SIPROTEC

Differential Protection 7SD610

V4.2

Manual

C53000–G1176–C145–2

Liability statement

We have checked the contents of this manual against the described hardware and software. Nevertheless, deviations may occur so that we cannot guarantee the entire harmony with the product.

The contents of this manual will be checked in periodical intervals, corrections will be made in the following editions. We look forward to your suggestions for improvement.

We reserve the right to make technical improvements without notice.

4.20.02

Siemens Aktiengesellschaft Buch-Nr. C53000–G1176–C145–2

Preface

Aim of This Manual

This manual describes the functions, operation, installation, and commissioning of the device. In particularly, you will find:

- Description of the device functions and setting facilities → Chapter 2,
- Instruction for installation and commissioning → Chapter 3,
- List of the technical data → Chapter 4,
- As well as a compilation of the most significant data for experienced users in the Appendix.

General information about design, configuration, and operation of SIPROTEC® devices are laid down in the SIPROTEC® 4 system manual, order no. E50417–H1176–C151.

Target Audience

Protection engineers, commissioning engineers, persons who are involved in setting, testing and service of protection, automation, and control devices, as well as operation personnel in electrical plants and power stations.

Applicability of this Manual

This manual is valid for SIPROTEC® 7SD610 differential protection; firmware version 4.2.

Indication of Conformity

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 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage Directive 73/23/EEC).

This conformity has been proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 60000–6–2 and EN 50082 (for EMC directive) and the standards EN 60255-6 (for low-voltage directive).

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

Further Standards

IEEE C37.90.*.

This product is UL-certified with the data as stated in the Technical Data:

IND. CONT. EQ.
TYPE 1
69CA

IND. CONT. EQ.
TYPE 1

Additional Support

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the local Siemens representative.

Training Courses

Individual course offerings may be found in our Training Catalogue, or questions may be directed to our training center. Please contact your Siemens representative.

Instructions and Warnings

The warnings and notes contained in this manual serve for your own safety and for an appropriate lifetime of the device. Please observe them!

The following terms are used:

DANGER

indicates that death, severe personal injury or substantial property damage will result if proper precautions are not taken.

Warning

indicates that death, severe personal injury or substantial property damage can result if proper precautions are not taken.

Caution

indicates that minor personal injury or property damage can result if proper precautions are not taken. This particularly applies to damage on or in the device itself and consequential damage thereof.

Note
indicates information about the device or respective part of the instruction manual which is essential to highlight.

Warning!

Hazardous voltages are present in this electrical equipment during operation. Non-observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

The successful and safe operation of this device is dependent on proper handling, installation, operation, and maintenance by qualified personnel under observance of all warnings and hints contained in this manual.

In particular the general erection and safety regulations (e.g. IEC, DIN, VDE, EN or other national and international standards) regarding the correct use of hoisting gear must be observed. Non-observance can result in death, personal injury or substantial property damage.

QUALIFIED PERSONNEL

For the purpose of this instruction manual and product labels, a qualified person is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he has the following qualifications:

- Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

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:

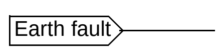
`Parameter names`, i.e. designators of configuration or function parameters which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI®), are marked in bold letters of a monospace type style.

`Parameter options`, i.e. 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 written in italic style, additionally.

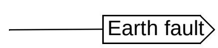
“`Annunciations`”, i.e. designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotation marks.

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

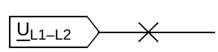
The following symbols are used in drawings:



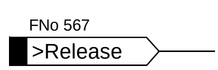
device-internal logical input signal



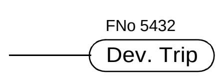
device-internal logical output signal



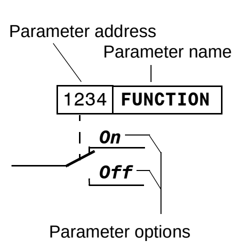
internal input signal of an analogue quantity



external binary input signal with function number Fno

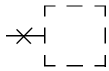


external binary output signal with function number Fno

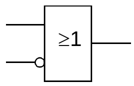


example of a parameter switch designated **`FUNCTION`** with the address 1234 and the possible settings ***`On`*** and ***`Off`***

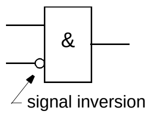
Besides these, graphical symbols are used according to IEC 60617–12 and IEC 60617–13 or similar. Some of the most frequently used are listed below:



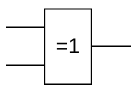
Input signal of an analogue quantity



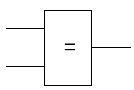
OR gate



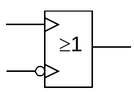
AND gate



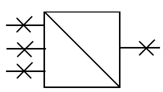
Exclusive-OR gate (antivalence): output is active, if only *one* of the inputs is active



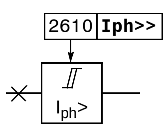
Coincidence gate (equivalence): output is active, if *both* input are active or inactive at the same time



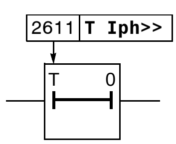
Dynamic inputs (edge-triggered)
above with positive, below with negative edge



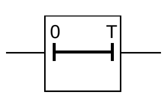
Formation of one analogue output signal from
a number of analogue input signals (example: 3)



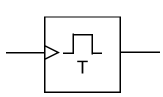
Limit stage with setting address and parameter designator (name)



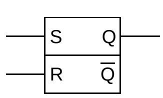
Timer (pickup delay T, example adjustable)
with setting address and parameter designator (name)



Timer (dropout delay T, example non-adjustable)



Dynamic triggered pulse timer T (monoflop)



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

Furthermore, the graphic symbols according IEC 60617–12 and IEC 60617–13 or similar are used in most cases.

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Table of Contents

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Introduction 1

The SIPROTEC® 4 devices 7SD610 are introduced in this chapter. An overview of the devices is presented in their application, features, and scope of functions.

1.1 Overall Operation

The numerical differential protection SIPROTEC® 7SD610 is equipped with a powerful 32 Bit microprocessor. This provides fully numerical 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 end of the protected area. Figure 1-1 shows the basic structure of the device.

Analog Inputs

The analog inputs “AI” transform the currents and voltages derived from the instrument transformers and match them to the internal signal levels for processing in the device. The device has 4 current and 4 voltage inputs. Three current inputs are pro-

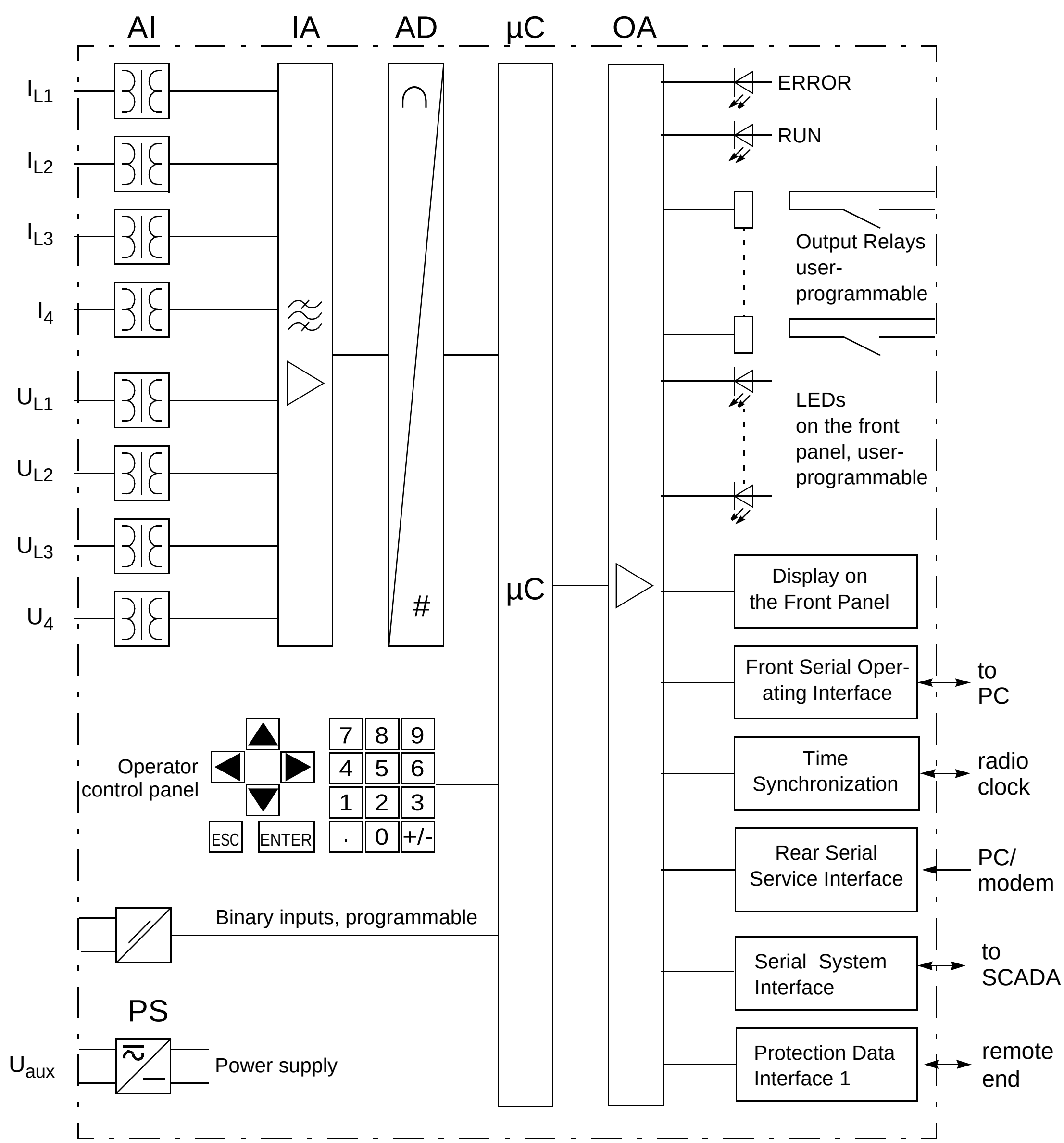

Figure 1-1 Hardware structure of the numerical device 7SD610

vided for measurement of the phase currents, a further analog input (I_4) may be used for the residual current (current transformer starpoint or a separate earth current transformer). A voltage input is provided for each phase-earth voltage. In principle, the differential protection does not require any measured voltage. However, voltages that allow to measure voltages and powers and voltages that enable the user to measure the line voltage also for automatic reclosure can be switched to the device. A further voltage input (U_4) may optionally be used to measure the displacement voltage (e-n-voltage). The analog signals are then routed to the input amplifier group “IA”.

The input amplifier group “IA” ensures that there is high impedance termination for the measured signals and contains filters which are optimized in terms of band-width and speed with regard to the signal processing.

The analog/digital converter group “AD” has a multiplexer, analog/digital converters and memory modules for the data transfer to the microcomputer system “µC”.

Microcomputer System

Apart from processing the measured values, the microcomputer system also executes the actual protection and control functions. In particular, the following are included:

– Filtering and conditioning of the measured signals,

– Continuous supervision of the measured signals,

– Supervision of pickup conditions of each protection function,

– Formation of the local differential protection values (phasor analysis and charge computation) and creation of the transmission protocol,

– Decoding of the received transmission protocol, synchronism of differential protection values and summing up of the differential currents and charges,

– Monitoring of the communication with the device of the opposite end,

– Interrogation of threshold values and time sequences,

– Processing of signals for the logic functions,

– Reaching trip and close command decisions,

– Storage of fault messages, fault annunciations as well as fault recording data for system fault analysis,

– Operating system and related function management such as e.g. data storage, real time clock, communication, interfaces etc.,

The information is provided via output amplifier “OA”.

Binary Inputs and Outputs

The microcomputer system obtains external information through binary inputs such as remote resetting or blocking commands for protective elements. The “µC” issues information to external equipment via the output contacts. These outputs include, in particular, trip commands to circuit breakers and signals for remote annunciation of important events and conditions.

Front Elements

Light emitting diodes (LEDs) and a display screen (LCD) on the front panel provide information such as targets, measured values, messages related to events or faults, status, and functional status of the 7SD610.

Integrated control and numeric keys in conjunction with the LCD facilitate local interaction with the 7SD610. All information of the device can be accessed using the integrated control and numeric keys. The information includes protective and control settings, operating and fault messages, and measured values (see also SIPROTEC® System Manual, order-no. E50417–H1176–C151). The settings can be modified as are discussed in Chapter 2.

Using integrated switchgear control functions, the control of circuit breakers and other equipment is possible from the 7SD610 front panel.

Serial Interfaces

A serial **operator** interface (PC port) on the front panel is provided for local communications with the 7SD610 through a personal computer. Convenient operation of all functions of the device is possible using the SIPROTEC® 4 operating program DIGSI®.

A separate serial **service** interface is provided for remote communications via a modem, or local communications via a substation master computer that is permanently connected to the 7SD610. DIGSI® is required.

All 7SD610 data can be transferred to a central master or main control system through the serial **system** (SCADA) interface. Various protocols and physical arrangements are available for this interface to suit the particular application.

Another interface is provided for the time synchronization of the internal clock via external synchronization sources.

Via additional interface modules further communication protocols may be created.

The **operating** and **service** interface allow the communication from one PC with both devices at the line ends during commissioning, checking and also during operation of the device, using a standard browser. There is a range of PC-tools supporting this function (e.g. “IBS-tool”) which have been optimized with regard to the differential protection system.

Protection Data Interface

The protection data interfaces are a particular case. Via these interfaces the measured value data of each end of the protected object is transmitted to the other end; during this procedure measured values from the other end may also be added. 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 other end via the protection data interfaces.

Power Supply

The 7SD610 can be supplied with any of the common power supply voltages. Transient dips of the supply voltage which may occur during short-circuit in the power supply system, are bridged by a capacitor (see Technical Data, Subsection 4.1.2).

1.2 Applications

The numerical differential protection SIPROTEC® 7SD610 functions as a selective short-circuit protection for overhead lines and cables with single- and multi-ended in-feeds in radial, ring or any type of meshed systems of any transmission 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 is a power transformer is situated 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 function is the instantaneous tripping in the event of a short-circuit at any point in the entire protected zone. The current transformers limit the protected zone at the ends towards the remaining system. This rigid limit is the reason why the differential protection scheme shows such an ideal selectivity.

The total 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, they can, however, be connected for the purpose of indicating and processing measured values (voltages, power, power factor).

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. Two type 7SD610 devices can be used for an object with two ends to be protected: cable, overhead line or both, with or without unit-connected power transformer (option).

As a fault-free data transfer being the prerequisite for the proper operation of the protective system, it is continuously monitored internally.

Protective Functions

Recognition of short circuits in the protection zone — even of weak-current or high-resistive shorting — is the basic function of the device. Also complex multiphase faults are precisely detected, as the measured values are evaluated phase segregated. The protection system is stabilized against inrush currents of power transformers. When switching onto a fault at any point of the 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 again. This time overcurrent protection has three definite time overcurrent stages and one inverse time (IDMT) stage; a series of characteristics according to various standards is available for the inverse time stage. 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 link can be used for transmitting further information. Apart from measured values, binary commands or other information can be transmitted (option).

Depending on the version ordered, the short-circuit protection functions can also trip single-pole. They may operate in co-operation with an integrated automatic reclosure (available as an option) with which single-pole, three-pole or single- and three-pole rapid automatic reclosure as well as multi-shot automatic reclosure are possible 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. An optional circuit breaker failure protection provides rapid backup fault clearance instruction to the adjacent circuit breakers in case the local breaker fails to respond.

1.3 Features

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 and reliable separation between the internal processing circuits of the 7SD610 and the external measurement, control, and power supply circuits because of the design of the analog input transducers, binary inputs and outputs, and the DC/DC or AC/DC converters.
- Simple device operation using the integrated operator panel or by means of a connected personal computer running DIGSI®.

Differential Protection

- Differential protection system for 2 ends with digital protection data transmission.
- Protection for all types of short-circuits in systems with any starpoint conditioning.
- Reliable distinction between load and short-circuit conditions, also on high-resistant, current-weak faults, by means of adaptive measuring procedures.
- High sensitivity during weak-infeed conditions, extreme stability against load jumps and power swings.
- Due to phase segregated measurement the pickup sensitivity is independent of the type of fault.
- Suited for transformers in the protected zone (order option).
- Detection of high-resistant, current-weak faults due to high sensitivity.
- Insensitive against in-rush and charging currents — also for transformers in the protected zone (order option) — and against higher-frequency switching transients.
- High stability also for different current transformer saturation.
- Adaptive stabilization that is automatically derived from the measured values and the configured current transformer data.
- Fast phase segregated tripping also on weak or zero infeed ends (Intertrip).
- Low dependence on frequency due to frequency tracking.
- Digital transmission of protection data; communication between devices via dedicated communication connections (in general optical fibre) or a communication system.
- Communication possible via ISDN-networks or two-wire telephone connections (up to approx 8 km or 5 miles).
- Protection data synchronization via GPS receiver possible, resulting in automatic correction of transmission time differences thus increasing once more the sensitivity.
- Permanent supervision of the protection data transmission concerning disturbance, failure, and transfer time deviation in the transmission network, with automatic transfer time correction.

- Phase segregated tripping (in conjunction with single-pole or single- and three-pole auto-reclosure) is possible (order option).

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 an external device via binary input.

Transmission of Information

- Transmission of measured values from both ends of the protected object.
- Transmission of up to 4 fast commands or binary signals to the remote end (order option).

Time Delayed Overcurrent Protection

- Selectable as emergency function during protection data communication failure or as back-up function or as both.
- Up to a maximum of three definite time stages (DT) and one inverse time stage (IDMT), each for phase currents and residual current.
- For IDMT protection a selection from various characteristics based on several standards is possible.
- Blocking options e.g. for reverse interlocking using any stage.
- Instantaneous trip with any desired stage when switching on to a fault is possible.

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 energization detection.

Automatic Reclosure (optional)

- For reclosure after single-pole, three-pole or single and three-pole tripping.
- Single or multiple shot reclosure (up to 8 reclosure attempts).
- With separate action times for every reclosure attempt, optionally without action times.
- With separate dead times after single-pole and three-pole tripping, separate for the first four reclosure attempts.
- With the option of an adaptive dead time: in this case only *one* device controls the automatic reclosure cycles whilst at the *other* end the automatic reclosure solely depends on the *one* controlling device; the following criteria may apply: voltage return recognition and/or close command transmission (“Remote close”).
- Automatic reclosure controlled optionally by protection start with separate dead times after single, two and three-pole starting.

Circuit Breaker Failure Protection (optional)

- With independent current detectors for monitoring of current flow through each individual circuit breaker pole.
- With independent delay timers for single-pole trip and three-pole trip.
- Initiation by each of the internal trip functions.
- Initiation by external trip functions possible via binary inputs.

- Single-stage or two-stage delay.
- Short reset and overshoot times.
- End fault protection and pole discrepancy monitoring possible.

Thermal Overload Protection

- Provides thermal replica of the current heat losses of the protected object.
- True RMS measurement of all three conductor currents.
- Adjustable thermal and current-dependent warning stages.

User Defined Logic Functions

- Freely programmable linkage between internal and external signals for the implementation of user defined logic functions.
- All common logic functions.
- Time delays and measured value set point interrogation.

Commissioning; Operation; Maintenance

- Indication of the local and remote measured values, amplitudes and phase relation.
- Indication of the calculated differential and restraint currents.
- Indication of the characteristic values of the communication link, as transfer delay times and availability.
- Function logout of a device from the differential protection system during maintenance work at an end of a power line, test mode operation possible.

Monitoring Functions

- Monitoring of the internal measuring circuits, the auxiliary voltage supply, as well as the hard- and software, resulting in increased reliability.
- Supervision of the current and voltage transformer secondary circuits by means of summation and symmetry checks.
- Monitoring of communication with statistics showing the availability of 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 is possible.
- 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.

Further Functions

- Battery buffered real time clock, which may be synchronized via a synchronization signal (e.g. DCF77, IRIG B or 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 line end.

- Fault event memory for the last 8 network faults (faults in the power system), with real time stamps (ms-resolution).
- Fault recording memory and data transfer for analog and user configurable binary signal traces with a maximum time range of 15 s, synchronized between the devices of the differential protection system.
- Switching statistics: counters with the trip and close commands issued by the device, as well as record of the fault current and accumulation of the interrupted fault currents.
- Communication with central control and data storage equipment via serial interfaces through the choice of data cable, modem, or optical fibres, as an option.
- Commissioning aids such as connection and direction checks as well as interface check and circuit breaker test functions.
- The “IBS-tool” (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 protection system are displayed as a graph.

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Functions 2

This chapter describes the numerous functions available on the SIPROTEC® 7SD610 relay. The setting options for each function are explained, including instructions to determine setting values and formulae where required.

2.1 General

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

Configuration settings (Subsection 2.1.1) may be entered using a PC and the software program DIGSI® and transferred via the operating interface on the device front, or via the serial service interface. Operation via DIGSI® is described in the SIPROTEC® 4 System Manual, order no. E50417–H1176–C151. Entry of password No. 7 (for setting modification) is required to modify configuration settings. Without the password, the settings may be read, but cannot be modified and transmitted to the device.

The function parameters, i.e. settings of function options, threshold values, etc., can be entered via the keypad and display on the front of the device, or by means of a personal computer connected to the front or service interface of the device utilising the DIGSI® software package. The level 5 password (individual parameters) is required.

2.1.1 Configuration of the Scope of Functions

General

The 7SD610 relay contains a series of protective and additional functions. The scope of hardware and firmware is matched to these functions. Furthermore, commands (control actions) can be suited to individual needs of the protected object. In addition, individual functions may be enabled or disabled during configuration, or interaction between functions may be adjusted.

Example for the configuration of the scope of functions:

7SD610 devices should be intended to be used for overhead lines and transformers. Overload protection should only be applied on transformers. If the device is used for overhead lines this function is set to ***Disabled*** and if used for transformers this function is set to ***Enabled***.

The available function are configured ***Enabled*** or ***Disabled***. For some functions, a choice may be presented between several options which are explained below.

Functions configured as ***Disabled*** are not processed by the 7SD610. There are no messages, and associated settings (functions, limit values, etc.) are not displayed during detailed settings.

Note:

Available functions and default settings are depending on the ordering code of the relay (see ordering code in the Appendix Section A.1 for details).

Determination of Functional Scope

Configuration settings may be entered using a PC and the software program DIGSI® and transferred via the operating interface on the device front, or via the serial service interface. Operation via DIGSI® is described in the SIPROTEC® system manual, order number E50417–H1176–C151 (Section 5.3).

Entry of password No. 7 (for setting modification) is required to modify configuration settings. Without the password, the settings may be read, but cannot be modified and transmitted to the device.

Special Cases

Many settings are self-explanatory. The special cases are described below.

If the setting group change-over function is to be used, the setting in address 103 **Grp Chge OPTION** must be set to ***Enabled***. In this case, it is possible to apply up to four different groups of settings for the function parameters (refer also to Subsection 2.1.3). During normal operation, a convenient and fast switch-over between these setting groups is possible. The setting ***Disabled*** implies that only one function parameter setting group can be applied and used.

Address 110 **Trip 1pole** applies only to devices with single-pole or three-pole tripping. Set ***1-/3pole*** if single-pole is also desired, i. e. if the device is supposed to operate with single-pole or with single-pole/three-pole automatic reclosure. A pre-condition is that the device is equipped with an automatic reclosure function or that an external device is used to carry out automatic reclosure. Additionally the circuit breaker must be suited for single-pole tripping.

Note:

When having changed address 110, then first save this alteration by clicking **OK**. Re-open the dialogue box, since there are other settings which are dependent 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.

A preselection of the tripping characteristics of the time overcurrent protection can be made in address 126 **Back-Up O/C**. 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. The characteristics are shown in the Technical Data (Section 4.6). The time overcurrent protection may naturally also be set to ***Disabled***.

If the device provides an automatic reclosure function (AR), the addresses 133 and 134 are relevant. If no automatic reclosure is desired for the feeder the device 7SD610 is connected to, or if an external device carries out the automatic reclosure, address 133 **Auto Reclose** is set to ***Disabled***. 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.

In the address mentioned the number of desired reclosure cycles is set. Choose the desired number of AR-cycles from a total scope of ***8 AR-cycles***. You can also set ***ADT*** (adaptive dead time): in this case the behaviour of the automatic reclosure depends on the cycles of the remote end. However, at one end of the line the number of cycles must be configured. This end must provide an infeed. The other end may operate with adaptive dead time. See Subsection 2.9.1 for detailed information.

The **AR control mode** under address 134 allows a total of four options. You can determine whether the sequence of automatic reclosure cycles is defined by the fault situation of the *pickup* of the starting protection function(s) or by the type of *trip* command. The automatic reclosure can also operate with or without action time.

The ***Trip w/ Tact*** or ***Trip w/o Tact*** setting is preferred when single-pole or single/three-pole automatic reclosure cycles are desired and are 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 dependent on this.

The ***Pickup w/ Tact*** or ***Pickup w/o Tact*** setting is only possible for three-pole trip, i.e. if the device is ordered for exclusively three-pole trip or three-pole trip is configured (address 110 **Trip 1pole** = ***3pole only***). In this case, different dead times can be set for the auto-reclosure cycles after single, two- and three-phase pickup on faults. The fault detection (pickup) image of the protection functions at the instant the trip command disappears is decisive. This operating mode also enables the dead times to be made dependent on the type of fault; but tripping is always three-pole.

The ***Trip w/ Tact*** or ***Pickup w/ Tact*** (with action time) setting provides an action time for every AR-cycle. This is started by the general pickup signal (i. e. logic OR combination of all internal and external pickup signals of all protection functions which are configured to start the automatic reclosure function). If there is yet no trip command when the action time has expired, the corresponding automatic reclosure cycle cannot be executed. See Subsection 2.9.1 for more information. For time graded protection this setting is recommended. If the protection function to operate with reclosure does not have a general fault detection signal for starting the action times, select the setting ***Trip w/o Tact*** or ***Pickup w/out Tact*** (without action time).

For the trip circuit supervision the number of trip circuits that shall be monitored is set in address 140 **Trip Cir. Sup.** with the following settings: ***1 trip circuit***, ***2 trip circuits*** or ***3 trip circuits***.

If the device is connected to voltage transformers, set this condition in address 144 **V-TRANSFORMER**. Only if set ***connected***, the voltage dependent functions (measured values of voltages, power and power factor) can be registered by the device.

If a power transformer is located within the protected zone, set this condition in address 145 **TRANSFORMER**. The data of the transformer are registered by the device during the configuration of the general protection data (see “Topological Data for Transformers (optional)” in Subsection 2.1.4).

2.1.1.1 Setting Overview

Note: Depending on the type and version of the device it is possible that addresses are missing or have different default settings.

Addr.	Setting Title	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip 1pole	3pole only 1-/3pole	3pole only	1pole trip permitted
112	DIFF.PROTECTION	Enabled Disabled	Enabled	Differential protection
118	GPS-SYNC.	Enabled Disabled	Disabled	GPS synchronization
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 Time Overcurrent Curve IEC Time Overcurrent Curve ANSI	Disabled	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 Adaptive Dead Time (ADT) Disabled	Disabled	Auto-Reclose Function
134	AR control mode	with Pickup and Action time with Pickup but without Action time with Trip and Action time with Trip but without Action time	with Trip and Action time	AR control mode
139	BREAKER FAILURE	Disabled Enabled	Disabled	Breaker Failure Protection
140	Trip Cir. Sup.	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
144	V-TRANSFORMER	not connected connected	not connected	Voltage transformers
145	TRANSFORMER	NO YES	NO	Transformer inside protection zone

2.1.2 Power System Data 1

General

The device requires some plant and power system data in order to be able to adapt its functions accordingly, dependent 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 is a number of settings associated with several functions rather than a specific protection, control or monitoring function. These **Power System Data 1** can only be changed from a PC running DIGSI® and are discussed in this Subsection.

Polarity of the Current Transformers

Address 201 **CT Starpoint** asks for the polarity of the current transformers, i.e. the position of the transformer starpoint (Figure 2-1). The setting defines the measuring direction of the device (current in line direction is defined as positive at both ends). The reversal of this parameter also reverses the polarity of the residual current input I_E.

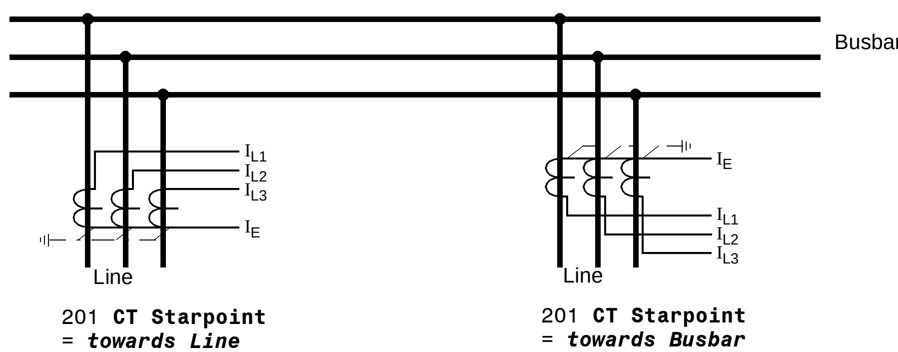


Figure 2-1 Polarity of the current transformers

Rated Quantities of the Instrument Transformers

In principle, the differential protection is designed such that it can operate without measured voltages. 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), it has been determined whether the device is to work with or without measured voltages.

In the addresses 203 **Unom PRIMARY** and 204 **Unom SECONDARY** you inform the device of the primary and secondary rated voltage (phase-to-phase) of the voltage transformers. These settings are not relevant if no voltage transformers are connected and configured when determining the functional scope according to Subsection 2.1.1.

In the addresses 205 **CT PRIMARY** and 206 **CT SECONDARY** you inform the device of the primary and secondary rated currents of the current transformers (phases).

Address 206 **CT SECONDARY** must correspond to the nominal current of the device, otherwise the processor system cannot be started. Also make sure that the secondary rated CT currents are in accordance with the rated current of the device, because otherwise the device will calculate wrong primary values (refer also to Subsection 3.1.3.3 under margin header “Input/Output Board I/O-11”).

The correct primary data are required for the calculation of the proper primary information of the operational measured values. If the settings of the device are performed with primary values using DIGSI®, these primary data are an indispensable requirement for the fault-free operation of the device.

Connection of the Voltages

Four inputs for measured voltages are available if the device is connected to the voltage transformers. This subtitle is not relevant if no voltages are connected.

Three voltage inputs are connected to the voltage transformer set. Various possibilities exist for the fourth voltage input U_4:

- Connection of the input U_4 to the open delta winding e-n of the voltage transformer set, see also Appendix A, Figure A-6:
  Address 210 is set in that case to: **U4 transformer** = ***Udelta transf.***.
  With U_4 connected to the e-n-windings (open delta) of the voltage transformer set, the voltage transformation of the transformer is normally

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

  The factor U_{ph}/U_{en} (secondary voltage, address 211 **Uph / Udelta**) must then be set to $3/\sqrt{3} = \sqrt{3} \approx 1.73$. For other transformation ratios, e.g. if the residual voltage is formed by an interposed transformer set, the factor must be adapted accordingly. This factor is important for the monitoring of measured quantities and the scaling of the measured values and fault values.

- If the input U_4 is not required, set:
  Address 210 **U4 transformer** = ***Not connected***.
  In this case as well, the factor **Uph / Udelta** (address 211, see above) is important, since it is used for the scaling of the measured values and the fault values.

Connection of the Currents

The device has four measured current inputs, three of which are connected to the current transformer set. Various possibilities exist for the fourth current input I_4:

- Connect the input I_4 to the residual current of the CT starpoint of the protected line (standard circuit arrangement, see also Appendix A, Figure A-3):
  Address 220 is set in that case to: **I4 transformer** = ***In prot. line*** and
  Address 221 **I4/Iph CT** = ***1***.

- Connect the input I_4 to a separate ground current transformer of the protected line (e.g. a summation current transformer, see also Appendix A, Figure A-4).
  Address 220 is set in that case to: **I4 transformer** = ***In prot. line*** and
  Address 221 **I4/Iph CT** is set to:

  $$I_4/I_{ph\ CT} = \frac{\text{Transformation of ground current transformer}}{\text{Transformation of phase current transformers}}$$

  <u>Example:</u>

Phase-current transformers	500 A/5 A
Ground-current transformer	60 A/1 A

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

- If the input I_4 is not required, set:
  Address 220 **I4 transformer** = ***Not connected***,
  Address 221 **I4/Iph CT** is not relevant.
  In this case, the residual current is calculated from the sum of the phase currents.

Rated Frequency

The rated frequency of the network is set under address 230 **Rated Frequency**. The default setting is made in the factory in accordance with the design variant and needs to be changed only if the device is to be used for a different purpose than ordered for. It can be set to ***50 Hz*** or ***60 Hz***.

Command Duration

The minimum trip command duration **TMin TRIP CMD** is set in address 240A. This duration is valid for all protection and control functions which can issue a trip command. It also determines the duration of a tripping pulse during the circuit breaker test via the device. This parameter can only be altered with DIGSI® under "**Additional Settings**".

The maximum duration of a closing command **TMax CLOSE CMD** is set in address 241A. This setting is valid for all closing commands of the device. It also determines the duration of a closing pulse during the circuit breaker test via the device. This duration must be long enough to ensure that the circuit breaker has closed. There is no risk in setting it too long, because the closing command is interrupted in any case as soon as a protective function trips the circuit breaker again. This parameter can only be altered with DIGSI® under "**Additional Settings**".

Circuit Breaker Test

7SD610 allows a circuit breaker test during operation by means of a tripping and a closing command entered on the front panel or via DIGSI®. The duration of the trip commands is set as explained above. Address 242 **T-CBtest-dead** determines the time from the end of the tripping command until the beginning of the closing command during the test. It should not be less than 0.1 s.

Current Transformer Characteristics

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 sum of the secondary currents can reach considerable peaks due to the saturation of the transformers when a high fault current flows through the line. These peaks may feign an internal fault. The features included in the 7SD610 to prevent errors in case of current transformer saturation work completely satisfying if the protection knows the response characteristic of the current transformers.

For this, the characteristic data of the current transformers and of their secondary circuits are set (see also Figure 2-6 in Subsection 2.2.1). The preset values are adequate in most cases; they correspond to usual current transformers for protection purposes.

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 stated refers to reference conditions (rated current, rated burden). For example (according to IEC 60044)

Current transformer 10P10; 30 VA $\rightarrow$ n = 10; P_N = 30 VA
Current transformer 10P20; 20 VA $\rightarrow$ n = 20; P_N = 20 VA

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

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

with n' = operational accuracy limit factor (effective accuracy limit factor)
n = rated accuracy limit factor of CTs (distinctive number behind P)
P_N = rated burden of 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 current transformers is stated in the test report. If unknown, it can be calculated roughly from the DC resistance R_i of the secondary winding.

$$P_i \approx R_i \cdot I_N^2$$

The ratio between the operational accuracy limit factor and the rated accuracy limit factor n'/n is parameterized under address 251 **K_ALF/K_ALF_N**.

The CT error at rated current, plus a safety margin, is set under address 253 **E% ALF/ALF_N**. It is equal to the “current measuring deviation for primary rated current intensity F1” according to IEC 60044.

The CT error at rated accuracy limit factor, plus a safety margin, is set under 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 current transformer types with their characteristic data and the recommended settings.

Table 2-1 Setting recommendation for current transformer data

CT Class	Standard	Error at Rated Current		Error at Short-Circuit Limit Current	Setting		
		Transformation	Angle		Address 251	Address 253	Address 254
5P	IEC 60044–1	1.0 %	±60 min	≤5 %	≤1.50 *)	3.0 %	10.0 %
10P		3.0 %	—	≤10 %	≤1.50 *)	5.0 %	15.0 %
TPX	IEC 60044–1	0.5 %	±30 min	ε ≤10 %	≤1.50 *)	1.0 %	15.0 %
TPY		1.0 %	±30 min	ε ≤10 %	≤1.50 *)	3.0 %	15.0 %
TPZ		1.0 %	±180 min ±18 min	ε ≤10 % (only I~)	≤1.50 *)	6.0 %	20.0 %
TPS	IEC 60044–1 BS: Class X				≤1.50 *)	3.0 %	10.0 %
C100 to C800	ANSI				≤1.50 *)	5.0 %	15.0 %

*) If n’/n ≤ 1.50 set address 251 to calculated value; if n’/n > 1.50 set address 251 to 1.50

With this data the device establishes an approximate CT error characteristic and calculates the restraint quantity (see also Subsection 2.2.1).

Exemplary calculation:

Current transformers 5P10; 20 VA
transformation 600 A/5 A
internal burden 2 VA

Secondary lines 4 mm^2 Cu
length 20 m

Device 7SD610 I_N = 5 A
burden at 5 A 0.3 VA

The resistance of secondary lines is (with the resistivity for copper ρ_{Cu} = 0.0175 $\Omega mm^2/m$)

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

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

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

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

$$\frac{n'}{n} = \frac{P_N + P_i}{P' + P_i} = \frac{20\ VA + 2\ VA}{4.375\ VA + 2\ VA} = 3.30$$

According to the above table, address 251 should be set to 1.50 if the calculated ratio is higher than 1,50. 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**.

Power Transformer with Voltage Regulation

If the protected object covers a power transformer with voltage regulation, a differential current may occur even during normal healthy operation under steady-state conditions. This differential current depends on the current intensity as well as on the position of the tap changer of the transformer. Since this differential current is current-proportional it is meaningful to consider it like a current transformer error. You may calculate the maximum differential current at the limits of the tap changer under nominal conditions (referred to the mean current) and add it to the current transformer error as discussed above (addresses 253 and 254). This correction is performed only at that relay facing the regulated winding of the power transformer.

Exemplary calculation:

Transformer YNd5
35 MVA
110 kV/25 kV
Y-side regulated ±10 %

From this resulting:
rated current at nominal 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

$$\text{mean current value } I_{mean} = \frac{I_{min} + I_{max}}{2} = \frac{167\text{ A} + 202\text{ A}}{2} = 184.5\text{ A}$$

The maximum deviation from this mean current is

$$\text{max. deviation } \delta_{max} = \frac{I_{max} - I_{mean}}{I_{mean}} = \frac{202\text{ A} - 184.5\text{ A}}{184.5\text{ A}} = 0.095 = 9.5\ \%$$

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

It must be considered that this deviation is referred to the mean current value between the extrema of the tap changer position at rated apparent power, not to the current value at rated voltage and rated power. This demands a further correction of the data of the protected object as discussed in Subsection 2.1.4 under subtitle “Topological Data for Transformers (optional)” (page 24).

2.1.2.1 Setting Overview

Note: The setting ranges and presettings listed in this table refer to a nominal current value I_N = 1 A. For a secondary nominal current value I_N = 5 A the current values are to be multiplied by 5.

The presetting of the rated frequency corresponds to the rated frequency according to the device version.

Note: Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Addr.	Setting Title	Setting Options	Default Setting	Comments
201	CT Starpoint	towards Line towards Busbar	towards Line	CT Starpoint
203	Unom PRIMARY	0.4..1200.0 kV	11.0 kV	Rated Primary Voltage
204	Unom SECON-DARY	80..125 V	100 V	Rated Secondary Voltage (Ph-Ph)
205	CT PRIMARY	10..5000 A	400 A	CT Rated Primary Current
206	CT SECONDARY	1A 5A	1A	CT Rated Secondary Current

Addr.	Setting Title	Setting Options	Default Setting	Comments
210	U4 transformer	not connected Udelta 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 Neutral Current (of the protected line)	not connected	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
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
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 Setting Groups

Purpose of Setting Groups

In the 7SD610 relay, four independent setting groups (A to D) are possible. During operation, you may switch between setting groups locally, via binary inputs (if so configured), via the operator or service interface using 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 as ***Enabled*** or another active option during configuration (see Subsection 2.1.1). Whilst setting values may vary among the four setting groups, the scope of functions of each setting group remains the same.

Multiple setting groups allows a specific relay to be used for more than one application. While all setting groups are stored in the relay, only one setting group is active at a given time.

If multiple setting groups are not required, Group A is the default selection, and the rest of this subsection is of no importance.

If multiple setting groups are desired, address 103 **Grp Chge OPTION** must have been set to ***Enabled*** in the relay configuration. Refer to Subsection 2.1.1. Each of these sets (A to D) is adjusted one after the other. You will find more details how to navigate between the setting groups, to copy and reset setting groups, and how to switch over between the setting groups during operation, in the SIPROTEC® System Manual, order number E50417–H1176–C151.

The preconditions to switch from one setting group to another via binary inputs is described in Subsection 3.1.2 under margin header “Changing Setting Groups with Binary Inputs”, page 181.

2.1.3.1 Setting Overview

Addr.	Setting Title	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

2.1.3.2 Information Overview

F.No.	Alarm	Comments
00007	>Set Group Bit0	>Setting Group Select Bit 0
00008	>Set Group Bit1	>Setting Group Select Bit 1
	Group A	Group A
	Group B	Group B
	Group C	Group C
	Group D	Group D

2.1.4 General Protection Data (Power System Data 2)

General protection data (**P.System Data2**) includes settings associated with all functions rather than a specific protective or monitoring function. In contrast to the **P.System Data1** as discussed in Subsection 2.1.2, these settings can be changed over with the setting groups and can be configured via the operator panel of the device.

The nominal operating data under Power System Data 2 should be set to the same values at both ends of the protected object. This ensures uniform measured values displayed during commissioning and operation and sent to a central computer station.

Rated Values of Protected Lines

The statements under this subtitle refer to protected lines (cables or overhead lines) if no power transformer is situated within the protected zone, i.e. for models without transformer option or if the transformer option is disabled during configuration of the scope of function (address 145 **TRANSFORMER** = ***NO***, see Subsection 2.1.1). If a transformer is part of the protected zone, proceed with the next subtitle “Topological Data for Transformers (optional)”.

With address 1103 **FullScaleVolt.** you inform the device of the primary rated voltage (phase-to-phase) of the equipment to be protected (if voltages are applied). 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 selected. For overhead lines the rated current is usually not defined; set the rated current of the current transformers (as set in address 205, Subsection 2.1.2). If the current transformers have different rated currents at the ends of the protected object, set the highest rated current value for both ends.

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

Topological Data for Transformers (optional)

The statements under this subtitle apply to protected objects which cover a power transformer being situated within the protected zone, i.e. for models with transformer option and if the transformer option is enabled during configuration of the scope of function (address 145 **TRANSFORMER** = ***YES***, see Subsection 2.1.1). If no transformer is part of the protected zone, this subtitle can be passed over.

The topological data make it possible to relate all measured quantities to the rated data of the power transformer.

With address 1103 **FullScaleVolt.** you inform the device of the primary rated voltage (phase-to-phase) of the transformer to be protected. This setting is also needed for computing the current reference value of the differential protection. Therefore, **it is important to set the correct rated voltage for each end of the protected object even if no measured voltages are applied to the relay**.

In general, select the rated voltage of the transformer winding facing the device. But, if the protected transformer is equipped with a voltage tap changer at one winding, then 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 regulation are minimized.

Exemplary calculation:

Transformer YNd5
35 MVA
110 kV/25 kV
Y-side regulated ±10 %

Thus resulting for the regulated winding (110 kV):
maximum voltage U_{max} = 121 kV
minimum voltage U_{min} = 99 kV

Setting value for the rated voltage at this side (address 1103)

$$\text{FullScaleVolt.} = \frac{2}{\frac{1}{U_{max}} + \frac{1}{U_{min}}} = \frac{2}{\frac{1}{121\ \text{kV}} + \frac{1}{99\ \text{kV}}} = 108.9\ \text{kV}$$

The **OPERATION POWER** (address 1106) is the direct primary rated apparent power for transformers and other machines. **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 a primary value, even if the device is generally configured in secondary values. The device calculates the rated current of the protected object from this 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.

Example:

Transformer **Yd5**
For the **Y**-end is set: **VECTOR GROUP I** = ***0***,
for the **d**-end is set: **VECTOR GROUP I** = ***5***.

If the other winding is chosen as reference winding, i.e. the d-winding, this has to be taken into consideration:
For the **Y**-end is set: **VECTOR GROUP I** = ***7*** (12 – 5),
For the **d**-end is set: **VECTOR GROUP I** = ***0*** (5 – 5 = 0 = reference side).

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

If the vector group of the transformer is matched with external means, e.g. because there are matching transformers in the measuring circuit that are still used, set **VECTOR GROUP I = *0***, at both ends. In this case the differential protection operates without proper matching computation. But, the measuring voltages transmitted via the transformer would not be adapted in the 7SD610 and therefore not correctly calculated and displayed. Address 1161 **VECTOR GROUP U** serves to remove this disadvantage. 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 computation of measured voltages beyond the transformer.

Address 1163 **TRANS STP IS** is used to set 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 may cause a spurious tripping in case of an earth fault outside of the protected zone.

Circuit Breaker Status

Various protection and ancillary functions require information on the status of the circuit breaker for faultless operation. The device has a circuit breaker status recognition which processes the status of the circuit breaker auxiliary contacts and it also contains a metrological opening and closing recognition (see also Section 2.13).

The open-pole current **PoleOpenCurrent** which is safely undershot when the circuit breaker pole is open, is set in address 1130A. High sensitivity may be set if parasitic currents (e.g. from induction) can be excluded when the line is de-energized. Otherwise the value must be increased correspondingly.

The seal-in time **SI Time all Cl.** (address 1132A) determines how long the protection functions that are effective when the line is energized (e.g. the increased pickup threshold for the differential protection) are enabled when the internal status recognition has recognized the closing of the breaker or when the device receives a signal via a binary input and the CB auxiliary contact that the circuit breaker has been closed. Therefore, this seal-in time should be longer than the CB operating time during the closing plus the command time of the relevant protective function plus the CB operating time during opening. This parameter can only be altered with DIGSI® under “**Additional Settings**”.

Address 1134 **Line status** determines the criteria for the functioning of the integrated status recognition. With ***CurrentOpenPole*** the rise of the open-pole current above the threshold set in address 1130A (**PoleOpenCurrent**, see above) is interpreted as the closing of the circuit breaker. ***Current AND CB***, on the other hand, means that both the currents and the position of the circuit breaker auxiliary contacts are processed for the status recognition. This means, that ***Current AND CB*** should be set if the auxiliary contacts of the circuit breaker exist and are connected and allocated to corresponding binary inputs, and ***CurrentOpenPole*** in all other cases. Note that the I>>>-stage of the instantaneous high-speed trip (see Section 2.7) can only work if the auxiliary contacts for both devices at the ends of the protected object are connected.

Whilst the **SI Time all Cl.** (address 1132A, see above) becomes effective with each energization of the line, the seal-in time **SI Time Man.Cl** (address 1150A) determines the time during which a possible influence on the protection functions becomes effective after the <u>*manual*</u> closing (e.g. the switch-on pickup threshold for differential protection or overcurrent protection, see loc cit). This parameter can only be altered with DIGSI® under “**Additional Settings**”.

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 rest of this subtitle 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* decision results 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 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 functions is also contained in Subsection 2.13.3, “Fault Detection Logic of the Entire Device”.

With the setting ***with PICKUP***, each multi-phase *pickup* causes a three-pole tripping, even if only a single-phase ground fault has occurred in the protected area and a further external fault, e.g. through overcurrent, is recognized. Even if a single-pole tripping command is already present, each further pick-up will lead to a three-pole coupling.

If, on the other hand, the address is set on ***with TRIP*** (normal setting for differential protection), only multi-pole *tripping commands* will lead to a three-pole tripping. Therefore, if a single-phase fault occurs within the protected 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 protected zone.

This parameter is valid for all protection functions of 7SD610 which are capable of single-pole tripping. Standard setting: ***with TRIP***.

Applying the time overcurrent protection function the difference is noticeable when multiple faults occur, which means faults that nearly occur at the same time at different places in the system.

If, for example, two single-phase ground faults occur on different lines — these may also be parallel lines — (Figure 2-2), the protective relays of all four line ends detect a fault L1–L2–E, i.e. the pickup image is consistent with a two-phase ground fault. But since each of the two lines has only a single-phase fault, a single-phase auto-reclosure on each of the two lines is desirable. This is possible with setting 1155 **3pole coupling** to ***with TRIP***. Each of the four devices recognizes a single-pole internal fault and is therefore able to perform a single-pole trip.

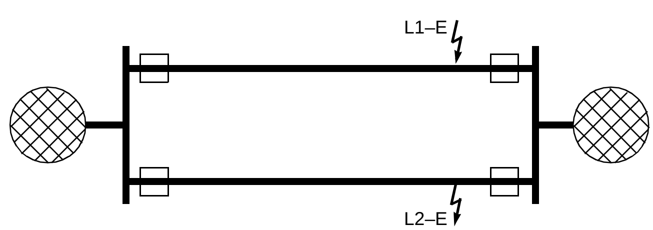


Figure 2-2 Multiple fault on a double-circuit line

In some cases, however, a three-pole trip would be preferable in this fault scenario, e.g. if the double-circuit line is located close to a large generator unit (Figure 2-3). This is because the generator considers the two single-phase ground faults as one double ground fault, with correspondingly high dynamic stress of the turbine shaft. With 1155 **3pole coupling** set to ***with PICKUP***, the two lines are switched off, since each device picks up as with L1–L2–E, i.e. as with a multi-phase fault.

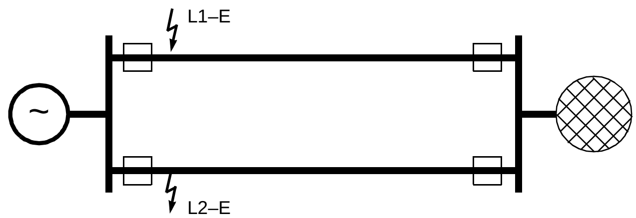


Figure 2-3 Multiple fault on a double-circuit line close to a generator

Address 1156A **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 reclosure cycle for this kind of fault. The trip type can be set to ***1pole leading Ø*** or ***1pole lagging Ø***. The parameter is only available in versions with single-pole and three-pole tripping. This parameter can only be altered with DIGSI® under "**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 both ends of one line. More information on the functions is also contained in Subsection 2.13.3 "Fault Detection Logic of the Entire Device". The usual and default setting is ***3pole***.

2.1.4.1 Setting Overview

Note: The setting ranges and presettings listed in this table refer to a nominal current value I_N = 1 A. For a secondary nominal current value I_N = 5 A the current values are to be multiplied by 5.

Note: Addresses which have an "A" attached to their end can only be changed in DIGSI®, under "**Additional Settings**".

Addr.	Setting Title	Setting Options	Default Setting	Comments
1106	OPERATION POWER	0.2..5000.0 MVA	7.6 MVA	Operational power of protection zone
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
1103	FullScaleVolt.	0.4..1200.0 kV	11.0 kV	Measurement: Full Scale Voltage (100%)
1104	FullScaleCurr.	10..5000 A	400 A	Measurement: Full Scale Current (100%)
1130A	PoleOpenCurrent	0.05..1.00 A	0.10 A	Pole Open Current Threshold
1132A	SI Time all Cl.	0.01..30.00 sec	0.10 sec	Seal-in Time after ALL closures

Addr.	Setting Title	Setting Options	Default Setting	Comments
1134	Line status	with Pole Open Current Threshold only with CBaux open AND I < PoleOpenCurrent	with Pole Open Current Threshold only	Line status
1150A	SI Time Man.Cl	0.01..30.00 sec	0.30 sec	Seal-in Time after MANUAL closures
1155	3pole coupling	with Pickup with Trip	with Trip	3 pole coupling
1156A	Trip2phFlt	3pole 1pole, leading phase 1pole, lagging phase	3pole	Trip type with 2phase faults

2.1.4.2 Information Overview

F.No.	Alarm	Comments
00301	Pow.Sys.Flt.	Power System fault
00302	Fault Event	Fault Event
00351	>CB Aux. L1	>Circuit breaker aux. contact: Pole L1
00352	>CB Aux. L2	>Circuit breaker aux. contact: Pole L2
00353	>CB Aux. L3	>Circuit breaker aux. contact: Pole L3
00356	>Manual Close	>Manual close signal
00357	>CloseCmd.Blo	>Block all close commands from external
00361	>FAIL:Feeder VT	>Failure: Feeder VT (MCB tripped)
00366	>CB1 Pole L1	>CB1 Pole L1 (Pos. Contact=Breaker)
00367	>CB1 Pole L2	>CB1 Pole L2 (Pos. Contact=Breaker)
00368	>CB1 Pole L3	>CB1 Pole L3 (Pos. Contact=Breaker)
00371	>CB1 Ready	>Circuit Breaker 1 READY for reclosing
00378	>CB faulty	>CB faulty
00379	>CB 3p Closed	>CB aux. contact 3pole Closed
00380	>CB 3p Open	>CB aux. contact 3pole Open
00381	>1p Trip Perm	>Single-phase trip permitted from ext.AR
00382	>Only 1ph AR	>External AR programmed for 1phase only
00383	>Enable ARzones	>Enable all AR Zones / Stages
00385	>Lockout SET	>Lockout SET

F.No.	Alarm	Comments
00386	>Lockout RESET	>Lockout RESET
00410	>CB1 3p Closed	>CB1 aux. 3p Closed (for AR, CB-Test)
00411	>CB1 3p Open	>CB1 aux. 3p Open (for AR, CB-Test)
00501	Relay PICKUP	Relay PICKUP
00503	Relay PICKUP L1	Relay PICKUP Phase L1
00504	Relay PICKUP L2	Relay PICKUP Phase L2
00505	Relay PICKUP L3	Relay PICKUP Phase L3
00506	Relay PICKUP E	Relay PICKUP Earth
00507	Relay TRIP L1	Relay TRIP command Phase L1
00508	Relay TRIP L2	Relay TRIP command Phase L2
00509	Relay TRIP L3	Relay TRIP command Phase L3
00510	Relay CLOSE	General CLOSE of relay
00511	Relay TRIP	Relay GENERAL TRIP command
00512	Relay TRIP 1pL1	Relay TRIP command - Only Phase L1
00513	Relay TRIP 1pL2	Relay TRIP command - Only Phase L2
00514	Relay TRIP 1pL3	Relay TRIP command - Only Phase L3
00515	Relay TRIP 3ph.	Relay TRIP command Phases L123
00530	LOCKOUT	LOCKOUT is active
00533	IL1 =	Primary fault current IL1
00534	IL2 =	Primary fault current IL2
00535	IL3 =	Primary fault current IL3
00536	Final Trip	Final Trip
00545	PU Time	Time from Pickup to drop out
00546	TRIP Time	Time from Pickup to TRIP
00560	Trip Coupled 3p	Single-phase trip was coupled 3phase
00561	Man.Clos.Detect	Manual close signal detected
00563	CB Alarm Supp	CB alarm suppressed

2.2 Differential Protection

The differential protection is the main feature 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.

7SD610 is designed for protected objects with 2 ends. A version which covers a power transformer or machine in unit connection is available as an option. The protected zone is limited selectively at its ends by the current transformer sets.

2.2.1 Function Description

Basic Principle

Differential protection is based on current comparison. It makes use of the fact that e.g. a line section **L** (Figure 2-4) carries always 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 $\underline{I}$; 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 $\underline{I}_1 + \underline{I}_2$ which is proportional to the fault currents $i_1 + i_2$ flowing in from both sides is fed to the measuring element. As a result, the simple circuit shown in Figure 2-4 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.

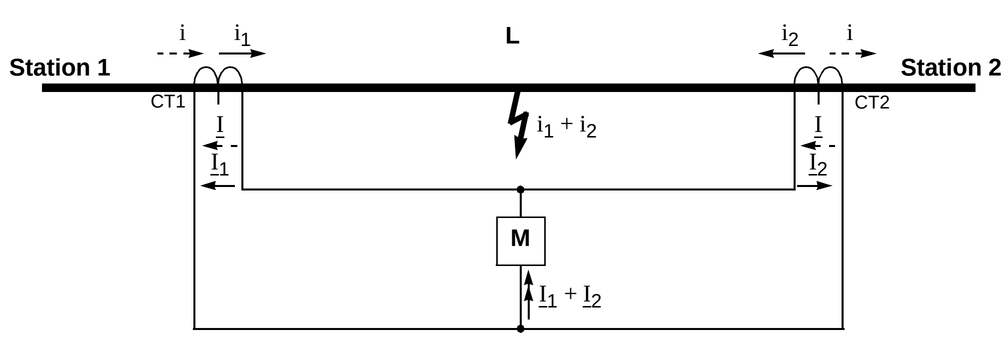


Figure 2-4 Basic principle of differential protection for a line

Transmission of Measured Values

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 both 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.

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

Figure 2-5 shows this for a line. 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 protection devices is called the protection data interface. As a result, the currents can be added up an processed in each device.

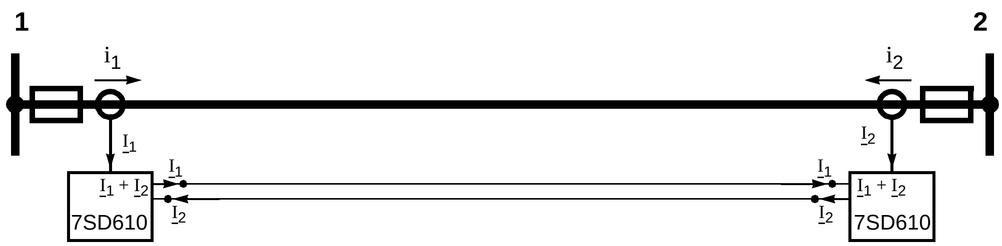


Figure 2-5 Differential protection for a line

You will find detailed information on the topology of device communication in Section 2.4.

Measured Value Synchronization

The devices measure the local currents asynchronously. This means that each device measures, digitizes and pre-processes the associated currents of the current transformers with its own, random processor pulse. If the currents of two line ends are to be compared, it is necessary, however, to process all currents with the same time base.

Both devices exchange their time with each telegram. The device with index 1 functions as a “timing master” thus determining the time base. The other device then calculates the time delay based on the transmission and processing times related on the timing master. With this rough synchronization the equality of the time bases with a precision of ± 0.5 ms is provided.

To achieve a sufficiently precise synchronization all current values are marked with a “time stamp” before they are transmitted from one device to the other as digital telegrams. This time stamp indicates at which point in time the transmitted current data were valid. Therefore, the receiving device can carry out an optimized synchronization of the current comparisons based on the received time stamp and its own time management, i.e. it can compare the currents which were actually measured at exactly the same time (<5 µs tolerance).

The transmission periods are permanently monitored by the devices using the time stamps and considered at the respective receiving end.

The frequency of the measured quantities, which is decisive for the comparison of complex phasors, is also continuously measured and, if necessary, corrected to achieve a synchronous comparison of the phasors. If the device is connected to voltage transformers and at least one voltage of a sufficient level is available, the frequency is derived from this voltage. If not, the measured currents are used for the determination of the frequency. The measured frequencies are interchanged between the devices via the communication link. Under these conditions both devices work with the currently valid frequency.

Restraint

The precondition for the basic principle of 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 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 stabilized 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 2.2.2 under “Pickup Value of Differential Current”). The same is true for the steady-state magnetizing currents across shunt reactances. For transient inrush currents 7SD610 has a separate inrush restraint feature (see below under the subtitle “Inrush Restraint”).

Current Transformer Errors

To consider the influences of current transformer errors, each device calculates a self-restraining quantity ΔI. This is calculated by estimating the possible local transformer errors from the data of the local current transformers and the intensity of the measured currents. The transformer data have been parameterized under the power system data (cf. Subsection 2.1.2 under “Current Transformer Characteristics”) and apply to each individual device. Since each device transmits its estimated errors to the other device, each device is capable to form the total sum of possible errors; this sum is used for restraint.

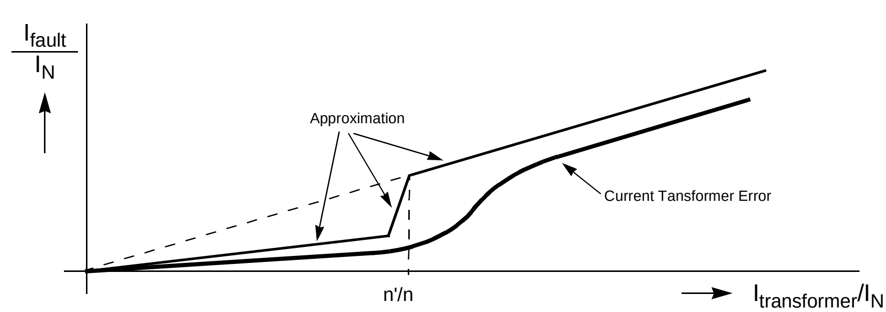


Figure 2-6 Approximation of the current transformer errors

Further Influences

Further measuring errors which may arise in the device itself by hardware tolerances, calculation tolerances, deviations in time or which are due to the “quality” of the measured quantities such as harmonics and deviations in frequency, are also estimated by the device and increase the local self-restraining quantity automatically. Here, the permissible variations in the protection 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 measuring error will be set by definition to the maximum permissible deviation. For the frequency this means that if the frequency cannot be determined, because no sufficient measured quantities are available, the device will assume rated frequency. But since the actual frequency can deviate from the rated frequency within the permissible range (±20 % of the rated 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 of interest during operation if no measured quantities are existing in the protected zone 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 point of time, an increased restraint will be active until the actual frequency is determined. This may delay the tripping somewhat, but only close to the pickup threshold, i.e. in case of very low-current faults.

These self-restraining quantities are calculated by 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 above, “Transmission of Measured Values“), each device calculates thus the total sum of the restraining quantities and thereby stabilizes the differential currents.

It is due to the self-restraint that the differential protection works with a maximum of sensitivity at all times, since the restraining quantities adapt themselves automatically in a dynamic way to possible errors. In this way, even high-resistance faults, with high load currents at the same time, can be detected effectively. Using GPS-synchronization, the self-restraining is minimized once more since differences in the transmission times are compensated automatically.

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 reach a multiple of the rated current and is characterized by a relatively high content in second harmonics (double rated frequency) which is almost absent in the case of a short-circuit. If the content in second harmonics exceeds an adjustable threshold in differential current, the tripping will be prevented.

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 2-7 shows a simplified logic diagram. The conditions for the inrush restraint are examined in each device in which this function has been activated. The blocking condition is transmitted to both devices so that it is effective at both ends of the protected object.

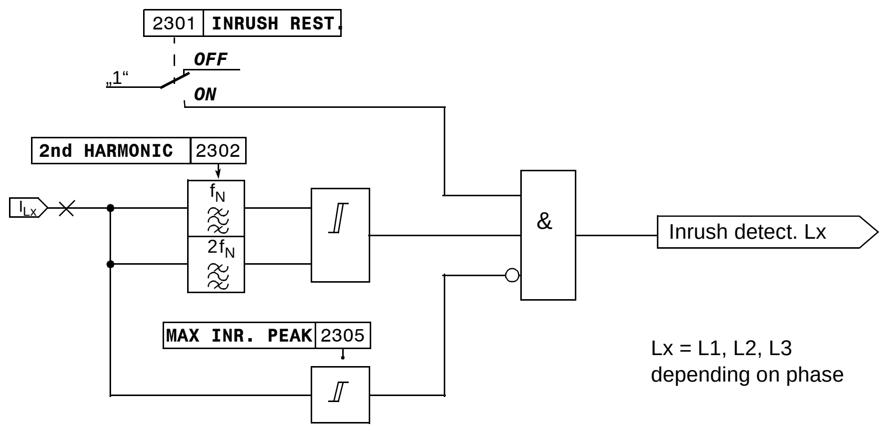


Figure 2-7 Logic diagram of the inrush restraint for one phase

Since the inrush restraint works individually for each phase, the protection is fully effective even with the transformer switched onto a single-phase fault, whereas it is possible that an inrush current may be flowing in a different, healthy phase. It is, however, possible to set the protection in 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 so-called “crossblock” function can be limited in time. Figure 2-8 shows the logic diagram.

The “crossblock” function affects both devices as well, since it extends the inrush restraint to all three phases.

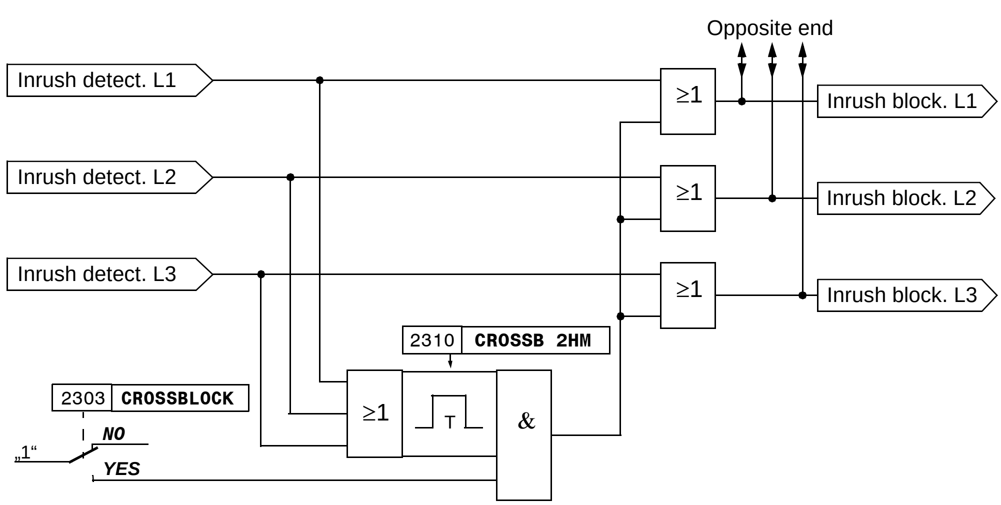


Figure 2-8 Logic diagram of the “crossblock” function for one end

Evaluation of Measured Values

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 were formed at each end of the protected zone and transmitted to the other end. The differential current value is equal to the value of the fault current that is registered by the differential protection system. In the ideal case it is equal to the fault current value. In a healthy system the differential current value is low and similar to the charging current.

The restraining current counteracts the differential current. It is the total of the maximum measured errors at the ends of the protected object and is calculated from the actual measured values and power system parameters that were set. Therefore the highest possible error value of 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. The total value, including the measured internal errors, is then transmitted to the other end. This is the reason why the restraining current is always an image of the greatest possible measurement error of the differential protection system.

The pickup characteristic of the differential protection (Figure 2-9) 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 (current errors)

If the calculated differential current exceeds the pickup limit and the greatest possible measurement error, the fault must be internal (shaded area in Figure 2-9).

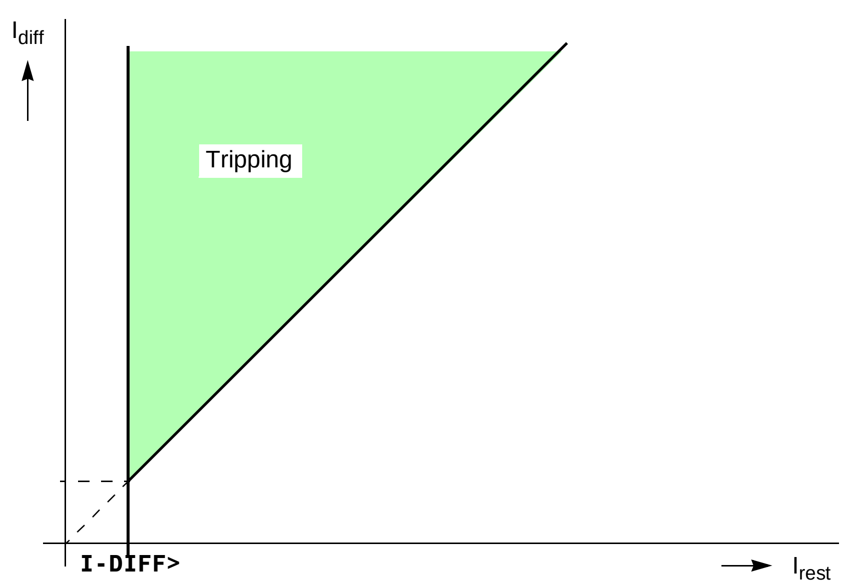


Figure 2-9 Pickup characteristic of the differential protection I_{diff}>-stage

High-Speed Charge Comparison

The charge comparison protection function is a differential stage which is superimposed on the current comparison (the actual differential protection). If a high-current fault occurs, high-speed tripping decision is then possible.

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:

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

It includes the integration interval from t_1 to t_2, for the 7SD610 device determined as a quarter AC cycle.

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 both ends of the protected zone.

Right after a fault occurrence within the protected zone a charge difference emerges. For high fault currents which can lead to saturation of current transformers, decision is made 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, blocking remains effective. 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 the power line is switched on, the pickup value of the charge comparison is automatically redoubled for a period of approximately 1.5 s. This is to prevent from malfunction caused by transient current in the CT secondary circuit due to remanence of the CTs (e.g. during auto-reclosure). This current would simulate a charge value which is not found in the primary quantities.

Each phase is subject to the charge comparison. Therefore an internal fault (evolving fault) in a different phase after the external fault occurred is registered immediately. The functional limitation of the charge comparison is reached in the less probable case that an internal fault (evolving fault) appears after occurrence of an external fault with considerable current transformer saturation in the *same* phase; this must then be detected by the actual 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.

Blocking/Interblocking

The differential protection can be blocked via a binary input. The blocking at one end of a protected object affects both ends 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.

Pickup of the Differential Protection

Figure 2-10 shows the logic diagram of the differential protection. The phase-segregated stages are totalled to phase information. Additionally the device provides information of which stage picked up.

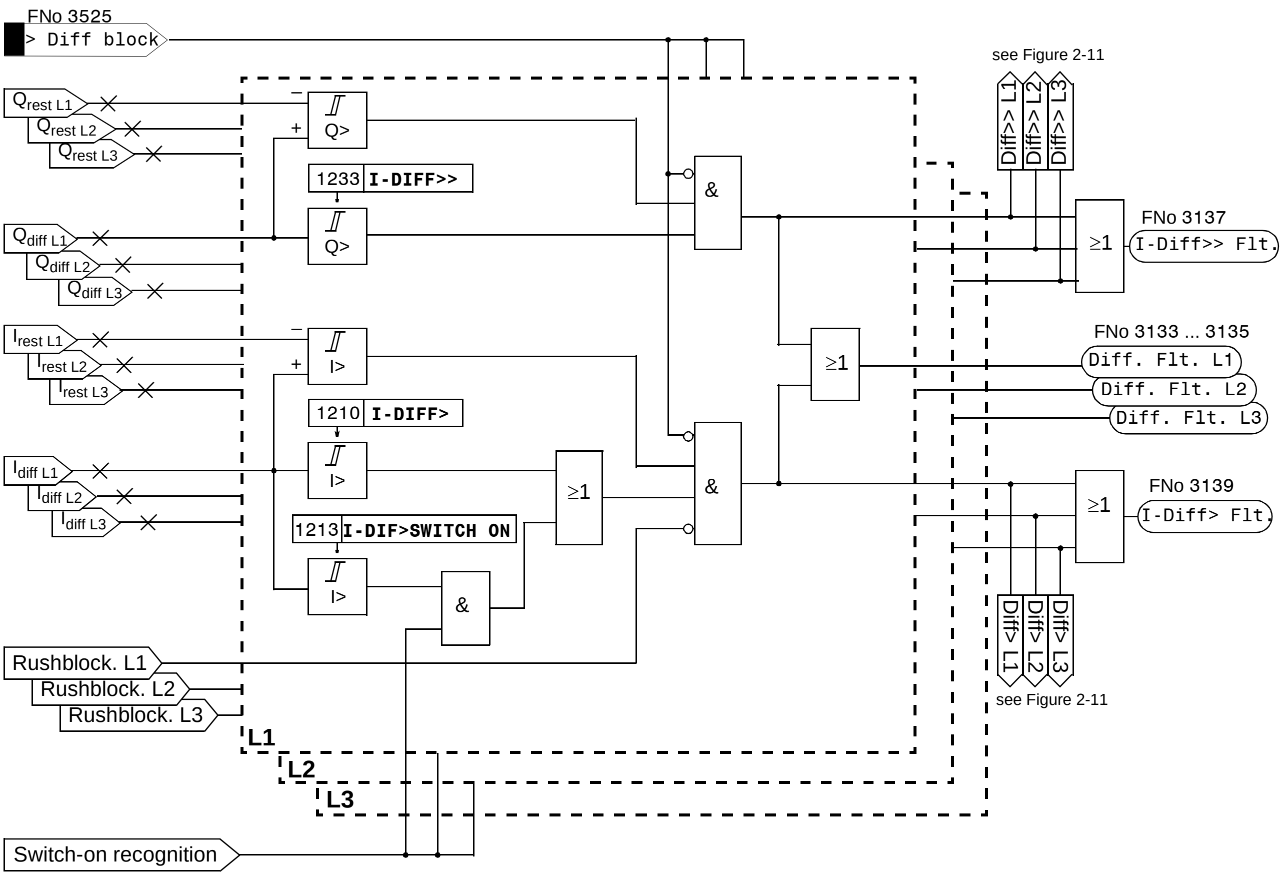


Figure 2-10 Logic diagram of the differential protection

As soon as the differential protection function registers a fault within its tripping zone, the signal “`Diff. Gen. Flt.`” (general fault detection 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 (Figure 2-11).

The pickup signals that identify the concerned stages of the differential protection can be delayed via the time stage **`T-DELAY I-DIFF>`**. Independently from 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-earthed system.

The output signals generated by the stages are combined to 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. Here, the single-pole information indicates that only single-pole tripping is to be carried out. The actual generation of the commands for the tripping (output) relay is executed within the “Tripping Logic of the Entire Device” (see Subsection 2.13.4).

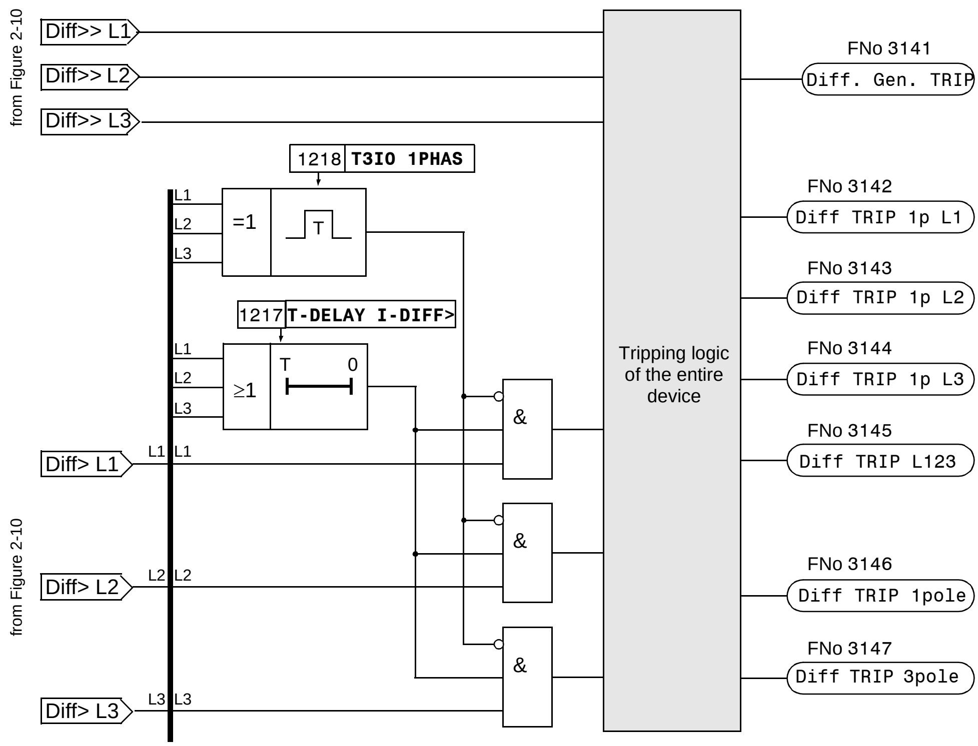


Figure 2-11 Tripping logic of the differential protection

2.2.2 Setting the Function Parameters

General

The differential protection can be switched ***ON*** or ***OFF*** with address 1201 **`STATE OF DIFF.`**. If a single device is switched off at one end of a protective object, the calculation of measured values becomes impossible. The entire differential protection system of both ends then is 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 fault. 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. It 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 Rated voltage of the network in kV primary
f_N Rated frequency of the network in Hz
C_B' Per unit line length service 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 value set 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 operating rated current. The operating rated current either derives from the rated apparent power of a transformer in the protected area (see “Topological Data for Transformers (optional)” in Subsection 2.1.4, page 24) or from the addresses 1104 **FullScaleCurr.** according to Subsection 2.1.4, “Rated Values of Protected Lines” (page 24). It must be equal at both 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.

Exemplary calculation:

110 kV single-conductor oil-filled cable 240 mm^2 in a 50-Hz-network with the data:

s (length) = 16 km
C_B' = 310 nF/km

Current transformers 600 A/5 A

From that the steady-state charging current is calculated:

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

For the setting with primary values at least the double 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:

$$\text{Setting value } \textbf{I-DIFF>} = \frac{198\text{ A}}{600\text{ A}} \cdot 5\text{ A} = 1.65\text{ A}$$

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. Therefore it is essential to calculate the maximum differential current at the end positions of the tap changer and to add this current to the pickup value setting for **I-DIFF>** (referred to the rated transformer current).

Pickup Value during Switch-on

When switching on long, unloaded cables, overhead lines and arc-compensated lines, considerable higher-frequency transient reactions may occur. Although these are damped considerably by means of digital filters 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 always active when 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 with the general protection data under address 1132A (Subsection 2.1.4 under margin “Circuit Breaker Status”, page 26), both devices are then switched over to this particular pickup value. A setting to three to four times the steady-state charging current ensures usually 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 Subtitle “Inrush Restraint”, page 41).

Final dynamic checks will be carried out during commissioning (see Subsection 3.3.12).

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 1217A) is only started upon detection of an internal fault. This parameter can only be altered with DIGSI® under “**Additional Settings**”.

If the differential protection is applied to an isolated or resonant-earthed network, it must be ensured that tripping is avoided during the transient oscillations of a single earth fault. With address 1218A **T3I0 1PHAS** the pickup to a single earth fault is therefore delayed for 0.04 s. In extended resonant-earthed networks this time should be increased. Setting the address to ∞ the single-phase tripping is totally suppressed. This parameter can only be altered with DIGSI® under “**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.

Setting near the operational nominal current is adequate in most cases. Please also remember that the setting is related to the operational rated values that must be equal (primary) at both ends of the protected object.

Since this stage reacts very fast, a pickup of capacitive charging currents (for lines) and inductive magnetizing currents (for transformers or reactors) — also for switch-on condition — must be excluded.

In resonant-earthed systems also the value of the non-compensated system earth fault current may not be undershot. It derives from the total capacitive earth fault current without considering the Petersen coil. As the Petersen coil serves to compensate nearly the total earth fault current, its rated current can be taken as a base.

For transformers set the value $I_{NTrafo}/u_{kTrafo.}$

Final dynamic checks will be carried out during commissioning (Subsection 3.3.12).

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. It can be switched ***ON*** and ***OFF*** with 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. The fraction necessary for the restraint can however be changed. 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 a value of above $\sqrt{2} \cdot I_{NTrafo}/u_{kTrafo}$ can be set. If a line ends on a transformer, a smaller value may be selected, considering the damping of the current by the line.

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

2.2.3 Setting Overview

Note: The indicated setting ranges and default settings refer to a secondary rated current of I_N = 1 A. For the secondary rated current of I_N = 5 A these values are to be multiplied by 5.

Note: Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Addr.	Setting Title	Setting Options	Default Setting	Comments
1201	STATE OF DIFF.	OFF ON	ON	State of differential protection
1210	I-DIFF>	0.10..20.00 A	0.30 A	I-DIFF>: Pickup value
1213	I-DIF>SWITCH ON	0.10..20.00 A	0.30 A	I-DIFF>: Value under switch on condition
1217A	T-DELAY I-DIFF>	0.00..60.00 sec; ∞	0.00 sec	I-DIFF>: Trip time delay
1218A	T3I0 1PHAS	0.00..60.00 sec; ∞	0.00 sec	Delay 1ph-faults (comp/isol. star-point)
1233	I-DIFF>>	0.8..100.0 A; ∞	1.2 A	I-DIFF>>: Pickup value
2301	INRUSH REST.	OFF ON	OFF	Inrush Restraint
2302	2nd HARMONIC	10..45 %	15 %	2nd. harmonic in % of funda-mental
2303	CROSS BLOCK	NO YES	NO	Cross Block
2305	MAX INRUSH PEAK	1.1..25.0 A	15.0 A	Maximum inrush-peak value
2310	CROSSB 2HM	0.00..60.00 sec; ∞	0.00 sec	Time for Crossblock with 2nd harmonic

2.2.4 Information Overview

F.No.	Alarm	Comments
03102	2nd Harmonic L1	Diff: 2nd Harmonic detected in phase L1
03103	2nd Harmonic L2	Diff: 2nd Harmonic detected in phase L2
03104	2nd Harmonic L3	Diff: 2nd Harmonic detected in phase L3
03120	Diff active	Diff: Active
03132	Diff. Gen. Flt.	Diff: Fault detection
03133	Diff. Flt. L1	Diff: Fault detection in phase L1
03134	Diff. Flt. L2	Diff: Fault detection in phase L2
03135	Diff. Flt. L3	Diff: Fault detection in phase L3
03136	Diff. Flt. E	Diff: Earth fault detection
03137	I-Diff>> Flt.	Diff: Fault detection of I-Diff>>
03139	I-Diff> Flt.	Diff: Fault detection of I-Diff>
03141	Diff. Gen. TRIP	Diff: General TRIP
03142	Diff TRIP 1p L1	Diff: TRIP - Only L1
03143	Diff TRIP 1p L2	Diff: TRIP - Only L2
03144	Diff TRIP 1p L3	Diff: TRIP - Only L3
03145	Diff TRIP L123	Diff: TRIP L123
03146	Diff TRIP 1pole	Diff: TRIP 1pole
03147	Diff TRIP 3pole	Diff: TRIP 3pole
03148	Diff block	Diff: Differential protection is blocked
03149	Diff OFF	Diff: Diff. protection is switched off
03176	Diff Flt. 1p.L1	Diff: Fault detection L1 (only)
03177	Diff Flt. L1E	Diff: Fault detection L1E
03178	Diff Flt. 1p.L2	Diff: Fault detection L2 (only)
03179	Diff Flt. L2E	Diff: Fault detection L2E
03180	Diff Flt. L12	Diff: Fault detection L12
03181	Diff Flt. L12E	Diff: Fault detection L12E
03182	Diff Flt. 1p.L3	Diff: Fault detection L3 (only)
03183	Diff Flt. L3E	Diff: Fault detection L3E
03184	Diff Flt. L31	Diff: Fault detection L31
03185	Diff Flt. L31E	Diff: Fault detection L31E
03186	Diff Flt. L23	Diff: Fault detection L23
03187	Diff Flt. L23E	Diff: Fault detection L23E
03188	Diff Flt. L123	Diff: Fault detection L123

F.No.	Alarm	Comments
03189	Diff Flt. L123E	Diff: Fault detection L123E
03190	Test Diff.	Diff: Set Teststate of Diff. protection
03191	Comm. Diff	Diff: Set Commissioning state of Diff.
03192	TestDiff.remote	Diff: Remote relay in Teststate
03193	Comm.Diff act.	Diff: Commissioning state is active
03194	>Test Diff.	Diff: >Test Diff.
03195	>Comm. Diff	Diff: >Comm. Diff
03525	> Diff block	>Differential protection blocking signal
03526	Diffblk.rec PI1	Differential blocking received at PI1
03528	Diffblk.sen PI1	Differential blocking sending via PI1

2.3 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 such a command is received 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.

2.3.1 Function Description

Transmission Circuit

The transmission signal can originate from two different sources (Figure 2-12). 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 protection data interfaces and communications links.

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 (three-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**.

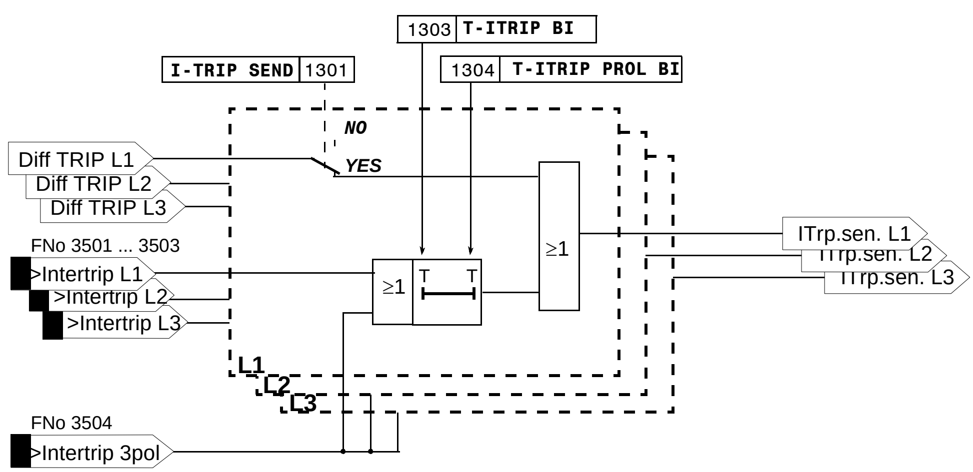


Figure 2-12 Logic diagram of the intertrip — transmission circuit

Receiving Circuit

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

Figure 2-13 shows the logic diagram. If the received signal is supposed to cause a trip, it will be forwarded to the tripping logic. The tripping logic of the entire device (see also Subsection 2.13.4) ensures, if necessary, that the conditions for single-pole tripping are fulfilled (e.g. single-pole tripping permissible, auto-reclosure function ready).

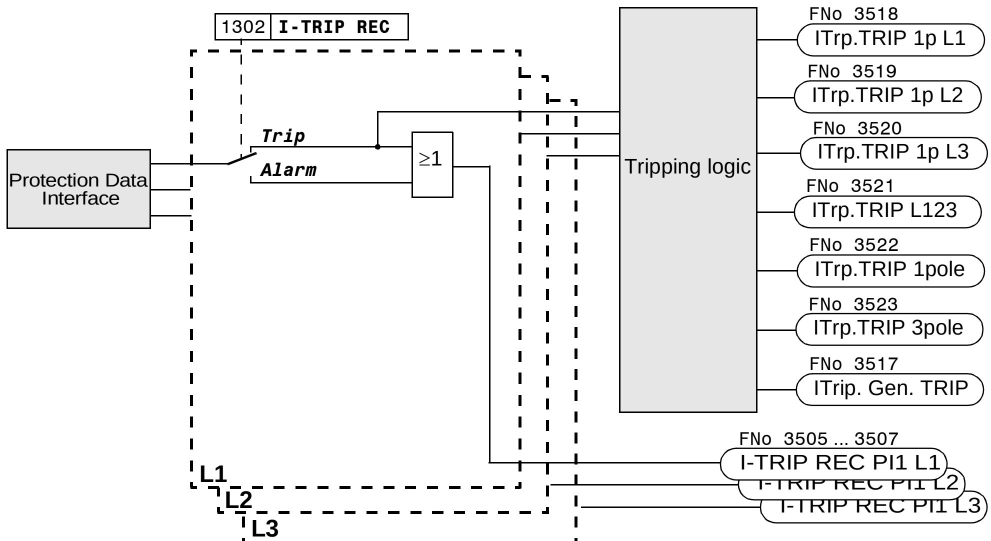


Figure 2-13 Logic diagram of the intertrip — receiving circuit

Further Facilities

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 commands or alarms a further 4 fast transmission channels are optionally available (see also Section 2.6).

2.3.2 Setting the Function Parameters

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 both ends of the protected object, a tripping in the event of an internal fault normally is also carried out at both 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 end does not issue a tripping command due to inevitable device tolerances. For these cases **I-TRIP SEND** = ***YES*** ensures the tripping at both ends of the protected object.

Intertrip/Remote Tripping

If the intertrip function is activated, it will automatically start when the differential protection trips.

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 originating signal against dynamic interferences which may possibly 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 to receiving an intertrip/remote tripping signal is set in address 1302 **I-TRIP RECEIVE**. If it is supposed to cause tripping, ***Trip*** must be set. If the received signal, however, is supposed to cause an alarm only, ***Alarm only*** must be set even if this annunciation 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 stabilization 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.

2.3.3 Setting Overview

Addr.	Setting Title	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

2.3.4 Information Overview

F.No.	Alarm	Comments
03501	>Intertrip L1	I.Trip: >Intertrip L1 signal input
03502	>Intertrip L2	I.Trip: >Intertrip L2 signal input
03503	>Intertrip L3	I.Trip: >Intertrip L3 signal input
03504	>Intertrip 3pol	I.Trip: >Intertrip 3 pole signal input
03505	ITrp.rec.PI1.L1	I.Trip: Received at Prot.Interface 1 L1
03506	ITrp.rec.PI1.L2	I.Trip: Received at Prot.Interface 1 L2
03507	ITrp.rec.PI1.L3	I.Trip: Received at Prot.Interface 1 L3
03511	ITrp.sen.PI1.L1	I.Trip: Sending at Prot.Interface 1 L1
03512	ITrp.sen.PI1.L2	I.Trip: Sending at Prot.Interface 1 L2
03513	ITrp.sen.PI1.L3	I.Trip: Sending at Prot.Interface 1 L3
03517	ITrp. Gen. TRIP	I.Trip: General TRIP
03518	ITrp.TRIP 1p L1	I.Trip: TRIP - Only L1
03519	ITrp.TRIP 1p L2	I.Trip: TRIP - Only L2
03520	ITrp.TRIP 1p L3	I.Trip: TRIP - Only L3
03521	ITrp.TRIP L123	I.Trip: TRIP L123
03522	Diff TRIP 1pole	I.Trip: TRIP 1pole
03523	Diff TRIP 3pole	I.Trip: TRIP 3pole

2.4 Protection Data Interfaces and Protection Data Topology

As described in the explanation of the function principle of differential protection (Subsection 2.2.1), the devices which belong to the protected object limited by the current transformer sets, have to exchange the data of the ends of the protected object. This does not only apply for the measured quantities relevant for the differential protection itself, but also for all data which are to be available at both ends. This includes the synchronization and 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 devices' protection data interface form the topology of the differential protection system and its communication.

2.4.1 Function Description

Protection Data Topology

For each device you require one protection data interface PI 1. Both protection data interfaces are connected with each other (see also Figure 2-14). When setting the function parameters, each device is identified with an index number: Index 1 and Index 2.

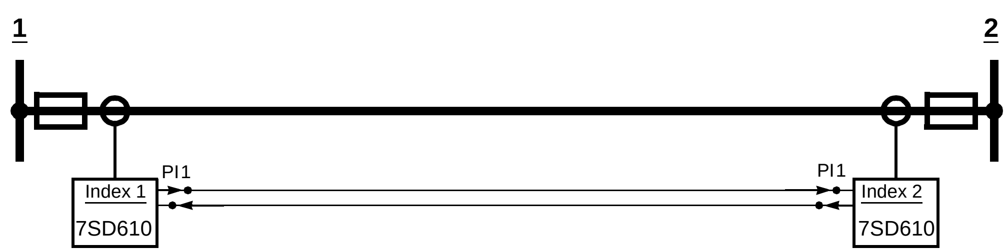


Figure 2-14 Differential protection with two 7SD610 devices, using the protection data interface (transmitter / receiver)

Communication Media

The communication is achieved by direct optical fibre connections or via communication networks. 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 having a transmission rate of 512 kBit/s is possible. Otherwise we recommend communication converters. A transmission via modem and communication networks can also be realized. Please take into consideration 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 2-15 shows some examples for communication connections. In case of a direct connection the distance depends on the type of the optical fibre. Table 2-2 lists the available options. Different types of communication modules can be installed in the device. For ordering information see Appendix A, Subsection A.1.1.

Table 2-2 Communication via direct connection

Module type	Connector type	Fibre type	Optical wavelength	Permissible path attenuation	Distance, typical
FO5	ST	Multimode 62.5/125 µm	820 nm	8 dB	1.5 km 0.95 miles
FO6	ST	Multimode 62.5/125 µm	820 nm	16 dB	3.5 km 2.2 miles
FO7	ST	Monomode 9/125 µm	1300 nm	7 dB	10 km 6.25 miles
FO8	FC	Monomode 9/125 µm	1300 nm	18 dB	35 km 22 miles

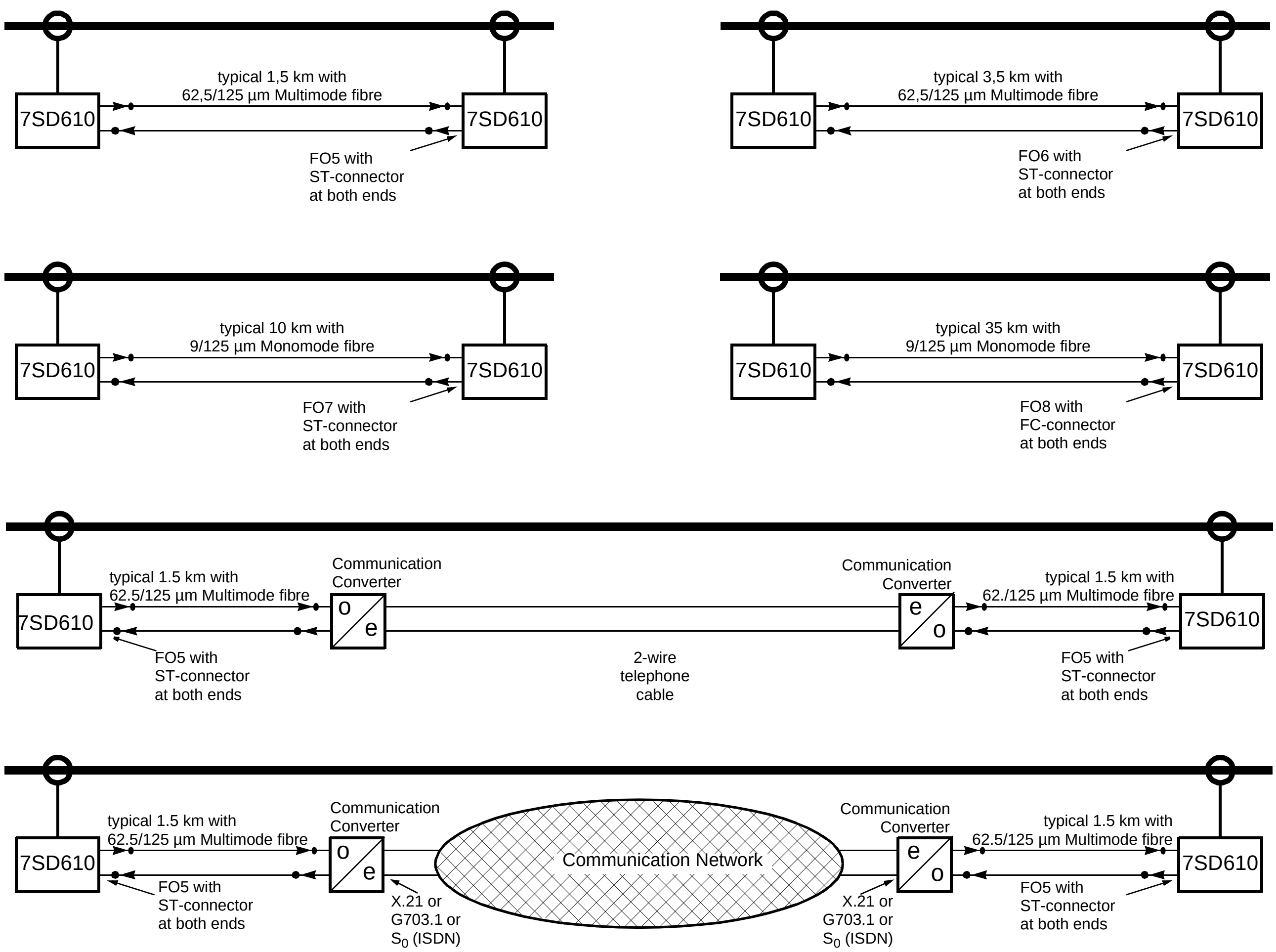


Figure 2-15 Examples for communication connections

If communication converters are used, the device and the communication converter are always linked with a FO5 module via optical fibres. The converters themselves are available with different interfaces for the connection to the communication network. For ordering information see Appendix A, Subsection A.1.1.

Establishing the Protection Data Communication

When the devices are linked to each other and switched on, they will automatically establish the protection data communication. The successful link is indicated by an annunciation, e.g. "`Rel2 Login`", when relay 1 has contacted relay 2. Both devices of a differential protection system inform the other device of the successful communication.

Additionally, the protection data interface is indicated when a healthy link is established.

These are helpful features during commissioning and are described — together with further commissioning tools — in Subsection 3.3.5. But even during operation, the regular communication of the devices can be checked.

Monitoring of Protection Data Transmission

The communication is continuously 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 time interval as statistical information.

You can define a limit for the permissible rate of faulty data telegrams. When, during operation, this limit is exceeded, an alarm is given ("`PI1 Error`", FNo 03258). 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 **data fault** as soon as a time delay for data disturbance alarm (default setting 100 ms, can be altered) is exceeded. A corresponding alarm is output ("`PI1 Data fault`", FNo 03229). The differential protection will stop operating. 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 faultlessly 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`", FNo 03230). The same reactions apply as for the data fault.

Transmission time jumps that, for example, can occur in case of switchover in the communication network are recognized (Annunciation "`PI1 jump`", FNo 03254) and corrected by the devices. The differential protection system continues to operate without any loss of sensitivity. The transmission times are measured again and actualized within less than 2 seconds. If GPS-synchronization (with satellite receiver) is used, asymmetric transmission times are recognized and corrected immediately.

The permissible transmission time difference can be set. This has a direct influence on the sensitivity of the differential protection system. The automatic self-restraint of the protection adapts the restraint quantities to these differences so that a spurious operation of the differential protection due to these influences is prevented. Thus, higher difference values reduce the sensitivity of the protection, which may be noticeable in case of very low-current 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." (FNo 03250) will be issued.

When a transmission time jump exceeds the maximum permissible transmission 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 (selectable). An alarm is issued ("PI1 unsym.", FNo 03256). This blocking can only be cancelled via a binary input (">SYNC PI1 RESET", FNo 03252).

Changeover of Operating Mode

During protection test, plant inspection, but also during operational switch-off of a feeder, it is possible to change the operating mode of a devices in order to perform such work without effect on running operation.

The following modes are available:

- Log out device: logging out a device from the differential protection system with the circuit breaker being switched off. The device at the other end remains in operation; thus, the line may remain switched on at the other end as a spur line. As the local circuit breaker is open (as well as the outgoing disconnector) revision work can be done at the local feeder without affecting operation at the other end.
  This mode can also be set via a binary input (FNo 03451 ">Logout") if this has been configured when allocating the binary inputs.
- Test mode: All currents from the other device are set to zero in the local device. Thus the local device has been isolated from the differential protection system and can be checked. If the device has been logged out before (see above), the other device can operate normally. Otherwise, the differential protection system is blocked in both devices. Emergency operation with time overcurrent protection is feasible.
- Commissioning mode: All tripping commands of the differential protection system are blocked. The differential system as an entity can be checked using primary or secondary values.

2.4.2 Setting the Function Parameters

General about Protection Data Interfaces

The protection data interfaces connect the devices with the communication media. The communication is permanently monitored by the devices. Address 1509 **T-DATA DISTURB** defines after which delay time the user is informed about faulty or missing data telegrams. Address 1510 **T-DATAFAIL** is used to set the time after which a transmission failure alarm is output. Address 1512 **Td ResetRemote** determines how long time remote information remains standing after a transmission fault has been cleared.

Protection Data Interface 1

The protection data interface 1 can be switched ***ON*** or ***OFF*** with address 1501 **STATE PROT I 1**. If it is switched ***OFF***, this corresponds to a transmission failure. The differential protection and all functions which require the transmission of data, cannot continue their operation.

In address 1502 **CONNEC. 1 OVER**, set the transmission media that you want to connect to protection data interface PI 1. The following media are possible:
F.optic direct, i.e. communication directly by fibre-optic cable with 512 kBit/s;
Com conv 64 kB, i.e. via communication converters with 64 kBit/s (G703.1 or X.21);
Com conv 128 kB, i.e. via communication converters 128 kBit/s (X.21) or 2-wire copper bidirectional;
Com conv 512 kB, i.e. via communication converters 512 kBit/s (X.21).
The possibilities may vary for the different device versions. The data must be identical at both ends of a communication route.

The setting depends on the features of the communication media. As a general rule, it can be stated that the higher the transmission rate the shorter the response time of the differential protection system.

The devices measure and monitor the transmission times. Deviations are corrected, as long as they are within the permissible range. These permissible ranges are set under addresses 1505A and 1506A and can normally be left at their default values.

The maximum permissible transmission time (address 1505A **PROT 1 T-DELAY**) is preset to a value that does not exceed the usual value of communication networks. This parameter can only be altered with DIGSI® under "**Additional Settings**". If it is exceeded during operation (e.g. because of switchover to a different transmission route), the message "PI1 TD alarm" (FNo 03239) will be issued. Increased transmission times only have an impact on the tripping time of the differential protection system.

The maximum transmission time *difference* (outgoing telegram vs. return telegram) can be altered in address 1506A **PROT 1 UNSYM.**. This parameter can only be altered with DIGSI® under "**Additional Settings**". With a direct fibre-optic connection, this value can be set to ***0***. For transmission via communication networks a higher value is needed. The standard value is 100 µs (presetting). The permissible transmission time *difference* has a direct influence on the sensitivity of the differential protection.

If GPS-synchronization is used this value is relevant only in case the GPS-signal is missing. As soon as the GPS-synchronization is restored the transmission time differences are compensated again. As long as GPS-synchronization is intact transmission time differences do *not* affect the sensitivity of the protection.

Address 1511 **PI1 SYNCMODE** is only relevant if GPS-synchronization is used. It determines the conditions for differential protection operation when the protection data communication has been re-established (initially or after transmission failure):

- **PI1 SYNCMODE** = ***TEL or GPS*** means that the differential protection will become active as soon as the protection communication has been established (data telegrams are received). Until the GPS-synchronization is effective, the differential protection operates with increased self-restraint determined by the maximum transmission time difference without GPS (address 1506A **PROT 1 UNSYM.**).
- **PI1 SYNCMODE** = ***TEL and GPS*** means that the differential protection is active, after reception of proper protection data telegrams, first when GPS-synchronization has taken place. The operator can determine by manual acknowledgement (via a binary input) that the differential protection starts operation with increased self-restraint determined by the maximum transmission time difference without GPS

(address 1506A **PROT 1 UNSYM.**). When the GPS-synchronization is re-established, full sensitivity is regained since transmission time differences are compensated by the GPS-synchronization.

- **PI1 SYNCMODE** = ***GPS SYNC OFF*** means that no GPS-synchronization takes place for this protection data interface. This is meaningful if no transmission time differences are expected (e.g. for fibre-optic direct data link). This setting option can also be used to remove this protection data interface from the GPS synchronization.

You can determine a limit for the permissible rate of faulty protection data telegrams under address 1513A **PROT1 max ERROR**. This parameter can only be altered with DIGSI® under "**Additional Settings**". The preset value ***1*** % means that one faulty telegram per 100 telegrams is permissible. The sum of telegrams in both directions is decisive.

If frequent transmission time jumps occur the regular operation of the differential protection is endangered. Under address 1515A **PI1 BLOCK UNSYM** you can decide whether the differential protection shall be blocked in this case. This parameter can only be altered with DIGSI® under "**Additional Settings**". Normal setting is ***YES*** (presetting).

GPS Satellite Synchronization

If GPS synchronization (order option) is used, this synchronization mode can be switched ***ON*** or ***OFF*** in address 1801 **GPS-SYNC.**.

Address 1803A **TD GPS FAILD** is used to set the delay time after which an alarm is output "GPS loss" (FNo 03247) after a GPS failure is detected.

Further parameters concerning GPS-synchronization were set for the protection data interface (see above).

Protection Data Topology

First of all, define the device index numbers: One relay gets index no. 1, the other index no. 2. For the differential protection system the device with index 1 is always the timing master, i.e. the absolute time management of both devices which belong together depends on the absolute time management of this device. As a result the time information of both devices is comparable at all times.

Allocate also an identification number (device-ID) for each device. 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 identifies the devices in the communication system since the exchange of information between several differential protection systems (thus also for several protected objects) can be performed via the same communication system. Please make sure that the communications link and the existing interfaces are in accordance with each other.

Next, the addresses 1701 **ID OF RELAY 1** and 1702 **ID OF RELAY 2** are set, e.g. for device 1 the device-ID ***16*** and for device 2 the device-ID ***17*** (Figure 2-16, compare also with Figure 2-14). The indices of the devices and the device-IDs do not have to match here, as mentioned above.

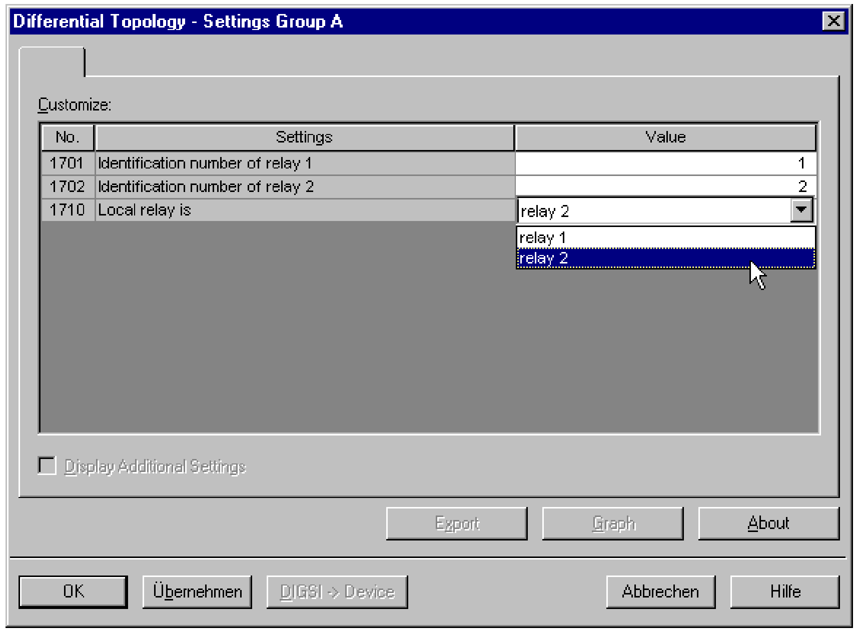


Figure 2-16 Differential protection topology for 2 ends with 2 devices — example

Finally, you enter in address 1710 **LOCAL RELAY** the index of the actual local device. Enter the index 1 or 2 of that relay which is under consideration.

Make sure that the settings of the differential protection topology for the differential protection system are consistent:

- Each device index must 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 the start-up of the protection system, the above listed conditions are checked. If one out of these conditions is not fulfilled, no differential protection operation is possible. The device signals “DT inconsistent” (“Device table inconsistent”).

2.4.3 Setting Overview

Note: Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Protection Data Interfaces

Addr.	Setting Title	Setting Options	Default Setting	Comments
1509	T-DATA DISTURB	0.05..2.00 sec	0.10 sec	Time delay for data disturbance alarm
1510	T-DATAFAIL	0.0..60.0 sec	6.0 sec	Time del for transmission failure alarm
1512	Td ResetRemote	0.00..300.00 sec; ∞	0.00 sec	Remote signal RESET DELAY for comm.fail
1501	STATE PROT I 1	ON OFF	ON	State of protection interface 1
1502	CONNEC. 1 OVER	Direct connection with fibre optic cable Communication converter with 64 kBit/s Communication converter with 128 kBit/s Communication converter with 512 kBit/s	Direct connection with fibre optic cable	Connection 1 over
1505A	PROT 1 T-DELAY	0.1..30.0 ms	30.0 ms	Prot 1: Maximal permissible delay time
1506A	PROT 1 UNSYM.	0.000..3.000 ms	0.000 ms	Prot 1: Diff. in send and receive time
1511	PI1 SYNCMODE	Telegram and GPS Telegram or GPS GPS synchronization OFF	Telegram and GPS	PI1 Synchronizationmode
1513A	PROT1 max ERROR	0.5..20.0 %	1.0 %	Prot 1: Maximal permissible error rate
1515A	PI1 BLOCK UNSYM	YES NO	YES	Prot.1: Block. due to unsym. delay time
1801	GPS-SYNC.	ON OFF	OFF	GPS synchronization
1803A	TD GPS FAILD	0.5..60.0 sec	2.1 sec	Delay time for local GPS-pulse loss

Topological Data

Addr.	Setting Title	Setting Options	Default Setting	Comments
1701	ID OF RELAY 1	1..65534	1	Identification number of relay 1
1702	ID OF RELAY 2	1..65534	2	Identification number of relay 2
1710	LOCAL RELAY	relay 1 relay 2	relay 1	Local relay is

2.4.4 Information Overview

Protection Data Interfaces

F.No.	Alarm	Comments
03215	Wrong Firmware	Incompatible Firmware Versions
03217	PI1 Data reflec	Prot Int 1: Own Datas received
03227	>PI1 light off	>Prot Int 1: Transmitter is switched off
03229	PI1 Data fault	Prot Int 1: Reception of faulty data
03230	PI1 Datafailure	Prot Int 1: Total receiption failure
03233	DT inconsistent	Device table has inconsistent numbers
03234	DT unequal	Device tables are unequal
03235	Par. different	Differences between common parameters
03236	PI1<->PI2 error	Different PI for transmit and receive
03239	PI1 TD alarm	Prot Int 1: Transmission delay too high
03243	PI1 with	Prot Int 1: Connected with relay ID
03252	>SYNC PI1 RESET	> PI1 Synchronization RESET
03256	PI1 unsym.	Prot.1: Delay time unsymmetry to large
03254	PI1 jump	Prot.1: Delay time change recognized
03258	PI1 Error	ProtInt1:Permissible error rate exceeded
03245	>GPS failure	> GPS failure from external
03247	GPS loss	GPS: local pulse loss
03248	PI 1 GPS sync.	GPS: Prot Int 1 is GPS sychronized
03250	PI 1 PD unsym.	GPS:PI1 unsym.propagation delay too high

Topological Data

F.No.	Alarm	Comments
03451	>Logout	> Logout input signal
03458	Chaintopology	System operates in a open Chaintopology
03464	Topol complete	Communication topology is complete
03475	Rel1Logout	Relay 1 in Logout state
03476	Rel2Logout	Relay 2 in Logout state
03484	Logout	Local activation of Logout state
03487	Equal IDs	Equal IDs in constellation
03491	Rel1 Login	Relay 1 in Login state
03492	Rel2 Login	Relay 2 in Login state

2.5 Direct Local Trip

2.5.1 Function Description

Direct Trip of the Local Circuit Breaker

Any signal from an external protection, monitoring or control device can be injected into the processing of 7SD610 via binary inputs. It can be delayed, output as an alarm and be routed to one or more output relays. Figure 2-17 shows the logic diagram. If the devices and circuit breakers are designed for single-pole control, single-pole tripping is possible. The tripping logic of the device ensures that the conditions for single-pole tripping are fulfilled (e.g. single-pole tripping permissible, reclosure function ready).

The direct local trip can be switched on and off by parameters, and blocked via a binary input.

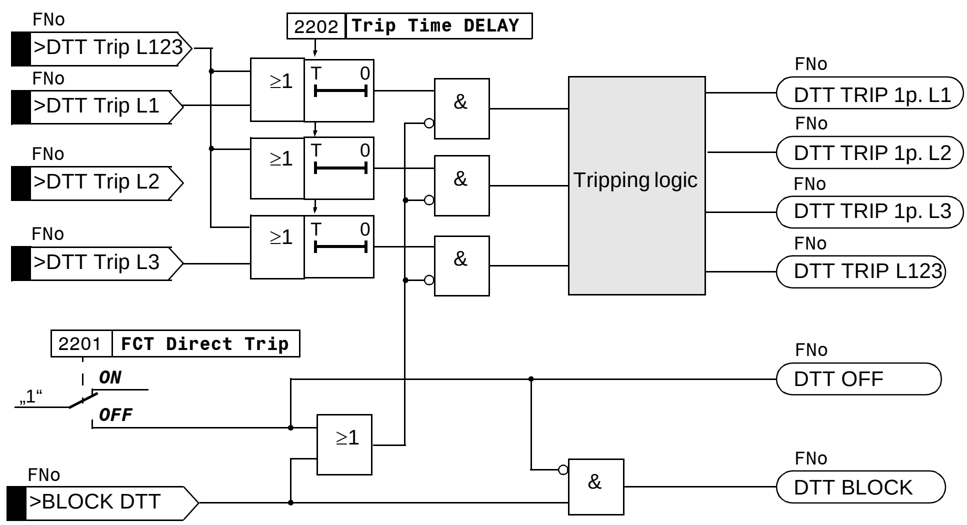


Figure 2-17 Logic diagram of the direct local trip (DTT)

2.5.2 Setting the Function Parameters

A precondition for the direct local trip is that during the configuration of the functions (Subsection 2.1.1) **DTT Direct Trip** = ***Enabled*** has been configured in address 122. It can also be switched ***ON*** and ***OFF*** with address 2201 **FCT Direct Trip**.

For direct local trip a trip time delay can be set in address 2202 **Trip Time DELAY**. This delay can be used as a grading margin.

A tripping command which has been issued is maintained for at least the minimum tripping command duration **TMin TRIP CMD** which was configured for the device in address 240A (Subsection 2.1.2). This ensures that the circuit breaker can be operated reliably even if the control pulse is very short.

2.5.3 Setting Overview

Addr.	Setting Title	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

2.5.4 Information Overview

F.No.	Alarm	Comments
04403	>BLOCK DTT	>BLOCK Direct Transfer Trip function
04412	>DTT Trip L1	>Direct Transfer Trip INPUT Phase L1
04413	>DTT Trip L2	>Direct Transfer Trip INPUT Phase L2
04414	>DTT Trip L3	>Direct Transfer Trip INPUT Phase L3
04417	>DTT Trip L123	>Direct Transfer Trip INPUT 3ph L123
04421	DTT OFF	Direct Transfer Trip is switched OFF
04422	DTT BLOCK	Direct Transfer Trip is BLOCKED
04432	DTT TRIP 1p. L1	DTT TRIP command - Only L1
04433	DTT TRIP 1p. L2	DTT TRIP command - Only L2
04434	DTT TRIP 1p. L3	DTT TRIP command - Only L3
04435	DTT TRIP L123	DTT TRIP command L123

2.6 Direct Remote Trip or Transmission of Binary Information (optional)

7SD610 allows the transmission of up to 4 items of binary information of any type from one device to the other via the communications links provided for protection tasks. These are transmitted like protection signals with high priority, i.e. very fast, and are therefore especially suitable for the transmission of external protection signals which are generated outside of 7SD610. Of course, they are suitable for any information, such as information on the events taking place in a substation which may also be useful in the other substation as well.

The information is injected into the device via binary inputs and can be output at the other end again 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 device's protection and monitoring functions. Also an internal indication can be assigned via CFC to a transmission input and transmitted to the remote end.

The binary outputs and the binary inputs to be used must be allocated appropriately during the configuration of the input and output functions. The signals are injected into the device via the binary inputs "`>Remote Trip1`" to "`>Remote Trip4`", are transmitted to the device at the other end and can be processed at the receiving side with the output functions "`RemoteTrip1 rec`" to "`RemoteTrip4 rec`".

When allocating the binary inputs and outputs with 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 to the other end, you may use the input "`>Remote Trip1`" and designate it "`>Buchholz Trip`". At the other end, you designate the incoming information "`RemoteTrip1 rec`" as "`Buchholz remote`" and assign it to an output trip relay. In case of Buchholz protection trip the annunciations will then be given according to your designations.

Even devices that have logged out functionally (Subsection 2.4.1 under margin "Changeover of Operating Mode") can send and receive remote information and commands.

The annunciations "`Relx Login`" of the topology exploration can be used to determine whether the signals of the sending devices are still available. They are issued if device x is involved in the communication topology and this state is stable.

Once a transmission fault has been detected, the time **`Td ResetRemote`** at address `1512` is started for resetting the remote signals.

No further settings are required for the transmission of binary information. Each device sends the injected information immediately to the other.

2.6.1 Information Overview

F.No.	Alarm	Comments
03541	>Remote Trip1	>Remote Trip 1 signal input
03542	>Remote Trip2	>Remote Trip 2 signal input
03543	>Remote Trip3	>Remote Trip 3 signal input
03544	>Remote Trip4	>Remote Trip 4 signal input
03545	RemoteTrip1 rec	Remote Trip 1 received
03546	RemoteTrip2 rec	Remote Trip 2 received
03547	RemoteTrip3 rec	Remote Trip 3 received
03548	RemoteTrip4 rec	Remote Trip 4 received

2.7 Instantaneous High-Current Switch-onto-Fault Protection

2.7.1 Function Description

General Information

The instantaneous high-current switch-onto-fault protection 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 devices at both ends 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>>>`. The currents are numerically filtered so that only the fundamental component is evaluated. This high-current pickup is practically unaffected by DC components in the fault current as well as in the secondary current after switching off high currents. 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 so that extremely short command times are possible.

This stage is only enabled when the local circuit breaker is closed while the other line end of the protected object is open. The devices exchange the status of their respective circuit breakers continuously via the communication link. If the protected object is already live (from the other end) the stage is not effective. An indispensable precondition for the functioning of the I>>> stage is that the auxiliary contacts of the circuit breakers are connected at both ends of the protected object and allocated to the relevant binary inputs. If this is not the case, this stage is not effective. The central function control communicates the information of the circuit breaker position to the high-current instantaneous tripping (see also Subsection 2.13.2).

Figure 2-18 shows the logic diagram. The I>>> stage at the bottom of the diagram operates separately for each phase. During the manual closing of the circuit breaker all three phases are enabled via the internal signal “SOTF enab. L123” which is issued by the central functional control of the protection, provided that the manual closing can be recognized there (see Section 2.13).

Tripping can also be enabled separately for each phase by the signals “SOTF enab. Lx”. This applies also to e.g. automatic reclosure after single-pole tripping. Then, single-pole tripping with this stage is possible, but only if the device is designed for single-pole tripping.

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 2-18 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 (example can be found with the advice on setting, Subsection 2.7.2).

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.

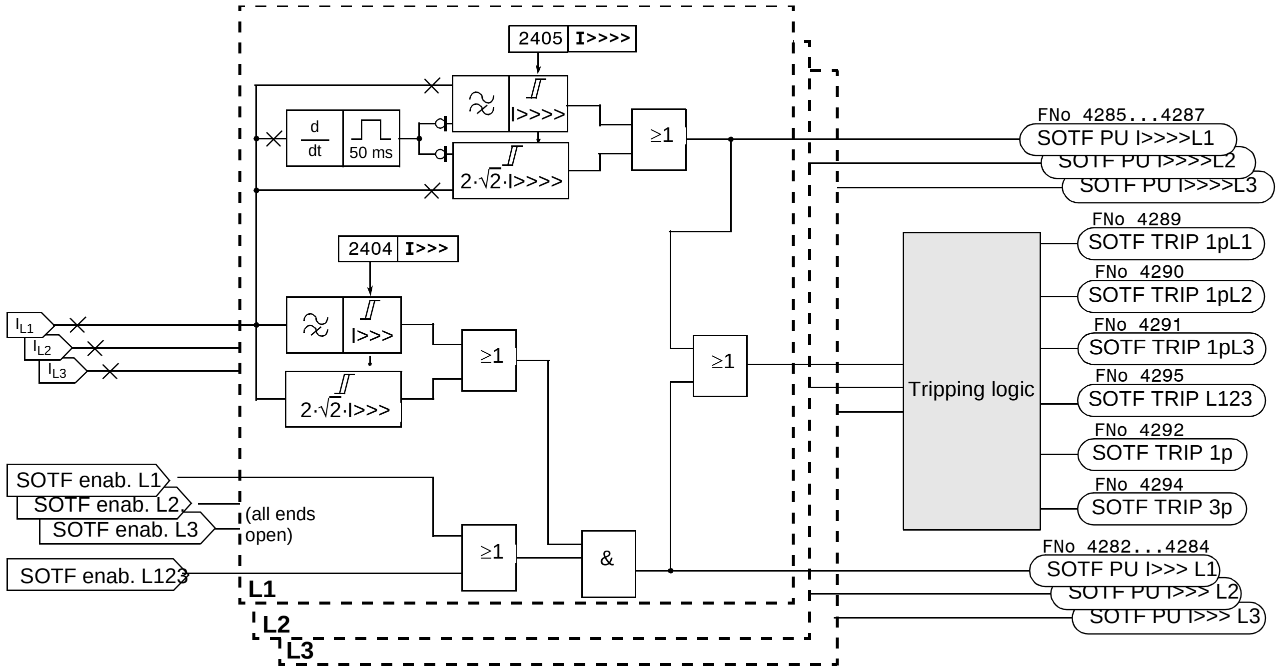


Figure 2-18 Logic diagram of the instantaneous high-speed SOTF overcurrent function

2.7.2 Setting the Function Parameters

A precondition for the use of the instantaneous high-speed SOTF overcurrent function is that during the configuration of the device functions (Section 2.1.1) **HS/SOTF-O/C** = ***Enabled*** has been configured in address 124. It can also be switched ***ON*** and ***OFF*** with address 2401 **FCT HS/SOTF-O/C**.

I>>> Stage

The magnitude of fault current which leads to the pickup of the I>>>-stage is set as I>>> in address 2404. This stage is active only during the connecting of local end while the circuit breaker at the other end is open. Choose a value which is high enough for the protection not to pickup 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 need not be considered.

During setting with a personal computer and DIGSI® the values can be entered in primary or secondary quantities. If secondary quantities are configured, the currents are converted to the secondary side of the current transformers.

I>>>> Stage

The I>>>> stage (address 2405A) works regardless of the circuit breaker position. Since it trips extremely fast it must be set high enough not to pickup on a fault 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**”.

During setting with a personal computer and DIGSI® 4 the values can be entered in primary or secondary quantities. If secondary quantities are configured, the currents are converted to the secondary side of the current transformers.

Exemplary calculation:

110 kV overhead line 150 mm^2 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_{sc}" = 3.5 GVA (subtransient, since the I>>>> stage can respond to the first peak value)

Current transformers 600 A/5 A

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

$$Z_1/s = \sqrt{0.19^2 + 0.42^2}\ \Omega/\text{km} = 0.46\ \Omega/\text{km}$$
$$Z_L = 0.46\ \Omega/\text{km} \cdot 60\ \text{km} = 27.66\ \Omega$$

$$Z_S = \frac{110^2\ \text{kV}^2}{3500\ \text{MVA}} = 3.46\ \Omega$$

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

$$I"_{sc\ end} = \frac{1.1 \cdot U_N}{\sqrt{3} \cdot (Z_V + Z_L)} = \frac{1.1 \cdot 110\ \text{kV}}{\sqrt{3} \cdot (3.46\ \Omega + 27.66\ \Omega)} = 2245\ \text{A}$$

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

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

Or the secondary setting value:

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

i.e. in case of fault currents exceeding 2470 A (primary) or 20.6 A (secondary) you can be sure that a short-circuit 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. Only if the angles of the source impedance and the line impedance vary considerably, a complex calculation will have to be carried out.

2.7.3 Setting Overview

Note: The indicated setting ranges and default settings refer to a secondary rated current of I_N = 1 A. For the secondary rated current of I_N = 5 A these values are to be multiplied by 5.

Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Addr.	Setting Title	Setting Options	Default Setting	Comments
2401	FCT HS/SOTF-O/C	ON OFF	ON	Inst. High Speed/SOTF-O/C is
2404	I>>>	0.10..15.00 A; ∞	1.50 A	I>>> Pickup
2405A	I>>>>	1.00..25.00 A; ∞	∞ A	I>>>> Pickup

2.7.4 Information Overview

F.No.	Alarm	Comments
04253	>BLOCK SOTF-O/C	>BLOCK Instantaneous SOTF Overcurrent
04271	SOTF-O/C OFF	SOTF-O/C is switched OFF
04272	SOTF-O/C BLOCK	SOTF-O/C is BLOCKED
04273	SOTF-O/C ACTIVE	SOTF-O/C is ACTIVE
04281	SOTF-O/C PICKUP	SOTF-O/C PICKED UP
04282	SOF O/CpickupL1	SOTF-O/C Pickup L1
04283	SOF O/CpickupL2	SOTF-O/C Pickup L2
04284	SOF O/CpickupL3	SOTF-O/C Pickup L3
04285	I>>>>O/C p.upL1	High Speed-O/C Pickup I>>>> L1
04286	I>>>>O/C p.upL2	High Speed-O/C Pickup I>>>> L2
04287	I>>>>O/C p.upL3	High Speed-O/C Pickup I>>>> L3
04289	HS/SOF TRIP1pL1	High Speed/SOTF-O/C TRIP - Only L1
04290	HS/SOF TRIP1pL2	High Speed/SOTF-O/C TRIP - Only L2
04291	HS/SOF TRIP1pL3	High Speed/SOTF-O/C TRIP - Only L3
04292	HS/SOF TRIP 1p	High Speed/SOTF-O/C TRIP 1pole
04293	HS/SOF Gen.TRIP	High Speed/SOTF-O/C General TRIP
04294	HS/SOF TRIP 3p	High Speed/SOTF-O/C TRIP 3pole
04295	HS/SOF TRIPL123	High Speed/SOTF-O/C TRIP command L123

2.8 Time Overcurrent Protection

General Information

The 7SD610 has a time overcurrent protection function which can be used as either a back-up or an emergency overcurrent protection.

Whereas the differential protection can only operate correctly if each device receives the protection data of the other device properly, the emergency overcurrent protection requires only the local currents. The emergency overcurrent protection is automatically activated when the data communication of the differential protection is disturbed (emergency operation) and the differential protection is blocked as a result.

This means that emergency operation will replace the differential protection for short-circuit protection if the protection data communication fails.

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 a total of four stages for each phase current and for the residual current; these are:

- Two overcurrent stages with independent trip time (definite time overcurrent protection),
- One overcurrent stage with current-dependent trip time (inverse time overcurrent protection),
- 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.

These four stages do not depend on one another and can be combined as desired. Blocking from external criteria is possible via binary inputs just like instantaneous tripping. It is also possible to switch to any one or more of the stages if the protected object is switched onto a fault. The stages not required can be deactivated by setting the pickup value to ∞.

2.8.1 Function Description

Measured Quantities

The phase currents are fed to the device via the input transformers of the measurement input. The residual current $3 \cdot I_0$ is either measured directly or calculated, depending on the version ordered and the use of the device's fourth current input I_4.

If I_4 is connected to the starpoint of the current transformer set, the residual current will be available directly as measured quantity.

If I_4 is connected to a separate residual current transformer, this will be used, while considering the factor **I4/Iph CT** (address 221, see Subsection 2.1.2) of the “Power System Data 1”.

If the residual current is not connected to the fourth current input I_4 (address 220 **I4 transformer** = ***Not connected***, see Subsection 2.1.2 under margin “Connection of the Currents”), the device will calculate the residual current from the phase currents. Of course, all three phase currents of three star-connected current transformers must be available and connected in this case.

Definite Time High-current Stage I>>

Each phase current is compared with the setting value **Iph>>** after numerical filtering; the residual current is compared with **3I0>> PICKUP**. Currents above the associated pickup value are detected and annunciated. When the relevant delay time **T Iph>>** or **T 3I0>>** has expired, a tripping command is issued. The reset value is approximately 5 % less than the pickup value, but at least 1.5 % of the rated current below it.

Figure 2-19 shows the logic diagram of the I>> stages. They can be blocked via the binary input “>BLOCK O/C I>>”. In addition, the residual current stage can be blocked separately via the binary input “>BLOCK O/C Ie>>”, e.g. during a single-pole dead time before reclosure in order to avoid a spurious tripping with the zero phase-sequence system which is present then.

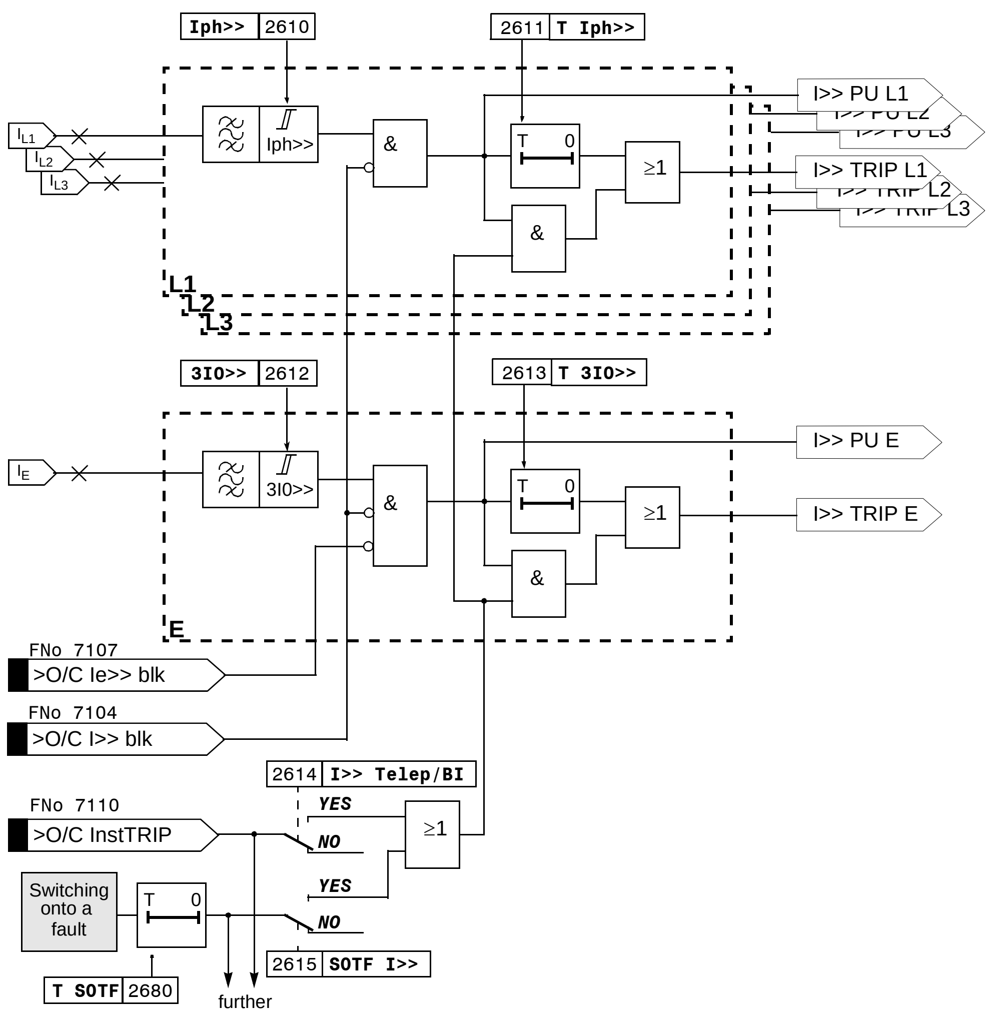


Figure 2-19 Logic diagram of the I>> stage

The binary input “>O/C InstTRIP” and the function block “Switch onto fault” are the same for all stages and explained in detail below. They can, however, affect the phase and/ or residual stages separately. This can be achieved with two parameters:

- **I>> Telep/BI** (address 2614) defines whether an instantaneous tripping without delay of this stage is possible (***YES***) via the binary input “>O/C InstTRIP” or impossible (***NO***). This parameter is also used for instantaneous tripping before automatic reclosure.
- **I>> SOTF** (address 2615) defines whether an instantaneous tripping is to be performed by this stage (***YES***) or not (***NO***) if the line is switched onto a fault.

Definite Time Overcurrent Stage I>

The logic of the overcurrent stages I> is designed like the I>> stages, except that in all designations **Iph>>** is replaced by **Iph>** and **3I0>> PICKUP** by **3I0>**.

Inverse Time Overcurrent Stage I_p

The logic of the current-dependent (inverse time) stage operates basically like the other stages. However, the time delay is calculated here based on the type of the set characteristic (parameter **IEC Curve**), the intensity of the current and a time multiplier (Figure 2-20). A preselection of the possible characteristics has been made during the configuration of the protection functions. Moreover, a constant additional time **T Ip Add** or **T 3I0p Add** can be selected which is added to the current-dependent time. The possible characteristics are shown in Section 4.6, Technical Data.

Figure 2-20 shows the logic diagram. Here, exemplary setting addresses for the IEC characteristics are shown. The setting notes (Subsection 2.8.2) explain the various setting addresses in detail.

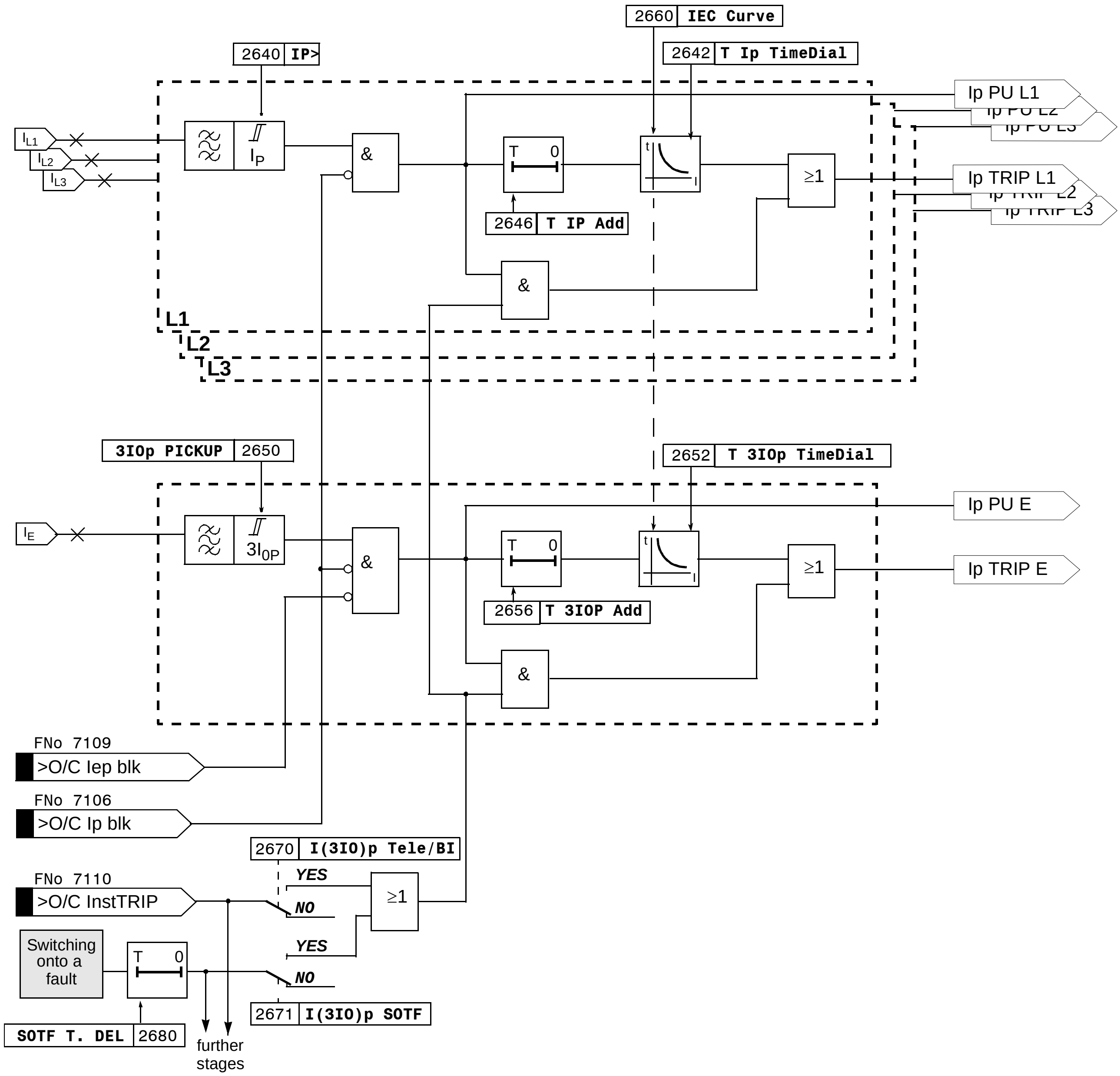


Figure 2-20 Logic diagram of the I_p stage (inverse-time overcurrent protection) — example for IEC characteristics

Additional Overcurrent Stage I-STUB

The additional definite time or instantaneous overcurrent stage I-STUB has an extra enable input (Figure 2-21) and is therefore also suitable e.g. as a stub protection or as an emergency stage if the remaining stages are used as backup stages. The enable input “`>I-STUB ENABLE`” can 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 when the differential protection is not effective, e.g. due to a data disturbance.

The I-STUB 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 release input “>I-STUB ENABLE” must be permanently activated (via a binary input or CFC).

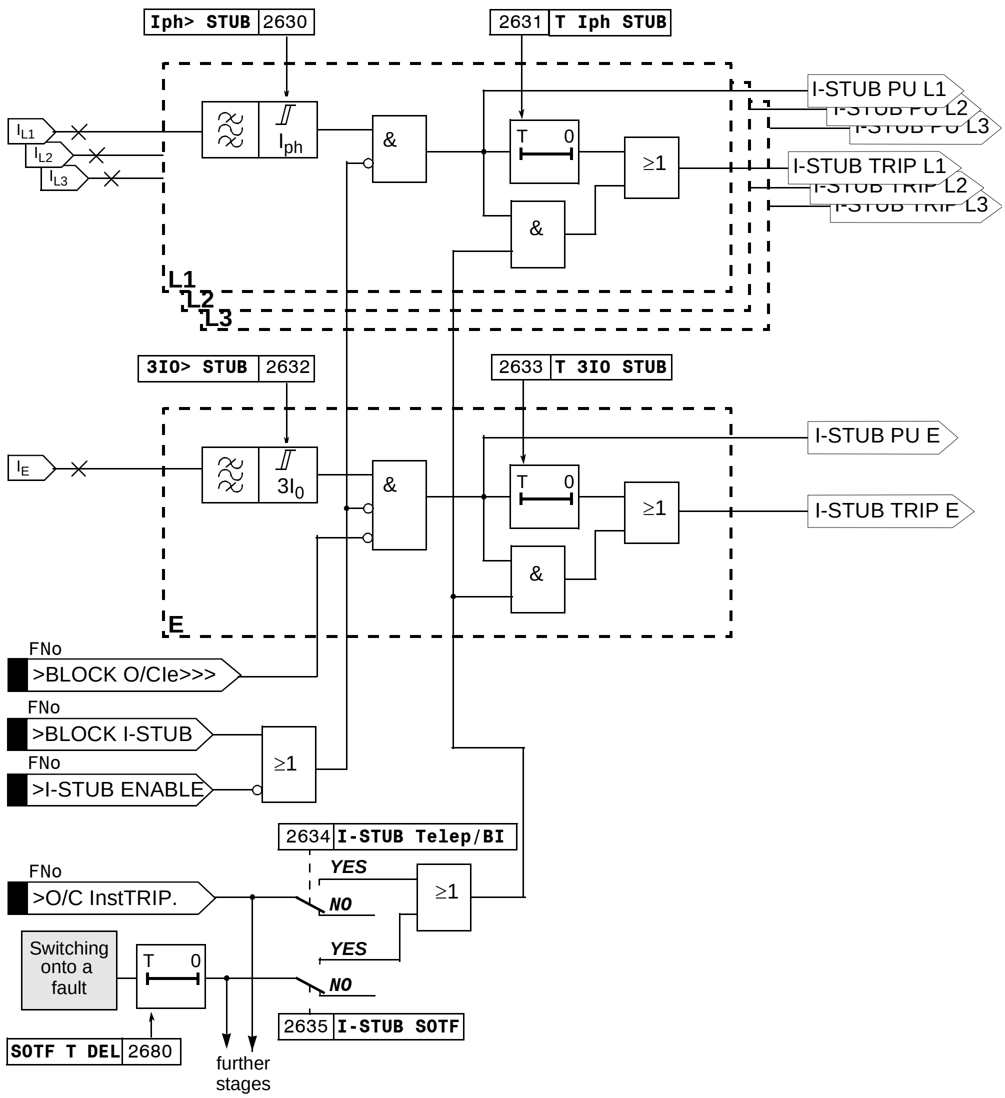


Figure 2-21 Logic diagram of the I-STUB stage

Instantaneous Tripping before Automatic Reclosure

If automatic reclosure is to be carried out, a rapid clearing of the fault is usually desirable before reclosure. A “ready for reclosure” signal from an external automatic reclosure device can be injected via binary input “>O/C InstTRIP”. The internal automatic reclosure function — if existent — acts on this input as well. Any stage of the overcurrent protection can thus perform an instantaneous trip before reclosure via the parameters **I...Telep/BI**.

Switching onto a Dead Fault

To perform an instantaneous trip when the circuit breaker is manually closed onto a dead fault, the manual closing command of the control discrepancy switch can be fed to the device via a binary input. The overcurrent protection then performs a three-pole trip with no or almost no delay. The stage(s) for which the instantaneous trip after manual closing is valid are determined by parameters (see also logic diagrams Figure 2-19, 2-20 and 2-21).

Pickup and Tripping Logic

The pickup signals of the individual phases (or the residual) and of the stages are linked in such a way that both the phase information and the stage which has picked up are output (Table 2-3).

For the tripping signals, the stage which caused the tripping is output as well. For single-pole tripping, the pole is identified (see also Subsection 2.13.4 Tripping Logic of the Entire Device).

Table 2-3 Pickup signals of the time overcurrent protection

Internal message	Figure	Output message	FNo
I>> PU L1 I> PU L1 Ip PU L1 I-STUB PU L1	2-19 2-20 2-21	O/C Pickup L1	07162
I>> PU L2 I> PU L2 Ip PU L2 I-STUB PU L2	2-19 2-20 2-21	O/C Pickup L2	07163
I>> PU L3 I> PU L3 Ip PU L3 I-STUB PU L3	2-19 2-20 2-21	O/C Pickup L3	07164
I>> PU E I> PU E Ip PU E I-STUB PU E	2-19 2-20 2-21	O/C Pickup E	07165
I>> PU L1 I>> PU L2 I>> PU L3 I>> PU E	2-19 2-19 2-19 2-19	O/C PICKUP I>>	07191
I> PU L1 I> PU L2 I> PU L3 I> PU E		O/C PICKUP I>	07192
Ip PU L1 Ip PU L2 Ip PU L3 Ip PU E	2-20 2-20 2-20 2-20	O/C PICKUP Ip	07193
I-STUB PU L1 I-STUB PU L2 I-STUB PU L3 I-STUB PU E	2-21 2-21 2-21 2-21	I-STUB PICKUP	07201
(all pick-ups)		O/C PICKUP	07161

2.8.2 Setting the Function Parameters

General Information

During the configuration of the device functions (see Subsection 2.1.1, address 126) the available characteristics have been pre-selected. Depending on the configuration and depending on the version ordered, only those parameters are accessible which are valid for the available characteristics.

Address 2601 is set according to the desired mode of operation of the overcurrent protection: **Operating Mode** = ***ON*** 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 a transmission failure, ***Only Emer. prot*** must be set. Finally, it can also be set to ***OFF***.

If some stages are not needed, those not needed can be deactivated by setting the pickup value 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-STUB stage is even effective if ***Only Emer. prot*** has been set for the operating mode of the overcurrent protection.

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 tripping due to transient overcurrents a delay **SOTF Time DELAY** (address 2680) can be set. Normally the default setting ***0.00*** 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 duration the of the transient phenomena and on the stages used for the instantaneous tripping.

High-Current Stages Iph>>, 3I0>> Definite Time

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

If the I>> stages are used for instantaneous tripping before the automatic reclosure, the current-setting corresponds to the I> or I_p stages. In this case only the different delay times are of interest. The times **T Iph>>** (address 2611) and **T 3IO>>** (address 2613) can than be set to ***0.00*** 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), the I>> 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 ***0.00*** or to a small value.

During the parameterization from a personal computer using DIGSI®, the parameters can be set as primary or secondary quantities. If secondary quantities are used, all currents must be converted to the secondary side of the current transformers.

<u>Exemplary calculation:</u>

110 kV overhead line 150 mm^2 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 beginning of the line:
S_{sc}' = 2.5 GVA

Current transformers 600 A/5 A

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

$$Z_1/s = \sqrt{0.19^2 + 0.42^2}\ \Omega/\text{km} = 0.46\ \Omega/\text{km}$$
$$Z_L = 0.46\ \Omega/\text{km} \cdot 60\ \text{km} = 27.66\ \Omega$$

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

The three-phase fault current at the line end is $I_{sc\ End}$ (presumed source EMF = $1.1 \cdot U_N$):

$$I_{k\ End} = \frac{1.1 \cdot U_N}{\sqrt{3} \cdot (Z_S + Z_L)} = \frac{1,1 \cdot 110\ \text{kV}}{\sqrt{3} \cdot (4.84\ \Omega + 27.66\ \Omega)} = 2150\ \text{A}$$

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:

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

i.e. in case of fault currents exceeding 2365 A (primary) or 19.7 A (secondary) you can be sure that a short-circuit has occurred on the protected line. It can be disconnected by the overcurrent protection immediately.

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

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

The set times are pure additional delays which do not include the inherent operating time of the protection.

The parameter **I>> Telep/BI** (address 2614) defines whether the time delays **T Iph>>** (address 2611) and **T 3I0>>** (address 2613) can be bypassed by the binary input “>O/C InstTRIP” (FNo 07110) or by the operational automatic reclosure function. The binary input (if allocated) is the same for all stages of the overcurrent protection. With **I>> 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*** 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 back-up protection may not perform a non-selective trip, even before auto-reclosure.

If the I>> stage is to perform an instantaneous trip (when the line is switched onto a fault) or a trip with a short time delay **SOTF Time DELAY** (address 2680, refer to “General Information” above), set the parameter **I>> SOTF** (address 2615) to ***YES***. Any other stage can be selected as well for this instantaneous tripping.

Overcurrent Stages Iph>, 3I0> Definite Time

For the setting of the current pickup value, **Iph>** (address 2620), the maximum operating current is most decisive. Pickup through overload must be excluded, since the device works in this operating mode as a short-circuit protection, not as an overload protection, and the command times are relatively short. The pickup value should therefore be set to a higher value than the maximum (over-)load to be expected, i.e. approx. 10 % for lines and approximately 20 % for transformers and motors.

During configuration from a personal computer using DIGSI® the parameters can be set either to primary or secondary quantities. If secondary quantities are used, all currents must be converted to the secondary side of the current transformers.

Exemplary calculation:

110 kV overhead line 150 mm^2 as above:

Maximum transmitted power
P_{max} = 120 MVA corresponding to
I_{max} = 630 A

Current transformers 600 A/5 A

Safety factor 1.1

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

Setting value I> = 1.1 · 630 A = 693 A

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

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

The residual current stage **3I0>** (address 2622) should be set to detect the smallest ground fault current to be expected.

The time delay **T Iph>** (address 2621) results from the time grading schedule designed for the network. For use as an 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 protection data communication of the differential protection system.

The time **T 3I0>** (address 2623) can normally be set shorter, according to a separate time grading schedule for residual 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 for a stage, set the pickup value of the residual current stage to ∞.

The parameter **I> Telep/BI** (address 2624) defines whether the time delays **T Iph>** (address 2621) and **T 3I0>** (address 2623) can be bypassed by the binary input “>O/C InstTRIP” (FNo 07110) or by the operational automatic reclosure function. The binary input (if allocated) is the same for all stages of the overcurrent protection. With **I> 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*** 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 back-up protection must not perform a non-selective trip, even before auto-reclosure.

If the I> stage is to perform an instantaneous trip, when the line is switched onto a fault, or a trip with a short time delay **SOTF Time DELAY** (address 2680, refer to "General Information" above), set the parameter **I> SOTF** (address 2625) to ***YES***. However, the stage selected for instantaneous tripping should not be too sensitive since a strong fault current is to be expected when switching onto a fault, and transient pickup of the selected stage on switching on must be avoided.

Overcurrent Stages IP, 3I0P Inverse Time with IEC Characteristics

Various characteristics can be chosen for the inverse time stages, depending on the the configuration (Subsection 2.1.1, address 126). For **Back-Up O/C** = ***TOC IEC***, the following IEC characteristics are available under address 2660 **IEC Curve**:

Normal Inverse (Type A in accordance with IEC 60255–3),
Very Inverse (Type B in accordance with IEC 60255–3),
Extremely Inv. (Type C in accordance with IEC 60255–3), and
LongTimeInverse (Type B in accordance with IEC 60255–3).

The characteristics and the formulae on which they are based, are shown in the Technical Data (Section 4.6).

The considerations for the overcurrent stages of the definite-time overcurrent protection (see above) are also valid for the setting of the pickup values **Ip>** (address 2640) and **3I0p PICKUP** (address 2650). It should be noted that a safety margin has already been included between the pickup value and the setting value and that the protection picks up only when the setting value is exceeded by 10 %.

Referring to the above example, the maximum operational current to be expected can be set here:

Primary: Setting value **Ip>** = 630 A,

Secondary: Setting value **Ip>** = 5.25 A, i.e. (630 A / 600 A) · 5 A.

The time multiplier **T Ip Time Dial** (address 2642) derives from the time grading schedule set 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 protection data communication of the differential protection.

The time multiplier **T 3I0p TimeDial** (address 2652) can normally be set shorter, according to a separate time grading schedule for residual currents. If only the phase currents are to be monitored, set the pickup value of the residual current stage to ∞.

In addition to the current-dependent delays, a delay of constant length can be set, if necessary. The settings **T Ip Add** (address 2646 for phase currents) and **T 3I0p Add** (address 2656 for residual current) are added to the times of the set characteristics.

The parameter **I(3I0)p Tele/BI** (address 2670) defines whether the time delays **T Ip Time Dial** (address 2642) including the additional time **T Ip Add** (address 2646) and **T 3I0p TimeDial** (address 2652) including the additional time **T 3I0p Add** (address 2656) can be bypassed by the binary input ">O/C InstTRIP" (FNo 07110) or by the operational automatic reclosure function. The binary input (if allocated) is the same for all stages of the overcurrent protection. With **I(3I0)p Tele/BI** = ***YES*** you define that the $I_P$stages trip without delay after pickup if the binary input was activated. For **I(3I0)p Tele/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 must not perform a non-selective trip, even before auto-reclosure.

If the inverse time stage is to perform an instantaneous trip, when the line is switched onto a fault, or a trip with a short time delay **SOTF Time DELAY** (address 2680, refer to "General Information" above), set the parameter **I(3I0)p SOTF** (address 2671) to ***YES***. However, the stage selected for instantaneous tripping should not be too sensitive since a strong fault current is to be expected when switching onto a fault, and transient pickup of the selected stage on switching on must be avoided.

Overcurrent Stages IP, 3I0P Inverse Time with ANSI Characteristics

Various characteristics can be chosen for the inverse time stages, depending on the configuration (Subsection 2.1.1, address 126). For **Back-Up O/C** = ***TOC ANSI***, the following ANSI-characteristics are available under address 2661 **ANSI Curve**:

Inverse,
Short Inverse,
Long Inverse,
Moderately Inv.,
Very Inverse,
Extremely Inv. and
Definite Inv.

The characteristics and the formulae on which they are based, are shown in the Technical Data (Section 4.6).

The considerations for the overcurrent stages of the definite-time overcurrent protection (see above) are also valid for the setting of the pickup values **Ip>** (address 2640) and **3I0p PICKUP** (address 2650). It should be noted that a safety margin has already been included between the pickup value and the setting value and that the protection picks up only when the setting value is exceeded by 10 %.

Referring to the above example, the maximum operational current to be expected can be set here:

Primary: setting value **Ip>** = 630 A,

Secondary: setting value **Ip>** = 5.25 A, i.e. (630 A / 600 A) · 5 A.

The time multiplier **Time Dial TD Ip** (address 2643) derives from the time grading schedule set 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 the case of an interruption of the data communication of the differential protection.

The time multiplier **TimeDial TD3I0p** (address 2653) can normally be set shorter, according to a separate time grading schedule for residual currents. If only the phase currents are to be monitored, set the pickup value of the residual current stage to ∞.

In addition to the current-dependent delays, a delay of constant length can be set, if necessary. The settings **T Ip Add** (address 2646 for phase currents) and **T 3I0p Add** (address 2656 for residual current) are added to the times of the set characteristics.

The parameter **I(3I0)p Tele/BI** (address 2670) defines whether the time delays **Time Dial TD Ip** (address 2643) including the additional time **T Ip Add** (address 2646) and **TimeDial TD3I0p** (address 2653) including the additional time **T 3I0p Add** (address 2656) can be bypassed by the binary input ">O/C InstTRIP" (FNo 07110) or by the operational automatic reclosure function. The binary input (if allocated) is the same for all stages of the overcurrent protection. With **I(3I0)p Tele/BI** = ***YES*** you define that the I_P stages trip without delay after pickup if the binary input was activated. For **I(3I0)p Tele/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 back-up protection must not perform a non-selective trip, even before auto-reclosure.

If the inverse time stage is to perform an instantaneous trip (when the line is switched onto a fault) or a trip with a short time delay **SOTF Time DELAY** (address 2680, refer to “General Information” above), set the parameter **I(3I0)p SOTF** (address 2671) to ***YES***. However, the stage selected for instantaneous tripping should not be too sensitive since a strong fault current is to be expected when switching onto a fault, and transient pickup of the selected stage on switching on must be avoided.

Additional Stage I-STUB

The I-STUB stage can be used as an additional definite time overcurrent stage, since it works independently of the other stages. In this case, the enable input “>I-STUB ENABLE” (FNo 07131) must be activated permanently (via a binary input or CFC). Alternatively, it can be used as a stub bus protection. In this case, the enable input “>I-STUB ENABLE” is activated by the indication of the open line disconnector.

Since the I-STUB 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 release input “>I-STUB ENABLE” (FNo 07131) can be assigned the output signal “Emer. mode” (FNo 02054) (either via binary outputs and inputs or via the user-definable logic CFC functions).

The considerations for the use of the I-STUB stage as an emergency function are the same 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. Normally, one time step above the base time of the differential protection is sufficient.

The residual current stage **3I0> STUB** (address 2632) should correspondingly pick up on the smallest residual current to be expected during a ground fault and the delay **T 3I0 STUB** (address 2633) should exceed the base time of the differential protection by a grading time. If only the phase currents are to be monitored, set the pickup value of the ground fault stage to ∞.

The I-STUB stage can also be accelerated by the enable signal “>O/C InstTRIP” (FNo 07110), e.g. before an auto-reclosure. This is defined with parameter **I-STUB Telep/BI** (address 2634). Set it on ***YES*** if the I-STUB stage is to trip without delay as long as the binary input “>O/C InstTRIP” is activated or the internal auto-reclosure function is ready to operate. Instantaneous tripping by the operational auto-reclosure should only be chosen if the I-STUB stage is set as an emergency function. If the differential protection is out of operation, this emergency stage guarantees instantaneous tripping before auto-reclosure.

Instantaneous tripping when the line is switched onto a fault is also possible with the I-STUB stage. Set parameter **I-STUB SOTF** (address 2635) to ***YES***, if instantaneous tripping is desired.

2.8.3 Setting Overview

Note: The indicated setting ranges and default settings refer to a secondary rated current of I_N = 1 A. For the secondary rated current of I_N = 5 A these values are to be multiplied by 5.

Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Addr.	Setting Title	Setting Options	Default Setting	Comments
2601	Operating Mode	ON Only Emergency protection OFF	ON	Operating mode
2680	SOTF Time DELAY	0.00..30.00 sec	0.00 sec	Trip time delay after SOTF
2610	Iph>>	0.10..25.00 A; ∞	2.00 A	Iph>> Pickup
2611	T Iph>>	0.00..30.00 sec; ∞	0.30 sec	T Iph>> Time delay
2612	3I0>> PICKUP	0.05..25.00 A; ∞	0.50 A	3I0>> Pickup
2613	T 3I0>>	0.00..30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> Telep/BI	NO YES	YES	Instantaneous trip via Teleprot./BI
2615	I>> SOTF	NO YES	NO	Instantaneous trip after SwitchOnToFault
2620	Iph>	0.10..25.00 A; ∞	1.50 A	Iph> Pickup
2621	T Iph>	0.00..30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	0.05..25.00 A; ∞	0.20 A	3I0> Pickup
2623	T 3I0>	0.00..30.00 sec; ∞	2.00 sec	T 3I0> Time delay
2624	I> Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./BI
2625	I> SOTF	NO YES	NO	Instantaneous trip after SwitchOnToFault
2640	Ip>	0.10..4.00 A; ∞	∞ A	Ip> Pickup
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	0.05..4.00 A; ∞	∞ A	3I0p Pickup
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 Inverse Long time inverse	Normal Inverse	IEC Curve

Addr.	Setting Title	Setting Options	Default Setting	Comments
2661	ANSI Curve	Inverse Short Inverse Long Inverse Moderately Inverse Very Inverse Extremely Inverse Definite Inverse	Inverse	ANSI Curve
2670	I(3I0)p Tele/BI	NO YES	NO	Instantaneous trip via Teleprot./ BI
2671	I(3I0)p SOTF	NO YES	NO	Instantaneous trip after Swit- chOnToFault
2630	Iph> STUB	0.10..25.00 A; ∞	1.50 A	Iph> STUB Pickup
2631	T Iph STUB	0.00..30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	0.05..25.00 A; ∞	0.20 A	3I0> STUB Pickup
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 Teleprot./ BI
2635	I-STUB SOTF	NO YES	NO	Instantaneous trip after Swit- chOnToFault

2.8.4 Information Overview

F.No.	Alarm	Comments
07104	>BLOCK O/C I>>	>BLOCK Backup OverCurrent I>>
07105	>BLOCK O/C I>	>BLOCK Backup OverCurrent I>
07106	>BLOCK O/C Ip	>BLOCK Backup OverCurrent Ip
07107	>BLOCK O/C Ie>>	>BLOCK Backup OverCurrent Ie>>
07108	>BLOCK O/C Ie>	>BLOCK Backup OverCurrent Ie>
07109	>BLOCK O/C Iep	>BLOCK Backup OverCurrent Iep
07110	>O/C InstTRIP	>Backup OverCurrent InstantaneousTrip
07130	>BLOCK I-STUB	>BLOCK I-STUB
07131	>I-STUB ENABLE	>Enable I-STUB-Bus function
07132	>BLOCK O/CIe>>>	>BLOCK Backup OverCurrent Ie>>>
07151	O/C OFF	Backup O/C is switched OFF
07152	O/C BLOCK	Backup O/C is BLOCKED
07153	O/C ACTIVE	Backup O/C is ACTIVE
07161	O/C PICKUP	Backup O/C PICKED UP
07162	O/C Pickup L1	Backup O/C PICKUP L1
07163	O/C Pickup L2	Backup O/C PICKUP L2
07164	O/C Pickup L3	Backup O/C PICKUP L3
07165	O/C Pickup E	Backup O/C PICKUP EARTH
07191	O/C PICKUP I>>	Backup O/C Pickup I>>
07192	O/C PICKUP I>	Backup O/C Pickup I>
07193	O/C PICKUP Ip	Backup O/C Pickup Ip
07201	I-STUB PICKUP	O/C I-STUB Pickup
07211	O/C TRIP	Backup O/C General TRIP command
07212	O/C TRIP 1p.L1	Backup O/C TRIP - Only L1
07213	O/C TRIP 1p.L2	Backup O/C TRIP - Only L2
07214	O/C TRIP 1p.L3	Backup O/C TRIP - Only L3
07215	O/C TRIP L123	Backup O/C TRIP Phases L123
07221	O/C TRIP I>>	Backup O/C TRIP I>>
07222	O/C TRIP I>	Backup O/C TRIP I>
07223	O/C TRIP Ip	Backup O/C TRIP Ip
07235	I-STUB TRIP	O/C I-STUB TRIP

2.9 Automatic Reclosure

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 reclosed. Reclosure is performed by an automatic reclosure function (AR). An example of the normal time sequence of a double-shot reclosure is shown in Figure 2-22.

Automatic reclosure is only permitted on overhead lines because the possibility of automatic extinguishing of a fault arc 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 single-pole trip followed by an auto-reclosure is often initiated in the case of single-phase faults and a three-pole trip with auto-reclosure in the case of multi-phase faults in the network with earthed system starpoint. If the fault still exists after reclosure (arc not extinguished or metallic short-circuit), the protection issues a final trip. Repeated reclosure attempts are made in some networks.

In the version with single-pole tripping, 7SD610 allows phase-segregated, single-pole tripping. A single- and three-pole, single and multiple shot automatic reclosure function is integrated, depending on the order version.

7SD610 can also operate together with an external automatic reclosure device provided the binary inputs and outputs are available. In this case the signal exchange between 7SD610 and the external reclosure device must take place via the binary inputs and outputs. It is also possible to have the integrated automatic reclosure function controlled by an external protection (e.g. alternate protection).

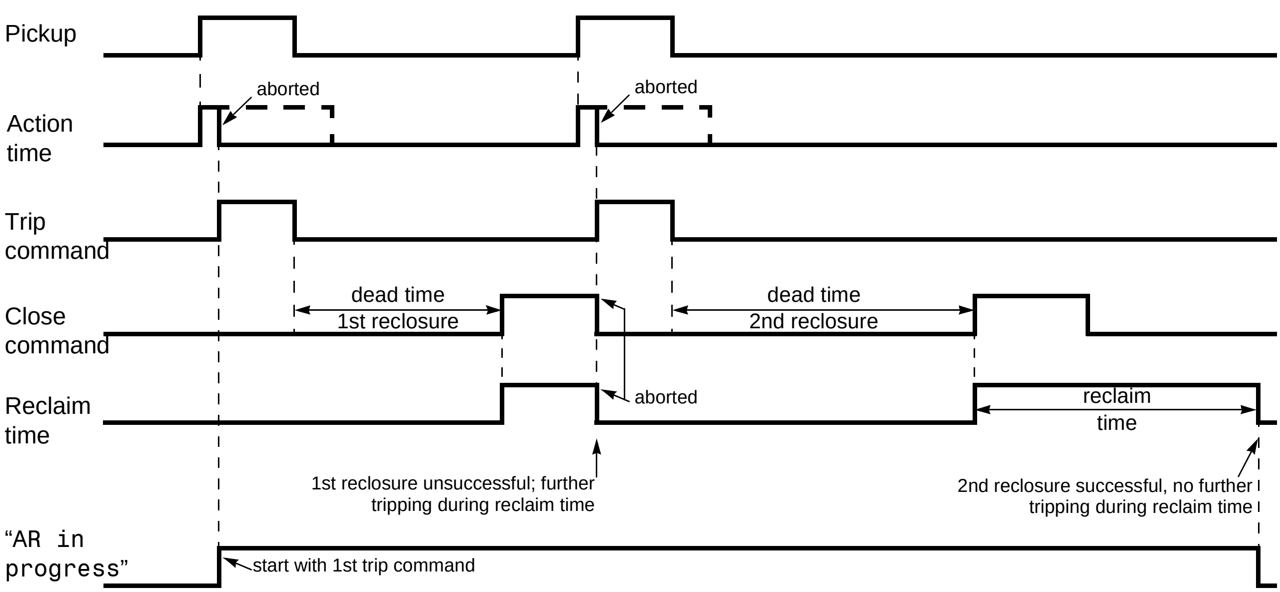


Figure 2-22 Timing diagram of a double-shot reclosure with action time (2nd reclosure successful)

2.9.1 Function Description

The integrated automatic reclosure function allows up to 8 reclosure attempts. The first four reclosure cycles may operate with different parameters (action and dead times, single/three-pole). The parameters of the fourth cycle apply from the fifth cycle onwards.

Switching On and Off

The automatic reclosure function can be switched on and off, by means of the parameter 3401 **AUTO RECLOSE**, or via the system interface (if available) or via binary input (if this is allocated). The switched state is saved internally (refer to Figure 2-23) and secured against loss of auxiliary supply. It is only possible to switch on from the source where previously it had been switched off from. To be active, it is necessary that the function is switched on from all three switching sources.

Alteration of the switching state via setting or the system interface is not possible during a running fault.

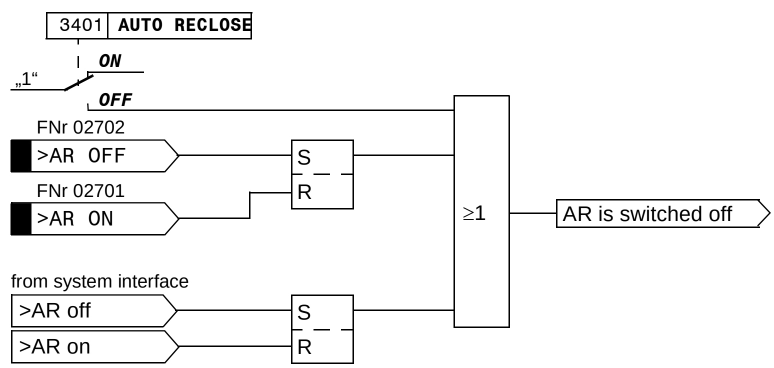


Figure 2-23 Switching on and off of the internal auto-reclosure function

Selectivity before Reclosure

In order for the automatic reclosure to be successful, all faults on the whole overhead line must be cleared at both line ends at the same — as short as possible — time. 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 undelayed 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 undelayed tripping in at least one stage when the automatic reclosure function is ready for the first reclosure cycle.

Fast tripping before reclosure is also possible for multiple reclosures. Appropriate links between the output messages (e.g. 2nd reclosure ready: “AR 2.CycZoneRel”) and the inputs for undelayed tripping of the protective functions can be established via the binary inputs and outputs or the integrated user-definable logic functions (CFC).

Start

Starting the automatic reclosure function means storing the first trip signal of a system fault generated by a protection function operating with automatic reclosure. In the case of multiple reclosure, starting therefore only takes place once which is with the first trip command. Storing this 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 is not started if the circuit breaker has not been ready for at least one TRIP-CLOSE-TRIP-cycle at the instant of the first trip command. This can be achieved by setting parameters. See also subtitle “Interrogation of Circuit Breaker Ready” (page 86).

Setting parameters can be used for every short-circuit protection function to determine whether or not this is to operate with reclosure, i.e. whether or not it is to start the automatic reclosure function. The same applies accordingly for trip commands which are applied externally via binary inputs and/or generated by transfer trip signals/remote tripping.

The protection and monitoring functions of the device which do not react to short-circuit-like phenomena do not start the automatic reclosure because reclosure is of no use here. In 7SD610, for example, this is the overload protection. The breaker failure protection must not start the auto-reclosure either.

Action Times

It is often desirable to suppress the readiness for reclosure if the short-circuit has existed 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 extinguishing during the dead time. For reasons of selectivity also (see above), frequently faults with delayed trip should not lead to reclosure.

The automatic reclosure function of 7SD610 can be operated with or without action times (configuration parameter **AR control mode**, address 134, see Subsection 2.1.1). Provision of a pickup signal is not necessary from the protective functions or external protection equipment if the auto-reclosure function is operated without action time. Starting of the auto-reclosure takes place then as soon as the first trip command appears.

In operation with action time, an action time is available for each reclosure cycle. The action times are always started by the pickup signals linked with *OR* of all protective functions which can start the automatic reclosure function. If there is still no trip command available at the end of an action time, the corresponding reclosure cycle cannot be performed.

For each reclosure cycle, it can be set whether or not it allows a start. With the *first* general fault detection, only *those* action times the cycles of which allow a start have a meaning because the other cycles may not start. Using the action times and the start permission you can control which cycles can be run under different command time conditions.

<u>Example 1</u>: 3 cycles are set. Starting of the auto-reclosure is allowed for at least the first cycle. It is assumed that the action times are set as follows:
1.AR: T-ACTION = 0.2 s;
2.AR: T-ACTION = 0.8 s;
3.AR: T-ACTION = 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. The automatic reclosure function is started as a result. After unsuccessful reclosure the 2nd cycle would then become active; but the time overcurrent protection would not trip in this ex-

ample until after 1 s according to its grading time. Since the action time for the second cycle was exceeded here, it is blocked. The 3rd cycle with its parameters is therefore performed now. If the trip command after the 1st reclosure had not appeared within 1.2 s after the 1st reclosure, there would be no further reclosure.

Example 2: 3 cycles are set. Starting of the auto-reclosure 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 reclosure function. However, the 2nd and 3rd cycles cannot take place because they are not set to start. There is therefore no reclosure, because no starting at all can take place.

Example 3: 3 cycles are set. Starting of the auto-reclosure is allowed for at least the first two cycles. 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 starting is allowed, is activated immediately. This starts the automatic reclosure function, the 1st cycle is practically skipped.

Control Modes of the Automatic Reclosure

The dead times — these are the times from elimination of the fault (drop off of the trip command or signalling via auxiliary contacts) to the initiation of the automatic close command — may vary, depending on the automatic reclosure control mode selected when determining the function scope (Subsection 2.1.1, address 134 **AR control mode**) and the resulting signals of the starting protective functions.

In the ***Trip***... control mode single-pole or single/three-pole reclosure cycles are possible if the device and the circuit breaker are suitable for single-pole trip. In this case different dead times after single-pole tripping on the one hand and after three-pole tripping on the other hand are possible (for every reclosure cycle). The tripping protective function determines the type of tripping: single-pole or three-pole. Control of the dead time depends on this.

In the ***Pickup***... control mode, different dead times can be set for every reclosure cycle after single-, two- and three-phase faults. Decisive here is the *pickup* situation of the protective functions at the instant the trip command disappears. This control mode enables the dead times to be made dependent on the type of fault in the case of three-pole reclosure cycles.

Blocking Reclosure

Different events lead to blocking of automatic reclosure. No reclosure is possible for example if it is blocked via a binary input. If the automatic reclosure has not yet been started, it cannot be started at all. If a reclosure cycle is already in progress, dynamic lockout takes place (see below).

Every cycle can also be blocked individually by a binary input. In this case the cycle concerned is invalid and will be skipped in the sequence of permissible cycles. If blocking takes place while the cycle concerned is in progress, this leads to aborting of the reclosure, i.e. no reclosure takes place even if other valid cycles have been parameterized.

Internal blockings restricted with certain time periods are processed during the course of reclosure cycles:

The reclaim time **T-RECLAIM** begins with every automatic reclosure command. If the reclosure is successful, all the functions of the automatic reclosure 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 network. Re-tripping of a protective function within the reclaim time initiates the next reclosure cycle in the case of multiple reclosure; if no further reclosure is permitted, the last reclosure is treated as unsuccessful in the case of re-tripping within the reclaim time. The automatic reclosure is locked out 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 final tripping or other events which block the automatic reclosure after it has been started. Restarting is blocked for this time. When this time has elapsed, the automatic reclosure returns to its idle position and is ready to process a new fault in the network.

If the circuit breaker is closed manually (by the control discrepancy switch connected to a binary input, via the integrated control functions, or via the system interface, see also Subsection 2.13.1), the automatic reclosure is blocked for a manual-close-blocking time **T-BLOCK MC**. When a trip command is given during this time, it can be assumed that a metallic short-circuit be present (e.g. closed earthing isolator). 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 Circuit Breaker Ready

Precondition for a reclose attempt after trip is that the circuit breaker is ready for at least one TRIP-CLOSE-TRIP-cycle at the instant the automatic reclosure function is started (i.e. before the first trip command). The ready status of the circuit breaker is signalled to the device through the binary input “>CB1 Ready” (FNo 00371). If no such signal is available, the circuit breaker interrogation can be suppressed (presetting) because otherwise automatic reclosure would not be possible at all.

This interrogation usually suffices for a single reclosure scheme. 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.

It is of advantage, particularly in the case of multiple reclosure, to check the ready status of the circuit breaker not only at the instant of the first trip command but also before every subsequent reclosure. The reclosure is blocked as long as the CB does not indicate its ready status for another CLOSE-TRIP-cycle.

The recovery time of the circuit breaker can be monitored by the 7SD610. This monitoring time **CB TIME OUT** begins as soon as the CB ready signal becomes inactive. The dead time may be extended if no readiness is signalled at the end of it. However, if the circuit breaker does not indicate its ready status for a longer period than the monitoring time, reclosure is locked out dynamically (see also above under subtitle “Blocking Reclosure” page 85).

Processing the Auxiliary Contact Position of the Circuit Breaker

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 individual control of the individual breaker poles this concerns each individual breaker pole. This assumes that the auxiliary contacts are connected to the appropriate binary inputs for each pole (“>CB1 Pole L1”, FNo 00366); “>CB1 Pole L2”, FNo 00367); and “>CB1 Pole L3”, FNo 00368).

If the series connections of the make and break auxiliary contacts are connected instead of the individual pole auxiliary contacts, the CB is assumed to have all poles open when the series connection of the break contacts is closed (binary input “>CB1 3p Open”, FNo 00411). It is assumed to have all poles closed when the series connection of the make contacts is closed (binary input “>CB1 3p Closed”, FNo 00410).

If none of these input messages is active, it is assumed that the breaker is open at one pole (even if this condition also exists theoretically when two poles are open).

The device checks the position of the circuit breaker continuously: As long as the auxiliary contacts indicate that the CB is not closed (three-pole), the automatic reclosure function cannot be started. This guarantees that a close command can only be given when the CB was previously tripped (out of the closed state).

The valid dead time begins when the trip command disappears or signals taken from the CB auxiliary contacts indicate that the CB (pole) has opened.

If the CB opens *three-pole* after a *single-pole* trip command, this is considered as a three-pole tripping. If three-pole reclosure cycles are allowed, the dead time for three-pole tripping becomes active in the control mode with trip command (see above under subtitle “Control Modes of the Automatic Reclosure”, page 85); in control by pickup, the pickup configuration of the starting protective function(s) is still decisive. If three-pole cycles are not allowed, the reclosure is locked out dynamically. The trip command then was final.

The latter also applies if the CB is tripped at two poles after a single-pole trip command. The device only detects this if the auxiliary contacts for each pole are connected individually. The device couples the poles immediately resulting in a three-pole trip command.

If the CB auxiliary contacts indicate that at least one further pole has opened during the dead time after single-pole tripping, a three-pole reclosure cycle is initiated with the dead time for three-pole reclosure provided 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 three-pole trip command provided the forced three-pole trip is activated (see below under subtitle “Forced Three-pole Trip”, page 90).

Sequence of a Three-pole Auto-reclose Cycle

If the automatic reclosure is ready, the short-circuit protection trips all three poles for all faults within the stages parameterized for auto-reclosure. The automatic reclosure function is started. When the trip command drops off 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) reclaim time is started. If **AR control mode** = ***Pickup*** ... was set under address 134 during configuration of the protective functions, different dead times can be parameterized depending on the type of fault detected by the protection.

If the fault has been eliminated (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 three-pole trip following a protection stage active without reclosure. Any fault during the reclaim time leads to final tripping.

After unsuccessful reclosure (final tripping), the automatic reclosure is locked out dynamically (see also above under subtitle “Blocking Reclosure”, page 85).

The sequence above applies for single-shot reclosure. In the 7SD610 multiple reclosure (up to 8 shots) is also possible (see below).

Sequence of a Single-pole Auto-reclose Cycle

Single-pole auto-reclosure cycles are only possible if the device includes the option for single-pole tripping and this had been enabled in the protective function configuration (address 110, see also Subsection 2.1.1). Of course, the circuit breaker must also be suitable for single-pole tripping.

If the automatic reclosure is ready, the short-circuit protection trips single-pole for all single-phase faults within the stages parameterized for reclosure. It can also be determined, by setting (address 1156A **Trip2phFlt**, see also Subsection 2.1.4), that single-pole tripping should take place for two-phase, earth-free faults. Single-pole tripping is of course only possible by short-circuit protective functions which can determine the faulty phase.

In the case of multi-phase faults, the short-circuit protection performs a final three-pole trip following a protection stage active without reclosure. Every three-pole tripping is final. The automatic reclosure is locked dynamically (see also above under subtitle “Blocking Reclosure”, page 85).

The automatic reclosure is started in the case of single-pole tripping. The (adjustable) dead time for the single-pole auto-reclosure cycle starts with drop-off of the trip command or opening of the circuit breaker pole (auxiliary contact criterion). At the end of this 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 single-pole trip, immediate three-pole tripping can take place as an option (“Forced Three-pole Trip”, see below, page 90).

If the fault has been eliminated (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 three-pole trip following a protection stage active without reclosure. Any fault during the reclaim time leads to final three-pole tripping.

After unsuccessful reclosure (final tripping), the automatic reclosure is blocked dynamically (see also above under subtitle “Blocking Reclosure”, page 85).

The sequence above applies for single-shot reclosure. In 7SD610 multiple reclosure (up to 8 shots) is also possible (see below).

Sequence of a Single and Three-pole Auto-reclosure

This operating mode is only possible if the device includes the option for single-pole tripping and this had been enabled in the protective functions configuration (address 110, see also Subsection 2.1.1). Of course, the circuit breaker must also be suitable for single-pole tripping.

If the automatic reclosure is ready, the short-circuit protection trips single-pole for single-phase faults within the stage(s) configured for automatic reclosure and three-pole for multi-phase faults. It can also be determined, by setting (address 1156A **Trip2phFlt**, see also Subsection 2.1.4), that single-pole tripping should take place for two-phase, earth-free faults. Single-pole tripping is of course only possible for short-circuit protective functions which can determine the faulty phase. The stages parameterized for reclosure apply for all fault types.

The automatic reclosure is started at the moment of tripping. Depending on the type of fault the (adjustable) dead time for the single-pole auto-reclosure cycle or the (separately adjustable) dead time for the three-pole auto-reclosure cycle starts with the drop off of the trip command or opening of the circuit breaker (pole). At the end 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 single-pole trip, immediate three-pole tripping can take place as an option (Forced Three-pole Trip, see below, page 90).

If the fault has been eliminated (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 three-pole trip following a protection stage active without auto-reclosure. Any fault during the reclaim time also leads to final three-pole tripping.

After unsuccessful reclosure (final tripping) the automatic reclosure is blocked dynamically (see also above under subtitle “Blocking Reclosure”, page 85).

The sequence above applies for single-shot reclosure. In 7SD610 multiple reclosure (up to 8 shots) is also possible (see below).

Multiple Auto-reclosure

If a fault 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 7SD610.

The first four reclosure cycles are independent of each other. Each one has separate action and dead times, can operate with single- or three-pole trip and can be blocked separately via binary inputs. The parameters and intervention possibilities of the fourth cycle also apply for the fifth cycle and further cycles.

The sequence is in principle the same as in the different reclosure programs described above. However, in this case, if the first reclosure attempt was unsuccessful, the reclosure is not blocked but the next reclosure cycle begins. The respective dead time starts with drop-off of the trip command or opening of the circuit breaker (pole) (auxiliary contact criterion). The circuit breaker receives a further close command after this. At the same time the reclaim time is started.

Until the set maximum number of permissible auto-reclose cycles has been reached, the reclaim time is reset with every new trip command after reclosure and started again with the next close command.

If one of the cycles is successful, i.e. the fault has been eliminated after reclosure, the reclaim time expires and all functions return to their quiescent states. The fault is cleared.

If none of the cycles is successful, the short-circuit protection initiates a final three-pole trip after the last permissible reclosure, following a protection stage active without auto-reclosure. The automatic reclosure is blocked dynamically (see also above under subtitle “Blocking Reclosure”, page 85).

Handling Evolving Faults

If single-pole or single- and three-pole reclosure cycles are executed in the network, particular attention must be paid to evolving faults.

Evolving faults are faults which occur during the dead time after clearance of the first fault.

There are various ways of handling evolving faults in the 7SD610 depending on the requirements of the network:

For **detection** of an evolving fault you can select whether the *trip command* of a protective function during the dead time or every further *fault detection* (pickup) is 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.

a) **`EV. FLT. MODE`** ***Stops AutoRecl***:
The reclosure is blocked as soon as a evolving fault is detected. Tripping caused by the evolving fault is three-pole. This applies irrespective of whether three-pole cycles have been permitted or not. There are no further reclosure attempts; the auto-reclosure is blocked dynamically (see also above under subtitle “Blocking Reclosure”, page 85).

b) **`EV. FLT. MODE`** ***`starts 3p AR`***:
As soon as an evolving fault is detected the auto-reclosure function is switched over to a cycle for three-pole auto-reclosure. Every trip command is three-pole. The separately settable dead time for evolving faults begins with elimination of the evolving fault; after this the circuit breaker receives a close command. The further procedure is the same as for single- and three-pole cycles.

The complete dead time in this case consists of the part of the dead time for the single-pole reclosure up to the elimination of the evolving fault plus the dead time for the evolving fault. This is useful because the duration of the dead time after the three-pole tripping is essential for the stability of the network.

If auto-reclosure is blocked due to an evolving fault without the protection issuing a three-pole trip command (e.g. for evolving fault detection with pickup), the device can send a three-pole trip command so that the circuit breaker does not remain open with one pole (“Forced Three-pole Trip”).

Forced Three-pole Trip

If reclosure is blocked during the dead time of a single-pole cycle without a three-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. You can achieve by a setting parameter that the tripping logic of the device sends immediately a three-pole trip command in this case. This forced three-pole trip pre-empts the pole discrepancy supervision of the CB because the forced three-pole trip of the device is initiated as soon as the reclosure is blocked following a single-pole trip or if the CB auxiliary contacts report an implausible breaker state.

When different internal protection functions of the device initiate a single-pole trip in different phases the device will issue a three-pole trip command due to the tripping logic of the entire device (Subsection 2.13.4), independent of this forced three-pole trip function. This is true also for trip commands given via the direct local trip inputs (Section 2.5 or the reception of a remote trip (Section 2.6) since theses signals are passed through the tripping logic of the entire device.

But, when the device issues a single-pole trip command while an external single-pole trip signal reaches the device via one of the binary inputs “`>Trip Lx AR`” then this is not routed to the tripping logic but only to the auto-reclosure function. In this case, three-pole trip is ensured only if the forced three-pole trip is effective.

The forced three-pole trip is also initiated when only three-pole cycles are allowed but a single-pole open position is indicated externally through the binary inputs.

Dead Line Check (DLC)

If the voltage of a disconnected phase does not disappear after tripping on a fault, auto-reclosure can be prevented. This presupposes that the voltage transformers are installed on the line side and connected to the device. This has to be in accordance with the configuration described in Subsection 2.1.1. The dead line check must be switched active. The automatic reclosure function then checks the disconnected line for no-voltage. This requires an adequate measuring time within the dead time. If the voltage has not disappeared the reclosure is blocked dynamically.

This dead-line 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 possibilities it has been assumed that defined and equal dead times have been set at both line ends, if necessary for different fault types and/or auto-reclosure cycles.

It is also possible to set the dead times at one line end only and to configure the adaptive dead time at the other end. This presumes that the voltage transformers are arranged on the line side and connected to the device.

Figure 2-24 shows an example. It is assumed that the device I is operating with defined dead times whereas the adaptive dead time is configured at position II. It is important that the line is fed at least from busbar A, i.e. the side with the defined dead times.

With the adaptive dead time the automatic reclosure function at the line end II decides independently whether and when reclosure is useful and permissible and when it is not. The criterion is the line voltage at end II, which was re-applied from end I following reclosure there. Reclosure therefore takes place at end II as soon as it is detected that voltage has been re-applied to the line from end I.

In the illustrated example, the line is disconnected at positions I and II. In I reclosure takes place after the parameterized 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 ended.

If the fault has not been cleared after reclosure at I (unsuccessful reclosure), the line is re-connected at I but no healthy voltage appears at II. The device there detects this and does not reclose.

In the case of multiple reclosure the process may be repeated at I several times until one of the reclosure attempts is successful or a final trip takes place.

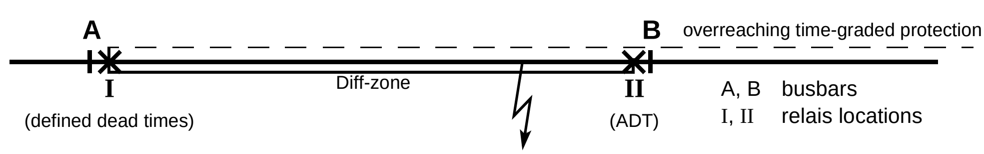


Figure 2-24 Example of adaptive dead time (ADT)

As the example shows, the adaptive dead time has the following advantages:

- The circuit breaker at position II is not reclosed at all if the fault persists and is not unnecessarily stressed as a result.
- With non-selective tripping on an external fault due to an overreaching time-graded protection at position I no further auto-reclosure attempts occur at position II because the fault current path via busbar B and position II remains interrupted even after several reclosure attempts at I.
- At position I overreaching is allowed in the case of multiple reclosures and even in the case of final tripping because the open breaker at position II forms the limit of any overreaching zone at I.

Close Command Transmission (Remote Close)

With close command transmission the dead times are only set at one line end. The other is set to “adaptive dead time”. The latter only reacts to the received close commands from the transmitting end.

The transmission of the close command at the transmitting line end is delayed until it is sure that the local reclosure was successful. This means a further possible local fault detection is checked after reclosure. This prevents unnecessary closing at the remote end on the one hand but also extends the time until reclosure takes place there. This is not critical for a single-pole auto-reclosure or in radial or meshed networks because no stability problems are to be expected.

In the 7SD610 relay the existing protection data interfaces are used to transmit the close command.

Control of the Internal Auto-Reclosure by an External Protection Device

If 7SD610 is equipped with the internal automatic reclosure function, this can also be controlled by an external protection device. This is useful for example for line ends with redundant protection or backup protection when the second protection is used for the same line end and is to work with the automatic reclosure function integrated in the 7SD610.

Specific binary inputs and outputs must be considered in this case. It must be decided whether the internal auto-reclosure is to be controlled by the starting (pickup) or by the trip command of the external protection (see also above under “Control Modes of the Automatic Reclosure“, page 85).

If the auto-reclosure is controlled by the trip command, the following inputs and outputs are recommended to be used:

The auto-reclosure is started via the binary inputs:

`02711 >AR Start` general fault detection (pickup) for the automatic reclosure (only required for action time),

`02712 >Trip L1 AR`trip command L1 for automatic reclosure,

`02713 >Trip L2 AR`trip command L2 for automatic reclosure,

`02714 >Trip L3 AR`trip command L3 for automatic reclosure.

The general fault detection is decisive for starting the action times. It is also necessary if the automatic reclosure is to detect evolving faults by fault detection. In other cases this input information is superfluous.

The trip commands decide whether the dead time for single-pole or three-pole auto-reclosure cycles is activated or whether the reclosure is blocked in three-pole tripping (depending on the parameterization of dead times).

Figure 2-25 shows the interconnection between the internal automatic reclosure of 7SD610 and an external protection device, as a connection example for single- and three-pole auto-reclosure.

To couple the external protection three-pole and to release its accelerated stages before reclosure if necessary, the following output functions are suitable:

`02864 AR 1p Trip Perm` internal automatic reclosure ready for 1-pole reclose cycle, i.e. allows 1-pole tripping (logic inversion of the 3-pole coupling).

`02889 AR 1.CycZoneRel` internal automatic reclosure ready for the first reclose cycle, i.e. enables the stage of the external protection decisive for reclosure, the corresponding outputs can be used for other cycles. The output can be omitted if the external protection does not require an overreach stage (e.g. differential protection).

`02820 AR Program1polei` internal automatic reclosure is programmed for single-pole AR, i.e. only reclosures after single-pole tripping. The output can be omitted if no overreach stage is used (e.g. differential protection).

Instead of the individual phase-dedicated trip commands, the single-pole and three-pole tripping can be signalled to the internal automatic reclosure — provided the external protection device supports it —, i.e. you can assign the following binary inputs of the 7SD610:

`02711 >AR Start` general fault detection for the internal automatic reclosure (only required for action time),

`02715 >Trip 1p for AR` trip command 1-pole for the internal automatic reclosure,

`02716 >Trip 3p for AR` trip command 3-pole for the internal automatic reclosure.

If *only* three-pole reclosure cycles are to be executed, it is sufficient to assign the binary input “`>Trip 3p for AR`” (FNo `02716`) for the trip signal. Figure 2-26 shows an example. Any overreaching stages of the external protection are enabled again by “`AR 1.CycZoneRel`” (FNo `02889`) and of further cycles if applicable.

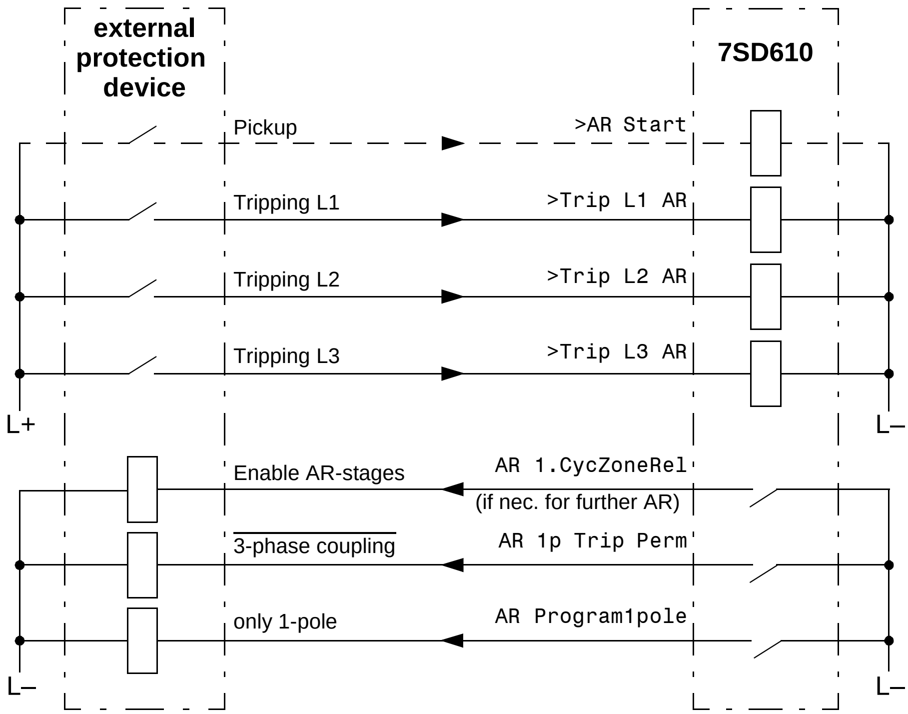


Figure 2-25 Connection example with external protection device for 1-/3-pole reclosure; AR control mode = ***Trip***

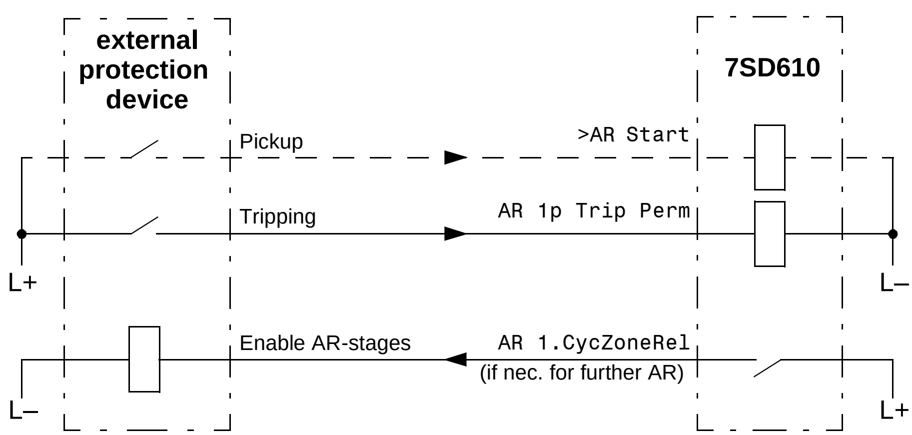
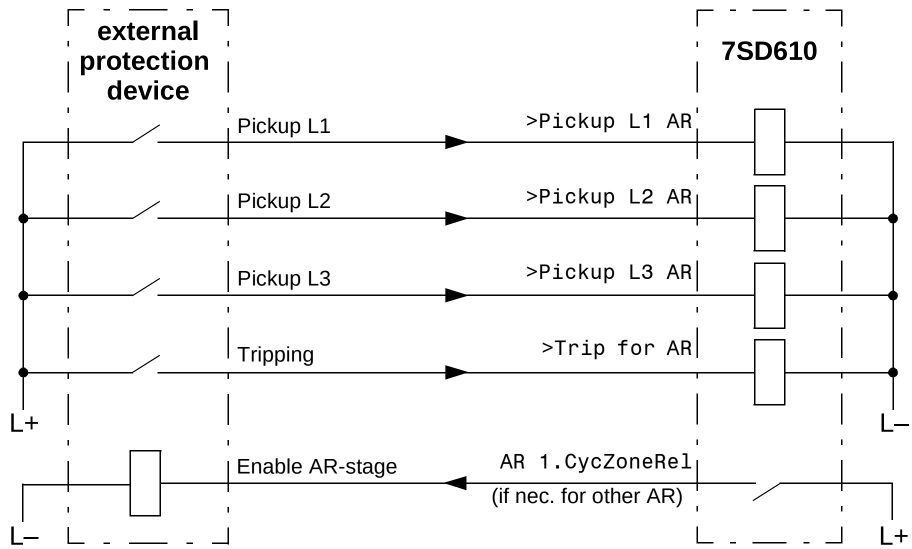
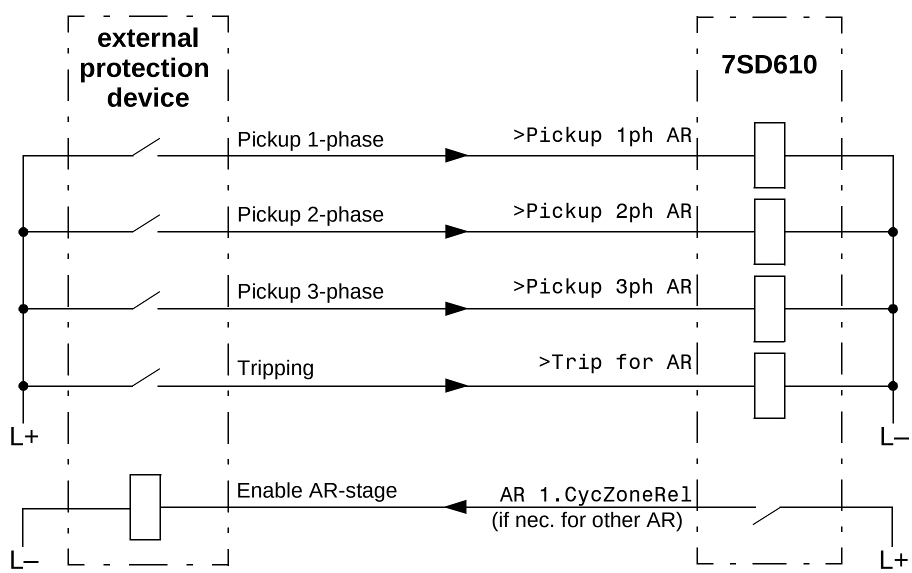


Figure 2-26 Connection example with external protection device for 3-pole reclosure; AR control mode = ***Trip***

If the internal automatic reclosure function is controlled by the pickup, the phase-dedicated *pickup* signals of the external protection must be connected if distinction shall be made between different types of fault. The general trip command is sufficient to indicate tripping (FNo 02746). Figure 2-27 shows connection examples.



Pickup signal for each phase



Pickup signal 1-phase, 2-phase and 3-phase

Figure 2-27 Connection example with external protection device for fault detection dependent dead time — dead time control by start signals of the protection device; AR control mode = ***Pickup***

2.9.2 Setting the Function Parameters

General

If no reclosure is required on the feeder for which the differential protection 7SD610 is used (e.g. for cables, transformers, motors or similar), the automatic reclosure function must be disabled during configuration (see Subsection 2.1.1, address 133). The automatic reclosure is then totally removed, i.e. the automatic reclosure is not processed in the 7SD610. No signals are generated, binary inputs for the automatic reclosure are ignored. All parameters for setting the automatic reclosure are inaccessible and insignificant.

If, on the other hand, the internal automatic reclosure is to be used, the type of reclosure must be set in the configuration of the device scope (see Subsection 2.1.1) under address 133 **Auto Reclose** and the **AR control mode** under address 134.

Up to 8 reclosure attempts are possible with the integrated automatic reclosure function of 7SD610. Whereas the settings in the addresses 3401 to 3441 are common to all reclosure cycles, the individual settings of the cycles are made from address 3450 onwards. You can set different individual parameters for the first four reclosure cycles. The same parameters of the fourth cycle apply to the fifth cycle and further.

Under address 3401 **AUTO RECLOSE** the automatic reclosure function can be switched ***ON*** or ***OFF***.

Prerequisite for an automatic reclosure being possible after trip on a fault is that the circuit breaker is ready for at least one TRIP-CLOSE-TRIP-cycle at the instant the auto-reclosure is started (i.e. at the initiation of the first trip command). The ready status of the circuit breaker is indicated to the device through the binary input ">CB1 Ready" (FNo 00371). If no such signal is available, leave the setting under address 3402 **CB? 1.TRIP** = ***NO*** because otherwise no auto-reclosure would be possible at all. If circuit breaker interrogation is possible, you should set **CB? 1.TRIP** = ***YES***.

Furthermore, the ready status of the circuit breaker can be interrogated before every reclosure. This is stated when setting the individual reclosure cycles (see below).

To check the ready status of the circuit breaker is regained during the dead times, you can set a circuit breaker ready monitor time under address 3409 **CB TIME OUT**. The time is set slightly longer than the recovery time of the circuit breaker after a TRIP-CLOSE-TRIP-cycle. If the circuit breaker has not been ready again within this time, there is no reclosure, the auto-reclosure is blocked dynamically.

Waiting for the circuit breaker charge mechanism can lead to a lengthening of the dead times. Interrogation of a synchronism check (if used) can also delay reclosure. To avoid uncontrolled prolongation you can set a maximum extension of the dead time in this case under address 3411A **T-DEAD EXT.**. This extension is unlimited if you set ∞. This parameter can only be altered with DIGSI® under "**Additional Settings**". Remember that longer dead times are only permissible after three-pole tripping when no stability problems occur or a synchronism check takes place before reclosure.

The reclaim time **T-RECLAIM** (address 3403) is the time after which the network fault is considered to be cleared after a successful reclosure. Re-tripping of a protective function within this time initiates the next reclosure cycle in the case of multiple reclosures; if no further reclosure is permitted, the last reclosure is treated as unsuccessful. The reclaim time must therefore be longer than the longest command time of a protective function which can start the automatic reclosure function.

A few seconds are generally sufficient. In regions with frequent thunderstorms or storms a shorter reclaim time is advisable to reduce the danger of final tripping as a result of repeated lightning strikes or conductor flashovers (conductor vibration).

A long reclaim time must be selected in the case of multiple reclosure (see above) if there is no circuit breaker monitoring possibility (e.g. due to missing auxiliary contacts and CB-ready-information). Then the reclaim time must be longer than the recovery time of the circuit breaker.

The blocking duration in manual-close detection **T-BLOCK MC** (address 3404) must guarantee safe closing and tripping of the circuit breaker (0.5 s to 1 s). If a fault has been detected by a protective function within this time after detected closing of the circuit breaker, a final three-pole trip is carried out and no reclosure will take place. If this is undesirable, address 3404 is set to ***0***.

The options for handling evolving faults are described in Subsection 2.9.1 under subtitle “Handling Evolving Faults”, page 89. The handling of evolving faults is not relevant on line ends where the adaptive dead time is applied (address 133 **Auto Reclose** = ***ADT***, Subsection 2.1.1). Addresses 3406 and 3407 are then insignificant and inaccessible.

You can define recognition of an evolving fault under address 3406. **EV. FLT. RECOG.** ***with PICKUP*** means that, during a dead time, every fault detection (*pickup*) of a protective 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 of a protective function. This may also include trip commands which are coupled in externally via a binary input or which have been transmitted from the other end of the protected object. If an external protection device operates together with the auto-reclosure, evolving fault detection with pickup presupposes that a pickup signal of 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.

Select the reaction to evolving faults under address 3407. **EV. FLT. MODE** ***Stops AutoRecl*** means that no reclosure takes place after detection of an evolving fault. This is always useful when only single-pole reclosure is to take place or when stability problems are to be expected due to closing after a subsequent three-pole dead time. If a three-pole reclose cycle is to be initiated by tripping of the evolving fault, set **EV. FLT. MODE** = ***starts 3p AR***. In this case a three-pole reclose cycle with separately adjustable dead time is started with the three-pole trip command on the evolving fault. This is only useful if three-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 after this time (from the beginning of the trip command), the automatic reclosure is locked dynamically. The criterion for opening is the position of the circuit breaker auxiliary contact(s) or the disappearance of the trip command. If a circuit breaker failure protection (internal or external) is used on the same 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.

If the reclosure command is transmitted to the other end, you can delay this transmission with address 3410 **T RemoteClose**. This transmission requires that the device at the remote end operates with adaptive dead time (address 133 **Auto Reclose** = ***ADT*** at the remote end, see also Subsection 2.1.1). This parameter is otherwise irrelevant. If no transmission of the close command is desired, although ***ADT*** is set at the other end, set **T RemoteClose** = ∞. On the one hand, this delay serves to prevent the remote end device from reclosing unnecessarily when the local reclosure is unsuccessful. The setting of **T RemoteClose** should therefore be a total of the closing time of the circuit breaker, the maximum response time and command duration of the protection function, the tripping time of the circuit breaker, the drop-off time of the protection function and a safety margin. On the other hand, it should be noted that the line is not available for energy transport until the remote end has also reclosed. It must therefore be added to the dead time in the consideration of the network stability.

Configuration of the Automatic Reclosure

This configuration concerns the interaction between the protective and supplementary functions of the device and the automatic reclosure function. Here you can determine which functions of the device are to start the automatic reclosure and which not.

In 7SD610 this concerns:
Address 3420 **AR WITH DIFF**, i.e. with differential protection,
Address 3421 **AR w/ SOTF-O/C**, i.e. with instantaneous high-speed overcurrent tripping,
Address 3423 **AR WITH I.TRIP**, i.e. with intertrip and remote trip,
Address 3424 **AR w/ DTT**, i.e. with externally coupled direct trip command,
Address 3425 **AR w/ BackUpO/C**, i.e. with time overcurrent protection.
For the functions which are to start the auto-reclosure function, the corresponding address is set to ***YES***, for the others to ***NO***. The remaining functions (overload protection, breaker failure protection) cannot start the auto-reclosure because reclosure is of no use here.

Forced Three-pole Trip

If reclosure is blocked during the dead time of a single-pole cycle without a three-pole trip command having been initiated, the breaker remains open at one pole. With address 3430 **AR TRIP 3pole** you determine that the tripping logic of the device sends a three-pole trip command in this case (pole discrepancy prevention). Set this address to ***YES*** if the breaker can be controlled single-pole and has no pole discrepancy supervision itself. Nevertheless, the device pre-empts the pole discrepancy supervision of the CB because the forced three-pole trip of the device is immediately initiated as soon as the reclosure is blocked following a single-pole trip or if the CB auxiliary contacts report an implausible breaker state.

The forced three-pole trip is unnecessary if only a common three-pole control of the circuit breaker is possible.

Dead Line Check (DLC)

Under 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 / RDT** = ***WITHOUT***.

DLC / RDT = ***DLC*** means that the dead line check is used. An automatic reclosure is only possible if it was determined that the line had been dead. In this case, the phase-earth voltage limit is set in address 3441 **U-dead<** below which the line is considered voltage-free (disconnected). The setting is made in secondary Volts. This value can be entered as a primary value when parameterizing with a PC and DIGSI®. Address 3438 **T U-stable** determines the minimum measuring time for determining the voltage-free condition.

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 may operate with adaptive dead time. You will find details about the procedure in Subsection 2.9.1 under subtitle “Adaptive Dead Time (ADT)” on page 91 and “Close Command Transmission (Remote Close)“, page 92.

For the line end with defined dead times the number of desired reclosure cycles must be set in the configuration of the protective functions (Subsection 2.1.1) under address 133 **Auto Reclose**. Additionally the intertrip command of the differential protection should be activated (see Subsection 2.4.2, address 1301 **I-TRIP SEND** = ***YES***). For the device operating with adaptive dead time, **Auto Reclose** = ***ADT*** must be set in the configuration of the protective functions (Subsection 2.1.1) under address 133. Only the parameters described below are interrogated in the latter case. Then no settings are made for the individual reclosure cycles.

The adaptive dead time may be voltage-controlled or Remote-CLOSE-controlled. Both is even possible at the same time. In the first case, reclosure after tripping takes place as soon as the voltage from the re-energized remote end is detected. This requires that the voltage transformers are installed on the line side of the feeder and connected to the device. With Remote-CLOSE-controlled adaptive dead time, the auto-reclosure function waits for the reception of the remote close command from the remote end.

The action time **T-ACTION ADT** (address 3433) is the time after pickup of any protective function which can start the automatic reclosure within which the trip command must appear. If the trip command has not appeared before expiry of the action time, there is no reclosure. Depending on the configuration of the functional scope (see Subsection 2.1.1) the action time may also be omitted; this applies especially when a starting protective function does not provide a pickup indication.

The dead times are controlled by the reclosure command of the device at the line end with defined dead times. In cases where this reclosure command is missing, e.g. because reclosure has been blocked there during the dead time, the auto-reclosure function of the device with adaptive dead time must return to the quiescent state after some time. This takes place after the maximum wait time **T-MAX ADT** (address 3434). This must be long enough to include the last possible reclosure of the initiating end. In the case of single-shot reclosure, the total sum of maximum dead time plus reclaim time of the device of the initiating end is sufficient. In the case of multiple reclosure the worst case is that all reclosures of the initiating 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, you may use the total sum of all dead times and all command times of the trippings plus a reclaim time.

Under address 3435 **ADT 1p allowed** you determine whether single-pole tripping is to be allowed (on condition that single-pole tripping is possible at all). If ***NO***, the protection trips three-pole for all fault types. If ***YES*** the possible tripping situations of the starting protective functions are decisive.

Under address 3436 **ADT CB? CLOSE** you determine whether circuit breaker ready is to be interrogated before reclosure after adaptive dead time. If you set ***YES*** the dead time may be extended if at the end of this time the circuit breaker is not ready for a CLOSE-TRIP-cycle. The dead time is extended by the circuit breaker monitoring time at the most; this was set for all reclosure cycles under address 3409 (see above). You will find details about the circuit breaker monitoring in the function description, Subsection 2.9.1, under subtitle “Interrogation of Circuit Breaker Ready“, page 86.

If there is a danger of stability problems in the network during a three-pole reclosure cycle, you should set address 3437 **ADT SynRequest** to ***YES***. In this case a check is made before reclosure following a three-pole trip whether the voltages of the feeder and busbar are sufficiently synchronous. This requires that an external synchro-check device is available for this. If only single-pole reclosure cycles are executed or no stability problems are to be expected during three-pole dead times (e.g. due to a high degree of interconnection within the network 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. Set under address 3440 **U-live>** the limit for the phase-earth voltage above which the line is to be considered fault-free. The setting must be lower than the smallest operating voltage to be expected. The setting is made in secondary Volts. 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 voltage. It should be longer than any transient voltage oscillations resulting from line energization.

1st Reclosure Cycle

If working on a line with adaptive dead time, no other parameters are needed for the individual reclosure cycles here. All following parameters assigned to the individual cycles are then superfluous and inaccessible.

Address 3450 **1.AR: START** is only available, if the automatic reclosure is configured with action time, i.e. if the address 134 **AR control mode** = ***Pickup w/ Tact*** or ***Trip w/ Tact*** (the first only for three-pole tripping) was set during the configuration of the protective functions (refer to Subsection 2.1.1). It determines whether an automatic reclosure start is to take place at all with the first cycle. This address is included mainly for the sake of uniformity of the parameters for every reclosure attempt and is set to ***YES*** for the first cycle. If several cycles are to be executed you can control the effect of the individual cycles with this parameter together with different action times. Notes and examples can be found in Subsection 2.9.1 under subtitle “Action Times” (page 84).

The action time **1.AR: T-ACTION** (address 3451) is the time after pickup of any protective function which can start the automatic reclosure within which the trip command must appear. If the trip command has not appeared before expiry of the action time, there is no reclosure. Depending on the configuration of the functional scope (see Subsection 2.1.1) the action time may also be omitted; this applies especially when a starting protective function does not provide a pickup indication.

Depending on the configured control mode of the automatic reclosure (see Subsection 2.1.1 under address 134 **AR control mode**) only addresses 3456 and 3457 (if control mode ***Trip***...) or the addresses 3453 to 3455 (if control mode ***Pickup***...) are available.

In the control mode ***Trip***... you can set different dead times for single-pole and three-pole reclose cycles. Whether single-pole or three-pole tripping takes place depends solely on the protective functions which start the auto-reclosure function. Single-pole tripping is only possible of course if the device and the corresponding protective function are also capable of single-pole tripping.

Address 3456 **1.AR Tdead1Trip** is the dead time after 1-pole tripping,
Address 3457 **1.AR Tdead3Trip** is the dead time after 3-pole tripping.

If you only want to allow a single-pole reclosure cycle, set the dead time for three-pole tripping to ∞. If you only want to allow a three-pole reclosure cycle, set the dead time for single-pole tripping to ∞; the protection then trips three-pole for every fault type.

The dead time after single-pole tripping (if set) **1.AR Tdead1Trip** (address 3456) should be long enough to allow for the fault arc to be extinguished and the surrounding air be de-ionized so that the reclosure is likely to be successful. The longer the line, the longer is this time due to the charging of the conductor capacitances. The typical values are 0.9 s to 1.5 s.

For three-pole tripping (address 3457 **1.AR Tdead3Trip**) the stability of the network is the main concern. Since the disconnected line cannot transfer any synchronizing forces, only a short dead time is often permitted. 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 networks with a high degree of interconnection or in radial networks.

In the control mode ***Pickup***... you can make the dead times dependent on the type of fault detected by pickup of the starting protective function(s):

Address 3453 **1.AR Tdead 1Flt** is the dead time after 1-phase pickup,
Address 3454 **1.AR Tdead 2Flt** is the dead time after 2-phase pickup,
Address 3455 **1.AR Tdead 3Flt** is the dead time after 3-phase pickup.

If the dead time is to be the same for all types of faults, set all three parameters to the same value. Note that these settings only cause different dead times for different *pickups*. The *tripping* can only be three-pole.

If you have set ***starts 3p AR*** when setting the reaction to evolving faults (see above under "General", page 97) address 3407 **EV. FLT. MODE**, you can set a separate value **1.AR: Tdead EV.** (address 3458) for the three-pole dead time after clearance of the evolving fault. Stability aspects are also decisive here. Normally it can be set equal to address 3457 **1.AR Tdead3Trip**.

Under address 3459 **1.AR: CB? CLOSE** you determine whether circuit breaker ready is to be interrogated before this first reclosure. If you set ***YES*** the dead time may be extended if at the end of this time the circuit breaker is not ready for a CLOSE-TRIP-cycle. The dead time is extended by the circuit breaker monitoring time at the most; this was set for all reclosure cycles under address 3409 (see above). You will find details about the circuit breaker monitoring in the function description, Subsection 2.9.1, under subtitle "Interrogation of Circuit Breaker Ready", page 86.

If there is a danger of stability problems in the network during a three-pole reclosure cycle, you should set address 3460 **1.AR SynRequest** to ***YES***. In this case a check is made before reclosure following a three-pole trip whether the voltages of the feeder and busbar are sufficiently synchronous. This requires that an external synchro-check device is available for this. If only single-pole reclosure cycles are executed or no stability problems are to be expected during three-pole dead times (e.g. due to close meshing of the network or in radial networks), set address 3460 to ***NO***.

2nd to 4th Reclosure Cycle

If several cycles have been set in the configuration of the function scope (Subsection 2.1.1), you can set individual reclosure parameters for the 2nd to 4th cycles. The possibilities are the same as for the 1st cycle. Only some of the following parameters may be available here depending on the configuration of the protective function (Subsection 2.1.1).

For the 2nd cycle:
Address 3461 **2.AR: START**; start in 2nd cycle allowed at all
Address 3462 **2.AR: T-ACTION**; active time for the 2nd cycle
Address 3464 **2.AR Tdead 1Flt**; dead time after 1-phase starting
Address 3465 **2.AR Tdead 2Flt**; dead time after 2-phase starting
Address 3466 **2.AR Tdead 3Flt**; dead time after 3-phase starting
Address 3467 **2.AR Tdead1Trip**; dead time after 1-pole tripping
Address 3468 **2.AR Tdead3Trip**; dead time after 3-pole tripping
Address 3469 **2.AR: Tdead EV.**; dead time in case of sequential fault

Address 3470 **2.AR: CB? CLOSE**; check CB ready before reclosure
Address 3471 **2.AR SynRequest**; synchronism check after 3-pole tripping

For the 3rd cycle:
Address 3472 **3.AR: START**; start in 3rd cycle allowed at all
Address 3473 **3.AR: T-ACTION**; active time for the 3rd cycle
Address 3475 **3.AR Tdead 1Flt**; dead time after 1-phase starting
Address 3476 **3.AR Tdead 2Flt**; dead time after 2-phase starting
Address 3477 **3.AR Tdead 3Flt**; dead time after 3-phase starting
Address 3478 **3.AR Tdead1Trip**; dead time after 1-pole tripping
Address 3479 **3.AR Tdead3Trip**; dead time after 3-pole tripping
Address 3480 **3.AR: Tdead EV.**; dead time in case of sequential fault
Address 3481 **3.AR: CB? CLOSE**; check CB ready before reclosure
Address 3482 **3.AR SynRequest**; synchronism check after 3-pole tripping

For the 4th cycle:
Address 3483 **4.AR: START**; start in the 4th cycle allowed at all
Address 3484 **4.AR: T-ACTION**; active time for the 4th cycle
Address 3486 **4.AR Tdead 1Flt**; dead time after 1-phase starting
Address 3487 **4.AR Tdead 2Flt**; dead time after 2-phase starting
Address 3488 **4.AR Tdead 3Flt**; dead time after 3-phase starting
Address 3489 **4.AR Tdead1Trip**; dead time after 1-pole tripping
Address 3490 **4.AR Tdead3Trip**; dead time after 3-pole tripping
Address 3491 **4.AR: Tdead EV.**; dead time in case of sequential fault
Address 3492 **4.AR: CB? CLOSE**; check CB ready before reclosure
Address 3493 **4.AR SynRequest**; synchronism check after 3-pole tripping

5th to 8th Reclosure Cycles

If more than 4 cycles have been set in the configuration of the function scope (Subsection 2.1.1), the cycles following the fourth cycle operate with the same settings as the fourth cycle.

2.9.3 Setting Overview

Note: Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Addr.	Setting Title	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
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

Addr.	Setting Title	Setting Options	Default Setting	Comments
3407	EV. FLT. MODE	Stops Auto Reclose starts 3pole AR-cycle	starts 3pole AR-cycle	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
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
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

Addr.	Setting Title	Setting Options	Default Setting	Comments
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
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 over-current
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 Dead Line Check (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

Addr.	Setting Title	Setting Options	Default Setting	Comments
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

2.9.4 Information Overview

The following paragraphs explain some important device information signals in brief insofar as they are not explained in the following lists or covered in detail in the preceding subsections.

“`>BLK 1.AR-cycle`” (FNo 02742) to “`>BLK 4.-n. AR`” (FNo 02745)
The respective auto-reclose cycle is blocked. If the blocking signal is already active when the auto-reclosure is started, the concerned cycle is not executed and may be skipped (if further cycles are allowed). The same applies accordingly if auto-reclosure was already started ignoring a possibly blocked cycle. If a cycle is blocked during its execution, automatic reclosure is locked out dynamically; there are then no further automatic reclosures.

“`AR 1.CycZoneRel`” (FNo 02889) to “`AR 4.CycZoneRel`” (FNo 02892)
The automatic reclosure is ready for the respective reclosure cycle. The information indicates which cycle will be executed next. For example, external protective functions can be set to enable accelerated or overreaching stages before the respective reclosure.

“`AR is blocked`” (FNo 02783)
The automatic reclosure is blocked (e.g. circuit breaker not ready). The information indicates to the system management that any trip will be a final tripping, i.e. without reclosure for an impending system fault. If the automatic reclosure has been started, this information does not appear.

“`AR is NOT ready`” (FNo 02784)
The automatic reclosure is not ready for reclosure at the moment. In addition to the “`AR is blocked`” (FNo 02783) mentioned above there are also obstructions during the course of the auto-reclosure cycles such as “action time run out” or “last reclaim time running”. The information is particularly helpful during relay testing because no reclosure can be initiated while this indication is active.

“`AR in progress`” (FNo 02801)
This information appears with starting of the automatic reclosure, i.e. with the first trip command which is to start the automatic reclosure. If the reclosure attempt was successful (or all in the case of several), this information disappears at the end of the last

reclaim time. If no reclosure attempt was successful or reclosure was blocked, it resets with the last — the final — trip command.

“`AR Sync.Request`” (FNo `02865`)
Measuring request to an external synchronism check device. The information appears at the end of a dead time subsequent to three-pole tripping if a synchronism request was parameterized for the corresponding cycle. Reclosure only takes place when the synchronism check device has provided release signal “`>Sync.release`” (FNo `02731`).

“`>Sync.release`” (FNo `02731`)
Release of reclosure by an external synchronism check device if this was requested by the output information “`AR Sync.Request`” (FNo `02865`).

F.No.	Alarm	Comments
00127	AR ON/OFF	Auto Reclose ON/OFF (via system port)
02701	>AR ON	>Auto reclose ON
02702	>AR OFF	>Auto reclose OFF
02703	>BLOCK AR	>BLOCK Auto reclose
02711	>AR Start	>External start of internal Auto reclose
02712	>Trip L1 AR	>AR: Ext. Trip L1 for internal AR
02713	>Trip L2 AR	>AR: Ext. Trip L2 for internal AR
02714	>Trip L3 AR	>AR: Ext. Trip L3 for internal AR
02715	>Trip 1p for AR	>Ext. 1pole Trip for internal Auto Recl.
02716	>Trip 3p for AR	>Ext. 3pole Trip for internal Auto Recl.
02727	>AR RemoteClose	>AR: Remote Close signal
02731	>Sync.release	>AR: Synchronism from ext. sync.-check
02737	>BLOCK 1pole AR	>AR: Block 1pole AR-cycle
02738	>BLOCK 3pole AR	>AR: Block 3pole AR-cycle
02739	>BLK 1phase AR	>AR: Block 1phase-fault AR-cycle
02740	>BLK 2phase AR	>AR: Block 2phase-fault AR-cycle
02741	>BLK 3phase AR	>AR: Block 3phase-fault AR-cycle
02742	>BLK 1.AR-cycle	>AR: Block 1st AR-cycle
02743	>BLK 2.AR-cycle	>AR: Block 2nd AR-cycle
02744	>BLK 3.AR-cycle	>AR: Block 3rd AR-cycle
02745	>BLK 4.-n. AR	>AR: Block 4th and higher AR-cycles
02746	>Trip for AR	>AR: External Trip for AR start
02747	>Pickup L1 AR	>AR: External pickup L1 for AR start
02748	>Pickup L2 AR	>AR: External pickup L2 for AR start
02749	>Pickup L3 AR	>AR: External pickup L3 for AR start

F.No.	Alarm	Comments
02750	>Pickup 1ph AR	>AR: External pickup 1phase for AR start
02751	>Pickup 2ph AR	>AR: External pickup 2phase for AR start
02752	>Pickup 3ph AR	>AR: External pickup 3phase for AR start
02781	Auto recl. OFF	Auto recloser is switched OFF
02782	Auto recl. ON	Auto recloser is switched ON
02783	AR is blocked	AR: Auto-reclose is blocked
02784	AR is NOT ready	Auto recloser is NOT ready
02787	CB not ready	AR: Circuit breaker not ready
02788	AR T-CBreadyExp	AR: CB ready monitoring window expired
02801	AR in progress	Auto-reclose in progress
02809	AR T-Start Exp	AR: Start-signal monitoring time expired
02810	AR TdeadMax Exp	AR: Maximum dead time expired
02818	AR evolving Flt	AR: Evolving fault recognition
02820	AR Program1pole	AR is set to operate after 1p trip only
02821	AR Td. evol.Flt	AR dead time after evolving fault
02839	AR Tdead 1pTrip	AR dead time after 1pole trip running
02840	AR Tdead 3pTrip	AR dead time after 3pole trip running
02841	AR Tdead 1pFlt	AR dead time after 1phase fault running
02842	AR Tdead 2pFlt	AR dead time after 2phase fault running
02843	AR Tdead 3pFlt	AR dead time after 3phase fault running
02844	AR 1stCyc. run.	AR 1st cycle running
02846	AR 3rdCyc. run.	AR 3rd cycle running
02845	AR 2ndCyc. run.	AR 2nd cycle running
02847	AR 4thCyc. run.	AR 4th or higher cycle running
02848	AR ADT run.	AR cycle is running in ADT mode
02851	AR Close	Auto-reclose Close command
02852	AR Close1.Cyc1p	AR: Close command after 1pole 1st cycle
02853	AR Close1.Cyc3p	AR: Close command after 3pole 1st cycle
02854	AR Close 2.Cyc	AR: Close command after 2nd cycle
02861	AR T-Recl. run.	AR: Reclaim time is running
02862	AR Successful	Auto reclose cycle successful
02863	AR Lockout	Auto reclose Lockout
02864	AR 1p Trip Perm	AR: 1pole trip permitted by internal AR
02865	AR Sync.Request	AR: Synchro-check request

F.No.	Alarm	Comments
02871	AR TRIP 3pole	AR: TRIP command 3pole
02889	AR 1.CycZoneRel	AR 1st cycle zone extension release
02890	AR 2.CycZoneRel	AR 2nd cycle zone extension release
02891	AR 3.CycZoneRel	AR 3rd cycle zone extension release
02892	AR 4.CycZoneRel	AR 4th cycle zone extension release
02893	AR Zone Release	AR zone extension (general)
02894	AR Remote Close	AR Remote close signal send
02796	AR on/off BI	AR: Auto-reclose ON/OFF via BI

2.10 Circuit Breaker Failure Protection (optional)

2.10.1 Method of Operation

General

The circuit breaker failure protection provides rapid backup fault clearance, in the event that the circuit breaker fails to respond to a trip command from a feeder protection.

Whenever e.g. a short-circuit protection relay of a feeder issues a trip command to the circuit breaker, this is repeated to the breaker failure protection (Figure 2-28). A timer T–BF in the breaker failure protection is started. The timer runs as long as a trip command is present and current continues to flow through the breaker poles.

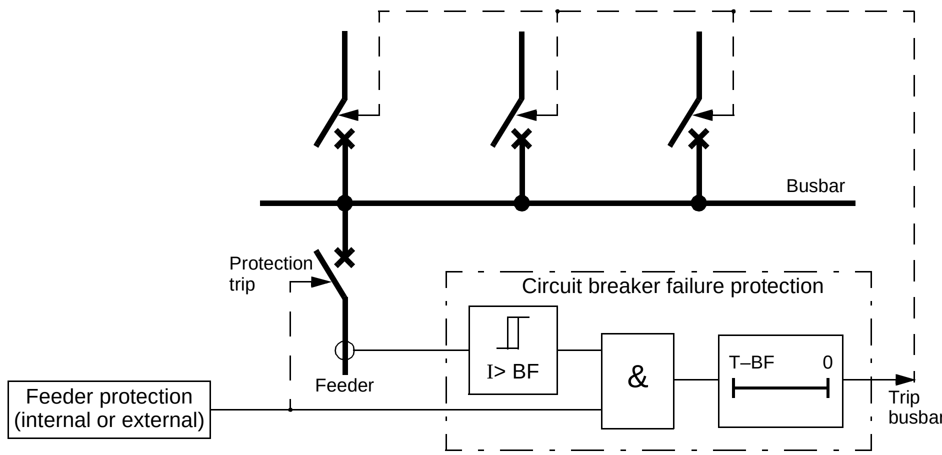


Figure 2-28 Simplified function diagram of circuit breaker failure protection with current flow monitoring

Normally, the breaker will open and interrupt the fault current. The current monitoring stage I> BF quickly resets (typical $^1/_2$ AC cycle) and stops the timer T–BF.

If the trip command is not executed (breaker failure case), current continues to flow and the timer runs to its set limit. The breaker failure protection then issues a command to trip the backup breakers which interrupt the fault current.

The reset time of the feeder protection is not relevant because the breaker failure protection itself detects the interruption of the current.

For protection functions where the tripping criteria is not dependent on current (e.g. Buchholz protection), current flow is not a reliable criterion to determine the correct response of the breaker. In such cases, the circuit breaker position can be derived from the auxiliary contacts of the breaker. Therefore, instead of monitoring the current, the condition of the auxiliary contacts is monitored (see Figure 2-29). For this purpose, the outputs from the auxiliary contacts must be connected to binary inputs on the relay (refer also to Subsection 2.13.2).

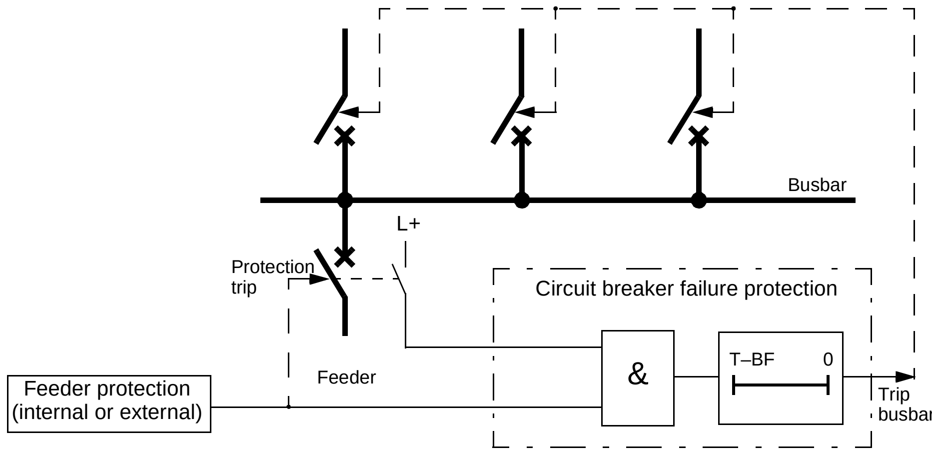


Figure 2-29 Simplified function diagram of circuit breaker failure protection controlled by the circuit breaker auxiliary contact(s)

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 frequency is used for further evaluation.

Special features detect the instant of current interruption. With sinusoidal currents, current interruption is detected after approx. $^1/_2$ AC 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 one AC cycle before the interruption of the primary current is reliably detected.

The currents are monitored and compared with the set threshold. In addition to the three phase currents, two further current detectors are provided in order to allow a plausibility check (see Figure 2-30):

As plausibility current, the earth current (residual current $I_E = 3 \cdot I_0$) is preferably used. If the residual current from the starpoint of the current transformer set is connected to the device this is used for $3 \cdot I_0$. If the residual current is not available the device calculates it according to the formula:

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

Additionally, the value of three times the negative sequence current $3 \cdot I_2$ is used for plausibility check. This is calculated by the 7SD610 according to the formula:

$$3 \cdot \underline{I}_2 = \underline{I}_{L1} + \underline{a}^2 \cdot \underline{I}_{L2} + \underline{a} \cdot \underline{I}_{L3}$$

where

$$\underline{a} = e^{j120°}.$$

These plausibility currents do not have any direct influence on the basic functionality of the breaker failure protection but they allow a plausibility check in that at least two current thresholds must have been exceeded before any of the breaker failure delay times can be started, thus providing high security against false operation.

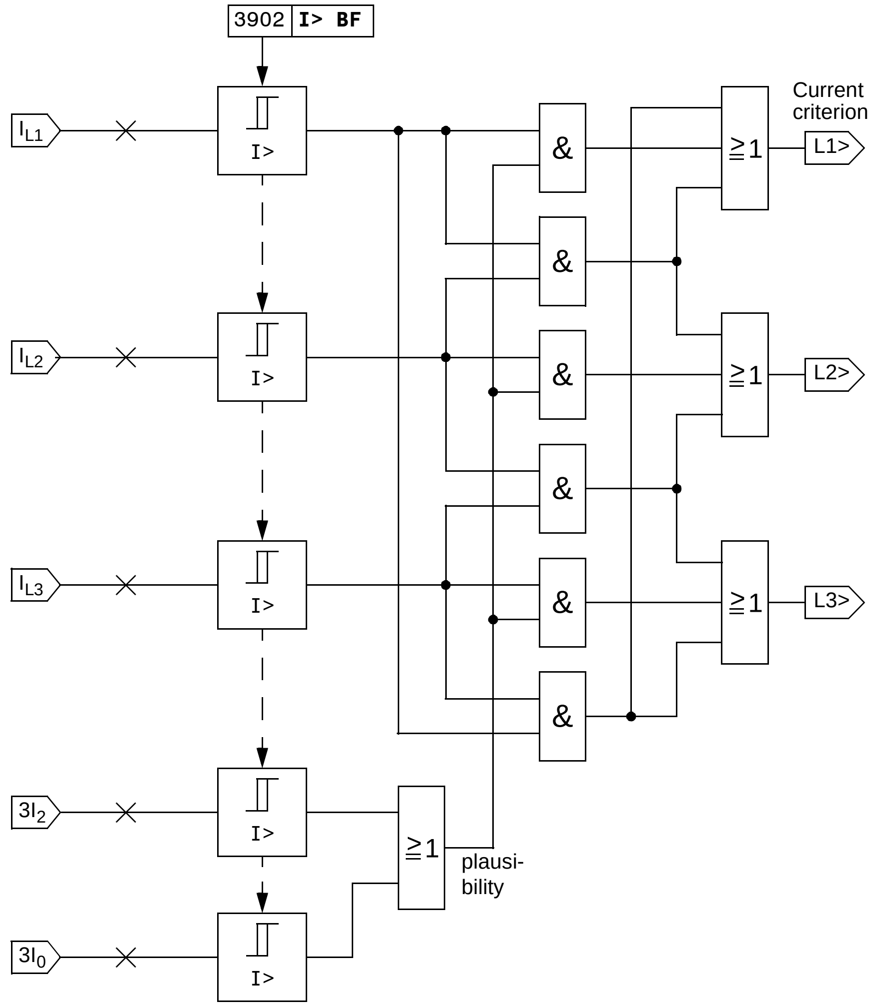


Figure 2-30 Current flow monitoring with the plausibility currents $3 \cdot I_0$ and $3 \cdot I_2$

Processing of the Circuit Breaker Auxiliary Contacts

The position of the circuit breaker is derived from the central function control of the device (refer also to Subsection 2.13.2). Evaluation of the breaker auxiliary contacts is carried out in the 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 2-31). This gives preference to the more reliable current criterion and avoids false operation 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 three-pole trip.

It is possible to disable the auxiliary contact criterion. If you set the parameter switch **Chk BRK CONTACT** (Figure 2-33 top) to ***NO***, the 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.

On the other hand, current flow is not a reliable criterion for proper operation of the circuit breaker for faults which do not necessarily 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” (FNo 01439) is provided (Figure 2-33 left). This input initiates the breaker failure protection even if no current flow is detected.

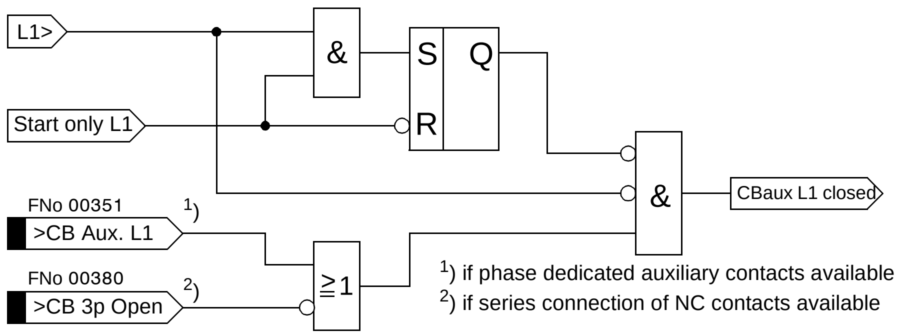


Figure 2-31 Interlock of the auxiliary contact criterion — example for phase L1

Common Phase Initiation

Common phase initiation is used, for example, for lines without automatic reclosure, for lines with only three-pole automatic reclosure, for transformer feeders, or if the busbar protection trips. This is the only available initiation mode if the applied 7SD610 model is able to trip three-pole only.

If the breaker failure protection is intended to be initiated by further external protection devices, it is recommended, for security reasons, to connect two starting criteria to the 7SD610 device: the trip command to the input “>BF Start 3pole” (FNo 01415) and an additional release signal (e.g. fault detection, pickup) to the input “>BF release” (FNo 01432). For Buchholz protection it is recommended that the trip command is connected to the 7SD610 by two separate wire pairs in order to achieve dual-channel initiation of the breaker failure protection.

Nevertheless, it is possible to initiate the breaker failure protection in single-channel mode should a separate release criterion not be available. The binary input “>BF release” (FNo 01432) must then not be assigned to any physical input of the device during configuration.

The scheme functionality is shown in Figure 2-33. When the trip signal is given from any internal or external feeder protection and at least one current flow criterion (according to Figure 2-30) is present, the 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(s) is interrogated provided that this is available. If the circuit breaker poles have individual auxiliary contacts, the series connection of the three normally closed (NC) auxiliary contacts is used (all 3 NC contacts are closed when all 3 breaker poles are open). The circuit breaker has operated correctly after a three-pole trip command only if none of the phases carries current and when all three NC auxiliary contacts have closed.

Figure 2-32 shows the formation of the signal “CB closed >1-p” (cf. Figure 2-33 left), when at least one CB pole is closed, i.e. not all three poles open.

If an internal protection function or an external protection device trips without current flow, the internal input “Start internal w/o I” or the external input “`>BF Start w/o I`” (FNo `01439`) is used to initiate the breaker failure protection. In these cases the breaker auxiliary contact position is the only criterion for the response of the circuit breaker.

Initiation can be blocked via the binary input “`>BLOCK BkrFail`” (FNo `01403`) (e.g. during testing of the feeder protection relay). Additionally, an internal blocking option is provided.

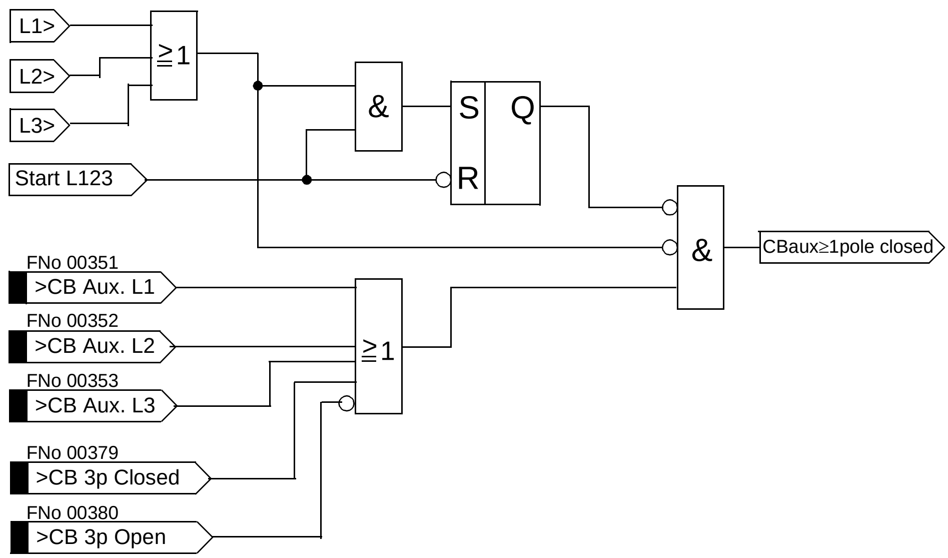


Figure 2-32 Formation of the signal “CBaux≥1pole closed”

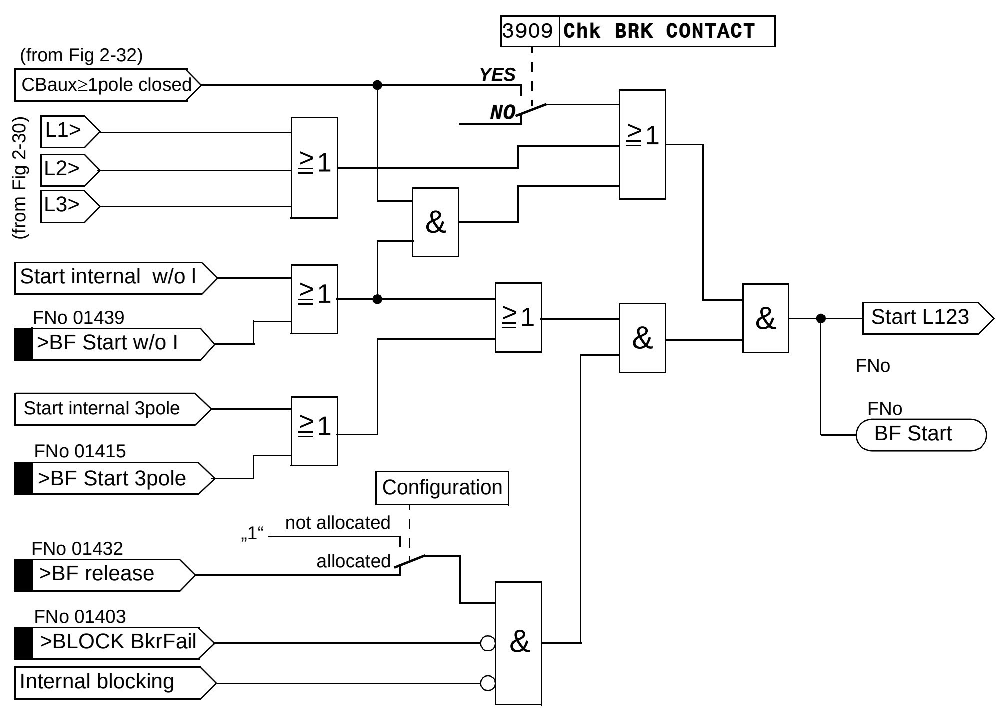


Figure 2-33 Breaker failure protection with common phase initiation

Phase Segregated Initiation

Phase segregated initiation of the breaker failure protection is necessary if the circuit breaker poles can be operated individually, e.g. if single-pole automatic reclosure is used. This is possible if the device is able to trip single-pole.

If the breaker failure protection is intended to be initiated by further external protection devices, it is recommended, for security reasons, to connect an additional release signal (e.g. fault detection, pickup) at the input “>BF release” (FNo 01432), in addition to the trip commands at the inputs “>BF Start L1” (FNo 01435), “>BF Start L2” (FNo 01436), and “>BF Start L3” (FNo 01437). Figure 2-34 shows the connections of this dual-channel initiation.

Nevertheless, it is possible to initiate the breaker failure protection in single-channel mode should a separate release criterion not be available. The binary input “>BF release” (FNo 01432) must then not be assigned to any physical input of the device during configuration.

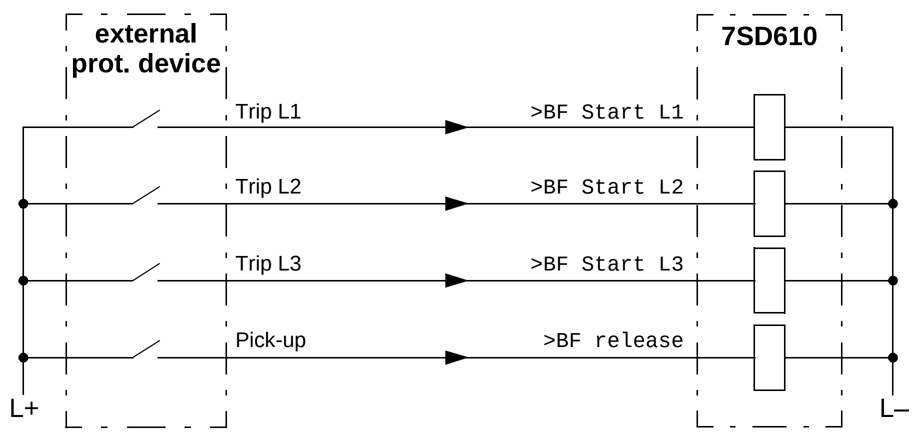


Figure 2-34 Breaker failure protection with phase segregated initiation — example for initiation by an external protection device with release by a fault detection signal

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 2-35.

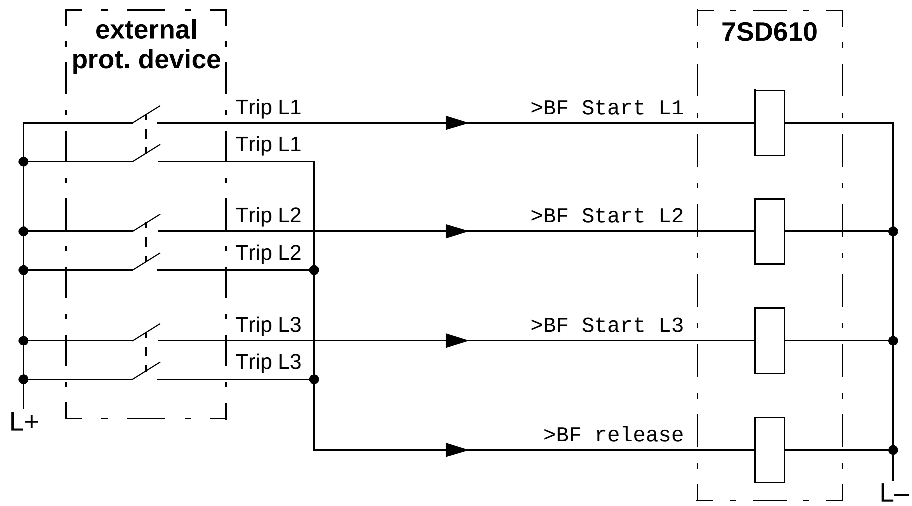


Figure 2-35 Breaker failure protection with phase segregated initiation — example for initiation by an external protection device with release by a separate set of trip contacts

The starting condition logic for the delay times is shown in Figure 2-36. In principle, it is designed similar to that for the common phase initiation, but, individually for each of the three phases. Thus, current flow and initiation conditions are processed for each individual phase. In case of single-pole trip before an automatic reclose cycle, current interruption is reliably monitored for the tripped breaker pole only.

Initiation of a single-phase, e.g. “Start L1 only” is active when the starting input (= trip command of any feeder protection) appears for only this phase and current flow is detected in at least this phase. If current flow is not detected, the auxiliary contact position can be interrogated according to Figure 2-31, dependent on the setting (**Chk BRK CONTACT** = ***YES***).

The auxiliary contact criterion is also processed for each individual breaker pole. If however the breaker auxiliary contacts are not available for each individual breaker pole, then a single-pole trip command is assumed to be correctly executed only when the series connection of the normally open (NO) auxiliary contacts is interrupted. This information is given to the breaker failure protection by the central function control of the device (refer to Subsection 2.13.2).

The three-phase starting signal “Start L123” is generated if trip signals appear in more than one pole (regardless from which protection function). Phase segregated initiation is then blocked. The input “>BF Start w/o I” (FNo 01439) (e.g. from Buchholz protection) operates in three-phase mode as well. The function is the same as with common phase initiation.

The additional release-signal “>BF release” (FNo 01432) (if assigned to a binary input) affects all starting conditions. Initiation can be blocked via the binary input “>BLOCK BkrFail” (FNo 01403) (e.g. during test of the feeder protection relay). Additionally, an internal blocking option is provided.

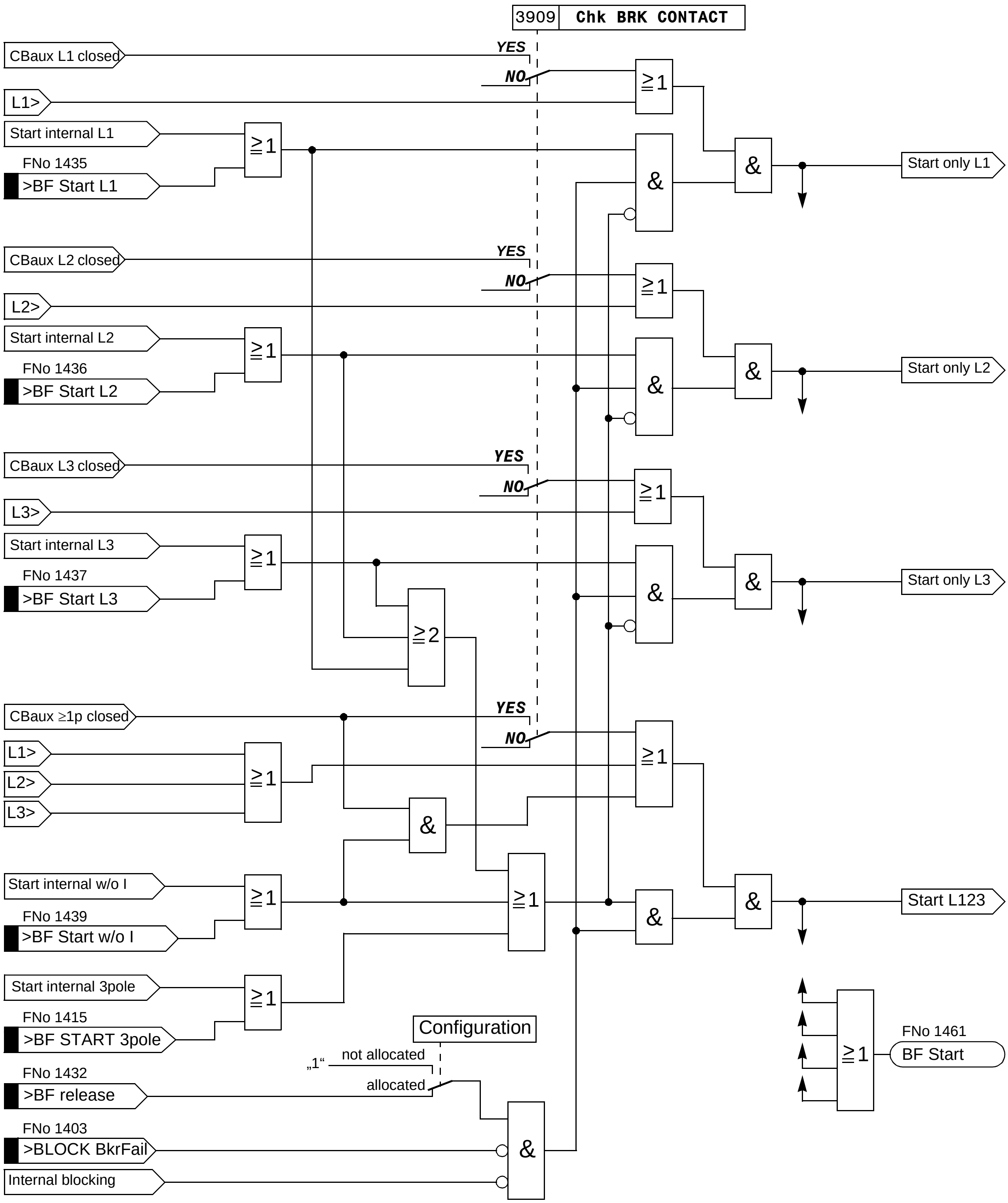


Figure 2-36 Initiation conditions with phase segregated initiation

Delay Timers

When the starting conditions are fulfilled, the associated timers of the breaker failure protection are started. The circuit breaker pole(s) must open before the respective time has elapsed.

Different delay timers are provided for operation after common phase initiation and phase segregated initiation. A further time stage can be used for two-stage breaker failure protection.

With single-stage breaker failure protection, the trip command is routed to the adjacent circuit breakers should the local feeder breaker fail (refer to Figure 2-28 or 2-29). The adjacent circuit breakers are all those which must trip in order to interrupt the fault current, i.e. the breakers which feed the busbar or the busbar section to which the feeder under consideration is connected. The possible initiation conditions for the breaker failure protection are those discussed above. Depending on the application of the feeder protection, common phase or phase segregated initiation conditions may occur. Tripping by the breaker failure protection is always three-pole.

The simplest solution is to start the delay timer **T2** (Figure 2-37). The phase-segregated initiation signals are ignored if the feeder protection always trips three-pole or if the circuit breaker is not capable of single-pole tripping.

If different delay times are required after a single-pole trip or three-pole trip it is possible to use the timer stages **T1-1pole** and **T1-3pole** according to Figure 2-38.

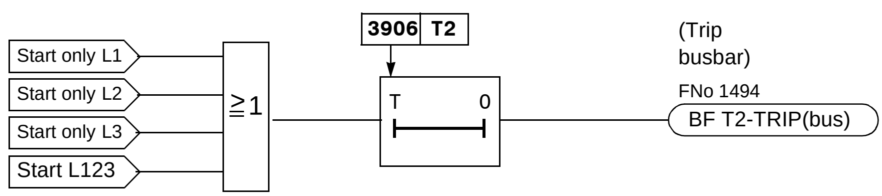


Figure 2-37 Single-stage breaker failure protection with common phase initiation

With two-stage 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. That is if the breaker has not responded to the original trip command. A second time stage monitors the response to this repeated trip command and is used to trip the breakers of the relevant busbar section, if the fault has not yet been cleared after the second trip command.

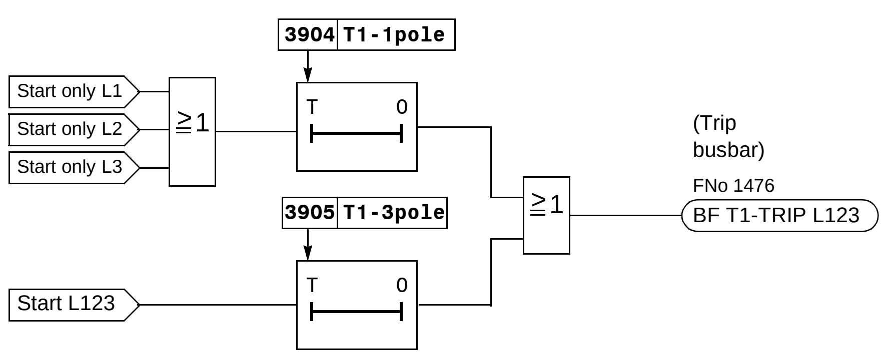


Figure 2-38 Single-stage breaker failure protection with different delay timers

For the first time stage, different time delays can be selected for a single-pole trip and three-pole trip by the feeder protection. Additionally, you can select (parameter **`1p-RETRIP (T1)`**) whether this repeated trip should be single-pole or three-pole.

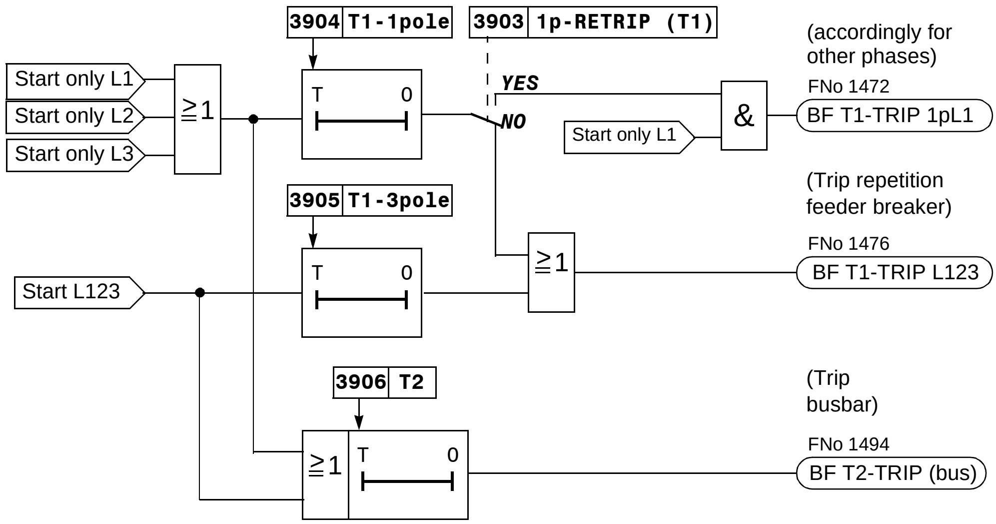


Figure 2-39 Two-stage breaker failure protection with phase segregated initiation — one phase

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 correct 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`” (FNo `00378`) of the 7SD610. On occurrence of this alarm and a trip command by the feeder protection, a separate timer **`T3-BkrDefective`**, which is normally set to 0, is started (Figure 2-40). In this case, the adjacent circuit breakers (busbar) are tripped immediately.

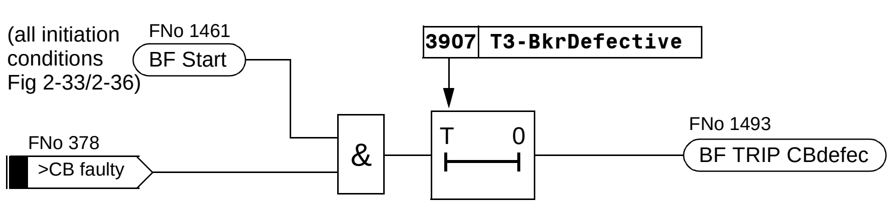


Figure 2-40 Circuit breaker not operational

Transfer Trip to the Remote End Circuit Breaker

The 7SD610 has the facility to provide an additional intertrip signal to the circuit breaker at the remote line end in the event that the local feeder circuit breaker fails. For this, the transmission of the trip command is used.

To perform this intertrip, the desired 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`" (FNo `03504`). Refer also to Section 2.3. 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.

This situation is shown in Figure 2-41. The fault is located — as seen from the current transformers (= measurement location) — on the busbar side, thus, it will not be regarded by the feeder protection relay as a feeder fault. It can only be detected by a bus-bar protection. Nevertheless, a trip command given to the feeder circuit breaker cannot 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.

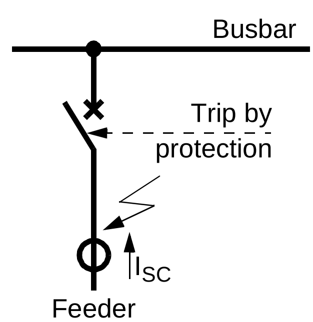


Figure 2-41 End fault between circuit breaker and current transformers

The end fault protection has the task to recognize this situation and to transmit a trip signal to the remote end of the protected object to clear the fault. For this purpose, the output command "`BF EndFlt TRIP`" (FNo `01495`) 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 connection or via CFC.

The end fault is detected when the current continues flowing although the circuit breaker auxiliary contacts indicate that the breaker is open. In the 7SD610, an additional criterion is the presence of any breaker failure protection initiate signal. The scheme's functionality is shown in Figure 2-42. If the breaker failure protection is initiated and current flow is detected (current criteria "L∗>" according Figure 2-30), but no circuit breaker pole is closed (auxiliary contact criterion "any pole closed"), then a timer **`T-EndFault`** is started. At the end of this time an intertrip signal is transmitted to the opposite end of the protected object.

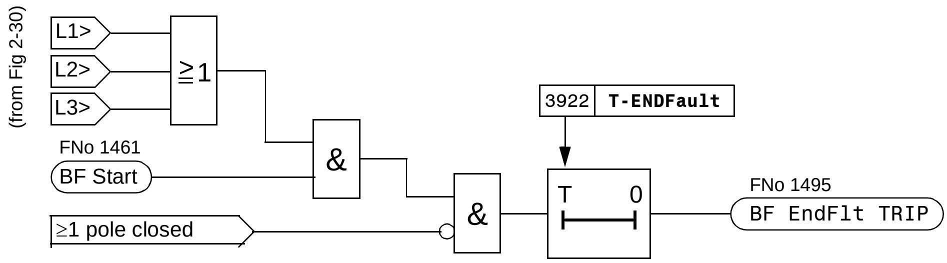


Figure 2-42 Function block diagram of end fault protection

Circuit Breaker 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 conditions, either all three poles of the breaker must be closed, or all three poles must be open. Discrepancy is permitted only for a short time interval during a single-pole automatic reclose cycle.

The scheme's functionality is shown in Figure 2-43. The signals which are processed here are the same as those used for the breaker failure protection. The pole discrepancy condition is established when at least one pole is closed ("any pole closed") and at the same time not all poles are closed ("any pole open").

Additionally, the current criteria (from Figure 2-30) are processed. Pole discrepancy can only be detected when current is not flowing through all three poles (<3), 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 breaker auxiliary contacts indicate a different status.

If pole discrepancy is detected, this is indicated by a fault detection signal. This signal identifies the pole which was open and caused the trip command of the pole discrepancy supervision.

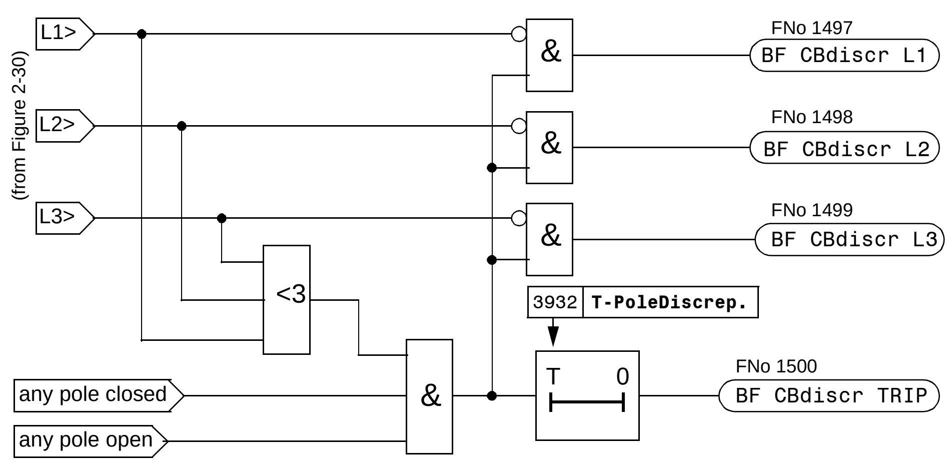


Figure 2-43 Function block diagram of pole discrepancy supervision

2.10.2 Setting the Function Parameters

General

The breaker failure protection and its ancillary functions (end fault protection, pole discrepancy supervision) can only operate if they were configured as ***Enabled*** during setting of the scope of functions (see Subsection 2.1.1, address 139).

Breaker Failure Protection

The complete breaker failure protection including its ancillary functions is switched ***OFF*** or ***ON*** under 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. To ensure this, the value should be 10 % less than the minimum anticipated fault current. On the other hand, the value should not be set lower than necessary.

Normally, the breaker failure protection evaluates the current flow criterion as well as the position of the 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***.

The breaker failure protection in the 7SD610 can be operated single-stage or two-stage

Two-stage Breaker Failure Protection

With two-stage operation, the trip command is repeated after a time delay T1 to the local feeder breaker, normally to a different set of trip coils of this breaker. A choice can be made whether this trip repetition shall be single-pole or three-pole if the initial feeder protection trip was single-pole (provided single-pole trip is possible). This choice is made in address 3903 **1p-RETRIP (T1)**. Set this parameter to ***YES*** if you wish single-pole trip for the first stage, otherwise to ***NO***.

If the breaker does not respond to this first stage trip, the adjacent circuit breakers must be tripped provided the fault has not yet been cleared. The adjacent breakers are those of the other feeders on the busbar or busbar section and, if applicable, the breaker at the remote end of the protected object.

In the 7SD610, after a further delay time **T2** (address 3906), the adjacent circuit breakers (i.e. the breakers of the busbar zone and, if applicable, the breaker at the remote end) are tripped provided the fault has not yet been cleared. An example of the time sequence is illustrated in Figure 2-44.

Separate delay times can be set:

– for single- or three-pole trip repetition to the local feeder circuit breaker after **1**-pole trip of the feeder protection under address 3904 **T1-1pole**,

– for three-pole trip repetition to the local feeder circuit breaker after **3**-pole trip of the feeder protection under address 3905 **T1-3pole**,

– for trip of the adjacent circuit breakers (busbar zone and remote end if applicable) under address 3906 **T2**.

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 breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. The time sequence is illustrated in Figure 2-44. For sinusoidal currents one can assume that the reset time of the current detectors is less than 15 ms but if current transformer saturation is expected then 25 ms should be assumed.

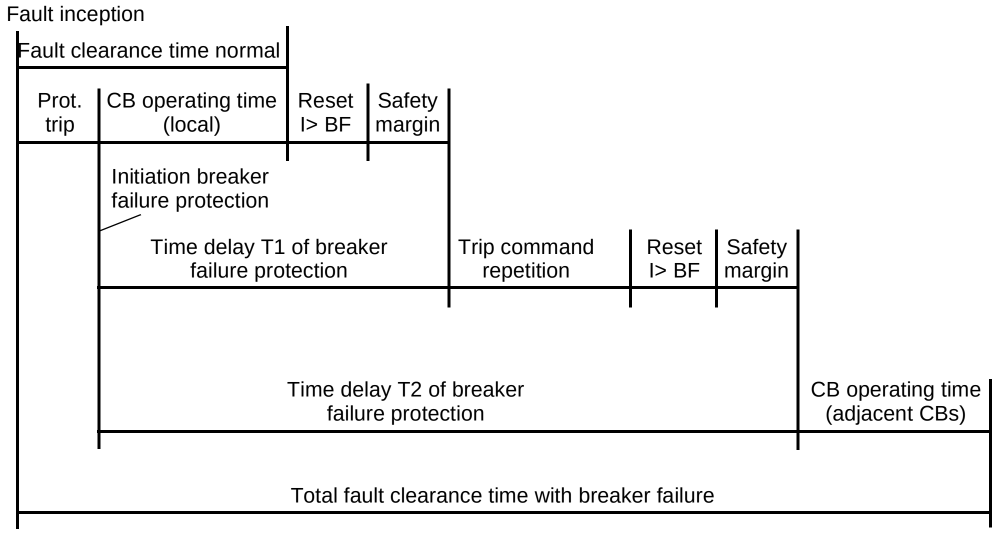


Figure 2-44 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using two-stage breaker failure protection

Single-stage Breaker Failure Protection

With single-stage operation, the adjacent circuit breakers (i.e. the breakers of the busbar zone and, if applicable, the breaker at the remote end) are tripped after a delay time **T2** (address 3906) following initiation, should the fault not have been cleared within this time.

The timers **T1-1pole** (address 3904) and **T1-3pole** (address 3905) are then set to ∞ since they are not needed.

Alternatively, you may use the T1-timers for single-stage protection if you wish to utilize the facility of setting different delay times after single-pole trip and three-pole trip of the feeder protection. In this case, set the desired times under addresses 3904 **T1-1pole** and 3905 **T1-3pole** but set address 3903 **1p-RETRIP (T1)** to ***NO*** to avoid single-pole trip to the busbar. Set **T2** (address 3906) to ∞ or equal to **T1-3pole** (address 3905). Be sure that the correct trip commands are assigned to the respective trip relay(s).

The delay times are determined from the maximum operating time of the feeder circuit breaker, the reset time of the current detectors of the breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. The time sequence is illustrated in Figure 2-45. For sinusoidal currents one can assume that the reset time of the current detectors is less than 15 ms but if current transformer saturation is expected then 25 ms should be assumed.

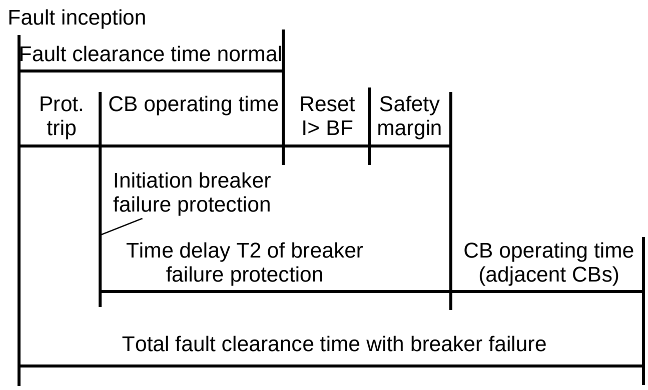


Figure 2-45 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using single-stage breaker failure protection

Circuit Breaker not Operational

If the circuit breaker associated with the feeder is not operational (e.g. control voltage failure or air pressure failure), it is obvious that the local breaker cannot clear the fault. Time delay before tripping the adjacent breakers is not necessary in this case. If the relay is informed about this disturbance (via the binary input “>CB faulty” (FNo 00378), 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 breaker is not operational when a feeder protection trip occurs. Select that output which is intended to trip the adjacent breakers (busbar trip).

End Fault Protection

The end fault protection can be switched ***ON*** or ***OFF*** separately under address 3921 **End Flt. stage**. 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 breaker auxiliary contacts connected to binary inputs.

If, during an end fault, the circuit breaker is tripped by a busbar protection (the fault is seen as a busbar fault 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 protected object.

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 used for the transmission of an intertrip signal to the remote end circuit breaker.

Thus, the delay time must be set such that it can bridge out short transient apparent end fault conditions which may occur during switching of the breaker.

Pole Discrepancy Supervision

The pole discrepancy supervision can be switched ***ON*** or ***OFF*** separately under address 3931 **PoleDiscrepancy**. It is only useful if the breaker poles can be operated individually. It avoids that only one or two poles of the local breaker remain open continuously. It presumes that either the breaker auxiliary contacts of each pole, or the series connection of the normally open contacts (NO contacts) and of the normally closed contacts (NC contacts) be connected to binary inputs on the device. If these conditions are not fulfilled, switch the pole discrepancy supervision ***OFF***.

The delay time **T-PoleDiscrep.** (address 3932) determines how long a 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 three-pole trip command. This time must clearly be longer than the duration of a single-pole automatic reclose cycle. However, 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. Conventional values are 2 s to 5 s.

2.10.3 Setting Overview

Note: The indicated secondary current values for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A these values are to be multiplied by 5.

Addr.	Setting Title	Setting Options	Default Setting	Comments
3901	FCT BreakerFail	ON OFF	ON	Breaker Failure Protection is
3902	I> BF	0.05..20.00 A	0.10 A	Pick-up threshold I>
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)
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 trips with T1-trip-signal trips with T2-trip-signal trips with T1 and T2-trip-signal	NO	Trip output selection with defective bkr
3909	Chk BRK CON-TACT	NO YES	YES	Check Breaker contacts
3921	End Flt. stage	ON OFF	OFF	End fault stage is
3922	T-EndFault	0.00..30.00 sec; ∞	2.00 sec	Trip delay of end fault stage
3931	PoleDiscrepancy	ON OFF	OFF	Pole Discrepancy supervision
3932	T-PoleDiscrep.	0.00..30.00 sec; ∞	2.00 sec	Trip delay with pole discrepancy

2.10.4 Information Overview

F.No.	Alarm	Comments
01401	>BF on	>BF: Switch on breaker fail protection
01402	>BF off	>BF: Switch off breaker fail protection
01403	>BLOCK BkrFail	>BLOCK Breaker failure
01432	>BF release	>BF: External release
01439	>BF Start w/o I	>BF: External start 3pole (w/o current)
01415	>BF Start 3pole	>BF: External start 3pole
01435	>BF Start L1	>BF: External start L1
01436	>BF Start L2	>BF: External start L2
01437	>BF Start L3	>BF: External start L3
01440	BkrFailON/offBI	Breaker failure prot. ON/OFF via BI
01451	BkrFail OFF	Breaker failure is switched OFF
01452	BkrFail BLOCK	Breaker failure is BLOCKED
01453	BkrFail ACTIVE	Breaker failure is ACTIVE
01461	BF Start	Breaker failure protection started
01493	BF TRIP CBdefec	BF Trip in case of defective CB
01472	BF T1-TRIP 1pL1	BF Trip T1 (local trip) - only phase L1
01473	BF T1-TRIP 1pL2	BF Trip T1 (local trip) - only phase L2
01474	BF T1-TRIP 1pL3	BF Trip T1 (local trip) - only phase L3
01476	BF T1-TRIP L123	BF Trip T1 (local trip) - 3pole
01494	BF T2-TRIP(bus)	BF Trip T2 (busbar trip)
01495	BF EndFlt TRIP	BF Trip End fault stage
01496	BF CBdiscrSTART	BF Pole discrepancy pickup
01497	BF CBdiscr L1	BF Pole discrepancy pickup L1
01498	BF CBdiscr L2	BF Pole discrepancy pickup L2
01499	BF CBdiscr L3	BF Pole discrepancy pickup L3
01500	BF CBdiscr TRIP	BF Pole discrepancy Trip

2.11 Thermal Overload Protection

2.11.1 Function Description

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 applicable for overhead lines, since no reliable temperature rise can be calculated due to the great variations in the environmental conditions (temperature, wind). In this case, however, a current-dependent alarm stage can indicate an imminent overload.

The unit computes the temperature rise according to a thermal single-body model based on the following thermal differential equation

$$\frac{d\Theta}{dt} + \frac{1}{\tau_{th}} \cdot \Theta = \frac{1}{\tau_{th}} \cdot \left(\frac{I}{k \cdot I_N}\right)^2$$

with Θ – current level of temperature rise referred to the final temperature rise for the maximum continuous permissible line current $k \cdot I_N$
τ_{th} – thermal time constant for temperature rise
k – k-factor which states the maximum permissible continuous current referred to the rated current of the current transformers
I – present RMS current
I_N – rated current of current transformers

The solution of this equation under steady-state conditions is an e-function whose asymptote shows the final temperature rise Θ_{end}. When the temperature rise reaches the first settable temperature threshold Θ_{alarm}, which is below the final temperature rise, a warning alarm is given in order to allow an preventive load reduction. When the second temperature threshold, i.e. the final temperature rise or tripping temperature, is reached, the protected object is disconnected from the network. The overload protection can, however, also be set on ***Alarm Only***. In this case only an alarm is given when the final temperature rise is reached.

The temperature rises 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 temperature rise of the three phases, the average temperature rise, or the temperature rise 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 rated 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 in the settings of the protection.

Apart from the thermal alarm stage, the overload protection also includes a current overload alarm stage I_{alarm}, which can be provided as an early warning that an overload current is imminent, even when the temperature rise has not yet reached the alarm or trip temperature rise values.

The overload protection can be blocked via a binary input. In doing so, the thermal replica are reset to zero.

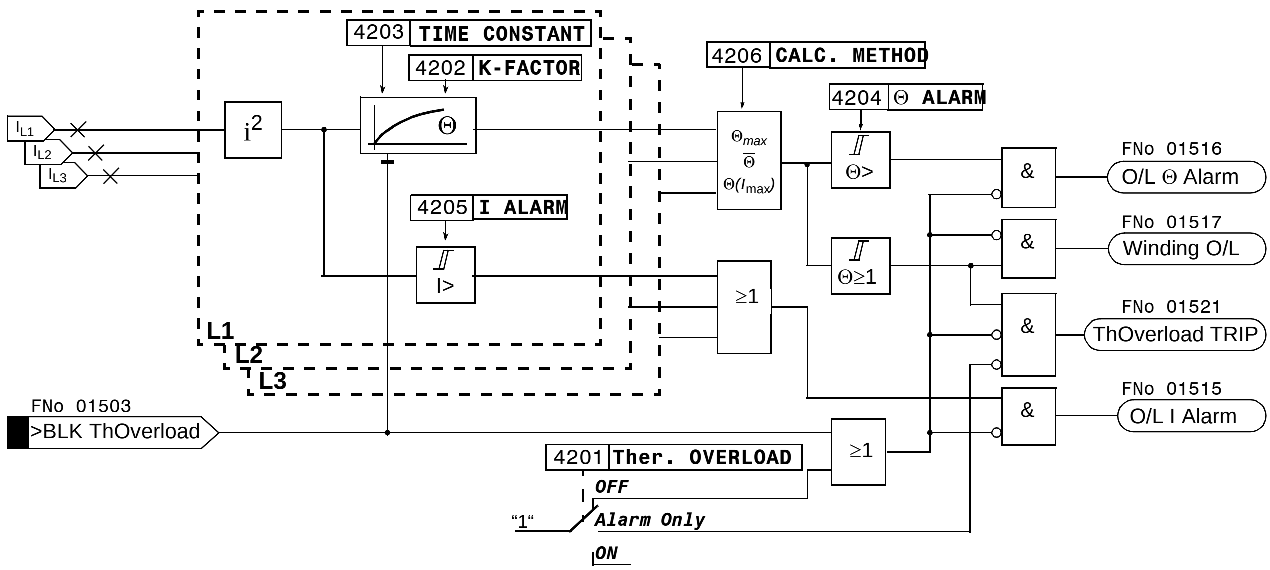


Figure 2-46 Logic diagram of the thermal overload protection

2.11.2 Setting the Function Parameters

General Information

A precondition for the use of the thermal overload protection is that **`Therm.Overload`** = ***`Enabled`*** was configured under address 142 (Subsection 2.1.1). It can be switched ***`ON`*** or ***`OFF`*** under address 4201 **`Ther. OVERLOAD`**. Furthermore ***`Alarm Only`*** can be set. With that latter setting the protection function is active but only provides an alarm when the tripping temperature rise is reached, i.e. the output function “`ThOverload TRIP`” is not active.

k-Factor

The rated current of the device is taken as the base current for detecting an overload. 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 rated current:

$$k = \frac{I_{max}}{I_N}$$

The permissible continuous current is at the same time the current at which the e-function of the temperature rise 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 rated 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. It can be derived from the relevant technical tables.

Please note that the overload capability of electrical equipment relates to its primary current. This has to be considered if the nominal primary current of the equipment differs from the rated current of the current transformers.

Example:

Belted cable 10 kV 150 mm^2
Permissible continuous current I_{max} = 322 A

Current transformers 400 A/5 A

$$k = \frac{322\text{ A}}{400\text{ A}} = 0.805$$

Setting value **K-FACTOR** = ***0.80***

Time Constant τ

The thermal time constant τ_{th} is set under the address 4203 **TIME CONSTANT**. This value is normally stated 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

$$\frac{\tau_{th}}{\text{min}} = \frac{1}{60} \cdot \left(\frac{\text{perm. 1-s current}}{\text{perm. contin. current}}\right)^2$$

- permissible current for application time other than 1 s, e.g. for 0.5 s

$$\frac{\tau_{th}}{\text{min}} = \frac{0.5}{60} \cdot \left(\frac{\text{perm. 0.5-s current}}{\text{perm. contin. current}}\right)^2$$

- t_6-time; this is the time in seconds for which a current of 6 times the rated current of the protected object may flow

$$\frac{\tau_{th}}{\text{min}} = 0.6 \cdot t_6$$

Example:

Cable as above with
permissible 1-s current 13.5 kA

$$\frac{\tau_{th}}{\text{min}} = \frac{1}{60} \cdot \left(\frac{13500\text{ A}}{322\text{ A}}\right)^2 = \frac{1}{60} \cdot 42^2 = 29.4$$

Setting value **TIME CONSTANT** = ***29.4*** min.

Alarm Stages

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 setpoint **I ALARM** (address 4205) is stated as a factor of the rated 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 thus practically ineffective.

Calculating the Temperature Rise

The thermal replica is calculated individually for each phase. Address 4406 **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 ***at Imax***) should be decisive for the thermal alarm and tripping stage.

Since an overload usually occurs in a balanced way, this setting is of minor importance. If unbalanced 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.

2.11.3 Setting Overview

Note: The indicated setting ranges and default settings refer to a secondary rated current of I_N = 1 A. For the secondary rated current of I_N = 5 A these values are to be multiplied by 5.

Addr.	Setting Title	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	0.10..4.00 A	1.00 A	Current Overload Alarm Setpoint
4206	CALC. METHOD	Theta Max Average Theta Theta @ Imax	Theta Max	Method of Acquiring Temperature

2.11.4 Information Overview

F.No.	Alarm	Comments
01503	>BLK ThOverload	>BLOCK Thermal Overload Protection
01511	Th.Overload OFF	Thermal Overload Protection OFF
01512	Th.Overload BLK	Thermal Overload Protection BLOCKED
01513	Th.Overload ACT	Thermal Overload Protection ACTIVE
01515	O/L I Alarm	Overload Current Alarm (I alarm)
01516	O/L Θ Alarm	Overload Alarm! Near Thermal Trip
01517	Winding O/L	Winding Overload
01521	ThOverload TRIP	Thermal Overload TRIP

2.12 Monitoring functions

The device incorporates comprehensive monitoring functions which cover both hardware and software; the measured values are continuously checked for plausibility, so that the current and voltage transformer circuits are also included in the monitoring system to a large extent. Furthermore, binary inputs are available for supervision of the trip circuits.

2.12.1 Function Description

2.12.1.1 Hardware Monitoring

The complete hardware including the measurement inputs and the output relays is monitored for faults and inadmissible states by monitoring circuits and by the processor.

Auxiliary and Reference Voltages

The processor voltage is monitored by the hardware as the processor cannot operate if the voltage drops below the minimum value. In that case, the device is not operational. When the correct voltage is re-established the processor system is restarted.

Failure or switch-off of the supply voltage sets the system out of operation; this status is signalled by a fail-safe contact. Transient dips in supply voltage will not disturb the function of the relay (see also Subsection 4.1.2 in the Technical Data).

The processor monitors the offset and the reference voltage of the ADC (analog-to-digital converter). In case of inadmissible deviations the protection is blocked; persistent faults are signalled.

Back-up Battery

The back-up battery guarantees that the internal clock continues to work and that metered values and alarms are stored if the auxiliary voltage fails. The charge level of the battery is checked regularly. If the voltage drops below the permissible minimum the alarm “`Fail Battery`” (FNo `00177`) is output.

If the device is not supplied with auxiliary voltage for more than 12 to 24 hours, the internal back-up battery is switched off automatically, i.e. the time is not registered any more. Messages and fault recordings however remain stored.

Memory Modules

All working memories (RAMs) are checked during start-up. If a fault occurs, the start is aborted and an LED starts flashing. During operation the memories are checked with the help of their checksum.

For the program memory, the cross-check sum is cyclically generated and compared to a stored reference program cross-check sum.

For the parameter memory, the cross-check sum is cyclically generated and compared to the cross-check sum that is refreshed after each parameterization change.

If a fault occurs the processor system is restarted.

Sampling Frequency

The sampling frequency and the synchronism between the ADC's (analog-to-digital converters) is continuously monitored. If deviations cannot be corrected by another synchronization attempt, the device sets itself out of operation and the red LED "Blocked" lights up; the "Device OK" relay drops off and signals the malfunction by its life contact.

Measured Value Acquisition: Currents

There are four measurement inputs in the current paths. If the three phase currents and the residual current of the current transformer starpoint or of an separate summation current transformer of the protected line are connected to the device, the sum of the four digitized current values must always be zero. A fault in the current path is recognized when

$$i_F = |i_{L1} + i_{L2} + i_{L3} + k_I \cdot i_E| \quad > \quad \Sigma\mathbf{I\ THRESHOLD} + \Sigma\mathbf{I\ FACTOR} \cdot \Sigma|i|$$

Factor k_I (parameter **I4/Iph CT**, address 221) considers the possibly different ratio of a separate I_E-transformer (e.g. summation current transformer). **ΣI THRESHOLD** and **ΣI FACTOR** are setting parameters. The component **ΣI FACTOR** $\cdot \Sigma|i|$ takes into account permissible current proportional transformation errors in the input converters which may particularly occur under conditions of high fault currents (Figure 2-47). The resetting ratio is approx. 97 %. $\Sigma|i|$ is the sum of all rectified currents:

$$\Sigma|i| = |i_{L1}| + |i_{L2}| + |i_{L3}| + |k_I \cdot i_E|$$

As soon as a summation current fault is detected after or before a system disturbance, the differential protection is blocked. This fault is reported with "`Failure Σi`" (FNo `00289`). For not causing a blocking due to transformation errors (saturation) in case of high fault currents, this monitoring function is not effective during a system fault.

Note:

Current sum monitoring can only operate properly when the residual current of the protected line is fed to the fourth current input (I_4) of the relay.

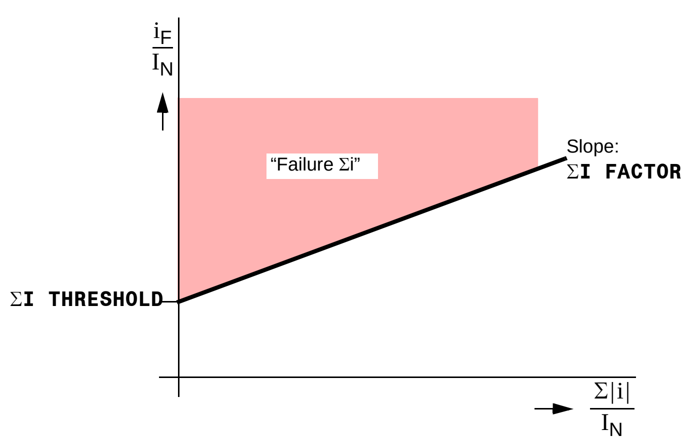


Figure 2-47 Summation current monitoring

2.12.1.2 Software Monitoring

Watchdog

For continuous monitoring of the program sequences, a watchdog timer is provided in the hardware (hardware watchdog) which will reset and completely restart the processor system in the event of processor failure or if a program falls out of step.

A further software watchdog ensures that any error in the processing of the programs will be recognized. Such errors also lead to a reset of the processor.

If such an error is not eliminated by restarting, another 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 "Blocked" lights up. The "Device OK" relay drops off and signals the malfunction by its live status contact.

2.12.1.3 Monitoring of External Transformer Circuits

The device detects and signals most of the interruptions, short-circuits, or wrong connections in the secondary circuits of current or voltage transformers (an important commissioning aid). For this the measured values are checked in background routines at cyclic intervals, as long as no pickup condition exists.

Current Balance

In healthy network operation it can be expected that the currents will be approximately balanced. The monitoring of the measured values in the device checks this balance. For this the lowest phase current is set in relation to the highest. An unbalance is detected when

$|I_{min}| / |I_{max}|$ < **BAL. FACTOR I** provided that

I_{max} / I_N > **BALANCE I LIMIT** / I_N

I_{max} is the highest, I_{min} the lowest of the three phase currents. The balance factor **BAL. FACTOR I** represents the degree of unbalance of the phase currents, the limiting value **BALANCE I LIMIT** is the lower threshold of the operating range of this monitoring function (see Figure 2-48). Both parameters can be set. The resetting ratio is approx. 97 %.

This fault is indicated with the alarm "`Fail I balance`" (FNo 00163).

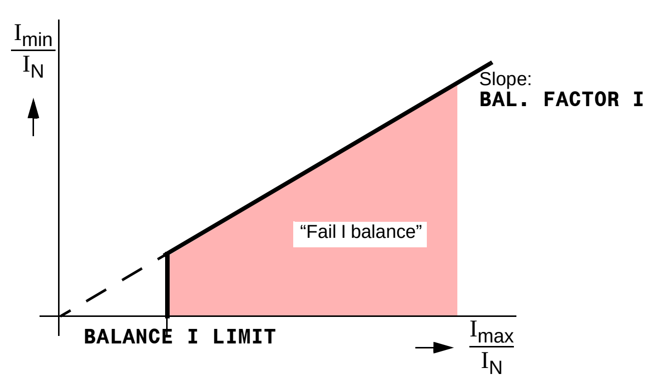


Figure 2-48 Current balance monitoring

Voltage Balance

In healthy network operation it can be expected that the voltages are nearly balanced. If measured voltages are connected to the device, this symmetry is checked by the device. To ensure the monitoring function not picking up during a single earth fault, which can also be a permanent operating state in non-earthed networks, the phase-to-phase voltages are being considered.

Thus the lowest phase-to-phase voltage is set in relation to the highest. An unbalance is detected when

$|U_{min}| / |U_{max}| <$ **BAL. FACTOR U** provided that |Umax| > **BALANCE U-LIMIT**

U_{max} is the highest, U_{min} the lowest of the three phase-to-phase voltages. The symmetry factor **BAL. FACTOR U** is the measure for the asymmetry of the phase voltages, the limiting value **BALANCE U-LIMIT** is the lower threshold of the operating range of this monitoring function (see Figure 2-49). Both parameters can be set. The resetting ratio is approx. 97 %.

This fault is indicated with the alarm “`Fail U balance`” (FNo 00167).

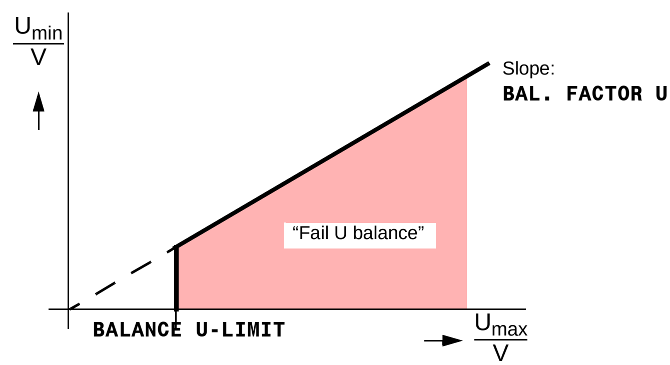


Figure 2-49 Voltage balance monitoring

Broken-Wire Monitoring

During steady-state operation the broken wire monitoring registers 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 interruptions simulates differential currents to the differential protection, such as those evoked by faults in the protected object.

The broken-wire monitor scans the current of each phase and picks up when the current drops abruptly to *0* (from > $0.1 \cdot I_N$), while no corresponding drop appears in the earth current. The differential protection is blocked immediately in the relevant phase. This blocking has an impact on both ends of the protected object. The device issues the message “`Broken Iwire`” indicating also the involved phase.

The blocking is cancelled as soon as the device is again supplied with current in the relevant phase. It is also suppressed as long as a high fault current is registered by the other device of the differential protection system.

Note:

The broken-wire monitor only operates if the earth current of a separate earth current transformer of the protected line is connected to the fourth current input (I_4) of the relay, or if no earth current is connected to this input.

2.12.1.4 Trip Circuit Supervision

The differential protection relay 7SD610 is equipped with an integrated trip circuit supervision. Depending on the number of available binary inputs that are not connected to a common potential, supervision modes with one or two binary inputs can be selected. If the allocation of the necessary binary inputs does not comply with the selected monitoring mode, an alarm is given (with identification of the non-compliant circuit). If single-pole tripping is possible, trip circuit supervision can be performed for each circuit breaker pole provided the binary inputs are available.

Supervision Using Two Binary Inputs

If two binary inputs are used, they are connected according to Figure 2-50, one in parallel to the assigned command relay contact of the protection and the other parallel to the circuit breaker auxiliary contact.

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 ($U_{Ctrl} > 2 \cdot U_{BImin}$). As at least 19 V are needed at each binary input, supervision can be used with a control voltage higher than 38 V.

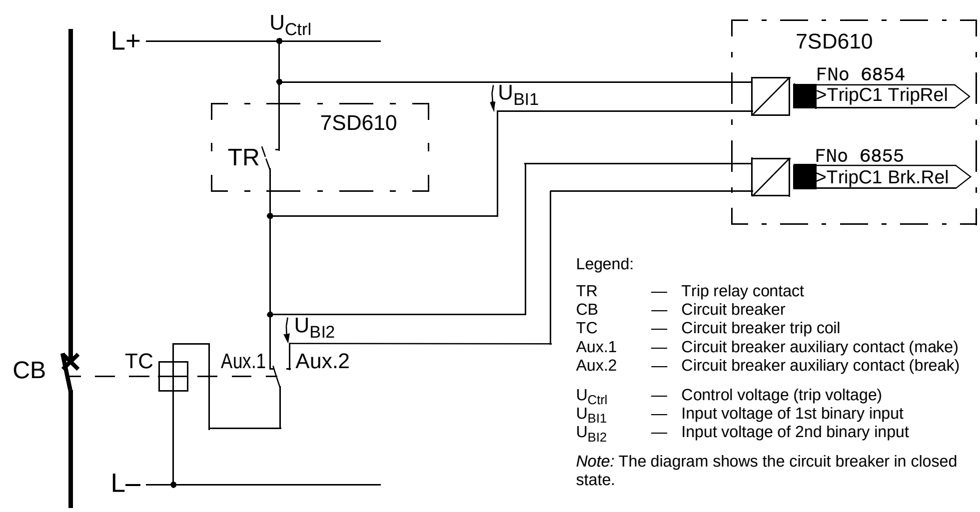


Figure 2-50 Principle of the trip circuit supervision with two binary inputs

Depending on the state of the trip relay and the circuit breaker's auxiliary contacts, the binary inputs are triggered (logic state “H” in Table 2-4) or short-circuited (logic state “L”).

A state in which both binary inputs are not activated (“L”) is only possible in healthy trip circuits for a short transition period (trip relay contact closed but circuit breaker not yet open).

This state is only permanent in the event of interruptions or short-circuits in the trip circuit, a battery voltage failure. Therefore, this state is one of the supervision criteria.

Table 2-4 Status table of the binary inputs depending on TR and CB

No	Trip relay	Circuit breaker	Aux.1	Aux.2	BI 1	BI 2
1	open	CLOSED	closed	open	H	L
2	open	OPEN	open	closed	H	H
3	closed	CLOSED	closed	open	L	L
4	closed	OPEN	open	closed	L	H

The states of the two binary inputs are interrogated periodically, approximately every 500 ms. Only after n = 3 of these consecutive state queries have detected a fault an alarm is given (see Figure 2-51). These repeated measurements result in a delay of this alarm and thus avoid that an alarm is given during short-time transient periods. After the fault is removed in the trip circuit, the fault message is reset automatically after the same time delay.

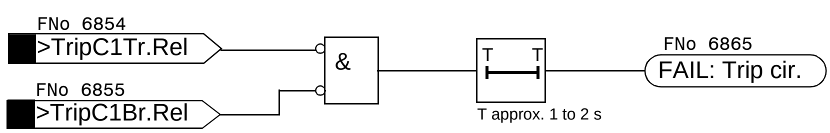


Figure 2-51 Logic diagram of the trip circuit supervision with two binary inputs

Supervision Using One Binary Input

The binary input is connected in parallel to the respective command relay contact of the protection device according to Figure 2-52. The circuit breaker auxiliary contact is bridged with the help of a high-ohmic substitute 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 necessary for the binary input, this supervision can be used with a control voltage higher than approximately 38 V.

An calculation example for the substitute resistance of R is shown in Subsection 3.1.2, margin “Trip Circuit Supervision”, page 183.

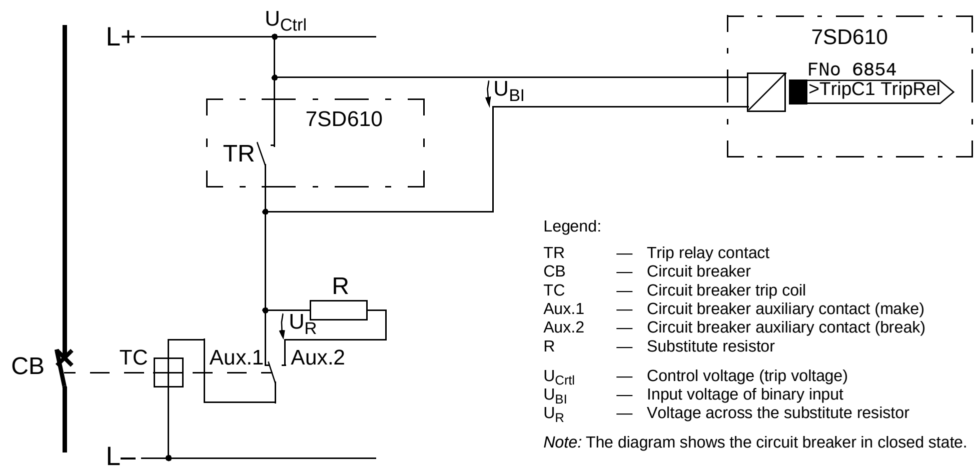


Figure 2-52 Principle of the trip circuit supervision with one binary input

In normal operation the binary input is energized when the trip relay contact is open and the trip circuit is healthy (logic state “H”), as the monitoring circuit is closed via the auxiliary contact (if the circuit breaker is closed) or via the substitute resistance R. The binary input is short-circuited and thus deactivated only as long as the tripping relay is closed (logic state “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.

As the trip circuit supervision is not operative during a system fault condition (picked-up status of the device), the closed trip contact does not lead to an alarm. If, however, the trip contacts of other devices are connected in parallel, the alarm must be delayed with **Alarm Delay** (see also Figure 2-53). After the fault in the trip circuit is removed, the alarm is reset automatically after approximately 1 to 2 seconds.

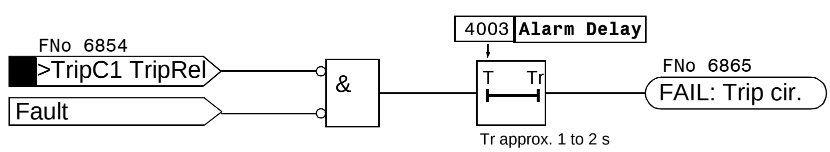


Figure 2-53 Logic diagram of the trip circuit supervision with one binary input

2.12.1.5 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. If the fault is still present after three restart attempts the protection system will take itself out of service and indicate this condition by drop-off of the “Device OK” relay, thus indicating the device failure by its life contact. The red LED “Blocked” 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 2-5 shows a summary of the monitoring functions and the fault reactions of the device.

Table 2-5 Summary of the fault reactions of the device

Supervision	Possible causes	Fault reaction	Alarm	Output
Auxiliary voltage failure	External (aux. voltage) Internal (converter)	Device out of operation or alarm, if possible	All LEDs dark “Error 5 V“	DOK[2]) drops off
Measured value acquisition	Internal (converter or reference voltage)	Protection out of operation, alarm	LED “ERROR” “Error A/D-conv.“	DOK[2]) drops off
Back-up battery	Internal (back-up battery)	Alarm	“Fail. Battery“	as allocated
Hardware watchdog	Internal (processor failure)	Device out of operation	LED “ERROR“	DOK[2]) drops off
Software watchdog	Internal (program flow)	Restart attempt[1])	LED “ERROR“	DOK[2]) drops off
Working memory	Internal (RAM)	Restart attempt[1]), Restart abort device out of operation	LED flashes	DOK[2]) drops off
Program memory	Internal (EPROM)	Restart attempt[1])	LED “ERROR“	DOK[2]) drops off
Parameter memory	Internal (Flash-EEPROM or RAM)	Restart attempt[1])	LED “ERROR“	DOK[2]) drops off
Scanning frequency	Internal (clock generator)	Device out of operation	LED “ERROR“	DOK[2]) drops off
1 A/5 A–setting	1/5 A jumper wrong	Alarms: Protection out of operation	“IN (1/5A) wrong“ “Error A/D-conv.“ LED “ERROR“	DOK[2]) drops off
Calibration data	Internal (EEPROM or RAM)	Alarm: Using default values	“Alarm adjustm.”	as allocated
Modules	Module does not comply with ordering number	Alarms: Protection out of operation	“Error Board 1...” and if applicable “Error A/D-conv.”	DOK[2]) drops off
Summation current	Internal (measured data acquisition)	Alarm	“Failure ΣI“	as allocated
Current symmetry	External (system or transformer)	Alarm	“Fail I Balance”	as allocated
Wire break	External (system or transformer)	Alarm	“Broken Wire”	as allocated
Voltage symmetry	External (system or current transforme)r	Alarm	“Fail U Balance”	as allocated
Trip circuit supervision	External (trip circuit or control voltage)	Alarm	“FAIL: Trip cir.”	as allocated

[1]) After three unsuccessful attempts the device is put out of operation
[2]) DOK = “Device OK” relay (Life contact)

2.12.1.6 Group Alarms

Certain messages of the monitoring functions are already combined to group alarms. Table 2-6 shows an overview of these group alarms an their composition.

Table 2-6 Group alarms

Group alarm		Composed of	
FNo	**Designation**	**FNo**	**Designation**
00161	Fail I Superv.	00289 00163	Failure Σi Fail I balance
00164	Fail U Superv.	00167	`Fail U balance`
00160	Alarm Sum Event	00289 00163 00167 00361 00182 00177 00193 03464 00183 00184 00185 00186 00187 00188 00189	Failure Σi Fail I balance `Fail U balance` >FAIL:Feeder VT Alarm Clock Fail Battery Alarm adjustm. Topol complete, negated Error Board 1 Error Board 2 [1]) Error Board 3 [1]) Error Board 4 [1]) Error Board 5 [1]) Error Board 6 [1]) Error Board 7 [1])
00140	Error Sum Alarm	00144 00192 00181	Error 5V Error1A/5Awrong Error A/D-conv.

[1]) depending on the identification number of printed circuit boards

2.12.2 Setting the Function Parameters

The sensitivity of the measurement supervision can be altered. Experiential values set ex works are adequate in most cases. If an extremely high operational unbalance of the currents and/or voltages is to be expected in the specific application, or if during operation monitoring functions are activated sporadically, the relevant parameters should be set less sensitive.

Symmetry Supervision

The symmetry supervision can be switched ***ON*** or ***OFF*** in address 2901 **MEASURE. SUPERV**.

Address 2902A **BALANCE U-LIMIT** determines the threshold voltage (phase-to-phase) above which the voltage symmetry supervision is effective (see also Figure 2-49). Address 2903A **BAL. FACTOR U** is the associated balance factor, i.e. the gradient of the symmetry characteristic (Figure 2-49). This parameter can only be altered with DIGSI® under “**Additional Settings**”.

Address 2904A **BALANCE I LIMIT** determines the threshold current above which the current balance supervision is effective (also see Figure 2-48). Address 2905A **BAL. FACTOR I** is the associated balance factor, i.e. the gradient of the balance characteristic (Figure 2-48).

Broken Wire Supervision

The broken wire supervision can be switched ***ON*** or ***OFF*** in address 2908 **BROKEN WIRE**.

Summated Current Supervision

The summated current supervision can be switched ***ON*** or ***OFF*** in address 2921 **FAST Σ i SUPERV**.

Address 2906A **ΣI THRESHOLD** determines the threshold current above which the summation current supervision (see Figure 2-47) is effective (absolute value, only referred to I_N). The relative value (referred to the maximum phase current) for the pickup of the summated current supervision (Figure 2-47) is set in address 2907A **ΣI FACTOR**. This parameter can only be altered with DIGSI® under “**Additional Settings**”.

Note:

Current sum monitoring can operate properly only when the residual current of the protected line is connected to the fourth current input (I_4) of the relay.

Trip Circuit Supervision

When address 140 **Trip Cir. Sup.** was configured (Subsection 2.1.1), the number of trip circuits that are to be monitored was set. If the trip circuit supervision function is not used at all, ***Disabled*** is set there.

The trip circuit supervision can be switched ***ON*** or ***OFF*** in address 4001 **FCT Trip-Superv.**. The number of the binary inputs per trip circuit is entered under address 4002 **No. of BI**. If the routing of the binary inputs required for this does not comply with the selected supervision mode, an alarm is given (with identification of the non-compliant circuit).

The trip circuit alarm is delayed for approximately 1 s to 2 s in supervision with two binary inputs, whereas the delay can be set under address 4003 **Alarm Delay** for supervision with one binary input. 1 s to 2 s are sufficient if only device 7SD610 is connected to the trip circuits as the trip circuit supervision does not operate during a system fault. If, however, the trip contacts of other devices work also on the trip circuit in parallel, the alarm must be delayed for longer than the longest possible duration of a tripping command.

2.12.3 Setting Overview

Measured Value Supervision

Note: The indicated setting ranges and default settings refer to a secondary rated current of I_N = 1 A. For the secondary rated current of I_N = 5 A these values are to be multiplied by 5.

Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Addr.	Setting Title	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	0.10..1.00 A	0.50 A	Current Balance Monitor
2905A	BAL. FACTOR I	0.10..0.95	0.50	Balance Factor for Current Monitor
2908	BROKEN WIRE	ON OFF	OFF	Fast broken current-wire supervision
2921	FAST Σ i SUPERV	ON OFF	ON	State of fast current summation supervis
2906A	ΣI THRESHOLD	0.10..2.00 A	0.25 A	Summated Current Monitoring Threshold
2907A	ΣI FACTOR	0.00..0.95	0.50	Summated Current Monitoring Factor

Trip Circuit Supervision

Addr.	Setting Title	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

2.12.4 Information Overview

Hardware and Software Monitoring

F.No.	Alarm	Comments
00140	Error Sum Alarm	Error with a summary alarm
00144	Error 5V	Error 5V
00160	Alarm Sum Event	Alarm Summary Event
00177	Fail Battery	Failure: Battery empty
00181	Error A/D-conv.	Error: A/D converter
00182	Alarm Clock	Alarm: Real Time Clock
00190	Error Board 0	Error Board 0
00183	Error Board 1	Error Board 1
00184	Error Board 2	Error Board 2
00185	Error Board 3	Error Board 3
00186	Error Board 4	Error Board 4
00187	Error Board 5	Error Board 5
00188	Error Board 6	Error Board 6
00189	Error Board 7	Error Board 7
00192	Error1A/5Awrong	Error:1A/5Ajumper different from setting
00193	Alarm adjustm.	Alarm: Analog input adjustment invalid
00191	Error Offset	Error: Offset
	HWTestMod	Hardware Test Mode
02054	Emer. mode	Emergency mode

Measured Value Supervision

F.No.	Alarm	Comments
00161	Fail I Superv.	Failure: General Current Supervision
00163	Fail I balance	Failure: Current Balance
00164	Fail U Superv.	Failure: General Voltage Supervision
00167	Fail U balance	Failure: Voltage Balance
00197	MeasSup OFF	Measurement Supervision is switched OFF
00295	Broken wire OFF	Broken wire supervision is switched OFF
00296	Σi superv. OFF	Current summation superv is switched OFF
00289	Failure Σi	Alarm: Current summation supervision

F.No.	Alarm	Comments
00290	Broken Iwire L1	Alarm: Broken current-wire detected L1
00291	Broken Iwire L2	Alarm: Broken current-wire detected L2
00292	Broken Iwire L3	Alarm: Broken current-wire detected L3

Trip Circuit Supervision

F.No.	Alarm	Comments
06854	>TripC1 TripRel	>Trip circuit superv. 1: Trip Relay
06855	>TripC1 Bkr.Rel	>Trip circuit superv. 1: Breaker Relay
06856	>TripC2 TripRel	>Trip circuit superv. 2: Trip Relay
06857	>TripC2 Bkr.Rel	>Trip circuit superv. 2: Breaker Relay
06858	>TripC3 TripRel	>Trip circuit superv. 3: Trip Relay
06859	>TripC3 Bkr.Rel	>Trip circuit superv. 3: Breaker Relay
06861	TripC OFF	Trip circuit supervision OFF
06865	FAIL: Trip cir.	Failure Trip Circuit
06866	TripC1 ProgFAIL	TripC1 blocked: Binary input is not set
06867	TripC2 ProgFAIL	TripC2 blocked: Binary input is not set
06868	TripC3 ProgFAIL	TripC3 blocked: Binary input is not set

2.13 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. Among these are

- switch-in recognition,
- processing of the circuit breaker position,
- fault detection/pickup logic,
- tripping logic.

2.13.1 Switch-in Recognition

During energization of the protected object, several measures may be required or desirable; e.g. for manual closure onto a fault usually instantaneous tripping is 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 manual closing, as mentioned in the relevant sections. Also see Subsection 2.1.4 under the subtitle “Circuit Breaker Status”, page 26.

The manual closing command must be indicated to the device via a binary input. The command duration is fixed to a defined length (to be set under address 1150A **`SI Time Man.Cl`**). That is to make the processing of the switch-in recognition independent of the actual duration of an individual manual closing operation. Figure 2-54 shows the logic diagram.

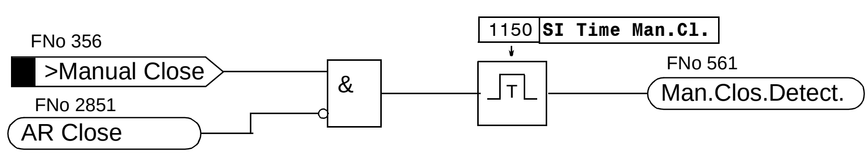


Figure 2-54 Logic diagram of the manual closing procedure

If the 7SD610 is equipped with an integrated auto-reclosure function, the integrated manual closing logic differentiates automatically between an external control command via the binary input and an automatic reclosure through the internal auto-reclose function. Thus the binary input configured with “`>Manual Close`” can be connected directly to the circuit of the closing coil of the circuit breaker (Figure 2-55). With the user definable logic functions (CFC) further control functions can be processed in the same way as a manual-close command.

If, however, external closing commands are possible which must not activate the manual closing function (e.g. external reclosure device), the binary input configured with “`>Manual Close`” must be activated by a separate contact of the control-discrepancy switch (Figure 2-56).

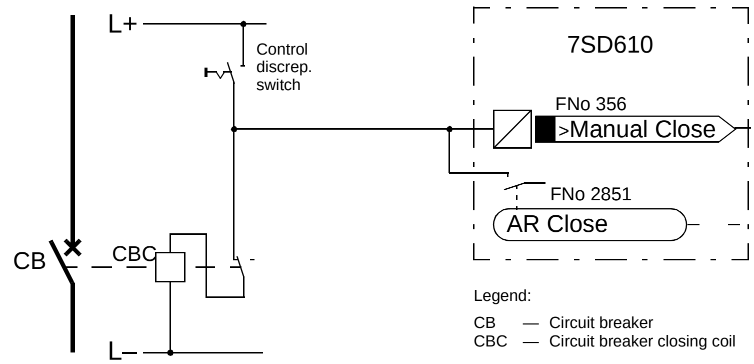


Figure 2-55 Manual closing with internal auto-reclosure function

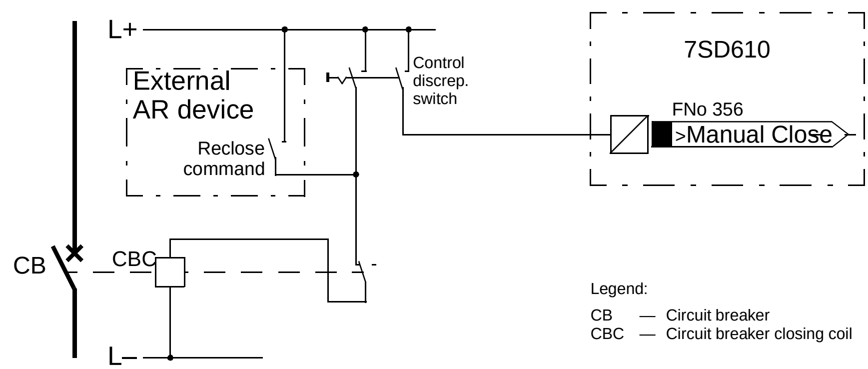


Figure 2-56 Manual closing with external auto-reclosure device

If internal control commands are intended to cause manual close, they have to be included into the manual close processing, either by means of interconnection between binary input and outputs or via the user definable logic functions (CFC).

2.13.2 Processing of the Circuit Breaker Position

Several protection and ancillary functions require information on the status of the circuit breaker for proper functioning. This is e.g. helpful for

- the conditions when connecting the protected object (cf. Subsection 2.7.1) to the network,
- start of the dead times before auto-reclosure (cf. Subsection 2.9.1),
- plausibility check before auto-reclosure (cf. Subsection 2.9.1),
- the enabling condition for the high-current switch-on-to-fault protection (I>>> stage, cf. Subsection 2.7.1), also applicable for both ends of the protected object,
- the circuit breaker failure protection (cf. Subsection 2.10.1),

– the verification of the reset conditions for the tripping command (cf. Subsection 2.13.4),

– the trip circuit check with the help of the TRIP-CLOSE-test cycle (cf. Subsection 2.13.5).

The device is equipped with a circuit breaker position logic (Figure 2-57), which offers different options depending on which auxiliary contacts of the circuit breaker are available and on how they are connected to the device.

In most cases it is sufficient to have the status of the circuit breaker signalled by its auxiliary contact to the device via a binary input. This is valid if the circuit breaker is always operated three-pole. In this case the make contact of the auxiliary contact is to be connected to a binary input which must be allocated to the input function “>CB 3p Closed” (FNo 00379). Then the other inputs are not assigned and the logic is limited to the transmission of this input information.

If the breaker poles can be operated individually and e.g. only the series-connected break contacts (pole open) are available, the associated binary input is also allocated to function “>CB 3p Open” (FNo 00380). The other inputs are not assigned either in that case.

If the breaker poles can be closed individually and the auxiliary contacts are accessible individually, each auxiliary contact should be assigned its own binary input as far as possible if the device can and is supposed to perform single-pole tripping. With the help of this connection, the device can process a maximum amount of information. Three binary inputs are necessary for this:

– “>CB Aux. L1” (FNo 00351), for the auxiliary contact of pole L1,

– “>CB Aux. L2” (FNo 00352), for the auxiliary contact of pole L2,

– “>CB Aux. L3” (FNo 00353), for the auxiliary contact of pole L3,

The inputs FNo 00379 and FNo 00380 are not used in this case.

If the breaker poles can be operated individually, two binary inputs are sufficient if both the series-connected make contacts (pole closed) and the series-connected break contacts (pole open) of the auxiliary contacts of the three poles are available. The series circuit of the make contacts is allocated on the input function “>CB 3p Closed” (FNo 00379) and the series circuit of the break contacts on the input function “>CB 3p Open” (FNo 00380) in this case.

Please note that Figure 2-57 shows the entire logic of all connection possibilities. Only a part of the inputs is used for the respective application as described above.

The 8 output signals of the circuit breaker status logic can be processed by the individual protection and ancillary 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.

In 7SD610 the position of the circuit breaker poles detected by the device is also transmitted to the remote end device. This way the position of the circuit breaker poles is also recognized by at the other end. The high-current switch-on-to-fault protection (see 2.7.1) makes use of this function.

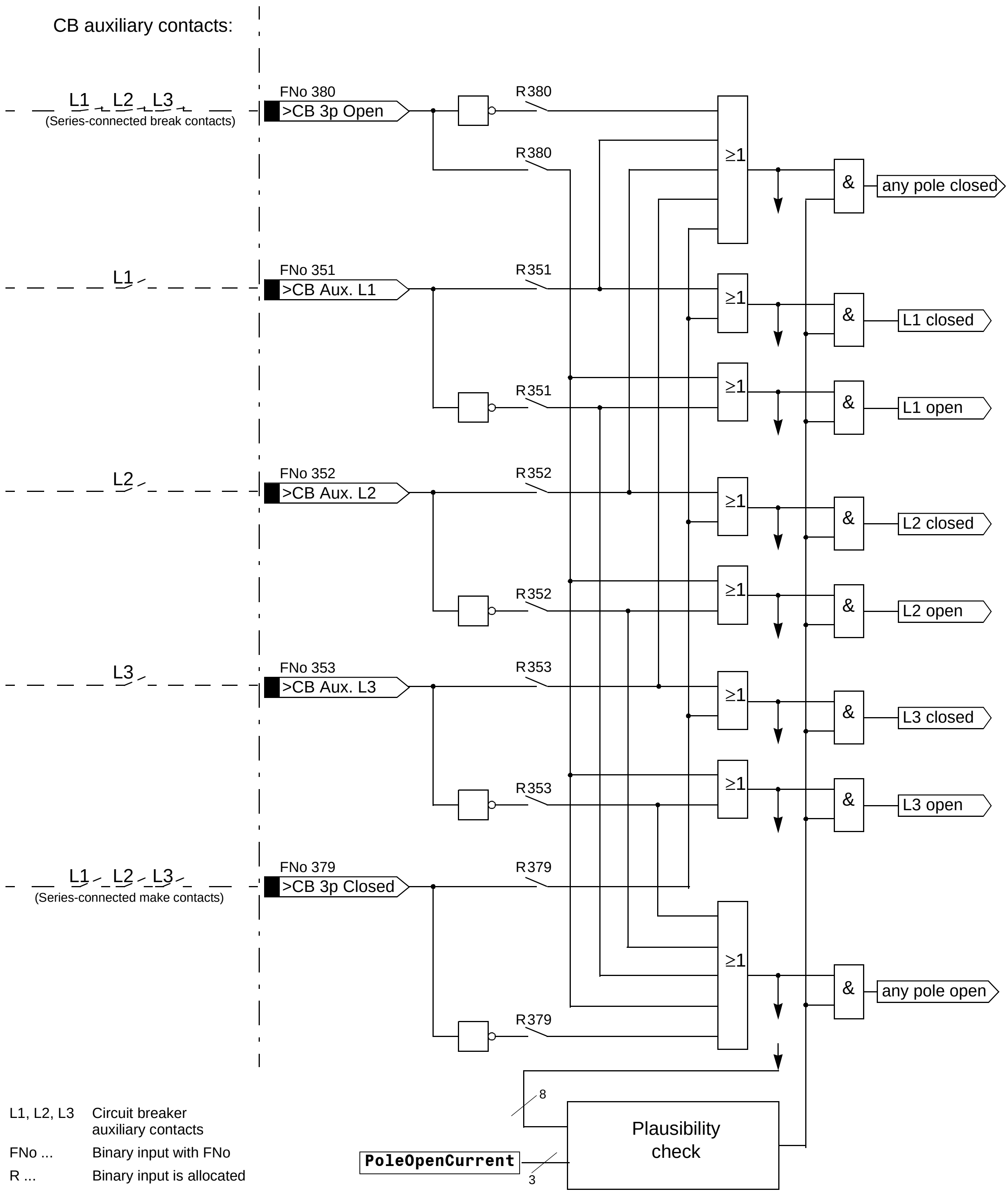


Figure 2-57 Circuit breaker position logic

Special binary inputs are available for the auto-reclosure function and for the circuit breaker check; they are to be handled in the same way and additionally allocated if necessary. These inputs have an analogue meaning to the inputs described above and are identified with "CB1 ..." for easier distinction:

– ">CB1 3p Closed" (FNo 00410) for the series circuit of the make contacts of the auxiliary contacts,
– ">CB1 3p Open" (FNo 00411) for the series circuit of the closing contacts of the auxiliary contacts,
– ">CB1 Pole L1" (FNo 00366) for the auxiliary contact of pole L1,
– ">CB1 Pole L2" (FNo 00367) for the auxiliary contact of pole L2,
– ">CB1 Pole L3" (FNo 00368) for the auxiliary contact of pole L3.

2.13.3 Fault Detection Logic of the Entire Device

Phase Segregated Pickup

The fault detection logic combines the pickup signals of all protection functions. For those protection functions which allow phase-segregated pickup, the pickup information is provided per phase. When a protection function has detected an earth fault, this is also indicated. Thus the alarms "Relay PICKUP L1", "Relay PICKUP L2", "Relay PICKUP L3" and "Relay PICKUP E" are available.

These alarms can be allocated to LEDs or output relays. Some protection functions can also indicate the phase pickup as a group signal for the local displaying of fault messages and for the transmission of the messages to a PC or a central control system, e.g. "Diff Flt. L2E" for differential protection pickup L1–L2–E; only one of these is displayed at a time and represents the entire pickup situation.

General Pickup

The pickup signals are combined with *OR* and lead to a general pickup of the device. It is signalled with the alarm "Relay PICKUP". If no protection function of the device has picked up any longer, "Relay PICKUP" disappears (message: "Off").

The general pickup is the precondition for a number of internal and external consequential functions. Among these functions, which are controlled by the general pickup, are:

- Start of a fault log: All fault messages are entered into the trip log from the beginning of the general pickup to the drop-off.
- Initialization of the fault recording: The recording and storage of fault wave forms can additionally be made subject to the presence of a trip command.
- Creation of spontaneous messages: Certain fault messages can be displayed as so called spontaneous messages (see "Spontaneous Indications" below). This display can additionally be made subject to the presence of a trip command.
- Start of the action time of the auto-reclosure (if available and used).

External functions can be controlled via an output contact. Examples are:

- Reclosure devices,
- Further additional devices or similar.

Spontaneous Indications

Spontaneous indications are alarms that are displayed automatically after a general pickup of the device or after the trip command of the device. In the case of 7SD610 they are the following:

- “`Diff PICKUP`“: pickup of a protection function, e.g. the differential protection, with phase indication;
- “`PU Time`: the operating time from the general pickup to the dropout of the device, the time is given in ms;
- “`TRIP Time`: the operating time from the general pickup to the first trip command of the device, the time is given in ms.

2.13.4 Tripping Logic of the Entire Device

Three-pole Tripping

Three-pole tripping is the usual action of the device in the event of a fault, single-pole tripping, however, is also possible depending on the version ordered (see below). If a single-pole tripping is generally not possible or not desired, the output function “`Relay TRIP 3ph.`” is used for the output of commands to the circuit breaker. In these cases the following subtitle on “Single-pole Tripping” is not relevant.

Single-pole Tripping

Single-pole tripping is advisable only for overhead lines on which auto-reclosures are to be executed and which are equipped with circuit breakers suitable for single-pole tripping on all ends. In this case, in the event of a single-phase fault, the faulty phase can be tripped single-pole with subsequent reclosure; in the event of two-phase or three-phase faults with or without ground a three-pole tripping is issued in general.

Preconditions for pole-segregated tripping concerning the device are,

- that the device is equipped with pole-segregated tripping (according to the order specification),
- that the tripping protection function is suitable for pole-segregated tripping (for example, not for overload protection),
- that the binary input “`>1p Trip Perm`” is allocated and activated or that the internal auto-reclosure function is ready for auto-reclosure on single-pole tripping.

In all other cases tripping will be three-pole. The binary input “`>1p Trip Perm`” is the logic inversion of a three-pole coupling and is activated by an external auto-reclosure device as long as this is ready for a single-pole auto-reclosure cycle.

With the 7SD610, three-pole coupling of the trip command is also possible if tripping only concerns one phase but more than one phase has picked up. This can be the case e.g. if two faults occur in two different places of which only one is within the range of the differential protection zone. This is achieved with the help of setting parameter **`3pole coupling`** (address 1155) which can be set to ***`with PICKUP`*** (each multiphase *pickup* leads to three-pole tripping) or ***`with TRIP`*** (three-pole *tripping* in the event of a multi-pole trip command).

The tripping logic combines the trip signals of all protection functions. Trip commands are output per phase if the protection functions allow single-pole tripping. The relevant informations are “`Relay TRIP L1`”, “`Relay TRIP L2`” and “`Relay TRIP L3`”.

These informations can be allocated to LEDs or output relays. In the event of a three-pole tripping all three informations are provided.

If single-pole tripping is possible, the protection functions can also output a group signal for the local displaying of alarms and for the transmission of the alarms to a PC or a central control system, e.g. "`Diff TRIP 1p L1`", "`Diff TRIP 1p L2`", "`Diff TRIP 1p L3`" for single-pole tripping by the differential protection and "`Diff TRIP L123`" for three-pole tripping. Only one of these alarms is displayed at a time. These informations are also used as trip commands to the circuit breaker.

Single-pole Tripping after a Two-phase Fault

The single-pole tripping after a two-phase fault is a special case. If a phase-to-phase fault clear of ground occurs in a grounded system, the fault may be cleared by a single-pole auto-reclosure, since this is sufficient to interrupt the fault current loop. The phase selected for this must be the same on both line ends and should be the same everywhere else within the system.

The setting parameter **`Trip2phFlt`** (address `1156`A) allows to select whether this tripping should be ***`1pole leading Ø`***, i.e. single-pole tripping of the leading phase, or ***`1pole lagging Ø`***, i.e. single-pole tripping of the lagging phase. Standard setting is ***`3pole`***, i.e. three-pole tripping after two-phase faults (default setting).

Table 2-7 shows a summary of the conditions for single-pole or three-pole tripping.

Table 2-7 Single- and three-pole tripping depending on the type of fault

Type of fault (of protection functions)				**Setting `Trip2phFlt`**	**Output signals for tripping**			
					`Relay TRIP 1pL1`	**`Relay TRIP 1pL2`**	**`Relay TRIP 1pL3`**	**`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

Table 2-7 Single- and three-pole tripping depending on the type of fault

Type of fault (of protection functions)				Setting `Trip2phFlt`	Output signals for tripping			
					`Relay TRIP 1pL1`	`Relay TRIP 1pL2`	`Relay TRIP 1pL3`	`Relay TRIP 3ph.`
L1	L2	L3		(any)				X
L1	L2	L3	E	(any)				X
			E	(any)				X

General Tripping

All tripping signals of the protection functions are *OR*-combined and lead to the alarm "`Relay TRIP`". This can be allocated to an LED or output relay.

Terminating the Trip Command

Once a trip command is activated, it is stored separately for each pole (for all three poles after three-pole tripping, see Figure 2-58). At the same time a minimum trip command duration **`TMin TRIP CMD`** is started to ensure that the command is sent to the circuit breaker long enough if the tripping protection function should drop off too quickly. The trip commands cannot be terminated until the last protection function has dropped off (no function activated) *AND* the minimum trip command time is over.

Another condition for terminating the trip command is that the circuit breaker is open (with single-pole tripping the relevant circuit breaker pole). The current must have fallen below the value that corresponds to the setting value **`PoleOpenCurrent`** (address `1130A`, refer to "Circuit Breaker Status" in Subsection 2.1.4, page 26) plus 10 % of the fault current.

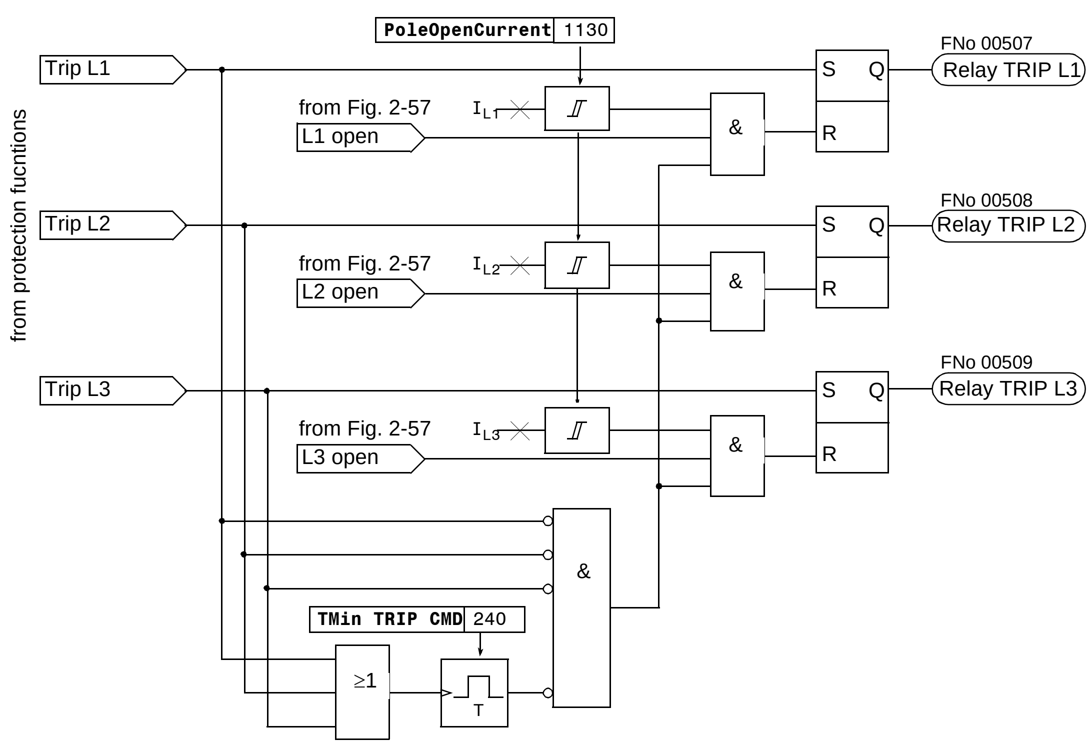


Figure 2-58 Storage and termination of the trip command

Reclosure Interlocking

When tripping the circuit breaker with a protection function the manual reclosure must often be blocked until the cause for the protection function operation is found. 7SD610 therefore provides the integrated reclosure interlocking function.

The interlocking feature is realized by a RS flipflop which is protected against auxiliary voltage failure (see Figure 2-59). The RS flipflop is set via a binary input “`>Lockout SET`” (FNo `00385`). With the output alarm “`LOCKOUT`” (FNo `00530`), 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`” (FNo `00386`).

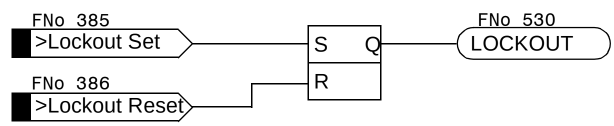


Figure 2-59 Reclosure lockout

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 reclosing lock-out, then combine the tripping command “`Relay TRIP`” (FNo `00511`) with the binary input “`>Lockout SET`” (FNo `00385`). If automatic reclosure is applied, only the final trip of the protection function should activate reclosing lock-out. Then combine the output alarm “`Final Trip`” (FNo `00536`) with the interlocking input “`>Lockout SET`” (FNo `00385`), so that the interlocking function is not activated when an automatic reclosure is still expected to come.

In the most simple case the output alarm “`LOCKOUT`” (FNo `00530`) can be allocated to the output which trips the circuit breaker without creating further links. Then the tripping command is maintained until the interlock is reset via the binary reset input. Naturally it has to be ensured in advance that the close coil at the circuit breaker — as is usually done — is blocked as long as a tripping command is maintained.

The output alarm “`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 “`>CloseCmd.Blo`” (FNo `00357`) or by connecting the inverted alarm with the bay interlocking of the feeder.

The reset input “`>Lockout RESET`” (FNo `00386`) 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, e.g.
a function key, operation of the device or using DIGSI® on a PC.

For each case please make sure the corresponding logical combinations, security measures, etc. are taken into account for the routing of the binary inputs and outputs and are also considered for the setting of user-defined logic functions, if necessary. For further information refer to the SIPROTEC® 4 System Manual, order no. E50417–H1176–C151.

"No Trip no Flag"

The storage of alarms allocated to local LEDs and the availability of spontaneous alarms can be made dependent on the device sending a trip command. Fault event information is then *not* output when one or more protection functions have picked up due to a fault but no tripping occurred because the fault was removed by another device (e.g. on a different line). The information is thus limited to faults on the protected line "no trip – no flag".

Figure 2-60 shows the logic diagram of this function.

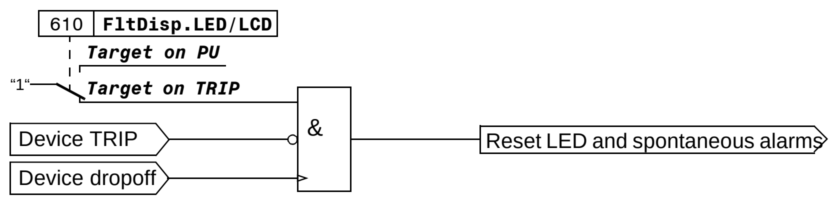


Figure 2-60 Logic diagram of the "no-trip-no-flag" function (command-dependent alarms)

CB Operation Statistics

The number of trips caused by the device 7SD610 is counted. If the device is to be used for single-pole tripping, this number is counted for each CB pole individually.

Furthermore, the interrupted current for each pole is acquired, provided as an information and accumulated in a memory. The maximum interrupted current can be retrieved, too.

If the device is equipped with an integrated auto-reclosure function, the automatic closing commands are counted, separately for reclosure after single-pole trip, after three-pole trip, as well as separately for the first reclosure cycle and further reclosure cycles.

The levels of these counted values are buffered against auxiliary voltage failure. They can be set to zero or to any other initial value. For further information refer to the SIPROTEC® 4 System Manual, order no. E50417–H1176–C151.

2.13.5 Circuit Breaker Test

The differential protection 7SD610 allows an easy check of the trip circuits and the circuit breakers.

The test programs according to Table 2-8 are available for the test. Of course, single-pole tests are available only if the device is suitable for 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 via the operation panel on the front of the device or via the PC with DIGSI®. Figure 2-61 shows the chronological sequence of one TRIP-CLOSE test cycle. The set times are those stated in Subsection 2.1.2 for "Command Duration" (addresses 240A **TMin TRIP CMD** and 241A **TMax CLOSE CMD**) and "Circuit Breaker

Test” (address 242 **T-CBtest-dead**). Details how to proceed are given in the SIPROTEC® 4 System Manual, order no. E50417–H1176–C151.

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 on the circuit breaker status during the circuit breaker test is not automatically adopted from the position logic according to 2.13.2 (Figure 2-57). It is rather that special binary inputs are provided to process the breaker status feedbacks for the circuit breaker test. This must be taken into consideration when allocating the binary inputs, as described in Subsection 2.13.2.

The device displays the states of the test sequence with the respective indications.

Table 2-8 Circuit breaker test programs

Item no.	Test programs	Circuit breaker	Output alarms (FNo)
1	Single-pole TRIP/CLOSE cycle phase L1	CB 1	CB1-TESTtrip L1 (7325)
2	Single-pole TRIP/CLOSE cycle phase L2		CB1-TESTtrip L2 (7326)
3	Single-pole TRIP/CLOSE cycle phase L3		CB1-TESTtrip L3 (7327)
4	Three-pole TRIP/CLOSE cycle		CB1-TESTtrip 123 (7328)
	Associated close command		CB1-TEST close (7329)

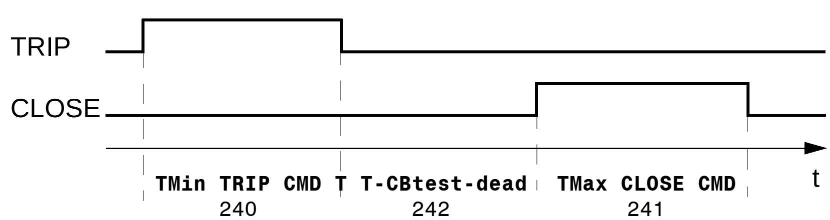


Figure 2-61 TRIP-CLOSE test cycle

2.13.6 Setting the Function Parameters

The parameters for the tripping logic of the entire device and the circuit breaker test have already been set in Subsections 2.1.4 and 2.1.2.

Address 610 **FltDisp.LED/LCD** still decides whether the alarms that are allocated to local LEDs and the spontaneous alarms that appear on the local display after a fault should be stored on every pickup of a protection function (***Target on PU***) or whether they should be stored only when a tripping command is given (***Target on TRIP***).

2.13.7 Setting Overview

Fault Display

Addr.	Setting Title	Setting Options	Default Setting	Comments
610	FltDisp.LED/LCD	Display Targets on every Pickup Display Targets on TRIP only	Display Targets on every Pickup	Fault Display on LED / LCD

2.13.8 Information Overview

Circuit Breaker Test

F.No.	Alarm	Comments
07325	CB1-TESTtrip L1	CB1-TEST TRIP command - Only L1
07326	CB1-TESTtrip L2	CB1-TEST TRIP command - Only L2
07327	CB1-TESTtrip L3	CB1-TEST TRIP command - Only L3
07328	CB1-TESTtrip123	CB1-TEST TRIP command L123
07329	CB1-TEST close	CB1-TEST CLOSE command
07345	CB-TEST running	CB-TEST is in progress
07346	CB-TSTstop FLT.	CB-TEST canceled due to Power Sys. Fault
07347	CB-TSTstop OPEN	CB-TEST canceled due to CB already OPEN
07348	CB-TSTstop NOTr	CB-TEST canceled due to CB was NOT READY
07349	CB-TSTstop CLOS	CB-TEST canceled due to CB stayed CLOSED
07350	CB-TST .OK.	CB-TEST was succesful
	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

2.14 Commissioning Tools

2.14.1 Function Description

The device is provided with a comprehensive commissioning and monitoring tool that checks the communication and the whole differential protection system. Using a personal computer in conjunction with a web-browser this tool enables the user to chart the state of the system and the communication of the differential protection clearly.

The necessary operator software is integrated in the device; online-help can be found on the DIGSI® CD and is also available in the Internet.

To ensure a proper communication between the device and the PC browser the transmission speed must be equal for both. Furthermore, the user must set an IP-address so that the browser can identify the device.

Thanks to the “IBS-tool” the user is able to operate the device with the PC. On the PC-screen the front panel of the device is emulated, a function that can also be deactivated by the settings.

2.14.2 Setting the Function Parameters

The parameters of the “IBS-tool” can be set separately for the front operating interface and the service interface. The relevant addresses are those which relate to the interface that is used for communication with the PC and the “IBS-tool”.

Addresses 4401 to 4406 are to configure the front interface. The 12-digit IP-address is formatted as follows: ***.***.***.***. There is a 3-digit block in each of the following setting addresses: 4401 **IP-A (A.x.x.x)**, 4402 **IP-B (x.B.x.x)**, 4403 **IP-C (x.x.C.x)** and 4404 **IP-D (x.x.x.D)**.

The address 4405 **NUM LOCK** determines if the differential protection device should be operated with the “IBS-tool” from the PC. When setting ***YES***, the devices cannot be operated by the front panel emulation of the PC. This is the normal state during operation. Once this address is set to ***NO*** during commissioning, all device parameters can be changed to correct, for example, false or inconsistent settings.

In address 4406 **LCP/NCP** set if your PC-interface supports LCP (Link Control Protocol) and NCP (Network Control Protocol). To make possible the long-distance data transmission for a point-to-point connection the setting must be ***YES*** (default setting). When using a star coupler only one device (master-device) requires the setting ***YES***, the other device requires ***NO***.

Addresses 4411 **IP-A (A.x.x.x)**, 4412 **IP-B (x.B.x.x)**, 4413 **IP-C (x.x.C.x)** and 4414 **IP-D (x.x.x.D)**, 4415 **NUM LOCK** and 4416 **LCP/NCP** are to configure the rear interface.

2.14.3 Setting Overview

Addr.	Setting Title	Setting Options	Default Setting	Comments
4401	IP-A (A.x.x.x)	0..255	141	IP-address ×××.xxx.xxx.xxx(Position 1-3)
4402	IP-B (x.B.x.x)	0..255	142	IP-address xxx.×××.xxx.xxx(Position 4-6)
4403	IP-C (x.x.C.x)	0..255	255	IP-address xxx.xxx.×××.xxx(Position 7-9)
4404	IP-D (x.x.x.D)	0..255	150	IP-address xxx.xxx.xxx.×××(Pos. 10-12)
4405	NUM LOCK	YES NO	YES	Num Lock
4406	LCP/NCP	NO YES	YES	Front interface supports LCP/ NCP mode
4411	IP-A (A.x.x.x)	0..255	141	IP-address ×××.xxx.xxx.xxx(Position 1-3)
4412	IP-B (x.B.x.x)	0..255	142	IP-address xxx.×××.xxx.xxx(Position 4-6)
4413	IP-C (x.x.C.x)	0..255	255	IP-address xxx.xxx.×××.xxx(Position 7-9)
4414	IP-D (x.x.x.D)	0..255	160	IP-address xxx.xxx.xxx.×××(Pos. 10-12)
4415	NUM LOCK	YES NO	YES	Num Lock
4416	LCP/NCP	NO YES	YES	Service interface supports LCP/ NCP mode

2.15 Ancillary Functions

The ancillary functions of the 7SD610 relay include:

- processing of messages,
- processing of operational measured values,
- storage of fault record data.

2.15.1 Processing of Messages

2.15.1.1 General

For the detailed fault analysis, the information regarding the reaction of the protection device and the measured values following a system fault are of interest. For this purpose, the device provides information processing which operates in a threefold manner:

Indicators (LEDs) and Binary Outputs (Output Relays)

Important events and states are indicated with optical indicators (LED) on the front plate. The device furthermore has output relays for remote indication. Most of the signals and indications can be marshalled, i.e. routing can be changed from the presetting with delivery. The procedure is described in detail in the SIPROTEC® 4 system manual, order no. E50417–H1176–C151. The state of the delivered relay (presetting) is listed in Section A.4 of the Appendix.

The output relays and the LEDs may be operated in a latched or unlatched mode (each may be individually set).

The latched state is saved against loss of auxiliary supply. It is reset:

– locally by operation of the key LED reset on the front of the device,

– from remote via a binary input,

– via one of the serial interfaces,

– automatically on detection of a new fault.

Condition messages should not be latched. Also, they cannot be reset until the condition to be reported has reset. This applies to e.g. messages from monitoring functions, or similar.

A green LED indicates that the device is in service (“RUN”); it can not be reset. It extinguishes if the self-monitoring of the microprocessor recognizes a fault or if the auxiliary supply fails.

In the event that the auxiliary supply is available while there is an internal device failure, the red LED (“ERROR”) is illuminated and the device is blocked.

The binary inputs, outputs, and LEDs of a SIPROTEC®4 device can be individually and precisely checked using DIGSI®. This feature is used to verify wiring from the device to plant equipment during commissioning (refer also to Subsection 3.3.4).

Information on the Integrated Display (LCD) or to a Personal Computer

Events and states can be obtained from the LCD on the front plate of the device. A personal computer can be connected to the front interface or the service interface for retrieval of information.

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). In the event of a system fault, information regarding the fault, the so-called spontaneous displays, are displayed instead. The quiescent state information is displayed again once the fault messages have been acknowledged. The acknowledgement is identical to the resetting of the LEDs (see above).

The device in addition has several event buffers for operational messages, switching statistics, etc., which are saved against loss of auxiliary supply by means of a battery buffer. These messages can be displayed on the LCD at any time by selection via the keypad or transferred to a personal computer via the serial service or PC interface. The retrieval of events/alarms during operation is extensively described in the SIPROTEC® 4 System Manual, order no. E50417–H1176–C151.

With a PC and the protection data processing program DIGSI® it is also possible to retrieve and display the events with the convenience of visualisation on a monitor and a menu-guided dialogue. The data may be printed or stored for later evaluation.

Information to a Control Centre

If the device has a serial system interface, the information may additionally be transferred via this interface to a centralized control and monitoring system. Several communication protocols are available for the transfer of this information.

You may test whether the information is transmitted correctly with DIGSI®.

Also the information transmitted to the control centre can be influenced during operation or tests. For on-site monitoring, the IEC protocol 60870–5–103 offers the option to add a comment saying “test mode” to all annunciations and measured values transmitted to the control centre. It is then understood as the cause of annunciation and there is no doubt on the fact that messages do not derive from real disturbances. Alternatively, you may disable the transmission of annunciations 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 A.4, margin heading “Preset CFC-Charts”, page 272).

For information on how to enable and disable the test mode and the transmission block see for the SIPROTEC® 4 System Manual E50417–H1176–C151.

Structure of Messages

The messages are categorized as follows:

- Event Log: These are operating messages that can occur during the operation of the device. They include information about the status of device functions, measurement data, system data, and similar information.
- Trip Log: These are fault messages from the last eight network faults that were processed by the device.
- Switching statistics: These messages count the breaker control commands initiated by the device, values of accumulated circuit currents, and interrupted currents.
- Resetting and presetting of the stored messages and counters.

A complete list of all message and output functions that can be generated by the device, with the associated information number (FNo), can be found in the Appendix. The lists also indicate where each message can be sent. The lists are based on a SIPROTEC® 4 device with the maximum complement of functions. If functions are not present in the specific version of the device, or if they are set as "***Disabled***" in device configuration, then the associated messages cannot appear.

2.15.1.2 Event Log (Operating Messages)

Operating messages contain information that the device generates during operation and about the operation. Up to 200 operating messages are stored in chronological order in the device. New messages are added at the end of the list. If the memory has been exceeded, then the oldest message is overwritten for each new message.

Operational annunciations come in automatically and can be read out from the device display or a personal computer. Faults in the power system are indicated with "`Network Fault`" and the present fault number. The fault messages (Trip Log) contain details about the history of faults. This topic is discussed in Subsection 2.15.1.3.

2.15.1.3 Trip Log (Fault Messages)

Following a system fault, it is possible to for example retrieve important information regarding its progress, such as pickup and trip. The start of the fault is time stamped with the absolute time of the internal system clock. The progress of the disturbance is output with a relative time referred to the instant of fault detection (first pickup of a protection function), so that the duration of the fault until tripping and up to reset of the trip command can be ascertained. The resolution of the time information is 1 ms.

A system fault starts with the recognition of the 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, or after the expiry of the auto-reclose reclaim time, so that several unsuccessful auto-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).

Spontaneous Displays

The spontaneous messages appear automatically in the display, after a general pickup of the device. The most important data about a fault can be viewed on the device front in the sequence shown in Figure 2-62.

```
Diff Pickup L1E
PU Time 93 ms
TRIP Time 0 ms
```

Protection function that had picked up latest, e.g. differencial protection, with phase information;
Elapsed time from pick-up until drop-off;
Elapsed time from pick-up until the first trip command of a protection function;
differential protection mostly 0

Figure 2-62 Display of spontaneous messages in the display — example

Retrieved messages

The messages for the last eight network faults can be retrieved. Altogether up to 600 indications can be stored. Oldest data are erased for newest data when the buffer is full.

2.15.1.4 Spontaneous Annunciations

Spontaneous annunciations contain information on new incoming annunciations. Each new incoming annunciation appears immediately, i.e. the user does no have to wait for an update or initiate one. This can be a useful help during operation, testing and commissioning.

Spontaneous annunciations can be read out via DIGSI®. For further information see the SIPROTEC® 4 System Manual (order-no. E50417–H1176–C151).

2.15.1.5 General Interrogation

The present condition of a SIPROTEC® device can be examined by using DIGSI® to view the contents of the “General Interrogation” annunciation. All of the messages that are needed for a general interrogation are shown along with the actual values or states.

2.15.1.6 Switching Statistics

The messages in switching statistics are counters for the accumulation of interrupted currents by each of the breaker poles, the number of control commands issued by the device to the breakers, and the maximum interrupted currents. The interrupted currents are in primary terms.

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.

In 7SD610 the statistics register the data of the protection communication. The transmission time of the information from device to device via protection data interfaces (to and fro) is measured steadily and registered in the folder “Statistic”. The availability of the means of transmission is also indicated. The availability is indicated in %/min and %/h. This enables the user to assess the transmission quality.

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 back to zero or to any value within the setting range.

A password is not required to read switching statistics; however, a password is required to change or delete the statistics. For further information see the SIPROTEC® 4 System Manual (order-no. E50417–H1176–C151).

2.15.2 Measurement during Operation

Display and Transmission of Measured Values

Operating measured values and metered values 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 (if available).

The operational measured values are also calculated in the event of a running fault in intervals of approximately 2 s.

Precondition for a correct display of primary and percentage values is the complete and correct entry of the rated values of the instrument transformers and the power system as well as the transformation ratio of the current and voltage transformers in the ground paths according to Subsection 2.1.2.

Table 2-9 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 in Table 2-9 is available.

Voltages can only be available if the voltages phase-to earth are connected to the relay and this is in accordance with the configuration of the device. The residual voltage $3U_0$ is the e-n-voltage multiplied by $\sqrt{3}$ (if U_{en} is connected) or calculated from the phase-to-earth-voltages $3U_0 = |U_{L1} + U_{L2} + U_{L3}|$. For this the three voltage inputs phase-to-earth must be connected.

The power components P, Q are positive, when real power or inductive reactive power are flowing into the protected object, assuming that this direction has been parameterized as “forward”.

The sign of the power factor cos φ corresponds to the sign of the real power.

Overload measured values can appear only if the overload protection was configured ***Enabled***.

Table 2-9 Operational measured values of the local device

Measured values		primary	secondary
I_{L1}, I_{L2}, I_{L3}	Phase currents	A	A
$3I_0$	Ground current (residual current)	A	A

Table 2-9 Operational measured values of the local device

Measured values		primary	secondary
$\varphi(I_{L1}-I_{L2})$, $\varphi(I_{L2}-I_{L3})$, $\varphi(I_{L3}-I_{L1})$	Phase angle of the phase currents towards each other	°	—
I_1, I_2	Positive and negative sequence component of the currents	A	A
U_{L1-L2}, U_{L2-L3}, U_{L3-L1}	Phase-to-phase voltages	kV	V
U_{L1-E}, U_{L2-E}, U_{L3-E}	Phase-to-ground voltages	kV	V
$3U_0$	Displacement voltage (Residual voltage)	kV	V
$\varphi(U_{L1}-U_{L2})$, $\varphi(U_{L2}-U_{L3})$, $\varphi(U_{L3}-U_{L1})$	Phase angle of the phase voltages towards each other	°	—
$\varphi(U_{L1}-I_{L1})$, $\varphi(U_{L2}-I_{L2})$, $\varphi(U_{L3}-I_{L3})$	Phase angle of the phase voltages towards the phase currents	°	—
U_1, U_2	Positive and negative sequence component of the voltages	kV	V
S, P, Q	Apparent, active and reactive power	MVA, MW, MVAR	—
cos φ	Power factor	(abs)	(abs)
f	Frequency	Hz	Hz
$\Theta_{L1}/\Theta_{TRIP}$, $\Theta_{L2}/\Theta_{TRIP}$, $\Theta_{L3}/\Theta_{TRIP}$	Thermal value of each phase, referred to the tripping value	%	—
Θ/Θ_{TRIP}	Thermal resultant value, referred to the tripping value, calculated according to the set method	%	—

Differential Protection Values

The differential and restraint values of the differential protection are listed in Table 2-10.

Table 2-10 Measured values of the differential protection

Measured values		% referring to
$IDiff_{L1}$, $IDiff_{L2}$, $IDiff_{L3}$	Calculated differential currents of the three phases	Rated operating current [1])
$IRest_{L1}$, $IRest_{L2}$, $IRest_{L3}$	Calculated restraint currents of the three phases	Rated operating current [1])
$IDiff_{3I0}$	Calculated differential current of the zero sequence system	Rated operating current [1])

[1]) for lines according to address 1104 (see Subsection 2.1.4),
for transformers calculated from address 1106 (see Subsection 2.1.4) $I_N = S_N/(\sqrt{3}\cdot U_N)$

Remote Measured Values

When the 7SD610 devices communicate, the data of the opposite end of the protected object can be read out. The currents and voltages involved as well as phase shifts between the local and remote measured quantities can be displayed. This is especially helpful for checking the correct and coherent phase allocation at both line ends and for the verification of the vector group if a power transformer is within the protected zone. Furthermore, the device address of the other device is transmitted. In this way all important data of both ends are available at any line end. All possible data are listed in Table 2-11.

Table 2-11 Operational measured values transmitted from the other end and compared with the local values

Data		% referring to
Device ADR	Device address of the remote device	(abs)
I_{L1}, I_{L2}, I_{L3} remote	Phase currents of the remote device	Rated operat. current [1])
I_{L1}, I_{L2}, I_{L3} local	Phase currents of the local device	Rated operat. current [1])
$\varphi(I_{L1})$, $\varphi(I_{L2})$, $\varphi(I_{L3})$	Phase angles between the remote and the local phase currents	°
U_{L1}, U_{L2}, U_{L3} remote	Voltages of the remote device	Rated operat. voltage/$\sqrt{3}$ [2])
U_{L1}, U_{L2}, U_{L3} local	Voltages of the local device	Rated operat. voltage/$\sqrt{3}$ [2])
$\varphi(U_{L1})$, $\varphi(U_{L2})$, $\varphi(U_{L3})$	Phase angles between the remote and the local voltages	°

[1]) for lines according to address 1104 (see Subsection 2.1.4),
for transformers calculated from address 1106 (see Subsection 2.1.4) $I_N = S_N/(\sqrt{3} \cdot U_N)$
[2]) according to address 1103 (see Subsection 2.1.4)

Transmission Statistics

In 7SD610 the data concerning the protection communication is registered in statistics. The transmission times of the information between the devices via interfaces (send and receive) are measured continuously. 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 allows the user to assess the quality of the transmission.

If GPS-synchronization is configured, the transmission times for each direction are regularly measured and indicated as long as GPS-synchronization is intact.

“IBS-tool”

The “IBS-tool” is a comprehensive commissioning and visualization tool which enables the user to chart data of the complete differential protection system on a PC-screen by means of an internet 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 refer to the “Online Help” for the “IBS-tool”.

This tool allows to illustrate the measured values, the currents, voltages (if connected to the system) and their phase relationship for all devices connected to the differential protection system. In addition to phasor diagrams, numerical values as well as frequency and device addresses are indicated. Figure 2-63 shows an example.

Additionally, the position of the differential and restraint values can be viewed in the pickup characteristic.

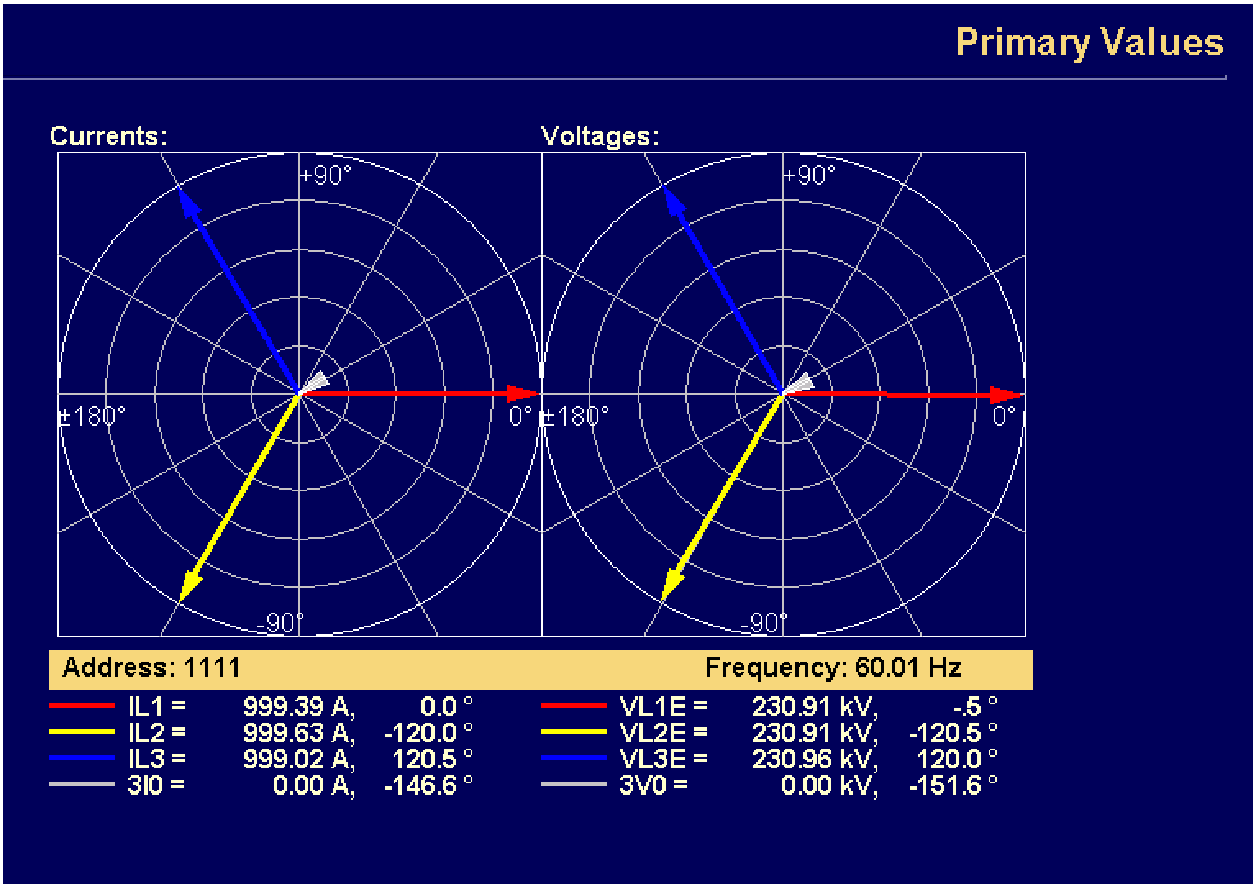


Figure 2-63 Local measured values in the “IBS-tool” — example for voltages and currents

2.15.3 Fault Recording

The differential protection 7SD610 is equipped with a fault recording function. The instantaneous values of the measured quantities

i_{L1}, i_{L2}, i_{L3}, $3\,i_0$, u_{L1}, u_{L2}, u_{L3}, $3\,u_0$ and I_{DiffL1}, I_{DiffL2}, I_{DiffL3}, I_{RestL1}, I_{RestL2}, I_{RestL3}

(voltages depending on the connection) are sampled at 1 ms intervals (for a frequency of 50 Hz) and stored in a cyclic buffer (20 samples per period). During a system fault these data are stored over a time span that can be set (5 s at the longest for each fault record). Up to 8 faults can be stored. The total capacity of the fault record memory is approx. 15 s. The fault recording buffer is updated when a new fault occurs, so that acknowledging is not necessary. Fault recording can be initiated, additionally to the protection pickup, via the integrated operator panel, the serial operator interface and the serial service interface.

For the differential protection system of a protected object both fault records of both ends are synchronized by the time management features. This ensures that all fault records operate with exactly the same time basis. Therefore equal measured values are coincident at both ends.

The data can be retrieved via the serial interfaces by means of a personal computer and evaluated with the protection data processing program DIGSI® and the graphic analysis software SIGRA. The latter graphically represents the data recorded during the system fault and calculates additional information from the measured values. A selection may be made as to whether the measured quantities 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. The evaluation of the data is done by the respective programs in the central device. The measured quantities are referred to their maximum values, scaled to their rated values and prepared for graphic representation. In addition, internal events are recorded as binary traces (marks), e.g. “fault detection”, “tripping”.

Where transfer to a central device is possible, the request for data transfer can be executed automatically. It can be selected to take place after each fault detection by the protection, or only after a trip.

2.15.4 Setting the Function Parameters

Data Storage for Fault Recording

The parameters of the fault recording memory are set in the sub-menu **Oscillographic Fault Recordings** of the menu **Settings**.

Distinction is made between the starting instant (i.e. the instant where time tagging is T = 0) and the criterion to save the record (address 402A **WAVEFORMTRIGGER**). With the setting ***Save w. Pickup***, the starting instant and the criterion for saving are the same: the pickup of any protective element. The option ***Save w. TRIP***) means that the pickup of a protective function still starts fault recording but the record is saved only if the device issues a trip command. The third option for address 402A is ***Start w. TRIP***: A trip command issued by the device is both the starting instant and the criterion to save the record.

A fault event starts with the fault detection of any protection function and ends with the reset of the last fault detection. Usually this is also the extent of a fault recording (address 403A **WAVEFORM DATA** = ***Fault event***). If automatic reclosure is implemented, the entire system disturbance — possibly with several reclose attempts — up to the final fault clearance can be stored (address 403A **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).

The actual storage amount of data encompasses the pre-trigger time **PRE. TRIG. TIME** (address 411) before the starting instant, the normal recording time and the post-fault time **POST REC. TIME** (address 412) after the storage criterion has reset. The maximum permissible storage period per fault recording **MAX. LENGTH** is set in address 410. A maximum recording time of 5 s is available per fault recording. In total up to 8 fault records with a total recording time of max. 15 s can be stored.

An oscillographic record can be triggered and saved via a binary input or via the operating interface connected to a PC. The trigger is dynamic. The length of the fault recording is set in address 415 **BinIn CAPT.TIME** (maximum length however is **MAX. LENGTH**, address 410). The pre- and post-fault times are additive. If the time for the binary input is set to ∞, the length of the record equals the time that the binary input is activated (static), the maximum length however still is **MAX. LENGTH** (address 410).

2.15.5 Setting Overview

Note: Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Fault Recording

Addr.	Setting Title	Setting Options	Default Setting	Comments
402A	WAVEFORMTRIG-GER	Save with Pickup Save with TRIP Start with TRIP	Save with Pickup	Waveform Capture
403A	WAVEFORM DATA	Fault event Power System fault	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

2.15.6 Information Overview

Statistics

F.No.	Alarm	Comments
02895	AR #Close1./1p=	No. of 1st AR-cycle CLOSE commands 1pole
02896	AR #Close1./3p=	No. of 1st AR-cycle CLOSE commands 3pole
02897	AR #Close2./1p=	No. of higher AR-cycle CLOSE commands 1p
02898	AR #Close2./3p=	No. of higher AR-cycle CLOSE commands 3p
01000	# TRIPs=	Number of breaker TRIP commands
01001	TripNo L1=	Number of breaker TRIP commands L1

F.No.	Alarm	Comments
01002	TripNo L2=	Number of breaker TRIP commands L2
01003	TripNo L3=	Number of breaker TRIP commands L3
01027	Σ IL1 =	Accumulation of interrupted current L1
01028	Σ IL2 =	Accumulation of interrupted current L2
01029	Σ IL3 =	Accumulation of interrupted current L3
01030	Max IL1 =	Max. fault current Phase L1
01031	Max IL2 =	Max. fault current Phase L2
01032	Max IL3 =	Max. fault current Phase L3
07751	PI1 TD	Prot.Interface 1:Transmission delay
07753	PI1A/m	Prot.Interface 1: Availability per min.
07754	PI1A/h	Prot.Interface 1: Availability per hour
07875	PI1 TD R	Prot.Interface 1:Transmission delay rec.
07876	PI1 TD S	Prot.Interface 1:Transmission delay send

Local Values

F.No.	Alarm	Comments
00601	IL1 =	I L1
00602	IL2 =	I L2
00603	IL3 =	I L3
00610	3I0 =	3I0 (zero sequence)
00619	I1 =	I1 (positive sequence)
00620	I2 =	I2 (negative sequence)
07731	Φ IL1L2=	PHI IL1L2 (local)
07732	Φ IL2L3=	PHI IL2L3 (local)
07733	Φ IL3L1=	PHI IL3L1 (local)
00621	UL1E=	U L1-E
00622	UL2E=	U L2-E
00623	UL3E=	U L3-E
00624	UL12=	U L12
00625	UL23=	U L23
00626	UL31=	U L31
00631	3U0 =	3U0 (zero sequence)
00634	U1 =	U1 (positive sequence)
00635	U2 =	U2 (negative sequence)

F.No.	Alarm	Comments
00641	P =	P (active power)
00642	Q =	Q (reactive power)
00643	PF =	Power Factor
00645	S =	S (apparent power)
07734	Φ UL1L2=	PHI UL1L2 (local)
07735	Φ UL2L3=	PHI UL2L3 (local)
07736	Φ UL3L1=	PHI UL3L1 (local)
07737	Φ UIL1=	PHI UIL1 (local)
07738	Φ UIL2=	PHI UIL2 (local)
07739	Φ UIL3=	PHI UIL3 (local)
00644	Freq=	Frequency
00801	Θ /Θtrip =	Temperat. rise for warning and trip
00802	Θ /ΘtripL1=	Temperature rise for phase L1
00803	Θ /ΘtripL2=	Temperature rise for phase L2
00804	Θ /ΘtripL3=	Temperature rise for phase L3

Remote Values

F.No.	Alarm	Comments
07761	Relay ID	Relay ID of 1. relay
07762	IL1_opN=	IL1(% of Operational nominal current)
07763	ΦI L1=	Angle IL1_rem <-> IL1_loc
07764	IL2_opN=	IL2(% of Operational nominal current)
07765	ΦI L2=	Angle IL2_rem <-> IL2_loc
07766	IL3_opN=	IL3(% of Operational nominal current)
07767	ΦI L3=	Angle IL3_rem <-> IL3_loc
07769	UL1_opN=	UL1(% of Operational nominal voltage)
07770	ΦU L1=	Angle UL1_rem <-> UL1_loc
07771	UL2_opN=	UL2(% of Operational nominal voltage)
07772	ΦU L2=	Angle UL2_rem <-> UL2_loc
07773	UL3_opN=	UL3(% of Operational nominal voltage)
07774	ΦU L3=	Angle UL3_rem <-> UL3_loc

F.No.	Alarm	Comments
07781	Relay ID	Relay ID of 2. relay
07782	IL1_opN=	IL1(% of Operational nominal current)

F.No.	Alarm	Comments
07783	ΦI L1=	Angle IL1_rem <-> IL1_loc
07784	IL2_opN=	IL2(% of Operational nominal current)
07785	ΦI L2=	Angle IL2_rem <-> IL2_loc
07786	IL3_opN=	IL3(% of Operational nominal current)
07787	ΦI L3=	Angle IL3_rem <-> IL3_loc
07789	UL1_opN=	UL1(% of Operational nominal voltage)
07790	ΦU L1=	Angle UL1_rem <-> UL1_loc
07791	UL2_opN=	UL2(% of Operational nominal voltage)
07792	ΦU L2=	Angle UL2_rem <-> UL2_loc
07793	UL3_opN=	UL3(% of Operational nominal voltage)
07794	ΦU L3=	Angle UL3_rem <-> UL3_loc

Diff-Values

F.No.	Alarm	Comments
07742	IDiffL1=	IDiffL1(% Operational nominal current)
07743	IDiffL2=	IDiffL2(% Operational nominal current)
07744	IDiffL3=	IDiffL3(% Operational nominal current)
07745	IRestL1=	IRestL1(% Operational nominal current)
07746	IRestL2=	IRestL2(% Operational nominal current)
07747	IRestL3=	IRestL3(% Operational nominal current)
07748	Diff3I0=	Diff3I0 (Differential current 3I0)

Fault Recording

F.No.	Alarm	Comments
00004	>Trig.Wave.Cap.	>Trigger Waveform Capture
00203	Wave. deleted	Waveform data deleted
	FltRecSta	Fault Recording Start

2.16 Processing of Commands

General

In addition to the protective functions described so far, control command processing is integrated in the SIPROTEC® 7SD610 to coordinate the operation of circuit breakers and other equipment in the power system. Control commands can originate from four command sources:

– Local operation using the keypad on the local user interface of the device,

– Local or remote operation using DIGSI®,

– Remote operation via system (SCADA) interface (e.g. SICAM),

– Automatic functions (e.g. using a 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 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 configuration of the binary inputs and outputs, the preparation of user defined logic functions, and the procedure during switching operations are described in the SIPROTEC® 4 System Manual, order no. E50417–H1176–C151.

2.16.1 Types of Commands

Two types of commands can be issued with this device:

- Control commands,
- Internal / pseudo commands.

Control Commands

These commands operate binary outputs and change the power system status:

- Commands for the operation of circuit breakers (without synchro-check) as well as commands for the control of isolators and earthing disconnectors,
- Step commands, e.g. for raising and lowering transformer taps,
- Commands with configurable time settings (e.g. Petersen coils).

Internal / Pseudo Commands

These commands do not directly operate binary outputs. They serve to initiate internal functions, simulate or acknowledge changes of state.

- Manual entries to change the feedback indication of plant such as the status condition, for example in the case when the physical connection to the auxiliary contacts is not available or is defective. The process of manual entries is recorded and can be displayed accordingly.

- Additionally, tagging commands can be issued to establish internal settings, such as switching authority (remote / local), parameter set changeover, data transmission inhibit and metering counter reset or initialization.
- Acknowledgment and resetting commands for setting and resetting internal buffers.
- Status information commands for setting / deactivating the “information status” for the information value of an object:
  – Controlling activation of binary input status,
  – Blocking binary outputs.

2.16.2 Steps in the Command Sequence

Safety mechanisms in the command sequence ensure that a 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:

Check Sequence

- 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 that can be selected for each command
  – Switching authority (local, remote),
  – Switching direction control (target state = present state),
  – 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 protective functions).
- Fixed command checks
  – Timeout monitoring (time between command initiation and execution can be monitored),
  – Configuration in process (if setting modification is in process, commands are rejected or delayed),
  – Equipment not present at output (if controllable equipment is not assigned to a binary output, then the command is denied),
  – 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 denied),
  – Component hardware malfunction,

– Command in progress (only one command can be processed at a time for each circuit breaker or switch),

– 1-out-of-n check (for schemes with multiple assignments and common potential contact, it is checked whether a command has already been initiated for the common output contact).

Monitoring the Command Execution

The following is monitored:

– Interruption of a command because of a cancel command,

– Running time monitor (feedback message monitoring time).

2.16.3 Interlocking

Interlocking is executed by the user-defined logic (CFC). The interlocking checks of a SICAM/SIPROTEC®-system are classified into:

- System interlocking checked by a central control system (for interbay interlocking).
- Zone controlled/bay interlocking checked in the bay device (for the feeder-related interlocking), i.e. in the SIPROTEC® 4 device.

System interlocking relies on the system data base in the central control system. Zone controlled/bay interlocking relies on the status of the circuit breaker and other switches that are connected to the relay, i.e. the SIPROTEC® device.

The extent of the interlocking checks is determined by the configuration and interlocking logic of the relay.

Switchgear which is subject to system interlocking in the central control system is identified with a specific setting in the command properties (in the routing matrix).

For all commands the user can select the operation mode with interlocking (normal mode) or without interlocking (test mode):

– for local commands by reprogramming the settings with password check,

– for automatic commands via command processing with CFC,

– for local / remote commands by an additional interlocking command via Profibus.

2.16.3.1 Interlocked/Non-Interlocked Switching

The command checks that can be selected for the SIPROTEC®-relays are also referred to as “standard interlocking”. These checks can be activated (interlocked) or deactivated (non interlocked) via DIGSI®.

Deactivated interlock switching means the configured interlocking conditions are bypassed in the relay.

Interlocked switching means that all configured interlocking conditions are checked in the command check routines. If a condition could not be fulfilled, the command will be rejected by a message with a minus added to it (e.g. "**CO-**"), followed by an operation response information. Table 2-12 shows some types of commands and messages. For the device the messages designated with *) are displayed in the event logs, for DIGSI® they appear in spontaneous messages.

Table 2-12 Types of command and messages

Type of command	Abbrev.	Message
Control issued	CO	CO+/–
Manual tagging (positive / negative)	MT	MT+/–
Input blocking	IB	IB+/– *)
Output blocking	OB	OB+/– *)
Control abortion	CA	CA+/–

The "plus" sign indicated in the message is a confirmation of the command execution: the command execution was as expected, in other words positive. The "minus" is a negative confirmation, the command was rejected. Figure 2-64 shows the messages relating to command execution and operation response information for a successful operation of the circuit breaker.

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 manual entry or abort are not checked, i.e. carried out independent of the interlocking.

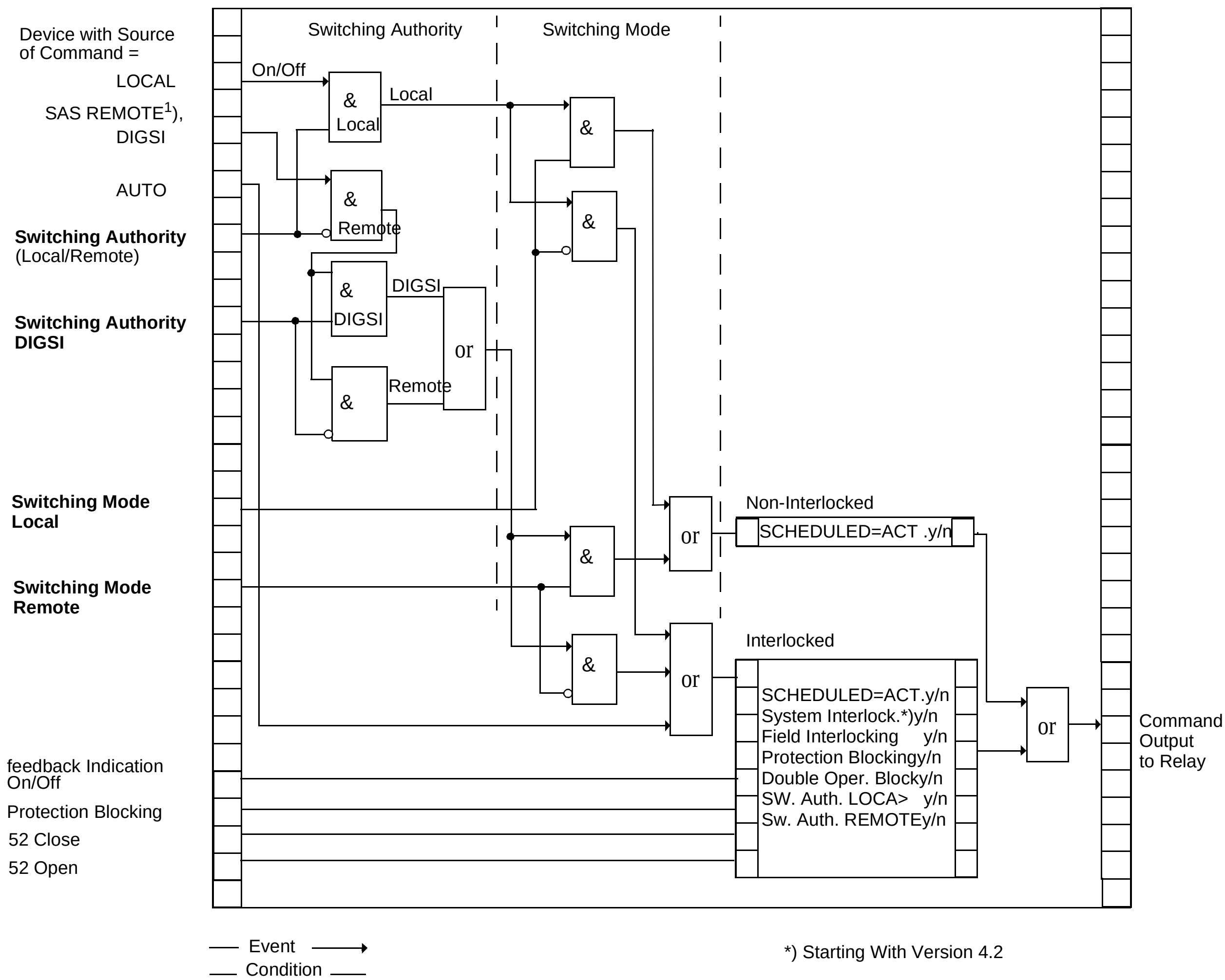
```
EVENT LOG
--------------------
19.06.99 11:52:05,625
Q0          CO+ close

19.06.99 11:52:06,134
Q0          FB+ close
```

Figure 2-64 Example of a message when closing the circuit breaker Q0

Standard Interlocking

The standard interlocking includes the checks for each device which were set during the configuration of inputs and outputs.

An overview for processing the interlocking conditions in the relay is shown by Figure 2-65.



[1]) Source REMOTE also includes SAS.

LOCAL Command via substation controller.

REMOTE Command via telecontrol system to substation controller and from substation controller to device.

Figure 2-65 Standard Interlocking Arrangements

The display shows the configured interlocking reasons. The are marked by letters explained in the following table 2-13.

Table 2-13 Interlocking commands

Interlocking commands	Abbrev.	Message
Control authorization	L	L
System interlock	S	S

Interlocking commands	Abbrev.	Message
Zone controlled	Z	Z
Target state = present state (check switch position)	P	P
Block by protection	B	B

Figure 2-66 shows all interlocking conditions (which usually appear in the display of the device) for three switchgear items with the relevant abbreviations explained in table 2-13. All parameterized interlocking conditions are indicated
(see Figure 2-66).

```
Interlocking   01/03
--------------------
Q0 Close/Open S – Z P B
Q1 Close/Open S – Z P B

Q8 Close/Open S – Z P B
```

Figure 2-66 Example of configured interlocking conditions

Control Logic using CFC

For zone controlled/field interlocking, control logic can be programmed, using the CFC. Via specific release conditions the information “released” or “bay interlocked” are available.

2.16.4 Recording and Acknowledgement of Commands

During the processing of the commands, independent of the further processing of information, command and process feedback information are sent to the message processing centre. These messages contain information on the cause. The messages are entered in the event list.

Acknowledgement of Commands to the Device Front

All information which relates to commands that were issued from the device front “Command Issued = Local” is transformed into a corresponding message and shown in the display of the device.

Acknowledgement of Commands to Local/Remote/Digsi

The messages 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 provided with a response indication as it is done with the local command but with ordinary recorded command and feedback information.

Monitoring of Feedback Information

The processing of commands monitors the command execution and timing of feedback information for all commands. At the same time the command is sent, the monitoring time is started (monitoring of the command execution). This time controls whether the device operation is executed with the required final result within the monitoring time. The monitoring time is stopped as soon as the feedback information is detected. If no feedback information arrives, a response “Timeout command monitoring time” is indicated and the command sequence is terminated.

Commands and information feedback are also recorded in the event list. 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.

The “plus” appearing in a feedback information confirms that the command was successful, 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 and Switching Relays

The command types needed for tripping and closing of the switchgear or for raising and lowering of transformer taps are described in the SIPROTEC® 4 System Manual, order no. E50417–H1176–C151.

2.16.5 Information Overview

F.No.	Alarm	Comments
	Cntrl Auth	Control Authority
	ModeLOCAL	Controlmode LOCAL
	ModeREMOTE	Controlmode REMOTE

■

Installation and Commissioning 3

This chapter is primarily for personnel who are experienced in installing, testing, and commissioning protective and control systems, and are familiar with applicable safety rules, safety regulations, and the operation of the power system.

Installation of the 7SD610 is described in this chapter. Hardware modifications that might be needed in certain cases are explained. Connection verifications required before the device is put in service are also given. Commissioning tests are provided. Some of the tests require the protected object (line, transformer, etc.) to carry load.

3.1 Mounting and Connections

Warning!

The successful and safe operation of the device is dependent on proper handling, installation, and application by qualified personnel under observance of all warnings and hints contained in this manual.

In particular the general erection and safety regulations (e.g. IEC, DIN, VDE, EN or other national and international standards) regarding the correct use of hoisting gear must be observed. Non-observance can result in death, personal injury, or substantial property damage.

Preconditions

Verify that the 7SD610 has the expected features by checking the complete ordering number with the ordering number codes given in Section A.1 of the Appendix. Also check that the required and expected accessories are included with the device. The ordering number of the device is on the nameplate sticker on the housing. The nameplate also indicates the ratings of the device. A verification that these ratings are the expected values is especially important.

3.1.1 Installation

Panel Flush Mounting

- ❑ Remove the 4 covering caps located on the corners of the front cover, reveal the 4 slots in the mounting flange.
- ❑ Insert the device into the panel cut-out and fasten with four screws. Refer to Figure 4-5 in Section 4.13 for dimensions.
- ❑ Replace the four cover caps.
- ❑ Connect the ground on the rear plate of the device to the protective ground of the panel. Use at least one M4 screw for the device ground. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-section of the ground wire must be at least 2.5 mm^2.
- ❑ Connect the plug terminals and/or the screwed terminals on the rear side of the device according to the wiring diagram for the panel.
  When using forked lugs or directly connecting wires to screwed terminals, the screws must be tightened so that the heads are even with the terminal block before the lugs or wires are inserted.
  A ring lug must be centred in the connection chamber so that the screw thread fits in the hole of the lug.
  The System Manual (order-no. E50417–H1176–C151) has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.

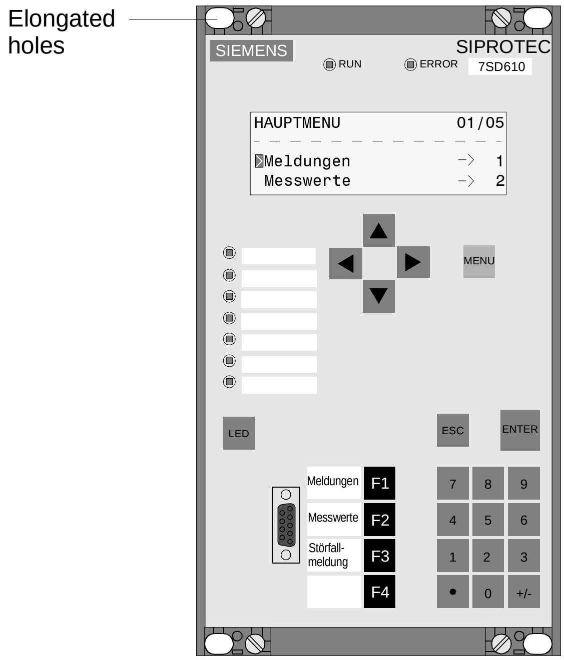


Figure 3-1 Panel mounting of a 7SD610

Rack Mounting and Cubicle Mounting

To install the device in a frame or cubicle, two mounting brackets are required. The ordering codes are stated in the Appendix in Section A.1.1.

- ❑ Loosely screw the two mounting brackets in the rack with four screws.
- ❑ Remove the 4 covers at the corners of the front cover. The 4 slots in the mounting flange are revealed and can be accessed.
- ❑ Fasten the device to the mounting brackets with four screws.
- ❑ Replace the four covers.
- ❑ Tighten the mounting brackets to the rack using eight screws.
- ❑ Connect the ground on the rear plate of the device to the protective ground of the rack. Use at least one M4 screw for the device ground. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-section of the ground wire must be at least 2.5 mm^2.
- ❑ Connect the plug terminals and/or the screwed terminals on the rear side of the device according to the wiring diagram for the rack.
  When using forked lugs or directly connecting wires to screwed terminals, the screws must be tightened so that the heads are even with the terminal block before the lugs or wires are inserted.
  A ring lug must be centred in the connection chamber so that the screw thread fits in the hole of the lug.
  The System Manual (order-no. E50417–H1176–C151) has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.

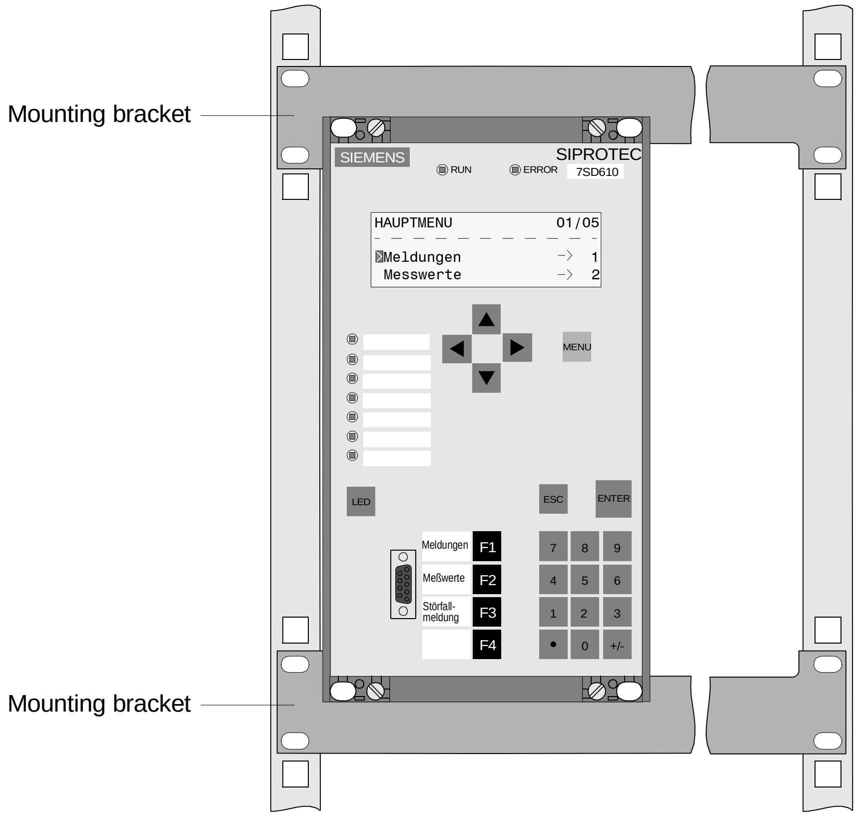


Figure 3-2 Installing a 7SD610 in a rack or cubicle

Panel Surface Mounting

- Secure the device to the panel with four screws. Refer to Figure 4-6 in Section 4.13 for dimensions.
- Connect the ground of the device to the protective ground of the panel. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-section of the ground wire must be at least 2.5 mm^2.
- Solid, low-impedance operational grounding (cross-sectional area $\geq$ 2.5 mm^2) must be connected to the grounding surface on the side. Use at least one M4 screw for the device ground.
- Connect the screwed terminals on the top and bottom of the device according to the wiring diagram for the panel. Optical connections are made on the inclined housings on the top and/or bottom of the case.
  The System Manual (order-no. E50417–H1176–C151) has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.

3.1.2 Termination variants

Outline diagrams are shown in Appendix A.2. Connection examples for current and voltage transformer circuits are provided in Appendix A.3. It must be checked that the setting configuration of the **Power System Data 1** corresponds with the connections to the device.

Currents

The Figures A-3 and A-4 show examples of the current transformer connection options.

For the normal connection according to Figure A-3 address 220 must be set to **I4 transformer** = ***In prot. line***, and furthermore address 221 must be set to **I4/Iph CT** = ***1.000***.

For the connection as shown in Figure A-4 the setting of address 220 must also be **I4 transformer** = ***In prot. line***. The factor 221 **I4/Iph CT** may deviate from 1. For notes on how to calculate the factor, refer to Subsection 2.1.2 under “Connection of the Currents”.

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, see Section 2.1.1).

The Figures A-5 and A-6 show examples of the voltage transformer connection options.

For the normal connection as shown in Figure A-5 the fourth voltage measuring input U_4 is not used. Correspondingly address 210 must be set to **U4 transformer** = ***Not connected***. The factor in address 211 **Uph / Udelta** must however be set to ***1.73*** (this factor is used internally for the conversion of measurement and fault recording values).

Figure A-6 shows the additional connection of an e-n-winding of the voltage transformer set. Address 210 **U4 transformer** = ***Udelta transf.*** must be set. The factor in address 211 **Uph / Udelta** depends on the transformation ratio of the e-n-winding. For more information refer to “Connecting the Voltage” in Subsection 2.1.2.

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 of the binary inputs and outputs of the device can be found in Tables A-1 and A-2 in Section A.4 of Appendix A. Also check that the labels on the front panel correspond to the configured message 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 assigned for this purpose (if used).

Changing Setting Groups with Binary Inputs

If binary inputs are used to switch setting groups, note:

- Two binary inputs must be dedicated to the purpose of changing setting groups when four groups are to be switched. One binary input must be set for “>Set Group Bit 0”, the other input for “>Set Group Bit 1”. If either of these input functions is not assigned, then it is considered as not controlled.

- To control two setting groups, one binary input set for “>Set Group Bit 0” is sufficient since the binary input “>Set Group Bit 1”, 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.

Table 3-1 shows the relationship between “>Set Group Bit 0”, “>Set Group Bit 1”, and the setting groups A to D. Principal connection diagrams for the two binary inputs are illustrated in Figure 3-3. 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 Setting group selection with binary inputs — example

Binary Input Events		Active Group
>Set Group Bit 0	>Set Group Bit 1	
no	no	Group A
yes	no	Group B
no	yes	Group C
yes	yes	Group D

no = not energized
yes = energized

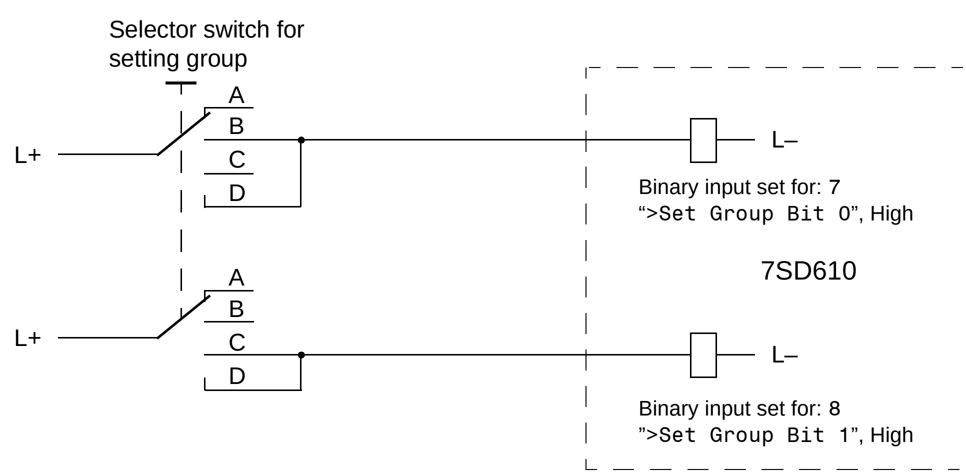


Figure 3-3 Connection diagram (example) for setting group switching with binary inputs

Trip Circuit Supervision

It must be noted 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 volt-free i.o.w. not be commoned with each other or with another binary input.

If *one* binary input is used, a bypass resistor R must be employed (refer to Figure 3-4). This resistor R is connected in series with the second circuit breaker auxiliary contact (Aux2), to also allow the detection of a trip circuit failure when the circuit breaker auxiliary contact 1 (Aux1) is open, and the command relay contact has reset. The value of this resistor must be such that in the circuit breaker open condition (therefore 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.

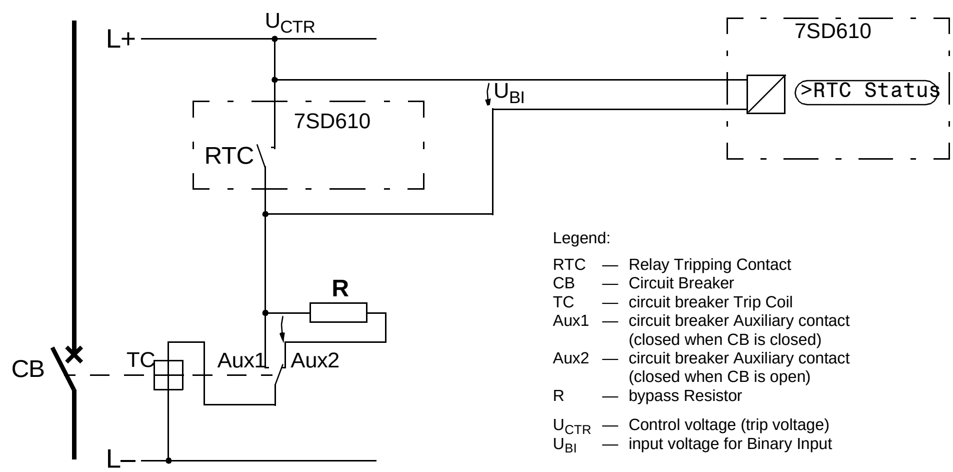


Figure 3-4 Trip circuit supervision with one binary input

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 should be selected.

$$R = \frac{R_{max} + R_{min}}{2}$$

In order that the minimum voltage for controlling the binary input is ensured, R_{max} is derived as:

$$R_{max} = \left(\frac{U_{CRT} - U_{BI\ min}}{I_{BI\ (High)}}\right) - R_{CBTC}$$

So the circuit breaker trip coil does not remain energized in the above case, R_{min} is derived as:

$$R_{min} = R_{TC} \cdot \left(\frac{U_{CTR} - U_{TC\ (LOW)}}{U_{TC\ (LOW)}}\right)$$

$I_{BI\ (HIGH)}$	Constant current with BI on (=1.8 mA)
$U_{BI\ min}$	Minimum control voltage for BI = 19 V for delivery setting for nominal voltages of 24/48/60 V; = 88 V for delivery setting for nominal voltages of 110/125/220/250 V; = 176 V for delivery setting for nominal voltages of 220/250 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 $U_{BI\ min}$, and this threshold must be implemented in the relay using plug-in bridges (see Subsection 3.1.3).

For the power consumption of the resistor:

$$P_R = I^2 \cdot R = \left(\frac{U_{CTR}}{R + R_{CBTC}}\right)^2 \cdot R$$

<u>Example:</u>

$I_{BI\ (HIGH)}$	1.8 mA (from SIPROTEC® 7SD610)
$U_{BI\ min}$	19 V for delivery setting for nominal voltage 24/48/60 V
U_{CTR}	110 V from trip circuit (control voltage)
R_{CBTC}	500 Ω from trip circuit (resistance of CB trip coil)
$U_{CBTC\ (LOW)}$	2 V from trip circuit (max. voltage not to trip breaker)

$$R_{max} = \left(\frac{110\ V - 19\ V}{1.8\ mA}\right) - 500\ \Omega$$

$$R_{min} = 500\ \Omega\ \left(\frac{110\ V - 2\ V}{2\ V}\right) - 500\ \Omega$$

$$R_{max} = 50.1\ k\Omega$$

$$R_{min} = 27\ k\Omega$$

$$R = \frac{R_{max} + R_{min}}{2} = 38.6\ k\Omega$$

The closest standard value of 39 kΩ is selected; the power is:

$$P_R = \left(\frac{110\ V}{39\ k\Omega + 0.5\ k\Omega}\right)^2 \cdot 39\ k\Omega$$

$$P_R \geq 0.3\ W$$

3.1.3 Hardware Modifications

3.1.3.1 General

Hardware modifications might be necessary or desired. For example, a change of the pick-up threshold for some of the binary inputs might be advantageous in certain applications. Terminating resistors might be required for the communication bus. In either case, hardware modifications are needed. If modifications are done or interface modules are replaced, please observe the details in Subsections 3.1.3.2 to 3.1.3.5.

Power Supply Voltage

There are different input ranges for the power supply voltage. Refer to the data for the 7SD610 ordering numbers in Section A.1 of Appendix A. The power supplies with the ratings 60/110/125 VDC and 110/125/220/250 VDC / 115 VAC are interconvertible. Jumper settings determine the rating. The assignment of these jumpers to the supply voltages are illustrated below in Section 3.1.3.3 under subtitle “Processor board CPU”. When the relay is delivered, these jumpers are set according to the name-plate sticker. Generally, they need not be altered.

Nominal Currents

Jumper settings determine the rating of the current input transducers of the device. When the relay is delivered, these jumpers are set according to the name-plate sticker to 1 A or 5 A. The physical arrangements of these jumpers that correspond to the different current ratings are described below in Section 3.1.3.3 under subtitle „Input/Output Board I/O-11“.

Note:

If nominal current ratings are changed for exceptional reason, then the new ratings must be recorded under address 206 **CT SECONDARY** in the **Power System Data 1** (see Subsection 2.1.2).

Control Voltages for Binary Inputs

When the device is delivered from the factory, the binary inputs are set to operate with a voltage that corresponds to the rated voltage of the power supply. In general, to optimize the operation of the inputs, the pickup voltage of the inputs should be set to most closely match the actual control voltage being used. Each binary input has a pickup voltage that can be independently adjusted; therefore, each input can be set according to the function performed.

Jumper positions can be changed to adjust the pickup voltage of a binary input. The physical arrangement of the binary input jumpers in relation to the pickup voltages is explained below in Section 3.1.3.3 under “Processor board CPU” and “Input/Output Board I/O-11”.

Note:

If the 7SD610 performs trip circuit monitoring, two binary inputs, or one binary input and a resistor, are connected in series. The pickup voltage of these inputs must be less than half of the nominal DC voltage of the trip circuit.

Interface Modules

The serial interface modules can be replaced in models for installation in panels or cubicles. Which kind of interfaces and how the interfaces can be replaced is described in „Replacing Interface Modules”, Section 3.1.3.4.

Termination of Serial Interfaces

If the device is equipped with a serial RS 485 port, the RS 485 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 CPU-board and on the interface modules. The physical arrangement and jumper positions on the CPU-board are explained in Subsection 3.1.3.3 under “Processor board CPU”, for the interface modules see Subsection 3.1.3.4 under “RS485 Interface”.

Spare Parts

Spare parts may be 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 physical location is shown in Figure 3-6. When exchanging the battery or fuse, please observe the hints given in the System Manual (order no. E50417–H1176–C151) in Chapter “Maintenance”.

3.1.3.2 Disassembling the Device

If changes to jumper settings are required to modify the rating of the power supply, the nominal rating of the current inputs, the pickup voltage of binary inputs, or the state of the terminating resistors, proceed as follows:

Caution!

Jumper-setting changes that affect nominal values of the device render the ordering number and the corresponding nominal values on the nameplate sticker invalid. If such changes are necessary, the changes should be clearly and fully noted on the device. Self-adhesive stickers are available that can be used as replacement stickers.

☐ Prepare area of work. Provide a grounded mat for protecting components subject to damage from electrostatic discharges (ESD). The following equipment is needed:

- screwdriver with a 5 to 6 mm wide tip,
- 1 Phillips screwdriver,
- 5 mm socket or nut driver.

☐ Unfasten the screw-posts of the D-subminiature connector on the back panel at location “A”.
This activity does not apply if the device is for surface mounting.

☐ If the device has more communication interfaces on the rear, the screws located diagonally to the interfaces must be removed.
This activity is not necessary if the device is for surface mounting.

☐ Remove the four caps on the front cover and loosen the screws that become accessible.

- ☐ Carefully pull off the front cover. The front cover is connected to the CPU board with a short ribbon-cable.

Caution!

Electrostatic discharges through the connections of the components, wiring, plugs, and jumpers must be avoided. Wearing a grounded wrist strap is preferred. Otherwise, first touch a grounded metal part.

The order of the boards is shown in Figure 3-5.

- ☐ At one end, disconnect the ribbon-cable between the front cover and the CPU board (❶). To disconnect the cable, push up the top latch of the plug connector and push down the bottom latch of the plug connector. Carefully set aside the front cover.
- ☐ Disconnect the ribbon-cables between the CPU board (❶) and the I/O-11 board (❷).
- ☐ Remove the boards and set them on the grounded mat to protect them from electrostatic damage. A greater effort is required to withdraw the CPU board, especially in versions of the device for surface mounting, because of the plug connectors.
- ☐ Check the jumpers according to Figures 3-6 to 3-10 and the following notes. Change or remove the jumpers as necessary.

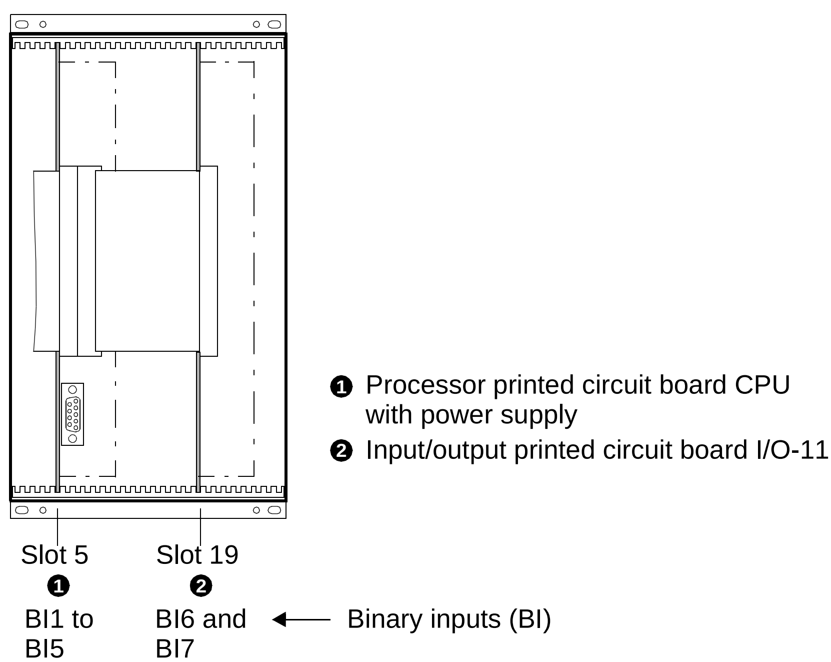


Figure 3-5 Front view of the device after removal of the front cover (simplified and scaled down)

3.1.3.3 Jumper Settings on Printed Circuit Boards

Processor board CPU

The design of a jumper setting for the processor board CPU is shown in Figure 3-6. The preset rated voltage of the integrated power supply is checked according to Table 3-2, the quiescent state of the life contact is checked according to Table 3-3, the pickup voltages of the binary inputs BI1 through BI5 are checked according to Table 3-4, and the integrated RS232/RS485 interface is checked according to Tables 3-5 to 3-7.

Before the jumpers of the RS232/RS485 can be checked, the interface modules (if available) must be removed.

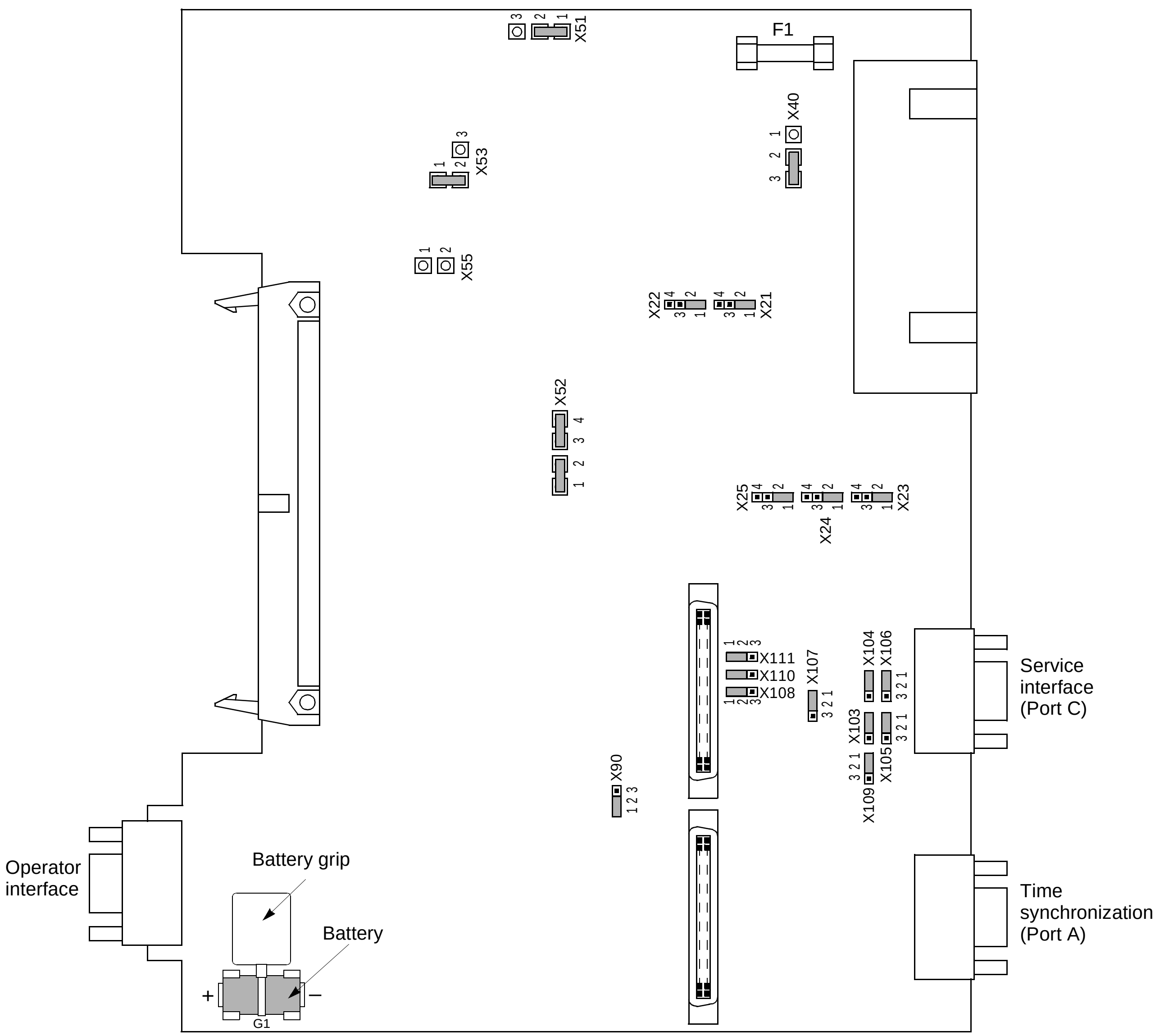


Figure 3-6 Processor board CPU with representation of the jumper settings required for the module configuration

Table 3-2 Jumper settings for the nominal voltage of the integrated **power supply** on the processor board

Jumper	Nominal voltage		
	DC 60/110/125 V	DC 110/125/220/250 V AC 115 V	DC 24/48 V
X51	1–2	2–3	not fitted
X52	1–2 and 3–4	2–3	
X53	1–2	2–3	
X55	not fitted	1–2	
	Can be interchanged		Not changeable
Mini-fuse	T2H250V		T4H250V

Table 3-3 Jumper setting for the quiescent state of the **life contact** on the processor board CPU

Jumper	Open in quiescent state (NO)	Closed in quiescent state (NC)	Presetting
X40	1–2	2–3	2–3

Table 3-4 Jumper settings for the **pick-up voltages** of the binary inputs BI1 through BI5 on the processor board CPU

Binary Inputs	Jumper	Pickup 17 V 1)	Pickup 73 V 2)	Pickup 154 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 24 VDC to 125 VDC
2) Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115 VAC
3) Factory setting for devices with power supply voltages DC 220 to 250 V and AC 115 V

RS485 interface can be changed to RS232 interface and versa by setting of jumpers. Jumpers X105 through X110 must be set on the same position!

Table 3-5 Jumper setting for the **RS232/RS485 service interface** on the processor board CPU

Jumper	RS232	RS485
X103 and X104	1–2	1–2
X105 to X110	1–2	2–3

When the device is delivered from the factory, the jumper setting corresponds to the configuration ordered.

When using the RS232 interface, the flow control which is important for modem communication is enabled with jumper X111. Note the following:

Jumper setting 2–3: The modem control signals CTS (Clear-To-Send) according to RS232 are not available. This is a standard connection via star coupler or optical fibre converter. They are not required since the connection to the SIPROTEC® devices is always operated in the half-duplex mode. Please use connection cable with order number 7XV5100–4.

Jumper setting 1–2: Modem signals are made available. For a direct RS232 connection between the device and the modem this setting can be selected optionally. We recommend to use a standard RS232 modem connection cable (converter 9-pole on 25-pole).

Note: When having connected a PC running DIGSI® to the RS232 port the jumper setting must be 2–3.

Table 3-6 Jumper setting for the **CTS (Clear-To-Send)** on the processor board CPU

Jumper	/CTS from RS232 interface	/CTS controlled by /RTS
X111	1–2	2–3

When using the RS485 interface, the last device on a serial RS 485 bus must be terminated with resistors via the jumpers X103 and X104 unless they are terminated by external means. Both jumpers X103 and X104 must be set on the same position! On delivery, the resistors are disconnected.

Table 3-7 Jumper setting for the **termination resistors** o the RS485 port on the processor board CPU

Jumper	Termination resistor connected (on)	Termination resistor disconnected (off)	as delivered
X103	2–3	1–2	1–2
X104	2–3	1–2	1–2

Terminating resistors can also be implemented outside the device (e.g. in the plug connectors) as shown in Figure 3-12. In that case the terminating resistors provided on the interface card or on the processor board CPU must be switched out (X103 and X104 in position 1–2).

Jumper X90 has no function. It is set 1–2.

Input/Output Board I/O-11

The design of a jumper setting for the input/output board I/O-11 is shown in Figure 3-7. The pick-up voltages of the binary inputs BI6 and BI7 are checked according to Table 3-8.

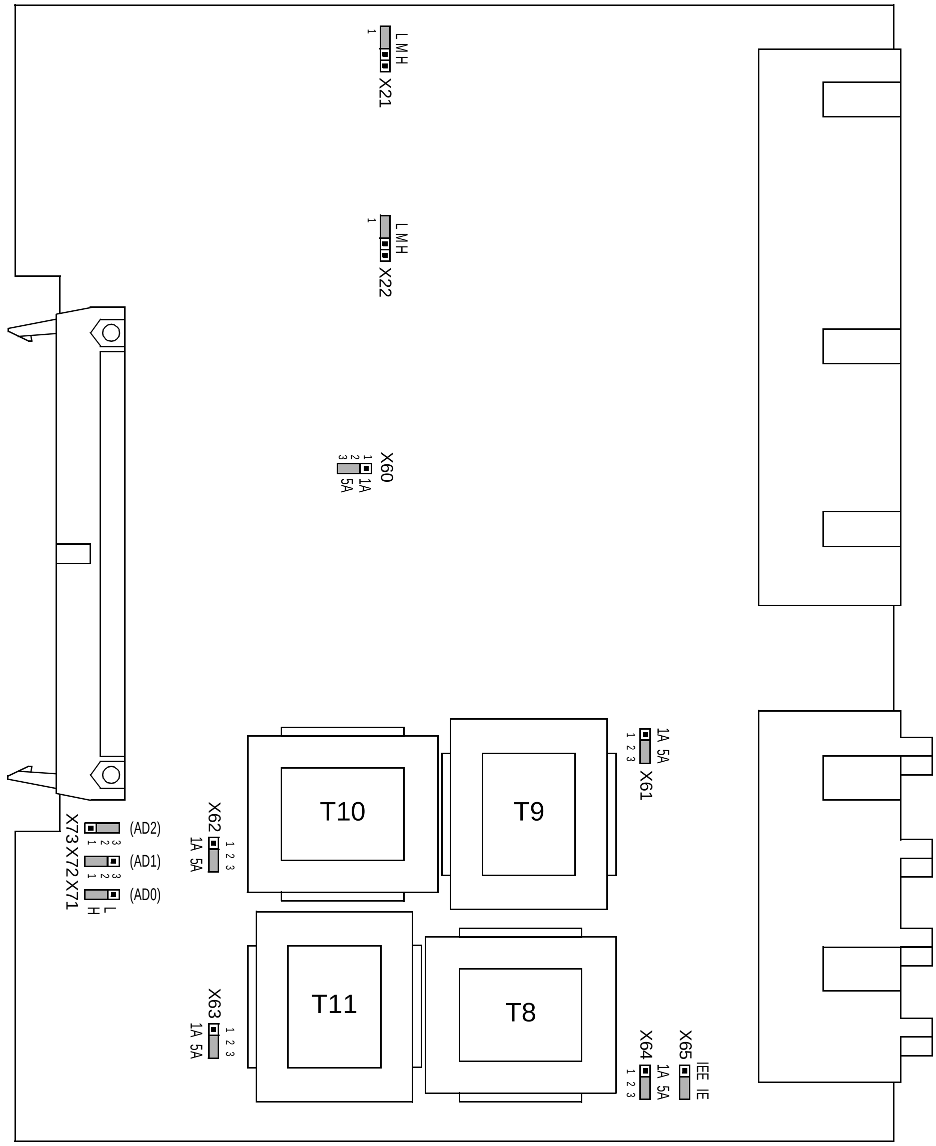


Figure 3-7 Input/output board I/O-11 with representation of the jumper settings required for the module configuration

Table 3-8 Jumper settings for the **pick-up voltages** of the binary inputs BI6 and B7 on the input/output board I/O-11

Binary Inputs	Jumper	Pickup 17 V [1])	Pickup 73 V [2])	Pickup 154 V [3])
BI6	X21	L	M	H
BI7	X22	L	M	H

[1]) Factory settings for devices with power supply voltages of 24 VDC to 125 VDC
[2]) Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115 VAC
[3]) Factory setting for devices with power supply voltages DC 220 to 250 V and AC 115 V

The preset rated currents of the current transformer are checked on the input/output board I/O-11. All jumpers must be set unitary for one rated current, i.e. one jumper (X61 to X64) for each current transformer, additionally there is one common jumper X60.

The jumper X65 is in position “IE”.

Jumpers X71, X72 and X73 on the input/output board I/O-11 are used to set the bus address and must not be changed. Table 3-9 shows the factory setting of the jumpers.

Table 3-9 Factory jumper setting for **module identification** on the input/output board I/O-11

Jumper	Presetting
X71	1–2 (H)
X72	1–2 (H)
X73	2–3 (L)

3.1.3.4 Interface Modules

Note:

Devices in surface mounted housing with optical fibre connection have the fibre-optic module installed in the inclined console housing. On the CPU board, however, an RS232 interface module is placed which communicates electrically with the fibre-optic module.

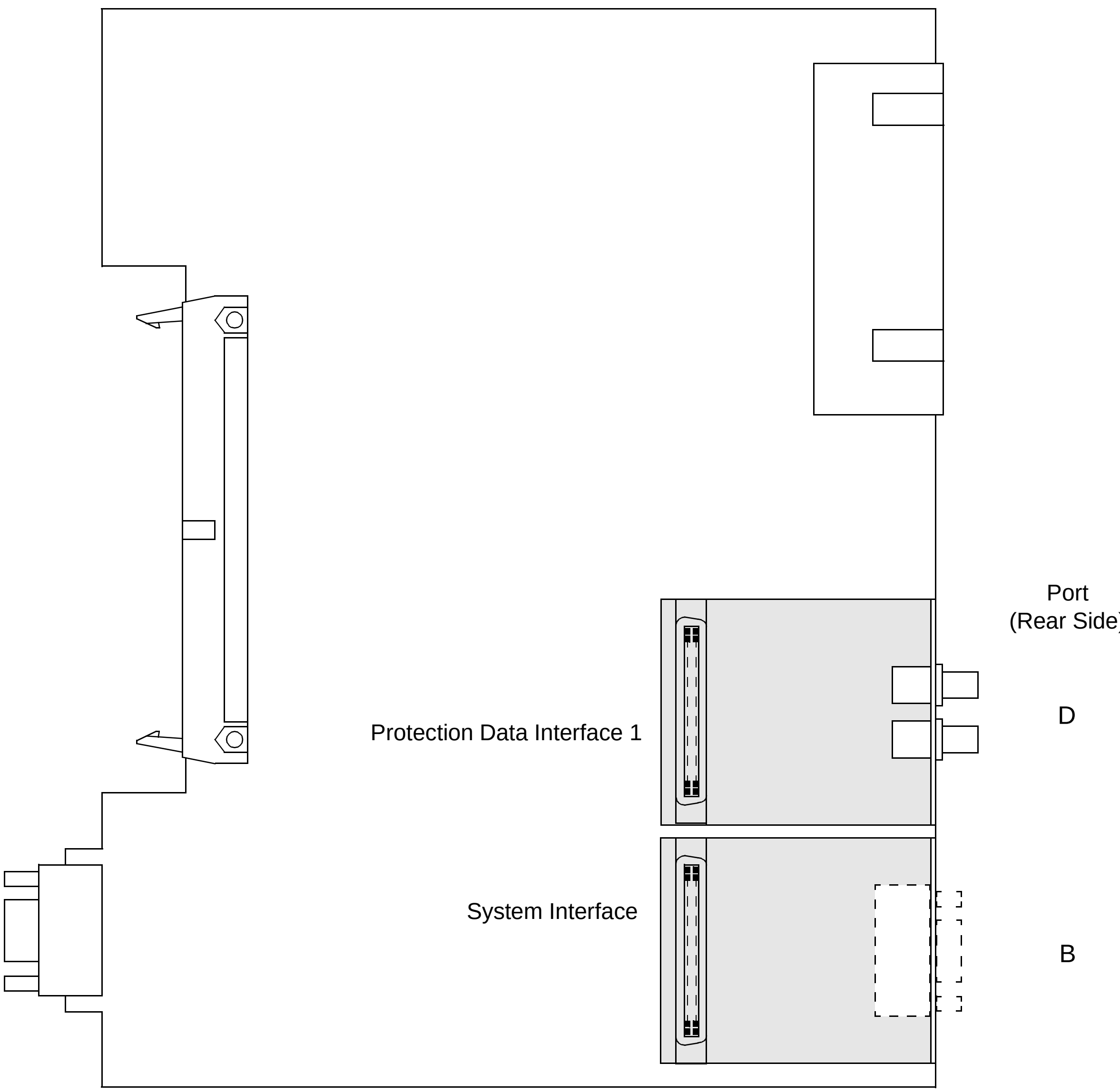


Figure 3-8 Processor board CPU with the interface modules

Replacing Interface Modules

The interface modules can be replaced in housings for flush or cubicle installation. They are located on the processor board CPU (❶ in Figure 3-5). Figure 3-8 shows the CPU board and the location of the interface modules. The ordering numbers of the exchange modules are listed in Appendix A.1.1 (Accessories).

Please note the following:

- Interface modules can only be exchanged for devices with flush mounting housing. Interface modules for devices with surface mounting housing must be exchanged in our manufacturing centre.
- Use only interface modules that can be ordered as an option of the device (see also Appendix A.1).
- With interfaces with bus capability, ensure that the bus termination is correct (if applicable); see head margin “RS485 Interface” below.

Table 3-10 Replacement interface modules for devices with flush mounting housing

Interface	Mounting Location	Exchange Module
System Interface	B	RS232
		RS485
		FO 820 nm
		Profibus DP; RS485
		Profibus DP; FO 820 nm
		DNP 3.0; RS485
		DNP 3.0; FO 820 nm
Service Interface	C	RS232
		RS485
		FO 820 nm
Protection Data Interface 1	D	FO5 to FO8

RS232 Interfaces

The interface RS232 can be transformed into interface RS485 according to Figure 3-10.

Figure 3-8 shows the PCB of the CPU with the location of the modules. Figure 3-9 shows how jumpers of interface RS232 are located on the interface module.

Here, terminating resistors are not required. They are always disabled.

Note that devices in surface mounted housing with optical fibre connection have an electrical RS232 module on the CPU board (see *Note* above). For this application type, the jumpers X12 and X13 on the RS232 module are plugged in position 2–3, in contrast to the illustration in Figure 3-9.

Jumpers illustrated
in Factory position

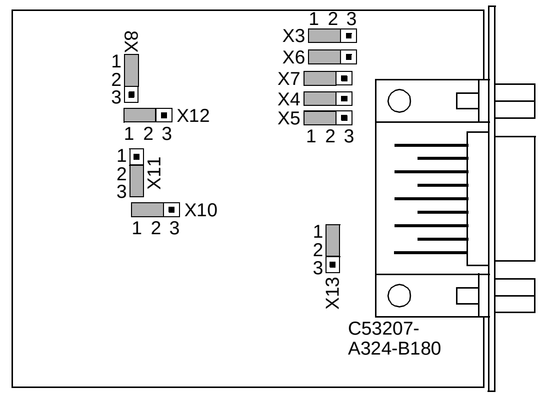


Figure 3-9 Location of the jumpers on the interface module for RS232

RS485 Interface

The interface RS485 can be transformed into interface RS232 according to Figure 3-9.

Using interfaces with bus capability requires a termination for the last device at the bus, i.e. terminating resistors must be switched to the line.

The terminating resistors are connected to the corresponding interface module that is mounted to the processor input/output board CPU (❶ in Figure 3-5). Figure 3-8 shows the printed circuit board of the CPU and the allocation of the modules.

The module for the RS485 interface is illustrated in Figure 3-10 for the Profibus and DNP interface in Figure 3-11. The two jumpers of a module must always be plugged in the same position.

When a module leaves the factory the jumpers are set in such a way that the terminating resistors are switched off.

Terminating resistors can also be implemented outside the device (e.g. in the plug connectors) as shown in Figure 3-12. In that case the terminating resistors provided on the interface module must be disconnected.

Jumper	Terminating resistors	
	Connected	Disconnected
X3	2-3	1-2*)
X4	2-3	1-2*)

*) Factory Setting

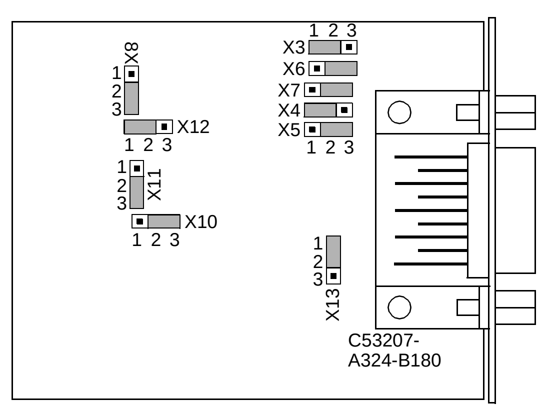


Figure 3-10 Location of the jumpers on the RS485-interface module with termination resistors

Jumpers	Terminating Resistors	
	connected	disconnected
X3	1–2	2–3 *)
X4	1–2	2–3 *)

*) Factory Setting

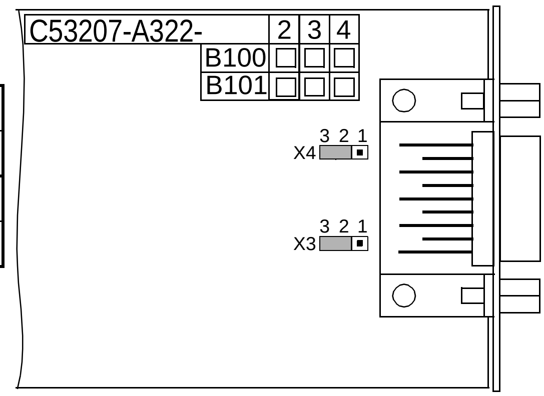


Figure 3-11 Location of the jumpers for the configuration of the termination resistors on the interfaces Profibus DP and DNP3.0

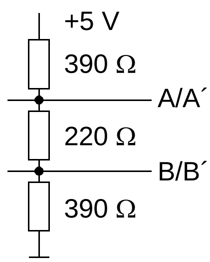


Figure 3-12 External terminating resistors

3.1.3.5 To Reassemble the Device

To reassemble the device, proceed as follows:

- ☐ Carefully insert the boards into the housing. The installation locations of the boards are shown in Figure 3-5.
  For the model of the device designed for surface mounting, use the metal lever to insert the CPU board. The installation is easier with the lever.
- ☐ First insert the plug connectors of the ribbon cable on the input/output board I/O-11 and then on the processor board CPU. Be careful not to bend any of the connecting pins! Do not use force!
- ☐ Insert the plug connector of the ribbon cable between the processor board CPU and the front cover in the socket on the front cover.
- ☐ Press the latches of the plug connectors together.
- ☐ Replace the front cover and secure to the housing with the screws.
- ☐ Replace the covers.
- ☐ Re-fasten the interfaces on the rear of the device housing.
  This activity is not necessary if the device is for surface mounting.

3.2 Checking the Connections

3.2.1 Data Connections

The tables of the following margin headers list the pin-assignments for the different serial interfaces of the device and the time synchronization interface. The physical arrangement of the connectors is illustrated in Figure 3-13.

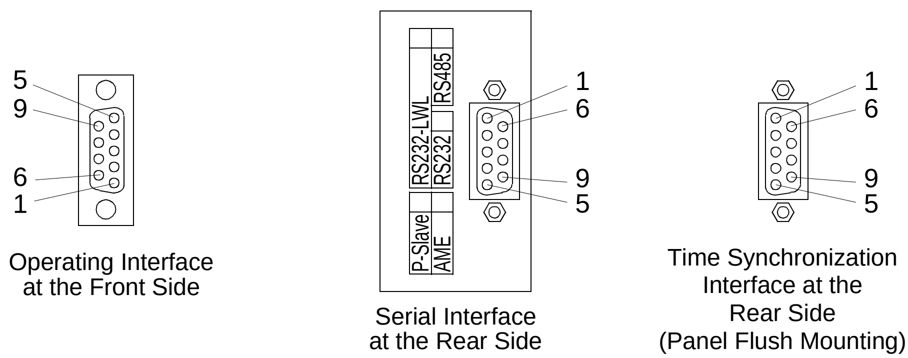


Figure 3-13 9-pin D-subminiature sockets

PC Operating Interface at Front

When the recommended communication cable is used, correct connection between the SIPROTEC® device and the PC is automatically ensured. See the Appendix A, Subsection A.1.1 for an ordering description of the cable.

System (SCADA) Interface

When a serial interface of the device is connected to a central substation control system, the data connection must be checked. A visual check of the transmit channel and the receive channel is important. Each connection is dedicated to one transmission direction. The data output of one device must be connected to the data input of the other device, and vice versa.

The data cable connections are designated in sympathy with DIN 66020 and ISO 2110 (see also Table 3-11):

- TxD data transmit
- RxD data receive
- $\overline{\text{RTS}}$ request to send
- $\overline{\text{CTS}}$ clear to send
- DGND signal/chassis ground

The cable shield is to be grounded at only **both ends**. For extremely EMC-loaded environments the GND may be integrated into a separate individually shielded wire pair to improve the immunity to interference.

Table 3-11 Installation of the D-subminiature connectors

Pin-No.	Operating interface	RS232	RS485	Profibus DP Slave, RS485	DNP3.0, RS485
1	Shield (with shield ends electrically connected)				
2	RxD	RxD	—	—	—
3	TxD	TxD	A/A' (RxD/TxD–N)	B/B' (RxD/TxD–P)	A
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
7	RTS	RTS	—*)	—	—
8	CTS	CTS	B/B' (RxD/TxD–P)	A/A' (RxD/TxD–N)	B
9	—	—	—	—	—

*) Pin 7 also may carry the RS232 RTS signal to an RS485 interface. Pin 7 must therefore not be connected!

RS 485 Termination

The RS485 interface is capable of half-duplex service with the signals A/A' and B/B' with a common relative potential C/C' (DGND). Verify that only the last device on the bus has the terminating resistors connected, and that the other devices on the bus do not. Jumpers for the terminating resistors are on the processor p.c.b. (see Figure 3-6 and Table 3-5) and/or on the interface modules RS 485 (Figure 3-10) or Profibus DP or DNP3.0 (Figure 3-11).

It is also possible that the terminating resistors are arranged externally (Figure 3-12); in this case, the internal termination resistors must be disconnected.

If the bus is extended, make sure again that only the last device on the bus has the terminating resistors switched in, and that all other devices on the bus do not.

Time Synchronization Interface

Either 5 VDC, 12 VDC or 24 VDC time synchronization signals can be processed if the connections are made as indicated in Table 3-12.

Table 3-12 Pin-assignment for the D-subminiature port of the time synchronization interface

Pin-No.	Designation	Signal meaning
1	P24_TSIG	Input 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return Line
4	M_TSYNC*)	Return Line*)
5	Screen	Shield potential
6	–	–
7	P12_TSIG	Input 12 V
8	P_TSYNC*)	Input 24 V*)
9	Screen	Shield potential

*) only for PPS signal (GPS)

Optical Fibres

Refer to Subsection 3.2.2 for differential protection data communication.

For the system (SCADA) interface, signals transmitted over optical fibres are unaffected by interference. The fibres guarantee electrical isolation between the connections. Transmit and receive connections are identified with the symbols •⟶ for transmit and ⟶• for receive.

The character idle state for the optical fibre interface is “Light off”. If this setting is to be changed, use the operating program DIGSI®, as described in the SIPROTEC® System Manual, order-no. E50417–H1176–C151.

Warning!

Laser injection! Do not look directly into the fibre-optic elements!

3.2.2 Checking the Differential Protection Data Communication

The differential protection communication is conducted either directly from device to device via optical fibres or by means of communication converters and a communication network or a dedicated transmission medium.

Optical Fibres

The direct optical fibre connection is visually checked like the other optical fibre connections. There is one connection for each direction. Therefore the output of the one device must be connected to the 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 receive channels is relevant. For use of the FO5-modules and the recommended fibre type for short distances, laser class 1 is valid. Higher laser powers can occur in other cases.

Warning!

Laser injection! Do not look into the LEDs or fibre-optic elements! Do not use optical instruments! Laser class 3A according to EN 60825–1.

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 direct optical fibre connections.

Verify that address 1502 **CONNEC. 1 OVER** (see also Section 2.4.2) is set to the correct type of connection.

Further connections

For further connections a visual control is sufficient for the time being. Electrical and functional controls are done during commissioning (Section 3.3.5).

3.2.3 Checking Power Plant Connections

Warning!

Some of the following test steps will be carried out in presence of hazardous voltages. They shall be performed only by qualified personnel which is thoroughly familiar with all safety regulations and precautionary measures and pay due attention to them.

Caution!

Operating the device on a battery charger without a connected battery can lead to unusually high voltages and consequently, the destruction of the device. For limit values see Subsection 4.1.2 under Technical Data.

Before the device is energized for the first time, the device should be in the final operating environment for at least 2 hours to equalize the temperature and to minimize humidity and avoid condensation. Connection are checked with the device at its final location. The plant must first be switched off and grounded.

Connection examples for the instrument transformer circuits are given in the Appendix Section A.3. Please observe the plant diagrams, too.

- ☐ Protective switches (e.g. test switches, fuses, or miniature circuit breakers) for the power supply and the measured voltages must be opened.
- ☐ Check the continuity of all current and voltage transformer connections against the system and connection diagrams:
  - ❑ Are the current transformers grounded properly?
  - ❑ Are the polarities of the current transformers the same?
  - ❑ Is the phase relationship of the current transformers correct?
  - ❑ Are the voltage transformers grounded 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 open delta winding)?
- ☐ Check the functions of all test switches that may be 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 (open).
- ☐ The short-circuit feature of the current circuits of the device are to be checked. An ohmmeter or other test equipment for checking continuity is needed. Make sure that continuity is not simulated by the reverse connected current transformers themselves or their short-circuit links.
  - ❑ Remove the front panel of the device (see Figure 3-5).

- ❑ Remove the ribbon cable connected to the I/O-11 board (❷ in Figure 3-5), and pull the board out until there is no contact between the board and the rear connections of the device.
- ❑ 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-11 board. Carefully connect the ribbon cable. Do not bend any connector pins! Do not use force!
- ❑ Check continuity for each of the current terminal-pairs again.
- ❑ 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.
- ☐ Close the protective switches to apply voltage to the power supply. Check the polarity and magnitude of the voltage at the device terminals.
- ☐ 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 equipment; restore the normal power supply connections.
- ☐ Apply voltage to the power supply.
- ☐ Close the protective switches for the voltage transformers (if used).
- ☐ Verify that the voltage phase rotation at the device terminals is correct.
- ☐ Open the protective switches for the voltage transformers (if used) and the power supply.
- ☐ Check the trip circuits to the power system circuit breakers.
- ☐ Check the close circuits to the power system circuit breakers (if used).
- ☐ Verify that the control wiring to and from other devices is correct.
- ☐ Check the signalling connections.
- ☐ Close the protective switches to apply voltage to the power supply.
- ☐ If communication converters are used, check the auxiliary voltage supply for the communication converters.
- ☐ If the communication converter is connected to the communication network, its “device-ready”-relay (DR) picks up. This also signalizes that the clock pulse of the communication network is recognized. Further checks are performed according to Subsection 3.3.5.
- ☐ Please also observe carefully the documentation on the communication converter.

3.3 Commissioning

Warning!

Hazardous voltages are present in this electrical equipment during operation. Non-observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

Particular attention must be drawn to the following:

- The earthing screw of the device must be connected solidly to the protective earth conductor before any other electrical connection is made.
- Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- Wait for at least 10 s after having disconnected the supply voltage before you re-apply the voltage in order to achieve defined initial conditions.
- The limit values stated in the Technical Data must not be exceeded at all, not even during testing and commissioning.

When testing the device with secondary test equipment, make sure that no other measurement quantities are connected. Take also into consideration that the trip and close commands to the circuit breakers and other primary switches are disconnected from the device unless expressly stated.

DANGER!

Current transformer secondary circuits must have been short-circuited before the current leads to the device are disconnected!

If test switches are installed that automatically short-circuit the current transformer secondary circuits, it is sufficient to place them into the “Test” position provided the short-circuit functions has been previously tested.

For the commissioning switching operations have to be carried out. A prerequisite for the prescribed tests is that these switching operations can be executed without danger. They are accordingly not meant for operational checks.

Warning!

Primary tests must only be carried out by qualified personnel, who are familiar with the commissioning of protection systems, the operation of the plant and the safety rules and regulations (switching, earthing, etc.).

3.3.1 Testing Mode and Transmission Blocking

If the device is connected to a substation control system or a server, the user is able to modify, in some protocols, information that is transmitted to the substation (see Section A.5 “Protocol Dependent Functions” in Appendix A).

In the **testing mode** all messages sent from a SIPROTEC®4 device to the substation are marked with an extra test bit so that the substation is able to identify them as messages announcing no real faults. Furthermore the **transmission blocking** function leads to a total blocking of the message transmission process via the system interface in the testing mode.

Refer to the System Manual (Order-no. E50417–H1176–C151) to know how the testing mode and the transmission blocking can be enabled and disabled. Please note that it is necessary to be **Online** to be able to use the testing mode.

3.3.2 Checking Time Synchronization

If external time synchronization sources are used the data of the time source (antenna system, time generator) are checked (see Subsection 4.1.4 under “Time Synchronization”). Using time signal IRIG B or DCF77 the correct time must appear at last 3 minutes after startup of the processor system, i.e. the clock alarm must go off (message “Alarm Clock OFF” in the operating messages or spontaneous messages. Table 3-13 shows the display indications under regular conditions of time control. Refer to the System Manual (Order-no. E50417–H1176–C151) for detailed information about time status.

Table 3-13 Time Status

Status Bits	No.	
–– –– –– ––	1	synchronized
–– –– –– ST	2	
–– –– ER ––	3	not synchronized
–– –– ER ST	4	
–– NS ER ––	5	
–– NS –– ––	6	
Legend: NS ER ST	 Not Synchronized (neither set nor synchronized) Time ERror (no synchronization within the tolerance) Saving Time (daylight savings time bit received)	

Additionally, if GPS-synchronization is used, check that the GPS signal is received: Approximately 3 seconds after startup of the processor system, the message “GPS loss OFF” appears.

3.3.3 Checking the System (SCADA) Interface

Preliminary Notes

Provided that the device is equipped with a system (SCADA) interface that is used for the communication with a substation, it is possible to test via the DIGSI® operational function if messages are transmitted correctly. Do **not** apply this test feature while the device is in service on a live system!

DANGER!

The transmission and reception of messages via the system (SCADA) interface by means of the testing mode is the real exchange of information between the SIPROTEC®4 device and the substation. Connected equipment such as circuit breakers or disconnectors can be operated as a result of these actions!

Note:

The device will reboot after termination of these tests. All annunciation buffers are erased. If required, these buffers should be extracted with DIGSI® prior to these tests.

The system interface test is carried out **`Online`** using DIGSI®:

- Double-click on the **`Online`** directory to open the required dialogue box.
- Click on **`Test`** and the functional options appear on the right side of the window.
- Double-click on **`Testing Messages for System Interface`** shown in the list view. The dialogue box **`Generate Indications`** opens (refer to Figure 3-14).

Structure of the Dialogue Box

In the column **`Indication`**, all message texts that were configured for the system interface in the matrix will then appear. In the column **`Status Scheduled`** the user has to define the value for the messages to be tested. Depending on the type of message different entering fields are available (e.g. message **`ON`** / message **`OFF`**). By double-clicking onto one of the fields the required value can be selected from the list.

Changing the Operating State

Clicking for the first time onto one of the field in column **`Action`** you will be asked for password no. 6 (for hardware test menus). Having entered the correct password messages can be issued. To do so, click on **`Send`**. The corresponding message is issued and can be read out either from the event log of the SIPROTEC®4 device as well as from the central master computer.

As long as the windows is open, further tests can be performed.

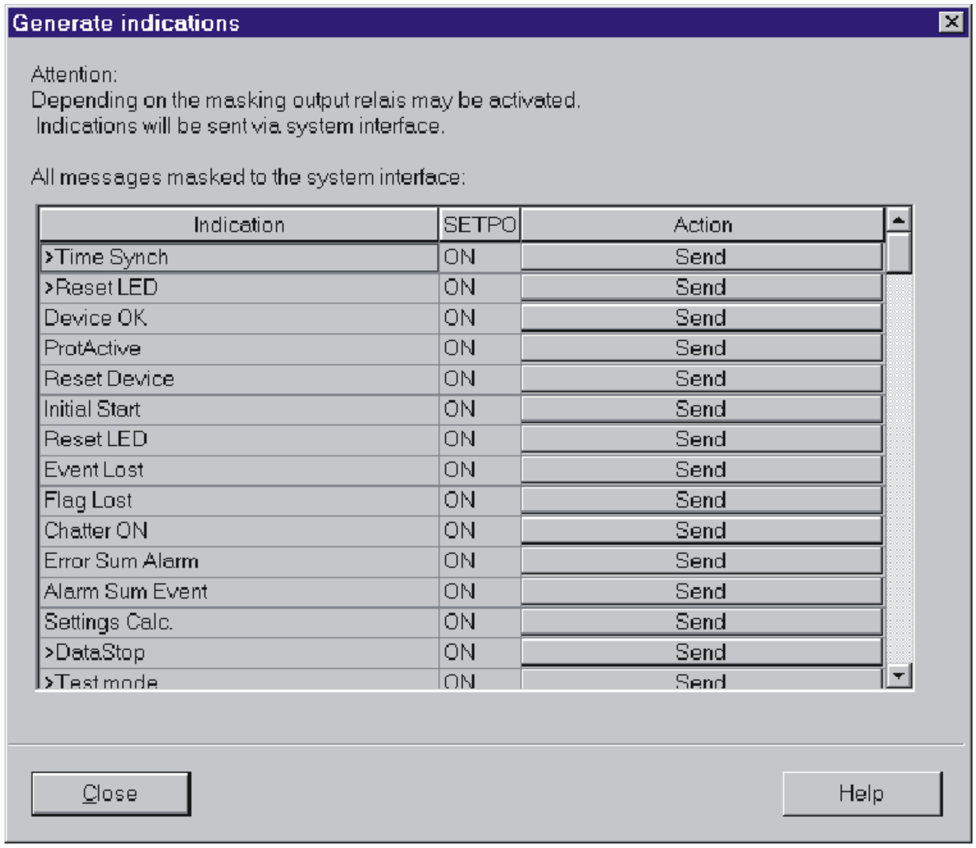


Figure 3-14 Dialogue box: Generate indications

Test in Message Direction

For all information that is transmitted to the central station the following is to be checked under **`Status Scheduled:`**

- ❑ 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 central station and shows the desired reaction. Information which are normally forwarded to the device via binary inputs (identified with a leading “>” sign) are also sent to the central station.

Exiting the Test Mode

To end the system interface test, click on **`Close`**. The device is briefly out of service while the processor system starting up. The dialogue box closes.

Test in Command Direction

The information beginning with “>” is transmitted towards the device. This kind of information must be sent by the central station. Check whether the reaction is correct.

3.3.4 Checking the Binary Inputs and Outputs

Preliminary Notes

The binary inputs, outputs, and LEDs of a SIPROTEC® 4 device can be individually and precisely controlled using DIGSI®. This feature is used to verify control wiring from the device to plant equipment during commissioning. This test feature shall **not** be used while the device is in service on a live system.

DANGER!

Changing the status of a binary input or output using the test feature of DIGSI® results in an actual and immediate corresponding change in the SIPROTEC® device. Connected equipment such as circuit breakers or disconnectors will be operated as a result of these actions!

Note:

The device will reboot after termination of these tests. All annunciation buffers are erased. If required, these buffers should be extracted with DIGSI® prior to these tests.

The hardware test can be done 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 screen.
- Double-click in the list view on **`Hardware Test`**. The dialogue box of the same name opens (see Figure 3-15).

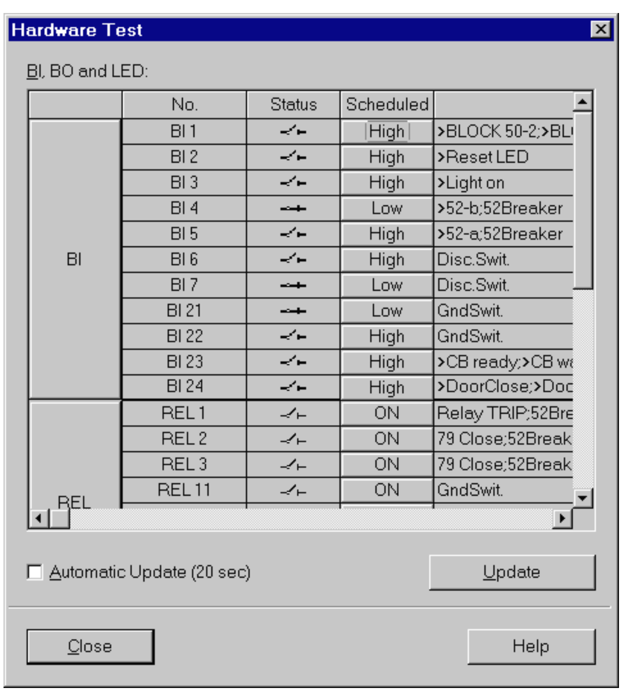


Figure 3-15 Dialogue box for hardware test — example

Structure of the Test Dialogue Box

The dialogue box is divided into three groups: **`BI`** for binary inputs, **`REL`** for output relays, and **`LED`** for light-emitting diodes. Each of these groups is associated with an appropriately marked switching area. By double-clicking in an area, components within the associated group can be turned on or off.

In the **`Status`** column, the present (physical) state of the hardware component is displayed. The binary inputs and outputs are indicated by an open or closed switch symbol, the LEDs by a dark or illuminated LED symbol.

The possible intended condition of a hardware component is indicated with clear text under the **`Scheduled`** column, which is next to the **`Status`** column. The intended condition offered for a component is always the opposite of the present state.

The right-most column indicates the commands or messages that are configured (masked) to the hardware components.

Changing the Hardware Conditions

To change the condition of a hardware component, click on the associated switching field in the **`Scheduled`** column.

Password No. 6 (if activated during configuration) will be requested before the first hardware modification is allowed. After entry of the correct password a condition change will be executed.

Further condition changes remain possible while the dialog box is open.

Test of the Binary Outputs

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 one 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 implies that a switching signal to an output relay from e.g. a protection function or control command cannot be executed.

- ❑ Ensured that the switching of the output relay can be executed without danger (see above under **DANGER**!).
- ❑ Each output relay must be tested via the corresponding **`Scheduled`**-cell in the dialog box.
- ❑ The test sequence must be terminated (refer to margin heading “Exiting the Procedure”), to avoid the initiation of inadvertent switching operations by further tests.

Test of the Binary Inputs

To test the wiring between the plant and the binary inputs of the 7SD610 the condition in the plant which initiates the binary input must be generated and the response of the device checked.

To do this, the dialogue box **`Hardware Test`** must again be opened to view the physical state of the binary inputs. The password is not yet required.

- ❑ Each state in the plant which causes a binary input to pick up must be generated.
- ❑ The response of the device must be checked in the **`Status`**-column of the dialogue box. To do this, the dialogue box must be updated. The options may be found below under the margin heading “Updating the Display”.

If however the effect of a binary input must be checked without carrying out any switching in the plant, 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 nr. 6 has been entered, *all* binary inputs are separated from the plant and can only be activated via the hardware test function.

- ❑ Terminate the test sequence (see above under the margin heading „Exiting the Procedure“).

Test of the LED's

The LED's 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 implies that no LED can be switched on anymore by e.g. a protection function or operation of the LED reset key.

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 occurs:

– for each harware component, if a command to change the condition is successfully performed,

– for all hardware components if the **Update** button is clicked,

– for all hardware components with cyclical updating if the **Automatic Update (20sec)** field is marked.

Exiting the Procedure

To end the hardware test, click on **Close**. The dialog box closes. The device becomes unavailable for a brief start-up period immediately after this. Then all hardware components are returned to the operating conditions determined by the plant settings.

3.3.5 Checking the Protection Data Topology

General

The communication topology can either be checked from the PC using DIGSI® or a web browser via the “IBS-Tool”. If you choose to work with the IBS-Tool, please note the Help files referring to the “IBS-Tool”.

You can either connect the PC to the device locally using the operator interface at the front, or the service interface at the rear of the device (Figure 3-16). Or you can log into the device using a modem via the service interface (example in Figure 3-17).

If you use the “IBS-Tool”:

- ❑ Make sure that the 12-digit IP-address valid for the browser is set correctly according to the following format: ***.***.***.***. A three-digit block of the IP address is inserted into each address from 4401 to 4404, or 4411 to 4414.
- ❑ Set the address 4405 or 4415 **NUM LOCK** to ***NO***, if you are directly interfaced to the device. You will then have the option to operate the device with the “IBS-Tool”.
- ❑ If you are interfaced to the devices via modem you can set the address 4405 or 4415 **NUM LOCK** to ***NO***. You will then have the option to access both devices with the “IBS-Tool”.

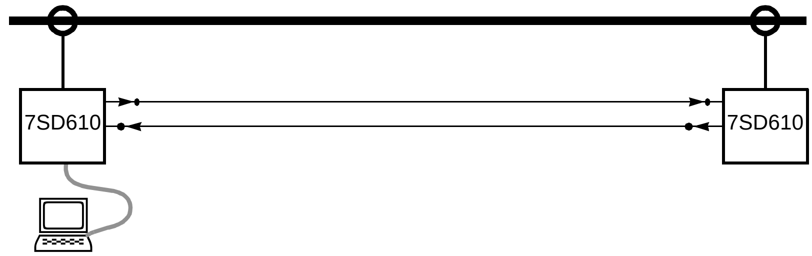


Figure 3-16   PC interfacing directly to the device — schematic example

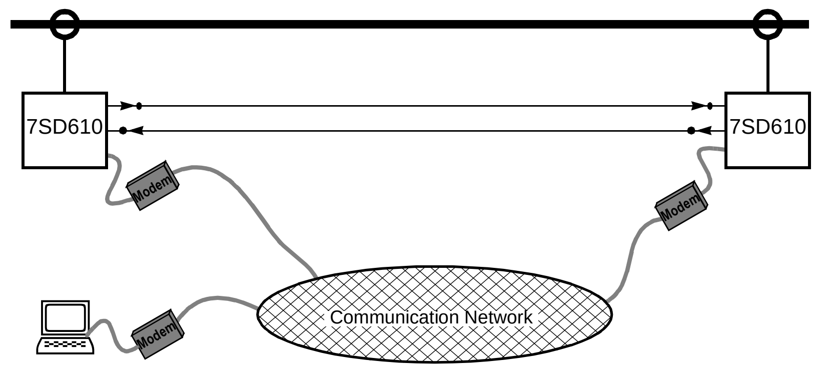


Figure 3-17   PC interfacing via modem — schematic example

Checking a Connection Using Direct Link

For two devices linked with fibre optical cables (as in Figure 3-16 or 3-17), this connection is checked as follows.

- ☐ Both devices at the link ends have to be switched on.
- ☐ Check in the Event Log or spontaneous annunciations for the following:
  - ❑ If the message “`PI1 with`” (protection data interface 1 connected with, FNo. `03243`) is provided with the device index of the other device, a link has been established and one device has recognized the other.
  - ❑ The device also indicates the device index of the device which communicates correctly (e.g. annunciation “`Rel2 Login`”, FNo `03492`, when relay 2 has been contacted).
- ☐ In the event of a communication link error the message “`PI1 Data fault`” (FNo. `03229`) will be displayed. In this case, check the fibre optical cable link again:
  - ❑ Have the devices been linked correctly and no cables been interchanged?
  - ❑ Are the cables free from mechanical damage, intact, and the connectors locked?
  - ❑ Repeat check if necessary.

Proceed then with “Consistency of Topology and Parameterization”, page 211.

Checking a Connection via 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 3-18, left).

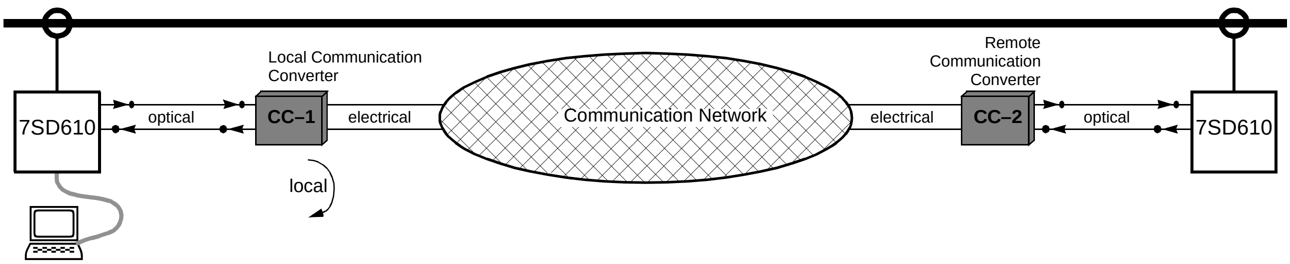


Figure 3-18 Differential protection communication via communication converter and communication network — schematic example

- ☐ 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.

DANGER!

Before opening the communication converter, it is absolutely necessary to isolate it from the auxiliary supply voltage at all poles! There is a danger to life by energized parts!

  - ❑ 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 1502 **CONNEC. 1 OVER**, see also Subsection 2.4.2).
  - ❑ 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 communication network (X.21 or G703.1 or ISDN) 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 does not 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 1502 **CONNEC. 1 OVER** = ***F.optic direct***

- [ ] Check the Event Log or spontaneous annunciations:
  - Message 03217 “PI1 Data reflec ON” (Protection interface 1 data reflection ON).
  - If the message 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 to the correct state:
  - Address 1502 **CONNEC. 1 OVER** = required setting.
- [ ] 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 then with “Consistency of Topology and Parameterization“.

Consistency of Topology and Parameterization

Having performed the above checks, the linking of the device pair — including their communication converters if applicable — has been completely tested and connected to auxiliary supply voltage. Now the devices communicate by themselves.

- [ ] Now check the Event Log or spontaneous annunciations of the device where you are working:
  - Message FNo. 03243 “PI1 with” (protection data interface 1 linked with) followed by the device index of the other device.
  - If the devices are connected, the message FNo 03464 “Topol complete” (Topology complete) will appear.
  - And if the device parameterization is also consistent, i.e. the prerequisites for setting the Configuration of the Scope of Functions (Section 2.1.1), the Power System Data 1 (2.1.2), the General Protection Data (Power System Data 2) (“Power System Data 2”, 2.1.4), the settings for Protection Data Interfaces and Protection Data Topology (Section 2.4.2) have been considered, the fault message, i.e. FNo. 03229 “PI1 Data fault” will go off. 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. Table 3-14 lists messages that indicate such faults.

Table 3-14 Messages announcing inconsistency

FNo	Setting	Meaning / Measures
03233	DT inconsistent	“Device table inconsistent”: the indexing of the devices is inconsistent (missing numbers or one number used twice, see Section 2.4.2
03234	DT unequal	“Device table unequal”: the ID-numbers of the devices are unequal (see Section 2.4.2)
03235	Par. different	“Parameterization different”: different functional parameters were set for the devices. They have to be equal at both ends: Differential protection available or not (see Section 2.1.1), Transformer in protected zone or not (see Section 2.1.1), Nominal frequency (see Section 2.1.2), Operational power or current (see Section 2.1.4)

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 the protection data interfaces and the transmission. Therefore, check the statistic information at the device where you are working.

Check the following messages:

- FNo 07753 “PI1A/m” indicates the availability of the protection data interface 1 per minute, FNo 07754 “PI1A/h” per hour. After 2 minutes of data transfer the first value should indicate at least 99.85 % per-minute-availability, after one hour the per-hour-availability should be at least 99.85 %.

If the values are not attained, the protection communication must be checked.

If GPS-synchronization is used, the transmission times can be retrieved, separately for each direction:

- FNo 07876 “PI1 TD S” indicates the transmission time in sending direction, FNo 07875 “PI1 TD R” in receiving direction.

In other cases, the mean value of both directions can be retrieved:

- FNo 07751 “PI1 TD” indicates the mean transmission time.

“IBS-Tool”

The topology can be displayed as a graph on the monitor using the “IBS-Tool”. For this you need a personal computer and a web browser. Figure 3-19 exemplifies a differential protection system for two ends. The devices have been properly linked (green shaded squares) and work as differential protection (Status: Differential Mode). The PC has been interfaced to the device with index 2 (PC-connected relay). The transmission time between device 2 and device 1 is 0.080 ms.

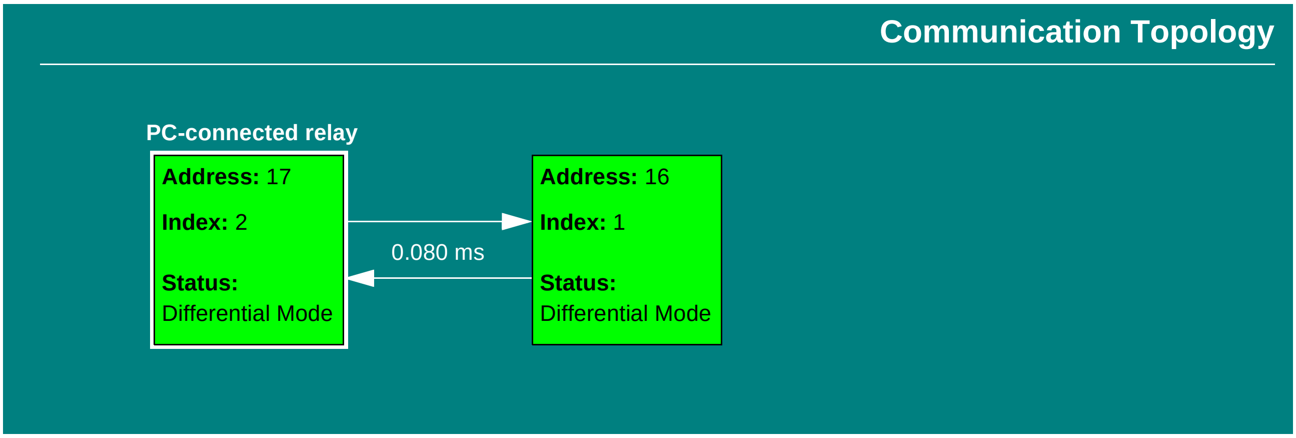


Figure 3-19 Example of a topology with two ends communicating correctly

3.3.6 Checking for Breaker Failure Protection

If the device is equipped with the breaker failure protection and this function is used, the interaction with the breakers of the power plant must be tested.

Because of the manifold application facilities and various configuration possibilities of the power plant it is not possible to give detailed description of the test steps necessary to verify the correct interaction between the breaker failure protection and the breakers. It is important to consider the local conditions and the protection and plant drawings.

It is advised to isolate the circuit breaker of the tested feeder at both sides, i.e. to keep the busbar disconnector and the line disconnector open, in order to ensure operation of the breaker without risk.

Caution!

Tripping of the complete busbar or busbar section will occur even during tests at the local feeder breaker. Therefore, it is recommended to interrupt the tripping commands to the adjacent (busbar) breakers e.g. by switch-off of the associated control voltage. Nevertheless ensure that trip remains possible in case of a real primary fault if parts of the power plant are live.

The trip command of the tested differential protection is made ineffective so that the local breaker can be tripped only by the breaker failure protection function.

The following lists do not claim to cover all possibilities. On the other hand, they may contain items that can be bypassed in the actual application.

Circuit Breaker Auxiliary Contacts

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 that the correct assignment has been checked (Subsection 3.3.4).

External Initiation Conditions

If the breaker failure protection is intended to be initiated by external protection devices, each of the external initiation conditions must be checked. Depending on the device version and the setting on the breaker failure protection, single-pole trip or single- and three-pole trip are possible. Note that the internal pole discrepancy supervision or the pole discrepancy supervision of the breaker itself may lead to a later three-pole trip after single-pole trip during the tests. Reconsider the settings of the breaker failure protection and its ancillary functions. Refer to Subsection 2.10.2 (addresses 3901 etc.) if more information is desired.

At least the tested phase of the device must be subjected to a test current to enable initiation of the breaker failure protection. This may be a secondary injected current.

Following every initiation the message "BF Start" (FNo 01461) must appear in the fault annunciations (trip log) or in the spontaneous messages.

<u>The following applies for phase segregated initiation:</u>

- ❑ Start by single-pole trip command L1 of the external protection:
  Binary inputs ">BF Start L1" (FNo 01435) and if necessary ">BF release" (FNo 01432); look up in the trip log or spontaneous messages.
  Trip command depending on the settings.
- ❑ Start by single-pole trip command L2 of the external protection:
  Binary inputs ">BF Start L2" (FNo 01436) and if necessary ">BF release" (FNo 01432); look up in the trip log or spontaneous messages.
  Trip command depending on the settings.
- ❑ Start by single-pole trip command L3 of the external protection:
  Binary inputs ">BF Start L3" (FNo 01437) and if necessary ">BF release" (FNo 01432); look up in the trip log or spontaneous messages.
  Trip command depending on the settings.
- ❑ Start by three-pole trip command L1, L2, L3 of the external protection via all three binary inputs:
  Binary inputs ">BF Start L1" (FNo 01435) and ">BF Start L2" (FNo 01436) and ">BF Start L3" (FNo 01437), and if necessary ">BF release" (FNo 01432); look up in the trip log or spontaneous messages.
  Trip command three-pole.

<u>The following applies for common phase initiation:</u>

- ❑ Start by three-pole trip command L123 of the external protection:
  Binary inputs ">BF Start 3pole" (FNo 01415) and if necessary ">BF release" (FNo 01432); look up in the trip log or spontaneous messages.
  Trip command three-pole (dependent on settings).

Switch off test current.

<u>The following applies if initiation without current flow is possible:</u>

- ❑ Start by trip command of the external protection without current flow:
  Binary inputs ">BF Start w/o I" (FNo 01439) and if necessary ">BF release" (FNo 01432); look up in the trip log or spontaneous messages.
  Trip command three-pole (dependent on settings).

Busbar trip

The most important thing is the check of the correct distribution of the trip commands to the adjacent circuit breakers in case the local breaker fails.

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. In other words, the adjacent breaker are those of all feeders which may feed the same busbar or busbar section as the faulty feeder.

The identification of the adjacent feeders depends widely on the topology of the busbar and its possible arrangement or switching states. That is why a generally detailed test description cannot be specified.

In particular if multiple busbars are concerned the trip distribution logic to the other breakers must be checked. It must be verified for each busbar section that all breakers connected to the same section are tripped in case the concerned feeder breaker fails, and no other breakers.

Remote Trip

If the trip command of the breaker failure protection or its ancillary functions (e.g. end fault protection) is intended to trip also the circuit breaker of the remote end of the concerned feeder, the correct transmission and reception of this remote trip must be checked. Practically, this is performed in conjunction with the transmission checks according to Subsection 3.3.9.

Termination of the Checks

After completion of the tests, re-establish all provisory measures which might have been taken for the above tests. Ensure that the states of all switching devices of the plant are correct, that interrupted trip commands are reconnected and control voltages are switched on, that setting values which might have been altered are reverted to correct values, and that protective function are switched to the intended state (on or off).

3.3.7 Checking the Instrument Transformer Connections of One Line End

Should secondary test equipment be 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 connections were made wrong.

Before energizing the object to be protected at any end, short-circuit protection must be ensured at least at the feeding ends. If a separate back-up protection (e.g. overcurrent protection) is available, this has to be put into operation and switched to alert first.

Voltage and Phase Rotation Test

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 margin header may be omitted.

The voltage transformer connections are individually tested at either end of the object to be protected. At the other end the circuit breaker remains open first.

☐ Having closed the local circuit breaker, none of the measurement monitoring functions in the device may respond.

- ❑ If there was a fault message, however, the Event Log or spontaneous messages (see also Subsection 2.15.1) could be checked to investigate the reason for it.
- ❑ At the indication of symmetry monitoring there might actually be asymmetries of the primary system. If they are part of normal operation, the corresponding monitoring function is set less sensitive (see Subsection 2.12.2 under “Voltage Balance”, page 133).

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. Apart from the absolute values of the line-earth and line-line voltages, voltage phase differences are indicated so that the correct phase sequence and polarity reversal of individual voltage transformers can be seen. The voltages can also be read with the “IBS-Tool” (see below, “Current Test”).

- ☐ The voltages should be almost equal. All the three angles $\varphi(U_{Lx}–U_{Ly})$ must be approximately 120°.
  - ❑ If the measured quantities are not plausible, the connections must be checked and revised after switching off the line. If the phase difference angle 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 almost equal the phase-to-ground voltages instead of having a value that is $\sqrt{3}$ greater. The measurements are to be repeated after setting the connections right.
  - ❑ In general, the phase rotation is a clockwise phase rotation. If the system has an counter-clockwise phase rotation, this must go for both ends of the protected object. The measured value allocation must be checked and corrected, if required, after the line has been isolated. The phase rotation check must then be repeated.
- ☐ Open the miniature circuit breaker of the feeder voltage transformers. The measured voltages in the operational measured values appear with a value close to zero (small measured voltages are of no concern).
  - ❑ Check in the event log or spontaneous messages that the VT mcb trip was noticed (message “`>FAIL:Feeder VT ON`”). A precondition is that the position of the VT mcb is connected to the device via a binary input.
- ☐ Close the VT mcb: The above message appears in the event log as “`OFF`”, i. e. “`>FAIL:Feeder VT OFF`”).
  - ❑ If one of the events does not appear, the connection and routing of these signals must be checked.
  - ❑ If the “`ON`”-state and “`OFF`”-state are swapped, the contact type (H-active or L-active) must be checked and remedied.
- ☐ The protected object is switched off.
- ☐ The check must be carried out for both ends.

3.3.8 Checking the Instrument Transformer Connections of Both 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 visual inspection of the correct current transformer connections. Therefore, the inspection according to Section 3.2.3 is a prerequisite.

- ☐ The current transformer connections are tested at each end of the protected object. The current flows through the protected object.
- ☐ After closing the circuit breakers, none of the measured value monitoring functions in the 7SD610 must respond. However, in the event of a monitoring signal, the reason for this signal can be investigated in the Event Log or in the spontaneous messages:
  - ❑ If current summation errors occur, check the matching factors (see Subsection 2.1.2, “Connection of the Currents”).
  - ❑ Messages 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 Subsection 2.12.2, “Symmetry Supervision”).

Currents can be viewed as primary or secondary measured values in the front display panel or via the operator or service interface with a personal computer, and compared with the actually measured values. The absolute values as well as the phase differences of the currents are indicated so that the correct phase sequence and polarity of individual transformers can also be seen.

The “IBS Tool” provides comfortable read-out possibilities for all measured values with visualisation using phasor diagrams (Figure 3-20).

- ☐ The current amplitudes must be approximately the same. Each one of the three angles φ(ILx–ILy) 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:
    - $3I_0 \approx$ phase current $\Rightarrow$ one or two phase currents are missing,
    - $3I_0 \approx$ doubled phase current $\Rightarrow$ one or two phase currents have a reversed polarity.
- ☐ The measurements are to be repeated after setting the connections right.
- ☐ The previously stated tests of the measured values are to be repeated 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 “IBS Tool”, the local and remote measured values can be graphically displayed. Figure 3-21 shows an example.

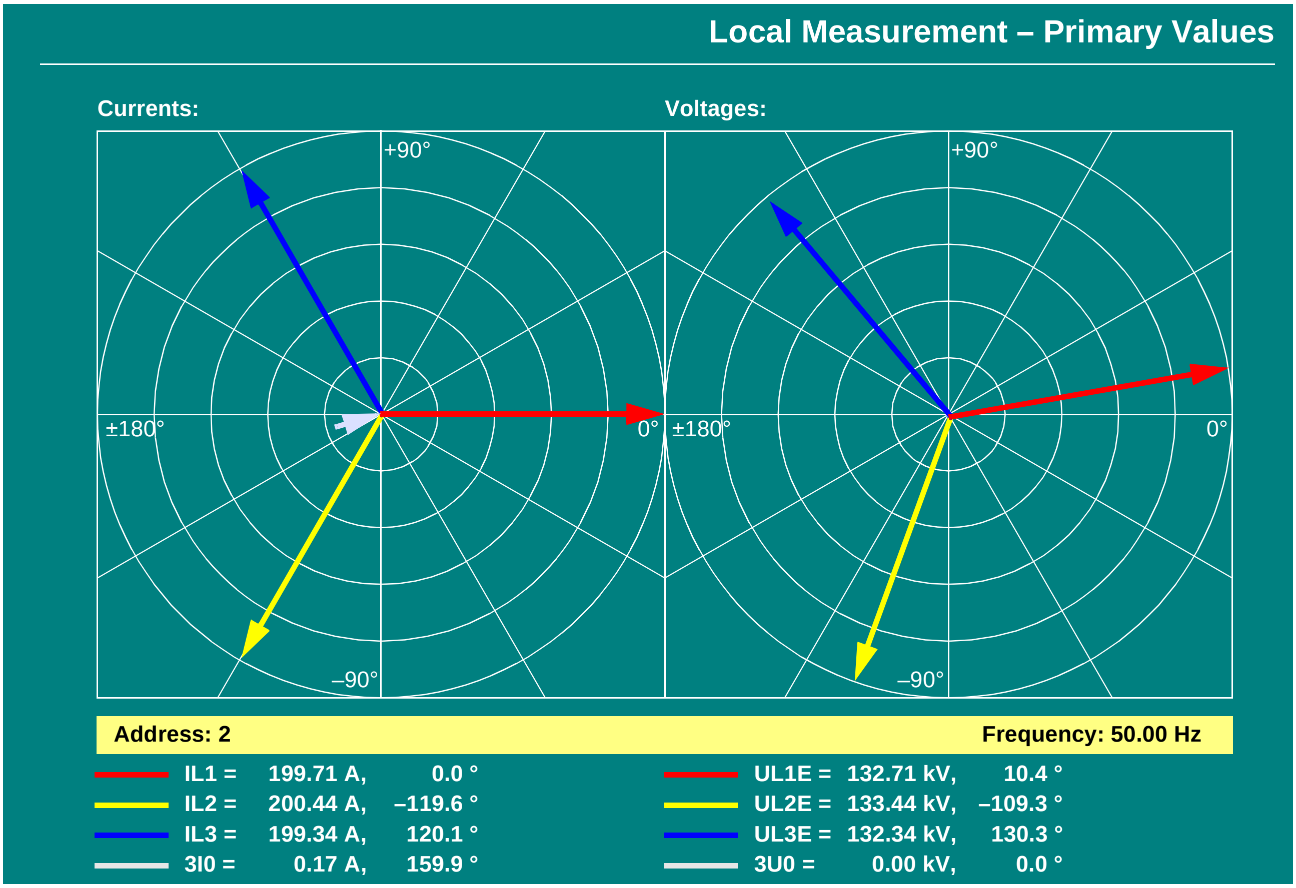


Figure 3-20 Local measured values in the “IBS Tool” — example of plausible measured values

Polarity Check

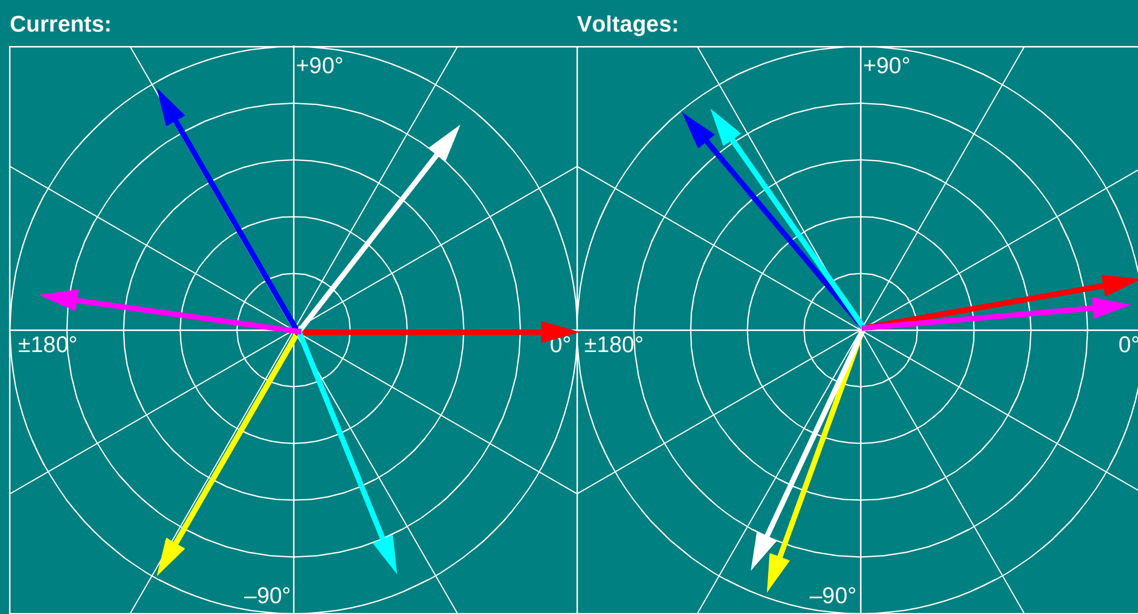
If the device is connected with voltage transformers, the local measured values already provide a polarity test.

A load current of at least 5 % of the rated operational current is required. Any direction is possible but must be known.

- ☐ With closed circuit breakers, the power values can be viewed as primary and secondary measured values in the front display panel or via the operator or service interface with a personal computer.

Here, again, the IBS Tool is a comfortable help as the vector diagrams also show the correlation between the currents and voltages (Figure 3-21). Cyclically and acyclically swapped phases can easily be detected.

Remote Measurement



Local Address: 2

IL1L =	24.96 %,	0.0 °	UL1EL =	99.94 %,	10.4 °
IL2L =	25.06 %,	–119.9 °	UL2EL =	100.50 %,	–109.3 °
IL3L =	24.92 %,	120.1 °	UL3EL =	99.66 %,	130.4 °

Remote Address: 1

IL1R =	23.22 %,	172.2 °	UL1ER =	94.94 %,	4.7 °
IL2R =	23.30 %,	52.4 °	UL2ER =	94.68 %,	–115.0 °
IL3R =	23.17 %,	–67.7 °	UL3ER =	95.48 %,	124.7 °

Constellation Data:

IdiffL1 =	2.63 %	Frequency =	50.00 Hz
IdiffL2 =	3.21 %		
IdiffL3 =	2.72 %		

Figure 3-21 Local and remote measured values in the “IBS Tool” — examples for plausible measured values

☐ With the aid of the measured power values you are able to verify that they correlate to the load direction, reading either at the device itself or in DIGSI® (Figure 3-22).

P positive, if active power flows into the protected object,

P negative, if active power flows towards the busbar,

Q positive, if (inductive) reactive power flows into the protected object,

Q negative, if (inductive) reactive power flows towards the busbar.

Therefore, the power results and their components must have opposite signs at both ends.

It must be taken into consideration that high charging currents, which might occur with long overhead lines or with cables, are capacitive, i.e. correspond to a negative reactive power into the line. In spite of a resistive-inductive load, this may lead to a slightly negative reactive power at the feeding end whereas the other end shows 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.

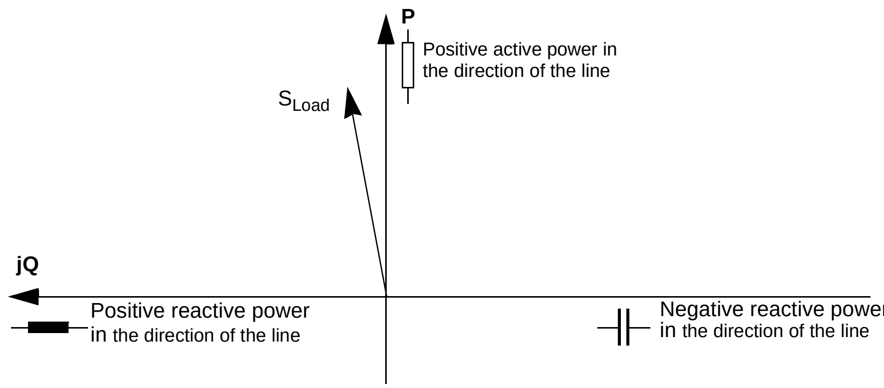


Figure 3-22 Complex (apparent) power

☐ The power measurement provides an initial indication as to whether the measured values of one end have the correct polarity.

- If the reactive power is correct but the active power has the wrong sign, cyclic phase swapping of the currents (right) or of the voltages (left) might be the cause.
- If the active power direction is correct but the reactive power has the wrong sign, cyclic phase swapping of the currents (left) or of the voltages (right) might be the cause.
- If both the active power and the reactive power have the wrong sign, the polarity according to the address 201 **CT Starpoint** is to be checked and corrected.

The phase angles between currents and voltages must also be conclusive. Each one of the three phase angles φ (U_{Lx}–I_{Lx}) must be approximately the same and must represent the operating status. In the event of power in the direction of the protected object, they represent 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 taken into consideration (see above).

☐ The measurements may have to be repeated after correction the connections.

☐ The above described tests of the measured values 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. Note that currents flowing through the object (without charging currents) ideally have opposite signs at both ends, i.e. turned by 180°.

In the “IBS Tool” the local and remote measured values can be shown graphically. You can see an example in Figure 3-21.

☐ The protected object is now switched off, i.e. the circuit breakers are opened.

Polarity Check for the Current Input I_4

If the standard connection of the device is used whereby the current measuring input I_4 is connected in the starpoint of the set of current transformers (refer also to the connection circuit diagram in the Appendix, Figure A-3), then the correct polarity of the earth current path in general automatically results.

If however the current I_4 is derived from a separate summation CT (e.g. a core balance CT) an additional direction check with this current is necessary.

- ☐ The test is done with a disconnected trip circuit and primary load current. It must be noted that during all simulations that do not exactly correspond with cases that may occur in practice, the non-symmetry of measured values may cause the measured value monitoring to pick up. These must therefore be ignored during such tests.

DANGER!

All precautionary measures must be observed when working on the instrument transformers! Secondary connections of the current transformers must have been short-circuited before any current lead to the relay is interrupted!

- ☐ 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 3-23). If no connection on 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 load in the first quadrant, the protection is in principle subjected to the same conditions that exist during an earth fault in the direction of the line.
- ☐ The same manipulation is carried out with the current and voltage transformers at the other end.

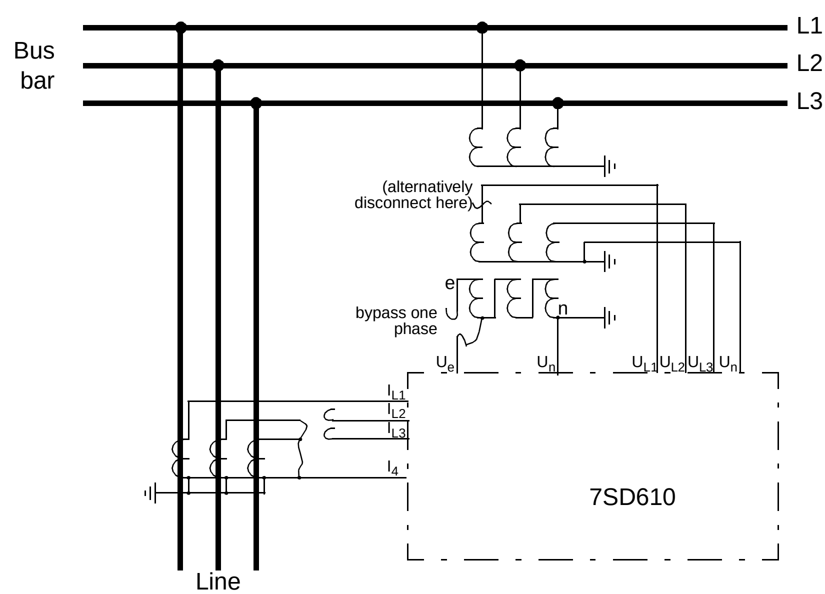


Figure 3-23 Polarity testing for I_4, example with current transformers configured in a Holmgreen connection

- ☐ Figure 3-24 illustrates an example corresponding to the circuit in Figure 3-23, when the current flows in direction of the object to be protected. The currents I_{L2} and I_{L3} are almost zero, an earth current $3I_0$ of the same value as I_{L1} appears. 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 sequence voltage $3U_0$ supplements the other two voltages to a (here false) voltage star. Open the circuit breakers, short-circuit current transformers and set current and voltage transformer connections right. Repeat test.
- ☐ Having finished the test, open all circuit breakers, short-circuit current transformers and restore current and voltage transformer connections.

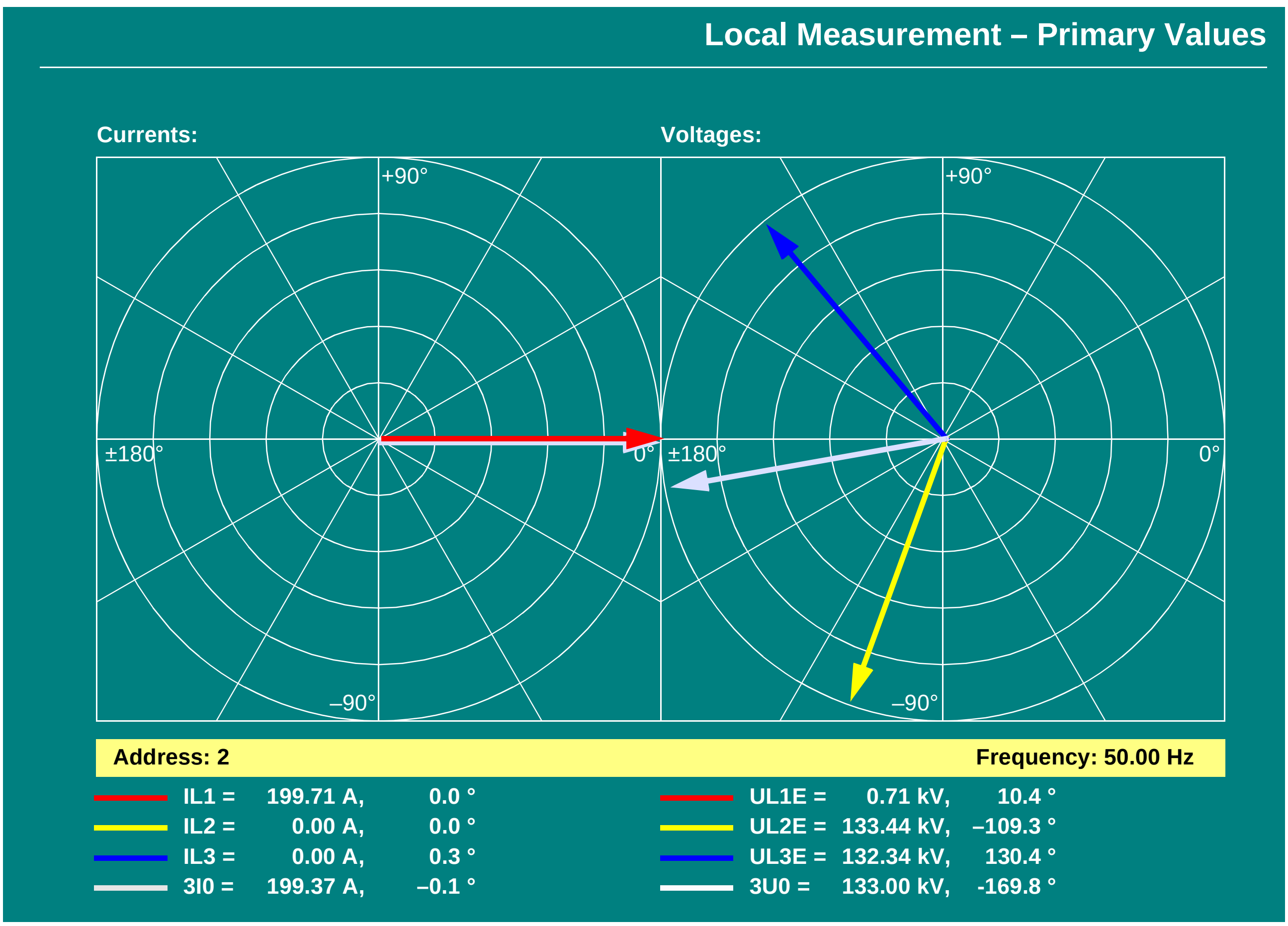


Figure 3-24 Local measured values — example for single-phase, asymmetrical test

Measuring Differential and Restraint Currents

The test for two ends is terminated with the reading of the differential and restraint currents which simultaneously check that the current transformer connections have been restored correctly after the I_4 test (if performed).

- ☐ Read out the differential and restraint currents. They are available for every phase at the device display or in DIGSI® amongst 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.

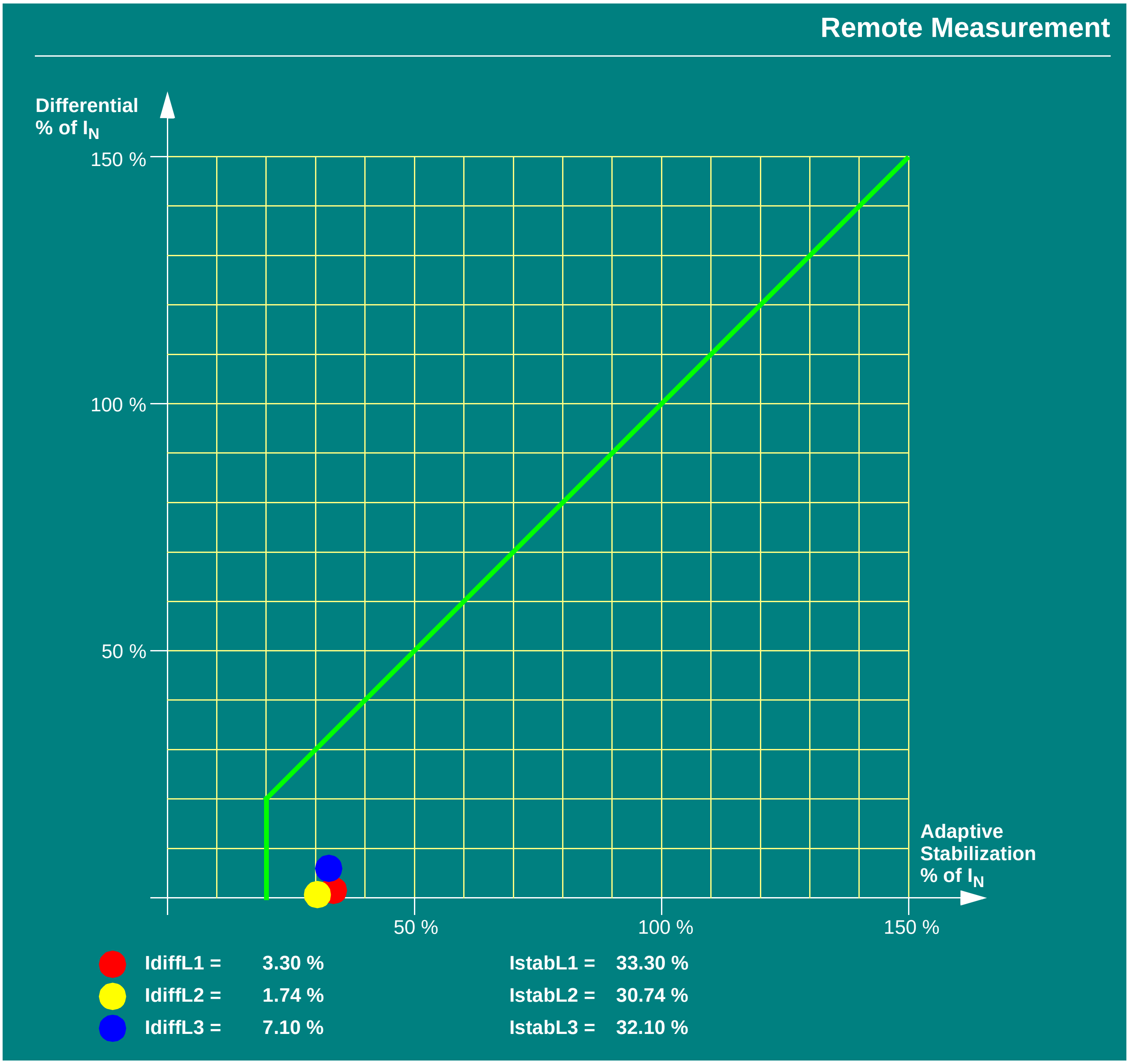


Figure 3-25 Differential and restraint currents — example for plausible currents

- The restraint currents result from the pickup value **I-DIFF>** (address 1210, cf. Subsection 2.2.2) in addition to the sum of the current errors to be tolerated: such as the locally permissible current transformer error according to address 0253 **E% ALF/ALF_N** (cf. Subsection 2.1.2) the permissible current transformer errors at the remote end according to that setting there, as well as the internal estimation of the system errors (frequency, synchronization 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) there is:

$$\frac{I_{stab}}{I_{NO}} = \underbrace{0.3}_{\substack{\text{Set value}\\ \texttt{I-DIFF>}}} + \underbrace{0.05 \cdot \frac{I}{I_{N1}}}_{\substack{\text{Permiss. Lo-}\\ \text{cal CT error}}} + \underbrace{0.05 \cdot \frac{I}{I_{N2}}}_{\substack{\text{Permiss. Re-}\\ \text{mote CT error}}} + \text{System errors}$$

with
I the actual current flowing,
I_{NO} the nominal operating current as parameterized,
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 “IBS-Tool”, the differential and restraint currents are displayed as a graph in a characteristics diagram. An example is illustrated in Figure 3-25.

☐ 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. Check the polarity again and set it right after short-circuiting all the three current transformers. If you have modified these current transformers, also perform a power and angle test.

☐ Finally, open circuit breaker again.

☐ If parameter settings have been changed for the tests, reset them to the values necessary for operation.

3.3.9 Remote Tripping, Remote Signalling etc.

As soon as the communication between the devices has been established, the functions that depend on the transmission can be tested.

This applies in particular to

- ❑ remote tripping via a binary input (cf. Section 2.3),
- ❑ transmission of further remote commands or remote signals (cf. Section 2.6),
- ❑ tripping of the remote circuit breaker by breaker failure protection and/or end fault protection (cf. Subsection 3.3.6),
- ❑ verification of remote circuit breaker positions.

The “IBS-Tool” can be used to achieve the latter. It contains a sheet where the circuit breaker position is notified. Note that the circuit breaker position can only be indicated reliably, if the circuit breaker's feed-back information has been signalled to the corresponding device via binary inputs. Without these auxiliary contacts the devices can only deduce the circuit breaker positions from the current flow. But as the current may be zero even if the circuit breaker is closed, you must expect wrong indications. The circuit breaker position is, however, always interpreted by the protection functions in such a way that it goes on the safe side if in doubt.

For all the other commands and information to be transmitted, generate the source of the information and check that the desired effect is created at the receiving end. Also note the following:

DANGER!

Make sure that switching operations produced by remote command can be performed without any danger during the actual switching state!

3.3.10 Testing User Defined Functions

7SD610 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.

Of course, general test procedures cannot be given. Rather, the configuration of these user defined functions and the necessary associated conditions must be known and verified. Of particular importance are possible interlocking conditions of the switchgear (circuit breakers, isolators, etc.). They must be considered and tested.

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 Section 2.13.5.

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. It is accordingly not sufficient that the auxiliary contacts are assigned to the binary inputs with FNo 00351 to 00353, 00379 and/or 00380 (depending on the options of the auxiliary contacts); in addition, the corresponding FNos 00366 to 00368 and/or 00410 and/or 00411 (depending on the options of the auxiliary contacts) must be configured (see also Section 2.13.2). These are exclusively used for the CB-test. In addition, the ready state of the circuit breaker for the CB-test must be indicated to the binary input FNo 00371.

3.3.12 Stability Check and Triggering Oscillographic Recordings

At the end of commissioning, an investigation of switching operations of the circuit breaker(s), under load conditions, should be done to assure the stability of the protection during the dynamic processes. Oscillographic recordings obtain the maximum information about the behaviour of the 7SD610.

Requirements

Along with the capability of recording waveform data during system faults, the 7SD610 also has the capability of capturing the same data when commands are given to the device via the service program DIGSI®, the serial interfaces, or a binary input. For the latter, the binary input must be assigned to the function “>Trig.Wave.Cap.” (FNo 00004). Triggering for the oscillographic recording then occurs when the input is energized. For example, a close command to the circuit breaker may be used to control the binary input for triggering.

An oscillographic recording that is externally triggered (that is, without a protective element pickup or device trip) is processed by the device as a normal fault recording with the exception that data are not given in the fault messages (trip log). The externally triggered record has a consecutive number for establishing a sequence.

Triggering with DIGSI®

To trigger oscillographic recording with DIGSI®, click on **Test** in the left part of the window. Double-click the entry **Test Wave Form** in the list in the right part of the window to trigger the recording. See Figure 3-26.

A report is given in the bottom left region of the screen. In addition, message segments concerning the progress of the procedure are displayed.

The SIGRA program or the Comtrade Viewer program is required to view and analyse the oscillographic data.

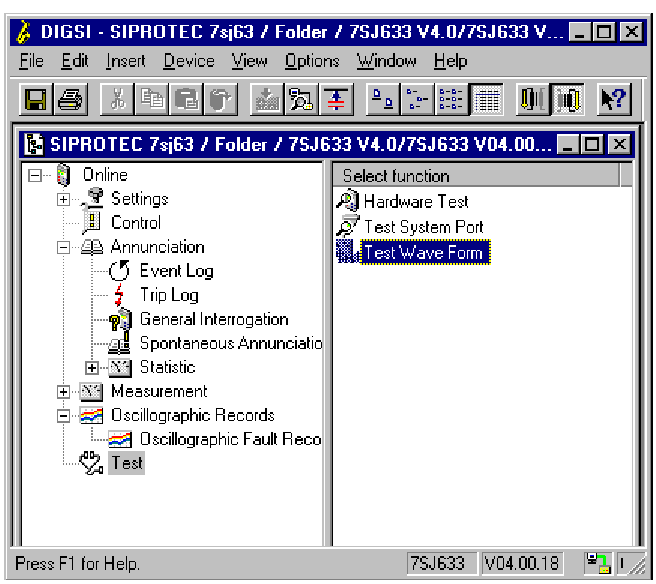


Figure 3-26 Triggering oscillographic recording with DIGSI®

3.4 Final Preparation of the Device

Tighten the used screws at the terminals; those ones not being used should be slightly fastened. Ensure all pin connectors are properly inserted.

Caution!

Do not use force! The permissible tightening torques must not be exceeded as the threads and terminal chambers may otherwise be damaged!

Verify that all service settings are correct. This is a crucial step because some setting changes might have been made during commissioning. The protective settings under device configuration, input/output configuration are especially important as well as the power system data, and activated Groups A through D (if applicable). All desired elements and functions must be set ***ON***. See (Chapter 2). Keep a copy of all of the in-service settings on a PC.

Check the internal clock of the device. If necessary, set the clock or synchronize the clock if it is not automatically synchronized. For assistance, refer to the system manual, order-no. E50417–H1176–C151.

The annunciation memory buffers should be cleared, particularly the operational messages (event log) and fault messages (trip log). Future information will then only apply for actual system events and faults. To clear the buffers, press **MAIN MENU** → **Annunciation** → **Set/Reset**. Refer to the system manual if further assistance is needed. The numbers in the switching statistics should be reset to the values that were existing prior to the testing, or to values in accordance with the user's practices. Set the statistics by pressing **MAIN MENU** → **Annunciation** → **Statistic**.

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. Any output relays that were picked up prior to clearing the LEDs are reset when the clearing action is performed. Future indications of the LEDs will then apply only for actual events or faults. Pressing the **LED** key also serves as a test for the LEDs because they should all light when the button is pushed. Any LEDs that are lit after the clearing attempt are displaying actual conditions.

The green “RUN” LED must be on. The red “ERROR” LED must not be lit.

Close the protective switches. If test switches are available, then these must be in the operating position.

The device is now ready for operation.

■

Technical Data 4

This chapter provides the technical data of the SIPROTEC® 4 7SD610 device and its individual functions, including the limiting values that must not be exceeded under any circumstances. The electrical and functional data of fully equipped 7SD610 devices are followed by the mechanical data, with dimensional drawings.

4.1 General Device Data

4.1.1 Analog 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 – at I_N = 5 A	 approx. 0.05 VA approx. 0.3 VA
	Current overload capability per input – thermal (rms) – dynamic (pulse)	 500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half cycle)
Requirements for Current Transformers	1st condition: For a maximum fault current the current transformers must not be saturated under steady-state conditions	$n' \geq \frac{I_{F\ cont\ max}}{I_{N\ prim}}$
	2nd condition: The accuracy limiting factor must be at least 30 or a non-saturated period of at least $^1/_4$ AC cycle after fault inception must be ensured	$n' \geq 30$ **OR** $t'_{AL} \geq {}^1/_2$ AC cycle
	3rd 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	Nominal voltage U_N	80 V to 125 V (adjustable)
	Power consumption per phase at 100 V	≤ 0.1 VA
	Voltage overload capability per phase – thermal (rms)	 230 V continuous

4.1.2 Power Supply

Direct Voltage

Voltage supply via integrated DC/DC converter:

Nominal power supply direct voltage U_{NDC}	24/48 VDC	60/110/125 VDC
Permissible voltage ranges	19 to 58 VDC	48 to 150 VDC

Nominal power supply direct voltage U_{NDC}	110/125/220/250 VDC
Permissible voltage ranges	88 to 300 VDC

	Permissible AC ripple voltage, peak to peak	$\leq$15 % of the nominal power supply voltage
	Power consumption – quiescent – energized	 approx. 6.5 W approx. 10 W
	Bridging time for failure/short-circuit of the power supply	$\geq$50 ms at U_H = 48 V and $U_{NDC} \geq$ 110 V $\geq$20 ms at U_H = 24 V and U_{NDC} = 60 V
Alternating Voltage	Voltage supply via integrated AC/DC converter	

Nominal power supply alternating voltage U_{NAC}	115 VAC
Permissible voltage ranges	92 to 132 VAC

Power consumption – quiescent – energized	 approx. 10 VA approx. 17 VA
Bridging time for failure/short-circuit of the power supply	$\geq$ 50 ms

4.1.3 Binary Inputs and Outputs

Binary Inputs	Number	7 (allocatable)
	Nominal voltage	24 VDC to 250 VDC in 3 ranges, bipolar
	Switching thresholds	adjustable with jumpers
	– for nominal voltages 24/48 VDC 60/110/125 VDC	$U_{high} \geq$ 19 VDC $U_{low} \leq$ 10 VDC
	– for nominal voltages 110/125/ 220/250 VDC	$U_{high} \geq$ 88 VDC $U_{low} \leq$ 44 VDC
	– for nominal voltages 220/250 VDC	$U_{high} \geq$ 176 VDC $U_{low} \leq$ 88 VDC
	Current consumption, energized	approx. 1.8 mA independent of the control voltage
	Maximum permissible voltage	300 VDC
	Input interference suppression	220 nF coupling capacitance at 220 V with recovery time >60 ms
Binary Outputs	Command/signal relays (see also General Diagrams in Section A.2 of Appendix A)	
	Number	3, each with 1 NO contact (commoned) 2, each with 1 NO contact (voltfree) (allocatable) plus 1 alarm relay (NO/NC adjustable)
	Switching capability MAKE BREAK	1000 W/VA 30 VA 40 W ohmic 25 W for L/R $\leq$ 50 ms

Switching voltage	250 V
Permissible current per contact make and carry	5 A continuous 30 A for 0.5 s (NO contact)
Permissible total current on common paths	5 A continuous 30 A for 0.5 s (NO contact)
UL-Listing for command/signal relays with the following rated data	120 Vac Pilot duty, B300 240 Vac Pilot duty, B300 240 Vac 5 A General Purpose 24 Vdc 5 A General Purpose 48 Vdc 0.8 A General Purpose 240 Vdc 0.1 A General Purpose 120 Vac 1/6 hp (4.4 FLA) 240 Vac 1/2 hp (4.9 FLA)

4.1.4 Communications Interfaces

Protection Data Interface	See Section 4.5	
Operation Interface	– Connection	front panel, non-isolated, RS 232 9-pin DSUB socket for connecting a personal computer
	– Operation	with DIGSI®
	– Transmission speed	min. 4800 Baud; max. 115200 Baud factory setting: 38400 Baud; parity: 8E1
	– Maximum transmission distance	15 m (50 ft)
Service/Modem Interface (optional)	RS232/RS485/	isolated interface for data transfer acc. ordered version
	Operation	with DIGSI®
	RS232	
	– Connection for flush mounted case	rear panel, mounting location “C” 9-pin DSUB socket
	for surface mounted case	at the inclined housing on the case bottom 9-pin DSUB socket
		shielded data cable
	– Test voltage	500 V; 50 Hz
	– Transmission speed	min. 4800 Baud; max. 115200 Baud factory setting: 38400 Baud
	– Maximum transmission distance	15 m (50 ft)

	RS485	
	– Connection for flush mounted case	rear panel, mounting location “C” 9-pin DSUB socket
	for surface mounted case	at the inclined housing on the case bottom 9-pin DSUB socket
		shielded data cable
	– Test voltage	500 V; 50 Hz
	– Transmission speed	min. 4800 Baud; max. 115200 Baud factory setting: 38400 Baud
	– Maximum transmission distance	1000 m (3300 ft)
System (SCADA) Interface (optional)	RS232/RS485/Optical Profibus RS485/Profibus Optical DNP3.0 RS485/DNP3.0 Optical	isolated interface for data transfer to a master terminal acc. to ordered version
	RS232	
	– Connectionfor flush mounted case	rear panel, mounting location “B” 9-pin DSUB socket
	for surface mounted case	at the inclined housing on the case bottom 9-pin DSUB socket
	– Test voltage	500 V; 50 Hz
	– Transmission speed	min. 4800 Bd, max. 38400 Bd factory setting: 19200 Bd
	– Maximum transmission distance	15 m (50 ft)
	RS485	
	– Connection for flush mounted case	rear panel, mounting location “B” 9-pin DSUB socket
	for surface mounted case	at the inclined housing on the case bottom 9-pin DSUB socket
	– Test voltage	500 V, 50 Hz
	– Transmission speed	min. 4800 Bd, max. 38400 Bd factory setting: 19200 Bd
	– Maximum transmission distance	1000 m (3300 ft)
	Optical fibre	
	– Connector type for flush mounted case for surface mounted case	ST-connector rear panel, mounting location “B” at the inclined housing on the case bottom
	– Optical wavelength	λ = 820 nm
	– Laser class 1 acc. EN 60825–1/ –2	using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
	– Permissible optical signal attenuation	max. 8 dB, using glass fibre 62.5/125 µm

– Maximum transmission distance	1.5 km (0.9 miles)
– Character idle state	selectable; factory setting: “Light off”

Profibus RS485

– Connection for flush mounted case	rear panel, mounting location “B” 9-pin DSUB socket	
for surface mounted case	at the inclined housing on the case bottom 9-pin DSUB socket	
– Test voltage	500 V; 50 Hz	
– Transmission speed	up to 12 MBd	
– Maximum transmission distance	1000 m (3300 ft)	at ≤ 93.75 kBd
	500 m (1650 ft)	at ≤ 187.5 kBd
	200 m (665 ft)	at ≤ 1.5 MBd
	100 m (330 ft)	at ≤ 12 MBd

Profibus Optical

– Connector type	ST-connector twin ring	
– Connection for flush mounted case	rear panel, mounting location “B”	
for surface mounted case	only with external OLM	
– Transmission speed recommended:	to 1.5 MBd > 500 kBd	
– Optical wavelength	λ = 820 nm	
– Laser class 1 acc. EN 60825–1/ –2	using glass fibre 50/125 µm or using glass fibre 62.5/125 µm	
– Optical budget	max. 8 dB using glass fibre 62.5/125 µm	
– Maximum transmission distance between 2 modules at redundant optical ring	1.6 km (1 mile)	at 500 kB/s
topology and glass fiber 62.5/125 µm	530 m ($^1/_3$ mile)	at 1500 kB/s
– Character idle state	“Light off”	
– Number of modules in optical rings	max. 41 at 500 kB/s or 1500 kB/s	

DNP3.0 RS485

– Connection for flush mounted case	rear panel, mounting location “B” 9-pin DSUB socket
for surface mounted case	at the inclined housing on the case bottom 9-pin DSUB socket
– Test voltage	500 V; 50 Hz
– Transmission speed	up to 19200 Bd
– Maximum transmission distance	1000 m (3300 ft)

DNP3.0 Optical

– Connector type	ST-connector
– Connection for flush mounted case for surface mounted case	rear panel, mounting location “B” only with external converter
– Transmission speed	to 19200 Bd
– Optical wavelength	λ = 820 nm
– Laser class 1 acc. EN 60825–1/ –2	using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
– Permissible optical signal attenuation	max. 8 dB using glass fibre 62.5/125 µm
– Maximum transmission distance	1500 m (0.9 miles)

Time Synchronization

– Signal type	DCF77/IRIG B/GPS
– Connection for flush mounted case	rear panel, mounting location “A” 9-pin DSUB socket
for surface mounted case	at the terminal on the case bottom

– Signal properties for DCF77/IRIG B (Format IRIG-B000):

	Nominal signal input 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
R_I	890 Ω at U_I = 4 V 640 Ω at U_I = 6 V	1930 Ω at U_I = 8.7 V 1700 Ω at U_I = 15.8 V	3780 Ω at U_I = 17 V 3560 Ω at U_I = 31 V

– Signal properties for GPS

Nominal signal voltage	24 V
PPS signal pulse duty factor max. rise/fall time deviation of all receivers	 1/999 to 1/1 ±3 µs
GPS-receiver, antenna, power supply	see Appendix, Section A.1.1 Accessories

4.1.5 Electrical Tests

Specifications

Standards:

IEC 60255 (Product standards)
IEEE Std C37.90.0; C37.90.0.1; C37.90.0.2
UL 508
VDE 0435
See also standards for individual tests

Insulation Tests	Standards:	IEC 60255–5 and 60870–2–1
	– High voltage test (routine test) all circuits except power supply, binary inputs, and communication/time sync. interfaces	2.5 kV (RMS); 50 Hz
	– High voltage test (routine test) only power supply and binary inputs	3.5 kVDC
	– High Voltage Test (routine test) only isolated communication /time sync. interfaces	500 V (RMS); 50 Hz
	– Impulse voltage test (type test) all circuits except communication /time sync. interfaces, class III	5 kV (peak); 1.2/50 µs; 0.5 Ws; 3 positive and 3 negative impulses in intervals of 5 s
EMC Tests; Interference Immunity (Type Tests)	Standards:	IEC 60255–6 and –22 (Product standards) EN 61000–6–2 (Generic standard) VDE 0435
	– High frequency test IEC 60255–22–1; VDE 0435 part 301 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; 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, IEC 61000–4–3 class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz
	– Irradiation with HF field, individual frequencies IEC 60255–22–3, IEC 61000–4–3 class III	10 V/m
	amplitude modulated	80 MHz; 160 MHz; 450 MHz; 900 MHz; 80 % AM; 1 kHz; duty >10 s
	pulse modulated	900 Hz; 50 % PM; repetition frequency 200 Hz
	– Fast transient disturbance/burst IEC 60255–22–4, IEC 61000–4–4 class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
	– High energy surge voltages (SURGE) IEC 61000–4–5, installation class 3	impulse: 1.2/50 µs
	power supply	common mode: 2 kV; 12 Ω; 9 µF diff. mode: 1 kV; 2 Ω; 18 µF
	analogue inputs, binary inputs and outputs	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 61000–4–8, IEC 60255–6 class IV	 30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
	– Oscillatory surge withstand capability IEEE Std C37.90.1	2.5 kV (peak value); 1 MHz; τ = 15 µs; 400 surges per s; R_i = 200 Ω; test duration 2 s
	– Fast transient surge withstand capability IEEE Std C37.90.1	 4 kV (peak value); 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; R_i = 80 Ω; duration 2 s;
	– Radiated electromagnetic interference IEEE Std C37.90.2	35 V/m; 25 MHz to 1000 MHz amplitude and pulse modulated
	– 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; Interference Emission (Type Tests)	Standard:	EN 50081–* (Generic standard)
	– Conducted interference, only power supply voltage IEC–CISPR 22	150 kHz to 30 MHz limit class B
	– Radio interference field strength IEC–CISPR 22	30 MHz to 1000 MHz limit class B
	– Harmonic currents on the mains conductors at 230 VAC IEC 61000–3–2	class A limits are fulfilled
	Voltage fluctuations and flicker on the mains conductors at 230 VAC IEC 61000–3–3	limits are fulfilled

4.1.6 Mechanical Stress Tests

Vibration and Shock During Operation	Standards:	IEC 60255–21 and IEC 60068
	– Vibration 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 rate 1 octave/min 20 cycles in 3 orthogonal axes.
	– Shock IEC 60255–21–2, class 1 IEC 60068–2–27	half-sine shaped acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes

	– Seismic vibration IEC 60255–21–3, class 1 IEC 60068–3–3	sinusoidal 1 Hz to 8 Hz: (horizontal axis) 1 Hz to 8 Hz: (vertical axis) 8 Hz to 35 Hz: (horizontal axis) 8 Hz to 35 Hz: (vertical axis) Frequency sweep rate 1 cycle in 3 orthogonal axes	 ± 3.5 mm amplitude ± 1.5 mm amplitude 1 g acceleration 0.5 g acceleration 1 octave/min
Vibration and Shock During Transport	Standards:	IEC 60255–21 and IEC 60068	
	– Vibration IEC 60255–21–1, class 2 IEC 60068–2–6	sinusoidal 5 Hz to 8 Hz: 8 Hz to 150 Hz: Frequency sweep rate 20 cycles in 3 orthogonal axes	 ±7.5 mm amplitude 2 g acceleration 1 octave/min
	– Shock IEC 60255–21–2, class 1 IEC 60068–2–27	half-sine shaped acceleration 15 g; duration 11 ms; 3 shocks in each direction of 3 orthogonal axes	
	– Continuous shock IEC 60255–21–2, class 1 IEC 60068–2–29	half-sine shaped acceleration 10 g; duration 16 ms; 1000 shocks in each direction of 3 orthogonal axes	

Note:

All mechanical stress specifications are valid for standard works packaging!

4.1.7 Climatic Stress Tests

Temperatures [1])	– Type tested (acc. IEC60068–2–1 and –2, Test condition for 16 h)	–25 °C to +85 °C	(–13 °F to +185 °F)
	– Limiting temporary (transient) operating temperature (tested for 96 h)	–20 °C to +70 °C (–4 °F to 158 °F)	Visibility of display may be impaired above +55 °C/130 °F
	– Recommended permanent operating temperature (acc. IEC 60255–6)	–5 °C to +55 °C	(+23 °F to +131 °F)
	– Limiting temperature during storage	–25 °C to +55 °C	(–13 °F to 131 °F)
	– Limiting temperature during transport	–25 °C to +70 °C	(–13 °F to 158 °F)

Storage and transport of the device with factory packaging!

[1])	UL-certified (Standard 508, Industrial Control Equipment):	
	– Limiting temperatures for normal operation (output relays not energized)	–20 °C to +70 °C (–4 °F to +158 °F)
	– Limiting temperatures with max. load (max. cont. permissible energization of inputs and outputs)	–5 °C to +40 °C (+23 °F to +104 °F)
Humidity	Permissible humidity	mean value p. year ≤75 % relative humidity on 56 days per year up to 93 % relative humidity; condensation not permissible!
	All devices shall be installed such that they are not exposed to direct sunlight, nor subject to large fluctuations in temperature that may cause condensation to occur.	

4.1.8 Service Conditions

The device is designed for use in an industrial environment or an electrical utility environment, for installation in standard relay rooms and compartments so that proper installation and electromagnetic compatibility (EMC) is ensured. In addition, the following are recommended:

- All contactors and relays that operate in the same cubicle, cabinet, or relay panel as the numerical protective device should, as a rule, be equipped with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables should be shielded with a conductive shield grounded at both ends. The shield must be capable of carrying the fault currents that could occur. For substations with lower operating voltages, no special measures are normally required.
- Do not withdraw or insert individual modules or boards while the protective device is energized. When handling the modules or the boards outside of the case, standards for components sensitive to electrostatic discharge (ESD) must be observed. The modules, boards, and device are not endangered when the device is completely assembled.

4.1.9 Construction

Housing	7XP20
Dimensions	see drawings, Section 4.13
Weight (mass), approx. – in flush mounted case, size $^1/_2$ – in surface mounted case, size $^1/_2$	 5,0 kg (11 lb) 9,5 kg (21 lb)
Degree of protection acc. IEC 60529 – for the device in surface mounted case in flush mounted case front rear – for human safety	 IP 51 IP 51 IP 50 IP 2x with closed protection cover
UL-certification conditions:	“For use on a Flat Surface of a Type 1 Enclosure”

4.2 Differential Protection

Pickup Values

Differential current I_{DIFF}>	0.10 A to 20.00 A[1])	(steps 0.01 A)
Differential current when switching onto a fault $I_{DIFF\ switch\ on}$	0.10 A to 20.00 A[1])	(steps 0.01 A)
Differential current High set differential current I_{DIFF}>>	0.5 A to 100.0 A[1]) or ∞ (stage disabled)	(steps 0.01 A)

Tolerances
- I_{DIFF}>-stage: 5 % of setting value
- I_{DIFF}>>-stage: 5 % of setting value

[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.

Tripping Time

The tripping time depends on the communication speed.

Pickup/trip times of the I_{DIFF}>>-stages approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
minimum	16 ms	18 ms	24 ms
typical	20 ms	23 ms	32 ms

Drop-off time of the I_{DIFF}>>-stages approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
typical	39 ms	42 ms	52 ms

Pickup / trip times of the I_{DIFF}>-stages approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
minimum (50 Hz)	34 ms	39 ms	47 ms
minimum(60 Hz)	32 ms	36 ms	43 ms
typical	38 ms	44 ms	57 ms

Drop-off time of the I_{DIFF}>-stages approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
typical	30 ms	35 ms	45 ms

Delay Times

Delay time of the	I_{DIFF}>-stage $T_{I\text{-}DIFF>}$	0.00 s to 60.00 s or ∞ (stage ineffective)	(steps 0.01 s)
Delay time of the for 1-phase pickup	I_{DIFF}>-stage $T_{3I0\ 1PHAS}$	0.00 s to 60.00 s or ∞ (stage ineffective for 1-phase pickup)	(steps 0.01 s)
Expiry tolerance		1 % of setting value or 10 ms	

The times set 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	(steps 0.01)
	Transformer error at n'/n	0.5 % to 50.0 %	(steps 0.1 %)
	Transformer error at n × I_N (class)	0.5 % to 50.0 %	(steps 0.1 %)
	Further stabilizing quantities (adaptive self-restraint)	Frequency deviation, transmission time differences, harmonics, synchronization quality, jitter	
Inrush Restraint	Restraint ratio 2nd harmonic I_{2fN}/I_{fN}	10 % to 45 %	(steps 1 %)
	Maximum current for restraint	1.1 A to 25.0 A [1])	(steps 0.1 A)
	Crossblock function	can be enabled and disabled	
	Max. action time for crossblock CROSSB 2HM	0.00 s to 60.00 s or ∞ (active until drop off)	(steps 0.01 s)
	[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.		
Conditioning for Transformers (optional)	Vector group matching	0 to 11 (× 30°)	(steps 1)
	Star-point conditioning	earthed or unearthed (for each winding)	
Emergency Operation	Communication failure	see Section 4.6	
Frequency	Frequency correction within range	$0.8 \leq f/f_N \leq 1.2$ stable when starting machine	

4.3 Intertripping, External Direct Local and Remote Tripping

Intertrip

Intertripping of the opposite end when singe-end tripping — can be enabled and disabled

External Direct Local Tripping

Operating time, total	approx. 12 ms	
Trip time delay	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
Expiry tolerance	1 % of setting value or 10 ms	

The set times are pure delay times.

External Direct Remote Tripping

Tripping of remote end by a command that is coupled into a binary input

Operating times, total approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
minimum typical	15 ms 18 ms	18 ms 21 ms	24 ms 31 ms

Drop-off times, total approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
typical	13 ms	15 ms	26 ms

Trip time delay	0.00 s to 30.00 s	(steps 0.01 s)
Trip time prolongation	0.00 s to 30.00 s	(steps 0.01 s)
Expiry tolerance	1 % of setting value or 10 ms	

The set times are pure delay times.

4.4 Direct Remote Trip or Transmission of Binary Information (optional)

Remote Commands

Number of possible remote commands — 4

Operating times, total approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
minimum typical	15 ms 18 ms	18 ms 21 ms	24 ms 31 ms

Drop-off times, total approx.

transmission speed	512 kBit/s	128 kBit/s	64 kBit/s
typical	13 ms	15 ms	26 ms

4.5 Protection Data Interface and Differential Protection Topology

Topology	Number of devices for protected object	2
Protection Data Interface	– Connection optical fibre for flush mounted case for surface mounted case	mounting position “D” on the rear side at the inclined housing on the case top

Connection modules for protection data interface, depending on the ordering version:

Module in device	Type of connector	Type of fibre	Optical wavelength	Perm. path attenuation	Distance, typical
FO5 [1])	ST	Multimode 62.5/125 µm	820 nm	8 dB	1.5 km 0.95 miles
FO6 [2])	ST	Multimode 62.5/125 µm	820 nm	16 dB	3.5 km 2.2 miles
FO7 [2])	ST	Monomode 9/125 µm	1300 nm	7 dB	10 km 6.25 miles
FO8 [2])	FC	Monomode 9/125 µm	1300 nm	18 dB	35 km 22 miles

[1]) Laser class 1 according to EN 60825–1/ –2 using glass fibre 62.5/125 µm
[2]) Laser class 3A according to EN 60825–1/ –2

Character idle state — “Light off”

Protection Data Communication

Direct connection:

Transmission speed	512 kBit/s
Type of fibre Optical wavelength Permissible path attenuation Transmission distance	see Table above

Connection via communication networks:

Communication converter	see Appendix, Section A.1.1 Accessories	
Supported network interfaces	G703.1 with 64 kBit/s; X.21 with 64 or 128 or 512 kBit/s S0 (ISDN) with 64 or 128 kBit/s Pilot wires up to 8 km (5 miles) 128 kBit/s	
Connection to communication converter	see Table above under module FO5	
Max. transmission time	0.1 ms to 30 ms	(steps 0.1 ms)
Max. transmission time difference	0.000 ms to 3.000 ms	(steps 0.001 ms)

4.6 Time Overcurrent Protection

Operating Modes	As emergency overcurrent protection or back-up overcurrent protection:			
	Emergency overcurrent protection		operates on communication failure	
	Back-up overcurrent protection		operates independent of any events	
Characteristics	Definite time stages	(definite)	I_{Ph}>>, $3I_0$>>, I_{Ph}>, $3I_0$>	
	Inverse time stage	(IDMT)	I_P, $3I_{0P}$ one of the characteristics according to Figure 4-1 to 4-3 can be selected	
Current Stages	High set stages	I_{Ph}>> (phases)	0.10 A to 25.00 A^{1}) or ∞ (ineffective)	(steps 0.01 A)
		$T_{IPh>>}$ (phases)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
		$3I_0$>> (earth)	0.05 A to 25.00 A^{1}) or ∞ (ineffective)	(steps 0.01 A)
		$T_{3I0>>}$ (earth)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Overcurrent stages (definite time)	I_{Ph}> (phases)	0.10 A to 25.00 A^{1}) or ∞ (ineffective)	(steps 0.01 A)
		$T_{IPh>}$ (phases)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
		$3I_0$> (earth)	0.05 A to 25.00 A^{1}) or ∞ (ineffective)	(steps 0.01 A)
		$T_{3I0>}$ (earth)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Overcurrent stages (inverse time acc. IEC)	I_P (phases)	0.10 A to 4.00 A^{1}) or ∞ (ineffective)	(steps 0.01 A)
		T_{IP} (phases)	0.05 s to 3.00 s or ∞ (ineffective)	(steps 0.01 s)
		$T_{IP\,add}$ (phases)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
		$3I_{0P}$ (earth)	0.05 A to 4.00 A^{1}) or ∞ (ineffective)	(steps 0.01 A)
		T_{3I0P} (earth)	0.05 s to 3.00 s or ∞ (ineffective)	(steps 0.01 s)
		$T_{3I0P\,add}$ (earth)	0.00 s to 30.00 s	(steps 0.01 s)
	Overcurrent stages (inverse time acc. ANSI)	I_P (phases)	0.10 A to 4.00 A^{1}) or ∞ (ineffective)	(steps 0.01 A)
		D_{IP} (phases)	0.50 s to 15.00 s or ∞ (ineffective)	(steps 0.01 s)
		$T_{IP\,add}$ (phases)	0.00 s to 30.00 s	(steps 0.01 s)

	$3I_{0P}$ (earth)	0.05 A to 4.00 A[1]) or ∞ (ineffective)	(steps 0.01 A)
	D_{3I0P} (earth)	0.50 s to 15.00 s or ∞ (ineffective)	(steps 0.01 s)
	$T_{3I0P\,add}$ (earth)	0.00 s to 30.00 s	(steps 0.01 s)
Tolerances with definite time	currents times	3 % of set value or 1% of nominal current 1 % of set value or 10 ms	
Tolerances with inverse time (IEC)	currents	Pickup at or	$1.05 \le I/I_P \le 1.15$; $1.05 \le I/3I_{0P} \le 1.15$
	times	5 % ± 15 ms	for $2 \le I/I_P \le 20$ and $T_{IP}/s \ge 1$; or $2 \le I/3I_{0P} \le 20$ and $T_{3I0P}/s \ge 1$
(ANSI)	times	5 % ± 15 ms	for $2 \le I/I_P \le 20$ and $D_{IP}/s \ge 1$; or $2 \le I/3I_{0P} \le 20$ and $D_{3I0P}/s \ge 1$

The set times are pure delay times with definite time protection.

[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.

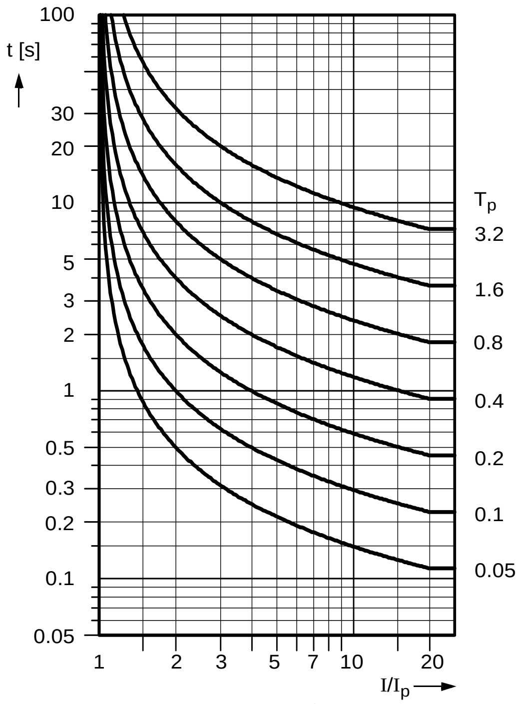
Further Definite Stages; Stub Protection	Overcurrent	$I_{Ph}>_{STUB}$ (phases)	0.10 A to 25.00 A[1]) (steps 0.01 A) or ∞ (ineffective)
		$T_{IPh\,STUB}$ (phases)	0.00 s to 30.00 s (steps 0.01 s) or ∞ (ineffective)
		$3I_0>_{STUB}$ (earth)	0.05 A to 25.00 A[1]) (steps 0.01 A) or ∞ (ineffective)
		$T_{3I0\,STUB}$ (earth)	0.00 s to 30.00 s (steps 0.01 s) or ∞ (ineffective)
	Tolerances	currents times	3 % of setting value or 1% of rated current 1 % of setting value or 10 ms

Enable via special binary input is necessary.

The set times are pure delay times.

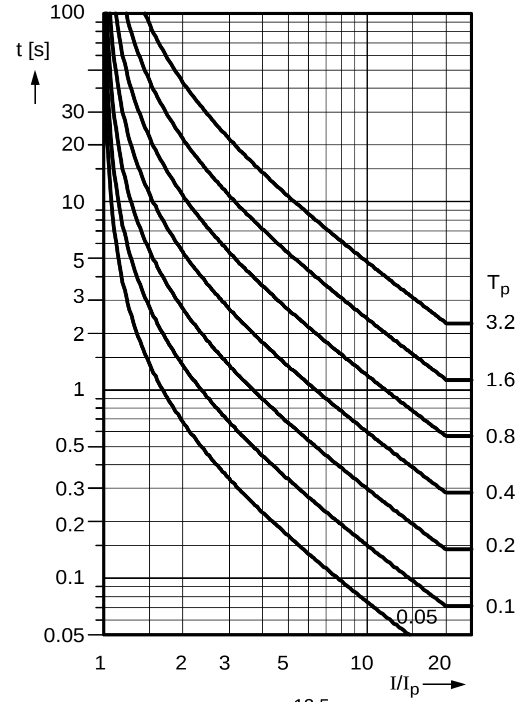
[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.

Operating Times of Definite Stages	Pickup time, minimum	approx. 23 ms with f_N = 50 Hz approx. 21 ms with f_N = 60 Hz
	Pickup time, typical	approx. 28 ms with f_N = 50 Hz approx. 26 ms with f_N = 60 Hz
	Dropout time, typical	approx. 30 ms with f_N = 50 Hz approx. 27 ms with f_N = 60 Hz
Drop-off to Pickup Ratios	Current stages	approx. 0.95 for $I_P/I_N \ge 0.5$



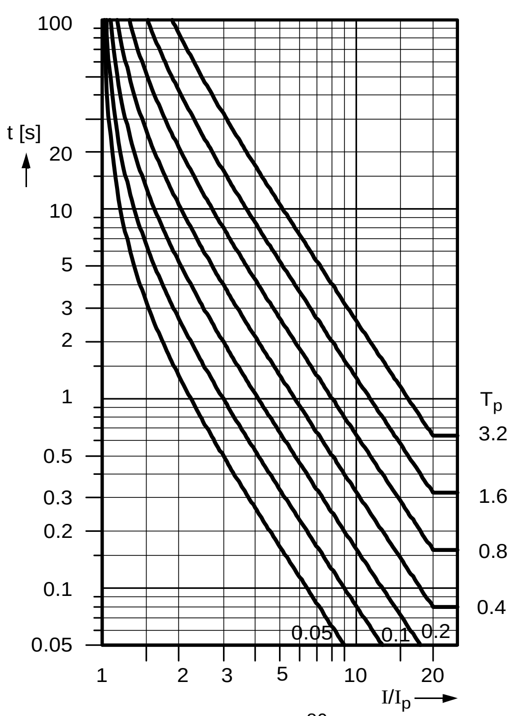
Normal inverse:
(Type A)

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p \quad [s]$$



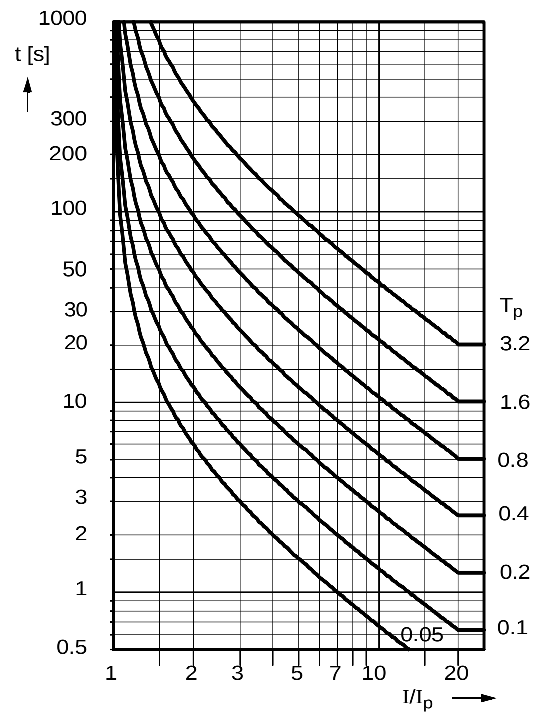
Very inverse:
(Type B)

$$t = \frac{13.5}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$



Extremely inverse:
(Type C)

$$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p \quad [s]$$



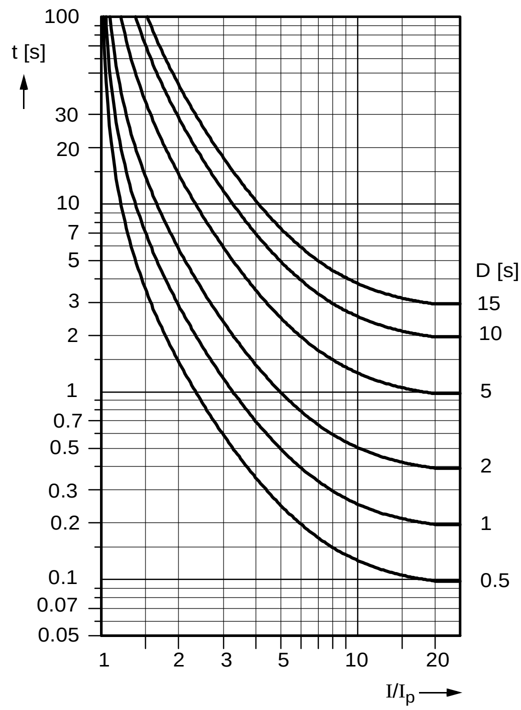
Longtime inverse:

$$t = \frac{120}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$

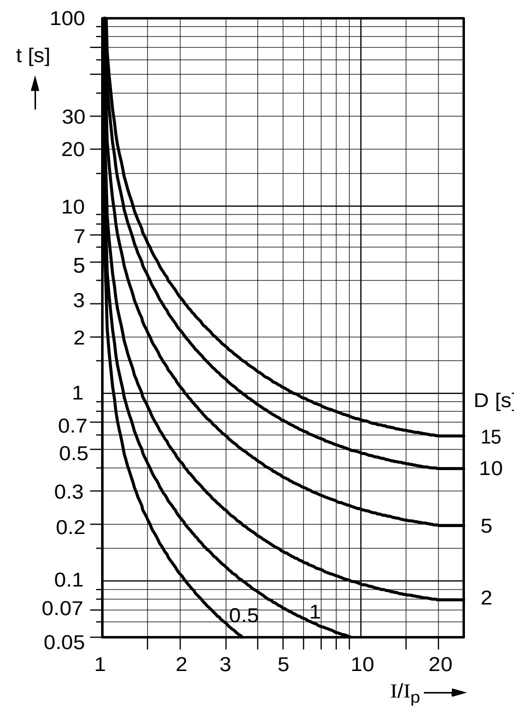
t	trip time
T_p	setting value time multiplier
I	fault current
I_p	setting value current

Note: For earth fault read $3I_{0p}$ instead of I_p and T_{3I0p} instead of T_p

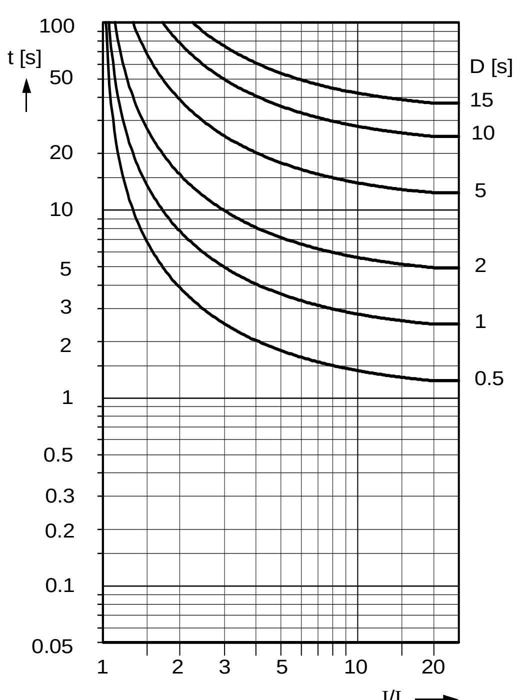
Figure 4-1 Trip time characteristics of inverse time overcurrent protection, acc. IEC (phases and earth)



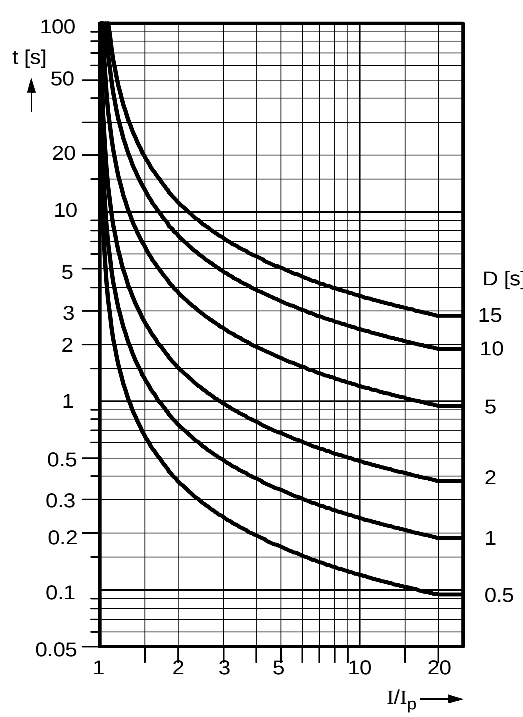
INVERSE $t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966\right) \cdot D \quad [s]$



SHORT INVERSE $t = \left(\frac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393\right) \cdot D \quad [s]$

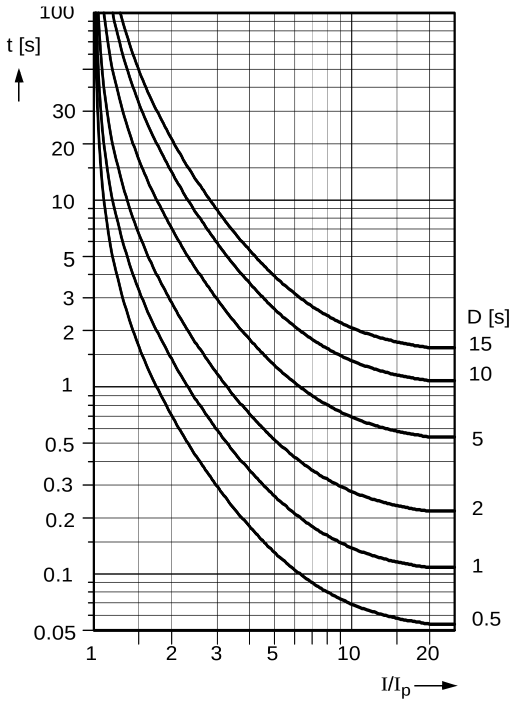


LONG INVERSE $t = \left(\frac{5.6143}{(I/I_p) - 1} + 2.18592\right) \cdot D \quad [s]$

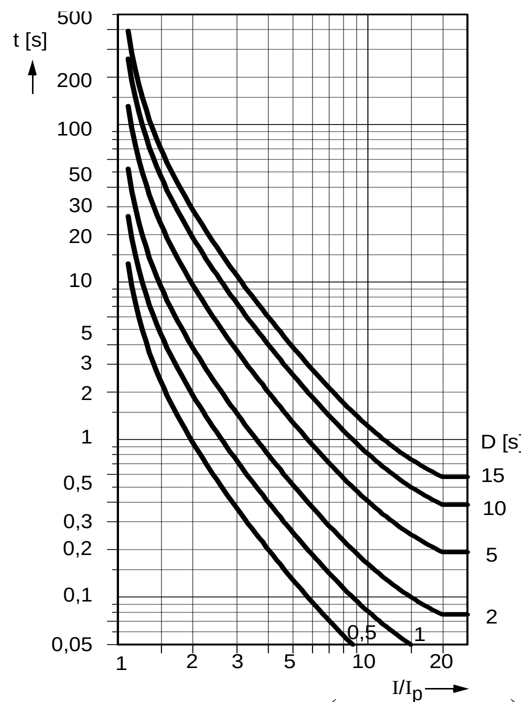


MODERATELY INVERSE $t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228\right) \cdot D \quad [s]$

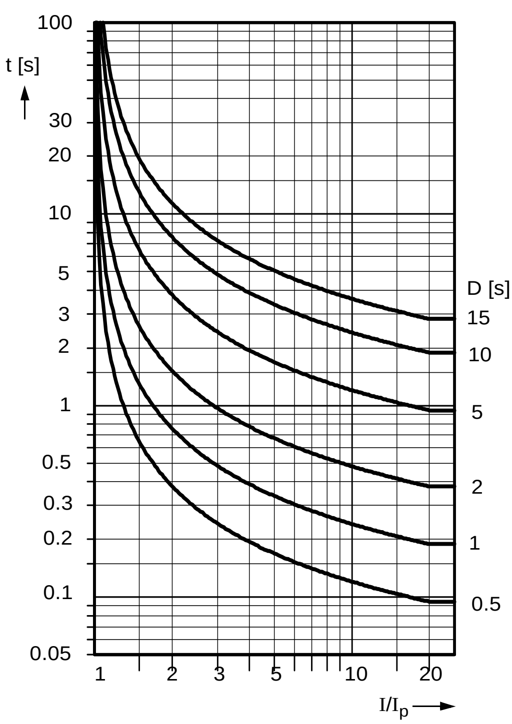
Figure 4-2 Trip time characteristics of inverse time overcurrent protection, acc. ANSI/IEEE, (phases and earth)



VERY INVERSE $t = \left(\frac{3{,}922}{(I/I_p)^2 - 1} + 0.0982\right) \cdot D \quad [s]$



Extremely inverse $t = \left(\frac{5.64}{(I/I_p)^2 - 1} + 0.02434\right) \cdot D \quad [s]$



DEFINITE INVERSE $t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359\right) \cdot D \quad [s]$

t	trip time
D	setting value time multiplier
I	fault current
I_p	setting value current

Note: For earth fault read $3I_{0p}$ instead of I_p and D_{3I0p} instead of D_{Ip}

Figure 4-3 Trip time characteristics of inverse time overcurrent protection, acc. ANSI/IEEE (phases and earth)

4.7 Instantaneous High-Current Switch-onto-Fault Protection

Pickup	High-current pickup	I>>>	0.10 A to 15.00 A[1])	(steps 0.01 A)
	High-current pickup	I>>>>	1.00 A to 25.00 A[1]) or ∞ (ineffective)	(steps 0.01 A)
	Dropout to pickup ratio		approx. 0.90	
	Pickup tolerance		≤ 3 % of set value or 1% of I_N	
	[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.			
Times	Shortest tripping time		approx. 13 ms	

4.8 Automatic Reclosure Function (optional)

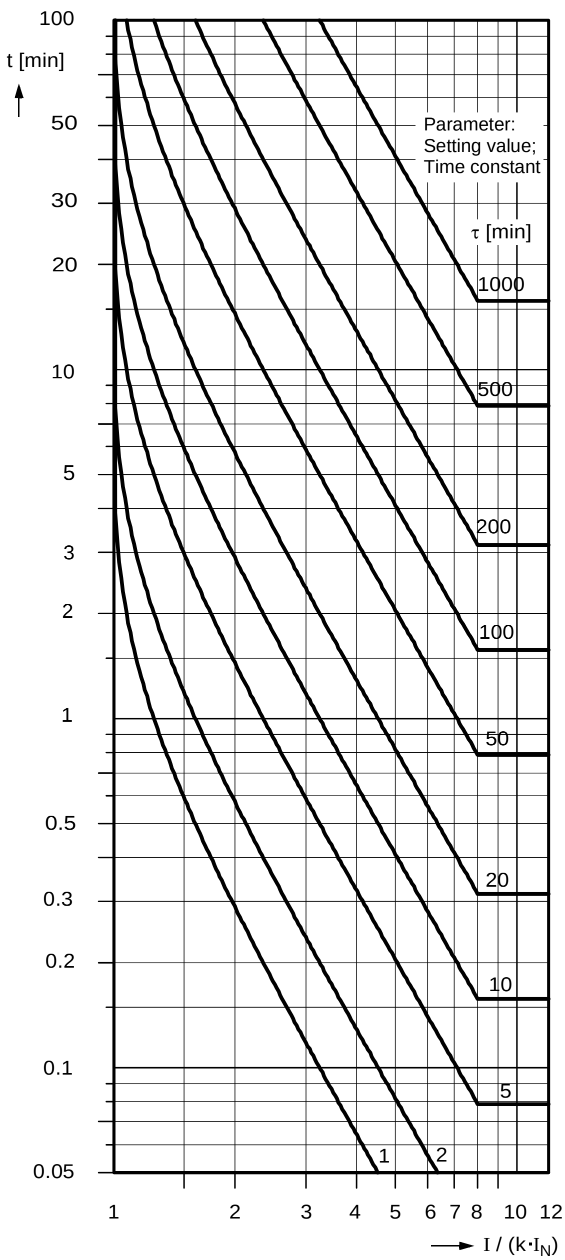
Automatic Reclosures	Number of reclosure attempts	max. 8, first 4 with individual settings	
	Operating modes	1-pole, 3-pole or 1-/3-pole	
	Control	with pickup or trip command	
	Action times Initiation possible without pickup and action time	0.01 s to 300.00 s; ∞	(steps 0.01 s)
	Dead times for all cycles	0.01 s to 1800.00 s; ∞	(steps 0.01 s)
	Dead times after evolving fault recognition	0.01 s to 1800.00 s;	(steps 0.01 s)
	Reclaim time after reclosure	0.50 s to 300.00 s	(steps 0.01 s)
	Lockout time after dynamic blocking	0.5 s	(fix)
	Blocking time after manual closing	0.50 s to 300.00 s; 0	(steps 0.01 s)
	Start signal monitoring time	0.01 s to 300.00 s	(steps 0.01 s)
	Circuit breaker supervision time	0.01 s to 300.00 s	(steps 0.01 s)
Adaptive Dead Time / Dead Line Check	Operating modes	with voltage measurement or with close command transmission	
	Action time Initiation possible without pickup and action time	0.01 s to 300.00 s; ∞	(steps 0.01 s)
	Maximum dead time	0.50 s to 3000.00 s; ∞	(steps 0.01 s)
	Voltage measurement dead line	2 V to 70 V (phase-to-earth)	(steps 1 V)
	Voltage measurement live line	30 V to 90 V (phase-to-earth)	(steps 1 V)
	Measuring time	0.10 s to 30.00 s	(steps 0.01 s)
	Delay for close comm. transmission	0.00 s to 300 s; ∞	(steps 0.01 s)

4.9 Circuit Breaker Failure Protection (optional)

Circuit Breaker Supervision	Current flow monitoring	0.25 A to 20.00 A[1])	(steps 0.01 A)
	Dropoff to pickup ratio	approx. 0.95	
	Pickup tolerance	5 % of set value or 0.01 A[1])	
	Breaker status monitoring		
	– with three-pole control	binary input for CB auxiliary contact	
	– with individual pole control	1 binary input each for each pole, or 1 binary input each for NO and NC contacts	
	Note: Breaker failure protection can operate without the mentioned breaker auxiliary contacts but with reduced functionality. Processing of the auxiliary contacts are necessary for: Breaker failure protection without or with insufficient current flow (e.g. Buchholz protection), end fault protection, pole discrepancy supervision.		
	[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.		
Starting Conditions	for beaker failure protection	single-pole trip internally three-pole trip internally single-pole trip externally three-pole trip externally three-pole trip without current	via binary inputs (last three)
Times	Pickup time	approx. 3 ms with measured quantities present approx. 20 ms after switch-on of measured quantities	
	Reset time	≤15 ms with sinusoidal meas. quantities, ≤25 ms maximum	
	Delay times for all stages	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Time tolerance	1 % of setting value or 10 ms	
End Fault Protection	with signal transmission to the opposite line end		
	Delay time	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Time tolerance	1 % of setting value or 10 ms	
Pole Discrepancy Supervision	Starting criterion	any pole open and any pole closed	
	Supervision time	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Time tolerance	1 % of setting value or 10 ms	

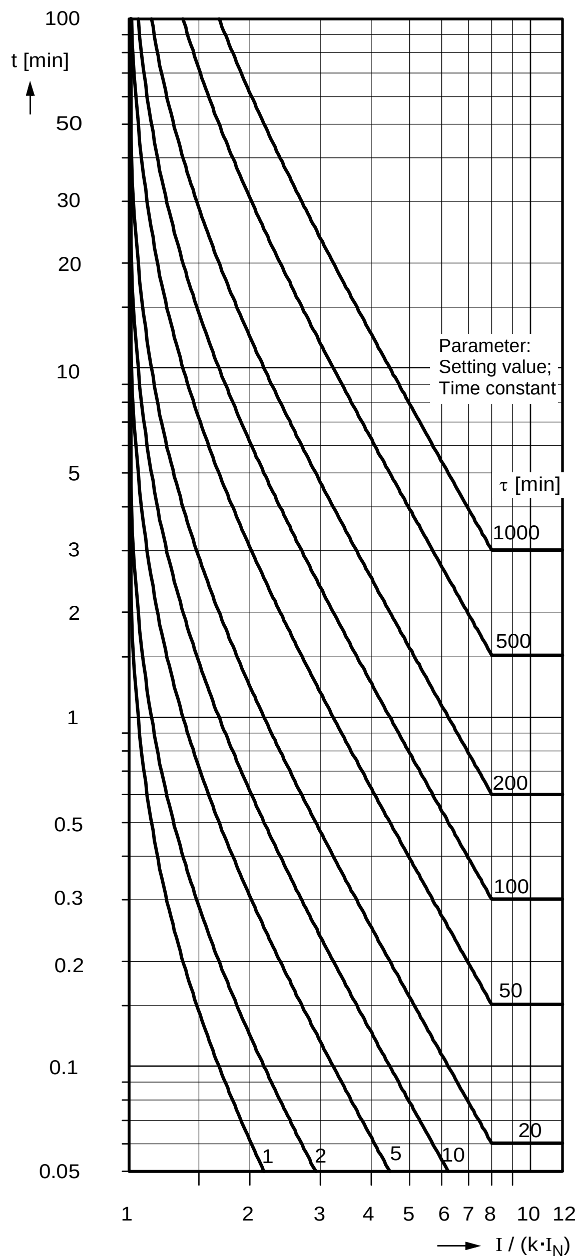
4.10 Thermal Overload Protection

Setting Ranges	Factor k according to IEC 60255–8		0.10 to 4.00 (steps 0.01)
	Time factor	τ	1.0 min to 999.9 min (steps 0.1 min)
	Alarm temperaturerise	$\Theta_{alarm}/\Theta_{trip}$	50 % to 100 % related to the trip temperature rise (steps 1 %)
	Current alarm stage	I_{alarm}	0.10 A to 4.00 A[1]) (steps 0.01 A)
	[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.		
Calculation Method	Calculation method temperature rise		maximum temperature rise of 3 phases means of temperature rise of 3 phases temperature rise from maximum current
Tripping Characteristic			see Figure 4-4
	Tripping characteristic for $(I/k \cdot I_N) \le 8$		$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$
	Meaning of abbreviations:		t tripping time τ thermal time constant I actual load current I_{pre} previous load current k setting factor according to IEC 60255–8 I_N rated current of protected object
Drop-off Ratios	Θ/Θ_{trip}		drop-off with Θ_{alarm}
	Θ/Θ_{alarm}		approx. 0.99
	I/I_{alarm}		approx. 0.95
Tolerances	Relating to $k \cdot I_N$		2 % or 10 mA[1]); class 2 % according to IEC 60 255–8
	Relating to tripping time		3 % or 1 s; class 3 % according to IEC 60 255–8 for $I/(k \cdot I_N) > 1.25$
	[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.		



without previous load current

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [min]$$



with 90 % previous load current

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [min]$$

Figure 4-4 Tripping characteristic of the overload protection

4.11 Monitoring Functions

Measured Values	Current sum	$I_F = \lvert i_{L1} + i_{L2} + i_{L3} + k_I \cdot i_E \rvert >$ **ΣI THRESHOLD** + **ΣI FACTOR** $\cdot \Sigma \lvert i \rvert$	
	– ΣI THRESHOLD	0.05 A to 2.00 A[1])	(steps 0.01[1])
	– ΣI FACTOR	0.00 to 0.95	(steps 0.01)
	Current symmetry	$\lvert I_{min} \rvert / \lvert I_{max} \rvert <$ **BAL. FACTOR I** as long as $I_{max} >$ **BALANCE I LIMIT**	
	– BAL. FACTOR I	0.10 to 0.95	(steps 0.01)
	– BALANCE I LIMIT	0.10 A to 1.00 A[1])	(steps 0.01 A[1])
	Voltage symmetry	$\lvert U_{min} \rvert / \lvert U_{max} \rvert <$ **BAL. FACTOR U** as long as $\lvert U_{max} \rvert >$ **BALANCE U-LIMIT**	
	– BAL. FACTOR U	0.58 to 0.95	(steps 0.01)
	– BALANCE U-LIMIT	10 V to 100 V	(steps 1 V)
	Open circuit	Monitoring of current transformer circuits on current step change in one phase without residual current	
	[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.		
Trip Circuit Supervision	Number of supervised trip circuits	1 to 3	
	Operation of each trip circuit	with 1 binary input or with 2 binary inputs	
	Pickup and reset delay	approx 1 s to 2 s	
	adjustable alarm delay with 1 binary input	1 s to 30 s	(steps 1 s)

4.12 Ancillary Functions

Operational Measured Values

Operational measured values of currents	I_{L1}; I_{L2}; I_{L3} in A primary and secondary and % of $I_{N\,oper}$
– Tolerance	1 % of measured value or 1 % of I_N
Operational measured values of currents	$3I_0$; I_1; I_2 in A primary and secondary
– Tolerance	1 % of measured value or 1 % of I_N
Phase angles of currents	$\varphi(I_{L1}–I_{L2})$; $\varphi(I_{L2}–I_{L3})$; $\varphi(I_{L3}–I_{L1})$ in °
– Tolerance	1° at rated current
Operational measured values of voltages (if applied)	$U_{L1–L2}$; $U_{L2–L3}$; $U_{L3–L1}$ in kV primary and V secondary
– Tolerance	1 % of measured value or 1 % of U_N
Operational measured values of voltages (if applied)	$U_{L1–E}$; $U_{L2–E}$; $U_{L3–E}$ in kV primary and V secondary
– Tolerance	1 % of measured value or 1 % of U_N
Operational measured values of voltages (if applied)	$U_{L1–E}$; $U_{L2–E}$; $U_{L3–E}$ in % of $U_{N\,oper}/\sqrt{3}$
– Tolerance	2 % of measured value or 2 % of U_N
Operational measured values of voltages (if applied)	$3U_0$; U_1; U_2 in kV primary and V secondary
– Tolerance	1 % of measured value or 1 % of U_N 2 % for $3U_0$ if $3U_0$ is not connected
Phase angles of voltages (if applied)	$\varphi(U_{L1}–U_{L2})$; $\varphi(U_{L2}–U_{L3})$; $\varphi(U_{L3}–U_{L1})$ in °
– Tolerance	1° at rated voltage
Phase angles of voltages vs. currents (if voltages applied)	$\varphi(U_{L1}–I_{L1})$; $\varphi(U_{L2}–I_{L2})$; $\varphi(U_{L3}–I_{L3})$ in °
– Tolerance	1° at rated voltage and current
Operational measured values of power (if voltages applied)	S; P; Q (apparent; active; reactive power) in MVA, MW or Mvar primary
– Tolerance	2 % of measured apparent power ($\sqrt{3} \cdot U \cdot I$) or 1 MVA/MW/Mvar
Operational measured values of power factor (if voltages applied)	cos φ
– Tolerance	0.02 at rated voltage and current
Operational measured values of frequency	f in Hz
– Range	10 Hz to 75 Hz
– Tolerance	20 mHz within range $f_N \pm 10$ % at nominal measured values
Operational measured value for thermal values (if overload protection enabled)	Θ_{L1}; Θ_{L2}; Θ_{L3}; Θ_{res} referred to tripping temperature rise Θ_{trip}

	Measured values of the differential protection	$I_{DIFF L1}$; $I_{DIFF L2}$; $I_{DIFF L3}$; $I_{REST L1}$; $I_{REST L2}$; $I_{REST L3}$ in % of $I_{N\ oper}$
	Remote measured values of currents	I_{L1}; I_{L2}; I_{L3} of remote end in % of $I_{N\ oper}$; $\varphi(I_{L1})$; $\varphi(I_{L2})$; $\varphi(I_{L3})$ (remote vs. local) in °
	Remote measured values of voltages	U_{L1}; U_{L2}; U_{L3} of remote end in % of $U_{N\ oper}$; $/\sqrt{3}$ $\varphi(U_{L1})$; $\varphi(U_{L2})$; $\varphi(U_{L3})$ (remote vs. local) in°
Event Log (Operat. Annuncations)	Buffer capacity	200 messages
Fault Event Data Log	Storage of the messages of the last 8 faults	with a total of max. 200 messages
Fault Recording	Number of stored fault records	max. 8
	Storage period (start with pickup or trip)	max. 5 s for each fault approx. 15 s in total
	Sampling rate at f_N = 50 Hz Sampling rate at f_N = 60 Hz	1 ms 0.83 ms
	The fault recordings are synchronized between the ends.	
Statistics	Number of trip events caused by 7SD610	pole segregated
	Number of auto-reclose events caused by 7SD610	segregated according to – 1-pole AR and 3-pole AR – 1st AR and further AR’s
	Total of interrupted currents caused by 7SD610	pole segregated
	Max. interrupted current	pole segregated
	Availability of transmission Delay time of transmission	availability in %/min and %/h resolution 0.01 ms
Real Time Clock and Buffer Battery	Resolution for operational messages	1 ms
	Resolution for fault messages	1 ms
	Buffer battery	3 V/1 Ah, type CR 1/2 AA self-discharging time approx. 10 years
Time Synchronization	Operation modes:	
	Internal IEC 60870–5–103	Internal via RTC External via system interface (IEC 60870–5–103)
	Time signal IRIG B Time signal DCF77 Time signal synchro-box GPS-synchronization Pulse via binary input	external via IRIG B external, via time signal DCF77 external, via synchro-box external, via GPS-signal external with pulse via binary input
	and between the devices from the timing master	

User-configurable Functions (CFC)	Processing times for function blocks:
	Block, Basic requirements — 5 TICKS
	Beginning with the 3rd additional input for generic blocks per input — 1 TICK
	Connection with input margin — 6 TICKS
	Connection with output margin — 7 TICKS
	In addition to each chart — 1 TICK
	Maximum number of TICKS in sequence levels:
	MW_BEARB (processing of meas. values) — 10,000 TICKS
	PLC1_BEARB (slow PLC processing) — 1,900 TICKS
	PLC_BEARB (fast PLC processing) — 200 TICKS
	SFS_BEARB (switchgear interlocking) — 10,000 TICKS

4.13 Dimensions

Housing for Panel Flush Mounting or Cubicle Installation

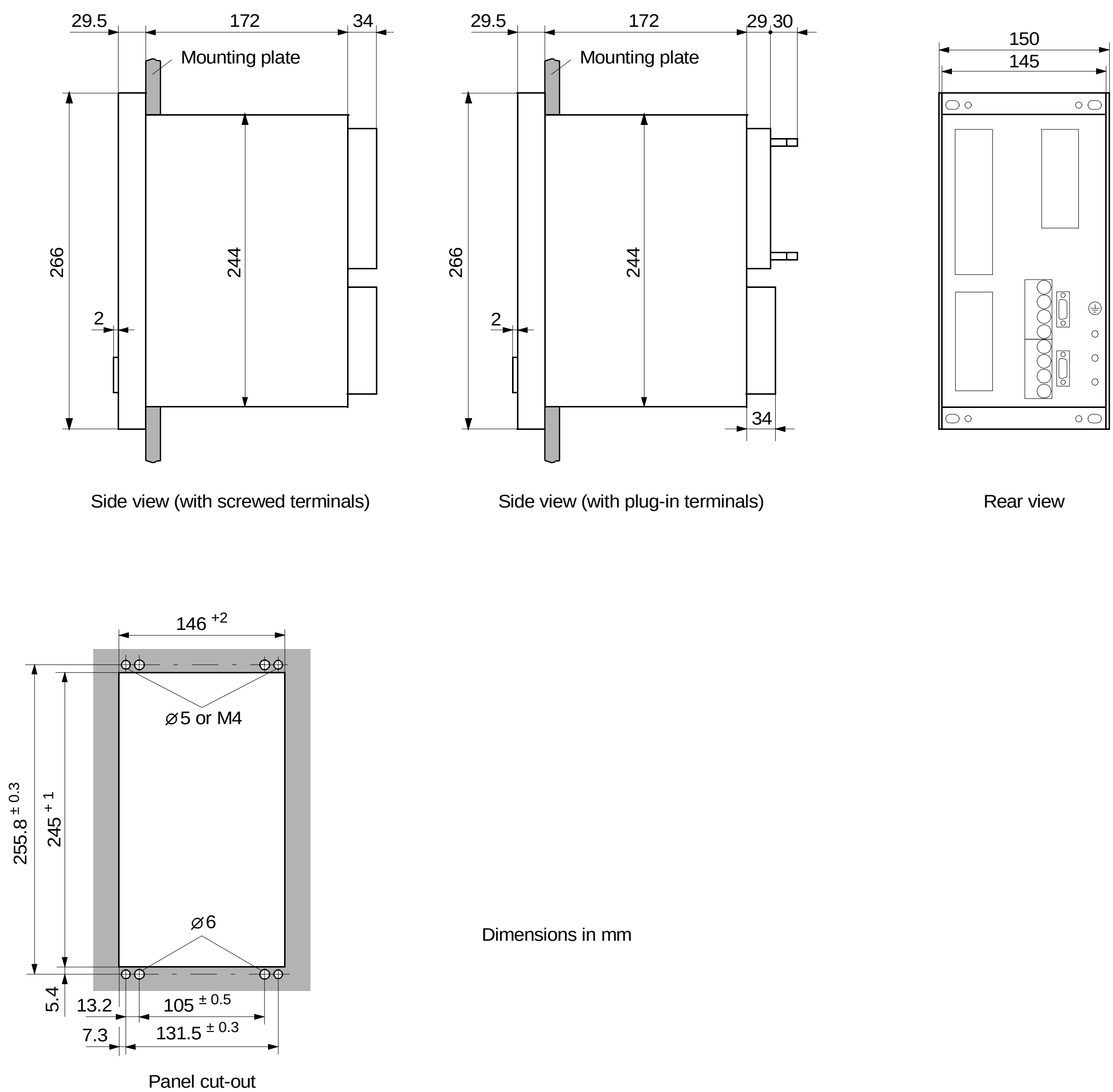


Figure 4-5 Dimensions 7SD610 for panel flush mounting or cubicle installation

Housing for Panel Surface Mounting

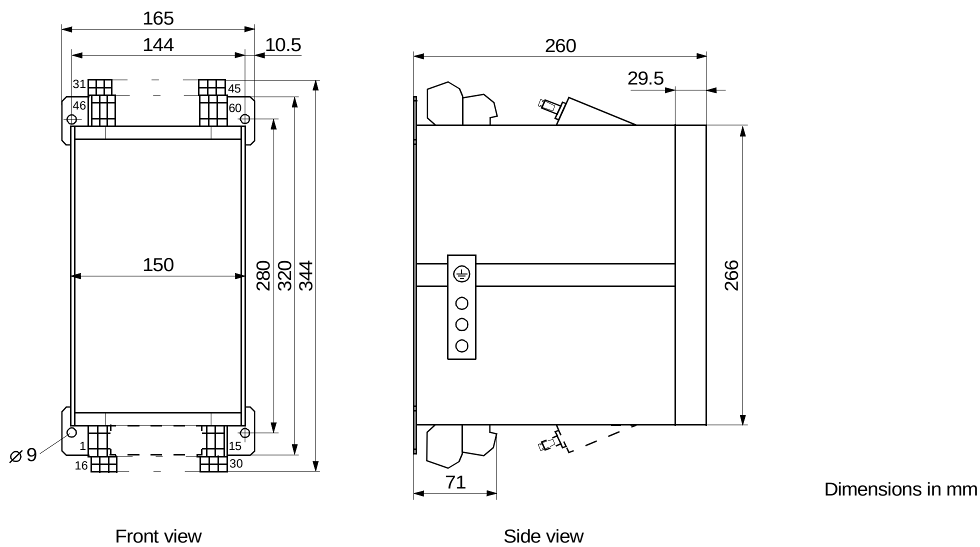


Figure 4-6 Dimensions 7SD610 for panel surface mounting

■

Appendix A

This appendix is primarily a reference for the experienced user. This Chapter provides ordering information for the models of 7SD610. General diagrams indicating the terminal connections of the 7SD610 models are included. Connection examples show the proper connections of the device to primary equipment in typical power system configurations. Tables with all settings and all information available in a 7SD610 equipped with all options are provided.

A.1 Ordering Information and Accessories

		7		8	9	10	11	12		13	14	15	16
Differential Protection for Two End Operation	**7SD610**	□	–	□	□	□	□	□	–	□	□	□	□

Measured Current Inputs	
I_{Ph} = 1 A, I_E = 1 A	1
I_{Ph} = 5 A, I_E = 5 A	5
Auxiliary Voltage (Power Supply, Pick-up Threshold of Binary Inputs)	
DC 24 to 48 V, binary input threshold 17 V [2])	2
DC 60 to 125 V [1]), binary input threshold 17 V [2])	4
DC 110 to 250 V [1]), AC 115 V, binary input threshold 73 V [2])	5
Housing, Number of Binary Inputs (BI) **and Outputs** (BO)	
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	
Region GE: 50 Hz; IEC; German language (can be changed)	A
Region world: 50/60 Hz; IEC/ANSI, English language (can be changed)	B
Region US: 60 Hz; ANSI; US-English language (can be changed)	C
Port B**: System Interface**	
No system interface	0
IEC Protocol, electrical RS232	1
IEC Protocol, electrical RS485	2
IEC Protocol, optical 820 nm, ST-plug	3
further protocols see additional specification L	9

Additional specification L + L □ □
Port B: System Interface

Profibus DP Slave, electrical RS485	0 A
Profibus DP Slave, optical 820 nm, ST-plug [3])	0 B
DNP 3.0, electrical RS485	0 G
DNP 3.0, optical 820 nm, twin ring, ST-plug [3])	0 H

Port C**: DIGSI/Modem Interface and Protection Data Interface 1**	
See additional specification M	9

Additional Specification M + M □ □

Port C**: Digsi/Modem Interface**	
No DIGSI/**Modem**-Interface	0
DIGSI 4, electrical RS232	1
DIGSI 4, electrical RS485	2
Port D**: Protect Data Interface 1**	
Optical 820 nm, 2 ST-plugs, optical fibre up to a length of 1.5 km, for direct connection or communication networks	A
Optical 820 nm, 2 ST-plugs, optical fibre up to a length of 3.5 km, for direct connection via multimode fibre	B
Optical 1300 nm, 2 ST-plugs, optical fibre up to a length of 10 km, for direct connection via monomode fibre	C
Optical 1300 nm, 2 FC-plugs, optical fibre up to a length of 35 km, for direct connection via monomode fibre	D

[1]) with plug-in jumper one of the 2 voltage ranges can be selected
[2]) for each binary input one of three pick-up threshold ranges can be selected with plug-in jumper
[3]) not possible for models with surface mounted housing (9th digit = F). For this purpose, please order a model with the corresponding electrical RS485 interface, and additionally supplementary parts according to Subsection A.1.1 under "External Converters"

continued next page

Differential Protection for Two End Operation

7SD610 ☐ – ☐☐☐☐☐ – ☐☐☐☐

Positions: 7 | 8 9 10 11 12 | 13 14 15 16

Functions 1

		Pos. 13
Three-pole tripping	without automatic reclosure	0
Three-pole tripping	with automatic reclosure	1
Single-/three-pole tripping	without automatic reclosure	2
Single-/three-pole tripping	with automatic reclosure	3

Backup Functions

	Pos. 14
without breaker failure protection	B
with breaker failure protection	C

Additional Functions 1

4 remote commands	**Transformer Expansion (Vector Group Adaptation)**	Pos. 15
without	without	A
without	with	E
with	without	J
with	with	N

	Pos. 16
without external GPS synchronisation	0
with external GPS synchronisation	1

Ordering example: 7SD6101–4BA39–2BJ0 +M1A

Differential protection for two end operation
here: pos. 12 = 9 pointing at M1A, i.e. version with DIGSI-interface RS232 on the rear side
Protection Interface 1: 820 nm direct connection or communication networks

A.1.1 Accessories

Communication Converter

Converter for the serial connection of the differential protection system 7SD610 to the synchronous communication interfaces X.21 or G.703 (X/G) or ISDN (S0) or copper cable (Cu).

Name	Order No.
Optical-electrical communication converter (CC-X/G)	7XV5662–0AA00
Optical-electrical communication converter (CC-S0)	7XV5662–0AB01
Optical-electrical communication converter (CC-Cu)	7XV5662–0AC00

Isolating Transformer

Isolating transformers become necessary on copper pilot wires if the induced longitudinal voltage of the wires can lead to more than 60 % of the insulation test voltage at the communication converter (i.e. 3 kV for CC-Cu). They are installed between the communication converter and the pilot wires.

Name	Order No.
Isolating transformer 20 kV insulation test voltage	7XR6516

GPS

Name	Order No.
GPS-receiver and antenna	7XV5664–0AA00
Power supply	7XV5810–0BA00

Voltage Transformer Miniature Circuit Breaker

Nominal varies	Order No.
Thermal 1.6 A; magnetic 6 A	3RV1611–1AG14

External Converters

Optical connectors for Profibus and DNP3.0 are not available in surface mounting housings. Please order a device with the corresponding electrical RS485 interface and the matching converter according to the following table:

For Interface Type	Order Device with	Additional Accessories
Profibus DP double ring	Profibus DP RS485	6GK1502–4AB10 7XV5810–0BA00
DNP3.0 820 nm	DNP3.0 RS485	7XV5650–0BA00

Interface Modules

Exchange interface modules

Name	Order No.
RS232	C53207–A351–D641–1
RS485	C53207–A351–D642–1
Fibre-optic 820 nm	C53207–A351–D643–1
Profibus DP; RS485	C53207–A351–D611–1
Profibus DP; fibre-optic 820 nm twin ring	C53207–A351–D613–1
[1]) is also used for the connection to an optical-electrical communication converter	

Name	Order No.
DNP 3.0; RS485	C53207–A351–D631–3
DNP 3.0; fibre-optic 820 nm	C53207–A351–D633–3
F05 with ST-plug; 820 nm; multimode fibre up to a length of 1.5 km [1])	C53207–A351–D651–1
F06 with ST-plug; 820 nm; multimode fibre up to a length of 3.5 km	C53207–A351–D652–1
F07 with ST-plug; 1300 nm; monomode fibre up to a length of 10 km	C53207–A351–D653–1
F08 with FC-plug; 1300 nm; monomode fibre up to a length of 35 km	C53207–A351–D654–1
[1]) is also used for the connection to an optical-electrical communication converter	

Terminal Block Covering Caps

Covering cap for terminal 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 No.
3 links for current terminals plus 6 links for voltage terminals	C73334–A1–C40–1

Plug-in Connectors

Connector Type	Order No.
2 pin	C73334–A1–C35–1
3 pin	C73334–A1–C36–1

Mounting Bracket for 19"-Racks

Name	Order No.
Angle Strip (Mounting Rail)	C73165–A63–C200–3

Battery

Lithium-Battery 3 V/1 Ah, Type CR 1/2 AA	Order No.
VARTA	6127 101 501

Interface Cable

An interface cable is necessary for communication between the SIPROTEC device and a PC. Requirements for the computer are at least Windows 95 or Windows NT4 and the operating software DIGSI®.

Interface cable between PC or SIPROTEC device	Order No.
Cable with 9-pin male/female connections	7XV5100–4

Operating Software DIGSI®

Software for setting and operating SIPROTEC® 4 devices

Operating Software DIGSI®	Order No.
DIGSI®, basic version with license for 10 computers	7XS5400–0AA00
DIGSI®, complete version with all option packages	7XS5402–0AA00

Graphical Analysis Program SIGRA

Software for graphical visualization, analysis, and evaluation of fault data. Option package of the complete version of DIGSI®

Graphical analysis program SIGRA®	Order No.
Full version with license for 10 machines	7XS5410–0AA00

DIGSI REMOTE 4

Software for remotely operating protective devices via a modem (and possibly a star connector) using DIGSI®.
(Option package of the complete version of DIGSI®.

DIGSI REMOTE 4	Order No.
Full version with license for 10 machines	7XS5440–1AA00

SIMATIC CFC 4

Graphical software for setting interlocking (latching) control conditions and creating additional function is SIPROTEC 4 devices. Option package for the complete version of DIGSI®.

SIMATIC CFC 4	Order No.
Full version with license for 10 machines	7XS5450–0AA00

A.2 General Diagrams

A.2.1 Panel Flush Mounting or Cubicle Mounting

7SD610∗–∗B/K

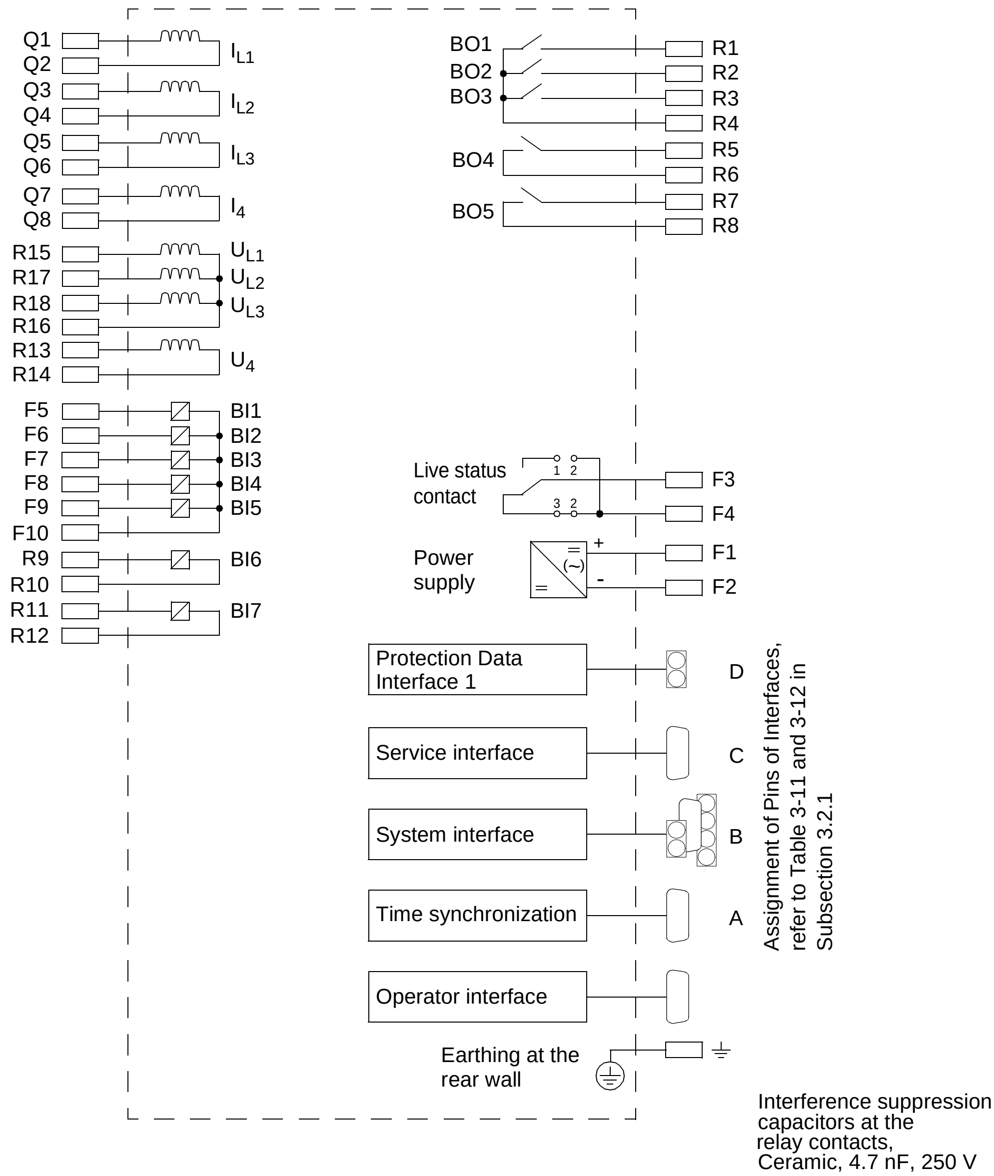


Figure A-1 General diagram for 7SD610∗–∗B/K (panel flush mounting or cubicle mounting)

A.2.2 Panel Surface Mounting

7SD610∗–∗F

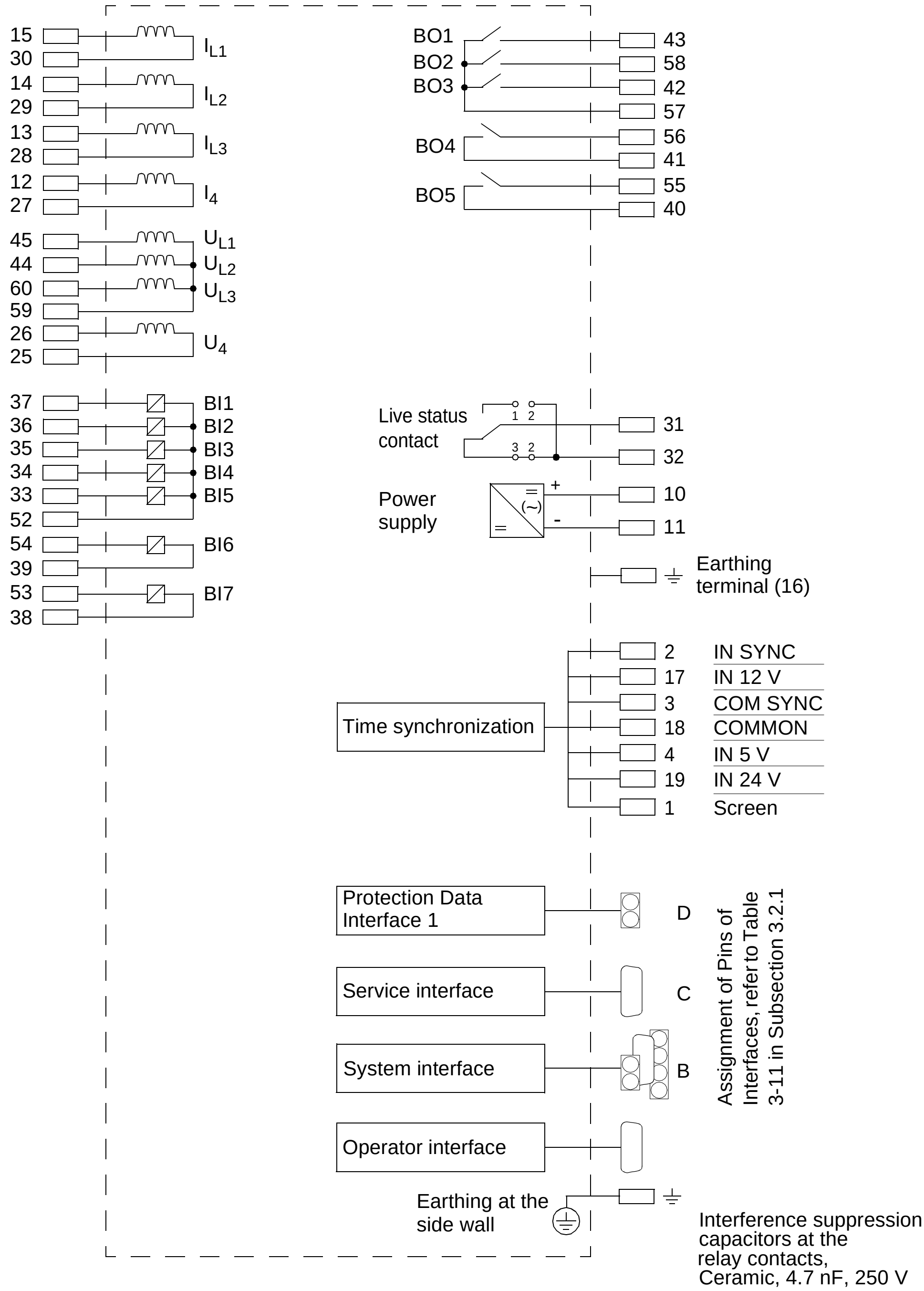


Figure A-2 General diagram 7SD610∗–∗F (panel surface mounting)

A.3 Connection Examples

Current Transformer Connection Examples

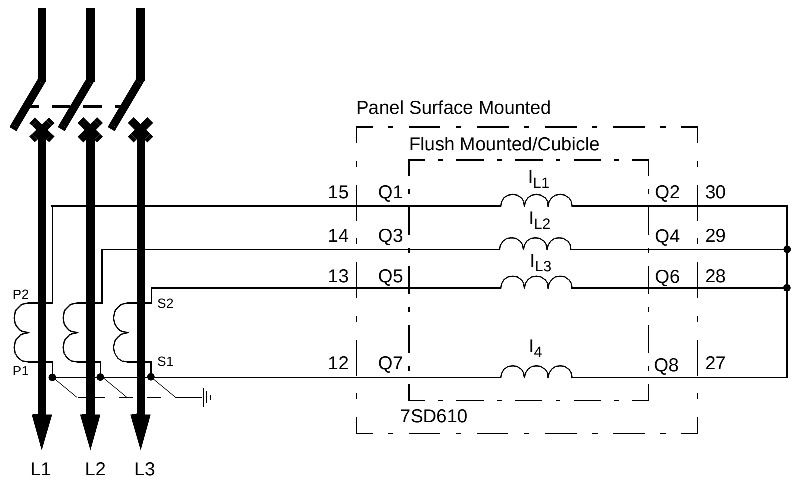
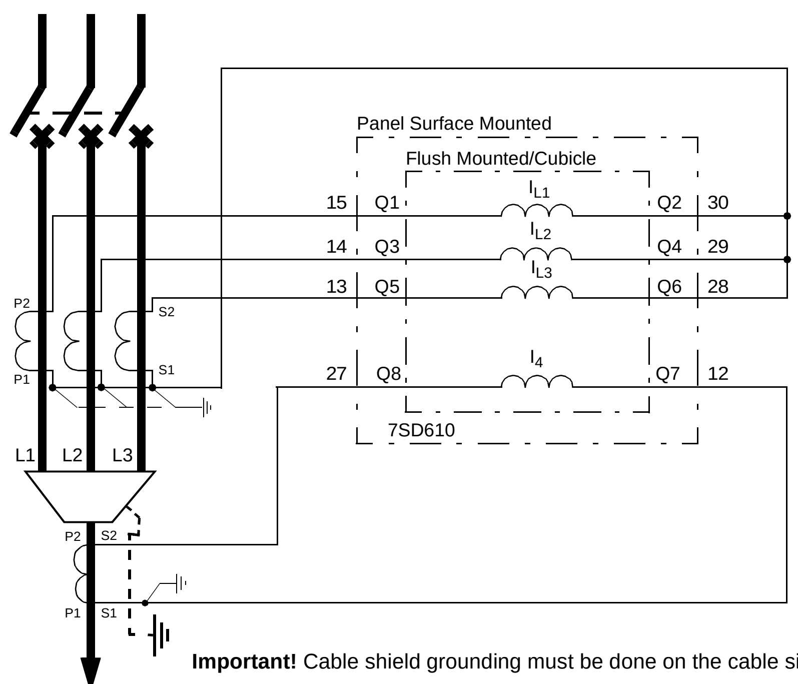


Figure A-3 Current connections to three current transformers with a star-point connection for earth current (residual $3I_0$ neutral current), normal circuit layout — appropriate for all systems



Important! Cable shield grounding must be done on the cable side!

Note: Change of Address 0201 setting changes polarity of $3I_0$ Current Input, i.e. terminal Q7 must be connected to that CT terminal pointing in the same direction as the starpoint of the phase current CTs (towards “Line side” in this diagram)

Figure A-4 Current connections to three current transformers and a separate neutral current transformer (summation transformer) for earth current — preferred for solidly or low-resistive earthed systems

Voltage Transformer Connection Examples

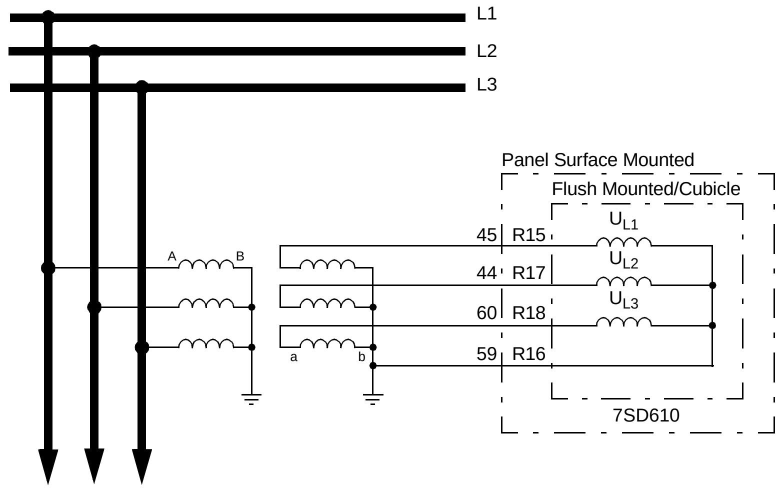


Figure A-5 Voltage connections to three Wye-connected voltage transformers (normal circuit layout)

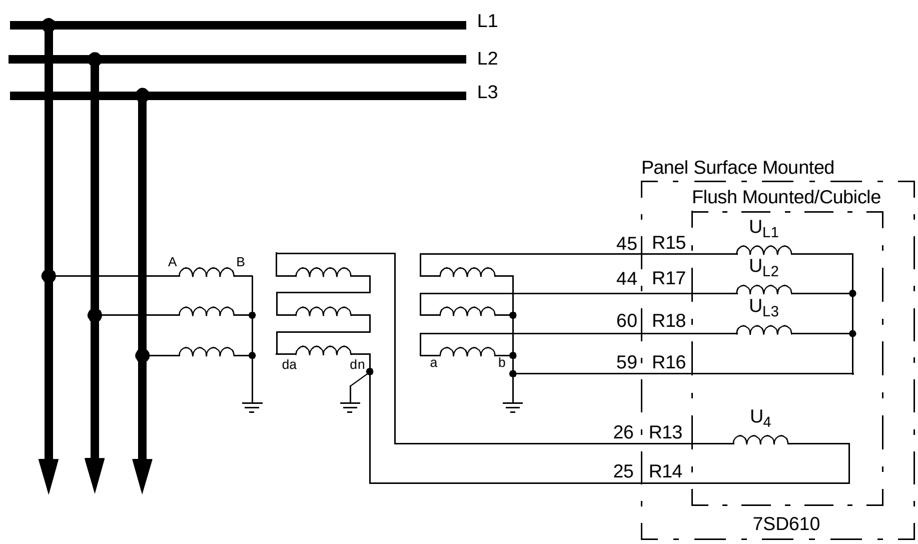


Figure A-6 Voltage connections to three Wye-connected voltage transformers with additional open-delta windings (da-dn-winding)

A.4 Preset Configurations

Binary Inputs

Table A-1 Binary input presettings

Binary Input	LCD Text	Function No.	Remarks
BI 1	>Intertrip 3pol	3504	Intertrip signal for remote end, H-active
BI 2	>Reset LED	0005	Reset of latched indications, H-active
BI 3	>Diff block	3525	Block differential protection, H-active
BI 4	>DTT Trip L123	4417	Direct local trip (three-pole), H-active
BI 5	>BLOCK O/C I>> >BLOCK O/C I> >BLOCK O/C Ip >BLOCK O/C Ie>> >BLOCK O/C Ie> >BLOCK O/C Iep >BLOCK I-STUB >BLOCK O/CIe>>>	7104 7105 7106 7107 7108 7109 7130 7132	Block stages of the time-overcurrent protection, H-active
BI 6	>Test mode	3194	Switch over to test mode, H-active
BI 7	>CB1 Ready	0371	Circuit breaker ready for TRIP-CLOSE cycle (CB check before AR), H-active

Binary Outputs

Table A-2 Binary output presettings

Binary Output	LCD Text	Function No.	Remarks
BO 1	Relay PICKUP L1	0503	Device (general) pickup phase L1, non-latched
BO 2	Relay PICKUP L2	0504	Device (general) pickup phase L2, non-latched
BO 3	Relay PICKUP L3	0505	Device (general) pickup phase L3, non-latched
BO 4	Relay TRIP	0511	Device (general) trip command, non-latched
BO 5	Relay TRIP	0511	Device (general) trip command, non-latched

LEDs

Table A-3 LED presettings

LED	LCD Text	Function No.	Remarks
LED1	Relay TRIP	0511	Device (general) trip command, latched
LED2	Relay PICKUP L1	0503	Device (general) pickup phase L1, latched
LED3	Relay PICKUP L2	0504	Device (general) pickup phase L2 latched
LED4	Relay PICKUP L3	0505	Device (general) pickup phase L3, latched
LED5	Par. different	3235	Different parameters are set in the 2 devices; non-latched
LED6	PI1 Data fault	3229	Protection data interface 1 faulty, non-latched
LED7	DT inconsistent DT unequal Equal IDs	3233 3234 3487	Inconsistencies between devices: Device table, both devices with the same address, non-latched

Function keys

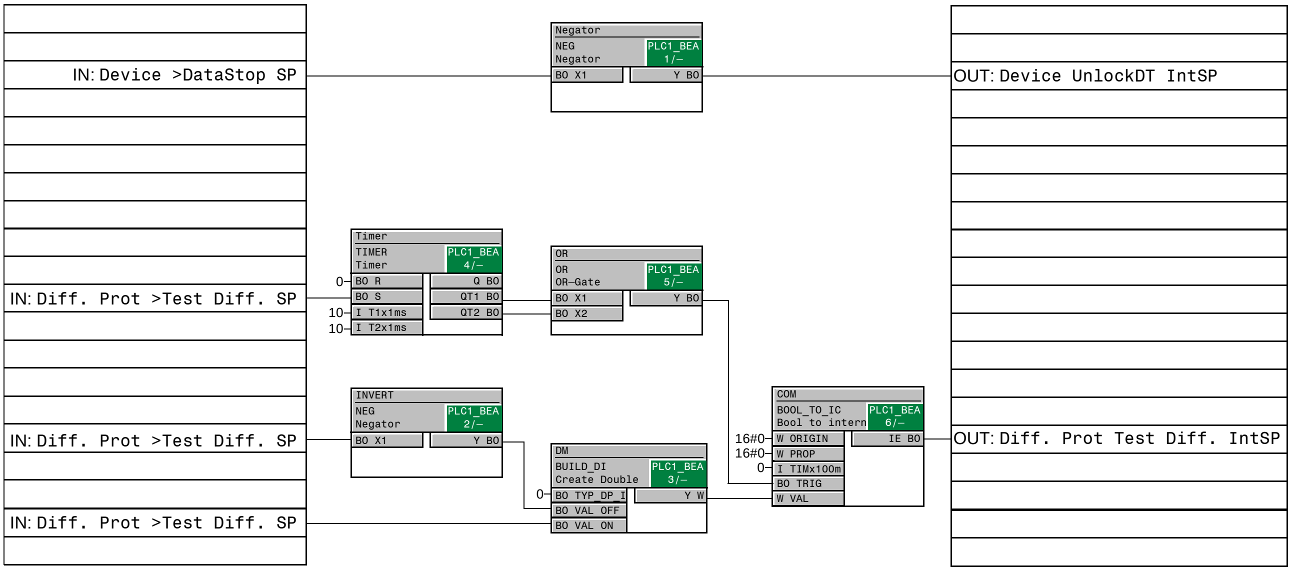
The 4 function keys on the front have the following presetting:

Table A-4 Preset function keys

Function key	Brief Text	Remarks
F1		Jump to the menu “`Event Log`” (operational annunciations)
F2		Jump to the menu “`Meas. Values pri`” (Measured values, primary)
F3		Jump to the menu “`Trip Log`” → “`Last Fault`” (Fault annunciations)
F4		no presetting

Preset CFC-Charts

7SD610 provides a CFC configuration sheet with preset logical functions. These convert the binary inputs “`>DataStop`” and “`>Test Diff.`” from single point indication (SP) into internal single point indication (IntSP).


IN: Device >DataStop SP
IN: Diff. Prot >Test Diff. SP
IN: Diff. Prot >Test Diff. SP
IN: Diff. Prot >Test Diff. SP
Negator
NEG
Negator
PLC1_BEA
1/–
BO X1
Y BO
Timer
TIMER
Timer
PLC1_BEA
4/–
BO R
BO S
I T1x1ms
I T2x1ms
Q BO
QT1 BO
QT2 BO
OR
OR
OR–Gate
PLC1_BEA
5/–
BO X1
BO X2
Y BO
INVERT
NEG
Negator
PLC1_BEA
2/–
BO X1
Y BO
DM
BUILD_DI
Create Double
PLC1_BEA
3/–
BO TYP_DP_I
BO VAL_OFF
BO VAL_ON
Y W
COM
BOOL_TO_IC
Bool to intern
PLC1_BEA
6/–
W ORIGIN
W PROP
I TIMx100m
BO TRIG
W VAL
IE BO
OUT: Device UnlockDT IntSP
OUT: Diff. Prot Test Diff. IntSP

A.5 Protocol Dependent Functions

Protocol → Function ↓	IEC 60870–5–103	Profibus DP	DNP3.0
Operational measured values	Yes	Yes	Yes
Metering values	Yes	Yes	Yes
Fault recording	Yes	No	No
User-defined alarms and switching objects	Yes	Pre-defined "user-specified messages" in CFC	Pre-defined "user-specified messages" in CFC
Time synchronization	Via Protocol; DCF77/IRIG B/GPS; Interface; Binary Input	Via Protocol; DCF77/IRIG B/GPS; Interface; Binary Input	Via Protocol; DCF77/IRIG B/GPS; Interface; Binary Input
Alarms with Time Stamp	Yes	No	Yes
Commissioning Tools			
Alarm and measured value transmission blocking	Yes	No	No
Generate test alarms	Yes	No	No
Further Data			
Physical Mode	Asynchronous	Asynchronous	Asynchronous
Transmission Mode	Cyclic/Event	Cyclic/Event	Cyclic/Event
Baud Rate	4800 to 38400	Up to 1.5 MBaud	2400 to 19200
Type	RS 232; RS 485; Optical fibre	RS 485; Optical fibre (Double ring)	RS 485 ; Optical fibre

A.6 List of Settings

Note: Depending on the version and the variant ordered some addresses are not used or have different default settings.

The setting ranges and presettings listed in the following tables refer to a nominal current value I_N = 1 A. For a secondary nominal current value I_N = 5 A the current values are to be multiplied by 5.

Addresses which have an “A” attached to their end can only be changed in DIGSI®, under “**Additional Settings**”.

Addr.	Setting Title	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip 1pole	3pole only 1-/3pole	3pole only	1pole trip permitted
112	DIFF.PROTECTION	Enabled Disabled	Enabled	Differential protection
118	GPS-SYNC.	Enabled Disabled	Disabled	GPS synchronization
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 Time Overcurrent Curve IEC Time Overcurrent Curve ANSI	Disabled	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 Adaptive Dead Time (ADT) Disabled	Disabled	Auto-Reclose Function
134	AR control mode	with Pickup and Action time with Pickup but without Action time with Trip and Action time with Trip but without Action time	with Trip and Action time	AR control mode
139	BREAKER FAILURE	Disabled Enabled	Disabled	Breaker Failure Protection
140	Trip Cir. Sup.	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision

Addr.	Setting Title	Setting Options	Default Setting	Comments
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
144	V-TRANSFORMER	not connected connected	not connected	Voltage transformers
145	TRANSFORMER	NO YES	NO	Transformer inside protection zone

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
201	CT Starpoint	Power System Data 1	towards Line towards Busbar	towards Line	CT Starpoint
203	Unom PRIMARY	Power System Data 1	0.4..1200.0 kV	11.0 kV	Rated Primary Voltage
204	Unom SECON-DARY	Power System Data 1	80..125 V	100 V	Rated Secondary Voltage (Ph-Ph)
205	CT PRIMARY	Power System Data 1	10..5000 A	400 A	CT Rated Primary Current
206	CT SECONDARY	Power System Data 1	1A 5A	1A	CT Rated Secondary Cur-rent
210	U4 transformer	Power System Data 1	not connected Udelta transformer	not connected	U4 voltage transformer is
211	Uph / Udelta	Power System Data 1	0.10..9.99	1.73	Matching ratio Phase-VT To Open-Delta-VT
220	I4 transformer	Power System Data 1	not connected Neutral Current (of the protected line)	not connected	I4 current transformer is
221	I4/Iph CT	Power System Data 1	0.010..5.000	1.000	Matching ratio I4/Iph for CT's
230	Rated Frequency	Power System Data 1	50 Hz 60 Hz	50 Hz	Rated Frequency
240A	TMin TRIP CMD	Power System Data 1	0.02..30.00 sec	0.10 sec	Minimum TRIP Command Duration
241A	TMax CLOSE CMD	Power System Data 1	0.01..30.00 sec	1.00 sec	Maximum Close Command Duration
242	T-CBtest-dead	Power System Data 1	0.00..30.00 sec	0.10 sec	Dead Time for CB test-autoreclosure
251	K_ALF/K_ALF_N	Power System Data 1	1.00..10.00	1.00	k_alf/k_alf nominal
253	E% ALF/ALF_N	Power System Data 1	0.5..50.0 %	5.0 %	CT Error in % at k_alf/k_alf nominal
254	E% K_ALF_N	Power System Data 1	0.5..50.0 %	15.0 %	CT Error in % at k_alf nomi-nal

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
301	ACTIVE GROUP	Change Group	Group A Group B Group C Group D	Group A	Active Setting Group is
302	CHANGE	Change Group	Group A Group B Group C Group D Binary Input Protocol	Group A	Change to Another Setting Group
402A	WAVEFORMTRIG-GER	Oscillographic Fault Records	Save with Pickup Save with TRIP Start with TRIP	Save with Pickup	Waveform Capture
403A	WAVEFORM DATA	Oscillographic Fault Records	Fault event Power System fault	Fault event	Scope of Waveform Data
410	MAX. LENGTH	Oscillographic Fault Records	0.30..5.00 sec	2.00 sec	Max. length of a Waveform Capture Record
411	PRE. TRIG. TIME	Oscillographic Fault Records	0.05..0.50 sec	0.25 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	Oscillographic Fault Records	0.05..0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	Oscillographic Fault Records	0.10..5.00 sec; ∞	0.50 sec	Capture Time via Binary Input
610	FltDisp.LED/LCD	Device	Display Targets on every Pickup Display Targets on TRIP only	Display Targets on every Pickup	Fault Display on LED / LCD
1103	FullScaleVolt.	Power System Data 2	0.4..1200.0 kV	11.0 kV	Measurement: Full Scale Voltage (100%)
1104	FullScaleCurr.	Power System Data 2	10..5000 A	400 A	Measurement: Full Scale Current (100%)
1106	OPERATION POWER	Power System Data 2	0.2..5000.0 MVA	7.6 MVA	Operational power of protection zone
1130A	PoleOpenCurrent	Power System Data 2	0.05..1.00 A	0.10 A	Pole Open Current Threshold
1132A	SI Time all Cl.	Power System Data 2	0.01..30.00 sec	0.10 sec	Seal-in Time after ALL closures
1134	Line status	Power System Data 2	with Pole Open Current Threshold only with CBaux open AND I < PoleOpen-Current	with Pole Open Current Threshold only	Line status
1150A	SI Time Man.Cl	Power System Data 2	0.01..30.00 sec	0.30 sec	Seal-in Time after MANUAL closures
1155	3pole coupling	Power System Data 2	with Pickup with Trip	with Trip	3 pole coupling

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
1156A	Trip2phFlt	Power System Data 2	3pole 1pole, leading phase 1pole, lagging phase	3pole	Trip type with 2phase faults
1161	VECTOR GROUP U	Power System Data 2	0..11	0	Vector group numeral for voltage
1162	VECTOR GROUP I	Power System Data 2	0..11	0	Vector group numeral for current
1163	TRANS STP IS	Power System Data 2	Solid Earthed Not Earthed	Solid Earthed	Transformer starpoint is
1201	STATE OF DIFF.	Differential Protection	OFF ON	ON	State of differential protection
1210	I-DIFF>	Differential Protection	0.10..20.00 A	0.30 A	I-DIFF>: Pickup value
1213	I-DIF>SWITCH ON	Differential Protection	0.10..20.00 A	0.30 A	I-DIFF>: Value under switch on condition
1217A	T-DELAY I-DIFF>	Differential Protection	0.00..60.00 sec; ∞	0.00 sec	I-DIFF>: Trip time delay
1218A	T3I0 1PHAS	Differential Protection	0.00..60.00 sec; ∞	0.00 sec	Delay 1ph-faults (comp/ isol. star-point)
1233	I-DIFF>>	Differential Protection	0.8..100.0 A; ∞	1.2 A	I-DIFF>>: Pickup value
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
1501	STATE PROT I 1	Protection Interface (Port D+E)	ON OFF	ON	State of protection interface 1
1502	CONNEC. 1 OVER	Protection Interface (Port D+E)	Direct connection with fibre optic cable Communication converter with 64 kBit/s Communication converter with 128 kBit/s Communication converter with 512 kBit/s	Direct connection with fibre optic cable	Connection 1 over
1505A	PROT 1 T-DELAY	Protection Interface (Port D+E)	0.1..30.0 ms	30.0 ms	Prot 1: Maximal permissible delay time
1506A	PROT 1 UNSYM.	Protection Interface (Port D+E)	0.000..3.000 ms	0.000 ms	Prot 1: Diff. in send and receive time
1509	T-DATA DISTURB	Protection Interface (Port D+E)	0.05..2.00 sec	0.10 sec	Time delay for data disturbance alarm

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
1510	T-DATAFAIL	Protection Interface (Port D+E)	0.0..60.0 sec	6.0 sec	Time del for transmission failure alarm
1511	PI1 SYNCMODE	Protection Interface (Port D+E)	Telegram and GPS Telegram or GPS GPS synchronization OFF	Telegram and GPS	PI1 Synchronizationmode
1512	Td ResetRemote	Protection Interface (Port D+E)	0.00..300.00 sec; ∞	0.00 sec	Remote signal RESET DELAY for comm.fail
1513A	PROT1 max ERROR	Protection Interface (Port D+E)	0.5..20.0 %	1.0 %	Prot 1: Maximal permissible error rate
1515A	PI1 BLOCK UNSYM	Protection Interface (Port D+E)	YES NO	YES	Prot.1: Block. due to unsym. delay time
1701	ID OF RELAY 1	Differential Topology	1..65534	1	Identification number of relay 1
1702	ID OF RELAY 2	Differential Topology	1..65534	2	Identification number of relay 2
1710	LOCAL RELAY	Differential Topology	relay 1 relay 2	relay 1	Local relay is
1801	GPS-SYNC.	Protection Interface (Port D+E)	ON OFF	OFF	GPS synchronization
1803A	TD GPS FAILD	Protection Interface (Port D+E)	0.5..60.0 sec	2.1 sec	Delay time for local GPS-pulse loss
2201	FCT Direct Trip	DTT Direct Transfer Trip	ON OFF	OFF	Direct Transfer Trip (DTT)
2202	Trip Time DELAY	DTT Direct Transfer Trip	0.00..30.00 sec; ∞	0.01 sec	Trip Time Delay
2301	INRUSH REST.	Differential Protection	OFF ON	OFF	Inrush Restraint
2302	2nd HARMONIC	Differential Protection	10..45 %	15 %	2nd. harmonic in % of fundamental
2303	CROSS BLOCK	Differential Protection	NO YES	NO	Cross Block
2305	MAX INRUSH PEAK	Differential Protection	1.1..25.0 A	15.0 A	Maximum inrush-peak value
2310	CROSSB 2HM	Differential Protection	0.00..60.00 sec; ∞	0.00 sec	Time for Crossblock with 2nd harmonic
2401	FCT HS/SOTF-O/C	Instantaneous HighSpeed SOTF Overcurrent	ON OFF	ON	Inst. High Speed/SOTF-O/C is
2404	I>>>	Instantaneous HighSpeed SOTF Overcurrent	0.10..15.00 A; ∞	1.50 A	I>>> Pickup

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
2405A	I>>>>	Instantaneous HighSpeed SOTF Overcurrent	1.00..25.00 A; ∞	∞ A	I>>>> Pickup
2601	Operating Mode	Backup overcurrent	ON Only Emergency protection OFF	ON	Operating mode
2610	Iph>>	Backup overcurrent	0.10..25.00 A; ∞	2.00 A	Iph>> Pickup
2611	T Iph>>	Backup overcurrent	0.00..30.00 sec; ∞	0.30 sec	T Iph>> Time delay
2612	3I0>> PICKUP	Backup overcurrent	0.05..25.00 A; ∞	0.50 A	3I0>> Pickup
2613	T 3I0>>	Backup overcurrent	0.00..30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> Telep/BI	Backup overcurrent	NO YES	YES	Instantaneous trip via Teleprot./BI
2615	I>> SOTF	Backup overcurrent	NO YES	NO	Instantaneous trip after SwitchOnToFault
2620	Iph>	Backup overcurrent	0.10..25.00 A; ∞	1.50 A	Iph> Pickup
2621	T Iph>	Backup overcurrent	0.00..30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	Backup overcurrent	0.05..25.00 A; ∞	0.20 A	3I0> Pickup
2623	T 3I0>	Backup overcurrent	0.00..30.00 sec; ∞	2.00 sec	T 3I0> Time delay
2624	I> Telep/BI	Backup overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
2625	I> SOTF	Backup overcurrent	NO YES	NO	Instantaneous trip after SwitchOnToFault
2630	Iph> STUB	Backup overcurrent	0.10..25.00 A; ∞	1.50 A	Iph> STUB Pickup
2631	T Iph STUB	Backup overcurrent	0.00..30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	Backup overcurrent	0.05..25.00 A; ∞	0.20 A	3I0> STUB Pickup
2633	T 3I0 STUB	Backup overcurrent	0.00..30.00 sec; ∞	2.00 sec	T 3I0 STUB Time delay
2634	I-STUB Telep/BI	Backup overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
2635	I-STUB SOTF	Backup overcurrent	NO YES	NO	Instantaneous trip after SwitchOnToFault

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
2640	Ip>	Backup over-current	0.10..4.00 A; ∞	∞ A	Ip> Pickup
2642	T Ip Time Dial	Backup over-current	0.05..3.00 sec; ∞	0.50 sec	T Ip Time Dial
2643	Time Dial TD Ip	Backup over-current	0.50..15.00; ∞	5.00	Time Dial TD Ip
2646	T Ip Add	Backup over-current	0.00..30.00 sec	0.00 sec	T Ip Additional Time Delay
2650	3I0p PICKUP	Backup over-current	0.05..4.00 A; ∞	∞ A	3I0p Pickup
2652	T 3I0p TimeDial	Backup over-current	0.05..3.00 sec; ∞	0.50 sec	T 3I0p Time Dial
2653	TimeDial TD3I0p	Backup over-current	0.50..15.00; ∞	5.00	Time Dial TD 3I0p
2656	T 3I0p Add	Backup over-current	0.00..30.00 sec	0.00 sec	T 3I0p Additional Time Delay
2660	IEC Curve	Backup over-current	Normal Inverse Very Inverse Extremely Inverse Long time inverse	Normal Inverse	IEC Curve
2661	ANSI Curve	Backup over-current	Inverse Short Inverse Long Inverse Moderately Inverse Very Inverse Extremely Inverse Definite Inverse	Inverse	ANSI Curve
2670	I(3I0)p Tele/BI	Backup over-current	NO YES	NO	Instantaneous trip via Tele-prot./BI
2671	I(3I0)p SOTF	Backup over-current	NO YES	NO	Instantaneous trip after SwitchOnToFault
2680	SOTF Time DELAY	Backup over-current	0.00..30.00 sec	0.00 sec	Trip time delay after SOTF
2901	MEASURE. SUPERV	Measurement Supervision	ON OFF	ON	Measurement Supervision
2902A	BALANCE U-LIMIT	Measurement Supervision	10..100 V	50 V	Voltage Threshold for Balance Monitoring
2903A	BAL. FACTOR U	Measurement Supervision	0.58..0.95	0.75	Balance Factor for Voltage Monitor
2904A	BALANCE I LIMIT	Measurement Supervision	0.10..1.00 A	0.50 A	Current Balance Monitor
2905A	BAL. FACTOR I	Measurement Supervision	0.10..0.95	0.50	Balance Factor for Current Monitor
2906A	ΣI THRESHOLD	Measurement Supervision	0.10..2.00 A	0.25 A	Summated Current Monito-ring Threshold

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
2907A	ΣI FACTOR	Measurement Supervision	0.00..0.95	0.50	Summated Current Monito-ring Factor
2908	BROKEN WIRE	Measurement Supervision	ON OFF	OFF	Fast broken current-wire supervision
2921	FAST Σ i SUPERV	Measurement Supervision	ON OFF	ON	State of fast current sum-mation supervis
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 suc-cessful 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 Auto Reclose starts 3pole AR-cycle	starts 3pole AR-cycle	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) Super-vision 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 exten-sion
3420	AR WITH DIFF	Auto Reclose	YES NO	YES	AR with differential protec-tion ?
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 Dead Line Check (DLC)	Without	Dead Line Check / Redu-ced 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

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
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
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

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
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
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

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3901	FCT BreakerFail	Breaker Failure	ON OFF	ON	Breaker Failure Protection is
3902	I> BF	Breaker Failure	0.05..20.00 A	0.10 A	Pick-up threshold I>
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 trips with T1-trip-signal trips with T2-trip-signal trips with T1 and T2-trip-signal	NO	Trip output selection with defective bkr
3909	Chk BRK CON-TACT	Breaker Failure	NO YES	YES	Check Breaker contacts
3921	End Flt. stage	Breaker Failure	ON OFF	OFF	End fault stage is
3922	T-EndFault	Breaker Failure	0.00..30.00 sec; ∞	2.00 sec	Trip delay of end fault stage
3931	PoleDiscrepancy	Breaker Failure	ON OFF	OFF	Pole Discrepancy supervi-sion
3932	T-PoleDiscrep.	Breaker Failure	0.00..30.00 sec; ∞	2.00 sec	Trip delay with pole discre-pancy
4001	FCT TripSuperv.	Trip Circuit Supervision	ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	Trip Circuit Supervision	1..2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	Trip Circuit Supervision	1..30 sec	2 sec	Delay Time for alarm
4201	Ther. OVERLOAD	Thermal Over-load	OFF ON Alarm Only	OFF	Thermal overload protec-tion
4202	K-FACTOR	Thermal Over-load	0.10..4.00	1.10	K-Factor
4203	TIME CONSTANT	Thermal Over-load	1.0..999.9 min	100.0 min	Time Constant
4204	Θ ALARM	Thermal Over-load	50..100 %	90 %	Thermal Alarm Stage

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
4205	I ALARM	Thermal Over-load	0.10..4.00 A	1.00 A	Current Overload Alarm Setpoint
4206	CALC. METHOD	Thermal Over-load	Theta Max Average Theta Theta @ Imax	Theta Max	Method of Acquiring Tem-perature
4401	IP-A (A.x.x.x)	Commissioning Tool	0..255	141	IP-address ×××.xxx.xxx.xxx(Position 1-3)
4402	IP-B (x.B.x.x)	Commissioning Tool	0..255	142	IP-address xxx.×××.xxx.xxx(Position 4-6)
4403	IP-C (x.x.C.x)	Commissioning Tool	0..255	255	IP-address xxx.xxx.×××.xxx(Position 7-9)
4404	IP-D (x.x.x.D)	Commissioning Tool	0..255	150	IP-address xxx.xxx.xxx.×××(Pos. 10-12)
4405	NUM LOCK	Commissioning Tool	YES NO	YES	Num Lock
4406	LCP/NCP	Commissioning Tool	NO YES	YES	Front interface supports LCP/NCP mode
4411	IP-A (A.x.x.x)	Commissioning Tool	0..255	141	IP-address ×××.xxx.xxx.xxx(Position 1-3)
4412	IP-B (x.B.x.x)	Commissioning Tool	0..255	142	IP-address xxx.×××.xxx.xxx(Position 4-6)
4413	IP-C (x.x.C.x)	Commissioning Tool	0..255	255	IP-address xxx.xxx.×××.xxx(Position 7-9)
4414	IP-D (x.x.x.D)	Commissioning Tool	0..255	160	IP-address xxx.xxx.xxx.×××(Pos. 10-12)
4415	NUM LOCK	Commissioning Tool	YES NO	YES	Num Lock
4416	LCP/NCP	Commissioning Tool	NO YES	YES	Service interface supports LCP/NCP mode

A.7 List of Information

The following tables list all data which are available in the maximum complement of the device. Depending on the version and the variant ordered only those data may be present which are valid for the actual version.

The leading ‘>’ sign indicates a binary input as a source.

Indications according to IEC 60870-5-103 are always announced “ON” and “OFF” if they are mandatory for general interrogation, otherwise only “ON”.

User-specified indications or indications which are user-allocated to the IEC 60870-5-103 protocol, are announced “ON” and “OFF” only in case they are not configured as pulse outputs.

The following terminology applies for the columns under “Log-Buffers”:

CAPITAL LETTERS: preset ON/OFF indication, cannot be changed
lowercase letters: preset ON/OFF indication, can be changed
*: not preset, can be allocated and configured
<blank>: neither preset nor allocatable

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
00003	>Synchronize Internal Real Time Clock (>Time Synch)	Device	SP	*	*			LED	BI		BO					
00004	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Oscillographic Fault Records	SP	ON	*			LED	BI		BO					
00005	>Reset LED (>Reset LED)	Device	SP	*	*			LED	BI		BO					
00007	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	SP	*	*			LED	BI		BO					
00008	>Setting Group Select Bit 1 (>Set Group Bit1)	Change Group	SP	*	*			LED	BI		BO					
00015	>Test mode (>Test mode)	Device	SP	ON OFF	*			LED	BI		BO		135	53	1	GI
00016	>Stop data transmission (>DataStop)	Device	SP	*	*			LED	BI		BO		135	54	1	GI
00051	Device is Operational and Protecting (Device OK)	Device	OUT	ON OFF	*			LED			BO		135	81	1	GI
00052	At Least 1 Protection Funct. is Active (ProtActive)	Device	IntSP	ON OFF	*			LED			BO		192	18	1	GI
00055	Reset Device (Reset Device)	Device	OUT	*	*			LED			BO		192	4	1	
00056	Initial Start of Device (Initial Start)	Device	OUT	ON	*			LED			BO		192	5	1	
00060	Reset LED (Reset LED)	Device	OUT_Ev	ON	*			LED			BO		192	19	1	
00067	Resume (Resume)	Device	OUT	ON	*			LED			BO		135	97	1	
00068	Clock Synchronization Error (Clock SyncError)	Device	OUT	ON OFF	*			LED			BO					

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
00069	Daylight Saving Time (DayLightSav-Time)	Device	OUT	ON OFF	*			LED			BO					
00070	Setting calculation is running (Settings Calc.)	Device	OUT	ON OFF	*			LED			BO		192	22	1	GI
00071	Settings Check (Settings Check)	Device	OUT	*	*			LED			BO					
00072	Level-2 change (Level-2 change)	Device	OUT	ON OFF	*			LED			BO					
00073	Local setting change (Local change)	Device	OUT	*	*											
00110	Event lost (Event Lost)	Device	OUT_Ev	ON	*			LED			BO		135	130	1	
00113	Flag Lost (Flag Lost)	Device	OUT	ON	*		M	LED			BO		135	136	1	GI
00125	Chatter ON (Chatter ON)	Device	OUT	ON OFF	*			LED			BO		135	145	1	GI
00126	Protection ON/OFF (via system port) (ProtON/OFF)	Device	IntSP	ON OFF	*			LED			BO					
00127	Auto Reclose ON/OFF (via system port) (AR ON/OFF)	Auto Reclose	IntSP	ON OFF	*			LED			BO					
00140	Error with a summary alarm (Error Sum Alarm)	Device	OUT	ON OFF	*			LED			BO		192	47	1	GI
00144	Error 5V (Error 5V)	Device	OUT	ON OFF	*			LED			BO		135	164	1	GI
00160	Alarm Summary Event (Alarm Sum Event)	Device	OUT	*	*			LED			BO		192	46	1	GI
00161	Failure: General Current Supervision (Fail I Superv.)	Measurement Supervision	OUT	*	*			LED			BO		192	32	1	GI
00163	Failure: Current Balance (Fail I balance)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	183	1	GI
00164	Failure: General Voltage Supervision (Fail U Superv.)	Measurement Supervision	OUT	*	*			LED			BO		192	33	1	GI
00167	Failure: Voltage Balance (Fail U balance)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	186	1	GI
00177	Failure: Battery empty (Fail Battery)	Device	OUT	ON OFF	*			LED			BO		135	193	1	GI
00181	Error: A/D converter (Error A/D-conv.)	Device	OUT	ON OFF	*			LED			BO		135	178	1	GI
00182	Alarm: Real Time Clock (Alarm Clock)	Device	OUT	ON OFF	*			LED			BO		135	194	1	GI
00183	Error Board 1 (Error Board 1)	Device	OUT	ON OFF	*			LED			BO		135	171	1	GI
00184	Error Board 2 (Error Board 2)	Device	OUT	ON OFF	*			LED			BO		135	172	1	GI
00185	Error Board 3 (Error Board 3)	Device	OUT	ON OFF	*			LED			BO		135	173	1	GI

F.No.	Description	Function	Type of Infor-ma-tion	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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
00186	Error Board 4 (Error Board 4)	Device	OUT	ON OFF	*			LED			BO		135	174	1	GI
00187	Error Board 5 (Error Board 5)	Device	OUT	ON OFF	*			LED			BO		135	175	1	GI
00188	Error Board 6 (Error Board 6)	Device	OUT	ON OFF	*			LED			BO		135	176	1	GI
00189	Error Board 7 (Error Board 7)	Device	OUT	ON OFF	*			LED			BO		135	177	1	GI
00190	Error Board 0 (Error Board 0)	Device	OUT	ON OFF	*			LED			BO		135	210	1	GI
00191	Error: Offset (Error Offset)	Device	OUT	ON OFF	*			LED			BO					
00192	Error:1A/5Ajumper different from setting (Error1A/5Awrong)	Device	OUT	ON OFF	*			LED			BO		135	169	1	GI
00193	Alarm: Analog input adjustment invalid (Alarm adjustm.)	Device	OUT	ON OFF	*			LED			BO		135	181	1	GI
00197	Measurement Supervision is switched OFF (MeasSup OFF)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	197	1	GI
00203	Waveform data deleted (Wave. deleted)	Oscillographic Fault Records	OUT_Ev	ON	*			LED			BO		135	203	1	
00289	Alarm: Current summation supervision (Failure Σi)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	250	1	GI
00290	Alarm: Broken current-wire detected L1 (Broken Iwire L1)	Measurement Supervision	OUT	ON	*			LED			BO		135	137	1	GI
00291	Alarm: Broken current-wire detected L2 (Broken Iwire L2)	Measurement Supervision	OUT	ON	*			LED			BO		135	138	1	GI
00292	Alarm: Broken current-wire detected L3 (Broken Iwire L3)	Measurement Supervision	OUT	ON	*			LED			BO		135	139	1	GI
00295	Broken wire supervision is switched OFF (Broken wire OFF)	Measurement Supervision	OUT	ON OFF	*			LED			BO					
00296	Current summation superv is switched OFF (Σi superv. OFF)	Measurement Supervision	OUT	ON OFF	*			LED			BO					
00301	Power System fault (Pow.Sys.Flt.)	Power System Data 2	OUT	ON OFF	ON								135	231	2	GI
00302	Fault Event (Fault Event)	Power System Data 2	OUT	*	ON								135	232	2	
00351	>Circuit breaker aux. contact: Pole L1 (>CB Aux. L1)	Power System Data 2	SP	*	*			LED	BI		BO		150	1	1	GI
00352	>Circuit breaker aux. contact: Pole L2 (>CB Aux. L2)	Power System Data 2	SP	*	*			LED	BI		BO		150	2	1	GI
00353	>Circuit breaker aux. contact: Pole L3 (>CB Aux. L3)	Power System Data 2	SP	*	*			LED	BI		BO		150	3	1	GI
00356	>Manual close signal (>Manual Close)	Power System Data 2	SP	*	*			LED	BI		BO		150	6	1	GI

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
00357	>Block all close commands from external (>CloseCmd.Blo)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		150	7	1	GI
00361	>Failure: Feeder VT (MCB tripped) (>FAIL:Feeder VT)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		192	38	1	GI
00366	>CB1 Pole L1 (Pos. Contact=Breaker) (>CB1 Pole L1)	Power System Data 2	SP	*	*			LED	BI		BO		150	66	1	GI
00367	>CB1 Pole L2 (Pos. Contact=Breaker) (>CB1 Pole L2)	Power System Data 2	SP	*	*			LED	BI		BO		150	67	1	GI
00368	>CB1 Pole L3 (Pos. Contact=Breaker) (>CB1 Pole L3)	Power System Data 2	SP	*	*			LED	BI		BO		150	68	1	GI
00371	>Circuit Breaker 1 READY for reclosing (>CB1 Ready)	Power System Data 2	SP	*	*			LED	BI		BO		150	71	1	GI
00378	>CB faulty (>CB faulty)	Power System Data 2	SP	*	*			LED	BI		BO					
00379	>CB aux. contact 3pole Closed (>CB 3p Closed)	Power System Data 2	SP	*	*			LED	BI		BO		150	78	1	GI
00380	>CB aux. contact 3pole Open (>CB 3p Open)	Power System Data 2	SP	*	*			LED	BI		BO		150	79	1	GI
00381	>Single-phase trip permitted from ext.AR (>1p Trip Perm)	Power System Data 2	SP	ON OFF	*			LED	BI		BO					
00382	>External AR programmed for 1phase only (>Only 1ph AR)	Power System Data 2	SP	ON OFF	*			LED	BI		BO					
00383	>Enable all AR Zones / Stages (>Enable ARzones)	Power System Data 2	SP	ON OFF	ON OFF			LED	BI		BO					
00385	>Lockout SET (>Lockout SET)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		150	35	1	GI
00386	>Lockout RESET (>Lockout RESET)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		150	36	1	GI
00410	>CB1 aux. 3p Closed (for AR, CB-Test) (>CB1 3p Closed)	Power System Data 2	SP	*	*			LED	BI		BO		150	80	1	GI
00411	>CB1 aux. 3p Open (for AR, CB-Test) (>CB1 3p Open)	Power System Data 2	SP	*	*			LED	BI		BO		150	81	1	GI
00501	Relay PICKUP (Relay PICKUP)	Power System Data 2	OUT	*	*		M	LED			BO		192	84	2	GI
00503	Relay PICKUP Phase L1 (Relay PIKKUP L1)	Power System Data 2	OUT	*	*		M	LED			BO		192	64	2	GI
00504	Relay PICKUP Phase L2 (Relay PIKKUP L2)	Power System Data 2	OUT	*	*		M	LED			BO		192	65	2	GI
00505	Relay PICKUP Phase L3 (Relay PIKKUP L3)	Power System Data 2	OUT	*	*		M	LED			BO		192	66	2	GI
00506	Relay PICKUP Earth (Relay PICKUP E)	Power System Data 2	OUT	*	*		M	LED			BO		192	67	2	GI
00507	Relay TRIP command Phase L1 (Relay TRIP L1)	Power System Data 2	OUT	*	*		M	LED			BO		192	69	2	

F.No.	Description	Function	Type of Infor-ma-tion	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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
00508	Relay TRIP command Phase L2 (Relay TRIP L2)	Power System Data 2	OUT	*	*		M	LED			BO		192	70	2	
00509	Relay TRIP command Phase L3 (Relay TRIP L3)	Power System Data 2	OUT	*	*		M	LED			BO		192	71	2	
00510	General CLOSE of relay (Relay CLOSE)	Power System Data 2	OUT	*	*			LED			BO					
00511	Relay GENERAL TRIP command (Relay TRIP)	Power System Data 2	OUT	*	OFF		M	LED			BO		192	68	2	
00512	Relay TRIP command - Only Phase L1 (Relay TRIP 1pL1)	Power System Data 2	OUT	*	*			LED			BO					
00513	Relay TRIP command - Only Phase L2 (Relay TRIP 1pL2)	Power System Data 2	OUT	*	*			LED			BO					
00514	Relay TRIP command - Only Phase L3 (Relay TRIP 1pL3)	Power System Data 2	OUT	*	*			LED			BO					
00515	Relay TRIP command Phases L123 (Relay TRIP 3ph.)	Power System Data 2	OUT	*	*			LED			BO					
00530	LOCKOUT is active (LOCKOUT)	Power System Data 2	IntSP	ON OFF	*			LED			BO					
00533	Primary fault current IL1 (IL1 =)	Power System Data 2	OUT	*	ON OFF								150	177	4	
00534	Primary fault current IL2 (IL2 =)	Power System Data 2	OUT	*	ON OFF								150	178	4	
00535	Primary fault current IL3 (IL3 =)	Power System Data 2	OUT	*	ON OFF								150	179	4	
00536	Final Trip (Final Trip)	Power System Data 2	OUT	ON	ON			LED			BO		150	180	2	GI
00545	Time from Pickup to drop out (PU Time)	Power System Data 2	OUT													
00546	Time from Pickup to TRIP (TRIP Time)	Power System Data 2	OUT													
00560	Single-phase trip was coupled 3phase (Trip Coupled 3p)	Power System Data 2	OUT	*	ON			LED			BO		150	210	2	
00561	Manual close signal detected (Man.Clos.Detect)	Power System Data 2	OUT	ON	*			LED			BO		150	211	1	
00563	CB alarm suppressed (CB Alarm Supp)	Power System Data 2	OUT	*	*			LED			BO					
01000	Number of breaker TRIP commands (# TRIPs=)	Statistics	OUT													
01001	Number of breaker TRIP commands L1 (TripNo L1=)	Statistics	OUT													
01002	Number of breaker TRIP commands L2 (TripNo L2=)	Statistics	OUT													
01003	Number of breaker TRIP commands L3 (TripNo L3=)	Statistics	OUT													

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
01027	Accumulation of interrupted current L1 (Σ IL1 =)	Statistics	OUT													
01028	Accumulation of interrupted current L2 (Σ IL2 =)	Statistics	OUT													
01029	Accumulation of interrupted current L3 (Σ IL3 =)	Statistics	OUT													
01030	Max. fault current Phase L1 (Max IL1 =)	Statistics	OUT													
01031	Max. fault current Phase L2 (Max IL2 =)	Statistics	OUT													
01032	Max. fault current Phase L3 (Max IL3 =)	Statistics	OUT													
01401	>BF: Switch on breaker fail protection (>BF on)	Breaker Failure	SP	*	*			LED	BI		BO					
01402	>BF: Switch off breaker fail protection (>BF off)	Breaker Failure	SP	*	*			LED	BI		BO					
01403	>BLOCK Breaker failure (>BLOCK BkrFail)	Breaker Failure	SP	ON OFF	*			LED	BI		BO		166	103	1	GI
01415	>BF: External start 3pole (>BF Start 3pole)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
01432	>BF: External release (>BF release)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
01435	>BF: External start L1 (>BF Start L1)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
01436	>BF: External start L2 (>BF Start L2)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
01437	>BF: External start L3 (>BF Start L3)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
01439	>BF: External start 3pole (w/o current) (>BF Start w/o I)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
01440	Breaker failure prot. ON/OFF via BI (BkrFailON/offBI)	Breaker Failure	IntSP	ON OFF	*			LED			BO					
01451	Breaker failure is switched OFF (BkrFail OFF)	Breaker Failure	OUT	ON OFF	*			LED			BO		166	151	1	GI
01452	Breaker failure is BLOCKED (BkrFail BLOCK)	Breaker Failure	OUT	ON OFF	ON OFF			LED			BO		166	152	1	GI
01453	Breaker failure is ACTIVE (BkrFail ACTIVE)	Breaker Failure	OUT	*	*			LED			BO		166	153	1	GI
01461	Breaker failure protection started (BF Start)	Breaker Failure	OUT	*	ON OFF			LED			BO		166	161	2	GI
01472	BF Trip T1 (local trip) - only phase L1 (BF T1-TRIP 1pL1)	Breaker Failure	OUT	*	ON			LED			BO					
01473	BF Trip T1 (local trip) - only phase L2 (BF T1-TRIP 1pL2)	Breaker Failure	OUT	*	ON			LED			BO					

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
01474	BF Trip T1 (local trip) - only phase L3 (BF T1-TRIP 1pL3)	Breaker Failure	OUT	*	ON			LED			BO					
01476	BF Trip T1 (local trip) - 3pole (BF T1-TRIP L123)	Breaker Failure	OUT	*	ON			LED			BO					
01493	BF Trip in case of defective CB (BF TRIP CBdefec)	Breaker Failure	OUT	*	ON			LED			BO					
01494	BF Trip T2 (busbar trip) (BF T2-TRIP(bus))	Breaker Failure	OUT	*	ON			LED			BO		192	85	2	
01495	BF Trip End fault stage (BF EndFlt TRIP)	Breaker Failure	OUT	*	ON			LED			BO					
01496	BF Pole discrepancy pickup (BF CBdiscrSTART)	Breaker Failure	OUT	*	ON OFF			LED			BO					
01497	BF Pole discrepancy pickup L1 (BF CBdiscr L1)	Breaker Failure	OUT	*	ON OFF			LED			BO					
01498	BF Pole discrepancy pickup L2 (BF CBdiscr L2)	Breaker Failure	OUT	*	ON OFF			LED			BO					
01499	BF Pole discrepancy pickup L3 (BF CBdiscr L3)	Breaker Failure	OUT	*	ON OFF			LED			BO					
01500	BF Pole discrepancy Trip (BF CBdiscr TRIP)	Breaker Failure	OUT	*	ON			LED			BO					
01503	>BLOCK Thermal Overload Protection (>BLK ThOverload)	Thermal Overload	SP	*	*			LED	BI		BO		167	3	1	GI
01511	Thermal Overload Protection OFF (Th.Overload OFF)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	11	1	GI
01512	Thermal Overload Protection BLOKKED (Th.Overload BLK)	Thermal Overload	OUT	ON OFF	ON OFF			LED			BO		167	12	1	GI
01513	Thermal Overload Protection ACTIVE (Th.Overload ACT)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	13	1	GI
01515	Overload Current Alarm (I alarm) (O/L I Alarm)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	15	1	GI
01516	Overload Alarm! Near Thermal Trip (O/L Θ Alarm)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	16	1	GI
01517	Winding Overload (Winding O/L)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	17	1	GI
01521	Thermal Overload TRIP (ThOverload TRIP)	Thermal Overload	OUT	*	ON			LED			BO		167	21	2	GI
02054	Emergency mode (Emer. mode)	Device	OUT	ON OFF	ON OFF			LED			BO		192	37	1	GI
02701	>Auto reclose ON (>AR ON)	Auto Reclose	SP	*	*			LED	BI		BO		40	1	1	GI
02702	>Auto reclose OFF (>AR OFF)	Auto Reclose	SP	*	*			LED	BI		BO		40	2	1	GI
02703	>BLOCK Auto reclose (>BLOCK AR)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	3	1	GI
02711	>External start of internal Auto reclose (>AR Start)	Auto Reclose	SP	*	ON			LED	BI		BO		40	11	2	GI

F.No.	Description	Function	Type of Infor-ma-tion	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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
02712	>AR: Ext. Trip L1 for internal AR (>Trip L1 AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	12	2	GI
02713	>AR: Ext. Trip L2 for internal AR (>Trip L2 AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	13	2	GI
02714	>AR: Ext. Trip L3 for internal AR (>Trip L3 AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	14	2	GI
02715	>Ext. 1pole Trip for internal Auto Recl. (>Trip 1p for AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	15	2	GI
02716	>Ext. 3pole Trip for internal Auto Recl. (>Trip 3p for AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	16	2	GI
02727	>AR: Remote Close signal (>AR RemoteClose)	Auto Reclose	SP	*	ON			LED	BI		BO		40	22	2	GI
02731	>AR: Synchronism from ext. sync.-check (>Sync.release)	Auto Reclose	SP	*	*			LED	BI		BO		40	31	2	GI
02737	>AR: Block 1pole AR-cycle (>BLOCK 1pole AR)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	32	1	GI
02738	>AR: Block 3pole AR-cycle (>BLOCK 3pole AR)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	33	1	GI
02739	>AR: Block 1phase-fault AR-cycle (>BLK 1phase AR)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	34	1	GI
02740	>AR: Block 2phase-fault AR-cycle (>BLK 2phase AR)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	35	1	GI
02741	>AR: Block 3phase-fault AR-cycle (>BLK 3phase AR)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	36	1	GI
02742	>AR: Block 1st AR-cycle (>BLK 1.AR-cycle)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	37	1	GI
02743	>AR: Block 2nd AR-cycle (>BLK 2.AR-cycle)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	38	1	GI
02744	>AR: Block 3rd AR-cycle (>BLK 3.AR-cycle)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	39	1	GI
02745	>AR: Block 4th and higher AR-cycles (>BLK 4.-n. AR)	Auto Reclose	SP	ON OFF	*			LED	BI		BO		40	40	1	GI
02746	>AR: External Trip for AR start (>Trip for AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	41	2	GI
02747	>AR: External pickup L1 for AR start (>Pickup L1 AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	42	2	GI
02748	>AR: External pickup L2 for AR start (>Pickup L2 AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	43	2	GI
02749	>AR: External pickup L3 for AR start (>Pickup L3 AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	44	2	GI
02750	>AR: External pickup 1phase for AR start (>Pickup 1ph AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	45	2	GI
02751	>AR: External pickup 2phase for AR start (>Pickup 2ph AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	46	2	GI

F.No.	Description	Function	Type of Infor-ma-tion	Log-Buffers: Event Log On/Off	Log-Buffers: Trip (Fault) Log On/Off	Log-Buffers: Ground Fault Log On/Off	Log-Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Binary Output	Configurable in Matrix: Chatter Blocking	IEC 60870-5-103: Type	IEC 60870-5-103: Information-No	IEC 60870-5-103: Data Unit (ASDU)	IEC 60870-5-103: General Interrogation
02752	>AR: External pickup 3phase for AR start (>Pickup 3ph AR)	Auto Reclose	SP	*	ON			LED	BI		BO		40	47	2	GI
02781	Auto recloser is switched OFF (Auto recl. OFF)	Auto Reclose	OUT	ON OFF	*			LED			BO		40	81	1	GI
02782	Auto recloser is switched ON (Auto recl. ON)	Auto Reclose	IntSP	*	*			LED			BO		192	16	1	GI
02783	AR: Auto-reclose is blocked (AR is blocked)	Auto Reclose	OUT	ON OFF	*			LED			BO		40	83	1	GI
02784	Auto recloser is NOT ready (AR is NOT ready)	Auto Reclose	OUT	*	ON			LED			BO		192	130	2	GI
02787	AR: Circuit breaker not ready (CB not ready)	Auto Reclose	OUT	*	*			LED			BO		40	87	1	GI
02788	AR: CB ready monitoring window expired (AR T-CBreadyExp)	Auto Reclose	OUT	*	ON			LED			BO		40	88	2	GI
02796	AR: Auto-reclose ON/OFF via BI (AR on/off BI)	Auto Reclose	IntSP	*	*			LED			BO					
02801	Auto-reclose in progress (AR in pro-gress)	Auto Reclose	OUT	*	ON			LED			BO		40	101	2	GI
02809	AR: Start-signal monitoring time expired (AR T-Start Exp)	Auto Reclose	OUT	*	ON			LED			BO		40	174	2	GI
02810	AR: Maximum dead time expired (AR TdeadMax Exp)	Auto Reclose	OUT	*	ON			LED			BO		40	175	2	GI
02818	AR: Evolving fault recognition (AR evolving Flt)	Auto Reclose	OUT	*	ON			LED			BO		40	118	2	GI
02820	AR is set to operate after 1p trip only (AR Program1pole)	Auto Reclose	OUT	*	*			LED			BO		40	143	1	GI
02821	AR dead time after evolving fault (AR Td. evol.Flt)	Auto Reclose	OUT	*	ON OFF			LED			BO		40	197	2	GI
02839	AR dead time after 1pole trip running (AR Tdead 1pTrip)	Auto Reclose	OUT	*	ON			LED			BO		40	148	2	GI
02840	AR dead time after 3pole trip running (AR Tdead 3pTrip)	Auto Reclose	OUT	*	ON			LED			BO		40	149	2	GI
02841	AR dead time after 1phase fault run-ning (AR Tdead 1pFlt)	Auto Reclose	OUT	*	ON			LED			BO		40	150	2	GI
02842	AR dead time after 2phase fault run-ning (AR Tdead 2pFlt)	Auto Reclose	OUT	*	ON			LED			BO		40	151	2	GI
02843	AR dead time after 3phase fault run-ning (AR Tdead 3pFlt)	Auto Reclose	OUT	*	ON			LED			BO		40	154	2	GI
02844	AR 1st cycle running (AR 1stCyc. run.)	Auto Reclose	OUT	*	ON			LED			BO		40	155	2	GI
02845	AR 2nd cycle running (AR 2ndCyc. run.)	Auto Reclose	OUT	*	ON			LED			BO		40	157	2	GI
02846	AR 3rd cycle running (AR 3rdCyc. run.)	Auto Reclose	OUT	*	ON			LED			BO		40	158	2	GI

F.No.	Description	Function	Type of Infor-ma-tion	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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
02847	AR 4th or higher cycle running (AR 4thCyc. run.)	Auto Reclose	OUT	*	ON			LED			BO		40	159	2	GI
02848	AR cycle is running in ADT mode (AR ADT run.)	Auto Reclose	OUT	*	ON			LED			BO		40	130	2	GI
02851	Auto-reclose Close command (AR Close)	Auto Reclose	OUT	*	ON		M	LED			BO		192	128	2	
02852	AR: Close command after 1pole 1st cycle (AR Close1.Cyc1p)	Auto Reclose	OUT	*	*			LED			BO		40	152	1	GI
02853	AR: Close command after 3pole 1st cycle (AR Close1.Cyc3p)	Auto Reclose	OUT	*	*			LED			BO		40	153	1	GI
02854	AR: Close command after 2nd cycle (AR Close 2.Cyc)	Auto Reclose	OUT	*	*			LED			BO		192	129	1	
02861	AR: Reclaim time is running (AR T-Recl. run.)	Auto Reclose	OUT	*	*			LED			BO		40	161	1	GI
02862	Auto reclose cycle successful (AR Successful)	Auto Reclose	OUT	*	*			LED			BO		40	162	1	GI
02863	Auto reclose Lockout (AR Lockout)	Auto Reclose	OUT	*	*			LED			BO		40	163	1	GI
02864	AR: 1pole trip permitted by internal AR (AR 1p Trip Perm)	Auto Reclose	OUT	*	*			LED			BO		40	164	1	GI
02865	AR: Synchro-check request (AR Sync.Request)	Auto Reclose	OUT	*	*			LED			BO		40	165	2	GI
02871	AR: TRIP command 3pole (AR TRIP 3pole)	Auto Reclose	OUT	*	ON			LED			BO		40	171	2	GI
02889	AR 1st cycle zone extension release (AR 1.CycZoneRel)	Auto Reclose	OUT	*	*			LED			BO		40	160	1	GI
02890	AR 2nd cycle zone extension release (AR 2.CycZoneRel)	Auto Reclose	OUT	*	*			LED			BO		40	169	1	GI
02891	AR 3rd cycle zone extension release (AR 3.CycZoneRel)	Auto Reclose	OUT	*	*			LED			BO		40	170	1	GI
02892	AR 4th cycle zone extension release (AR 4.CycZoneRel)	Auto Reclose	OUT	*	*			LED			BO		40	172	1	GI
02893	AR zone extension (general) (AR Zone Release)	Auto Reclose	OUT	*	*			LED			BO		40	173	1	GI
02894	AR Remote close signal send (AR Remote Close)	Auto Reclose	OUT	*	ON			LED			BO		40	129	2	GI
02895	No. of 1st AR-cycle CLOSE commands 1pole (AR #Close1./1p=)	Statistics	OUT													
02896	No. of 1st AR-cycle CLOSE commands 3pole (AR #Close1./3p=)	Statistics	OUT													
02897	No. of higher AR-cycle CLOSE commands 1p (AR #Close2./1p=)	Statistics	OUT													
02898	No. of higher AR-cycle CLOSE commands 3p (AR #Close2./3p=)	Statistics	OUT													

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
03102	Diff: 2nd Harmonic detected in phase L1 (2nd Harmonic L1)	Differential Protection	OUT	*	*			LED			BO		92	89	1	GI
03103	Diff: 2nd Harmonic detected in phase L2 (2nd Harmonic L2)	Differential Protection	OUT	*	*			LED			BO		92	90	1	GI
03104	Diff: 2nd Harmonic detected in phase L3 (2nd Harmonic L3)	Differential Protection	OUT	*	*			LED			BO		92	91	1	GI
03120	Diff: Active (Diff active)	Differential Protection	OUT	ON OFF	*		M	LED			BO		92	92	1	GI
03132	Diff: Fault detection (Diff. Gen. Flt.)	Differential Protection	OUT	*	ON OFF		M	LED			BO					
03133	Diff: Fault detection in phase L1 (Diff. Flt. L1)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	93	2	GI
03134	Diff: Fault detection in phase L2 (Diff. Flt. L2)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	94	2	GI
03135	Diff: Fault detection in phase L3 (Diff. Flt. L3)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	95	2	GI
03136	Diff: Earth fault detection (Diff. Flt. E)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	96	2	GI
03137	Diff: Fault detection of I-Diff>> (I-Diff>> Flt.)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	97	2	GI
03139	Diff: Fault detection of I-Diff> (I-Diff> Flt.)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	98	2	GI
03141	Diff: General TRIP (Diff. Gen. TRIP)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	99	2	GI
03142	Diff: TRIP - Only L1 (Diff TRIP 1p L1)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	100	2	GI
03143	Diff: TRIP - Only L2 (Diff TRIP 1p L2)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	101	2	GI
03144	Diff: TRIP - Only L3 (Diff TRIP 1p L3)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	102	2	GI
03145	Diff: TRIP L123 (Diff TRIP L123)	Differential Protection	OUT	*	ON OFF		M	LED			BO		92	103	2	GI
03146	Diff: TRIP 1pole (Diff TRIP 1pole)	Differential Protection	OUT	*	ON OFF			LED			BO					
03147	Diff: TRIP 3pole (Diff TRIP 3pole)	Differential Protection	OUT	*	ON OFF			LED			BO					
03148	Diff: Differential protection is blocked (Diff block)	Differential Protection	OUT	ON OFF	*			LED			BO		92	104	1	GI
03149	Diff: Diff. protection is switched off (Diff OFF)	Differential Protection	OUT	ON OFF	*			LED			BO		92	105	1	GI
03176	Diff: Fault detection L1 (only) (Diff Flt. 1p.L1)	Differential Protection	OUT	*	*			LED			BO					
03177	Diff: Fault detection L1E (Diff Flt. L1E)	Differential Protection	OUT	*	*			LED			BO					

F.No.	Description	Function	Type of Information	Log-Buffers: Event Log On/Off	Log-Buffers: Trip (Fault) Log On/Off	Log-Buffers: Ground Fault Log On/Off	Log-Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Binary Output	Configurable in Matrix: Chatter Blocking	IEC 60870-5-103: Type	IEC 60870-5-103: Information-No	IEC 60870-5-103: Data Unit (ASDU)	IEC 60870-5-103: General Interrogation
03178	Diff: Fault detection L2 (only) (Diff Flt. 1p.L2)	Differential Protection	OUT	*	*			LED			BO					
03179	Diff: Fault detection L2E (Diff Flt. L2E)	Differential Protection	OUT	*	*			LED			BO					
03180	Diff: Fault detection L12 (Diff Flt. L12)	Differential Protection	OUT	*	*			LED			BO					
03181	Diff: Fault detection L12E (Diff Flt. L12E)	Differential Protection	OUT	*	*			LED			BO					
03182	Diff: Fault detection L3 (only) (Diff Flt. 1p.L3)	Differential Protection	OUT	*	*			LED			BO					
03183	Diff: Fault detection L3E (Diff Flt. L3E)	Differential Protection	OUT	*	*			LED			BO					
03184	Diff: Fault detection L31 (Diff Flt. L31)	Differential Protection	OUT	*	*			LED			BO					
03185	Diff: Fault detection L31E (Diff Flt. L31E)	Differential Protection	OUT	*	*			LED			BO					
03186	Diff: Fault detection L23 (Diff Flt. L23)	Differential Protection	OUT	*	*			LED			BO					
03187	Diff: Fault detection L23E (Diff Flt. L23E)	Differential Protection	OUT	*	*			LED			BO					
03188	Diff: Fault detection L123 (Diff Flt. L123)	Differential Protection	OUT	*	*			LED			BO					
03189	Diff: Fault detection L123E (Diff Flt. L123E)	Differential Protection	OUT	*	*			LED			BO					
03190	Diff: Set Teststate of Diff. protection (Test Diff.)	Differential Protection	IntSP	ON OFF	*			LED		FK	BO		92	106	1	GI
03191	Diff: Set Commissioning state of Diff. (Comm. Diff)	Differential Protection	IntSP	ON OFF	*			LED		FK	BO		92	107	1	GI
03192	Diff: Remote relay in Teststate (Test-Diff.remote)	Differential Protection	OUT	ON OFF	*			LED			BO		92	108	1	GI
03193	Diff: Commissioning state is active (Comm.Diff act.)	Differential Protection	OUT	ON OFF	*			LED			BO		92	109	1	GI
03194	Diff: >Test Diff. (>Test Diff.)	Differential Protection	SP	ON OFF	*			LED	BI		BO					
03195	Diff: >Comm. Diff (>Comm. Diff)	Differential Protection	SP	ON OFF	*			LED	BI		BO					
03215	Incompatible Firmware Versions (Wrong Firmware)	Protection Interface (Port D+E)	OUT	ON	*			LED			BO					
03217	Prot Int 1: Own Datas received (PI1 Data reflec)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03227	>Prot Int 1: Transmitter is switched off (>PI1 light off)	Protection Interface (Port D+E)	SP	ON OFF	*			LED	BI		BO					
03229	Prot Int 1: Reception of faulty data (PI1 Data fault)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO		93	135	1	GI

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
03230	Prot Int 1: Total receiption failure (PI1 Datafailure)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO		93	136	1	GI
03233	Device table has inconsistent numbers (DT inconsistent)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03234	Device tables are unequal (DT unequal)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03235	Differences between common parameters (Par. different)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03236	Different PI for transmit and receive (PI1<->PI2 error)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03239	Prot Int 1: Transmission delay too high (PI1 TD alarm)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO		93	139	1	GI
03243	Prot Int 1: Connected with relay ID (PI1 with)	Protection Interface (Port D+E)	OUT	ON OFF	*											
03245	> GPS failure from external (>GPS failure)	Protection Interface (Port D+E)	SP	ON OFF	*			LED	BI		BO					
03247	GPS: local pulse loss (GPS loss)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03248	GPS: Prot Int 1 is GPS sychronized (PI 1 GPS sync.)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03250	GPS:PI1 unsym.propagation delay too high (PI 1 PD unsym.)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03252	> PI1 Synchronization RESET (>SYNC PI1 RESET)	Protection Interface (Port D+E)	SP	ON OFF	*			LED	BI		BO					
03254	Prot.1: Delay time change recognized (PI1 jump)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03256	Prot.1: Delay time unsymmetry to large (PI1 unsym.)	Protection Interface (Port D+E)	IntSP	ON OFF	*			LED			BO					
03258	ProtInt1:Permissible error rate exceeded (PI1 Error)	Protection Interface (Port D+E)	OUT	ON OFF	*			LED			BO					
03451	> Logout input signal (>Logout)	Differential Topology	SP	ON OFF	*			LED	BI		BO					
03458	System operates in a open Chaintopology (Chaintopology)	Differential Topology	OUT	ON OFF	*			LED			BO		93	142	1	GI
03464	Communication topology is complete (Topol complete)	Differential Topology	OUT	ON OFF	*			LED			BO					
03475	Relay 1 in Logout state (Rel1Logout)	Differential Topology	IntSP	ON OFF	*			LED		FK	BO		93	143	1	GI
03476	Relay 2 in Logout state (Rel2Logout)	Differential Topology	IntSP	ON OFF	*			LED		FK	BO		93	144	1	GI
03484	Local activation of Logout state (Logout)	Differential Topology	IntSP	ON OFF	*			LED		FK	BO		93	149	1	GI
03487	Equal IDs in constellation (Equal IDs)	Differential Topology	OUT	ON OFF	*			LED			BO					

F.No.	Description	Function	Type of Infor-ma-tion	Log-Buffers: Event Log On/Off	Log-Buffers: Trip (Fault) Log On/Off	Log-Buffers: Ground Fault Log On/Off	Log-Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Binary Output	Configurable in Matrix: Chatter Blocking	IEC 60870-5-103: Type	IEC 60870-5-103: Information-No	IEC 60870-5-103: Data Unit (ASDU)	IEC 60870-5-103: General Interrogation
03491	Relay 1 in Login state (Rel1 Login)	Differential Topo-logy	OUT	ON OFF	*			LED			BO					
03492	Relay 2 in Login state (Rel2 Login)	Differential Topo-logy	OUT	ON OFF	*			LED			BO					
03501	I.Trip: >Intertrip L1 signal input (>Inter-trip L1)	Intertrip	SP	ON OFF	*			LED	BI		BO					
03502	I.Trip: >Intertrip L2 signal input (>Inter-trip L2)	Intertrip	SP	ON OFF	*			LED	BI		BO					
03503	I.Trip: >Intertrip L3 signal input (>Inter-trip L3)	Intertrip	SP	ON OFF	*			LED	BI		BO					
03504	I.Trip: >Intertrip 3 pole signal input (>Intertrip 3pol)	Intertrip	SP	ON OFF	*			LED	BI		BO					
03505	I.Trip: Received at Prot.Interface 1 L1 (ITrp.rec.PI1.L1)	Intertrip	OUT	on off	*			LED			BO					
03506	I.Trip: Received at Prot.Interface 1 L2 (ITrp.rec.PI1.L2)	Intertrip	OUT	on off	*			LED			BO					
03507	I.Trip: Received at Prot.Interface 1 L3 (ITrp.rec.PI1.L3)	Intertrip	OUT	on off	*			LED			BO					
03511	I.Trip: Sending at Prot.Interface 1 L1 (ITrp.sen.PI1.L1)	Intertrip	OUT	ON OFF	*			LED			BO					
03512	I.Trip: Sending at Prot.Interface 1 L2 (ITrp.sen.PI1.L2)	Intertrip	OUT	ON OFF	*			LED			BO					
03513	I.Trip: Sending at Prot.Interface 1 L3 (ITrp.sen.PI1.L3)	Intertrip	OUT	ON OFF	*			LED			BO					
03517	I.Trip: General TRIP (ITrp. Gen. TRIP)	Intertrip	OUT	*	ON OFF		M	LED			BO					
03518	I.Trip: TRIP - Only L1 (ITrp.TRIP 1p L1)	Intertrip	OUT	*	ON OFF		M	LED			BO		93	150	2	GI
03519	I.Trip: TRIP - Only L2 (ITrp.TRIP 1p L2)	Intertrip	OUT	*	ON OFF		M	LED			BO		93	151	2	GI
03520	I.Trip: TRIP - Only L3 (ITrp.TRIP 1p L3)	Intertrip	OUT	*	ON OFF		M	LED			BO		93	152	2	GI
03521	I.Trip: TRIP L123 (ITrp.TRIP L123)	Intertrip	OUT	*	ON OFF		M	LED			BO		93	153	2	GI
03522	I.Trip: TRIP 1pole (Diff TRIP 1pole)	Intertrip	OUT	*	ON OFF			LED			BO					
03523	I.Trip: TRIP 3pole (Diff TRIP 3pole)	Intertrip	OUT	*	ON OFF			LED			BO					
03525	>Differential protection blocking signal (> Diff block)	Differential Pro-tection	SP	ON OFF	*			LED	BI		BO					
03526	Differential blocking received at PI1 (Diffblk.rec PI1)	Differential Pro-tection	OUT	ON OFF	*			LED			BO					
03528	Differential blocking sending via PI1 (Diffblk.sen PI1)	Differential Pro-tection	OUT	ON OFF	*			LED			BO					

F.No.	Description	Function	Type of Infor-ma-tion	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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
03541	>Remote Trip 1 signal input (>Remote Trip1)	Remote Signals	SP	on off	*			LED	BI		BO					
03542	>Remote Trip 2 signal input (>Remote Trip2)	Remote Signals	SP	on off	*			LED	BI		BO					
03543	>Remote Trip 3 signal input (>Remote Trip3)	Remote Signals	SP	on off	*			LED	BI		BO					
03544	>Remote Trip 4 signal input (>Remote Trip4)	Remote Signals	SP	on off	*			LED	BI		BO					
03545	Remote Trip 1 received (RemoteTrip1 rec)	Remote Signals	OUT	on off	*			LED			BO		93	154	1	GI
03546	Remote Trip 2 received (RemoteTrip2 rec)	Remote Signals	OUT	on off	*			LED			BO		93	155	1	GI
03547	Remote Trip 3 received (RemoteTrip3 rec)	Remote Signals	OUT	on off	*			LED			BO		93	156	1	GI
03548	Remote Trip 4 received (RemoteTrip4 rec)	Remote Signals	OUT	on off	*			LED			BO		93	157	1	GI
04253	>BLOCK Instantaneous SOTF Over-current (>BLOCK SOTF-O/C)	Instantaneous HighSpeed SOTF Overcur-rent	SP	*	*			LED	BI		BO					
04271	SOTF-O/C is switched OFF (SOTF-O/C OFF)	Instantaneous HighSpeed SOTF Overcur-rent	OUT	ON OFF	*			LED			BO		25	71	1	GI
04272	SOTF-O/C is BLOCKED (SOTF-O/C BLOCK)	Instantaneous HighSpeed SOTF Overcur-rent	OUT	ON OFF	ON OFF			LED			BO		25	72	1	GI
04273	SOTF-O/C is ACTIVE (SOTF-O/C ACTIVE)	Instantaneous HighSpeed SOTF Overcur-rent	OUT	*	*			LED			BO		25	73	1	GI
04281	SOTF-O/C PICKED UP (SOTF-O/C PICKUP)	Instantaneous HighSpeed SOTF Overcur-rent	OUT	*	OFF		M	LED			BO		25	81	2	GI
04282	SOTF-O/C Pickup L1 (SOF O/CpickupL1)	Instantaneous HighSpeed SOTF Overcur-rent	OUT	*	ON			LED			BO		25	82	2	GI
04283	SOTF-O/C Pickup L2 (SOF O/CpickupL2)	Instantaneous HighSpeed SOTF Overcur-rent	OUT	*	ON			LED			BO		25	83	2	GI
04284	SOTF-O/C Pickup L3 (SOF O/CpickupL3)	Instantaneous HighSpeed SOTF Overcur-rent	OUT	*	ON			LED			BO		25	84	2	GI

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
04285	High Speed-O/C Pickup I>>>> L1 (I>>>>O/C p.upL1)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	85	2	GI
04286	High Speed-O/C Pickup I>>>> L2 (I>>>>O/C p.upL2)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	86	2	GI
04287	High Speed-O/C Pickup I>>>> L3 (I>>>>O/C p.upL3)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	87	2	GI
04289	High Speed/SOTF-O/C TRIP - Only L1 (HS/SOF TRIP1pL1)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	89	2	GI
04290	High Speed/SOTF-O/C TRIP - Only L2 (HS/SOF TRIP1pL2)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	90	2	GI
04291	High Speed/SOTF-O/C TRIP - Only L3 (HS/SOF TRIP1pL3)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	91	2	GI
04292	High Speed/SOTF-O/C TRIP 1pole (HS/SOF TRIP 1p)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	94	2	
04293	High Speed/SOTF-O/C General TRIP (HS/SOF Gen.TRIP)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO					
04294	High Speed/SOTF-O/C TRIP 3pole (HS/SOF TRIP 3p)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO					
04295	High Speed/SOTF-O/C TRIP command L123 (HS/SOF TRIPL123)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	95	2	GI
04403	>BLOCK Direct Transfer Trip function (>BLOCK DTT)	DTT Direct Transfer Trip	SP	*	*			LED	BI		BO					
04412	>Direct Transfer Trip INPUT Phase L1 (>DTT Trip L1)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					
04413	>Direct Transfer Trip INPUT Phase L2 (>DTT Trip L2)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					
04414	>Direct Transfer Trip INPUT Phase L3 (>DTT Trip L3)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					
04417	>Direct Transfer Trip INPUT 3ph L123 (>DTT Trip L123)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
04421	Direct Transfer Trip is switched OFF (DTT OFF)	DTT Direct Transfer Trip	OUT	ON OFF	*			LED			BO		51	21	1	GI
04422	Direct Transfer Trip is BLOCKED (DTT BLOCK)	DTT Direct Transfer Trip	OUT	ON OFF	ON OFF			LED			BO		51	22	1	GI
04432	DTT TRIP command - Only L1 (DTT TRIP 1p. L1)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	32	2	
04433	DTT TRIP command - Only L2 (DTT TRIP 1p. L2)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	33	2	
04434	DTT TRIP command - Only L3 (DTT TRIP 1p. L3)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	34	2	
04435	DTT TRIP command L123 (DTT TRIP L123)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	35	2	
06854	>Trip circuit superv. 1: Trip Relay (>TripC1 TripRel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
06855	>Trip circuit superv. 1: Breaker Relay (>TripC1 Bkr.Rel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
06856	>Trip circuit superv. 2: Trip Relay (>TripC2 TripRel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
06857	>Trip circuit superv. 2: Breaker Relay (>TripC2 Bkr.Rel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
06858	>Trip circuit superv. 3: Trip Relay (>TripC3 TripRel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
06859	>Trip circuit superv. 3: Breaker Relay (>TripC3 Bkr.Rel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
06861	Trip circuit supervision OFF (TripC OFF)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO		170	53	1	GI
06865	Failure Trip Circuit (FAIL: Trip cir.)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO		170	55	1	GI
06866	TripC1 blocked: Binary input is not set (TripC1 ProgFAIL)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
06867	TripC2 blocked: Binary input is not set (TripC2 ProgFAIL)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
06868	TripC3 blocked: Binary input is not set (TripC3 ProgFAIL)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
07104	>BLOCK Backup OverCurrent I>> (>BLOCK O/C I>>)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	4	1	GI
07105	>BLOCK Backup OverCurrent I> (>BLOCK O/C I>)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	5	1	GI
07106	>BLOCK Backup OverCurrent Ip (>BLOCK O/C Ip)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	6	1	GI
07107	>BLOCK Backup OverCurrent Ie>> (>BLOCK O/C Ie>>)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	7	1	GI
07108	>BLOCK Backup OverCurrent Ie> (>BLOCK O/C Ie>)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	8	1	GI

F.No.	Description	Function	Type of Infor-ma-tion	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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
07109	>BLOCK Backup OverCurrent Iep (>BLOCK O/C Iep)	Backup overcur-rent	SP	ON OFF	*			LED	BI		BO		64	9	1	GI
07110	>Backup OverCurrent Instantane-ousTrip (>O/C InstTRIP)	Backup overcur-rent	SP	ON OFF	ON OFF			LED	BI		BO		64	10	1	GI
07130	>BLOCK I-STUB (>BLOCK I-STUB)	Backup overcur-rent	SP	ON OFF	*			LED	BI		BO		64	30	1	GI
07131	>Enable I-STUB-Bus function (>I-STUB ENABLE)	Backup overcur-rent	SP	ON OFF	ON OFF			LED	BI		BO		64	31	1	GI
07132	>BLOCK Backup OverCurrent Ie>>> (>BLOCK O/CIe>>>)	Backup overcur-rent	SP	ON OFF	*			LED	BI		BO		64	32	1	GI
07151	Backup O/C is switched OFF (O/C OFF)	Backup overcur-rent	OUT	ON OFF	*			LED			BO		64	51	1	GI
07152	Backup O/C is BLOCKED (O/C BLOCK)	Backup overcur-rent	OUT	ON OFF	ON OFF			LED			BO		64	52	1	GI
07153	Backup O/C is ACTIVE (O/C ACTIVE)	Backup overcur-rent	OUT	*	*			LED			BO		64	53	1	GI
07161	Backup O/C PICKED UP (O/C PIK-KUP)	Backup overcur-rent	OUT	*	OFF		M	LED			BO		64	61	2	GI
07162	Backup O/C PICKUP L1 (O/C Pickup L1)	Backup overcur-rent	OUT	*	ON			LED			BO		64	62	2	GI
07163	Backup O/C PICKUP L2 (O/C Pickup L2)	Backup overcur-rent	OUT	*	ON			LED			BO		64	63	2	GI
07164	Backup O/C PICKUP L3 (O/C Pickup L3)	Backup overcur-rent	OUT	*	ON			LED			BO		64	64	2	GI
07165	Backup O/C PICKUP EARTH (O/C Pickup E)	Backup overcur-rent	OUT	*	ON			LED			BO		64	65	2	GI
07191	Backup O/C Pickup I>> (O/C PICKUP I>>)	Backup overcur-rent	OUT	*	ON		M	LED			BO		64	91	2	GI
07192	Backup O/C Pickup I> (O/C PICKUP I>)	Backup overcur-rent	OUT	*	ON		M	LED			BO		64	92	2	GI
07193	Backup O/C Pickup Ip (O/C PICKUP Ip)	Backup overcur-rent	OUT	*	ON		M	LED			BO		64	93	2	GI
07201	O/C I-STUB Pickup (I-STUB PICKUP)	Backup overcur-rent	OUT	*	ON OFF		M	LED			BO		64	101	2	GI
07211	Backup O/C General TRIP command (O/C TRIP)	Backup overcur-rent	OUT	*	*			LED			BO		64	111	2	
07212	Backup O/C TRIP - Only L1 (O/C TRIP 1p.L1)	Backup overcur-rent	OUT	*	ON			LED			BO		64	112	2	
07213	Backup O/C TRIP - Only L2 (O/C TRIP 1p.L2)	Backup overcur-rent	OUT	*	ON			LED			BO		64	113	2	
07214	Backup O/C TRIP - Only L3 (O/C TRIP 1p.L3)	Backup overcur-rent	OUT	*	ON			LED			BO		64	114	2	
07215	Backup O/C TRIP Phases L123 (O/C TRIP L123)	Backup overcur-rent	OUT	*	ON			LED			BO		64	115	2	

F.No.	Description	Function	Type of Infor-ma-tion	Log-Buffers: Event Log On/Off	Log-Buffers: Trip (Fault) Log On/Off	Log-Buffers: Ground Fault Log On/Off	Log-Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Binary Output	Configurable in Matrix: Chatter Blocking	IEC 60870-5-103: Type	IEC 60870-5-103: Information-No	IEC 60870-5-103: Data Unit (ASDU)	IEC 60870-5-103: General Interrogation
07221	Backup O/C TRIP I>> (O/C TRIP I>>)	Backup overcur-rent	OUT	*	ON			LED			BO		64	121	2	
07222	Backup O/C TRIP I> (O/C TRIP I>)	Backup overcur-rent	OUT	*	ON			LED			BO		64	122	2	
07223	Backup O/C TRIP Ip (O/C TRIP Ip)	Backup overcur-rent	OUT	*	ON			LED			BO		64	123	2	
07235	O/C I-STUB TRIP (I-STUB TRIP)	Backup overcur-rent	OUT	*	ON			LED			BO		64	135	2	
07325	CB1-TEST TRIP command - Only L1 (CB1-TESTtrip L1)	Testing	OUT	ON OFF	*			LED			BO		153	25	1	GI
07326	CB1-TEST TRIP command - Only L2 (CB1-TESTtrip L2)	Testing	OUT	ON OFF	*			LED			BO		153	26	1	GI
07327	CB1-TEST TRIP command - Only L3 (CB1-TESTtrip L3)	Testing	OUT	ON OFF	*			LED			BO		153	27	1	GI
07328	CB1-TEST TRIP command L123 (CB1-TESTtrip123)	Testing	OUT	ON OFF	*			LED			BO		153	28	1	GI
07329	CB1-TEST CLOSE command (CB1-TEST close)	Testing	OUT	ON OFF	*			LED			BO		153	29	1	GI
07345	CB-TEST is in progress (CB-TEST running)	Testing	OUT	ON OFF	*			LED			BO		153	45	1	GI
07346	CB-TEST canceled due to Power Sys. Fault (CB-TSTstop FLT.)	Testing	OUT_Ev	ON	*											
07347	CB-TEST canceled due to CB already OPEN (CB-TSTstop OPEN)	Testing	OUT_Ev	ON	*											
07348	CB-TEST canceled due to CB was NOT READY (CB-TSTstop NOTr)	Testing	OUT_Ev	ON	*											
07349	CB-TEST canceled due to CB stayed CLOSED (CB-TSTstop CLOS)	Testing	OUT_Ev	ON	*											
07350	CB-TEST was succesful (CB-TST .OK.)	Testing	OUT_Ev	ON	*											
	>Back Light on (>Light on)	Device	SP	ON OFF	*				BI							
	CB1-TEST trip/close Phases L123 (CB1tst 123)	Testing	-		*											
	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	-		*											
	Clock Synchronization (SynchClock)	Device	IntSP_Ev	*	*			LED			BO					
	Control Authority (Cntrl Auth)	Control Authori-zation	IntSP	ON OFF	*			LED					101	85	1	GI

F.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	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
	Controlmode LOCAL (ModeLOCAL)	Control Authorization	IntSP	ON OFF	*			LED					101	86	1	GI
	Controlmode REMOTE (ModeREMOTE)	Control Authorization	IntSP	ON OFF	*			LED								
	Fault Recording Start (FltRecSta)	Oscillographic Fault Records	IntSP	ON OFF	*			LED			BO					
	Group A (Group A)	Change Group	IntSP	ON OFF	*			LED			BO		192	23	1	GI
	Group B (Group B)	Change Group	IntSP	ON OFF	*			LED			BO		192	24	1	GI
	Group C (Group C)	Change Group	IntSP	ON OFF	*			LED			BO		192	25	1	GI
	Group D (Group D)	Change Group	IntSP	ON OFF	*			LED			BO		192	26	1	GI
	Hardware Test Mode (HWTestMod)	Device	IntSP	ON OFF	*			LED			BO					
	Stop data transmission (DataStop)	Device	IntSP	ON OFF	*			LED			BO		192	20	1	GI
	Test mode (Test mode)	Device	IntSP	ON OFF	*			LED			BO		192	21	1	GI
	Unlock data transmission via BI (UnlockDT)	Device	IntSP													

A.8 Measured Values

F.No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Function type	Information-No	Compatibility	Data Unit (ASDU)	Position	CFC	Control Display	Default Display
00601	I L1 (IL1 =)	Measurement	192	148	comp	9	1	CFC		
			134	129	priv	9	1			
00602	I L2 (IL2 =)	Measurement	192	148	comp	9	2	CFC		
			134	129	priv	9	2			
00603	I L3 (IL3 =)	Measurement	192	148	comp	9	3	CFC		
			134	129	priv	9	3			
00610	3I0 (zero sequence) (3I0 =)	Measurement						CFC		
00619	I1 (positive sequence) (I1 =)	Measurement						CFC		
00620	I2 (negative sequence) (I2 =)	Measurement						CFC		
00621	U L1-E (UL1E=)	Measurement	192	148	comp	9	4	CFC		
			134	129	priv	9	4			
00622	U L2-E (UL2E=)	Measurement	192	148	comp	9	5	CFC		
			134	129	priv	9	5			
00623	U L3-E (UL3E=)	Measurement	192	148	comp	9	6	CFC		
			134	129	priv	9	6			
00624	U L12 (UL12=)	Measurement	134	129	priv	9	10	CFC		
00625	U L23 (UL23=)	Measurement	134	129	priv	9	11	CFC		
00626	U L31 (UL31=)	Measurement	134	129	priv	9	12	CFC		
00631	3U0 (zero sequence) (3U0 =)	Measurement						CFC		
00634	U1 (positive sequence) (U1 =)	Measurement						CFC		
00635	U2 (negative sequence) (U2 =)	Measurement						CFC		
00641	P (active power) (P =)	Measurement	192	148	comp	9	7	CFC		
			134	129	priv	9	7			
00642	Q (reactive power) (Q =)	Measurement	192	148	comp	9	8	CFC		
			134	129	priv	9	8			
00643	Power Factor (PF =)	Measurement						CFC		
00644	Frequency (Freq=)	Measurement	192	148	comp	9	9	CFC		
			134	129	priv	9	9			
00645	S (apparent power) (S =)	Measurement						CFC		
00801	Temperat. rise for warning and trip (Θ /Θtrip =)	Measurement						CFC		
00802	Temperature rise for phase L1 (Θ /ΘtripL1=)	Measurement						CFC		
00803	Temperature rise for phase L2 (Θ /ΘtripL2=)	Measurement						CFC		
00804	Temperature rise for phase L3 (Θ /ΘtripL3=)	Measurement						CFC		

F.No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Function type	Information-No	Compatibility	Data Unit (ASDU)	Position	CFC	Control Display	Default Display
07731	PHI IL1L2 (local) (Φ IL1L2=)	Measurement						CFC		
07732	PHI IL2L3 (local) (Φ IL2L3=)	Measurement						CFC		
07733	PHI IL3L1 (local) (Φ IL3L1=)	Measurement						CFC		
07734	PHI UL1L2 (local) (Φ UL1L2=)	Measurement						CFC		
07735	PHI UL2L3 (local) (Φ UL2L3=)	Measurement						CFC		
07736	PHI UL3L1 (local) (Φ UL3L1=)	Measurement						CFC		
07737	PHI UIL1 (local) (Φ UIL1=)	Measurement						CFC		
07738	PHI UIL2 (local) (Φ UIL2=)	Measurement						CFC		
07739	PHI UIL3 (local) (Φ UIL3=)	Measurement						CFC		
07742	IDiffL1(% Operational nominal current) (IDiffL1=)	Differential and Restraint Current	134	122	priv	9	1	CFC		
07743	IDiffL2(% Operational nominal current) (IDiffL2=)	Differential and Restraint Current	134	122	priv	9	2	CFC		
07744	IDiffL3(% Operational nominal current) (IDiffL3=)	Differential and Restraint Current	134	122	priv	9	3	CFC		
07745	IRestL1(% Operational nominal current) (IRestL1=)	Differential and Restraint Current	134	122	priv	9	4	CFC		
07746	IRestL2(% Operational nominal current) (IRestL2=)	Differential and Restraint Current	134	122	priv	9	5	CFC		
07747	IRestL3(% Operational nominal current) (IRestL3=)	Differential and Restraint Current	134	122	priv	9	6	CFC		
07748	Diff3I0 (Differential current 3I0) (Diff3I0=)	Differential and Restraint Current						CFC		
07751	Prot.Interface 1:Transmission delay (PI1 TD)	Statistics	134	122	priv	9	7	CFC		
07753	Prot.Interface 1: Availability per min. (PI1A/m)	Statistics						CFC		
07754	Prot.Interface 1: Availability per hour (PI1A/h)	Statistics	134	121	priv	9	3	CFC		
			134	122	priv	9	8			
07761	Relay ID of 1. relay (Relay ID)	Measurements from relay 1						CFC		
07762	IL1(% of Operational nominal current) (IL1_opN=)	Measurements from relay 1						CFC		
07763	Angle IL1_rem <-> IL1_loc (ΦI L1=)	Measurements from relay 1						CFC		
07764	IL2(% of Operational nominal current) (IL2_opN=)	Measurements from relay 1						CFC		
07765	Angle IL2_rem <-> IL2_loc (ΦI L2=)	Measurements from relay 1						CFC		
07766	IL3(% of Operational nominal current) (IL3_opN=)	Measurements from relay 1						CFC		
07767	Angle IL3_rem <-> IL3_loc (ΦI L3=)	Measurements from relay 1						CFC		

F.No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Function type	Information-No	Compatibility	Data Unit (ASDU)	Position	CFC	Control Display	Default Display
07769	UL1(% of Operational nominal voltage) (UL1_opN=)	Measurements from relay 1						CFC		
07770	Angle UL1_rem <-> UL1_loc (ΦU L1=)	Measurements from relay 1						CFC		
07771	UL2(% of Operational nominal voltage) (UL2_opN=)	Measurements from relay 1						CFC		
07772	Angle UL2_rem <-> UL2_loc (ΦU L2=)	Measurements from relay 1						CFC		
07773	UL3(% of Operational nominal voltage) (UL3_opN=)	Measurements from relay 1						CFC		
07774	Angle UL3_rem <-> UL3_loc (ΦU L3=)	Measurements from relay 1						CFC		
07781	Relay ID of 2. relay (Relay ID)	Measurements from relay 2						CFC		
07782	IL1(% of Operational nominal current) (IL1_opN=)	Measurements from relay 2						CFC		
07783	Angle IL1_rem <-> IL1_loc (ΦI L1=)	Measurements from relay 2						CFC		
07784	IL2(% of Operational nominal current) (IL2_opN=)	Measurements from relay 2						CFC		
07785	Angle IL2_rem <-> IL2_loc (ΦI L2=)	Measurements from relay 2						CFC		
07786	IL3(% of Operational nominal current) (IL3_opN=)	Measurements from relay 2						CFC		
07787	Angle IL3_rem <-> IL3_loc (ΦI L3=)	Measurements from relay 2						CFC		
07789	UL1(% of Operational nominal voltage) (UL1_opN=)	Measurements from relay 2						CFC		
07790	Angle UL1_rem <-> UL1_loc (ΦU L1=)	Measurements from relay 2						CFC		
07791	UL2(% of Operational nominal voltage) (UL2_opN=)	Measurements from relay 2						CFC		
07792	Angle UL2_rem <-> UL2_loc (ΦU L2=)	Measurements from relay 2						CFC		
07793	UL3(% of Operational nominal voltage) (UL3_opN=)	Measurements from relay 2						CFC		
07794	Angle UL3_rem <-> UL3_loc (ΦU L3=)	Measurements from relay 2						CFC		
07875	Prot.Interface 1:Transmission delay rec. (PI1 TD R)	Statistics	134	121	priv	9	1	CFC		
07876	Prot.Interface 1:Transmission delay send (PI1 TD S)	Statistics	134	121	priv	9	2	CFC		

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