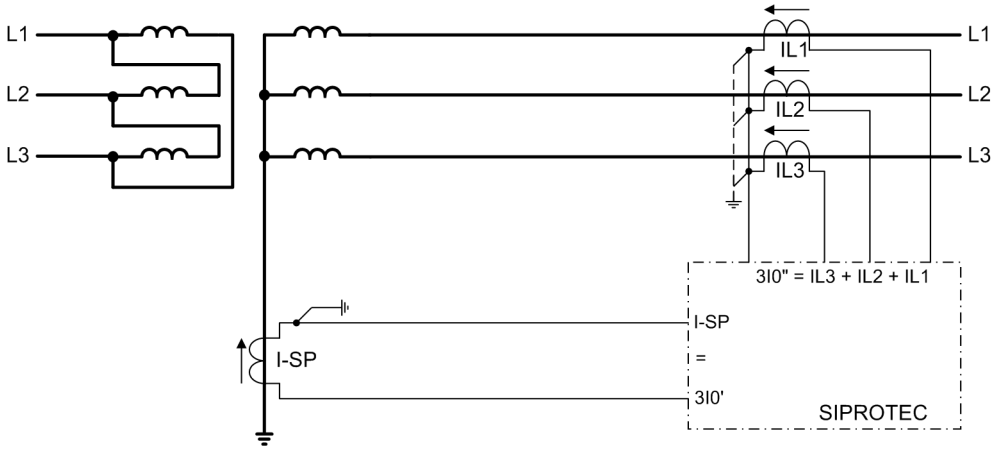
No.	Information	Type of Information	Comments
3501	>Intertrip L1	SP	I.Trip: >Intertrip L1 signal input
3502	>Intertrip L2	SP	I.Trip: >Intertrip L2 signal input
3503	>Intertrip L3	SP	I.Trip: >Intertrip L3 signal input
3504	>Intertrip 3pol	SP	I.Trip: >Intertrip 3 pole signal input
3505	ITrp.rec.PI1.L1	OUT	I.Trip: Received at Prot.Interface 1 L1
3506	ITrp.rec.PI1.L2	OUT	I.Trip: Received at Prot.Interface 1 L2
3507	ITrp.rec.PI1.L3	OUT	I.Trip: Received at Prot.Interface 1 L3
3511	ITrp.sen.PI1.L1	OUT	I.Trip: Sending at Prot.Interface 1 L1
3512	ITrp.sen.PI1.L2	OUT	I.Trip: Sending at Prot.Interface 1 L2
3513	ITrp.sen.PI1.L3	OUT	I.Trip: Sending at Prot.Interface 1 L3
3517	ITrp. Gen. TRIP	OUT	I.Trip: General TRIP
3518	ITrp.TRIP 1p L1	OUT	I.Trip: TRIP - Only L1
3519	ITrp.TRIP 1p L2	OUT	I.Trip: TRIP - Only L2
3520	ITrp.TRIP 1p L3	OUT	I.Trip: TRIP - Only L3
3521	ITrp.TRIP L123	OUT	I.Trip: TRIP L123
3522	ITrp.TRIP 1pole	OUT	I.Trip: TRIP 1pole
3523	ITrp.TRIP 3pole	OUT	I.Trip: TRIP 3pole

2.5 Restricted Earth Fault Protection (optional)

The restricted earth fault protection detects earth faults in power transformers, the starpoint of which is earthed. It is also suitable when a starpoint former is installed within a protected zone of a non-earthed power transformer. A precondition is that a current transformer is installed in the starpoint connection, i.e. between the starpoint and the earthing electrode. The starpoint CT and the phase CTs define the limits of the protected zone exactly.

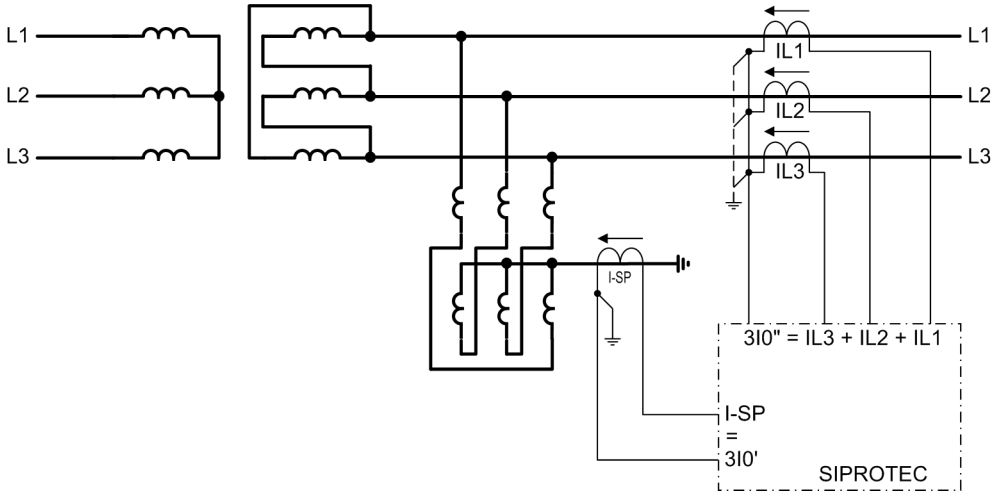
2.5.1 Application Examples

Figures *Figure 2-25* and *Figure 2-26* show two application examples. A prerequisite is that the I4 transformer detects the starpoint current of the transformer side to be protected.



[erddiff-sternwicklung-020926-rei, 1, en_GB]

Figure 2-25 Restricted earth fault protection on an earthed transformer winding



[erddiff-dreieckswicklung-020926-rei, 1, en_GB]

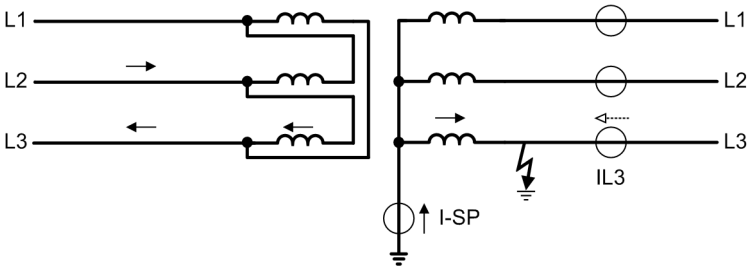
Figure 2-26 Earth fault differential protection at a delta winding with earthed artificial starpoint (neutral earthing transformer, zigzag reactor)

2.5.2 Functional Description

Messprinzip

During normal operation, no starpoint current $\underline{I}_{SP}$ flows through the starpoint lead. The sum of the phase currents $3\underline{I}_0 = \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$ approximates zero.

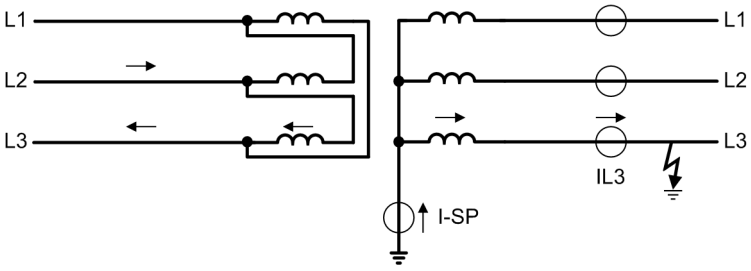
When an earth fault occurs in the protected zone, a starpoint current $\underline{I}_{SP}$ will flow; depending on the earthing conditions of the power system a further earth current may be recognized in the residual current path of the phase current transformers (dashed arrow in *Figure 2-27*), which is, however, more or less in phase with the starpoint current. The current direction into the protected object is defined as positive.



[erddiff-erdkurzschluss-innerhalb, 1, en_GB]

Figure 2-27 Beispiel für Erdkurzschluss innerhalb des Trafos mit Stromverteilung

When an earth fault occurs outside the protected zone (*Figure 2-28*), a starpoint current $\underline{I}_{SP}$ will also flow. But an equally large current $3\underline{I}_0$ must then flow through the phase current transformers. Since the current direction into the protected object is defined as positive, this current is in phase opposition with $\underline{I}_{SP}$.



[erddiff-erdkurzschluss-ausserhalb, 1, en_GB]

Figure 2-28 Example for an earth fault outside a transformer with current distribution

When an external non-earthed fault causes heavy currents to flow through the protected zone, differences in the magnetic characteristics of the phase current transformers under conditions of saturation may cause a significant summation current which could resemble an earth current flowing into the protected zone. Measures must be taken to prevent this current from causing a trip. For this, the restricted earth fault protection provides stabilization methods which differ strongly from the usual stabilization methods of differential protection schemes since it considers both the magnitude of the measured currents and their direction (phase relationship).

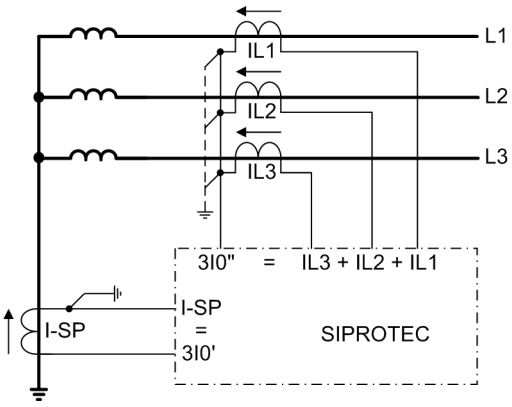
Evaluation of Measurement Quantities

The earth fault differential protection compares the fundamental component of the current flowing in the starpoint connection, which is designated as $3\underline{I}_0'$ in the following, with the fundamental component of the sum of the phase currents designated in the following as $3\underline{I}_0''$. Thus, the following applies (*Figure 2-29*):

$3\underline{I}_0' = \underline{I}_{SP}$

$3\underline{I}_0'' = \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$

Only $3\underline{I}_0'$ acts as the tripping effect quantity. During a fault within the protected zone this current is always present.



[erddiff-prinzip-020926-rei, 1, en_GB]

Figure 2-29 Principle of restricted earth fault protection

When an earth fault occurs outside the protected zone, a zero sequence current also flows though the phase current transformers. This is, on the primary side, in counter-phase with the starpoint current and has equal magnitude. Therefore, both the magnitude of the currents and their phase relationship are evaluated for restraint purposes. The following is defined:

A tripping current

$I_{Ref} = |3\underline{I}_0'|$

and a stabilisation or restraining current

$I_{Rest} = k \cdot (|3\underline{I}_0' - 3\underline{I}_0''| - |3\underline{I}_0' + 3\underline{I}_0''|)$

where k is a stabilisation factor which will be explained below, at first we assume k = 1. I_{REF} produces the tripping effect quantity, I_{Rest} counteracts this effect.

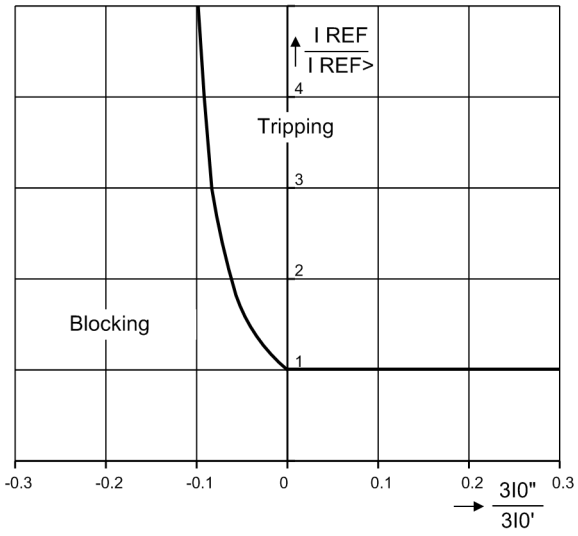
To illustrate the effect, have a look at the three important operating conditions with ideal and adapted measured values:

- Through current on an external earth fault:
  $3\underline{I}_0''$ is in phase opposition with $3\underline{I}_0'$, .e. $3\underline{I}_0'' = -3\underline{I}_0'$
  $I_{Ref} = |3\underline{I}_0'|$
  $I_{Rest} = |3\underline{I}_0' + 3\underline{I}_0'| - |3\underline{I}_0' - 3\underline{I}_0'| = 2 \cdot |3\underline{I}_0'|$
  The tripping effect current (I_{Ref}) equals the starpoint current; restraint (I_{Rest}) corresponds to twice the tripping effect current.
- Internal earth fault, fed only from the starpoint
  In this case $3\underline{I}_0'' = 0$
  $I_{Ref} = |3\underline{I}_0'|$
  $I_{Rest} = |3\underline{I}_0' - 0| - |3\underline{I}_0' + 0| = 0$
  The tripping effect current (I_{Ref}) equals the starpoint current; restraint (I_{Rest}) is zero, i.e. full sensitivity during internal earth fault.
- Internal earth fault, fed from the starpoint and from the system, e.g. with equal earth current magnitude:
  In this case $3\underline{I}_0'' = 3\underline{I}_0'$
  $I_{Ref} = |3\underline{I}_0'|$
  $I_{Rest} = |3\underline{I}_0' - 3\underline{I}_0'| - |3\underline{I}_0' + 3\underline{I}_0'| = -2 \cdot |3\underline{I}_0'|$
  The tripping effect current (I_{Ref}) equals the starpoint current; the restraining quantity (I_{Rest}) is negative and, therefore, set to zero, i.e. full sensitivity during internal earth fault.

This result shows that for an internal fault no restraint is effective since the restraining quantity is either zero or negative. Thus, even small earth currents can cause tripping. In contrast, strong restraint becomes effective for external earth faults. *Figure 2-30* shows that the higher the zero-sequence current transmitted by the phase current transformers, the stronger results the restraint in case of external earth faults (area $3I_0''/3I_0'$

negative). With ideal transmission behaviour, the currents $3I_0$" and $3I_0$' would be inversely equal, i.e. $3I_0"/3I_0' = -1$.

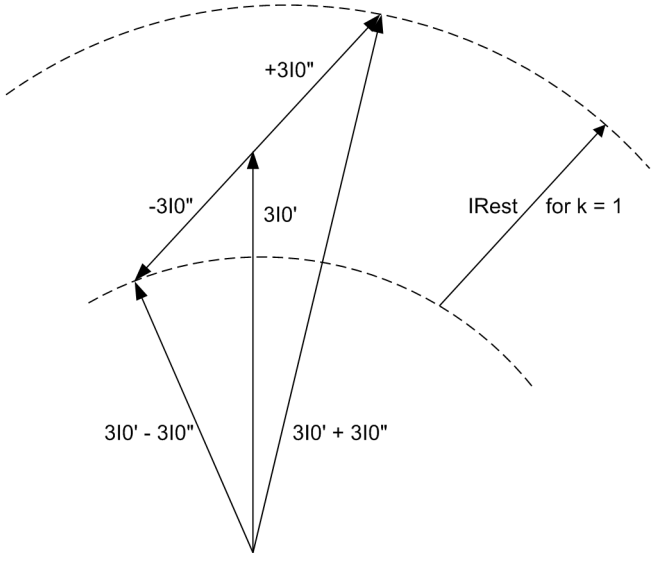
If the starpoint current transformer is designed weaker than the phase current transformers (e.g. by selection of a smaller accuracy limit factor or by higher secondary burden), no trip will be possible under through-fault condition even in case of severe saturation as the magnitude of $3I_0$" is always higher than that of $3I_0$'.



[erddiff-ausloesekennlinie-020926-rei, 1, en_GB]

Figure 2-30 Tripping characteristic of the restricted earth fault protection depending on the earth current ratio $3I_0"/3I_0'$ (both currents in phase + or counter-phase –); $I_{Ref}>$ = setting; I_{Ref} = tripping current

It was assumed in the above examples that the currents $3\underline{I}_0$" and $3\underline{I}_0$' are in counter-phase for external earth faults which is, is in fact, true for the primary measured quantities. Current transformer saturation may, however, feign a phase displacement between the starpoint current and the sum of the phase currents which reduces the restaint quantity. With $\phi(3\underline{I}_0"; 3\underline{I}_0') = 90°$ the restraint quantity is zero. This corresponds to the conventional direction determination using the method of summation and and difference comparison.



[erddiff-stabgroesse-020926-rei, 1, en_GB]

Figure 2-31 Phasor diagram of the restraint quantity during external fault

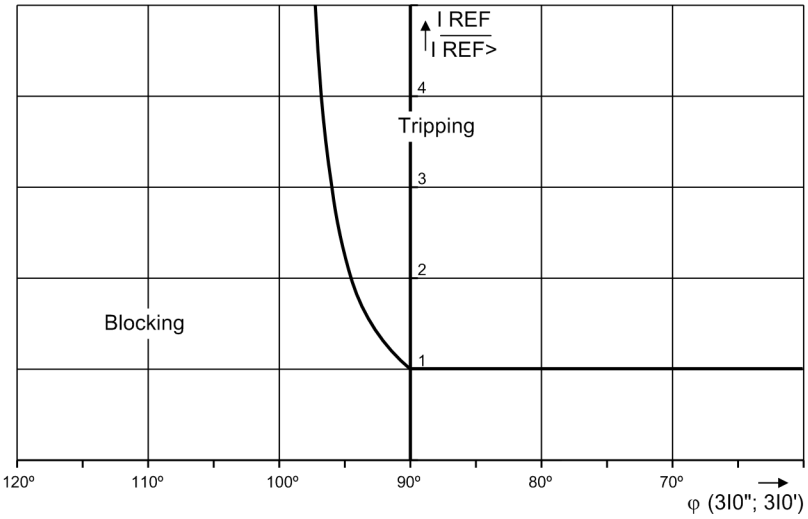
The restraint quantity can be influenced by a factor k. This factor has a certain relationship to the limit angle ϕ_{limit}.

This limit angle determines for which phase displacement between $3\underline{I}_0$" and $3\underline{I}_0$' the pickup value for $3\underline{I}_0$" = $3\underline{I}_0$' grows to ∞, i.e. no pickup occurs. In 7SD610 k = 4.

In the aforementioned example 1), the restraint quantity I_{Rest} is quadrupled once more; thus, it becomes 8 times the tripping quantity I_{REF}.

The threshold angle φ_{Grenz} = 100°. That means no trip is possible for phase displacement $\varphi(3\underline{I}_0"; 3\underline{I}_0') \geq 100°$.

Figure 2-32 shows the operating characteristics of the restricted earth fault protection dependent of the phase displacement between $3\underline{I}_0$" and $3\underline{I}_0$' for a constant infeed ratio $|3\underline{I}_0"| = |3\underline{I}_0'|$.



[erddiff-ausloesekennlinie-phasenw-020926-rei, 1, en_GB]

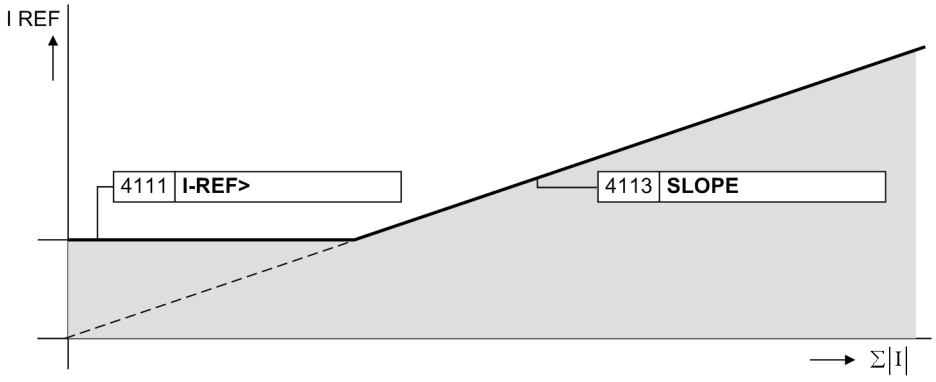
Figure 2-32 Auslösekennlinie des Erdfehlerdifferentialschutzes in Abhängigkeit von Phasenwinkel zwischen $3I_0$" and $3I_0$' at $3I_0$" = $3I_0$' (180° = external fault)

It is also possible to increase the tripping value proportional to the current sum. In this case the pickup value is stabilized with the arithmetic sum of all currents, i.e. with $IrestREF = \Sigma |I| = |I_{L1}| + |I_{L2}| + |I_{L3}| + |I_4|$ (*Figure 2-33*). The slope of the characteristic curve can be adjusted.

Pickup

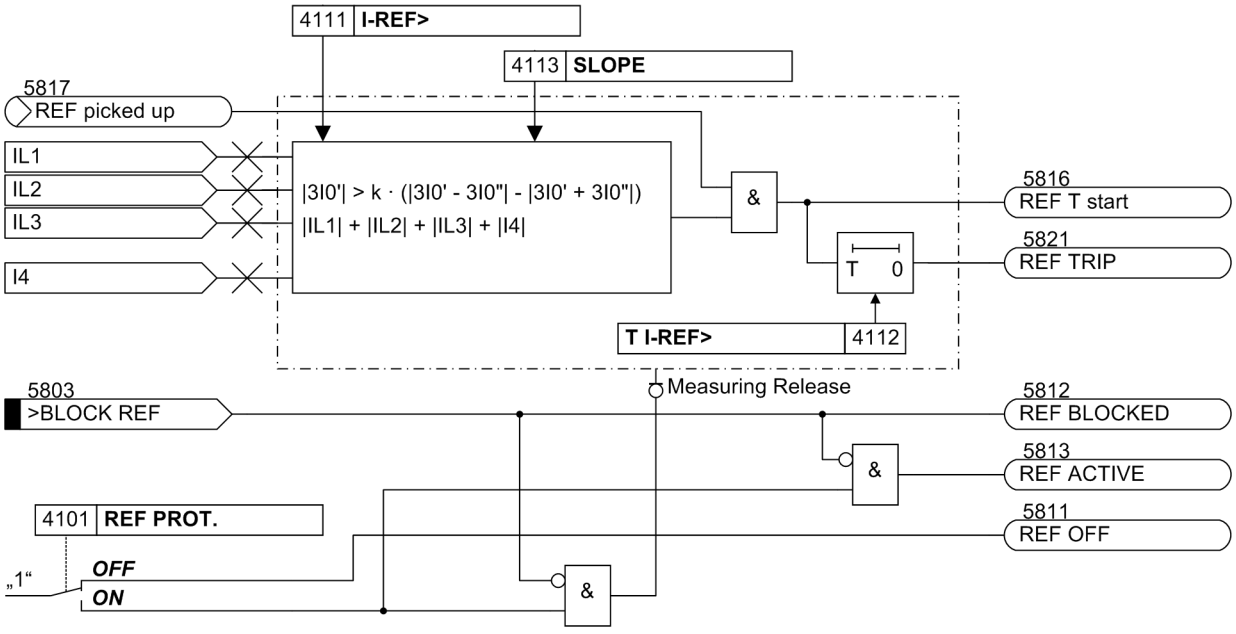
Normally, a differential protection does not need a "pickup", since the fault detection and the trip condition are identical. But the earth fault differential protection, like all protection functions, has a pickup function which is required for tripping and serves as the starting point for a number of further activities.

As soon as the fundamental component of the differential current reaches approximately 85 % of the pickup value, pickup is recognized. In this aspect, the differential current is represented by the sum of all in-flowing currents.



[erddiff-ansprechwerterh-020926-rei, 1, en_GB]

Figure 2-33 Increasing the pickup value



[logik-erdfehlerdiff-schutz, 1, en_GB]

Figure 2-34 Logic diagram of the restricted earth fault protection (simplified)

2.5.3 Setting Notes

General

The restricted earth fault protection can only operate if this function has been set during configuration of the functional scope (Section *2.1.2 General Power System Data (Power System Data 1)*) under address 141 **REF PROT.** on ***Enabled***. Operation requires the address **TRANSFORMER** to be set on ***YES*** and the address 220 **I4 transformer** on ***IY starpoint***. The address 221 **I4/Iph CT** must be set under margin heading “Connection of the Currents” as described in section *2.1.2.1 Setting Notes*.

The earth fault differential protection can be activated (***ON***) or deactivated (***OFF***) under address 4101 **REF PROT.**.

NOTE

When delivered from factory, the restricted earth fault protection is switched OFF. The reason is that the protection must not be in operation unless at least the assigned side and CT polarity have been properly set before. Without proper settings, the device may show unexpected reactions (incl. tripping)!

The sensitivity of the protection is determined by the **I-REF>** (address 4111). This is the earth fault current that flows through the starpoint lead of the transformer. Any other earth current which may be supplied from the network does not influence the sensitivity.

The set pickup value can be additionally increased in the tripping zone (stabilization by the sum of all current magnitudes) which is set at address 4113 **SLOPE**. This setting can only be made in DIGSI under **Additional Settings**. The default value 0 is usually adequate.

For special applications, it may be advantageous to delay the trip command of the protection. This can be done by setting an additional delay time (address 4112 **T I-REF>**). This setting can only be made in DIGSI under **Additional Settings**. Normally, this additional delay is set to 0. This setting value is an additional delay time which does not include the inherent measuring time of the protection function.

The value indication 5827 ***REF S:*** is the restraining quantity resulting from the tripping characteristic, and is not identical with the measured value 30655 ***IrestREF=***.

The value message5826 ***REF D:*** is the tripping value stabilized via the tripping characteristic. The reported values ***REF S:*** and ***REF D:*** refer to the time when the output message 5816 ***REF T start*** is reported, i.e. the starting time of **T I-REF>** (address 4112).

The following relations apply for calculating the quantities (see section *2.5 Restricted Earth Fault Protection (optional)* margin heading “Evaluation of measured quantities”):

$REF\ S = |3\underline{I}_0' - 3\underline{I}_0''| - |3\underline{I}_0' + 3\underline{I}_0''|$

$REF\ D = |3\underline{I}_0'|$ for REF S ≤ 0

$REF\ D = |3\underline{I}_0'| - k \cdot REF\ S$ for REF S > 0 (with k = 4)

2.5.4 Settings

Addresses which have an appended “A” can only be changed with DIGSI, under “Additional Settings”.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
4101	REF PROT.		OFF ON	OFF	Restricted Earth Fault Protection
4111	I-REF>	1A	0.05 .. 2.00 A	0.15 A	Pick up value I REF>
		5A	0.25 .. 10.00 A	0.75 A	
4112A	T I-REF>		0.00 .. 60.00 sec; ∞	0.00 sec	T I-REF> Time Delay
4113A	SLOPE		0.00 .. 0.95	0.00	Slope of Charac. I-REF> = f(I-SUM)

2.5.5 Information List

No.	Information	Type of Information	Comments
5803	>BLOCK REF	SP	>BLOCK restricted earth fault prot.
5811	REF OFF	OUT	Restricted earth fault is switched OFF
5812	REF BLOCKED	OUT	Restricted earth fault is BLOCKED
5813	REF ACTIVE	OUT	Restricted earth fault is ACTIVE
5816	REF T start	OUT	Restr. earth flt.: Time delay started
5817	REF picked up	OUT	Restr. earth flt.: picked up
5821	REF TRIP	OUT	Restr. earth flt.: TRIP
5826	REF D:	VI	REF: Value D at trip (without Tdelay)
5827	REF S:	VI	REF: Value S at trip (without Tdelay)

2.6 Direct Local Trip

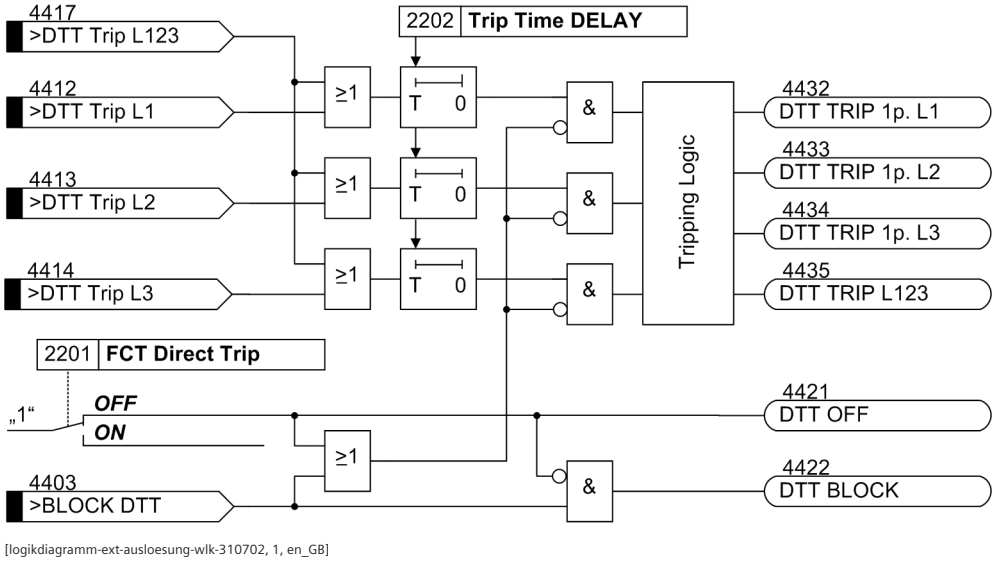
Any signal from an external protection or monitoring device can be coupled into the signal processing of the 7SD610 by means of a binary input. This signal can be delayed, alarmed and routed to one or several output relays.

2.6.1 Funktional Description

External trip of the local circuit breaker

Figure 2-35 shows the logic diagram. If device and circuit breaker are capable of single-phase operation, it is also possible to trip single-pole. The tripping logic of the device ensures that the conditions for single-pole tripping are met (e.g. single-phase tripping permissible, automatic reclosure ready).

The external tripping can be switched on and off with a setting parameter and may be blocked via binary input.



[logikdiagramm-ext-ausloesung-wlk-310702, 1, en_GB]

Figure 2-35 Logic diagram of the local external tripping

2.6.2 Setting Notes

General

A precondition for using the external local trip is that during the configuration of the device functions (Section *2.1.1 Functional Scope*) address 122 **DTT Direct Trip** was set to ***Enabled***. At address 2201 **FCT Direct Trip** it can also be switched ***ON*** or ***OFF***.

For the external local trip, a trip time delay can be set in address 2202 **Trip Time DELAY**. This delay time can be used as security time margin.

Once a trip command has been issued, it is maintained for at least as long as the set minimum trip command duration **TMin TRIP CMD** which was set for the device in general in address 240 (Section *2.1.2 General Power System Data (Power System Data 1)*). Reliable operation of the circuit breaker is therefore ensured, even if the initiating signal pulse is very short. This parameter can only be altered in DIGSI at **Additional Settings**.

2.6.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
2201	FCT Direct Trip	ON OFF	OFF	Direct Transfer Trip (DTT)
2202	Trip Time DELAY	0.00 .. 30.00 sec; ∞	0.01 sec	Trip Time Delay

2.6.4 Information List

No.	Information	Type of Informa-tion	Comments
4403	>BLOCK DTT	SP	>BLOCK Direct Transfer Trip function
4412	>DTT Trip L1	SP	>Direct Transfer Trip INPUT Phase L1
4413	>DTT Trip L2	SP	>Direct Transfer Trip INPUT Phase L2
4414	>DTT Trip L3	SP	>Direct Transfer Trip INPUT Phase L3
4417	>DTT Trip L123	SP	>Direct Transfer Trip INPUT 3ph L123
4421	DTT OFF	OUT	Direct Transfer Trip is switched OFF
4422	DTT BLOCK	OUT	Direct Transfer Trip is BLOCKED
4432	DTT TRIP 1p. L1	OUT	DTT TRIP command - Only L1
4433	DTT TRIP 1p. L2	OUT	DTT TRIP command - Only L2
4434	DTT TRIP 1p. L3	OUT	DTT TRIP command - Only L3
4435	DTT TRIP L123	OUT	DTT TRIP command L123

2.7 Transmission of binary commands and messages

2.7.1 Functional Description

Provided that the devices work with protection data transmission via digital communication links at the ends, the transmission of up to 28 items of binary information of any type from one device to the other is possible in the 7SD610. Four of them are transmitted like protection signals with high priority, i.e. very fast, and are therefore especially suitable for the transmission of other protection signals which are generated outside of 7SD610. The other 24 are transmitted with low priority and are suitable for information on the events taking place in a substation which may also be useful in other substations (see also the specifications in the "Technical Data").

The information can be injected into the device via binary inputs and output at the other devices via binary outputs. The integrated user-defined CFC logic allows to perform on both the transmitting and the receiving side logical operations on the signals and on other information from the protection and monitoring functions of the device. Via CFC, internal signals can effect the transmission of information also.

The used binary inputs and the signal outputs must be allocated accordingly when configuring the input and output functions. The four priority signals are fed into the device via the binary inputs *>Remote CMD 1* to *>Remote CMD 4*, forwarded to the devices of the other end and can be signalled or processed at the receiving end with the output functions *Remote CMD1 rec* to *Remote CMD4 rec*.

The remaining 24 items of information reach the device via the binary inputs *>Rem. Signal 1* to *>Rem.Signal24* and are correspondingly available under *Rem.Sig 1recv* etc. at the receiving side.

When assigning the binary inputs and outputs using DIGSI, you can provide the information to be transmitted with your own designation. If, for example, a line has a unit-connected power transformer at one end and you wish to transmit trip by the Buchholz protection as *>Remote CMD 1* to the other end, you may use the binary input and designate it as "Buchholz TRIP". At the other end, you name the incoming command *Remote CMD1 rec* e.g. "Buchholz remote" and assign it to tripping of the local circuit breaker. The Buchholz protection trip command then generates the indications you specified.



NOTE

Also devices which have logged out of the line protection system (see Section 2.2.2.1 "Mode: Log out device") can send and receive remote indications and commands.

The indications of the devices, e.g. *Rel1 Login* of the topology exploration, can be used to determine whether the signals of the sending devices are still available. They are transmitted if a device x is actively involved in the communication topology.

Once an error in the protection data interface communication has been detected, the time **Td ResetRemote** at address 4512 is started for resetting the remote signals. This means that, if the communication is interrupted, a present receive signal retains its last status for the time **Td ResetRemote** before it is reset.

No further settings are required for the transmission of binary information. Each device sends the injected information to the device at the other end of the protected object. Where selection is necessary, it will have to be carried out by appropriate allocation and, if necessary, by a link at the receiving side.

2.7.2 Information List

No.	Information	Type of Information	Comments
3541	>Remote CMD 1	SP	>Remote Command 1 signal input
3542	>Remote CMD 2	SP	>Remote Command 2 signal input
3543	>Remote CMD 3	SP	>Remote Command 3 signal input
3544	>Remote CMD 4	SP	>Remote Command 4 signal input
3545	Remote CMD1 rec	OUT	Remote Command 1 received

No.	Information	Type of Informa-tion	Comments
3546	Remote CMD2 rec	OUT	Remote Command 2 received
3547	Remote CMD3 rec	OUT	Remote Command 3 received
3548	Remote CMD4 rec	OUT	Remote Command 4 received
3549	>Rem. Signal 1	SP	>Remote Signal 1 input
3550	>Rem.Signal 2	SP	>Remote Signal 2 input
3551	>Rem.Signal 3	SP	>Remote Signal 3 input
3552	>Rem.Signal 4	SP	>Remote Signal 4 input
3553	>Rem.Signal 5	SP	>Remote Signal 5 input
3554	>Rem.Signal 6	SP	>Remote Signal 6 input
3555	>Rem.Signal 7	SP	>Remote Signal 7 input
3556	>Rem.Signal 8	SP	>Remote Signal 8 input
3557	>Rem.Signal 9	SP	>Remote Signal 9 input
3558	>Rem.Signal10	SP	>Remote Signal 10 input
3559	>Rem.Signal11	SP	>Remote Signal 11 input
3560	>Rem.Signal12	SP	>Remote Signal 12 input
3561	>Rem.Signal13	SP	>Remote Signal 13 input
3562	>Rem.Signal14	SP	>Remote Signal 14 input
3563	>Rem.Signal15	SP	>Remote Signal 15 input
3564	>Rem.Signal16	SP	>Remote Signal 16 input
3565	>Rem.Signal17	SP	>Remote Signal 17 input
3566	>Rem.Signal18	SP	>Remote Signal 18 input
3567	>Rem.Signal19	SP	>Remote Signal 19 input
3568	>Rem.Signal20	SP	>Remote Signal 20 input
3569	>Rem.Signal21	SP	>Remote Signal 21 input
3570	>Rem.Signal22	SP	>Remote Signal 22 input
3571	>Rem.Signal23	SP	>Remote Signal 23 input
3572	>Rem.Signal24	SP	>Remote Signal 24 input
3573	Rem.Sig 1recv	OUT	Remote signal 1 received
3574	Rem.Sig 2recv	OUT	Remote signal 2 received
3575	Rem.Sig 3recv	OUT	Remote signal 3 received
3576	Rem.Sig 4recv	OUT	Remote signal 4 received
3577	Rem.Sig 5recv	OUT	Remote signal 5 received
3578	Rem.Sig 6recv	OUT	Remote signal 6 received
3579	Rem.Sig 7recv	OUT	Remote signal 7 received
3580	Rem.Sig 8recv	OUT	Remote signal 8 received
3581	Rem.Sig 9recv	OUT	Remote signal 9 received
3582	Rem.Sig10recv	OUT	Remote signal 10 received
3583	Rem.Sig11recv	OUT	Remote signal 11 received
3584	Rem.Sig12recv	OUT	Remote signal 12 received
3585	Rem.Sig13recv	OUT	Remote signal 13 received
3586	Rem.Sig14recv	OUT	Remote signal 14 received
3587	Rem.Sig15recv	OUT	Remote signal 15 received
3588	Rem.Sig16recv	OUT	Remote signal 16 received
3589	Rem.Sig17recv	OUT	Remote signal 17 received
3590	Rem.Sig18recv	OUT	Remote signal 18 received

No.	Information	Type of Information	Comments
3591	Rem.Sig19recv	OUT	Remote signal 19 received
3592	Rem.Sig20recv	OUT	Remote signal 20 received
3593	Rem.Sig21recv	OUT	Remote signal 21 received
3594	Rem.Sig22recv	OUT	Remote signal 22 received
3595	Rem.Sig23recv	OUT	Remote signal 23 received
3596	Rem.Sig24recv	OUT	Remote signal 24 received

2.8 Instantaneous High-Current Switch-onto-Fault Protection (SOTF)

2.8.1 Functional Description

General

The high-speed overcurrent protection function is provided to disconnect immediately and without delay feeders that are switched onto a high-current fault. It serves, e.g. as a rapid protection for connecting a feeder with closed grounding disconnector. In order to function properly, the device at the other end of the protected object must know the circuit breaker positions (breaker auxiliary contacts).

A second stage works fast and without delay, regardless of the circuit breaker position.

I>>>-Stage

The pickup of the I>>> stage measures each phase current and compares it to the setting value **I>>>** (address 2404). The currents are numerically filtered to eliminate the DC component. DC current components in the fault current as well as in the CT secondary circuit after switching off large currents practically have no influence on this high-current pickup operation. If the setting value is exceeded by more than twice its value, the stage will automatically use the peak value of the unfiltered measured quantity. In this way, extremely short command times are possible.

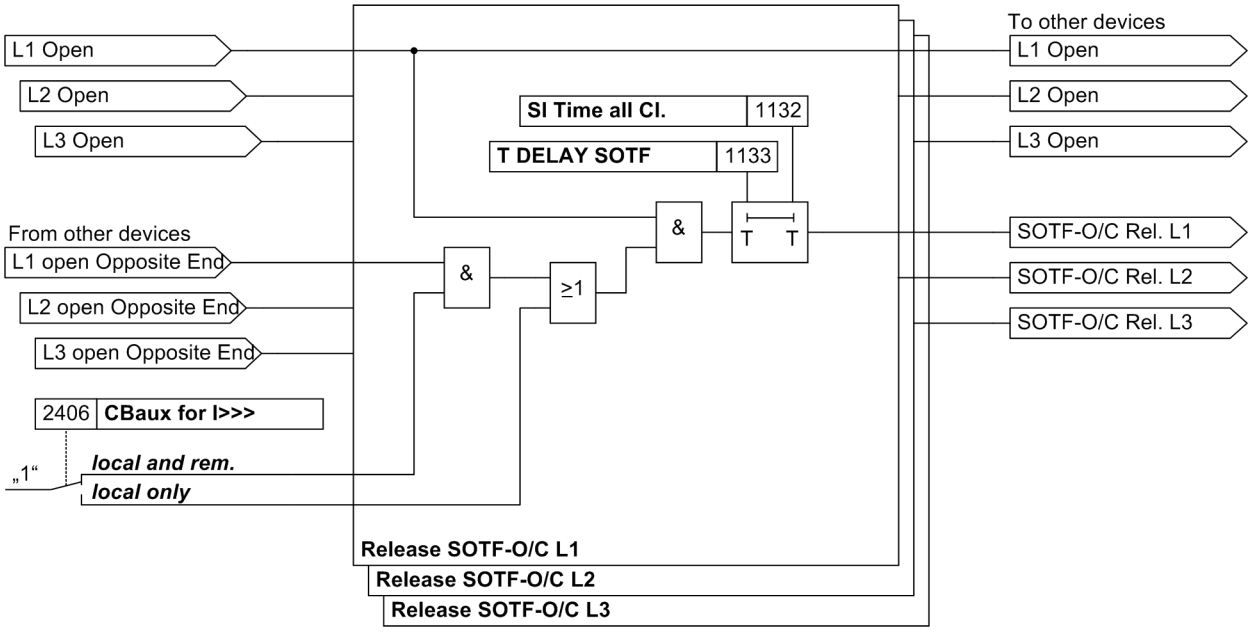
The I>>> stage works in 2 modes which can be selected using the parameter **CBaux for I>>>** (address 2406). If the parameter 2406 is set to ***local only*** for the first mode, only the position of the local circuit breaker is considered. If the circuit breaker is open (at least for the time set in parameter **SI Time all Cl.** (address 1132)) and an energization takes place, the I>>> stage is activated for the time set in parameter **SI Time all Cl.**. The I>>> stage trips unselectively in case that the threshold is exceeded.

If the parameter **CBaux for I>>>** is set to ***local and rem.*** for the second mode, the switch positions of all circuit breakers of the devices involved in the constellation are taken into consideration. The I>>> stage is only active if all circuit breakers of the constellation are open and the local device is the first device that energizes the line. For this, the circuit breaker auxiliary contacts of all devices must be connected. If the circuit breaker of the second device of the constellation are closed, the I>>> stage is not activated because the line (the object to be protected) is already energized and a huge current flow can only be caused by an external fault.

The high-current instantaneous tripping gets the switch position via the central function control (see also Section *2.16.1 Function Control*).

Figure 2-37 shows the functioning logic of the instantaneous high-current tripping. The I>>> stage in the lower part of the diagram is released phase-segregated with the release signals “SOTF-O/C Rel. Lx”. If the device is designed for 1-pole tripping, a 1-pole tripping is also possible with the I>>> stage.

Figure 2-36 shows the generation of the enable signals for the I>>> stage.



[hochstrom-zuschalt-20100421, 1, en_GB]

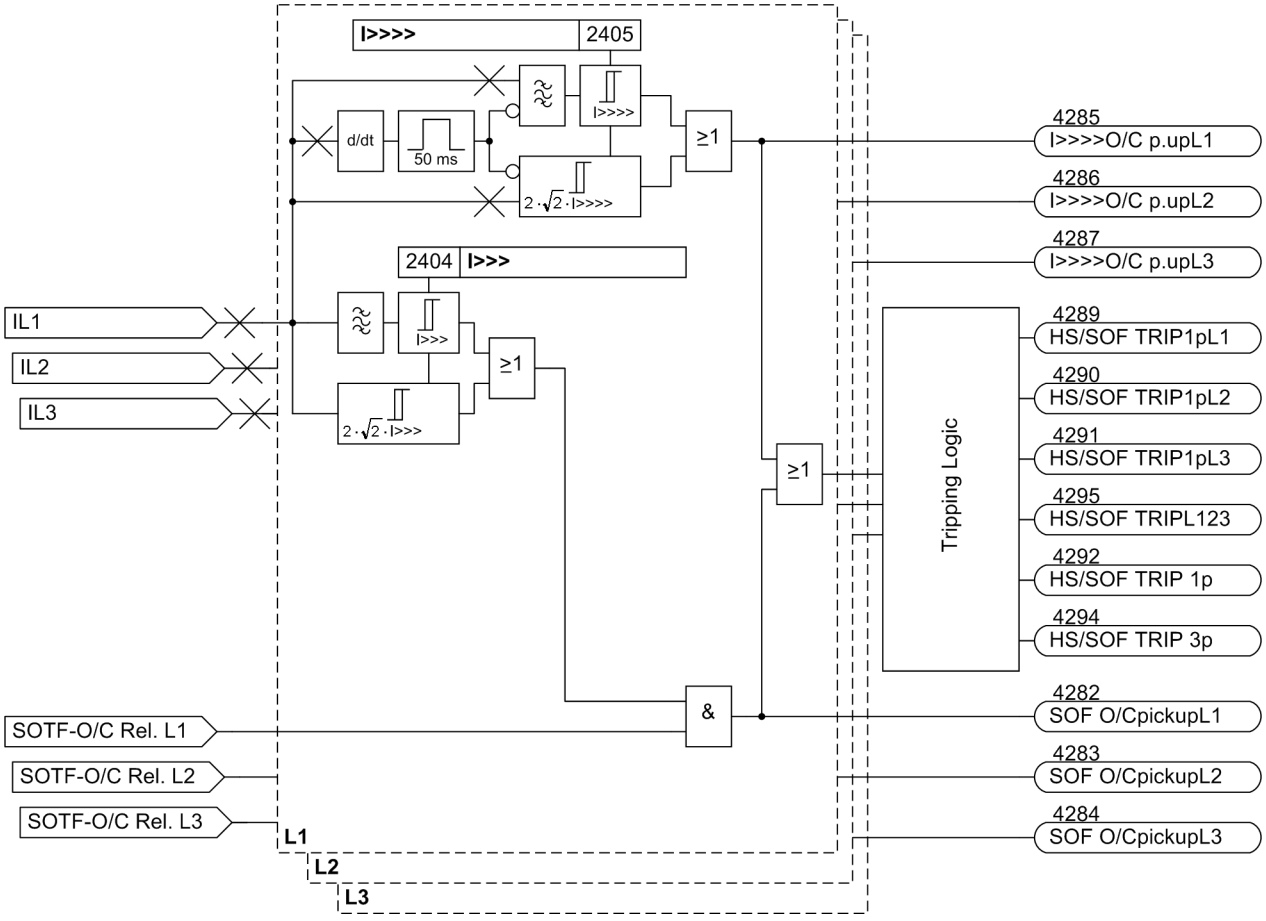
Figure 2-36 Activation of the I>>> stage

I>>>>-Stage

The I>>>> stage trips regardless of the position of the circuit breakers. Here, the currents are also numerically filtered and the peak value of the currents is measured from the double setting value onwards. *Figure 2-37* shows the logic diagram in the upper part.

Therefore, this stage is used when current grading is possible. This is possible with a small source impedance and at the same time a high impedance of the protected object (an example can be found in the advice on setting notes, Section *2.8.2 Setting Notes*).

The I>>>> stage is enabled automatically by the current-step monitoring $^{dI}/_{dt}$ of the device for a duration of 50 ms. This stage operates separately for each phase.



[logikdia-hochstrom-schnellabschaltung-020903-st, 1, en_GB]

Figure 2-37 Logic diagram of the high current switch on to fault protection

2.8.2 Setting Notes

General

A precondition for using the fast tripping function is that the configuration of the device functions (Section *2.1.1 Functional Scope*) has been set at address 124 **HS/SOTF-O/C** = ***Enabled***. At address 2401 **FCT HS/SOTF-O/C** it can also be switched to ***ON*** or ***OFF***.

I>>>-Stage

The magnitude of fault current which leads to the pickup of the I>>> stage is set as **I>>>** in address 2404. Choose a value which is high enough for the protection not to pick up on the RMS value of the inrush current produced during the connection of the protected object. On the other hand, fault currents flowing through the protected object do not need to be considered.

When using a PC and DIGSI for the parameterization, the values can be optionally entered as primary or secondary quantities. For settings with secondary values, the currents will be converted for the secondary side of the current transformers.

At address 2406 **CBaux for I>>>**, you can specify whether only the switch position of the local circuit breaker is checked to release the stage (***local only***) or also the switch position of the circuit breaker at the other end (***local and rem.***). If set to ***local and rem.***, this stage is active when the local end is energized while the circuit breaker at the other end of the protected object is open.

I>>>>-Stage

TheI>>>> stage (address 2405) works regardless of the circuit breaker position. Since it trips extremely fast it must be set high enough not to pickup on a load current flowing through the protected object. This means that it can be used only if the protected object allows current grading, as is the case with transformers, series reactors or long lines with small source impedance. In other cases it is set to ∞ (default setting). This parameter can only be altered with DIGSI under **Additional Settings**.

When using a PC and DIGSI for the parameterisation, the values can be optionally entered as primary or secondary quantities. For settings with secondary quantities the currents will be converted to the secondary side of the current transformers.

Exemplary calculation:

110 kV overhead line 150 mm² with the data:

s (Length)	= 60 km
R_1/s	= 0.19 Ω/km
X_1/s	= 0.42 Ω/km

Short-circuit power at the feeding end:

S_k" = 3.5 GVA (subtransient, since the I>>>> I>>>>stage can respond to the first peak value)

Current transformer 600 A/5 A

From that the line impedance Z_L and the source impedance Z_V are calculated:

Z_1/s	$\sqrt{0.19^2 + 0.42^2}\,\Omega/\mathrm{km} = 0.46\ \Omega/\mathrm{km}$
Z_L	= 0.46 Ω/km · 60 km = 27.66 Ω

$$Z_V = \frac{110\ \mathrm{kV}^2}{3500\ \mathrm{MVA}} = 3.46\ \Omega$$

[hs_bsp1-280803-rei, 1, en_GB]

The three-phase short-circuit current at line end is $I''_{sc\ end}$ (with source voltage $1.1 \cdot U_N$):

$$I''_{k\ End} = \frac{1.1 \cdot U_N}{\sqrt{3} \cdot (Z_V + Z_L)} = \frac{1.1 \cdot 110\ \mathrm{kV}}{\sqrt{3} \cdot (3.46\ \Omega + 27.66\ \Omega)} = 2245\ \mathrm{A}$$

[hs_bsp2-280803-rei, 1, en_GB]

With a safety factor of 10 %, the following primary setting value results:

Setting value **I>>>>** = 1.1 · 2245 A = 2470 A

or the secondary settings value:

$$\text{Setting Value I>>>>} = 1.1 \cdot \frac{2245\ \mathrm{A}}{600\ \mathrm{A}} \cdot 5\ \mathrm{A} = 20.6\ \mathrm{A}$$

[hs_bsp3-280803-rei, 1, en_GB]

i.e. in case of fault currents exceeding 2470 A (primary) or 20.6 A (secondary) you can be sure that a shortcircuit has occurred on the protected line. This line can be disconnected immediately.

Note: The calculation was carried out with absolute values, which is sufficiently precise for overhead lines. A complex calculation is only needed if the angles of the source impedance and the line impedance vary considerably.

2.8.3 Settings

Addresses which have an appended “A” can only be changed with DIGSI, under “Additional Settings”.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2401	FCT HS/SOTF-O/C		ON OFF	ON	Inst. High Speed/SOTF-O/C is
2404	I>>>	1A	0.10 .. 15.00 A; ∞	1.50 A	I>>> Pickup
		5A	0.50 .. 75.00 A; ∞	7.50 A	
2405A	I>>>>	1A	1.00 .. 25.00 A; ∞	∞ A	I>>>> Pickup
		5A	5.00 .. 125.00 A; ∞	∞ A	
2406	CBaux for I>>>		local only local and rem.	local and rem.	CB-aux check for activation of I>>>

2.8.4 Information List

No.	Information	Type of Information	Comments
4253	>BLOCK SOTF-O/C	SP	>BLOCK Instantaneous SOTF Overcurrent
4271	SOTF-O/C OFF	OUT	SOTF-O/C is switched OFF
4272	SOTF-O/C BLOCK	OUT	SOTF-O/C is BLOCKED
4273	SOTF-O/C ACTIVE	OUT	SOTF-O/C is ACTIVE
4281	SOTF-O/C PICKUP	OUT	SOTF-O/C PICKED UP
4282	SOF O/CpickupL1	OUT	SOTF-O/C Pickup L1
4283	SOF O/CpickupL2	OUT	SOTF-O/C Pickup L2
4284	SOF O/CpickupL3	OUT	SOTF-O/C Pickup L3
4285	I>>>>O/C p.upL1	OUT	High Speed-O/C Pickup I>>>> L1
4286	I>>>>O/C p.upL2	OUT	High Speed-O/C Pickup I>>>> L2
4287	I>>>>O/C p.upL3	OUT	High Speed-O/C Pickup I>>>> L3
4289	HS/SOF TRIP1pL1	OUT	High Speed/SOTF-O/C TRIP - Only L1
4290	HS/SOF TRIP1pL2	OUT	High Speed/SOTF-O/C TRIP - Only L2
4291	HS/SOF TRIP1pL3	OUT	High Speed/SOTF-O/C TRIP - Only L3
4292	HS/SOF TRIP 1p	OUT	High Speed/SOTF-O/C TRIP 1pole
4293	HS/SOF Gen.TRIP	OUT	High Speed/SOTF-O/C General TRIP
4294	HS/SOF TRIP 3p	OUT	High Speed/SOTF-O/C TRIP 3pole
4295	HS/SOF TRIPL123	OUT	High Speed/SOTF-O/C TRIP command L123

2.9 Backup Time Overcurrent Protection

The 7SD610 features a time overcurrent protection function which can be used as either a back-up or an emergency overcurrent protection. All stages may be configured independently of each other and combined according to the user's requirements.

2.9.1 General

Whereas the differential protection can only operate correctly if both devices receive the protection data of the respective other device properly, the emergency overcurrent protection requires only the local currents. As an emergency overcurrent protection it automatically replaces the differential protection as short-circuit protection, if data communication of the differential protection is faulty (emergency operation). The differential protection is blocked as a result.

If the overcurrent protection is set as a backup overcurrent protection, it will work independently of other protection and monitoring functions, i.e. also independently of the differential protection. The backup overcurrent protection can also be used as sole short-circuit protection if no suitable channels for the communication between the protection devices are available during the initial commissioning.

The overcurrent protection has directional and non-directional stages for the phase currents and for the earth current; these are:

- 2 overcurrent stages with a definite time characteristic (O/C with DT),
- 1 directional overcurrent stage with a definite time characteristic (O/C with DT),
- A further overcurrent stage which has an additional enable input and can therefore be used as an emergency stage e.g. if the remaining stages are used as backup stages, or as a stub protection.
- 1 overcurrent stage with inverse time characteristic (IDMT),
- One directional overcurrent stage with a inverse time characteristic (O/C with IDMT)

These 6 stages are independent of each other and are freely combinable. Blocking from external criteria via binary inputs is possible, as well as switch-onto-fault tripping. During the single-pole pause, all earth stages of the overcurrent protection are automatically blocked.

It is also possible to release one or more of the stages in switching-onto-fault conditions. If not all stages are required, each individual stage can be deactivated by setting the pickup threshold to ∞.

2.9.2 Functional Description

Measured Values

The phase currents are fed to the device via the input transformers of the measuring input. The earth current $3 \cdot I_0$ is either measured directly or calculated.

If I_4 is connected to the starpoint of the current transformer set (address 220 **I4 transformer** = ***In prot. line***, see Section *2.1.2 General Power System Data (Power System Data 1)* of **P.System Data 1**), the earth current will be directly available as measured value. It is used considering the **I4/Iph CT** factor (address 221).

If the ground current of own the neutral line is not connected to the fourth current input I_4 (address 220 **I4 transformer**r cannot be parameterized to ***In prot. line***), the device will calculate the ground current from the phase currents. Of course, all three phase currents of three star-connected current transformers must be available and connected.

For the directional Iph> stages, the measuring voltage used is determined by the fault condition. The selection occurs according to the availability of the measured values listed below.

The current phase earth voltage is used

- for single-pole or three-pole faults,
- if phase-earth voltage > 4 V,
- not within the first 50 ms after short-circuit, as the current voltage is then disturbed by transients.

The saved phase-earth voltage is used

- for single-pole faults
- up to a maximum of 2 s after saving the phasors
- if there was no triggering or single-pole pause prior to the short-circuit.

The unfaulted current phase-earth voltage is used

- for single-pole faults
- for undisturbed unfaulted phase-earth voltages
- if the voltage level is > 70% of the rated voltage.

The negative sequence systems $\underline{U}_2$ and $\underline{I}_2$ are used

- for single-pole or two-pole faults
- if $\underline{I}_2$ > 50 mA and $\underline{U}_2$ > 5V.

If the negative sequence systems are used in the case of two single-pole short-circuits, the most powerful short circuit is valid for direction determination.

The current voltage is used if it is > 5V.

If none of the previously measuring values is available, an already existing result of the direction determination is used, or the directional stage is blocked for the respective phase.

For the directional 3I0> stages, the measuring voltage used is determined by the parameter 2603 **Direct. 3I0**.

- If ***with U0/I0*** has been set, the current zero sequence values $3\underline{U}_0$ and $3\underline{I}_0$ are used. If the zero sequence voltage is too small for a direction measurement, the directional 3I0>stages are blocked.
- If ***with U2/I2*** has been set, the current negative sequence values $3\underline{U}_2$ and $3\underline{I}_2$ are used. If the negative sequence voltage is too small for a direction measurement, the directional 3I0>stages are blocked.
- If ***U0/I0 or U2/I0*** has been set, negative sequence or zero sequence values can be used. Negative sequence system values are used if they are larger then the respective zero sequence system values. If the measuring variables of both systems are unavailable, the directional 3I0> stages are blocked.



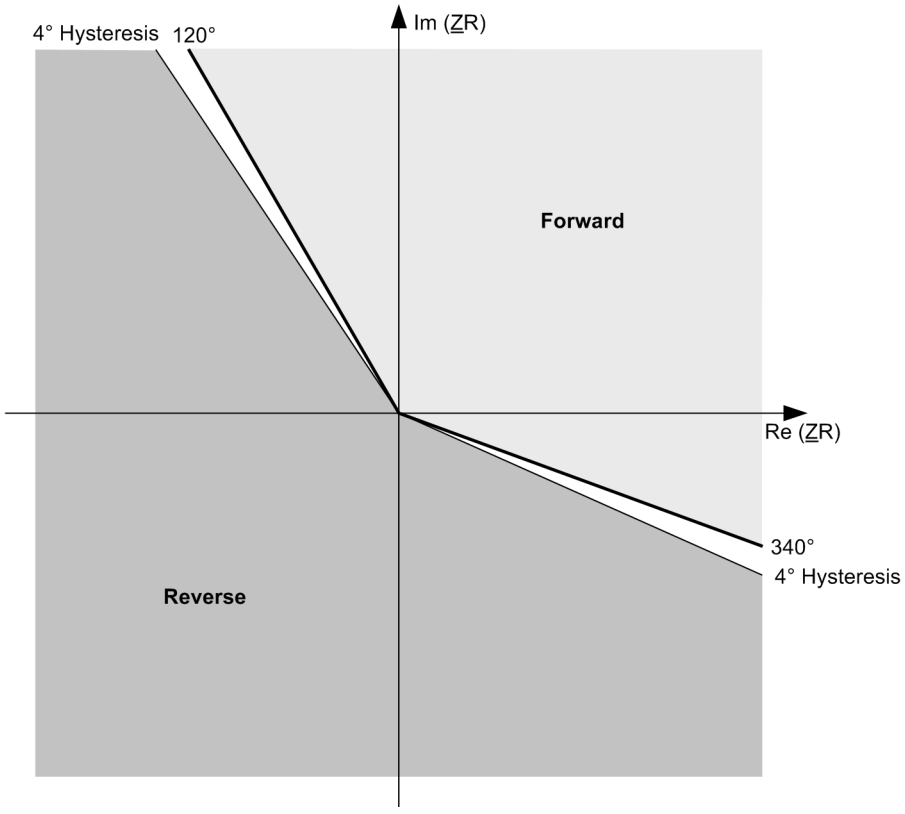
NOTE

During a measuring voltage failure, all directional stages are blocked.

During the single-pole dead time, all earth current stages are blocked.

Directional Characteristic

The directional characteristic of the directional overcurrent stages is preset. From the voltage and current vectors used for direction determination, the angle difference φ($\underline{U}$) - φ($\underline{I}$) is calculated via the impedance $\underline{Z}$ = $\underline{U}/\underline{I}$ and the direction determined based on the directional characteristic displayed.



[richtl-ueberstrom-060724, 1, en_GB]

Figure 2-38 Directional characteristic of the time overcurrent protection

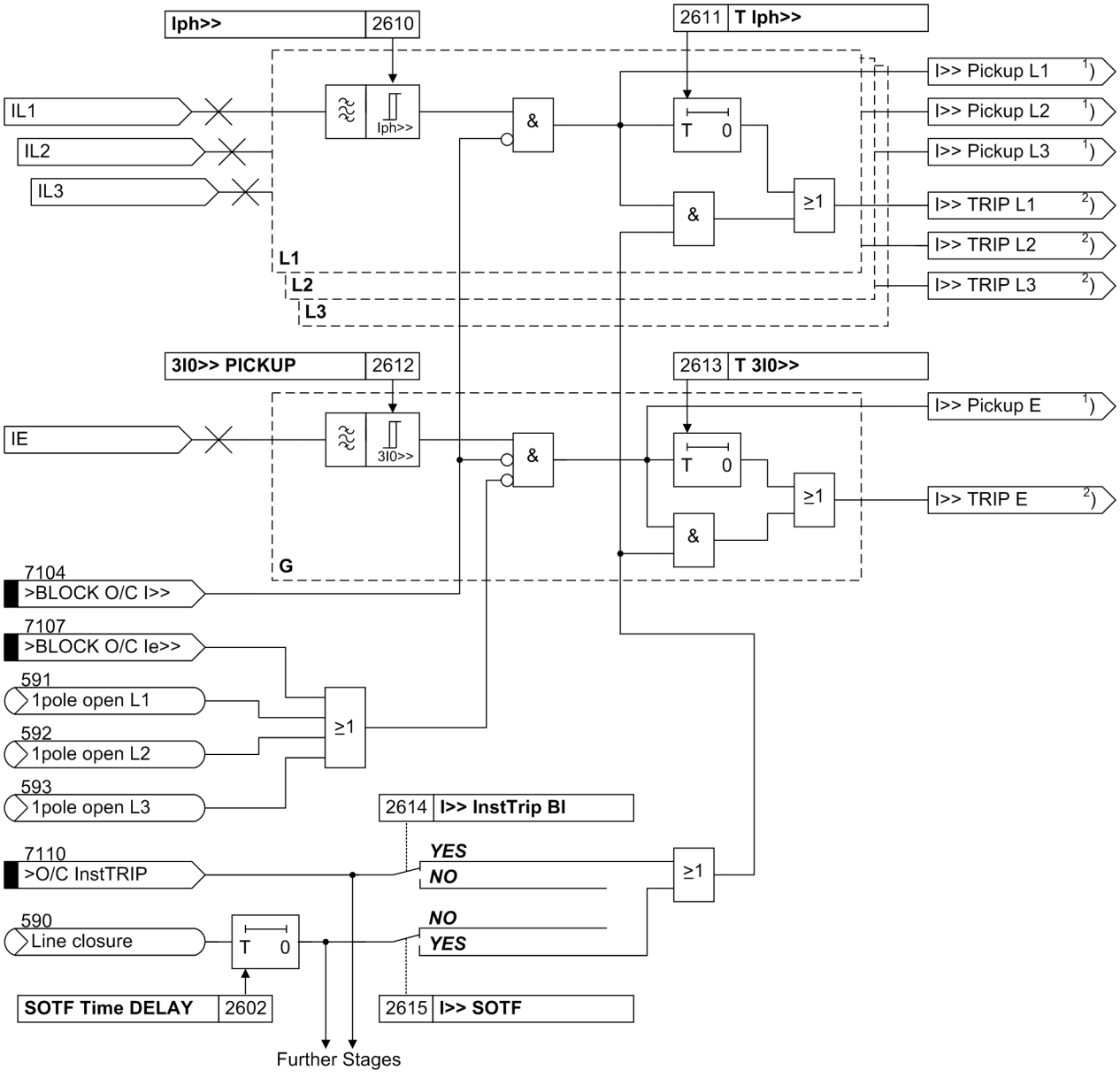
Definite Time High-set Current Stage I>>

Each phase current is compared with the setting value **Iph>>** after numerical filtering; the earth current is compared with **3I0>> PICKUP**. After pickup of a stage and expiry of the associated delay times **T Iph>>** or **T 3I0>>** a trip command is issued. The dropout value is approximately 7% below the pickup value, but at least 1.8% of the nominal current.

Figure 2-39 shows the logic diagram of the I>> stages. The stages can be blocked via the binary input *>BLOCK O/C I>>*. Additionally, the earth current can be blocked separately via a binary input *>BLOCK O/C Ie>>*. During the single-pole pause, the earth current stage is always blocked to avoid a fault pickup.

The binary input *>O/C InstTRIP* and the evaluation of the indication "switch" (onto fault) are common to all stages and described below. They may, however, separately affect the phase and/or earth current stages. This can be achieved with two parameters:

- **I>> InstTrip BI** (address 2614), determines whether a non-delayed trip of this stage via binary input *>O/C InstTRIP* is possible (***YES***) or impossible (***NO***). This parameter is also used for instantaneous tripping before automatic reclosure.
- **I>> SOTF** (address 2615), determines whether this stage shall issue non-delayed tripping (***YES***) or not (***NO***) in case of switching-onto-fault conditions.



[logikdiagramm-7sd-i-vg-stufe-wlk-310702, 1, en_GB]

Figure 2-39 Logic diagram of the I>>-Stage

1) Output indications associated with the pickup signals are listed in *Table 2-3*
2) Output indications associated with the trip signals are listed in *Table 2-4*

Definite time overcurrent stage I>

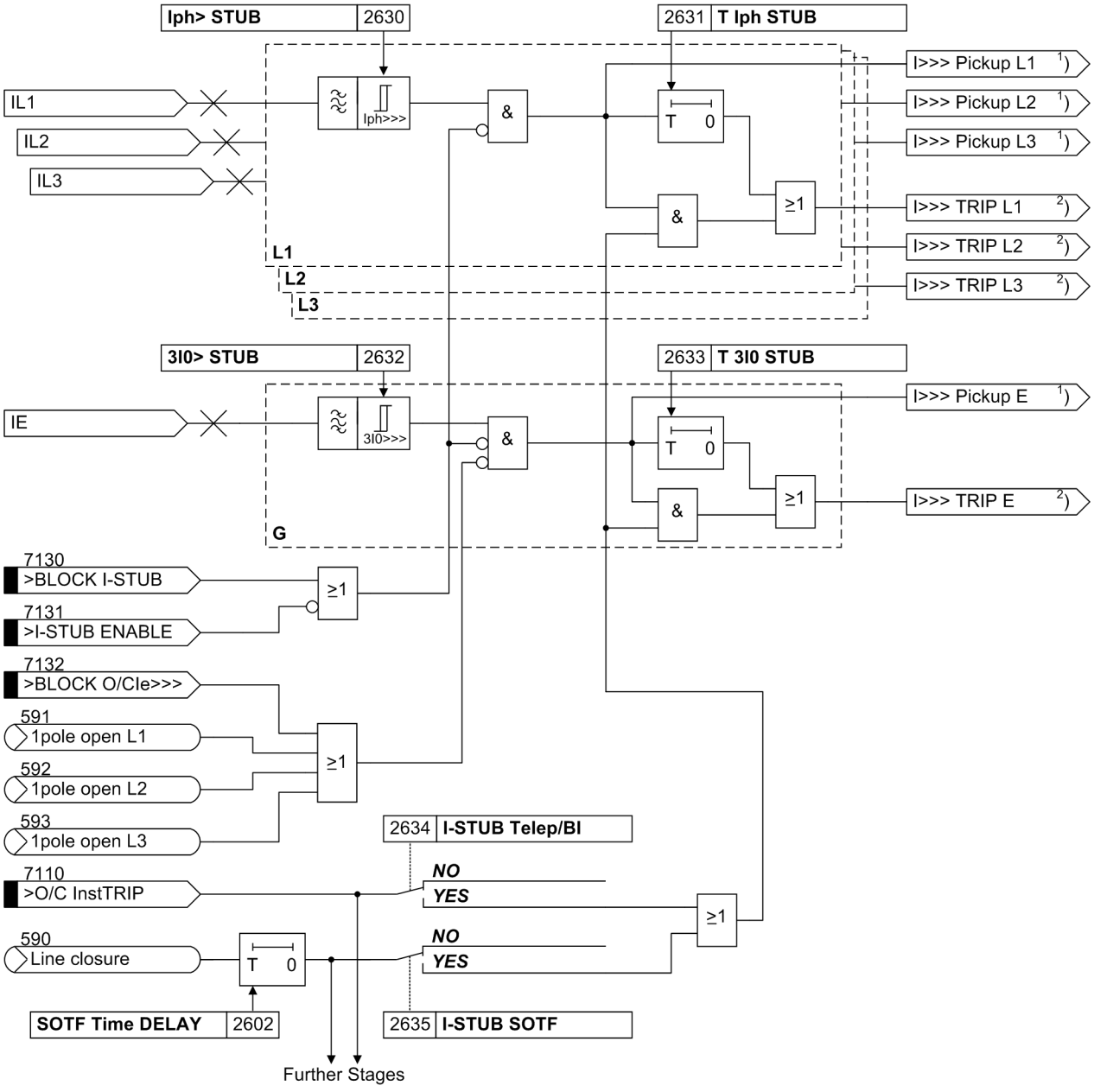
The logic of the overcurrent stages I> is structured identically to the I>> stages. In all references, **Iph>>** must merely be replaced by **Iph>** or **3I0>> PICKUP** by **3I0>**. The parameter 2624 **I> Telep/BI** is set to NO by default. In all other respects, *Figure 2-39* applies.

Die Logik der Überstromstufen I> ist ebenso aufgebaut wie die I>>-Stufen. In allen Bezeichnungen ist lediglich **Iph>>** durch **Iph>** bzw. **3I0>> PICKUP** durch **3I0>** zu ersetzen. Der Parameter 2624 **I> Telep/BI** ist mit ***NO*** voreingestellt. Ansonsten ist auch *Figure 2-39* gültig.

Additional Stage I>>>

An additional overcurrent stage I>>> has an extra enable input (*Figure 2-40*) It is therefore also suitable e.g. as an emergency stage if the remaining stages are used as backup stages. The enable input *>I-STUB ENABLE* can then be assigned to the output signal „Emer. mode“ (either via binary outputs and inputs or via the user-definable logic CFC functions). The stage is then automatically active whenever the differential protection is not effective, e.g. due to a data disturbance.

The I>>> stage can, however, also be used as a standard additional and independent overcurrent stage, since it works independent of the other stages. In this case, the enable input *>I-STUB ENABLE* must be activated permanently (via a binary input or CFC).



[logikdiagramm-ueberstromstufe-st-290803, 1, en_GB]

Figure 2-40 Logic diagram of the I>>>-Stage

1) Output indications associated with the pickup signals are listed in *Table 2-3*

2) Output indications associated with the trip signals are listed in *Table 2-4*

Directional, Definite Time Overcurrent Stage I> dir

The directional overcurrent stages follow the same principle as the non-directional stages. However, triggering is not dependent on the result of the direction determination. Direction determination occurs via the measuring values and the respective directional characteristics.

The pickup of the phase current stages is non-directional, if address 2680 **Direction Iph>** is parameterised to ***Non-Directional***. The pickup of the earth stage is non-directional, if address 2683 **Direction 3I0>** is parameterized to ***Non-Directional***.

Iph> Dir. is used as setting values for the phase current, **3I0> Dir.** for the earth current. After pickup of a stage and expiry of the associated time delays **T Iph> Dir.** or **T 3I0> Dir.**, a trip command is issued. The dropout value is approximately 7 % of the pickup value, but at least 1.8 % of the nominal current, below the pickup value.

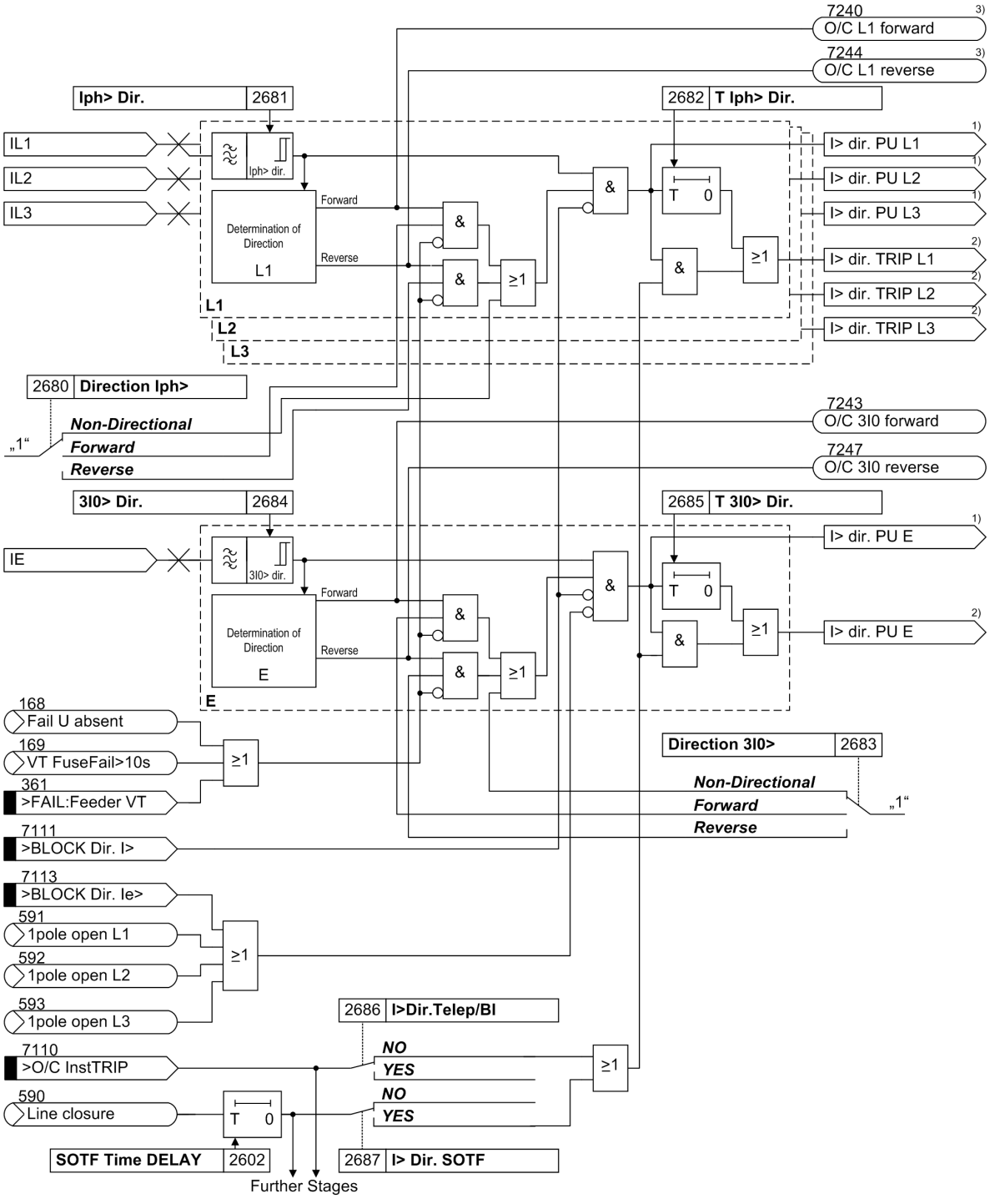
Figure 2-41 shows the logic diagram of the I>ger stages. The stages can be blocked via the binary input *>BLOCK Dir. I>*. Additionally, the earth current can be blocked separately via a binary input *>BLOCK Dir. Iep*.

During fuse failure or pickup of the Fuse Failure Monitor all stages which are parameterized as ***Forward*** or Reverse are blocked. During the single-pole pause, the earth current stage is always blocked to avoid a fault trigger.

The binary input *>O/C InstTRIP* and the evaluation of the indication “switch” (onto fault) can separately affect the phase and/or earth current stages. This can be achieved with two parameters:

- **I>Dir.Telep/BI** (address 2686), determines whether a non-delayed trip of this stage via binary input *>O/C InstTRIP* is possible (***YES***) or impossible (***NO***). This parameter is also used for instantaneous tripping before automatic reclosure.
- **I> Dir. SOTF** (address 2687), determines whether this stage shall issue non-delayed tripping (***YES***) or not (***NO***) in case of switching-onto-fault conditions.

From the individual phase or earth current specific direction determination (7240 to 7247) the indications *O/C Dir. forward* or *O/C Dir. reverse* are created, if there is a valid result of the direction determination for a phase or earth current (forward or backward). These indications can then be transferred to a different device and there cause an immediate trip if an overcurrent stage of the receiving device has picked up. The indications must then be combined via CFC (OR function).



[i-gr-stufe-gerichtet-060724, 1, en_GB]

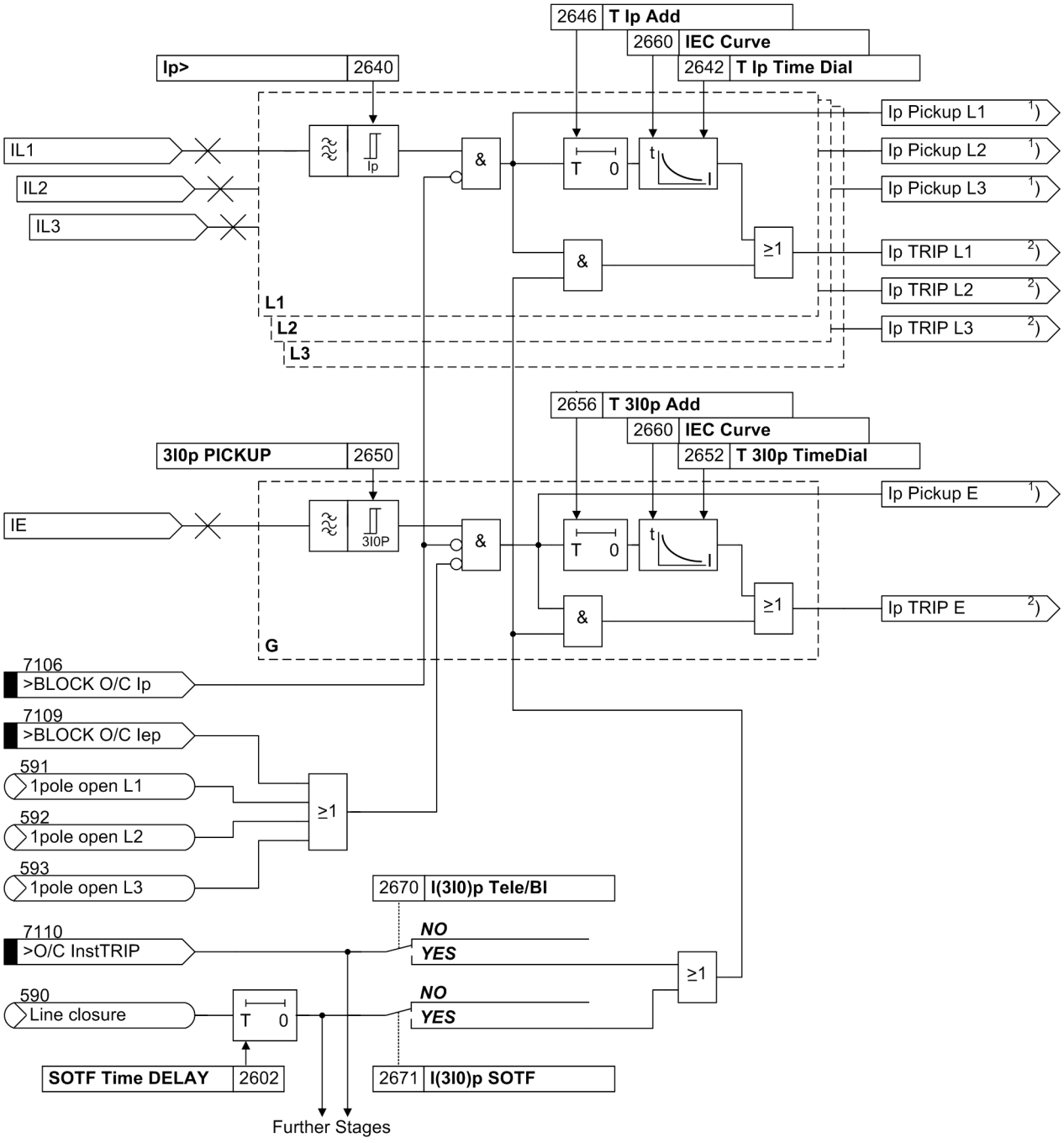
Figure 2-41 Logic diagram of the I> dir Stage

1) Output indications associated with the pickup signals are listed in *Table 2-3*
2) Output indications associated with the trip signals are listed in *Table 2-4*
3) The indications *O/C L2 forward*, *O/C L3 forward*, *O/C L2 reverse*, *O/C L3 reverse* have not been represented in the Figure, however, they are reported if necessary.

Inverse time overcurrent stage I_P

The logic of the inverse overcurrent stage also operates chiefly in the same way as the remaining stages. However, the time delay is calculated here based on the type of the set characteristic, the intensity of the current and a time multiplier (following figure). A pre-selection of the available characteristics was already carried out during the configuration of the protection functions. Furthermore, an additional constant time delay **`T Ip Add`** or **`T 3I0p Add`** may be selected, which is added to the inverse time. The possible characteristics are shown in the Technical Data.

The following figure shows the logic diagram. The setting parameter addresses of the IEC characteristics are shown by way of an example. In the setting information (Section *2.9.3 Setting Notes*) the different setting addresses are elaborated upon.



[logikdia-7sd-ip-stufe-amz-iec-wlk-310702, 1, en_GB]

Figure 2-42 Logic diagram of the I_p stage (inverse time overcurrent protection) - example of IEC curve

1) Output indications associated with the pickup signals are listed in *Table 2-3*
2) Output indications associated with the trip signals are listed in *Table 2-4*

Directional inverse time overcurrent stage I_P dir

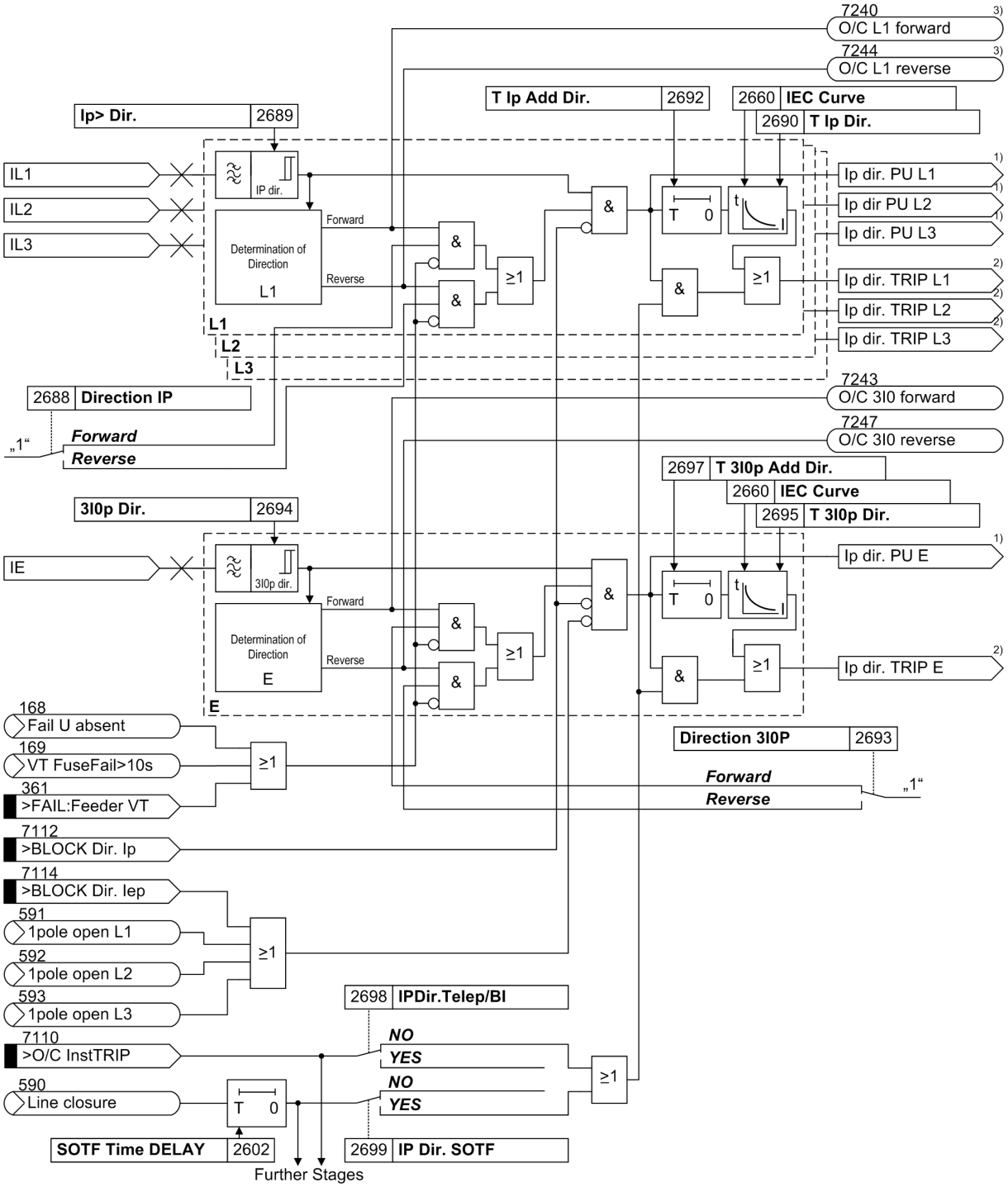
The logic of the inverse overcurrent stage also operates chiefly in the same way as that of the non-directional stage. However, pickup is dependent on the result of the direction determination. Direction determination occurs via the measuring values and the respective directional characteristics.

However, the time delay is calculated here based on the type of the set characteristic, the intensity of the current and a time multiplier **`D Ip Dir.`** or **`D 3I0p Dir.`**. Furthermore, an additional constant time delay **`T Ip Add Dir.`** or **`T 3I0p Add Dir.`** may be selected, which is added to the inverse time. The possible characteristics are shown in the Technical Data.

The individual phase or earth specific directional indications (7240 to 7247) are used to generate the indications *`O/C Dir. forward`* or *`O/C Dir. reverse`* if a valid direction result (forward or backward) was determined for a phase or earth current. These messages can then be transferred to a different device and there they can cause an immediate trip if an overcurrent stage of the receiving device has also picked up. The indications must then be combined via CFC (OR function).

The following figure shows the logic diagram of the directional $I_P$dir stages. The setting parameter addresses of the IEC characteristics are shown by way of an example. In the setting information (Section *2.9.3 Setting Notes*) the different setting addresses are elaborated upon.

The directional and the non-directional inverse overcurrent stage $I_P$dir always uses the same characteristic parameterized via the parameter 2660 (IEC) or 2661 (ANSI). Various inverse times and additional times can be configured.



[ip-stufe-gerichtet-iec-060724, 1, en_GB]

Figure 2-43 Logic diagram of the $I_p$dir stage (directional, inverse time overcurrent protection), for example IEC characteristics

1) Output indications associated with the pickup signals are listed in *Table 2-3*
2) Output indications associated with the trip signals are listed in *Table 2-4*
3) The indications *O/C L2 forward*, *O/C L3 forward*, *O/C L2 reverse*, *O/C L3 reverse* have not been represented in the Figure, however, they are reported if necessary.

Instantaneous tripping before automatic reclosure

If automatic reclosure is to be carried out, quick fault clearance before reclosure is usually desirable. A release signal from an external automatic reclosure device can be injected via binary input *>O/C InstTRIP*. The interconnection of the internal automatic reclose function is performed via an additional CFC logic, which typically connects the output signal 2889 *AR 1.CycZoneRel* with the input signal *>O/C InstTRIP*. Any stage of the overcurrent protection can thus perform an instantaneous trip before reclosure via the parameter ***Telep / BI ...***.

Switching onto a fault

The internal line energization detection can be used to achieve quick tripping of the circuit breaker in case of an earth fault. The time overcurrent protection can then trip three-pole without delay or with a reduced delay. It can be determined via parameter setting for which stage(s) the instantaneous tripping following energization applies (refer also to the logic diagrams *Figure 2-39*, *Figure 2-42* and *Figure 2-40*). This function is independent of the highcurrent instantaneous tripping described in Subsection *2.8 Instantaneous High-Current Switch-onto-Fault Protection (SOTF)*.

Pickup logic and tripping logic

The pickup signals of the single phases (or earth) and of the individual stages are thus linked with each other that both the phase information and the stage that has picked up is indicated (*Table 2-3*).

Table 2-3 Pickup signals of the single phases

Internal indication	Display	Output indication	No
I>> PU L1 I> PU L1 I>>> PU L1 I> dir PU L1 Ip PU L1 Ip dir PU L1	*Figure 2-39* *Figure 2-40* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C Pickup L1*	7162
I>> PU L2 I> PU L2 I>>> PU L2 I> dir PU L2 Ip PU L2 Ip dir PU L2	*Figure 2-39* *Figure 2-40* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C Pickup L2*	7163
I>> PU L3 I> PU L3 I>>> PU L3 I> dir PU L3 Ip PU L3 Ip dir PU L3	*Figure 2-39* *Figure 2-40* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C Pickup L3*	7164
I>> PU E I> PU E I>>> PU E I> dir PU E Ip PU E Ip dir PU E	*Figure 2-39* *Figure 2-40* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C Pickup E*	7165
I>> PU L1 I>> PU L2 I>> PU L3 I>> PU E	*Figure 2-39* *Figure 2-39* *Figure 2-39* *Figure 2-39*	*O/C PICKUP I>>*	7191

Internal indication	Display	Output indication	No
I> PU L1 I> PU L2 I> PU L3 I> PU E		*O/C PICKUP I>*	7192
I>>> PU L1 I>>> PU L2 I>>> PU L3 I>>> PU E	*Figure 2-40* *Figure 2-40* *Figure 2-40* *Figure 2-40*	*I-STUB PICKUP*	7201
I> dir PU L1 I> dir PU L2 I> dir PU L3 I> dir PU E	*Figure 2-41* *Figure 2-41* *Figure 2-41* *Figure 2-41*	*O/C PICK. I>Dir*	7202
Ip PU L1 Ip PU L2 Ip PU L3 Ip PU E	*Figure 2-42* *Figure 2-42* *Figure 2-42* *Figure 2-42*	*O/C PICKUP Ip*	7193
Ip dir PU L1 Ip dir PU L2 Ip dir PU L3 Ip dir PU E	*Figure 2-43* *Figure 2-43* *Figure 2-43* *Figure 2-43*	*O/C PICK. IpDir*	7203
(All pickups)		*O/C PICKUP*	7161

For the tripping signals *Table 2-4*) the stage which caused the tripping is also output. If the device has the option to trip single-pole, and if this option has been activated, the pole which has been tripped is also indicated (refer also to “Section Tripping Logic of the Entire Device”).

Table 2-4 Trip signals of the single phases

Internal indication	Display	Output indication	No
I>> TRIP L1 I> TRIP L1 I>>> TRIP L1 [1)] I> dir TRIP L1 Ip TRIP L1 Ip dir TRIP L1	*Figure 2-39* *Figure 2-40* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C TRIP 1p.L1* bzw. *O/C TRIP L123*	7212 bzw. 7215
I>> TRIP L2 I> TRIP L2 I>>> TRIP L2 [1)] I> dir TRIP L2 Ip TRIP L2 Ip dir TRIP L2	*Figure 2-39* *Figure 2-40* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C TRIP 1p.L2* bzw. *O/C TRIP L123*	7213 bzw. 7215
I>> TRIP L3 I> TRIP L3 I>>> TRIP L3 [1)] I> dir TRIP L3 Ip TRIP L3 Ip dir TRIP L3	*Figure 2-39* *Figure 2-40* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C TRIP 1p.L3* bzw. *O/C TRIP L123*	7214 bzw. 7215

Internal indication	Display	Output indication	No
I>> TRIP E I> TRIP E I>>> TRIP E [2)] I> dir TRIP E Ip TRIP E Ip dir TRIP E	*Figure 2-39* *Figure 2-41* *Figure 2-42* *Figure 2-43*	*O/C TRIP L123*	7215
I>> TRIP L1 I>> TRIP L2 I>> TRIP L3 I>> TRIP E	*Figure 2-39* *Figure 2-39* *Figure 2-39* *Figure 2-39*	*O/C TRIP I>>*	7221
I> TRIP L1 I> TRIP L2 I> TRIP L3 I> TRIP E		*O/C TRIP I>*	7222
I>>> TRIP L1 I>>> TRIP L2 I>>> TRIP L3 I>>> TRIP E	*Figure 2-40* *Figure 2-40* *Figure 2-40* *Figure 2-40*	*I-STUB TRIP*	7235
I> dir TRIP L1 I> dir TRIP L2 I> dir TRIP L3 I> dir TRIP E	*Figure 2-41* *Figure 2-41* *Figure 2-41* *Figure 2-41*	*O/C TRIP I>Dir.*	7236
Ip TRIP L1 Ip TRIP L2 Ip TRIP L3 Ip TRIP E	*Figure 2-42* *Figure 2-42* *Figure 2-42* *Figure 2-42*	*O/C TRIP Ip*	7223
Ip dir TRIP L1 Ip dir TRIP L2 Ip dir TRIP L3 Ip dir TRIP E	*Figure 2-43* *Figure 2-43* *Figure 2-43* *Figure 2-43*	*O/C TRIP IpDir.*	7237
(General TRIP)		*O/C TRIP*	7211

[1)] If tripping by the 3I0 measuring unit is performed simultaneous with or after tripping by a phase measuring unit and if single-pole tripping is effective, *O/C TRIP 1p.L1*, *O/C TRIP 1p.L2* or *O/C TRIP 1p.L3* is signaled.

[2)] If tripping is only performed by the 3I0 measuring unit but not by a phase measuring unit, *O/C TRIP L123* is signaled.

2.9.3 Setting Notes

General

During configuration of the scope of functions for the device (address 126) the available characteristics were determined. Depending on the configuration and the order variant, only those parameters that apply to the selected characteristics are accessible in the procedures described below.

Address 2601 is set according to the desired mode of operation of the overcurrent protection: **Operating Mode** = ***ON:always activ*** means that the overcurrent protection works independently of other protection functions, i.e. as a backup overcurrent protection. If it is to work only as an emergency function in case of loss of VT supply, ***ON:with VT loss*** must be set. Finally, it can also be set to ***OFF***.

If not all stages are required, each individual stage can be deactivated by setting the pickup threshold to ∞. But if you set only an associated time delay to ∞ this does not suppress the pickup signals but prevents the timers from running.

The I>>> stage is effective even if the operating mode of the time overcurrent protection has been set to ***Only Emer. prot*** and ***>I-STUB ENABLE*** is released.

One or several stages can be set as instantaneous tripping stages when switching onto a fault. This is chosen during the setting of the individual stages (see below). To avoid a spurious pick-up due to transient overcurrents, the delay **SOTF Time DELAY** (address 2680) can be set. Typically, the presetting of **0** s is correct. A short delay can be useful in case of long cables for which high inrush currents can be expected, or for transformers. This delay depends on the intensity and the duration of the transient overcurrents as well as on which stages were selected for the fast switch onto fault clearance.

Directional Stages

The directional stages require additional settings.

At address 2603 **Direct. 3I0**, you set the measuring variables to be used for the direction determination of the earth current stages.

If ***U0/I0 or U2/I0*** has been set (default setting), negative sequence or zero-sequence values can be used. Negative sequence system values are used if they are larger then the respective zero-sequence system values. If the measuring variables of both systems are unavailable, the directional 3I0>stages are blocked.

If ***with U0/I0*** has been set, the current zero-sequence values $3\underline{U}_0$ and $3\underline{I}_0$ are used. If the zero-sequence voltage is too small for a direction measurement, the directional 3I0>stages are blocked.

If ***with U2/I2*** has been set, the current negative sequence values $3\underline{U}_2$ and $3\underline{I}_2$ are used. If the negative sequence voltage is too small for a direction measurement, the directional 3I0>stages are blocked.

In addition, at address 2680 **Direction Iph>** or 2683 **Direction 3I0>**, set the pickup direction for the directional stages I>dir and 3I0dir. The settings ***Non-Directional*** (presetting), ***Forward***, and ***Reverse*** are possible.

In address 2688 **Direction IP** or 2693 **Direction 3I0P**, you set the pickup direction for the directional stages IPdir and 3I0Pdir. Settings ***Forward*** (default setting) and ***Forward*** are possible.

High current stages $\mathbf{I_{ph}>>}$, $\mathbf{3I_0>>}$

The I>>-stages **Iph>>** (address 2610) and **3I0>> PICKUP** (address 2612) together with the I>-stages or the I_p stages from a two0stage characteristic curve. Of course, all three stages can be combined as well. If one stage is not required, the pickup value has to be set to ∞. The I>> stages always operate with a defined delay time.

If the I>> stages are used for instantaneous tripping before the automatic reclosure (via CFC interconnection), the current setting corresponds to the I> or I_p stages (see below). In this case, only the different delay times are of interest. The times **T Iph>>** (address 2611) and **T 3I0>>** (address 2613) can then be set to **0** s or a very low value, as the fast clearance of the fault takes priority over the selectivity before the automatic reclosure is initiated. These stages have to be blocked before final trip in order to achieve the selectivity.

For very long lines with a small source impedance or on applications with large reactances (e.g. transformers, series reactors), theI>> stages can also be used for current grading. In this case, they must be set in such a way that they do not pick up in case of a fault at the end of the line. The times can then be set to **0**s or to a small value.

When using a personal computer and DIGSI to apply the settings, these can be optionally entered as primary or secondary values. For settings with secondary values the currents will be converted for the secondary side of the current transformers.

Calculation Example:

110 kV overhead line 150 mm^2:

s (length)	= 60 km
R_1/s	= 0.19 Ω/km
X_1/s	= 0.42 Ω/km

Short-circuit power at the beginning of the line:

S_k'	= 2.5 GVA
Current Transformer	600 A/5 A

From that the line impedance Z_L and the source impedance Z_S are calculated:

$$\frac{Z_L}{s} = \sqrt{0.19^2 + 0.42^2}\ \frac{\Omega}{km} = 0.46\ \frac{\Omega}{km}$$

[fo_7sa6_fkt-UMZ_bsp, 1, en_GB]

$Z_L = 0.46\ \Omega/km \cdot 60\ km = 27.66\ \Omega$

$$Z_S = \frac{(110\ kV)^2}{2500\ MVA} = 4.84\ \Omega$$

[formel-ueberstromzeit-hochstrom-1-oz-010802, 1, en_GB]

The 3-phase short-circuit current at the end of the line is $I_{k\ end}$:

$$I_{F\ End} = \frac{1.1 \cdot U_N}{\sqrt{3} \cdot (Z_S + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (4.84\ \Omega + 27.66\ \Omega)} = 2150\ A$$

[formel-ueberstromzeit-hochstrom-2-oz-010802, 1, en_GB]

With a safety factor of 10%, the following primary setting value is calculated:

Setting value I>> = 1.1 · 2150 A = 2365 A

or the secondary setting value:

$$\text{Setting value I>>} = 1.1 \cdot \frac{2150\ A}{600\ A} \cdot 5\ A = 19.7\ A$$

[formel-ueberstromzeit-hochstrom-3-oz-010802, 1, en_GB]

If short-circuit currents exceed 2365 A (primary) or 19.7 A (secondary), there is a short circuit on the line to be protected. This fault can immediately be cleared by the time overcurrent protection.

Note: the calculation was carried out with absolute values, which is sufficiently precise for overhead lines. If the angles of the source impedance and the line impedance vary considerably, a complex calculation must be carried out.

A similar calculation must be carried out for earth faults, with the maximum earth current occurring at the line end during a short-circuit being decisive.

The set time delays are pure additional delays, which do not include the operating time (measuring time).

The parameter **I>> InstTrip BI** (address 2614) determines, whether the time delays *>O/C InstTRIP* (No 7110) or the automatic reclosure in ready state can be bypassed by the binary input **T Iph>>** (address 2611) and **T 3I0>>** (address2613) is possible. The binary input (if allocated) is applied to all stages of the time-overcurrent protection. With **I>> InstTrip BI** = ***YES*** you define that the I>> stages trip without delay after pickup if the binary input was activated. For **I>> InstTrip BI** = ***NO*** the set delays are always active

Instantaneous tripping by the operational auto-reclosure function should only be chosen if the overcurrent protection is set to emergency function. Since the differential protection guarantees a fast and selective tripping with or without auto-reclosure, the overcurrent protection as a backup protection may not perform a non-selective trip, even before auto-reclosure.

If the I>>-stage, when switching the line onto a fault, is to trip without delay or with a short delay, **SOTF Time DELAY** (address 2680, see above under margin heading "General") set the parameter **I>> SOTF** (address 2615) to ***YES***. Any other stage can be selected as well for this instantaneous tripping.

Overcurrent Stages I_{ph}>, $3I_0$>, I_{ph}>dir, $3I_0$>dir in Definite-time Overcurrent Protection

For the setting of the current pickup value, **Iph>** (address 2620), the maximum operating current is most decisive. Pickup due to overload should never occur, since the device in this operating mode operates as fault protection with correspondingly short tripping times and not as overload protection. For this reason, a pickup

value of about 10 % above the expected peak load is recommended for line protection, and a setting of about 20 % above the expected peak load is recommended for transformers and motors.

When using a personal computer and DIGSI to apply the settings, these can be optionally entered as primary or secondary values. For settings with secondary values the currents will be converted for the secondary side of the current transformers.

Calculation Example:

110 kV overhead line 150 mm²

maximum transmittable power

P_{max} = 120 MVA

corresponding to

I_{max}	= 630 A
Current Transformer	600 A/5 A
Safety factor	1.1

With settings in primary quantities the following setting value is calculated:

Set value I> = 1.1 · 630 A = 693 A

With settings in secondary quantities the following setting value is calculated:

$$\text{Setting value I>} = 1.1 \cdot \frac{630\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 5.8\ \text{A}$$

[formel-ueberstromzeit-ueberstrom-oz-310702, 1, en_GB]

The earth current stage **3I0>** (address 2622) or **3I0> Dir.** (address 2684), should be set to detect the smallest earth fault current to be expected.

The settable delay time **T Iph>** (addresse 2621) or **T Iph> Dir.** (address 2682), results from the time grading schedule designed for the network. When using the function as emergency overcurrent protection, shorter delay times make sense (one grading time step above instantaneous tripping), since in this case the function is to work only if the local measuring voltages, fail.

The time **T 3I0>** (address 2623) or**T 3I0> Dir.** (adresse2685) can normally be set shorter, according to a separate time grading schedule for earth currents.

The set times are mere additional delays for the independent stages, which do not include the inherent operating time of the protection. If only the phase currents are to be monitored, set the pickup value of the earth fault stage to ∞.

The parameter **I> Telep/BI** (address 2624) or **I>Dir.Telep/BI** (address 2686) defines whether the time delays **T Iph>** (address 2621) or **T Iph> Dir.** (address 2682) and **T 3I0>** (address 2623)or **T 3I0> Dir.** (address 2685) can be bypassed by the binary input *>O/C InstTRIP*. The binary input (if allocated) is applied to all stages of the time-overcurrent protection. With **I> Telep/BI** = ***YES*** or **I>Dir.Telep/BI** = ***YES*** you define that the I> stages trip without delay after pickup if the binary input was activated. For **I> Telep/BI** = ***NO*** or **I>Dir.Telep/BI** = ***NO*** the set delays are always active.

Instantaneous tripping by the operational auto-reclosure function should only be chosen if the overcurrent protection is set to emergency function. Since the differential protection guarantees a fast and selective tripping with or without auto-reclosure, the overcurrent protection as a backup protection may not perform a non-selective trip, even before auto-reclosure.

If the I> stage, when switching the line onto a fault, is to retrip without delay or with a short delay **SOTF Time DELAY** (address 2680, see above under side title “General”), set parameter **I> SOTF** (address 2625) or **I> Dir. SOTF** (address 2687) to ***YES***. We recommend, however, not to choose the sensitive setting for the fast tripping as switching onto a fault typically causes a solid short circuit. It is important to avoid that the selected stage picks up due to transients during line energization.

Overcurrent Stages I_P, $3I_{0P}$ for Inverse-time Overcurrent Protection with IEC Characteristics

In the case of the inverse time overcurrent stages, various characteristics can be selected, depending on the ordering version of the device and the configuration (address 126). With IEC characteristics (address 126 **Back-Up O/C** = ***TOC IEC***) the following options are available in address 2660 **IEC Curve**:

Normal Inverse (inverse, type A according to IEC 60255-3),

Very Inverse (very inverse, type B according to IEC 60255-3),

Extremely Inv. (extremely inverse, type C according to IEC 60255-3) und

LongTimeInverse (longtime, type B according to IEC 60255-3).

The characteristics and equations they are based on are listed in the „Technical Data". They apply for directional and non-directional stages alike.

For the setting of the current thresholds **Ip>** (address 2640) or **Ip> Dir.** (address 2689) and **3I0p PICKUP** (address 2650) or **3I0p Dir.** (address 2694) the same considerations as for the overcurrent stages of the definite time protection (see above) apply. In this case, it must be noted that a safety margin between the pickup threshold and the set value has already been incorporated. Pickup only occurs at a current which is approximately 10 % above the set value.

The above example shows that the maximum expected operating current may directly be applied as setting here.

Primary: Set value IP = 630 A,

Secondary: Set value IP = 5.25 A, d.h. (630 A/600 A) · 5 A.

The time multiplier setting **T Ip Time Dial** (address 2642) or **T Ip Dir.** (address 2690) derives from the time grading schedule set for the network. For use as emergency overcurrent protection shorter delay times make sense (one grading time step above instantaneous tripping), since this function is to work only in case of an interruption of the data communication for the differential protection.

The time multiplier setting **T 3I0p TimeDial** (address 2652) or **T 3I0p Dir.** (address 2695) can usually be set smaller according to a separate earth fault grading plan. If only the phase currents are to be monitored, set the pickup value of the earth fault stage to ∞.

In addition to the current-dependent delays, a time fixed delay can be set, if necessary. The settings **T Ip Add** (address 2646 bzw. **T Ip Add Dir.** (address 2692) for phase currents) and **T 3I0p Add** (address 2656 or **T 3I0p Add Dir.** (address 2697) for earth currents) are in addition to the time delays resulting from the set curves.

The parameter **I(3I0)p Tele/BI** (address 2670) or **IPDir.Telep/BI** (address 2698) defines whether the time delays **T Ip Time Dial** (address 2642) or **T Ip Dir.** (address 2690), including the additional delay **T Ip Add** (address 2646) or **T Ip Add Dir.** (address 2692), and **T 3I0p TimeDial** (address 2652) or **T 3I0p Dir.** (address 2695), including the additional delay **T 3I0p Add** (address 2656) or **T 3I0p Add Dir.** (address 2697), can be bypassed by the binary input *>O/C InstTRIP* (No. 7110). The binary input (if allocated) is applied to all stages of the time-overcurrent protection. With **I(3I0)p Tele/BI** = ***YES*** or **IPDir.Telep/BI** = ***YES*** you define that the IP stages trip without delay after pickup if the binary input was activated. For **I(3I0)p Tele/BI** = ***NO*** or **IPDir.Telep/BI** = ***NO*** the set delays are always active.

Instantaneous tripping by the operational auto-reclosure function should only be chosen if the overcurrent protection is set to emergency function. Since the differential protection guarantees a fast and selective tripping with or without auto-reclosure, the overcurrent protection as a backup protection may not perform a non-selective trip, even before auto-reclosure.

If the IP stage, when switching the line onto a fault, is to retrip without delay or with a short delay **SOTF Time DELAY** (address 2680, see above under side title "General"), set parameter **I(3I0)p SOTF** (address 2671) or **IP Dir. SOTF** (address 2699) to ***YES***. We recommend, however, not to choose the sensitive setting for the fast tripping as switching onto a fault typically causes a solid short circuit. It is important to avoid that the selected stage picks up due to transients during line energization.

Overcurrent Stages I_P, $3I_{0P}$,$I_P$dir, $3I_{0P}$dir for inverse-time O/C protection with ANSI characteristic

In the case of the inverse time overcurrent stages, various characteristics can be selected, depending on the ordering version of the device and the configuration (address 126). With ANSI characteristics (address 126 **Back-Up O/C** = ***TOC ANSI***) the following options are available in address 2661 **ANSI Curve**:

Inverse,

Short Inverse,

Long Inverse,

Moderately Inv.,

Very Inverse,

Extremely Inv. and

Definite Inv..

For the setting of the current thresholds **Ip>** (address 2640) and **3I0p PICKUP** (address 2650) the same considerations as for the overcurrent stages of the definite time protection (see above) apply. In this case, it must be noted that a safety margin between the pickup threshold and the set value has already been incorporated. Pickup only occurs at a current which is approximately 10 % above the set value.They apply for directional and non-directional stages alike.

For the setting of the current thresholds **Ip>** (address 2640) or **Ip> Dir.** (address 2689) and **3I0p PICKUP** (address 2650) or **3I0p Dir.** (address 2694), the same considerations as for the overcurrent stages of the definite time protection (see above) apply. In this case, it must be noted that a safety margin between the pickup threshold and the set value has already been incorporated. Pickup only occurs at a current which is approximately 10°% above the set value.

The above example shows that the maximum expected operating current may directly be applied as setting here.

Primary: Set value IP = 630 A,

Secondary: Setting value IP = 5.25 A, d.h. (630 A/600 A) · 5 A.

The set time multiplier **Time Dial TD Ip** (address 2643) or D Ip Dir. (address 2691) results from the grading coordination chart defined for the network. For the use as emergency overcurrent protection, shorter delay times make sense (one grading time step above instantaneous tripping), since this function is to work only in case of an interruption of the data communication for the differential protection.

The time multiplier setting **TimeDial TD3I0p** (address 2653) or **D Ip Dir.** (address 2691) can usually be set smaller according to a separate earth fault grading plan. If only the phase currents are to be monitored, set the pickup value of the earth fault stage to ∞.

In addition to the inverse-time delays, a delay of constant length can be set, if necessary. The settings **T Ip Add** (address 2646 or **T Ip Add Dir.** (address 2692) for phase currents) and **T 3I0p Add** (address 2656 or **T 3I0p Add Dir.** (address 2697) for ground current) are added to the times of the set characteristic curves.

The parameter **I(3I0)p Tele/BI** (address 2670) or **IPDir.Telep/BI** (address 2698) defines whether the time delays **Time Dial TD Ip** (address 2643) or **D Ip Dir.** (address 2691), including the additional delay **T Ip Add** (address 2646) or **T Ip Add Dir.** (address 2692), and **TimeDial TD3I0p** (address 2653) or **T 3I0p Dir.** (address 2695), including the additional delay **T 3I0p Add** (address 2656) or **T 3I0p Add Dir.** (address 2697), can be bypassed by the binary input *>O/C InstTRIP* (No. 7110). The binary input (if allocated) is applied to all stages of the time-overcurrent protection. With **I(3I0)p Tele/BI** = ***YES*** or **IPDir.Telep/BI** = ***YES*** you define that the IP stages trip without delay after pickup if the binary input was activated. For **I(3I0)p Tele/BI** = ***NO*** or **IPDir.Telep/BI** = ***NO*** the set delays are always active.

Instantaneous tripping by the operational auto-reclosure function should only be chosen if the overcurrent protection is set to emergency function. Since the differential protection guarantees a fast and selective tripping with or without auto-reclosure, the overcurrent protection as a backup protection may not perform a non-selective trip, even before auto-reclosure.

If the IP stage, when switching the line onto a fault, is to retrip without delay or with a short delay **SOTF Time DELAY** (address 2680, see above under side title “General”), set parameter **I(3I0)p SOTF** (address 2671) or **IP Dir. SOTF** (address 2699) to ***YES***. We recommend, however, not to choose the sensitive setting for the fast tripping as switching onto a fault typically causes a solid short circuit. It is important to avoid that the selected stage picks up due to transients during line energization.

Additional Stage I_{ph}>>>

The I>>> stage can be used as an additional definite-time overcurrent stage since it operates independently of the other stages In this case, the enable input *>I-STUB ENABLE* (no. 7131) must be activated permanently (via a binary input or CFC).

Since the I>>> stage has an additional enable input, it is also suitable e.g. as an emergency stage if the remaining stages are used as backup stages. The enable input *>I-STUB ENABLE* (no. 7131) is then assigned the output signal *Emer. mode* (no. 2054) - either via binary outputs and inputs or via the user-definable CFC logic functions.

When using the I>>> stage as an emergency function, similar considerations apply as for the I> stages. The setting value **Iph> STUB** (address 2630) must here too be higher than the maximum operational current to be expected, in order to avoid pickup without fault. The delay **T Iph STUB** (address 2631) however, can be shorter than defined in the time grading schedule since this stage works only in emergency operation, i.e. in case of a communication failure of the differential protection. One grading time above the base time of the differential protection is usually sufficient

Accordingly, the earth current stage **3I0> STUB** (address 2632) should pick up on the smallest earth current to be expected during an earth fault and the delay **T 3I0 STUB** (address 2633) should exceed the base time of the differential protection by one grading time. If only the phase currents are to be monitored, set the pickup value of the earth current stage to ∞.

The I>>> stage can also be accelerated by the release signal *>O/C InstTRIP* (no. 7110) e.g. before automatic reclosing. This is defined using parameter **I-STUB Telep/BI** (address 2634). Set this parameter to ***YES*** if you want the I>>> stage to trip instantaneously while the binary input *>O/C InstTRIP* is active or the internal automatic reclosing function is ready to operate.

Instantaneous tripping by the ready automatic reclosing function should only be chosen if the I>>> stage is used as an emergency function. If the Differential protection is out of operation, this emergency stage ensures instantaneous tripping before automatic reclosure.

Instantaneous tripping when the line is switched onto a fault is also possible with the I>>> stage. Set parameter **I-STUB SOTF** (address 2635) to ***YES*** if instantaneous tripping is desired.

2.9.4 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2601	Operating Mode		ON Only Emer. prot OFF	ON	Operating mode
2602	SOTF Time DELAY		0.00 .. 30.00 sec	0.00 sec	Trip time delay after SOTF
2603A	Direct. 3I0		U0/I0 or U2/I0 with U0/I0 with U2/I2	U0/I0 or U2/I0	Measurement of direction for 3I0
2610	Iph>>	1A	0.05 .. 50.00 A; ∞	2.00 A	Iph>> Pickup
		5A	0.25 .. 250.00 A; ∞	10.00 A	
2611	T Iph>>		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph>> Time delay
2612	3I0>> PICKUP	1A	0.05 .. 25.00 A; ∞	0.50 A	3I0>> Pickup
		5A	0.25 .. 125.00 A; ∞	2.50 A	
2613	T 3I0>>		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> InstTrip BI		NO YES	YES	Instantaneous trip via BI
2615	I>> SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2620	Iph>	1A	0.05 .. 50.00 A; ∞	1.50 A	Iph> Pickup
		5A	0.25 .. 250.00 A; ∞	7.50 A	
2621	T Iph>		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> Pickup
		5A	0.25 .. 125.00 A; ∞	1.00 A	
2623	T 3I0>		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Time delay

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2624	I> Telep/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2625	I> SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2630	Iph> STUB	1A	0.05 .. 50.00 A; ∞	1.50 A	Iph> STUB Pickup
		5A	0.25 .. 250.00 A; ∞	7.50 A	
2631	T Iph STUB		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> STUB Pickup
		5A	0.25 .. 125.00 A; ∞	1.00 A	
2633	T 3I0 STUB		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0 STUB Time delay
2634	I-STUB Telep/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2635	I-STUB SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2640	Ip>	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> Pickup
		5A	0.50 .. 20.00 A; ∞	∞ A	
2642	T Ip Time Dial		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Time Dial
2643	Time Dial TD Ip		0.50 .. 15.00 ; ∞	5.00	Time Dial TD Ip
2646	T Ip Add		0.00 .. 30.00 sec	0.00 sec	T Ip Additional Time Delay
2650	3I0p PICKUP	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p Pickup
		5A	0.25 .. 20.00 A; ∞	∞ A	
2652	T 3I0p TimeDial		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Time Dial
2653	TimeDial TD3I0p		0.50 .. 15.00 ; ∞	5.00	Time Dial TD 3I0p
2656	T 3I0p Add		0.00 .. 30.00 sec	0.00 sec	T 3I0p Additional Time Delay
2660	IEC Curve		Normal Inverse Very Inverse Extremely Inv. LongTimeInverse	Normal Inverse	IEC Curve
2660	IEC Curve		Normal Inverse Very Inverse Extremely Inv. LongTimeInverse	Normal Inverse	IEC Curve
2661	ANSI Curve		Inverse Short Inverse Long Inverse Moderately Inv. Very Inverse Extremely Inv. Definite Inv.	Inverse	ANSI Curve
2661	ANSI Curve		Inverse Short Inverse Long Inverse Moderately Inv. Very Inverse Extremely Inv. Definite Inv.	Inverse	ANSI Curve

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2670	I(3I0)p Tele/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2671	I(3I0)p SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2680	Direction Iph>		Non-Directional Forward Reverse	Non-Directional	Direction of stage Iph> Dir.
2681	Iph> Dir.	1A	0.05 .. 50.00 A; ∞	1.50 A	Iph> directional Pickup
		5A	0.25 .. 250.00 A; ∞	7.50 A	
2682	T Iph> Dir.		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Dir. Time delay
2683	Direction 3I0>		Non-Directional Forward Reverse	Non-Directional	Direction of stage 3I0> Dir.
2684	3I0> Dir.	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> directional Pickup
		5A	0.25 .. 125.00 A; ∞	1.00 A	
2685	T 3I0> Dir.		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Dir. Time delay
2686	I>Dir.Telep/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2687	I> Dir. SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2688	Direction IP		Forward Reverse	Forward	Direction of stage Ip> Dir.
2689	Ip> Dir.	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> directional Pickup
		5A	0.50 .. 20.00 A; ∞	∞ A	
2690	T Ip Dir.		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Dir.: Inv.-Time delay for IEC-Char.
2691	D Ip Dir.		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2692	T Ip Add Dir.		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2693	Direction 3I0P		Forward Reverse	Forward	Direction of stage 3I0p
2694	3I0p Dir.	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p directional Pickup
		5A	0.25 .. 20.00 A; ∞	∞ A	
2695	T 3I0p Dir.		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Dir.:Inv.-Time delay for IEC-Char
2696	D 3I0p Dir.		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2697	T 3I0p Add Dir.		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2698	IPDir.Telep/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2699	IP Dir. SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault

2.9.5 Information List

No.	Information	Type of Information	Comments
7104	>BLOCK O/C I>>	SP	>BLOCK Backup OverCurrent I>>
7105	>BLOCK O/C I>	SP	>BLOCK Backup OverCurrent I>
7106	>BLOCK O/C Ip	SP	>BLOCK Backup OverCurrent Ip
7107	>BLOCK O/C Ie>>	SP	>BLOCK Backup OverCurrent Ie>>
7108	>BLOCK O/C Ie>	SP	>BLOCK Backup OverCurrent Ie>
7109	>BLOCK O/C Iep	SP	>BLOCK Backup OverCurrent Iep
7110	>O/C InstTRIP	SP	>Backup OverCurrent InstantaneousTrip
7111	>BLOCK Dir. I>	SP	>BLOCK direct. Backup OverCurrent I>
7112	>BLOCK Dir. Ip	SP	>BLOCK direct. Backup OverCurrent Ip
7113	>BLOCK Dir. Ie>	SP	>BLOCK direct. Backup OverCurrent Ie>
7114	>BLOCK Dir. Iep	SP	>BLOCK direct. Backup OverCurrent Iep
7130	>BLOCK I-STUB	SP	>BLOCK I-STUB
7131	>I-STUB ENABLE	SP	>Enable I-STUB-Bus function
7132	>BLOCK O/CIe>>>	SP	>BLOCK Backup OverCurrent Ie>>>
7151	O/C OFF	OUT	Backup O/C is switched OFF
7152	O/C BLOCK	OUT	Backup O/C is BLOCKED
7153	O/C ACTIVE	OUT	Backup O/C is ACTIVE
7161	O/C PICKUP	OUT	Backup O/C PICKED UP
7162	O/C Pickup L1	OUT	Backup O/C PICKUP L1
7163	O/C Pickup L2	OUT	Backup O/C PICKUP L2
7164	O/C Pickup L3	OUT	Backup O/C PICKUP L3
7165	O/C Pickup E	OUT	Backup O/C PICKUP EARTH
7171	O/C PU only E	OUT	Backup O/C Pickup - Only EARTH
7172	O/C PU 1p. L1	OUT	Backup O/C Pickup - Only L1
7173	O/C Pickup L1E	OUT	Backup O/C Pickup L1E
7174	O/C PU 1p. L2	OUT	Backup O/C Pickup - Only L2
7175	O/C Pickup L2E	OUT	Backup O/C Pickup L2E
7176	O/C Pickup L12	OUT	Backup O/C Pickup L12
7177	O/C Pickup L12E	OUT	Backup O/C Pickup L12E
7178	O/C PU 1p. L3	OUT	Backup O/C Pickup - Only L3
7179	O/C Pickup L3E	OUT	Backup O/C Pickup L3E
7180	O/C Pickup L31	OUT	Backup O/C Pickup L31
7181	O/C Pickup L31E	OUT	Backup O/C Pickup L31E
7182	O/C Pickup L23	OUT	Backup O/C Pickup L23
7183	O/C Pickup L23E	OUT	Backup O/C Pickup L23E
7184	O/C Pickup L123	OUT	Backup O/C Pickup L123
7185	O/C PickupL123E	OUT	Backup O/C Pickup L123E
7191	O/C PICKUP I>>	OUT	Backup O/C Pickup I>>
7192	O/C PICKUP I>	OUT	Backup O/C Pickup I>
7193	O/C PICKUP Ip	OUT	Backup O/C Pickup Ip
7201	I-STUB PICKUP	OUT	O/C I-STUB Pickup
7202	O/C PICK. I>Dir	OUT	Backup O/C Pickup I> directional
7203	O/C PICK. IpDir	OUT	Backup O/C Pickup Ip directional

No.	Information	Type of Information	Comments
7211	O/C TRIP	OUT	Backup O/C General TRIP command
7212	O/C TRIP 1p.L1	OUT	Backup O/C TRIP - Only L1
7213	O/C TRIP 1p.L2	OUT	Backup O/C TRIP - Only L2
7214	O/C TRIP 1p.L3	OUT	Backup O/C TRIP - Only L3
7215	O/C TRIP L123	OUT	Backup O/C TRIP Phases L123
7221	O/C TRIP I>>	OUT	Backup O/C TRIP I>>
7222	O/C TRIP I>	OUT	Backup O/C TRIP I>
7223	O/C TRIP Ip	OUT	Backup O/C TRIP Ip
7235	I-STUB TRIP	OUT	O/C I-STUB TRIP
7236	O/C TRIP I>Dir.	OUT	Backup O/C TRIP I> directional
7237	O/C TRIP IpDir.	OUT	Backup O/C Pickup Ip directional
7240	O/C L1 forward	OUT	Backup O/C L1 forward direction
7241	O/C L2 forward	OUT	Backup O/C L2 forward direction
7242	O/C L3 forward	OUT	Backup O/C L3 forward direction
7243	O/C 3I0 forward	OUT	Backup O/C 3I0 forward direction
7244	O/C L1 reverse	OUT	Backup O/C L1 reverse direction
7245	O/C L2 reverse	OUT	Backup O/C L2 reverse direction
7246	O/C L3 reverse	OUT	Backup O/C L3 reverse direction
7247	O/C 3I0 reverse	OUT	Backup O/C 3I0 reverse direction
7248	O/C Dir.forward	OUT	Backup O/C forward direction
7249	O/C Dir.reverse	OUT	Backup O/C reverse direction

2.10 Automatic Reclosure Function (optional)

Experience shows that about 85% of the arc faults on overhead lines are extinguished automatically after being tripped by the protection. The line can therefore be re-energised. Reclosure is performed by an automatic reclose function (AR).

Automatic reclosure function is only permitted on overhead lines because the possibility of extinguishing a fault arc automatically only exists there. It must not be used in any other case. If the protected object consists of a mixture of overhead lines and other equipment (e.g. overhead line in block with a transformer or overhead line/cable), it must be ensured that reclosure can only be performed in the event of a fault on the overhead line.

If the circuit breaker poles can be operated individually, a 1-pole automatic reclosure is usually initiated in the case of 1-phase faults and a 3-pole automatic reclosure in the case of multi-phase faults in the network with earthed system star point. If the fault still exists after reclosure (arc not extinguished or metallic short-circuit), the protection issues a final trip. In some systems several reclosing attempts are performed.

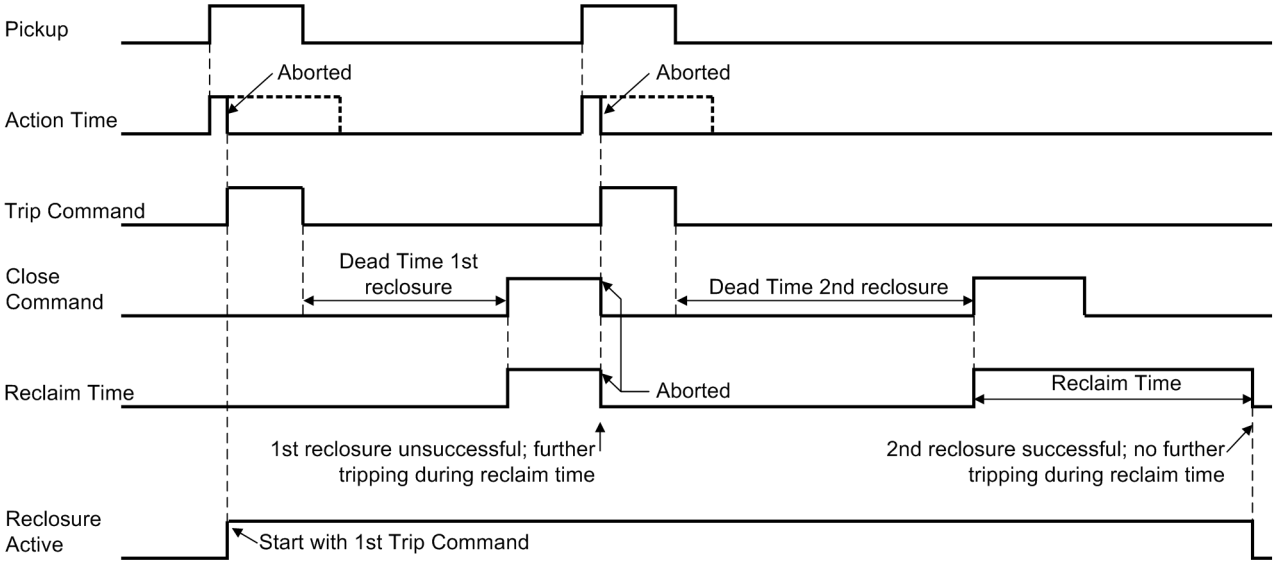
In the model with 1-pole tripping the 7SD610 allows phase-selective 1-pole tripping. A 1- and 3-pole, one- and multi-shot automatic reclosure is integrated depending on the order variant.

The 7SD610 can also operate in conjunction with an external automatic reclosure device. In this case, the signal exchange between 7SD610 and the external reclosure device must be effected via binary inputs and outputs.

It is also possible to initiate the integrated auto reclose function by an external protection device (e.g. a backup protection). The use of two 7SD610 with automatic reclosure function or the use of one 7SD610 with an automatic reclosure function and a second protection with its own automatic reclosure function is also possible.

2.10.1 Functional Description

Reclosure is performed by an automatic reclosure circuit (ARC). An example of the normal time sequence of a double reclosure is shown in the figure below.



[ablaufdia-2-mal-we-wirkzeit-wlk-310702, 1, en_GB]

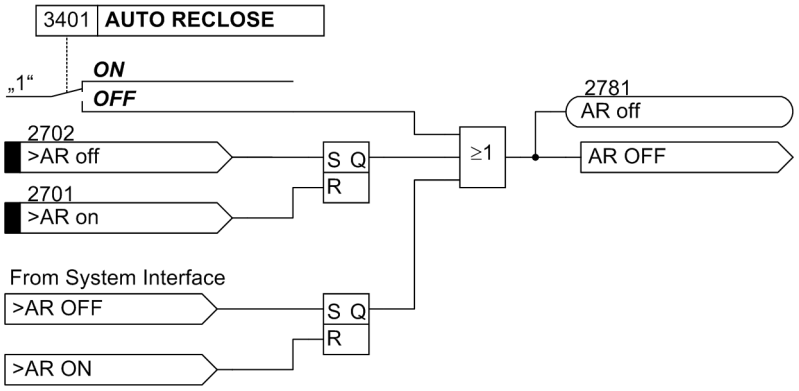
Figure 2-44 Timing diagram of a double-shot reclosure with action time (2nd reclosure successful)

The integrated automatic reclosing function allows up to 8 reclosing attempts. The first four reclose cycles may operate with different parameters (action and dead times, 1-/3-pole). The parameters of the fourth cycle apply to the fifth cycle and onwards.

Activation and deactivation

The automatic reclosure function can be switched on and off by means of the parameter 3401 **AUTO RECLOSE** via the system interface (if available) and via binary inputs (if allocated). The switch states are saved internally (refer to *Figure 2-45*) and secured against loss of auxiliary supply. Basically, it can only be switched on from where it had previously been switched off. To be active, the function must be switched on from all three switching sources.

Alteration of the switching state via setting or system interface is not possible during a running fault.



[logik-ein-aus-wiedereinschaltautomatik-st-290803, 1, en_GB]

Figure 2-45 Activation and deactivation of the auto-reclosure function

Selectivity before Reclosure

In order that automatic reclosure function can be successful, all faults on the entire overhead line must be cleared at all line ends simultaneously — as fast as possible.

This is the usual case in differential protection schemes because the strict selective zone definition of the protected object by the current transformer sets always allows non-delayed tripping.

However, fast tripping of the protection may also be desired before reclosure after tripping by other short-circuit protection functions. For this purpose, every short-circuit protection which can start the automatic reclosure function has the possibility of initiating non-delayed tripping in at least one stage when the automatic reclosure function is ready for the first reclosure cycle. Please note, however, that fast, non-selective tripping should be avoided as long as the differential protection works properly.

Fast tripping before reclosure is also possible with multiple reclosures. Appropriate links between the output signals (e.g. 2nd reclosure ready: *AR 2.CycZoneRel*) and the inputs for enabling/releasing non-delayed tripping of the protection functions can be established via the binary inputs and outputs or the integrated userdefinable logic functions (CFC).

Initiation

Initiation of the automatic reclosure function means storing the first trip signal of a power system fault that was generated by a protection function which operates with the automatic reclosure function. In case of multiple reclosure, initiation therefore only takes place once, with the first trip command. This storing of the first trip signal is the prerequisite for all subsequent activities of the automatic reclosure function. The starting is important when the first trip command has not appeared before expiry of an action time (see below under “Action times”).

Automatic reclosure function is not started if the circuit breaker has not been ready for at least one OPEN-CLOSE- OPEN–cycle at the instant of the first trip command. This can be achieved by setting parameters. For further information, please refer to “Interrogation of Circuit Breaker Ready State”.

Each short-circuit protection function can be parameterized as to whether it should operate with the automatic reclose function or not, i.e. whether it should start the reclose function or not. The same goes for external trip commands applied via binary input and/or the trip commands generated by the teleprotection via permissive or intertrip signals.

Those protection and monitoring functions in the device which do not respond to short-circuits or similar conditions (e.g. an overload protection) do not initiate the automatic reclosure function because a reclosure

will be of no use here. The circuit breaker failure protection must not start the automatic reclosure function either.

Action Times

It is often desirable to neutralise the ready–for–reclosure–state if the short-circuit condition was sustained for a certain time, e.g. because it is assumed that the arc has burned in to such an extent that there is no longer any chance of automatic arc extinction during the reclose dead time. Also for the sake of selectivity (see above), faults that are usually cleared after a time delay should not lead to reclosure.

The automatic reclosure function of the 7SD610 can be operated with or without action times (configuration parameter **AR control mode**, address 134, see Section *2.1.1.2 Setting Notes*). No starting signal is necessary from the protection functions or external protection devices that operate without action time. Initiation takes place as soon as the first trip command appears.

When operating with action time, an action time is available for each reclose cycle. The action times are always started by the general starting signal (with logic OR combination of all internal and external protection functions which can start the automatic reclose function). If no trip command is present before the action time expires, the corresponding reclosure cycle is not carried out.

For each reclosure cycle, it can be specified whether or not it should allow the initiation. Following the first general pickup, only those action times are relevant whose cycles allow starting because the other cycles are not allowed to initiate. By means of the action times and the permission to start the recloser (permission to be the first cycle that is executed), it is possible to determine which reclose cycles are executed depending on the time it takes the protection function to trip.

Example 1: 3 cycles are set. Starting of the automatic reclosure function is allowed for at least the first cycle. The action times are set as follows:

- 1.WE: T WIRK = 0.2 s;
- 2.WE: T WIRK = 0.8 s;
- 3.WE: T WIRK = 1.2 s;

Since reclosure is ready before the fault occurs, the first trip of a time overcurrent protection following a fault is fast, i.e. before the end of any action time. This starts the automatic reclose function. After unsuccessful reclosure, the 2nd cycle would then become active; but the time overcurrent protection does not trip in this example until after 1s according to its grading time. Since the action time for the second cycle was exceeded here, the second cycle is blocked. The 3rd cycle with its parameters is therefore carried out now. If the trip command appeared more than 1.2 s after the 1st reclosure, there would be no further reclosure.

Example 2: 3 cycles are set. Starting is only allowed for the first. The action times are set as in example 1. The first protection trip takes place 0.5 s after starting. Since the action time for the 1st cycle has already expired at this time, this cannot start the automatic reclose function. As the 2nd and 3rd cycles are not permitted to start the reclose function they will also not be initiated. Therefore no reclosure takes place as no starting took place.

Example 3: 3 cycles are set. At least the first two cycles are set such that they can start the recloser. The action times are set as in example 1. The first protection trip takes place 0.5 s after starting. Since the action time for the 1st cycle has already expired at this time, it cannot start the automatic reclosure function, but the 2nd cycle, for which initiating is allowed, is activated immediately. This 2nd cycle therefore starts the automatic reclosure function, the 1st cycle is practically skipped.

Operating modes of the automatic reclosure function

The dead times — these are the times from elimination of the fault (drop off of the trip command or signaling via auxiliary contacts) to the initiation of the automatic close command — may vary depending on the automatic reclosure function operating mode selected when determining the function scope and the resulting signals of the starting protection functions.

In control mode ***TRIP...*** (With TRIP command ...), 1-polige or 1-/3-polige reclose cycles are possible if the device and the circuit breaker are suitable. In this case, different dead times (for every AR cycle) are possible after 1-pole tripping and after 3-pole tripping. The protection function that issues the trip command determines the type of trip: 1-pole or 3-pole. The dead time is controlled dependent on this.

In control mode ***PICKUP ... ...*** (With PICKUP...), different dead times can be set for every reclose cycle after 1-, 2- und 3-phasigen faults. The pickup diagram of the protection functions at the instant when the trip

command disappears is the decisive factor. This mode allows the dead time to be made dependent on the type of fault in the case of 3-pole tripping applications.

Blocking reclosure

Different conditions lead to blocking of the automatic reclosure function. No reclosure is possible, for example, if it is blocked via a binary input. If the automatic reclosure function has not yet been started, it cannot be started at all. If a reclosure cycle is already in progress, dynamic blocking takes place (see below).

Each individual cycle may also be blocked via binary input. In this case the cycle concerned is declared as invalid and will be skipped in the sequence of permissible cycles. If blocking takes place while the cycle concerned is already running, this leads to aborting of the reclosure, i.e. no reclosure takes place even if other valid cycles have been parameterized.

Internal blocking signals, with a limited duration, arise during the course of the reclose cycles:

The reclaim time **T-RECLAIM** (address 3403) is started with each automatic reclosure command, the only exception is the ADT mode where the reclaim time can be disabled by setting it to 0 s. If the reclosure is successful, all functions of the automatic reclosure function return to the idle state at the end of the reclaim time; a fault after expiry of the reclaim time is treated as a new fault in the power system. If the reclaim time is disabled in ADT mode, each new trip after reclosing is considered as a new fault. If one of the protection functions causes another trip during the reclaim time, the next reclosure cycle will be started if multiple reclosure has been set. If no further reclosure attempts are permitted, the last reclosure is regarded as unsuccessful in case of another trip during the reclaim time. The automatic reclosure function is blocked dynamically.

The dynamic lock-out locks the reclosure for the duration of the dynamic lock-out time (0.5 s). This occurs, for example, after a endgültigen trip or other events which block the auto reclose function after it has been started. Restarting is blocked during this time. When this time expires, the automatic reclosure function returns to its quiescent state and is ready for a new fault in the network.

If the circuit breaker is closed manually (by the control discrepancy switch connected to a binary input, the local control functions or via one of the serial interfaces), the automatic reclosure function is blocked for a manual-close-blocking time **T-BLOCK MC**, address 3404. If a trip command occurs during this time, it can be assumed that a metallic short-circuit is present (e.g. closed earth switch). Every trip command within this time is therefore final. With the user definable logic functions (CFC) further control functions can be processed in the same way as a manual–close command.

Interrogation of the Circuit Breaker Ready State

A precondition for automatic reclosure function following clearance of a short-circuit is that the circuit breaker is ready for at least one OPEN-CLOSE-OPEN-cycle when the automatic reclosure circuit is started (i.e. at the time of the first trip command). The readiness of the circuit breaker is signaled to the device via the binary input *>CB1 Ready* (No. 371). If no such signal is available, the circuit breaker interrogation can be suppressed (presetting of address 3402) as automatic reclosure function would otherwise not be possible at all.

In the event of a single cycle reclosure this interrogation is usually sufficient. Since, for example, the air pressure or the spring tension for the circuit breaker mechanism drops after the trip, no further interrogation should take place.

For multiple reclosing attempts it is highly recommended to monitor the circuit breaker condition not only prior to the first, but also before each following reclosing attempt. Reclosure will be blocked until the binary input indicates that the circuit breaker is ready to complete another CLOSE-TRIP cycle.

The time needed by the circuit breaker to regain the ready state can be monitored by the 7SD610. This monitoring time **CB TIME OUT** (address 3409) starts as soon as the CB indicates the not ready state. The dead time may be extended if the ready state is not indicated when it expires. However, if the circuit breaker does not indicate its ready status for a longer period than the monitoring time, reclosure is dynamically blocked (see also above under margin heading “Reclosure Blocking”).

Processing the circuit breaker auxiliary contacts

If the circuit breaker auxiliary contacts are connected to the device, the reaction of the circuit breaker is also checked for plausibility.

In the case of 1-pole tripping this applies to each individual circuit breaker pole. This assumes that the auxiliary contacts are connected to the appropriate binary inputs for each pole (*>CB1 Pole L1*, No. 366; *>CB1 Pole L2*, No. 367; *>CB1 Pole L3*, No. 368).

If, instead of the individual pole auxiliary contacts, the series connections of the normally open and normally closed contacts are used, the CB is assumed to have all three poles open when the series connection of the normally closed contacts is closed (binary input *>CB1 3p Open*, No 411). All three poles are assumed closed when the series connection of the normally open contacts is closed (binary input *>CB1 3p Closed*, No. 410). If none of these input indications is active, it is assumed that the circuit breaker is open at one pole (even if this condition also exists theoretically when two poles are open).

The device continuously checks the position of the circuit breaker: As long as the auxiliary contacts indicate that the CB is not closed (3-pole), the automatic reclosure function cannot be started. This ensures that a close command can only be issued if the CB has previously tripped (out of the closed state).

The valid dead time begins when the trip command disappears or, in addition, when signals taken from the CB auxiliary contacts indicate that the CB (pole) has opened.

If, after a **1**-pole trip command, the CB has opened **3**-pole, this is considered as a 3-pole tripping. If 3-pole reclose cycles are allowed, the dead time for 3-pole tripping becomes active in the operating mode with **trip command** (see margin heading “Operating modes of the automatic reclosure”, above). If 3-pole cycles are not allowed, the reclosure is blocked dynamically. The trip command is final.

The latter also applies if the CB trips two poles following a 1-pole trip command. The device can only detect this if the auxiliary contacts of each pole are connected individually. The device immediately initiates 3-pole coupling which results in a 3-pole trip command.

If the CB auxiliary contacts indicate that at least one further pole has opened during the dead time after 1-pole tripping, a 3-pole reclose cycle is initiated with the dead time for 3-pole reclosure provided that this is permitted. If the auxiliary contacts are connected for each pole individually, the device can detect a two-pole open CB. In this case the device immediately sends a 3-pole trip command provided that the forced 3-pole trip is activated (see Section *2.10.2 Setting Notes* at margin heading “Forced 3-pole trip”).

Sequence of a 3-pole reclose cycle

If the automatic reclosure function is ready, the fault protection trips 3-pole for all faults inside the stage selected for reclosure. The automatic reclosure function is started. When the trip command resets or the circuit breaker opens (auxiliary contact criterion) an adjustable dead time starts. At the end of this dead time, the circuit breaker receives a close command. At the same time, the (adjustable) dead time is started. If, when configuring the protection functions, at address 134 **AR control mode** = ***with Pickup*** was set, different dead times can be parameterised depending on the type of fault recognised by the protection.

If the fault is cleared (successful reclosure), the reclaim time expires and all functions return to their quiescent state. The fault is cleared.

If the fault has not been eliminated (unsuccessful reclosure), the short-circuit protection initiates a final trip following a protection stage active without reclosure. Any fault during the reclaim time leads to a final trip.

After unsuccessful reclosure (final tripping) the automatic reclosure function is blocked dynamically (see also margin heading “Reclose Block”, above).

The sequence above applies for single reclosure cycles. In 7SD610 multiple reclosure (up to 8 shots) is also possible (see below).

Sequence of a 1-pole reclose cycle

1-pole reclose cycles are only possible with the appropriate device version and if this was selected during the configuration of the protection functions (address 110 **Trip mode**, see also Section *2.1.1.2 Setting Notes*). Of course, the circuit breaker must also be suitable for 1-pole tripping.

If the automatic reclosure function is ready, the short-circuit protection trips 1-pole for all 1-phase faults inside the stage(s) selected for reclosure. Under the general settings (address 1156 **Trip2phFlt**, see also Section *2.1.4.1 Setting Notes*) it can also be selected that 1-pole tripping takes place for two-phase faults without earth. 1-pole tripping is of course only possible by short-circuit protection functions which can determine the faulty phase.

If multiple-phase faults occur, the fault protection issues a final 3-pole trip with the stage that is valid without reclosure. Any 3-pole trip is final. The automatic reclosure function is blocked dynamically (see also margin heading “Blocking reclosure”, above).

The automatic reclosure function is started in the case of 1-pole tripping. The (adjustable) dead time for the 1-pole reclose cycle starts with reset of the trip command or opening of the circuit breaker pole (auxiliary contact criterion). After expiry of the dead time, the circuit breaker receives a close command. At the same time, the (adjustable) reclaim time is started. If the reclosure is blocked during the dead time following a 1-pole trip, immediate 3-pole tripping can take place as an option (forced 3-pole trip).

If the fault is cleared (successful reclosure), the reclaim time expires and all functions return to their quiescent state. The fault is cleared.

If the fault has not been eliminated (unsuccessful reclosure), the short-circuit protection initiates a final 3-pole trip with the protection stage that is valid without reclosure. All faults during the reclaim time also lead to a final 3-pole trip.

After unsuccessful reclosure (final tripping) the automatic reclosure function is blocked dynamically (see also margin heading “Reclose Block”, above).

The sequence above applies for single reclosure cycles. In 7SD610 multiple reclosure (up to 8 shots) is also possible (see below).

Sequence of a 1-pole and 3-pole Reclose Cycle

This operating mode is only possible with the appropriate device version if selected during configuration of the protection functions (address 110, see also Section *2.1.1.2 Setting Notes*). Also, the circuit breaker must be suitable for 1- pole tripping.

If the automatic reclosure function is ready, the short-circuit protection trips 1-pole for 1-phase faults and 3-pole for multi-phase faults. Under the general settings (address 1156 **`Trip2phFlt`**, see also Section *2.1.4.1 Setting Notes*) 1- pole tripping for two-phase faults without earth can be selected. 1-pole tripping is only possible for short-circuit protection functions that can determine the faulted phase. The valid protection stage selected for reclosure ready state applies for all fault types.

The automatic reclosure function is started at the moment of tripping. Depending on the type of fault, the (adjustable) dead time for the 1-pole reclose cycle or the (separately adjustable) dead time for the 3-pole reclose cycle starts following the reset of the trip command or opening of the circuit breaker (pole) (auxiliary contact criterion). After expiry of the dead time, the circuit breaker receives a close command. At the same time, the (adjustable) reclaim time is started. If the reclosure is blocked during the dead time following a 1-pole trip, immediate 3-pole tripping can take place as an option (forced 3-pole trip).

If the fault is cleared (successful reclosure), the reclaim time expires and all functions return to their quiescent state. The fault is cleared.

If the fault has not been eliminated (unsuccessful reclosure), the short-circuit protection initiates a final 3-pole trip with the protection stage that is valid without reclosure. All faults during the reclaim time also lead to a final 3-pole trip.

After unsuccessful reclosure (final tripping), the automatic reclosure function is blocked dynamically (see also margin heading “Reclose Block”, above).

The sequence above applies for single reclosure cycles. In 7SD610 multiple reclosure (up to 8 shots) is also possible (see below).

Multiple reclosure

If a short-circuit still exists after a reclosure attempt, further reclosure attempts can be made. Up to 8 reclosure attempts are possible with the automatic reclosure function integrated in the 7SD610.

The first four reclosure cycles are independent of each other. Each one has separate action and dead times, can operate with 1- or 3-pole trip and can be blocked separately via binary inputs. The parameters and intervention possibilities of the fourth cycle also apply to the fifth cycle and onwards.

The sequence is the same in principle as in the different reclosure programs described above. However, if the first reclosure attempt was unsuccessful, the reclosure function is not blocked, but instead the next reclose cycle is started. The appropriate dead time starts with the reset of the trip command or opening of the circuit breaker (pole) (auxiliary contact criterion). The circuit breaker receives a new close command after expiry of the dead time. At the same time the reclaim time is started.

The reclaim time is reset with each new trip command after reclosure and is started again with the next close command until the set maximum number of permissible auto-reclose cycles has been reached.

If one of the reclosing attempts is successful, i.e. the fault disappeared after reclosure, the blocking time expires and the automatic reclosing system is reset. The fault is cleared.

If none of the cycles is successful, the short-circuit protection initiates a final 3-pole trip after the last permissible reclosure, following a protection stage that is valid without auto-reclosure. The automatic reclosing function is blocked dynamically (see also above under margin heading “Blocking the Reclosing Function”).

Handling Evolving Faults

When 1-pole or 1-and 3-pole reclose cycles are executed in the network, particular attention must be paid to sequential faults.

Evolving faults are faults which occur during the dead time after clearance of the first fault.

There are various ways of handling sequential faults in the 7SD610depending on the requirements of the network:

To **detect** an evolving fault, you can select either the trip command of a protection function during the dead time or every further pickup as the criterion for an evolving fault.

There are also various selectable possibilities for the **response** of the internal auto- reclose function to a detected evolving fault.

- **EV. FLT. MODE** ***blocks AR***:

  The reclosure is blocked as soon as a sequential fault is detected. The tripping by the sequential fault is always 3-pole. This applies irrespective of whether 3-pole cycles have been permitted or not. There are no further reclosure attempts; the automatic reclosure function is blocked dynamically (see also margin heading “Blocking reclosure”, above).

- **EV. FLT. MODE** ***starts 3p AR***:

  As soon as a sequential fault is detected, the recloser switches to a 3-pole cycle. Each trip command is 3-pole. The separately settable dead time for sequential faults starts with the clearance of the sequential fault; after the dead time the circuit breaker receives a close command. The further sequence is the same as for 1- and 3-pole cycles.

  The complete dead time in this case consists of the part of the dead time for the 1-pole reclosure up to the clearance of the sequential fault plus the dead time for the sequential fault. This makes sense because the duration of the 3-pole dead time is most important for the stability of the network.

If reclosure is blocked due to a sequential fault without the protection issuing a 3-pole trip command (e.g. for sequential fault detection with starting), the device can send a 3-pole trip command so that the circuit breaker does not remain open with one pole (forced 3-pole trip).

Forced 3-pole trip

If reclosure is blocked during the dead time of a 1-pole cycle without a 3-pole trip command having been initiated, the breaker would remain open at one pole. In most cases, the circuit breaker is equipped with a pole discrepancy supervision which will trip the remaining poles after a few seconds. By setting a parameter, you can achieve that the tripping logic of the device immediately sends a 3-pole trip command in this case. This forced 3-pole trip pre-empts the pole discrepancy supervision of the CB because the forced 3-pole trip of the device is initiated as soon as the reclosure is blocked following a 1-pole trip or if the CB auxiliary contacts report an implausible breaker state.

When different internal protection functions initiate a 1-pole trip in different phases, the device will issue a 3-pole trip command due to the tripping logic (Section *2.16.1 Function Control*), independent of this forced 3-pole trip. This is also true for trip commands given via the direct local trip inputs (Section *2.6 Direct Local Trip*) or the reception of a remote trip (Section *2.7 Transmission of binary commands and messages*) since these signals directly affect the tripping logic of the device.

If the device trips 1-pole and if an external trip command in another phase only reaches the device via one of the binary inputs, e.g. *>Trip L1 AR* to the internal automatic reclosure function, this is not routed to the tripping logic. In this case, 3-pole trip is ensured only if the forced 3-pole trip is effective.

The forced 3-pole trip is also activated when only 3-pole cycles are allowed, but a 1-pole trip is signalled externally via a binary input.

Dead Line Check (DLC)

If the voltage of a disconnected phase does not disappear following a trip, reclosure can be prevented. A prerequisite for this function is that the voltage transformers are connected on the line side of the circuit breaker. To select this function the dead line check must be activated. The automatic reclosure function then

checks the disconnected line for no-voltage: the line must have been without voltage for at least an adequate measuring time during the dead time. If this was not the case, the reclosure is blocked dynamically.

This no-voltage check on the line is of advantage if a small generator (e.g. wind generator) is connected along the line.

Adaptive Dead Time (ADT)

In all the previous alternatives it was assumed that defined and equal dead times were set at both line ends, if necessary for different fault types and/or reclose cycles.

It is also possible to set the dead times (if necessary different for various fault types and/or reclose cycles) at one line end only and to configure the adaptive dead time at the other end. This can be done provided that the voltage transformers are located on the line side of the circuit breaker or that a means for transfer of a close command to the remote line end exists.

Figure 2-46 shows an example with voltage measurement. It is assumed that device I operates with defined dead times whereas the adaptive dead time is configured at position II. It is important that the line is at least fed from busbar A, i.e. the side with the defined dead times.

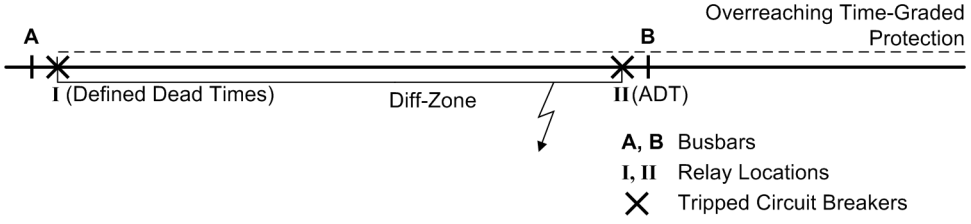
When using the adaptive dead time, the automatic reclosing function at line end II decides autonomously whether to allow reclosing or not. Its decision is based on the line voltage at end II, which was reapplied from end I following reclosure. Device II will thus initiate reclosing as soon as it is evident that the line has been reenergized from end I. All phase-to-phase and phase-to-earth voltages are monitored.

In the illustrated example of a short circuit, the lines are disconnected at positions I, and II. In I reclosure takes place after the configured dead time.

If the fault has been cleared (successful reclosure), line A - B is re-connected to the voltage at busbar A through position I. Device II detects this voltage and also recloses after a short delay (to ensure a sufficient voltage measuring time). The fault is cleared.

If the fault has not been cleared after reclosure at I (unsuccessful reclosure), the line will be disconnected again in position I with the result that no healthy voltage is detected at location II so that the circuit breaker there does not reclose.

In the case of multiple reclosure the sequence may be repeated several times following an unsuccessful reclosure until one of the reclosure attempts is successful or a final trip takes place.



[bsp-asp-060405, 1, en_GB]

Figure 2-46 Example of adaptive dead time (ADT)

A, B	Busbars
I, II	Relay locations

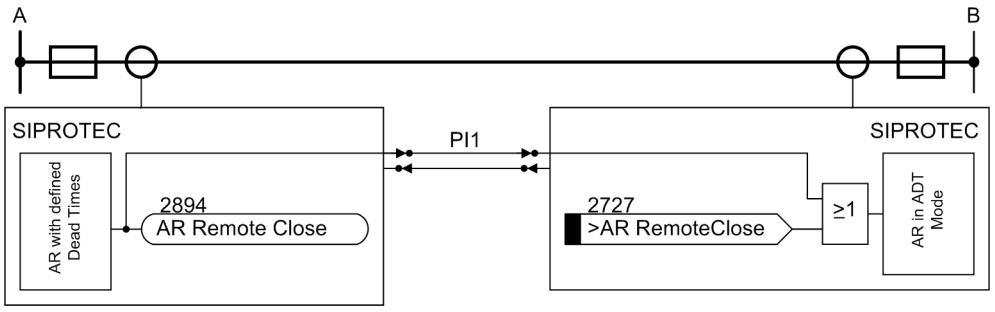
As is shown by the example, the adaptive dead time has the following advantages:

- The circuit breaker at position II is not reclosed if the fault persists and is not unnecessarily stressed as a result.
- With non-selective tripping outside the protected zone by an overreaching time-graded protection, no further reclosure cycles can be generated there because the fault current path via busbar B and position II remains interrupted even after several reclosures.
- At position I overreach is allowed in the case of multiple reclosures and even in the event of final tripping because the line remains open at position II and therefore no actual overreach can occur at I.

CLOSE Command Transmission (Remote-CLOSE)

With close command transmission via the digital connection paths the dead times are only set at one line end. The other line end (or line ends in lines with more than two ends) is set to “Adaptive Dead Time (ADT)”. The latter merely responds to the close commands received from the transmitting end.

At the sending line end, the transmission of the close command is delayed until it is sure that the local reclosure was successful. This means that the device waits whether a local pickup still occurs after reclosing. This delay prevents unnecessary closing at the remote end on the one hand but also increases the time until reclosure takes place there. This is not critical for a 1-pole interruption or in radial or meshed networks if no stability problems are expected under these conditions.



[awe-inter-ein-ws-wlk-310702, 1, en_GB]

Figure 2-47 AR Remote-Close function via protection data interface

The close command can be transmitted by a teleprotection scheme using the protection data interfaces (ordering variant). When the indication *AR Remote Close* is output, this information is transmitted at the same time to the remote end via the protection data interface. The information is ORed with the information of the binary input *>AR RemoteClose* and made available to the automatic reclosure function. (*Figure 2-47*).

Connecting an External Auto-Reclosure Device

If the 7SD610 has to work with an external reclosure device, the binary inputs and outputs provided for this purpose must be taken into consideration. The following inputs and outputs are recommended:

Binary inputs:

381 *>1p Trip Perm*	The external reclosure device allows 1-pole tripping (logic inversion or 3- pole coupling). If this input is not assigned or not routed (matrix), the protection functions trip 3-pole for all faults. If the external reclosure device cannot supply this signal but supplies a “3-pole coupling” signal instead, this must be taken into account in the allocation of the binary inputs: the signal must be inverted in this case (L-active = active without voltage).

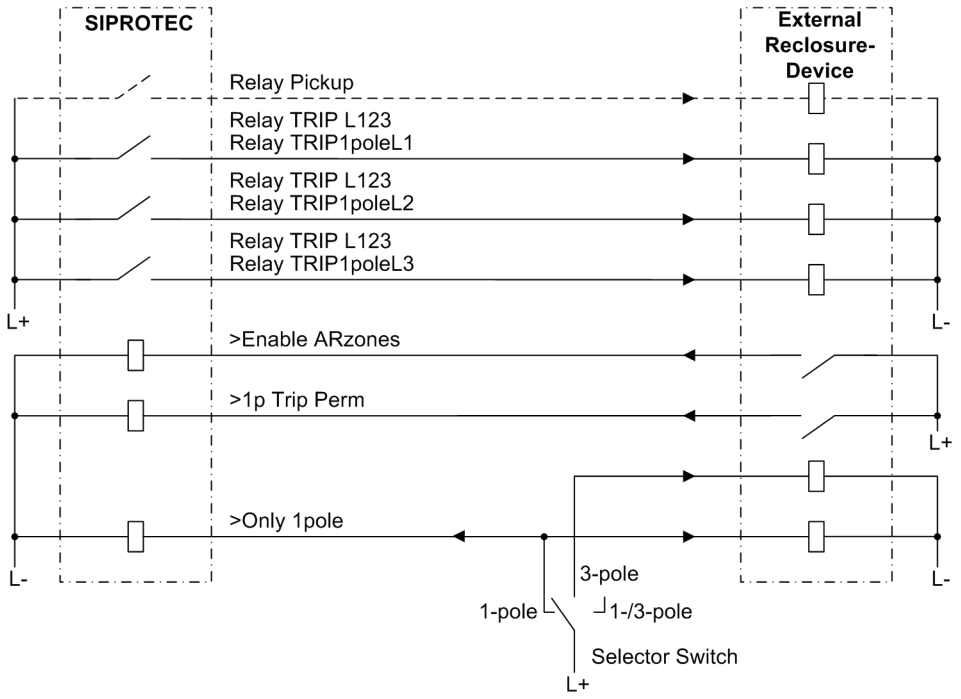
Binary outputs:

501 *Relay PICKUP*	Start of protection device, general (if required by external recloser device).
512 *Relay TRIP 1pL1*	Trip of the device 1-pole L1.
513 *Relay TRIP 1pL2*	Trip of the device 1-pole L2.
514 *Relay TRIP 1pL3*	Trip of the device 1-pole L3.
515 *Relay TRIP 3ph.*	Trip of the device 3-pole.

Figure 2-48 for example, shows the interconnection between a 7SD610 and an external reclosure device with a mode selector switch.

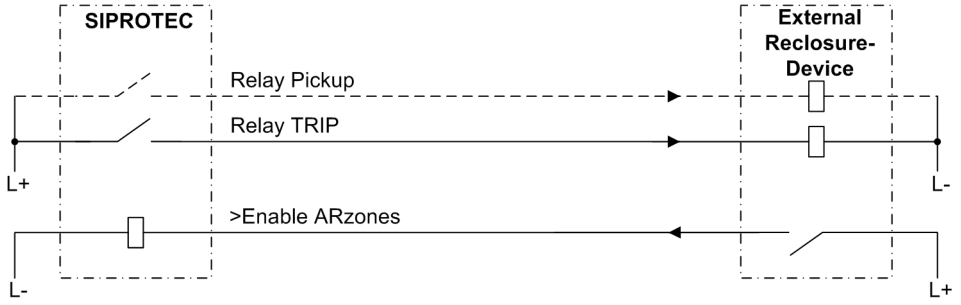
Depending on the external reclosure device requirements, the three 1-pole indications (No. 512, 513, 514) can be combined to one “1-pole tripping” output; No. 515 sends the “3-pole tripping” signal to the external device.

In case of exclusively 3-pole reclose cycles, the general pickup signal (No. 501, if required by the external reclosure device) and trip signal (No. 511) of 7SD610 (see *Figure 2-49*) are usually sufficient.



[anschlussbsp-ext-weger-1-o-3-pol-we-wlk-310702, 1, en_GB]

Figure 2-48 Connection example with external auto-reclosure device for 1-/3-pole AR with mode selector switch



[anschlussbsp-ext-weger-3-pol-we-wlk-310702, 1, en_GB]

Figure 2-49 Connection example with external reclosure device for 3-pole AR

Control of the internal automatic reclosure by an external protection device

If the 7SD610 is equipped with the internal automatic reclosure function, this can also be controlled by an external protection device. This is of use, for example, on line ends with redundant protection or additional back-up protection when the second protection is used for the same line end and has to work with the automatic reclosure function integrated in the 7SD610.

The binary inputs and outputs provided for this functionality must be considered in this case. It must be decided whether the internal automatic reclosure function is to be controlled by the starting (pickup) or by the trip command of the external protection (see also above under "Control Mode of the Automatic Reclosure").

If the automatic reclosure function is controlled by the **trip command**, the following inputs and outputs are recommended:

The automatic reclosure function is started via the Binary inputs:

2711 *>AR Start*	Generalanregung für die Wiedereinschaltautomatik (nur für Wirkzeit benötigt),
2712 *>Trip L1 AR*	Auslösekommando L1 für die Wiedereinschaltautomatik,
2713 *>Trip L2 AR*	Auslösekommando L2 für die Wiedereinschaltautomatik,
2714 *>Trip L3 AR*	Auslösekommando L3 für die Wiedereinschaltautomatik.

The general pickup is decisive for starting the action times. It is also required if the automatic reclosing function has to detect sequential faults via pickup. In other cases, this input information is irrelevant.

The trip commands decide whether the dead time is activated for 1-pole or 3-pole reclose cycles or whether the reclosure is blocked in the event of a 3-pole trip (depending on the configured dead times).

Figure 2-50 shows the interconnection between the internal automatic reclosure function of the 7SD610 and an external protection device, as a connection example for 1-pole cylces.

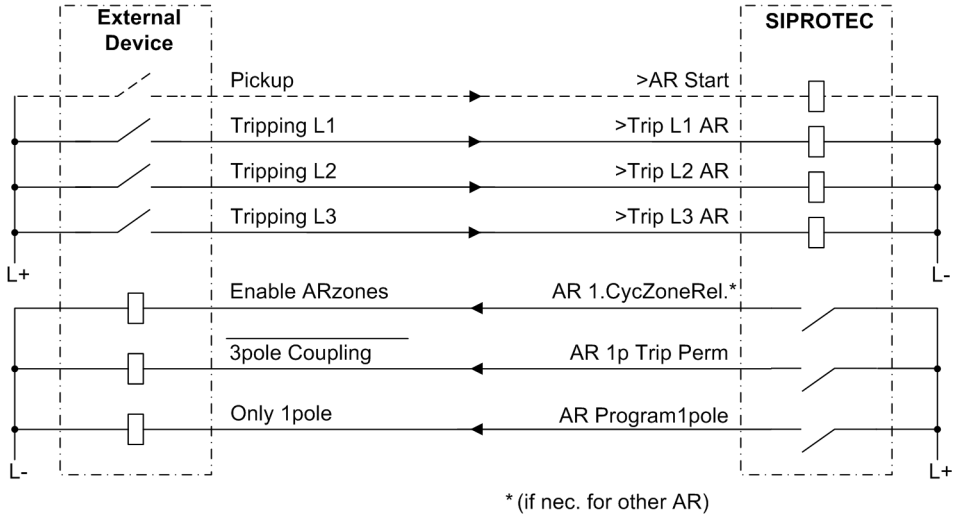
To achieve 3-pole coupling of the external protection and to release, if necessary, its accelerated stages before reclosure, the following output functions are suitable:

2864 *AR 1p Trip Perm*	Internal automatic reclosure function ready for 1-pole reclose cycle, i.e. allows 1-pole tripping (logic inversion of the 3-pole coupling).
2889 *AR 1.CycZoneRel*	Internal automatic reclosure function ready for the first reclose cycle, i.e. releases the stage of the external protection device for reclosure, the corresponding outputs can be used for other cycles. This output can be omitted if the external protection does not require an overreaching stage (e.g. differential protection).
2820 *AR Program1pole*	Internal automatic reclosure function is programmed for one pole, i.e. only recloses after 1-pole tripping. This output can be omitted if no overreaching stage is required (e.g. differential protection).

Instead of the 3-phase-segregated trip commands, the 1-pole and 3-pole tripping may also be signalled to the internal automatic reclosure function - provided that the external protection device is capable of this -, i.e. assign the following binary inputs of the 7SD610:

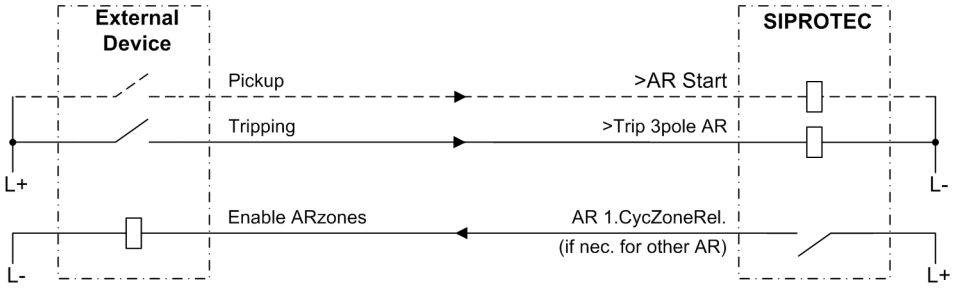
2711 *>AR Start*	General fault detection for the internal automatic reclosure function (only required for action time),
2715 *>Trip 1pole AR*	Trip command 1-pole for the internal automatic reclosure function,
2716 *>Trip 3pole AR*	Trip command 3-pole for the internal automatic reclosure function.

If only 3-pole reclosure cycles are to be executed, it is sufficient to assign the binary input *>Trip 3pole AR* (No. 2716) for the trip signal. *Figure 2-51* shows an example. Any overreaching stages of the external protection are enabled again by *AR 1.CycZoneRel* (No. 2889) and of further cycles, if applicable.



[anschlussbsp-ext-schutzger-1-o-3-pol-we-wlk-310702, 1, en_GB]

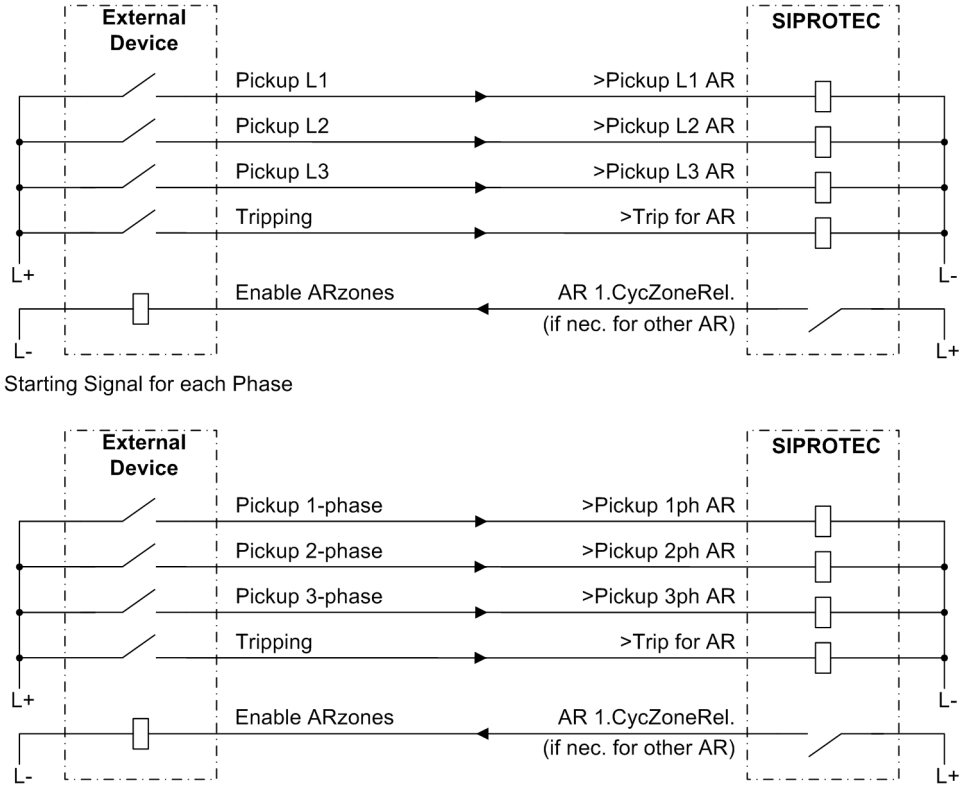
Figure 2-50 Connection example with external protection device for 1-/3-pole reclosure; AR control mode = with TRIP



[anschlussbsp-ext-schutzger-3-pol-we-wlk-310702, 1, en_GB]

Figure 2-51 Connection example with external protection device for 3-pole reclosure; AR control mode = with TRIP

But if the internal automatic reclose function is controlled by the **pickup** (only possible for 3-pole tripping: 110 **`Trip mode`** = ***`3pole only`***), the phase-selective pickup signals of the external protection must be connected if distinction shall be made between different types of fault. The general trip command then suffices for tripping (No. 2746). *Figure 2-52* shows a connection example.



[anschlussbsp-ext-schutzger-fehlerab-pause-wlk-310702, 1, en_GB]

Figure 2-52 Connection example with external protection device for fault detection dependent dead time — dead time control by pickup signals of the protection device; AR control mode = with PICKUP

2 Protection Relays with 2 Automatic Reclosure Circuits

If redundant protection is provided for a line and each protection operates with its own automatic reclosure function, a certain signal exchange between the two combinations is necessary. The connection example in *Figure 2-53* shows the necessary cross-connections.

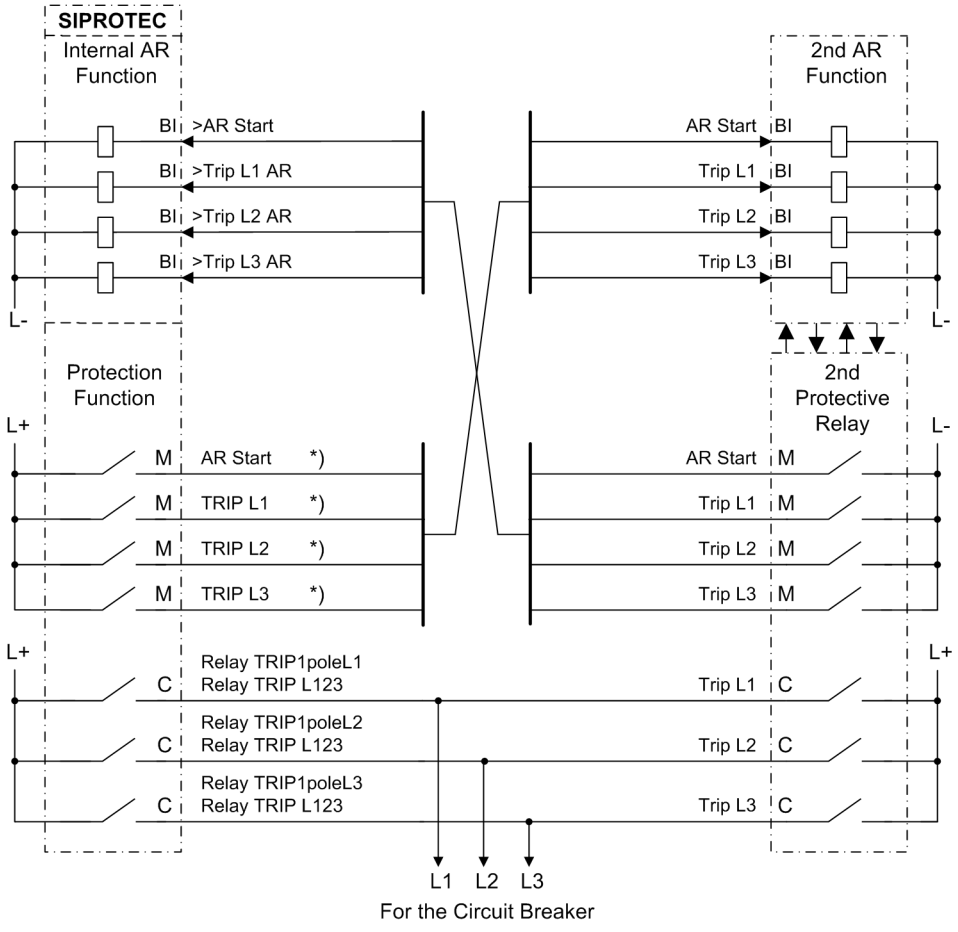
If the auxiliary contacts of the circuit breaker are connected to the correct phases, a 3-pole coupling by the 7SD610 is ensured when more than one CB pole is tripped. This requires the activation of the forced 3-pole trip (see Section *2.10.2 Setting Notes* at margin heading “Forced 3-pole trip”). An external automatic 3-pole

coupling is therefore unnecessary if the above conditions are met. This prevents 2-pole tripping under all circumstances.

For the connection according to *Figure 2-53* it must be considered that the cross connections to the second protection must be interrupted during the check of one of the two protection systems with protection monitoring equipment. This is done, for example, by means of a test switch installed in between.

Alternatively, the variant with a minimum cross connection according to *Figure 2-54* can be applied. In this case, the following information should be considered:

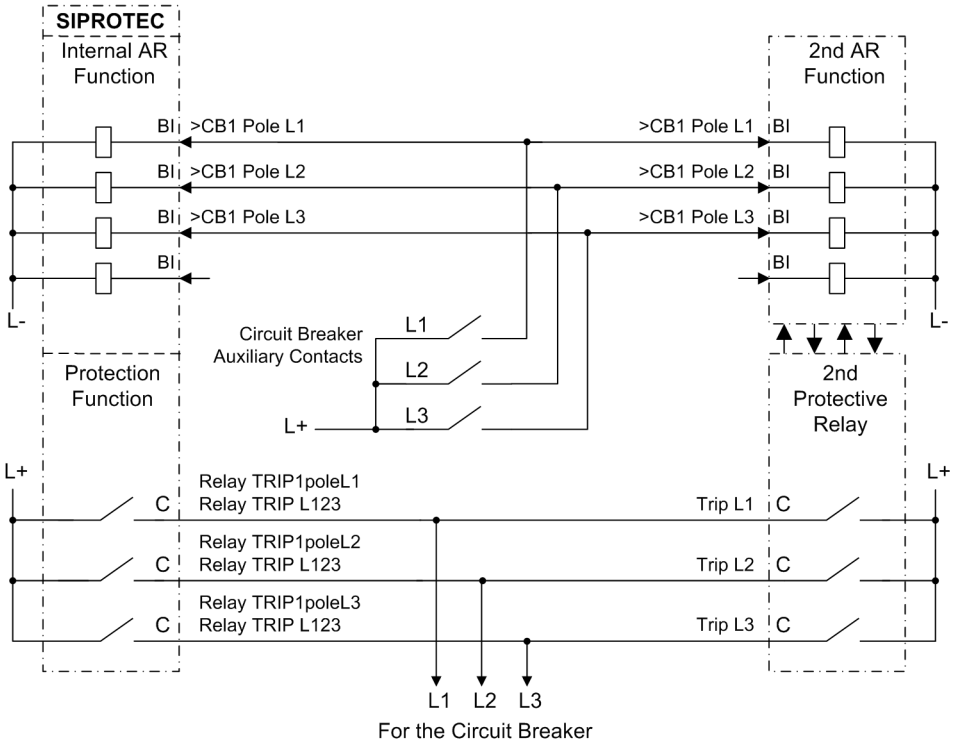
- The switching state of the circuit breaker must be connected in a phase-selective way via the auxiliary contacts to the corresponding binary inputs of both protection systems in case of a 1-pole reclosure. If only 3- pole tripping is possible, the 3-pole status is sufficient.
- In order to prevent that a very quick response (1-pole) of a protection leads to an undesired 3-pole coupling of a second protection, a “software filter time” for the binary inputs of the auxiliary contacts is to be set (refer to *Figure 2-55*).



[anschlussbsp-2-schutzeinri-2-wes-wlk-310702, 1, en_GB]

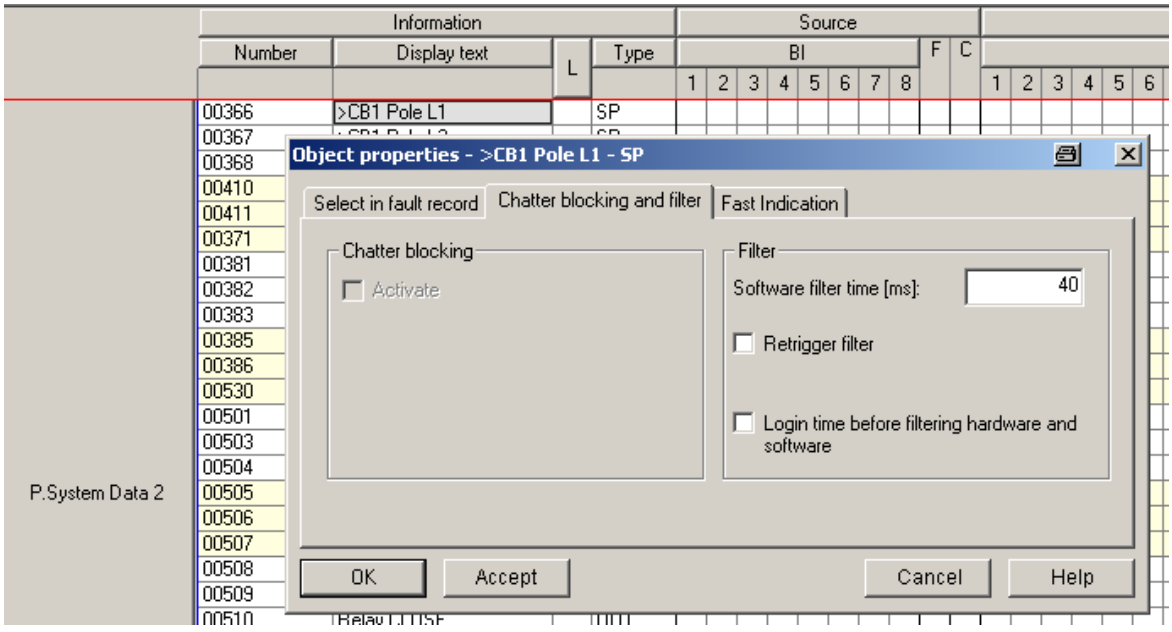
Figure 2-53 Connection example for 2 protection devices with 2 automatic reclosure functions

BI	Binary inputs
M	Signal output
K	Command
*)	for all protection functions operating with AR.



[anschlussbsp-2-schutzger-int-awe-100413, 1, en_GB]

Figure 2-54 Connection example for 2 protection devices with internal automatic reclosure function and minimum cross connection



[digsi-einstellung-sw-filterzeit-090410-wlk, 1, en_GB]

Figure 2-55 Setting of the software filter time

2.10.2 Setting Notes

General

If no reclosure is required on the feeder to which the 7SD610 distance protection is applied (e.g. for cables, transformers, motors or similar), the automatic reclosure function must be inhibited during configuration of the device (see Section *2.1.1.2 Setting Notes*, address 133). The automatic reclosure function is then fully disabled, i.e. the automatic reclosure is not processed in the 7SD610. No signals regarding the automatic reclosure function are generated, and the binary inputs for the automatic reclosure function are ignored. All settings of the automatic reclosure function are inaccessible and of no significance.

But if the internal automatic reclosure function is to be used, the type of reclosure must be selected during the configuration of the device functions (see Section *2.1.1.2 Setting Notes*) in address 133 **Auto Reclose** and in address 134 die **AR control mode** mode.

Up to 8 reclosure attempts are allowed with the integrated automatic reclosure function in the 7SD610. Whereas the settings in address 3401 to 3441 are common to all reclosure cycles, the individual settings of the cycles are made from address 3450 onwards. It is possible to set different individual parameters for the first four reclose cycles. From the fifth cycle on the parameters for the fourth cycle apply.

The automatic reclosing function can be turned ***ON*** or ***OFF*** under address 3401 **AUTO RECLOSE**.

A prerequisite for automatic reclosure taking place after a trip due to a short-circuit is that the circuit breaker is ready for at least one OPEN-CLOSE-OPEN cycle at the time the automatic reclosure circuit is started, i.e. at the time of the first trip command. The readiness of the circuit breaker is signalled to the device via the binary input *>CB1 Ready* (No. 371). If no such signal is available, leave the setting under address 3402 **CB? 1.TRIP** = ***NO*** because no automatic reclosure would be possible at all otherwise. If circuit breaker interrogation is possible, you should set **CB? 1.TRIP** = ***YES***.

Furthermore, the circuit breaker ready state can also be interrogated prior to every reclosure. This is set when setting the individual reclose cycles (see below).

To check that the ready status of the circuit breaker is regained during the dead times, you can set a circuit breaker ready monitoring time under address 3409 **CB TIME OUT**. The time is set slightly longer than the recovery time of the circuit breaker after an OPEN-CLOSE-OPEN cycle. If the circuit breaker is not ready again by the time this timer expires, no reclosure takes place and the automatic reclosure function is blocked dynamically.

Waiting for the circuit breaker to be ready can cause an increase of the dead times. Interrogation of a synchronism check (if used) can also delay reclosure. To avoid uncontrolled prolongation, it is possible to set a maximum prolongation of the dead time in this case in address 3411 **T-DEAD EXT.**. This prolongation is unlimited if the setting ∞ is applied. This parameter can only be altered in DIGSI at Display **Additional Settings**. Remember that longer dead times are only permissible after 3-pole tripping when no stability problems occur.

T-RECLAIM (address 3403) is the time after which the fault is considered eliminated following successful reclosure. If a protection function provokes a new trip before this time has elapsed, the next reclosing cycle is started in case of multiple reclosure. If no further reclosing attempt is allowed, the last reclosure will be considered failed in the event of a new trip. The reclaim time must therefore be longer than the longest response time of a protection function which can start the automatic reclosure function. When operating the AR in ADT mode, it is possible to deactivate the reclaim time by setting it to 0 s.

A few seconds are generally sufficient. In areas with frequent thunderstorms or storms, a shorter blocking time may be necessary to avoid feeder lockout due to sequential lightning strikes or cable flashovers.

A longer reclaim time should be chosen where circuit breaker supervision is not possible (see above) during multiple reclosures, e.g. because of missing auxiliary contacts and information on the circuit breaker ready status. In this case, the reclaim time should be longer than the time required for the circuit breaker mechanism to be ready.

The blocking duration following manual-close detection **T-BLOCK MC** (address 3404) must ensure the circuit breaker to open and close reliably (0.5 s to 1 s). If a fault is detected by a protection function within this time after closing of the circuit breaker was detected, no reclosure takes place and a final 3-pole trip command is issued. If this is not desired, address 3404 is set to **0**.

The options for handling evolving faults are described in Section *2.10 Automatic Reclosure Function (optional)* under margin heading “Handling Evolving Faults”. The treatment of sequential faults is not necessary on line

ends where the adaptive dead time is applied (address 133 **Auto Reclose** = ***ADT***). The addresses 3406 and 3407 are then of no consequence and therefore not accessible.

The detection of an evolving fault can be defined under address 3406 **EV. FLT. RECOG.**. **EV. FLT. RECOG.** ***with PICKUP*** means that, during a dead time, every **pickup** of a protection function will be interpreted as an evolving fault. With **EV. FLT. RECOG.** ***with TRIP*** a fault during a dead time is only interpreted as an evolving fault if it has led to a **trip command** by a protection function. This may also include trip commands which are received from an external device via a binary input or which have been transmitted from another end of the protected object. If an external protection device operates together with the internal auto-reclosure, evolving fault detection with pickup presupposes that a pickup signal from the external device is also connected to the 7SD610; otherwise an evolving fault can only be detected with the external trip command even if ***with PICKUP*** was set here.

The reaction in response to sequential faults can be selected at address 3407. **EV. FLT. MODE** ***blocks AR*** means that no reclosure is performed after detection of a sequential fault. This is always useful when only 1-pole reclosure is to take place or when stability problems are expected due to the subsequent 3-pole dead time. If a 3-pole reclose cycle is to be initiated by tripping of the sequential fault, set **EV. FLT. MODE** = ***starts 3p AR***. In this case a separately adjustable 3-pole dead time is started with the 3-pole trip command due to the sequential fault. This is only useful if 3-pole reclosure is also permitted.

Address 3408 **T-Start MONITOR** monitors the reaction of the circuit breaker after a trip command. If the CB has not opened during this time (from the beginning of the trip command), the automatic reclosure is blocked dynamically. The criterion for circuit breaker opening is the position of the circuit breaker auxiliary contact or the disappearance of the trip command. If a circuit breaker failure protection (internal or external) is used on the feeder, this time should be shorter than the delay time of the circuit breaker failure protection so that no reclosure takes place if the circuit breaker fails.



NOTE

If the circuit breaker failure protection (BF) should perform a 1-pole TRIP repetition, the time setting of parameter 3408 **T-Start MONITOR** must be longer than the time set for parameter 3903 **1p-RETRIP (T1)**.

To enable that the busbar is tripped by the circuit breaker failure protection without preceding 3-pole coupling of the trip command (by AR or BF), the time set for 3408 **T-Start MONITOR** also has to be longer than the time set for 3906 **T2**. In this case, the AR must be blocked by a signal from the BF to prevent the AR from reclosing after a busbar TRIP. It is recommended to connect the signal 1494 *BF T2-TRIP(bus)* to the AR input 2703 *>AR block* via CFC.

If the reclosure command is transmitted to the opposite end, this transmission can be delayed by the time setting in address 3410 **T RemoteClose**. This transmission is only possible if the device operates with adaptive dead time at the remote end (address 133 **Auto Reclose** = ***ADT***). This parameter is otherwise irrelevant. On the one hand, this delay serves to prevent the remote end device from reclosing unnecessarily when local reclosure is unsuccessful. On the other hand, it should be noted that the line is not available for energy transport until the remote end has also closed. Therefore this delay must be added to the dead time for consideration of the network stability.

Configuration of auto-reclosure

This configuration concerns the interaction between the protection and supplementary functions of the device and the automatic reclosure function. Here, you can determine which functions of the device should start the automatic reclosure and which not.

address 3420	**AR WITH DIFF**, i.e. with differential protection
address 3421	**AR w/ SOTF-O/C**, i.e. with high-current fast tripping
address 3423	**AR WITH I.TRIP**, i.e. with permissive underreach transfer trip (PUTT)
address 3424	**AR w/ DTT**, i.e. with externally fed trip command
address 3425	**AR w/ BackUpO/C**, i.e. with time overcurrent protection

For the functions which should start the auto-reclosure function, the corresponding address is set to ***YES***, for the others to ***NO***. The other functions cannot start the automatic reclosure because reclosure is not reasonable here.

Forced 3-pole trip

If a blocking of the auto-reclosure occurs during the dead time of a 1-pole cycle without a previous 3-pole trip command, the circuit breaker remains open at one pole. With address 3430 **AR TRIP 3pole** it is possible to determine that the tripping logic of the device issues a 3-pole trip command in this case (pole discrepancy prevention for the CB poles). Set this address to ***YES*** if the CB can be tripped 1-pole and if it has no pole discrepancy protection. Nevertheless, the device preempts the pole discrepancy supervision of the CB because the forced 3-pole trip of the device is immediately initiated as soon as the reclosure is blocked following a 1-pole trip or if the CB auxiliary contacts report an implausible circuit breaker state (see also Section *2.10 Automatic Reclosure Function (optional)* at margin heading "Processing the circuit breaker auxiliary contacts"). The forced 3-pole trip is also activated when only 3-pole cycles are allowed, but a 1-pole trip is signaled externally via a binary input.

The forced 3-pole trip is unnecessary if only a common 3-pole control of the CB is possible.

Dead line check

At address 3431 the dead line check can be switched active. It presupposes that voltage transformers are installed on the line side of the feeder and connected to the device. If this is not the case or the function is not used, set **DLC or RDT** = ***WITHOUT***.

DLC or RDT = ***DLC*** means that the dead line check of the line voltage is used. It only allows reclosing after it has been verified in advance that the line is dead. In this case, the phase-to-earth voltage limit is set in address 3441 **U-dead<** below which the line is considered voltage-free (disconnected). The setting is applied in Volts secondary. This value can be entered as a primary value when parameterizing with a PC and DIGSI. Address 3438 **T U-stable** determines the measuring time available for determining the no-voltage condition. Address 3440 is irrelevant here.

Adaptive dead time (ADT)

When operating with adaptive dead time, it must be ensured in advance that **one** end per line operates with defined dead times and has an infeed. The other (or the others in multi-branch lines) may operate with adaptive dead time. It is essential that the voltage transformers are located on the line side of the circuit breaker. Details about this function can be found in Section *2.10 Automatic Reclosure Function (optional)* at margin heading "Adaptive Dead Time (ADT) and Close Command-transfer (Remote-CLOSE)".

For the line end with defined dead times the number of desired reclose cycles must be set during the configuration of the protection functions (Section *2.1.1 Functional Scope*) in address 133 **Auto Reclose**. Additionally, the intertrip command of the differential protection should be activated (see Section *2.4 Breaker Intertrip and Remote Tripping*, address 1301 **I-TRIP SEND** = ***YES***). For the devices operating with adaptive dead time, address 133 **Auto Reclose** must have been set to ***ADT*** during the configuration of the protection functions (Section *2.1.1 Functional Scope*). Only the parameters described below are interrogated in the latter case. No settings are then made for the individual reclosure cycles.

The adaptive dead time may be voltage-controlled or Remote–CLOSE–controlled. Both are possible at the same time. In the first case, reclosure takes place as soon as the returning voltage, after reclosure at the remote end, is detected. For this purpose the device must be connected to voltage transformers located on the line side. In the case of Remote-CLOSE, the autoreclosure waits until the Remote-CLOSE command is received from the remote end.

The action time **T-ACTION ADT** (address 3433) is started after any protection function has triggered the automatic reclosing function. The trip command must occur during this time. If no trip command is issued until the action time has expired, reclosing will not be initiated. Depending on the configuration of the protection functions (see Section *2.1.1.2 Setting Notes*), the action time may also be omitted; this applies especially when an initiating protection function has no fault detection signal.

The dead times are determined by the reclosure command of the device at the line end with the defined dead times. In cases where this reclosure command does not appear, e.g. because the reclosure was in the meantime blocked at this end, the readiness of the local device must return to the quiescent state at some time. This takes place after the maximum wait time **T-MAX ADT** (address 3434). It must be long enough to include

the last reclosure of the remote end. In the case of single-shot reclosing, the sum of the maximum dead time plus reclaim time of the other device is sufficient. In the case of multiple reclosure, the worst case is that all reclosures of the other end except the last one are unsuccessful. The time of all these cycles must be taken into account. To save having to make exact calculations, it is possible to use the sum of all dead times and all protection operating times plus one reclaim time.

Under address 3435 **ADT 1p allowed** allowed it can be determined whether 1-pole tripping is allowed (provided that 1-pole tripping is possible). If ***NO***, the protection trips 3-pole for all fault types. If ***YES***, the actual trip signal of the starting protection functions is decisive. If the reclaim time is unequal to 0 s and 1-pole tripping is allowed, 1- pole tripping will be prevented during the reclaim time. Each fault is thus disconnected in three poles while the reclaim time is active.

Address 3403 **T-RECLAIM** allows disabling the reclaim time in ADT mode. In doing so, the ADT cycle including its settings and release conditions is restarted after unsuccessful automatic reclosing. If the reclaim time is activated, the 1-pole trip permission at address 3435 and the protection releases are disabled while the reclaim time is running.

Under address 3436 **ADT CB? CLOSE** it can be determined whether circuit breaker ready is interrogated before reclosure after an adaptive dead time. With the setting ***YES***, the dead time may be extended if the circuit breaker is not ready for a CLOSE–OPEN–cycle when the dead time expires. The maximum extension that is possible is the circuit breaker monitoring time; this was set for all reclosure cycles under address 3409 (see above). Details about the circuit breaker monitoring can be found in the function description, Section *2.10 Automatic Reclosure Function (optional)*, at margin heading “Interrogation of the Circuit Breaker Ready State”.

If there is a danger of stability problems in the network during a 3-pole reclosure cycle, set address 3437 **ADT SynRequest** to ***YES***. In this case a check is made before reclosure following a 3-pole trip whether the voltages of feeder and busbar are sufficiently synchronous. This is only done on condition that either the internal synchronism and voltage check functions are available, or that an external device is available for synchronism and voltage check. If only 1-pole reclose cycles are executed or if no stability problems are expected during 3-pole dead times (e.g. due to closely meshed networks or in radial networks), set address 3437 to ***NO***.

Addresses 3438 and 3440 are only significant if the voltage-controlled adaptive dead time is used. 3440 **U-live>** is the phase-to-earth voltage limit above which the line is considered to be fault-free. The setting must be smaller than the lowest expected operating voltage. The setting is applied in volts secondary. This value can be entered as a primary value when parameterising with a PC and DIGSI. Address 3438 **T U-stable** defines the measuring time used to determine the voltage. It should be longer than any transient oscillations resulting from line energization.

1st reclose cycle

If working on a line with adaptive dead time, no further parameters are needed for the individual reclose cycles in this case. All the following parameters assigned to the individual cycles are then superfluous and inaccessible.

Address3450 **1.AR: START**is only available if the automatic reclosing function works in the operating mode with action time, i.e. is set during configuration of the protection functions (see Section *2.1.1.2 Setting Notes*) Address 134 **AR control mode** = ***Pickup w/ Tact*** or ***Trip w/ Tact*** (the first setting only applies to 3-pole tripping). It determines whether automatic reclosure should be started at all with the first cycle. This address is included mainly due to the uniformity of the parameters for every reclosure attempt and is set to ***YES*** for the first cycle. If several cycles are performed, you can (at **AR control mode** = ***Trip ...***) set this parameter and different action times to control the effectiveness of the cycles. In Section *2.10 Automatic Reclosure Function (optional)* notes and examples are at margin heading “Action times”.

The action time **1.AR: T-ACTION** (address 3451) is started after a protection function has triggered the automatic reclosing function. The trip command must occur during this time. If no trip command is issued until the action time has expired, reclosing will not be initiated. Depending on the configuration of the protection functions, the action time may also be omitted; this applies especially when an initiating protection function has no fault detection signal.

Depending on the configured operating mode of the automatic reclosure (address 134 **AR control mode**) only the addresses 3456 and 3457 (if **AR control mode** = ***TRIP...***) or the addresses 3453 to 3455 are available (if **AR control mode** = ***Pickup. ...***).

In **AR control mode** = ***TRIP ...*** you can set different dead times for 1-pole and 3-pole reclose cycles. Whether 1-pole or 3-pole tripping is triggered depends solely on the initiating protection functions. 1-pole tripping is of course only possible if the device and the corresponding protection function are also capable of 1-pole tripping:

Table 2-5 **AR control mode** = TRIP ...

3456	**1.AR Tdead1Trip**	is the dead time after 1-pole tripping.
3457	**1.AR Tdead3Trip**	is the dead time after 3-pole tripping.

If you only want to allow a 1-pole reclose cycle, set the dead time for 3-pole tripping to ∞. If you only want to allow a 3-pole reclose cycle, set the dead time for 1-pole tripping to ∞, the protection then trips 3-pole for each fault type.

The dead time after 1-pole tripping (if set) **1.AR Tdead1Trip** (address 3456) should be long enough for the short-circuit arc to be extinguished and the surrounding air to be de-ionized so that the reclosure promises to be successful. The longer the line, the longer is this time due to the charging of the conductor capacitances. Standard durations are between 0.9 s and 1.5 s.

For three-pole tripping (address 3457 **1.AR Tdead3Trip**) the network stability is the main concern. Since the de-energized line cannot transfer synchronizing energy, only short dead times are allowed. The usual values are 0.3 s to 0.6 s. If the device is operating with a synchronism check device, a longer dead time may be tolerated under certain circumstances. Longer three-pole dead times are also possible in radial networks.

For **AR control mode** = ***TRIP ...*** it is possible to make the dead times dependent on the type of fault detected by the initiating protection function(s).

Table 2-6 **AR control mode** = Trip ...

3453	**1.AR Tdead 1Flt**	is the dead time after 1-phase pickup.
3454	**1.AR Tdead 2Flt**	is the dead time after 2-phase pickup.
3455	**1.AR Tdead 3Flt**	is the dead time after 3-phase pickup.

If the dead time is to be the same for all fault types, set all three parameters the same. Note that these settings only cause different dead times for different pickups. The tripping can only be 3-pole.

If, when setting the reaction to sequential faults (see above at "General") you have set address 3407 **EV. FLT. MODE** ***starts 3p AR*** you can set a separate dead time for the 3-pole dead time after clearance of the sequential fault **1.AR: Tdead EV.** (address 3458). Stability aspects are also decisive here. Normally the setting constraints are similar to address3457 **1.AR Tdead3Trip**.

Under address 3459 **1.AR: CB? CLOSE** it can be determined whether the readiness of the circuit breaker ("circuit breaker ready") is interrogated before this first reclosure. With the setting ***YES***, the dead time may be extended if the circuit breaker is not ready for a CLOSE–OPEN–cycle when the dead time expires. The maximum extension that is possible is the circuit breaker monitoring time; this was set for all reclosure cycles under address 3409 **CB TIME OUT** (see above). Details about the circuit breaker monitoring can be found in the function description, Section *2.10 Automatic Reclosure Function (optional)*, at margin heading "Interrogation of the Circuit Breaker Ready State".

If there is a danger of stability problems in the network during a 3-pole reclosure cycle, set address3460 **1.AR SynRequest** to ***YES***. In this case, it is verified before each reclosure following a 3-pole trip whether the voltages of feeder and busbar are sufficiently synchronous. This is only done on condition that either the internal synchronism and voltage check functions are available, or that an external device is available for synchronism and voltage check. If only 1-pole reclose cycles are executed or if no stability problems are expected during 3-pole dead times (e.g. due to closely meshed networks or in radial networks), set address3460 to ***NO***.

2nd to 4th Reclose Cycle

If several cycles have been set in the configuration of the scope of protection functions, you can set individual reclosure parameters for the 2nd to 4th cycles. The same options are available as for the first cycle. Again, only some of the parameters shown below will be available depending on the selections made during configuration of the scope of protection functions.

For the 2nd cycle:

3461	**2.AR: START**	Start in 2nd cycle generally allowed
3462	**2.AR: T-ACTION**	Action time for the 2nd cycle
3464	**2.AR Tdead 1Flt**	Dead time after 1-phase pickup
3465	**2.AR Tdead 2Flt**	Dead time after 2-phase pickup
3466	**2.AR Tdead 3Flt**	Dead time after 3-phase pickup
3467	**2.AR Tdead1Trip**	Dead time after 1-pole tripping
3468	**2.AR Tdead3Trip**	Dead time after 3-pole tripping
3469	**2.AR: Tdead EV.**	Dead time after evolving fault
3470	**2.AR: CB? CLOSE**	CB ready interrogation before reclosing
3471	**2.AR SynRequest**	Sync. check after 3-pole tripping

For the 3rd cycle:

3472	**3.AR: START**	Start in 3rd cycle generally allowed
3473	**3.AR: T-ACTION**	Action time for the 3rd cycle
3475	**3.AR Tdead 1Flt**	Dead time after 1-phase pickup
3476	**3.AR Tdead 2Flt**	Dead time after 2-phase pickup
3477	**3.AR Tdead 3Flt**	Dead time after 3-phase pickup
3478	**3.AR Tdead1Trip**	Dead time after 1-pole tripping
3479	**3.AR Tdead3Trip**	Dead time after 3-pole tripping
3480	**3.AR: Tdead EV.**	Dead time after evolving fault
3481	**3.AR: CB? CLOSE**	CB ready interrogation before reclosing
3482	**3.AR SynRequest**	Sync. check after 3-pole tripping

For the 4th cycle:

3483	**4.AR: START**	Start in 4th cycle generally allowed
3484	**4.AR: T-ACTION**	Action time for the 4th cycle
3486	**4.AR Tdead 1Flt**	Dead time after 1-phase pickup
3487	**4.AR Tdead 2Flt**	Dead time after 2-phase pickup
3488	**4.AR Tdead 3Flt**	Dead time after 3-phase pickup
3489	**4.AR Tdead1Trip**	Dead time after 1-pole tripping
3490	**4.AR Tdead3Trip**	Dead time after 3-pole tripping
3491	**4.AR: Tdead EV.**	Dead time after evolving fault
3492	**4.AR: CB? CLOSE**	CB ready interrogation before reclosing
3493	**4.AR SynRequest**	Sync. check after 3-pole tripping

5th to 8th Reclose Cycle

If more than four cycles were set during configuration of the functional scope, the dead times preceding the fifth (5th) through the ninth (9th) reclosing attempts are equal to the open circuit breaker time which precedes the fourth (4th) reclosing attempt.

Notes on the Information List

The most important information about automatic reclosure is briefly explained insofar as it was not mentioned in the following lists or described in detail in the preceding text.

>BLK 1.AR-cycle (No. 2742) to *>BLK 4.-n. AR* (No. 2745)

The respective auto-reclose cycle is blocked. If the blocking state already exists when the automatic reclosure function is initiated, the blocked cycle is not executed and may be skipped (if other cycles are permitted). The same applies if the automatic reclosure function is started (running), but not internally blocked. If the block signal of a cycle appears while this cycle is being executed (in progress), the automatic reclosure function is blocked dynamically; no further automatic reclosures cycles are then executed.

AR 1.CycZoneRel (No. 2889) to *AR 4.CycZoneRel* (No. 2892)

The automatic reclosure is ready for the respective reclosure cycle. This information indicates which cycle will be run next. For example, external protection functions can use this information to release accelerated or overreaching trip stages prior to the corresponding reclose cycle.

AR is blocked (No. 2783)

The automatic reclosure is blocked (e.g. circuit breaker not ready). This information indicates to the operational information system that in the event of an upcoming system fault there will be a final trip, i.e. without reclosure. If the automatic reclosure has been started, this information does not appear.

AR not ready (No. 2784)

The automatic reclosure is not ready for reclosure at the moment. In addition to the *AR is blocked* mentioned above (No. 2783)there are also obstructions during the course of the auto-reclosure cycles such as "action time" elapsed or "last reclaim time running". This information is particularly helpful during testing because no protection test cycle with reclosure may be initiated during this state.

AR in progress (No. 2801)

This information appears following the start of the automatic reclosure function, i.e. with the first trip command that can start the automatic reclosure function. If this reclosure was successful (or any in the case of multiple cycles), the information is reset with the expiry of the last reclaim time. If no reclosure was successful or if reclosure was blocked, it ends with the last – the final – trip command.

AR Sync.Request (No. 2865)

Measuring request to an external synchronism check device. The information appears at the end of a dead time subsequent to 3-pole tripping if a synchronism request was parameterized for the corresponding cycle. Reclosure only takes place when the synchronism check device has provided the release signal *>Sync.release* (No. 2731.

>Sync.release (No. 2731)

Release of reclosure by an external synchronism check device if this was requested by the output information *AR Sync.Request* (No. 2865).

2.10.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

Addr.	Parameter	Setting Options	Default Setting	Comments
3401	AUTO RECLOSE	OFF ON	ON	Auto-Reclose Function
3402	CB? 1.TRIP	YES NO	NO	CB ready interrogation at 1st trip
3403	T-RECLAIM	0.50 .. 300.00 sec	3.00 sec	Reclaim time after successful AR cycle
3403	T-RECLAIM	0.50 .. 300.00 sec; 0	3.00 sec	Reclaim time after successful AR cycle
3404	T-BLOCK MC	0.50 .. 300.00 sec; 0	1.00 sec	AR blocking duration after manual close
3406	EV. FLT. RECOG.	with PICKUP with TRIP	with TRIP	Evolving fault recognition
3407	EV. FLT. MODE	Stops AutoRecl starts 3p AR	starts 3p AR	Evolving fault (during the dead time)
3408	T-Start MONITOR	0.01 .. 300.00 sec	0.50 sec	AR start-signal monitoring time
3409	CB TIME OUT	0.01 .. 300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3410	T RemoteClose	0.00 .. 300.00 sec; ∞	0.20 sec	Send delay for remote close command
3411A	T-DEAD EXT.	0.50 .. 300.00 sec; ∞	∞ sec	Maximum dead time extension

Addr.	Parameter	Setting Options	Default Setting	Comments
3420	AR WITH DIFF	YES NO	YES	AR with differential protection ?
3421	AR w/ SOTF-O/C	YES NO	YES	AR with switch-onto-fault overcurrent ?
3423	AR WITH I.TRIP	YES NO	YES	AR with intertrip ?
3424	AR w/ DTT	YES NO	YES	AR with direct transfer trip ?
3425	AR w/ BackUpO/C	YES NO	YES	AR with back-up overcurrent ?
3430	AR TRIP 3pole	YES NO	YES	3pole TRIP by AR
3431	DLC / RDT	WITHOUT DLC	WITHOUT	Dead Line Check / Reduced Dead Time
3433	T-ACTION ADT	0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3434	T-MAX ADT	0.50 .. 3000.00 sec	5.00 sec	Maximum dead time
3435	ADT 1p allowed	YES NO	NO	1pole TRIP allowed
3436	ADT CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3437	ADT SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3438	T U-stable	0.10 .. 30.00 sec	0.10 sec	Supervision time for dead/live voltage
3440	U-live>	30 .. 90 V	48 V	Voltage threshold for live line or bus
3441	U-dead<	2 .. 70 V	30 V	Voltage threshold for dead line or bus
3450	1.AR: START	YES NO	YES	Start of AR allowed in this cycle
3451	1.AR: T-ACTION	0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3453	1.AR Tdead 1Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3454	1.AR Tdead 2Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3455	1.AR Tdead 3Flt	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3456	1.AR Tdead1Trip	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1pole trip
3457	1.AR Tdead3Trip	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3458	1.AR: Tdead EV.	0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3459	1.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3460	1.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3461	2.AR: START	YES NO	NO	AR start allowed in this cycle
3462	2.AR: T-ACTION	0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3464	2.AR Tdead 1Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3465	2.AR Tdead 2Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3466	2.AR Tdead 3Flt	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3467	2.AR Tdead1Trip	0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip

Addr.	Parameter	Setting Options	Default Setting	Comments
3468	2.AR Tdead3Trip	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3469	2.AR: Tdead EV.	0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3470	2.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3471	2.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3472	3.AR: START	YES NO	NO	AR start allowed in this cycle
3473	3.AR: T-ACTION	0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3475	3.AR Tdead 1Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3476	3.AR Tdead 2Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3477	3.AR Tdead 3Flt	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3478	3.AR Tdead1Trip	0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3479	3.AR Tdead3Trip	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3480	3.AR: Tdead EV.	0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3481	3.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3482	3.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3483	4.AR: START	YES NO	NO	AR start allowed in this cycle
3484	4.AR: T-ACTION	0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3486	4.AR Tdead 1Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3487	4.AR Tdead 2Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3488	4.AR Tdead 3Flt	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3489	4.AR Tdead1Trip	0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3490	4.AR Tdead3Trip	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3491	4.AR: Tdead EV.	0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3492	4.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3493	4.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR

2.10.4 Information List

No.	Information	Type of Informa-tion	Comments
127	AR ON/OFF	IntSP	Auto Reclose ON/OFF (via system port)
2701	>AR on	SP	>AR: Switch on auto-reclose function
2702	>AR off	SP	>AR: Switch off auto-reclose function
2703	>AR block	SP	>AR: Block auto-reclose function
2711	>AR Start	SP	>External start of internal Auto reclose
2712	>Trip L1 AR	SP	>AR: External trip L1 for AR start
2713	>Trip L2 AR	SP	>AR: External trip L2 for AR start
2714	>Trip L3 AR	SP	>AR: External trip L3 for AR start
2715	>Trip 1pole AR	SP	>AR: External 1pole trip for AR start

No.	Information	Type of Information	Comments
2716	>Trip 3pole AR	SP	>AR: External 3pole trip for AR start
2727	>AR RemoteClose	SP	>AR: Remote Close signal
2731	>Sync.release	SP	>AR: Sync. release from ext. sync.-check
2737	>BLOCK 1pole AR	SP	>AR: Block 1pole AR-cycle
2738	>BLOCK 3pole AR	SP	>AR: Block 3pole AR-cycle
2739	>BLK 1phase AR	SP	>AR: Block 1phase-fault AR-cycle
2740	>BLK 2phase AR	SP	>AR: Block 2phase-fault AR-cycle
2741	>BLK 3phase AR	SP	>AR: Block 3phase-fault AR-cycle
2742	>BLK 1.AR-cycle	SP	>AR: Block 1st AR-cycle
2743	>BLK 2.AR-cycle	SP	>AR: Block 2nd AR-cycle
2744	>BLK 3.AR-cycle	SP	>AR: Block 3rd AR-cycle
2745	>BLK 4.-n. AR	SP	>AR: Block 4th and higher AR-cycles
2746	>Trip for AR	SP	>AR: External Trip for AR start
2747	>Pickup L1 AR	SP	>AR: External pickup L1 for AR start
2748	>Pickup L2 AR	SP	>AR: External pickup L2 for AR start
2749	>Pickup L3 AR	SP	>AR: External pickup L3 for AR start
2750	>Pickup 1ph AR	SP	>AR: External pickup 1phase for AR start
2751	>Pickup 2ph AR	SP	>AR: External pickup 2phase for AR start
2752	>Pickup 3ph AR	SP	>AR: External pickup 3phase for AR start
2781	AR off	OUT	AR: Auto-reclose is switched off
2782	AR on	IntSP	AR: Auto-reclose is switched on
2783	AR is blocked	OUT	AR: Auto-reclose is blocked
2784	AR not ready	OUT	AR: Auto-reclose is not ready
2787	CB not ready	OUT	AR: Circuit breaker not ready
2788	AR T-CBreadyExp	OUT	AR: CB ready monitoring window expired
2796	AR on/off BI	IntSP	AR: Auto-reclose ON/OFF via BI
2801	AR in progress	OUT	AR: Auto-reclose in progress
2809	AR T-Start Exp	OUT	AR: Start-signal monitoring time expired
2810	AR TdeadMax Exp	OUT	AR: Maximum dead time expired
2818	AR evolving Flt	OUT	AR: Evolving fault recognition
2820	AR Program1pole	OUT	AR is set to operate after 1p trip only
2821	AR Td. evol.Flt	OUT	AR dead time after evolving fault
2839	AR Tdead 1pTrip	OUT	AR dead time after 1pole trip running
2840	AR Tdead 3pTrip	OUT	AR dead time after 3pole trip running
2841	AR Tdead 1pFlt	OUT	AR dead time after 1phase fault running
2842	AR Tdead 2pFlt	OUT	AR dead time after 2phase fault running
2843	AR Tdead 3pFlt	OUT	AR dead time after 3phase fault running
2844	AR 1stCyc. run.	OUT	AR 1st cycle running
2845	AR 2ndCyc. run.	OUT	AR 2nd cycle running
2846	AR 3rdCyc. run.	OUT	AR 3rd cycle running
2847	AR 4thCyc. run.	OUT	AR 4th or higher cycle running
2848	AR ADT run.	OUT	AR cycle is running in ADT mode
2851	AR CLOSE Cmd.	OUT	AR: Close command
2852	AR Close1.Cyc1p	OUT	AR: Close command after 1pole, 1st cycle
2853	AR Close1.Cyc3p	OUT	AR: Close command after 3pole, 1st cycle

No.	Information	Type of Information	Comments
2854	AR Close 2.Cyc	OUT	AR: Close command 2nd cycle (and higher)
2861	AR T-Recl. run.	OUT	AR: Reclaim time is running
2862	AR successful	OUT	AR successful
2864	AR 1p Trip Perm	OUT	AR: 1pole trip permitted by internal AR
2865	AR Sync.Request	OUT	AR: Synchro-check request
2871	AR TRIP 3pole	OUT	AR: TRIP command 3pole
2889	AR 1.CycZoneRel	OUT	AR 1st cycle zone extension release
2890	AR 2.CycZoneRel	OUT	AR 2nd cycle zone extension release
2891	AR 3.CycZoneRel	OUT	AR 3rd cycle zone extension release
2892	AR 4.CycZoneRel	OUT	AR 4th cycle zone extension release
2893	AR Zone Release	OUT	AR zone extension (general)
2894	AR Remote Close	OUT	AR Remote close signal send

2.11 Undervoltage and Overvoltage Protection (optional)

Voltage protection has the function of protecting electrical equipment against undervoltage and overvoltage. Both operational states are unfavourable as overvoltage may cause, for example, insulation problems or undervoltage may cause stability problems.

The overvoltage protection in the 7SD610 detects the phase voltages U_{L1-E}, U_{L2-E} and U_{L3-E}, the phase-to-phase voltages U_{L1-L2}, U_{L2-L3} and U_{L3-L1}, as well as the displacement voltage $3U_0$. Instead of the displacement voltage any other voltage that is connected to the fourth voltage input U_4 of the device can be detected. Furthermore, the device calculates the positive sequence system voltage and the negative sequence system voltage so that the symmetrical components are also monitored. Here compounding is also possible which calculates the voltage at the remote line end.

The undervoltage protection can also use the phase voltages U_{L1-E}, U_{L2-E} and U_{L3-E}, the phase-to-phase voltages U_{L1-L2}, U_{L2-L3} and U_{L3-L1}, as well as the positive sequence components.

These voltage protection functions can be combined according to the user's requirements. They can be switched on or off separately, or used for alarm purposes only. In the latter case, the respective trip commands do not appear. Each voltage protection function is dual-stage, i.e. it is provided with two threshold settings each with the appropriate times delay.

Abnormally high voltages often occur e.g. in low loaded, long distance transmission lines, in islanded systems when generator voltage regulation fails, or after full load shutdown of a generator with the generator disconnected from the system. Even if compensation reactors are used to avoid line overvoltages by compensation of the line capacitance and thus reduction of the overvoltage, the overvoltage will endanger the insulation if the reactors fail (e.g. due to fault clearance). The line must be de-energised within a very short time.

The undervoltage protection can be applied, for example, for disconnection or load shedding tasks in a system. Furthermore, this protection scheme can detect impending stability problems. With induction machines undervoltages have an effect on the stability and permissible torque thresholds.

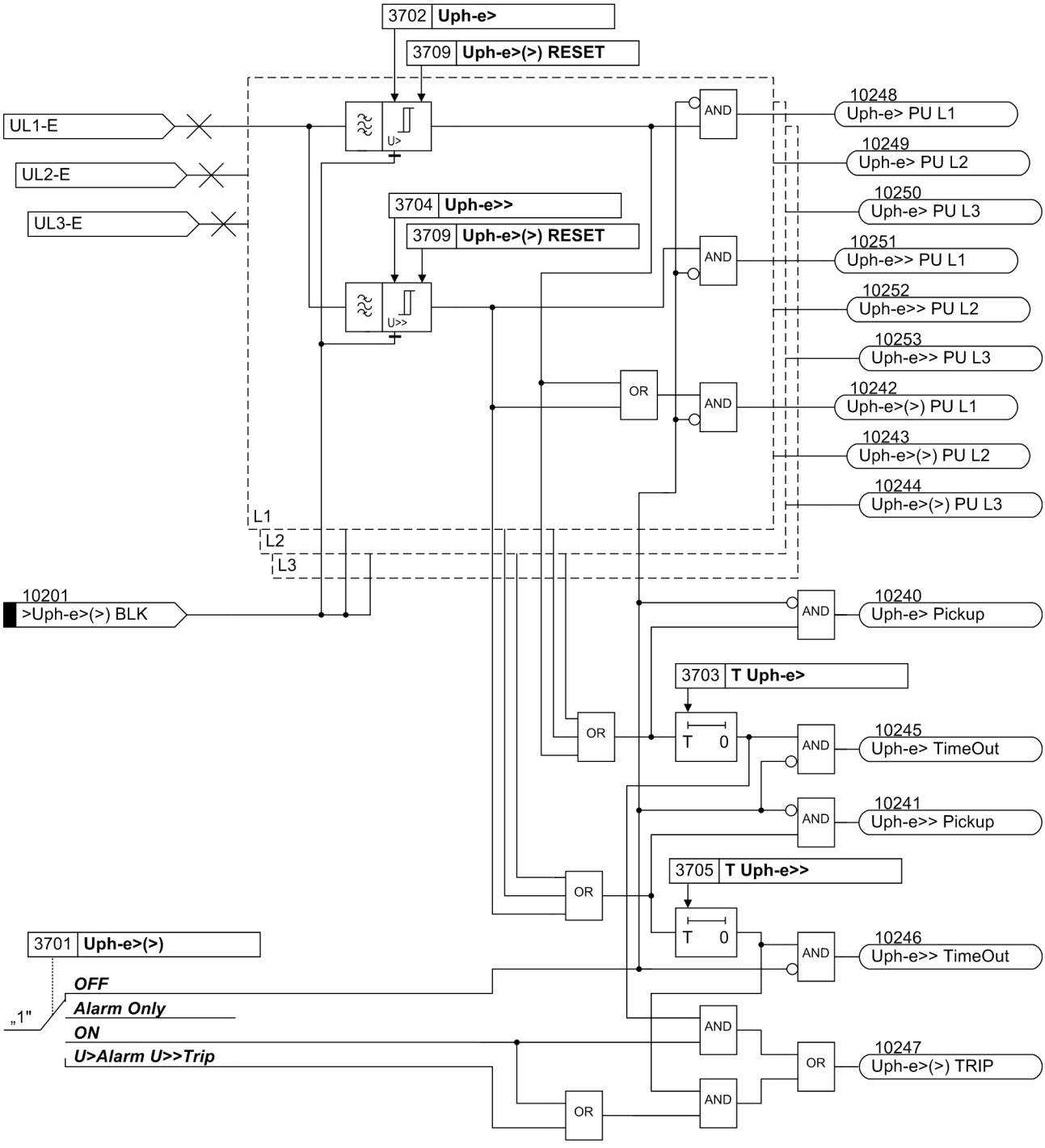
2.11.1 Overvoltage Protection

Phase-to-earth overvoltage

Figure 2-56 depicts the logic diagram of the phase voltage stages. The fundamental component is numerically filtered from each of the three measuring voltages so that harmonics or transient voltage peaks are largely eliminated. Two threshold stages **Uph-e>** (address3702) and **Uph-e>>** (address 3704) are compared with the voltages. If a phase voltage exceeds these thresholds, it is indicated in a phase-segregated way. In addition there is a general pickup indication for each stage *Uph-e> Pickup* and *Uph-e>> Pickup*. The drop out to pick up ratio can be set (**Uph-e>(>) RESET** (address3709)).

Every stage starts a time delay which is common to all phases. Expiry of the respective time delay **T Uph-e>** (address3703) or **T Uph-e>>** (address3705) is signaled and normally results in the trip command *Uph-e>(>) TRIP*.

The phase-to-earth overvoltage protection can be blocked via a binary input *>Uph-e>(>) BLK*.



[logikdia-ueberspgschutz-phasenspg-wlk-310702, 1, en_GB]

Figure 2-56 Logic diagram of the overvoltage protection for phase voltage

Phase-to-phase overvoltage

The phase-to-phase overvoltage protection operates just like the phase-to-earth protection except that it detects phase-to-phase voltages. Accordingly, phase-to-phase voltages which have exceeded one of the stage thresholds **Uph-ph>** (address 3712) or **Uph-ph>>** (address3714 are also indicated. Beyond this, applies in principle. *Figure 2-56*.

The phase-to-phase overvoltage protection can also be blocked via a binary input *>Uph-ph>(>) BLK*.

Overvoltage positive sequence system U_1

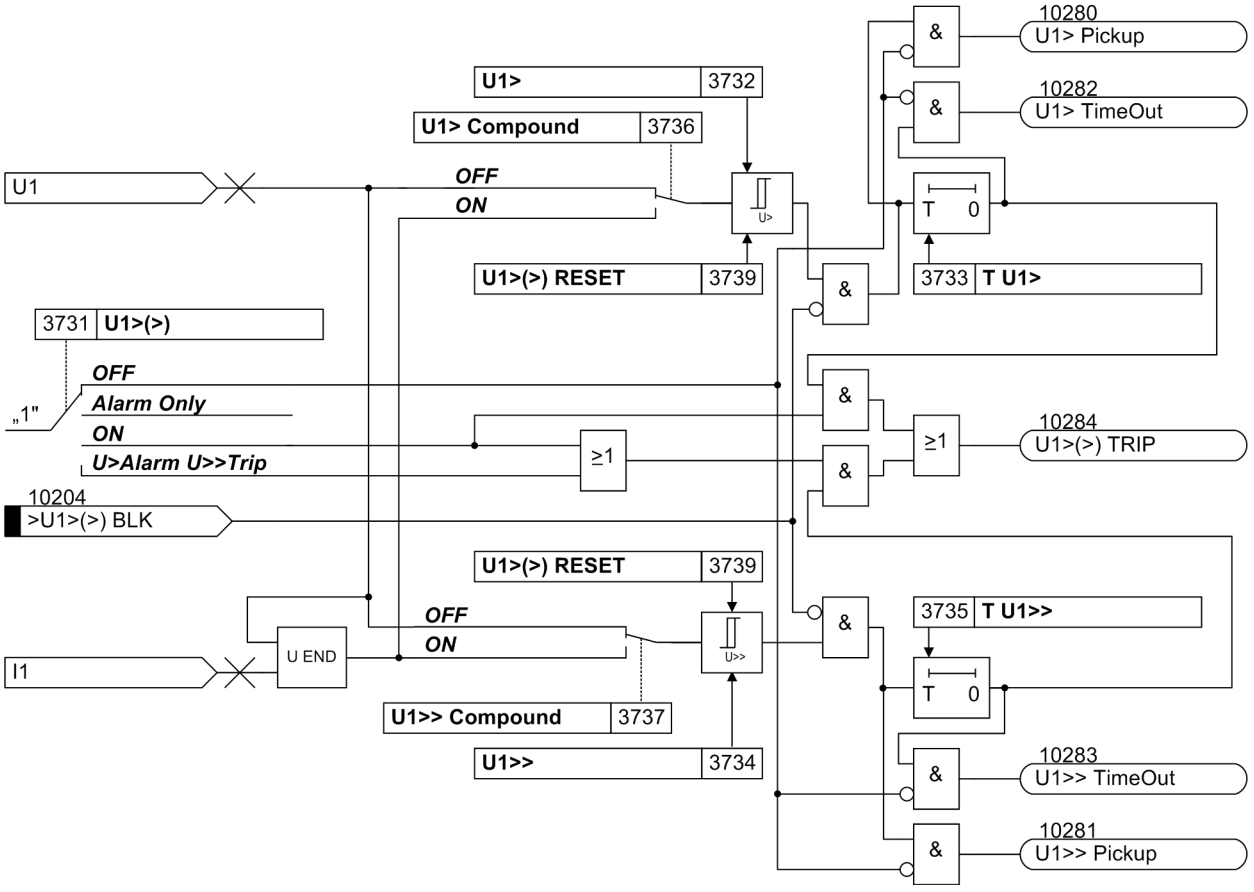
The device calculates the positive sequence system according to its defining equation

$$\underline{U}_1 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3})$$

where $\underline{a} = e^{j120°}$.

The resulting positive sequence voltage is fed to the two threshold stages **U1>** (address 3732) and **U1>>** (address 3734) (see *Figure 2-57*). Combined with the associated time delays **T U1>** (address 3733) and **T U1>>** (address 3735), these stages form a two-stage overvoltage protection based on the positive sequence system. Here too, the drop-out to pickup ratio can be set.

The overvoltage protection for the positive sequence system can also be blocked via a binary input *>U1>(>) BLK*.



[logikdia-ueberspgschutz-spgmitsys-wlk-310702, 1, en_GB]

Figure 2-57 Logic diagram of the overvoltage protection for the positive sequence voltage system

Overvoltage protectionU_1 with configurable compounding

The overvoltage protection for the positive sequence system may optionally operate with compounding. The compounding calculates the positive sequence system of the voltage at the remote line end. This option is thus particularly well suited for detecting a steady-state voltage increase caused by long transmission lines operating at weak load or no load due to the capacitance per unit length (Ferranti effect). In this case the overvoltage condition exists at the other line end but it can only be removed by switching off the local line end.

For calculating the voltage at the opposite line end, the device requires the line data (inductance per unit length, capacitance per unit length, line angle, line length) which were entered in the Power System Data 2 (Section *2.1.4.1 Setting Notes*) during configuration.

Compounding is only available if address 137 is set to ***Enabl. w. comp.***. In this case the calculated voltage at the other line end is also indicated in the operational measured values.

NOTE

Compounding is not suited for lines with series capacitors.

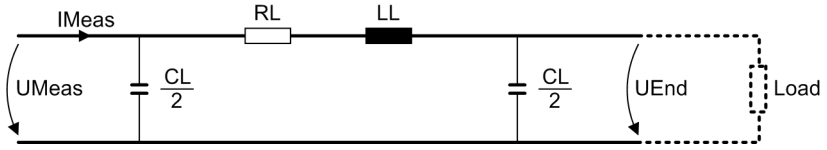
The voltage at the remote line end is calculated from the voltage measured at the local line end and the flowing current by means of a PI equivalent circuit diagram (refer also to *Figure 2-58*).

$$\underline{U}_{End} = \underline{U}_{Meas} - \left(\underline{I}_{Meas} - \frac{j\omega C_L}{2} \cdot \underline{U}_{Meas}\right) \cdot (R_L + j\omega L_L)$$

[formel-kompoundierung-wlk-210802, 1, en_GB]

with

$\underline{U}_{End}$	the calculated voltage at the remote line end,
$\underline{U}_{Meas}$	the measured voltage at the local line end,
$\underline{I}_{Meas}$	the measured current at the local line end,
C_L	the line capacitance,
R_L	the line resistance,
L_L	the line inductance.



[ersatzschaltbild-kompoundierung-wlk-210802, 1, en_GB]

Figure 2-58 PI equivalent diagram for compounding

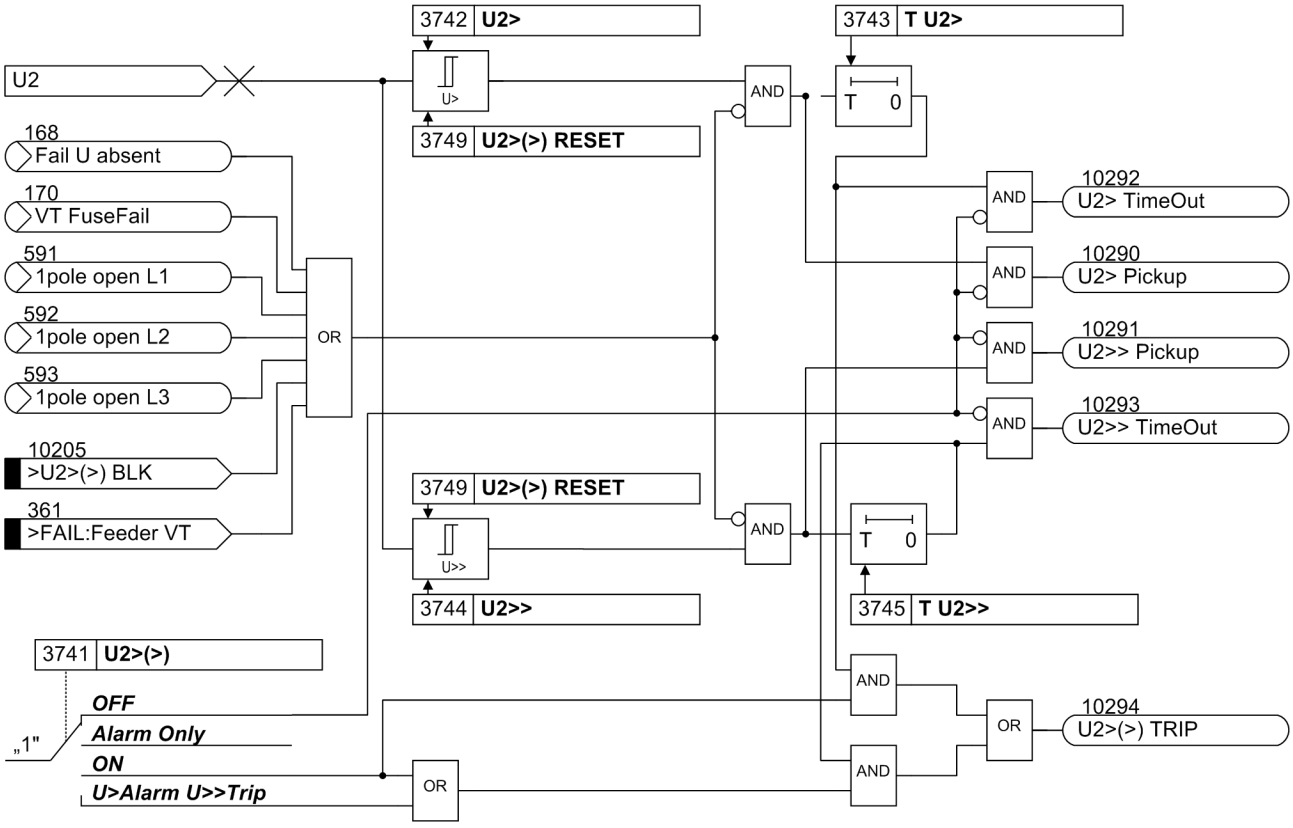
Overvoltage negative sequence system U_2

The device calculates the negative sequence system voltages according to its defining equation:

$\underline{U}_2 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a}^2 \cdot \underline{U}_{L2} + \underline{a} \cdot \underline{U}_{L3})$

where $\underline{a} = e^{j120°}$.

The resulting negative sequence voltage is fed to the two threshold stages **U2>** (address 3742) and **U2>>** (address 3744). *Figure 2-59* shows the logic diagram. Combined with the associated time delays **T U2>** (address 3743) and **T U2>>** (address 3745), these stages form a two-stage overvoltage protection for the negative sequence system. Here too, the drop-out to pickup ratio can be set.



[logikdia-ueberspgschutz-u2-spggegsys-wlk-280802, 1, en_GB]

Figure 2-59 Logic diagram of the overvoltage protection for the negative sequence voltage system U_2

The overvoltage protection for the negative sequence system can also be blocked via a binary input *>U2>(>) BLK*. The stages of the negative sequence voltage protection are automatically blocked as soon as an asymmetrical voltage failure was detected ("Fuse-Failure-Monitor", also see Section *2.15.1 Measurement Supervision*, margin heading "Fast Fuse Failure Monitor (Non-symmetrical Voltages)") or when tripping of the MCB for voltage transformers has been signalled via the binary input *>FAIL:Feeder VT*.

During the single-pole dead time, the stages of the negative-sequence overvoltage protection are automatically blocked since the occurring negative sequence values are only influenced by the asymmetrical power flow, not by the fault in the system. If the device cooperates with an external automatic reclosure function, or if a singlepole tripping can be triggered by a different protection system (working in parallel), the overvoltage protection for the negative sequence system must be blocked via a binary input during single-pole tripping.

Overvoltage zero-sequence system $3U_0$

Figure 2-60 depicts the logic diagram of the zero-sequence voltage stage. The fundamental component is numerically filtered from the measuring voltage so that the harmonics or transient voltage peaks remain largely eliminated.

The triple zero-sequence voltage $3 \cdot U_0$ is fed to the two threshold stages **3U0>** (address 3722) and **3U0>>** (address 3724). Combined with the associated time delays **T 3U0>** (address 3723) and **T 3U0>>** (address 3725), these stages form a two-stage overvoltage protection for the zero-sequence system. Here too, the dropout to pickup ratio can be set (**3U0>(>) RESET**, address **3U0>(>) RESET**). Furthermore, a restraint delay can be configured which is implemented by repeated measuring (approx. 3 periods).

The overvoltage protection for the zero-sequence system can also be blocked via a binary input *>3U0>(>) BLK*. The stages of the zero-sequence voltage protection are automatically blocked as soon as an asymmetrical voltage failure was detected ("Fuse-Failure-Monitor", also see Section *2.15.1 Measurement Supervision*, margin heading "Fuse Failure Monitor (Non-symmetrical Voltages)") or when the trip of the mcb for voltage transformers has been signalled via the binary input *>FAIL:Feeder VT* (internal indication "internal blocking").

The stages of the zero-sequence voltage protection are automatically blocked during single-pole automatic reclose dead time to avoid pickup with the asymmetrical power flow arising during this state. If the device cooperates with an external automatic reclosure function, or if a single-pole tripping can be triggered by a different protection system (working in parallel), the overvoltage protection for the zero-sequence system must be blocked via a binary input during single-pole tripping.

According to *Figure 2-60* the device calculates the voltage to be monitored:

$3 \cdot \underline{U}_0 = \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}$.

This applies if no suitable voltage is connected to the fourth measuring input U_4.

However, if the displacement voltage U_{delta} of the voltage transformer set is directly connected to the fourth measuring input U_4 of the device and this information was entered during configuration, the device will automatically use this voltage and calculate the triple zero-sequence voltage.

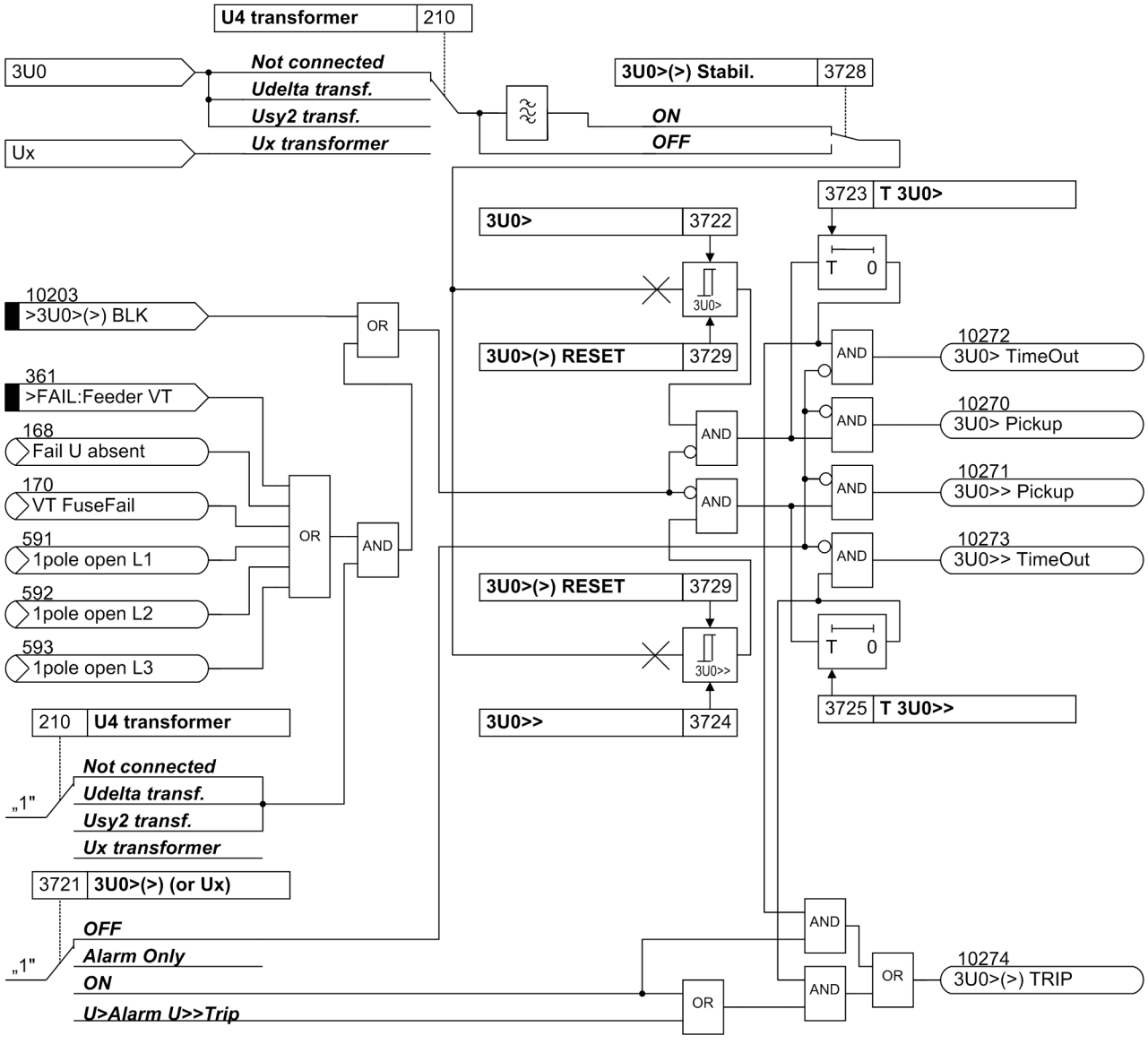
$3 \cdot U_0 =$ **Uph / Udelta** $\cdot U_4$

Since the voltage transformation ratio of the voltage transformer set is usually

$$\frac{U_{N\,prim}}{\sqrt{3}} / \frac{U_{N\,sec}}{\sqrt{3}} / \frac{U_{N\,sec}}{3}$$

[spguebersetz-spgwdlr-wlk-310702, 1, en_GB]

the factor is set to **Uph / Udelta** = $3/\sqrt{3} = \sqrt{3} = 1.73$. For more details, refer to Power System Data 1 in Section *2.1.4.1 Setting Notes* at margin heading “Voltage Connections” via address 211.



[logikdia-ueberspgschutz-nullspg-wlk-310702, 1, en_GB]

Figure 2-60 Logic diagram of the overvoltage protection for zero sequence voltage

Freely selectable single-phase voltage

As the zero-sequence voltage stages operate separately and independently of the other protection overvoltage functions, they can be used for any other single-phase voltage. Therefore the fourth voltage input U_4 of the device must be assigned accordingly (also see Section *2.1.2 General Power System Data (Power System Data 1)* "Voltage Connection").

The stages can be blocked via a binary input *>3U0>(>) BLK*. Internal blocking is not accomplished in this application case.

2.11.2 Undervoltage Protection

Undervoltage Phase-to-earth

Figure 2-61 depicts the logic diagram of the phase voltage stages. The fundamental component is numerically filtered from each of the three measuring voltages so that harmonics or transient voltage peaks are largely eliminated. Two threshold stages **Uph-e<** (address 3752) and **Uph-e<<** (address 3754) are compared with

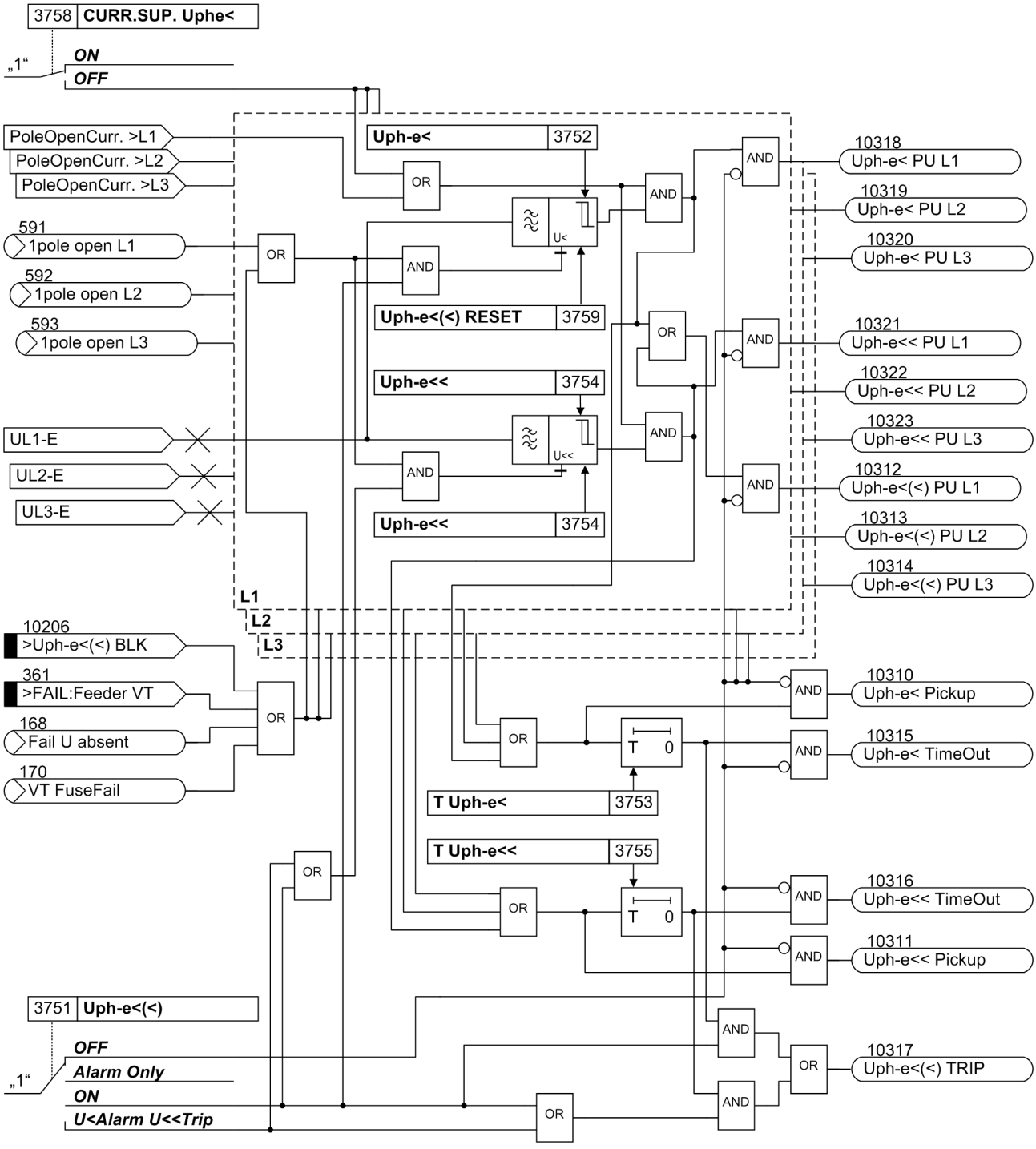
the voltages. If the phase voltage falls below a threshold it is indicated in a phase-segregated way. Furthermore, a general pickup indication *Uph-e< Pickup* and *Uph-e<< Pickup* is given. The drop-out to pickup ratio can be set (**Uph-e<(<) RESET**, address 3759).

Every stage starts a time delay which is common to all phases. The expiry of the respective time delay **T Uph-e<** (address 3753) or **T Uph-e<<** (address 3755) is signalled and usually results in the trip command *Uph-e<(<) TRIP*.

Depending on the configuration of the substations, the voltage transformers are located on the busbar side or on the outgoing feeder side. This results in a different behaviour of the undervoltage protection when the line is de-energised. While the voltage usually remains present or reappears on the busbar side after a trip command and opening of the circuit breaker, it becomes zero on the outgoing side. For the undervoltage protection, this results in a pickup state being present if the voltage transformers are on the outgoing side. If this pickup must be reset, the current can be used as an additional criterion (current supervision **CURR.SUP. Uphe<**, address 3758) to achieve this result. Undervoltage will then only be detected if, together with the undervoltage condition, the minimum current **PoleOpenCurrent** of the corresponding phase is also exceeded. This condition is communicated by the central function control of the device.

The undervoltage protection phase-to-earth can be blocked via a binary input *Uph-e<(<) BLK*. The stages of the undervoltage protection are then automatically blocked if a voltage failure is detected (“Fuse-Failure-Monitor”, also see Section *2.15.1 Measurement Supervision*) or if the trip of the mcb of the voltage transformers is indicated (internal blocking) via the binary input *>FAIL:Feeder VT*.

Also during a single-pole automatic reclose dead time the stages of the undervoltage protection are automatically blocked in the pole open state. If necessary, the current criterion will be considered, so that the stages do not respond to the undervoltage of the disconnected phase when voltage transformers are located on the outgoing side. Only such stages are blocked during the single-pole dead time that can actually generate a trip command according to their setting.



[logikdia-unterspgschutz-phasenspg-wlk-310702, 1, en_GB]

Figure 2-61 Logic diagram of the undervoltage protection for phase voltages

Phase-to-phase undervoltage

Basically, the phase-to-phase undervoltage protection operates like the phase-to-earth protection except that it detects phase-to-phase voltages. Accordingly, both phases are indicated during pickup of an undervoltage stage the value fell below one of the stage thresholds **Uph-ph<** (address 3762) or **Uph-ph<<** (address 3764). Beyond this, *Figure 2-61* applies in principle.

It is sufficient for the current criterion that current flow is detected in one of the involved phases.

The phase-to-phase undervoltage protection can also be blocked via a binary input *>Uphph<(<) BLK*. There is an automatic blocking if the measuring voltage failure was detected or voltage mcb tripping was indicated (internal blocking of the phases affected by the voltage failure).

During single-pole dead time for automatic reclosure the stages of the undervoltage protection are automatically blocked in the disconnected phase so that they do not respond to the undervoltage of the disconnected phase provided that the voltage transformers are located on the outgoing side. Only such stages are blocked during the single-pole dead time that can actually initiate tripping according to their setting.

Undervoltage positive sequence system U_1

The device calculates the positive sequence system according to its defining equation

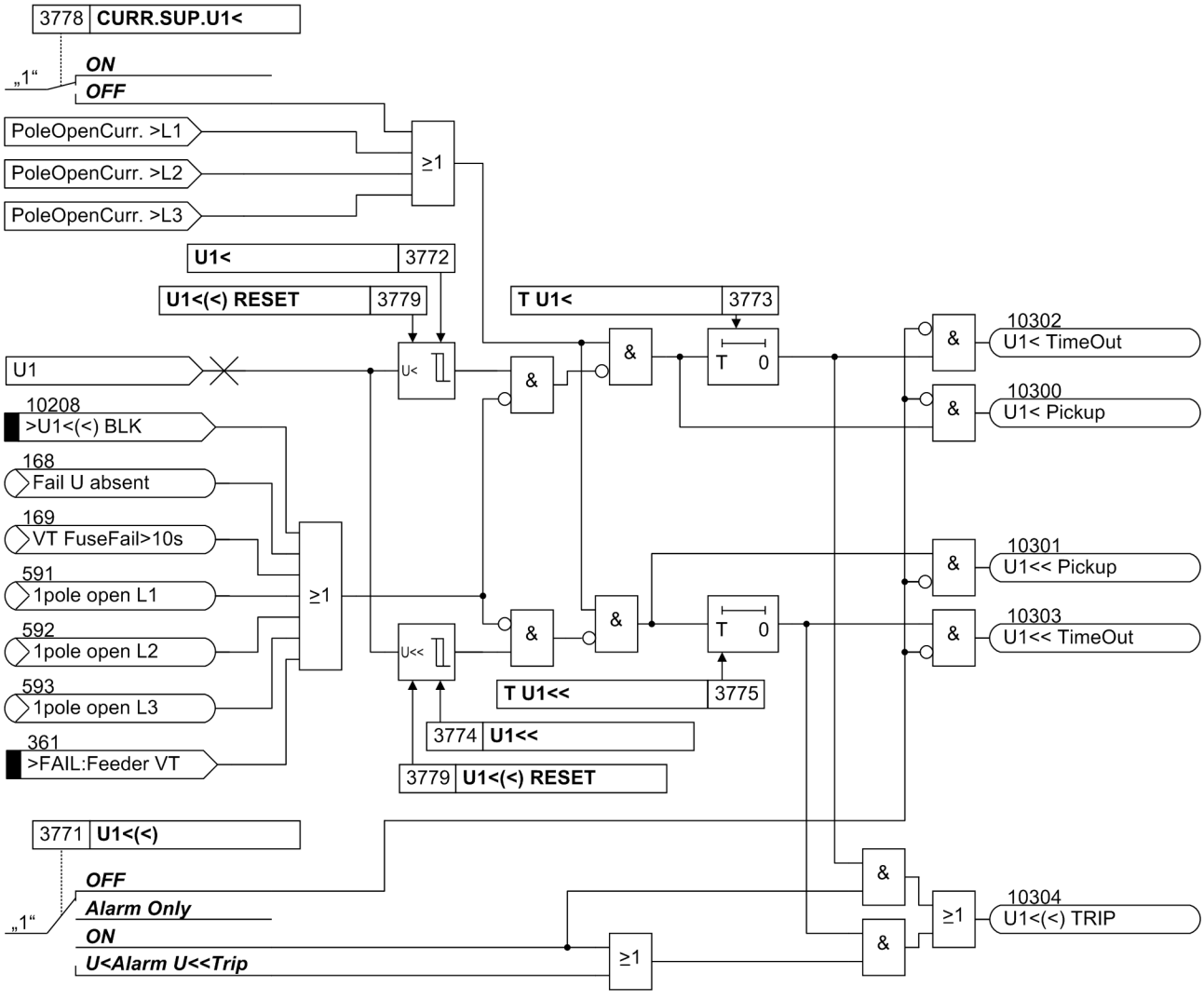
$$\underline{U}_1 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3})$$

where $\underline{a} = e^{j120°}$.

The resulting positive sequence voltage is fed to the two threshold stages **U1<** (address 3772) and **U1<<** (address 3774 (see *Figure 2-62*). Combined with the associated time delays **T U1<** (address 3773) and **T U1<<** (address 3775). these stages form a two-stage undervoltage protection for the positive sequence system.

The current can be used as an additional criterion for the undervoltage protection of the positive sequence system (current supervision **CURR.SUP.U1<**, address 3778). An undervoltage is only detected if the current flow is detected in at least one phase together with the undervoltage criterion.

The undervoltage protection for the positive sequence system can be blocked via the binary input *>U1<(<) BLK*. The stages of the undervoltage protection are automatically blocked if voltage failure is detected ("Fuse-Failure-Monitor", also see Section *2.15.1 Measurement Supervision*) or, if the trip of the mcb for the voltage transformer is indicated via the binary input *>FAIL:Feeder VT*.



[logikdia-unterspgschutz-spgmitsys-wlk-310702, 1, en_GB]

Figure 2-62 Logic diagram of the undervoltage protection for positive sequence voltage system

During single-pole dead time for automatic reclosure, the stages of positive sequence undervoltage protection are automatically blocked. In this way, the stages do not respond to the reduced positive sequence voltage caused by the disconnected phase in case the voltage transformers are located on the outgoing side.

2.11.3 Setting Notes

General

The voltage protection can only operate if, when configuring the device scope (address 137), it has been set to ***Enabled***. Compounding is only available if (address 137) is set to ***Enabl. w. comp.***.

The overvoltage and undervoltage stages can detect phase-to-earth voltages, phase-to-phase voltages or the positive sequence voltages; for overvoltage also the negative sequence voltage, zero-sequence voltage or a different single-phase voltage can be used. Any combination is possible. Stages that are not required are switched ***OFF***.

NOTE

For overvoltage protection it is particularly important to observe the setting notes: NEVER set an overvoltage stage (U_{L-E}, U_{L-L}, U_1)lower than an undervoltage stage. This would put the device immediately into a state of permanent pickup which cannot be reset by any measured value operation. As a result, operation of the device would be impossible!

Phase-to-earth overvoltage

The phase voltage stages can be switched ***ON*** or ***OFF*** in address 3701 **Uph-e>(>)**. In addition to this, you can set ***Alarm Only***, i.e. these stages operate and send alarms but do not generate any trip command. The setting ***U>Alarm U>>Trip*** creates in addition also a trip command only for the U>> stage.

The settings of the voltage threshold and the timer values depend on the type of application. To detect steady-state overvoltages on long lines carrying no load, set the **Uph-e>** stage (address 3702) to at least 5 % above the maximum stationary phase-to-earth voltage expected during operation. Additionally, a high dropout to pickup ratio is required (address 3709 **Uph-e>(>) RESET** = ***0.98*** presetting). This parameter can only be changed in DIGSI at Display **Additional Settings**. The delay time **T Uph-e>** (address 3703) should be a few seconds so that overvoltages with short duration do not cause tripping.

The U_{ph}>> stage (address 3704) is provided for high overvoltages with short duration. Here an adequately high pickup value is set, e.g. the $1^1/_2$-fold of the nominal phase-to-earth voltage. 0.1 s to 0.2 s are sufficient for the delay time **T Uph-e>>** (address 3705).

Phase-to-phase overvoltage

Basically, the same considerations apply as for the phase voltage stages. These stages can be used instead of the phase voltage stages or additionally. Depending on your choice, set address 3711 **Uph-ph>(>)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U>Alarm U>>Trip***.

As phase-to-phase voltages are monitored, the phase-to-phase values are used for the settings **Uph-ph>** (address 3712) and **Uph-ph>>** (address 3714).

For the delay times **T Uph-ph>** (address 3713) and **T Uph-ph>>** (address 3715) the same considerations apply as above. The same is true for the pickup ratios (address 3719 **Uphph>(>) RESET**). The latter setting can only be altered in DIGSI at **Display Additional Settings**.

Overvoltage positive sequence system U_1

You can use the positive sequence voltage stages instead of or in addition to previously mentioned overvoltage stages. Depending on your choice, set address 3731 **U1>(>)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U>Alarm U>>Trip***.

For symmetrical voltages an increase of the positive sequence system corresponds to an AND gate of the voltages. These stages are particularly suited to the detection of steady-state overvoltages on long, weak-loaded transmission lines (Ferranti effect). Here too, the **U1>** stage (address 3732) with a longer delay time **T U1>** (address 3733) is used for the detection of steady-state overvoltages (some seconds), the **U1>>** stage (address 3734) with the short delay time **T U1>>** (address 3735) is used for the detection of high overvoltages that may jeopardise insulation.

Note that the positive sequence system is established according to its defining equation

$U_1 = {}^1/_3 \cdot |\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3}|$. For symmetrical voltages this is equivalent to a phase-to-earth voltage.

If the voltage at the remote line end is to be decisive for overvoltage detection, you can use the compounding feature. This requires that address 137 **U/O VOLTAGE** is already set to ***Enabl. w. comp.*** (enabled with compounding) when configuring the protection functions (Section *2.1.1.2 Setting Notes*).

In addition, the compounding feature needs the line data which have been set in the Power System Data 2 (Section *2.1.4.1 Setting Notes*): at address 1111 **x'**, address 1112 **c'** and address 1113 **Line Length** and address 1105 **Line Angle**. These data are vital for a correct compounding calculation. If the values provided here do not correspond to real conditions, the compounding may calculate a too high voltage at the remote end causing the protection to pick up immediately as soon as the measured values are applied. In this case, the pickup state can only be reset by switching off the measuring voltage.

Compounding can be switched ***ON*** or ***OFF*** separately for each of the U1 stages: for the **U1>** stage at address 3736 **U1> Compound** and for the **U1>>** stage at address 3737 **U1>> Compound**.

The dropout to pickup ratio (address 3739 **U1>(>) RESET**) is set as high as possible with regard to the detection of even small steady-state overvoltages. This parameter can only be altered in DIGSI at Display **Additional Settings**.

Overvoltage negative sequence system U_2

The negative sequence voltage stages detect asymmetrical voltages. If such voltages should cause tripping, set address 3741 **U2>(>)** to ***ON***. If such conditions will only be reported, set address 3741 **U2>(>)** to ***Alarm Only***. If only one stage is desired to generate a trip command, choose the setting ***U>Alarm U>>Trip***. With this setting a trip command is output by the 2nd stage only. If negative sequence voltage protection is not required, set ***OFF***.

This protection function also has two stages, one being **U2>** stage (address 3742) with a longer time delay **T U2>** (address 3743) for steady-state asymmetrical voltages and the other being **U2>>** stage (address 3744) with a short delay time **T U2>>** (address 3745) for high asymmetrical voltages.

Note that the negative sequence system is calculated according to its defining equation $U_2 = {}^1/_3 \cdot |\underline{U}_{L1} + \underline{a}^2 \cdot \underline{U}_{L2} + \underline{a} \cdot \underline{U}_{L3}|$. For symmetrical voltages and two swapped phases this is equivalent to the phase-to-earth voltage value.

The resetting ratio can be changed **U2>(>) RESET** using the address 3749. This parameter can only be altered in DIGSI at **Display Additional Settings**.

Overvoltage zero-sequence system

The zero-sequence voltage stages can be switched in address 3721 **3U0>(>) (or Ux)** ***ON*** or ***OFF***. In addition to this, you can set ***Alarm Only***, i.e. these stages operate and also send alarms but do not generate any trip command. If a trip command of the 2nd stage is still desired, the setting must be ***U>Alarm U>>Trip***. This protection function can be used for any other single-phase voltage which is connected to the fourth voltage measurement input U_4. Also see section *2.1.2.1 Setting Notes* at margin heading "Voltage Connection".

This protection function also has two stages. The settings of the voltage threshold and the timer values depend on the type of application. Therefore, no general guidelines can be established. The stage **3U0>** (address 3722) is usually set with a high sensitivity and a longer delay time **T 3U0>** (address 3723). The **3U0>>** stage (address 3724) and its delay time **T 3U0>>** (address 3725) enables a second stage to be implemented with less sensitivity and a shorter delay time.

Similar considerations apply if this voltage stage is used for a different voltage at the measuring input U_4.

The zero-voltage stages feature a special time stabilization due to repeated measurements allowing them to be set rather sensitive. This stabilization can be disabled in address 3728 **3U0>(>) Stabil.** if a shorter pickup time is required. This parameter can only be altered in DIGSI at **Display Additional Settings**. Please consider that sensitive settings combined with short pickup times are not recommended.

The drop out to pick up ratio can be changed **3U0>(>) RESET** using the address 3729. This parameter can only be altered in DIGSI at **Display Additional Settings**.

When setting the voltage values please observe the following:

- If U_4 is connected with U_{en} voltage of the set of voltage transformers and this is set as with the Power System Data 1 (see Section *2.1.2.1 Setting Notes* at margin heading "Voltage Connection", address 210 **U4 transformer** = ***Udelta transf.***), the device multiplies this voltage by the matching ratio **Uph / Udelta** (address 211), usually with 1.73. Therefore the voltage measured is $\sqrt{3}\cdot U_{en} = 3\cdot U_0$. When the voltage triangle is fully displaced, the voltage will be $\sqrt{3}$ times the phase-to-phase voltage.
- If any other voltage is connected to U_4 which is not used for voltage protection, and if this was already set in the Power System Data 1 (refer also to Section *2.1.2.1 Setting Notes* at margin heading "Voltage Connection", e.g. **U4 transformer** = ***Usy2 transf.*** or **U4 transformer** = ***Not connected***), the device calculates the zero-sequence voltage from the phase voltages according to its definition $3\cdot U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. When the voltage triangle is fully displaced, the voltage will thus be $\sqrt{3}$ times the phase-to-phase voltage.
- If any other AC voltage is connected to U_4 which is used for voltage protection, and if this was already set in the Power System Data 1 (Section *2.1.2.1 Setting Notes* at margin heading "Voltage Connection", **U4 transformer** = ***Ux transformer***), this voltage will be used for the voltage stages without any further factors. This "zero-sequence voltage protection" is then, in reality, a single-phase voltage protection for any kind of voltage at U_4. Note that with a sensitive setting, i.e. close to operational values that are to be expected, not only the time delay **T 3U0>** (address 3723) must be set high, but also the reset ratio **3U0>(>) RESET**(address 3729) must be set as high as possible.

Phase-to-earth undervoltage

The phase voltage stages can be switched ***ON*** or ***OFF*** in address 3751 **Uph-e<(<)**. In addition to this, you can set ***Alarm Only***, i.e. these stages operate and send alarms but do not generate any trip command. You can generate a trip command for the 2nd stage only in addition to the alarm by setting ***U<Alarm U<<Trip***.

This undervoltage protection function has two stages. The **Uph-e<** stage (address 3752) with a longer setting of the time **T Uph-e<** (address 3753) operates in the case of minor undervoltages. However, the value set here must not be higher than the undervoltage permissible in operation. In the presence of higher voltage dips, the **Uph-e<<** stage (address 3754) with the delay **T Uph-e<<** (address 3755) becomes active.

The dropout to pickup ratio **Uph-e<(<) RESET** can be set in address 3759. This parameter can only be altered in DIGSI at Display **Additional Settings**.

The settings of the voltages and times depend on the intended use; therefore no general recommendations for the settings can be given. For load shedding, for example, the values are often determined by a priority grading coordination chart. In case of stability problems, the permissible levels and durations of overvoltages must be observed. With induction machines undervoltages have an effect on the permissible torque thresholds.

If the voltage transformers are located on the line side, the measuring voltages will be missing when the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP. Uphe<** (address 3758) is switched ***ON***. With busbar side voltage transformers it can be switched ***OFF***. However, if the busbar is dead, the undervoltage protection will pick up and expire and then remain in a picked-up state. It must therefore be ensured in such cases that the protection is blocked by a binary input.

Phase-to-phase undervoltage

Basically, the same considerations apply as for the phase voltage stages. These stages may replace the phase voltage stages or be used additionally. Depending on your choice, set address 3761 **Uph-ph<(<)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U<Alarm U<<Trip***.

As phase-to-phase voltages are monitored, the phase-to-phase values are used for the settings **Uph-ph<** (address 3762) and **Uph-ph<<** (address 3764).

The corresponding time delays are **T Uph-ph<** (address 3763) and **T Uphph<<** (address 3765).

The dropout to pickup ratio **Uphph<(<) RESET** can be set in address 3769. This parameter can only be altered in DIGSI at Display **Additional Settings**.

If the voltage transformers are located on the line side, the measuring voltages will be missing when the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP.Uphph<** (address 3768) is switched ***ON***. With busbar side voltage transformers it can be

switched ***OFF***. However, if the busbar is dead, the undervoltage protection will pick up and expire and then remain in a picked-up state. It must therefore be ensured in such cases that the protection is blocked by a binary input.

Undervoltage positive sequence systemU_1

The positive sequence undervoltage stages can be used instead of or in addition to previously mentioned undervoltage stages. Depending on your choice, set address 3771 **U1<(<)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U<Alarm U<<Trip***.

Basically, the same considerations apply as for the other undervoltage stages. Especially in case of stability problems, the positive sequence system is advantageous, since the positive sequence system is relevant for the limit of the stable energy transmission.

To achieve the two-stage condition, the **U1<** stage (address 3772) is combined with a greater time delay **T U1<** (address 3773), and the **U1<<** stage (address **U1<<**) with a shorter time delay T**T U1<<** (address 3775).

Note that the positive sequence system is calculated according to its defining equation

$U_1 = {}^1\!/_3 \cdot |\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3}|$. For symmetrical voltages this is equivalent to a phase-to-earth voltage.

The dropout to pickup ratio **U1<(<) RESET** can be set in address 3779. This parameter can only be altered in DIGSI at Display **Additional Settings**.

If the voltage transformers are located on the line side, the measuring voltages will be missing when the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP.U1<** (address 3778) is switched ***ON***. With busbar side voltage transformers it can be switched ***OFF***. However, if the busbar is dead, the undervoltage protection will pick up and expire and then remain in a pickedup state. It must therefore be ensured in such cases that the protection is blocked by a binary input.

2.11.4 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

Addr.	Parameter	Setting Options	Default Setting	Comments
3701	Uph-e>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-e overvoltage prot.
3702	Uph-e>	1.0 .. 170.0 V; ∞	85.0 V	Uph-e> Pickup
3703	T Uph-e>	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e> Time Delay
3704	Uph-e>>	1.0 .. 170.0 V; ∞	100.0 V	Uph-e>> Pickup
3705	T Uph-e>>	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e>> Time Delay
3709A	Uph-e>(>) RESET	0.30 .. 0.99	0.98	Uph-e>(>) Reset ratio
3711	Uph-ph>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-ph overvoltage prot.
3712	Uph-ph>	2.0 .. 220.0 V; ∞	150.0 V	Uph-ph> Pickup
3713	T Uph-ph>	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph> Time Delay
3714	Uph-ph>>	2.0 .. 220.0 V; ∞	175.0 V	Uph-ph>> Pickup
3715	T Uph-ph>>	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph>> Time Delay
3719A	Uphph>(>) RESET	0.30 .. 0.99	0.98	Uph-ph>(>) Reset ratio
3721	3U0>(>) (or Ux)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode 3U0 (or Ux) overvoltage
3722	3U0>	1.0 .. 220.0 V; ∞	30.0 V	3U0> Pickup (or Ux>)

Addr.	Parameter	Setting Options	Default Setting	Comments
3723	T 3U0>	0.00 .. 100.00 sec; ∞	2.00 sec	T 3U0> Time Delay (or T Ux>)
3724	3U0>>	1.0 .. 220.0 V; ∞	50.0 V	3U0>> Pickup (or Ux>>)
3725	T 3U0>>	0.00 .. 100.00 sec; ∞	1.00 sec	T 3U0>> Time Delay (or T Ux>>)
3728A	3U0>(>) Stabil.	ON OFF	ON	3U0>(>): Stabilization 3U0-Measurement
3729A	3U0>(>) RESET	0.30 .. 0.99	0.95	3U0>(>) Reset ratio (or Ux)
3731	U1>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U1 overvoltage prot.
3732	U1>	2.0 .. 220.0 V; ∞	150.0 V	U1> Pickup
3733	T U1>	0.00 .. 100.00 sec; ∞	2.00 sec	T U1> Time Delay
3734	U1>>	2.0 .. 220.0 V; ∞	175.0 V	U1>> Pickup
3735	T U1>>	0.00 .. 100.00 sec; ∞	1.00 sec	T U1>> Time Delay
3736	U1> Compound	OFF ON	OFF	U1> with Compounding
3737	U1>> Compound	OFF ON	OFF	U1>> with Compounding
3739A	U1>(>) RESET	0.30 .. 0.99	0.98	U1>(>) Reset ratio
3741	U2>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U2 overvoltage prot.
3742	U2>	2.0 .. 220.0 V; ∞	30.0 V	U2> Pickup
3743	T U2>	0.00 .. 100.00 sec; ∞	2.00 sec	T U2> Time Delay
3744	U2>>	2.0 .. 220.0 V; ∞	50.0 V	U2>> Pickup
3745	T U2>>	0.00 .. 100.00 sec; ∞	1.00 sec	T U2>> Time Delay
3749A	U2>(>) RESET	0.30 .. 0.99	0.98	U2>(>) Reset ratio
3751	Uph-e<(<)	OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-e undervoltage prot.
3752	Uph-e<	1.0 .. 100.0 V; 0	30.0 V	Uph-e< Pickup
3753	T Uph-e<	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e< Time Delay
3754	Uph-e<<	1.0 .. 100.0 V; 0	10.0 V	Uph-e<< Pickup
3755	T Uph-e<<	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e<< Time Delay
3758	CURR.SUP. Uphe<	ON OFF	ON	Current supervision (Uph-e)
3759A	Uph-e<(<) RESET	1.01 .. 1.20	1.05	Uph-e<(<) Reset ratio
3761	Uph-ph<(<)	OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-ph undervoltage prot.
3762	Uph-ph<	1.0 .. 175.0 V; 0	50.0 V	Uph-ph< Pickup
3763	T Uph-ph<	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph< Time Delay
3764	Uph-ph<<	1.0 .. 175.0 V; 0	17.0 V	Uph-ph<< Pickup
3765	T Uphph<<	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph<< Time Delay

Addr.	Parameter	Setting Options	Default Setting	Comments
3768	CURR.SUP.Uphph<	ON OFF	ON	Current supervision (Uph-ph)
3769A	Uphph<(<) RESET	1.01 .. 1.20	1.05	Uph-ph<(<) Reset ratio
3771	U1<(<)	OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode U1 undervoltage prot.
3772	U1<	1.0 .. 100.0 V; 0	30.0 V	U1< Pickup
3773	T U1<	0.00 .. 100.00 sec; ∞	2.00 sec	T U1< Time Delay
3774	U1<<	1.0 .. 100.0 V; 0	10.0 V	U1<< Pickup
3775	T U1<<	0.00 .. 100.00 sec; ∞	1.00 sec	T U1<< Time Delay
3778	CURR.SUP.U1<	ON OFF	ON	Current supervision (U1)
3779A	U1<(<) RESET	1.01 .. 1.20	1.05	U1<(<) Reset ratio

2.11.5 Information List

No.	Information	Type of Information	Comments
234.2100	U<, U> blk	IntSP	U<, U> blocked via operation
10201	>Uph-e>(>) BLK	SP	>BLOCK Uph-e>(>) Overvolt. (phase-earth)
10202	>Uph-ph>(>) BLK	SP	>BLOCK Uph-ph>(>) Overvolt (phase-phase)
10203	>3U0>(>) BLK	SP	>BLOCK 3U0>(>) Overvolt. (zero sequence)
10204	>U1>(>) BLK	SP	>BLOCK U1>(>) Overvolt. (positive seq.)
10205	>U2>(>) BLK	SP	>BLOCK U2>(>) Overvolt. (negative seq.)
10206	>Uph-e<(<) BLK	SP	>BLOCK Uph-e<(<) Undervolt (phase-earth)
10207	>Uphph<(<) BLK	SP	>BLOCK Uphph<(<) Undervolt (phase-phase)
10208	>U1<(<) BLK	SP	>BLOCK U1<(<) Undervolt (positive seq.)
10215	Uph-e>(>) OFF	OUT	Uph-e>(>) Overvolt. is switched OFF
10216	Uph-e>(>) BLK	OUT	Uph-e>(>) Overvolt. is BLOCKED
10217	Uph-ph>(>) OFF	OUT	Uph-ph>(>) Overvolt. is switched OFF
10218	Uph-ph>(>) BLK	OUT	Uph-ph>(>) Overvolt. is BLOCKED
10219	3U0>(>) OFF	OUT	3U0>(>) Overvolt. is switched OFF
10220	3U0>(>) BLK	OUT	3U0>(>) Overvolt. is BLOCKED
10221	U1>(>) OFF	OUT	U1>(>) Overvolt. is switched OFF
10222	U1>(>) BLK	OUT	U1>(>) Overvolt. is BLOCKED
10223	U2>(>) OFF	OUT	U2>(>) Overvolt. is switched OFF
10224	U2>(>) BLK	OUT	U2>(>) Overvolt. is BLOCKED
10225	Uph-e<(<) OFF	OUT	Uph-e<(<) Undervolt. is switched OFF
10226	Uph-e<(<) BLK	OUT	Uph-e<(<) Undervolt. is BLOCKED
10227	Uph-ph<(<) OFF	OUT	Uph-ph<(<) Undervolt. is switched OFF
10228	Uph-ph<(<) BLK	OUT	Uphph<(<) Undervolt. is BLOCKED
10229	U1<(<) OFF	OUT	U1<(<) Undervolt. is switched OFF
10230	U1<(<) BLK	OUT	U1<(<) Undervolt. is BLOCKED
10231	U</> ACTIVE	OUT	Over-/Under-Voltage protection is ACTIVE
10240	Uph-e> Pickup	OUT	Uph-e> Pickup

No.	Information	Type of Informa-tion	Comments
10241	Uph-e>> Pickup	OUT	Uph-e>> Pickup
10242	Uph-e>(>) PU L1	OUT	Uph-e>(>) Pickup L1
10243	Uph-e>(>) PU L2	OUT	Uph-e>(>) Pickup L2
10244	Uph-e>(>) PU L3	OUT	Uph-e>(>) Pickup L3
10245	Uph-e> TimeOut	OUT	Uph-e> TimeOut
10246	Uph-e>> TimeOut	OUT	Uph-e>> TimeOut
10247	Uph-e>(>) TRIP	OUT	Uph-e>(>) TRIP command
10248	Uph-e> PU L1	OUT	Uph-e> Pickup L1
10249	Uph-e> PU L2	OUT	Uph-e> Pickup L2
10250	Uph-e> PU L3	OUT	Uph-e> Pickup L3
10251	Uph-e>> PU L1	OUT	Uph-e>> Pickup L1
10252	Uph-e>> PU L2	OUT	Uph-e>> Pickup L2
10253	Uph-e>> PU L3	OUT	Uph-e>> Pickup L3
10255	Uphph> Pickup	OUT	Uph-ph> Pickup
10256	Uphph>> Pickup	OUT	Uph-ph>> Pickup
10257	Uphph>(>)PU L12	OUT	Uph-ph>(>) Pickup L1-L2
10258	Uphph>(>)PU L23	OUT	Uph-ph>(>) Pickup L2-L3
10259	Uphph>(>)PU L31	OUT	Uph-ph>(>) Pickup L3-L1
10260	Uphph> TimeOut	OUT	Uph-ph> TimeOut
10261	Uphph>> TimeOut	OUT	Uph-ph>> TimeOut
10262	Uphph>(>) TRIP	OUT	Uph-ph>(>) TRIP command
10263	Uphph> PU L12	OUT	Uph-ph> Pickup L1-L2
10264	Uphph> PU L23	OUT	Uph-ph> Pickup L2-L3
10265	Uphph> PU L31	OUT	Uph-ph> Pickup L3-L1
10266	Uphph>> PU L12	OUT	Uph-ph>> Pickup L1-L2
10267	Uphph>> PU L23	OUT	Uph-ph>> Pickup L2-L3
10268	Uphph>> PU L31	OUT	Uph-ph>> Pickup L3-L1
10270	3U0> Pickup	OUT	3U0> Pickup
10271	3U0>> Pickup	OUT	3U0>> Pickup
10272	3U0> TimeOut	OUT	3U0> TimeOut
10273	3U0>> TimeOut	OUT	3U0>> TimeOut
10274	3U0>(>) TRIP	OUT	3U0>(>) TRIP command
10280	U1> Pickup	OUT	U1> Pickup
10281	U1>> Pickup	OUT	U1>> Pickup
10282	U1> TimeOut	OUT	U1> TimeOut
10283	U1>> TimeOut	OUT	U1>> TimeOut
10284	U1>(>) TRIP	OUT	U1>(>) TRIP command
10290	U2> Pickup	OUT	U2> Pickup
10291	U2>> Pickup	OUT	U2>> Pickup
10292	U2> TimeOut	OUT	U2> TimeOut
10293	U2>> TimeOut	OUT	U2>> TimeOut
10294	U2>(>) TRIP	OUT	U2>(>) TRIP command
10300	U1< Pickup	OUT	U1< Pickup
10301	U1<< Pickup	OUT	U1<< Pickup
10302	U1< TimeOut	OUT	U1< TimeOut

No.	Information	Type of Information	Comments
10303	U1<< TimeOut	OUT	U1<< TimeOut
10304	U1<(<) TRIP	OUT	U1<(<) TRIP command
10310	Uph-e< Pickup	OUT	Uph-e< Pickup
10311	Uph-e<< Pickup	OUT	Uph-e<< Pickup
10312	Uph-e<(<) PU L1	OUT	Uph-e<(<) Pickup L1
10313	Uph-e<(<) PU L2	OUT	Uph-e<(<) Pickup L2
10314	Uph-e<(<) PU L3	OUT	Uph-e<(<) Pickup L3
10315	Uph-e< TimeOut	OUT	Uph-e< TimeOut
10316	Uph-e<< TimeOut	OUT	Uph-e<< TimeOut
10317	Uph-e<(<) TRIP	OUT	Uph-e<(<) TRIP command
10318	Uph-e< PU L1	OUT	Uph-e< Pickup L1
10319	Uph-e< PU L2	OUT	Uph-e< Pickup L2
10320	Uph-e< PU L3	OUT	Uph-e< Pickup L3
10321	Uph-e<< PU L1	OUT	Uph-e<< Pickup L1
10322	Uph-e<< PU L2	OUT	Uph-e<< Pickup L2
10323	Uph-e<< PU L3	OUT	Uph-e<< Pickup L3
10325	Uph-ph< Pickup	OUT	Uph-ph< Pickup
10326	Uph-ph<< Pickup	OUT	Uph-ph<< Pickup
10327	Uphph<(<)PU L12	OUT	Uphph<(<) Pickup L1-L2
10328	Uphph<(<)PU L23	OUT	Uphph<(<) Pickup L2-L3
10329	Uphph<(<)PU L31	OUT	Uphph<(<) Pickup L3-L1
10330	Uphph< TimeOut	OUT	Uphph< TimeOut
10331	Uphph<< TimeOut	OUT	Uphph<< TimeOut
10332	Uphph<(<) TRIP	OUT	Uphph<(<) TRIP command
10333	Uphph< PU L12	OUT	Uph-ph< Pickup L1-L2
10334	Uphph< PU L23	OUT	Uph-ph< Pickup L2-L3
10335	Uphph< PU L31	OUT	Uph-ph< Pickup L3-L1
10336	Uphph<< PU L12	OUT	Uph-ph<< Pickup L1-L2
10337	Uphph<< PU L23	OUT	Uph-ph<< Pickup L2-L3
10338	Uphph<< PU L31	OUT	Uph-ph<< Pickup L3-L1

2.12 Frequency Protection (optional)

The frequency protection function detects overfrequencies or underfrequencies in the system or in electrical machines. If the frequency is outside the permissible range, appropriate actions are initiated such as load shedding or separating the generator from the system.

Underfrequency is caused by increased real power demand of the loads or by a reduction of the generated power e.g. in the event of disconnection from the network, generator failure or faulty operation of the power frequency control. Underfrequency protection is also applied for generators which operate (temporarily) to an island network. This is due to the fact that the reverse power protection cannot operate in case of a drive power failure. The generator can be disconnected from the power system by means of the underfrequency protection. Underfrequency also results in increased reactive power demand of inductive loads.

Overfrequency is caused for instance by load shedding, system disconnection or malfunction of the power frequency control. There is also a risk of self-excitation for generators feeding long lines under no-load conditions.

2.12.1 Functional Description

Frequency stages

Frequency protection consists of the four frequency stages f1 to f4 Each stage can be set as overfrequency stage (f>) or as underfrequency stage (f<) with individual thresholds and time delays. This enables the stages to be adapted to the particular application.

- If a stage is set to a value above the rated frequency, it is automatically interpreted to be an overfrequency stage f>.
- If a stage is set to a value below the rated frequency, it is automatically interpreted to be an underfrequency stage f<.
- If a stage is set exactly to the rated frequency, it is inactive.

Each stage can be blocked via binary input and also the entire frequency protection function can be blocked.

Frequency measurement

The largest of the 3 phase-to-phase voltages is used for frequency measurement. It must amount to at least 65 % of the nominal voltage set in parameter 204, **Unom SECONDARY**. Below that value frequency measurement will not take place.

Numerical filters are used to calculate a virtual quantity from the measured voltage. This quantity is proportional to the frequency and is practically linear in the specified range (fN ± 10 %). Filters and repeated measurements ensure that the frequency measurement is free from harmonic and phase jumps influences.

An accurate and quick measurement result is obtained by considering also the frequency change. When changing the frequency of the power system, the sign of the quotient $^{\Delta f}/_{dt}$ remains unchanged during several repeated measurements. If, however, a phase jump in the measured voltage temporarily simulates a frequency deviation, the sign of $^{\Delta f}/_{dt}$ will subsequently reverse. Thus the measurement results corrupted by a phase jump are quickly discarded.

The dropout value of each frequency element is approximately 20 mHz below (for f>) or above (for f<) of the pickup value.

Operating ranges

Frequency evaluation requires a measured quantity that can be processed. This implies that at least a sufficiently high voltage is available and that the frequency of this voltage is within the working range of the frequency protection.

The frequency protection automatically selects the largest of the phase-to-phase voltages. If all three voltages are below the operating range of 65 % · U_N (secondary), the frequency cannot be determined. In that case the indication 5215 *Freq UnderV Blk* is displayed. If the voltage falls below this minimum value after a frequency stage has picked up, the picked up element will drop out. This implies also that all frequency stages will drop out after a line has been switched off (with voltage transformers on line side).

When connecting a measuring voltage with a frequency outside the configured threshold of a frequency stage, the frequency protection is immediately ready to operate. Since the filters of the frequency measurement must first go through a transient state, the command output time may increase slightly (approx. 1 period). This is because a frequency stage picks up only if the frequency has been detected outside the configured threshold in five consecutive measurements.

The frequency range is from 25 Hz to 70 Hz. If the frequency leaves this operating range, the frequency stages will drop out. If the frequency returns into the operating range, the measurement can be resumed provided that the measuring voltage is also inside the working range. But if the measuring voltage is switched off, the picked up stage will drop out immediately.

Power swings

In interconnected networks, frequency deviations may also be caused by power swings. Depending on the power swing frequency, the mounting location of the device and the setting of the frequency stages, power swings may cause the frequency protection to pickup and even to trip. In these cases it is reasonable to block the frequency protection once power swings are detected. This can be accomplished via binary inputs and binary outputs (e.g. power swing detection of an external distance protection) or by corresponding logic operations using the user-defined logic (CFC). If, however, the power swing frequencies are known, tripping of the frequency protection function can also be avoided by adapting the delay times of the frequency protection correspondingly.

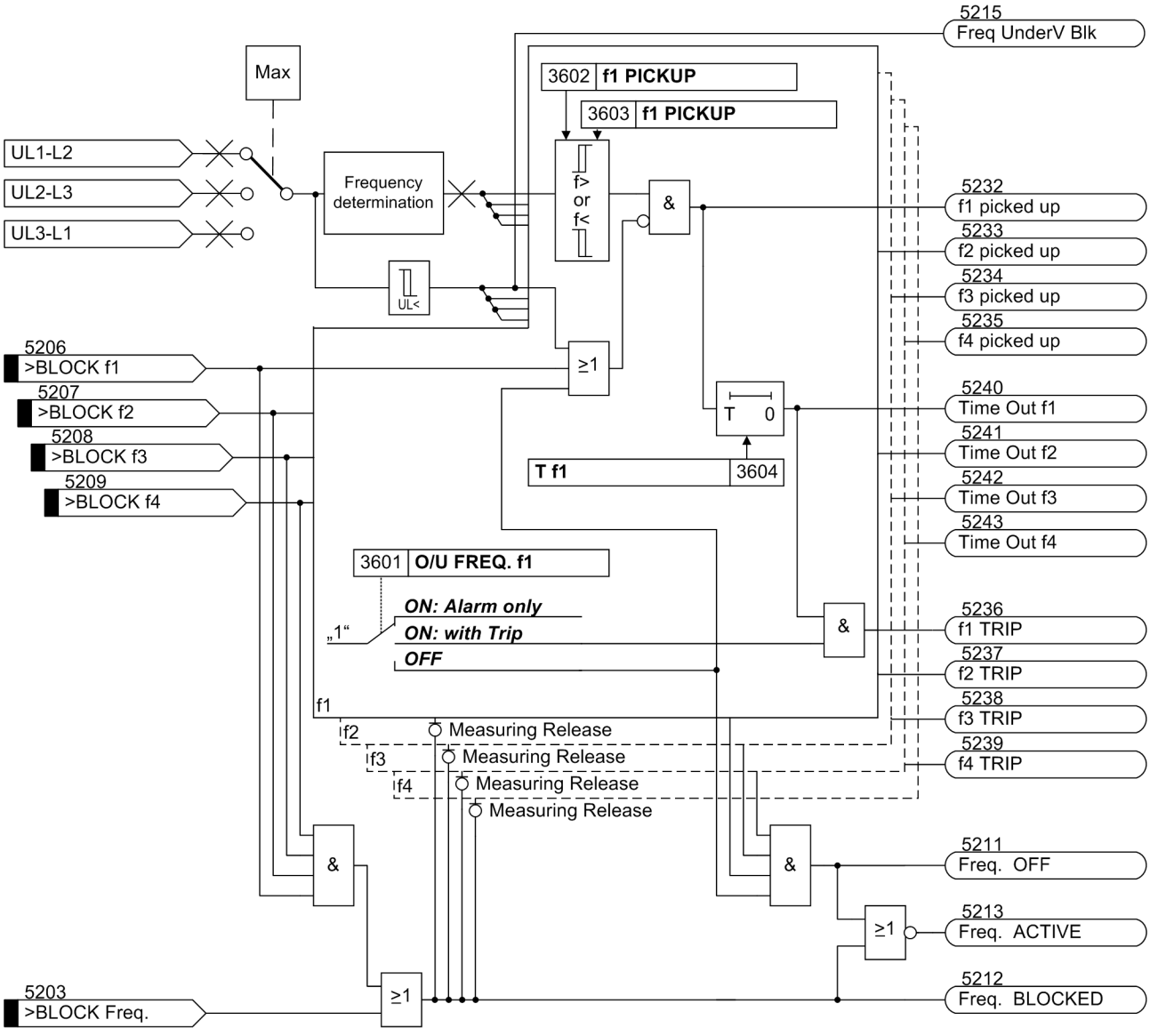
Pickup/tripping

Figure 2-63 shows the logic diagram for the frequency protection function.

Once the frequency was reliably detected to be outside the configured thresholds of a stage (above the setting value for f> stages or below for f< stages), a pickup signal of the corresponding stage is generated. The decision is considered reliable if five measurements taken in intervals of $^1/_2$ period yield one frequency outside the set threshold.

After pickup, one delay time per stage can be started. When the associated time has elapsed, one trip command per stage is issued. A picked up stage drops out if the cause of the pickup is no longer valid after five measurements or if the measuring voltage was switched off or the frequency is outside the operating range. When a frequency stage drops out, the tripping signal of of the corresponding frequency stage is immediately terminated, but the trip command is maintained for at least the minimum command duration which was set for all tripping functions of the device.

Each of the four frequency stages can be blocked individually by binary inputs. The blocking takes immediate effect. It is also possible to block the entire frequency protection function via binary input.



[logikdiagramm-frequenzschutz-wlk-190802, 1, en_GB]

Figure 2-63 Logic diagram of the frequency protection

2.12.2 Setting Notes

General

Frequency protection is only in effect and accessible if address 136 **FREQUENCY Prot.** is set to ***Enabled***. If the function is not required, ***Disabled*** is to be set.

The frequency protection function features 4 frequency stages f1 to f4 each of which can function as overfrequency stage or underfrequency stage. Each stage can be set active or inactive. This is set in addresses:

- 3601 **O/U FREQ. f1** for frequency stage f1,
- 3611 **O/U FREQ. f2** for frequency stage f2,
- 3621 **O/U FREQ. f3** for frequency stage f3,
- 3631 **O/U FREQ. f4** for frequency stage f4.

The following 3 options are available:

- Stage ***OFF***: The stage is ineffective;
- Stage ***ON: with Trip***: The stage is effective and issues an alarm and a trip command (after time has expired) following irregular frequency deviations;
- Stage ***ON: Alarm only***: The stage is effective and issues an alarm but no trip command following irregular frequency deviations.

Pickup values, delay time

The configured pickup value determines whether a frequency stage is to respond to overfrequency or underfrequency.

- If a stage is set to a value above the rated frequency, it is automatically interpreted to be an overfrequencystage f>.
- If a stage is set to a value below the rated frequency, it is automatically interpreted to be an underfrequency stage f<.
- If a stage is set exactly to the rated frequency, it is inactive.

A pickup value can be set for each stage according to above rules. The addresses and possible setting ranges are determined by the nominal frequency as configured in the Power System Data 1 (Section *2.1.2.1 Setting Notes*) in **Rated Frequency** (address 230).

Please note that none of the frequency stages is set to less than 30 mHz above (for f>) or below (for f<) the nominal frequency. Since the frequency stages have a hysteresis of approx. 20°mHz, it may otherwise happen that the stage does not drop out when returning to the nominal frequency.

Only those addresses are accessible that match the configured nominal frequency. For each element, a trip delay time can be set:

- address 3602 **f1 PICKUP** pickup value for frequency stage f1 at f_N = 50 Hz,
  address 3603 **f1 PICKUP** pickup value for frequency stage f1 at f_N = 60 Hz,
  address 3604 **T f1** trip delay for frequency stage f1;
- address 3612 **f2 PICKUP** pickup value for frequency stage f2 at f_N = 50 Hz,
  address 3613 **f2 PICKUP** pickup value for frequency stage f2 at f_N = 60 Hz,
  address 3614 **T f2** trip delay for frequency stage f2;
- address 3622 **f3 PICKUP** pickup value for frequency stage f3 at f_N = 50 Hz,
  address 3623 **f3 PICKUP** pickup value for frequency stage f3 at f_N = 60 Hz,
  address 3624 **T f3** trip delay for frequency stage f3;
- address 3632 **f4 PICKUP** pickup value for frequency stage f4 at f_N = 50 Hz,
  address 3633 **f4 PICKUP** pickup value for frequency stage f4 at f_N = 60 Hz,
  address 3634 **T f4** trip delay for frequency stage f4.

The set times are additional delay times not including the operating times (measuring time, dropout time) of the protection function.

If underfrequency protection is used for load shedding purposes, then the frequency settings relative to other feeder relays are generally based on the priority of the customers served by the protection relay. Normally, it is required for load shedding a frecuency / time grading that takes into account the importance of the consumers or consumer groups.

In interconnected networks, frequency deviations may also be caused by power swings. Depending on the power swing frequency, the mounting location of the device and the setting of the frequency stages, it is reasonable to block the entire frequency protection function or single stages once a power swing has been detected. The delay times must then be co-ordinated thus that a power swing is detected before the frequency protection trips.

Further application examples exist in the field of power stations. The frequency values to be set mainly depend, also in these cases, on the specifications of the power system/power station operator. In this context, the underfrequency protection also ensures the power station's own demand by disconnecting it from the

power system on time. The turbo regulator regulates the machine set to the nominal speed. Consequently, the station's own demands can be continuously supplied at nominal frequency

Since the dropout threshold is 20 mHz below or above the trip frequency, the resulting “minimum” trip frequency is 30 mHz above or below the nominal frequency.

A frequency increase can, for example, occur due to a load shedding or malfunction of the speed regulation (e.g. in a stand-alone system). In this way, the frequency protection can, for example, be used as overspeed protection.

2.12.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
3601	O/U FREQ. f1	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f1
3602	f1 PICKUP	45.50 .. 54.50 Hz	49.50 Hz	f1 Pickup
3603	f1 PICKUP	55.50 .. 64.50 Hz	59.50 Hz	f1 Pickup
3604	T f1	0.00 .. 600.00 sec	60.00 sec	T f1 Time Delay
3611	O/U FREQ. f2	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f2
3612	f2 PICKUP	45.50 .. 54.50 Hz	49.00 Hz	f2 Pickup
3613	f2 PICKUP	55.50 .. 64.50 Hz	57.00 Hz	f2 Pickup
3614	T f2	0.00 .. 600.00 sec	30.00 sec	T f2 Time Delay
3621	O/U FREQ. f3	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f3
3622	f3 PICKUP	45.50 .. 54.50 Hz	47.50 Hz	f3 Pickup
3623	f3 PICKUP	55.50 .. 64.50 Hz	59.50 Hz	f3 Pickup
3624	T f3	0.00 .. 600.00 sec	3.00 sec	T f3 Time Delay
3631	O/U FREQ. f4	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f4
3632	f4 PICKUP	45.50 .. 54.50 Hz	51.00 Hz	f4 Pickup
3633	f4 PICKUP	55.50 .. 64.50 Hz	62.00 Hz	f4 Pickup
3634	T f4	0.00 .. 600.00 sec	30.00 sec	T f4 Time Delay

2.12.4 Information List

No.	Information	Type of Informa-tion	Comments
5203	>BLOCK Freq.	SP	>BLOCK frequency protection
5206	>BLOCK f1	SP	>BLOCK frequency protection stage f1
5207	>BLOCK f2	SP	>BLOCK frequency protection stage f2
5208	>BLOCK f3	SP	>BLOCK frequency protection stage f3
5209	>BLOCK f4	SP	>BLOCK frequency protection stage f4
5211	Freq. OFF	OUT	Frequency protection is switched OFF
5212	Freq. BLOCKED	OUT	Frequency protection is BLOCKED
5213	Freq. ACTIVE	OUT	Frequency protection is ACTIVE

No.	Information	Type of Information	Comments
5215	Freq UnderV Blk	OUT	Frequency protection undervoltage Blk
5232	f1 picked up	OUT	Frequency protection: f1 picked up
5233	f2 picked up	OUT	Frequency protection: f2 picked up
5234	f3 picked up	OUT	Frequency protection: f3 picked up
5235	f4 picked up	OUT	Frequency protection: f4 picked up
5236	f1 TRIP	OUT	Frequency protection: f1 TRIP
5237	f2 TRIP	OUT	Frequency protection: f2 TRIP
5238	f3 TRIP	OUT	Frequency protection: f3 TRIP
5239	f4 TRIP	OUT	Frequency protection: f4 TRIP
5240	Time Out f1	OUT	Frequency protection: TimeOut Stage f1
5241	Time Out f2	OUT	Frequency protection: TimeOut Stage f2
5242	Time Out f3	OUT	Frequency protection: TimeOut Stage f3
5243	Time Out f4	OUT	Frequency protection: TimeOut Stage f4

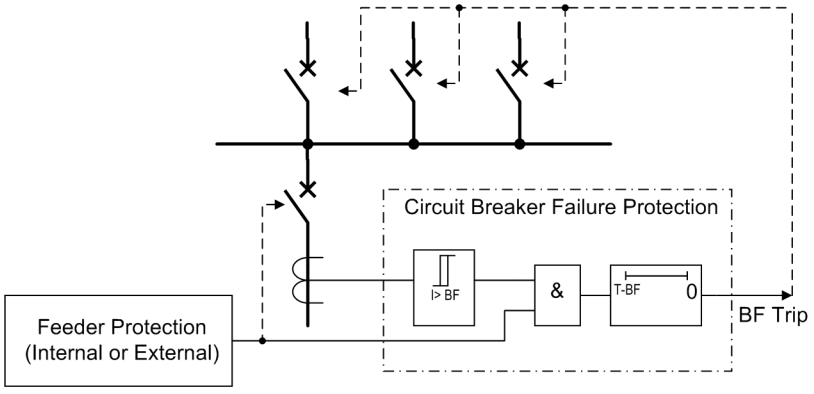
2.13 Circuit Breaker Failure Protection

The circuit breaker failure protection provides rapid back-up fault clearance in the event that the circuit breaker fails to respond to a trip command from a protection function of the local circuit breaker.

2.13.1 Functional Description

General

Whenever e.g. a short-circuit protection relay of a feeder issues a trip command to the circuit breaker, this is repeated to the circuit breaker failure protection (*Figure 2-64*). A timer T–BF in the circuit breaker failure protection is started. The timer runs as long as a trip command is present and current continues to flow through the circuit breaker poles.



[funktionsschema-lvs-ueberwach-wlk-010802, 1, en_GB]

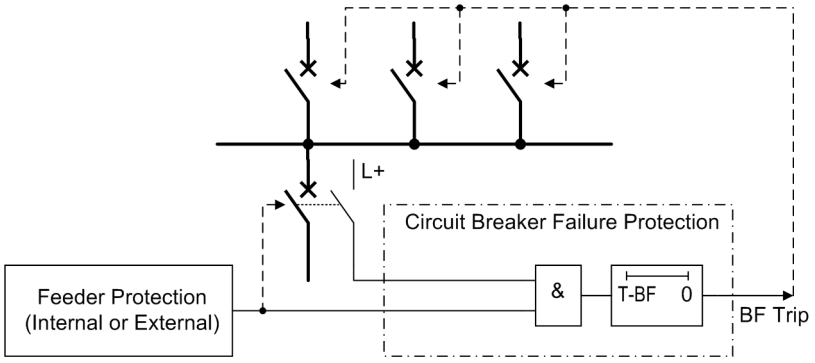
Figure 2-64 Simplified function diagram of circuit breaker failure protection with current flow monitoring

Normally, the circuit breaker will open and interrupt the fault current. The current monitoring stage quickly resets (typical 10 ms) and stops the timer T–BF.

If the trip command is not carried out (circuit breaker failure case), current continues to flow and the timer runs to its set limit. The circuit breaker failure protection then issues a command to trip the backup circuit breakers and interrupt the fault current.

The reset time of the feeder protection is not relevant because the circuit breaker failure protection itself recognizes the interruption of the current.

For protection functions where the tripping criterion is not dependent on current (e.g. Buchholz protection), current flow is not a reliable criterion for proper operation of the circuit breaker. In such cases, the circuit breaker position can be derived from the auxiliary contacts of the circuit breaker. Therefore, instead of monitoring the current, the position of the auxiliary contacts is monitored (*Figure 2-65*). For this purpose, the outputs from the auxiliary contacts must be fed to binary inputs on the relay (refer also to Section *2.16.1 Function Control*).



[funktionsschema-lvs-lshiko-wlk-010802, 1, en_GB]

Figure 2-65 Simplified function diagram of circuit breaker failure protection controlled by circuit breaker auxiliary contact

Current flow monitoring

Each of the phase currents and an additional plausibility current (see below) are filtered by numerical filter algorithms so that only the fundamental component is used for further evaluation.

Special features recognize the instant of current interruption. In case of sinusoidal currents the current interruption is detected after approximately a $^3/_4$ cycle. With aperiodic DC current components in the fault current and/or in the current transformer secondary circuit after interruption (e.g. current transformers with linearized core), or saturation of the current transformers caused by the DC component in the fault current, it can take up to 1 $^1/_4$ AC cycles before the interruption of the primary current is reliably detected.

The currents are monitored and compared with the set limit value. Besides the three phase currents, two further current thresholds are provided in order to allow a plausibility check. If configured correspondingly, a separate threshold value can be used for this plausibility check (see *Figure 2-66*).

The earth current I_E ($3 \cdot I_0$) is preferably used as plausibility current. The earth current from the starpoint of the current transformer set will be used if it is connected to the device. If this current is not available, the device will calculate it from the phase currents using this formula:

$$3 \cdot \underline{I}_0 = \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$$

Additionally, the value calculated by 7SD610 of three times the negative sequence current $3 \cdot I_2$ is used for plausibility check. This is calculated according to the equation:

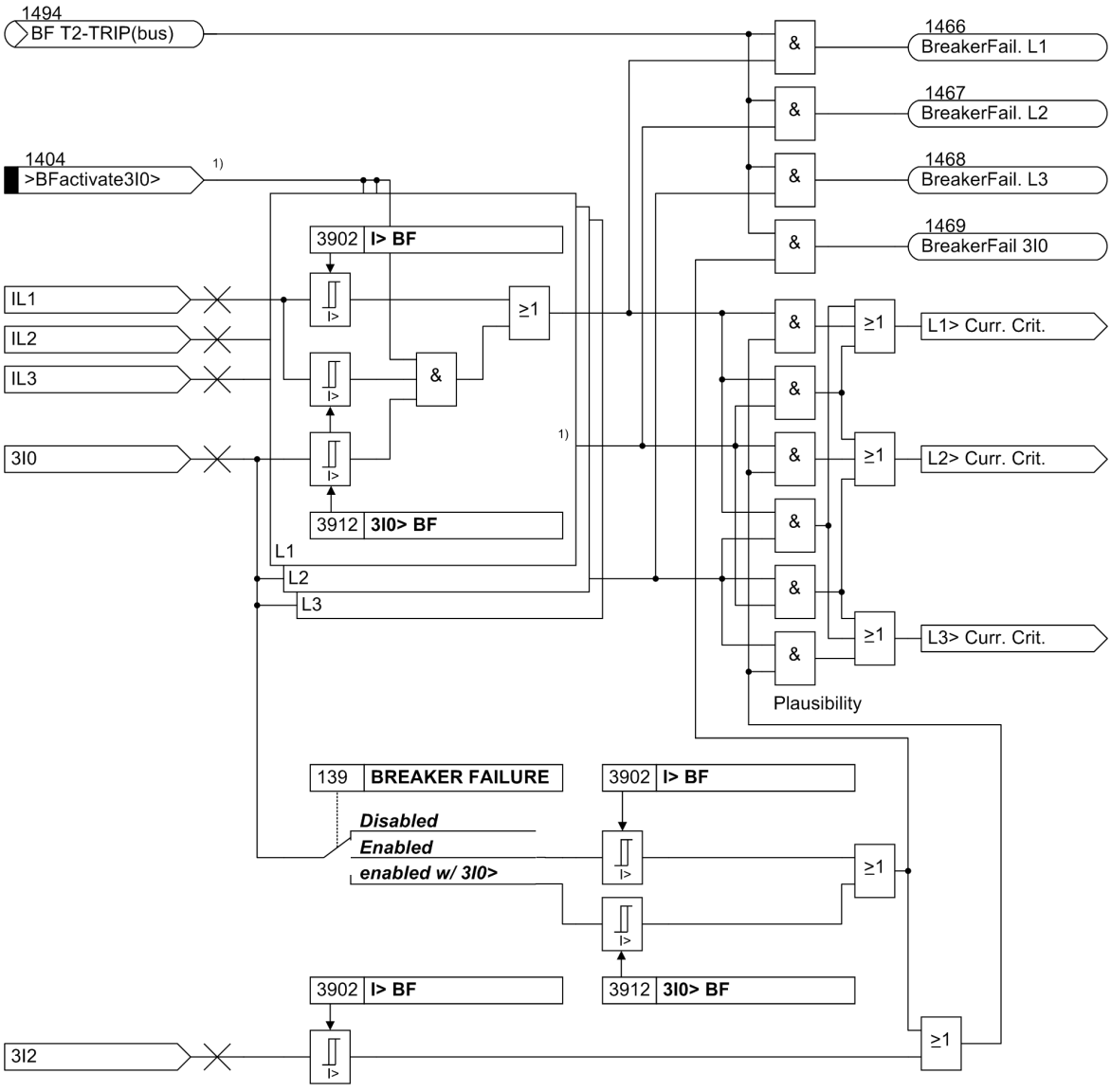
$$3 \cdot \underline{I}_2 = \underline{I}_{L1} + \underline{a}^2 \cdot \underline{I}_{L2} + \underline{a} \cdot \underline{I}_{L3}$$

mit

$$\underline{a} = e^{j120°}.$$

These plausibility currents do not have any direct influence on the basic functionality of the circuit breaker failure protection but they allow a plausibility check in that at least two current thresholds must have been exceeded before any of the circuit breaker failure delay times can be started, thus providing high security against false operation.

In case of high-resistance earth faults it may occur that the earth current exceeds the sensitively parameterized threshold value **3I0> BF** (address 3912), the phase current involved in the short-circuit, however, does not exceed the threshold value **I> BF** (address 3902).The plausibility monitoring would prevent the breaker failure protection from being initiated. In this case the pickup threshold of the phase current monitoring **I> BF** can be switched over to the threshold value **3I0> BF**. For this purpose, use the binary input 1404 *>BFactivate3I0>*. This binary input is linked to an external signal which indicates a high resistance fault, e.g. earth fault detection, or detection of displacement voltage. With this method, the more sensitively parameterized earth current threshold is also used for the phase current monitoring (*Figure 2-66*).



[logik-strmflsueberw-plausibilitaet-110113, 1, en_GB]

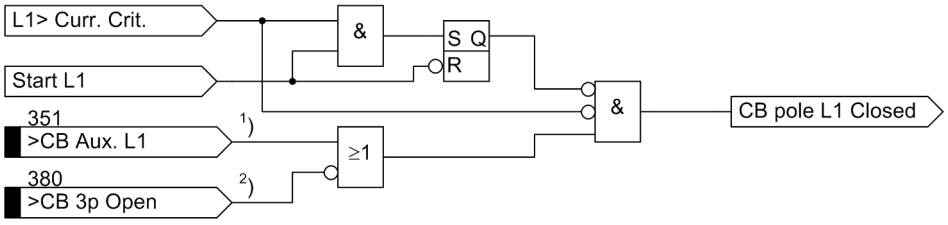
Figure 2-66 Current flow monitoring with plausibility currents $3{\cdot}I_0$ und $3{\cdot}I_2$

1) only available/visible if 139 is set to ***enabled w/ 3I0>***

Monitoring the circuit breaker auxiliary contacts

It is the central function control of the device that informs the circuit breaker failure protection on the position of the circuit breaker (see Section *2.16.1 Function Control*). The evaluation of the circuit breaker auxiliary contacts is carried out in the circuit breaker failure protection function only when the current flow monitoring has not picked up. Once the current flow criterion has picked up during the trip signal from the feeder protection, the circuit breaker is assumed to be open as soon as the current disappears, even if the associated auxiliary contact does not (yet) indicate that the circuit breaker has opened (*Figure 2-67*). This gives preference to the more reliable current criterion and avoids overfunctioning due to a defect e.g. in the auxiliary contact mechanism or circuit. This interlock feature is provided for each individual phase as well as for 3-pole tripping.

It is possible to disable the auxiliary contact criterion. If you set the parameter switch **Chk BRK CONTACT** (*Figure 2-69* top) to ***NO*** the circuit breaker failure protection can only be started when current flow is detected. The position of the auxiliary contacts is then not evaluated even if the auxiliary contacts are connected to the device.



[logik-verriegel-hikos-wlk-010802, 1, en_GB]

Figure 2-67 Interlock of the auxiliary contact criterion - example for phase L1

1) if phase-segregated auxiliary contacts are available

2) if series-connected NC contacts are available

On the other hand, current flow is not a reliable criterion for proper operation of the circuit breaker for faults which do not cause detectable current flow (e.g. Buchholz protection). Information regarding the position of the circuit breaker auxiliary contacts is required in these cases to check the correct response of the circuit breaker. For this purpose, the binary input *>BF Start w/o I* No. 1439 (*Figure 2-69* left). This input initiates the circuit breaker failure protection even if no current flow is detected.

Common phase initiation

Common phase initiation is used, for example, in systems with only 3-pole tripping, for transformer feeders, or if the busbar protection trips. It is the only available initiation mode when using the 7SD610 version capable of 3- pole tripping only.

If the circuit breaker failure protection is intended to be initiated by further external protection devices, it is recommended, for security reasons, to connect two binary inputs to the device. Besides the trip command of the external protection to the binary input *>BF Start 3pole* No. 1415 it is recommended to connect also the general device pickup to binary input *>BF release* No. 1432. For Buchholz protection it is recommended that both inputs are connected to the device by two separate wire pairs.

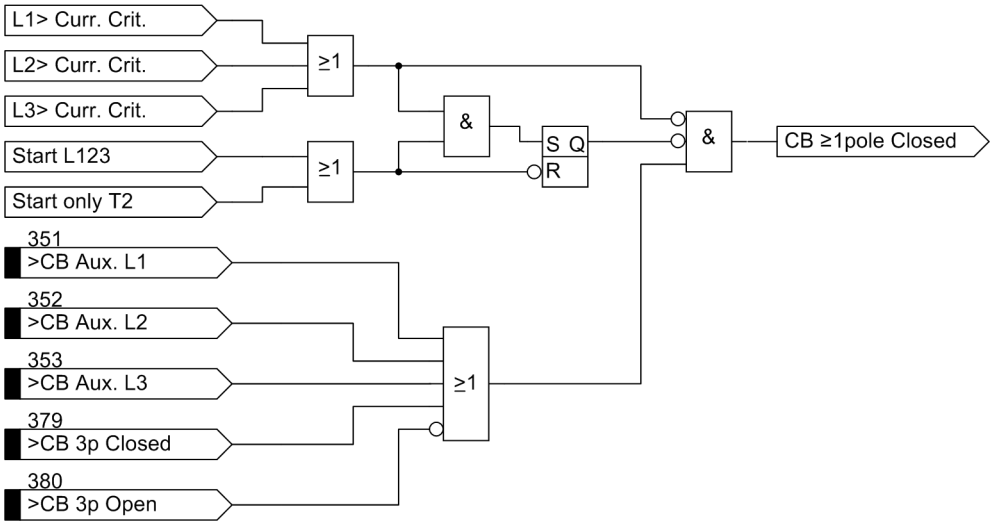
Nevertheless, it is possible to initiate the circuit breaker failure protection in single-channel mode should a separate release criterion not be available. The binary input *>BF release* (No. 1432) must then not be assigned to any physical input of the device during configuration.

Figure 2-69 shows the operating principle. When the trip signal appears from any internal or external feeder protection and at least one current flow criterion according to *Figure 2-66* is present, the circuit breaker failure protection is initiated and the corresponding delay time(s) is (are) started.

If the current criterion is not fulfilled for any of the phases, the position of the circuit breaker auxiliary contact can be queried as shown in *Figure 2-68*. If the circuit breaker poles have individual auxiliary contacts, the series connection of the three normally closed (NC) auxiliary contacts is used. After a 3-pole trip command the circuit breaker has only operated correctly if no current is flowing via any phase or alternatively all three auxiliary contacts indicate the CB is open.

Figure 2-68 illustrates how the internal signal “CB pole ≥L1 closed” is created (see *Figure 2-69* left) if at least one circuit breaker pole is closed.

By means of the binary input 1424 *>BF STARTonlyT2*, the tripping delay 3906 **T2** can be started. After this time stage has elapsed, the circuit breaker failure TRIP command 1494 *BF T2-TRIP(bus)* is issued.

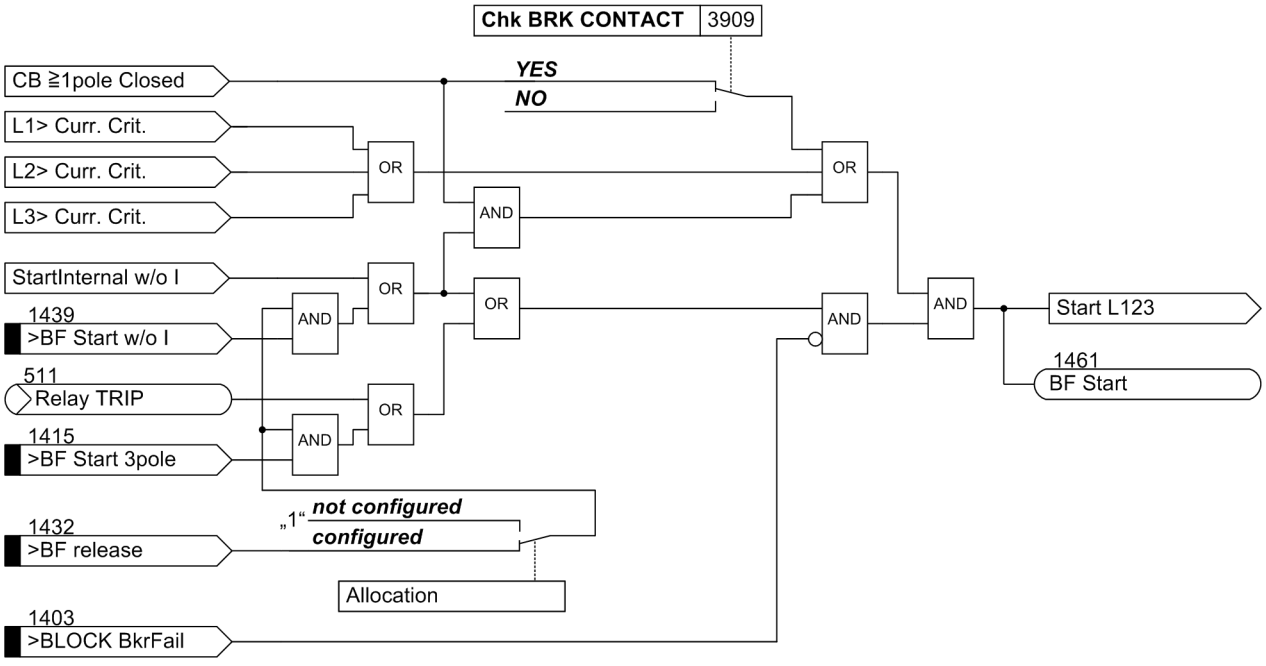


[logik-entsteh-signal-ls-hiko-wlk-010802, 1, en_GB]

Figure 2-68 Creation of signal "CB ≥ any pole closed"

If an internal protection function or an external protection device trips without current flow, the circuit breaker failure protection is initiated by the internal input "Start internal w/o I", if the trip signal comes from the internal voltage protection or frequency protection, or by the external input *>BF Start w/o I*. In this case the start signal is maintained until the circuit breaker is reported to be open by the auxiliary contact criterion.

Initiation can be blocked via the binary input*>BLOCK BkrFail* (e.g. during test of the feeder protection relay).



[logik-svs-phasengem-anwurf-wlk-010802, 1, en_GB]

Figure 2-69 Breaker failure protection with common phase initiation

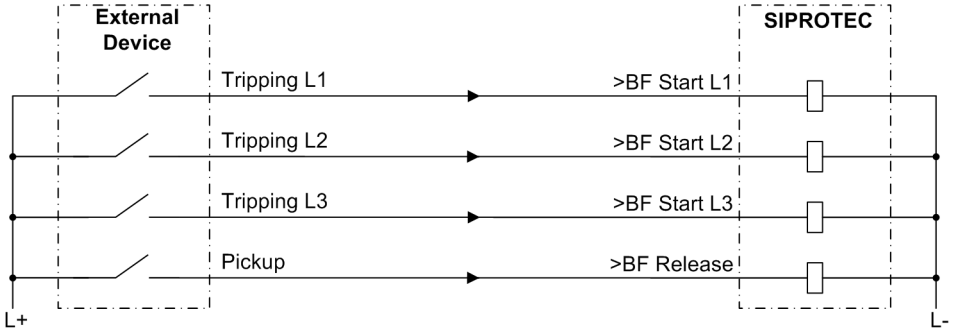
Phase-segregated initiation

Phase segregated initiation of the circuit breaker failure protection is necessary if the circuit breaker poles are operated individually, e.g. if 1-pole automatic reclosure is used. This is possible if the device is able to trip 1-pole.

If the circuit breaker failure protection is intended to be initiated by further external protection devices, it is recommended, for security reasons, to connect two binary inputs to the device. Besides the three trip commands of the external relay to the binary input *>BF Start L1*, *>BF Start L2* and *>BF Start L3* it is recommended to connect also, for example, the general device pickup to binary input *>BF release*. *Figure 2-70* shows this connection.

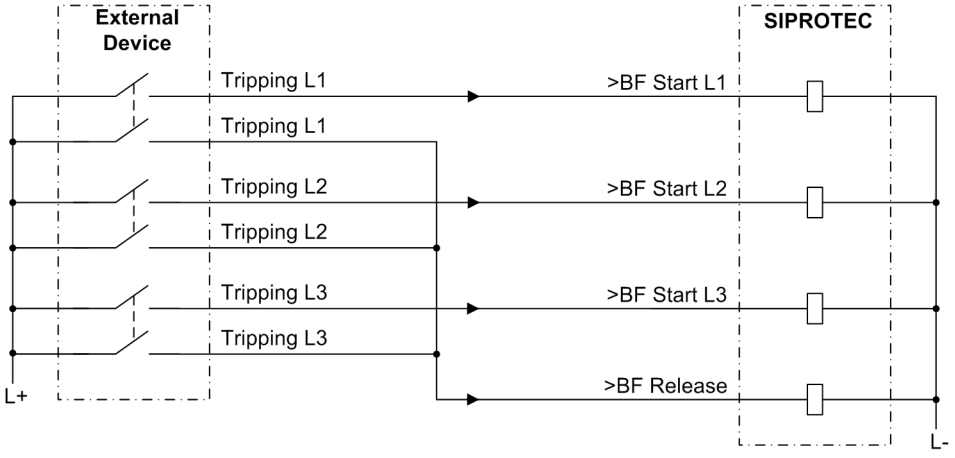
Nevertheless, it is possible to initiate the circuit breaker failure protection in single-channel mode should a separate release criterion not be available. The binary input *>BF release* must then not be assigned to any physical input of the device during configuration.

If the external protection device does not provide a general fault detection signal, a general trip signal can be used instead. Alternatively, the parallel connection of a separate set of trip contacts can produce such a release signal as shown in *Figure 2-71*.



[svs-phasegetr-anwurf-ext-geraet-wlk-010802, 1, en_GB]

Figure 2-70 Breaker failure protection with phase segregated initiation — example for initiation by an external protection device with release by a fault detection signal



[svs-phasegetr-anwurf-ext-geraet-frei-ausloese-wlk-010802, 1, en_GB]

Figure 2-71 Schalterversagerschutz mit phasengetrenntem Anwurf — Beispiel für Anwurf von externem Schutzgerät mit Freigabe durch einen getrennten Satz Auslösekontakte

In principle, the starting condition logic for the delay time(s) is designed similar to that for the common phase initiation, however, individually for each of the three phases (as shown in *Figure 2-72*). Thus, current and initiation conditions are processed for each CB pole. Also during a 1-pole automatic reclosure, the current interruption is reliably monitored for the tripped CB pole only.

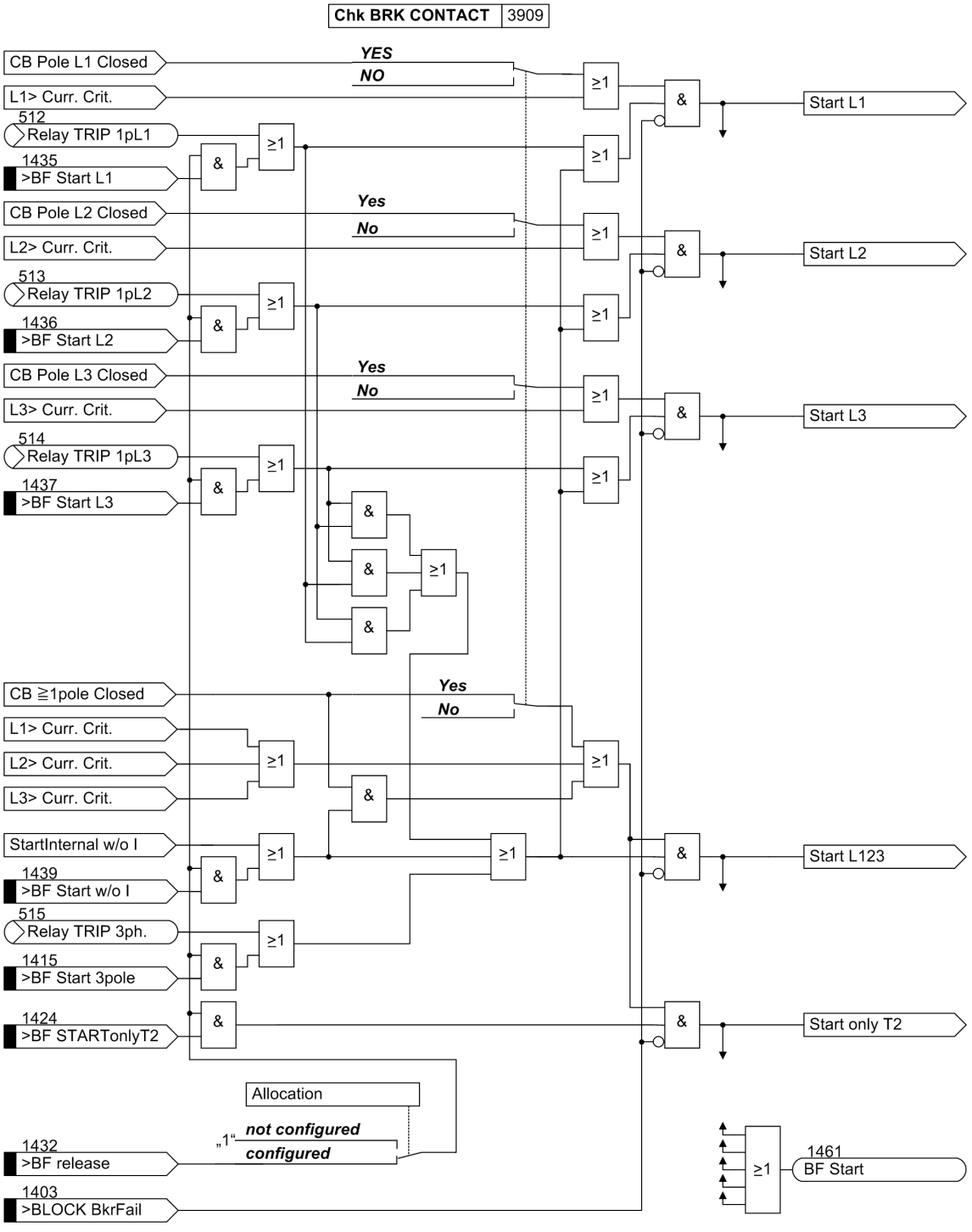
Initiation of an individual phase, e.g. “Start L1”, is only valid if the starting signal (= tripping signal of the feeder protection) appears for this phase and if the current criterion is met for at least this phase. If it is not met, the circuit breaker auxiliary contact can be interrogated according to *Figure 2-67* – if parameterised (**Chk BRK CONTACT** = ***YES***).

The auxiliary contact criterion is also processed for each individual circuit breaker pole. If, however, the circuit breaker auxiliary contacts are not available for each individual circuit breaker pole, then a 1-pole trip command is assumed to be executed only if the series connection of the normally open (NO) auxiliary

contacts is interrupted. This information is provided to the circuit breaker failure protection by the central function control of the device (refer to Section *2.16.1 Function Control*).

The 3-phase starting signal “Start L123” is generated if there are start signals for more than one phase. The input "BF Start w/o I" (e.g. from Buchholz protection) operates only in 3-phase mode. The function is the same as with common phase initiation.

The additional release-signal *>BF release* (if assigned to a binary input) affects all external initiation conditions. Initiation can be blocked via the binary input *>BLOCK BkrFail* (e.g. during test of the feeder protection relay).



[logik-7vk61-anwurfbed-1-pol-ausloese, 1, en_GB]

Figure 2-72 Initiation conditions for single-pole trip commands

Delay times

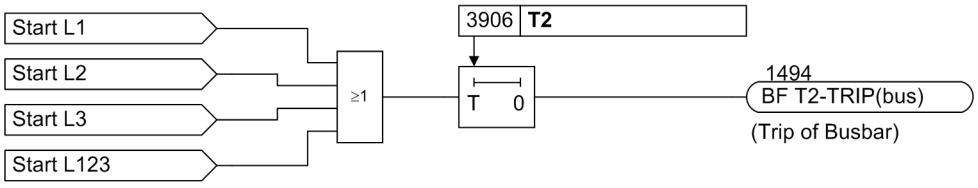
When the initiatiation conditions are fulfilled, the associated timers are started. The circuit breaker pole(s) must open before the associated time has elapsed.

Different delay times are possible for 1-pole and 3-pole initiation. An additional delay time can be used for twostage circuit breaker failure protection.

With single-stage circuit breaker failure protection, the trip command is relayed to the adjacent circuit breakers which interrupt the fault current if the local feeder breaker fails (see *Figure 2-64* and *Figure 2-65*). The adjacent circuit breakers are those located at the busbar or busbar section to which the feeder under consideration is connected. The possible initiation conditions for the circuit breaker failure protection are those discussed above. Depending on the application of the feeder protection, common phase or phase-segregated initiation conditions may occur. The circuit breaker failure protection always trips 3-pole.

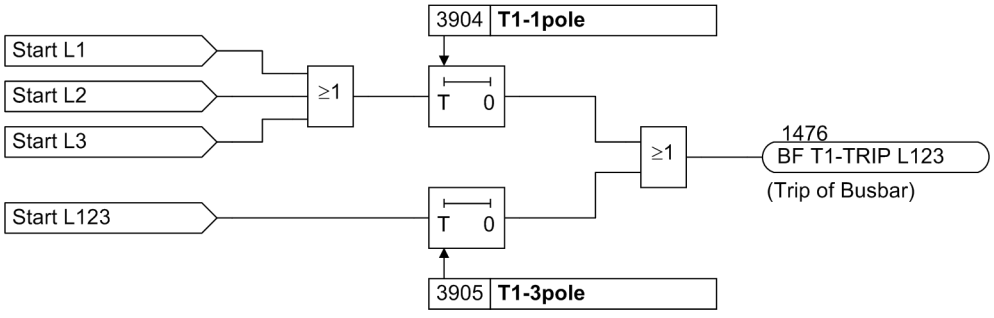
The simplest solution is to start the delay timer **T2** (*Figure 2-73*). The phase-segregated initiation signals are omitted if the feeder protection always trips 3-pole or if the circuit breaker is not capable of 1-pole tripping.

If different delay times are required after a 1-pole trip or 3-pole trip it is possible to use the timer stages **T1-3pole** and **T1-1pole** according to *Figure 2-74*.



[logik-1-stufiger-svs-phgem-anwurf-wlk-010802, 1, en_GB]

Figure 2-73 Single-stage breaker failure protection with common phase initiation



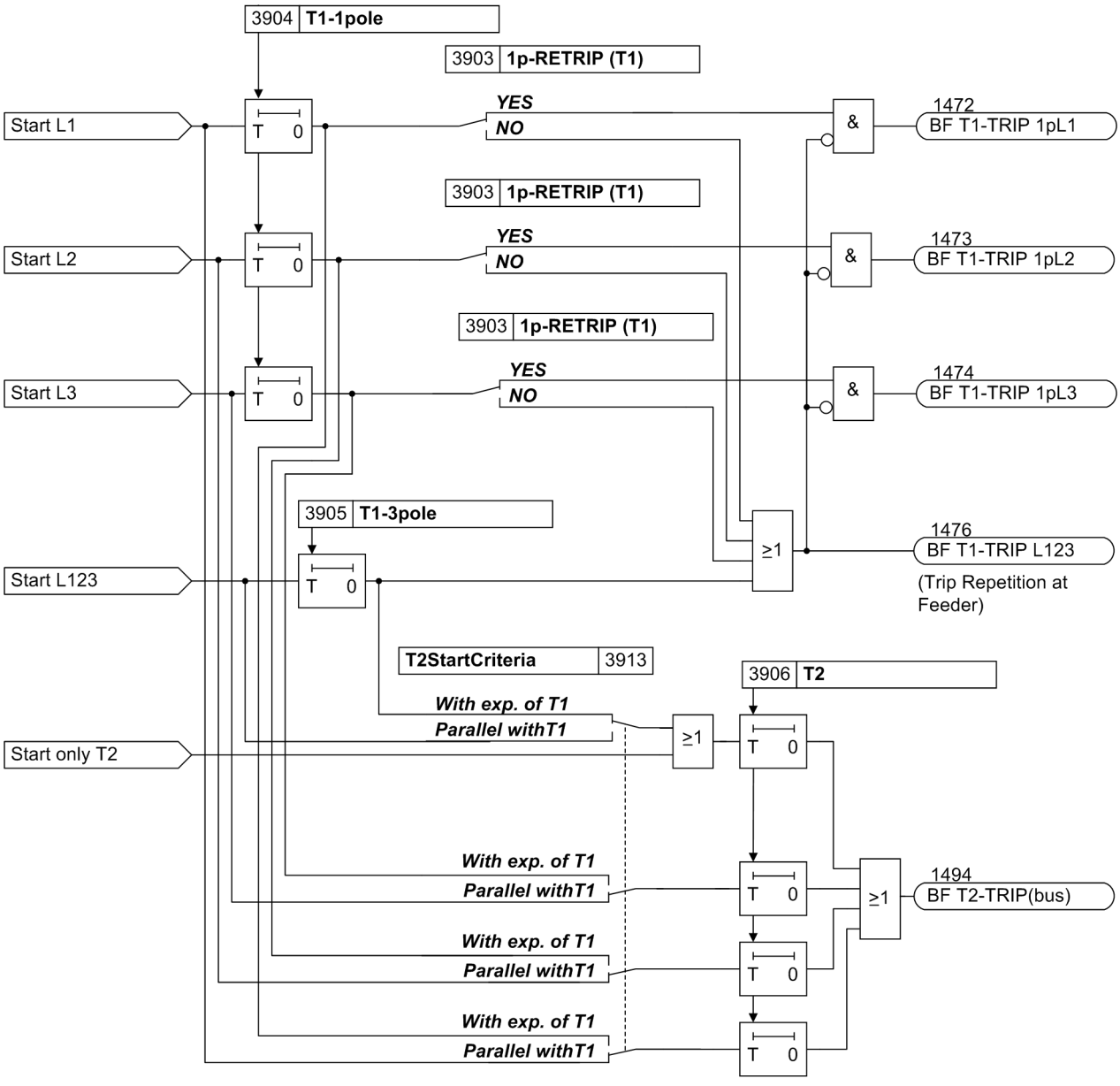
[logik-1-stufiger-svs-unterscht-verz-t-wlk-010802, 1, en_GB]

Figure 2-74 Single-stage breaker failure protection with different delay times

With two-stage circuit breaker failure protection the trip command of the feeder protection is usually repeated, after a first time stage, to the feeder circuit breaker, often via a second trip coil or set of trip coils, if the circuit breaker has not responded to the original trip command. A second time stage monitors the response to this repeated trip command and trips the circuit breakers of the relevant busbar section if the fault has not yet been cleared after this second time.

For the first stage, a different delay **T1-1pole** can be set for 1-pole trip than for 3-pole trip by the feeder protection. Additionally, you can select (by setting parameter **1p-RETRIP (T1)**) whether this repeated trip should be 1-pole or 3-pole. In case of a multi-pole tripping of the feeder protection, **T1-1pole** and **T1-3pole** are started simultaneously. By means of **T1-3pole**, the tripping of the circuit breaker failure protection can be accelerated in comparison to **T1-1pole**.

Address 3913 **T2StartCriteria** is used to set whether the delay time **T2** will be started after expiry of T1 (**T2StartCriteria** = ***With exp. of T1***) or simultaneously with it (**T2StartCriteria** = ***Parallel withT1***). The time **T2** can also be initiated via a separate binary input 1424 *>BF STARTonlyT2*.



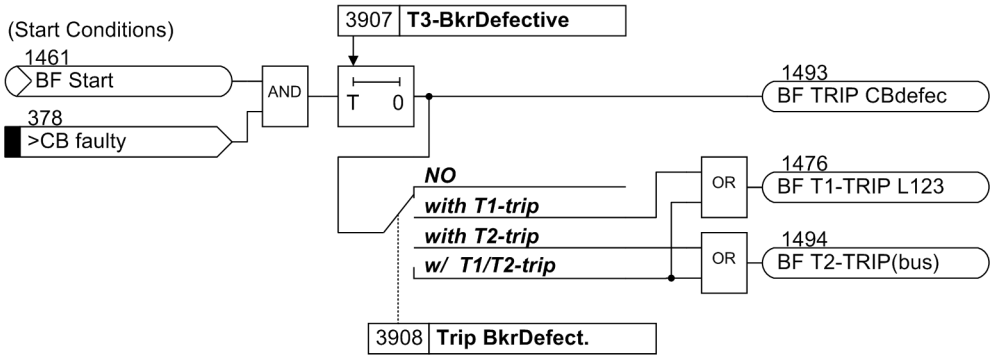
[logik-7vk61-2-stufiger-svs-phgem-anwurf, 1, en_GB]

Figure 2-75 Logic diagram of the two-stage breaker failure protection

Circuit breaker not operational

There may be cases when it is already obvious that the circuit breaker associated with a feeder protection relay cannot clear a fault, e.g. when the tripping voltage or the tripping energy is not available.

In such a case it is not necessary to wait for the response of the feeder circuit breaker. If provision has been made for the detection of such a condition (e.g. control voltage monitor or air pressure monitor), the monitor alarm signal can be fed to the binary input *>CB faulty* of the 7SD610. On occurrence of this alarm and a trip command by the feeder protection, a separate timer **T3-BkrDefective** is started (see *Figure 2-76*), which is normally set to 0. Thus, the adjacent circuit breakers (bus-bar) are tripped immediately in case the feeder circuit breaker is not operational.



[logik-ls-gestoert-wlk-010802, 1, en_GB]

Figure 2-76 Circuit breaker faulty

Transfer trip to the remote end circuit breaker

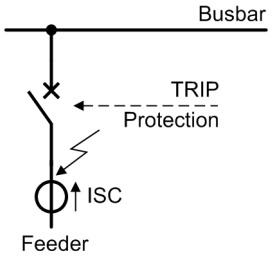
When the local feeder circuit breaker fails, tripping of the circuit breaker at the remote line end is often also desired. This requires the command to be transmitted.

In case of 7SD610 the corresponding command — usually the trip command which is intended to trip the adjacent breakers — is assigned to the input function for intertrip of the devices. This can be achieved by external wiring: The command output is connected to the binary input *>Intertrip 3pol* (No. 3504) (see also Section *2.4 Breaker Intertrip and Remote Tripping*). An easier procedure is to combine the command output with the intertrip input via the user definable logic functions (CFC).

End fault protection

An end fault is defined here as a short–circuit which has occurred at the end of a line or protected object, between the circuit breaker and the current transformer set.

Figure 2-77 shows the situation. The fault is located — as seen from the current transformer (= measurement location) — on the busbar side, it will thus not be regarded as a feeder fault by the feeder protection relay. It can only be detected by either a reverse stage of the feeder protection or by the busbar protection. However, a trip command given to the feeder circuit breaker does not clear the fault since the opposite end continues to feed the fault. Thus, the fault current does not stop flowing even though the feeder circuit breaker has properly responded to the trip command.

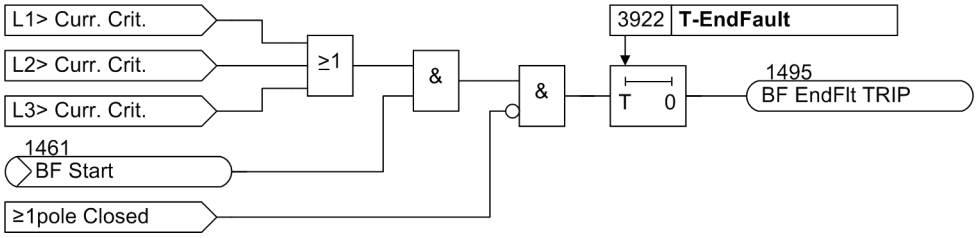


[endfehler-ls-strwdlr-wlk-010802, 1, en_GB]

Figure 2-77 End fault between circuit breaker and current transformers

The end fault protection has the task to recognize this status and to transmit a trip signal to the remote end of the line. For this purpose, the command *BF EndFlt TRIP* (No. 1495) is available to trigger the intertrip input of the differential protection — if applicable, together with other commands that need to be transferred. This can be achieved by external wiring or via CFC.

The end fault is recognized when the current continues flowing although the circuit breaker auxiliary contacts indicate that the circuit breaker is open. An additional criterion is the presence of any circuit breaker failure protection initiate signal. *Figure 2-78* illustrates the functional principle. If the circuit breaker failure protection is initiated and current flow is detected (current criteria "L*> current criterion" according to *Figure 2-66*), but no circuit breaker pole is closed (auxiliary contact criterion "any pole closed"), then the timer **T-EndFault** is started. At the end of this time an intertrip signal is transmitted to the opposite end(s) of the protected object.



[funktionsschema-endfehlerschutz-wlk-010802, 1, en_GB]

Figure 2-78 Functional scheme of the end fault protection

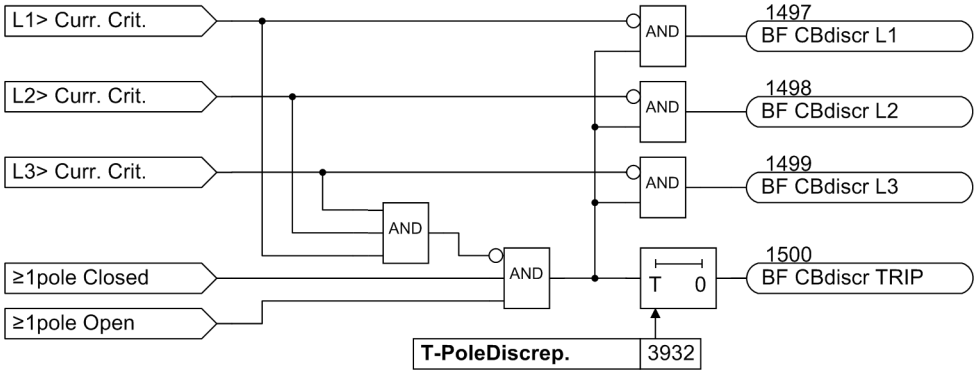
Pole discrepancy supervision

The pole discrepancy supervision has the task to detect discrepancies in the position of the three circuit breaker poles. Under steady-state operating conditions, either all three poles of the circuit breaker must be closed, or all three poles must be open. Discrepancy is permitted only for a short time interval during a 1-pole automatic reclose cycle.

Figure 2-79 the functional principle. The signals which are processed here are the same as those used for the circuit breaker failure protection. The pole discrepancy condition is established when at least one pole is closed (" ≥ one pole closed") and at the same time not all three poles are closed (" ≥ one pole open").

Additionally, the current criteria (from *Figure 2-66*) are processed Pole discrepancy can only be detected when current is not flowing through all three poles, i.e. through only one or two poles. When current is flowing through all three poles, all three poles must be closed even if the circuit breaker auxiliary contacts indicate a different status.

Detection of the discrepancy of the CB poles is signaled phase-selective as "Pickup". The signal identifies the pole that was open before the trip command of the pole discrepancy supervision occurred.



[logikschema-schalt-gleichlfueberwch-wlk-010802, 1, en_GB]

Figure 2-79 Function diagram of pole discrepancy supervision

2.13.2 Setting Notes

General

The circuit breaker failure protection and its ancillary functions (end fault protection, pole discrepancy supervision) can only operate if they were set during configuration of the scope of functions (address 139 **BREAKER FAILURE**) to ***Enabled*** or ***enabled w/ 3I0>***.

Circuit breaker failure protection

The circuit breaker failure protection is switched ***ON*** or ***OFF*** at address 3901 **FCT BreakerFail**.

The current threshold **I> BF** (address 3902) should be selected such that the protection will operate with the smallest expected short-circuit current. A setting of 10% below the minimum fault current for which circuit breaker failure protection must operate is recommended. On the other hand, the value should not be set lower than necessary.

If the circuit breaker failure protection is configured with zero sequence current threshold (address 139 = ***vorh. mit 3I0>***), the pickup threshold for the zero sequence current **3I0> BF** (address 3912) can be set independently of **I> BF**.

Normally, the circuit breaker failure protection evaluates the current flow criterion as well as the position of the circuit breaker auxiliary contact(s). If the auxiliary contact(s) status is not available in the device, this criterion cannot be processed. In this case, set address 3909 **Chk BRK CONTACT** to ***NO***.

Two-stage circuit breaker failure protection

With two-stage operation, the trip command is repeated after a time delay T1 to the local feeder circuit breaker, normally to a different set of trip coils of this circuit breaker. A choice can be made whether this trip repetition shall be 1-pole or 3-pole if the initial feeder protection trip was 1-pole (provided that 1-pole trip is possible). This choice is made in address 3903 **1p-RETRIP (T1)**. Set this parameter to ***YES*** if the first stage is to trip 1-pole, otherwise set it to ***NO***.

If the circuit breaker does not respond to this trip repetition, the adjacent circuit breakers are tripped after T2, i.e. the circuit breakers of the busbar or of the concerned busbar section and, if necessary, also the circuit breaker at the remote end unless the fault has been cleared.

Separate delay times can be set

- for 1- or 3-pole trip repetition to the local feeder circuit breaker after a **1**-pole trip of the feeder protection **T1-1pole** at address 3904,
- for 3-pole trip repetition to the local feeder circuit breaker after **3**-pole trip of the feeder protection **T1-3pole** (address 3905),
- for trip of the adjacent circuit breakers (busbar zone and remote end if applicable) **T2** at address 3906.

NOTE

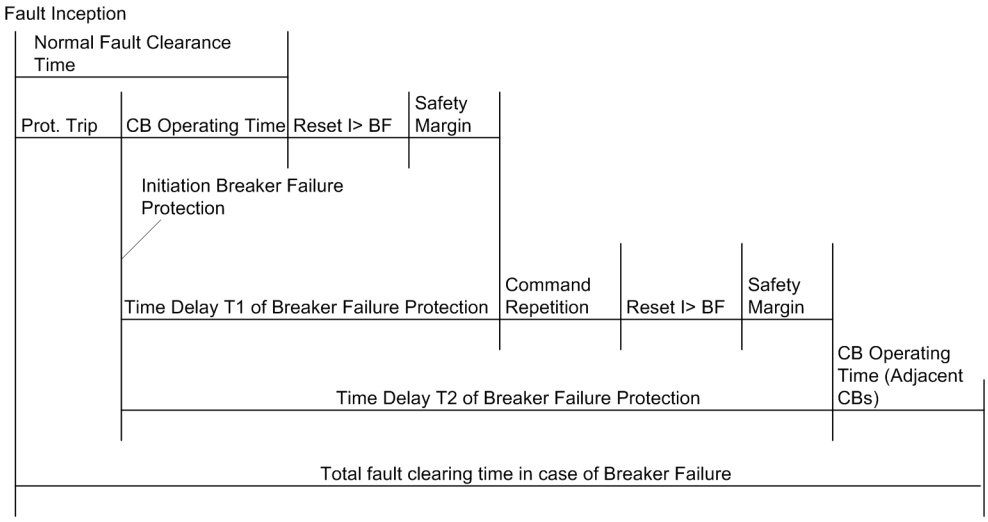
In case of multi-phase tripping of the feeder protection, **T1-1pole** and **T1-3pole** are started in parallel. **T1-3pole** therefore allows accelerating the tripping of the breaker failure protection compared to **T1-1pole**. Therefore, you should set **T1-1pole** equal to or longer than **T1-3pole**.

The delay times are set dependant on the maximum operating time of the feeder circuit breaker and the reset time of the current detectors of the circuit breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. *Figure 2-80* illustrates the timing of a typical circuit breaker failure scenario. The dropout time for sinusoidal currents is ≤ 15 ms. If current transformer saturation is anticipated, the time should be set to 25 ms.

NOTE

If the breaker failure protection is to perform a single-pole TRIP repetition, the time set for the AR, address3408 **T-Start MONITOR**, has to be longer than the time set for address 3903 **1p-RETRIP (T1)** to prevent 3-pole coupling by the AR before **T1** expires.

To prevent AR after *BF T2-TRIP(bus)*, the time 3408**T-Start MONITOR** can be set to expire together with **T2**.



[ls-versag-zeitabl-2stuf-versag-oz-020802, 1, en_GB]

Figure 2-80 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using two-stage breaker failure protection

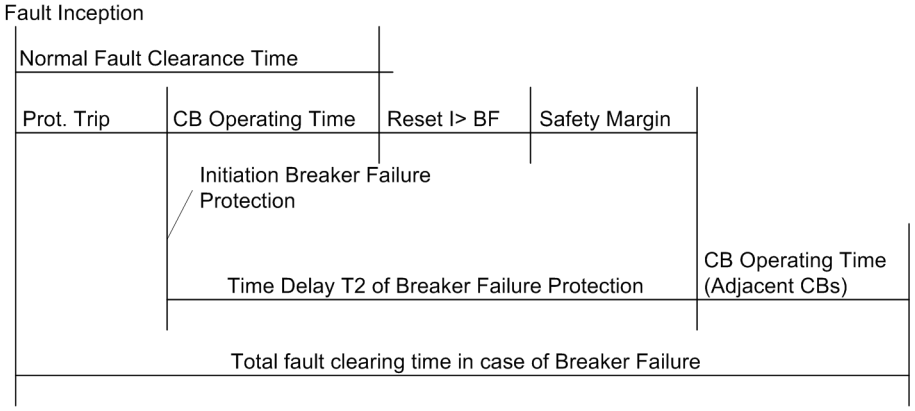
Single-stage circuit breaker failure protection

With single-stage operation, the adjacent circuit breakers (i.e. the circuit breakers of the busbar zone and, if applicable, the circuit breaker at the remote end) are tripped after a delay time **T2** (address 3906) should the fault not have been cleared within this time.

The times **T1-1pole** (address 3904) and **T1-3pole** (address 3905) are then set to ∞ since they are not needed.

You can also use the first stage alone if you wish to use different delay times after 1-pole and 3-pole tripping of the feeder protection. In this case set **T1-1pole** (address 3904) and **T1-3pole** (address 3905) separately, but address 3903 **1p-RETRIP (T1)** to ***NO***, to avoid a 1-pole trip command to the busbar. Set **T2** (address3906) to ∞ or equal to **T1-3pole** (address 3905). Be sure that the correct trip commands are assigned to the desired trip relay(s).

The delay time is determined from the maximum operating time of the feeder circuit breaker, the reset time of the current detectors of the circuit breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. *Figure 2-81* illustrates the timing of a typical circuit breaker failure scenario The dropout time for sinusoidal currents is ≤ 15 ms. If current transformer saturation is anticipated, the time should be set to 25 ms.



[ls-versag-zeitabl-1stuf-versag-oz-020802, 1, en_GB]

Figure 2-81 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using single-stage breaker failure protection

Circuit breaker not operational

These delays are not necessary if the control circuit of the local circuit breaker is faulted (e.g. control voltage failure or air pressure failure) since it is apparent that the circuit breaker is not capable of clearing the fault. If the relay is informed about this disturbance (via the binary input *>CB faulty*, the adjacent circuit breakers (busbar and remote end if applicable) are tripped after the time **T3-BkrDefective** (address 3907) which is usually set to **0**.

Address 3908 **Trip BkrDefect.** determines to which output the trip command is routed in the event that the circuit breaker is not operational when a feeder protection trip occurs. Select that output which is used to trip the adjacent circuit breakers (bus-bar trip).

End fault protection

The end fault protection can be switched in address 3921 **End Flt. stage** separately to ***ON*** or ***OFF***. An end fault is a short-circuit between the circuit breaker and the current transformer set of the feeder. The end fault protection presumes that the device is informed about the circuit breaker position via circuit breaker auxiliary contacts connected to binary inputs.

If, during an end fault, the circuit breaker is tripped by a reverse stage of the feeder protection or by the busbar protection (the fault is a busbar fault as determined from the location of the current transformers), the fault current will continue to flow, because the fault is fed from the remote end of the feeder circuit.

The time **T-EndFault** (address 3922) is started when, during the time of pickup condition of the feeder protection, the circuit breaker auxiliary contacts indicate open poles and, at the same time, current flow is still detected (address 3902). The trip command of the end fault protection is intended for the transmission of an intertrip signal to the remote end circuit breaker.

Thus, the delay time must be set so that it can bridge out short transient apparent end fault conditions which may occur during switching of the circuit breaker.

Pole discrepancy supervision

In address 3931 **PoleDiscrepancy** (pole discrepancy protection), the pole discrepancy supervision can be switched separately ***ON*** or ***OFF***. It is only useful if the circuit breaker poles can be operated individually. It avoids that only one or two poles of the local circuit breaker are open continuously. It has to be provided that either the auxiliary contacts of each pole or the series connection of the NO auxiliary contacts and the series connection of the NC auxiliary contacts are connected to the device's binary inputs. If these conditions are not fulfilled, switch address 3931 ***OFF***.

The delay time **T-PoleDiscrep.** (address 3932) indicates how long a circuit breaker pole discrepancy condition of the feeder circuit breaker, i.e. only one or two poles open, may be present before the pole discrepancy supervision issues a 3-pole trip command. This time must be clearly longer than the duration of a 1-pole automatic reclose cycle. The time should be less than the permissible duration of an unbalanced load condition which is caused by the unsymmetrical position of the circuit breaker poles. Standard durations are between 2 s and 5 s.

2.13.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
3901	FCT BreakerFail		ON OFF	ON	Breaker Failure Protection
3902	I> BF	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold I>
		5A	0.25 .. 100.00 A	0.50 A	
3903	1p-RETRIP (T1)		NO YES	YES	1pole retrip with stage T1 (local trip)
3904	T1-1pole		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 1pole start (local trip)

Addr.	Parameter	C	Setting Options	Default Setting	Comments
3905	T1-3pole		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 3pole start (local trip)
3906	T2		0.00 .. 30.00 sec; ∞	0.15 sec	T2, Delay of 2nd stage (busbar trip)
3907	T3-BkrDefective		0.00 .. 30.00 sec; ∞	0.00 sec	T3, Delay for start with defective bkr.
3908	Trip BkrDefect.		NO with T1-trip with T2-trip w/ T1/T2-trip	NO	Trip output selection with defective bkr
3909	Chk BRK CONTACT		NO YES	YES	Check Breaker contacts
3912	3I0> BF	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold 3I0>
		5A	0.25 .. 100.00 A	0.50 A	
3913	T2StartCriteria		With exp. of T1 Parallel withT1	Parallel withT1	T2 Start Criteria
3921	End Flt. stage		ON OFF	OFF	End fault protection
3922	T-EndFault		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay of end fault protection
3931	PoleDiscrepancy		ON OFF	OFF	Pole Discrepancy supervision
3932	T-PoleDiscrep.		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay with pole discrepancy

2.13.4 Information List

No.	Information	Type of Information	Comments
1401	>BF on	SP	>BF: Switch on breaker fail protection
1402	>BF off	SP	>BF: Switch off breaker fail protection
1403	>BLOCK BkrFail	SP	>BLOCK Breaker failure
1404	>BFactivate3I0>	SP	>BF Activate 3I0> threshold
1415	>BF Start 3pole	SP	>BF: External start 3pole
1424	>BF STARTonlyT2	SP	>BF: Start only delay time T2
1432	>BF release	SP	>BF: External release
1435	>BF Start L1	SP	>BF: External start L1
1436	>BF Start L2	SP	>BF: External start L2
1437	>BF Start L3	SP	>BF: External start L3
1439	>BF Start w/o I	SP	>BF: External start 3pole (w/o current)
1440	BkrFailON/offBI	IntSP	Breaker failure prot. ON/OFF via BI
1451	BkrFail OFF	OUT	Breaker failure is switched OFF
1452	BkrFail BLOCK	OUT	Breaker failure is BLOCKED
1453	BkrFail ACTIVE	OUT	Breaker failure is ACTIVE
1461	BF Start	OUT	Breaker failure protection started
1472	BF T1-TRIP 1pL1	OUT	BF Trip T1 (local trip) - only phase L1
1473	BF T1-TRIP 1pL2	OUT	BF Trip T1 (local trip) - only phase L2

No.	Information	Type of Information	Comments
1474	BF T1-TRIP 1pL3	OUT	BF Trip T1 (local trip) - only phase L3
1476	BF T1-TRIP L123	OUT	BF Trip T1 (local trip) - 3pole
1493	BF TRIP CBdefec	OUT	BF Trip in case of defective CB
1494	BF T2-TRIP(bus)	OUT	BF Trip T2 (busbar trip)
1495	BF EndFlt TRIP	OUT	BF Trip End fault stage
1496	BF CBdiscrSTART	OUT	BF Pole discrepancy pickup
1497	BF CBdiscr L1	OUT	BF Pole discrepancy pickup L1
1498	BF CBdiscr L2	OUT	BF Pole discrepancy pickup L2
1499	BF CBdiscr L3	OUT	BF Pole discrepancy pickup L3
1500	BF CBdiscr TRIP	OUT	BF Pole discrepancy Trip

2.14 Thermal Overload Protection

The thermal overload protection prevents damage to the protected object caused by thermal overloading, particularly in case of transformers, rotating machines, power reactors and cables. It is in general not necessary for overhead lines, since no meaningful overtemperature can be calculated because of the great variations in the environmental conditions (temperature, wind). In this case, however, a current-dependent alarm stage can signal an imminent overload.

2.14.1 Functional Description

The unit computes the overtemperature according to a thermal single-body model as per the following thermal differential equation

$$\frac{d\Theta}{dt} + \frac{1}{\tau_{th}} \cdot \Theta = \frac{1}{\tau_{th}} \cdot \left(\frac{I}{k \cdot I_N}\right)^2$$

[formel-therm-diffgl-wlk-010802, 1, en_GB]

with

- Θ – Current overtemperature in per cent of the final overtemperature at the maximum permissible phase current $k \cdot I_N$
- τ_{th} – Thermal time constant for the heating
- I – Present rms current
- k – k–factor indicating the maximum permissible constant current referred to the nominal current of the current transformers
- I_N – Rated current of the device

The solution of this equation is an e-function in steady-state operation whose asymptote represents the final temperature Θ_{End}. When the overtemperature reaches the first settable temperature threshold Θ_{alarm}, which is below the final overtemperature, an alarm is generated in order to allow a preventive load reduction. When the second overtemperature threshold, i.e. the final overtemperature (= tripping temperature), is reached, the protected object is disconnected from the network. The overload protection can, however, also be set to ***Alarm Only***. If this option is set, the device only generates an alarm, even if the end temperature is reached.

The overtemperatures are calculated separately for each phase in a thermal replica from the square of the associated phase current. This guarantees a true RMS value measurement and also includes the effect of harmonic content. A choice can be made whether the maximum calculated overtemperature of the three phases, the average overtemperature, or the overtemperature calculated from the phase with maximum current should be decisive for evaluation of the thresholds.

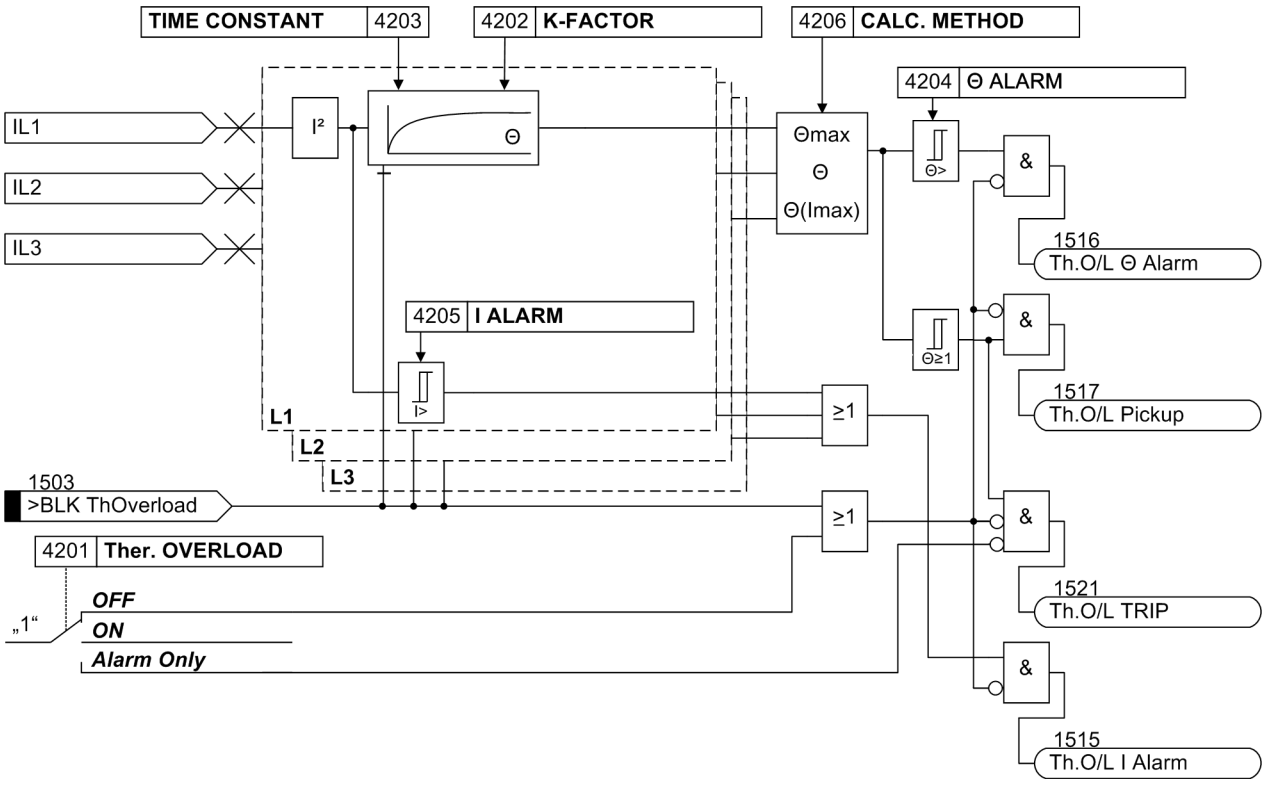
The maximum permissible continuous thermal overload current I_{max} is described as a multiple of the nominal current I_N:

$$I_{max} = k \cdot I_N$$

In addition to the k-factor, the time constant τ_{th} as well as the alarm temperature Θ_{alarm} must be entered as settings of the protection.

In addition to the temperature warning stage, the overload protection also features a current warning element I_{alarm}. It reports an overload current prematurely, even if the calculated overtemperature has not yet attained the warning or tripping temperature levels.

The overload protection can be blocked via a binary input. In doing so, the thermal images are also reset to zero.



[logikdia-therm-ueberlst-wlk-010802, 1, en_GB]

Figure 2-82 Logic diagram of the thermal overload protection

2.14.2 Setting Notes

General

A prerequisite for using the thermal overload protection is that during the configuration of the scope of functions at address 142 **Ther. OVERLOAD** = ***Enabled*** was applied. At address 4201 **Ther. OVERLOAD** the function can be turned ***ON*** or ***OFF***. Furthermore, ***Alarm Only*** can be set. With the latter setting the protection function is active but only outputs the indication *Th.O/L Pickup* (address 1517) when the tripping temperature is reached. The indication *Th.O/L TRIP* (address 1521) is not generated.

k-factor

The nominal device current is taken as a basis for overload detection. The setting factor k is set under address 4202 **K-FACTOR**. It is determined by the relation between the permissible thermal continuous current and this nominal current:

$$k = \frac{I_{max}}{I_N}$$

[formel-therm-ueberl-k-fakt-1-oz-020802, 1, en_GB]

The permissible continuous current is at the same time the current at which the e-function of the overtemperature has its asymptote. It is not necessary to determine the tripping temperature since it results automatically from the final rise temperature at $k \cdot I_N$. Manufacturers of electrical machines usually state the permissible continuous current. If no data are available, k is set to 1.1 times the nominal current of the protected object. For cables, the permissible continuous current depends on the cross section, the insulation material, the design and the way they are laid, and can be derived from the relevant tables.

Please note that the overload capability of electrical equipment relates to its primary current. This has to be considered if the primary current differs from the nominal current of the current transformers.

Example:

Belted cable 10 kV 150 mm²

Permissible continuous current I_{max} = 322 A

Current transformers 400 A/5 A

$$k = \frac{322\ A}{400\ A} = 0.805$$

[formel-therm-ueberl-k-fakt-2-oz-020802, 1, en_GB]

Setting value **K-FACTOR** = **0,80**

Time constant τ

The thermal time constant τ_{th} is set at address 4203 **TIME CONSTANT**. This is also provided by the manufacturer. Please note that the time constant is set in minutes. Quite often other values for determining the time constant are stated which can be converted into the time constant as follows:

1-s current

$$\frac{\tau_{th}}{min} = \frac{1}{60} \cdot \left(\frac{\text{perm. 1-s current}}{\text{perm. contin.current}}\right)^2$$

[formel-therm-ueberl-zeitkonst-1-oz-020802, 1, en_GB]

Permissible current for application time other than 1 s, e.g. for 0.5 s

$$\frac{\tau_{th}}{min} = \frac{0,5}{60} \left(\frac{\text{perm. 0.5-s current}}{\text{perm. contin.current}}\right)^2$$

[formel-therm-ueberl-zeitkonst-2-oz-020802, 1, en_GB]

t_6-time; this is the time in seconds for which a current of 6 times the nominal current of the protected object may flow

$$\frac{\tau_{th}}{min} = 0.6 \cdot t_6$$

[formel-therm-ueberl-zeitkonst-3-oz-020802, 1, en_GB]

Example:

Cable as above with

Permissible 1-s current 13.5 kA

$$\frac{\tau_{th}}{min} = \frac{1}{60} \cdot \left(\frac{13500\ A}{322\ A}\right)^2 = \frac{1}{60} \cdot 42^2 = 29.4$$

[formel-therm-ueberl-zeitkonst-4-oz-020802, 1, en_GB]

Setting value **TIME CONSTANT** = **29.4 min**

Alarm levels

By setting a thermal alarm stage **Θ ALARM** (address 4204) an alarm can be provided before the tripping temperature is reached, so that a trip can be avoided by preventive load reduction or by switching over. The percentage is referred to the tripping temperature rise.

The current overload alarm stage **I ALARM** (address 4205) is stated as a factor of the nominal device current and should be set equal to or slightly below the permissible continuous current $k \cdot I_N$. It can also be used instead of the thermal alarm stage. In this case the thermal alarm stage is set to 100 % and is thus practically ineffective.

Calculating the overtemperature

The thermal replica is calculated individually for each phase. Address 4206 **CALC. METHOD** decides whether the highest of the three calculated temperatures (***Θ max***) or their arithmetic average (***Average Θ***) or the temperature calculated from the phase with maximum current (***Θ from Imax***) should be decisive for the thermal alarm and tripping stage.

Since overload is usually a symmetrical process, this setting is of minor importance. If asymmetrical overloads are to be expected, however, these options lead to different results.

Averaging should only be used if a rapid thermal equilibrium is possible in the protected object, e.g. with belted cables. If the three phases are, however, more or less thermally isolated (e.g. single conductor cables or overhead lines), one of the maximum settings should be chosen at any rate.

2.14.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
4201	Ther. OVERLOAD		OFF ON Alarm Only	OFF	Thermal overload protection
4202	K-FACTOR		0.10 .. 4.00	1.10	K-Factor
4203	TIME CONSTANT		1.0 .. 999.9 min	100.0 min	Time Constant
4204	Θ ALARM		50 .. 100 %	90 %	Thermal Alarm Stage
4205	I ALARM	1A	0.10 .. 4.00 A	1.00 A	Current Overload Alarm Setpoint
		5A	0.50 .. 20.00 A	5.00 A	
4206	CALC. METHOD		Θ max Average Θ Θ from Imax	Θ max	Method of Acquiring Temperature

2.14.4 Information List

No.	Information	Type of Information	Comments
1503	>BLK ThOverload	SP	>BLOCK Thermal Overload Protection
1511	Th.Overload OFF	OUT	Thermal Overload Protection OFF
1512	Th.Overload BLK	OUT	Thermal Overload Protection BLOCKED
1513	Th.O/L ACTIVE	OUT	Thermal Overload Protection ACTIVE
1515	Th.O/L I Alarm	OUT	Th. Overload: Current Alarm (I alarm)
1516	Th.O/L Θ Alarm	OUT	Th. Overload Alarm: Near Thermal Trip
1517	Th.O/L Pickup	OUT	Th. Overload Pickup before trip
1521	Th.O/L TRIP	OUT	Th. Overload TRIP command

2.15 Monitoring Functions

The device is equipped with extensive monitoring capabilities - concerning both, hardware and software. In addition, the measured values are also constantly checked for plausibility, so that the current and voltage transformer circuits are largely integrated into the monitoring. It is also possible to implement trip circuit supervision. This supervision is possible using appropriate available binary inputs.

2.15.1 Measurement Supervision

2.15.1.1 Hardware Monitoring

The device is monitored from the measuring inputs up to the command relays. Monitoring circuits and the processor check the hardware for malfunctions and inadmissible conditions.

Auxiliary and Reference Voltages

The processor voltage of 5 V is monitored by the hardware, as the processor no longer functions on undershooting the minimum value. In that case, the device is not operational. On recovery of the voltage the processor system is restarted.

If the supply voltage is removed or switched off, the device is taken out of service, and an indication is immediately generated by a normally closed contact. Brief voltage interruptions of up to 50 ms do not disturb the operational readiness of the device (see Technical Data).

The processor monitors the reference voltage of the ADC (analog-to-digital converter). The protection is suspended if the voltages deviate outside an allowable range, and persistent deviations are reported.

Buffer battery

The buffer battery, which ensures the operation of the internal clock and the storage of counters and indications if the auxiliary voltage fails, is periodically checked for charge status. On its undershooting a minimum admissible voltage, the indication *Fail Battery* (no.177) is issued.

If the device is not supplied with auxiliary voltage for more than 1 or 2 days, the internal clock is switched off automatically, i.e. the time is not registered any more. The data in the event and fault buffers, however, remain stored.

Memory Components

The main memory (RAM) is tested when the system starts up. If a fault is detected during this process, the startup is aborted. Error LED and LED 1 light up and the remaining LEDs start flashing simultaneously. During operation the memory is checked by means of its checksum.

A checksum of the program memory (EPROM) is cyclically generated and compared with the stored program checksum.

A checksum for the parameter memory (FLASH-EPROM) is cyclically generated and compared with the checksum which is computed after each change of the stored parameters.

If a malfunction occurs, the processor system is restarted.

Sampling Frequency

The sampling frequency and the synchronism between the ADCs (analog-to-digital converters) is continuously monitored. If deviations that may occur cannot be corrected by another synchronisation, the device sets itself out of operation and the red LED “ERROR” lights up; The device-ready relay relay drops off and signals the malfunction by its life “contact”.

Measured Value Acquisition - Currents

Up to four input currents are measured by the device. If the three phase currents and the earth current from the current transformer starpoint or a separated earth current transformer of the line to be protected are connected to the device, their digitized sum must be zero. Faults in the current circuit are recognized if

$I_F = |\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} + k_I \cdot \underline{I}_E| > \mathbf{\Sigma I\ THRESHOLD} + \mathbf{\Sigma I\ FACTOR} \cdot \Sigma |I|$

Factor k_I (address 221 **I4/Iph CT**) takes into account a possible different ratio of a separate I_E transformer (e.g. cable core balance current transformer). **ΣI THRESHOLD** and **ΣI FACTOR**. are setting parameters.

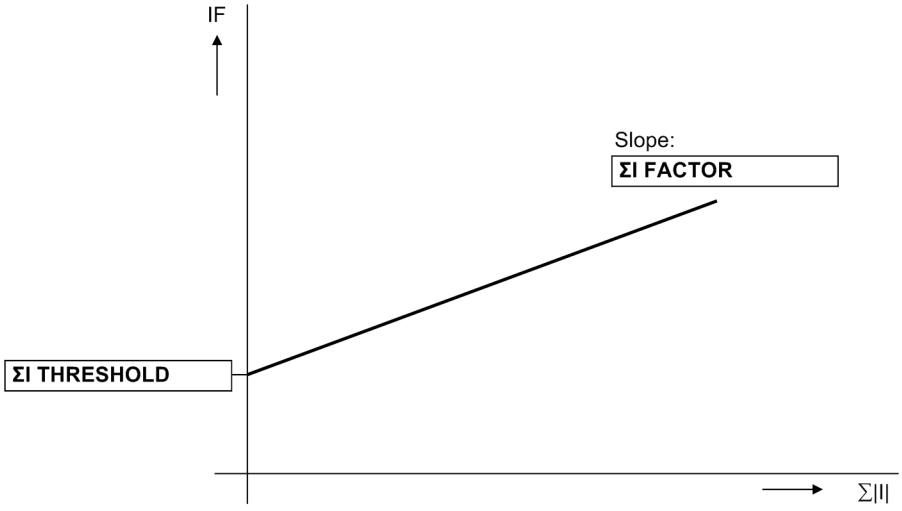
The **ΣI FACTOR** $\Sigma |I|$ part takes into account permissible current-proportional transformation errors of the transformer, which can occur in the case of high short-circuit currents.*Figure 2-83*). $\Sigma |I|$ is the sum of all currents:

$\Sigma |I| = |\underline{I}_{L1}| + |\underline{I}_{L2}| + |\underline{I}_{L3}| + |k_I \cdot \underline{I}_E|$

As soon as the current summation supervision detects a fault in the current transformer circuits, the differential protection is blocked. This supervision is signalled as *Failure ΣI* (No. 289). In order to avoid a blocking due to transformation errors (saturation) in case of high fault currents, this monitoring function is not effective during a system fault.

NOTE

The I_4 transformer must have been configured with parameter **I4 transformer** (address 220) as ***In prot. line***.



[stromsummenueberwachung-020313-kn, 1, en_GB]

Figure 2-83 Current sum monitoring

Measured Value Acquisition Voltages

Four measuring inputs are available in the voltage path: three for phase-to-earth voltages and one input for the displacement voltage (e-n voltage of open delta winding) or a busbar voltage. If the displacement voltage is connected to the device, the sum of the three digitized phase voltages must equal three times the zero sequence voltage. Errors in the voltage transformer circuits are detected when

$U_F = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \cdot \underline{U}_{EN}| > 25\ V.$

The factor k_U allows for a difference of the transformation ratio between the displacement voltage input and the phase voltage inputs (address 211 **Uph / Udelta**).

This fault is signaled as *Fail Σ U Ph-E* (no. 165).

NOTE

Voltage sum monitoring is only effective if an external displacement voltage is connected to the displacement voltage measuring input.

Voltage sum monitoring can operate properly only if the adaptation factor **Uph / Udelta** at address 211 has been correctly configured (see Subsection *2.1.2.1 Setting Notes*).

2.15.1.2 Software Monitoring

Watchdog

For continuous monitoring of the program sequences, a time monitor is provided in the hardware (watchdog for hardware) that expires upon failure of the processor or an internal program, and causes a reset of the processor system with complete restart.

An additional software watchdog ensures that malfunctions during the processing of programs are discovered. This also initiates a restart of the processor system.

If the fault is not eliminated by the restart, a second restart attempt is initiated. If the fault is still present after three restart attempts within 30 s, the protection system will take itself out of service, and the red LED "ERROR" lights up. The device ready relay drops out and alarms the device malfunction with its normally closed contact("Life-Contact").

2.15.1.3 Measurement Circuit Monitoring

Interruptions or short circuits in the secondary circuits of the current and voltage transformers, as well as faults in the connections (important for commissioning!), are detected and reported by the device. To this end, the measured values are cyclically checked in the background as long as no fault detection is present.

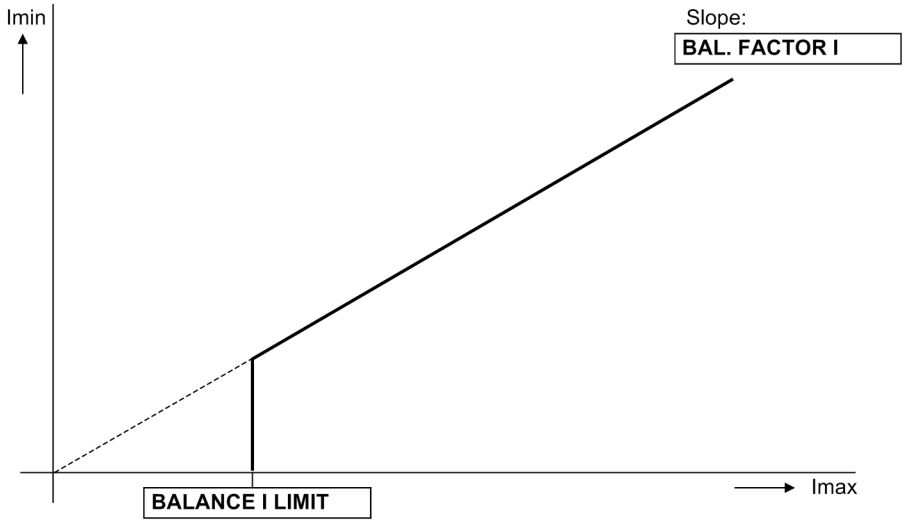
Current Symmetry

During normal system operation the currents are assumed to be largely symmetrical. The symmetry is monitored in the device by magnitude comparison. The smallest phase current is compared to the largest phase current. Asymmetry is recognized if:

$|I_{min}| / |I_{max}| <$ **BAL. FACTOR I** as long as $I_{max} >$ **BALANCE I LIMIT**

I_{max} is the highest, I_{min} the lowest of the three phase currents. The symmetry factor **BAL. FACTOR I** (address 2905) represents the allowable asymmetry of the phase currents while the limit value **BALANCE I LIMIT** (address 2904) is the lower limit of the operating range of this monitoring (see *Figure 2-84*). The dropout ratio is about 97 %.

After a settable time (5 s -100 s), this malfunction is signaled as *Fail I balance* (No. 163).



[stromsymmetrieueberwachung-020313-kn, 1, en_GB]

Figure 2-84 Current symmetry monitoring

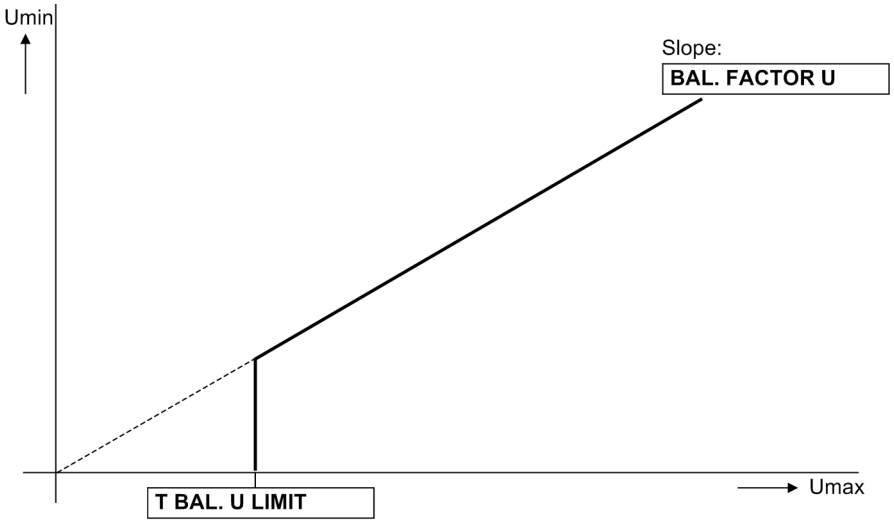
Voltage Symmetry

During normal system operation the voltages are assumed to be largely symmetrical. The symmetry is monitored in the device by magnitude comparison. The smallest phase voltage is compared to the largest. Asymmetry is recognized if:

$|U_{min}| / |U_{max}| <$ **BAL. FACTOR U** as long as $|U_{max}| >$ **BALANCE U-LIMIT**

Thereby U_{max} is the largest of the three phase-to-phase voltages and U_{min} the smallest. The symmetry factor **BAL. FACTOR U** (address 2903) represents the allowable asymmetry of the voltages while the limit value **BALANCE U-LIMIT** (address 2902) is the lower limit of the operating range of this monitoring (see *Figure 2-85*). The dropout ratio is about 97 %.

After a settable time, this malfunction is signaled as *Fail U balance* (no.167).



[spannungssymmetrieueberwachung-020313-kn, 1, en_GB]

Figure 2-85 Voltage symmetry monitoring

Broken wire monitoring

During steady-state operation the broken wire monitoring detects interruptions in the secondary circuit of the current transformers. In addition to the hazard potential caused by high voltages in the secondary circuit, this kind of interruption causes differential currents to the differential protection, such as those evoked by faults in the protected object.

The broken wire monitoring function monitors the local phase currents of all three phases and the results of the broken wire monitoring supplied by the devices on the other ends of the protected object. At each sampling moment, the function checks whether there is a jump in one of the three phase currents; if there is, it generates the “suspected wire break” signal.

There is a suspected local wire break if a jump has been detected in the affected phase and the current has dropped to 0 A.

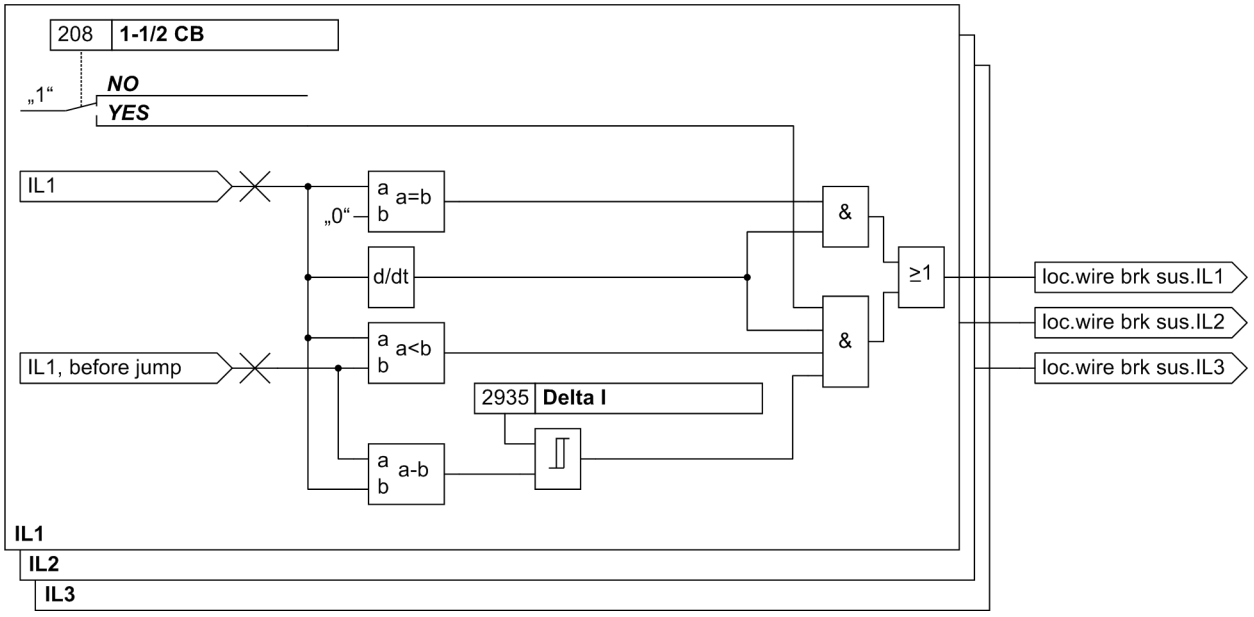
In case of a 1-1/2 circuit breaker arrangement, the current will not necessarily jump to 0 in case of a wire break because the second primary current transformer will continue to measure one part of the phase current; this means that the current of the affected phase will simply jump to a different value. For such circuit breaker arrangements, parameter 2935 **ΔI min** min is used as the criterion. This setting value specifies the difference that must exist between the measured current values before and after the jump in order to detect a suspected local wire break. Local wire break detection is only possible if the current amplitude after the jump is lower than the current amplitude before the jump.

WARNING

If the CT secondary circuits are inadvertently opened while the broken wire monitoring is activated, the differential protection is phase-selectively blocked and will be no longer able to trip!

This state may give rise to hazardous overvoltages in the open CT circuit, which will not lead to a trip because the differential protection is blocked.

✧



[logik-lokal-drahtbruch-081024, 1, en_GB]

Figure 2-86 Generating the suspected local wire break information

A wire break is signalled under the following conditions:

- A suspected local wire break has been detected.
- The logic for detecting the circuit breaker position (see Section *2.16.1 Function Control*, Detection of the Circuit Breaker Position) does not signal an open circuit breaker pole. Wire break detection is not possible if the circuit breaker is open. If the breaker position cannot be determined, a closed circuit breaker is assumed.
- In all voltage channels, no jump must have been detected. Jumps in these channels indicate a genuine power system fault.
- In the other current channels, there must have been no jump without wire break detection. Jumps in the other current channels also suggest a power system fault, except if a suspected local wire break has been detected for the affected phases.
- The device at the other end of the protected object must not have signalled a jump. The jump information is transferred together with the differential protection measurements, so that this information is available simultaneously with the first run of the differential protection after the jump.
- In the phase, also the devices at the other end of the protected object must not have measured a phase current of more than 2 I_N. A phase current of such a magnitude is a certain indicator of a power system fault.

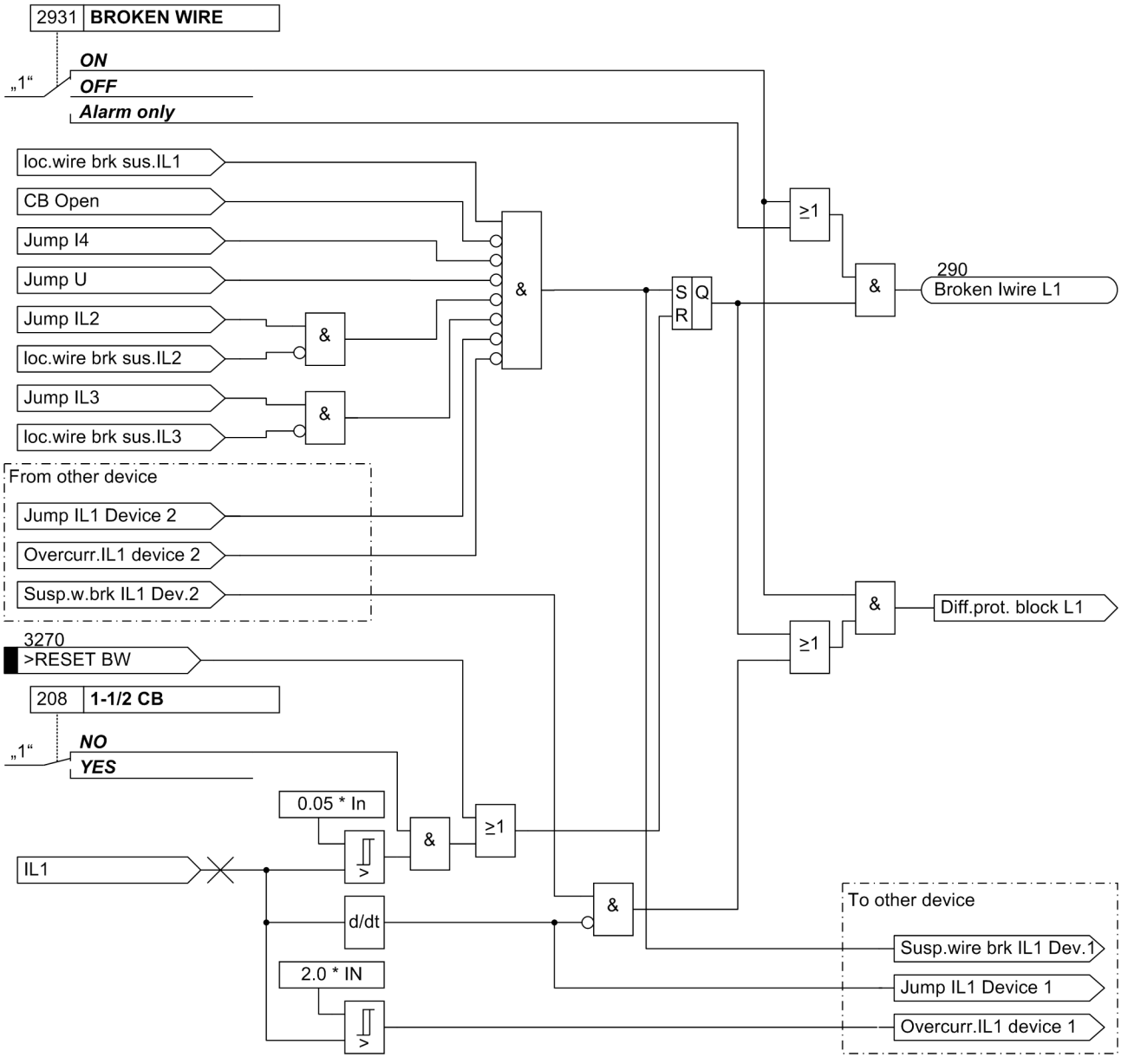
When a wire break has been detected according to the above critera, it is signalled via the protection data interface to the other devices of the constellation, and leads immediately to a wire break message. The differential protection functions are blocked as well if this has been configured.

A local wire break generates the message “Wire break I_{Lx}” (No.290, 291, 292), the detection of a wire break in another device generates the message “Wire break at the other end II_{Lx}” (No. 297, 298, 299). If the broken wire monitoring is disabled, the message 295 *Broken wire OFF* is output.

The broken wire monitoring is reset by the return of the phase current ($I_{Lx} > 0.05\ I_N$) or by the binary input message 3270 *>RESET BW*. In 1-1/2 circuit breaker arrangements, the function can only be reset by the binary input message because the current magnitude is no reliable criterion for a reset of the broken wire monitoring.

If the communication between the devices is disturbed, the device operates in emergency operation. The differential protection is not active. The wire break detection then operates only with the locally available information. Multipole wire break is not indicated in emergency operation.

It has to be observed that electronic test devices do not behave like a circuit breaker so that pickup can occur during such tests.



[logik-7sd610-drahtbruch, 1, en_GB]

Figure 2-87 Broken-wire monitoring

Voltage Phase Sequence

The phase rotation of the measured voltages is checked by monitoring of the voltage phase sequence.

$\underline{U}_{L1}$ before $\underline{U}_{L2}$ before $\underline{U}_{L3}$

This check takes place if each measured voltage has a minimum magnitude of

$|U_{L1}|, |U_{L2}|, |U_{L3}| > 40\ V/\sqrt{3}$

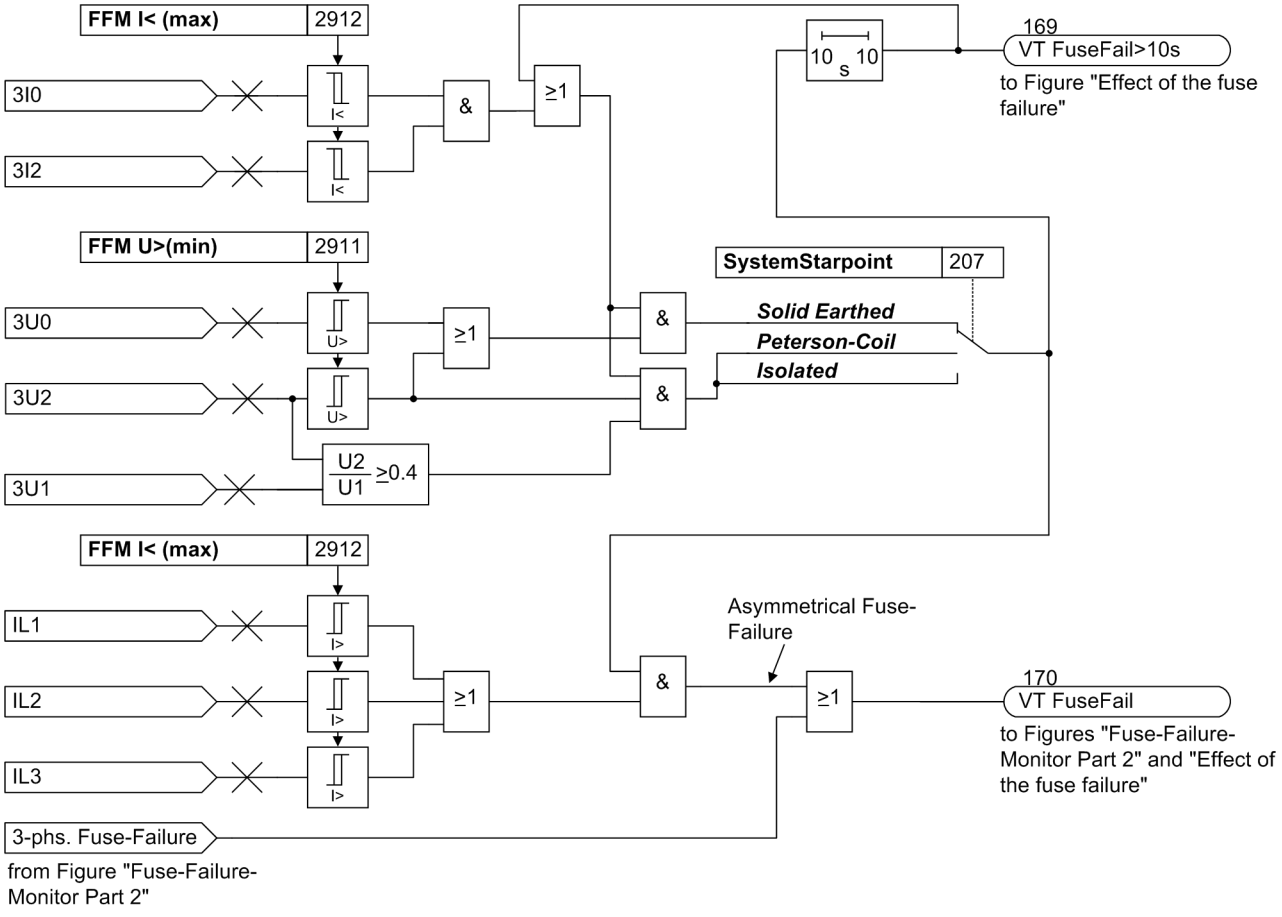
In case of negative phase rotation, the indication *Fail Ph. Seq.* (No. 171) is issued.

Fast Asymmetrical Measuring Voltage Failure "Fuse Failure Monitor"

In the event of a measured voltage failure due to a short circuit fault or a broken conductor in the voltage transformer secondary circuit certain measuring loops may mistakenly see a voltage of zero. Simultaneously existing load currents may then cause a spurious pickup.

If fuses are used instead of a voltage transformer miniature circuit breaker (VT mcb) with connected auxiliary contacts, then the "Fuse-Failure-Monitor" can detect problems in the voltage transformer secondary circuit. Of course, the VT miniature circuit breaker and the "Fuse-Failure-Monitor" can be used at the same time.

Figure 2-88 and *Figure 2-89* show the logic diagram of the "Fuse-Failure-Monitors".



[lo-ffm-mcl-01-20101014, 1, en_GB]

Figure 2-88 Fuse failure monitoring Part 1: Detection of asymmetrical measuring voltage failure

The **asymmetrical measured voltage failure** is characterised by its voltage asymmetry with simultaneous current symmetry. If there is substantial voltage asymmetry of the measured values, without asymmetry of the currents being registered at the same time, this indicates the presence of an asymmetrical failure in the voltage transformer secondary circuit.

The asymmetry of the voltage is detected by the fact that either the zero sequence voltage or the negative sequence voltage exceed a settable value **`FFM U>(min)`** (address 2911). The current is assumed to be sufficiently symmetrical if both the zero sequence as well as the negative sequence current are below the settable threshold **`FFM I< (max)`** (address 2912).

In non-earthed systems (address 207 **`SystemStarpoint`**), the zero-sequence system quantities are no reliable criterion since a considerable zero sequence voltage occurs also in case of a simple earth fault where a significant zero sequence current does not necessarily flow. Therefore, the zero sequence voltage is not evaluated in these systems but only the negative sequence voltage and the ratio between negative sequence and positive sequence voltage.

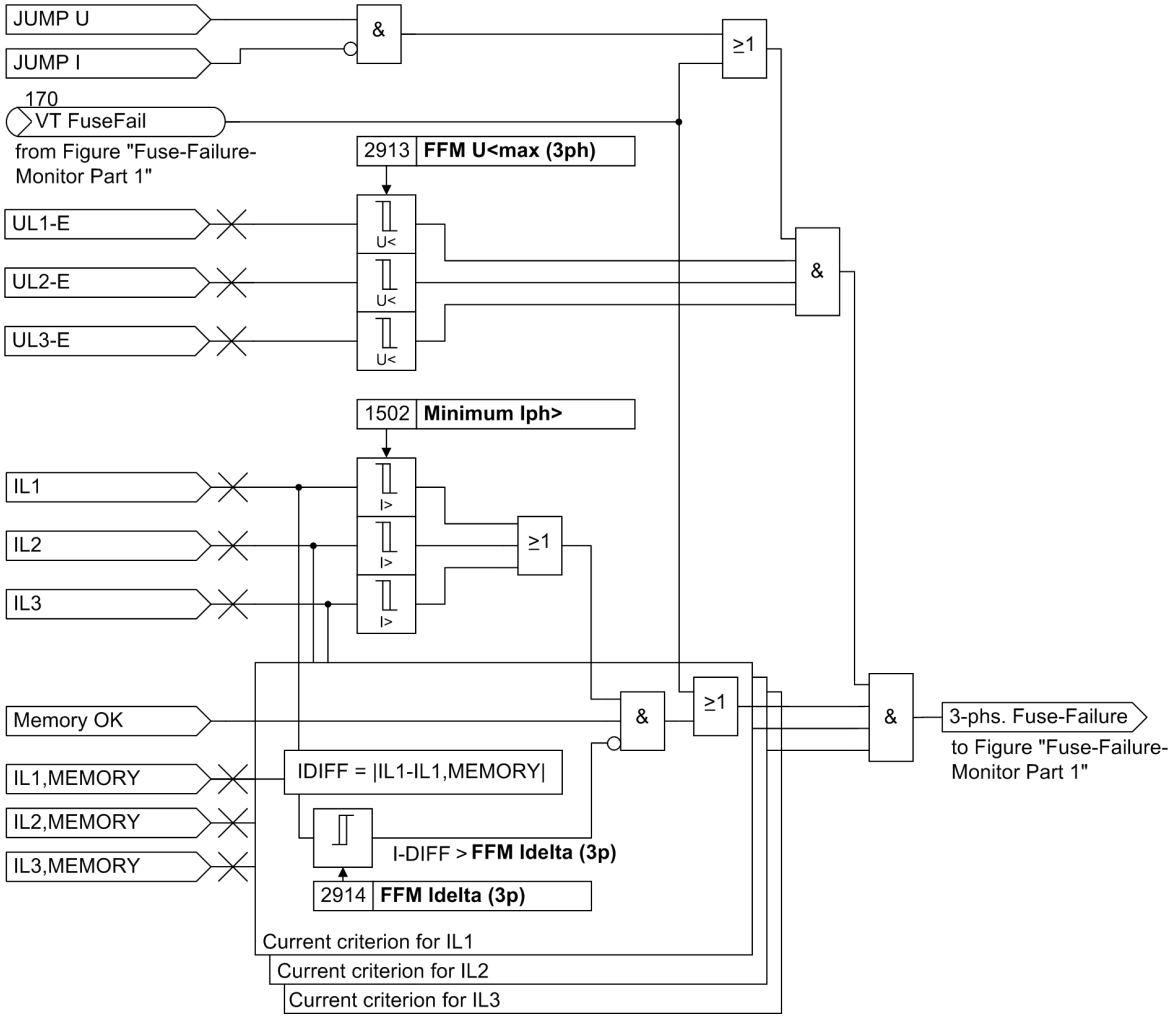
As soon as such an error has been detected, all functions that work on the basis of undervoltage are blocked. The immediate blocking requires that current flows in at least one of the phases. The differential protection

can be switched to emergency operation, provided that these functions are parameterized accordingly (refer also to Section *2.9 Backup Time Overcurrent Protection*).

The immediate effect of the "Fuse-Failure-Monitors" is signaled by means of the indication *VT FuseFail* (No. 170). To detect an asymmetrical measuring voltage failure, at least one phase current must exceed the value **FFM I< (max)** (address 2912).

In case that zero sequence or negative sequence current arise within 10 s after detecting an asymmetrical measuring voltage failure, a short-circuit in the network is assumed and the signal *VT FuseFail* is immediately reset. If the zero-sequence voltage or the negative-sequence voltage exceed the presettable value **FFM U>(min)** (address 2911) for more than 10 s, the signal *VT FuseFail>10s* (No. 169) will be generated. In this status, a reset of the signal *VT FuseFail* will no longer be effected by means of an increase of the zero-sequence current or the negative-sequence current, but only through the fact that the voltages in the zerosequence system and in the negative-sequence system fall below the threshold value. The signal *VT FuseFail* can also be generated independently from the quantity of the phase currents.

During a single-pole automatic reclose dead time, the "Fuse-Failure-Monitor" does not detect an asymmetrical measuring voltage failure. Due to the de-energization in one phase, an operational asymmetry is caused on the primary side which cannot be distinguished from a measuring voltage failure in the secondary circuit (not represented in the logic diagram).



[lo_7sd5-ffm-mcl-02, 1, en_GB]

Figure 2-89 Fuse failure monitoring Part 2: Detection of three-phase measuring voltage failure

A **3-phase failure of the secondary measured voltages** can be distinguished from an actual system fault by the fact that the currents have no significant change in the event of a failure in the secondary measured voltage. For this reason, the current values are routed to a buffer so that the difference between present and

stored current values can be analysed to recognise the magnitude of the current differential (current differential criterion), see *Figure 2-89*.

A three-pole measuring voltage failure is detected if:

- All 3 phase-to-earth voltages are smaller than the threshold **FFM U<max (3ph)** (address 2913).
- The current differential in all 3 phases is smaller than the threshold **FFM Idelta (3p)** (address 2914).

If such a voltage failure is recognized, the protection functions whose measuring principle is based on undervoltage are blocked until the voltage failure is removed; afterwards the blocking is automatically reset. O/C emergency operation is possible during the voltage failure, provided that the time overcurrent protection is parameterized accordingly (refer also to Section *2.9 Backup Time Overcurrent Protection*).

A three-pole measuring voltage failure is also detected without the mentioned criteria if the signal *VT FuseFail* (No. 170) previously has been generated by an asymmetrical measuring voltage failure. The measuring voltage failure is still detected in this state if the three phase-to-earth voltages subsequently fall below the threshold value **FFM U<max (3ph)** (address 2913).

The effect of the signals *VT FuseFail* (No. 170) and *VT FuseFail>10s* (No. 169) on the protection functions is described in the following section “Effect of the measuring voltage failure”.

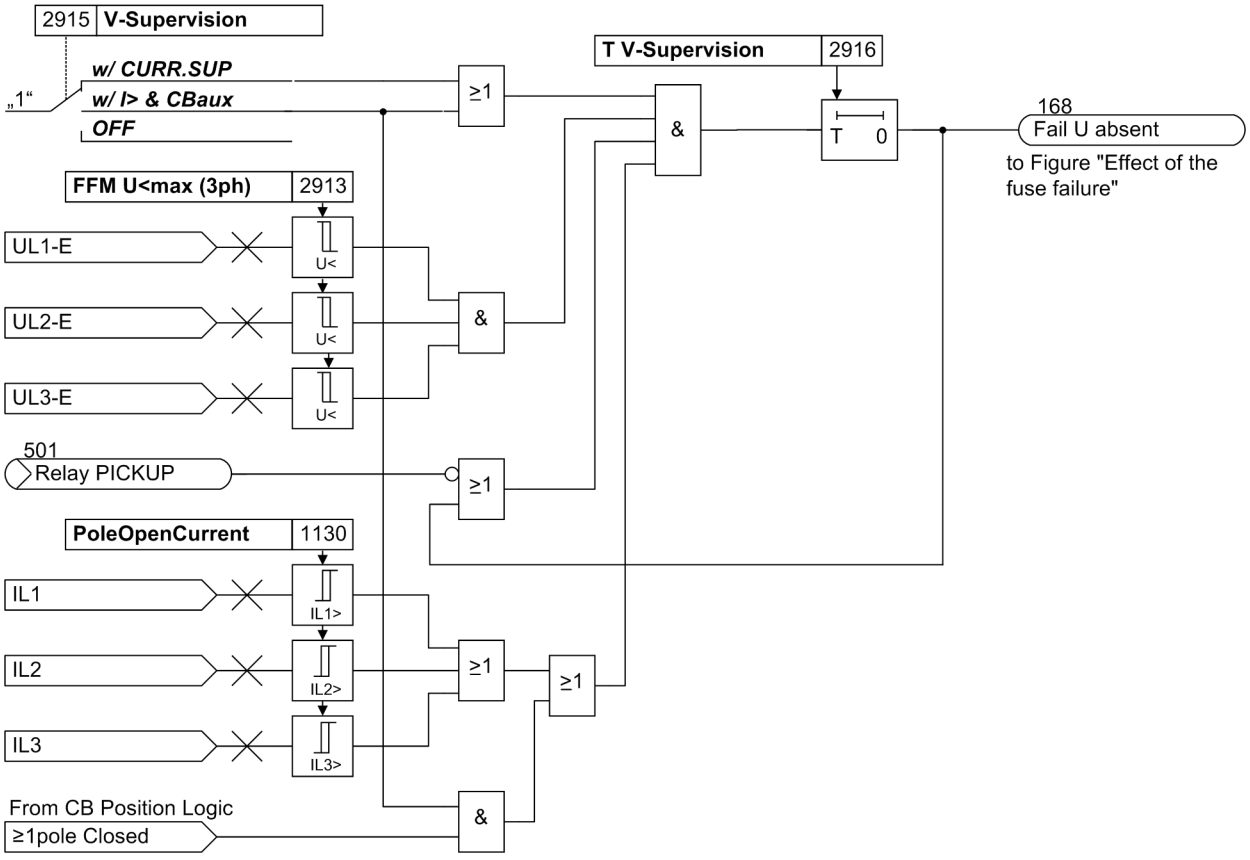
Additional Measured Voltage Failure Monitoring

If no measuring voltage is available after power-on of the circuit breaker (e.g. because the voltage transformers are not connected), the absence of the voltage can be detected and reported by an additional monitoring function. Where circuit breaker auxiliary contacts are used, they should be used for monitoring as well. *Figure 2-90* shows the logic diagram of the measured voltage failure monitoring. A failure of the measured voltage is detected if the following conditions are met at the same time:

- All 3 phase-to-earth voltages are less than **FFM U<max (3ph)**
- At least 1 phase current is larger than **PoleOpenCurrent** or at least 1 breaker pole is closed (can be set), • No protection function has picked up,
- es liegt keine Anregung einer Schutzfunktion vor
- This condition persists for a settable time **T V-Supervision** (default setting: 3 s).

The time **T V-Supervision** is required to prevent that a voltage failure is detected before the protection picks up.

If this monitoring function picks up, the indication *Fail U absent* (No. 168) will be issued. The effect of this monitoring indication will be described in the following section “Effect of the Measuring Voltage Failure”.



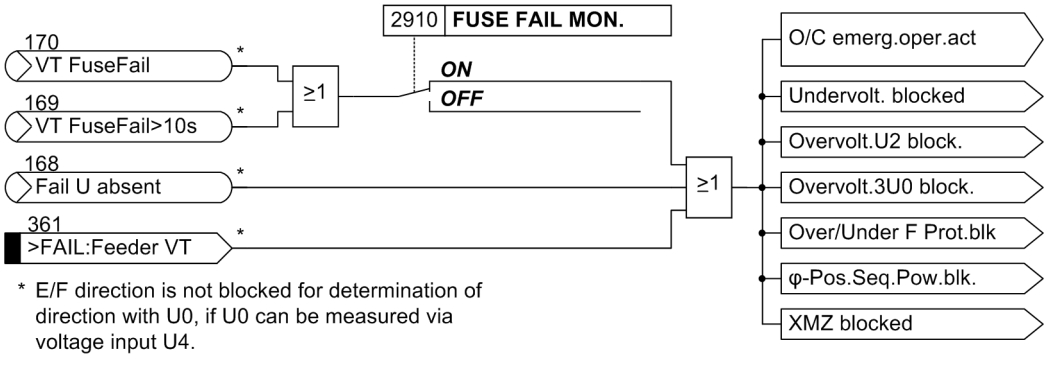
[logikdia-zusaetzl-messspgausfall-wlk-010802, 1, en_GB]

Figure 2-90 Logic diagram of the additional measured voltage failure monitoring *Fail U absent*

Effect of the Measuring Voltage Failure

In the event of a measuring voltage failure due to a short-circuit or broken conductor in the voltage transformer secondary circuit, some or all measuring loops may mistakenly see a voltage of zero. In case that load currents exist simultaneously, incorrect pickup could occur. If such a voltage failure is detected, the protection functions that operate on the basis of undervoltage are blocked.

The following figure shows the effect on the protection functions in case that a measuring voltage is detected by the "Fuse-Failure-Monitor"" *VT FuseFail* (No. 170), *VT FuseFail>10s* (No. 169), the additional measuring voltage failure monitoring *Fail U absent* (No. 168) and the binary input of the VT miniature circuit breaker *>FAIL:Feeder VT* (No. 361).



[lo-ffm-mcl-7sd6, 1, en_GB]

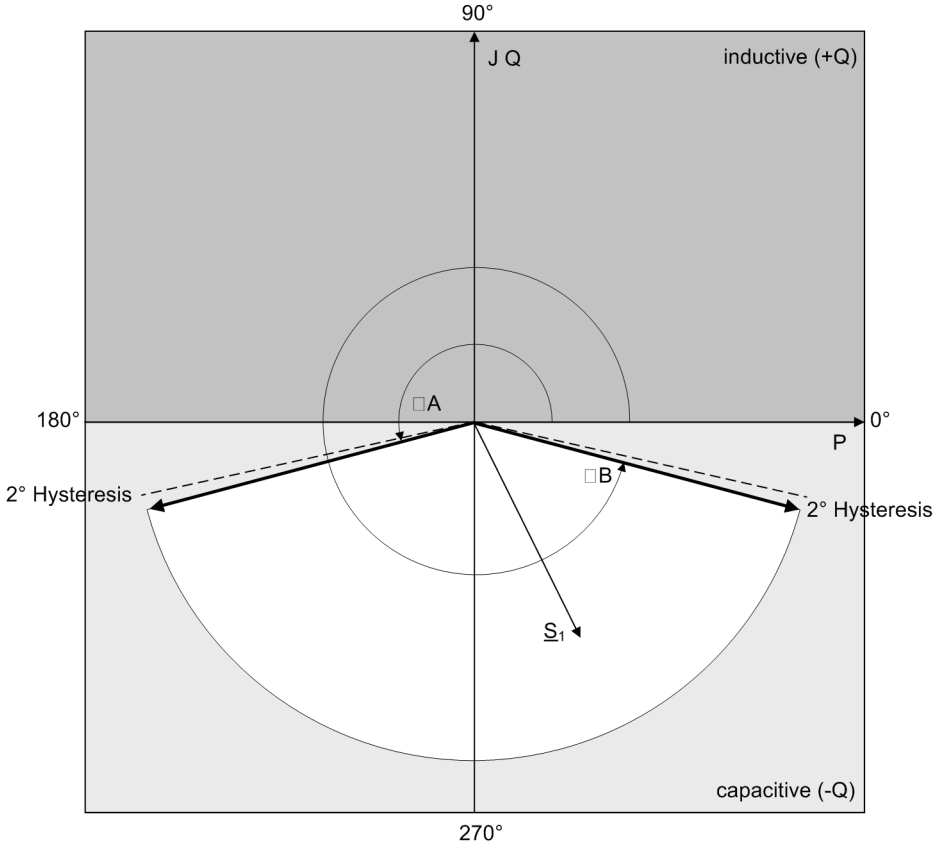
Figure 2-91 Effect of the measuring voltage failure

2.15.1.4 Monitoring the Phase Angle of the Positive Sequence Power

This monitoring function allows determining the direction of power flow. You can monitor the phase angle of the complex power, and generate an indication when the power phasor is inside a settable segment.

One example of this application is the indication of capacitive reactive power. The monitoring indication can then be used to control the overvoltage protection function. For this purpose, two angles must be set, as shown in *Figure 2-92* . In this example, φA = 200° und φB = 340° have been set.

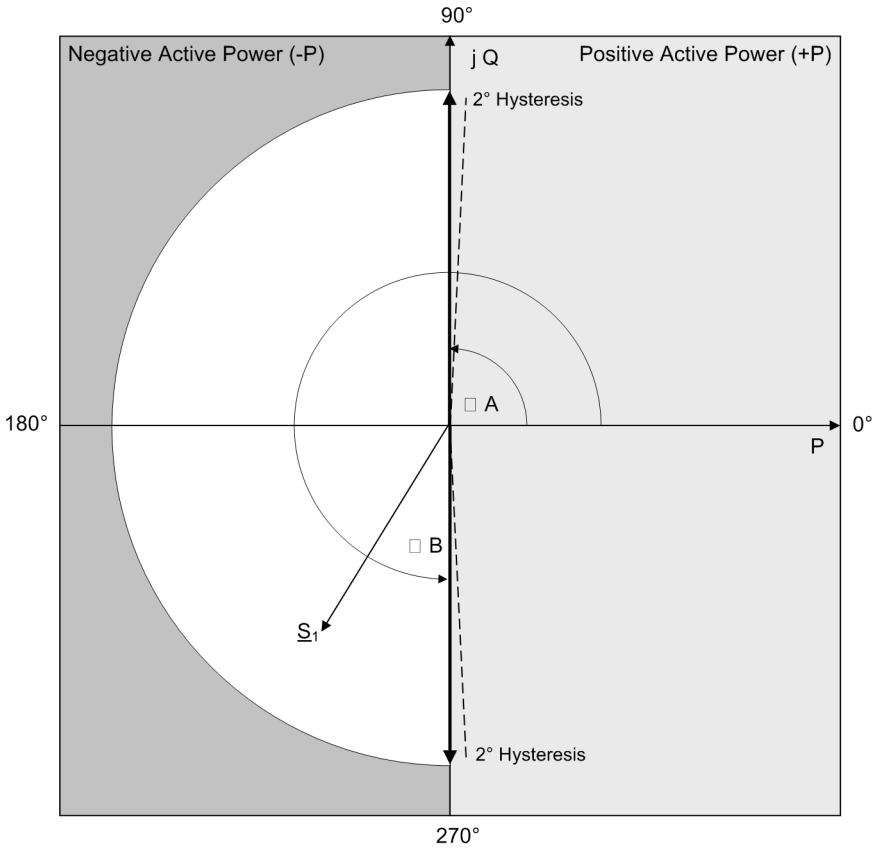
If the measured phase angle φ($\underline{S}_1$) of the positive sequence power is innerhalb the area of the P-Q plane delimited by the angles φA and φB, the indication *ϕ(PQ Pos. Seq.)* (No. 130) is output. The angles φA and φB can be freely set in the range between 0° and 359°. The area starts at φA and extends in a mathematically positive sense as far as the angle φB. A hysteresis of 2° is provided to prevent erroneous indications which might emerge at the threshold limits.



[blindleistung-ind-kap-wlk040602, 1, en_GB]

Figure 2-92 Characteristic of the Positive Sequence System Phase Angle Monitoring

The monitoring function can also be used for the display of negative active power. In this case the areas must be defined as shown in *Figure 2-93* .



[wirkleistung-ind-kap--wlk040602, 1, en_GB]

Figure 2-93 Phase Angle Monitoring for Negative Active Power

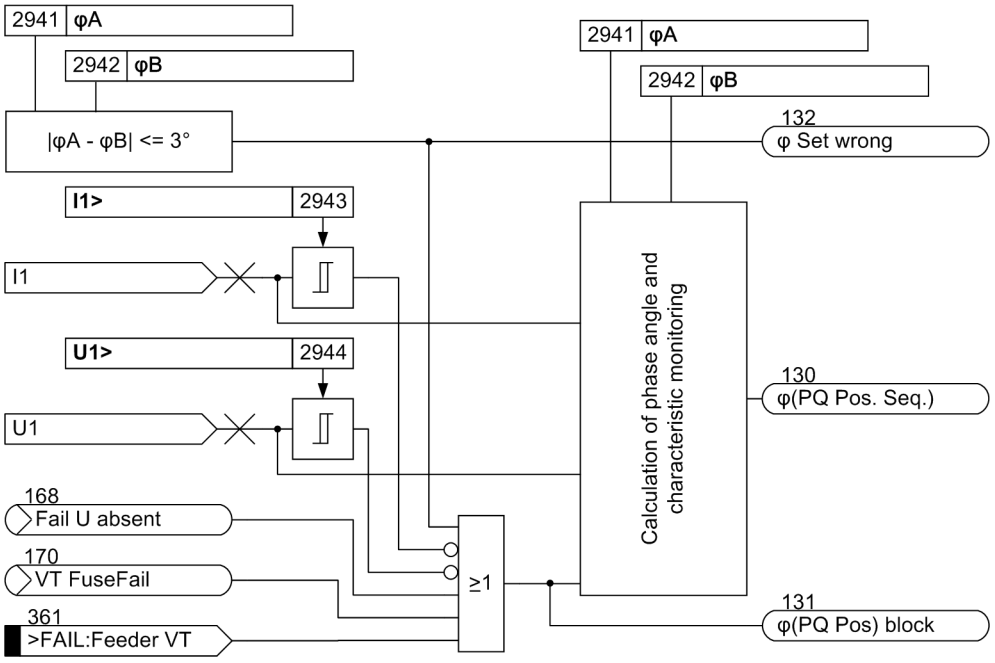
The two angles must be at least 3° apart; if they are not, monitoring is blocked, and the indication *ϕ Set wrong* (No. 132 is output.

The following conditions must be fulfilled for measurement to be enabled:

- The positive sequence current $\underline{I}_1$ is higher than the value set in parameter 2943 **I1>**.
- The positive sequence voltage $\underline{U}_1$ is higher than the value set in parameter 2944 **U1>**.
- The angles set in address 2941 **φA** and 2942 **φB** must be at least 3° apart. Incorrect parameter settings cause the indication 132 *ϕ Set wrong* to be output.
- The "Fuse-Failure-Monitor" and the measured voltage failure monitoring must not have responded, and binary input indication 361 *>FAIL:Feeder VT* must not be present.

If monitoring is not active, this fact is signaled by the indication *ϕ(PQ Pos) block* (No. 131).

Figure 2-94 shows the logic of the positive sequence system phase angle monitoring.



[logikphasenwinkelueberwachung-wlk-040514, 1, en_GB]

Figure 2-94 Logic of the Positive Sequence System Phase Angle Monitoring

2.15.1.5 Fault Reactions

Depending on the kind of fault detected, an alarm is given, the processor is restarted or the device is taken out of operation. After three unsuccessful restart attempts, the device is taken out of service. The device ready relay drops out and indicates the device failure with its NC contact ("life contact"). The red LED "ERROR" on the device front lights up, provided that there is an internal auxiliary voltage, and the green LED "RUN" goes off. If the internal auxiliary voltage supply fails, all LEDs are dark. Table 2-19 shows a summary of the monitoring functions and the malfunction responses of the device.

Table 2-7 Summary of malfunction responses of the device

Monitoring	Possible Causes	Malfunction Response	Indication (No.)	Output
Auxiliary Supply Voltage Loss	External (aux. voltage) internal (converter)	Device out of operation or alarm	All LEDs dark *Error 5V* (144)	DOK[2] drops
Measured Value Acquisition	Internal (converter or reference voltage)	Protection out of operation, alarm	LED "ERROR" *Error A/D-conv.* (181)	DOK[2] drops
Buffer battery	Internal (battery)	Indication	*Fail Battery* (177)	as allocated
Hardware Watchdog	Internal (processor failure)	Device not in operation	LED "ERROR"	DOK[2] drops
Software-Watchdog	Internal (program sequence)	Restart attempt [1]	LED "ERROR"	DOK[2] drops
RAM	Internal (RAM)	Restart attempt [1], Restart abort Device not in operation	LED flashes	DOK[2] drops
ROM	Internal (EPROM)	Restart attempt [1]	LED "ERROR"	DOK[2] drops
Settings memory	Internal (Flash-EPROM or RAM)	Restart attempt [1]	LED "ERROR"	life contact[2] drops
Scanning frequency	Internal ((clock generator)	Restart attempt [1]	LED "ERROR"	DOK[2] drops

Monitoring	Possible Causes	Malfunction Response	Indication (No.)	Output
1 A/5 A setting	1/5 A jumper wrong	Messages: Protection out of operation	*Error1A/5Awrong* (192) *Error A/D-conv.* (181) LED "ERROR"	DOK[2] drops
Adjustment values	Internal (EEPROM or RAM)	Indication: Use of default values	*Alarm adjustm.* (193)	as allocated
Modules	Module does not comply with ordering number (MLFB).	Indications: Protection out of operation	"Error Board BG1...7" (183 ... 189) and if applicable *Error A/D-conv.*. (181)	DOK[2] drops
Current sum	Internal (measured value acquisition)	Indication Total blocking of differential protection	*Failure Σ I* (162)	as allocated
Current symmetry	External (power system or current transformer)	Indication	*Fail I balance* (163)	as allocated
Broken Conductor	External (power system or current transformer)	Indication Total blocking of differential protection	*Fail Conductor* (195)	as allocated
Voltage sum	Internal (measured value acquisition)	Indication	*Fail Σ U Ph-E* (165)	as allocated
Voltage symmetry	External (power system or voltage transformer)	Indication	*Fail U balance* (167)	as allocated
Voltage phase sequence	External (power system or connection)	Indication	*Fail Ph. Seq.* (171)	as allocated
Voltage failure, 3-phase"Fuse-Failure-Monitor"	External (power system or connection)	Indication Undervoltage protection is blocked, Frequency protection is blocked, and	*VT FuseFail>10s* (169), *VT FuseFail* (170)	as allocated
Voltage failure, 1-/2-phase"Fuse-Failure-Monitor"	External (voltage transformers)	Indication Undervoltage protection is blocked, Frequency protection is blocked, and	*VT FuseFail>10s* (169), *VT FuseFail* (170)	as allocated
Voltage failure, 3-phase	External (power system or connection)	Indication Undervoltage protection is blocked, Frequency protection is blocked, and	*Fail U absent* (168)	as allocated
Trip Circuit Monitoring	External (trip circuit or control voltage)	Indication	*FAIL: Trip cir.* (6865)	as allocated

[1] after three unsuccessful restarts, the device is taken out of service.

[2] DOK = "Devive OK" = NC contact of the operational readiness relay = life contact

2.15.1.6 Setting Notes

General

The sensitivity of the measured value monitoring can be changed. Experiential values set ex works are adequate in most cases. If particularly high operational asymmetries of the currents and/or voltages are

expected, or if one or more monitoring functions pick up sporadically during normal operation, the sensitivity settings should be made less sensitive..

At address 2901 **MEASURE. SUPERV** measurement supervision can be switched ***ON*** or ***OFF***.

Symmetry monitoring

Address2902 **BALANCE U-LIMIT** determines the limit voltage (phase-to-phase), above which the voltage symmetry monitoring is effective. Address 2903 **BAL. FACTOR U** is the associated balance factor, i.e. the gradient of the balance characteristic. The indication *Fail U balance* (No 167) can be delayed under address 2908 **T BAL. U LIMIT**. These settings can only be changed via DIGSI at **Display Additional Settings**.

Address2904 **BALANCE I LIMIT** determines the limit current above which the current symmetry monitoring is effective. Address 2905 **BAL. FACTOR I** is the associated balance factor, i.e. the gradient of the balance characteristic. The indication *Fail I balance* (No 163) can be delayed under address 2909 **T BAL. I LIMIT**. These settings can only be changed via DIGSI at **Display Additional Settings**.

Sum Monitoring

Address 2906 **ΣI THRESHOLD** determines the limit current above which the current sum monitoring is activated (absolute portion, only relative to I_N). The relative portion (relative to the maximum phase current) for activating the current sum monitoring is set at 2907 **ΣI FACTOR**. These settings can only be changed via DIGSI at **Display Additional Settings**.



NOTE

Current sum monitoring can operate properly only when the residual current of the protected line is fed to the fourth current input (I_4) of the relay.

The I_4 transformer must have been configured with parameter **I4 transformer** (address 220) as ***In prot. line***.

Broken wire monitoring

The broken wire monitoring is enabled or disabled via the parameter 2931 **BROKEN WIRE**. The differential protection function is only blocked with the setting ***ON***. By means of the setting ***Alarm only***, a broken wire can be signalled; the protection functions are not blocked.

In case of a 1-1/2 circuit breaker arrangement, the parameter 208 **1-1/2 CB** is to be set to ***YES***. Parameter 2935 **ΔI min** indicates the minimum difference for this circuit breaker arrangement by which the current would decrease in case of a wire break.

Asymmetrical measuring voltage failure "Fuse Failure Monitor"

The settings for the “fuse failure monitor” for non-symmetrical measuring voltage failure must be selected such that on the one hand it is reliably activated if a phase voltage fails (address 2911 **FFM U>(min)**), but does not pick up on earth faults in an earthed network on the other hand. Accordingly, address 2912 **FFM I<(max)** (max) must be set sufficiently sensitive (below the smallest fault current during earth faults). These settings can only be changed via DIGSI at **Display Additional Settings**.

In address 2910 **FUSE FAIL MON.** the “Fuse-Failure-Monitor”, e.g. during asymmetrical testing, can be switched ***OFF***.

Three-phase measuring voltage failure „Fuse-Failure-Monitor“

In address 2913 **FFM U<max (3ph)** the minimum voltage threshold is set. If the measured voltage drops below this threshold and a simultaneous current jump which exceeds the limits according to address 2914 **FFM Idelta (3p)** is not detected a threephase measured voltage failure is recognized. These settings can only be changed via DIGSI at Display **Additional Settings**.

In address 2910 **FUSE FAIL MON.**, the „Fuse Failure Monitor“, e.g. during asymmetrical testing, can be switched ***OFF***.

Measured voltage failure monitoring

The measured voltage failure monitoring can be switched under address 2915 **V-Supervision w/ *CURR.SUP***, ***w/ I> & CBaux*** or ***OFF***. Address 2916 **T V-Supervision** is used to set the waiting time of the voltage failure supervision. This setting can only be changed in DIGSI at **Display Additional Settings**.

Circuit breaker for voltage transformers

If a circuit breaker for voltage transformers (VT mcb) is installed in the secondary circuit of the voltage transformers, the status is sent, via binary input, to the device informing it about the position of the VT mcb. If a shortcircuit in the secondary circuit initiates the tripping of the VT mcb, the voltage protection function is blocked, as otherwise it would cause spurious tripping as a result of the absent measured voltage. The reaction time is set at address 2921 **T mcb**.

2.15.1.7 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2901	MEASURE. SUPERV		ON OFF	ON	Measurement Supervision
2902A	BALANCE U-LIMIT		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
2903A	BAL. FACTOR U		0.58 .. 0.95	0.75	Balance Factor for Voltage Monitor
2904A	BALANCE I LIMIT	1A	0.10 .. 1.00 A	0.50 A	Current Balance Monitor
		5A	0.50 .. 5.00 A	2.50 A	
2905A	BAL. FACTOR I		0.10 .. 0.95	0.50	Balance Factor for Current Monitor
2906A	ΣI THRESHOLD	1A	0.10 .. 2.00 A	0.25 A	Summated Current Monitoring Threshold
		5A	0.50 .. 10.00 A	1.25 A	
2907A	ΣI FACTOR		0.00 .. 0.95	0.50	Summated Current Monitoring Factor
2908A	T BAL. U LIMIT		5 .. 100 sec	5 sec	T Balance Factor for Voltage Monitor
2909A	T BAL. I LIMIT		5 .. 100 sec	5 sec	T Current Balance Monitor
2910	FUSE FAIL MON.		ON OFF	ON	Fuse Failure Monitor
2911A	FFM U>(min)		10 .. 100 V	30 V	Minimum Voltage Threshold U>
2912A	FFM I< (max)	1A	0.05 .. 1.00 A	0.10 A	Maximum Current Threshold I<
		5A	0.25 .. 5.00 A	0.50 A	
2913A	FFM U<max (3ph)		2 .. 100 V	15 V	Maximum Voltage Threshold U< (3phase)
2914A	FFM Idelta (3p)	1A	0.05 .. 1.00 A	0.10 A	Delta Current Threshold (3phase)
		5A	0.25 .. 5.00 A	0.50 A	
2915	V-Supervision		w/ CURR.SUP w/ I> & CBaux OFF	w/ CURR.SUP	Voltage Failure Supervision
2916A	T V-Supervision		0.00 .. 30.00 sec	3.00 sec	Delay Voltage Failure Supervision
2921	T mcb		0 .. 30 ms	0 ms	VT mcb operating time

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2931	BROKEN WIRE		ON OFF Alarm only	OFF	Fast broken current-wire supervision
2933	FAST Σ i SUPERV		ON OFF	ON	State of fast current summation supervis
2935A	ΔI min	1A	0.05 .. 1.00 A	0.10 A	Min. current diff. for wire break det.
		5A	0.25 .. 5.00 A	0.50 A	
2941	φA		0 .. 359 °	200 °	Limit setting PhiA
2942	φB		0 .. 359 °	340 °	Limit setting PhiB
2943	I1>	1A	0.05 .. 2.00 A	0.05 A	Minimum value I1>
		5A	0.25 .. 10.00 A	0.25 A	
2944	U1>		2 .. 70 V	20 V	Minimum value U1>

2.15.1.8 Information List

No.	Information	Type of Information	Comments
130	φ(PQ Pos. Seq.)	OUT	Load angle Phi(PQ Positive sequence)
131	φ(PQ Pos) block	OUT	Load angle Phi(PQ) blocked
132	φ Set wrong	OUT	Setting error: |PhiA - PhiB| < 3°
161	Fail I Superv.	OUT	Failure: General Current Supervision
163	Fail I balance	OUT	Failure: Current Balance
164	Fail U Superv.	OUT	Failure: General Voltage Supervision
165	Fail Σ U Ph-E	OUT	Failure: Voltage summation Phase-Earth
167	Fail U balance	OUT	Failure: Voltage Balance
168	Fail U absent	OUT	Failure: Voltage absent
169	VT FuseFail>10s	OUT	VT Fuse Failure (alarm >10s)
170	VT FuseFail	OUT	VT Fuse Failure (alarm instantaneous)
171	Fail Ph. Seq.	OUT	Failure: Phase Sequence
196	Fuse Fail M.OFF	OUT	Fuse Fail Monitor is switched OFF
197	MeasSup OFF	OUT	Measurement Supervision is switched OFF
289	Failure Σi	OUT	Alarm: Current summation supervision
290	Broken Iwire L1	OUT	Alarm: Broken current-wire detected L1
291	Broken Iwire L2	OUT	Alarm: Broken current-wire detected L2
292	Broken Iwire L3	OUT	Alarm: Broken current-wire detected L3
295	Broken wire OFF	OUT	Broken wire supervision is switched OFF
296	Σi superv. OFF	OUT	Current summation superv is switched OFF
297	ext.Brk.Wire L1	OUT	Broken current-wire at other end L1
298	ext.Brk.Wire L2	OUT	Broken current-wire at other end L2
299	ext.Brk.Wire L3	OUT	Broken current-wire at other end L3
3270	>RESET BW	SP	>RESET broken wire monitoring
3271	Broken Iwire L1	IntSP	Alarm: Broken current-wire detected L1
3272	Broken Iwire L2	IntSP	Alarm: Broken current-wire detected L2
3273	Broken Iwire L3	IntSP	Alarm: Broken current-wire detected L3

2.15.2 Trip Circuit Supervision

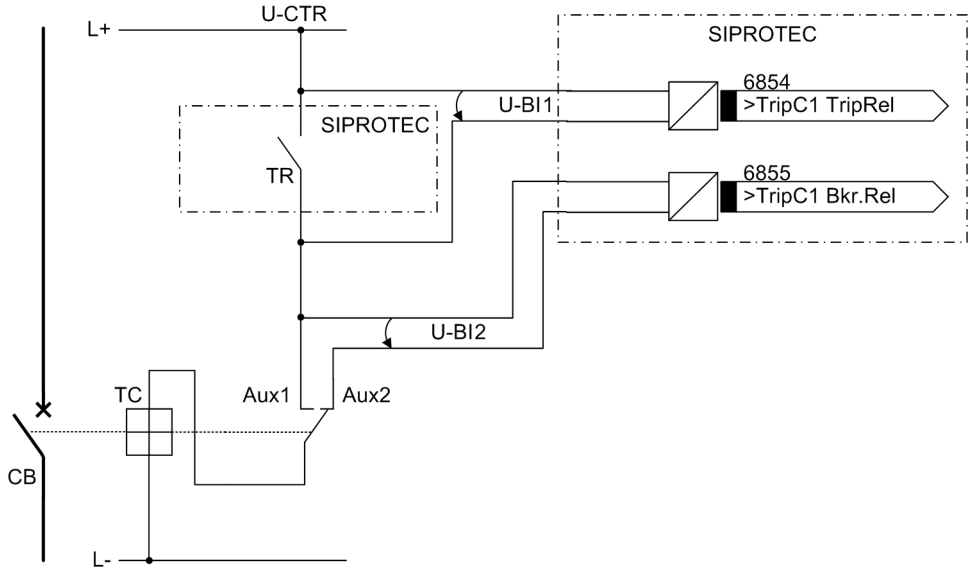
The line protection 7SD610 is equipped with an integrated trip circuit supervision function. Depending on the number of available binary inputs (not connected to a common potential), supervision with one or two binary inputs can be selected. If the routing of the binary inputs required for this does not comply with the selected supervision mode, an alarm is given (“TripC1 ProgFAIL ...”, with identification of the non-compliant circuit). When using two binary inputs, malfunctions in the trip circuit can be detected under all circuit breaker conditions. When only one binary input is used, malfunctions in the circuit breaker itself cannot be detected. If singlepole tripping is possible, a separate trip circuit supervision can be implemented for each circuit breaker pole provided the required binary inputs are available.

2.15.2.1 Functional Description

Supervision with Two Binary Inputs

When using two binary inputs, these are connected according to *Figure 2-95* parallel to the associated trip contact on one side, and parallel to the circuit breaker auxiliary contacts on the other.

A precondition for the use of the trip circuit supervision is that the control voltage for the circuit breaker is higher than the total of the minimum voltages drops at the two binary inputs ($U_{Ctrl} > 2 \cdot U_{BImin}$). Since at least 19 V are needed for each binary input, the supervision function can only be used with a system control voltage of over 38 V.



[prinzip-ausloesekrueb-2-be-wlk-010802, 1, en_GB]

Figure 2-95 Principle of the trip circuit supervision with two binary inputs

TR	Trip relay contact
CB	Circuit breaker
TC	Circuit breaker trip coil
Aux1	Circuit breaker auxiliary contact (NO contact)
Aux2	Circuit breaker auxiliary contact (NC contact)
U-CTR	Control voltage (trip voltage)
U-BI1	Input voltage of 1st binary input
U-BI2	Input voltage of 2nd binary input

Supervision with two binary inputs not only detects interruptions in the trip circuit and loss of control voltage, it also supervises the response of the circuit breaker using the position of the circuit breaker auxiliary contacts.

Depending on the conditions of the trip contact and the circuit breaker, the binary inputs are activated (logical condition “H” in the following table), or short-circuited (logical condition “L”).

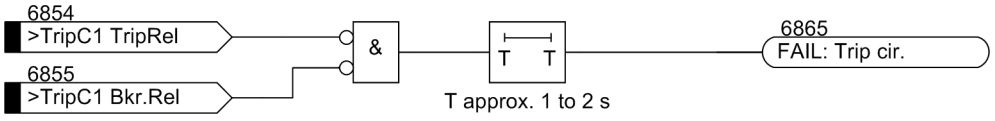
A state in which both binary inputs are not activated (“L”) is only possible in intact trip circuits for a short transition period (trip relay contact closed but circuit breaker not yet open).

A continuous state of this condition is only possible when the trip circuit has been interrupted, a short-circuit exists in the trip circuit, a loss of battery voltage occurs, or malfunctions occur with the circuit breaker mechanism. Therefore, it is used as supervision criterion.

Table 2-8 Condition table for binary inputs, depending on RTC and CB position

No.	Trip Contact	Circuit Breaker	Aux 1	Aux 2	BI 1	BI 2	Dynamic State	Static State
1	open	ON	closed	open	H	L	Normal operation with circuit breaker closed	
2	open	OFF	open	closed	H	H	Normal operation with circuit breaker open	
3	closed	ON	closed	open	L	L	Transition or malfunction	Malfunction
4	closed	OFF	open	closed	L	H	TR has tripped successfully	

The conditions of the two binary inputs are checked periodically. A query takes place about every 500 ms. If three consecutive conditional checks detect an abnormality, a fault indication is output (see *Figure 2-96*). The repeated measurements determine the delay of the alarm message and avoid that an alarm is output during short transition periods. After clearance of the failure in the trip circuit, the failure alarm automatically resets with the same time delay.



[logikdiagramm-auskruebrwchg-2-be-wlk-310702, 1, en_GB]

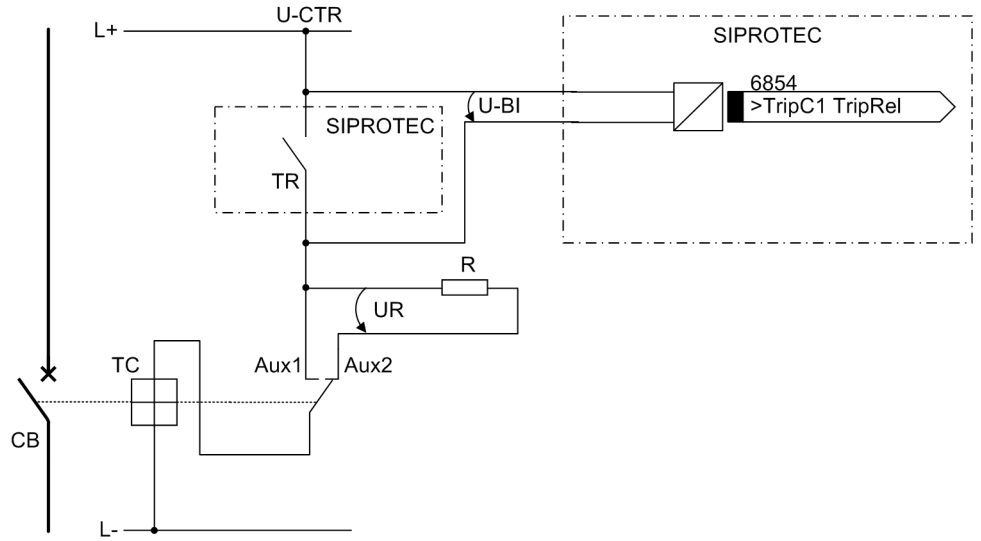
Figure 2-96 Logic diagram of the trip circuit supervision with two binary inputs

Supervision with One Binary Input

According to *Figure 2-97*, the binary input is connected in parallel to the respective command relay contact of the protection device. The circuit breaker auxiliary contact is bridged with a high-resistance bypass resistor R.

The control voltage for the circuit breaker should be at least twice as high as the minimum voltage drop at the binary input ($U_{Ctrl} > 2 \cdot U_{BImin}$). Since at least 19 V are needed for the binary input, the monitor can be used with a system control voltage of over 38 V.

A calculation example for the bypass resistor R is shown in the configuration notes in Section “Mounting and Connections”, margin heading “Trip Circuit Supervision”.



[prinzip-ausloesekrueb-1-be-wlk-010802, 1, en_GB]

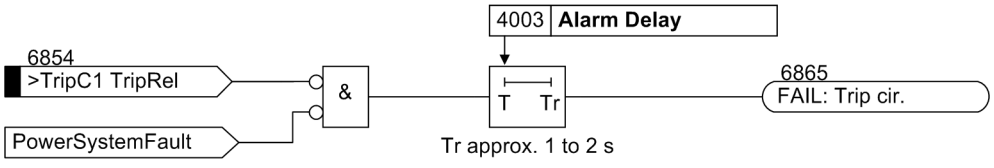
Figure 2-97 Principle of the trip circuit supervision with one binary input

TR	Trip relay contact
CB	Circuit breaker
TC	Circuit breaker trip coil
Aux1	Circuit breaker auxiliary contact (NO contact)
Aux2	Circuit breaker auxiliary contact (NC contact)
U-CTR	Control voltage for trip circuit
U-BI	Input voltage of binary input
R	Bypass resistor
UR	Voltage across the bypass resistor

During normal operation, the binary input is activated (logical condition “H”) when the trip contact is open and the trip circuit is intact, because the supervision circuit is closed either by the circuit breaker auxiliary contact (if the circuit breaker is closed) or through the bypass resistor R. Only as long as the trip contact is closed, the binary input is short-circuited and thereby deactivated (logical condition “L”).

If the binary input is permanently deactivated during operation, an interruption in the trip circuit or a failure of the (trip) control voltage can be assumed.

The trip circuit supervision does not operate during system faults. A momentary closed tripping contact does not lead to a fault indication. If, however, other trip relay contacts from different devices are connected in parallel in the trip circuit, the fault indication must be delayed by **`Alarm Delay`** (see also *Figure 2-98*). After clearance of the failure in the trip circuit, the fault message automatically resets with the same time delay.



[logikdiagramm-auskruebrwchg-1-be-wlk-310702, 1, en_GB]

Figure 2-98 Logic diagram for trip circuit supervision with one binary input

2.15.2.2 Setting Notes

General

The number of circuits to be supervised was set during the configuration in address 140 **Trip Cir. Sup.** (Section *2.1.1.2 Setting Notes*). If the trip circuit supervision is not used at all, the setting ***Disabled*** must be applied there.

The trip circuit supervision can be switched in address 4001 **FCT TripSuperv.** ***ON*** or ***OFF***. The number of binary inputs that shall be used in each of the supervised circuits is set in address 4002 **No. of BI**. If the routing of the required binary inputs does not comply with the selected monitoring mode, an alarm is issued (*TripC ProgFAIL...* with identification of the non-compliant circuit).

Supervision with one binary input

The alarm for supervision with two binary inputs is always delayed by approx. 1s to 2s, whereas the delay time of the alarm for supervision with one binary input can be set in address 4003 **Alarm Delay**. If only the device 7SD610 is connected to the trip circuits 1 s to 2 s are sufficient, as the trip circuit supervision does not operate during a system fault. If, however, trip contacts from other devices are connected in parallel in the trip circuit, the alarm must be delayed such that the longest trip command duration can be reliably bridged.

2.15.2.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4001	FCT TripSuperv.	ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	1 .. 2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	1 .. 30 sec	2 sec	Delay Time for alarm

2.15.2.4 Information List

No.	Information	Type of Information	Comments
6854	>TripC1 TripRel	SP	>Trip circuit superv. 1: Trip Relay
6855	>TripC1 Bkr.Rel	SP	>Trip circuit superv. 1: Breaker Relay
6856	>TripC2 TripRel	SP	>Trip circuit superv. 2: Trip Relay
6857	>TripC2 Bkr.Rel	SP	>Trip circuit superv. 2: Breaker Relay
6858	>TripC3 TripRel	SP	>Trip circuit superv. 3: Trip Relay
6859	>TripC3 Bkr.Rel	SP	>Trip circuit superv. 3: Breaker Relay
6861	TripC OFF	OUT	Trip circuit supervision OFF
6865	FAIL: Trip cir.	OUT	Failure Trip Circuit
6866	TripC1 ProgFAIL	OUT	TripC1 blocked: Binary input is not set
6867	TripC2 ProgFAIL	OUT	TripC2 blocked: Binary input is not set
6868	TripC3 ProgFAIL	OUT	TripC3 blocked: Binary input is not set

2.16 Function Control and Circuit Breaker Test

2.16.1 Function Control

The function control is the control centre of the device. It coordinates the sequence of the protection and ancillary functions, processes their decisions and the information coming from the power system.

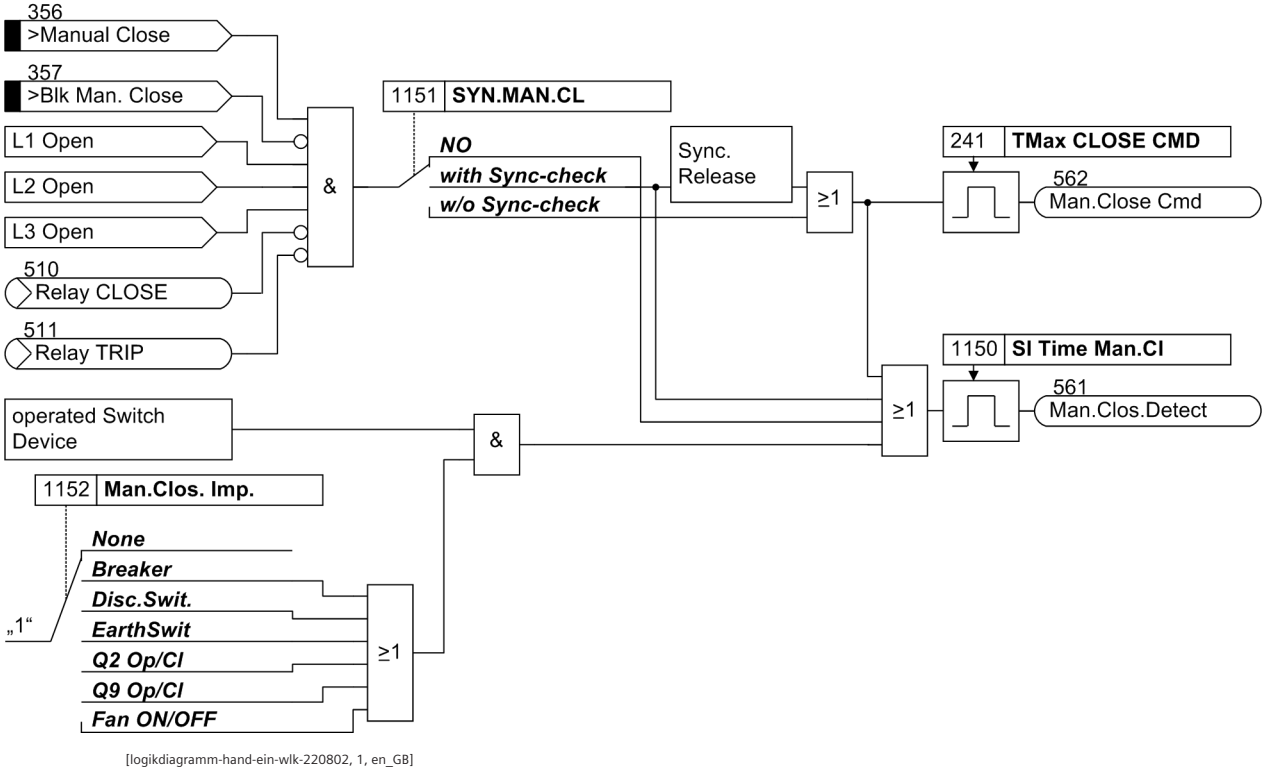
Applications

- Line energization recognition,
- Processing of the circuit breaker position,
- Open Pole Detector,
- Fault detection logic,
- Tripping logic.

2.16.1.1 Line Energization Recognition

During energization of the protected object, several measures may be required or desirable. Following a manual closure onto a short-circuit, immediate trip of the circuit breaker is usually desired. This is done, e.g. in the overcurrent protection, by bypassing the delay time of specific stages. For every short-circuit protection function which can be delayed, at least one stage can be selected that will operate instantaneously in the event of a closing, as mentioned in the relevant sections. Also see Section *2.1.4.1 Setting Notes* at margin heading “Circuit Breaker Status”.

The manual closing command must be indicated to the device via a binary input. In order to be independent of the duration that the switch is closed, the command is set to a defined length in the device (adjustable with the address 1150 **`SI Time Man.Cl`**). This setting can only be changed using DIGSI at **Additional Settings**. *Figure 2-99* shows the logic diagram.



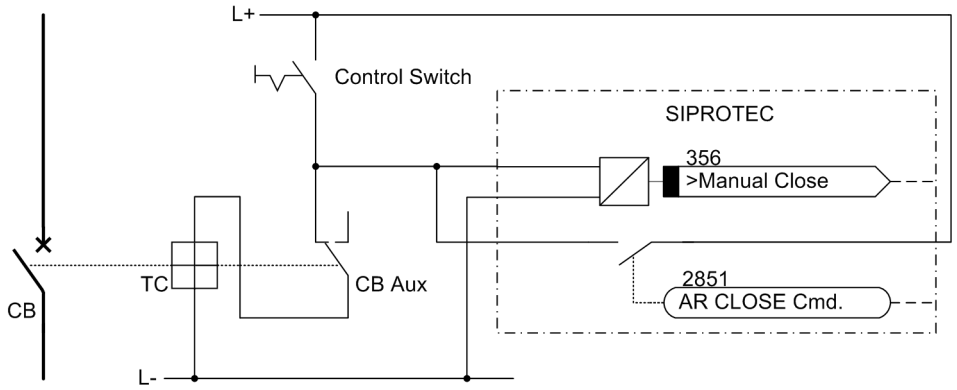
[logikdiagramm-hand-ein-wlk-220802, 1, en_GB]

Figure 2-99 Logic diagram of the manual closing procedure

Reclosure via the integrated control functions - on-site control, control via DIGSI, control via serial interface - can have the same effect as manual closure, see parameter 1152 Section *2.1.4.1 Setting Notes* at margin heading „Circuit Breaker Status“.

If the device has an integrated automatic reclosure, the integrated manual closure logic of the 7SD610 automatically distinguishes between an external control command via the binary input and an automatic reclosure by the internal automatic reclosure so that the binary input *>Manual Close* can be connected directly to the control circuit of the close coil of the circuit breaker (*Figure 2-100*). Each closing operation that is not initiated by the internal automatic reclosure function is interpreted as a manual closure, even it has been initiated by a control command from the device.

With the user definable logic functions (CFC) further control functions can be processed in the same way as a manual–close command.



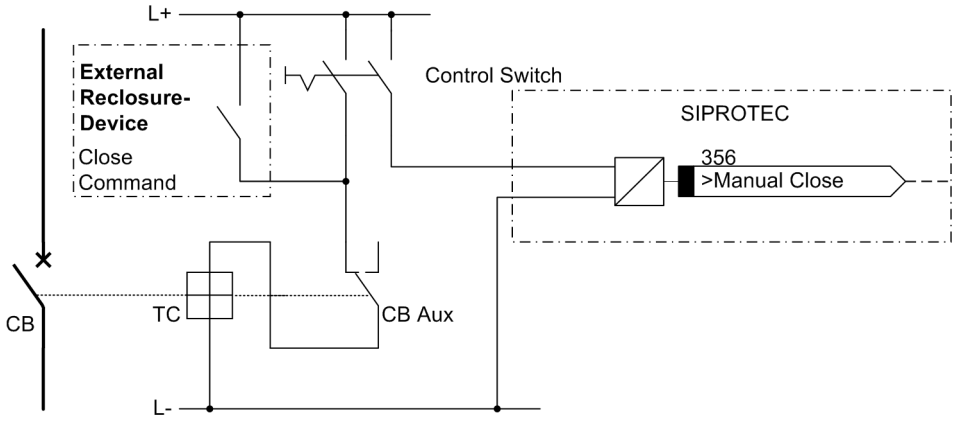
[hand-ein-mit-we-wlk-010802, 1, en_GB]

Figure 2-100 Manual closure with internal automatic reclosure

CB	Circuit breaker
TC	Circuit breaker close coil
CBaux	Circuit breaker auxiliary contact

If, however, external close commands which should not activate the manual close function are possible (e.g. external reclosure device), the binary input *>Manual Close* must be triggered by a separate contact of the control switch (*Figure 2-101*).

If in that latter case a manual close command can also be given by means of an internal control command from the device, such a command must be combined with the manual CLOSE function via parameter 1152 **`Man.Clos. Imp.`** (*Figure 2-99*).



[hand-ein-mit-ext-we-wlk-010802, 1, en_GB]

Figure 2-101 Manual closure with external automatic reclosure

CB	Circuit breaker
TC	Circuit breaker close coil
CBaux	Circuit breaker auxiliary contact

Besides the manual CLOSE detection, the device records any energization of the line via the integrated line energization detection. This function processes a change-of-state of the measured quantities as well as the position of the breaker auxiliary contacts. The current status of the circuit breaker is detected, as described in the following Section at "Detection of the Circuit Breaker Position". The criteria for the line energization detection change according to the local conditions of the measuring points and the setting of the parameter address 1134 **Line Closure** (see Section *2.1.4 General Protection Data (Power System Data 2)* at margin heading "Circuit Breaker Status").

The phase currents and the phase-to-earth voltages are available as measuring quantities. A flowing current excludes that the circuit breaker is open (exception: a fault between current transformer and circuit breaker). If the circuit breaker is closed, it may, however, still occur that no current is flowing. The voltages can only be used as a criterion for the de-energised line if the voltage transformers are installed on the feeder side. Therefore, the device only evaluates those measuring quantities that provide information on the status of the line according to address 1134.

But a change-of-state, such as a voltage jump from zero to a considerable value (address 1131 **PoleOpenVoltage**) or the occurrence of a considerable current (address 1130 **PoleOpenCurrent**), can be a reliable indicator for line energization as such changes can neither occur during normal operation nor in case of a fault. These settings can only be changed via DIGSI at **Additional Settings**.

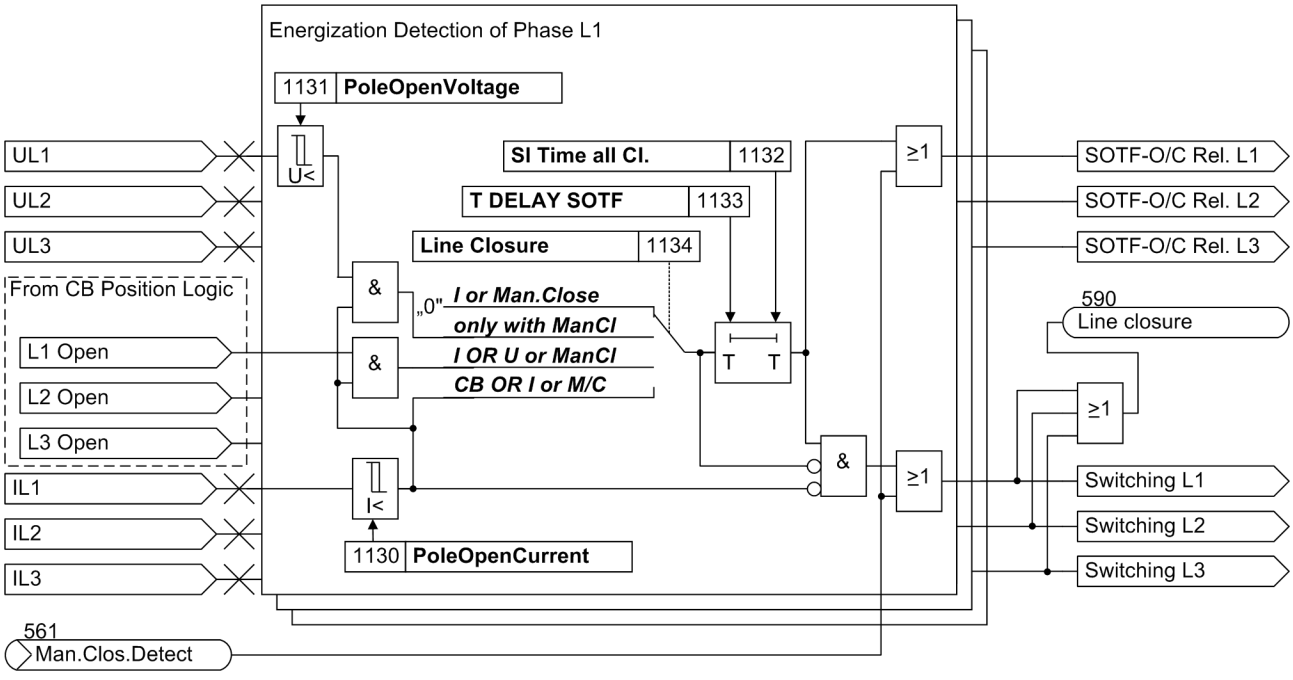
NOTE

When the Line Closure detection (addresse 1134) is set to: with ***I or Man.Close***, there is a risk that, in the event of very small load current - less than I-pole open, the line closure may incorrectly assert if a fault now occurs. In networks with resonant or isolated neutral a wrong operation is also possible with the setting ***I OR U or ManCl*** when a earth fault is present because the line closure detection is done on a phase selective basis. The setting ***CB OR I or M/C*** is therefore recommended for networks with isolated or resonant grounded neutral.

The position of the auxiliary contacts of the circuit breakers directly indicate the position of the circuit breaker. If the circuit breaker is controlled single-pole, energization takes place if at least one contact changes from open to closed.

The detected energization is signalled through the message *Line closure* (No. 590). The parameter 1132 **SI Time all Cl.** is used to set the signal to a defined length. These settings can only be changed via DIGSI at Display **Additional Settings**. *Figure 2-102* shows the logic diagram.

In order to avoid that an energization is detected mistakenly, the state "line open", which precedes any energization, must apply for a minimum time (settable with the address 1133 **T FRG. ZUSCHALT**). The default setting for this enable delay is 250 ms. This setting can only be changed using DIGSI at **Additional Settings**.



[logik-zuschalterk-wlk-220802, 1, en_GB]

Figure 2-102 Generation of the energization signal

The line energization detection enables the time-overcurrent protection and high-current switch onto fault protection to trip without delay after energization of their line was detected.

2.16.1.2 Detection of the Circuit Breaker Position

For Protection Purposes

Information regarding the circuit breaker position is required by various protection and supplementary functions to ensure their optimal functionality. This is, for example, of assistance for

- The high-current instantaneous tripping (refer to Section *2.8 Instantaneous High-Current Switch-onto-Fault Protection (SOTF)*),
- The circuit breaker failure protection (refer to Section *2.13 Circuit Breaker Failure Protection*),
- Verification of the dropout condition for the trip command (see Section “Terminating the Trip Signal”).

The device is equipped with a circuit breaker position logic (*Figure 2-103*) which offers different options depending on the type of auxiliary contacts provided by the circuit breaker and on how they are connected to the device.

In most cases it is sufficient to report the status of the circuit breaker with its auxiliary contacts to the device via binary input. This always applies if the circuit breaker is only switched 3-pole. Then the NO auxiliary contact of the circuit breaker is connected to a binary input which must be configured to the input function *>CB 3p Closed* (No. 379). The other inputs are then not used and the logic is restricted in principle to simply forwarding the input information.

If the circuit breaker poles can be switched individually, and only a parallel connection of the NO individual pole auxiliary contacts is available, the relevant binary input (BI) is allocated to the function *>CB 3p Open* (no. 380). The remaining inputs are not used in this case.

If the circuit breaker poles can be switched individually and if the individual auxiliary contacts are available, an individual binary input should be used for each auxiliary contact if this is possible and if the device can and is to trip 1-pole. With this configuration, the device can process the maximum amount of information. Three binary inputs are used for this purpose:

- *>CB Aux. L1* (No. 351) for the auxiliary contact of pole L1,
- *>CB Aux. L2* (No. 352) for the auxiliary contact of pole L2,
- *>CB Aux. L3* (No. 353) for the auxiliary contact of pole L3,

The inputs No. 379 and No. 380 are not used in this case.

If the circuit breaker can be switched individually, two binary inputs are sufficient if both the parallel as well as series connection of the auxiliary contacts of the three poles are available. In this case, the parallel connection of the auxiliary contacts is routed to the input function *>CB 3p Closed* (No.379) and the series connection is routed to the input function „*>CB 3p Open* (No. 380).

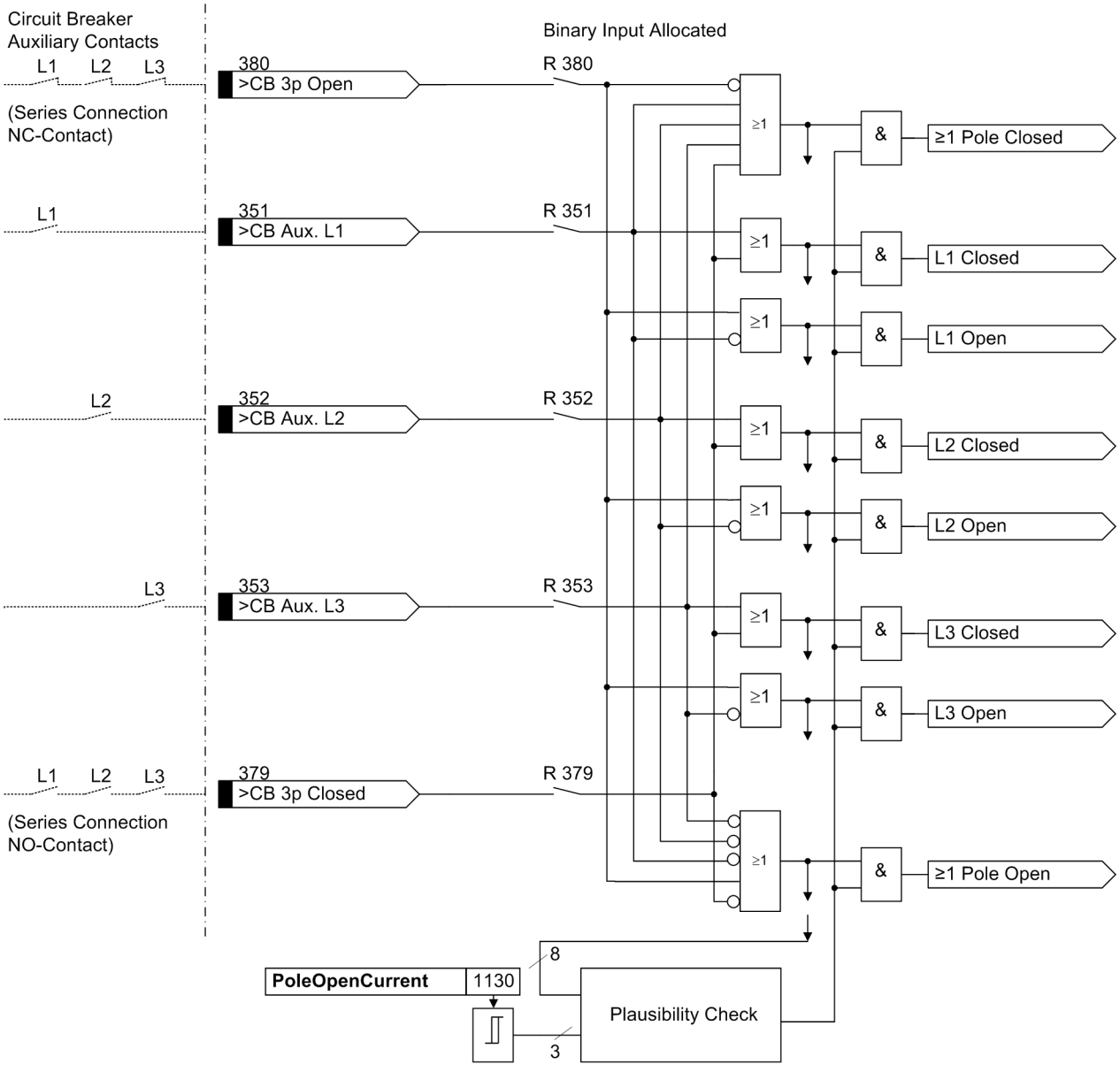
Please note that *Figure 2-103* shows the complete logic for all connection alternatives. For each particular application, only a portion of the inputs is used as described above.

The eight output signals of the circuit breaker position logic can be processed by the individual protection and supplementary functions. The output signals are blocked if the signals transmitted from the circuit breaker are not plausible: for example, the circuit breaker cannot be open and closed at the same time. Furthermore, no current can flow over an open breaker contact.

The evaluation of the measuring quantities is according to the local conditions of the measuring points (see Section *2.1.4.1 Setting Notes* at margin heading “Circuit Breaker Status”).

The phase currents are available as measuring quantities. A flowing current excludes that the circuit breaker is open (exception: A fault between current transformer and circuit breaker). If the circuit breaker is closed, it may, however, still occur that no current is flowing. The decisive setting for the evaluation of the measuring quantities is **PoleOpenCurrent** (address 1130) for the presence of the currents.

In 7SD610 the position of the circuit breaker poles detected by the device is also transmitted to the remote end device(s). This way, the circuit breaker positions of all ends are known at all ends. The highcurrent switch-onto- fault protection (Section *2.8 Instantaneous High-Current Switch-onto-Fault Protection (SOTF)*) makes use of this function.



[logik-ls-stellung-wlk-020802, 1, en_GB]

Figure 2-103 Circuit breaker position logic

For automatic reclosure and circuit breaker test

Separate binary inputs comprising information on the position of the circuit breaker are available for the automatic reclosure and the circuit breaker test. This is important for

- The plausibility check before automatic reclosure (refer to Section *2.10 Automatic Reclosure Function (optional)*),
- the trip circuit check with the help of the TRIP–CLOSE–test cycle (refer to Section *2.16.2 Circuit Breaker Test*).

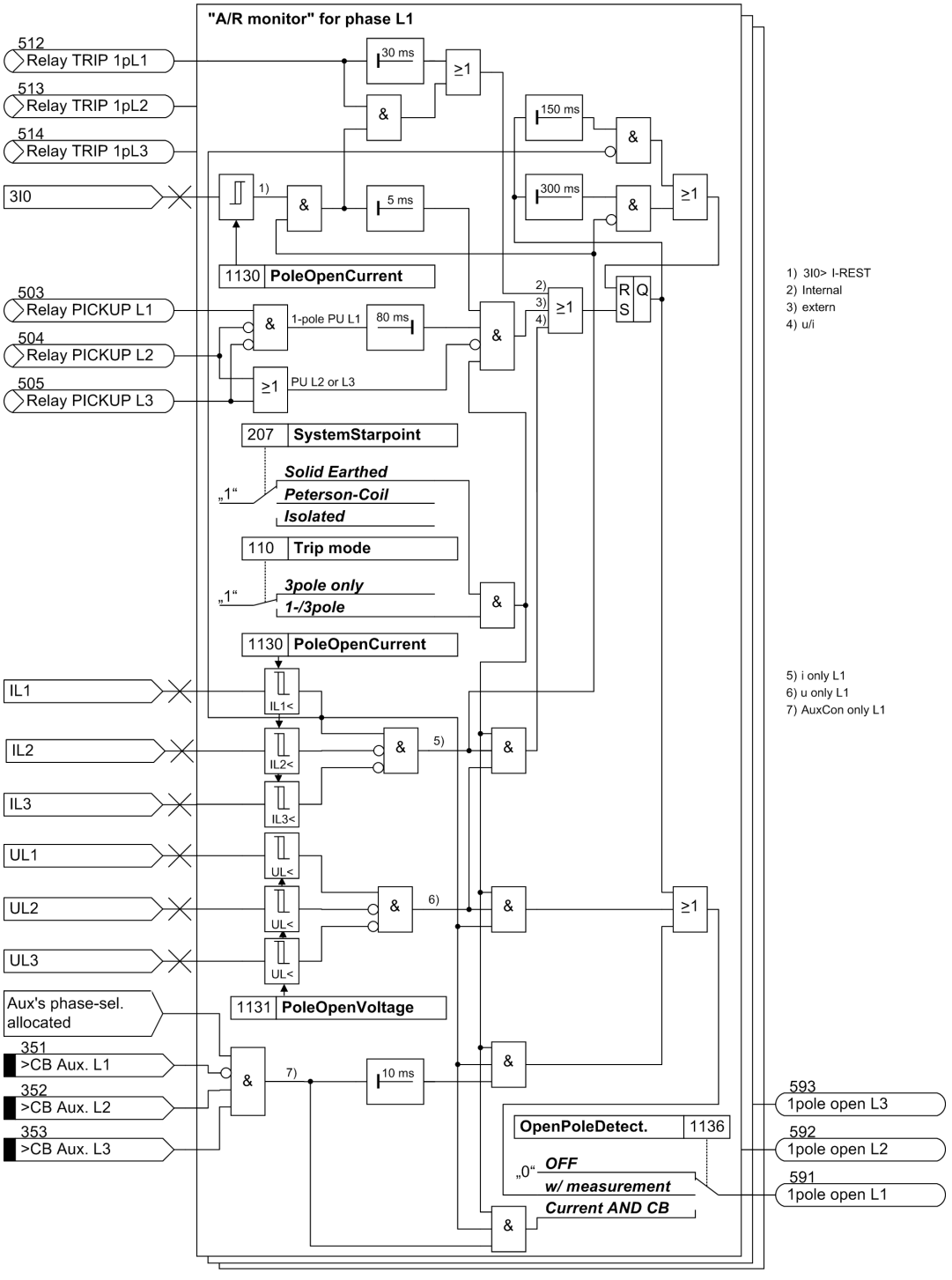
When using $1^1/_2$ or 2 circuit breakers in each feeder, the automatic reclosure function and the circuit breaker test refer to **one** circuit breaker. The feedback information of this circuit breaker can be connected separately to the device.

For this, separate binary inputs are available, which should be treated the same and configured additionally if necessary. These have a similar significance as the inputs described above for protection applications and are marked with “CB1 ...” to distinguish them, i.e.:

- *>CB1 3p Closed* (No. 410) for the series connection of the NO auxiliary contacts of the CB,
- *>CB1 3p Open* (No. 411) for the series connection of the NC auxiliary contacts of the CB,
- *>CB1 Pole L1* (No. 366) for the auxiliary contact of pole L1,
- *>CB1 Pole L2* (No. 367) for the auxiliary contact of pole L2,
- *>CB1 Pole L3* (No. 368) for the auxiliary contact of pole L3,

2.16.1.3 Open Pole Detector

Single-pole dead times can be detected and reported via the Open Pole Detector. The corresponding protection and monitoring functions can respond. The following figure shows the logic structure of an Open Pole Detector.



[logik-open-pole-detek-wlk-120902, 1, en_GB]

Figure 2-104 Open pole detector logic

1-pole dead time

During a 1-pole dead time, the load current flowing in the two healthy phases forces a current flow via earth which may cause undesired pickup. The raising zero- sequence voltage can also produce undesired responses of the functions.

The indications *1pole open L1* (No. 591), *1pole open L2* (No. 592) and *1pole open L3* (No. 593) are additionally generated if the “Open Pole Detector” detects that current and voltage are absent in one phase –

while current flow is detected in both other phases. In this case, one of the indications will only be maintained while the condition is met. This enables a single-pole automatic reclosure to be detected on an unloaded line.

Specially for applications with busbar side voltage transformers the indication *1pole open Lx* is additionally transmitted if the phase-selective CB auxiliary contacts clearly show a single-pole open circuit breaker, and the current of the affected phase falls below the parameter 1130 **PoleOpenCurrent**.

Depending on the setting of parameter 1136 **OpenPoleDetect.** the Open Pole Detector evaluates all available measured values including the auxiliary contacts (default setting ***w/ measurement***) or it processes only the information from the auxiliary contacts including the phase current values (setting ***Current AND CB***). To disable the Open Pole Detector, set parameter 1136 to ***OFF***.

2.16.1.4 Pickup Logic of the Entire Device

Phase Segregated Fault Detection

The fault detection logic combines the fault detection (pickup) signals of all protection functions. In the case of those protection functions that allow for phase segregated pickup, the pickup is output in a phase segregated manner. If a protection function detects an earth fault, this is also output as a common device alarm. Thus, the alarms *Relay PICKUP L1*, *Relay PICKUP L2*, *Relay PICKUP L3* and *Relay PICKUP E* are available.

The above annunciations can be allocated to LEDs or output relays. For the local display of fault event messages and for the transmission of event messages to a personal computer or a centralized control system, several protection functions provide the possibility to display the faulted phase information in a single message, e.g. *Diff Flt. L12E* for differential protection fault detection L1-L2-E or ; only one such message appears. It represents the complete definition of the fault detection.

General Pickup

The pickup signals are combined with OR and lead to a general pickup of the device. It is signalled with *Relay PICKUP*. If no function of the device is picked up any longer, *Relay PICKUP* disappears (indication "OFF").

General device pickup is a precondition for a series of internal and external functions that occur subsequently. The following are among the internal functions controlled by general device pickup:

- Opening of a trip log: from general device pickup to general device dropout, all fault indications are entered in the trip log.
- Initialization of fault record: the storage and maintenance of fault values can also be made dependent on the occurrence of a trip command.
- Generation of spontaneous indications: Certain fault indications can be displayed as spontaneous indications (see margin heading "Spontaneous Indications"). In addition, this indication can be made dependent on the general device trip.
- Start action time of automatic reclosure (if available and used).

External functions may be controlled by this indication via an output contact. Examples are:

- Automatic reclose devices,
- Further additional devices or similar.

Spontaneous Displays

Spontaneous indications are fault indications which appear in the display automatically following a general fault detection or trip command of the device. For the 7SD610, these indications include:

"Relay PICKUP":	Protection function that picked up;
PU Time:	Operating time from the general pickup to the dropout of the device, in ms;
TRIP Time:	the operating time from general pickup to the first trip command of the device, in ms;

2.16.1.5 Tripping Logic of the Entire Device

Three-pole tripping

In general, the device trips three-pole in the event of a fault. Depending on the version ordered (see Section *A Ordering Information and Accessories*, "Ordering Information"), single-pole tripping is also possible. If, in general, single-pole tripping is not possible or desired, the output function *Relay TRIP* is used for the trip command output to the circuit breaker. In these cases, the following sections regarding single-pole tripping are not of interest.

Single-pole tripping

Single-pole tripping only makes sense on overhead lines on which automatic reclosure is to be carried out and where the circuit breakers at both ends of the line are capable of single-pole tripping. Single-pole tripping of the faulted phase with subsequent reclosure is then possible for single phase faults; three-pole tripping is generally performed in case of two-phase or three-phase faults with and without earth.

Device prerequisites for phase segregated tripping are:

- Phase segregated tripping is provided by the device (according to the ordering code);
- The tripping function is suitable for pole-segregated tripping (for example, not for frequency protection, overvoltage protection or overload protection),
- The binary input *>1p Trip Perm* is configured and activated or the internal automatic reclosure function is ready for reclosure after single-pole tripping.

In all other cases tripping is always three-pole. The binary input *>1p Trip Perm* is the logic inversion of a three-pole coupling and activated by an external auto-reclosure device as long as this is ready for a single-pole auto-reclosure cycle.

With the 7SD610, it is also possible to trip three-pole when only one phase is subjected to the trip conditions, but more than one phase indicates a fault detection. This can be the case, for instance, when two faults at different locations occur simultaneously, but only one of them is within the range of the differential protection. This is selected with the setting parameter **3pole coupling** (address 1155), which can be set to ***with PICKUP*** (every multiple-phase fault detection causes three-pole trip) or ***with TRIP*** (in the event of multiple-phase faults in the tripping area, the tripping is always three-pole).

The tripping logic combines the trip signals from all protection functions. The trip commands of those functions that allow single-pole tripping are phase segregated. The corresponding indications are named *Relay TRIP L1*, *Relay TRIP L2* und *Relay TRIP L3*.

These indications can be allocated to LEDs or output relays. In the event of three-pole tripping all three indications are displayed. These alarms are also intended for the trip command output to the circuit breaker.

Für lokale Anzeigen von Störfallmeldungen und für die Übertragung der Meldungen zu einem Personalcomputer oder einer leittechnischen Zentrale steht für die Schutzfunktionen – sofern 1-polige Auslösung möglich – auch die Auslösung als Gesamtmeldung zur Verfügung, z.B. für 1-polige Auslösung durch Differentialschutz *Diff TRIP 1p L1*, *Diff TRIP 1p L2*, *Diff TRIP 1p L3* sowie *Diff TRIP L123* für 3-polige Auslösung, von denen jeweils nur eine erscheint.

If single-pole tripping is possible, the protection functions generate a group signal for the local display of fault indications and for the transmission of the indications to a PC or a central control system, e.g. for single-pole tripping by differential protection *Diff TRIP 1p L1*, *Diff TRIP 1p L2*, *Diff TRIP 1p L3* and *Diff TRIP L123* for three-pole tripping; only one of these messages is displayed at a time.

Single-pole tripping for two-phase faults

Single-pole tripping for two-phase faults is a special feature. If a phase-to-phase fault without earth occurs in an earthed system, this fault can be cleared by single-pole trip and automatic reclosure in one of the faulted phases as the short-circuit path is interrupted in this manner. The phase selected for tripping must be the same at both line ends (and should be the same for the entire system).

The setting parameter **Trip2phFlt** (address 1156) allows to select whether this tripping is to be ***1pole leading Ø***, i.e. single-pole tripping in the leading phase or ***1pole lagging Ø***, i.e. single-pole tripping in the lagging phase. Standard setting is ***3pole*** tripping in the event of two-phase faults (default setting).

Table 2-9 Single-pole and three-pole trip depending on fault type

Type of Fault (from Protection Function)				Parameter	Output signals for trip			
				Trip2phFlt	**TRIP 1p. L1**	**TRIP 1p. L2**	**TRIP 1p.pol L3**	**Relay TRIP 3ph.**
L1				(any)	X			
	L2			(any)		X		
		L3		(any)			X	
L1			E	(any)	X			
	L2		E	(any)		X		
		L3	E	(any)			X	
L1	L2			***3pole***				X
L1	L2			***1pole leading Ø***	X			
L1	L2			***1pole lagging Ø***		X		
	L2	L3		***3pole***				X
	L2	L3		***1pole leading Ø***		X		
	L2	L3		***1pole lagging Ø***			X	
L1		L3		***3pole***				X
L1		L3		***1pole leading Ø***			X	
L1		L3		***1pole lagging Ø***	X			
L1	L2		E	(any)				X
	L2	L3	E	(any)				X
L1		L3	E	(any)				X
L1	L2	L3		(any)				X
L1	L2	L3	E	(any)				X
			E	(any)				X

General Trip

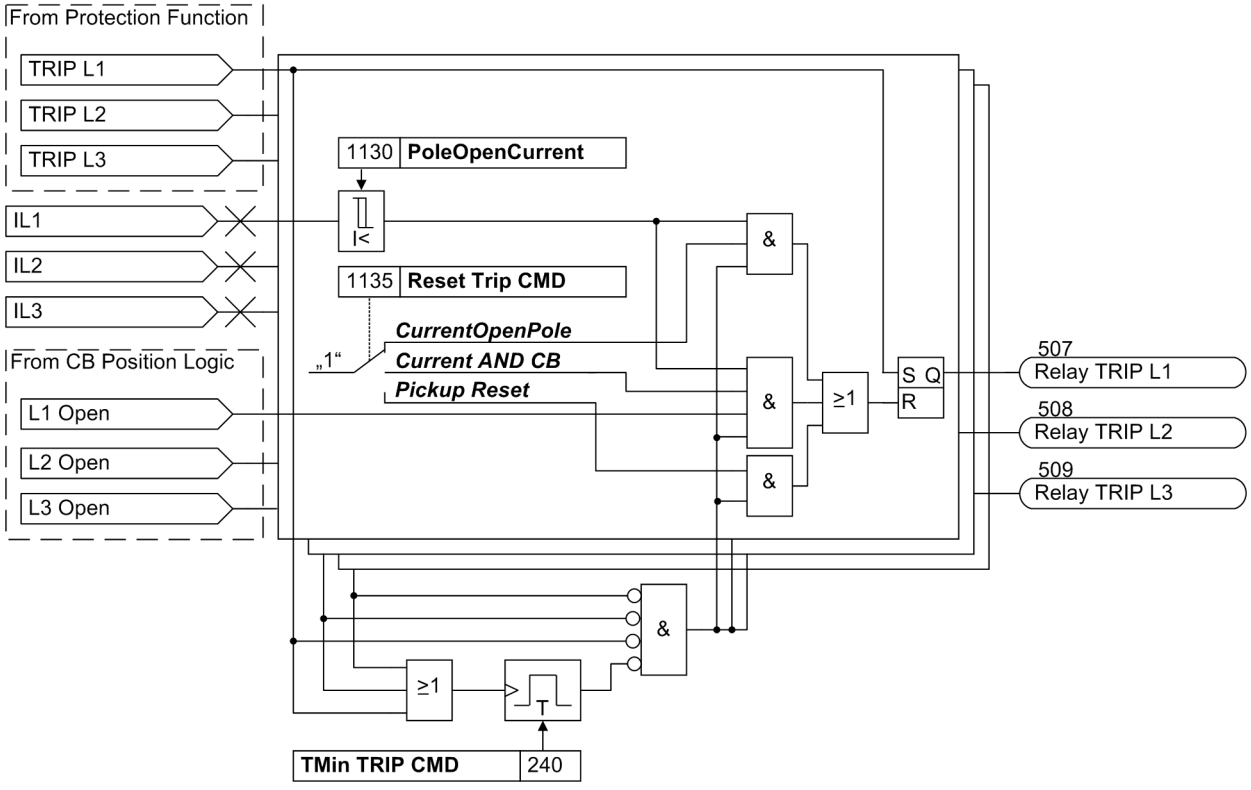
All trip signals for the functions are connected by OR and generate the message ***Relay TRIP***. This can be allocated to LED or output relay.

Terminating the Trip Signal

Once a trip command is initiated, it is phase segregatedly latched (in the event of three-pole tripping for each of the three poles) (refer to *Figure 2-105*). At the same time, the minimum trip command duration **TMin TRIP CMD** (address 240) is started. This ensures that the trip command is output to the circuit breaker for a sufficiently long time even if the tripping protection function resets very rapidly. The trip commands can only be reset after all tripping protection functions have dropped out and after the minimum trip command duration has elapsed.

A further condition for the reset of the trip command is that the circuit breaker has opened, in the event of singlepole tripping the relevant circuit breaker pole. In the function control of the device, this is checked by means of the circuit breaker position feedback (Section “Detection of the Circuit Breaker Position”) and the flow of current. In address 1130 **PoleOpenCurrent**, the residual current threshold which may definitely not be exceeded when the circuit breaker pole is open, is set. Address 1135 **Reset Trip CMD** determines under which conditions a trip command is reset. If ***CurrentOpenPole*** is set, the trip command is reset as soon as the current disappears. It is important that the value set in address 1130 **PoleOpenCurrent** (see above) is undershot. If ***Current AND CB*** is set, the circuit breaker auxiliary contact must send a message that the

circuit breaker is open. It is a prerequisite for this setting that the position of the auxiliary contact is allocated via a binary input. If this additional condition is not required for resetting the trip command (e.g. if test sockets are used for protection testing), it can be switched off with the setting Pickup Reset.



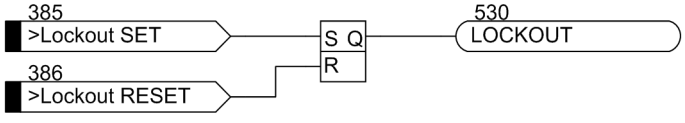
[logik-speich-absteuer-ausloese-wlk-020802, 1, en_GB]

Figure 2-105 Storage and termination of the trip command

Reclosure Interlocking

When a protection function has tripped the circuit breaker, it is often desired to prevent reclosing until the tripping cause has been found. 7SD610 enables this via the integrated reclosure interlocking.

The interlocking state (“LOCKOUT”) will be realized by an RS flipflop which is protected against auxiliary voltage failure (*Figure 2-106*). The RS flipflop is set via binary input *>Lockout SET* (No. 385). With the output alarm *LOCKOUT* (No. 530), if interconnected correspondingly, a reclosure of the circuit breaker (e.g. for automatic reclosure, manual close signal, synchronization, closing via control) can be blocked. Only once the cause for the protection operation is known, should the interlocking be reset by a manual reset via binary input *>Lockout RESET* (No. 386).



[logik-we-verriegelung-wlk-020802, 1, en_GB]

Figure 2-106 Reclosure Interlocking

Conditions which cause reclosure interlocking and control commands which have to be interlocked can be set individually. The two inputs and the output can be wired via the correspondingly allocated binary inputs and outputs or be linked via user-defined logic functions (CFC).

If, for example, each trip by the protection function has to cause a closing lock-out, then combine the tripping command *Relay TRIP* (No. 511) with the locking input *>Lockout SET*. If automatic reclosure is used, only the final trip of the protection function should activate reclosing lock-out. Remember that the indication *Definitive TRIP* (No. 536) only continues 500 ms. Then c *Definitive TRIP* (No. 536) with the inter-

locking input *>Lockout SET*, so that the interlocking is not activated if an automatic reclosure is still expected.

You can configure the output indication *LOCKOUT* (No 530) in the simplest case without other links to the same output that operated the trip of the circuit breaker. Then the tripping command is maintained until the interlock is reset via the reset input. This requires the close coil at the circuit breaker to be blocked as usual for as long as a tripping command is maintained.

The output indication *LOCKOUT* can also be applied to interlock certain closing commands (externally or via CFC), e.g. by combining the output alarm with the binary input *>Blk Man. Close* (No. 357) or by connecting the inverted alarm with the bay interlocking of the feeder.

The reset input*>Lockout RESET* (No. 386) resets the interlocking state. This input is initiated by an external device which is protected against unauthorized or unintentional operation. The interlocking state can also be controlled by internal sources using CFC, e.g. a function key, operation of the device or using DIGSI on a PC.

For each case please ensure that the corresponding logic operations, security measures, etc. are taken into account when routing the binary inputs and outputs and may have to be considered when creating the user-defined logic functions. See also the SIPROTEC 4 System Description.

Breaker Tripping Alarm Suppression

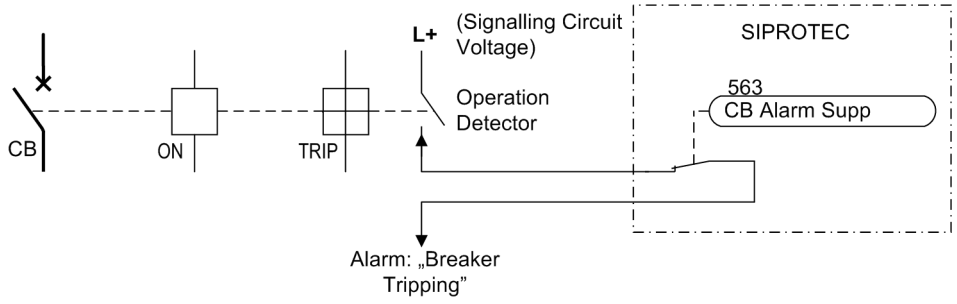
On feeders without automatic reclosure, every trip command by a protection function is final. But when using automatic reclosure, it is desired that the operation detector of the circuit breaker (fleeting contact at the breaker) should only generate an alarm if the trip of the breaker is final (*Figure 2-107*).

To accomplish this, the signal from the circuit breaker can be routed via an output contact of the 7SD610 (output alarm *CB Alarm Supp*, No. 563) that is configured accordingly. In the idle state and when the device is turned off, this contact is closed. This requires that a normally closed contact is allocated. Which contact is to be allocated depends on the device version. See also the general views in the Appendix.

Prior to a trip command with the internal automatic reclosure in the ready state, the contact opens so that the tripping of the circuit breaker is not passed on. This is only the case if the device is equipped with internal automatic reclosure and if the latter was taken into consideration when configuring the protection functions (address 133).

Also when closing the breaker via the binary input *>Manual Close* (No. 356) or via the integrated automatic reclosure the contact is interrupted so that the breaker alarm is inhibited.

Further optional closing commands which are not sent via the device are not taken into consideration. Closing commands for control can be linked to the alarm suppression via the user-defined logic functions (CFC).

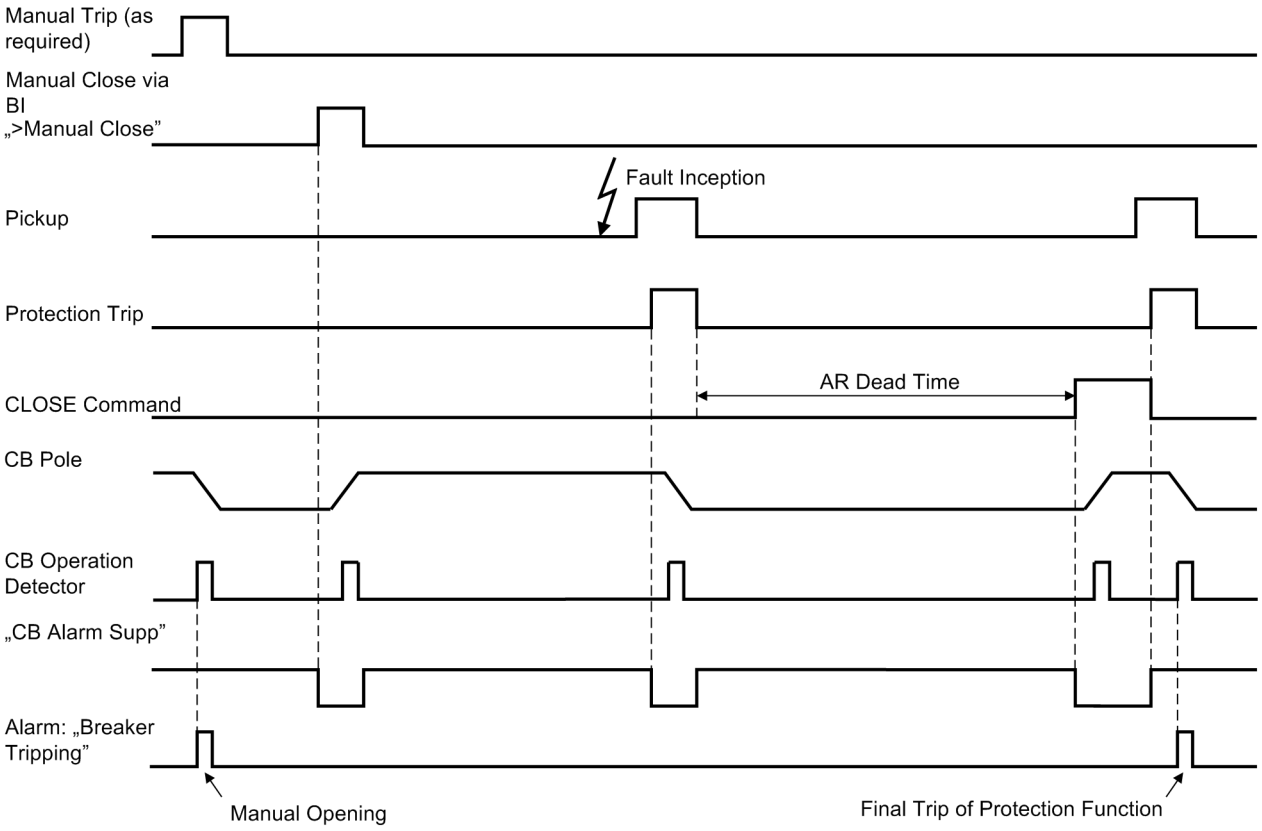


[schalterfall-meldeunterdrueck-wlk-020802, 1, en_GB]

Figure 2-107 Breaker tripping alarm suppression

If the device issues a final trip command, the contact remains closed. This is the case, during the reclaim time of the automatic reclosure cycle, when the automatic reclosure is blocked or switched off or, due to other reasons is not ready for automatic reclosure (e.g. tripping only occurred after the action time expired).

Figure 2-108 shows time diagrams for manual trip and close as well as for short-circuit tripping with a single, failed automatic reclosure cycle.



[schalterfall-meldeunterdrueck-ablauf-wlk-020802, 1, en_GB]

Figure 2-108 Breaker tripping alarm suppression — sequence examples

2.16.2 Circuit Breaker Test

The 7SD610 distance protection relay allows for convenient testing of the trip circuits and the circuit breakers.

2.16.2.1 Functional Description

The test programs shown in *Table 2-10* are available. The single-pole tests are of course only possible if the device you are using is capable of single-pole tripping.

The output alarms mentioned must be allocated to the relevant command relays that are used for controlling the circuit breaker coils.

The test is started using the operator panel on the front of the device or using the PC with DIGSI. The procedure is described in detail in the SIPROTEC 4 System Description. *Figure 2-109* shows the progression over time of an open-close test cycle. The set times are those stated in Section *2.1.2.1 Setting Notes* for “Trip Command Duration” and “Circuit Breaker Test”.

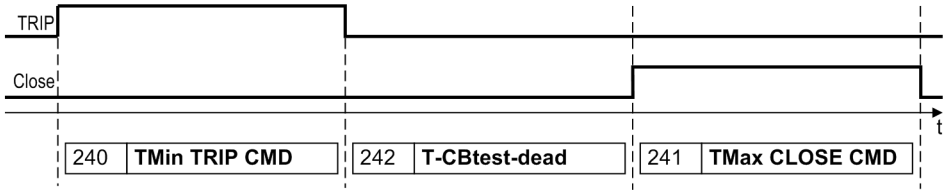
Where the circuit breaker auxiliary contacts indicate the status of the circuit breaker or of its poles to the device via binary inputs, the test cycle can only be initiated if the circuit breaker is closed.

The information regarding the position of the circuit breakers is not automatically derived from the position logic according to the above section. For the circuit breaker test function (auto recloser) there are separate binary inputs for the switching status feedback of the circuit breaker position. These must be taken into consideration when allocating the binary inputs as mentioned in the previous section.

The alarms of the device show the respective state of the test sequence.

Table 2-10 Circuit breaker test programs

Serial No.	Test Programs	Circuit Breaker	Output Indications (No.)
1	1-pole TRIP/CLOSE-cycle phase L1	CB 1	CB1-TESTtrip L1 (7325)
2	1-pole TRIP/CLOSE-cycle phase L2		CB1-TESTtrip L2 (7326)
3	1-pole TRIP/CLOSE-cycle phase L3		CB1-TESTtrip L3 (7327)
4	3-pole TRIP/CLOSE-cycle		CB1-TESTtrip 123 (7328)
	Associated close command		CB1-TEST CLOSE (7329)



[ein-aus-pruefzyklus-wlk-170902, 1, en_GB]

Figure 2-109 TRIP-CLOSE test cycle

2.16.2.2 Information List

No.	Information	Type of Information	Comments
-	CB1tst L1	-	CB1-TEST trip/close - Only L1
-	CB1tst L2	-	CB1-TEST trip/close - Only L2
-	CB1tst L3	-	CB1-TEST trip/close - Only L3
-	CB1tst 123	-	CB1-TEST trip/close Phases L123
7325	CB1-TESTtrip L1	OUT	CB1-TEST TRIP command - Only L1
7326	CB1-TESTtrip L2	OUT	CB1-TEST TRIP command - Only L2
7327	CB1-TESTtrip L3	OUT	CB1-TEST TRIP command - Only L3
7328	CB1-TESTtrip123	OUT	CB1-TEST TRIP command L123
7329	CB1-TEST close	OUT	CB1-TEST CLOSE command
7345	CB-TEST running	OUT	CB-TEST is in progress
7346	CB-TSTstop FLT.	OUT_Ev	CB-TEST canceled due to Power Sys. Fault
7347	CB-TSTstop OPEN	OUT_Ev	CB-TEST canceled due to CB already OPEN
7348	CB-TSTstop NOTr	OUT_Ev	CB-TEST canceled due to CB was NOT READY
7349	CB-TSTstop CLOS	OUT_Ev	CB-TEST canceled due to CB stayed CLOSED
7350	CB-TST .OK.	OUT_Ev	CB-TEST was successful

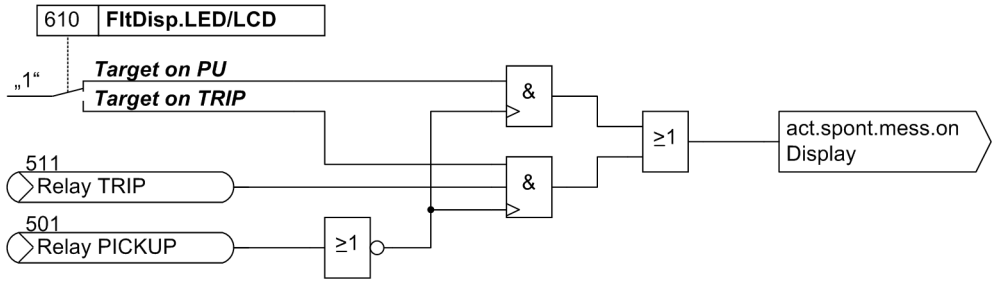
2.16.3 Device

The device requires some general information. This may be, for example, the type of indication to be issued in the event a power system fault occurs.

2.16.3.1 Trip-Dependent Indications

Spontaneous Fault Messeges

After a fault, the essential fault data spontaneously appear on the device display. Under address 610 **FltDisp.LED/LCD** you can select whether the spontaneous fault indications are updated in every case of fault (***Target on PU***) or only in faults with tripping (***Target on TRIP***).



[logik-spondanmeld-display-081024, 1, en_GB]

Figure 2-110 Generation of spontaneous fault indications on the display

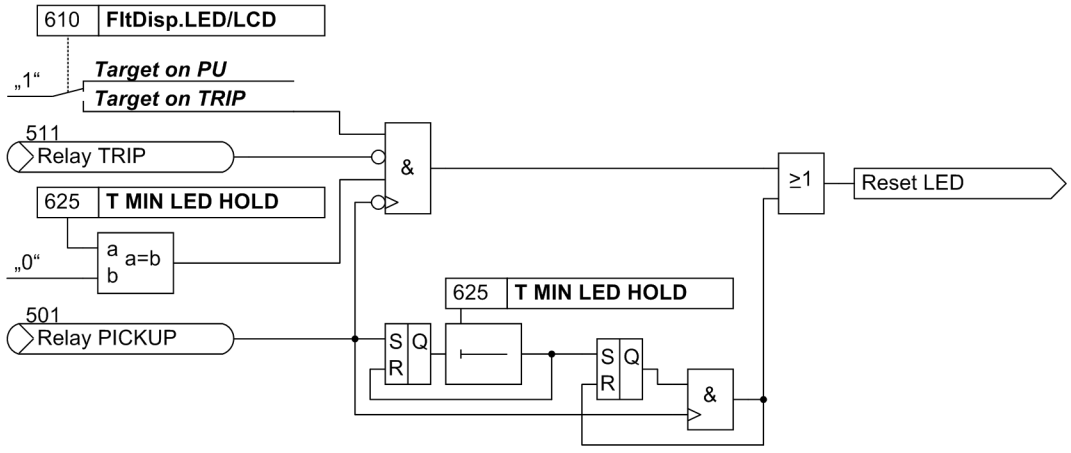
Reset of Stored LED / Relays

Pickup of a new protection function generally deletes all stored LED/relays so that only the information of the latest fault is displayed at a time. The deletion of the stored LED and relays can be inhibited for a settable time under address 625 **T MIN LED HOLD**. Any information occurring during this time are then combined with a logical OR function.

Under address 610 **FltDisp.LED/LCD** also the information of the latest fault stored on LED and relays can be deleted with the setting (***Target on TRIP***) unless this fault has lead to a trip command of the device.

NOTE

Setting the address 610 **FltDisp.LED/LCD** to (***Target on TRIP***) only makes sense if address 625 **T MIN LED HOLD** is set to 0.



[logik-ruecksetz-gesp-led-081024, 1, en_GB]

Figure 2-111 Creation of the reset command for saved LED/relays

2.16.3.2 Switching Statistics

The number of trips initiated by the device 7SD610 are counted. If the device is capable of single-pole tripping, a separate counter for each circuit breaker pole is provided.

Furthermore, for each trip command the interrupted current for each pole is measured, output in the trip log and accumulated in a memory. The maximum interrupted current is also stored.

If the device is equipped with the integrated automatic reclosing function, the automatic close commands are also counted, separately for reclosure after single-pole tripping, after three-pole tripping and separately for the first and further reclosure cycles.

The counter and memory content are secured against loss of auxiliary voltage. They can be set to zero or to any other initial value. For more details, please refer to the SIPROTEC 4 System Description.

2.16.3.3 Setting Notes

Fault Annunciations

Pickup of a new protection function generally turns off any previously set displays, so that only the latest fault is displayed at any one time. It can be selected whether the stored LED displays and the spontaneous indications on the display appear upon renewed pickup, or only after a renewed trip signal is issued. In order to enter the desired type of display, select the submenu General Device Settings in the SETTINGS menu. At address 610 **FltDisp.LED/LCD** the two alternatives ***Target on PU*** and ***Target on TRIP*** ("No trip - no flag") are offered.

After startup of the device featuring a 4-line display, default measured values are displayed. Use the arrow keys on the device front to select different measured value views to be used as the so-called default display. The start page of the default display, which will open after each startup of the device, can be selected via parameter 640 **Start image DD**. The available representation types for the measured value are listed in the Appendix.

2.16.3.4 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

Addr.	Parameter	Setting Options	Default Setting	Comments
610	FltDisp.LED/LCD	Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
625A	T MIN LED HOLD	0 .. 60 min; ∞	0 min	Minimum hold time of latched LEDs
640	Start image DD	image 1 image 2 image 3 image 4 image 5 image 6	image 1	Start image Default Display

2.16.3.5 Information List

No.	Information	Type of Information	Comments
-	Test mode	IntSP	Test mode
-	DataStop	IntSP	Stop data transmission
-	UnlockDT	IntSP	Unlock data transmission via BI
-	Reset LED	IntSP	Reset LED
-	SynchClock	IntSP_Ev	Clock Synchronization
-	>Light on	SP	>Back Light on
-	HWTestMod	IntSP	Hardware Test Mode
-	Distur.CFC	OUT	Disturbance CFC
-	Brk OPENED	IntSP	Breaker OPENED
-	FdrEARTHED	IntSP	Feeder EARTHED
3	>Time Synch	SP	>Synchronize Internal Real Time Clock
5	>Reset LED	SP	>Reset LED
11	>Annunc. 1	SP	>User defined annunciation 1
12	>Annunc. 2	SP	>User defined annunciation 2
13	>Annunc. 3	SP	>User defined annunciation 3
14	>Annunc. 4	SP	>User defined annunciation 4
15	>Test mode	SP	>Test mode

No.	Information	Type of Informa-tion	Comments
16	>DataStop	SP	>Stop data transmission
51	Device OK	OUT	Device is Operational and Protecting
52	ProtActive	IntSP	At Least 1 Protection Funct. is Active
55	Reset Device	OUT	Reset Device
56	Initial Start	OUT	Initial Start of Device
60	Reset LED	OUT_Ev	Reset LED
67	Resume	OUT	Resume
68	Clock SyncError	OUT	Clock Synchronization Error
69	DayLightSavTime	OUT	Daylight Saving Time
70	Settings Calc.	OUT	Setting calculation is running
71	Settings Check	OUT	Settings Check
72	Level-2 change	OUT	Level-2 change
73	Local change	OUT	Local setting change
110	Event Lost	OUT_Ev	Event lost
113	Flag Lost	OUT	Flag Lost
125	Chatter ON	OUT	Chatter ON
126	ProtON/OFF	IntSP	Protection ON/OFF (via system port)
140	Error Sum Alarm	OUT	Error with a summary alarm
144	Error 5V	OUT	Error 5V
160	Alarm Sum Event	OUT	Alarm Summary Event
177	Fail Battery	OUT	Failure: Battery empty
181	Error A/D-conv.	OUT	Error: A/D converter
183	Error Board 1	OUT	Error Board 1
184	Error Board 2	OUT	Error Board 2
185	Error Board 3	OUT	Error Board 3
186	Error Board 4	OUT	Error Board 4
187	Error Board 5	OUT	Error Board 5
188	Error Board 6	OUT	Error Board 6
189	Error Board 7	OUT	Error Board 7
190	Error Board 0	OUT	Error Board 0
191	Error Offset	OUT	Error: Offset
192	Error1A/5Awrong	OUT	Error:1A/5Ajumper different from setting
193	Alarm adjustm.	OUT	Alarm: Analog input adjustment invalid
194	Error neutralCT	OUT	Error: Neutral CT different from MLFB
320	Warn Mem. Data	OUT	Warn: Limit of Memory Data exceeded
321	Warn Mem. Para.	OUT	Warn: Limit of Memory Parameter exceeded
322	Warn Mem. Oper.	OUT	Warn: Limit of Memory Operation exceeded
323	Warn Mem. New	OUT	Warn: Limit of Memory New exceeded
2054	Emer. mode	OUT	Emergency mode

2.16.4 EN100-Modul 1

2.16.4.1 Functional Description

An Ethernet **`Ethernet EN100-Module`** allows for the integration of the 7SD610 into 100 Mbit Ethernet communication networks used by process control and automation systems according to the IEC 61850 protocols. This standard enables integrated inter-relay communication without using gateways or protocol converters. This allows open and interoperable use of SIPROTEC 4 devices even in heterogeneous environments. In addition to the process control integration of the device, this interface can also be used for communication with DIGSI and for interrelay communication via GOOSE messaging.

2.16.4.2 Setting Notes

Interface selection

No settings are required for operation of the Ethernet system interface module (IEC 61850 Ethernet EN100-Modul). If the device is equipped with such a module (see MLFB), the module is automatically configured to the interface available for it.

2.16.4.3 Information List

No.	Information	Type of Information	Comments
009.0100	Failure Modul	IntSP	Failure EN100 Modul
009.0101	Fail Ch1	IntSP	Failure EN100 Link Channel 1 (Ch1)
009.0102	Fail Ch2	IntSP	Failure EN100 Link Channel 2 (Ch2)

2.17 Auxiliary Functions

The additional functions of the 7SD610 differential protection relay include:

- Commissioning tool
- Processing of messages
- Processing of operational measured values
- Storage of fault record data

2.17.1 Commissioning Aids

2.17.1.1 Functional Description

There is a comprehensive commissioning and monitoring tool that checks the communication and the whole differential protection function. The WEB-Monitor is an integral part of the device. The respective online-help is available with DIGSI on CD-ROM or via the internet at www.siprotec.de.

To ensure proper communication between the device and the PC browser, several prerequisites must be met. The transmission speed must be the same and an IP address has to be assigned so that the browser can identify the device.

Thanks to the WEB Monitor, the user is able to operate the device from a PC. On the PC screen, the front panel of the device with its operator keyboard is emulated. The actual operation of the device can be simulated using the mouse pointer. This feature can be disabled.

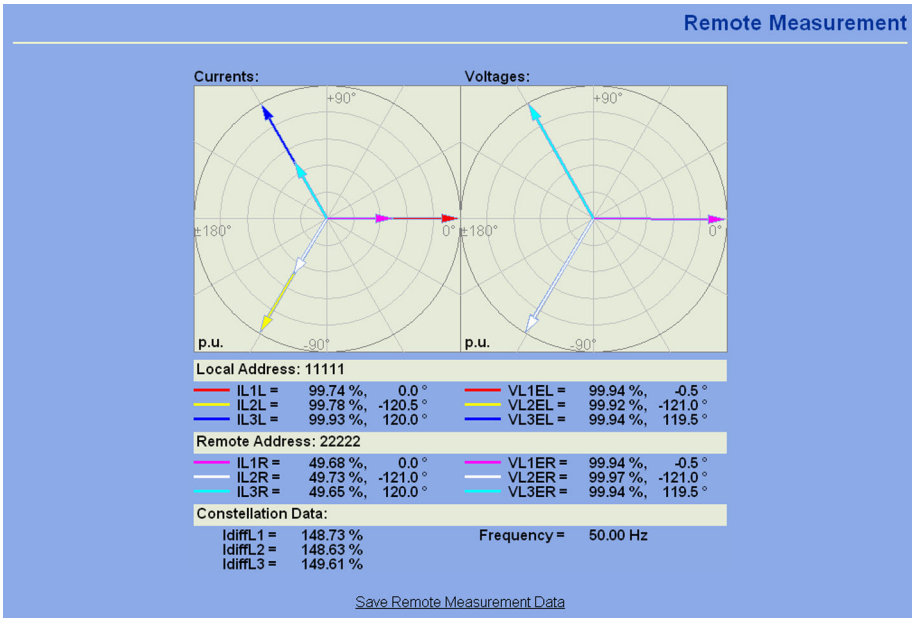
If the device is equipped with an EN100 module, operation by DIGSI or the WEB Monitor is possible via Ethernet. This is done by simply setting the IP configuration of the device accordingly. Parallel operation of DIGSI and WEB Monitor via different interfaces is possible.

WEB-Monitor

The “WEB-Monitor” is a comprehensive commissioning and monitoring tool which enables to clearly display the differential protection communication and the most important measured data using a PC with a web browser. Measured values and the values derived from them are graphically displayed as phasor diagrams. You can also view tripping diagrams, scalar values are shown in numerical form. For more details please refer to the online help for the “WEB-Monitor”.

This tool enables to graphically display, for instance, the currents, voltages (if connected to the system) and their phase angles for all devices of a differential protection system on a PC. In addition to phasor diagrams of the measured values, the numerical values as well as frequency and device addresses are indicated. *Figure 2-112* shows an example.

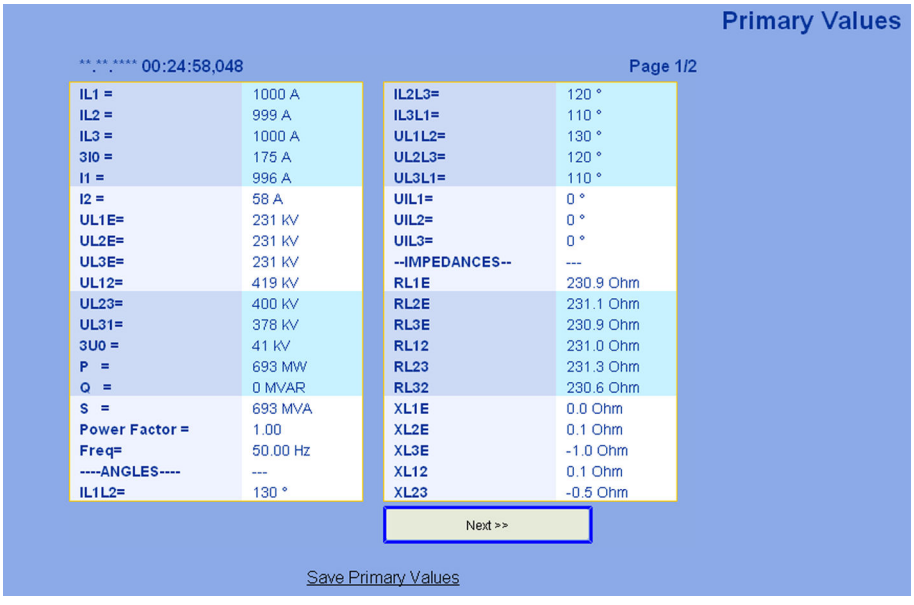
Additionally the position of the differential and restraint values can be viewed in the tripping characteristic



[web-mw-fern, 1, en_GB]

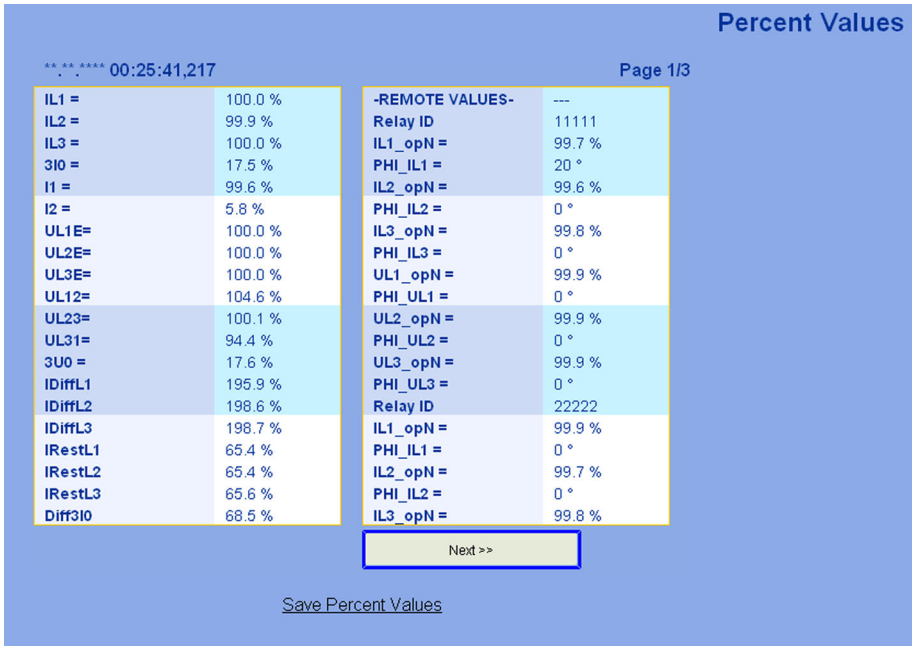
Figure 2-112 WEB-Monitor – Example of voltages and currents

Furthermore, the browser enables a clear display of the most important measured data. The measured values list can be selected from the navigation toolbar separately for the local and the remote device. In each case a list with the desired information is displayed (see *Figure 2-112* and *Figure 2-114*).



[mw-primaer, 1, en_GB]

Figure 2-113 Local measured values in the WEB-Monitor — Examples for measured values



[mw-prozent, 1, en_GB]

Figure 2-114 List of measured percentage values with given angle differences – Example

The following types of indications can be retrieved and displayed with the WEB-Monitor

- Operational indications (buffer: event log)
- Fault indications (buffer: trip log)
- Spontaneous Indications

You can print these lists with the “Print event buffer” button.

2.17.1.2 Setting Notes

The parameters of the WEB-Monitor can be set separately for the front operator interface and the service interface. The relevant IP address of the interface is the one that is used for communication with the PC and the WEB-Monitor.

Make sure that the 12-digit IP address valid for the browser is set correctly via DIGSI in the format ***.***.***.***.

2.17.2 Processing of Messages

After the occurrence of a system fault, data regarding the response of the protection relay and the measured quantities should be saved for future analysis. For this reason message processing is done in three ways:

2.17.2.1 Functional Description

Indicators and Binary Outputs (Output Relays)

Important events and states are displayed by LEDs on the front cover. The device also contains output relays for remote signaling. Most indications and displays can be configured differently from the delivery default settings (for information on the delivery default setting see Appendix). The SIPROTEC 4 System Description gives a detailed description of the configuration procedure.

The output relays and the LEDs may be operated in a latched or unlatched mode (each may be individually set).

The latched conditions are protected against loss of the auxiliary voltage. They are reset

- On site by pressing the LED key on the relay,
- Remotely using a binary input configured for that purpose,
- via one of the serial interfaces,
- Automatically at the beginning of a new pickup.

Status messages should not be latched. Also, they cannot be reset until the criterion to be reported is remedied. This applies to, e.g., indications from monitoring functions, or the like.

A green LED displays operational readiness of the relay (“RUN”); it cannot be reset. It extinguishes if the self-check feature of the microprocessor detects an abnormal occurrence, or if the auxiliary voltage fails.

When auxiliary voltage is present but the relay has an internal malfunction, the red LED (“ERROR”) lights up and the processor blocks the relay.

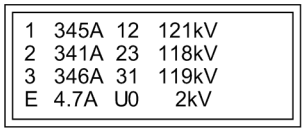
DIGSI enables you to selectively control each output relay and LED of the device and, in doing so, check the correct connection to the system. In a dialog box, you can, for instance, cause each output relay to pick up, and thus test the wiring between the 7SD610 and the system without having to create the indications masked to it.

Information on the Integrated Display (LCD) or to a Personal Computer

Events and conditions can be read out on the display on the front panel of the relay. Using the front operator interface or the rear service interface, for instance, a personal computer can be connected, to which the information can be sent.

In the quiescent state, i.e. as long as no system fault is present, the LCD can display selectable operational information (overview of the operational measured values) (default display). In the event of a system fault, information regarding the fault, the so-called spontaneous displays, are displayed instead. After the fault indications have been acknowledged, the quiescent data are shown again. Acknowledgement is accomplished by pressing the LED buttons on the front panel (see above).

Various default displays can be selected via the arrow keys. Parameter 640 can be set to change the default setting for the default display page shown in idle state. Two examples of possible default display selections are given below.



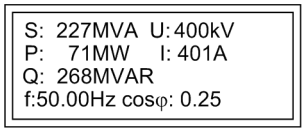
Example:

IL1	= 345 A	UL1-L2	= 121 kV
IL2	= 341 A	UL2-L3	= 118 kV
IL3	= 346 A	UL3-L1	= 119 kV
IE (3I0)	= 4.7 A	U0	= 2 kV

[beispiel-grundb-4-zeil-disp-wlk-210802, 1, en_GB]

Figure 2-115 Operational measured values in the default display

Default display 3 shows the measured power values and the measured values U_{L1-L2} and I_{L2} dargestellt.



Example:

S	= 227 MVA	UL1-L2	= 400 kV
P	= 71 MW	IL2	= 401 A
Q	= 268 MVAR		
f	= 50.00 Hz	cos φ	= 0.25

[grundb-3-4-zeil-displ-wlk-230802, 1, en_GB]

Figure 2-116 Operational measured values in the default display

Moreover, the device has several event buffers for operational indications, fault indications, switching statistics, etc., which are protected against loss of auxiliary supply by means of a backup battery. These indications can be displayed on the LCD at any time by selection using the keypad or transferred to a personal computer via the serial service or operator interface. Reading out indications during operation is described in detail in the SIPROTEC 4 System Description.

After a system fault, for example, important information about the progression of the fault can be retrieved, such as the pickup of a protection stage or the initiation of a trip signal. The system clock accurately provides the absolute time when the fault first occurred. The fault progression is output with a relative time referred to

the instant of pickup so that the time until tripping and until reset of the trip command can be recognized. The resolution of the time information is 1 ms.

With a PC and the DIGSI protection data processing software, it is also possible to retrieve and display the events with the convenience of visualisation on a monitor and a menu-guided dialog. The data can either be printed out or stored elsewhere for later evaluation.

The protection device stores the messages of the last eight system faults; in the event of a ninth fault, the oldest is erased.

A system fault starts with the detection of the fault by the fault detection of any protection function and ends with the reset of the fault detection of the last protection function or after the expiry of the auto-reclose reclaim time, so that several unsuccessful reclose cycles are also stored cohesively. Accordingly a system fault may contain several individual fault events (from fault detection up to reset of fault detection).

Information to a Control Centre

If the device has a serial system interface, stored information may additionally be transferred via this interface to a central control and storage device. Transmission is possible via different transmission protocols.

You may test whether the indications are transmitted correctly with DIGSI.

Also the information transmitted to the control centre can be influenced during operation or tests. The IEC 60870-5-103 protocol allows to identify all indications and measured values transferred to the central control system with an added indication “test mode” while the device is being tested on site (test mode). This identification prevents the indications from being incorrectly interpreted as resulting from an actual power system disturbance or event. Alternatively, you may disable the transmission of indications to the system interface during tests “Transmission Block”).

To influence information at the system interface during test mode (“test mode” and “transmission block”), a CFC logic is required. Default settings already include this logic (see Appendix).

The SIPROTEC 4 System Description describes in detail how to activate and deactivate test mode and blocked data transmission.

Classification of Indications

Indications are classified as follows:

- Operational indications: messages generated while the device is in operation: They include information about the status of device functions, measurement data, system data, and similar information.
- Fault indications: messages from the last eight system faults that were processed by the device.
- Indications on Statistics: they include counters for the switching actions of the circuit breakers initiated by the device, maybe reclose commands as well as values of interrupted currents and accumulated fault currents.

A complete list of all indications and output functions generated by the device with the associated information number (No.) can be found in the Appendix. This list also indicates where each indication can be sent. If certain functions are not avaiable in a device version with reduced function scope or if they are configured as in the function scope, then the associated indications will not appear.

Operational Indications

Operational indications contain information generated by the device during operation about operational conditions.

Up to 200 operational indications are recorded in chronological order in the device. Newly generated indications are added to those already present. If the maximum capacity of the memory has been exceeded, the oldest indication will be overwritten.

Operational indications arrive automatically and can be read out from the device display or a personal computer at any time. Faults in the power system are indicated with “Network Fault” and the present fault number. The fault indications contain detailed information on the response during system faults.

Fault Indications

Following a system fault it is possible to retrieve important information regarding its progress, such as pickup and trip. The system clock accurately provides the absolute time when the fault first occurred. The fault

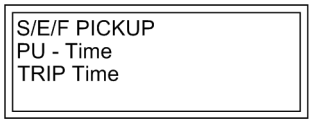
progression is output with a relative time referred to the instant of pickup so that the time until tripping and until reset of the trip command can be recognized. The resolution of the time information is 1 ms.

A system fault starts with the recognition of a fault by the fault detection, i.e. first pickup of any protection function, and ends with the reset of the fault detection, i.e. dropout of the last protection function. Where a fault causes several protection functions to pick up, the fault is considered to include all that occurred between pickup of the first protection function and dropout of the last protection function.

If automatic reclosure is performed, the network fault ends after the last blocking time has expired, thus after a successful or unsuccessful reclosure. Therefore the entire clearing process, including the reclosure cycle shot (or all reclosure cycles), occupies only one fault log. Within a network fault, several faults can occur (from the first pickup of a protection function to the dropout of the last pickup). Without automatic reclosure each fault represents a network fault.

Spontaneous annunciations

After a fault, automatically and without operator action, the most important fault data from the general device pickup appear on the display in the sequence shown in the following figure.



[spontane-display-stoerfallanzeigen, 1, en_GB]

Figure 2-117 Spontaneous fault indication display

Retrievable Indications

The indications of the last eight system faults can be retrieved and read out. A total of 600 indications can be stored. The oldest indications are erased for the newest fault indications when the buffer is full.

Spontaneous Indications

Spontaneous indications contain information that new indications have arrived. Each new incoming indication appears immediately, i.e. the user does not have to wait for an update or initiate one. This can be a useful help during operation, testing and commissioning.

Spontaneous indications can be read out via DIGSI. For more information see the SIPROTEC 4 System Description.

General Interrogation

The present condition of the SIPROTEC 4 device can be retrieved via DIGSI by viewing the contents of the General Interrogation. It shows all indications that are subject to general interrogation with their current value.

2.17.3 Statistics

Counting includes the number of trips initiated by 7SD610, the accumulated breaking currents resulting from trips initiated by protection functions, the number of close commands initiated by the auto-reclosure function.

2.17.3.1 Functional Description

Counters and Memories

The counters and memories of the statistics are saved by the device. Therefore, the information will not get lost in case the auxiliary voltage supply fails. The counters, however, can be reset to zero or to any value within the setting range.

Switching statistics can be viewed on the LCD of the device, or on a PC running DIGSI and connected to the operating or service interface.

A password is not required to read switching statistics; however, a password is required to change or delete the statistics. For more information see the SIPROTEC 4 System Description.

Number of trips

The number of trips initiated by the device 7SD610 is counted. If the device is capable of single-pole tripping, a separate counter for each circuit breaker pole is provided.

Number of automatic reclosing commands

If the device is equipped with the integrated automatic reclosure, the automatic close commands are also counted, separately for reclosure after 1-pole tripping, after 3-pole tripping as well as separately for the first reclosure cycle and other reclosure cycles.

Interrupted currents

Furthermore, for each trip command the interrupted current for each pole is acquired, output in the trip log and accumulated in a memory. The maximum interrupted current is stored as well. The indicated measured values are indicated in primary values.

Transmission statistics

In 7SD610 the protection communication is registered in statistics. The delay times of the information between the devices via interfaces (run and return) are measured steadily. The values are kept stored in the Statistics folder. The availability of the transmission media is also reported. The availability is indicated in % / min and % / h. This enables an evaluation of the transmission quality.

If GPS synchronization is configured, the transmission times for each direction and each protection data interface are regularly measured and indicated as long as GPS synchronization is intact.

2.17.3.2 Information List

No.	Information	Type of Information	Comments
1000	# TRIPs=	VI	Number of breaker TRIP commands
1001	TripNo L1=	VI	Number of breaker TRIP commands L1
1002	TripNo L2=	VI	Number of breaker TRIP commands L2
1003	TripNo L3=	VI	Number of breaker TRIP commands L3
1027	Σ IL1 =	VI	Accumulation of interrupted current L1
1028	Σ IL2 =	VI	Accumulation of interrupted current L2
1029	Σ IL3 =	VI	Accumulation of interrupted current L3
1030	Max IL1 =	VI	Max. fault current Phase L1
1031	Max IL2 =	VI	Max. fault current Phase L2
1032	Max IL3 =	VI	Max. fault current Phase L3
2895	AR #Close1./1p=	VI	No. of 1st AR-cycle CLOSE commands,1pole
2896	AR #Close1./3p=	VI	No. of 1st AR-cycle CLOSE commands,3pole
2897	AR #Close2./1p=	VI	No. of higher AR-cycle CLOSE commands,1p
2898	AR #Close2./3p=	VI	No. of higher AR-cycle CLOSE commands,3p
7751	PI1 TD	MV	Prot.Interface 1:Transmission delay
7753	PI1A/m	MV	Prot.Interface 1: Availability per min.
7754	PI1A/h	MV	Prot.Interface 1: Availability per hour
7875	PI1 TD R	MV	Prot.Interface 1:Transmission delay rec.
7876	PI1 TD S	MV	Prot.Interface 1:Transmission delay send

2.17.4 Measurement During Operation

2.17.4.1 Function Description

A series of measured values and the values derived from them are available for on-site retrieval or for data transfer.

A precondition for the correct display of primary and percentage values is the complete and correct entry of the nominal values of the instrument transformers and the power system as well as the transformation ratio of the current and voltage transformers in the earth paths.

Display of measured values

Operational measured values and metered values are determined in the background by the processor system. They can be called up on the front of the device, read out via the operator interface using a PC with DIGSI, or transferred to a control centre via the system interface.

Table 2-11 shows a survey of the measured values of the local device. Depending on the version ordered, the connection of the device, and the configured protection functions, only a part of the measured operating values listed is available.

Phase-to-earth voltages can only be measured if the phase-to-earth voltage inputs are connected. The displacement voltage $3U_0$ is e-n-voltage multiplied by $\sqrt{3}$ — if U_{en} is connected — or calculated from the phaseto- earth voltages $3U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. All three voltage inputs must be phase-earth connected for this.

Both devices connected via the protection interface form a joint frequency value (constellation frequency). This value is displayed as the operational measured value “Frequency”. It allows to display a frequency even in devices in which local frequency measurement is not possible. The constellation frequency is also used by the differential protection for synchronizing the measured values. Locally operating functions always use the locally measured frequency.

If the device is in “Log out device” ON mode, in differential protection test mode or if there is no protection data interface connection, the locally measured frequency is displayed.

For the thermal overload protection, the calculated overtemperatures are indicated in relation to the trip overtemperature. Overload measured values can appear only if the overload protection was configured ***Enabled***.

The power and operating values upon delivery are set such that power in line direction is positive. Active components in line direction and inductive reactive components in line direction are also positive. The same applies for the power factor cosφ.

It is occasionally desired to define the power drawn from the line (e.g. as seen from the consumer) positively. Using parameter 1107 **`P,Q sign`** the signs for these components can be inverted.

The computation of the operational measured values is also executed during an existent system fault in intervals of approx. 0.5s.

Table 2-11 Operational measured values of the local device

Measured Values		Primary	Secondary	% Referred to
I_{L1}, I_{L2}, I_{L3}	Phase currents	A	A	Nominal operational current [1]
$3I_0$	Earth current	A	A	Nominal operational current [1]
$\varphi(I_{L1}\text{-}I_{L2})$, $\varphi(I_{L2}\text{-}I_{L3})$, $\varphi(I_{L3}\text{-}I_{L1})$	Phase angle of the phase currents towards each other	°	–	–
I_1, I_2	Positive and negative sequence currents	A	A	Nominal operational current [1]
I_Y	Transformer starpoint current	A	A	Nominal operational current [1] [1)3)]
$U_{L1\text{-}L2}$, $U_{L2\text{-}L3}$, $U_{L3\text{-}L1}$	Phase-to-phase voltages	kV	V	Nominal operational voltage [2]

Measured Values		Primary	Secondary	% Referred to
U_{L1-E}, U_{L2-E}, U_{L3-E}	Phase-earth voltage	kV	V	Rated operational voltage / $\sqrt{3}$ 2)
$3U_0$	Displacement Voltage	kV	V	Rated operational voltage / $\sqrt{3}$ 2)
$\varphi(U_{L1}\text{-}U_{L2})$, $\varphi(U_{L2}\text{-}U_{L3})$, $\varphi(U_{L3}\text{-}U_{L1})$	Phase angle of the phase voltages towards each other	°	–	–
$\varphi(U_{L1}\text{-}I_{L1})$, $\varphi(U_{L2}\text{-}I_{L2})$, $\varphi(U_{L3}\text{-}I_{L3})$	Phase angle of the phase voltages towards the phase currents	°	–	–
U_1, U_2	Positive and negative sequence component of the voltages	kV	V	Rated operational voltage / $\sqrt{3}$ 2)
U_X, U_{EN}	Voltage at measuring input U_4	–	V	–
$U_{1kompoundiert}$	Positive sequence component of voltages at the remote end (if compounding is active in voltage protection)	kV	V	Operational rated voltage / $\sqrt{3}$ 2)
S, P, Q	Apparent, active and reactive power	MVA, MW, MVAR	–	$\sqrt{3}\cdot U_N\cdot I_N$ Nominal operational quantities 1)2)
cos φ	Power factor	(abs)	(abs)	–
f	Frequency (constellation frequency)	Hz	Hz	Nominal Frequency
$\Theta_{L1}/\Theta_{TRIP}$, $\Theta_{L2}/\Theta_{TRIP}$, $\Theta_{L3}/\Theta_{TRIP}$	Thermal value of each phase, referred to the tripping value	%	–	Trip overtemperature
Θ/Θ_{TRIP}	Resulting thermal value, referred to the tripping value, calculated according to the set method	%	–	Trip overtemperature

1) according to address 1104

2) according to address 1103

3) considering factor 221 **I4/Iph CT**

2.17.4.2 Information List

No.	Information	Type of Information	Comments
601	IL1 =	MV	I L1
602	IL2 =	MV	I L2
603	IL3 =	MV	I L3
610	3I0 =	MV	3I0 (zero sequence)
612	IY =	MV	IY (star point of transformer)
619	I1 =	MV	I1 (positive sequence)
620	I2 =	MV	I2 (negative sequence)
621	UL1E=	MV	U L1-E
622	UL2E=	MV	U L2-E
623	UL3E=	MV	U L3-E
624	UL12=	MV	U L12
625	UL23=	MV	U L23
626	UL31=	MV	U L31
627	Uen =	MV	Uen
631	3U0 =	MV	3U0 (zero sequence)
633	Ux =	MV	Ux (separate VT)

No.	Information	Type of Information	Comments
634	U1 =	MV	U1 (positive sequence)
635	U2 =	MV	U2 (negative sequence)
641	P =	MV	P (active power)
642	Q =	MV	Q (reactive power)
643	PF =	MV	Power Factor
644	Freq=	MV	Frequency
645	S =	MV	S (apparent power)
679	U1co=	MV	U1co (positive sequence, compounding)
684	U0 =	MV	U0 (zero sequence)
801	Θ/Θtrip =	MV	Temperat. rise for warning and trip
802	Θ/ΘtripL1=	MV	Temperature rise for phase L1
803	Θ/ΘtripL2=	MV	Temperature rise for phase L2
804	Θ/ΘtripL3=	MV	Temperature rise for phase L3
7731	Φ IL1L2=	MV	PHI IL1L2 (local)
7732	Φ IL2L3=	MV	PHI IL2L3 (local)
7733	Φ IL3L1=	MV	PHI IL3L1 (local)
7734	Φ UL1L2=	MV	PHI UL1L2 (local)
7735	Φ UL2L3=	MV	PHI UL2L3 (local)
7736	Φ UL3L1=	MV	PHI UL3L1 (local)
7737	Φ UIL1=	MV	PHI UIL1 (local)
7738	Φ UIL2=	MV	PHI UIL2 (local)
7739	Φ UIL3=	MV	PHI UIL3 (local)

2.17.5 Differential Protection Values

2.17.5.1 Measured values of differential protection

The differential and restraint current values of the differential protection which are listed in the following table can be called up at the front of the device, read out via the operating interface using a PC with DIGSI or transferred to a control centre via the system interface.

Table 2-12 Measured values of the differential protection

Measured Values		% Referred to
$IDiff_{L1}$, $IDiff_{L2}$, $IDiff_{L3}$	Calculated differential currents of the three phases	Nominal operational current [1)]
$IStab_{L1}$, $IStab_{L2}$, $IStab_{L3}$	Calculated restraining currents of the three phases	Nominal operational current [1)]
$IDiff_{3I0}$	Calculated differential current of the zero sequence system	Nominal operational current [1)]

[1)] for lines according to address (see Section *2.1.4 General Protection Data (Power System Data 2)*), for transformers calculated from address (see Section *2.1.4 General Protection Data (Power System Data 2)*) $I_N = S_N / (\sqrt{3} \cdot U_N)$

2.17.5.2 Information List

No.	Information	Type of Information	Comments
7742	IDiffL1=	MV	IDiffL1(% Operational nominal current)
7743	IDiffL2=	MV	IDiffL2(% Operational nominal current)
7744	IDiffL3=	MV	IDiffL3(% Operational nominal current)
7745	IRestL1=	MV	IRestL1(% Operational nominal current)
7746	IRestL2=	MV	IRestL2(% Operational nominal current)
7747	IRestL3=	MV	IRestL3(% Operational nominal current)
7748	Diff3I0=	MV	Diff3I0 (Differential current 3I0)
30654	IdiffREF=	MV	Idiff REF(% Operational nominal current)
30655	IrestREF=	MV	Irest REF(% Operational nominal current)

2.17.6 Measured Values Constellation

2.17.6.1 Functional Description

The measured values constellation of both possible devices are shown here by evaluating the device 1 (see *Table 2-13*). Information on the second device is given in the Appendix.

The computation of this measured values constellation is also performed during an existing system fault at an interval of approx. 2 s.

The locally measured current/voltage is used as a reference for the angle. The angle values of the remote ends refer to the locally measured value.

Example for the current of a 2-ends constellation:

Current IL1 at the local end 98 % angle 0°

Current IL1 at the local end 98 % angle 180°

By means of the device address, the devices can be distinguished one from another. Via the device address, a polarity reversal of the current transformer can be detected immediately and the line angle can be read (if voltages are available).

Table 2-13 Constellation measured values for device 1

No.	Information	Info type	Explanation
7761	*Relay ID*	MW	Device address of the first devcie
7762	*IL1_opN=*	MW	IL1 (% of operational rated current)
7763	*ΦI L1=*	MW	Angle IL1_remote <-> IL1_local
7764	*IL2_opN=*	MW	IL2 (% of operational rated current)
7765	*ΦI L2=*	MW	Angle IL2_remote <-> IL2_local
7766	*IL3_opN=*	MW	IL3 (% of operational rated current)
7767	*ΦI L3=*	MW	Angle IL3_remote <-> IL3_local
7769	*UL1_opN=*	MW	UL1 (% of operational rated voltage)
7770	*ΦU L1=*	MW	Angle UL1_remote <-> UL1_local
7771	*UL2_opN=*	MW	UL2 (% of operational rated voltage)
7772	*ΦU L2=*	MW	Angle UL2_remote <-> UL2_local
7773	*UL3_opN=*	MW	UL3 (% of operational rated voltage)
7774	*ΦU L3=*	MW	Angle UL3_remote <-> UL3_local

2.17.7 Oscillographic Fault Records

2.17.7.1 Functional Description

The 7SD610 is equipped with a fault recording function. The instantaneous values of the measured quantities i_{L1}, i_{L2}, i_{L3}, 3_{i0}, u_{L1}, u_{L2}, u_{L3}, $3\ u_0$ or u_{en} or u_x sowie I_{diffL1}, I_{diffL2}, I_{diffL3}, I_{stabL1}, I_{stabL2}, I_{stabL3} (voltages depending on the connection) are sampled at intervals of 1 ms (for 50 Hz) and stored in a circulating buffer (20 samples per cycle). For a fault, the data are stored for an adjustable period of time, but no more than 5 seconds per fault. A total of 8 faults can be saved spanning a total time of 15 s maximum. The fault record memory is automatically updated with every new fault, so that no acknowledgment is required. The storage of fault values can be started by pickup of a protection function, as well as via binary input and via the serial interface.

Für das Differentialschutzsystem eines Schutzobjektes werden die Störwertaufzeichnungen aller Enden über die Zeitverwaltung synchronisiert. Dadurch ist gewährleistet, dass alle Störwertaufzeichnungen mit der praktisch absolut gleichen Zeitbasis arbeiten. Gleiche Messgrößen sind in Folge dessen an allen Enden deckungsgleich.

The data can be retrieved via the serial interfaces by means of a personal computer and evaluated with the operating software DIGSI and the graphic analysis software SIGRA 4. The latter graphically represents the data recorded during the system fault and calculates additional information such as the impedance or r.m.s. values from the measured values. A selection may be made as to whether the currents and voltages are represented as primary or secondary values. Binary signal traces (marks) of particular events, e.g. “fault detection”, “tripping” are also represented.

If the device has a serial system interface, the fault recording data can be passed on to a central device via this interface. Data are evaluated by appropriate programs in the central device. Currents and voltages are referred to their maximum values, scaled to their rated values and prepared for graphic presentation. Binary signal traces (marks) of particular events e.g. “fault detection”, “tripping” are also represented.

In the event of transfer to a central device, the request for data transfer can be executed automatically and can be selected to take place after each fault detection by the protection, or only after a trip.

2.17.7.2 Setting Notes

General

Other settings pertaining to fault recording (waveform capture) are found in the submenu **Oscillographic Fault Records** submenu of the **Settings** menu. Waveform capture makes a distinction between the trigger instant for an oscillographic record and the criterion to save the record (address402 **WAVEFORMTRIGGER**). This parameter can only be altered in DIGSI at **Display Additional Settings**. Normally the trigger instant is the device pickup, i.e. the pickup of an arbitrary protection function is assigned the time. The criterion for saving may be both the device pickup(***Save w. Pickup***) or the device trip ***Save w. TRIP***). A trip command issued by the device can also be used as trigger instant (***Start w. TRIP***), in this case it is also the saving criterion.

An oscillographic fault record includes data recorded prior to the time of trigger, and data after the dropout of the recording criterion. Usually this is also the extent of a fault recording (address 403 **WAVEFORM DATA** = ***Fault event***). If automatic reclosure is implemented, the entire system disturbance — possibly with several reclose attempts — up to the ultimate fault clearance can be stored (address 403 **WAVEFORM DATA** = ***Pow.Sys.Flt.***). This facilitates the representation of the entire system fault history, but also consumes storage capacity during the auto reclosure dead time(s). This parameter can only be altered in DIGSI at **Display Additional Settings**.

The actual storage time encompasses the pre-fault time **PRE. TRIG. TIME** (address 411) ahead of the reference instant, the normal recording time and the post-fault time **POST REC. TIME** (address 412) after the storage criterion has reset. The maximum recording duration to each fault **MAX. LENGTH** is set at address 410.

The fault recording can also be triggered via a binary input, via the keypad on the front of the device or with a PC via the operation or service interface. The storage is then dynamically triggered. The length of the fault recording is set in address 415 **BinIn CAPT.TIME** (maximum length however is **MAX. LENGTH**, address 410). Pre-fault and post-fault times will be included. If the binary input time is set for ∞ , then the length of

the record equals the time that the binary input is activated (static), or the **MAX. LENGTH** setting in address 410, whichever is shorter.

2.17.7.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

Addr.	Parameter	Setting Options	Default Setting	Comments
402A	WAVEFORMTRIGGER	Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403A	WAVEFORM DATA	Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
410	MAX. LENGTH	0.30 .. 5.00 sec	2.00 sec	Max. length of a Waveform Capture Record
411	PRE. TRIG. TIME	0.05 .. 0.50 sec	0.25 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input

2.17.7.4 Information List

No.	Information	Type of Information	Comments
-	FltRecSta	IntSP	Fault Recording Start
4	>Trig.Wave.Cap.	SP	>Trigger Waveform Capture
30053	Fault rec. run.	OUT	Fault recording is running

2.17.8 Energy

Metered values for active and reactive power are determined in the background by the processor system. They can be called up at the front of the device, read out via the operating interface using a PC with DIGSI, or transferred to a central master station via the system interface.

2.17.8.1 Energy Metering

7SD610 integrates the calculated power as a function of time and then provides the results under the measured values. The components as listed in *Table 2-14* can be read out. The signs of the operating values depend on the setting at address 1107 **P,Q sign** (see Section *2.17.4 Measurement During Operation* under margin heading"Display of Measured Values").

Please take into consideration that 7SD610 is, above all, a protection device. The accuracy of the metered values depends on the instrument transformers (normally protection core) and the device tolerances. The metering is therefore not suited for tariff purposes.

The counters can be reset to zero or any initial value (see also SIPROTEC 4 System Description).

Table 2-14 Operational metered values

Measured values		Primary
W_p+	Active power, output	kWh, MWh, GWh
W_p-	Active power, input	kWh, MWh, GWh
W_q+	Reactive power, output	kVARh, MVARh, GVARh
W_q-	Reactive power, input	kVARh, MVARh, GVARh

2.17.8.2 Setting Notes

Retrieving Parameters

The SIPROTEC System Description describes in detail how to read out the statistical counters via the device front panel or DIGSI. The values are added up in direction of the protected object Provided the direction was configured as “forward” (address 201).

2.17.8.3 Information List

No.	Information	Type of Information	Comments
-	Meter res	IntSP_Ev	Reset meter
888	Wp(puls)	PMV	Pulsed Energy Wp (active)
889	Wq(puls)	PMV	Pulsed Energy Wq (reactive)
916	WpΔ=	-	Increment of active energy
917	WqΔ=	-	Increment of reactive energy
924	Wp+=	MVMV	Wp Forward
925	Wq+=	MVMV	Wq Forward
928	Wp-=	MVMV	Wp Reverse
929	Wq-=	MVMV	Wq Reverse

2.18 Command Processing

The SIPROTEC 4 7SD610 includes a command processing for initiating switching operations in the system. Control can originate from four command sources:

- Local operation using the keypad on the local user interface of the device,
- Operation using DIGSI,
- Remote operation using a substation automation and control system (e.g. SICAM),
- Automatic functions (e.g. using binary inputs, CFC).

The number of switchgear devices that can be controlled is basically limited by the number of available and required binary inputs and outputs. For the output of control commands it has to be ensured that all the required binary inputs and outputs are configured and provided with the correct properties.

If specific interlocking conditions are needed for the execution of commands, the user can program the device with bay interlocking by means of the user-defined logic functions (CFC). The interlocking conditions of the system can be injected via the system interface and must be allocated accordingly.

The procedure for switching resources is described in the SIPROTEC 4 System Description under Control of Switchgear.

2.18.1 Control Authorization

2.18.1.1 Type of Commands

Commands to the Process

These commands are directly output to the switchgear to change their process state:

- Commands for the operation of circuit breakers as well as commands for the control of isolators and earth switches.
- Step commands, e.g. for raising and lowering transformer taps,
- Setpoint commands with configurable time settings, e.g. to control arc-suppression coils.

Device-internal Commands

These commands do not directly operate binary outputs. They serve for initiating internal functions, communicating the detection of status changes to the device or for acknowledging them.

- Manual override commands for “manual update”of information on process-dependent objects such as annunciations and switching states, e.g. if the communication with the process is interrupted. Manually overridden objects are marked as such in the information status and can be displayed accordingly.
- Tagging commands (for “setting”) the information value of internal objects, such as switching authority (remote/local), parameter changeovers, blocking of transmission and deletion/presetting of metered values.
- Acknowledgment and resetting commands for setting and resetting internal buffers or data stocks.
- Information status commands to set/delete the additional “Information Status” item of a process object, such as
  - Acquisition blocking,
  - Output blocking.

2.18.1.2 Sequence in the Command Path

Safety mechanisms in the command sequence ensure that a switch command can only be released after a thorough check of preset criteria has been successfully concluded. Additionally, user-defined interlocking conditions can be configured separately for each device. The actual execution of the command is also monitored after its release. The entire sequence of a command is described briefly in the following list:

Checking a Command Execution

Please observe the following:

- Command entry, e.g. using the keypad on the local user interface of the device
  - Check password → access rights;
  - Check switching mode (interlocking activated/deactivated) → selection of deactivated interlocking status.
- User configurable interlocking checks:
  - Switching authority;
  - Device position check (set vs. actual comparison);
  - Zone controlled / bay interlocking (logic using CFC);
  - System interlocking (centrally via SICAM);
  - Double operation (interlocking against parallel switching operation);
  - Protection blocking (blocking of switching operations by protection functions);
- Fixed commands:
  - Internal process time (software watch dog which checks the time for processing the control action between initiation of the control and final close of the relay contact);
  - Configuration in process (if setting modification is in process, commands are rejected or delayed);
  - Equipment present as output;
  - Output block (if an output block has been programmed for the circuit breaker, and is active at the moment the command is processed, then the command is rejected);
  - Component hardware malfunction;
  - Command in progress (only one command can be processed at a time for each circuit breaker or switch);
  - 1–of–n check (for multiple allocations such as common contact relays or multiple protection commands configured to the same contact it is checked if a command procedure was already initiated for the output relays concerned or if a protection command is present. Superimposed commands in the same switching direction are tolerated).

Command Execution Monitoring

The following is monitored:

- Interruption of a command because of a cancel command,
- Running time monitor (feedback monitoring time).

2.18.1.3 Interlocking

Interlocking can be executed by the user-defined logic (CFC). Switchgear interlocking checks in a SICAM/ SIPROTEC 4 system are normally divided in the following groups:

- System interlocking checked by a central control system (for interbay interlocking),
- Zone controlled/bay interlocking checked in the bay device (for the feeder).
- Cross-bay interlocking via GOOSE messages directly between bay controllers and protection relays (with rollout of IEC 61850; inter-relay communication by GOOSE messaging is performed via the EN100 module)

System interlocking is based on the process image in the central device. Zone controlled/bay interlocking relies on the object database (feedback information) of the bay unit (here the SIPROTEC 4 relay) as was determined during configuration (see SIPROTEC 4 System Description).

The extent of the interlocking checks is determined by the configuration and interlocking logic of the relay. For more information on GOOSE messaging, please refer to the SIPROTEC 4 System Description.

Switching objects that require system interlocking in a central control system are marked by a specific parameter inside the bay unit (via configuration matrix).

For all commands, operation with interlocking (normal mode) or without interlocking (test mode) can be selected:

- For local commands by reprogramming the settings with password check,
- For automatic commands, via command processing by CFC and Deactivated Interlocking Recognition,
- For local/remote commands, using an additional interlocking disable command via PROFIBUS.

Interlocked/non-interlocked Switching

The configurable command checks in the SIPROTEC 4 devices are also called “standard interlocking”. These checks can be activated via DIGSI (interlocked switching/tagging) or deactivated (non-interlocked).

De-interlocked or non-interlocked switching means that the configured interlock conditions are not tested.

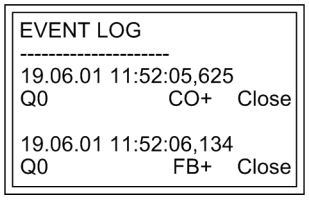
Interlocked switching means that all configured interlocking conditions are checked within the command processing. If a condition could not be fulfilled, the command will be rejected by an indication with a minus added to it, e.g. “CO–”, followed by an operation response information. *Table 2-15* shows some types of commands and indications. The indications marked with *) are displayed only in the event logs on the device display; for DIGSI they appear in spontaneous indications.

Table 2-15 Command types and corresponding indications

Type of Command	Control	Cause	Indication
Control issued	Switching	CO	CO+/–
Manual tagging (positive/negative)	Manual tagging	MT	MT+/–
Information state command, Input blocking	Input blocking	ST	ST+/– *)
Information state command, Output blocking	Output blocking	ST	ST+/– *)
Cancel command	Cancel	CA	CA+/–

The plus sign in the indication is a confirmation of the command execution: The command output has a positive result, as expected. A minus sign means a negative, i.e. an unexpected result. The command was rejected. *Figure 2-118* shows an example for successful switching of the circuit breaker in the Event Log (command and feedback).

The check of interlocking can be programmed separately for all switching devices and tags that were set with a tagging command. Other internal commands such as overriding or abort are not tested, i.e. are executed independently of the interlockings.



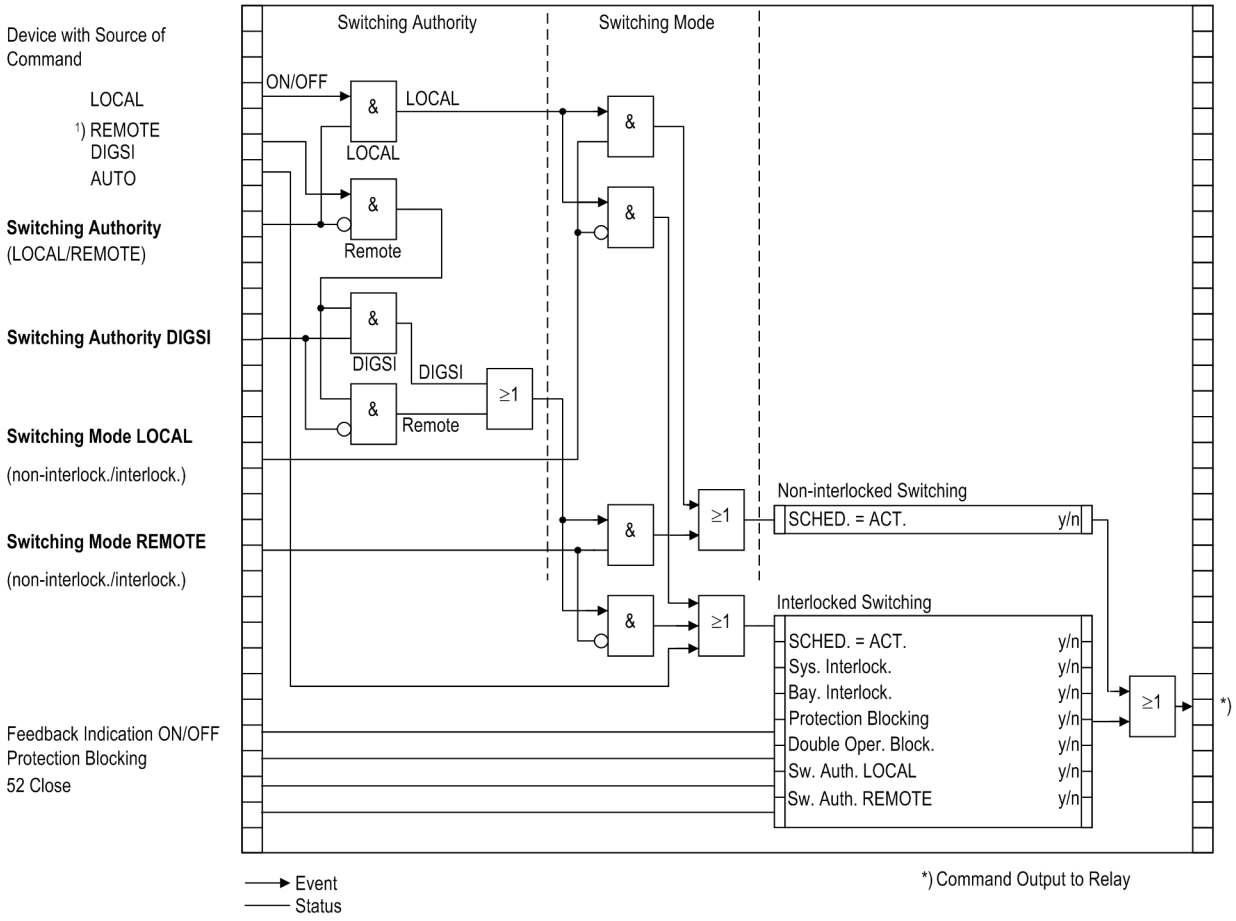
[leistungsschalterbetriebsmeldung-020315-wlk, 1, en_GB]

Figure 2-118 Example of an operational indication for switching circuit breaker (Q0)

Standard Interlocking

The standard interlocking includes the checks for each switchgear which were set during the configuration of inputs and outputs, see SIPROTEC 4 System Description.

An overview for processing the interlocking conditions in the relay is shown in *Figure 2-119*.



[standardveriegelungen-wlk-020802, 1, en_GB]

Figure 2-119 Standard interlockings

1) Source of Command REMOTE includes LOCAL.

(NAH Command using substation controller

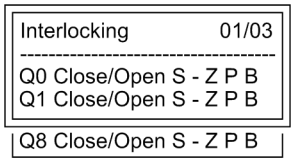
FERN Command via telecontrol station to power system management and from power system management to the device)

The display shows the configured interlocking reasons. They are marked by letters as explained in *Table 2-16* .

Table 2-16 Interlocking Commands

Interlocking Commands	Command (abbreviation)	Display
Control Authority	SV	S
System Interlocking	AV	A
Bay Interlocking	BI	F
SET = ACTUAL (switch direction check)	SI	I
Protection Blockage	SB	B

Figure 2-120 shows all interlocking conditions (which usually appear in the display of the device) for three switchgear items with the relevant abbreviations explained in Table . *Table 2-16* explained abbreviations. All parameterized interlocking conditions are indicated.



[verriegelungsbed-020315-wlk, 1, en_GB]

Figure 2-120 Example of configured interlocking conditions

Control Logic via CFC

For bay interlocking, a release logic can be created using CFC. Via specific release conditions the information "released" or "bay interlocked" are available, e.g. object "Release CD Close" and "Release CD Open" with the information values: ON/OFF).

2.18.1.4 Information List

No.	Information	Type of Information	Comments
-	ModeREMOTE	IntSP	Controlmode REMOTE
-	Cntrl Auth	IntSP	Control Authority
-	ModeLOCAL	IntSP	Controlmode LOCAL

2.18.2 Control Device

2.18.2.1 Information List

No.	Information	Type of Information	Comments
-	Breaker	CF_D12	Breaker
-	Breaker	DP	Breaker
-	Disc.Swit.	CF_D2	Disconnect Switch
-	Disc.Swit.	DP	Disconnect Switch
-	EarthSwit	CF_D2	Earth Switch
-	EarthSwit	DP	Earth Switch
-	Brk Open	IntSP	Interlocking: Breaker Open
-	Brk Close	IntSP	Interlocking: Breaker Close
-	Disc.Open	IntSP	Interlocking: Disconnect switch Open
-	Disc.Close	IntSP	Interlocking: Disconnect switch Close
-	E Sw Open	IntSP	Interlocking: Earth switch Open
-	E Sw Cl.	IntSP	Interlocking: Earth switch Close
-	Q2 Op/Cl	CF_D2	Q2 Open/Close
-	Q2 Op/Cl	DP	Q2 Open/Close
-	Q9 Op/Cl	CF_D2	Q9 Open/Close
-	Q9 Op/Cl	DP	Q9 Open/Close
-	Fan ON/OFF	CF_D2	Fan ON/OFF
-	Fan ON/OFF	DP	Fan ON/OFF
31000	Q0 OpCnt=	VI	Q0 operationcounter=
31001	Q1 OpCnt=	VI	Q1 operationcounter=
31002	Q2 OpCnt=	VI	Q2 operationcounter=
31008	Q8 OpCnt=	VI	Q8 operationcounter=

No.	Information	Type of Information	Comments
31009	Q9 OpCnt=	VI	Q9 operationcounter=

2.18.3 Process Data

During the processing of commands, independently of the further allocation and processing of indications, command and process feedbacks are sent to the indication processing. These indications contain information on the cause. With the corresponding allocation (configuration) these indications are entered in the event log, thus serving as a report.

A listing of possible operational indications and their meaning, as well as the command types needed for tripping and closing the switchgear or for raising and lowering transformer taps and detailed information are described in the SIPROTEC 4 System Description.

2.18.3.1 Functional Description

Acknowledgement of Commands to the Device Front

All indications with the source of command LOCAL are transformed into a corresponding response and shown in the display of the device.

Acknowledgement of commands to local/remote/DIGSI

The acknowledgement of indications which relate to commands with the origin “Command Issued = Local/ Remote/DIGSI” are sent back to the initiating point independent of the routing (configuration on the serial digital interface).

The acknowledgement of commands is therefore not executed by a response indication as it is done with the local command but by ordinary command and feedback information recording.

Feedback monitoring

Command processing time monitors all commands with feedback. Parallel to the command, a monitoring time period (command runtime monitoring) is started which checks whether the switchgear has achieved the desired final state within this period. The monitoring time is stopped as soon as the feedback information arrives. If no feedback information arrives, a response *Time Limit Expired* appears and the process is terminated.

Commands and their feedbacks are also recorded as operational indications. Normally the execution of a command is terminated as soon as the feedback information (**FB+**) of the relevant switchgear arrives or, in case of commands without process feedback information, the command output resets.

In the feedback, the plus sign means that a command has been positively completed. The command was as expected, in other words positive. The "minus" is a negative confirmation and means that the command was not executed as expected.

Command output/switching relays

The command types needed for tripping and closing of the switchgear or for raising and lowering transformer taps have been defined during the configuration, see also SIPROTEC 4 System Description.

2.18.3.2 Information List

No.	Information	Type of Information	Comments
-	>Door open	SP	>Cabinet door open
-	>CB wait	SP	>CB waiting for Spring charged
-	>Err Mot U	SP	>Error Motor Voltage

No.	Information	Type of Information	Comments
-	>ErrCntrlU	SP	>Error Control Voltage
-	>SF6-Loss	SP	>SF6-Loss
-	>Err Meter	SP	>Error Meter
-	>Tx Temp.	SP	>Transformer Temperature
-	>Tx Danger	SP	>Transformer Danger

2.18.4 Protocol

2.18.4.1 Information List

No.	Information	Type of Information	Comments
-	SysIntErr.	IntSP	Error Systeminterface

3 Mounting and Commissioning

This chapter is primarily intended for experienced commissioning engineers. The commissioning engineer must be familiar with the commissioning of protection and control systems, with the management of power systems and with the relevant safety rules and guidelines. Under certain circumstances adaptations of the hardware to the particular power system data may be necessary. The primary tests require the protected object (line, transformer etc.) to carry load.

3.1	Mounting and Connections	244
3.2	Checking Connections	261
3.3	Commissioning	266
3.4	Final Preparation of the Device	290

3.1 Mounting and Connections

General



WARNING

Warning of improper transport, storage, installation, and application of the device.

Non-observance can result in death, personal injury or substantial property damage.

- ✧ Trouble free and safe use of this device depends on proper transport, storage, installation, and application of the device according to the warnings in this instruction manual.
- ✧ Of particular importance are the general installation and safety regulations for work in a high-voltage environment (for example, VDE, IEC, EN, DIN, or other national and international regulations). These regulations must be observed.

3.1.1 Configuration Information

Prerequisites

For installation and connections the following conditions must be met:
The rated device data has been tested as recommended in the SIPROTEC 4 System Description and their compliance with the Power System Data is verified.

Connection Variants

General Diagrams are shown in Appendix *B Terminal Assignments*. Connection examples for current transformer and voltage transformer circuits are provided in Appendix *C Connection Examples*. It must be checked that the setting of the **`P.System Data 1`**, Section *2.1.2.1 Setting Notes*, was made in accordance to the device connections.

Currents

Appendix *C Connection Examples* shows current transformer connection examples in dependence on network conditions.

For normal connection, address 220 **`I4 transformer`** = ***`In prot. line`*** must be set and furthermore, address 221 **`I4/Iph CT`** = ***`1.000`***.

When using separate earth current transformers, address 220 **`I4 transformer`** = ***`In prot. line`*** must be set. The setting value of the address 221 **`I4/Iph CT`** may deviate from ***`1`***. For information on the calculation, please refer to Section *2.1.2.1 Setting Notes*.

Voltages

This Section is only relevant if the measured voltages are connected to the device, a condition which was already set during the configuration (address 144 **`V-TRANSFORMER`**, see Section *2.1.1.2 Setting Notes*).

Connection examples for current and voltage transformer circuits are provided in Appendix *C Connection Examples*.

For the normal connection the 4th voltage measuring input is not used; correspondingly the address must be set to 210 **`U4 transformer`** = ***`Not connected`***.

For an additional connection of an e-n-winding of a set of voltage transformers, the address 210 **`U4 transformer`** = ***`Udelta transf.`*** must be set. The setting value of the address 211 **`Uph / Udelta`** depends on the transformation ratio of the e–n-winding. For additional hints, please refer to Section *2.1.2.1 Setting Notes* under “Transformation Ratio”.

Binary Inputs and Outputs

The connections to the power plant depend on the possible allocation of the binary inputs and outputs, i.e. how they are assigned to the power equipment. The preset allocation can be found in the tables in Section *D Default Settings and Protocol-dependent Functions* of the Appendix. Check also whether the labelling corresponds to the allocated indication functions.

It is also very important that the feedback components (auxiliary contacts) of the circuit breaker monitored are connected to the correct binary inputs which are assigned for this purpose.

Changing Setting Group

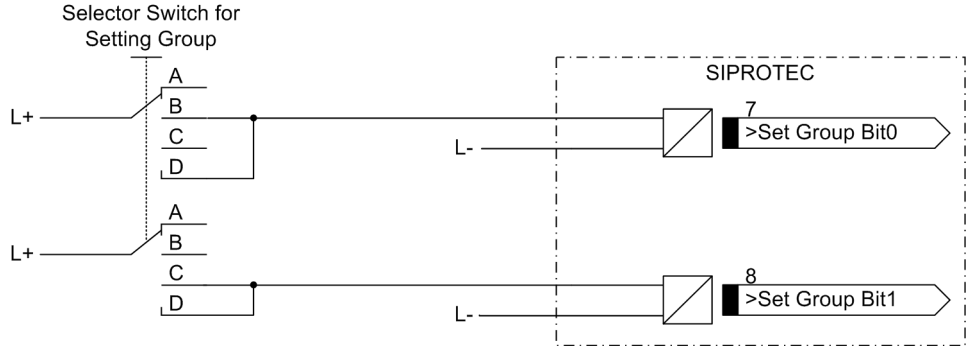
If binary inputs are used to change setting groups, please observe the following:

- To enable the control of 4 possible setting groups 2 binary inputs have to be available. One binary input must be set for *>Set Group Bit0*, the other input for *>Set Group Bit1*.
- To control two setting groups, one binary input set for *>Set Group Bit0* is sufficient since the binary input *>Set Group Bit1*", which is not assigned, is considered to be not controlled.
- The status of the signals controlling the binary inputs to activate a particular setting group must remain constant as long as that particular group is to remain active.

The following Table shows the relationship between binary inputs and the setting groups A to D. Principal connection diagrams for the two binary inputs are illustrated in the following figure. The Figure illustrates an example in which both Set Group Bits 0 and 1 are configured to be controlled (actuated) when the associated binary input is energized (high).

Table 3-1 Changing setting groups with binary inputs

Binary Input		Active settings group
>Set Group Bit 0	>Set Group Bit 1	
Not energized	Not energized	GroupA
Energized	Not energized	Group B
Not energized	Energized	Group C
Energized	Energized	Group D



[einstellgruppenumschalt-7sa-ueber-binaere-240702-kn, 1, en_GB]

Figure 3-1 Connection diagram (example) for setting group switching with binary inputs

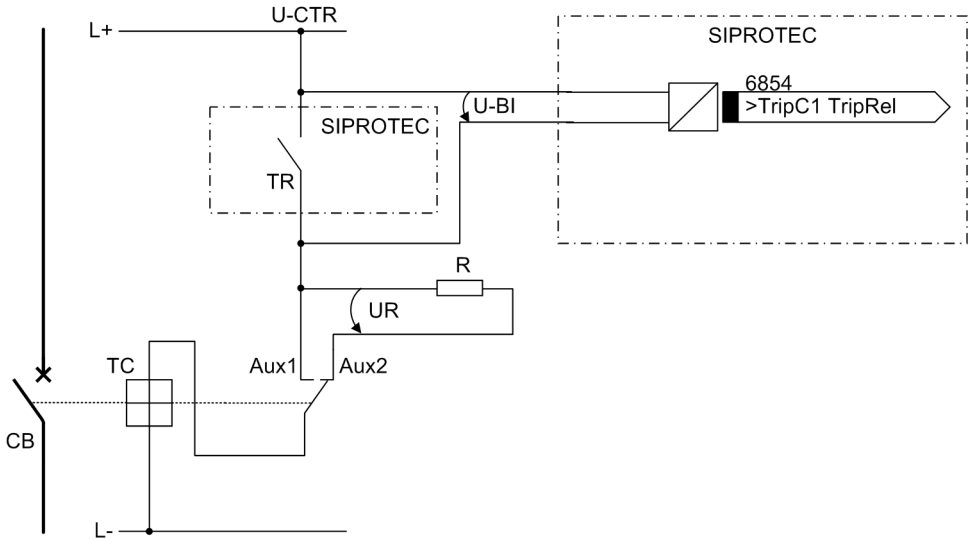
Trip Circuit Supervision

Please note that two binary inputs or one binary input and one bypass resistor R must be connected in series. The pick-up threshold of the binary inputs must therefore be substantially below half the rated control DC voltage.

If **two** binary inputs are used for the trip circuit supervision, these binary inputs must be isolated, i.o.w. not be communed with each other or with another binary input.

If **one** binary input is used, a bypass resistor R must be inserted (see following figure). The resistor R is connected in series with the second circuit breaker auxiliary contact (Aux2) to allow the detection of a trip circuit failure even when circuit breaker auxiliary contact (Aux1) is open and the command relay has dropped

out. The value of this resistor must be such that in the circuit breaker open condition (Aux1 is open and Aux2 is closed) the circuit breaker trip coil (TC) is no longer picked up and binary input (BI1) is still picked up if the command relay contact is open.



[prinzip-ausloesekrueb-1-be-wlk-010802, 1, en_GB]

Figure 3-2 Principle of the trip circuit supervision with one binary input

TR	Trip relay contact
CB	Circuit breaker
TC	Circuit breaker trip coil
Aux1	Circuit breaker auxiliary contact (NO contact)
Aux2	Circuit breaker auxiliary contact (NC contact)
U-CTR	Control voltage for trip circuit
U-BI	Input voltage of binary input
R	Bypass resistor
UR	Voltage across the bypass resistor

This results in an upper limit for the resistance dimension, R_{max} and a lower limit R_{min}, from which the optimal value of the arithmetic mean R should be selected:

$$R = \frac{R_{max} + R_{min}}{2}$$

[formel-mittelwert-r-260602-kn, 1, en_GB]

In order that the minimum voltage for controlling the binary input is ensured, R_{max} is derived as::

$$R_{max} = \left(\frac{U_{CTR} - U_{BI\ min}}{I_{BI\ (High)}}\right) - R_{TC}$$

[formel-rmax-260602-kn, 1, en_GB]

To keep the circuit breaker trip coil not energized in the above case,R_{min} is derived as:

$$R_{min} = R_{TC} \cdot \left(\frac{U_{CTR} - U_{TC\ (LOW)}}{U_{TC\ (LOW)}}\right)$$

[formel-rmin-260602-kn, 1, en_GB]

$I_{BI\ (HIGH)}$	Constant current with activated BI (= 1.8 mA)

$U_{BI\ min}$	Minimum control voltage for BI 19 V for delivery setting for nominal voltages of 24 V/48 V/60 V; 88 V for delivery setting for nominal voltages of 110 V/125 V/220 V/250 V; 176 Vfor delivery setting for nominal voltages of 220 V/250 V
U_{CTR}	Control voltage for trip circuit
R_{CBTC}	DC resistance of circuit breaker trip coil
$U_{CBTC\ (LOW)}$	Maximum voltage on the circuit breaker trip coil that does not lead to tripping

If the calculation results that $R_{max} < R_{min}$ then the calculation must be repeated, with the next lowest switching threshold $U_{BE\ min}$ and this threshold must be implemented in the relay using plug-in jumpers (see Section "Hardware Modifications").
For the power consumption of the resistance the following applies:

$$P_R = I^2 \cdot R = \left(\frac{U_{CTR}}{R + R_{CBTC}}\right)^2 \cdot R$$

[formel-leistungvon-r-260602-kn, 1, en_GB]

Example:

$I_{BI\ (HIGH)}$	1.8 mA (vom SIPROTEC 4 7SD610)
$U_{BE\ min}$	19 V for delivery setting for nominal voltages 24 V/48 V/60 V (from the device 7SD610); 88 V for delivery setting for nominal voltages 110 V/125 V/220 V/250 V (from the device 7SD610); 176 V for delivery setting for nominal voltages 220 V/250 V (from the devicet 7SD610)
U_{ST}	110 V (system / trip circuit)
R_{CBTC}	500 Ω (system / trip circuit)
$U_{LSS\ (LOW)}$	2 V (system / trip circuit)

$$R_{max} = \left(\frac{110\ V - 17\ V}{1.8\ mA}\right) - 500\ \Omega = 51.17\ k\Omega$$

[beispiel-rmax-150502-kn, 1, en_GB]

$$R_{min} = 500\ \Omega \cdot \left(\frac{110\ V - 2\ V}{2\ V}\right) = 27\ k\Omega$$

[beispiel-rmin-150502-kn, 1, en_GB]

$$R = \frac{R_{max} + R_{min}}{2} = 39.1\ k\Omega$$

[beispiel-rmittelwert-150502-kn, 1, en_GB]

The closest standard value of 39 kΩ is selected; the power is:

$$P_R = \left(\frac{110\ V}{39\ k\Omega + 0.5\ k\Omega}\right)^2 \cdot 39\ k\Omega \geq 0.3\ W$$

[beispiel-leistungvonr-150502-kn, 1, en_GB]

3.1.2 Hardware Modifications

3.1.2.1 General

A subsequent adaptation of hardware to the power system conditions can be necessary for example with regard to the control voltage for binary inputs or termination of bus-capable interfaces. Follow the procedure described in this section, whenever hardware modifications are carried out.

Auxiliary Voltage

There are different ranges of input voltage for the auxiliary voltage *A Ordering Information and Accessories*). The power supplies of the variants for DC 60 V/110 V/125 V und DC 110 V/125 V/220 V/250 V and AC 115 V are largely interchangeable by modifying the position of the jumpers. The assignment of these jumpers to the nominal voltage ranges and their spatial arrangement on the PCB are described further below at "Processor Board C-CPU-2" Location and ratings of the miniature fuse and the buffer battery are also shown. When the device is delivered, these jumpers are set according to the name-plate sticker. Generally, they do not need to be altered.

Life contact

The life contact of the device is a changeover contact from which either the NC contact or the NO contact can be connected to the device terminals via a plug-in jumper (X40). Assignments of the jumpers to the contact type and the spatial layout of the jumpers are described in the following Section at margin heading "Processor Board C-CPU-2".

Rated Currents

The input transformers of the device are set to a nominal current of 1 A or 5 A by burden switching. The jumpers are factory-set according to the name-plate sticker. The assignment of the jumpers to the nominal current and the spatial arrangement of the jumpers are described in the following section under the margin heading "Input/ Output Board C-I/O-11". All jumpers must be set for one nominal current, i.e. one jumper (X61 to X64) for each input transformer and additionally the common jumper X60.



NOTE

If in exceptional cases the current ratings are changed, you have to inform the device of these changes by entering the new values in address 206 **CT SECONDARY** in the Power System Data (see Section *2.1.2.1 Setting Notes*).

Control Voltage for Binary Inputs

When the device is delivered the binary inputs are set to operate with a voltage that corresponds to the nominal voltage of the power supply. If the nominal values differ from the power system control voltage, it may be necessary to change the switching threshold of the binary inputs.

To change the switching threshold of a binary input, a jumper must be reallocated in each case. The physical arrangement of the binary input jumpers in relation to the pickup voltages is explained in the sections below under margin headings "Processor Board C-CPU-2" and "Input/Output Board C-I/O-11".



NOTE

If binary inputs are used for trip circuit supervision, please note that two binary inputs (or a binary input and a bypass resistance) are connected in series. The switching threshold must lie clearly below halben the nominal control voltage.

Exchanging Interfaces

The serial interfaces can only be replaced in devices designed for panel flush and cubicle mounting The following section under margin heading "Replacing Interface Modules" describes which interfaces can be exchanged, and how this is done.

Terminating interfaces with bus capability

If the device is equipped with a serial RS485 port, the RS485 bus must be terminated with resistors at the last device on the bus to ensure reliable data transmission. For this purpose, terminating resistors are provided on the PCB of the C-CPU-2 processor board and on the RS485 or PROFIBUS/DNP interface module which can be connected via jumpers. The spatial arrangement of the jumpers on the PCB of the processor module C-CPU-2 is described in the following sections under the margin heading “Processor Module C-CPU-2” and on the interface modules under “RS485 Interface” and “PROFIBUS Interface”. Both jumpers must always be plugged in the same way.

The termination resistors are disabled on delivery.

Spare Parts

Spare parts can include the backup battery that maintains the data in the battery-buffered RAM when the voltage supply fails, and the miniature fuse of the internal power supply. Their spatial arrangement is shown in the figure of the processor module. The ratings of the fuse are printed on the board next to the fuse. When replacing the fuse, please observe the guidelines given in the SIPROTEC 4 System Description in the chapter “Maintenance” and “Corrective Maintenance”.

3.1.2.2 Demontage

Work on the Printed Circuit Boards



NOTE

It is assumed for the following steps that the device is not operative.



CAUTION

Caution when changing jumper settings that affect nominal values of the device:

As a consequence, the ordering number (MLFB) and the ratings on the name plate no longer match the actual device properties.

✧ Where such changes are necessary in exceptional cases, they MUST be marked clearly and visibly on the device. Self-adhesive stickers are available that can be used as supplementary name plate.

To perform work on the printed circuit boards, such as checking or moving switching elements or exchanging modules, proceed as follows:

- Prepare your workplace: provide a suitable pad for electrostatically sensitive devices (ESD). Also the following tools are required:
  - screwdriver with a 5 to 6 mm wide tip,
  - a crosstip screwdriver for Pz size 1,
  - a 5 mm socket wrench.
-
-
- Remove the covers on the front panel and loosen the screws which can then be accessed.
- Remove the front cover and place it carefully to the side. For device versions with a detached operator panel, the front cover can be lifted off directly after the screws have been released.

Work on the Plug Connectors

CAUTION

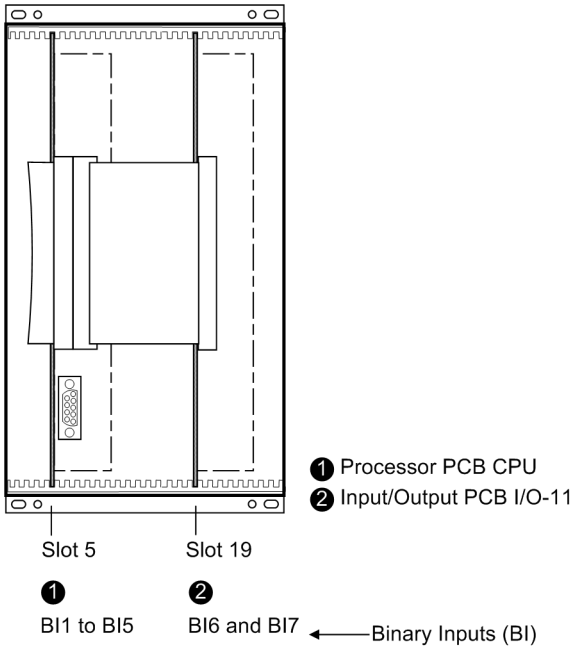
Mind electrostatic discharges:

Non-observance can result in minor personal injury or property damage.

- ✧ In order to avoid electrostatic discharges when handling plug connectors, first touch an earthed metal surface.
- ✧ Do not plug or unplug interface connectors under voltage!

The order of the boards is shown in *Figure 3-3* hervor.

- Release the connector of the ribbon cable between processor module C-CPU-2 and front cover at the front cover itself. To do this, spread the latches on the upper and lower end of the plug connector to release the plug connector of the ribbon cable.
- Disconnect the ribbon cables between the processor board C-CPU-2 (No. 1 in *Figure 3-3*) and the input/output board I/O-11 (No. 2 in *Figure 3-3*) lösen.
- Remove the boards and put them on the earth mat to protect them from ESD damage. In the case of the device variant for panel surface mounting, please be aware of the fact that a certain amount of force is required in order to remove the C-CPU-2 module due to the existing plug connectors.
- Check the jumpers according to *Figure 3-4* to and the following information. Change or remove the jumpers if necessary.



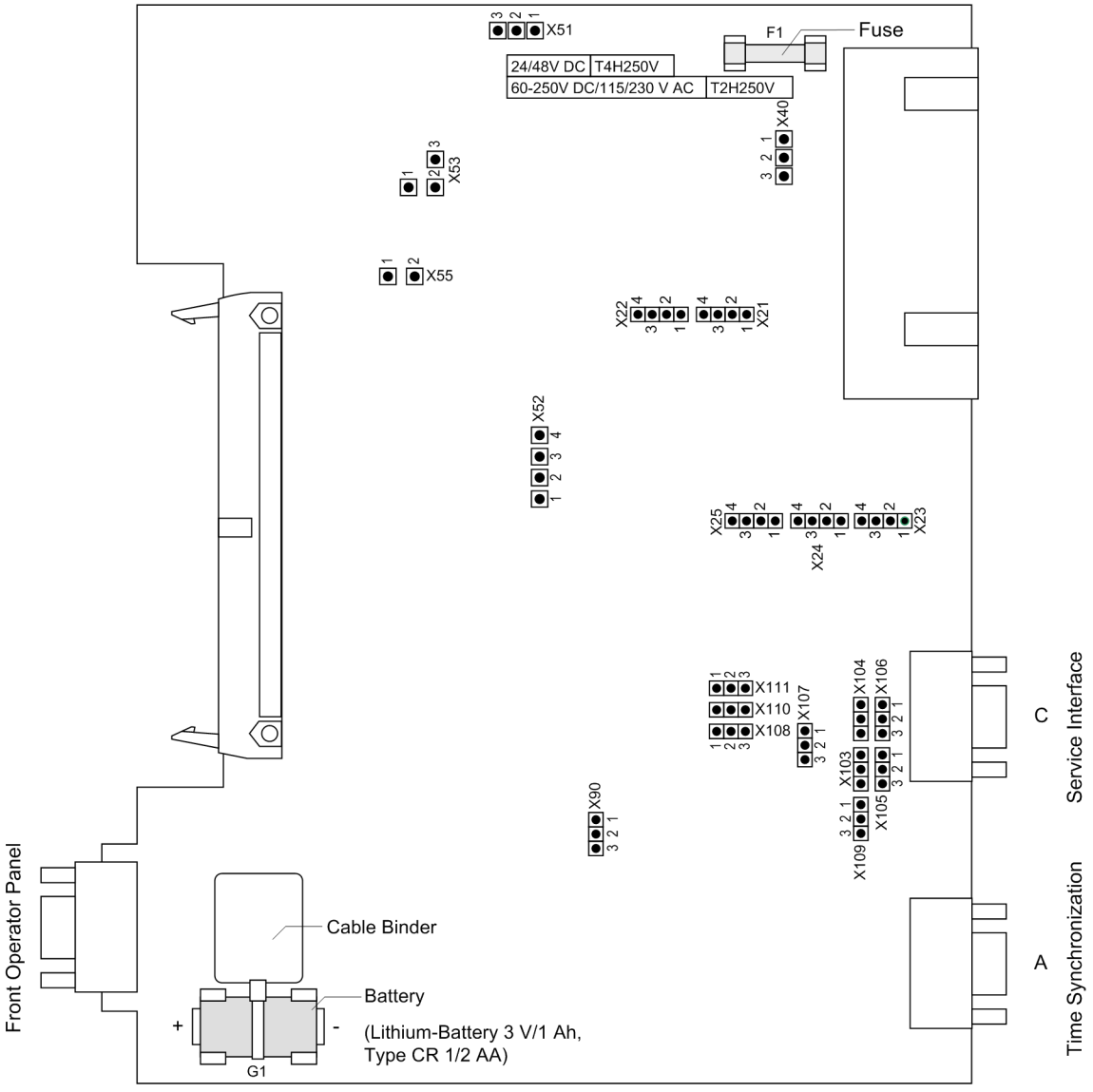
[frontgeh-drittel-o-kappe-060523, 1, en_GB]

Figure 3-3 Frontansicht nach Entfernen der Frontkappe (vereinfacht und verkleinert)

3.1.2.3 Switching Elements on Printed Circuit Boards

C-CPU-2 processor board

The PCB layout of the processor board C–CPU-2 is illustrated in the following figure. The set nominal voltage of the integrated power supply is checked according to *Table 3-2*, the quiescent state of the life contact according to *Table 3-3*, the selected control voltages of the binary inputs BI1 to BI5 according to *Table 3-4* and the integrated RS232 / RS485 interface according to *Table 3-5* to *Table 3-7*. The location and ratings of the miniature fuse (F1) and of the buffer battery (G1) are shown in the following figure. Before checking the integrated RS232/RS485 interface it may be necessary to remove the interface modules placed above.



[prozbgr-c-cpu-2-160502-wlk, 1, en_GB]

Figure 3-4 Processor printed circuit board C-CPU-2 with jumpers settings required for the board configuration

Table 3-2 Jumper setting of the rated voltage of the integrated **Power Supply** on the C-CPU-2 processor board

Jumper	Nominal voltage		
	DC 24 V to 48 V	DC 60 V to 125 V	DC 110 V to 250 V, AC 115 V/230 V
X51	Not used	1-2	2-3

Jumper	Nominal voltage		
	DC 24 V to 48 V	DC 60 V to 125 V	DC 110 V to 250 V, AC 115 V/230 V
X52	Not used	1-2 and 3-4	2-3
X53	Not used	1-2	2-3
X55	Not used	Not used	1-2
Fuse	T4H250V	T2H250V	

Table 3-3 Jumper setting of the quiescent state of the **Life Contact** on the processor board C-CPU-2

Jumper	Open in the quiescent state	Closed in the quiescent state	Presetting
X40	1-2	2-3	2-3

Table 3-4 Jumper setting of the **Control Voltages** of the binary inputs BI1 to BI5 on the C-CPU-2 processor board

Binary Inputs	umper	Threshold 19 V [1)]	Threshold 88 V [2)]	Threshold 176 V [3)]
BI1	X21	1-2	2-3	3-4
BI2	X22	1-2	2-3	3-4
BI3	X23	1-2	2-3	3-4
BI4	X24	1-2	2-3	3-4
BI5	X25	1-2	2-3	3-4

[1)] Factory settings for devices with power supply voltages of DC 24 V bis 125 V

[2)] Factory settings for devices with power supply voltages of DC 110 V bis 250 V und AC 115 V

[3)] Use only with control voltages DC 220 V bis 250 V and AC 230 V

By repositioning jumpers the interface RS485 can be modified into a RS232 interface and vice versa.
Jumpers X105 to X110 must be set to the same position.

Table 3-5 Jumper settings of the integrated **RS232/485 Interface** aon the C-CPU-2 processor board

Jumper	RS232	RS485
X103 and X104	1-2	1-2
X105 to X110	1-2	2-3

The jumpers are preset at the factory according to the configuration ordered.
With interface RS232 jumper X111 is needed to activate CTS which enables the communication with the modem.

Table 3-6 Jumper setting for **CTS** (**C**lear **T**o **S**end, flow control) on the C-CPU-2 processor board

Jumper	/CTS from Interface RS232	/CTS controlled by /RTS
X111	1-2	2-3

Jumper setting 2-3: The connection to the modem is usually established with a star coupler or fibre-optic converter. Therefore the modem control signals according to RS232 standard DIN 66020 are not available. Modem signals are not required since the connection to the SIPROTEC 4 devices is always operated in the half-duplex mode. Please use the connection cable with order number 7XV5100-4.

Jumper setting 1-2: This setting makes the modem signals available, i. e. for a direct RS232-connection between the SIPROTEC 4 device and the modem this setting can be selected optionally. We recommend to use a standard RS232 modem connection cable (converter 9-pin to 25-pin).



NOTE

For a direct connection to DIGSI with interface RS232 jumper X111 must be plugged in position 2-3.

If there are no external terminating resistors in the system, the last devices on a RS485 bus must be configured via jumpers X103 and X104.

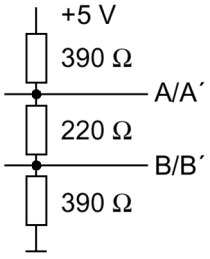
Table 3-7 Jumper settings of the **Terminating Resistors** of the RS485 interface on the C-CPU-2 processor board

Jumper	Terminating Resistor enabled	Terminating Resistor disabled	Presetting
X103	2-3	1-2	1-2
X104	2-3	1-2	1-2

Note: Both jumpers must always be plugged in the same way!

Jumper X90 has no function. The factory setting is 1-2.

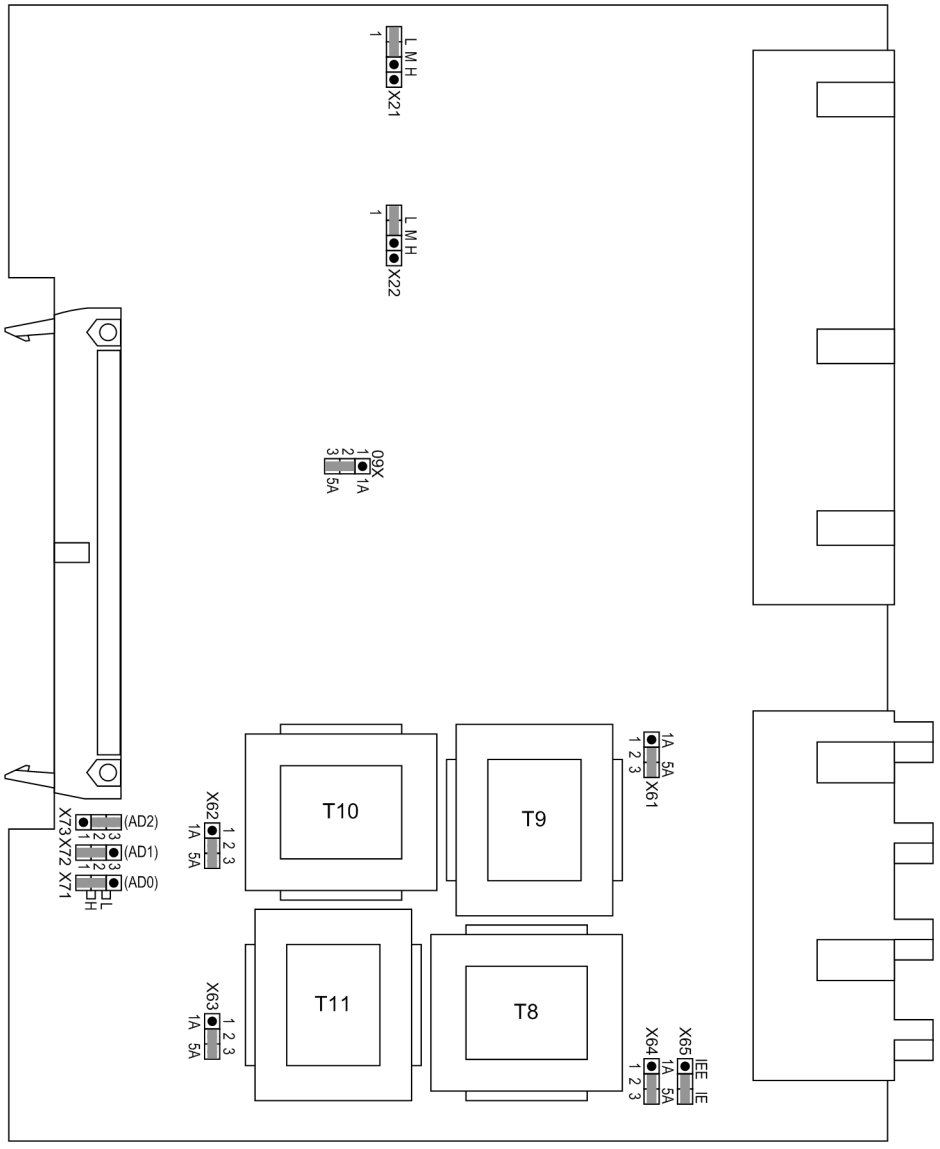
Terminating resistors can also be connected externally (e.g. to the terminal block). In this case, the terminating resistors located on the RS485 or PROFIBUS interface module or directly on the PCB of the processor board C-CPU-2 must be de-energized.



[externe-terminierung-020313-kn, 1, en_GB]

Figure 3-5 Termination of the RS485 interface (external)

Input/Output Board C-I/O-11



[ein-ausgabebgr-c-io-11-160502-wlk, 1, en_GB]

Figure 3-6 C-I/O-11 input/output board with representation of jumper settings required for checking configuration settings

Table 3-8 Jumper settings for **Control Voltages** of the binary inputs BI6 and BI7 on the input/output board C-I/O-11

Binary input	Jumper	Threshold 19 V [1]	Threshold 88 V [2]	Threshold 176 V [3]
BI6	X21	L	M	H
BI7	X22	L	M	H

[1] Factory settings for devices with power supply voltages of DC 24 V to 125 V

[2] Factory settings for devices with power supply voltages of DC 110 V to 250 V and AC 115 V

[3] Use only with pickup voltages of DC 220 V to 250 V and AC 230 V

The set nominal current of the current input transformers are checked on the input/output board C-I/O-11. The jumpers X60 to X64 must all be set to the same rated current, i.e. one jumper (X61 to X64) for each input transformer of the phase currents and in addition the common jumper X60.

Jumper X65 is plugged in position “IE”.

Jumpers X71, X72 and X73 on the input/output board C-I/O-11 are used for setting the bus address and must not be changed. The following Table lists the jumper presettings.

Table 3-9 Jumper settings of **Bus Address** of the input/output board C-I/O-11

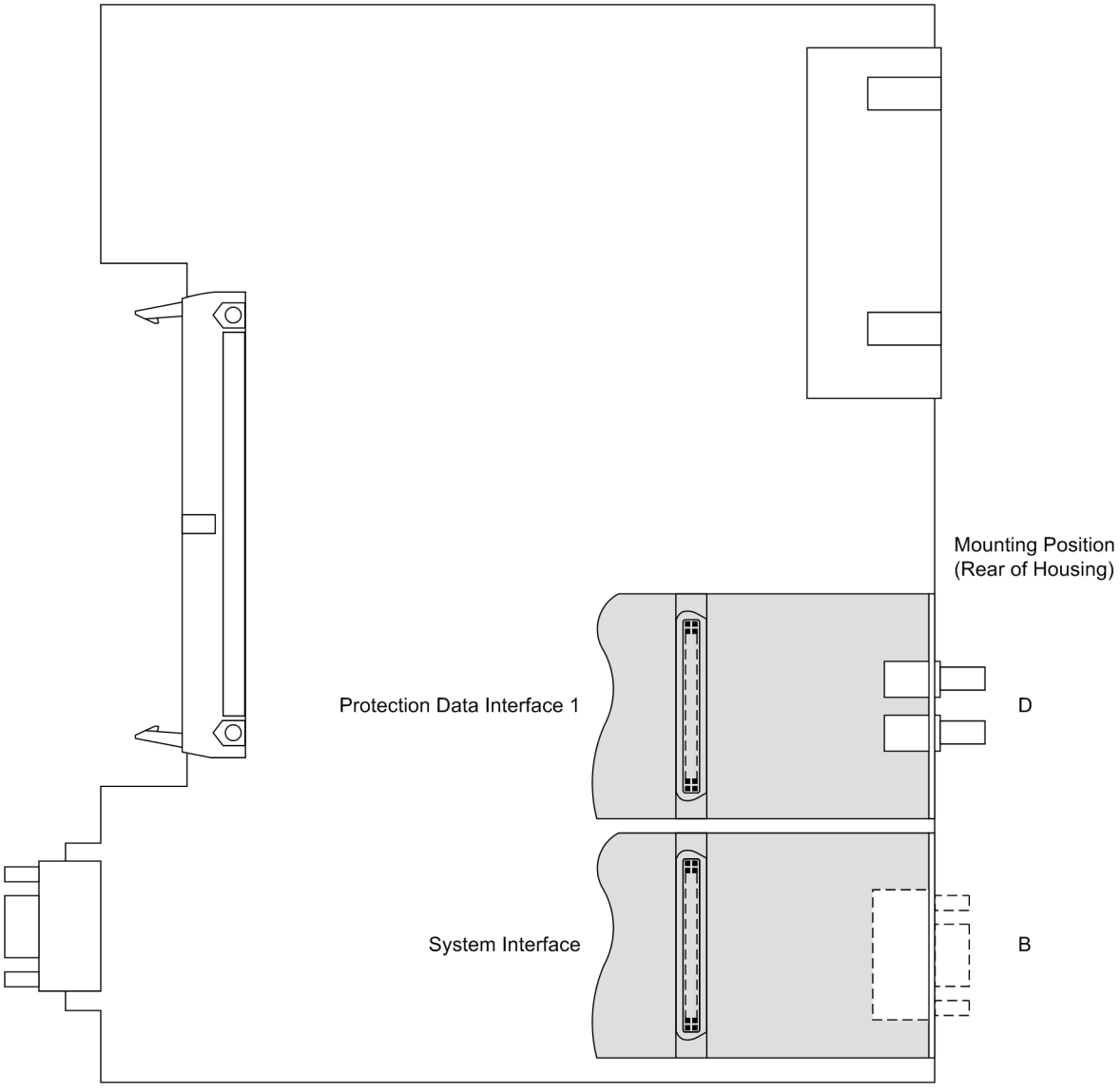
Jumper	Presetting
X71	1-2 (H)
X72	1-2 (H)
X73	2-3 (L)

Slot of input/output board C-I/O-11: No. 2 in *Figure 3-3*.

3.1.2.4 Interface Modules

Exchanging Interface Modules

The interface modules are located on the processor board C-CPU-2 (No. 1 in *Figure 3-3*).



[aufsicht-cpu-2-mit-schnittstellen-060523, 1, en_GB]

Figure 3-7 C-CPU-2 board with interface modules

Please observe the following:

- The interface modules can only be exchanged in devices in flush-mounted housing. Interface modules for devices with surface mounting housing must be retrofitted in our manufacturing centre.
- Use only interface modules that can be ordered ex-factory via the ordering code (see also Appendix, Section *A Ordering Information and Accessories*).
- You may have to ensure the termination of the interfaces featuring bus capability according to the margin heading “RS485 Interface”.

Interface	Mounting location / port	Exchange Module
System interface	B	Only interface modules that can be ordered in our facilities via the order key (see Appendix, Section *A Ordering Information and Accessories*)
Service Interface	C	RS232
		RS485
Protection Data Interface	D	FO5, FO6; FO17 to FO19, FO30

The ordering numbers of the exchange modules are listed in Appendix *A Ordering Information and Accessories*.

RS232-Interface

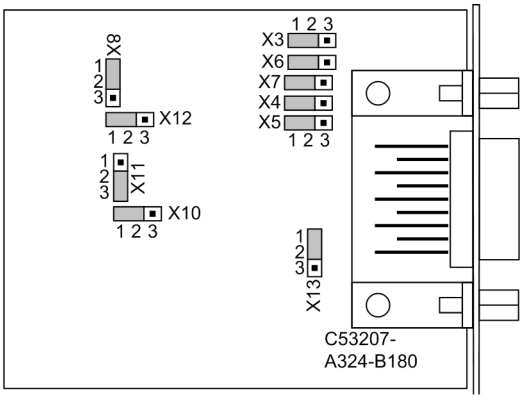
Interface RS232 can be modified to interface RS485 and vice versa (see *Figure 3-8* and *Figure 3-9*).

The following figure shows the location of the jumpers of interface RS232 on the interface module.

Surface-mounted devices with fibre optics connection have their fibre optics module fitted in the console housing on the case bottom. The fibre optics module is controlled via an RS232 interface module at the associated CPU interface slot. For this application type the jumpers X12 and X13 on the RS232 module are plugged in position 2-3.

Jumper	Terminating Resistors Disconnected
X3	1-2 *)
X4	1-2 *)

*) Default Setting



[steckbruecken-rs232-020313-kn, 1, en_GB]

Figure 3-8 Location of the jumpers for configuration of RS232

Terminating resistors are not required for RS232. They are disconnected.

Jumper X11 is used to activate the flow control which is important for the modem communication.

Table 3-10 Jumper setting for **CTS** (**C**lear **T**o **S**end; flow control) on the interface module

Jumper	/CTS from Interface RS232	/CTS controlled by /RTS
X11	1-2	2-3 [1)]
[1)] Factory Setting		

Jumper setting 2-3: The connection to the modem is usually established with a star coupler or fibre-optic converter. Therefore the modem control signals according to RS232 standard DIN 66020 are not available.

Modem signals are not required since the connection to the SIPROTEC 4 devices is always operated in the half-duplex mode. Please use the connection cable with order number 7XV5100-4.

Jumper setting 1-2: This setting makes the modem signals available, i. e. for a direct RS232-connection between the SIPROTEC 4 device and the modem this setting can be selected optionally. We recommend to use a standard RS232 modem connection cable (converter 9-pin to 25-pin).

NOTE

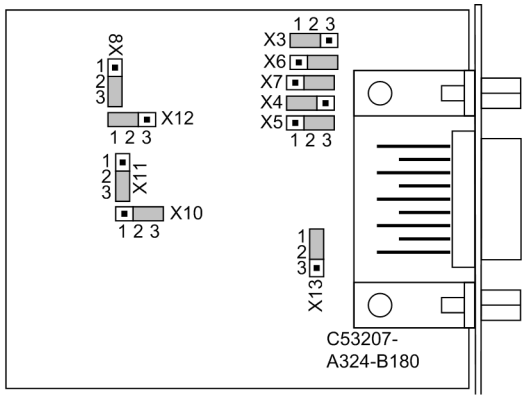
For a direct connection to DIGSI with interface RS232 jumper X11 must be plugged in position 2-3.

RS485 Interface

The following figure shows the location of the jumpers of interface RS485 on the interface module. Interface RS485 can be modified to *Figure 3-8* interface RS232 and vice versa.

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	2-3	1-2 *)
X4	2-3	1-2 *)

*) Default Setting



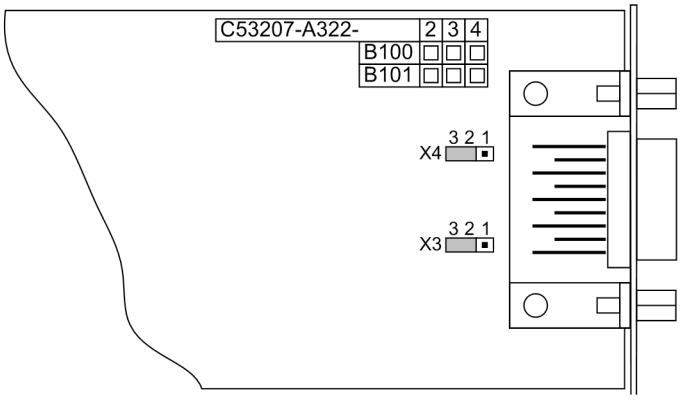
[steckbruecken-rs485-020313-kn, 1, en_GB]

Figure 3-9 Position of terminating resistors and the plug-in jumpers for configuration of the RS485 interface

Profibus/DNP/MODBUS Interface

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	1-2	2-3 *)
X4	1-2	2-3 *)

*) Default Setting



[steckbruecken-profibus-020313-kn, 1, en_GB]

Figure 3-10 Location of the jumpers for configuring the terminating resistors (PROFIBUS, DNP and MODBUS interface)

EN100 Ethernet Module (IEC 61850)

SIPROTEC, 7SA6, Manual C53000-G1176-C156-7, Release date 02.2011 476 Profibus/DNP Interface Figure 3-19 Location of the jumpers for configuring the terminating resistors of the active electrical module (PROFIBUS and DNP 3.0 interface) EN100 Ethernet Module (IEC 61850)

Termination

Bus-capable interfaces always require a termination at the last device on the bus, i.e. terminating resistors must be connected. On the 7SD610 device, this concerns the variants with RS485 or PROFIBUS7/DNP/MODBUS interfaces.

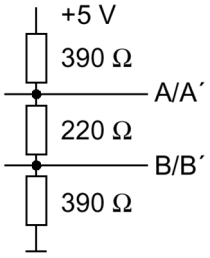
The terminating resistors are located on the interface module which is on the processor module C-CPU-2 (No. 1 in *Figure 3-3*) or directly on the PCB of the processor module C-CPU-2 (see margin heading “Processor module C-CPU-2”, *Table 3-7*).

The interface modules are displayed in *Figure 3-9* and in *Figure 3-10*.

For the configuration of the terminating resistors both jumpers have to be plugged in the same way.

On delivery the jumpers are set so that the terminating resistors are disconnected.

The terminating resistors can also be implemented outside the device (e.g. at the terminal block), see *Figure 3-11*. In this case, the terminating resistors located on the interface module or directly on the PCB of the processor board C-CPU-2 must be disconnected.



[externe-terminierung-020313-kn, 1, en_GB]

Figure 3-11 Termination of the RS485 Interface (External)

3.1.2.5 Reassembly

The device is assembled in the following steps:

- Insert the modules carefully in the housing. The mounting locations are shown in *Figure 3-3*. For the model of the device designed for surface mounting, use the metal lever to insert the C-CPU-2 board. The installation is easier with the lever.
- First insert the plug connectors of the ribbon cable on the input/output boards C-I/O–11 and then on the processor board C-CPU-2. Be careful not to bend any connector pins! Do not use force!
- Connect the plug connectors of the ribbon cable between the processor board C-CPU-2 and the front panel to the front panel plug connector.
- Press plug connector interlocks together.
- Put on the front cover and screw it onto the housing.
- Put the covers back on.
- Re-fasten the interfaces on the rear of the device housing. This activity is not necessary if the device is designed for surface mounting.

3.1.3 Mounting

3.1.3.1 Panel Flush Mounting

For 7SD610 (*Figure 3-12*) 4 covers and 4 holes exist.

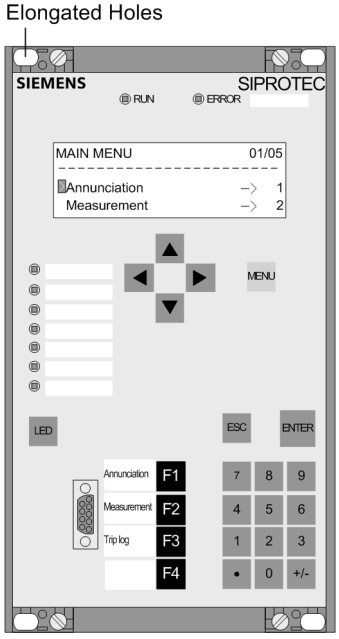
- Remove the 4 covers at the corners of the front cover. Thus, 4 elongated holes are revealed in the mounting bracket and can be accessed.
- Insert the device into the control panel section and tighten it with 4 screws. For dimensions refer to Section *4.17 Dimensions*
- Replace the 4 covers.

- Connect a solid low-impedance protective earthing at the rear of the device with at least one M4 screw. The cross-section of the earth wire must be equal to the cross-section of any other control conductor connected to the device. The cross-section of the earth wire must be at least 2.5 mm² betragen.
- Connections are realized via the plug terminals or screw terminals on the rear side of the device according to the circuit diagram.

  When using screwed connections with forked lugs or direct connection, before inserting wires the screws must be tightened so that the screw heads are flush with the outer edge of the connection block.

  A ring lug must be centred in the connection chamber, in such a way that the screw thread fits in the hole of the lug.

  The SIPROTEC 4 System Description has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.



[schalttafeleinbau-gehaeuse-4zeilig-display-drittel-st-040403, 1, en_GB]

Figure 3-12 Panel flush mounting of a device (housing size $^1/_3$)

3.1.3.2 Rack and Cubicle Mounting

To install the device in a rack or cubicle, a pair of mounting rails; one for top, one for bottom are required. The ordering codes are stated in Appendix, Section *A Ordering Information and Accessories*.

For 7SD610 (*Figure 3-13*) 4 covers and 4 holes exist.

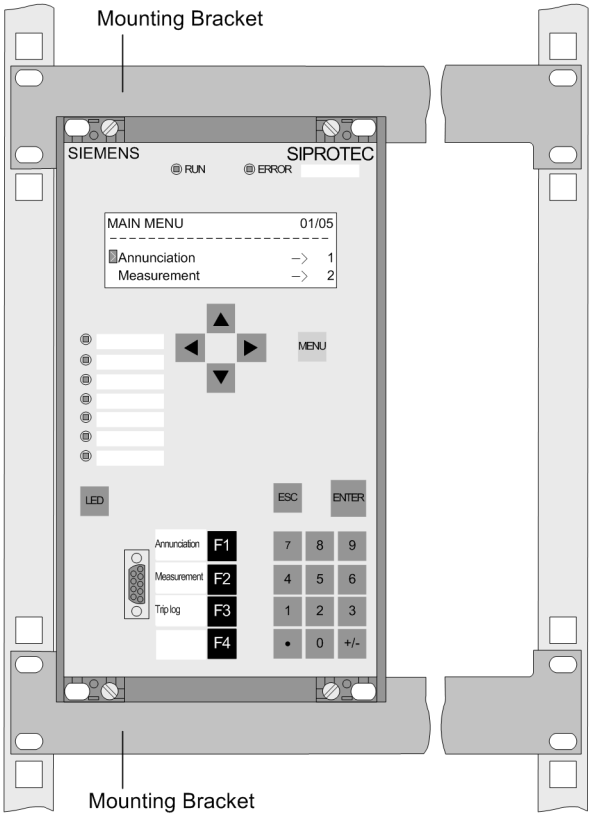
- Screw on loosely the two angle brackets in the rack or cabinet, each with four screws.
- Remove the 4 covers at the corners of the front cover. Thus, 4 elongated holes are revealed in the mounting bracket and can be accessed.
- Fasten the device to the a pair of mounting rails; one for top, one for bottom with 4 screws.
- Replace the 4 covers.
- Tighten fast the eight screws of the angle brackets in the rack or cabinet.
- Connect a solid low-impedance protective earthing at the rear of the device with at least one M4 screw. The cross-section of the earth wire must be equal to the cross-section of any other control conductor connected to the device. The cross-section of the earth wire must be at least 2.5 mm² betragen.

- Make the connections on the device's back panel using the plug or screw terminals as shown in the wiring diagram.

  For screw connections with forked lugs or direct connection, before inserting wires the screws must be tightened so that the screw heads are flush with the outer edge of the connection block.

  A ring lug must be centred in the connection chamber so that the screw thread fits in the hole of the lug.

  The SIPROTEC 4 System Description has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.



[montage-gehause-4zeilig-display-drittel, 1, en_GB]

Figure 3-13 Installing a device in a rack or cubicle (housing size $^1/_3$)

3.1.3.3 Panel Mounting

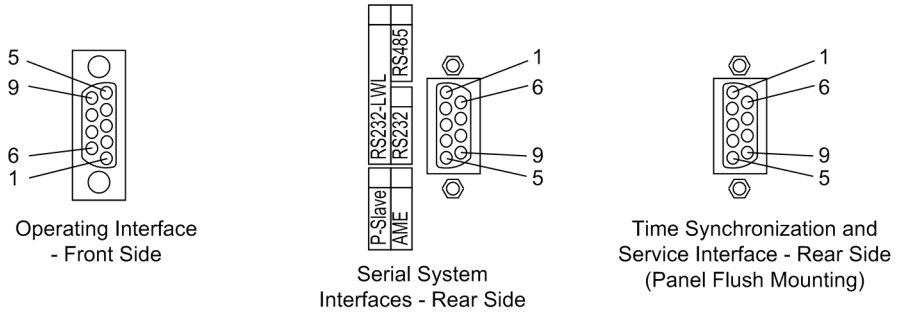
For mounting proceed as follows:

- Secure the device to the panel with four screws. For dimensions see the Technical Data in Section *4.17 Dimensions*.
- Connect the low-resistance operational and protective earth to the ground terminal of the device. The crosssectional area of the ground wire must be equal to the cross-sectional area of any other control conductor connected to the device. It must thus be at least 2.5 mm^2 betragen.
- Alternatively, there is the possibility to connect the aforementioned earthing to the lateral earthing surface with at least one M4 screw.
- Make the connections according to the circuit diagram via screw terminals, connections for optical fibres and electrical communication modules via the console housings. The specifications concerning the maximum cross-section, tightening torques, bending radii and strain relief given in the SIPROTEC 4 System Description must be observed. Installation notes are also given in the brief reference booklet that comes with the device.

3.2 Checking Connections

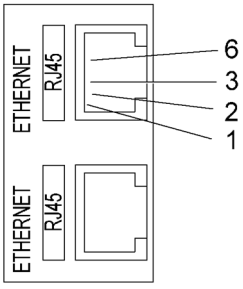
3.2.1 Checking Data Connections of Serial Interfaces

The tables in the following sections list the pin assignments for the different serial interfaces, the time synchronization interface and the Ethernet interface of the device. The position of the connectors is depicted in the following figures.



[dsub-buchsen-020313-kn, 1, en_GB]

Figure 3-14 9-pin D-subminiature female connectors



[ethernet-anschlussbuchsen-101103-kn, 1, en_GB]

Figure 3-15 Ethernet connector

Operator Interface

When the recommended communication cable is used (for order designation see Appendix *A Ordering Information and Accessories*) correct connection between the SIPROTEC 4 device and the PC or Laptop is automatically ensured

Service Interface

Check the data connection if the service interface is used to communicate with the device via hard wiring or modem.

System Interface

For versions equipped with a serial interface to a control center, the user must check the data connection. The visual check of the assignment of the transmission and reception channels is of particular importance. With RS232 and fiber optic interfaces, each connection is dedicated to one transmission direction. Therefore the output of one device must be connected to the input of the other device and vice versa.

With data cables, the connections are designated according to DIN 66020 and ISO 2110:

- TxD = Data Transmit
- RxD = Data Receive
- $\overline{\text{RTS}}$ = Request to send

- $\overline{\text{CTS}}$ = Clear to send
- GND = Signal / Chassis Ground

The cable shield is to be earthed at **both** line ends. For extremely EMC-prone environments, the earth may be connected via a separate individually shielded wire pair to improve immunity to interference.

Table 3-11 The assignments of the D-subminiature and RJ45 connector for the various interfaces

Pin No.	Operator interface	RS232	RS485	PROFIBUS FMS Slave, RS485 PROFIBUS DP Slave, RS485	DNP3.0 RS485	Ethernet EN 100
1	Shield (with shield ends electrically connected)					Tx+
2	RxD	RxD	-	-	-	Tx-
3	TxD	TxD	A/A' (RxD/TxD-N)	B/B' (RxD/TxD-P)	A	Rx+
4	-	-	-	CNTR-A (TTL)	RTS (TTL level)	-
5	GND	GND	C/C' (GND)	C/C' (GND)	GND1	-
6	-	-	-	+5 V (max. load < 100 mA)	VCC1	Rx-
7	$\overline{\text{RTS}}$	$\overline{\text{RTS}}$	- [1)]	-	-	-
8	$\overline{\text{CTS}}$	$\overline{\text{CTS}}$	B/B' (RxD/TxD-P)	A/A' (RxD/TxD-N)	B	-
9	-	-	-	-	-	Non Existent

[1)] Pin 7 also carries the RTS signal with RS232 level when operated as RS485 Interface. Pin 7 must therefore not be connected!

RS485-Terminierung

The RS485 interface is capable of half-duplex service with the signals A/A' and B/B' with a common relative potential C/C' (GND). It is necessary to check that the terminating resistors are connected to the bus only at the last unit, and not at other devices on the bus. The jumpers for the terminating resistors are on the interface module (see *Figure 3-8* or *Figure 3-9*) or directly on the C-CPU-2 (see *Figure 3-4* and *Table 3-7*). Terminating resistors can also be implemented outside the device (e.g. in the plug connectors) as shown in *Figure 3-5*. In this case, the terminating resistors located on the module must be disabled.

If the bus is extended, make sure again that only the terminating resistors at the last device on the bus are connected.

Time synchronisation interface

It is optionally possible to process 5 V, 12 V or 24 V time synchronization signals, provided that these are connected to the inputs named in the following table.

Table 3-12 D-subminiature connector assignment of the time synchronization interface

Pin-No.	Designation	Signal Significance
1	P24_TSIG	v 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return line
4	M_TSYNC [1)]	Return line[1)]
5	SCHIELD	Shield potential
6	-	-
7	P12_TSIG	Input 12 V
8	P_TSYNC [1)]	Input 24 V [1)]
9	SCHIELD	Shield potential
[1)] only for PPS signal (GPS)		

Optical Fibres



WARNING

Do not look directly into the fiber-optic elements, not even with optical devices! Laser class 1 according to EN 60825-1.

✧

For the protection data communication, refer to the following section.

The transmission via fiber optics is particularly insensitive to electromagnetic interference and thus ensures galvanic isolation of the connection. Transmit and receive connections are shown with the symbols ⟶■ or transmit and ■⟶ for receive.

The character idle state for the optical fibre interface is "Light off". If the character idle state is to be changed, use the operating program DIGSI, as described in the SIPROTEC 4 System Description.

3.2.2 Checking the Protection Data Communication

The protection data communication is conducted either directly from device to device via optical fibres or via communication converters and a communication network or a dedicated transmission medium.

Optical Fibres, Directly



WARNING

Laser Radiation Hazard!

Non-observance of the following measure can result in death, personal injury or substantial property damage.

✧ Do not look directly into the fibre-optic elements, not even with optical devices! Laser class 1 according to EN 60825-1.

The direct optical fibre connection is visually inspected by means of an optical fibre connector. There is one connection for each direction. The data output of one device must be connected to the data input of the other device and vice versa. Transmission and receiving connections are identified with the symbols ⟶■ for transmit and ■⟶ for receive. The visual check of the assignment of the transmission and reception channels is important.

For short distances, laser class 1 is fulfilled if FO5 modules and the recommended fibres are used. In other cases, the laser output may be higher

If using more than one device, the connections of all protection data interfaces are checked according to the topology selected.

Communication Converter

Optical fibres are usually used for the connections between the devices and communication converters. The optical fibres are checked in the same manner as the optical fibre direct connection which means for every protection data interface.

Make sure that under the address 4502 **CONNEC. 1 OVER** the right connection type is parameterized.

Further Connections

For further connections a visual inspection is sufficient for the time being. Electrical and functional controls are performed during commissioning (see the following main section).

3.2.3 Checking the System Connections



WARNING

Warning of dangerous voltages

Non-observance of the following measures can result in death, personal injury or substantial property damage.

✧ Therefore, only qualified people who are familiar with and adhere to the safety procedures and precautionary measures shall perform the inspection steps.



CAUTION

Be careful when operating the device on a battery charger without a battery

Non-observance of the following measure can lead to unusually high voltages and consequently, the destruction of the device.

✧ Do not operate the device on a battery charger without a connected battery. (For limit values see also Technical Data, Section *4.1 General*).

Before the device is energized for the first time, it should be in the final operating environment for at least 2 hours to equalize the temperature, to minimize humidity and avoid condensation. Connections are checked with the device at its final location. The plant must first be switched off and earthed.

Connection examples for current transformer connections are provided in Appendix *C Connection Examples*. Please observe the plant diagrams, too.

Proceed as follows in order to check the system connections:

- Protective switches for the power supply and the measured voltages must be switched off.
- Check the continuity of all current and voltage transformer connections against the system and connection diagrams:
  - Are the current transformers earthed properly?
  - Are the polarities of the current transformers the same?
  - Is the phase relationship of the current transformers correct?
  - Are the voltage transformers earthed properly (if used)?
  - Are the polarities of the voltage transformers correct (if used)?
  - Is the phase relationship of the voltage transformers correct (if used)?
  - Is the polarity for current input I_4 correct (if used)?
  - Is the polarity for voltage input U_4 correct (if used, e.g. with broken delta winding)?
- Check the functions of all test switches that are installed for the purposes of secondary testing and isolation of the device. Of particular importance are test switches in current transformer circuits. Be sure these switches short-circuit the current transformers when they are in the “test mode”.

- The short circuit links of the connectors for the current circuits have to be checked. This can be done using secondary test equipment or other test equipment for checking continuity. Make sure that terminal continuity is not wrongly simulated in reverse direction via current transformers or their short-circuiters.
  - Remove the front panel of the device *Figure 3-3*).
  - Remove the ribbon cable connected to the I/O board (viewed from the front side it is the respective circuit board on the right, see *Figure 3-3*). Then remove the printed circuit board so that there is no longer any contact with the plug-in terminal of the housing.
  - At the terminals of the device, check continuity for each pair of terminals that receives current from the CTs.
  - Firmly re-insert the I/O board. Carefully connect the ribbon cable. Be careful that no connector pins are bent! Don't apply force!
  - At the terminals of the device, again check continuity for each pair of terminals that receives current from the CTs.
  - Attach the front panel and tighten the screws.
- Connect an ammeter in the supply circuit of the power supply. A range of about 2.5 A to 5 A for the meter is appropriate.
- Switch on m.c.b. for auxiliary voltage (supply protection), check the voltage level and, if applicable, the polarity of the voltage at the device terminals or at the connection modules.
- The measured steady-state current should correspond to the quiescent power consumption of the device. Transient movement of the ammeter merely indicates the charging current of capacitors.
- Remove the voltage from the power supply by opening the protective switches.
- Disconnect the measuring test equipment; restore the normal power supply connections.
- Apply voltage to the power supply.
- Close the protective switches for the voltage transformers.
- Verify that the voltage phase rotation at the device terminals is correct.
- Open the miniature circuit breakers for the transformer voltage (VT mcb) and the power supply.
- Check tripping circuits to the circuit breakers.
- Check the close circuits to the power system circuit breakers
- Verify that the control wiring to and from other devices is correct.
- Check the signalling connections.
- Close the protective switches.
- If communication converters are used: check the auxiliary voltages for the communication converters
- If the communication converter is connected to the communication network, its device-ready relay (DOK = “Device Ok”) picks up. This also signalizes that the clock pulse is recognized by the communication network.
  Further checks are performed according to Section “Checking the Protection Data Topology”.
- Please also observe carefully the documentation attached to the communication converters.

3.3 Commissioning



WARNING

Warning of dangerous voltages when operating an electrical device

Non-observance of the following measures can result in death, personal injury or substantial property damage.

- ✧ Only qualified people shall work on and around this device. They must be thoroughly familiar with all warnings and safety notices in this instruction manual as well as with the applicable safety steps, safety regulations, and precautionary measures.
- ✧ Before making any connections, the device must be earthed at the protective conductor terminal.
- ✧ Hazardous voltages can exist in the power supply and at the connections to current transformers, voltage transformers, and test circuits.
- ✧ Hazardous voltages can be present in the device even after the power supply voltage has been removed (capacitors can still be charged).
- ✧ After removing voltage from the power supply, wait a minimum of 10 seconds before re-energizing the power supply. This wait allows the initial conditions to be firmly established before the device is re-energized.
- ✧ The limit values given in Technical Data must not be exceeded, neither during testing nor during commissioning.

For tests with a secondary test equipment ensure that no other measurement voltages are connected and the trip and close commands to the circuit breakers are blocked, unless otherwise specified.



DANGER

Hazardous voltages during interruptions in secondary circuits of current transformers

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

- ✧ Short-circuit the current transformer secondary circuits before current connections to the device are opened.

During the commissioning procedure, switching operations must be carried out. The tests described require that they can be done without danger. They are accordingly not meant for operational checks.



WARNING

Warning of dangers evolving from improper primary tests

Non-observance of the following measure can result in death, personal injury or substantial property damage.

- ✧ Primary tests may only be carried out by qualified persons who are familiar with commissioning protection systems, with managing power systems and the relevant safety rules and guidelines (switching, earthing etc.).

3.3.1 Test Mode / Transmission Block

Activation and Deactivation

If the device is connected to a central control system or a server via the SCADA interface, then the information that is transmitted can be modified with some of the protocols available (see Table "Protocol-dependent functions" in the Appendix *D.7 Protocol-dependent Functions*).

If **Test mode** is set ON, then a message sent by a SIPROTEC 4 device to the main system has an additional test bit. This bit allows the message to be recognized as resulting from testing and not an actual fault or power system event. Furthermore it can be determined by activating the **Transmission block** that no indications at all are transmitted via the system interface during test mode.

The SIPROTEC 4 System Description describes how to activate and deactivate test mode and blocked data transmission. Note that when DIGSI is being used, the program must be in the **Online** operating mode for the test features to be used.

3.3.2 Checking the Time Synchronisation Interface

If external time synchronization sources are used, the data of the time source (antenna system, time generator) are checked (see Section 4 under „Time Synchronization"). A correct function (IRIG B, DCF77) is recognized in such a way that 3 minutes after the startup of the device the clock status is displayed as *synchronized*, accompanied by the indication *Alarm Clock OFF*. For further information please refer to the SIPROTEC System Description.

Table 3-13 Time status

No.	Status text	Status
1	– – – – – – – –	synchronized
2	– – – – – – ST	
3	– – – – ER – –	not synchronized
4	– – – – ER ST	
5	– – NS ER – –	
6	– – NS – – – –	
Legend: – – NS – – – – – – – – ER – – – – – – – – ST		time invalid time fault summertime

If a GPS receiver is connected and a proper GPS signal is available, the message *>GPS failure* "OFF" appears approx. 3 seconds after startup of the device.

3.3.3 Checking the System Interface

Prefacing Remarks

If the device features a system interface and uses it to communicate with the control centre, the DIGSI device operation can be used to test if messages are transmitted correctly. This test option should however definitely "not"" be used while the device is in service on a live system.

DANGER

The sending or receiving of indications via the system interface by means of the test function is a real information exchange between the SIPROTEC 4 device and the control centre. Connected operating equipment such as circuit breakers or disconnectors can be switched in this way!

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

✧ Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during “real” operation performing transmission and reception of messages via the system interface.

NOTE

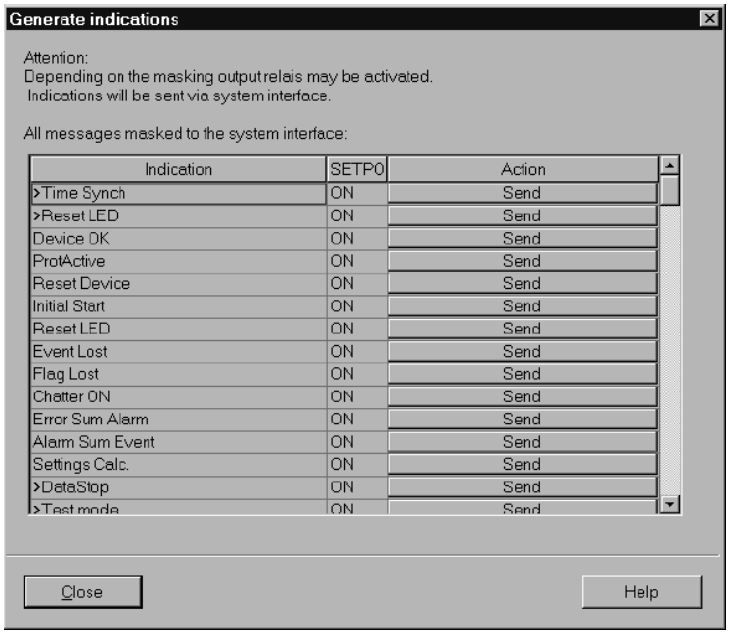
After termination of the hardware test, the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be extracted with DIGSI prior to the test.

The interface test is carried out using DIGSI in the Online operating mode:

- Open the **Online** directory by double-clicking; the operating functions for the device appear.
- Click on **Test**; the function selection appears in the right half of the window.
- Double-click on **Testing Messages for System Interface** shown in the list view. The dialog box **Generate Indications** is opened (see *Figure 3-16*).

Structure of the Dialog Box

In the column **Indication**, all message texts that were configured for the system interface in the matrix will then appear. In the column **Setpoint** you determine a value for the indications that shall be tested. Depending on the type of message different entering fields are available (e.g. ***message ON*** / ***message OFF***). By clicking on one of the buttons you can select the desired value from the pull-down menu.



[schnittstelle-testen-110402-wlk, 1, en_GB]

Figure 3-16 System interface test with dialog box: Generating indications – Example

Changing the operating state

On clicking one of the buttons in the column **Action** you will be prompted for the password No. 6 (for hardware test menus). After correct entry of the password, individual annunciations can be initiated. To do so, click on the button **Send** in the corresponding line. The corresponding message is issued and can be read out either from the event log of the SIPROTEC4 device or from the substation control center.

Further tests remain enabled until the dialog box is closed.

Test in Indication Direction

For all information that is transmitted to the central station, test in **Setpoint** the desired options in the list which appears:

- Make sure that each checking process is carried out carefully without causing any danger (see above and refer to DANGER!)
- Click on Send and check whether the transmitted information reaches the control centre and shows the desired reaction. Data which are normally linked via binary inputs (first character ">") are likewise indicated to the control centre with this procedure. The function of the actual binary inputs is tested separately.

Exiting the Procedure

To end the System Interface Test, click on **Close**. The dialog box closes. The processor system is restarted, then the device is ready for operation.

Test in Command Direction

Data which are normally linked via binary inputs (first character ">") are likewise checked with this procedure. The information transmitted in command direction must be indicated by the central station. Check whether the reaction is correct.

3.3.4 Checking the switching states of the binary Inputs/Outputs

Prefacing Remarks

The binary inputs, outputs, and LEDs of a SIPROTEC 4 device can be individually and precisely controlled in DIGSI. This feature is used to verify control wiring from the device to plant equipment (operational checks) during commissioning. This test option should however definitely "not"" be used while the device is in service on a live system.



DANGER

A changing of switching states by means of the test function causes a real change of the operating state at the SIPROTEC 4 device. Connected operating equipment such as circuit breakers or disconnectors will be switched in this way!

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

✧ Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during "real" operation performing transmission and reception of messages via the system interface.



NOTE

After termination of the hardware test the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be extracted with DIGSI prior to the test.

The hardware test can be carried out using DIGSI in the Online operating mode:

- Open the **Online** directory by double-clicking; the operating functions for the device appear.
- Click on **Test**; the function selection appears in the right half of the window.
- Double-click in the list view on **Device inputs and outputs**. The dialog box with this name is opened (see *Figure 3-17*).

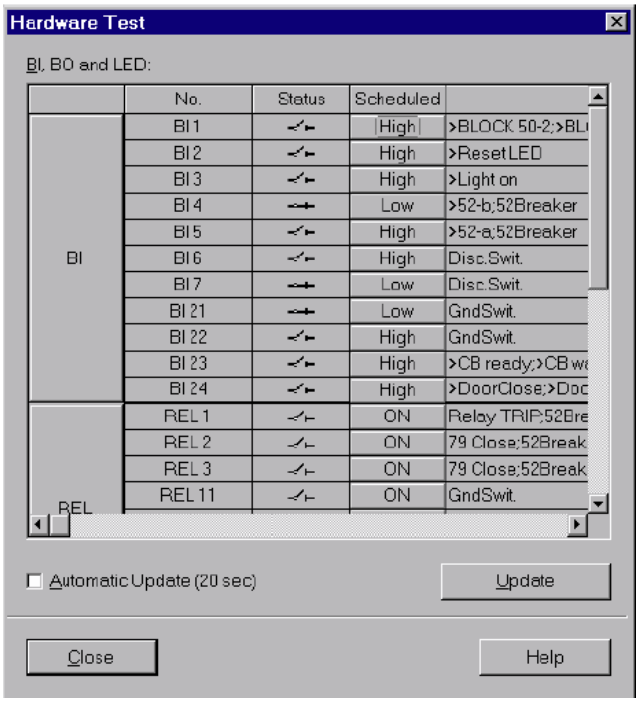
Structure of the Dialog Box

The dialog box is divided into three groups: **BI** for binary inputs, **BO** for binary outputs and **LED** for LEDs. An accordingly labeled button is on the left of each group. By double-clicking a button, information regarding the associated group can be shown or hidden.

In the column **Status** the present (physical) state of the hardware component is displayed. Indication is displayed symbolically. The physical actual states of the binary inputs and outputs are indicated by an open or closed switch symbol, the LEDs by switched on or switched off symbol.

The opposite state of each element is displayed in the column **Scheduled**. The display is in plain text.

The right-most column indicates the commands or messages that are configured (masked) to the hardware components.



[ein-ausgabe-testen-110402-wlk, 1, en_GB]

Figure 3-17 Test of the Binary Inputs and Outputs — Example

Changing the operating state

To change the operating state of a hardware component, click on the associated switching field in the **Scheduled** column.

Before executing the first change of the operating state the password No. 6 will be requested (if activated during configuration). After entry of the correct password a condition change will be executed. Further state changes remain enabled until the dialog box is closed.

Test of the output relay

Each individual output relay can be energized allowing a check of the wiring between the output relay of the 7SD610 and the plant, without having to generate the message that is assigned to the relay. As soon as the first change of state for any of the output relays is initiated, all output relays are separated from the internal device functions, and can only be operated by the hardware test function. This means, that e.g. a TRIP

command coming from a protection function or a control command from the operator panel to an output relay cannot be executed.

Proceed as follows in order to check the output relay:

- Make sure that the switching operations caused by the output relays can be executed without any danger (see above under DANGER!).
- Each output relay must be tested via the corresponding **Scheduled** field of the dialog box.
- Finish the testing (see margin heading below “Exiting the Procedure”), so that during further testings no unwanted switchings are initiated.

Test of the binary inputs

To test the wiring between the plant and the binary inputs of the 7SD610the condition in the system which initiates the binary input must be generated and the response of the device checked.

To do so, open the dialog box **Hardware Test** again to view the physical position of the binary input. The password is not yet required.

Proceed as follows in order to check the binary inputs:

- Each state in the system which causes a binary input to pick up must be generated.
- Check the reaction in the **Status** column of the dialog box. To do this, the dialog box must be updated. The options may be found below under the margin heading “Updating the Display”.
- Finish the test sequence (see margin heading below “Exiting the Procedure”).

If, however, the effect of a binary input must be checked without carrying out any switching in the system, it is possible to trigger individual binary inputs with the hardware test function. As soon as the first state change of any binary input is triggered and the password No. 6 has been entered, all binary inputs are separated from the system and can only be activated via the hardware test function.

Test of the LEDs

The light-emitting diodes (LEDs) may be tested in a similar manner to the other input/output components. As soon as the first state change of any LED has been triggered, all LEDs are separated from the internal device functionality and can only be controlled via the hardware test function. This means e.g. that no LED is illuminated anymore by a protection function or by pressing the LED reset button.

Updating the Display

When the dialog box **Hardware Test** is opened, the present conditions of the hardware components at that moment are read in and displayed.

An update is made:

- For the particular hardware component, if a command for change to another state was successful,
- For all hardware components if the **Update** button is clicked,
- For all hardware components with cyclical updating (cycle time is 20 sec) if the **Automatic Update (20 sec)** field is marked.

Exiting the Procedure

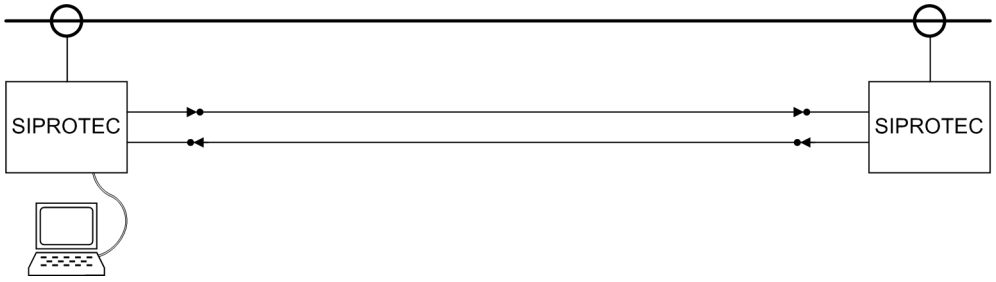
To end the hardware test, click on **Close**. The dialog box closes. Thus, all the hardware components are set back to the operating state specified by the plant states. The processor system is restarted, then the device is ready for operation.

3.3.5 Checking the Protection Data Topology

General

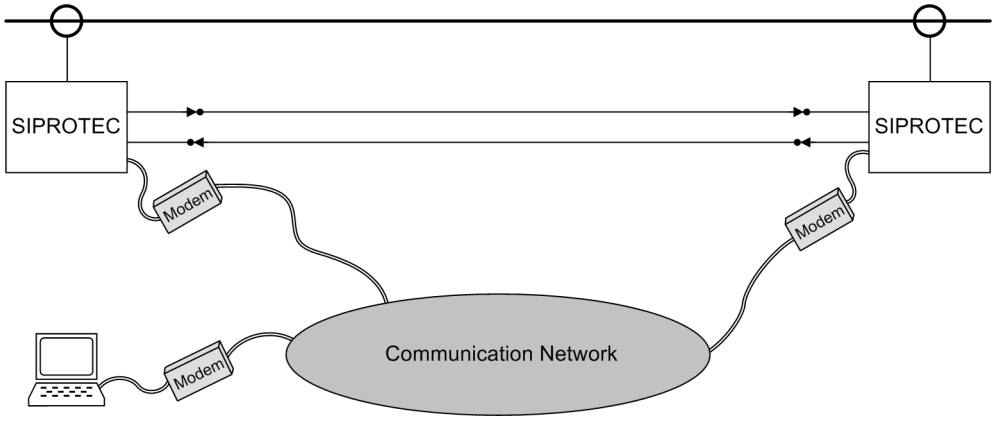
The communication topology can either be checked from the PC using DIGSI or with a “WEB-Monitor”. If you choose to work with the “WEB-Monitor”, please note the Help files referring to the “WEB-Monitor”.

You can either connect the PC to the device locally using the operator interface at the front, or the service interface at the back of the PC *Figure 3-18*). Or you can log into the device using a modem via the service interface (example in *Figure 3-19*).



[topologie-ankopplung-pc-geraet-240702-kn, 1, en_GB]

Figure 3-18 PC interfacing directly to the device - example



[topologie-ankopplung-pc-modem-240702-kn, 1, en_GB]

Figure 3-19 PC interfacing via modem — schematic example

Checking a Connection using Direct Link

For two devices linked with fibre optical cables (as in *Figure 3-18* or *Figure 3-19*), this connection is checked as follows.

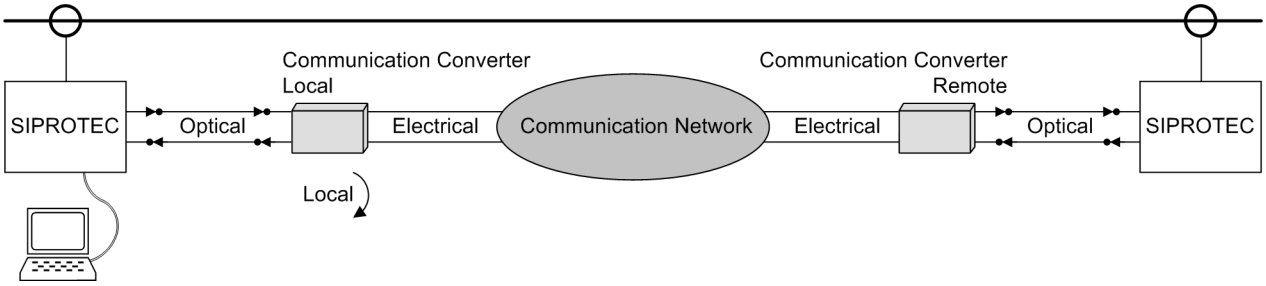
- Both devices at the link ends have to be switched on.
- Check in the operating indications or in the spontaneous indications:
  - If the indication *PI1 with* (protection data interface 1 connected with no. 3243) is provided with the device index of the other device, a link has been established and one device has detected the other.
  - The device also indicates the device index of the device which communicates correctly (e.g. annunciation *Rel2 Login*, No. 3492, when relay 2 has been contacted).
- In case of an incorrect communication link, the message *PI1 Data fault* (No. 3229) will appear. In this case, recheck the fibre optical cable link.
  - Have the devices been linked correctly and no cables been mixed up?
  - Are the cables free from mechanical damage, intact and the connectors locked?
  - Otherwise repeat check.

Continue with the margin heading “Consistency of Topology and Parameterization”.

Checking a Link with a Communication Converter

If a communication converter is used, please note the instructions enclosed with the device. The communication converter has a test setting where its outputs are looped back to the inputs.

Links via the communication converter are tested by means of local loop-back (*Figure 3-20* links).



[topologie-kommunikationsnetz-240702-kn, 1, en_GB]

Figure 3-20 Protection data communication via communication converter and communication network — schematic example

DANGER

Opening the Communication Converter

There is danger to life by energized parts!

✧ Before opening the communication converter, it is absolutely necessary to isolate it from the auxiliary supply voltage at all poles!

- Both devices at the link ends have to be switched on.
- First configure the communication converter CC-1:
  - Disconnect the auxiliary supply voltage from both poles.
  - Open the communication converter.
  - Set the jumpers to the matching position for the correct interface type and transmission rate; they must be identical with the parameterization of the 7SD610 (address 4502 **CONNEC. 1 OVER** for protection data interface 1, see also Subsection *2.2.3.1 Setting Notes*).
  - Move the communication converter into test position (jumper X32 in position 2-3).
  - Close the communication converter housing.
- Reconnect the auxiliary supply voltage for the communication converter.
- The system interface (X.21 or G703.1) must be active and connected to the communication converter. Check this by means of the "device ready"-contact of the communication converter (continuity at the NO contact).
  - If the "device ready"-contact of the communication converter doesn't close, check the connection between the communication converter and the net (communication device). The communication device must emit the correct transmitter clock to the communication converter.
- Change the interface parameters at the 7SD610 (at the device front or via DIGSI):
  - Address 4502 **CONNEC. 1 OVER** = ***F.optic direct*** when you are testing protection data interface 1,

- Check the operating indications or in the spontaneous annunciations:
  - Message 3217 *PI1 Data reflec* (Protection interface 1 data reflection ON) when you test protection data interface 1,
  - If the indication is not transmitted check for the following:
  - Has the 7SD610 fibre optical transmitting terminal output been correctly linked with the fibre optical receiving terminal input of the communication converter and vice versa (No erroneous interchanging)?
  - Does the 7SD610 device have the correct interface module and is it working correctly?
  - Are the fibre optic cables intact?
  - Are the parameter settings for interface type and transmission rate at the communication converter correct (see above; note the DANGER instruction!)?
  - Repeat the check after correction, if necessary.
- Reset the interface parameters at the 7SD610 correctly:
  - Address 4502 **CONNEC. 1 OVER** = required setting, when you have tested protection data interface 1,
- Disconnect the auxiliary supply voltage of the communication converter at both poles. Note the above DANGER instruction!
- Reset the communication converter to normal position (X32 in position 1-2) and close the housing again.
- Reconnect the supply voltage of the communication converter.

Perform the above check at the other end with the device being connected there and its corresponding communication converter.

Continue with the margin heading “Consistency of Topology and Parameterization”.

Consistency of Topology and Parameterisation

Having performed the above checks, the linking of a device pair, including their communication converters, has been completely tested and connected to the auxiliary supply voltage. Now the devices communicate by themselves.

- Check now the Event Log or the spontaneous annunciations of the device you are working on:
  - Indication No. 3243 *PI1 with* (protection data interface 1 linked with) followed by the device index of the other device, if interface 1 is applying.
  - If the devices are at least connected once, the message No. 3458 *Chaintopology* will appear..
  - If no other devices are involved in the topology as an entity, the message No. 3464 *Topol complete* will then be displayed, too.
  - And if the device configuration is also consistent, i.e. the prerequisites for setting the function scope (Section *2.1.1 Functional Scope*), Power System Data 1 (*2.1.2.1 Setting Notes*), Power System Data 2 (*2.1.4.1 Setting Notes*), topology and protection data interface parameters (Section *2.2.3.1 Setting Notes*) have been considered, the fault message, i.e. No.3229 *PI1 Data fault*, for the interface just checked will disappear. The communication and consistency test has now been completed.
  - If the fault message of the interface being checked does not disappear, however, the fault must be found and eliminated. The following table lists indications that indicate such faults.

Table 3-14 Inconsistency Messages

No	LCD Text	Status	Meaning / Measures
3233	*DT inconsis-tent*	ON	“Device table inconsistent”: The indexing of the devices is inconsistent (missing or double numbers, see Section *2.2.3.1 Setting Notes*)
3234	*DT unequal*	ON	“Device table unequal”: The ID numbers of the different devices are not equal (see Section *2.2.3.1 Setting Notes*)

No	LCD Text	Status	Meaning / Measures
3235	*Par. different*	ON	"Parameterization inconsistent": Different functional parameters were set for the devices. They must be equal at all ends: Differential protection exists or not (see Section *2.1.1 Functional Scope* Transformer in the protected zone or not (see Section *2.1.1 Functional Scope*) Nominal frequency (see Section *2.1.2 General Power System Data (Power System Data 1)*) Operational power or current (see Section *2.1.4 General Protection Data (Power System Data 2)*)
3487	*Equal IDs*	ON	"Same device address": The parameter 4710 **LOCAL RELAY** was set identical for several devices.

Finally, there should not be any more fault messages of the protection data interfaces.

Availability of the protection data interfaces

The quality of protection data transmission depends on the availability of all transmission media. Therefore, check the statistic information of the device.

Check the following indications:

- Indication No. 7753 *PI1A/m* (availability per minute) and indication No. 7754 *PI1A/h* (availability per hour) indicate the availability of protection data interface 1. The value of No. 7753 *PI1A/m* should attain a minimum per-minute-availability of 99.85% after two minutes of operation. The value for No. 7754 *PI1A/h* should attain a minimum per-hour-availability of 99.85 % after one hour of operation.

If these values are not attained, the protection communication should be checked.

be checked. If GPS synchronisation is used, the transmission times can be retrieved separately for each direction:

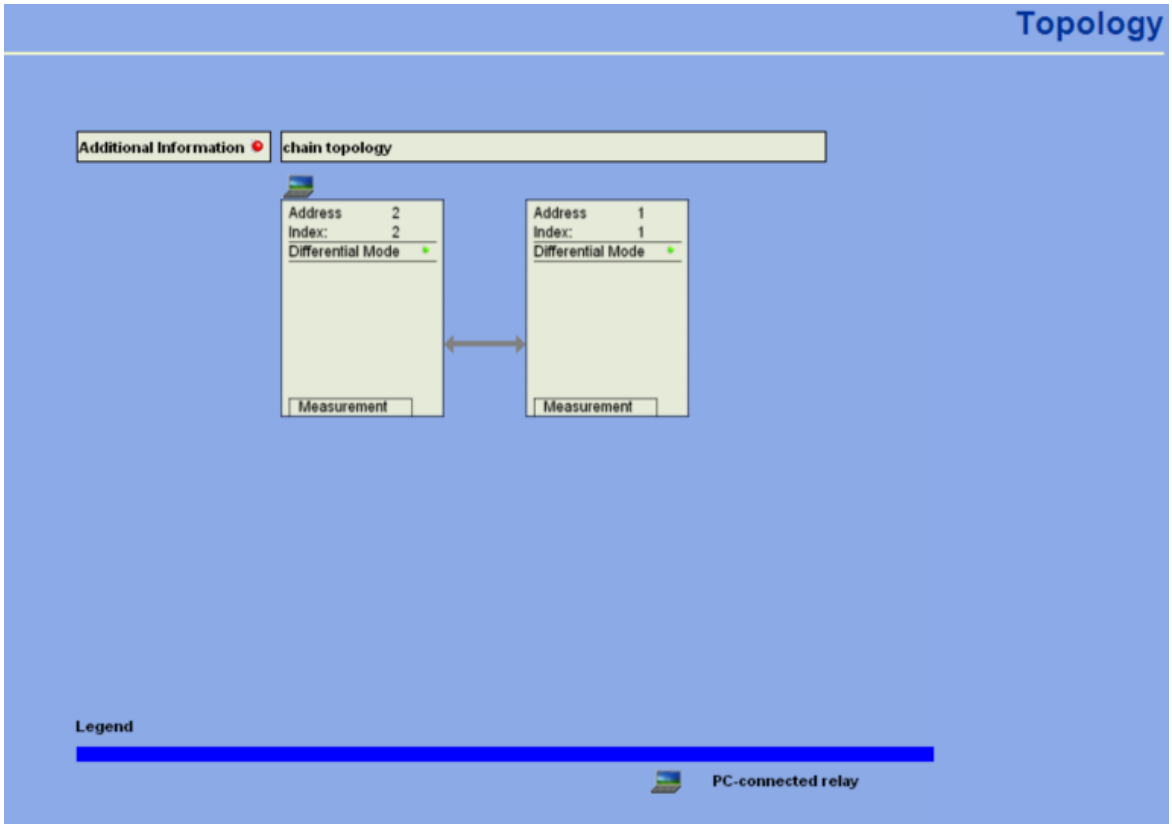
- For protection data interface 1, indication No. 7876 *PI1 TD S* indicates the transmission time in sending direction and No. 7877 *PI2 TD R* in receiving direction.

In all other cases, the mean value for both directions will be indicated:

- Indication No. 7751 *PI1 TD* indicates the transmission time for protection data interface 1.

WEB-Monitor

Topology and statistics of the protection data interfaces can be graphically displayed on the screen using the WEB Monitor. This requires a personal computer with web browser. *Figure 3-21* shows the general information of the communication topology.



[sd6-web-topologie, 1, en_GB]

Figure 3-21 Communication topology – Limited representation

The “Additional Information” button extends the representation by the following information:

The timing master is indicated by a clock icon in the communication topology display.

In the event of an incorrect parameterisation or faulty wiring, the indications “Communication topology not complete” (topol complete OFF), “Communication topology invalid” and “Protection topology invalid” are displayed in a red bar.

The display of the circuit breaker positions is integrated into the topology display. Closed circuit breakers are displayed in green, opened circuit breakers are displayed in red and circuit breakers in an undefined state are displayed in grey.

An LED is used to select whether the communication topology or the protection topology is to be displayed for the participating device. The display of the connections changes correspondingly.

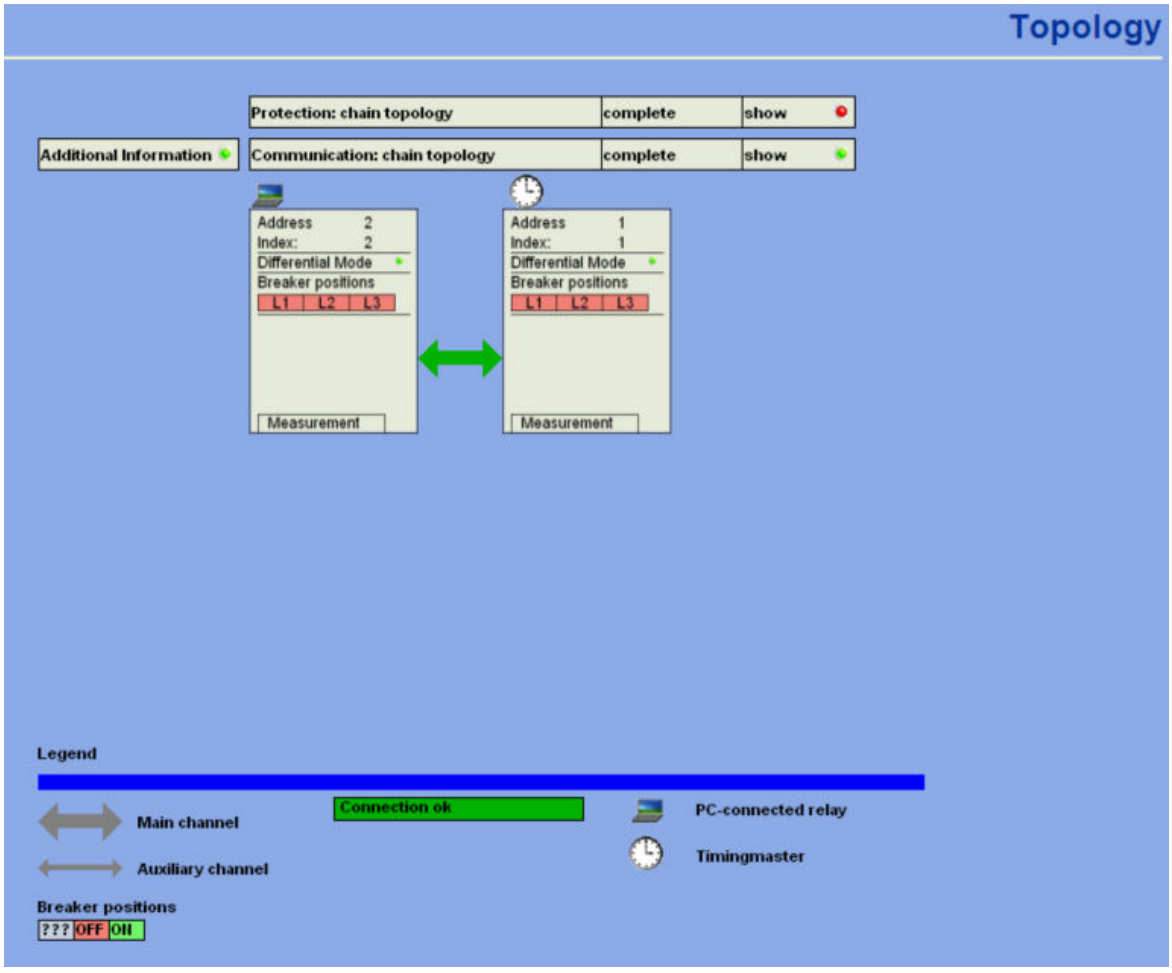
To get an overview of the quality of the individual communication paths, a connection status is displayed for each connection. The statuses can be “OK”, “asynchronous connection” and “unknown status” annehmen.

The status is displayed directly in the communication path display, i.e. in the display of the arrows symbolising the connection. The colour of the connection indicates its status, a legend at the lower screen edge explains its colour coding. If a connection fails completely, the connection is no longer displayed.

Table 3-15 Verbindungsstatus

Status	Colour of the connection display	Remark
OK	green	The connection is OK.
failed	is not displayed	
asynchro-nous	red	The connection cannot be used for protective functions.
unknown	grey	

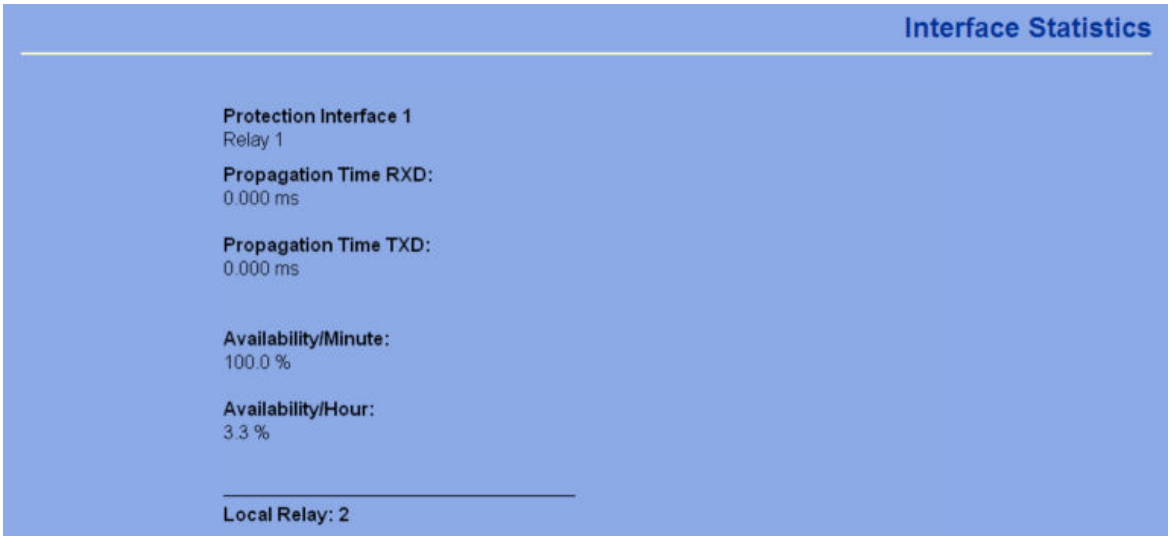
The following figure shows a topology example with additional information.



[sd6-web-topologie-zusatz, 1, en_GB]

Figure 3-22 Communication topology – Additional representation

Figure 3-23 shows an example of the protection data interface statistics of the device. The values for the transfer times and the availability are displayed. Both RX and TX direction of the transmission delay times are displayed, symmetric conditions are assumed if there is no GPS synchronisation. In this case, the values displayed for the transfer time are identical.



[sd6-ws-statistik, 1, en_GB]

Figure 3-23 Example of viewing the transmission times and availability of the protection data interface

3.3.6 Checking for Breaker Failure Protection

General

If the device is equipped with the breaker failure protection and this function is used, the integration of this protection function into the system must be tested under practical conditions.

Because of the manifold applications and various configuration possibilities of the plant it is not possible to give a detailed description of the necessary test steps. It is important to consider the local conditions and the protection and plant drawings.

Before starting the circuit tests it is recommended to isolate the circuit breaker of the feeder to be tested at both ends, i.e. line disconnectors and busbar disconnectors should be open so that the breaker can be operated without risk.



CAUTION

Also for tests on the local circuit breaker of the feeder a trip command to the surrounding circuit breakers can be issued for the busbar.

Non-observance of the following measure can result in minor personal injury or property damage.

✧ First disable the trip commands to the adjacent (busbar) breakers, e.g. by interrupting the associated control voltages.

Before the breaker is closed again for normal operation the trip command of the feeder protection routed to the circuit breaker must be disconnected so that the trip command can only be initiated by the breaker failure protection.

Although the following list does not claim to be complete, it may also contain points which are to be ignored in the current application.

Auxiliary Contacts of the CB

The circuit breaker auxiliary contact(s) form an essential part of the breaker failure protection system in case they have been connected to the device. Make sure the correct assignment has been checked.

External Initiation Conditions

If the breaker failure protection can also be started by external protection devices, the external start conditions are checked. Depending on the device version and the setting of the breaker failure protection, 1-pole or 3-pole trip are possible. The pole discrepancy check of the device or the actual breaker may lead to 3-pole tripping after 1-pole tripping. Therefore check first how the parameters of the breaker failure protection are set. Also see Section *2.13.2 Setting Notes*, addresses 3901 ff.

In order for the breaker failure protection to be started, a current must flow at least through the monitored phase and the earth. This may be a secondary injected current.

After every start, the indication *BF Start* (No. 1461) must appear in the spontaneous indications or fault indications.

If only 1-pole initiation is possible:

- Start by 1-pole trip command of the external protectionL1 :

  Binary input functions *>BF Start L1* and if necessary *>BF release* (in spontaneous or fault indications). Trip command (dependent on settings).

- Start by 1-pole trip command of the external protectionL2 :

  Binary input functions *>BF Start L2* and if necessary *>BF release* (in spontaneous or fault indications). Trip command (dependent on settings).

- Start by 1-pole trip command of the external protectionL3 :

  Binary input functions *>BF Start L3* and if necessary *>BF release* (in spontaneous or fault indications). Trip command (dependent on settings).

- Start by 3-pole trip command of the external protection via all three binary inputs L1, L2 and L3:

  Binary input functions *>BF Start L1*, *>BF Start L2* and *>BF Start L3* and if necessary *>BF release* (in spontaneous or fault indications). 3-pole trip command.

For 3-pole initiation:

- Start by 3-pole trip command of the external protection :

  Binary input functions *>BF Start 3pole* and if necessary *>BF release* (in spontaneous or fault indications). Trip command (dependent on settings).

Switch off test current.

If start is possible without current flow:

- Starting by trip command of the external protection without current flow:

  Binary input functions *>BF Start w/o I* and if necessary *>BF release* (in spontaneous or fault indications). Trip command (dependent on settings).

Busbar tripping

The most important thing is the check of the correct distribution of the trip commands to the adjacent circuit breakers in case of breaker failure.

The adjacent circuit breakers are those of all feeders which must be tripped in order to ensure interruption of the fault current should the local breaker fail. These 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 largely depends on the system topology.

In particular with multiple busbars the trip distribution logic for the surrounding circuit breakers must be checked. Here check for every busbar section that all circuit breakers which are connected to the same busbar section as the feeder circuit breaker under observation are tripped, and no other breakers.

Tripping of the Remote End

If the trip command of the circuit breaker failure protection must also trip the circuit breaker at the remote end of the feeder under observation, the transmission channel for this remote trip must also be checked. This is done together with transmission of other signals according to Sections “Testing of the Teleprotection Scheme with ...” further below.

Termination of the Checks

All temporary measures taken for testing must be undone, e.g. especially switching states, interrupted trip commands, changes to setting values or individually switched off protection functions.

3.3.7 Checking the Instrument Transformer Connections of One Line End

If secondary test equipment is connected to the device, it is to be removed or, if applying, test switches should be in normal operation position.



NOTE

It must be taken into consideration that tripping can occur even at the opposite ends of the protected object if wrong connections were made.

Before energizing the protected object at any end, short-circuit protection must be ensured at least at the feeding ends. If a separate backup protection (e.g. time overcurrent protection) is available, this has to be put into operation and switched to alert first.

Voltage and phase rotation check

If the device has been connected to voltage transformers, these connections are checked using primary values. For devices without voltage transformer connection, the rest of this section can be ignored.

The voltage transformer connections are individually tested at either end of the object to be protected. At the other end(s) the circuit breaker(s) first remains opened.

- Having closed the circuit breaker, none of the measurement monitoring functions in the device must respond.
  - If there was a fault indication, however, the Event Log or spontaneous indications could be checked to investigate the reason for it.
  - Indications of symmetry monitoring could occur because there are actually assymmetrial conditions in the primary system. If they are part of normal operation, the corresponding monitoring function is set less sensitive (see Section *2.15.1 Measurement Supervision* under side title “Symmetry Monitoring”).

  The voltages can be read as primary and secondary values on the display at the front, or called up in the PC via the operator or service interface, and compared with the actual measured quantities. Besides the magnitudes of the phase-to-earth and the phase-to-phase voltages, the phase differences of the voltages are also displayed so that the correct phase sequence and polarity of individual transformers can also be seen. The voltages can also be read with the “WEB-Monitor” (see below, “Current test”).
- The voltages have to be almost equal. All three angles φ (U_{Lx}–U_{Ly}) must be approximately 120°.
  - If the measured quantities are not plausible, the connections must be checked and corrected after switching off the line. If, for example, the phase difference between two voltages is 60° instead of 120°, one voltage must be polarity-reversed The same applies if there are phase-to-phase voltages which are almost equal to the phase voltages instead of having a value that is √3 larger. The measurements have to be repeated after correcting the connections.
  - In general, the phase rotation is clockwise. If the system has an anti-clockwise phase rotation, this must be identical at all ends of the protected object. The phase assignment of the measured quantities has to be checked and, if required, corrected after the line has been switched off. The measurement must then be repeated.
- Open the circuit breaker for voltage transformers of the feeder. The measured voltages in the operational measured values appear with a value close to zero (small measured voltages are of no consequence).
  - Check the Event Log and the spontaneous indications to make sure that the VT mcb trip was noticed (indication*>FAIL:Feeder VT*“ON”, No. 361). This requires the position of the circuit breaker for voltage transformers to be communicated to the device via a binary input.

- Close the circuit breaker for voltage transformers: The above indication is displayed in the spontaneous indications as "OFF", i.e. *>FAIL:Feeder VT* "OFF".
  - If one of the indications does not appear, the connection and allocation of these signals must be checked.
  - If "ON" state and "OFF" state are swapped, the contact type (H–active or L–active) must be checked and corrected.
- The protected object is switched off.
- The check must be carried out for all ends.

3.3.8 Checking the Instrument Transformer Connections with Two Line Ends

Current test

The connections of the current transformers are tested with primary values. A load current of at least 5% of the rated operational current is required. Any direction is possible.

This test cannot replace the visual inspection of the correct current transformer connections. Therefore, the inspection according to Section "Checking the System Connections" is a prerequisite.

- The current transformer connections are tested at each end of the protected object with current flowing through the protected object.
- After closing the circuit breakers, none of the measured value monitoring functions in the 7SD610 must respond. If there was a fault indication, however, the Event Log or spontaneous indications can be checked to investigate the reason for it.
  - If current summation errors occur, check the matching factors (see Section *2.1.2 General Power System Data (Power System Data 1)* under "Connection of the currents").
  - Indications from the symmetry monitoring could occur because there actually are asymmetrical conditions in the primary system. If they are part of normal operation, the corresponding monitoring function is set less sensitive (see Section *2.15.1 Measurement Supervision* under "Symmetry Monitoring").

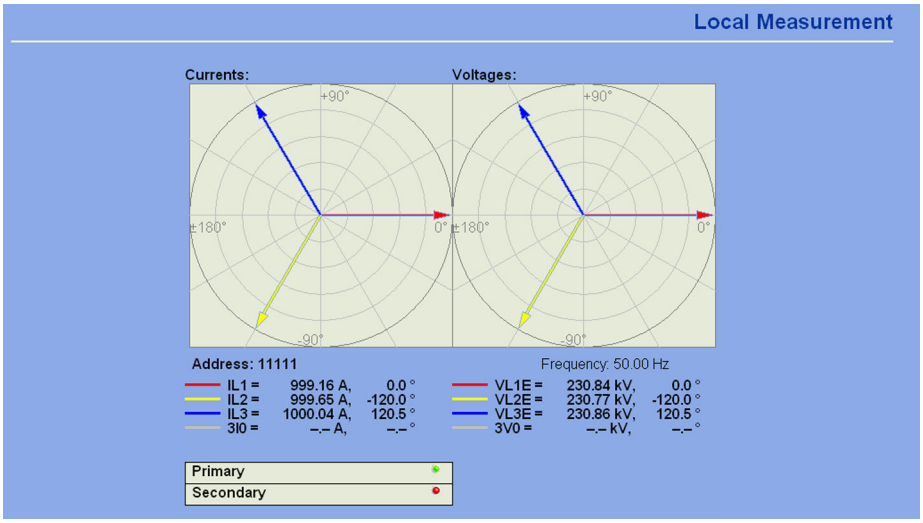
  The currents can be read as primary and secondary values on the display at the front, or called up in the PC via the operator or service interface, and compared with the actual measured quantities. The phase differences of the currents are indicated in addition to the absolute values so that the correct phase sequence and polarity of individual transformers can also be seen.

  The "WEB-Monitor" allows convenient readout of all measured values with visualization by means of phasor diagrams (*Figure 3-24*).
- The current amplitudes must be approximately the same. All three angles φ (I_{Lx}–I_{Ly}) must be approximately 120°.
  - If the measured values are not plausible, the connections must be checked and corrected after switching off the protected object and short-circuiting the current transformers. If, for example, the phase difference between two currents is 60° instead of 120°, one of the currents must have a reversed polarity. The same is the case, if a substantial earth current $3I_0$ occurs:

    3 I0 ≈ phase current → one or two phase currents are missing;

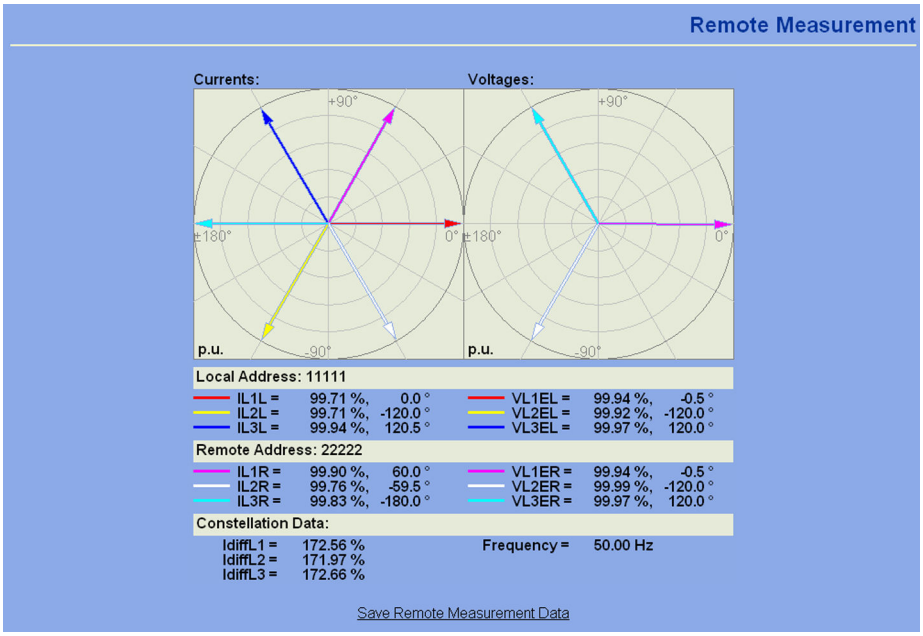
    3 I0 ≈ twice the phase current → one or two phase currents have a reversed polarity
- The measurements are to be repeated after correcting the connections.
- The above described tests of the measured quantities also have to be performed at the other end of the tested current path. The current value of the other end can also be read out locally as percentage values as well as the phase angles.

In the "WEB-Monitor", the local and remote measured values can be graphically displayed. The following figures show an example.



[web-mw-bsp1, 1, en_GB]

Figure 3-24 Local measured values in the WEB-Monitor - Examples of plausible measured values



[web-mw-bsp2, 1, en_GB]

Figure 3-25 Remote measured values in the WEB-Monitor - Examples of plausible measured values

Polarity check

If the device is connected to voltage transformers, the local measured values already allow a polarity check.

If there are more than two ends, one current path is still tested first. A load current of at least 5 % of the rated operational current is still required. Any direction is possible, but it must be known.

- With closed circuit breakers, the power values are viewed as primary and secondary values on the front display panel or via the operator or service interface with a personal computer.

  Here, again, the “WEB-Monitor” is a convenient help since the vector diagrams also show the allocation between the currents and voltages (*Figure 3-25*). Cyclically and acyclically swapped phases can easily be detected.

- The measured power values on the actual device or in DIGSI enable you to verify that they correspond to the load direction (*Figure 3-26*):

  P positive if active power flows into the protected object,

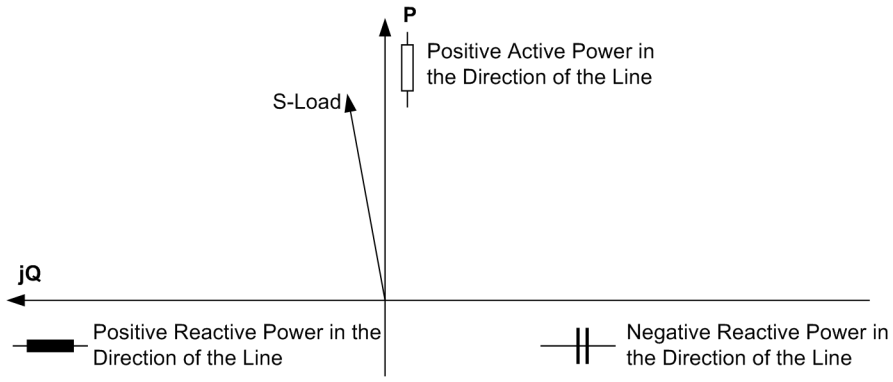
  P negative if active power flows toward the busbar

  Q positive if reactive power flows into the protected object,

  Q negative if reactive power flows toward the busbar.

  Consequently, the powers and their components must have opposite signs at both ends.

  Consider also that high load currents, which can occur on long overhead lines or cables, are capacitive, which means that they correspond to a negative reactive power. In spite of a resistive-inductive load, this may lead to a slightly negative reactive power at the feeding end, whereas the other end features an increased negative reactive power. The lower the load current for the test, the higher the significance of this influence. In order to get unambiguous results, you should increase the load current if necessary.



[lastscheinleistung-290803-st, 1, en_GB]

Figure 3-26 Apparent load power

- The power measurement provides an initial indication as to whether the measured values of one end have the correct polarity.
  - If the direction of the reactive power is correct but the sign of the active power is incorrect, cyclic phase swapping of the currents (right) or of the voltages (left) might be the cause;
  - If the direction of the active power is correct but the reactive power has an incorrect sign, cyclic phase swapping of the currents (left) or of the voltages (right) might be the cause;
  - If the signs of both active and reactive power are incorrect, the polarity in address 201 **`CT Star-point`** has to be checked and corrected.

  The phase angles between currents and voltages must also be conclusive. All three phase angles ϕ (U_{Lx}–I_{Lx}) must be approximately the same and represent the operating status. In the event of power in the direction of the protected object, they correspond to the current phase displacement (cos ϕ positive); in the event of power in the direction of the busbar they are higher by 180° (cos ϕ negative). However, charging currents might have to be considered (see above).
- The measurements may have to be repeated after correcting the connections.
- The above described tests of the measured quantities also have to be performed at the other end of the tested current path. The current and voltage values as well as the phase angles of the other end can also be read out locally as percentage values. Please observe that currents flowing through the object (without charging currents) ideally have opposite signs at both ends, i.e. they are turned by 180°. In the "WEB-Monitor", the local and remote measured values can be shown graphically. An example is shown in *Figure 3-25*.
- The protected object is now switched off, i.e. the circuit breakers are opened.

Polarity check for current input I_4

If the standard connection of the device is used with current input I_4 connected at the starpoint of the set of current transformers (also refer to the connection circuit diagram in Appendix *C Connection Examples*), the polarity of the ground current path is in general automatically correct.

But if the current I_4 is supplied by a separate summation CT, an additional direction check on this current is necessary.

Apart from that the test is carried out with a disconnected trip circuit and primary load current. It must be noted that during all simulations not exactly corresponding with cases that occur in practice, the asymmetry of measured values may cause the measured value monitoring to pick up. They must therefore be ignored during such tests.



DANGER

Hazardous voltages during interruptions in secondary circuits of current transformers

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

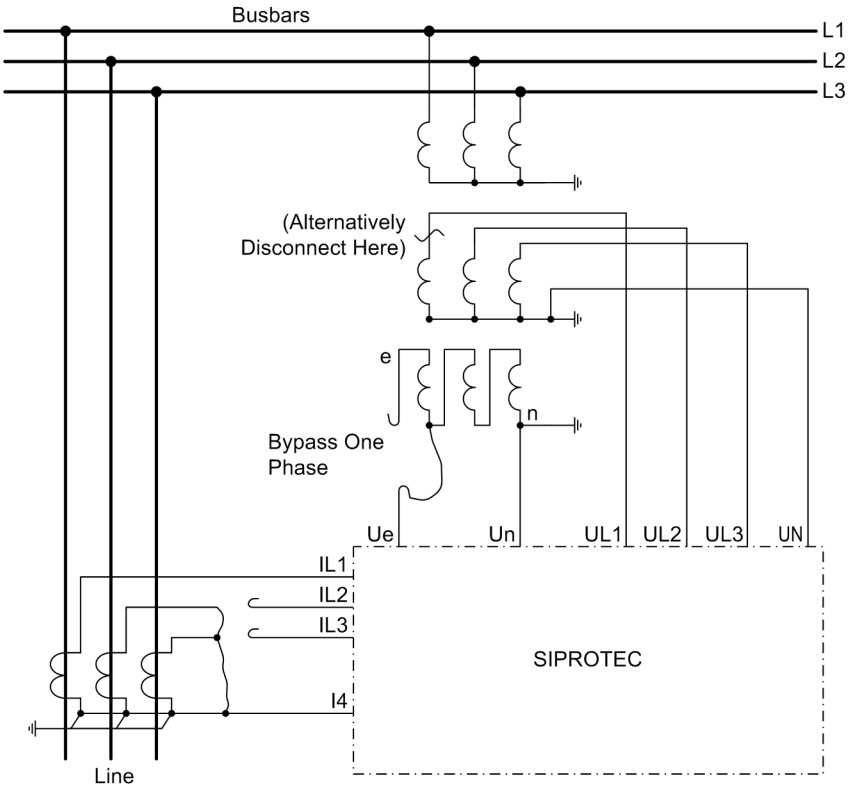
✧ Short-circuit the current transformer secondary circuits before current connections to the device are opened.

I_4 from Own Line

To generate a displacement voltage, the e-n winding of one phase in the voltage transformer set (e.g. L1) is bypassed (refer to *Figure 3-27*). If no connection to the e-n windings of the voltage transformer is available, the corresponding phase is open circuited on the secondary side. Via the current path only the current from the current transformer in the phase from which the voltage in the voltage path is missing, is connected; the other CTs are short-circuited. If the line carries resistive-inductive load, the protection is in principle subject to the same conditions that exist during an earth fault in the direction of the line.

The voltages can be read on the display at the front, or called up in the PC via the operator or service interface, and compared with the actual measured quantities as primary or secondary values. The absolute values as well as the phase differences of the voltages are indicated so that the correct phase sequence and polarity of individual transformers can also be seen. The voltages can also be read out with the Web-Monitor.

The same manipulation is carried out with the current and voltage transformers at the other end.



[polaritaetspruefung-i4-holmgreen-250702-kn, 1, en_GB]

Figure 3-27 Polarity check for I_4, example with current transformer configured in a Holmgreen connection

If the current flows towards the protected object according to the circuit in *Figure 3-27*, the currents I_{L2} and I_{L3} are virtually zero. An earth current $3I_0$ of the approximately same level as I_{L1} occurs. Accordingly, the voltage U_{L1E} is missing and a zero sequence voltage $3U_0$ appears.

In the event of a polarity fault, $3I_0$ is in opposite phase with I_{L1} or the zero voltage $3U_0$ supplements the other two voltages to a voltage star. Open the circuit breakers, short-circuit current transformers, set current and voltage transformer connections right and repeat the check.

NOTE

If parameters were changed for this test, they must be returned to their original state after completion of the test!

Measuring the differential and restraint currents

The test for two ends is terminated with the reading of the differential, restraint and load currents. It is simultaneously checked that the current transformer connections have been correctly restored after the I_4 test (if performed).

- Read out the differential, restraint and load currents. They are available for every phase on the device display or in DIGSI in the measured values.
  - The differential currents must be low, at least one scale less than the currents flowing through. If high charging currents are to be expected in long overhead lines or cables, these are additionally included in the differential currents.
  - The maximum values of the read measured values for the charging current (3 values) are converted to Ampere and entered in **I-DIFF>**. The recommended setting for the pickup threshold is $1 \cdot I_{cN}$.
  - The restraint currents result from the pickup value **I-DIFF>** (address 1210, see Section *2.3.2 Setting Notes*) plus the sum of the fault currents to be tolerated: Such as the locally permissible current transformer errors according to address 253 **E% ALF/ALF_N** (see Section *2.1.2 General Power System Data (Power System Data 1)*), the permissible current transformer errors at the other ends according to the respective setting, as well as the internal estimation of the system errors (frequency, synchronisation and delay time difference errors). With the default values for **I-DIFF>** ($0.3\ I_N$) and **E% ALF/ALF_N** (5.0 % = 0.05) the following ensues:

$$\frac{I_{Rest}}{I_{NB}} = \underbrace{0.3 \cdot \frac{I_{N1}}{I_{NB}}}_{\text{Setting Value IDIFF>}} + \underbrace{0.05 \cdot \frac{I}{I_{N1}}}_{\text{Adm. Local Tranformer Error}} + \underbrace{0.05 \cdot \frac{I}{I_{N2}}}_{\text{Adm. Remote Transformer Eror}} + \text{System Error}$$

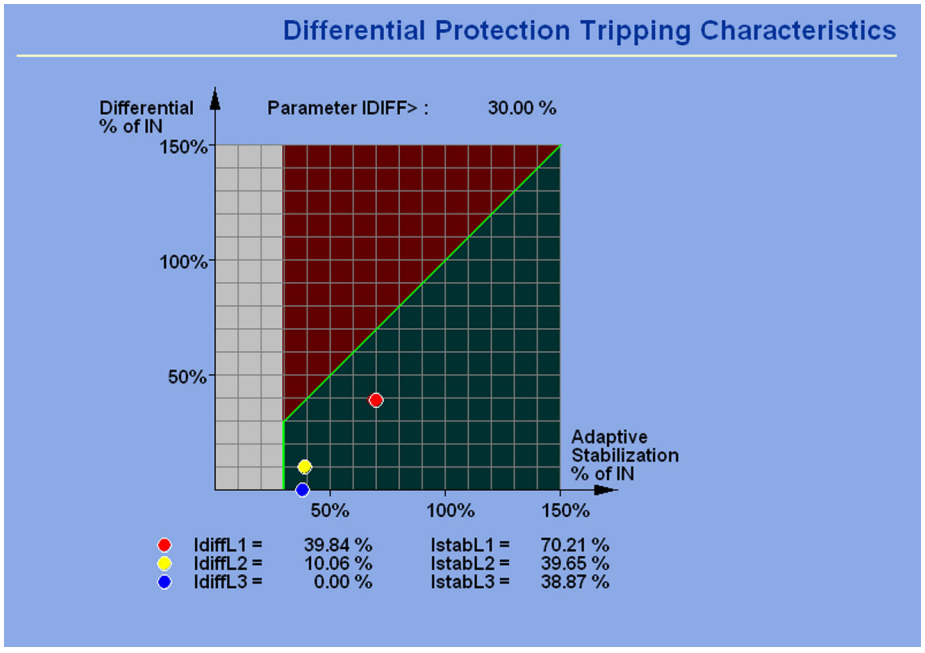
[mi_diffstab-280803-rei, 1, en_GB]

with

I	the actually flowing current,
I_{NB}	the rated operational current (as parameterised),
I_{N1}	the primary nominal current of the local current transformers,
I_{N2}	the primary nominal current of the current transformers of the remote end.

In the “WEB-Monitor” the differential and restraint currents are graphically displayed in a characteristics diagram. An example is shown in *Figure 3-28*.

- If there is a differential current in the size of twice the through-flowing current, you may assume a polarity reversal of the current transformer(s) at one line end. Again check the polarity and set it right after shortcircuiting all the three current transformers. If you have modified these current transformers, also perform a power or angle test.
- Finally, open the circuit breaker again.
- If parameter settings have been changed for the tests, reset them to the values necessary for operation.



[web-diffschutz, 1, en_GB]

Figure 3-28 Differential and restraint currents - Example of plausible measurements

3.3.9 Checking the Signal Transmission for Internal and External Remote Tripping

The 7SD610 provides the possibility to transmit a remote trip signal to the opposite line end if a signal transmission path is available for this purpose. This remote trip signal may be derived from both an internally generated trip signal as well as from any signal coming from an external protection or control device.

If an internal signal is used, the initiation of the transmitter must be checked. If the signal transmission path is the same and has already been checked as part of the previous sections, it need not be checked again here. Otherwise the initiating event is simulated and the response of the circuit breaker at the opposite line end is verified.

For the remote transmission, the external command input is employed on the receiving line end; it is therefore a prerequisite that: **DTT Direct Trip** is set to ***Enabled*** in address 122 and **FCT Direct Trip** is set to ***ON*** in address 2201. If the signal transmission path is the same and has already been checked as part of the previous sections, it need not be checked again here. A function check is sufficient, whereby the externally derived command is executed. For this purpose, the external tripping event is simulated and the response of the circuit breaker at the opposite line end is verified.

3.3.10 Checking the User-defined Functions

The device has a vast capability for allowing functions to be defined by the user, especially with the CFC logic. Any special function or logic added to the device must be checked.

A general procedure cannot in the nature of things be specified. Configuration of these functions and the set value conditions must be actually known beforehand and tested. Especially, possible interlocking conditions of the switching devices (circuit breakers, isolators, grounding electrodes) must be observed and checked.

3.3.11 Trip and Close Test with the Circuit Breaker

The circuit breaker and tripping circuits can be conveniently tested by the device 7SD610.

The procedure is described in detail in the SIPROTEC 4 System Description.

If the check does not produce the expected results, the cause may be established from the text in the display of the device or the PC. If necessary, the connections of the circuit breaker auxiliary contacts must be checked:

It must be noted that the binary inputs used for the circuit breaker auxiliary contacts must be assigned separately for the CB test. This means it is not sufficient that the auxiliary contacts are allocated to the binary inputs No. 351 to 353, 379 and 380 (according to the possibilities of the auxiliary contacts); additionally, the corresponding No. 366 to 368 or 410 and/or 411 must be allocated (according to the possibilities of the auxiliary contacts). In the CB test only the latter ones are analyzed. See also Section *2.16.2 Circuit Breaker Test*. Furthermore, the ready state of the circuit breaker for the CB test must be indicated to the binary input with No. 371.

3.3.12 Switching Test of the Configured Operating Equipment

Switching by Local Command

If the configured operating devices were not switched sufficiently in the hardware test already described, all configured switching devices must be switched on and off from the device via the integrated control element. The feedback information of the CB position injected via binary inputs should be read out and compared with the actual breaker position.

The switching procedure is described in the SIPROTEC 4 System Description. The switching authority must be set in correspondence with the source of commands used. With the switching mode, you can choose between locked and unlocked switching. In this case, you must be aware that unlocked switching is a safety risk.

Switching from a Remote Control Centre

If the device is connected to a remote substation via a system (SCADA) interface, the corresponding switching tests may also be checked from the substation. Please also take into consideration that the switching authority is set in correspondence with the source of commands used.

3.3.13 Triggering Oscillographic Recording for Test

In order to verify the reliability of the protection relay even during inrush processes, closing tests can be carried out to conclude the commissioning process. Oscillograhpic records provide the maximum information about the behavior of the protection relay.

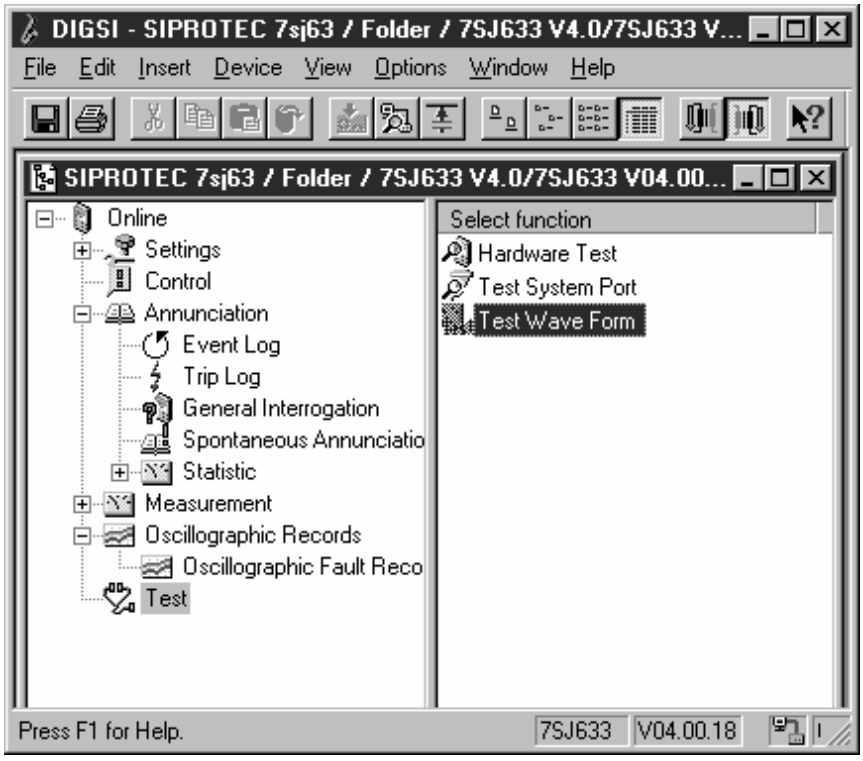
Prerequisite

Along with the capability of storing fault recordings via pickup of the protection function, the 7SD610 also has the capability of capturing the same data when commands are given to the device via the DIGSI software, the serial interface, or a binary input. For the latter, the information *>Trig.Wave.Cap.* must be allocated to a binary input. In this case, a fault record is triggered e.g. via binary input when the protected object is energized.

Such a test fault record triggered externally (i.e. not caused by pickup of a protection function) is processed like a normal oscillographic record, i.e. a fault log with number is generated which univocally identifies an oscillographic record. However, these recordings are not displayed in the trip log as they are not fault events.

Start Test Measurement Recording

To trigger test measurement recording with DIGSI, click on **Test** in the left part of the window. Double click in the list view the **Test Wave Form** entry (see *Figure 3-29*).



[7sa-testmessschrieb-starten-310702-kn, 1, en_GB]

Figure 3-29 Triggering oscillographic recording with DIGSI — example

Oscillographic recording is immediately started. During the recording, an annunciation is output in the left area of the status line. Bar segments additionally indicate the progress of the procedure.

The SIGRA or the Comtrade Viewer program is required to view and analyze the oscillographic data.

3.4 Final Preparation of the Device

The used terminal screws must be tightened, including those that are not used. All the plug connectors must be correctly inserted.



CAUTION

Do not apply force!

The tightening torques must not be exceeded as the threads and terminal chambers may otherwise be damaged!

✧

The setting values should be checked again if they were changed during the tests. Check if protection, control and auxiliary functions to be found with the configuration parameters are set correctly (Section *2.1.1 Functional Scope*, Functional Scope). All desired functions must be switched ***ON***. Ensure that a copy of the setting values is stored on the PC.

Check the internal clock of the device. If necessary, set the clock or synchronize the clock if the element is not automatically synchronized. Further details on this subject are described in */1/ SIPROTEC 4 System Description*.

The indication buffers are deleted under **Main Menu** → **Annunciation** → **Set/Reset**, so that in the future they only contain information on actual events and states. The numbers in the switching statistics should be reset to the values that were existing prior to the testing.

The counters of the operational measured values (e.g. operation counter, if available) are reset under Main **Menu** → **Measurement** → **Reset**.

Press the**ESC** key, several times if necessary, to return to the default display.

Clear the LEDs on the front panel by pressing the **LED** key, so that they only show real events and states. In this context, saved output relays are reset, too. Pressing the **LED** key also serves as a test for the LEDs on the front panel because they should all light when the button is pressed. If the LEDs display states relevant by that moment, these LEDs, of course, stay lit.

The green “RUN” LED must light up, whereas the red “ERROR” must not light up.

Close the protective switches. If test switches are available, then these must be in the operating position.

The device is now ready for operation.

4 Technical Data

This chapter presents the technical data of SIPROTEC 4 7SD610 device and its individual functions, including the limit values that must not be exceeded under any circumstances. The electrical and functional data of fully equipped devices are followed by the mechanical data, with dimensional drawings.

4.1	General	292
4.2	Protection Data Interfaces and Differential Protection Topology	302
4.3	Differential Protection	306
4.4	Restricted Earth Fault Protection	308
4.5	Breaker Intertrip and Remote Tripping- Direct Local Trip	309
4.6	Transmission of Binary Information (optional)	310
4.7	Instantaneous High-Current Switch-onto-Fault Protection (SOTF)	311
4.8	Backup Time Overcurrent Protection	312
4.9	Automatic Reclosure (optional)	319
4.10	Voltage Protection (optional)	320
4.11	Frequency Protection (optional)	323
4.12	Circuit Breaker Failure Protection (optional)	324
4.13	Thermal Overload Protection	325
4.14	Monitoring Functions	327
4.15	User defined functions (CFC)	329
4.16	Additional Functions	333
4.17	Dimensions	336

4.1 General

4.1.1 Analogue Inputs and Outputs

Nominal Frequency	f_N	50 Hz or 60 Hz	(adjustable)

Current Inputs

Nominal current	I_N	1 A or 5 A
Power Consumption per Phase and Earth Path		
- at I_N = 1 A		Approx. 0.05 VA
- at I_N = 5 A		Approx. 0.3 VA
Current Overload Capability per Current Input		
- thermal (rms)		500 A for 1 s 150 A for 10 s $4 \cdot I_N$ continuous
- dynamic (pulse current)		1250 A (half-cycle)

Current transformer requirements

1st condition: For a maximum fault current the current transformers must not be saturated under steady-state conditions	$n' \geq \frac{I_{kd\ max}}{I_{N\ prim}}$
2nd condition: The operational accuracy limit factor n' must be at least 30 or a non-saturated period t'_{AL} of at least $^1/_4$ AC cycle after fault inception must be ensured	$n' \geq 30$ **oder** $t'_{AL} \geq {}^1/_4$ Periode
3 rd Condition: Maximum ratio between primary currents of current transformers at the ends of the protected object	$\frac{I_{prim\ max}}{I_{prim\ min}} \leq 8$

Voltage Inputs

Rated Voltage	U_N	80 V to 125 V	(adjustable)
Measuring range		0 V bis 218.5 V (rms)	
Power consumption per phase	at100 V	≤ 0.1 VA	
Voltage Overload Capability in Voltage Path per Input			
- thermal (rms)		230 V continuous	

4.1.2 Auxiliary voltage

Direct Voltage

Voltage supply via integrated AC/DC converter			
Nominal auxiliary voltage DC U_{AUX}	DC 24 V/48 V	DC 60 V/110 V/ 125 V	DC 110 V/125 V/220 V/ 250 V
Admissible voltage ranges	DC 19 V to 58 V	DC 48 V to 150 V	DC 88 V to 300 V
Superimposed AC ripple voltage, Peak to peak IEC60255–11	≤ 15 % of the nominal auxiliary voltage		

Power Input	
- Quiescent	Approx. 6,5 W
- Energized	Approx. 10 W
Plus approx. 1.5 W per interface module	
Bridging time for failure / short circuit of DC auxiliary voltage	≥ 50 ms at U_{AUX} = 48 V and U_{AUX} ≥ 110 V
	≥ 20 ms at U_{AUX} = 24 V and U_{AUX} = 60 V

AC voltage

Voltage Supply via Integrated Converter		
Nominal auxiliary voltage ACU_{AUX}	AC 115 V/230 V	AC 230 V (release /CC and higher) [1)]
Permissible voltage ranges	AC 92 V to 265 V	AC 184 V to 265 V
Power Input		
- Quiescent	Approx. 10 VA	
- Energized	Approx. 17 VA	
plus approx. 1.5 VA per interface module		
Bridging time for power supply failure/short circuit of auxiliary AC voltage	≥ 50 ms	

[1)] maximum environment temperature +55 °C for operation with AC 230 V

4.1.3 Binary Inputs and Outputs

Binary inputs

Number	7 (configurable)	
Rated Voltage Range	DC 24 V to 250 V, in 3 ranges, bipolar	
Pick-up threshold	Changeable via jumpers	
- For nominal voltages	DC 24 V/48 V and DC 60 V/110 V/125 V	U_{high} ≥ DC 19 V U_{low} ≤ DC 10 V
- For nominal voltages	DC 110 V/125 V/220 V/250 V	U_{high} ≥ DC 88 V U_{low} ≤ DC 44 V
- For nominal voltages	DC 220 V/250 V	U_{high} ≥ DC 176 V U_{low} ≤ DC 88 V
Current consumption, energized	Approx. 1.8 mA Independent of the control voltage	
Maximum Permissible Voltage	DC 300 V	
Impulse filter on input	220 nF coupling capacitance at 220 V with recovery time > 60 ms	

Binary Outputs

Signalling/Trip Relays (see also terminal assignments in Appendix)			
Number and information	**(allocatable)**		
UL Listed	**NO Contact (normal) [1)]**	**NO Contact (fast) [1)]**	**NO/NC (switch selectable) [1)]**
x	5	-	1
Switching capability MAKE	1000 W/VA		

Signalling/Trip Relays (see also terminal assignments in Appendix)				
Number and information		**(allocatable)**		
UL Listed		**NO Contact (normal) [1])**	**NO Contact (fast) [1])**	**NO/NC (switch selectable) [1])**
Switching capability OFF		30 VA 40 W resistive 25 W/VA at L/R ≤ 50 ms		
Switching voltage				
DC		250 V		
AC		250 V		
Admissible current per contact (continuous)		5 A		
Permissible current per contact (close and hold)		30 A for 0.5 s (NO contact)		
Permissible total current on common path contacts		5 A continuous 30 A for 0,5 s		
Permissible relative closing time		-		
Operating time, approx.		8 ms	5 ms	8 ms
Alarm relay [1])		With 1 NC contact or 1 NO contact (switchable)		
Switching capacity	MAKE	1000 W/VA		
	OPEN	30 VA 40 W resistive 25 VA at L/R ≤ 50 ms		
Switching voltage		250 V		
Permissible Current per Contact		5 A continuous 30 A for 0,5 s		
[1])UL-listed with the following rated data:				
		AC 120 V	Pilot duty, B300	
		AC 240 V	Pilot duty, B300	
		AC 240 V	5 A General Purpose	
		DC 24 V	5 A General Purpose	
		DC 48 V	0.8 A General Purpose	
		DC 240 V	0.1 A General Purpose	
		AC 120 V	1/6 hp (4.4 FLA)	
		AC 240 V	1/2 hp (4.9 FLA)	

4.1.4 Communication Interfaces

Protection Data Interface

see Section “Protection Data Interfaces and Communication Topology”

Operator Interface

Connection	Front side, non-isolated, RS232, 9-pin D-subminiature female connector for connection of a PC
Operation	With DIGSI
Transmission rate	Min. 4800 Baud; max. 115200 Baud; Factory Setting: 38400 Baud; Parity: 8E1

Transmission distance	15 m / 50 feet

Service/Modem Interface (optional)

Connection Acc. to ordered version	Isolatede interface for data transfer
Operation	with DIGSI
RS232/RS485	
Connection for flush mounted case	Rear panel, mounting location“C”, 9-pole D-subminiature female connector Shielded data cable
Connection for surface mounted case	Shielded data cable at the terminal at the case bottom
	in console housing at the case bottom 9-pole D-subminiature female connector
Test Voltage	500 V; 50 Hz
Transmission rate	Min. 4800 Baud; max. 115200 Baud Factory setting 38400 Baud
RS232	
Maximum Distance of Transmission	15 m (50 ft)
RS485	
Maximum Distance of Transmission	1,000 m (3280 ft)

System Interface (optional)

Connection acc. to version ordered	potentialfreie Schnittstelle für Datentransfer zu einer Leitstelle
RS232	
Connection for flush-mounted housing	rear panel, slot “B”, 9-pole D-subminiature female connector
Connection for surface-mounted housing	at the bottom side of the console housing 9-pole D-subminiature female connector
Test voltage	500 V; 50 Hz
Transmission rate	min. 4800 Baud, max. 38400 Baud Factory setting 19200 baud
Transmission distance	max. 15 m
RS485	
Connection for flush-mounted housing	rear panel, slot “B”, 9-pole D-subminiature female connector
Connection for surface-mounted housing	at the bottom side of the console housing 9-pole D-subminiature female connector
Test voltage	500 V; 50 Hz
Transmission rate	min. 4800 Bd, max. 38400 Bd Factory setting 19200 baud
Transmission distance	max. 1 km
Optical fibre cable (FO	
FO connector type	ST connector
Connection for flush-mounted housing	rear panel, slot “B”

Connection for surface-mounted housing	at bottom side of the console housing
Optical wavelength	λ = 820 nm
Laser class 1 according to EN 60825-1/-2	Using glass fiber 50/125 µm or Using glass fibre 62.5/125 µm
Permissible optical signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
Maximum transmission distance	max. 1.5 km
Character idle state	Selectable, factory setting“Light off”
Profibus RS485 DP	
Connection for flush-mounted housing	rear panel, slot “B”, 9-pole D-subminiature female connector
Connection for surface-mounted housing	at the bottom side of the console housing 9-pole D-subminiature female connector
Test voltage	500 V; 50 Hz
Transmission rate	bis 12 MBaud
Transmission distance	1000 m at ≤ 93.75 kBaud 500 m at ≤ 187.5 kBaud 200 m at ≤ 1.5 MBaud 100 m at ≤ 12 MBaud
Profibus FO DP	
FO connector type	ST connector single ring / double ring FMS: depending on ordered version; DP: only double ring available
Connection for flush-mounted housing	rear panel, slot “B”
Connection for surface-mounted housing	Please use the version with Profibus RS485 in the console housing and a separate electrical/ optical converter.
Transmission rate	Conversion by means of external OLM up to 1.5 MBaud ≥ 500 kBaud for normal version ≤ 57600 Baud with detached operator panel
Recommended transmission rate:	> 500 kBaud
Optical wavelength	λ = 820 nm
Laser class 1 according to EN 60825-1/-2	Using glass fiber 50/125 µm or Using glass fibre 62.5/125 µm
Permissible optical signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
Transmission distance between two modules with redundant optical ring topology and glass fibre 62.5/125 m	2 m with plastic fibre 500 kBit/s max. 1.6 km 1500 kBit/s 530 m
Character idle state (status for “No character”)	Light OFF
Max. number of modules in optical rings with 500 kB/s or 1500 kB/s	41
DNP3.0/MODBUS RS485	
Connection for flush-mounted housing	rear panel, slot “B”, 9-pole D-subminiature female connector
Connection for surface-mounted housing	in console housing
Test voltage	500 V; 50 Hz
Transmission rate	up to 19200 Baud
Transmission distance	max. 1 km

DNP3.0/MODBUS FO	
FO connector type	ST connector receiver/transmitter
Connection for flush-mounted housing	rear panel, slot “B”
Connection for surface-mounted housing	in console housing
Transmission rate	up to 19200 Baud
Optical wavelength	λ = 820 nm
Laser class 1 according to EN60825-1/-2	Using glass fibre 50/125 µm or Using glass fibre 62.5/125 µm
Permissible optical signal attenuation	max. 8 dB, with glass fibre 62.5/125 µm
Transmission distance	max. 1.5 km
Ethernet electrical (EN 100) for IEC 61850 and DIGSI	
Connection for flush-mounted housing	rear panel, slot “B” 2 x RJ45 female connector 100BaseT acc. to IEEE802.3
Connection for surface-mounted housing	in console housing
Test voltage (female connector)	500 V; 50 Hz
Transmission rate	100 MBit/s
Transmission distance	20 m
Ethernet optisch (EN100) für IEC 61850 und DIGSI	
FO connector type	ST connector receiver/transmitter
Connection for flush-mounted housing	rear panel, slot “B”
Connection for surface-mounted housing	not available
Transmission rate	λ = 1350 nm
Optical wavelength	100 MBit/s
Laser class 1 according to EN60825-1/-2	Using glass fibre 50 µm/125 µm or Using glass fibre 62,5 µm/125 µm
Permissible optical signal attenuation	max. 5 dB, with glass fibre 62,5 µm/125 µm
Transmission distance	max. 800 m

Time Synchronisation Interface

Time synchronization	DCF77/IRIG B signal (telegram format IRIG-B000)
Connection for flush-mounted housing	rear panel, slot “A”; 9-pole D-subminiature female connector
Connection for surface-mounted housing	At the double-deck terminal on the case bottom
Signal nominal voltages	Selectable 5 V, 12 V or 24 V
Nominal signal voltages GPS	24 V
Test voltage	500 V; 50 Hz

Signal levels and burdens DCF77/IRIG-B:			
	Nominal Signal Voltage		
	5 V	**12 V**	**24 V**
U_{IHigh}	6.0 V	15.8 V	31 V
U_{ILow}	1.0 V at I_{ILow} = 0.25 mA	1.4 V at I_{ILow} = 0.25 mA	1.9 V at I_{ILow} = 0.25 mA
I_{IHigh}	4.5 mA to 9.4 mA	4.5 mA to 9.3 mA	4.5 mA to 8.7 mA

Signal levels and burdens DCF77/IRIG-B:			
	Nominal Signal Voltage		
	5 V	12 V	24 V
R_I	890 Ω at U_I = 4 V	1930 Ω at U_I = 8.7 V	3780 Ω at U_I = 17 V
	640 Ω at U_I = 6 V	1700 Ω at U_I = 15.8 V	3560 Ω at U_I = 31 V

PPS-Signal GPS	
ON/OFF pulse duty factor	1/999 to 1/1
max. rise/fall time deviation of all receivers	±3 µs
For GPS receiver, antenna and power supply unit please refer to Appendix, Section “Accessories”	

4.1.5 Electrical Tests

Specifications

Standards:	IEC 60255 (product standards)) IEEE Std C37.90.0/.1/.2 UL 508 VDE 0435 For more standards see also individual functions

Insulation Test

Standards:	IEC 60255-5 and IEC 60870-2-1
High voltage test (routine test) All circuits except power supply, Binary Inputs, High Speed Outputs, Communication Interface and Time Synchronization Interfaces	2.5 kV (rms), 50 Hz
High voltage test (routine test) Auxiliary voltage, binary inputs and high speed outputs	DC 3.5 kV
High voltage test (routine test) only isolated communication and time synchronization interfaces	500 V (rms), 50 Hz
Impulse voltage test (type test) All Circuits Except Communication and Time Synchronization Interfaces, Class III	5 kV (peak), 1.2/50 µs, 0.5 Ws, 3 positive and 3 negative impulses at intervals of 5 s

EMC Tests for Interference Immunity (Type Tests)

Standards:	IEC 60255-6 and -22, (product standards) EN 61000-6-2 (generic standard) VDE 0435 part 301DIN VDE 0435-110
High frequency test IEC 60255-22-1, Class III and VDE 0435 Teil 303, Class III	2.5 kV (Peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2, Class IV and IEC 61000-4-2, Class IV	8 kV contact discharge; 15 kV air discharge, both polarities; 150 pF; R_i = 330 Ω
Irradiation with HF field, frequency sweep IEC 60255-22-3, Class III IEC 61000-4-3, Class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz 10 V/m; 800 MHz to 960 MHz; 80 % AM; 1 kHz 20 V/m; 1,4 GHz to 2,0 GHz; 80 % AM; 1 kHz

Irradiation with HF field, single frequencies IEC 60255-22-3, IEC 61000-4-3, Class III – amplitude-modulated – pulse-modulated	 10 V/m 80 MHz; 160 MHz; 450 MHz; 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbances Burst IEC 60255-22-4 and IEC 61000-4-4, Class IV	4 kV; 5 ns/50 ns; 5 kHz; burst length = 15 ms; repetition 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High energy surge voltages (SURGE), IEC 61000-4-5 installation Class 3 - Auxiliary voltage – Analog measuring inputs, binary inputs, relay outputs	Pulse: 1.2 µs/50 µs common mode: 2 kV; 12 Ω; 9 µF diff. mode: 1 kV; 2 Ω; 18 µF common mode: 2 kV; 42 Ω; 0,5 µF diff. mode: 1 kV; 42 Ω; 0,5 µF
Line conducted HF, amplitude modulated IEC 61000-4-6, Class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field IEC 60255-6 IEC 61000-4-8, Class IV	 0,5 mT; 50 Hz, 30 A/m continuous; 300 A/m for 3 s; 50 Hz
Oscillatory Surge Withstand Capability IEEE Std C37.90.1	2.5 kV (Peak); 1 MHz; τ = 15 µs; 400 Surges per s; test duration 2 s; R_i = 200 Ω
Fast Transient Surge Withstand Cap. IEEE Std C37.90.1	4 kV; 5 ns/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
Radiated Electromagnetic Interference IEEE Std C37.90.2	35 V/m; 25 MHz to 1000 MHz
Damped oscillations IEC 60694, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz R_i = 200 Ω

EMC Tests for Interference Emission (Type Test)

Standard:	EN 61000-6-3 (generic standard)
Radio noise voltage to lines, only auxiliary voltage IECCISPR 22	150 kHz to 30 MHz Limit class B[1)]
Interference field strength IEC-CISPR 22	30 MHz to 1000 MHz Limit class B[1)]
Harmonic currents on the network lead at AC 230 V IEC 61000-3-2	Class A limits are observed
Voltage fluctuations and flicker on the network lead at AC 230 V IEC 61000-3-3	Limits are observed
[1)]From production series /EE, limit class A to IEC-CISPR 11	

4.1.6 Mechanical Tests

Vibration and Shock Resistance during Stationary Operation

Standards:	IEC 60255-21 and IEC 60068

Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	Sinusoidal 10 Hz to 60 Hz: ± 0,075 mm amplitude; 60 Hz to 150 Hz: 1 g Acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal 5 g acceleration, duration 11 ms, each 3 shocks (in both directions of the 3 axes)
Seismic vibration IEC 60255-21-3, Class 1 IEC 60068-3-3	Sinusoidal 1 Hz to 8 Hz: ± 3,5 mm amplitude (horizontal axis) 1 Hz to 8 Hz: ± 1,5 mm amplitude (vertical axis) 8 Hz to 35 Hz: 1 g acceleration (horizontal axis) 8 Hz to 35 Hz: 0,5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

Vibration and Shock Resistance during Transport

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7,5 mm amplitude; 8 Hz to 150 Hz: 2 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal 15 g acceleration, duration 11 ms, each 3 shocks (in both directions of the 3 axes)
Continuous shock IEC 60255-21-2, Class 1 IEC 60068-2-29	Semi-sinusoidal 10 g acceleration, duration 16 ms, 1000 shocks each in both directions of the 3 axes

4.1.7 Climatic Stress Tests

Temperatures

Standards:	IEC 60255-6
Type tested (acc. IEC 60086-2-1 and -2, Test Bd)	-25 °C to +85 °C or -13 °F to +185 °F
Admissible temporary operating temperature (tested for 96 h)	-20 °C to +70 °C or -4 °F to +158 °F (legibility of display may be restricted from +55 °C or 131 °F)
Recommended for permanent operation (according to IEC 60255-6)	-5 °C to +55 °C or 23 °F to +131 °F If max. half of the inputs and outputs are subjected to the max. permissible values
Limit temperatures for storage	-25 °C to +55 °C or -13 °F to +131 °F
Limit temperatures during transport	-25 °C to +70 °C or -13 °F to +158 °F
Storage and transport of the device with factory packaging!	
[1] Limit temperatures for normal operation (i.e. output relays not energized)	-20 °C to +70 °C or -4 °F to +158 °F
[1] Limit temperatures under maximum load (max. cont. admissible input and output values)	–5 °C to +40 °C

[1] UL-certified according to Standard 508 (Industrial Control Equipment)

Humidity

Admissible humidity	Annual average ≤ 75 % relative humidity; On 56 days of the year up to 93% relative humidity. Condensation must be avoided in operation!
It is recommended that all devices be installed so that they are not exposed to direct sunlight nor subject to large fluctuations in temperature that may cause condensation to occur.	

4.1.8 Deployment Conditions

The protection device is designed for installation in normal relay rooms and plants, so that electromagnetic immunity is ensured if installation is done properly.

In addition the following is recommended:

- Contacts and relays operating within the same cabinet or on the same relay board with digital protection equipment, should be in principle provided with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables shall be shielded with a conductive shield earthed at both ends. For substations with lower operating voltages, no special measures are normally required.
- For substations with lower operating voltages, no special measures are normally required. When removed, many components are electrostatically endangered; when handling the EEC standards (standards for **E**lectrostatically **E**ndangered **C**omponents) must be observed. The modules, boards, and device are not endangered when the device is completely assembled.

4.1.9 Constructive versions

Housing		7XP20
Dimensions		See dimensional drawings, Section *4.17 Dimensions*

Housing	**Weight (for maximum number of components)**
in flush mounting housing	5 kg (11.02 lb)
In panel surface mounting housing	9.5 kg (20.94 lb)

Degree of protection according to IEC 60529		
For surface mounting housing equipment		IP 51
For the device in flush-mounted housing		
	Front	IP 51
	Rear	IP 50
for personell protection		IP 2x with closed protection cover
UL-certification conditions		Type 1 for front panel mounting Surrounding air temperature: tsurr: max. 70 °C, normal operation

4.2 Protection Data Interfaces and Differential Protection Topology

Differential Protection Topology

Number of devices for one protected object (=number of ends delimited by the current transformer)	2

Protection Data Interfaces

Number	1
Connection of optical fibre cable	Mounting location"D"
for flush-mounted housing	on the rear side
for surface-mounted housing	at the upper side of the console housing
Connection modules for protection data interface, depending on the ordered version	

FO5 **FO30 (IEEE C37.94)**			
Distance, maximum	1.5 km		
Connector Type	ST connector		
Optical wavelength	λ = 820 nm		
Fibre Type	Multimode 62.5 µm /125 µm		
Transmit output (peak)	min.	Type	max.
50 µm /125 µm, NA = 0.2[1)] 62.5 µm /125 µm, NA = 0,275[1)]	-19.8 dBm -16.0 dBm	-15.8 dBm -12.0 dBm	-12.8 dBm -9.0 dBm
Receiver sensitivity (peak) – Optical power for high level – Optical power for low level	 max. -40 dBm min. -24 dBm		
Optical budget	min. 4.2 dB for 50 µm /125 µm , NA = 0.2[1)] min. 8 dB for 62.5 µm /125 µm , NA = 0.275[1)]		
Laser class 1 according to EN 60825-1/-2	Using glass fibre 62.5 µm /125 µm and 50 µm /125 µm		
Reach	for multimode optical fibre, an optical signal attenuation of 3 dB/km is used for calculating light with a wavelength of λ = 820 nm		
Attenuators required	no		

[1)] Numeric opening (NA = sin φ (coupling angle)

FO6		
Distance, maximum	3.5 km	
Connector Type	ST connector	
Optical wavelength	λ = 820 nm	
Fibre Type	Multimode 62.5 µm /125 µm	
Transmit output (avg)	min.	Typ
50 µm /125 µm, NA = 0.2[1)] 62.5 µm /125 µm, NA = 0.275[1)]	-18.0 dBm -17.0 dBm	-15.0 dBm -12.0 dBm
Receiver sensitivity (avg)	min. -33 dBm_{avg}	
Optical budget	min. 15.0 dB for 50 µm /125 µm , NA = 0.2[1)] min. 16.0 B for 62.5 µm /125 µm , NA = 0.275[1)]	
Laser class 1 according to EN 60825-1/-2	Using glass fibre 62.5 µm /125 µm and 50 µm /125 µm	

Reach	for multimode optical fibre, an optical signal attenuation of 3 dB/km is used for calculating light with a wavelength of λ = 820 nm
Attenuators required	no

[1] Numeric opening (NA = sin φ (coupling angle)

FO17	
Distance, maximum	24 km
Connector Type	LC duplex connector, SFF (IEC 61754–20 Standard)
Protocol	full-duplex
Baudrate	155 Mbits/s
Receiver interfacing	AC
Optical wavelength	λ = 1300 nm
Fibre Type	Monomode 9 µm /125 µm
Transmit output coupled in Monomodefaster	min. -15.0 dBm_{avg} max. -8.0 dBm_{avg}
Receiver sensitivity	min. -28.0 dBm_{avg} max. -31.0 dBm_{avg}
Optical budget	13.0 dB
Laser Class 1 according to EN 60825–1/-2	Using glass fibre 9 µm /125 µm
Reach	for multimode optical fibre, an optical signal attenuation of 0.3 dB/km is used for calculating light with a wavelength of λ = 1300 nm
Attenuators required	non

FO18	
Distance, maximum	60 km
Connector Type	LC duplex connector, SFF (IEC 61754–20 Standard)
Protocol	full-duplex
Baudrate	155 Mbits/s
Receiver interfacing	AC
Optical wavelength	λ = 1300 nm
Fibre Type	Monomode 9 µm /125 µm
Transmit output coupled in Monomodefaster	min. -5.0 dBm_{avg} max. -0 dBm_{avg}
Receiver sensitivity	min. -34.0 dBm_{avg} max. -34.5 dBm_{avg}
Optical budget	29.0 dB
Laser Class 1 according to EN 60825–1/-2	Using glass fibre 9 µm /125 µm
Reach	for multimode optical fibre, an optical signal attenuation of 0.3 dB/km is used for calculating light with a wavelength of λ = 1300 nm
Attenuators required	for distances of less than 25 km (15.5 miles)[1]

[1] If protection data interface communication is used for distances of less than 25 km or 15.5 miles , the transmit output has to be reduced by a set of optical attenuators. Both attenuators can be installed on one side.

FO19	
Distance, maximum	100 km

Connector Type	LC duplex connector, SFF (IEC 61754–20 Standard)
Protocol	full-duplex
Baudrate	155 Mbits/s
Receiver interfacing	AC
Optical wavelength	λ = 1550 nm
Fibre Type	Monomode 9 µm /125 µm
Transmit output coupled in Monomodefaster	min. -5.0 dBm_{avg} max. -0 dBm_{avg}
Receiver sensitivity	min. -34.0 dBm_{avg} max. -34.5 dBm_{avg}
Optical budget	29.0 dB
Laser Class 1 according to EN 60825–1/-2	Using glass fibre 9 µm /125 µm
Reach	for multimode optical fibre, an optical signal attenuation of 0.2 dB/km is used for calculating light with a wavelength of λ = 1550 nm
Attenuators required	for distances of less than 50 km (31.1 miles)[1)]

[1)] If protection data interface communication is used for distances of less than 50 km or 31.1 miles, the transmit output has to be reduced by a set of optical attenuators. Both attenuators can be installed on one side.

- Character idle state	"Light off"

Protection Data Communication

Direct connection :		
Transmission rate	512 kBit/s	
Fibre type	refer to table above	
Optical wavelength		
Permissible link signal attenuation		
Transmission distance		
Connection via communication networks:		
Kommunikationsumsetzer	see Appendix *A Ordering Information and Accessories* Section Accessories	
Supported network interfaces	G703.1 with 64 kBit/s G703.T1 with 1.455 MBit/s G703.E1 with 2.048 MBit/s	
	X.21 with 64 kBit/s or 128 kBit/s or 512 kBit/s	
	Pilot wires with 128 kBit/s	
	Connection to communication converter	see table above under module FO5

Transmission rate	64 kBit/s with G703.1 1.455 MBit/s with G703-T1 2.048 MBit/s with G703-E1		
	512 kBit/s or 128 kBit/s or 64 kBit/s with X.21		
	Pilot wires with 128 kBit/s		
	Max. runtime time	0.1 ms to 30 ms	Increments 0.1 ms
Max. runtime difference	0.000 ms to 3.000 ms	Increments 0.001 ms	

4.3 Differential Protection

Pickup Values

Differential current; **I-DIFF>**	I_N = 1 A	0.10 A to 20.00 A	Increments 0.01 A
	I_N = 5 A	0.50 A to 100.00 A	
Differential current when switching onto a fault; **I-DIF>SWITCH ON**	I_N = 1 A	0.10 A to 20.00 A	Increments 0.01 A
	I_N = 5 A	0.50 A to 100.00 A	
Differential current, high set differential current **I-DIFF>>**	I_N = 1 A	0.80 A to 100.00 A or ∞ (stage disabled)	Increments 0.01 A
	I_N = 5 A	4.00 A to 500.00 A oder ∞ (stage disabled)	
Differential current, high set differential current when switching onto a fault; **I-DIF>>SWITCHON**	I_N = 1 A	0.80 A to 100.00 A oder ∞ (stage disabled)	Increments 0.01 A
	I_N = 5 A	4.00 A to 500.00 A oder ∞ (stage disabled)	
Tolerances		5 % of setting value or 1% I_N per end	

Tripping Times

The operating times depend on the communication speed. The following data require a transfer rate of 512 kbit/s.		
Pickup / trip times of the I-DIFF>> stages at 50 or 60 Hz approx.	minimum	16 ms
	typical	20 ms
Dropout time of the I-DIFF>> stages approx.	typical	35 ms to 50 ms
Pickup / trip times of the I-DIFF> stages approx.	minimum (50 Hz/ 60 Hz)	31 ms/29 ms
	typical (50 Hz/ 60 Hz)	34 ms/32 ms
Dropout time of the I-DIFF> stages approx.	typical	35 ms to 50 ms

Delay times

Delay of I-DIFF stage	**T-DELAY I-DIFF>**	0.00 s to 60.00 s or ∞ (keine Auslösung)	Increments 0.01 s
Delay of I-DIFF stage for 1-phase pickup	**T3I0 1PHAS**	0.00 s to 0.50 s or ∞ (stage disabled for 1-phase pickup)	Increments 0.01 s
Expiry tolerances		1 % of set value or 10 ms	
The set times are pure delay times.			

Self-restraint

Current transformer error at each end of the protected object		
Ratio between operating accuracy limit factor and nominal accuracy limit factor n'/n	1.00 to 10.00	Increments 0.01
Transformer error at n'/n	0.5 % to 50.0 %	Increments 0.1 %
Transformer error at $n \cdot I_N$ (class)	0.5 % to 50.0 %	Increments 0.1 %
Further restraint quantities (adaptive self-restraint)	Frequency deviations, delay time differences, harmonics, synchronous quality, jitter	

Inrush restraint

Restraint ratio 2nd harmonics to the fundamental I_{2fN}/I_{fN}		0 % to 45 %	Increments 1 %
Max. current for restraint	I_N = 1 A	1.1 A to 25.0 A	Increments 0.1 A
	I_N = 5 A	5.5 A to 125.0 A	
Crossblock Function		zu- und abschaltbar	
Max. action time for crossblock **CROSSB 2HM**		0.00 s to 60.00 s or 0 (crossblock disabled) or ∞ (active until dropout)	Increments 0.01 s

Conditioning for transformers (optional)

Vector group matching	0 to 11 (x 30°)	Increments 1
Star-point conditioning	earthed or non-earthed (for each winding)	

Emergency operation

If the communication fails	See Section “Time Overcurrent Protection”

Frequency operating range

Frequency	$0,8 \leq f/f_N \leq 1.2$ stable when starting machine

Standard precision of operational measured values

The standard precision of the operational measured values of the differential protection from ± 0.5% of the rated operational current is ensured up to a transformer error adjustment of 2:1.

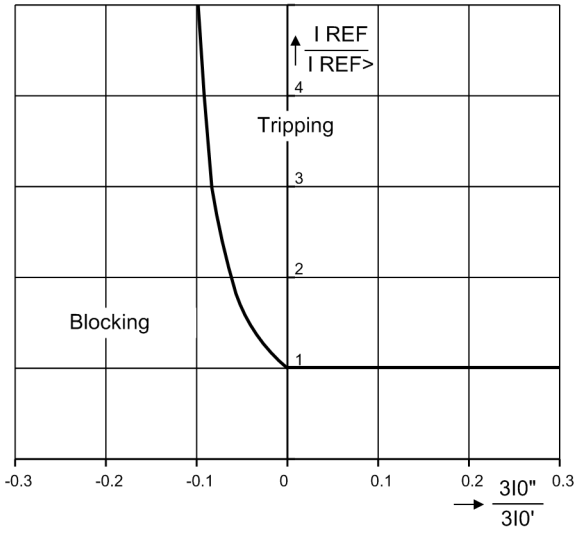
4.4 Restricted Earth Fault Protection

Setting ranges

Differential Current $I_{EDS}>$	for I_N = 1 A	0.05 A to 2.00 A	Increment 0.01 A
	for I_N = 5 A	0.25 A to 10.00 A	
Threshold angle φ_{Grenz}		100° (fixed)	
Trip characteristic		see Figure below *Figure 2-30*	
Pick-up tolerance for φ ($3\underline{I}_0$". $3\underline{I}_0$') < 90° and address 221 **I4/Iph CT** = ***1.000*** and address 4113 **SLOPE** = ***0.00***		5 % plus ± 0.01 · I_N	
Delay time T_{EDS}		0.00 s to 60.00 s oder ∞ ((no trip)	Increment 0.01 s
Expiry tolerances		1 % of set value or 10 ms	
The set times are pure delay times			

Operating Time

Pickup time at frequency		50 Hz	60 Hz
at 1.5 · set value $I_{EDS}>$ approx.	speed relays	35 ms	34 ms
	high-speed relays	30 ms	29 ms
at 2.5 · set value $I_{EDS}>$ approx.	speed relays	35 ms	34 ms
	high-speed relays	30 ms	29 ms
Dropout time, approx.		30 ms	30 ms
Dropout ratio		Approx. 0.7	



[erddiff-ausloesekennlinie-020926-rei, 1, en_GB]

Figure 4-1 Tripping characteristic of the restricted earth fault protection depending on the earth current ratio $3I_0$"/$3I_0$' (both currents in phase + or counter-phase –); $I_{EDS}>$ = setting; I_{aus} = tripping

4.5 Breaker Intertrip and Remote Tripping- Direct Local Trip

Breaker Intertrip and Remote Tripping

Intertripping of all opposite ends when single-end tripping	can be switched on/off

External direct trip

Operating time, total	Approx. 6 ms	
Trip time delay **Trip Time DELAY**	0.00 s to 30.00 s oder ∞ (ineffective)	Stufung 0.01 s
Time tolerance	1 % of setting value or 10 ms	
The set times are pure delay times		

Remote Tripping

Tripping of remote ends by a command that is coupled into a binary input. The operating times depend on the communication speed. The following data require a transmission rate of 512 kBit/s.			
Operating times, total approx.	minimum		7 ms
	typical		12 ms
Dropout times, total approx.	typical		19 ms
Trip time delay	**T-ITRIP BI**	0.00 s to 30.00 s	Increments 0.01 s
Trip time prolongation	**T-ITRIP PROL BI**	0.00 s to 30.00 s	Increments 0.01 s
Expiry tolerances		1 % of setting value or 10 ms	
The set times are pure delay times			

4.6 Transmission of Binary Information (optional)

Remote commands

Number of possible remote commands		4
The operating times depend on the communication speed. The following data require a transmission rate of 512 kBit/s. The operating times refer to the entire signal path from entry via binary inputs until output of commands via output relays.		
Operating times, total approx.	minimum	8 ms
	typical	12 ms
Dropout times, total approx.	typical	19 ms

Remote signals

Number of possible remote signals		24
The operating times depend on the communication speed. The following data require a transmission rate of 512 kBit/s. The operating times refer to the entire signal path from entry via binary inputs until output of commands via output relays.		
Operating times, total approx.	minimum	9 ms
	typical	16 ms
Dropout times, total approx.	typical	24 ms

4.7 Instantaneous High-Current Switch-onto-Fault Protection (SOTF)

Pickup

High current pickup **I>>>**	for I_N = 1 A	0.10 A to 15.00 A or ∞ (disabled)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 75.00 A or ∞ (disabled)	
High current pickup**I>>>>**	for I_N = 1 A	1.00 A to 25.00 A or ∞ (disabled)	Increments 0.01 A
	for I_N = 5 A	5.00 A to 125.00 A or ∞ (disabled)	
Dropout to pickup ratio		Approx. 90 %	
Pickup tolerance		3 % of setting value or 1 % of I_N	

Times

Shortest trip time fast relays	Approx. 10 ms

4.8 Backup Time Overcurrent Protection

Operating Modes

As emergency overcurrent protection or back-up overcurrent protection	
Backup time overcurrent protection	Effective when the differential protection system is blocked (e.g. because of a failure of the device communication)
Backup overcurrent protection	operates independent of any events

Characteristics

Definite time stages (definite)	$I_{Ph}>$, $3I_0>$, $I_{Ph}>>$, $3I_0>>$, $I_{Ph}>>>$, $3I_0>>>$, $I_{Ph}>_{dir}$, $3I_0>_{fir}$
Inverse time stages (IDMT)	I_P, $3I_{0P}$; I_{Pfir}, $3I_{0Pfir}$; one of the characteristics according to *Figure 4-2* to *Figure 4-4* can be selected

High-set Current Stages

Pickup value $I_{Ph}>>$ (phases)	for I_N = 1 A	0.10 A to 25.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 125.00 A or ∞ (ineffective)	
Pickup value $3I_0>>$ (earth)	for I_N = 1 A	0.05 A to 25.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.25 A to 125.00 A or ∞ (ineffective)	
Delay $T_{IPh}>>$ (phases)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Delay $T_{3I0}>>$ (earth)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Dropout ratio		Approx. 0.95 for $I/I_N \geq 0.5$	
Pickup times		Approx. 33 ms	
Dropout times		Approx. 30 ms	
Tolerances	Currents	3 % of setting value or 1 % nominal current	
	Times	1 % of setting value or 10 ms	
The set times are pure delay times			

Overcurrent Stages

Pickup value $I_{Ph}>$ (phases)	for I_N = 1 A	0.10 A to 25.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 125.00 A or ∞ (ineffective)	
Pickup value $3I_0>$ (earth)	for I_N = 1 A	0.05 A to 25.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.25 A to 125.00 A or ∞ (ineffective)	
Delay $T_{IPh}>$ (phases)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Delay $T_{3I0}>$ (earth)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Dropout ratio		Approx. 0.95 for $I/I_N \geq 0.5$	

Pickup times (fast relays/high-speed relays)		Approx. 25 ms/20 ms
Dropout times		Approx. 30 ms
Tolerances	Currents	3 % of setting value or 1 % nominal current
	Times	1 % of setting value or 10 ms
The set times are pure delay times		

Pickup value $I_{Phdir}>$ (phases directional)	for I_N = 1 A	0.10 A to 25.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 125.00 A or ∞ (ineffective)	
Pickup value$3I_{0dir}>$ (earth directional)	for I_N = 1 A	0.05 A to 25.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.25 A to 125.00 A or ∞ (ineffective)	
Delay $T_{IPhger}>$ (phases directional)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Delay $T_{3I0ger}>$ (earth directional)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Dropout ratio		Approx. 0.95 for $I/I_N \geq 0.5$	
Pickup times (fast relays/high-speed relays)		Approx. 33 ms	
Dropout times		Approx. 30 ms	
Tolerances	Currents	3 % of setting value or 1 % nominal current	
	Times	1 % of setting value or 10 ms	
The set times are pure delay times			

Inverse Time Stages (IEC)

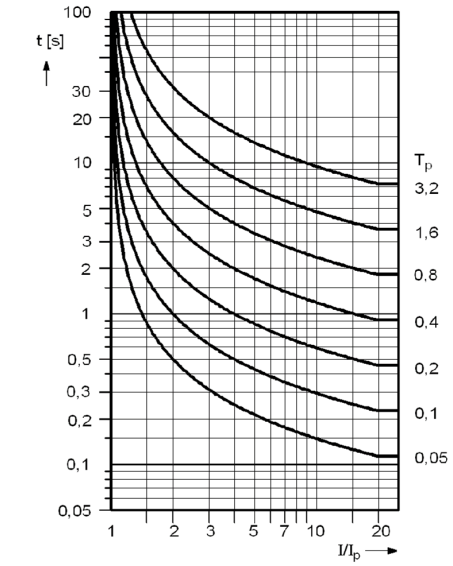
Pickup value I_{Ph} (phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (ineffective)	
Pickup value $3I_{0P}$ (earth)	for I_N = 1 A	0.05 A to 4.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.25 A to 20.00 A or ∞ (ineffective)	
Time multipliers	T_{IP} (phases)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
	T_{3I0P} (earth)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays	$T_{IP\ delayed}$ (phases)	0.00 s to 30.00 s	Increments 0.01 s
	$T_{3I0P\ delayed}$ (earth)	0.00 s to 30.00 s	Increments 0.01 s
Characteristics		see *Figure 4-2*	
Tolerances			
Pickup/dropout thresholds I_p, $3I_{0p}$		3% of set value, or 1% nominal current	
Pickup time for $2 \leq I/I_P \leq 20$ and $T_{IP} \geq 1$ s Pickup time for $2 \leq I/3I_{0P} \leq 20$ and $T_{3I0P} \geq 1$ s		5% of set value ± 15 ms 5% of set value ± 15 ms	
Defined times		1 % of setting value or 10 ms	

Pickup value **IP ger.** (directional phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (ineffective)	
Pickup value **3I0P ger.** (Earth directional)	for I_N = 1 A	0.05 A to 4.00 A or ∞ (ineffective)	Increments0.01 A
	for I_N = 5 A	0.25 A to 20.00 A oder ∞ (unwirksam)	
Time multipliers (directional stages)	**T IP ger.** (phases)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
	T 3I0P ger. (earth)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays (directional stages)	**T IPverz ger.** (phases)	0.00 s to 30.00 s	Increments 0.01 s
	T 3I0Pverz ger. (earth)	0.00 s to 30.00 s	Increments 0.01 s
Tolerances (directional stages)			
Pickup/dropout thresholds I_{Pdir}, $3I_{0Pdir}$		3% of set value, or 1% nominal current	
Pickup time for 2 ≤ I/I_{Pdir} ≤ 20 und T_{IPdir} ≥ 1 s Pickup time for 2 ≤ $I/3I_{0Pdir}$ ≤ 20 und $T_{3I0Pdir}$ ≥ 1 s		5% of set value ± 15 ms 5% of set value ± 15 ms	
Characteristics		see *Figure 4-2*	
Defined times		1 % of setting value or 10 ms	

Inverse Time Stages (ANSI)

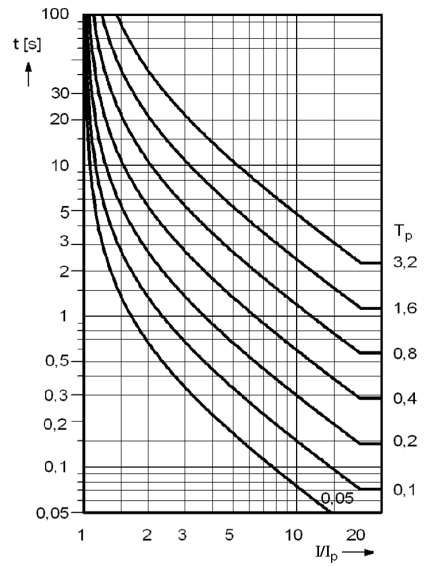
Pickup value I_{Ph} (phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (ineffective)	
Pickup value $3I_{0P}$ (earth)	for I_N = 1 A	0.05 A to 4.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.25 A to 20.00 A or ∞ (ineffective)	
Time multipliers	D_{IP} (phases)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
	D_{3I0P} (earth)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays	$T_{IP\ delayed}$ (phases)	0.00 s to 30.00 s	Increments 0.01 s
	$T_{3I0P\ delayed}$ (earth)	0.00 s to 30.00 s	Increments 0.01 s
Characteristics		see *Figure 4-3* and *Figure 4-4*	
Tolerances			
Pickup/dropout thresholds I_p, $3I_{0p}$		3% of set value, or 1% nominal current	
Pickup time for 2 ≤ I/I_P ≤ 20 and D_{IP} ≥ 1 s Pickup time for 2 ≤ $I/3I_{0P}$ ≤ 20 and D_{3I0P} ≥ 1 s		5% of set value ± 15 ms 5% of set value ± 15 ms	
Defined times		1 % of setting value or 10 ms	

Pickup value **Ip> Dir.** (directional phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (ineffective)	
Pickup value **3I0p Dir.** (Earth directional)	for I_N = 1 A	0.05 A to 4.00 A or ∞ (ineffective)	Increments 0.01 A
	for I_N = 5 A	0.25 A to 20.00 A or ∞ (ineffective)	
Time multipliers (directional stages)	**D Ip Dir.** (phases)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
	D 3I0p Dir. (earth)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays (directional stages)	**T Ip Add Dir.** (phases)	0.00 s to 30.00 s	Increments 0.01 s
	T 3I0p Add Dir. (earth)	0.00 s to 30.00 s	Increments 0.01 s
Tolerances (directional stages)			
Pickup/dropout thresholds I_{Pdir}, $3I_{0Pdir}$		3% of set value, or 1% nominal current	
Pickup time for $2 \le I/I_{Pdir} \le 20$ and $D_{IPdir} \ge 1$ s Pickup time for $2 \le I/3I_{0Pdir} \le 20$ and $D_{3I0Pdir} \ge 1$ s		5% of set value ± 15 ms 5% of set value ± 15 ms	
Characteristics		see *Figure 4-3* and *Figure 4-4*	
Defined times		1 % of setting value or 10 ms	



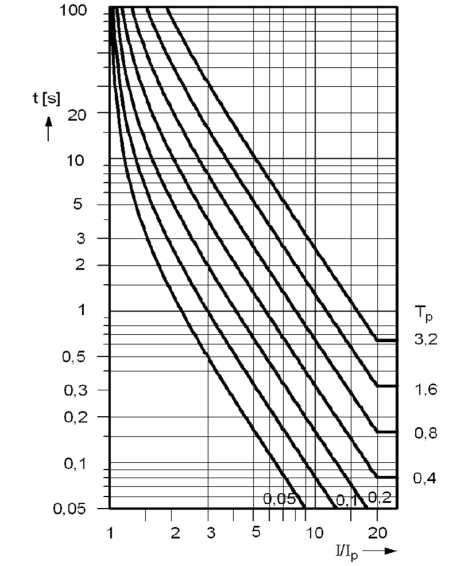
Normal Inverse:
(Type A)

$$t = \frac{0,14}{(I/I_p)^{0,02} - 1} \cdot T_p \quad [s]$$



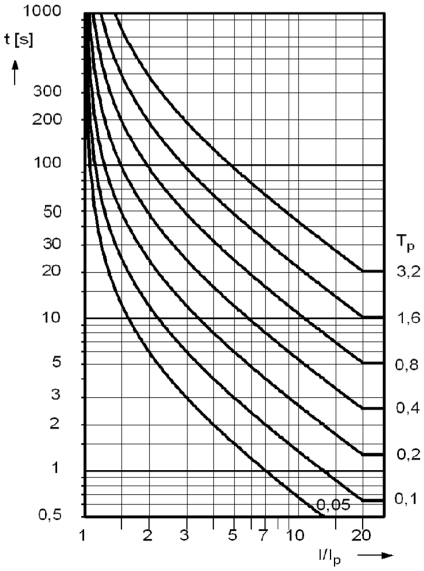
Very inverse:
(Type B)

$$t = \frac{13,5}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$



Extremely Inverse:
(Type C)

$$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p \quad [s]$$



Long-time Inverse:

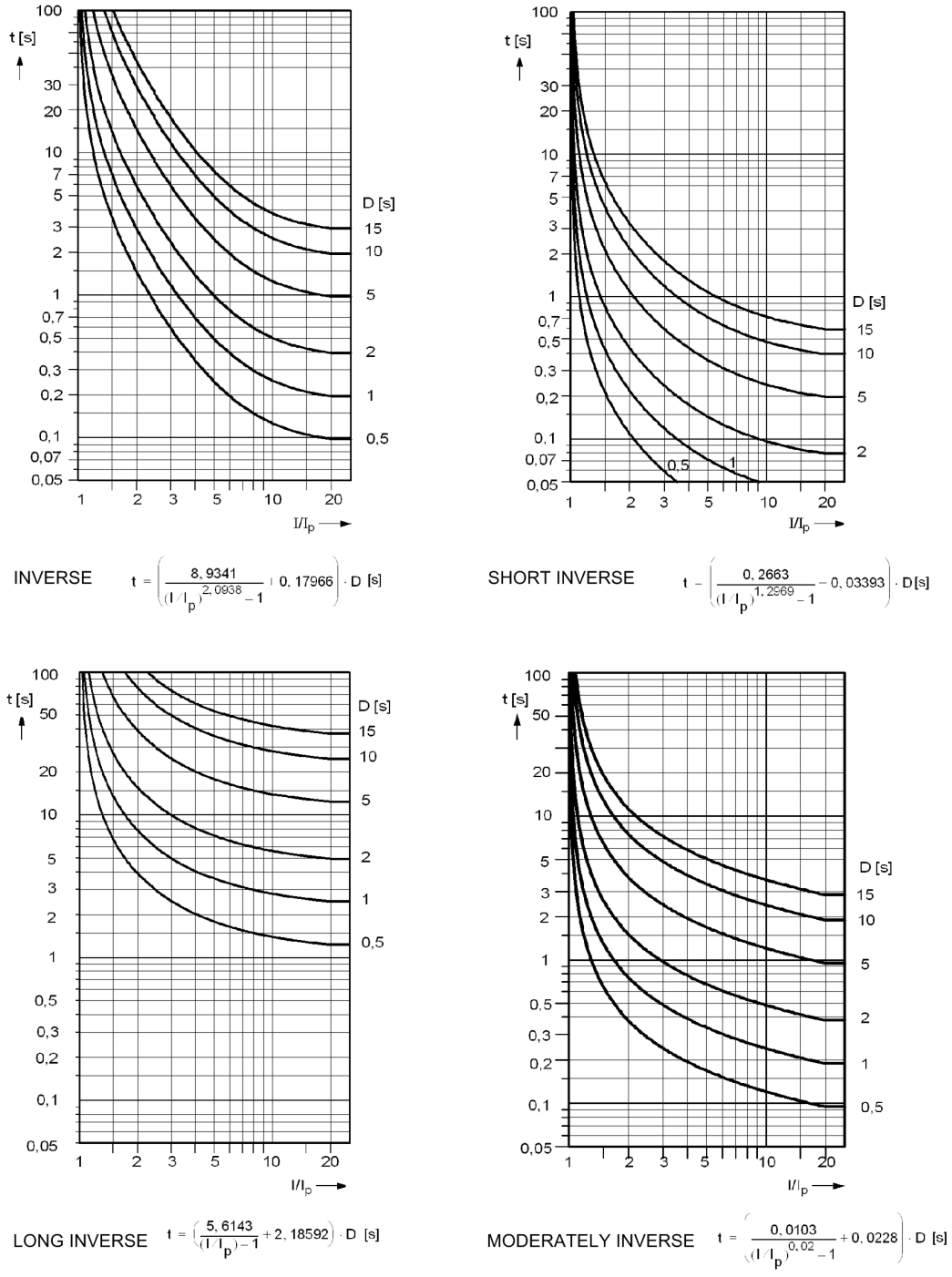
$$t = \frac{120}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$

t Trip Time
T_p Setting Value of the time multiplier
I Fault current
I_p Setting value current

Note:
For earth fault read 3I0p instead of Ip
and T3I0p instead of Tp.

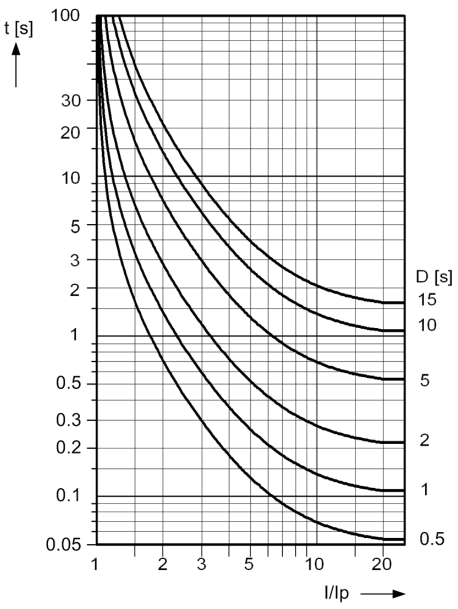
[td-kennl-amz-n-iec-oz-060802, 1, en_GB]

Figure 4-2 Trip time characteristics of inverse time overcurrent stage, acc. IEC (phases and earth)

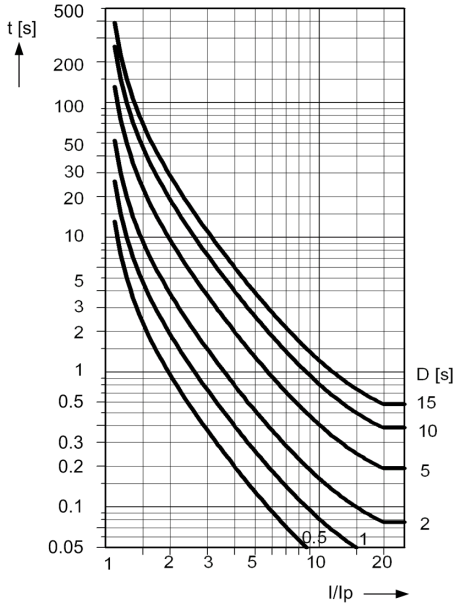


[td-kennl-amz-n-ansi-1-oz-060802, 1, en_GB]

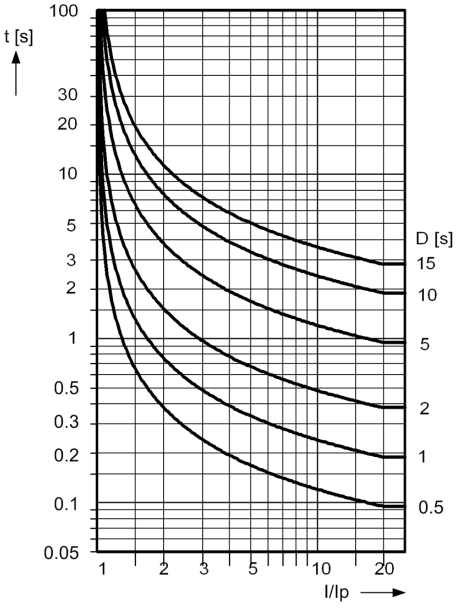
Figure 4-3 Trip time characteristics of inverse time overcurrent stage, acc. ANSI/IEEE (phases and earth)



VERY INVERSE: $t = \left(\frac{3{,}922}{(I/I_p)^2 - 1} + 0{,}0982 \right) \cdot D[s]$



EXTREMELY INVERSE: $t = \left(\frac{5{,}64}{(I/I_p)^2 - 1} + 0{,}02434 \right) \cdot D[s]$



t Trip Time
D Setting value time multiplier
I Fault current
Ip Setting value current

Note:
For earth fault read 3I0p instead of Ip and D3I0p instead of D.

DEFINITE INVERSE: $t = \left(\frac{0{,}4797}{(I/I_p)^{1{,}5625} - 1} + 0{,}21359 \right) \cdot D[s]$

[td-kennl-amz-n-ansi-2-oz-060802, 1, en_GB]

Figure 4-4 Trip time characteristics of inverse time overcurrent stage, acc. ANSI/IEEE (phases and earth)

4.9 Automatic Reclosure (optional)

Automatic Reclosures

Number of reclosures	Max. 8, first 4 with individual settings	
Type (depending on ordered version)	1-pole, 3-pole or 1-/3-pole	
Control	With pickup or trip command	
Action Times Initiation possible without pickup and action time	0.01 s to 300.00 s; ∞	Increments 0.01 s
Different dead times before reclosure can be set for all operating modes and cycles	0.01 s to 1800.00 s; ∞	Increments 0.01 s
Dead times after evolving fault recognition	0,01 s to 1800,00 s	Increments 0.01 s
Reclaim time after successful AR cycle	0,50 s to 300,00 s	Increments 0.01 s
Blocking time after dynamic Blocking	0.5 s	
Blocking time after manual closing	0.50 s to 300.00 s; 0	Increments 0.01 s
Start signal monitoring time	0,01 s to 300,00 s	Increments 0.01 s
Circuit breaker monitoring time	0,01 s to 300,00 s	Increments 0.01 s

Adaptive Dead Time/Reduced Dead Time/Dead Line Check

Adaptive dead time	With voltage measurement or with close command transmission	
Action Times Initiation possible without pickup and action time	0.01 s to 300.00 s; ∞	Increments 0.01 s
Maximum dead time	0,50 s to 3000,00 s	Increments 0.01 s
Voltage measurement dead line or bus	2 V to 70 V (Ph-E)	Increments 1 V
Voltage measurement live or bus	30 V to 90 V (Ph-E)	Increments 1 V
Voltage measuring time	0,10 s to 30,00 s	Increments 0.01 s
Time delay for close command transmission	0.00 s to 300.00 s; ∞	Increments 0.01 s

4.10 Voltage Protection (optional)

Phase-to-earth overvoltage

Over voltage U_{Ph}>>		1.0 V to 170.0 V; ∞	Increments 0,1 V
Delay $T_{UPh>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
OvervoltageU_{Ph}>		1.0 V to 170.0 V; ∞	Increments 0,1 V
Delay $T_{UPh>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio		0.30 to 0.99	Increments 0.01
Pickup time		approx. 40 ms	
Dropout time		approx. 30 ms	
Tolerances	Voltages	3 % of set value or 1 V	
	Times	1 % of setting value or 10 ms	

Phase-to-phase overvoltages

OvervoltageU_{PhPh}>>		2.0 V to 220.0 V; ∞	Increments 0,1 V
Delay $T_{UPhPh>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
OvervoltageU_{PhPh}>		2.0 V to 220.0 V; ∞	Increments 0,1 V
Delay $T_{UPhPh>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio		0.30 to 0.99	Increments 0.01
Pickup time		approx. 40 ms	
Dropout time		approx. 30 ms	
Tolerances	Voltages	3 % of set value or 1 V	
	Times	1 % of setting value or 10 ms	

Overvoltage positive sequence system U_1

OvervoltageU_1>>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{U1>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Overvoltage U_1>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{U1>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout ratio		0.30 to 0.99	Increments 0.01
Compounding		Can be switched on/off	
Pick-up times		Approx. 40 ms	
Dropout time		Approx. 30 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of setting value or 10 ms	

Overvoltage negative sequence system U_2

OvervoltageU_2>>		2.0 V to 220.0 V; ∞	Increments 0,1 V
Delay $T_{U2>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
OvervoltageU_2>		2.0 V to 220.0 V; ∞	Increments 0,1 V
Delay $T_{U2>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio		0,30 to 0,99	Increments 0.01
Pickup time		Approx. 40 ms	
Dropout time		Approx. 30 ms	

Tolerances	Voltages	3 % of set value or 1 V
	Times	1 % of setting value or 10 ms

Overvoltage zero-sequence system $3U_0$ or any single-phase voltage U_X

Overvoltage $3U_0$>>		1.0 V to 220.0 V; ∞	Increments 0,1 V
Delay $T_{3U0>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Overvoltage $3U_0$>		1.0 V to 220.0 V; ∞	Increments 0,1 V
Delay $T_{3U0>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio		0.30 to 0,.9	Increments 0.01
Pickup time			
With repeated measurement		approx. 75 m	
Without repeated measurement		approx. 35 m	
Dropout time			
With repeated measurement		approx. 75 ms (50 Hz)	
Without repeated measurement		approx. 30 ms (50 Hz)	
Tolerances	Voltages	3 % of set value or 1 V	
	Times	1 % of setting value or 10 ms	

Phase-to-earth undervoltage

Under voltage U_{Ph}<<		1.0 V to 100.0 V	Increments 0,1 V
Delay $T_{UPh<<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Under voltage U_{Ph}<		1.0 V to 100.0 V	Increments 0,1 V
Delay $T_{UPh<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio		1.01 to 1.20	Increments 0.01
Current criterion		Can be switched on/off	
Pickup time		Approx. 40 ms	
Dropout time		Approx. 30 ms	
Tolerances	Voltages	3 % of set value or 1 V	
	Times	1 % of setting value or 10 ms	

Undervoltages phase-to-phase

UndervoltageU_{PhPh}<<		1.0 V to 175.0 V	Increments 0,1 V
Delay $T_{UPhPh<<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
UndervoltageU_{PhPh}<		1.0 V to 175.0 V	Increments 0,1 V
Delay $T_{UPhPh<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio		1.01 to 1.20	Increments 0.01
Current criterion		Can be switched on/off	
Pickup time		Approx. 40 ms	
Dropout time		Approx. 30 ms	
Tolerances	Voltages	3 % of set value or 1 V	
	Times	1 % of setting value or 10 ms	

Undervoltage positive sequence system U_1

UndervoltageU_1<<	1.0 V to 100.0 V	Increments 0,1 V
Delay $T_{U1<<}$	0.00 s to 100.00 s; ∞	Increments 0.01 s

Under voltage $U_1<$		1.0 V to 100.0 V	Increments 0,1 V
Delay $T_{U1<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio		1.01 to 1.20	Increments 0.01
Current criterion		Can be switched on/off	
Pickup time		Approx. 40 ms	
Dropout time		Approx. 30 ms	
Tolerances	Voltages	3 % of set value or 1 V	
	Times	1 % of setting value or 10 ms	

4.11 Frequency Protection (optional)

Frequency Elements

Quantity	4, depending on setting effective on f< or f>

Pick-up Values

f> or f< adjustable for each element		
for f_N = 50 Hz	45.50 Hz to 54.50 Hz	Increments 0.01 Hz
for f_N = 60 Hz	55.50 Hz to 64.50 Hz	Increments 0.01 Hz

Times

Pickup times f>, f<	Approx. 85 ms	
Dropout times f>, f<	Approx. 30 ms	
Delay times T	0.00 s to 600.00 s	Increments 0.01 s
The set times are pure delay times. Note on dropout times: Dropout was enforced by current = 0 A and voltage = 0 V. Enforcing the dropout by means of a frequency change below the dropout threshold extends the dropout times.		

Dropout Frequency

Δf = | pickup value – dropout value |	Approx. 20 mHz

Operating Range

In voltage range	Approx. 0.65 · U_N up to 230 V (phase-phase)
In frequency range	25 Hz to 70 Hz

Tolerances

Frequencies f>, f< in specific range (f_N ± 10 %)	15 mHz in range U_{LL}: 50 V to 230 V
Time delays T(f<, f>)	1 % of setting value or 10 ms

4.12 Circuit Breaker Failure Protection (optional)

Circuit breaker monitoring

Current flow monitoring	for I_N = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 100.00 A	
Zero sequence current monitoring	for I_N = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 100.00 A	
Dropout to pickup ratio		Approx. 0.95	
Tolerance		5 % of set value or 1 % of nominal current	
Monitoring of circuit breaker auxiliary contact position			
for 3-pole tripping		binary input for CB auxiliary contact	
for 1-pole tripping		1 binary input for auxiliary contact per pole or 1 binary input for series connection NO contact and NC contact	
Note:: The circuit breaker failure protection can also operate without the indicated circuit breaker auxiliary contacts, but the function range is then reduced. Auxiliary contacts are necessary for the circuit breaker failure protection for tripping without or with a very low current flow (e.g. Buchholz protection) and for stub fault protection and circuit breaker pole discrepancy supervision.			

Initiation conditions

For circuit breaker failure protection	Internal or external 1-pole trip [1)] Internal or external 3-pole trip [1)] Internal or external 3-pole trip without current[1)]

[1)] Via binary inputs

Times

Pickup time	Approx. 5 ms with measured quantities present, Approx. 20 ms after switch-on of measured quantities	
Dropout time, internal (overshoot time)	≤ 15 ms at sinusoidal measured values, ≤ 25 ms maximum	
Delay times for all stages	0.00 s to 30.00 s; ∞	Increments 0.01 s
Tolerance	1 % of setting value or 10 ms	

End fault protection

With signal transmission to the opposite line end		
Time delay	0.00 s to 30.00 s; ∞	Increments 0.01 s
Tolerance	1 % of setting value or 10 ms	

Pole discrepancy supervision

Initiation criterion	Not all poles are closed or open	
Monitoring time	0.00 s to 30.00 s; ∞	Increments 0.01 s
Tolerance	1 % of setting value or 10 ms	

4.13 Thermal Overload Protection

Setting Ranges

Factor k according to IEC 60255-8		0.10 bis 4.00	Increments 0.01
Time Constant τ_{th}		1.0 min to 999.9 min	Increments 0.1 min
Thermal Alarm $\Theta_{Alarm}/\Theta_{Trip}$		50 % to 100 % of the trip overtemperature	Increments 1 %
Current Overload I_{Alarm}	for I_N = 1 A	0.10 A to 4.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A	

Calculation Method

Calculation method temperature rise	Maximum temperature rise of 3 phases Average of temperature rise of 3 phases Temperature rise from maximum current

Tripping Characteristic

Tripping characteristic for $(I / k \cdot I_N) \leq 8$

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

Meaning of abbreviations:

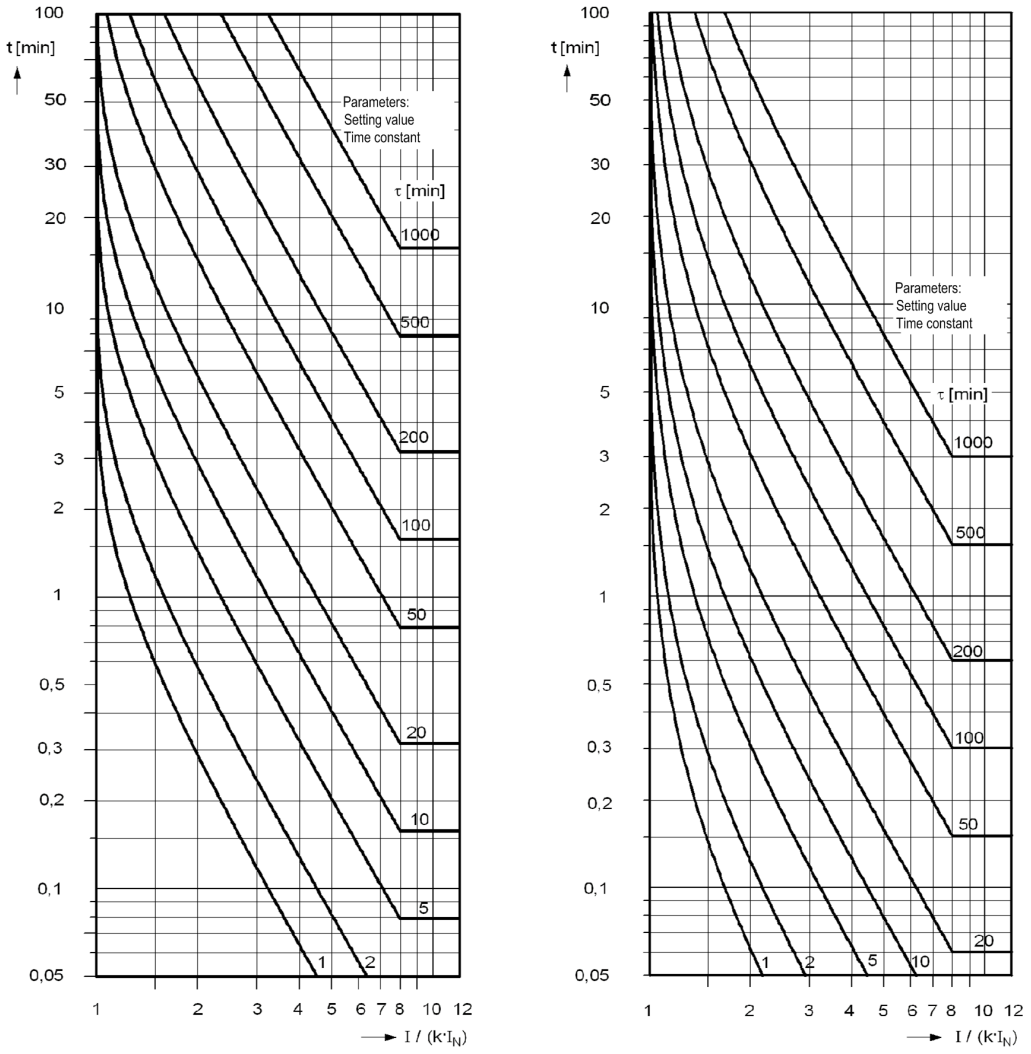
t	Tripping time
τ	Temperature rise time factor
I	Load current
I_{pre}	Previous load current
k	Setting factor according to IEC 60255-8
I_N	Rated current of protected object

Dropout to Pickup Ratio

Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0,99
I/I_{Alarm}	Approx. 0,97

Tolerances

Referring to $k \cdot I_N$	2 % or 1 % of nominal current; Class 2 % according to IEC 60255-8
Referring to tripping time	3 % or 1 s for $I/(k \cdot I_N) > 1,25$; class 3 acc. to IEC 60255-8



without pre-load:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [min]$$

with 90 % pre-load:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [min]$$

[td-kennl-therm-ueberlastschutz-oz-060802, 1, en_GB]

Figure 4-5 Trip time characteristics of the overload protection

4.14 Monitoring Functions

Measured values

Current sum		$I_F = \lvert \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} + k_I \cdot \underline{I}_E \rvert >$ SUM.I Threshold $\cdot I_N$ + SUM.FACTORI $\cdot \Sigma \lvert I \rvert$	
- SUM.ILimit	for I_N = 1 A	0.05 A to 2.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 10.00 A	Increments 0.01 A
- SUM.FACTORI		0.00 to 0.95	Increments 0.01
Voltage sum		$U_F = \lvert \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \cdot \underline{U}_{EN} \rvert > 25$ V	
Current Symmetry		$\lvert I_{min} \rvert / \lvert I_{max} \rvert <$ BAL.FACTOR.I as long as $I_{max}/I_N >$ BAL.ILIMIT/I_N	
- BAL.FACTOR.I		0.10 to 0.95	Increments 0.01
BAL.ILIMIT	for I_N = 1 A	0.10 A to 1.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 5.00 A	Increments 0.01 A
T BAL.ILIMIT		5 s to 100 s	Increments 1 s
Broken conductor		monitoring of current transformer circuits on current step change without voltage step change	
Voltage Symmetry		$\lvert U_{min} \rvert / \lvert U_{max} \rvert <$ BAL.FACTOR.U as long as $\lvert U_{max} \rvert >$ BAL.ULIMIT	
- BAL.FACTORU		0.58 to 0.95	Increments 0.01
- BAL.ULIMIT		10 V to 100 V	Increments 1 V
- T BAL.ULIMIT		5 s to 100 s	Increments 1 s
Voltage phase sequence		$\underline{U}_{L1}$ before $\underline{U}_{L2}$ before $\underline{U}_{L3}$ as long as $\lvert \underline{U}_{L1} \rvert . \lvert \underline{U}_{L2} \rvert . \lvert \underline{U}_{L3} \rvert > 40$ V/$\sqrt{3}$	
Non-symmetrical voltages (Fuse failure monitoring)		$3 \cdot U_0 >$ FFM U> or $3 \cdot U_2 >$ FFM U> and at the same time $3 \cdot I_0 <$ FFM I< and $3 \cdot I_2 <$ FFM I<	
- FFM U>		10 V to 100 V	Increments 1 V
- FFM I<	for I_N = 1 A	0.10 A to 1.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 5.00 A	Increments 0.01 A
Three-phase measuring voltage failure (Fuse failure monitoring)		all U_{Ph-E} < FFM UMEAS < and at the same time all ΔI_{Ph} < FFM I_{delta}	
- FFM UMEAS <		2 V to 100 V	Increments 1 V
- FFM I_{delta}	for I_N = 1 A	0.05 A to 1.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 5.00 A	Increments 0.01 A
- T U SUPERVISION (wait time for additional measured voltage failure monitoring)		0.00 s to 30.00 s	Increments 0.01 s
- T U mcb		0 ms to 30 ms	Increments 1 ms

Trip Circuit Supervision

Number of monitored circuits	1 to 3
Operation per circuit	With 1 binary input or with 2 binary inputs
Pickup and Dropout Time	Approx. 1 s to 2 s

Settable delay time for operation with 1 binary input	1 s to 30 s	Increments 1 s

4.15 User defined functions (CFC)

Function Blocks and their Possible Allocation to the Priority Classes

Function Module	Comments	Task Level			
		MW_BEARB	PLC1_BEARB	PLC_BEARB	SFS_BEARB
ABSVALUE	Magnitude Calculation	X	–	–	–
ADD	Addition	X	X	X	X
ALARM	Alarm clock	X	X	X	X
AND	AND - Gate	X	X	X	X
BLINK	Flash block	X	X	X	X
BOOL_TO_CO	Boolean to Control (conversion)	–	X	X	–
BOOL_TO_DI	Boolean to Double Point (conversion)	–	X	X	X
BOOL_TO_IC	Bool to Internal SI, Conversion	–	X	X	X
BUILD_DI	Create Double Point Annuncia-tion	–	X	X	X
CMD_CANCEL	Cancel command	X	X	X	X
CMD_CHAIN	Switching Sequence	–	X	X	–
CMD_INF	Command Information	–	–	–	X
COMPARE	Measured value comparison	X	X	X	X
CONNECT	Connection	–	X	X	X
COUNTER	Counter	X	X	X	X
CV_GET_STATUS	Information status of the metered value, decoder	X	X	X	X
D_FF	D- Flipflop	–	X	X	X
D_FF_MEMO	Status Memory for Restart	X	X	X	X
DI_GET_STATUS	Information status double point indication, decoder	X	X	X	X
DI_SET_STATUS	Double point indication with status, encoder	X	X	X	X
DI_TO_BOOL	Double Point to Boolean (conversion)	–	X	X	X
DINT_TO_REAL	DoubleInt after real, adapter	X	X	X	X
DIST_DECODE	Double point indication with status, decoder	X	X	X	X
DIV	Division	X	X	X	X
DM_DECODE	Decode Double Point	X	X	X	X
DYN_OR	Dynamic OR	X	X	X	X
LIVE_ZERO	Live zero monitoring, nonlinear characteristic	X	–	–	–
LONG_TIMER	Timer (max.1193h)	X	X	X	X
LOOP	Feedback Loop	X	X	X	X
LOWER_SETPOINT	Lower Limit	X	–	–	–
MUL	Multiplication	X	X	X	X
MV_GET_STATUS	Information status measured value, decoder	X	X	X	X
MV_SET_STATUS	Measured value with status, encoder	X	X	X	X
NAND	NAND - Gate	X	X	X	X

NEG	Negator	X	X	X	X
NOR	NOR - Gate	X	X	X	X
OR	OR - Gate	X	X	X	X
REAL_TO_DINT	Real after DoubleInt, adapter	X	X	X	X
REAL_TO_UINT	Real after U-Int, adapter	X	X	X	X
RISE_DETECT	Rising edge detector	X	X	X	X
RS_FF	RS- Flipflop	–	X	X	X
RS_FF_MEMO	Status memory for restart	X	X	X	X
SI_GET_STATUS	Information status single point indication, decoder	X	X	X	X
SI_SET_STATUS	Single point indication with status, encoder	X	X	X	X
SQUARE_ROOT	Root Extractor	X	X	X	X
SR_FF	SR- Flipflop	–	X	X	X
SR_FF_MEMO	Status memory for restart	X	X	X	X
ST_AND	AND gate with status	X	X	X	X
ST_NOT	Negator with status	X	X	X	X
ST_OR	OR gate with status	X	X	X	X
SUB	Substraction	X	X	X	X
TIMER	Timer	–	X	X	–
TIMER_SHORT	Simple timer	–	X	X	–
UINT_TO_REAL	U-Int to real, adapter	X	X	X	X
UPPER_SETPOINT	Upper Limit	X	–	–	–
X_OR	XOR - Gate	X	X	X	X
ZERO_POINT	Zero Supression	X	–	–	–

General limits

Description	Limit	Comments
Maximum number of all CFC charts considering all task levels	32	When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of all CFC charts considering one task level	16	Only error message (Evolving error in processing procedure)
Maximum number of all CFC inputs considering all charts	400	When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of inputs of one chart for each task level (number of unequal information items of the left border per task level)	400	Only error message; here the number of elements of the left border per task level is counted. Since the same information is indicated at the border several times, only unequal information is to be counted.
Maximum number of reset-resistant flipflops D_FF_MEMO, RS_FF_MEMO, SR_FF_MEMO	350	When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

Device-specific Limits

Description	Limit	Comments
Maximum number of concurrent changes to planned inputs per task level Chart inputs per task level	50	When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of chart outputs per task level	150	

Additional Limits

Additional limits [1] for the following 4 CFC blocks:				
Task Level				
	TIMER [2] [3]	TIMER_SHORT [2] [3]	CMD_CHAIN	D_FF_MEMO
MW_BEARB				350
PLC1_BEARB	15	30	20	
PLC_BEARB				
SFS_BEARB				

[1] When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

[2] TIMER and TIMER_SHORT share the available timer resources. The relation is TIMER = 2 · system timer and TIMER_SHORT = 1 · system timer. For the maximum used timer number the following side conditions are valid: (2 · number of TIMERs + number of TIMER_SHORTs) < 20. The LONG_TIMER is not subject to this condition.

[3] The time values for the blocks TIMER and TIMER_SHORT must not be smaller than the time resolution of the device, i.e. 5 ms, otherwise the blocks will not start with the starting impulse issued.

Maximum Number of TICKS in the Task Levels

Task Level	Limit in TICKS [1]
MW_BEARB (Measured Value Processing)	10 000
PLC1_BEARB (Slow PLC Processing)	1 900
PLC_BEARB (Fast PLC Processing)	200
SFS_BEARB (switchgear interlocking)	10 000

[1] When the sum of TICKS of all blocks exceeds the limits before-mentioned, an error message is output by CFC.

Processing Times in TICKS required by the Individual Elements

Individual Element		Number of TICKS
Block, basic requirement		5
Each input more than 3 inputs for generic modules		1
Connection to an input signal		6
Connection to an output signal		7
Additional for each chart		1
Operating sequence module	CMD_CHAIN	34
Flipflop	D_FF_MEMO	6
Loop module	LOOP	8
Decoder	DM_DECODE	8
Dynamic OR	DYN_OR	6
Addition	ADD	26
Subtraction	SUB	26
Multiplication	MUL	26

Individual Element		Number of TICKS
Division	DIV	54
Square root	SQUARE_ROOT	83
Timer	TIMER_SHORT	8
Timer	LONG_TIMER	11
Blinker lamp	BLINK	11
Counter	COUNTER	6
Adaptor	REAL_TO_DINT	10
Adaptor	REAL_TO_UINT	10
Alarm clock	ALARM	21
Comparison	COMPARE	12
Decoder	DIST_DECODE	8

4.16 Additional Functions

Measured values

Operational measured values for currents	I_{L1}; I_{L2}; I_{L3}; $3I_0$; I_1; I_2; I_Y; in A primary and secondary, and in % $I_{NOperation}$
Tolerance	0.5 % of measured value, or 0.5 % of I_N
Phase angles for currents	$\varphi(I_{L1}\text{-}I_{L2})$; $\varphi(I_{L2}\text{-}I_{L3})$; $\varphi(I_{L3}\text{-}I_{L1})$ in °
Tolerance	1° at nominal current
Operational measured values for voltages	$U_{L1\text{-}E}$, $U_{L2\text{-}E}$, $U_{L3\text{-}E}$; $3U_0$; U_0; U_1; U_2; U_{1Ko} in kV primary, in V secondary, or in % $U_{NOperation}/\sqrt{3}$
Tolerance	in kV primary, in V secondary, or in U_N
Operational measured values for voltages	U_{EN}; U_X in V secondary
Tolerance	0.5 % of measured value, or 0.5 % of U_N
Operational measured values for voltages	$U_{L1\text{-}L2}$, $U_{L2\text{-}L3}$, $U_{L3\text{-}L1}$ in kV primary, in V secondary, or in % $U_{NOperation}$
Tolerance	0.5 % of measured value, or 0.5 % of U_N
Phase angle for voltages	$\varphi(U_{L1}\text{-}U_{L2})$; $\varphi(U_{L2}\text{-}U_{L3})$; $\varphi(U_{L3}\text{-}U_{L1})$ in °
Tolerance	1 ° at nominal voltage
Phase angle for voltages and currents	$\varphi(U_{L1}\text{-}I_{L1})$; $\varphi(U_{L2}\text{-}I_{L2})$; $\varphi(U_{L3}\text{-}I_{L3})$ in °
Tolerance	1° at nominal voltage and nominal current
Operational measured values for power	S; P; Q (apparent, active, and reactive power) in MVA; MW; Mvar primary and % S_N (operational nominal power) = $\sqrt{3} \cdot U_N \cdot I_N$
Tolerance for S	1 % of S_N at I/I_N and U/U_N in range 50 % to 120 %
Toleranz for P	1 % f P_N at I/I_N and U/U_N in range 50 % to % and ABS(cos φ) in range ≥ 0,7
Tolerance for Q	1 % of Q_N at I/I_N and U/U_N in range 50 % to % and ABS(cos φ) in range ≤ 0,7
Operating measured value for power factor	cos φ
Tolerance	0.02
Counter values for energy	W_p+, W_q+; W_p-; W_q- (active and reactive energy) in kWh (MWh or GWh) or in kVARh (MVARh or GVARh)
Tolerance at nominal frequency	5 % für $I > 0{,}5\ I_N$, $U > 0{,}5\ U_N$ and $\lvert \cos\varphi \rvert \geq 0{,}707$
Operational measured values of frequency	f in Hz and % f_N
Range	10 Hz to 75 Hz
Tolerance	20 mHz in range f_N ±10 % at nominal values
Measured values of the differential protection	I_{DIFFL1}; I_{DIFFL2}; I_{DIFFL3}; I_{STABL1}; I_{STABL2}; I_{STABL3}; $I_{DIFF3I0}$ in % $I_{NOperation}$
Thermal measured values	$\Theta_{L1}/\Theta_{TRIP}$; $\Theta_{L2}/\Theta_{TRIP}$; $\Theta_{L3}/\Theta_{TRIP}$; Θ/Θ_{TRIP} related to tripping temperature rise

Remote measured values for currents	I_{L1}; I_{L2}; I_{L3} of remote end in % $I_{NBetrieb}$ $\varphi(I_{L1})$; $\varphi(I_{L2})$; $\varphi(I_{L3})$ ((remote versus local) in °
Remote measured values for voltages	U_{L1}; U_{L2}; U_{L3} of remote end in % $U_{NBetrieb}/\sqrt{3}$ $\varphi(U_{L1})$; $\varphi(U_{L2})$; $\varphi(U_{L3})$ ((remote versus local) in °

Operational Indication Buffer

Capacity	200 records

Fault Logging

Capacity	8 faults with a total of max. 600 messages and up to 100 binary signal traces (marks)

Fault Recording

Number of stored fault records	Max. 8
Storage time	Max. 5 s for each fault Approx. 15 s in total
Sampling rate at f_N = 50 Hz	1 ms
Sampling rate at f_N = 60 Hz	0,83 ms

Statistics (serial protection data interface)

Availability of transmission for applications with protection data interface	Availability in %/min and %/h
Delay time of transmission	Resolution 0.01 ms

Switching Statistics

Number of trip events caused by the device	Separately for each breaker pole (if single-pole tripping is possible)
Number of automatic reclosures initiated by the device	Separate for 1-pole and 3-pole AR; Separately for 1st AR cycle and for all further cyles
Total of interrupted currents	Pole segregated
Maximum interrupted current	Pole segregated

Real Time Clock and Buffer Battery

Resolution for operational messages	1 ms
Resolution for fault messages	1 ms
Buffer battery	Type: 3 V/1 Ah, Type CR 1/2 AA Self-discharging time approx. 10 years

Commissioning aids

Operational Measured Values Switching device test

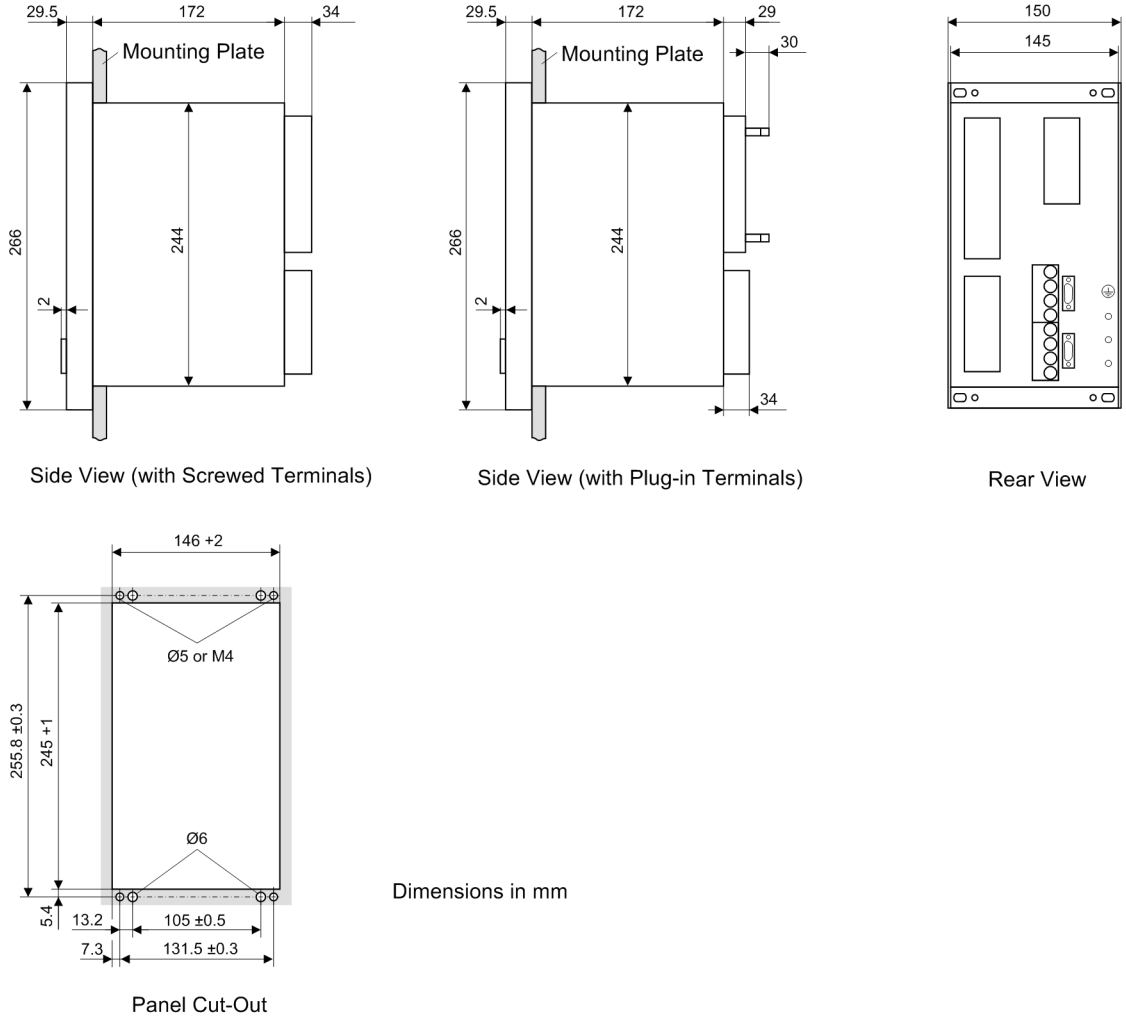
Time synchronisation/Clock

Time Synchronization	DCF 77/IRIG-B-Signal Binary Input Communication

Operating modes of the clock management		
No.	Operating mode	Explanations
1	**Intern**	Internal synchronisation via RTC or Timing Master
2	**IEC 60870-5-103**	External synchronisation via system interface (IEC 60870-5-103) or Timing Master
3	**Time signal IRIG-B**	External synchronisation via IRIG B (telegram format IRIG-B000) or Timing Master
4	**Time signal DCF 77**	External synchronization via DCF 77 or Timing Master
5	**Time signal Sync.-Box**	External synchronisation using SIMEAS Sync. box or Timing Master
6	**Pulse via binary input**	External synchronisation with pulse via binary input or Timing Master
7	**Ethernet NTP**	External synchronisation using system interface (IEC 61850)

4.17 Dimensions

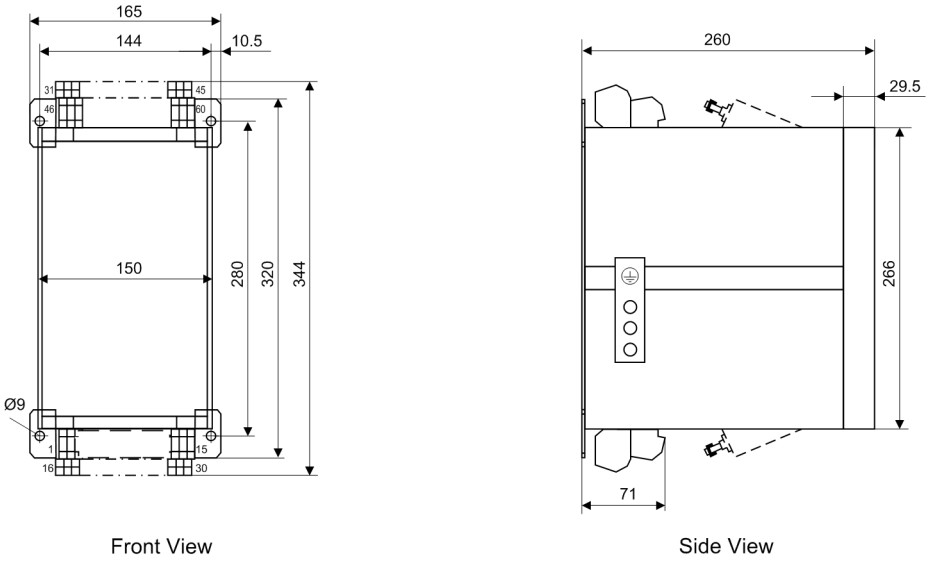
4.17.1 Housing for Panel Flush Mounting or Cubicle Installation



[massbild-schrankeinbau-gr-1-3-oz-050802, 1, en_GB]

Figure 4-6 Dimensions of a device for panel flush mounting or cubicle installation (size $^1/_3$)

4.17.2 Panel Surface Mounting



[massbild-schalttafelaufbau-gr-1-3-oz-050802, 1, en_GB]

Figure 4-7 Dimensions of a device for panel surface mounting (size $^1/_3$)

A Ordering Information and Accessories

A.1	Ordering Information	340
A.2	Accessories	343

A.1 Ordering Information

Line Differential Protection							7		8	9	10	11	12		13	14	15	16				
	7	S	D	6	1	0		—						—					+	L/M/N		

Measurement Input	Pos. 7
I_{Ph} = 1 A, I_E = 1 A	1
I_{Ph} = 5 A, I_E = 5 A	5

Auxiliary Voltage (Power Supply, Pickup Threshold of Binary Inputs)	Pos. 8
DC 24 V to 48 V, binary input threshold 19 V [2)]	2
DC 60 V to 125 V [1)], binary input threshold 19 V [2)]	4
DC 110 V to 250 V [1)], AC 115 V, binary input threshold 88 V [2)]	5
DC 220 V to 250 V[1)], AC 230 V, binary input threshold 176 V [2)]	6

[1)] With plug-in jumper one of the 2 voltage ranges can be selected

[2)] For each binary input one of 3 pickup threshold ranges can be selected with plug-in jumper

Mechanical Design: Housing, Number of Binary Inputs and Outputs BI: Binary Inputs, BO: Output Relays	Pos. 9
Flush mounting housing with screwed terminals, $^1/_3$ x 19", 7 BI, 5 BO, 1 life contact	B
Surface mounting housing with two-tier terminals, $^1/_3$ x 19", 7 BI, 5 BO, 1 life contact	F
Flush mounting housing with plug-in terminals, $^1/_3$ x 19", 7 BI, 5 BO, 1 life contact	K

Region-specific Default / Language Settings and Function Versions	Pos. 10
Region DE, 50 Hz, IEC, German language (language can be changed)	A
Region Welt, 50 Hz/60 Hz, IEC/ANSI, language: English (language can be changed)	B
Region USA, 60 Hz/50 Hz, ANSI, American English (language can be changed)	C
Region Welt, 50 Hz/60 Hz, IEC/ANSI, French (language can be changed)	D
Region Welt, 50 Hz/60 Hz, IEC/ANSI, Spanish (language can be changed)	E

System Interfaces (Port B)	Pos. 11
No system interface	0
IEC 60870-5-103 protocol, electrical RS232	1
IEC 60870-5-103 protocol, electrical RS485	2
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3
For more interface options see Additional Specification **L**	9

Additional Specification L for Further System Interfaces (Port B) ((only if Pos. 11 = 9)	Pos. 21	Pos. 22
Profibus DP Slave, electrical RS485	0	A
Profibus DP Slave, optical, 820 nm, double ring, ST connector [1)]	0	B
MODBUS, electrical RS 485	0	D
MODBUS, 820 nm, optical, ST connector [1)]	0	E
DNP 3.0, electrical RS485	0	G
DNP 3.0, optical, 820 nm, double ring, ST connector [1)]	0	H
IEC 61850, 100 Mbit Ethernet, double electrical, RJ45 connector	0	R
IEC 61850, 100 MBit Ethernet, optical, double, Duplex LC connector[2)]	0	S

[1] Not possible with surface mounting housing (position 9 = F). For the surface mounting version, please order a device with the appropriate electrical RS485 interface and accessories as stated in the Appendix under Accessories, "External converters".

[2] Not possible with surface mounting housing (position 9 = F).

Function Interface (Port C and D)	**Pos. 12**
see Additional Specification **M**	9

Additional Specification M for DIGSI/modem interface and protection data interface 1 (device rear, port C and D)	**Pos. 23**	**Pos. 24**
Port C: DIGSI/Modem/Browser, electrical RS232	1	
Port C: DIGSI/Modem/Browser, electrical RS485	2	
Port D: FO5 optical, 820 nm, 2 ST connectors, length of optical fibre up to 1.5 km, for FO direct connection or communication networks using multimode fibre		A
Port D: FO6 optical, 820 nm, 2 ST connectors, length of optical fibre up to 3.5 km, for FO direct connection using multimode fibre		B
Port D: FO17 optical, 1300 nm, 2 LC duplex connectors, length of optical fibre up to 24 km, for FO direct connection using monomode fibre [1]		G
Port D: FO18 optical, 1300 nm, 2 LC duplex connectors, length of optical fibre up to 60 km, for FO direct connection using monomode fibre [1]		H
Port D: FO19 optical, 1550 nm, 2 LC duplex connectors, length of optical fibre up to 100 km, for FO direct connection using monomode fibre [1]		J
Port D: FO30 optical, 820 nm, 2 ST connectors, length of optical fibre up to 1.5 km, for FO direct connection or communication networks with IEEE C37.94 via multimode fibre [2]		S

[1] For surface-mounting housing (MLFB position 9 = F), delivery with external repeater

[2] This interface is **only** available in the flush-mounting housing (MLFB position 9 # F).

Functions 1	**Pos. 13**
3-pole tripping, without automatic reclosure	0
3-pole tripping, with automatic reclosure	1
1-/3-pole tripping without automatic reclosure	2
1-/3-pole tripping with automatic reclosure	3

Functions 2	**Pos. 14**
with backup time delay overcurrent protection / emergency overcurrent protection	B
with backup time delay overcurrent protection / emergency overcurrent protection with breaker failure protection	C
with directional backup time delay overcurrent protection / emergency overcurrent protection	R
with directional backup time delay overcurrent protection / emergency overcurrent protection with breaker failure protection	S

Functions 3				**15**
4 remote commands/ 24 remote signals	Transformer inside protection zone	Voltage/ frequency protection	Restricted earth fault protection	
without	without	without	without	A
without	without	with	without	B
without	with	without	without	E
without	with	with	without	F
with	without	without	without	J
with	without	with	without	K

Functions 3				15
with	with	without	without	N
with	with	with	without	P
with	with	without	with	S
with	with	with	with	T

Funktionen 4	16
External GPS synchronization of the differential protection	
without	0
with	1

A.2 Accessories

Communication Converter

Converter for the serial connection of the line protection system 7SD610 to synchronous communication interfaces X.21 G703.1 (64 kbit/s), G703–T1 (1.1455 Mbit/s), G703–E1 (2.048 Mbit/s) or symmetrical communication cables.

Name	Order number
Optical-electrical communication converter CC-X/G with synchronous interface (X.21 / G703.1)	7XV5662-0AA00
Optical-electrical communication converter CC-CU with synchronous interface	7XV5662-0AC00
Optical-electrical communication converter CC-2M with synchronous interface (G703-E1, G703-T1)	7XV5662-0AD00

Wide-area fibre optical repeater

Wide-area fibre optical repeater for long-distance transmission of serial signals (up to 170 km / 105.5 miles)

Name	Order Number
Wide-area fibre optical repeater (24 km / 15 miles)	7XV5461-0BG00
Wide-area fibre optical repeater (60 km / 37.5 miles)[1)]	7XV5461-0BH00
Wide-area fibre optical repeater (100 km / 62 miles)[1)]	7XV5461-0BJ00
Wide-area fibre optical repeater (170 km / 105.5 miles)[1)]	7XV5461-0BM00
Bidirectional fibre optical repeater (40 km / 25 miles) The communication is performed via fibre-optic cables.)[2)]	7XV5461-0BK00
Bidirectional fibre optical repeater (40 km / 25 miles) The communication is performed via fibre-optic cables.)[2)]	7XV5461-0BL0

[1)] If wide-area fibre optical repeaters are used over distances that are below 25 km (7XV5461–0BH00) or below 50 km (7XV5461–0BJ00) or below 100 km (7XV5461–0BM00), you have to reduce the transmitting power using a set of optical attenuators (order number 7XV5107–0AA00). The two attenuators must be installed on one side

[2)] A device with the order variant 7XV5461–0BK00 can only cooperate with a device of the order variant 7XV5461–0BL00.

Optical attenuators/fibre-optic cables

Name	Order number
1 set of optical attenuators (2 pcs)	7XV5107-0AA00
Fibre-optic cables[1)]	6XV8100

[1)] Fibre-optic cables with different connectors, in different lengths and designs. More information will be available from your local Siemens sales representative.

Isolating Transformers

Isolating transformers are needed on copper lines if the longitudinal voltage induced in the pilot wires can result in more than 60 % of the test voltage at the communication converter (i.e. 3 kV for CC-CU). They are connected between the communication converter and the communication line.

Name	Order Number
Isolation transformer, test voltage 20 kV	7XR9516

GPS

Name	Order Number
GPS receiver with antenna, cable and power supply	7XV5664-1AA00
Time synchronization converter	7XV5654-0BA00
Bus cable for 7SD52 and 7SD61, for GPS sync.	7XV5105-0AAxx

External Converters

Optical interfaces for Profibus and DNP 3.0 are not possible with Aufbau housings. Please order in this case a device with the appropriate electrical RS485 interface, and the additional OLM converters listed below . **Note**: The OLM converter 6GK1502-3CB10 requires an operating voltage of DC 24 V. If the operating voltage is > DC 24 V the additional power supply 7XV5810-0BA00 is required.

Interface used	Order device with additional module/OLM converter
Profibus DP double ring	Profibus DP RS485/ 6GK1502-3CB01
DNP 3.0 820 nm	DNP 3.0 RS485/ 7XV5650-0BA00

Exchangeable Interface Modules

Name	Order Number
RS232	C53207-A351-D641-1
RS485	C53207-A351-D642-1
LWL 820 nm	C53207-A351-D643-1
Profibus DP RS485	C53207-A351-D611-1
Profibus DP double ring	C53207-A351-D613-1
Modbus RS485	C53207-A351-D621-1
Modbus 820 nm	C53207-A351-D623-1
DNP 3.0 RS485	C53207-A351-D631-1
DNP 3.0 820 nm	C53207-A351-D633-1
FO5 with ST connector; 820 nm; multimode optical fibre - maximum length: 1.5 km (0.94 miles)[1)]	C53207-A351-D651-1
FO5 with ST connector; 820 nm; multimode optical fibre - maximum length: 1.5 km (0.94 miles); for surface mounting housing[1)]	C53207-A406-D49-1
FO6 with ST-connector; 820 nm; multimode optical fibre - maximum length: 3.5 km (2.2 miles)	C53207-A351-D652-1
FO6 with ST connector; 820 nm; multimode optical fibre - maximum length: 3.5 km; for surface mounting housing	C53207-A406-D50-1
FO17 with LC duplex connector; 1300 nm; monomode optical fibre - maximum length: 24 km (15 miles)	C53207-A351-D655-1
FO18 with LC duplex connector; 1300 nm; monomode optical fibre - maximum length: 60 km (37.5 miles)	C53207-A351-D656-1
FO19 with LC duplex connector; 1550 nm; monomode optical fibre - maximum length: 100 km (62.5 miles)	C53207-A351-D657-1
FO30 with ST connector; 820 nm; multimode optical fibre - maximum length: 1.5 km (0.94 miles) (IEEE C37.94 interface)[2)]	C53207-A351-D658-1
Ethernet electrical (EN 100)	C53207-A351-D675-2
Ethernet optical (EN 100)	C53207-A351-D678-1

[1)] also used for connection to the optical-electrical communication converter

[2)] Module FO30 can **only** be used in a flush mounting housing

Terminal Block Covering Caps

Terminal Block Covering Cap for Block Type	Order No.
18 terminal voltage, 12 terminal current block	C73334-A1-C31-1
12 terminal voltage, 8 terminal current block	C73334-A1-C32-1

Short-Circuit Links

Short-circuit Links as Jumper Kit	Order Number
3 pcs for current terminals + 6 pcs for voltage terminals	C73334-A1-C40-1

Plug-in Connector

Plug-in Connector	Order No.
2-pin	C73334-A1-C35-1
3-pin	C73334-A1-C36-1

Mounting Brackets for 19" Racks

Name	Order No.
2 mounting brackets	C73165-A63-D200-1

Buffer battery

Lithium battery 3 V/1 Ah, type CR 1/2 AA	Order No.
VARTA	6127 101 301
Panasonic	BR-1/2AA

Interface Cable

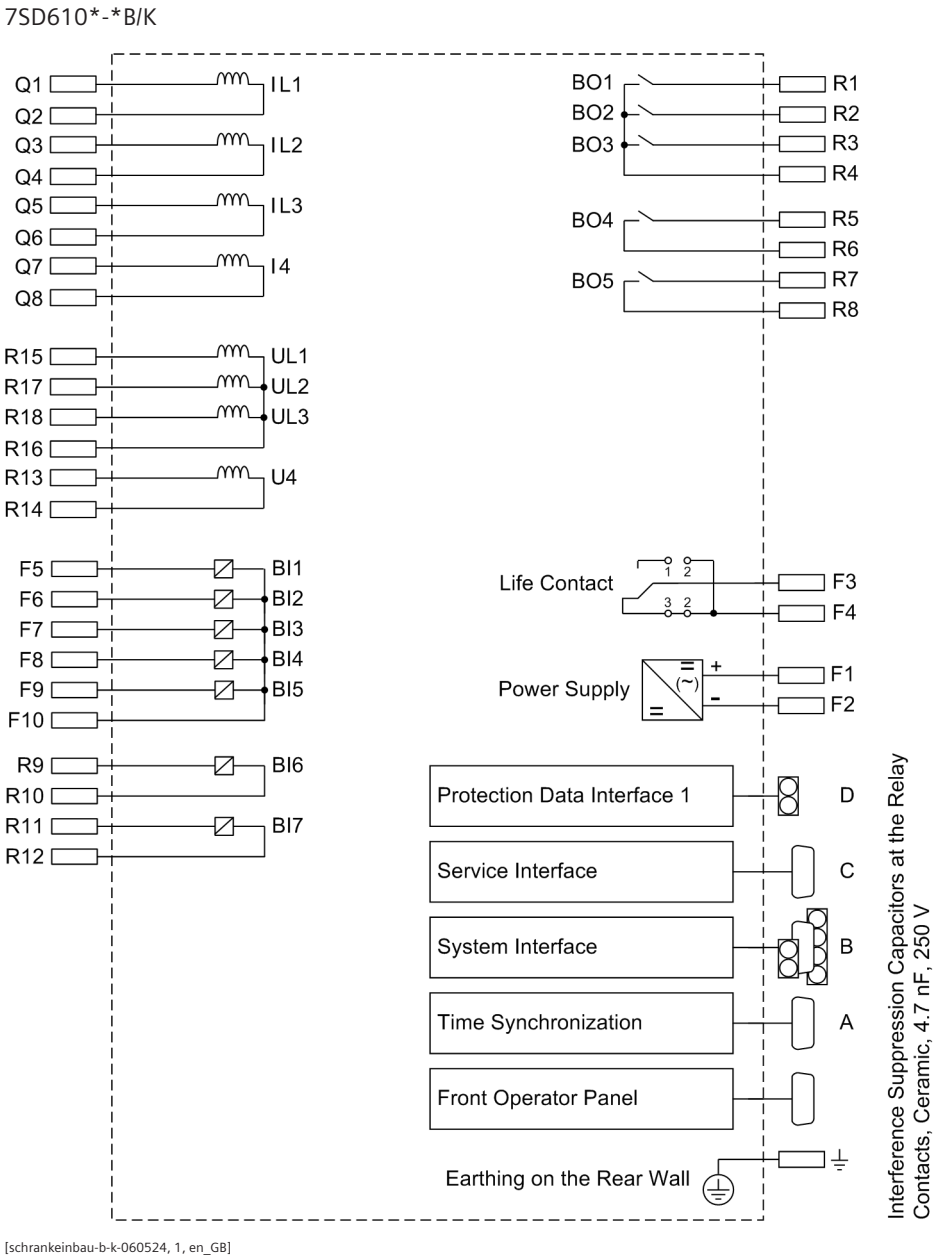
An interface cable and the DIGSI operating software are required for the communication between the SIPROTEC 4 device and a PC or laptop: The PC or laptop must run MS-WINDOWS 95, MS-WINDOWS 98, MS-WINDOWS NT 4, MS-WINDOWS 2000, MS-WINDOWS ME, MS-WINDOWS XP PRO or MS-WINDOWS VISTA

Name	Order No.
Interface cable between PC and SIPROTEC, Cable with 9-pin male/female connectors	7XV5100-4

B Terminal Assignments

B.1	Housing for Panel Flush and Cubicle Mounting	348
B.2	Housing for panel surface mounting	349

B.1 Housing for Panel Flush and Cubicle Mounting

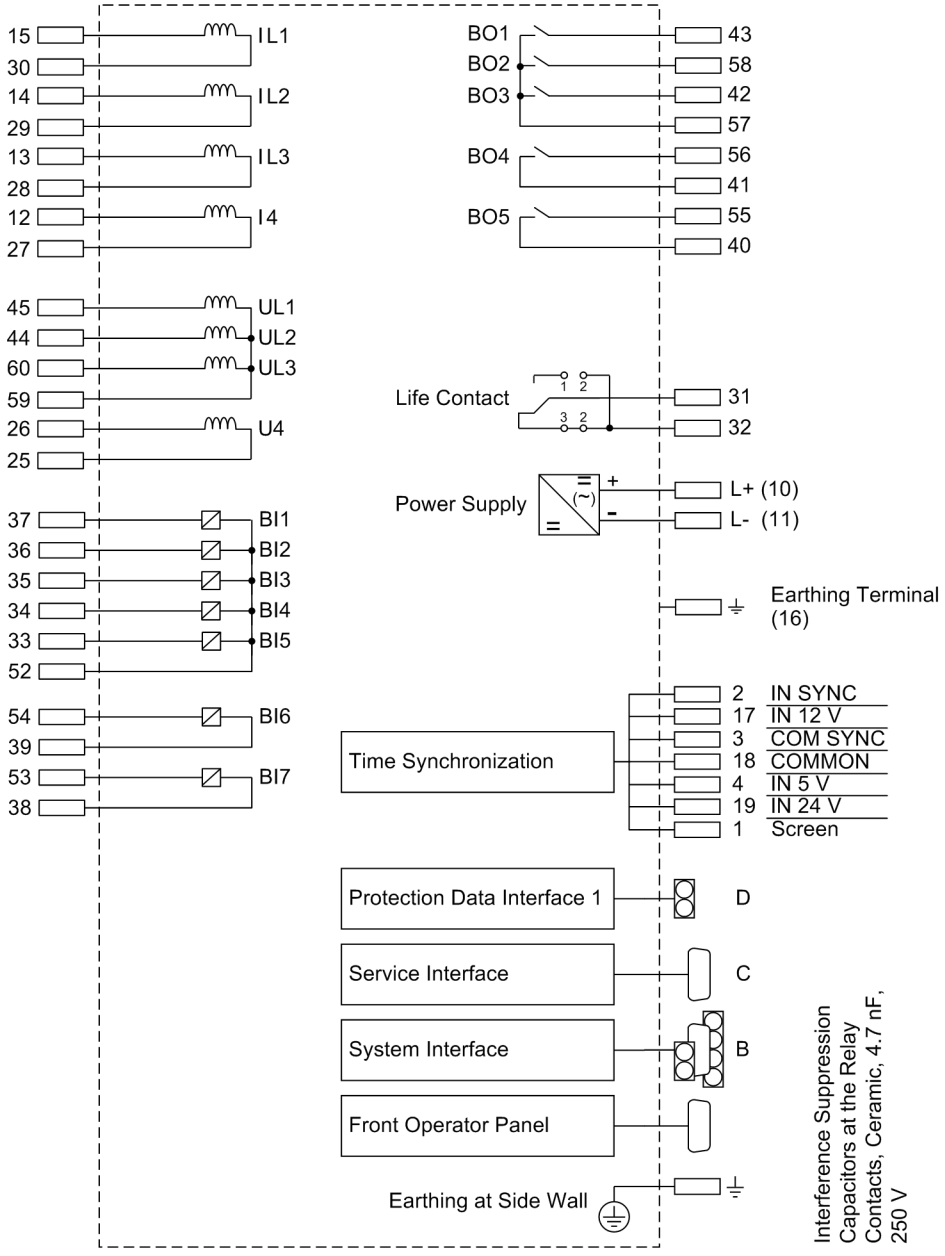


[schrankeinbau-b-k-060524, 1, en_GB]

Figure B-1 General diagram for 7SD610*-*B/K (panel flush mounted or cubicle mounted)

B.2 Housing for panel surface mounting

7SD610*-*F



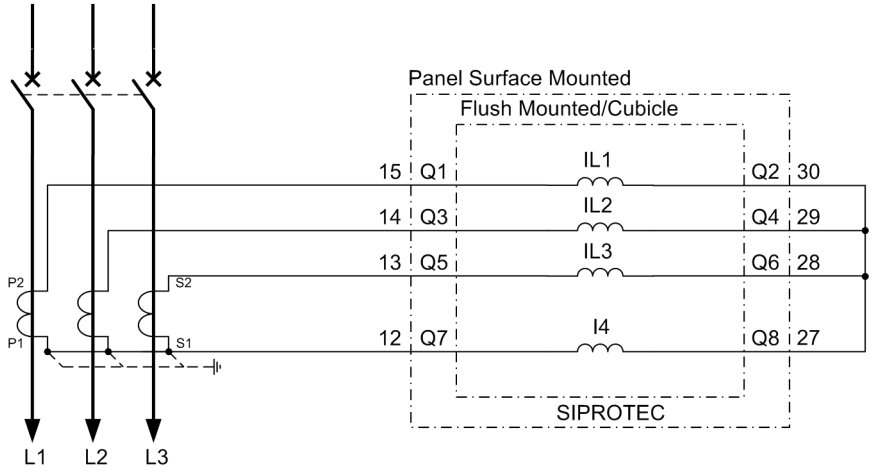
[schalttafelaufbau-f-060524, 1, en_GB]

Figure B-2 Connection diagram for 7SD610*-*F (panel surface mounted)

C Connection Examples

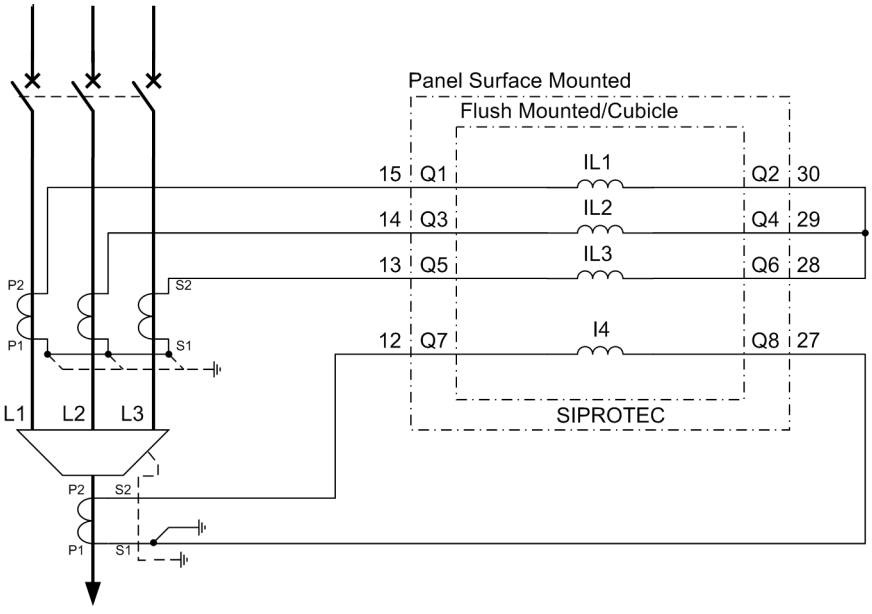
C.1	Current Transformer Connection Examples	352
C.2	Voltage Transformer Examples	354

C.1 Current Transformer Connection Examples



[stromanschl-3stromw-sternpkt-060524, 1, en_GB]

Figure C-1 Current connections to three current transformers with a starpoint connection for earth current (residual 3I0 neutral current), normal circuit layout

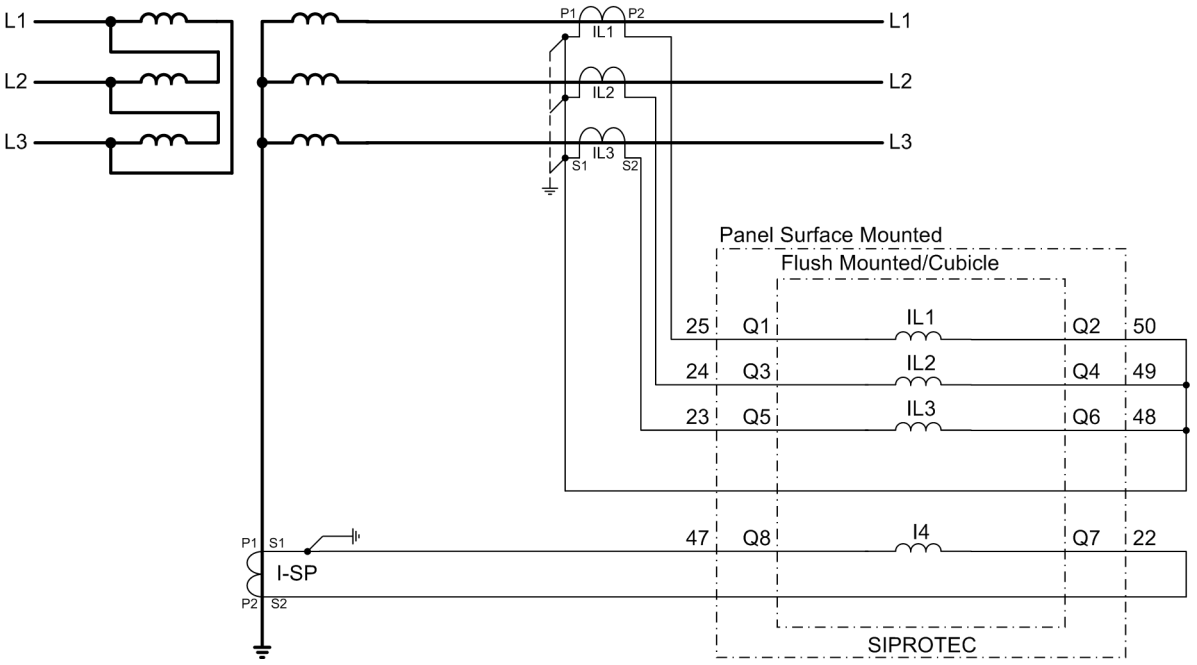


[stromanschl-3stromw-gesond-erdstrom-060524, 1, en_GB]

Figure C-2 Current connections to three current transformers with separate earth current transformer (summation current transformer or toroidal current transformer)

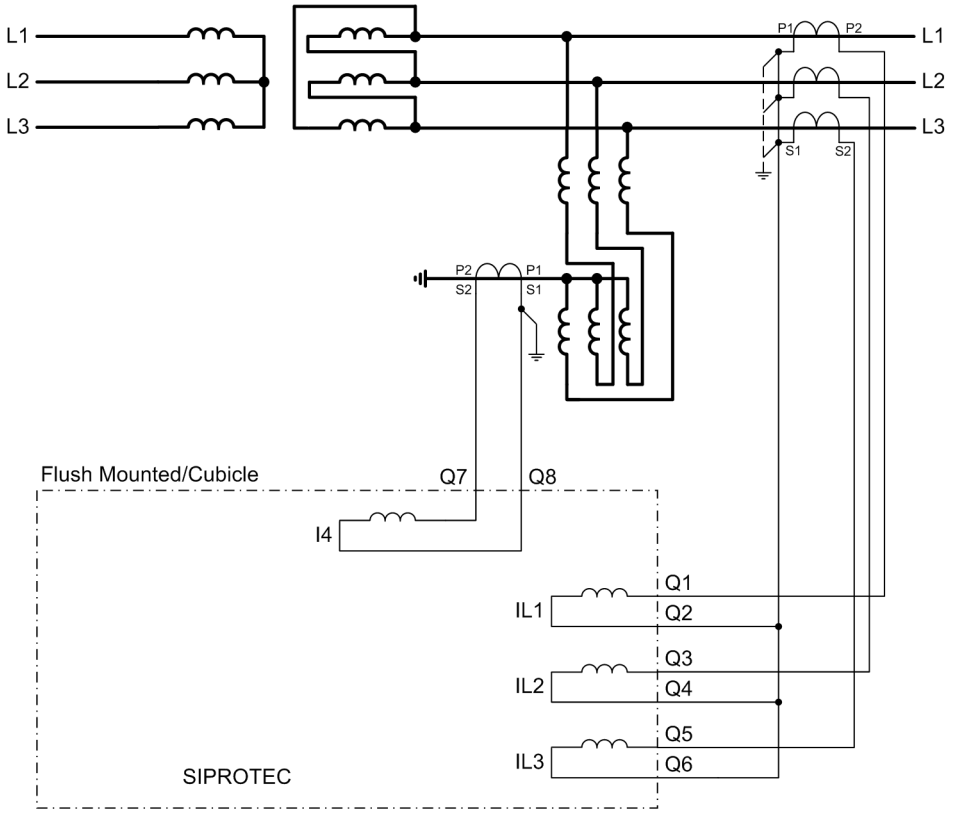
Important! The cable shield must be earthed on the cable side.

In case of an earthing of the current transformers on the busbar side, the current polarity of the device is changed via the address 0201. This also reverses the polarity of the current input I4.



[ef-diff-schutz-geerd-sternwick-20061212, 1, en_GB]

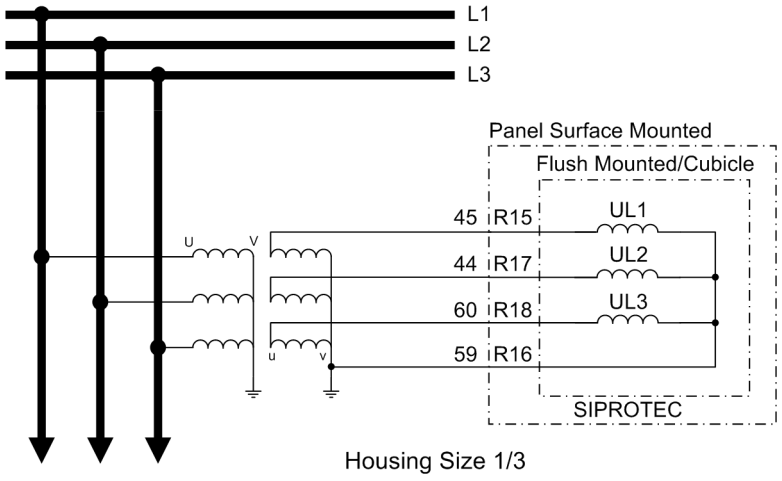
Figure C-3 Restricted earth fault protection on an earthed transformer winding



[dreiphtrafo-sternpktbildnerstromw-20061212, 1, en_GB]

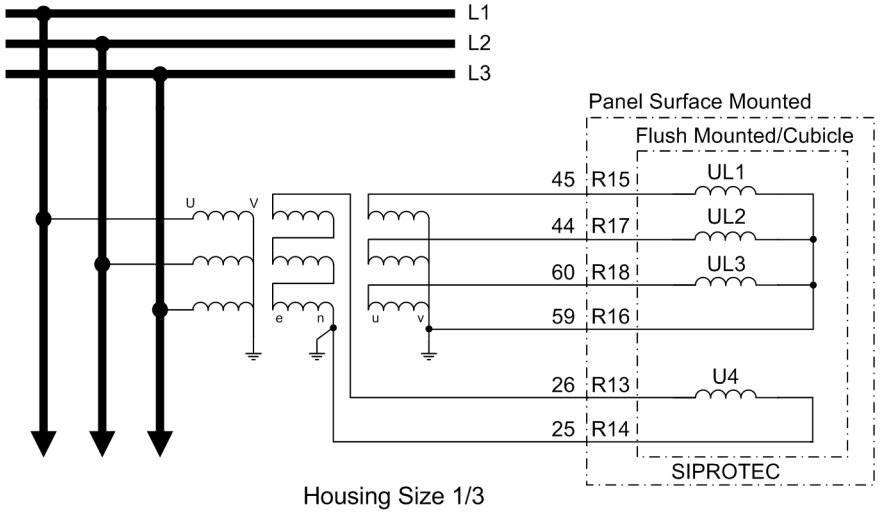
Figure C-4 Restricted earth fault protection on a non-earthed transformer winding with neutral reactor

C.2 Voltage Transformer Examples



[spgw-anschl-3stern-normal-310506, 1, en_GB]

Figure C-5 Voltage connections to three wye-connected voltage transformers (normal circuit layout)



[spgw-ansch-3stern-mit-e-n-wickl-060531, 1, en_GB]

Figure C-6 Voltage connections to three wye-connected voltage transformers with additional broken delta windings (da–dn–winding)

D Default Settings and Protocol-dependent Functions

D.1	LEDs	356
D.2	Binary Input	357
D.3	Binary Output	358
D.4	Function Keys	359
D.5	Default Display	360
D.6	Pre-defined CFC Charts	361
D.7	Protocol-dependent Functions	362

D.1 LEDs

Table D-1 LED Indication Presettings

LEDs	Allocated Function	Function No.	Description
LED1	Relay TRIP	511	Relay GENERAL TRIP command
LED2	Relay PICKUP L1	503	Relay PICKUP Phase L1
LED3	Relay PICKUP L2	504	Relay PICKUP Phase L2
LED4	Relay PICKUP L3	505	Relay PICKUP Phase L3
LED5	Par. different	3235	Differences between common parameters
LED6	PI1 Data fault	3229	Prot Int 1: Reception of faulty data
LED7	DT inconsistent	3233	Device table has inconsistent numbers
	DT unequal	3234	Device tables are unequal
	Equal IDs	3487	Equal IDs in constellation

D.2 Binary Input

Table D-2 Binary input presettings for all devices and ordering variants

Binary Input	Allocated Function	Function No.	Description
BI1	>Intertrip 3pol	3504	I.Trip: >Intertrip 3 pole signal input
BI2	>Reset LED	5	>Reset LED
BI3	> Diff block	3525	>Differential protection blocking signal
BI4	>DTT Trip L123	4417	>Direct Transfer Trip INPUT 3ph L123
BI5	>BLOCK O/C I>>	7104	>BLOCK Backup OverCurrent I>>
	>BLOCK O/C I>	7105	>BLOCK Backup OverCurrent I>
	>BLOCK O/C Ip	7106	>BLOCK Backup OverCurrent Ip
	>BLOCK O/C Ie>>	7107	>BLOCK Backup OverCurrent Ie>>
	>BLOCK O/C Ie>	7108	>BLOCK Backup OverCurrent Ie>
	>BLOCK O/C Iep	7109	>BLOCK Backup OverCurrent Iep
	>BLOCK I-STUB	7130	>BLOCK I-STUB
	>BLOCK O/CIe>>>	7132	>BLOCK Backup OverCurrent Ie>>>
	>BLOCK Dir. I>	7111	>BLOCK direct. Backup OverCurrent I>
	>BLOCK Dir. Ip	7112	>BLOCK direct. Backup OverCurrent Ip
BI7	>CB1 Ready	371	>CB1 READY (for AR,CB-Test)

D.3 Binary Output

Table D-3 Output relay presettings for all devices and ordering variants

Binary Output	Allocated Function	Function No.	Description
BO1	Relay PICKUP L1	503	Relay PICKUP Phase L1
BO2	Relay PICKUP L2	504	Relay PICKUP Phase L2
BO3	Relay PICKUP L3	505	Relay PICKUP Phase L3
BO4	Relay TRIP	511	Relay GENERAL TRIP command
BO5	Relay TRIP	511	Relay GENERAL TRIP command

D.4 Function Keys

Table D-4 Applies to all devices and ordered variants

Function Keys	Allocated Function
F1	Display of Operational Annunciations
F2	Operating Measured Values, Primary
F3	An overview of the last eight network faults
F4	Not pre-assigned

D.5 Default Display

4-line Display

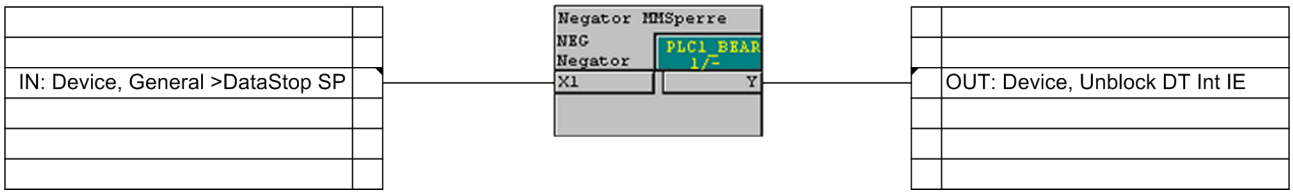
Table D-5 This selection is available as start page which may be configured

Page 1	1 ▮ 1000A 12 ▮ 400KV 2 ▮ 999A 23 ▮ 400KV 3 ▮ 1000A 31 ▮ 400KV E ▮ 0A 0U ▮ 0KV
Page 2	% ▮ IL ULE ULL L1 ▮ 78.4 99.6 99.5 L2 ▮ 78.1 99.4 99.3 L3 ▮ 78.9 99.8 99.7
Page 3	S: ▮ 0.0MVA U: 0kV P: ▮ 0.0MW I: 0A Q: ▮ 0.0MVAR f: ▮ --- cosφ: ---
Page 4	Diff Stab L1 0.0% 31.6% L2 0.0% 31.6% L3 0.0% 31.6%
Page 5	L1 ▮ 78.4A L2 ▮ 78.1A L3 ▮ 78.9A E ▮ 0.0A

D.6 Pre-defined CFC Charts

Device and System Logic

A negator block of the slow logic (PLC1-BEARB) is created from the binary input “>DataStop” into the internal single point indication “Unblock DT”.



[cfc-topo-geraet-abmeld-040216-wlk, 1, en_GB]

Figure D-1 Logical Link between Input and Output

D.7 Protocol-dependent Functions

Protocol → / Function ↓	IEC 60870-5-103	IEC 61850 Ethernet (EN100)	Profibus DP	DNP 3.0 Modbus
Operational measured values	Yes	Yes	Yes	Yes
Metered values	Yes	Yes	Yes	Yes
Fault recording	Yes	Yes	No, only via additional service interface	No, only via additional service interface
Remote relay setting	No, only via additional service interface	Yes with DIGSI via Ethernet	No, only via additional service interface	No, only via additional service interface
User-defined annunciations and switching objects	Yes	Yes	Pre-defined "User-defined messages" in CFC	Pre-defined "User-defined messages" in CFC
Time synchronisation	Via protocol DCF77/IRIG-B/GPS; interface; Protection data interface; binary input	Via protocol (NPT); DCF77/IRIG-B; interface; Protection data interface; binary input	Via DCF77/IRIG-B/GPS; interface; Protection data interface; binary input	Via protocol DCF77/IRIG-B/GPS; interface; Protection data interface; binary input
Messages with time stamp	Yes	Yes	Yes	Yes
Commissioning aids				
Message / measured value blocking	Yes	Yes	No	No
Creating test messages	Yes	Yes	No	No
Physical Mode	Asynchronous	Synchronous	Asynchronous	Asynchronous
Transmission mode	Cyclical/event	Cyclical/event	Cyclical	Cyclical/event (DNP) Cyclical (MODBUS)
Baud rate	4800 to 38400	up to 100 MBaud	up to 1,5 MBaud	2400 to 19200
Type	RS232 RS485 Fibre-optic cable	Ethernet TP optical or electrical	RS485 Fibre-optic cable Double ring	RS485 Fibre-optic cable

E Functions, Settings, Information

E.1	Functional Scope	364
E.2	Settings	366
E.3	Information List	381
E.4	Group Alarms	425
E.5	Measured Values	426

E.1 Functional Scope

Addr.	Information	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip mode	3pole only 1-/3pole	3pole only	Trip mode
112	DIFF.PROTECTION	Enabled Disabled	Enabled	Differential protection
122	DTT Direct Trip	Disabled Enabled	Disabled	DTT Direct Transfer Trip
124	HS/SOTF-O/C	Disabled Enabled	Disabled	Instantaneous HighSpeed/SOTF Overcurrent
126	Back-Up O/C	Disabled TOC IEC TOC ANSI	TOC IEC	Backup overcurrent
133	Auto Reclose	1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles ADT Disabled	Disabled	Auto-Reclose Function
134	AR control mode	Pickup w/ Tact Pickup w/o Tact Trip w/ Tact Trip w/o Tact	Trip w/o Tact	Auto-Reclose control mode
136	FREQUENCY Prot.	Disabled Enabled	Disabled	Over / Underfrequency Protection
137	U/O VOLTAGE	Disabled Enabled Enabl. w. comp.	Disabled	Under / Overvoltage Protection
139	BREAKER FAILURE	Disabled Enabled enabled w/ 3I0>	Disabled	Breaker Failure Protection
140	Trip Cir. Sup.	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision
141	REF PROT.	Disabled Enabled	Disabled	Restricted earth fault protection
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
143	TRANSFORMER	NO YES	NO	Transformer inside protection zone

Addr.	Information	Setting Options	Default Setting	Comments
144	V-TRANSFORMER	Not connected connected	connected	Voltage transformers
148	GPS-SYNC.	Enabled Disabled	Disabled	GPS synchronization

E.2 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under "Additional Settings".

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
201	CT Starpoint	P.System Data 1		towards Line towards Busbar	towards Line	CT Starpoint
203	Unom PRIMARY	P.System Data 1		0.4 .. 1200.0 kV	400.0 kV	Rated Primary Voltage
204	Unom SECONDARY	P.System Data 1		80 .. 125 V	100 V	Rated Secondary Voltage (Ph-Ph)
205	CT PRIMARY	P.System Data 1		10 .. 10000 A	1000 A	CT Rated Primary Current
206	CT SECONDARY	P.System Data 1		1A 5A	1A	CT Rated Secondary Current
207	SystemStarpoint	P.System Data 1		Solid Earthed Peterson-Coil Isolated	Solid Earthed	System Starpoint is
208A	1-1/2 CB	P.System Data 1		NO YES	NO	1-1/2 Circuit breaker arrangement
210	U4 transformer	P.System Data 1		Not connected Udelta transf. Ux transformer	Not connected	U4 voltage transformer is
211	Uph / Udelta	P.System Data 1		0.10 .. 9.99	1.73	Matching ratio Phase-VT To Open-Delta-VT
220	I4 transformer	P.System Data 1		Not connected In prot. line IY starpoint	In prot. line	I4 current transformer is
221	I4/Iph CT	P.System Data 1		0.010 .. 5.000	1.000	Matching ratio I4/Iph for CT's
230	Rated Frequency	P.System Data 1		50 Hz 60 Hz	50 Hz	Rated Frequency
236	Distance Unit	P.System Data 1		km Miles	km	Distance measurement unit
240A	TMin TRIP CMD	P.System Data 1		0.02 .. 30.00 sec	0.10 sec	Minimum TRIP Command Duration
241A	TMax CLOSE CMD	P.System Data 1		0.01 .. 30.00 sec	1.00 sec	Maximum Close Command Duration
242	T-CBtest-dead	P.System Data 1		0.00 .. 30.00 sec	0.10 sec	Dead Time for CB test-autoreclosure
251	K_ALF/K_ALF_N	P.System Data 1		1.00 .. 10.00	1.00	k_alf/k_alf nominal
253	E% ALF/ALF_N	P.System Data 1		0.5 .. 50.0 %	5.0 %	CT Error in % at k_alf/k_alf nominal
254	E% K_ALF_N	P.System Data 1		0.5 .. 50.0 %	15.0 %	CT Error in % at k_alf nominal
301	ACTIVE GROUP	Change Group		Group A Group B Group C Group D	Group A	Active Setting Group is

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
302	CHANGE	Change Group		Group A Group B Group C Group D Binary Input Protocol	Group A	Change to Another Setting Group
402A	WAVEFORM-TRIGGER	Osc. Fault Rec.		Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403A	WAVEFORM DATA	Osc. Fault Rec.		Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
410	MAX. LENGTH	Osc. Fault Rec.		0.30 .. 5.00 sec	2.00 sec	Max. length of a Waveform Capture Record
411	PRE. TRIG. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.25 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	Osc. Fault Rec.		0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input
610	FltDisp.LED/LCD	Device		Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
625A	T MIN LED HOLD	Device		0 .. 60 min; ∞	0 min	Minimum hold time of latched LEDs
640	Start image DD	Device		image 1 image 2 image 3 image 4 image 5 image 6	image 1	Start image Default Display
1103	FullScaleVolt.	P.System Data 2		0.4 .. 1200.0 kV	400.0 kV	Measurement: Full Scale Voltage (100%)
1104	FullScaleCurr.	P.System Data 2		10 .. 10000 A	1000 A	Measurement: Full Scale Current (100%)
1105	Line Angle	P.System Data 2		10 .. 89 °	85 °	Line Angle
1106	OPERATION POWER	P.System Data 2		0.2 .. 5000.0 MVA	692.8 MVA	Operational power of protection zone
1107	P,Q sign	P.System Data 2		not reversed reversed	not reversed	P,Q operational measured values sign
1111	x'	P.System Data 2	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	x' - Line Reactance per length unit
			5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
1111	x'	P.System Data 2	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	x' - Line Reactance per length unit
			5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
1112	c'	P.System Data 2	1A	0.000 .. 100.000 µF/km	0.010 µF/km	c' - capacit. per unit line len. µF/km
			5A	0.000 .. 500.000 µF/km	0.050 µF/km	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1112	c'	P.System Data 2	1A	0.000 .. 160.000 µF/mi	0.016 µF/mi	c' - capacit. per unit line len. µF/mile
			5A	0.000 .. 800.000 µF/mi	0.080 µF/mi	
1113	Line Length	P.System Data 2		0.1 .. 1000.0 km	100.0 km	Line Length
1113	Line Length	P.System Data 2		0.1 .. 650.0 Miles	62.1 Miles	Line Length
1130A	PoleOpenCurrent	P.System Data 2	1A	0.05 .. 1.00 A	0.10 A	Pole Open Current Threshold
			5A	0.25 .. 5.00 A	0.50 A	
1131A	PoleOpenVoltage	P.System Data 2		2 .. 70 V	30 V	Pole Open Voltage Threshold
1132A	SI Time all Cl.	P.System Data 2		0.01 .. 30.00 sec	0.10 sec	Seal-in Time after ALL closures
1133A	T DELAY SOTF	P.System Data 2		0.05 .. 30.00 sec	0.25 sec	minimal time for line open before SOTF
1134	Line Closure	P.System Data 2		only with ManCl I OR U or ManCl CB OR I or M/C I or Man.Close	I or Man.Close	Recognition of Line Closures with
1135	Reset Trip CMD	P.System Data 2		CurrentOpenPole Current AND CB Pickup Reset	CurrentOpenPole	RESET of Trip Command
1136	OpenPoleDetect.	P.System Data 2		OFF Current AND CB w/ measurement	w/ measurement	open pole detector
1150A	SI Time Man.Cl	P.System Data 2		0.01 .. 30.00 sec	0.30 sec	Seal-in Time after MANUAL closures
1151	SYN.MAN.CL	P.System Data 2		w/o Sync-check NO	NO	Manual CLOSE COMMAND generation
1152	Man.Clos. Imp.	P.System Data 2		(Einstellmöglich-keiten anwendung-sabhängig)	none	MANUAL Closure Impulse after CONTROL
1155	3pole coupling	P.System Data 2		with PICKUP with TRIP	with TRIP	3 pole coupling
1156A	Trip2phFlt	P.System Data 2		3pole 1pole leading Ø 1pole lagging Ø	3pole	Trip type with 2phase faults
1161	VECTOR GROUP U	P.System Data 2		0 .. 11	0	Vector group numeral for voltage
1162	VECTOR GROUP I	P.System Data 2		0 .. 11	0	Vector group numeral for current
1163	TRANS STP IS	P.System Data 2		Solid Earthed Not Earthed	Solid Earthed	Transformer starpoint is
1201	STATE OF DIFF.	Diff. Prot		OFF ON	ON	State of differential protection
1210	I-DIFF>	Diff. Prot	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Pickup value
			5A	0.50 .. 100.00 A	1.50 A	
1213	I-DIF>SWITCH ON	Diff. Prot	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Value under switch on condition
			5A	0.50 .. 100.00 A	1.50 A	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1217A	T-DELAY I-DIFF>	Diff. Prot		0.00 .. 60.00 sec; ∞	0.00 sec	I-DIFF>: Trip time delay
1218	T3I0 1PHAS	Diff. Prot		0.00 .. 0.50 sec; ∞	0.04 sec	Delay 1ph-faults (comp/ isol. star-point)
1219A	I> RELEASE DIFF	Diff. Prot	1A	0.10 .. 20.00 A; 0	0.00 A	Min. local current to release DIFF-Trip
			5A	0.50 .. 100.00 A; 0	0.00 A	
1233	I-DIFF>>	Diff. Prot	1A	0.8 .. 100.0 A; ∞	1.2 A	I-DIFF>>: Pickup value
			5A	4.0 .. 500.0 A; ∞	6.0 A	
1235	I-DIF>>SWITCHON	Diff. Prot	1A	0.8 .. 100.0 A; ∞	1.2 A	I-DIFF>>: Value under switch on cond.
			5A	4.0 .. 500.0 A; ∞	6.0 A	
1301	I-TRIP SEND	Intertrip		YES NO	NO	State of transmit. the intertrip command
1302	I-TRIP RECEIVE	Intertrip		Alarm only Trip	Trip	Reaction if intertrip command is receiv.
1303	T-ITRIP BI	Intertrip		0.00 .. 30.00 sec	0.02 sec	Delay for intertrip via binary input
1304	T-ITRIP PROL BI	Intertrip		0.00 .. 30.00 sec	0.00 sec	Prolongation for intertrip via bin.input
2201	FCT Direct Trip	DTT Direct Trip		ON OFF	OFF	Direct Transfer Trip (DTT)
2202	Trip Time DELAY	DTT Direct Trip		0.00 .. 30.00 sec; ∞	0.01 sec	Trip Time Delay
2301	INRUSH REST.	Diff. Prot		OFF ON	OFF	Inrush Restraint
2302	2nd HARMONIC	Diff. Prot		10 .. 45 %	15 %	2nd. harmonic in % of fundamental
2303	CROSS BLOCK	Diff. Prot		NO YES	NO	Cross Block
2305	MAX INRUSH PEAK	Diff. Prot	1A	1.1 .. 25.0 A	15.0 A	Maximum inrush-peak value
			5A	5.5 .. 125.0 A	75.0 A	
2310	CROSSB 2HM	Diff. Prot		0.00 .. 60.00 sec; ∞	0.00 sec	Time for Crossblock with 2nd harmonic
2401	FCT HS/SOTF-O/C	SOTF Overcurr.		ON OFF	ON	Inst. High Speed/SOTF-O/C is
2404	I>>>	SOTF Overcurr.	1A	0.10 .. 15.00 A; ∞	1.50 A	I>>> Pickup
			5A	0.50 .. 75.00 A; ∞	7.50 A	
2405A	I>>>>	SOTF Overcurr.	1A	1.00 .. 25.00 A; ∞	∞ A	I>>>> Pickup
			5A	5.00 .. 125.00 A; ∞	∞ A	
2406	CBaux for I>>>	SOTF Overcurr.		local only local and rem.	local and rem.	CB-aux check for activation of I>>>
2601	Operating Mode	Back-Up O/C		ON Only Emer. prot OFF	ON	Operating mode
2602	SOTF Time DELAY	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	Trip time delay after SOTF
2603A	Direct. 3I0	Back-Up O/C		U0/I0 or U2/I0 with U0/I0 with U2/I2	U0/I0 or U2/I0	Measurement of direction for 3I0
2610	Iph>>	Back-Up O/C	1A	0.05 .. 50.00 A; ∞	2.00 A	Iph>> Pickup
			5A	0.25 .. 250.00 A; ∞	10.00 A	
2611	T Iph>>	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph>> Time delay

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2612	3I0>> PICKUP	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.50 A	3I0>> Pickup
			5A	0.25 .. 125.00 A; ∞	2.50 A	
2613	T 3I0>>	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> InstTrip BI	Back-Up O/C		NO YES	YES	Instantaneous trip via BI
2615	I>> SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after SwitchOnToFault
2620	Iph>	Back-Up O/C	1A	0.05 .. 50.00 A; ∞	1.50 A	Iph> Pickup
			5A	0.25 .. 250.00 A; ∞	7.50 A	
2621	T Iph>	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> Pickup
			5A	0.25 .. 125.00 A; ∞	1.00 A	
2623	T 3I0>	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Time delay
2624	I> Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Teleprot./BI
2625	I> SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after SwitchOnToFault
2630	Iph> STUB	Back-Up O/C	1A	0.05 .. 50.00 A; ∞	1.50 A	Iph> STUB Pickup
			5A	0.25 .. 250.00 A; ∞	7.50 A	
2631	T Iph STUB	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> STUB Pickup
			5A	0.25 .. 125.00 A; ∞	1.00 A	
2633	T 3I0 STUB	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0 STUB Time delay
2634	I-STUB Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Teleprot./BI
2635	I-STUB SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after SwitchOnToFault
2640	Ip>	Back-Up O/C	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> Pickup
			5A	0.50 .. 20.00 A; ∞	∞ A	
2642	T Ip Time Dial	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Time Dial
2643	Time Dial TD Ip	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	Time Dial TD Ip
2646	T Ip Add	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T Ip Additional Time Delay
2650	3I0p PICKUP	Back-Up O/C	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p Pickup
			5A	0.25 .. 20.00 A; ∞	∞ A	
2652	T 3I0p TimeDial	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Time Dial
2653	TimeDial TD3I0p	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	Time Dial TD 3I0p
2656	T 3I0p Add	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T 3I0p Additional Time Delay
2660	IEC Curve	Back-Up O/C Back-Up O/C		Normal Inverse Very Inverse Extremely Inv. LongTimeInverse	Normal Inverse	IEC Curve

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2661	ANSI Curve	Back-Up O/C Back-Up O/C		Inverse Short Inverse Long Inverse Moderately Inv. Very Inverse Extremely Inv. Definite Inv.	Inverse	ANSI Curve
2670	I(3I0)p Tele/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Teleprot./BI
2671	I(3I0)p SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after SwitchOnToFault
2680	Direction Iph>	Back-Up O/C		Non-Directional Forward Reverse	Non-Directional	Direction of stage Iph> Dir.
2681	Iph> Dir.	Back-Up O/C	1A	0.05 .. 50.00 A; ∞	1.50 A	Iph> directional Pickup
			5A	0.25 .. 250.00 A; ∞	7.50 A	
2682	T Iph> Dir.	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Dir. Time delay
2683	Direction 3I0>	Back-Up O/C		Non-Directional Forward Reverse	Non-Directional	Direction of stage 3I0> Dir.
2684	3I0> Dir.	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> directional Pickup
			5A	0.25 .. 125.00 A; ∞	1.00 A	
2685	T 3I0> Dir.	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Dir. Time delay
2686	I>Dir.Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Teleprot./BI
2687	I> Dir. SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after SwitchOnToFault
2688	Direction IP	Back-Up O/C		Forward Reverse	Forward	Direction of stage Ip> Dir.
2689	Ip> Dir.	Back-Up O/C	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> directional Pickup
			5A	0.50 .. 20.00 A; ∞	∞ A	
2690	T Ip Dir.	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Dir.: Inv.-Time delay for IEC-Char.
2691	D Ip Dir.	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2692	T Ip Add Dir.	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2693	Direction 3I0P	Back-Up O/C		Forward Reverse	Forward	Direction of stage 3I0p
2694	3I0p Dir.	Back-Up O/C	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p directional Pickup
			5A	0.25 .. 20.00 A; ∞	∞ A	
2695	T 3I0p Dir.	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Dir.:Inv.-Time delay for IEC-Char
2696	D 3I0p Dir.	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2697	T 3I0p Add Dir.	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2698	IPDir.Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Teleprot./BI

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2699	IP Dir. SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after SwitchOnToFault
2901	MEASURE. SUPERV	Meas-urem.Superv		ON OFF	ON	Measurement Supervision
2902A	BALANCE U-LIMIT	Meas-urem.Superv		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
2903A	BAL. FACTOR U	Meas-urem.Superv		0.58 .. 0.95	0.75	Balance Factor for Voltage Monitor
2904A	BALANCE I LIMIT	Meas-urem.Superv	1A	0.10 .. 1.00 A	0.50 A	Current Balance Monitor
			5A	0.50 .. 5.00 A	2.50 A	
2905A	BAL. FACTOR I	Meas-urem.Superv		0.10 .. 0.95	0.50	Balance Factor for Current Monitor
2906A	ΣI THRESHOLD	Meas-urem.Superv	1A	0.10 .. 2.00 A	0.25 A	Summated Current Monitoring Threshold
			5A	0.50 .. 10.00 A	1.25 A	
2907A	ΣI FACTOR	Meas-urem.Superv		0.00 .. 0.95	0.50	Summated Current Monitoring Factor
2908A	T BAL. U LIMIT	Meas-urem.Superv		5 .. 100 sec	5 sec	T Balance Factor for Voltage Monitor
2909A	T BAL. I LIMIT	Meas-urem.Superv		5 .. 100 sec	5 sec	T Current Balance Monitor
2910	FUSE FAIL MON.	Meas-urem.Superv		ON OFF	ON	Fuse Failure Monitor
2911A	FFM U>(min)	Meas-urem.Superv		10 .. 100 V	30 V	Minimum Voltage Threshold U>
2912A	FFM I< (max)	Meas-urem.Superv	1A	0.05 .. 1.00 A	0.10 A	Maximum Current Threshold I<
			5A	0.25 .. 5.00 A	0.50 A	
2913A	FFM U<max (3ph)	Meas-urem.Superv		2 .. 100 V	15 V	Maximum Voltage Threshold U< (3phase)
2914A	FFM Idelta (3p)	Meas-urem.Superv	1A	0.05 .. 1.00 A	0.10 A	Delta Current Threshold (3phase)
			5A	0.25 .. 5.00 A	0.50 A	
2915	V-Supervision	Meas-urem.Superv		w/ CURR.SUP w/ I> & CBaux OFF	w/ CURR.SUP	Voltage Failure Supervision
2916A	T V-Supervision	Meas-urem.Superv		0.00 .. 30.00 sec	3.00 sec	Delay Voltage Failure Supervision
2921	T mcb	Meas-urem.Superv		0 .. 30 ms	0 ms	VT mcb operating time
2931	BROKEN WIRE	Meas-urem.Superv		ON OFF Alarm only	OFF	Fast broken current-wire supervision
2933	FAST Σ i SUPERV	Meas-urem.Superv		ON OFF	ON	State of fast current summation supervis
2935A	ΔI min	Meas-urem.Superv	1A	0.05 .. 1.00 A	0.10 A	Min. current diff. for wire break det.
			5A	0.25 .. 5.00 A	0.50 A	
2941	φA	Meas-urem.Superv		0 .. 359 °	200 °	Limit setting PhiA
2942	φB	Meas-urem.Superv		0 .. 359 °	340 °	Limit setting PhiB

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2943	I1>	Meas-urem.Superv	1A	0.05 .. 2.00 A	0.05 A	Minimum value I1>
			5A	0.25 .. 10.00 A	0.25 A	
2944	U1>	Meas-urem.Superv		2 .. 70 V	20 V	Minimum value U1>
3401	AUTO RECLOSE	Auto Reclose		OFF ON	ON	Auto-Reclose Function
3402	CB? 1.TRIP	Auto Reclose		YES NO	NO	CB ready interrogation at 1st trip
3403	T-RECLAIM	Auto Reclose		0.50 .. 300.00 sec	3.00 sec	Reclaim time after successful AR cycle
3403	T-RECLAIM	Auto Reclose		0.50 .. 300.00 sec; 0	3.00 sec	Reclaim time after successful AR cycle
3404	T-BLOCK MC	Auto Reclose		0.50 .. 300.00 sec; 0	1.00 sec	AR blocking duration after manual close
3406	EV. FLT. RECOG.	Auto Reclose		with PICKUP with TRIP	with TRIP	Evolving fault recognition
3407	EV. FLT. MODE	Auto Reclose		Stops AutoRecl starts 3p AR	starts 3p AR	Evolving fault (during the dead time)
3408	T-Start MONITOR	Auto Reclose		0.01 .. 300.00 sec	0.50 sec	AR start-signal monitoring time
3409	CB TIME OUT	Auto Reclose		0.01 .. 300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3410	T RemoteClose	Auto Reclose		0.00 .. 300.00 sec; ∞	0.20 sec	Send delay for remote close command
3411A	T-DEAD EXT.	Auto Reclose		0.50 .. 300.00 sec; ∞	∞ sec	Maximum dead time extension
3420	AR WITH DIFF	Auto Reclose		YES NO	YES	AR with differential protection ?
3421	AR w/ SOTF-O/C	Auto Reclose		YES NO	YES	AR with switch-onto-fault overcurrent ?
3423	AR WITH I.TRIP	Auto Reclose		YES NO	YES	AR with intertrip ?
3424	AR w/ DTT	Auto Reclose		YES NO	YES	AR with direct transfer trip ?
3425	AR w/ BackUpO/C	Auto Reclose		YES NO	YES	AR with back-up overcur-rent ?
3430	AR TRIP 3pole	Auto Reclose		YES NO	YES	3pole TRIP by AR
3431	DLC / RDT	Auto Reclose		WITHOUT DLC	WITHOUT	Dead Line Check / Reduced Dead Time
3433	T-ACTION ADT	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3434	T-MAX ADT	Auto Reclose		0.50 .. 3000.00 sec	5.00 sec	Maximum dead time
3435	ADT 1p allowed	Auto Reclose		YES NO	NO	1pole TRIP allowed
3436	ADT CB? CLOSE	Auto Reclose		YES NO	NO	CB ready interrogation before reclosing
3437	ADT SynRequest	Auto Reclose		YES NO	NO	Request for synchro-check after 3pole AR

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3438	T U-stable	Auto Reclose		0.10 .. 30.00 sec	0.10 sec	Supervision time for dead/live voltage
3440	U-live>	Auto Reclose		30 .. 90 V	48 V	Voltage threshold for live line or bus
3441	U-dead<	Auto Reclose		2 .. 70 V	30 V	Voltage threshold for dead line or bus
3450	1.AR: START	Auto Reclose		YES NO	YES	Start of AR allowed in this cycle
3451	1.AR: T-ACTION	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3453	1.AR Tdead 1Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3454	1.AR Tdead 2Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3455	1.AR Tdead 3Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3456	1.AR Tdead1Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1pole trip
3457	1.AR Tdead3Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3458	1.AR: Tdead EV.	Auto Reclose		0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3459	1.AR: CB? CLOSE	Auto Reclose		YES NO	NO	CB ready interrogation before reclosing
3460	1.AR SynRequest	Auto Reclose		YES NO	NO	Request for synchro-check after 3pole AR
3461	2.AR: START	Auto Reclose		YES NO	NO	AR start allowed in this cycle
3462	2.AR: T-ACTION	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3464	2.AR Tdead 1Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3465	2.AR Tdead 2Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3466	2.AR Tdead 3Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3467	2.AR Tdead1Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3468	2.AR Tdead3Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3469	2.AR: Tdead EV.	Auto Reclose		0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3470	2.AR: CB? CLOSE	Auto Reclose		YES NO	NO	CB ready interrogation before reclosing
3471	2.AR SynRequest	Auto Reclose		YES NO	NO	Request for synchro-check after 3pole AR
3472	3.AR: START	Auto Reclose		YES NO	NO	AR start allowed in this cycle
3473	3.AR: T-ACTION	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Action time

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3475	3.AR Tdead 1Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3476	3.AR Tdead 2Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3477	3.AR Tdead 3Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3478	3.AR Tdead1Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3479	3.AR Tdead3Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3480	3.AR: Tdead EV.	Auto Reclose		0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3481	3.AR: CB? CLOSE	Auto Reclose		YES NO	NO	CB ready interrogation before reclosing
3482	3.AR SynRequest	Auto Reclose		YES NO	NO	Request for synchro-check after 3pole AR
3483	4.AR: START	Auto Reclose		YES NO	NO	AR start allowed in this cycle
3484	4.AR: T-ACTION	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3486	4.AR Tdead 1Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3487	4.AR Tdead 2Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3488	4.AR Tdead 3Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3489	4.AR Tdead1Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3490	4.AR Tdead3Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3491	4.AR: Tdead EV.	Auto Reclose		0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3492	4.AR: CB? CLOSE	Auto Reclose		YES NO	NO	CB ready interrogation before reclosing
3493	4.AR SynRequest	Auto Reclose		YES NO	NO	Request for synchro-check after 3pole AR
3601	O/U FREQ. f1	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f1
3602	f1 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	49.50 Hz	f1 Pickup
3603	f1 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	59.50 Hz	f1 Pickup
3604	T f1	Frequency Prot.		0.00 .. 600.00 sec	60.00 sec	T f1 Time Delay
3611	O/U FREQ. f2	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f2
3612	f2 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	49.00 Hz	f2 Pickup
3613	f2 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	57.00 Hz	f2 Pickup
3614	T f2	Frequency Prot.		0.00 .. 600.00 sec	30.00 sec	T f2 Time Delay

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3621	O/U FREQ. f3	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f3
3622	f3 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	47.50 Hz	f3 Pickup
3623	f3 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	59.50 Hz	f3 Pickup
3624	T f3	Frequency Prot.		0.00 .. 600.00 sec	3.00 sec	T f3 Time Delay
3631	O/U FREQ. f4	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f4
3632	f4 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	51.00 Hz	f4 Pickup
3633	f4 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	62.00 Hz	f4 Pickup
3634	T f4	Frequency Prot.		0.00 .. 600.00 sec	30.00 sec	T f4 Time Delay
3701	Uph-e>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-e overvoltage prot.
3702	Uph-e>	Voltage Prot.		1.0 .. 170.0 V; ∞	85.0 V	Uph-e> Pickup
3703	T Uph-e>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e> Time Delay
3704	Uph-e>>	Voltage Prot.		1.0 .. 170.0 V; ∞	100.0 V	Uph-e>> Pickup
3705	T Uph-e>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e>> Time Delay
3709A	Uph-e>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	Uph-e>(>) Reset ratio
3711	Uph-ph>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-ph overvoltage prot.
3712	Uph-ph>	Voltage Prot.		2.0 .. 220.0 V; ∞	150.0 V	Uph-ph> Pickup
3713	T Uph-ph>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph> Time Delay
3714	Uph-ph>>	Voltage Prot.		2.0 .. 220.0 V; ∞	175.0 V	Uph-ph>> Pickup
3715	T Uph-ph>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph>> Time Delay
3719A	Uphph>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	Uph-ph>(>) Reset ratio
3721	3U0>(>) (or Ux)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode 3U0 (or Ux) overvoltage
3722	3U0>	Voltage Prot.		1.0 .. 220.0 V; ∞	30.0 V	3U0> Pickup (or Ux>)
3723	T 3U0>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T 3U0> Time Delay (or T Ux>)
3724	3U0>>	Voltage Prot.		1.0 .. 220.0 V; ∞	50.0 V	3U0>> Pickup (or Ux>>)
3725	T 3U0>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T 3U0>> Time Delay (or T Ux>>)
3728A	3U0>(>) Stabil.	Voltage Prot.		ON OFF	ON	3U0>(>): Stabilization 3U0-Measurement
3729A	3U0>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.95	3U0>(>) Reset ratio (or Ux)

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3731	U1>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U1 overvoltage prot.
3732	U1>	Voltage Prot.		2.0 .. 220.0 V; ∞	150.0 V	U1> Pickup
3733	T U1>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T U1> Time Delay
3734	U1>>	Voltage Prot.		2.0 .. 220.0 V; ∞	175.0 V	U1>> Pickup
3735	T U1>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T U1>> Time Delay
3736	U1> Compound	Voltage Prot.		OFF ON	OFF	U1> with Compounding
3737	U1>> Compound	Voltage Prot.		OFF ON	OFF	U1>> with Compounding
3739A	U1>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	U1>(>) Reset ratio
3741	U2>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U2 overvoltage prot.
3742	U2>	Voltage Prot.		2.0 .. 220.0 V; ∞	30.0 V	U2> Pickup
3743	T U2>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T U2> Time Delay
3744	U2>>	Voltage Prot.		2.0 .. 220.0 V; ∞	50.0 V	U2>> Pickup
3745	T U2>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T U2>> Time Delay
3749A	U2>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	U2>(>) Reset ratio
3751	Uph-e<(<)	Voltage Prot.		OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-e undervoltage prot.
3752	Uph-e<	Voltage Prot.		1.0 .. 100.0 V; 0	30.0 V	Uph-e< Pickup
3753	T Uph-e<	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e< Time Delay
3754	Uph-e<<	Voltage Prot.		1.0 .. 100.0 V; 0	10.0 V	Uph-e<< Pickup
3755	T Uph-e<<	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e<< Time Delay
3758	CURR.SUP. Uphe<	Voltage Prot.		ON OFF	ON	Current supervision (Uph-e)
3759A	Uph-e<(<) RESET	Voltage Prot.		1.01 .. 1.20	1.05	Uph-e<(<) Reset ratio
3761	Uph-ph<(<)	Voltage Prot.		OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-ph undervoltage prot.
3762	Uph-ph<	Voltage Prot.		1.0 .. 175.0 V; 0	50.0 V	Uph-ph< Pickup
3763	T Uph-ph<	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph< Time Delay
3764	Uph-ph<<	Voltage Prot.		1.0 .. 175.0 V; 0	17.0 V	Uph-ph<< Pickup
3765	T Uphph<<	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph<< Time Delay

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3768	CURR.SUP.Uphph<	Voltage Prot.		ON OFF	ON	Current supervision (Uph-ph)
3769A	Uphph<(<) RESET	Voltage Prot.		1.01 .. 1.20	1.05	Uph-ph<(<) Reset ratio
3771	U1<(<)	Voltage Prot.		OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode U1 undervoltage prot.
3772	U1<	Voltage Prot.		1.0 .. 100.0 V; 0	30.0 V	U1< Pickup
3773	T U1<	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T U1< Time Delay
3774	U1<<	Voltage Prot.		1.0 .. 100.0 V; 0	10.0 V	U1<< Pickup
3775	T U1<<	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T U1<< Time Delay
3778	CURR.SUP.U1<	Voltage Prot.		ON OFF	ON	Current supervision (U1)
3779A	U1<(<) RESET	Voltage Prot.		1.01 .. 1.20	1.05	U1<(<) Reset ratio
3901	FCT BreakerFail	Breaker Failure		ON OFF	ON	Breaker Failure Protection
3902	I> BF	Breaker Failure	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold I>
			5A	0.25 .. 100.00 A	0.50 A	
3903	1p-RETRIP (T1)	Breaker Failure		NO YES	YES	1pole retrip with stage T1 (local trip)
3904	T1-1pole	Breaker Failure		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 1pole start (local trip)
3905	T1-3pole	Breaker Failure		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 3pole start (local trip)
3906	T2	Breaker Failure		0.00 .. 30.00 sec; ∞	0.15 sec	T2, Delay of 2nd stage (busbar trip)
3907	T3-BkrDefective	Breaker Failure		0.00 .. 30.00 sec; ∞	0.00 sec	T3, Delay for start with defective bkr.
3908	Trip BkrDefect.	Breaker Failure		NO with T1-trip with T2-trip w/ T1/T2-trip	NO	Trip output selection with defective bkr
3909	Chk BRK CONTACT	Breaker Failure		NO YES	YES	Check Breaker contacts
3912	3I0> BF	Breaker Failure	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold 3I0>
			5A	0.25 .. 100.00 A	0.50 A	
3913	T2StartCriteria	Breaker Failure		With exp. of T1 Parallel withT1	Parallel withT1	T2 Start Criteria
3921	End Flt. stage	Breaker Failure		ON OFF	OFF	End fault protection
3922	T-EndFault	Breaker Failure		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay of end fault protection
3931	PoleDiscrepancy	Breaker Failure		ON OFF	OFF	Pole Discrepancy supervision
3932	T-PoleDiscrep.	Breaker Failure		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay with pole discrepancy

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
4001	FCT TripSuperv.	TripCirc.Superv		ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	TripCirc.Superv		1 .. 2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	TripCirc.Superv		1 .. 30 sec	2 sec	Delay Time for alarm
4101	REF PROT.	REF		OFF ON	OFF	Restricted Earth Fault Protection
4111	I-REF>	REF	1A	0.05 .. 2.00 A	0.15 A	Pick up value I REF>
			5A	0.25 .. 10.00 A	0.75 A	
4112A	T I-REF>	REF		0.00 .. 60.00 sec; ∞	0.00 sec	T I-REF> Time Delay
4113A	SLOPE	REF		0.00 .. 0.95	0.00	Slope of Charac. I-REF> = f(I-SUM)
4201	Ther. OVERLOAD	Therm. Overload		OFF ON Alarm Only	OFF	Thermal overload protection
4202	K-FACTOR	Therm. Overload		0.10 .. 4.00	1.10	K-Factor
4203	TIME CONSTANT	Therm. Overload		1.0 .. 999.9 min	100.0 min	Time Constant
4204	Θ ALARM	Therm. Overload		50 .. 100 %	90 %	Thermal Alarm Stage
4205	I ALARM	Therm. Overload	1A	0.10 .. 4.00 A	1.00 A	Current Overload Alarm Setpoint
			5A	0.50 .. 20.00 A	5.00 A	
4206	CALC. METHOD	Therm. Overload		Θ max Average Θ Θ from Imax	Θ max	Method of Acquiring Temperature
4501	STATE PROT I 1	Prot. Interface		ON OFF	ON	State of protection interface 1
4502	CONNEC. 1 OVER	Prot. Interface		F.optic direct Com c 64 kBit/s Com c 128kBit/s Com c 512kBit/s C37.94 1 slot C37.94 2 slots C37.94 4 slots C37.94 8 slots	F.optic direct	Connection 1 over
4505A	PROT 1 T-DELAY	Prot. Interface		0.1 .. 30.0 ms	30.0 ms	Prot 1: Maximal permissible delay time
4506A	PROT 1 UNSYM.	Prot. Interface		0.000 .. 3.000 ms	0.100 ms	Prot 1: Diff. in send and receive time
4509	T-DATA DISTURB	Prot. Interface		0.05 .. 2.00 sec	0.10 sec	Time delay for data disturbance alarm
4510	T-DATAFAIL	Prot. Interface		0.0 .. 60.0 sec	6.0 sec	Time del for transmission failure alarm
4511	PI1 SYNCMODE	Prot. Interface		TEL and GPS TEL or GPS GPS SYNC OFF	TEL and GPS	PI1 Synchronizationmode
4512	Td ResetRemote	Prot. Interface		0.00 .. 300.00 sec; ∞	0.00 sec	Remote signal RESET DELAY for comm.fail
4513A	PROT1 max ERROR	Prot. Interface		0.5 .. 20.0 %	1.0 %	Prot 1: Maximal permissible error rate

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
4515A	PI1 BLOCK UNSYM	Prot. Interface		YES NO	YES	Prot.1: Block. due to unsym. delay time
4701	ID OF RELAY 1	Diff.-Topo		1 .. 65534	1	Identification number of relay 1
4702	ID OF RELAY 2	Diff.-Topo		1 .. 65534	2	Identification number of relay 2
4710	LOCAL RELAY	Diff.-Topo		relay 1 relay 2	relay 1	Local relay is
4801	GPS-SYNC.	Prot. Interface		ON OFF	OFF	GPS synchronization
4803A	TD GPS FAILD	Prot. Interface		0.5 .. 60.0 sec	2.1 sec	Delay time for local GPS-pulse loss

E.3 Information List

Indications for IEC 60 870-5-103 are always reported ON / OFF if they are subject to general interrogation for IEC 60 870-5-103. If not, they are reported only as ON.

New user-defined indications or such newly allocated to IEC 60 870-5-103 are set to ON / OFF and subjected to general interrogation if the information type is not a spontaneous event ("..._Ev""). Further information on indications can be found in detail in the SIPROTEC 4 System Description, Order No. E50417-H1176-C151.

In columns "Event Log", "Trip Log" and "Ground Fault Log" the following applies:

UPPER CASE NOTATION "ON/OFF":	definitely set, not allocatable
lower case notation "on/off":	preset, allocatable
*:	not preset, allocatable
<blank>:	neither preset nor allocatable

In the column "Marked in Oscill. Record" the following applies:

UPPER CASE NOTATION "M":	definitely set, not allocatable
lower case notation "m":	preset, allocatable
*:	not preset, allocatable
<blank>:	neither preset nor allocatable

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
-	Test mode (Test mode)	Device	IntSP	On Off	*		*	LED			BO		192	21	1	Yes
-	Stop data transmission (DataStop)	Device	IntSP	On Off	*		*	LED			BO		192	20	1	Yes
-	Unlock data transmission via BI (UnlockDT)	Device	IntSP	*			*									
-	Reset LED (Reset LED)	Device	IntSP	On	*		*	LED			BO		192	19	1	No
-	Clock Synchronization (SynchClock)	Device	IntSP_Ev	*	*		*	LED			BO					
-	>Back Light on (>Light on)	Device	SP	On Off	*				BI							
-	Hardware Test Mode (HWTestMod)	Device	IntSP	On Off	*		*	LED			BO					
-	Disturbance CFC (Distur.CFC)	Device	OUT	On Off	*			LED			BO					
-	Breaker OPENED (Brk OPENED)	Device	IntSP	*	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
-	Feeder EARTHED (FdrEARTHED)	Device	IntSP	*	*		*	LED			BO					
-	Setting Group A is active (P-GrpA act)	Change Group	IntSP	On Off	*		*	LED			BO		192	23	1	Yes
-	Setting Group B is active (P-GrpB act)	Change Group	IntSP	On Off	*		*	LED			BO		192	24	1	Yes
-	Setting Group C is active (P-GrpC act)	Change Group	IntSP	On Off	*		*	LED			BO		192	25	1	Yes
-	Setting Group D is active (P-GrpD act)	Change Group	IntSP	On Off	*		*	LED			BO		192	26	1	Yes
-	Fault Recording Start (FltRecSta)	Osc. Fault Rec.	IntSP	On Off	*		M	LED			BO					
-	CB1-TEST trip/close - Only L1 (CB1tst L1)	Testing	-	*	*											
-	CB1-TEST trip/close - Only L2 (CB1tst L2)	Testing	-	*	*											
-	CB1-TEST trip/close - Only L3 (CB1tst L3)	Testing	-	*	*											
-	CB1-TEST trip/close Phases L123 (CB1tst 123)	Testing	-	*	*											
-	Controlmode REMOTE (ModeREMOTE)	Cntrl Authority	IntSP	On Off	*			LED			BO					
-	Control Authority (Cntrl Auth)	Cntrl Authority	IntSP	On Off	*			LED			BO		101	85	1	Yes
-	Controlmode LOCAL (ModeLOCAL)	Cntrl Authority	IntSP	On Off	*			LED			BO		101	86	1	Yes
-	Breaker (Breaker)	Control Device	CF_D12	On Off	*						BO		240	160	20	
-	Breaker (Breaker)	Control Device	DP	On Off	*				BI			CB	240	160	1	Yes
-	Disconnect Switch (Disc.Swit.)	Control Device	CF_D2	On Off	*						BO		240	161	20	

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
-	Disconnect Switch (Disc.Swit.)	Control Device	DP	On Off	*				BI			CB	240	161	1	Yes
-	Earth Switch (EarthSwit)	Control Device	CF_D2	On Off	*						BO		240	164	20	
-	Earth Switch (EarthSwit)	Control Device	DP	On Off	*				BI			CB	240	164	1	Yes
-	Interlocking: Breaker Open (Brk Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Breaker Close (Brk Close)	Control Device	IntSP	*	*		*									
-	Interlocking: Disconnect switch Open (Disc.Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Disconnect switch Close (Disc.Close)	Control Device	IntSP	*	*		*									
-	Interlocking: Earth switch Open (E Sw Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Earth switch Close (E Sw Cl.)	Control Device	IntSP	*	*		*									
-	Q2 Open/Close (Q2 Op/Cl)	Control Device	CF_D2	On Off	*						BO		240	162	20	
-	Q2 Open/Close (Q2 Op/Cl)	Control Device	DP	On Off	*				BI			CB	240	162	1	Yes
-	Q9 Open/Close (Q9 Op/Cl)	Control Device	CF_D2	On Off	*						BO		240	163	20	
-	Q9 Open/Close (Q9 Op/Cl)	Control Device	DP	On Off	*				BI			CB	240	163	1	Yes
-	Fan ON/OFF (Fan ON/ OFF)	Control Device	CF_D2	On Off	*						BO		240	175	20	
-	Fan ON/OFF (Fan ON/ OFF)	Control Device	DP	On Off	*				BI			CB	240	175	1	Yes
-	>Cabinet door open (>Door open)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	101	1	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
-	>CB waiting for Spring charged (>CB wait)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	101	2	1	Yes
-	>Error Motor Voltage (>Err Mot U)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	240	181	1	Yes
-	>Error Control Voltage (>ErrCntrlU)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	240	182	1	Yes
-	>SF6-Loss (>SF6-Loss)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	240	183	1	Yes
-	>Error Meter (>Err Meter)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	240	184	1	Yes
-	>Transformer Temperature (>Tx Temp.)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	240	185	1	Yes
-	>Transformer Danger (>Tx Danger)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	240	186	1	Yes
-	Reset meter (Meter res)	Energy	IntSP_Ev	ON	*											
-	Error Systeminterface (SysIntErr.)	Protocol	IntSP	On Off				LED			BO					
-	Threshold Value 1 (ThreshVal1)	Thresh.-Switch	IntSP	On Off	*		*	LED	BI	FK TO NL IN E	BO	CB				
3	>Synchronize Internal Real Time Clock (>Time Synch)	Device	SP	*	*		*	LED	BI		BO					
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Osc. Fault Rec.	SP	On	*		m	LED	BI		BO					
5	>Reset LED (>Reset LED)	Device	SP	*	*		*	LED	BI		BO					
7	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	SP	*	*		*	LED	BI		BO					
8	>Setting Group Select Bit 1 (>Set Group Bit1)	Change Group	SP	*	*		*	LED	BI		BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
009.0100	Failure EN100 Modul (Failure Modul)	EN100-Modul 1	IntSP	On Off			*	LED			BO					
009.0101	Failure EN100 Link Channel 1 (Ch1) (Fail Ch1)	EN100-Modul 1	IntSP	On Off			*	LED			BO					
009.0102	Failure EN100 Link Channel 2 (Ch2) (Fail Ch2)	EN100-Modul 1	IntSP	On Off			*	LED			BO					
11	>User defined annunciation 1 (>Annunc. 1)	Device	SP	*	*	*	*	LED	BI		BO		192	27	1	Yes
12	>User defined annunciation 2 (>Annunc. 2)	Device	SP	*	*	*	*	LED	BI		BO		192	28	1	Yes
13	>User defined annunciation 3 (>Annunc. 3)	Device	SP	*	*	*	*	LED	BI		BO		192	29	1	Yes
14	>User defined annunciation 4 (>Annunc. 4)	Device	SP	*	*	*	*	LED	BI		BO		192	30	1	Yes
15	>Test mode (>Test mode)	Device	SP	On Off	*		*	LED	BI		BO		135	53	1	Yes
16	>Stop data transmission (>DataStop)	Device	SP	*	*		*	LED	BI		BO		135	54	1	Yes
51	Device is Operational and Protecting (Device OK)	Device	OUT	On Off	*		*	LED			BO		135	81	1	Yes
52	At Least 1 Protection Funct. is Active (ProtActive)	Device	IntSP	On Off	*		*	LED			BO		192	18	1	Yes
55	Reset Device (Reset Device)	Device	OUT	*	*		*	LED			BO		192	4	1	No
56	Initial Start of Device (Initial Start)	Device	OUT	On	*		*	LED			BO		192	5	1	No
60	Reset LED (Reset LED)	Device	OUT_Ev	On	*		*	LED			BO					
67	Resume (Resume)	Device	OUT	On	*		*	LED			BO		135	97	1	No
68	Clock Synchronization Error (Clock SyncError)	Device	OUT	On Off	*		*	LED			BO					
69	Daylight Saving Time (DayLightSavTime)	Device	OUT	On Off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
70	Setting calculation is running (Settings Calc.)	Device	OUT	On Off	*		*	LED			BO		192	22	1	Yes
71	Settings Check (Settings Check)	Device	OUT	*	*		*	LED			BO					
72	Level-2 change (Level-2 change)	Device	OUT	On Off	*		*	LED			BO					
73	Local setting change (Local change)	Device	OUT	*	*											
110	Event lost (Event Lost)	Device	OUT_Ev	On	*		*	LED			BO		135	130	1	No
113	Flag Lost (Flag Lost)	Device	OUT	On	*		m	LED			BO		135	136	1	Yes
125	Chatter ON (Chatter ON)	Device	OUT	On Off	*		*	LED			BO		135	145	1	Yes
126	Protection ON/OFF (via system port) (ProtON/OFF)	Device	IntSP	On Off	*		*	LED			BO					
127	Auto Reclose ON/OFF (via system port) (AR ON/OFF)	Auto Reclose	IntSP	On Off	*		*	LED			BO					
130	Load angle Phi(PQ Positive sequence) (φ(PQ Pos. Seq.))	Measurem.Superv	OUT	*	*		*	LED			BO					
131	Load angle Phi(PQ) blocked (φ(PQ Pos) block)	Measurem.Superv	OUT	*	*		*	LED			BO					
132	Setting error: |PhiA - PhiB| < 3° (φ Set wrong)	Measurem.Superv	OUT	*	*		*	LED			BO					
140	Error with a summary alarm (Error Sum Alarm)	Device	OUT	On Off	*		*	LED			BO		192	47	1	Yes
144	Error 5V (Error 5V)	Device	OUT	On Off	*		*	LED			BO		135	164	1	Yes
160	Alarm Summary Event (Alarm Sum Event)	Device	OUT	*	*		*	LED			BO		192	46	1	Yes
161	Failure: General Current Supervision (Fail I Superv.)	Measurem.Superv	OUT	*	*		*	LED			BO		192	32	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
163	Failure: Current Balance (Fail I balance)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	183	1	Yes
164	Failure: General Voltage Supervision (Fail U Superv.)	Measurem.Superv	OUT	*	*		*	LED			BO		192	33	1	Yes
165	Failure: Voltage summation Phase-Earth (Fail Σ U Ph-E)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	184	1	Yes
167	Failure: Voltage Balance (Fail U balance)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	186	1	Yes
168	Failure: Voltage absent (Fail U absent)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	187	1	Yes
169	VT Fuse Failure (alarm >10s) (VT FuseFail>10s)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	188	1	Yes
170	VT Fuse Failure (alarm instantaneous) (VT FuseFail)	Measurem.Superv	OUT	On Off	*		*	LED			BO					
171	Failure: Phase Sequence (Fail Ph. Seq.)	Measurem.Superv	OUT	On Off	*		*	LED			BO		192	35	1	Yes
177	Failure: Battery empty (Fail Battery)	Device	OUT	On Off	*		*	LED			BO		135	193	1	Yes
181	Error: A/D converter (Error A/D-conv.)	Device	OUT	On Off	*		*	LED			BO		135	178	1	Yes
183	Error Board 1 (Error Board 1)	Device	OUT	On Off	*		*	LED			BO		135	171	1	Yes
184	Error Board 2 (Error Board 2)	Device	OUT	On Off	*		*	LED			BO		135	172	1	Yes
185	Error Board 3 (Error Board 3)	Device	OUT	On Off	*		*	LED			BO		135	173	1	Yes
186	Error Board 4 (Error Board 4)	Device	OUT	On Off	*		*	LED			BO		135	174	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
187	Error Board 5 (Error Board 5)	Device	OUT	On Off	*		*	LED			BO		135	175	1	Yes
188	Error Board 6 (Error Board 6)	Device	OUT	On Off	*		*	LED			BO		135	176	1	Yes
189	Error Board 7 (Error Board 7)	Device	OUT	On Off	*		*	LED			BO		135	177	1	Yes
190	Error Board 0 (Error Board 0)	Device	OUT	On Off	*		*	LED			BO		135	210	1	Yes
191	Error: Offset (Error Offset)	Device	OUT	On Off	*		*	LED			BO					
192	Error:1A/5Ajumper different from setting (Error1A/5Awrong)	Device	OUT	On Off	*		*	LED			BO		135	169	1	Yes
193	Alarm: Analog input adjustment invalid (Alarm adjustm.)	Device	OUT	On Off	*		*	LED			BO		135	181	1	Yes
194	Error: Neutral CT different from MLFB (Error neutralCT)	Device	OUT	On Off	*		*	LED			BO		135	180	1	Yes
196	Fuse Fail Monitor is switched OFF (Fuse Fail M.OFF)	Measurem.Superv	OUT	*	*		*	LED			BO		135	196	1	Yes
197	Measurement Supervision is switched OFF (MeasSup OFF)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	197	1	Yes
234.2100	U<, U> blocked via operation (U<, U> blk)	Voltage Prot.	IntSP	On Off	*		*	LED			BO					
285	Power factor alarm (cosφ alarm)	Set Points(MV)	OUT	On Off	*		*	LED			BO					
289	Alarm: Current summation supervision (Failure Σi)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	250	1	Yes
290	Alarm: Broken current-wire detected L1 (Broken Iwire L1)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	137	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
291	Alarm: Broken current-wire detected L2 (Broken Iwire L2)	Meas-urem.Superv	OUT	On Off	*		*	LED			BO		135	138	1	Yes
292	Alarm: Broken current-wire detected L3 (Broken Iwire L3)	Meas-urem.Superv	OUT	On Off	*		*	LED			BO		135	139	1	Yes
295	Broken wire supervision is switched OFF (Broken wire OFF)	Meas-urem.Superv	OUT	*	*		*	LED			BO					
296	Current summation superv is switched OFF (Σi superv. OFF)	Meas-urem.Superv	OUT	*	*		*	LED			BO					
297	Broken current-wire at other end L1 (ext.Brk.Wire L1)	Meas-urem.Superv	OUT	On Off	*		*	LED			BO					
298	Broken current-wire at other end L2 (ext.Brk.Wire L2)	Meas-urem.Superv	OUT	On Off	*		*	LED			BO					
299	Broken current-wire at other end L3 (ext.Brk.Wire L3)	Meas-urem.Superv	OUT	On Off	*		*	LED			BO					
301	Power System fault (Pow.Sys.Flt.)	P.System Data 2	OUT	ON OFF	ON		*						135	231	2	Yes
302	Fault Event (Fault Event)	P.System Data 2	OUT	*	ON		*						135	232	2	No
320	Warn: Limit of Memory Data exceeded (Warn Mem. Data)	Device	OUT	On Off	*		*	LED			BO					
321	Warn: Limit of Memory Parameter exceeded (Warn Mem. Para.)	Device	OUT	On Off	*		*	LED			BO					
322	Warn: Limit of Memory Operation exceeded (Warn Mem. Oper.)	Device	OUT	On Off	*		*	LED			BO					
323	Warn: Limit of Memory New exceeded (Warn Mem. New)	Device	OUT	On Off	*		*	LED			BO					
351	>Circuit breaker aux. contact: Pole L1 (>CB Aux. L1)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	1	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
352	>Circuit breaker aux. contact: Pole L2 (>CB Aux. L2)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	2	1	Yes
353	>Circuit breaker aux. contact: Pole L3 (>CB Aux. L3)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	3	1	Yes
356	>Manual close signal (>Manual Close)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	6	1	Yes
357	>Block manual close cmd. from external (>Blk Man. Close)	P.System Data 2	SP	On Off	*		*	LED	BI		BO		150	7	1	Yes
361	>Failure: Feeder VT (MCB tripped) (>FAIL:Feeder VT)	P.System Data 2	SP	On Off	*		*	LED	BI		BO		192	38	1	Yes
366	>CB1 Pole L1 (for AR,CB-Test) (>CB1 Pole L1)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	66	1	Yes
367	>CB1 Pole L2 (for AR,CB-Test) (>CB1 Pole L2)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	67	1	Yes
368	>CB1 Pole L3 (for AR,CB-Test) (>CB1 Pole L3)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	68	1	Yes
371	>CB1 READY (for AR,CB-Test) (>CB1 Ready)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	71	1	Yes
378	>CB faulty (>CB faulty)	P.System Data 2	SP	*	*		*	LED	BI		BO					
379	>CB aux. contact 3pole Closed (>CB 3p Closed)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	78	1	Yes
380	>CB aux. contact 3pole Open (>CB 3p Open)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	79	1	Yes
381	>Single-phase trip permitted from ext.AR (>1p Trip Perm)	P.System Data 2	SP	On Off	*		*	LED	BI		BO					
382	>External AR programmed for 1phase only (>Only 1ph AR)	P.System Data 2	SP	On Off	*		*	LED	BI		BO					
383	>Enable all AR Zones / Stages (>Enable ARzones)	P.System Data 2	SP	On Off	On Off		*	LED	BI		BO					
385	>Lockout SET (>Lockout SET)	P.System Data 2	SP	On Off	*		*	LED	BI		BO		150	35	1	Yes
386	>Lockout RESET (>Lockout RESET)	P.System Data 2	SP	On Off	*		*	LED	BI		BO		150	36	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
410	>CB1 aux. 3p Closed (for AR, CB-Test) (>CB1 3p Closed)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	80	1	Yes
411	>CB1 aux. 3p Open (for AR, CB-Test) (>CB1 3p Open)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	81	1	Yes
501	Relay PICKUP (Relay PICKUP)	P.System Data 2	OUT	*	*		m	LED			BO		192	84	2	Yes
502	Relay Drop Out (Relay Drop Out)	P.System Data 2	OUT													
503	Relay PICKUP Phase L1 (Relay PICKUP L1)	P.System Data 2	OUT	*	*		m	LED			BO		192	64	2	Yes
504	Relay PICKUP Phase L2 (Relay PICKUP L2)	P.System Data 2	OUT	*	*		m	LED			BO		192	65	2	Yes
505	Relay PICKUP Phase L3 (Relay PICKUP L3)	P.System Data 2	OUT	*	*		m	LED			BO		192	66	2	Yes
506	Relay PICKUP Earth (Relay PICKUP E)	P.System Data 2	OUT	*	*		m	LED			BO		192	67	2	Yes
507	Relay TRIP command Phase L1 (Relay TRIP L1)	P.System Data 2	OUT	*	*		m	LED			BO		192	69	2	No
508	Relay TRIP command Phase L2 (Relay TRIP L2)	P.System Data 2	OUT	*	*		m	LED			BO		192	70	2	No
509	Relay TRIP command Phase L3 (Relay TRIP L3)	P.System Data 2	OUT	*	*		m	LED			BO		192	71	2	No
510	Relay GENERAL CLOSE command (Relay CLOSE)	P.System Data 2	OUT	*	*		*	LED			BO					
511	Relay GENERAL TRIP command (Relay TRIP)	P.System Data 2	OUT	*	Off		m	LED			BO		192	68	2	No
512	Relay TRIP command - Only Phase L1 (Relay TRIP 1pL1)	P.System Data 2	OUT	*	*		*	LED			BO					
513	Relay TRIP command - Only Phase L2 (Relay TRIP 1pL2)	P.System Data 2	OUT	*	*		*	LED			BO					
514	Relay TRIP command - Only Phase L3 (Relay TRIP 1pL3)	P.System Data 2	OUT	*	*		*	LED			BO					
515	Relay TRIP command Phases L123 (Relay TRIP 3ph.)	P.System Data 2	OUT	*	*		*	LED			BO					
530	LOCKOUT is active (LOCKOUT)	P.System Data 2	IntSP	On Off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
533	Primary fault current IL1 (IL1 =)	P.System Data 2	VI	*	On Off								150	177	4	No
534	Primary fault current IL2 (IL2 =)	P.System Data 2	VI	*	On Off								150	178	4	No
535	Primary fault current IL3 (IL3 =)	P.System Data 2	VI	*	On Off								150	179	4	No
536	Relay Definitive TRIP (Definitive TRIP)	P.System Data 2	OUT	On	On			LED			BO		150	180	2	Yes
545	Time from Pickup to drop out (PU Time)	P.System Data 2	VI													
546	Time from Pickup to TRIP (TRIP Time)	P.System Data 2	VI													
560	Single-phase trip was coupled 3phase (Trip Coupled 3p)	P.System Data 2	OUT	*	On		*	LED			BO		150	210	2	No
561	Manual close signal detected (Man.Clos.Detect)	P.System Data 2	OUT	On	*		*	LED			BO		150	211	1	No
562	CB CLOSE command for manual closing (Man.Close Cmd)	P.System Data 2	OUT	*	*		*	LED			BO		150	212	1	No
563	CB alarm suppressed (CB Alarm Supp)	P.System Data 2	OUT	*	*		*	LED			BO					
590	Line closure detected (Line closure)	P.System Data 2	OUT	On Off	On Off		*	LED			BO					
591	Single pole open detected in L1 (1pole open L1)	P.System Data 2	OUT	On Off	On Off		*	LED			BO					
592	Single pole open detected in L2 (1pole open L2)	P.System Data 2	OUT	On Off	On Off		*	LED			BO					
593	Single pole open detected in L3 (1pole open L3)	P.System Data 2	OUT	On Off	On Off		*	LED			BO					
916	Increment of active energy (WpΔ=)	Energy	-													
917	Increment of reactive energy (WqΔ=)	Energy	-													
1000	Number of breaker TRIP commands (# TRIPs=)	Statistics	VI													
1001	Number of breaker TRIP commands L1 (TripNo L1=)	Statistics	VI													

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
1002	Number of breaker TRIP commands L2 (TripNo L2=)	Statistics	VI													
1003	Number of breaker TRIP commands L3 (TripNo L3=)	Statistics	VI													
1027	Accumulation of interrupted current L1 (Σ IL1 =)	Statistics	VI													
1028	Accumulation of interrupted current L2 (Σ IL2 =)	Statistics	VI													
1029	Accumulation of interrupted current L3 (Σ IL3 =)	Statistics	VI													
1030	Max. fault current Phase L1 (Max IL1 =)	Statistics	VI													
1031	Max. fault current Phase L2 (Max IL2 =)	Statistics	VI													
1032	Max. fault current Phase L3 (Max IL3 =)	Statistics	VI													
1401	>BF: Switch on breaker fail protection (>BF on)	Breaker Failure	SP	*	*		*	LED	BI		BO					
1402	>BF: Switch off breaker fail protection (>BF off)	Breaker Failure	SP	*	*		*	LED	BI		BO					
1403	>BLOCK Breaker failure (>BLOCK BkrFail)	Breaker Failure	SP	On Off	*		*	LED	BI		BO		166	103	1	Yes
1404	>BF Activate 3I0> threshold (>BFactivate3I0>)	Breaker Failure	SP	On Off	*		*	LED	BI		BO					
1415	>BF: External start 3pole (>BF Start 3pole)	Breaker Failure	SP	On Off	*		*	LED	BI		BO					
1424	>BF: Start only delay time T2 (>BF STARTonlyT2)	Breaker Failure	SP	On Off	On Off		*	LED	BI		BO					
1432	>BF: External release (>BF release)	Breaker Failure	SP	On Off	*		*	LED	BI		BO					
1435	>BF: External start L1 (>BF Start L1)	Breaker Failure	SP	On Off	*		*	LED	BI		BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
1436	>BF: External start L2 (>BF Start L2)	Breaker Failure	SP	On Off	*		*	LED	BI		BO					
1437	>BF: External start L3 (>BF Start L3)	Breaker Failure	SP	On Off	*		*	LED	BI		BO					
1439	>BF: External start 3pole (w/o current) (>BF Start w/o I)	Breaker Failure	SP	On Off	*		*	LED	BI		BO					
1440	Breaker failure prot. ON/OFF via BI (BkrFailON/offBI)	Breaker Failure	IntSP	On Off	*		*	LED			BO					
1451	Breaker failure is switched OFF (BkrFail OFF)	Breaker Failure	OUT	On Off	*		*	LED			BO		166	151	1	Yes
1452	Breaker failure is BLOCKED (BkrFail BLOCK)	Breaker Failure	OUT	On Off	On Off		*	LED			BO		166	152	1	Yes
1453	Breaker failure is ACTIVE (BkrFail ACTIVE)	Breaker Failure	OUT	*	*		*	LED			BO		166	153	1	Yes
1461	Breaker failure protection started (BF Start)	Breaker Failure	OUT	*	On Off		*	LED			BO		166	161	2	Yes
1466	Breaker failure L1 (BreakerFail. L1)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1467	Breaker failure L2 (BreakerFail. L2)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1468	Breaker failure L3 (BreakerFail. L3)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1469	Breaker failure 3I0 (BreakerFail 3I0)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1472	BF Trip T1 (local trip) - only phase L1 (BF T1-TRIP 1pL1)	Breaker Failure	OUT	*	On		*	LED			BO					
1473	BF Trip T1 (local trip) - only phase L2 (BF T1-TRIP 1pL2)	Breaker Failure	OUT	*	On		*	LED			BO					
1474	BF Trip T1 (local trip) - only phase L3 (BF T1-TRIP 1pL3)	Breaker Failure	OUT	*	On		*	LED			BO					
1476	BF Trip T1 (local trip) - 3pole (BF T1-TRIP L123)	Breaker Failure	OUT	*	On		*	LED			BO					
1493	BF Trip in case of defective CB (BF TRIP CBdefec)	Breaker Failure	OUT	*	On		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
1494	BF Trip T2 (busbar trip) (BF T2-TRIP(bus))	Breaker Failure	OUT	*	On		*	LED			BO		192	85	2	No
1495	BF Trip End fault stage (BF EndFlt TRIP)	Breaker Failure	OUT	*	On		*	LED			BO					
1496	BF Pole discrepancy pickup (BF CBdiscrSTART)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1497	BF Pole discrepancy pickup L1 (BF CBdiscr L1)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1498	BF Pole discrepancy pickup L2 (BF CBdiscr L2)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1499	BF Pole discrepancy pickup L3 (BF CBdiscr L3)	Breaker Failure	OUT	*	On Off		*	LED			BO					
1500	BF Pole discrepancy Trip (BF CBdiscr TRIP)	Breaker Failure	OUT	*	On		*	LED			BO					
1503	>BLOCK Thermal Overload Protection (>BLK ThOverload)	Therm. Overload	SP	*	*		*	LED	BI		BO		167	3	1	Yes
1511	Thermal Overload Protection OFF (Th.Overload OFF)	Therm. Overload	OUT	On Off	*		*	LED			BO		167	11	1	Yes
1512	Thermal Overload Protection BLOCKED (Th.Overload BLK)	Therm. Overload	OUT	On Off	On Off		*	LED			BO		167	12	1	Yes
1513	Thermal Overload Protection ACTIVE (Th.O/L ACTIVE)	Therm. Overload	OUT	On Off	*		*	LED			BO		167	13	1	Yes
1515	Th. Overload: Current Alarm (I alarm) (Th.O/L I Alarm)	Therm. Overload	OUT	On Off	*		*	LED			BO		167	15	1	Yes
1516	Th. Overload Alarm: Near Thermal Trip (Th.O/L Θ Alarm)	Therm. Overload	OUT	On Off	*		*	LED			BO		167	16	1	Yes
1517	Th. Overload Pickup before trip (Th.O/L Pickup)	Therm. Overload	OUT	On Off	*		*	LED			BO		167	17	1	Yes
1521	Th. Overload TRIP command (Th.O/L TRIP)	Therm. Overload	OUT	*	On		*	LED			BO		167	21	2	Yes
2054	Emergency mode (Emer. mode)	Device	OUT	On Off	On Off		*	LED			BO		192	37	1	Yes
2701	>AR: Switch on auto-reclose function (>AR on)	Auto Reclose	SP	*	*		*	LED	BI		BO		40	1	1	Yes
2702	>AR: Switch off auto-reclose function (>AR off)	Auto Reclose	SP	*	*		*	LED	BI		BO		40	2	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
2703	>AR: Block auto-reclose function (>AR block)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	3	1	Yes
2711	>External start of internal Auto reclose (>AR Start)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	11	2	Yes
2712	>AR: External trip L1 for AR start (>Trip L1 AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	12	2	Yes
2713	>AR: External trip L2 for AR start (>Trip L2 AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	13	2	Yes
2714	>AR: External trip L3 for AR start (>Trip L3 AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	14	2	Yes
2715	>AR: External 1pole trip for AR start (>Trip 1pole AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	15	2	Yes
2716	>AR: External 3pole trip for AR start (>Trip 3pole AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	16	2	Yes
2727	>AR: Remote Close signal (>AR RemoteClose)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	22	2	Yes
2731	>AR: Sync. release from ext. sync.-check (>Sync.release)	Auto Reclose	SP	*	*		*	LED	BI		BO		40	31	2	Yes
2737	>AR: Block 1pole AR-cycle (>BLOCK 1pole AR)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	32	1	Yes
2738	>AR: Block 3pole AR-cycle (>BLOCK 3pole AR)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	33	1	Yes
2739	>AR: Block 1phase-fault AR-cycle (>BLK 1phase AR)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	34	1	Yes
2740	>AR: Block 2phase-fault AR-cycle (>BLK 2phase AR)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	35	1	Yes
2741	>AR: Block 3phase-fault AR-cycle (>BLK 3phase AR)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	36	1	Yes
2742	>AR: Block 1st AR-cycle (>BLK 1.AR-cycle)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	37	1	Yes
2743	>AR: Block 2nd AR-cycle (>BLK 2.AR-cycle)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	38	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
2744	>AR: Block 3rd AR-cycle (>BLK 3.AR-cycle)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	39	1	Yes
2745	>AR: Block 4th and higher AR-cycles (>BLK 4.-n. AR)	Auto Reclose	SP	On Off	*		*	LED	BI		BO		40	40	1	Yes
2746	>AR: External Trip for AR start (>Trip for AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	41	2	Yes
2747	>AR: External pickup L1 for AR start (>Pickup L1 AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	42	2	Yes
2748	>AR: External pickup L2 for AR start (>Pickup L2 AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	43	2	Yes
2749	>AR: External pickup L3 for AR start (>Pickup L3 AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	44	2	Yes
2750	>AR: External pickup 1phase for AR start (>Pickup 1ph AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	45	2	Yes
2751	>AR: External pickup 2phase for AR start (>Pickup 2ph AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	46	2	Yes
2752	>AR: External pickup 3phase for AR start (>Pickup 3ph AR)	Auto Reclose	SP	*	On		*	LED	BI		BO		40	47	2	Yes
2781	AR: Auto-reclose is switched off (AR off)	Auto Reclose	OUT	On Off	*		*	LED			BO		40	81	1	Yes
2782	AR: Auto-reclose is switched on (AR on)	Auto Reclose	IntSP	*	*		*	LED			BO		192	16	1	Yes
2783	AR: Auto-reclose is blocked (AR is blocked)	Auto Reclose	OUT	On Off	*		*	LED			BO		40	83	1	Yes
2784	AR: Auto-reclose is not ready (AR not ready)	Auto Reclose	OUT	*	On		*	LED			BO		192	130	1	Yes
2787	AR: Circuit breaker not ready (CB not ready)	Auto Reclose	OUT	*	*		*	LED			BO		40	87	1	Yes
2788	AR: CB ready monitoring window expired (AR T-CBreadyExp)	Auto Reclose	OUT	*	On		*	LED			BO		40	88	2	Yes
2796	AR: Auto-reclose ON/OFF via BI (AR on/off BI)	Auto Reclose	IntSP	*	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
2801	AR: Auto-reclose in progress (AR in progress)	Auto Reclose	OUT	*	On		*	LED			BO		40	101	2	Yes
2809	AR: Start-signal monitoring time expired (AR T-Start Exp)	Auto Reclose	OUT	*	On		*	LED			BO		40	174	2	Yes
2810	AR: Maximum dead time expired (AR TdeadMax Exp)	Auto Reclose	OUT	*	On		*	LED			BO		40	175	2	Yes
2818	AR: Evolving fault recognition (AR evolving Flt)	Auto Reclose	OUT	*	On		*	LED			BO		40	118	2	Yes
2820	AR is set to operate after 1p trip only (AR Program1pole)	Auto Reclose	OUT	*	*		*	LED			BO		40	143	1	Yes
2821	AR dead time after evolving fault (AR Td. evol.Flt)	Auto Reclose	OUT	*	On Off		*	LED			BO		40	197	2	Yes
2839	AR dead time after 1pole trip running (AR Tdead 1pTrip)	Auto Reclose	OUT	*	On		*	LED			BO		40	148	2	Yes
2840	AR dead time after 3pole trip running (AR Tdead 3pTrip)	Auto Reclose	OUT	*	On		*	LED			BO		40	149	2	Yes
2841	AR dead time after 1phase fault running (AR Tdead 1pFlt)	Auto Reclose	OUT	*	On		*	LED			BO		40	150	2	Yes
2842	AR dead time after 2phase fault running (AR Tdead 2pFlt)	Auto Reclose	OUT	*	On		*	LED			BO		40	151	2	Yes
2843	AR dead time after 3phase fault running (AR Tdead 3pFlt)	Auto Reclose	OUT	*	On		*	LED			BO		40	154	2	Yes
2844	AR 1st cycle running (AR 1stCyc. run.)	Auto Reclose	OUT	*	On		*	LED			BO		40	155	2	Yes
2845	AR 2nd cycle running (AR 2ndCyc. run.)	Auto Reclose	OUT	*	On		*	LED			BO		40	157	2	Yes
2846	AR 3rd cycle running (AR 3rdCyc. run.)	Auto Reclose	OUT	*	On		*	LED			BO		40	158	2	Yes
2847	AR 4th or higher cycle running (AR 4thCyc. run.)	Auto Reclose	OUT	*	On		*	LED			BO		40	159	2	Yes
2848	AR cycle is running in ADT mode (AR ADT run.)	Auto Reclose	OUT	*	On		*	LED			BO		40	130	2	Yes
2851	AR: Close command (AR CLOSE Cmd.)	Auto Reclose	OUT	*	On		m	LED			BO		192	128	2	No

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
2852	AR: Close command after 1pole, 1st cycle (AR Close1.Cyc1p)	Auto Reclose	OUT	*	*		*	LED			BO		40	152	1	Yes
2853	AR: Close command after 3pole, 1st cycle (AR Close1.Cyc3p)	Auto Reclose	OUT	*	*		*	LED			BO		40	153	1	Yes
2854	AR: Close command 2nd cycle (and higher) (AR Close 2.Cyc)	Auto Reclose	OUT	*	*		*	LED			BO		192	129	1	No
2861	AR: Reclaim time is running (AR T-Recl. run.)	Auto Reclose	OUT	*	*		*	LED			BO		40	161	1	Yes
2862	AR successful (AR successful)	Auto Reclose	OUT	*	*		*	LED			BO		40	162	1	Yes
2864	AR: 1pole trip permitted by internal AR (AR 1p Trip Perm)	Auto Reclose	OUT	*	*		*	LED			BO		40	164	1	Yes
2865	AR: Synchro-check request (AR Sync.Request)	Auto Reclose	OUT	*	*		*	LED			BO		40	165	2	Yes
2871	AR: TRIP command 3pole (AR TRIP 3pole)	Auto Reclose	OUT	*	On		*	LED			BO		40	171	2	Yes
2889	AR 1st cycle zone extension release (AR 1.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	160	1	Yes
2890	AR 2nd cycle zone extension release (AR 2.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	169	1	Yes
2891	AR 3rd cycle zone extension release (AR 3.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	170	1	Yes
2892	AR 4th cycle zone extension release (AR 4.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	172	1	Yes
2893	AR zone extension (general) (AR Zone Release)	Auto Reclose	OUT	*	*		*	LED			BO		40	173	1	Yes
2894	AR Remote close signal send (AR Remote Close)	Auto Reclose	OUT	*	On		*	LED			BO		40	129	2	Yes
2895	No. of 1st AR-cycle CLOSE commands,1pole (AR #Close1./1p=)	Statistics	VI													
2896	No. of 1st AR-cycle CLOSE commands,3pole (AR #Close1./3p=)	Statistics	VI													

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
2897	No. of higher AR-cycle CLOSE commands,1p (AR #Close2./1p=)	Statistics	VI													
2898	No. of higher AR-cycle CLOSE commands,3p (AR #Close2./3p=)	Statistics	VI													
3102	Diff: 2nd Harmonic detected in phase L1 (2nd Harmonic L1)	Diff. Prot	OUT	*	*		*	LED			BO		92	89	1	Yes
3103	Diff: 2nd Harmonic detected in phase L2 (2nd Harmonic L2)	Diff. Prot	OUT	*	*		*	LED			BO		92	90	1	Yes
3104	Diff: 2nd Harmonic detected in phase L3 (2nd Harmonic L3)	Diff. Prot	OUT	*	*		*	LED			BO		92	91	1	Yes
3120	Diff: Active (Diff active)	Diff. Prot	OUT	On Off	*		m	LED			BO		92	92	1	Yes
3132	Diff: Fault detection (Diff. Gen. Flt.)	Diff. Prot	OUT	*	On Off		m	LED			BO					
3133	Diff: Fault detection in phase L1 (Diff. Flt. L1)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	93	2	Yes
3134	Diff: Fault detection in phase L2 (Diff. Flt. L2)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	94	2	Yes
3135	Diff: Fault detection in phase L3 (Diff. Flt. L3)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	95	2	Yes
3136	Diff: Earth fault detection (Diff. Flt. E)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	96	2	Yes
3137	Diff: Fault detection of I-Diff>> (I-Diff>> Flt.)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	97	2	Yes
3139	Diff: Fault detection of I-Diff> (I-Diff> Flt.)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	98	2	Yes
3141	Diff: General TRIP (Diff. Gen. TRIP)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	99	2	Yes
3142	Diff: TRIP - Only L1 (Diff TRIP 1p L1)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	100	2	Yes
3143	Diff: TRIP - Only L2 (Diff TRIP 1p L2)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	101	2	Yes
3144	Diff: TRIP - Only L3 (Diff TRIP 1p L3)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	102	2	Yes
3145	Diff: TRIP L123 (Diff TRIP L123)	Diff. Prot	OUT	*	On Off		m	LED			BO		92	103	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3146	Diff: TRIP 1pole (Diff TRIP 1pole)	Diff. Prot	OUT	*	On Off		*	LED			BO					
3147	Diff: TRIP 3pole (Diff TRIP 3pole)	Diff. Prot	OUT	*	On Off		*	LED			BO					
3148	Diff: Differential protection is blocked (Diff block)	Diff. Prot	OUT	On Off	*		*	LED			BO		92	104	1	Yes
3149	Diff: Diff. protection is switched off (Diff OFF)	Diff. Prot	OUT	On Off	*		*	LED			BO		92	105	1	Yes
3176	Diff: Fault detection L1 (only) (Diff Flt. 1p.L1)	Diff. Prot	OUT	*	*		*	LED			BO					
3177	Diff: Fault detection L1E (Diff Flt. L1E)	Diff. Prot	OUT	*	*		*	LED			BO					
3178	Diff: Fault detection L2 (only) (Diff Flt. 1p.L2)	Diff. Prot	OUT	*	*		*	LED			BO					
3179	Diff: Fault detection L2E (Diff Flt. L2E)	Diff. Prot	OUT	*	*		*	LED			BO					
3180	Diff: Fault detection L12 (Diff Flt. L12)	Diff. Prot	OUT	*	*		*	LED			BO					
3181	Diff: Fault detection L12E (Diff Flt. L12E)	Diff. Prot	OUT	*	*		*	LED			BO					
3182	Diff: Fault detection L3 (only) (Diff Flt. 1p.L3)	Diff. Prot	OUT	*	*		*	LED			BO					
3183	Diff: Fault detection L3E (Diff Flt. L3E)	Diff. Prot	OUT	*	*		*	LED			BO					
3184	Diff: Fault detection L31 (Diff Flt. L31)	Diff. Prot	OUT	*	*		*	LED			BO					
3185	Diff: Fault detection L31E (Diff Flt. L31E)	Diff. Prot	OUT	*	*		*	LED			BO					
3186	Diff: Fault detection L23 (Diff Flt. L23)	Diff. Prot	OUT	*	*		*	LED			BO					
3187	Diff: Fault detection L23E (Diff Flt. L23E)	Diff. Prot	OUT	*	*		*	LED			BO					
3188	Diff: Fault detection L123 (Diff Flt. L123)	Diff. Prot	OUT	*	*		*	LED			BO					
3189	Diff: Fault detection L123E (Diff Flt. L123E)	Diff. Prot	OUT	*	*		*	LED			BO					
3190	Diff: Set Teststate of Diff. protection (Test Diff.)	Diff. Prot	IntSP	On Off	*		*	LED		FK TO NL IN E	BO		92	106	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3191	Diff: Set Commissioning state of Diff. (Comm. Diff)	Diff. Prot	IntSP	On Off	*		*	LED		FK TO NL IN E	BO		92	107	1	Yes
3192	Diff: Remote relay in Test-state (TestDiff.remote)	Diff. Prot	OUT	On Off	*		*	LED			BO		92	108	1	Yes
3193	Diff: Commissioning state is active (Comm.Diff act.)	Diff. Prot	OUT	On Off	*		*	LED			BO		92	109	1	Yes
3197	Diff: >Set Teststate of Diff. protection (>Test Diff. ON)	Diff. Prot	SP	On Off	*		*	LED	BI		BO					
3198	Diff: >Reset Teststate of Diff. protec. (>Test Diff. OFF)	Diff. Prot	SP	On Off	*		*	LED	BI		BO					
3199	Diff: Teststate of Diff. prot. ON/OFF (Test Diff.ONoff)	Diff. Prot	IntSP	On Off	*		*	LED			BO					
3200	Diff: Teststate ON/OFF via BI (TestDiffONoffBI)	Diff. Prot	IntSP	On Off	*		*	LED			BO					
3215	Incompatible Firmware Versions (Wrong Firmware)	Prot. Interface	OUT	On	*			LED			BO					
3217	Prot Int 1: Own Datas received (PI1 Data reflec)	Prot. Interface	OUT	On Off	*			LED			BO					
3227	>Prot Int 1: Transmitter is switched off (>PI1 light off)	Prot. Interface	SP	On Off	*		*	LED	BI		BO					
3229	Prot Int 1: Reception of faulty data (PI1 Data fault)	Prot. Interface	OUT	On Off	*		*	LED			BO		93	135	1	Yes
3230	Prot Int 1: Total receiption failure (PI1 Datafailure)	Prot. Interface	OUT	On Off	*		*	LED			BO		93	136	1	Yes
3233	Device table has inconsistent numbers (DT inconsistent)	Prot. Interface	OUT	On Off	*			LED			BO					
3234	Device tables are unequal (DT unequal)	Prot. Interface	OUT	On Off	*			LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3235	Differences between common parameters (Par. different)	Prot. Interface	OUT	On Off	*			LED			BO					
3239	Prot Int 1: Transmission delay too high (PI1 TD alarm)	Prot. Interface	OUT	On Off	*			LED			BO		93	139	1	Yes
3243	Prot Int 1: Connected with relay ID (PI1 with)	Prot. Interface	VI	On Off	*											
3245	> GPS failure from external (>GPS failure)	Prot. Interface	SP	On Off	*		*	LED	BI		BO					
3247	GPS: local pulse loss (GPS loss)	Prot. Interface	OUT	On Off	*		*	LED			BO					
3248	GPS: Prot Int 1 is GPS sychronized (PI 1 GPS sync.)	Prot. Interface	OUT	On Off	*		*	LED			BO					
3250	GPS:PI1 unsym.propagation delay too high (PI 1 PD unsym.)	Prot. Interface	OUT	On Off	*		*	LED			BO					
3252	> PI1 Synchronization RESET (>SYNC PI1 RESET)	Prot. Interface	SP	On Off	*		*	LED	BI		BO					
3254	Prot.1: Delay time change recognized (PI1 jump)	Prot. Interface	OUT	On Off	*		*	LED			BO					
3256	Prot.1: Delay time unsymmetry to large (PI1 unsym.)	Prot. Interface	IntSP	On Off	*			LED			BO					
3258	ProtInt1:Permissible error rate exceeded (PI1 Error)	Prot. Interface	OUT	On Off	*		*	LED			BO					
3260	Diff: >Commissioning state ON (>Comm. Diff ON)	Diff. Prot	SP	On Off	*		*	LED	BI		BO					
3261	Diff: >Commissioning state OFF (>Comm. Diff OFF)	Diff. Prot	SP	On Off	*		*	LED	BI		BO					
3262	Diff: Commissioning state ON/OFF (Comm Diff.ONoff)	Diff. Prot	IntSP	On Off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3263	Diff: Commissioning state ON/OFF via BI (CommDiffONoffBI)	Diff. Prot	IntSP	On Off	*		*	LED			BO					
3270	>RESET broken wire monitoring (>RESET BW)	Meas-urem.Superv	SP	On Off	*		*	LED	BI	FK TO NL IN E	BO					
3271	Alarm: Broken current-wire detected L1 (Broken Iwire L1)	Meas-urem.Superv	IntSP	*	*											
3272	Alarm: Broken current-wire detected L2 (Broken Iwire L2)	Meas-urem.Superv	IntSP	*	*											
3273	Alarm: Broken current-wire detected L3 (Broken Iwire L3)	Meas-urem.Superv	IntSP	*	*											
3274	PI1: IEEE C37.94 not supported by module (PI1: C37.94 n/a)	Prot. Inter-face	OUT	On Off	*		*	LED			BO					
3277	GPS signal ok (GPS signal ok)	Prot. Inter-face	OUT	On Off	*		*	LED			BO					
3452	> Logout state ON (>Logout ON)	Diff.-Topo	SP	On Off	*		*	LED	BI		BO					
3453	> Logout state OFF (>Logout OFF)	Diff.-Topo	SP	On Off	*		*	LED	BI		BO					
3458	System operates in a open Chaintopology (Chaintopology)	Diff.-Topo	OUT	On Off	*		*	LED			BO		93	142	1	Yes
3459	Logout state ON/OFF (Logout ON/off)	Diff.-Topo	IntSP	On Off	*		*	LED			BO					
3460	Logout state ON/OFF via BI (Logout ON/offBI)	Diff.-Topo	IntSP	On Off	*		*	LED			BO					
3464	Communication topology is complete (Topol complete)	Diff.-Topo	OUT	On Off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3475	Relay 1 in Logout state (Rel1Logout)	Diff.-Topo	IntSP	On Off	*		*	LED		FK TO NL IN E	BO		93	143	1	Yes
3476	Relay 2 in Logout state (Rel2Logout)	Diff.-Topo	IntSP	On Off	*		*	LED		FK TO NL IN E	BO		93	144	1	Yes
3484	Local activation of Logout state (Logout)	Diff.-Topo	IntSP	On Off	*		*	LED		FK TO NL IN E	BO		93	149	1	Yes
3487	Equal IDs in constellation (Equal IDs)	Diff.-Topo	OUT	On Off	*		*	LED			BO					
3491	Relay 1 in Login state (Rel1 Login)	Diff.-Topo	OUT	On Off	*		*	LED			BO		93	191	1	Yes
3492	Relay 2 in Login state (Rel2 Login)	Diff.-Topo	OUT	On Off	*		*	LED			BO		93	192	1	Yes
3501	I.Trip: >Intertrip L1 signal input (>Intertrip L1)	Intertrip	SP	On Off	*		*	LED	BI		BO					
3502	I.Trip: >Intertrip L2 signal input (>Intertrip L2)	Intertrip	SP	On Off	*		*	LED	BI		BO					
3503	I.Trip: >Intertrip L3 signal input (>Intertrip L3)	Intertrip	SP	On Off	*		*	LED	BI		BO					
3504	I.Trip: >Intertrip 3 pole signal input (>Intertrip 3pol)	Intertrip	SP	On Off	*		*	LED	BI		BO					
3505	I.Trip: Received at Prot.Interface 1 L1 (ITrp.rec.PI1.L1)	Intertrip	OUT	On Off	*		*	LED			BO					
3506	I.Trip: Received at Prot.Interface 1 L2 (ITrp.rec.PI1.L2)	Intertrip	OUT	On Off	*		*	LED			BO					
3507	I.Trip: Received at Prot.Interface 1 L3 (ITrp.rec.PI1.L3)	Intertrip	OUT	On Off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3511	I.Trip: Sending at Prot.Interface 1 L1 (ITrp.sen.PI1.L1)	Intertrip	OUT	On Off	*		*	LED			BO					
3512	I.Trip: Sending at Prot.Interface 1 L2 (ITrp.sen.PI1.L2)	Intertrip	OUT	On Off	*		*	LED			BO					
3513	I.Trip: Sending at Prot.Interface 1 L3 (ITrp.sen.PI1.L3)	Intertrip	OUT	On Off	*		*	LED			BO					
3517	I.Trip: General TRIP (ITrp. Gen. TRIP)	Intertrip	OUT	*	On Off		m	LED			BO					
3518	I.Trip: TRIP - Only L1 (ITrp.TRIP 1p L1)	Intertrip	OUT	*	On Off		m	LED			BO		93	150	2	Yes
3519	I.Trip: TRIP - Only L2 (ITrp.TRIP 1p L2)	Intertrip	OUT	*	On Off		m	LED			BO		93	151	2	Yes
3520	I.Trip: TRIP - Only L3 (ITrp.TRIP 1p L3)	Intertrip	OUT	*	On Off		m	LED			BO		93	152	2	Yes
3521	I.Trip: TRIP L123 (ITrp.TRIP L123)	Intertrip	OUT	*	On Off		m	LED			BO		93	153	2	Yes
3522	I.Trip: TRIP 1pole (ITrp.TRIP 1pole)	Intertrip	OUT	*	On Off		*	LED			BO					
3523	I.Trip: TRIP 3pole (ITrp.TRIP 3pole)	Intertrip	OUT	*	On Off		*	LED			BO					
3525	>Differential protection blocking signal (> Diff block)	Diff. Prot	SP	On Off	*		*	LED	BI		BO					
3526	Differential blocking received at PI1 (Diffblk.rec PI1)	Diff. Prot	OUT	On Off	*		*	LED			BO					
3528	Differential blocking sending via PI1 (Diffblk.sen PI1)	Diff. Prot	OUT	On Off	*		*	LED			BO					
3541	>Remote Command 1 signal input (>Remote CMD 1)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3542	>Remote Command 2 signal input (>Remote CMD 2)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3543	>Remote Command 3 signal input (>Remote CMD 3)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3544	>Remote Command 4 signal input (>Remote CMD 4)	Remote Signals	SP	On Off	*		*	LED	BI		BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3545	Remote Command 1 received (Remote CMD1 rec)	Remote Signals	OUT	On Off	*		*	LED			BO		93	154	1	Yes
3546	Remote Command 2 received (Remote CMD2 rec)	Remote Signals	OUT	On Off	*		*	LED			BO		93	155	1	Yes
3547	Remote Command 3 received (Remote CMD3 rec)	Remote Signals	OUT	On Off	*		*	LED			BO		93	156	1	Yes
3548	Remote Command 4 received (Remote CMD4 rec)	Remote Signals	OUT	On Off	*		*	LED			BO		93	157	1	Yes
3549	>Remote Signal 1 input (>Rem. Signal 1)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3550	>Remote Signal 2 input (>Rem.Signal 2)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3551	>Remote Signal 3 input (>Rem.Signal 3)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3552	>Remote Signal 4 input (>Rem.Signal 4)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3553	>Remote Signal 5 input (>Rem.Signal 5)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3554	>Remote Signal 6 input (>Rem.Signal 6)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3555	>Remote Signal 7 input (>Rem.Signal 7)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3556	>Remote Signal 8 input (>Rem.Signal 8)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3557	>Remote Signal 9 input (>Rem.Signal 9)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3558	>Remote Signal 10 input (>Rem.Signal10)	Remote Signals	SP	On Off	*		*	LED	BI		BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3559	>Remote Signal 11 input (>Rem.Signal11)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3560	>Remote Signal 12 input (>Rem.Signal12)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3561	>Remote Signal 13 input (>Rem.Signal13)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3562	>Remote Signal 14 input (>Rem.Signal14)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3563	>Remote Signal 15 input (>Rem.Signal15)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3564	>Remote Signal 16 input (>Rem.Signal16)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3565	>Remote Signal 17 input (>Rem.Signal17)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3566	>Remote Signal 18 input (>Rem.Signal18)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3567	>Remote Signal 19 input (>Rem.Signal19)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3568	>Remote Signal 20 input (>Rem.Signal20)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3569	>Remote Signal 21 input (>Rem.Signal21)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3570	>Remote Signal 22 input (>Rem.Signal22)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3571	>Remote Signal 23 input (>Rem.Signal23)	Remote Signals	SP	On Off	*		*	LED	BI		BO					
3572	>Remote Signal 24 input (>Rem.Signal24)	Remote Signals	SP	On Off	*		*	LED	BI		BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3573	Remote signal 1 received (Rem.Sig 1recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	158	1	Yes
3574	Remote signal 2 received (Rem.Sig 2recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	159	1	Yes
3575	Remote signal 3 received (Rem.Sig 3recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	160	1	Yes
3576	Remote signal 4 received (Rem.Sig 4recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	161	1	Yes
3577	Remote signal 5 received (Rem.Sig 5recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	162	1	Yes
3578	Remote signal 6 received (Rem.Sig 6recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	163	1	Yes
3579	Remote signal 7 received (Rem.Sig 7recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	164	1	Yes
3580	Remote signal 8 received (Rem.Sig 8recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	165	1	Yes
3581	Remote signal 9 received (Rem.Sig 9recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	166	1	Yes
3582	Remote signal 10 received (Rem.Sig10recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	167	1	Yes
3583	Remote signal 11 received (Rem.Sig11recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	168	1	Yes
3584	Remote signal 12 received (Rem.Sig12recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	169	1	Yes
3585	Remote signal 13 received (Rem.Sig13recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	170	1	Yes
3586	Remote signal 14 received (Rem.Sig14recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	171	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
3587	Remote signal 15 received (Rem.Sig15recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	172	1	Yes
3588	Remote signal 16 received (Rem.Sig16recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	173	1	Yes
3589	Remote signal 17 received (Rem.Sig17recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	174	1	Yes
3590	Remote signal 18 received (Rem.Sig18recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	175	1	Yes
3591	Remote signal 19 received (Rem.Sig19recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	176	1	Yes
3592	Remote signal 20 received (Rem.Sig20recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	177	1	Yes
3593	Remote signal 21 received (Rem.Sig21recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	178	1	Yes
3594	Remote signal 22 received (Rem.Sig22recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	179	1	Yes
3595	Remote signal 23 received (Rem.Sig23recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	180	1	Yes
3596	Remote signal 24 received (Rem.Sig24recv)	Remote Signals	OUT	On Off	*		*	LED			BO		93	181	1	Yes
4253	>BLOCK Instantaneous SOTF Overcurrent (>BLOCK SOTF-O/C)	SOTF Over-curr.	SP	*	*		*	LED	BI		BO					
4271	SOTF-O/C is switched OFF (SOTF-O/C OFF)	SOTF Over-curr.	OUT	On Off	*		*	LED			BO		25	71	1	Yes
4272	SOTF-O/C is BLOCKED (SOTF-O/C BLOCK)	SOTF Over-curr.	OUT	On Off	On Off		*	LED			BO		25	72	1	Yes
4273	SOTF-O/C is ACTIVE (SOTF-O/C ACTIVE)	SOTF Over-curr.	OUT	*	*		*	LED			BO		25	73	1	Yes
4281	SOTF-O/C PICKED UP (SOTF-O/C PICKUP)	SOTF Over-curr.	OUT	*	Off		m	LED			BO		25	81	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
4282	SOTF-O/C Pickup L1 (SOF O/CpickupL1)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	82	2	Yes
4283	SOTF-O/C Pickup L2 (SOF O/CpickupL2)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	83	2	Yes
4284	SOTF-O/C Pickup L3 (SOF O/CpickupL3)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	84	2	Yes
4285	High Speed-O/C Pickup I>>>> L1 (I>>>>O/C p.upL1)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	85	2	Yes
4286	High Speed-O/C Pickup I>>>> L2 (I>>>>O/C p.upL2)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	86	2	Yes
4287	High Speed-O/C Pickup I>>>> L3 (I>>>>O/C p.upL3)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	87	2	Yes
4289	High Speed/SOTF-O/C TRIP - Only L1 (HS/SOF TRIP1pL1)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	89	2	Yes
4290	High Speed/SOTF-O/C TRIP - Only L2 (HS/SOF TRIP1pL2)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	90	2	Yes
4291	High Speed/SOTF-O/C TRIP - Only L3 (HS/SOF TRIP1pL3)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	91	2	Yes
4292	High Speed/SOTF-O/C TRIP 1pole (HS/SOF TRIP 1p)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	94	2	No
4293	High Speed/SOTF-O/C General TRIP (HS/SOF Gen.TRIP)	SOTF Over-curr.	OUT	*	On		*	LED			BO					
4294	High Speed/SOTF-O/C TRIP 3pole (HS/SOF TRIP 3p)	SOTF Over-curr.	OUT	*	On		*	LED			BO					
4295	High Speed/SOTF-O/C TRIP command L123 (HS/SOF TRIPL123)	SOTF Over-curr.	OUT	*	On		*	LED			BO		25	95	2	Yes
4403	>BLOCK Direct Transfer Trip function (>BLOCK DTT)	DTT Direct Trip	SP	*	*		*	LED	BI		BO					
4412	>Direct Transfer Trip INPUT Phase L1 (>DTT Trip L1)	DTT Direct Trip	SP	On Off	*		*	LED	BI		BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
4413	>Direct Transfer Trip INPUT Phase L2 (>DTT Trip L2)	DTT Direct Trip	SP	On Off	*		*	LED	BI		BO					
4414	>Direct Transfer Trip INPUT Phase L3 (>DTT Trip L3)	DTT Direct Trip	SP	On Off	*		*	LED	BI		BO					
4417	>Direct Transfer Trip INPUT 3ph L123 (>DTT Trip L123)	DTT Direct Trip	SP	On Off	*		*	LED	BI		BO					
4421	Direct Transfer Trip is switched OFF (DTT OFF)	DTT Direct Trip	OUT	On Off	*		*	LED			BO		51	21	1	Yes
4422	Direct Transfer Trip is BLOCKED (DTT BLOCK)	DTT Direct Trip	OUT	On Off	On Off		*	LED			BO		51	22	1	Yes
4432	DTT TRIP command - Only L1 (DTT TRIP 1p. L1)	DTT Direct Trip	OUT	*	On		*	LED			BO		51	32	2	No
4433	DTT TRIP command - Only L2 (DTT TRIP 1p. L2)	DTT Direct Trip	OUT	*	On		*	LED			BO		51	33	2	No
4434	DTT TRIP command - Only L3 (DTT TRIP 1p. L3)	DTT Direct Trip	OUT	*	On		*	LED			BO		51	34	2	No
4435	DTT TRIP command L123 (DTT TRIP L123)	DTT Direct Trip	OUT	*	On		*	LED			BO		51	35	2	No
5203	>BLOCK frequency protection (>BLOCK Freq.)	Frequency Prot.	SP	On Off	*		*	LED	BI		BO		70	176	1	Yes
5206	>BLOCK frequency protection stage f1 (>BLOCK f1)	Frequency Prot.	SP	On Off	*		*	LED	BI		BO		70	177	1	Yes
5207	>BLOCK frequency protection stage f2 (>BLOCK f2)	Frequency Prot.	SP	On Off	*		*	LED	BI		BO		70	178	1	Yes
5208	>BLOCK frequency protection stage f3 (>BLOCK f3)	Frequency Prot.	SP	On Off	*		*	LED	BI		BO		70	179	1	Yes
5209	>BLOCK frequency protection stage f4 (>BLOCK f4)	Frequency Prot.	SP	On Off	*		*	LED	BI		BO		70	180	1	Yes
5211	Frequency protection is switched OFF (Freq. OFF)	Frequency Prot.	OUT	On Off	*		*	LED			BO		70	181	1	Yes
5212	Frequency protection is BLOCKED (Freq. BLOCKED)	Frequency Prot.	OUT	On Off	On Off		*	LED			BO		70	182	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
5213	Frequency protection is ACTIVE (Freq. ACTIVE)	Frequency Prot.	OUT	On Off	*		*	LED			BO		70	183	1	Yes
5215	Frequency protection undervoltage Blk (Freq UnderV Blk)	Frequency Prot.	OUT	On Off	On Off		*	LED			BO		70	238	1	Yes
5232	Frequency protection: f1 picked up (f1 picked up)	Frequency Prot.	OUT	*	On Off		*	LED			BO		70	230	2	Yes
5233	Frequency protection: f2 picked up (f2 picked up)	Frequency Prot.	OUT	*	On Off		*	LED			BO		70	231	2	Yes
5234	Frequency protection: f3 picked up (f3 picked up)	Frequency Prot.	OUT	*	On Off		*	LED			BO		70	232	2	Yes
5235	Frequency protection: f4 picked up (f4 picked up)	Frequency Prot.	OUT	*	On Off		*	LED			BO		70	233	2	Yes
5236	Frequency protection: f1 TRIP (f1 TRIP)	Frequency Prot.	OUT	*	On		*	LED			BO		70	234	2	Yes
5237	Frequency protection: f2 TRIP (f2 TRIP)	Frequency Prot.	OUT	*	On		*	LED			BO		70	235	2	Yes
5238	Frequency protection: f3 TRIP (f3 TRIP)	Frequency Prot.	OUT	*	On		*	LED			BO		70	236	2	Yes
5239	Frequency protection: f4 TRIP (f4 TRIP)	Frequency Prot.	OUT	*	On		*	LED			BO		70	237	2	Yes
5240	Frequency protection: TimeOut Stage f1 (Time Out f1)	Frequency Prot.	OUT	*	*		*	LED			BO					
5241	Frequency protection: TimeOut Stage f2 (Time Out f2)	Frequency Prot.	OUT	*	*		*	LED			BO					
5242	Frequency protection: TimeOut Stage f3 (Time Out f3)	Frequency Prot.	OUT	*	*		*	LED			BO					
5243	Frequency protection: TimeOut Stage f4 (Time Out f4)	Frequency Prot.	OUT	*	*		*	LED			BO					
5803	>BLOCK restricted earth fault prot. (>BLOCK REF)	REF	SP	*	*		*	LED	BI		BO					
5811	Restricted earth fault is switched OFF (REF OFF)	REF	OUT	On Off	*		*	LED			BO		76	11	1	Yes
5812	Restricted earth fault is BLOCKED (REF BLOCKED)	REF	OUT	On Off	On Off		*	LED			BO		76	12	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
5813	Restricted earth fault is ACTIVE (REF ACTIVE)	REF	OUT	On Off	*		*	LED			BO		76	13	1	Yes
5816	Restr. earth flt.: Time delay started (REF T start)	REF	OUT	*	On Off		*	LED			BO		76	16	2	Yes
5817	Restr. earth flt.: picked up (REF picked up)	REF	OUT	*	On Off		m	LED			BO		76	17	2	Yes
5821	Restr. earth flt.: TRIP (REF TRIP)	REF	OUT	*	On		m	LED			BO		76	21	2	No
5826	REF: Value D at trip (without Tdelay) (REF D:)	REF	VI	*	On Off								76	26	4	No
5827	REF: Value S at trip (without Tdelay) (REF S:)	REF	VI	*	On Off								76	27	4	No
6854	>Trip circuit superv. 1: Trip Relay (>TripC1 TripRel)	Trip-Circ.Superv	SP	On Off	*		*	LED	BI		BO					
6855	>Trip circuit superv. 1: Breaker Relay (>TripC1 Bkr.Rel)	Trip-Circ.Superv	SP	On Off	*		*	LED	BI		BO					
6856	>Trip circuit superv. 2: Trip Relay (>TripC2 TripRel)	Trip-Circ.Superv	SP	On Off	*		*	LED	BI		BO					
6857	>Trip circuit superv. 2: Breaker Relay (>TripC2 Bkr.Rel)	Trip-Circ.Superv	SP	On Off	*		*	LED	BI		BO					
6858	>Trip circuit superv. 3: Trip Relay (>TripC3 TripRel)	Trip-Circ.Superv	SP	On Off	*		*	LED	BI		BO					
6859	>Trip circuit superv. 3: Breaker Relay (>TripC3 Bkr.Rel)	Trip-Circ.Superv	SP	On Off	*		*	LED	BI		BO					
6861	Trip circuit supervision OFF (TripC OFF)	Trip-Circ.Superv	OUT	On Off	*		*	LED			BO		170	53	1	Yes
6865	Failure Trip Circuit (FAIL: Trip cir.)	Trip-Circ.Superv	OUT	On Off	*		*	LED			BO		192	36	1	Yes
6866	TripC1 blocked: Binary input is not set (TripC1 ProgFAIL)	Trip-Circ.Superv	OUT	On Off	*		*	LED			BO					
6867	TripC2 blocked: Binary input is not set (TripC2 ProgFAIL)	Trip-Circ.Superv	OUT	On Off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
6868	TripC3 blocked: Binary input is not set (TripC3 ProgFAIL)	Trip-Circ.Superv	OUT	On Off	*		*	LED			BO					
7104	>BLOCK Backup OverCurrent I>> (>BLOCK O/C I>>)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	4	1	Yes
7105	>BLOCK Backup OverCurrent I> (>BLOCK O/C I>)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	5	1	Yes
7106	>BLOCK Backup OverCurrent Ip (>BLOCK O/C Ip)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	6	1	Yes
7107	>BLOCK Backup OverCurrent Ie>> (>BLOCK O/C Ie>>)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	7	1	Yes
7108	>BLOCK Backup OverCurrent Ie> (>BLOCK O/C Ie>)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	8	1	Yes
7109	>BLOCK Backup OverCurrent Iep (>BLOCK O/C Iep)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	9	1	Yes
7110	>Backup OverCurrent InstantaneousTrip (>O/C InstTRIP)	Back-Up O/C	SP	On Off	On Off		*	LED	BI		BO		64	10	1	Yes
7111	>BLOCK direct. Backup OverCurrent I> (>BLOCK Dir. I>)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	11	1	Yes
7112	>BLOCK direct. Backup OverCurrent Ip (>BLOCK Dir. Ip)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	12	1	Yes
7113	>BLOCK direct. Backup OverCurrent Ie> (>BLOCK Dir. Ie>)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	13	1	Yes
7114	>BLOCK direct. Backup OverCurrent Iep (>BLOCK Dir. Iep)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	14	1	Yes
7130	>BLOCK I-STUB (>BLOCK I-STUB)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	30	1	Yes
7131	>Enable I-STUB-Bus function (>I-STUB ENABLE)	Back-Up O/C	SP	On Off	On Off		*	LED	BI		BO		64	31	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
7132	>BLOCK Backup OverCurrent Ie>>> (>BLOCK O/C Ie>>>)	Back-Up O/C	SP	On Off	*		*	LED	BI		BO		64	32	1	Yes
7151	Backup O/C is switched OFF (O/C OFF)	Back-Up O/C	OUT	On Off	*		*	LED			BO		64	51	1	Yes
7152	Backup O/C is BLOCKED (O/C BLOCK)	Back-Up O/C	OUT	On Off	On Off		*	LED			BO		64	52	1	Yes
7153	Backup O/C is ACTIVE (O/C ACTIVE)	Back-Up O/C	OUT	*	*		*	LED			BO		64	53	1	Yes
7161	Backup O/C PICKED UP (O/C PICKUP)	Back-Up O/C	OUT	*	Off		m	LED			BO		64	61	2	Yes
7162	Backup O/C PICKUP L1 (O/C Pickup L1)	Back-Up O/C	OUT	*	On		*	LED			BO		64	62	2	Yes
7163	Backup O/C PICKUP L2 (O/C Pickup L2)	Back-Up O/C	OUT	*	On		*	LED			BO		64	63	2	Yes
7164	Backup O/C PICKUP L3 (O/C Pickup L3)	Back-Up O/C	OUT	*	On		*	LED			BO		64	64	2	Yes
7165	Backup O/C PICKUP EARTH (O/C Pickup E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	65	2	Yes
7171	Backup O/C Pickup - Only EARTH (O/C PU only E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	71	2	No
7172	Backup O/C Pickup - Only L1 (O/C PU 1p. L1)	Back-Up O/C	OUT	*	On		*	LED			BO		64	72	2	No
7173	Backup O/C Pickup L1E (O/C Pickup L1E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	73	2	No
7174	Backup O/C Pickup - Only L2 (O/C PU 1p. L2)	Back-Up O/C	OUT	*	On		*	LED			BO		64	74	2	No
7175	Backup O/C Pickup L2E (O/C Pickup L2E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	75	2	No
7176	Backup O/C Pickup L12 (O/C Pickup L12)	Back-Up O/C	OUT	*	On		*	LED			BO		64	76	2	No
7177	Backup O/C Pickup L12E (O/C Pickup L12E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	77	2	No
7178	Backup O/C Pickup - Only L3 (O/C PU 1p. L3)	Back-Up O/C	OUT	*	On		*	LED			BO		64	78	2	No
7179	Backup O/C Pickup L3E (O/C Pickup L3E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	79	2	No
7180	Backup O/C Pickup L31 (O/C Pickup L31)	Back-Up O/C	OUT	*	On		*	LED			BO		64	80	2	No
7181	Backup O/C Pickup L31E (O/C Pickup L31E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	81	2	No

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
7182	Backup O/C Pickup L23 (O/C Pickup L23)	Back-Up O/C	OUT	*	On		*	LED			BO		64	82	2	No
7183	Backup O/C Pickup L23E (O/C Pickup L23E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	83	2	No
7184	Backup O/C Pickup L123 (O/C Pickup L123)	Back-Up O/C	OUT	*	On		*	LED			BO		64	84	2	No
7185	Backup O/C Pickup L123E (O/C PickupL123E)	Back-Up O/C	OUT	*	On		*	LED			BO		64	85	2	No
7191	Backup O/C Pickup I>> (O/C PICKUP I>>)	Back-Up O/C	OUT	*	On		m	LED			BO		64	91	2	Yes
7192	Backup O/C Pickup I> (O/C PICKUP I>)	Back-Up O/C	OUT	*	On		m	LED			BO		64	92	2	Yes
7193	Backup O/C Pickup Ip (O/C PICKUP Ip)	Back-Up O/C	OUT	*	On		m	LED			BO		64	93	2	Yes
7201	O/C I-STUB Pickup (I-STUB PICKUP)	Back-Up O/C	OUT	*	On Off		m	LED			BO		64	101	2	Yes
7202	Backup O/C Pickup I> directional (O/C PICK. I>Dir)	Back-Up O/C	OUT	*	On		*	LED			BO		64	102	2	Yes
7203	Backup O/C Pickup Ip directional (O/C PICK. IpDir)	Back-Up O/C	OUT	*	On		*	LED			BO		64	103	2	Yes
7211	Backup O/C General TRIP command (O/C TRIP)	Back-Up O/C	OUT	*	*		*	LED			BO		64	111	2	No
7212	Backup O/C TRIP - Only L1 (O/C TRIP 1p.L1)	Back-Up O/C	OUT	*	On		*	LED			BO		64	112	2	No
7213	Backup O/C TRIP - Only L2 (O/C TRIP 1p.L2)	Back-Up O/C	OUT	*	On		*	LED			BO		64	113	2	No
7214	Backup O/C TRIP - Only L3 (O/C TRIP 1p.L3)	Back-Up O/C	OUT	*	On		*	LED			BO		64	114	2	No
7215	Backup O/C TRIP Phases L123 (O/C TRIP L123)	Back-Up O/C	OUT	*	On		*	LED			BO		64	115	2	No
7221	Backup O/C TRIP I>> (O/C TRIP I>>)	Back-Up O/C	OUT	*	On		*	LED			BO		64	121	2	No
7222	Backup O/C TRIP I> (O/C TRIP I>)	Back-Up O/C	OUT	*	On		*	LED			BO		64	122	2	No
7223	Backup O/C TRIP Ip (O/C TRIP Ip)	Back-Up O/C	OUT	*	On		*	LED			BO		64	123	2	No
7235	O/C I-STUB TRIP (I-STUB TRIP)	Back-Up O/C	OUT	*	On		*	LED			BO		64	135	2	No
7236	Backup O/C TRIP I> directional (O/C TRIP I>Dir.)	Back-Up O/C	OUT	*	On		*	LED			BO		64	136	2	No

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
7237	Backup O/C Pickup Ip directional (O/C TRIP IpDir.)	Back-Up O/C	OUT	*	On		*	LED			BO		64	137	2	No
7240	Backup O/C L1 forward direction (O/C L1 forward)	Back-Up O/C	OUT	*	On		*	LED			BO		64	140	2	No
7241	Backup O/C L2 forward direction (O/C L2 forward)	Back-Up O/C	OUT	*	On		*	LED			BO		64	141	2	No
7242	Backup O/C L3 forward direction (O/C L3 forward)	Back-Up O/C	OUT	*	On		*	LED			BO		64	142	2	No
7243	Backup O/C 3I0 forward direction (O/C 3I0 forward)	Back-Up O/C	OUT	*	On		*	LED			BO		64	143	2	No
7244	Backup O/C L1 reverse direction (O/C L1 reverse)	Back-Up O/C	OUT	*	On		*	LED			BO		64	144	2	No
7245	Backup O/C L2 reverse direction (O/C L2 reverse)	Back-Up O/C	OUT	*	On		*	LED			BO		64	145	2	No
7246	Backup O/C L3 reverse direction (O/C L3 reverse)	Back-Up O/C	OUT	*	On		*	LED			BO		64	146	2	No
7247	Backup O/C 3I0 reverse direction (O/C 3I0 reverse)	Back-Up O/C	OUT	*	On		*	LED			BO		64	147	2	No
7248	Backup O/C forward direction (O/C Dir.forward)	Back-Up O/C	OUT	*	*		*	LED			BO					
7249	Backup O/C reverse direction (O/C Dir.reverse)	Back-Up O/C	OUT	*	*		*	LED			BO					
7325	CB1-TEST TRIP command - Only L1 (CB1-TESTtrip L1)	Testing	OUT	On Off	*		*	LED			BO		153	25	1	Yes
7326	CB1-TEST TRIP command - Only L2 (CB1-TESTtrip L2)	Testing	OUT	On Off	*		*	LED			BO		153	26	1	Yes
7327	CB1-TEST TRIP command - Only L3 (CB1-TESTtrip L3)	Testing	OUT	On Off	*		*	LED			BO		153	27	1	Yes
7328	CB1-TEST TRIP command L123 (CB1-TESTtrip123)	Testing	OUT	On Off	*		*	LED			BO		153	28	1	Yes
7329	CB1-TEST CLOSE command (CB1-TEST close)	Testing	OUT	On Off	*		*	LED			BO		153	29	1	Yes
7345	CB-TEST is in progress (CB-TEST running)	Testing	OUT	On Off	*		*	LED			BO		153	45	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
7346	CB-TEST canceled due to Power Sys. Fault (CB-TSTstop FLT.)	Testing	OUT_Ev	On	*											
7347	CB-TEST canceled due to CB already OPEN (CB-TSTstop OPEN)	Testing	OUT_Ev	On	*											
7348	CB-TEST canceled due to CB was NOT READY (CB-TSTstop NOTr)	Testing	OUT_Ev	On	*											
7349	CB-TEST canceled due to CB stayed CLOSED (CB-TSTstop CLOS)	Testing	OUT_Ev	On	*											
7350	CB-TEST was successful (CB-TST .OK.)	Testing	OUT_Ev	On	*											
10201	>BLOCK Uph-e>(>) Overvolt. (phase-earth) (>Uph-e>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10202	>BLOCK Uph-ph>(>) Overvolt (phase-phase) (>Uph-ph>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10203	>BLOCK 3U0>(>) Overvolt. (zero sequence) (>3U0>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10204	>BLOCK U1>(>) Overvolt. (positive seq.) (>U1>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10205	>BLOCK U2>(>) Overvolt. (negative seq.) (>U2>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10206	>BLOCK Uph-e<(<) Undervolt (phase-earth) (>Uph-e<(<) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10207	>BLOCK Uphph<(<) Undervolt (phase-phase) (>Uphph<(<) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10208	>BLOCK U1<(<) Undervolt (positive seq.) (>U1<(<) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10215	Uph-e>(>) Overvolt. is switched OFF (Uph-e>(>) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	15	1	Yes
10216	Uph-e>(>) Overvolt. is BLOCKED (Uph-e>(>) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	16	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
10217	Uph-ph>(>) Overvolt. is switched OFF (Uph-ph>(>) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	17	1	Yes
10218	Uph-ph>(>) Overvolt. is BLOCKED (Uph-ph>(>) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	18	1	Yes
10219	3U0>(>) Overvolt. is switched OFF (3U0>(>) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	19	1	Yes
10220	3U0>(>) Overvolt. is BLOCKED (3U0>(>) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	20	1	Yes
10221	U1>(>) Overvolt. is switched OFF (U1>(>) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	21	1	Yes
10222	U1>(>) Overvolt. is BLOCKED (U1>(>) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	22	1	Yes
10223	U2>(>) Overvolt. is switched OFF (U2>(>) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	23	1	Yes
10224	U2>(>) Overvolt. is BLOCKED (U2>(>) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	24	1	Yes
10225	Uph-e<(<) Undervolt. is switched OFF (Uph-e<(<) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	25	1	Yes
10226	Uph-e<(<) Undervolt. is BLOCKED (Uph-e<(<) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	26	1	Yes
10227	Uph-ph<(<) Undervolt. is switched OFF (Uph-ph<(<) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	27	1	Yes
10228	Uphph<(<) Undervolt. is BLOCKED (Uph-ph<(<) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	28	1	Yes
10229	U1<(<) Undervolt. is switched OFF (U1<(<) OFF)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	29	1	Yes
10230	U1<(<) Undervolt. is BLOCKED (U1<(<) BLK)	Voltage Prot.	OUT	On Off	On Off		*	LED			BO		73	30	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
10231	Over-/Under-Voltage protection is ACTIVE (U</> ACTIVE)	Voltage Prot.	OUT	On Off	*		*	LED			BO		73	31	1	Yes
10240	Uph-e> Pickup (Uph-e> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	40	2	Yes
10241	Uph-e>> Pickup (Uph-e>> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	41	2	Yes
10242	Uph-e>(>) Pickup L1 (Uph-e>(>) PU L1)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	42	2	Yes
10243	Uph-e>(>) Pickup L2 (Uph-e>(>) PU L2)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	43	2	Yes
10244	Uph-e>(>) Pickup L3 (Uph-e>(>) PU L3)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	44	2	Yes
10245	Uph-e> TimeOut (Uph-e> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10246	Uph-e>> TimeOut (Uph-e>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10247	Uph-e>(>) TRIP command (Uph-e>(>) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	47	2	Yes
10248	Uph-e> Pickup L1 (Uph-e> PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO		73	133	2	Yes
10249	Uph-e> Pickup L2 (Uph-e> PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO		73	134	2	Yes
10250	Uph-e> Pickup L3 (Uph-e> PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO		73	135	2	Yes
10251	Uph-e>> Pickup L1 (Uph-e>> PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO		73	136	2	Yes
10252	Uph-e>> Pickup L2 (Uph-e>> PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO		73	137	2	Yes
10253	Uph-e>> Pickup L3 (Uph-e>> PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO		73	138	2	Yes
10255	Uph-ph> Pickup (Uphph> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	55	2	Yes
10256	Uph-ph>> Pickup (Uphph>> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	56	2	Yes
10257	Uph-ph>(>) Pickup L1-L2 (Uphph>(>)PU L12)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	57	2	Yes
10258	Uph-ph>(>) Pickup L2-L3 (Uphph>(>)PU L23)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	58	2	Yes
10259	Uph-ph>(>) Pickup L3-L1 (Uphph>(>)PU L31)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	59	2	Yes
10260	Uph-ph> TimeOut (Uphph> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
10261	Uph-ph>> TimeOut (Uphph>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10262	Uph-ph>(>) TRIP command (Uphph>(>) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	62	2	Yes
10263	Uph-ph> Pickup L1-L2 (Uphph> PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO		73	139	2	Yes
10264	Uph-ph> Pickup L2-L3 (Uphph> PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO		73	140	2	Yes
10265	Uph-ph> Pickup L3-L1 (Uphph> PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO		73	141	2	Yes
10266	Uph-ph>> Pickup L1-L2 (Uphph>> PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO		73	142	2	Yes
10267	Uph-ph>> Pickup L2-L3 (Uphph>> PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO		73	143	2	Yes
10268	Uph-ph>> Pickup L3-L1 (Uphph>> PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO		73	144	2	Yes
10270	3U0> Pickup (3U0> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	70	2	Yes
10271	3U0>> Pickup (3U0>> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	71	2	Yes
10272	3U0> TimeOut (3U0> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10273	3U0>> TimeOut (3U0>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10274	3U0>(>) TRIP command (3U0>(>) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	74	2	Yes
10280	U1> Pickup (U1> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	80	2	Yes
10281	U1>> Pickup (U1>> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	81	2	Yes
10282	U1> TimeOut (U1> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10283	U1>> TimeOut (U1>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10284	U1>(>) TRIP command (U1>(>) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	84	2	Yes
10290	U2> Pickup (U2> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	90	2	Yes
10291	U2>> Pickup (U2>> Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	91	2	Yes
10292	U2> TimeOut (U2> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
10293	U2>> TimeOut (U2>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10294	U2>(>) TRIP command (U2>(>) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	94	2	Yes
10300	U1< Pickup (U1< Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	100	2	Yes
10301	U1<< Pickup (U1<< Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	101	2	Yes
10302	U1< TimeOut (U1< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10303	U1<< TimeOut (U1<< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10304	U1<(<) TRIP command (U1<(<) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	104	2	Yes
10310	Uph-e< Pickup (Uph-e< Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	110	2	Yes
10311	Uph-e<< Pickup (Uph-e<< Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	111	2	Yes
10312	Uph-e<(<) Pickup L1 (Uph-e<(<) PU L1)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	112	2	Yes
10313	Uph-e<(<) Pickup L2 (Uph-e<(<) PU L2)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	113	2	Yes
10314	Uph-e<(<) Pickup L3 (Uph-e<(<) PU L3)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	114	2	Yes
10315	Uph-e< TimeOut (Uph-e< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10316	Uph-e<< TimeOut (Uph-e<< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10317	Uph-e<(<) TRIP command (Uph-e<(<) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	117	2	Yes
10318	Uph-e< Pickup L1 (Uph-e< PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO		73	145	2	Yes
10319	Uph-e< Pickup L2 (Uph-e< PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO		73	146	2	Yes
10320	Uph-e< Pickup L3 (Uph-e< PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO		73	147	2	Yes
10321	Uph-e<< Pickup L1 (Uph-e<< PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO		73	148	2	Yes
10322	Uph-e<< Pickup L2 (Uph-e<< PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO		73	149	2	Yes
10323	Uph-e<< Pickup L3 (Uph-e<< PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO		73	150	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	information number	Data Unit	General Interrogation
10325	Uph-ph< Pickup (Uph-ph< Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	125	2	Yes
10326	Uph-ph<< Pickup (Uph-ph<< Pickup)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	126	2	Yes
10327	Uphph<(<) Pickup L1-L2 (Uphph<(<)PU L12)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	127	2	Yes
10328	Uphph<(<) Pickup L2-L3 (Uphph<(<)PU L23)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	128	2	Yes
10329	Uphph<(<) Pickup L3-L1 (Uphph<(<)PU L31)	Voltage Prot.	OUT	*	On Off		*	LED			BO		73	129	2	Yes
10330	Uphph< TimeOut (Uphph< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10331	Uphph<< TimeOut (Uphph<< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10332	Uphph<(<) TRIP command (Uphph<(<) TRIP)	Voltage Prot.	OUT	*	On		*	LED			BO		73	132	2	Yes
10333	Uph-ph< Pickup L1-L2 (Uphph< PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO		73	151	2	Yes
10334	Uph-ph< Pickup L2-L3 (Uphph< PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO		73	152	2	Yes
10335	Uph-ph< Pickup L3-L1 (Uphph< PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO		73	153	2	Yes
10336	Uph-ph<< Pickup L1-L2 (Uphph<< PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO		73	154	2	Yes
10337	Uph-ph<< Pickup L2-L3 (Uphph<< PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO		73	155	2	Yes
10338	Uph-ph<< Pickup L3-L1 (Uphph<< PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO		73	156	2	Yes
30053	Fault recording is running (Fault rec. run.)	Osc. Fault Rec.	OUT	*	*		*	LED			BO					
31000	Q0 operationcounter= (Q0 OpCnt=)	Control Device	VI													
31001	Q1 operationcounter= (Q1 OpCnt=)	Control Device	VI													
31002	Q2 operationcounter= (Q2 OpCnt=)	Control Device	VI													
31008	Q8 operationcounter= (Q8 OpCnt=)	Control Device	VI													
31009	Q9 operationcounter= (Q9 OpCnt=)	Control Device	VI													

E.4 Group Alarms

Nr.	Bedeutung	Nr.	Bedeutung
140	Stör-Sammelmel.	144	Störung 5V
		192	IN(1/5A) falsch
		181	Störung Messw.
160	Warn-Sammelmel.	289	Störung ΣI
		163	Störung Isymm
		165	Störung ΣUphe
		167	Störung Usymm
		168	Störung Umess
		169	Fuse-Failure
		170	FFM unverzögert
		171	Stör. Ph-Folge
		177	Stör Batterie
		190	Störung BG0
		191	Stör. Offset
		193	Stör.Abgleichw.
		183	Störung BG1
		184	Störung BG2
		185	Störung BG3
		186	Störung BG4
		187	Störung BG5
		188	Störung BG6
		189	Störung BG7
161	Messw.-Überw.I	289	Störung ΣI
		163	Störung Isymm
164	Messw.-Überw.U	165	Störung ΣUphe
		167	Störung Usymm
		168	Störung Umess

E.5 Measured Values

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	information number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
-	Lower setting limit for Power Factor (PF<)	Set Points(MV)	-	-	-	-	-	CFC	CD	DD
601	I L1 (IL1 =)	Measurement	134	129	No	9	1	CFC	CD	DD
602	I L2 (IL2 =)	Measurement	134	129	No	9	2	CFC	CD	DD
603	I L3 (IL3 =)	Measurement	134	129	No	9	3	CFC	CD	DD
610	3I0 (zero sequence) (3I0 =)	Measurement	134	129	No	9	14	CFC	CD	DD
612	IY (star point of transformer) (IY =)	Measurement	-	-	-	-	-	CFC	CD	DD
619	I1 (positive sequence) (I1 =)	Measurement	-	-	-	-	-	CFC	CD	DD
620	I2 (negative sequence) (I2 =)	Measurement	-	-	-	-	-	CFC	CD	DD
621	U L1-E (UL1E=)	Measurement	134	129	No	9	4	CFC	CD	DD
622	U L2-E (UL2E=)	Measurement	134	129	No	9	5	CFC	CD	DD
623	U L3-E (UL3E=)	Measurement	134	129	No	9	6	CFC	CD	DD
624	U L12 (UL12=)	Measurement	134	129	No	9	10	CFC	CD	DD
625	U L23 (UL23=)	Measurement	134	129	No	9	11	CFC	CD	DD
626	U L31 (UL31=)	Measurement	134	129	No	9	12	CFC	CD	DD
627	Uen (Uen =)	Measurement	-	-	-	-	-	CFC	CD	DD
631	3U0 (zero sequence) (3U0 =)	Measurement	-	-	-	-	-	CFC	CD	DD
633	Ux (separate VT) (Ux =)	Measurement	-	-	-	-	-	CFC	CD	DD
634	U1 (positive sequence) (U1 =)	Measurement	-	-	-	-	-	CFC	CD	DD
635	U2 (negative sequence) (U2 =)	Measurement	-	-	-	-	-	CFC	CD	DD
641	P (active power) (P =)	Measurement	134	129	No	9	7	CFC	CD	DD
642	Q (reactive power) (Q =)	Measurement	134	129	No	9	8	CFC	CD	DD
643	Power Factor (PF =)	Measurement	134	129	No	9	13	CFC	CD	DD
644	Frequency (Freq=)	Measurement	134	129	No	9	9	CFC	CD	DD
645	S (apparent power) (S =)	Measurement	-	-	-	-	-	CFC	CD	DD
679	U1co (positive sequence, compounding) (U1co=)	Measurement	-	-	-	-	-	CFC	CD	DD
684	U0 (zero sequence) (U0 =)	Measurement	-	-	-	-	-	CFC	CD	DD
801	Temperat. rise for warning and trip (Θ/Θtrip =)	Measurement	-	-	-	-	-	CFC	CD	DD
802	Temperature rise for phase L1 (Θ/ ΘtripL1=)	Measurement	-	-	-	-	-	CFC	CD	DD
803	Temperature rise for phase L2 (Θ/ ΘtripL2=)	Measurement	-	-	-	-	-	CFC	CD	DD
804	Temperature rise for phase L3 (Θ/ ΘtripL3=)	Measurement	-	-	-	-	-	CFC	CD	DD
888	Pulsed Energy Wp (active) (Wp(puls))	Energy	133	55	No	205	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	information number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
889	Pulsed Energy Wq (reactive) (Wq(puls))	Energy	133	56	No	205	-	CFC	CD	DD
924	Wp Forward (Wp+=)	Energy	133	51	No	205	-	CFC	CD	DD
925	Wq Forward (Wq+=)	Energy	133	52	No	205	-	CFC	CD	DD
928	Wp Reverse (Wp-=)	Energy	133	53	No	205	-	CFC	CD	DD
929	Wq Reverse (Wq-=)	Energy	133	54	No	205	-	CFC	CD	DD
7731	PHI IL1L2 (local) (Φ IL1L2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7732	PHI IL2L3 (local) (Φ IL2L3=)	Measurement	-	-	-	-	-	CFC	CD	DD
7733	PHI IL3L1 (local) (Φ IL3L1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7734	PHI UL1L2 (local) (Φ UL1L2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7735	PHI UL2L3 (local) (Φ UL2L3=)	Measurement	-	-	-	-	-	CFC	CD	DD
7736	PHI UL3L1 (local) (Φ UL3L1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7737	PHI UIL1 (local) (Φ UIL1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7738	PHI UIL2 (local) (Φ UIL2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7739	PHI UIL3 (local) (Φ UIL3=)	Measurement	-	-	-	-	-	CFC	CD	DD
7742	IDiffL1(% Operational nominal current) (IDiffL1=)	IDiff/IRest	134	122	No	9	1	CFC	CD	DD
7743	IDiffL2(% Operational nominal current) (IDiffL2=)	IDiff/IRest	134	122	No	9	2	CFC	CD	DD
7744	IDiffL3(% Operational nominal current) (IDiffL3=)	IDiff/IRest	134	122	No	9	3	CFC	CD	DD
7745	IRestL1(% Operational nominal current) (IRestL1=)	IDiff/IRest	134	122	No	9	4	CFC	CD	DD
7746	IRestL2(% Operational nominal current) (IRestL2=)	IDiff/IRest	134	122	No	9	5	CFC	CD	DD
7747	IRestL3(% Operational nominal current) (IRestL3=)	IDiff/IRest	134	122	No	9	6	CFC	CD	DD
7748	Diff3I0 (Differential current 3I0) (Diff3I0=)	IDiff/IRest	-	-	-	-	-	CFC	CD	DD
7751	Prot.Interface 1:Transmission delay (PI1 TD)	Statistics	134	122	No	9	7	CFC	CD	DD
7753	Prot.Interface 1: Availability per min. (PI1A/m)	Statistics	-	-	-	-	-	CFC	CD	DD
7754	Prot.Interface 1: Availability per hour (PI1A/h)	Statistics	134	122	No	9	8	CFC	CD	DD
			134	121	No	9	3			
7761	Relay ID of 1. relay (Relay ID)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7762	IL1(% of Operational nominal current) (IL1_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7763	Angle IL1_rem <-> IL1_loc (ΦI L1=)	Measure relay1	-	-	-	-	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	information number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
7764	IL2(% of Operational nominal current) (IL2_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7765	Angle IL2_rem <-> IL2_loc (ΦI L2=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7766	IL3(% of Operational nominal current) (IL3_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7767	Angle IL3_rem <-> IL3_loc (ΦI L3=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7769	UL1(% of Operational nominal voltage) (UL1_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7770	Angle UL1_rem <-> UL1_loc (ΦU L1=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7771	UL2(% of Operational nominal voltage) (UL2_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7772	Angle UL2_rem <-> UL2_loc (ΦU L2=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7773	UL3(% of Operational nominal voltage) (UL3_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7774	Angle UL3_rem <-> UL3_loc (ΦU L3=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7781	Relay ID of 2. relay (Relay ID)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7782	IL1(% of Operational nominal current) (IL1_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7783	Angle IL1_rem <-> IL1_loc (ΦI L1=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7784	IL2(% of Operational nominal current) (IL2_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7785	Angle IL2_rem <-> IL2_loc (ΦI L2=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7786	IL3(% of Operational nominal current) (IL3_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7787	Angle IL3_rem <-> IL3_loc (ΦI L3=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7789	UL1(% of Operational nominal voltage) (UL1_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7790	Angle UL1_rem <-> UL1_loc (ΦU L1=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7791	UL2(% of Operational nominal voltage) (UL2_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7792	Angle UL2_rem <-> UL2_loc (ΦU L2=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7793	UL3(% of Operational nominal voltage) (UL3_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	information number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
7794	Angle UL3_rem <-> UL3_loc (ΦU L3=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7875	Prot.Interface 1:Transmission delay rec. (PI1 TD R)	Statistics	134	121	No	9	1	CFC	CD	DD
7876	Prot.Interface 1:Transmission delay send (PI1 TD S)	Statistics	134	121	No	9	2	CFC	CD	DD
30654	Idiff REF(% Operational nominal current) (IdiffREF=)	IDiff/IRest	-	-	-	-	-	CFC	CD	DD
30655	Irest REF(% Operational nominal current) (IrestREF=)	IDiff/IRest	-	-	-	-	-	CFC	CD	DD

Literature

/1/ SIPROTEC 4 System Description
E50417-H1176-C151

/2/ SIPROTEC DIGSI, Start UP; E50417-G1176-C152

/3/ DIGSI CFC, Manual
E50417-H1176-C098

/4/ SIPROTEC SIGRA 4, Manual
E50417-H1176-C070

/5/ Application Examples for SIPROTEC Protection Devices
E50001-K4451-A101-A1

/6/ Case Studies for SIPROTEC Protection Devices and Power Quality
E50001-K4452-A101-A1

Glossary

Bay controllers

Bay controllers are devices with control and monitoring functions without protective functions.

Bit pattern indication

Bit pattern indication is a processing function by means of which items of digital process information applying across several inputs can be detected together in parallel and processed further. The bit pattern length can be specified as 1, 2, 3 or 4 bytes.

BP_xx

→ Bit pattern indication (Bitstring Of x Bit), x designates the length in bits (8, 16, 24 or 32 bits).

Buffer battery

The buffer battery ensures that specified data areas, flags, timers and counters are retained retentively.

C_xx

Command without feedback

CF_xx

Command with feedback

CFC

Continuous Function Chart. CFC is a graphical editor with which a program can be created and configured by using ready-made blocks.

CFC blocks

Blocks are parts of the user program delimited by their function, their structure or their purpose.

Chatter ON

A rapidly intermittent input (for example, due to a relay contact fault) is switched off after a configurable monitoring time and can thus not generate any further signal changes. The function prevents overloading of the system when a fault arises.

Combination devices

Combination devices are bay devices with protection functions and a control display.

Combination matrix

From DIGSI V4.6 onward, up to 32 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination (IRC combination). Which device exchanges which information is defined with the help of the combination matrix.

Communication branch

A communications branch corresponds to the configuration of 1 to n users that communicate by means of a common bus.

Communication reference CR

The communication reference describes the type and version of a station in communication by PROFIBUS.

Component view

In addition to a topological view, SIMATIC Manager offers you a component view. The component view does not offer any overview of the hierarchy of a project. It does, however, provide an overview of all the SIPROTEC 4 devices within a project.

COMTRADE

Common Format for Transient Data Exchange, format for fault records.

Container

If an object can contain other objects, it is called a container. The object Folder is an example of such a container.

Control Display

The display which is displayed on devices with a large (graphic) display after you have pressed the control key is called the control display. It contains the switchgear that can be controlled in the feeder with status display. It is used to perform switching operations. Defining this display is part of the configuration.

Data pane

The right-hand area of the project window displays the contents of the area selected in the → navigation window, for example indications, measured values, etc. of the information lists or the function selection for the device configuration.

DCF77

The extremely precise official time is determined in Germany by the "Physikalisch-Technische-Bundesanstalt PTB" in Braunschweig. The atomic clock station 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. 1,500 km from Frankfurt/Main.

Device container

In the Component View, all SIPROTEC 4 devices are assigned to an object of type Device container. This object is a special object of DIGSI Manager. However, since there is no component view in DIGSI Manager, this object only becomes visible in conjunction with STEP 7.

Double command

Double commands are process outputs which indicate 4 process states at 2 outputs: 2 defined (for example ON/OFF) and 2 undefined states (for example intermediate positions)

Double-point indication

Double-point indications are items of process information which indicate 4 process states at 2 inputs: 2 defined (for example ON/OFF) and 2 undefined states (for example intermediate positions).

DP

→ Double-point indication

DP_I

→ Double point indication, intermediate position 00

Drag and drop

Copying, moving and linking function, used at graphics user interfaces. Objects are selected with the mouse, held and moved from one data area to another.

Earth

The conductive earth whose electric potential can be set equal to zero at every point. In the area of earth electrodes the earth can have a potential deviating from zero. The term "Earth reference plane" is often used for this state.

Earth (verb)

This term means that a conductive part is connected via an earthing system to the → earth.

Earthing

Earthing is the total of all means and measures used for earthing.

Electromagnetic compatibility

Electromagnetic compatibility (EMC) is the ability of an electrical apparatus to function fault-free in a specified environment without influencing the environment unduly.

EMC

→ Electromagnetic compatibility

ESD protection

ESD protection is the total of all the means and measures used to protect electrostatic sensitive devices.

EVA

Limiting value, user-defined

ExBPxx

External bit pattern indication via an ETHERNET connection, device-specific → Bit pattern indication

ExC

External command without feedback via an ETHERNET connection, device-specific

ExCF

Command with feedback via an ETHERNET connection, device-specific

ExDP

External double point indication via an ETHERNET connection, device-specific → Double point indication

ExDP_I

External double point indication via an ETHERNET connection, intermediate position 00, device-specific → Double point indication

ExMV

External metered value via an ETHERNET connection, device-specific

ExSI

External single point indication via an ETHERNET connection, device-specific → Single point indication

ExSI_F

External single point indication via an ETHERNET connection, Spontaneous event, device-specific → Fleeting indication, → Single point indication

Field devices

Generic term for all devices assigned to the field level: Protection devices, combination devices, bay controllers.

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.

FMS communication branch

Within an FMS communication branch, the users communicate on the basis of the PROFIBUS FMS protocol via a PROFIBUS FMS network.

Folder

This object type is used to create the hierarchical structure of a project.

General interrogation (GI)

During the system start-up the state of all the process inputs, of the status and of the fault image is sampled. This information is used to update the system-end process image. The current process state can also be sampled after a data loss by means of a GI.

GOOSE message

GOOSE messages (Generic Object Oriented Substation Event) according to IEC 61850 are data packets which are transferred event-controlled via the Ethernet communication system. They serve for direct information exchange among the relays. This mechanism implements cross-communication between bay units.

GPS

Global Positioning System. Satellites with atomic clocks on board orbit the earth twice a day on different paths in approx. 20,000 km. They transmit signals which also contain the GPS universal time. The GPS receiver determines its own position from the signals received. From its position it can derive the delay time of a satellite signal and thus correct the transmitted GPS universal time.

Hierarchy level

Within a structure with higher-level and lower-level objects a hierarchy level is a container of equivalent objects.

HV field description

The HV project description file contains details of fields which exist in a ModPara-project. The actual field information of each field is stored in a HV field description file. Within the HV project description file, each field is allocated such a HV field description file by a reference to the file name.

HV project description

All the data is exported once the configuration and parameterization of PCUs and sub-modules using ModPara has been completed. This data is split up into several files. One file contains details about the fundamental project structure. This also includes, for example, information detailing which fields exist in this project. This file is called a HV project description file.

ID

Internal double point indication → Double point indication

ID_S

Internal double point indication, intermediate position 00 → Double point indication

IEC

International Electrotechnical Commission, international standardization body

IEC61850

International communication standard for communication in substations. The objective of this standard is the interoperability of devices from different manufacturers on the station bus. An Ethernet network is used for data transfer.

IEC address

Within an IEC bus a unique IEC address has to be assigned to each SIPROTEC 4 device. A total of 254 IEC addresses are available for each IEC bus.

IEC communication branch

Within an IEC communication branch the users communicate on the basis of the IEC60-870-5-103 protocol via an IEC bus.

Initialization string

An initialization string comprises a range of modem-specific commands. These are transmitted to the modem within the framework of modem initialization. The commands can, for example, force specific settings for the modem.

Inter relay communication

→ IRC combination

IntSP

Internal single point indication → Single point indication

IntSP_Ev

Internal indication Spontaneous event → Fleeting indication, → Single point indication

IRC combination

Inter Relay Communication, IRC, is used for directly exchanging process information between SIPROTEC 4 devices. You require an object of type IRC combination to configure an inter relay communication. Each user of the combination and all the necessary communication parameters are defined in this object. The type and scope of the information exchanged between the users is also stored in this object.

IRIG B

Time signal code of the Inter-Range Instrumentation Group

ISO 9001

The ISO 9000 ff range of standards defines measures used to assure the quality of a product from the development stage to the manufacturing stage.

LFO-Filter

(Low-Frequency-Oscillation) Filter for low frequency oscillations

Link address

The link address gives the address of a V3/V2 device.

List view

The right window section of the project window displays the names and icons of objects which represent the contents of a container selected in the tree view. Because they are displayed in the form of a list, this area is called the list view.

LPS

Line Post Sensor

LV

Limiting value

Master

Masters may send data to other users and request data from other users. DIGSI operates as a master.

Metered value

Metered values are a processing function with which the total number of discrete similar events (counting pulses) is determined for a period, usually as an integrated value. In power supply companies the electrical work is usually recorded as a metered value (energy purchase/supply, energy transportation).

MLFB

MLFB is the abbreviation for "MaschinenLesbare FabrikateBezeichnung" (machine-readable product designation). This is the equivalent of an order number. The type and version of a SIPROTEC 4 device is coded in the order number.

Modem connection

This object type contains information on both partners of a modem connection, the local modem and the remote modem.

Modem profile

A modem profile consists of the name of the profile, a modem driver and may also comprise several initialization commands and a user address. You can create several modem profiles for one physical modem. To do so you need to link various initialization commands or user addresses to a modem driver and its properties and save them under different names.

Modems

Modem profiles for a modem connection are stored in this object type.

MV

Measured value

MVMV

Metered value which is formed from the measured value

MVT

Measured value with time

MVU

Measured value, user-defined

Navigation pane

The left pane of the project window displays the names and symbols of all containers of a project in the form of a folder tree.

Object

Each element of a project structure is called an object in DIGSI.

Object properties

Each object has properties. These might be general properties that are common to several objects. An object can also have specific properties.

Off-line

In offline mode a connection to a SIPROTEC 4 device is not required. You work with data which are stored in files.

On-line

When working in online mode, there is a physical connection to a SIPROTEC 4 device. This connection can be implemented as a direct connection, as a modem connection or as a PROFIBUS FMS connection.

OUT

Output Indication

OUT_Ev

Output indication Spontaneous event→ Fleeting indication

Parameterization

Comprehensive term for all setting work on the device. The parameterization is done with DIGSI or sometimes also directly on the device.

Parameter set

The parameter set is the set of all parameters that can be set for a SIPROTEC 4 device.

Phone book

User addresses for a modem connection are saved in this object type.

PMV

Pulse metered value

Process bus

Devices with a process bus interface allow direct communication with SICAM HV modules. The process bus interface is equipped with an Ethernet module.

PROFIBUS

PROcess FIeld BUS, the German process and field bus standard, as specified in the standard EN 50170, Volume 2, PROFIBUS. It defines the functional, electrical, and mechanical properties for a bit-serial field bus.

PROFIBUS address

Within a PROFIBUS network a unique PROFIBUS address has to be assigned to each SIPROTEC 4 device. A total of 254 PROFIBUS addresses are available for each PROFIBUS network.

Project

Content-wise, a project is the image of a real power 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.

Protection devices

All devices with a protective function and no control display.

Reorganizing

Frequent addition and deletion of objects results in memory areas that can no longer be used. By reorganizing projects, you can release these memory areas again. However, a cleanup also reassigns the VD addresses. The consequence is that all SIPROTEC 4 devices have to be reinitialized.

RIO file

Relay data Interchange format by Omicron.

RSxxx-interface

Serial interfaces RS232, RS422/485

Service interface

Rear serial interface on the devices for connecting DIGSI (for example, via modem).

SICAM PAS (Power Automation System)

Substation control system: The range of possible configurations spans from integrated standalone systems (SICAM PAS and M&C with SICAM PAS CC on one computer) to separate hardware for SICAM PAS and SICAM PAS CC to distributed systems with multiple SICAM Station Units. The software is a modular system with basic and optional packages. SICAM PAS is a purely distributed system: the process interface is implemented by the use of bay units / remote terminal units.

SICAM Station Unit

The SICAM Station Unit with its special hardware (no fan, no rotating parts) and its Windows XP Embedded operating system is the basis for SICAM PAS.

SICAM WinCC

The SICAM WinCC operator control and monitoring system displays the state of your network graphically, visualizes alarms, interrupts and indications, archives the network data, offers the possibility of intervening manually in the process and manages the system rights of the individual employee.

Single command

Single commands are process outputs which indicate 2 process states (for example, ON/OFF) at one output.

Single point indication

Single indications are items of process information which indicate 2 process states (for example, ON/OFF) at one output.

SIPROTEC

The registered trademark SIPROTEC is used for devices implemented on system base V4.

SIPROTEC 4 device

This object type represents a real SIPROTEC 4 device with all the setting values and process data it contains.

SIPROTEC 4 Variant

This object type represents a variant of an object of type SIPROTEC 4 device. The device data of this variant may well differ from the device data of the original object. However, all variants derived from the original object have the same VD address as the original object. For this reason they always correspond to the same real SIPROTEC 4 device as the original object. Objects of type SIPROTEC 4 variant have a variety of uses, such as documenting different operating states when entering parameter settings of a SIPROTEC 4 device.

Slave

A slave may only exchange data with a master after being prompted to do so by the master. SIPROTEC 4 devices operate as slaves.

SP

→ Single point indication

SP_W

→ Single point indication Spontaneous event → Fleeting indication, → Single point indication

System interface

Rear serial interface on the devices for connecting to a substation controller via IEC or PROFIBUS.

TI

Transformer Tap Indication

Time stamp

Time stamp is the assignment of the real time to a process event.

Topological view

DIGSI Manager always displays a project in the topological view. This shows the hierarchical structure of a project with all available objects.

Transformer Tap Indication

Transformer tap indication is a processing function on the DI by means of which the tap of the transformer tap changer can be detected together in parallel and processed further.

Tree view

The left pane of the project window displays the names and symbols of all containers of a project in the form of a folder tree. This area is called the tree view.

Ungrounded

Without any electrical connection to → ground.

User address

A user address comprises the name of the user, the national code, the area code and the user-specific phone number.

Users

From DIGSI V4.6 onward , up to 32 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination. The individual participating devices are called users.

VD

A VD (Virtual Device) includes all communication objects and their properties and states that are used by a communication user through services. A VD can be a physical device, a module of a device or a software module.

VD address

The VD address is assigned automatically by DIGSI Manager. It exists only once in the entire project and thus serves to identify unambiguously a real SIPROTEC 4 device. The VD address assigned by DIGSI Manager must be transferred to the SIPROTEC 4 device in order to allow communication with DIGSI Device Editor.

VFD

A VFD (Virtual Field Device) includes all communication objects and their properties and states that are used by a communication user through services.

VI

VI stands for Value Indication.

Index

1,2,3 ...

181, 202, 235, 340

A

AC voltage 293
Acknowledgement of Commands 240
Adaptive Dead Time 319
Adaptive dead time (ADT) 127
Alarm levels 179
Analogue Inputs 292
Anlagendaten 2 35
Asymmetrical measuring voltage failure 195
Automatic reclosing commands 227
Automatic reclosure
    Circuit breaker auxiliary contacts 114
    Circuit breaker test 207
Automatic Reclosure 319
Automatic reclosure function
    1-pole and 3-pole Reclose Cycle 116
    1-pole reclose cycle 115
    3-pole reclose cycle 115
    Action Times 113
    Control 120
    External Auto-Reclosure Device 119
    Initiation 112
    Operating modes 113
Auxiliary and Reference Voltages 181
Auxiliary voltage 292
Auxiliary Voltage 248

B

Binary inputs 293
Binary Outputs 223, 293
Breaker Intertrip
    Receiving circuit 68
    Remote tripping 69
    Transmission Circuit 68
Broken wire monitoring 184
Buffer battery 181
Busbar tripping 279

C

Change Group 34
Changing Setting Group 245
Check Oscillographic Recording 288
Check:
    Switching Test of Operating Equipment 288
Checking a Connection 272
Checking the System Connections 264
Checking:
    Breaker Failure Protection 278
    Instrument Transformer Connections with Two Line Ends 281
    Phase rotation 280
    Polarity 282
    Polarity current input I 284
    Signal Transmission (int., ext. Remote Tripping) 287
    Switching states of the binary Inputs/Outputs 269
    System Interface 267
    Time synchronisation interface 262
    Time Synchronisation Interface 267
    User-defined Functions 287
    Voltage connection 280
Circuit breaker
    External trip 78
    Malfunction 169
    position logic 205
    Test 30
    Tripping check 288
Circuit Breaker
    Detection Position 205
    Testing 215
Circuit breaker auxiliary contacts 163
Circuit breaker failure protection 161, 171
    End fault protection 324
    Pole discrepancy supervision 324
    Times 324
Circuit Breaker Failure Protection 324
    Circuit breaker monitoring 324
    Initiation conditions 324
Circuit breaker for voltage transformers 196
Circuit breaker not operational 174
Circuit breaker status 37
Climatic Stress Tests 300
Clock/Time synchronisation 334
Command Execution 236, 236
Command Output 240
Command Path 235

Commissioning aids 334
Commissioning Aids
WEB-Monitor 221
Common phase initiation 164
Communication 18
Monitoring 44
communication converter 43
Communication Converter 272, 273
Communication Interfaces 294
Communication links 53
Communication media 43
Configuration of auto-reclosure 126
Configuring the functional scope 25
Consistency
Parameterisation 274
Topology 274
Constructive versions 301
Control Logic 239
Control Voltage 251
Control Voltage BI1 to BI5 251
Control Voltage for Binary Inputs 248
Counters and Memories 226
CT error at rated accuracy limit factor 31
Cubicle Mounting 259
current direction 72
Current flow monitoring 162
Current Inputs 292
Current Symmetry 183
Current transformer characteristic 30
Current transformer requirements 292

D

Dead line check 127
Dead Line Check 319
Default displays 224
Delay times- single-stage/two-stage circuit breaker failure protection 168
Deployment Conditions 301
Device ID 53
Dialog Box 270
Differential current
Pickup value 63
Differential protection 230
Basic principle with two ends 56
Blocking 61
Charge comparison 60
Delay times 306
Delays 64
Device communication 57
Emergency operation 307
Evaluation of the measured quantities 59
Further influences 58
Inrush restraint 58, 307
Interblocking 61
Log Out Device 45
Pickup 61
Pickup value of charge comparison stage 65
Pickup values 63, 64
Restraint 57
Self-restraint 306
Tolerances 58
Transmission Measured Value 56
Tripping logic 62
Differential Protection
Commissioning Mode 48
Current transformer errors 57
Pickup Values 306
Protection Data Interfaces 302
Test Mode 47
Topology 302
Tripping Times 306
Differential protiection
Inrush restraint 65
Direct Voltage 292
Display of measured values 228

E

Earth fault 72
Earth Fault Protection
Operating characteristics 75
Restraint 74
Restraint quantity 75
Sensitivity 73
Starpoint current 73
Through current 73
Transformer saturation 74
Electrical Tests 298
EMC Tests for Interference Emission (Type Test) 299
EMC Tests for Interference Immunity (Type Tests) 298
EN100-Module
Interface selection 220
End fault protection 170, 174
Energy Metering 233
Event buffer 224
Exchange of information 53
Exchanging Interfaces 248
External direct trip 309

F

Fault Annunciations 218
Fault Indications 225
Fault Logging 334
Fault record 225
Fault Recording 18, 334
Fault Records 232
Feedback monitoring 240
Final Preparation of the Device 290
FO-Modul 43
Forced three-pole trip 127

Frequency 307
frequency protection 155
Overfrequency protection 155
Underfrequency protection 155
Frequency protection
delay time 158
Frequency measurement 155
Frequency stages 155
Operating ranges 155
pickup values 158
Pickup/tripping 156
Frequency Protection 323
Operating Range 323
Pick-up Values 323
Times 323
Tolerances 323
Function Blocks 329
Fuse-Failure-Monitor 187, 195

G

General Interrogation 226
GPS synchronisation 52

H

High current stages I>>, 3I>> 101
Hochstrom-Schnellabschaltung 311
Humidity 301

I

Indications 225
Information to a Control Centre 225
Input/Output Board
C-I/O-11 254
Instantaneous tripping
before automatic reclosure 98
Insulation Test 298
Integrated Display 224
Interfaces 53
Interlocking 236
Interrupted currents 227
Intertrip 69
Inverse Time Stages (time overcurrent protection)
IEC Curve 313
Inverse Time Stages (Time Overcurrent Protection)
ANSI-Characteristic 314

K

k-factor 178
Kontrolle:
Terminierung 262

L

Life contact 248
Limiting with user defined functions 330
Limits for CFC blocks 330
Line Energization Recognition 202

M

Measured Value Acquisition
Currents 181
Voltages 182
Measured values 228, 327
Measured Values 88
Measured values constellation 231
Measured voltage failure monitoring 196
Measured Voltage Failure Monitoring 189
Mechanische Prüfungen 299
Memory Components 181
Modem 43
Monitoring 44
Monitoring Functions 327
Monitoring the Phase Angle 191
Mounting: Panel Mounting 260

O

One-pole dead time 209
Open Pole Detector 208
Operating state change 270
Operational accuracy limit factor 31
Operational Indication Buffer 334
Operational Indications 225
Operational measured values 333
Operator Interface
Control 261
Optical Fibres 263
Output Relays 223
Overcurrent stage
I (directional inverse) 96
I (inverse) 95
Overcurrent Stages
3I (Inverse-time Overcurrent Protection with ANSI Characteristics) 104
3I (Inverse-time Overcurrent Protection with IEC Characteristics) 103
3I> (Definite-time Overcurrent Protection) 102

I (Inverse-time Overcurrent Protection with ANSI Characteristics) 104
I (Inverse-time Overcurrent Protection with IEC Characteristics) 103
I> (Definite-time Overcurrent Protection) 102
Overtemperature 180
overvoltage protection
any single-phase voltage 321
zero-sequence system 3 321
Overvoltage protection
Compounding 138
Negative sequence system 139, 148, 320
Phase-to-earth 147, 320
Phase-to-phase 137, 147, 320
positive sequence system 147, 320
Positive sequence system 138
Zero-sequence system 148
Zero-sequence system 3 140
Overvoltage Protection 136

P

Phase currents 72
Phase-segregated initiation - Circuit breaker failure protection 165
Pickup logic 98
Pickup Logic of the Entire Device 210
Polarity check 282
Polarity check for current input I 284
Pole discrepancy supervision 171, 174
Power supply 292
Power System Data 1 27
Protection data communication 44
Protection data interface 53, 80
Protection Data Interface
Protection Data Communication 304
Protection data interfaces 43, 50
Protection data topology 53
Protection Data Topology 43, 271
Availability of the protection data interfaces 275

R

Rack Mounting 259
rated accuracy limit factor 31
Rated Currents 248
Rated frequency 30
Real Time Clock and Buffer Battery 334
Reclose cycle 128, 129, 130
Reclosure
Blocking 114
Multiple 116
Reduced Dead Time 319
Remote commands 80, 310
Remote messages 80
Remote signals 310
Remote tripping 69
Remote Tripping 309
Reset of Stored LED / Relays 217
Restraint current values 230
Restricted Earth Fault Protection 19
Delay time 76
Measuring principle 72
Operating Time 308
Pickup value 76
Sensitivity 76
Setting ranges 308
Retrievable Indications 226
Retrieving Parameters 234
Ring topology 53

S

Schaltermitnahme 309
Schaltprüfung der projektierten Operating Equipment 288
Service Interface
Test 261
Service/Modem Interface 295
Setting Groups 34
Changing 245
Single-stage circuit breaker failure protection 173
SOTF 83
Specifications 298
Spontaneous annunciations 226
Spontaneous Fault Messeges 216
Spontaneous Indications 226
Standard Interlocking 237
Starpoint current 72
Starpoint current transformer 74
Start Test Measurement Recording 288
Statistics 334
Sum Monitoring 195
Supervision with binary input 201
Switch-on
Pickup value 64
Switch-onto-Fault Protection
I>>>-Stage 83
I>>>>-Stage 84
Switching
onto a fault 98
Switching (Interlocked/non-interlocked) 237
Switching Statistics 334
Symmetry monitoring 195
System Interface 295

T

Temperatures 300
Terminating interfaces with bus capability 249

Terminierung 262
Test Mode 267
Test:
Binary inputs 271
Indication Direction 269
LEDs 271
Operator Interface 261
Output relay 270
Service Interface 261
Test: System interface 261
Test:Command Direction 269
Thermal overload protection
Tripping Characteristic 325
Thermischer Überlastschutz 325
Three-phase measuring voltage failure 195
Three-pole coupling 38
Time constant τ 179
Time Overcurrent Protection 312
Characteristics 312
High-set Current Stages 312
Overcurrent Stages 312
Time synchronisation interface 262
Time Synchronisation Interface 297
Timesynchronization 53
Topology exploration 80
transformer
onditions of saturation 72
Transformer connection
Differential currents 285
Polarity check 282
Polarity current input I 284
Restraint currents 285
Transformers
Conditioning 307
Transmission Block 267
Transmission statistics 227
Trip Circuit Supervision 245, 327
Trip command duration 30
Trip-Dependent Indications 216
Tripping logic 98
Tripping Logic of the Entire Device 211
Trips 227
Two-stage circuit breaker failure protection 172
Type of Commands 235

U

Überstromstufe
I> (unabhängig) 91
Undervoltage
positive sequence system 145
Undervoltage protection
Phase to-phase 321
phase-to-earth 149
Phase-to-earth 321
phase-to-phase 149
Phase-to-phase 144
positive sequence system 150
Positive sequence system 321
Undervoltage Protection
Phase-to-Earth 142
User defined functions 329

V

Vibration and Shock Resistance during Stationary Operation 299
Vibration and Shock Resistance during Transport 300
Voltage Inputs 292
Voltage Phase Sequence 186
Voltage Protection 136
Voltage Symmetry 183

W

Watchdog 183
WEB-Monitor 16, 221, 275, 281, 286

Z

Zero sequence current 73
Zero-voltage stages for single-phase voltage 142