SIPROTEC

Differential Protection 7SD610

V4.6

Manual

C53000-G1176-C145-4

Disclaimer of liability

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

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

We reserve the right to make technical improvements without notice.

Document version 04.30.02

Preface

Purpose of this Manual

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

- Information regarding the configuration of the device and descriptions of device functions and settings → Chapter 2;
- Instruction for mounting and commissioning → Chapter 3,
- List of technical data → Chapter 4;
- As well as a compilation of the most significant data for experienced users → Appendix A.

General information about design, configuration, and operation of SIPROTEC 4 devices are laid down in the SIPROTEC 4 System Description /1/.

Target Audience

Protection engineers, commissioning engineers, personnel concerned with adjustment, checking, and service of selective protective equipment, automatic and control facilities, and personnel of electrical facilities and power plants.

Scope of validity of the manual

This manual is valid for SIPROTEC Differential Protection 7SD610 Firmware-Version V4.6

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 is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directive, and with the standard EN 61000-6-2 and EN 61000-6-4 for the low-voltage directive. This device was designed and produced for industrial use. The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

Further Standards

IEEE Std C37.90-*

This product is UL-certified according to the Technical Data:

IND. CONT. EQ.
69CA

IND. CONT. EQ.

Additional Support

Should further information on the SIPROTEC 4 System 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 centre in Nuremberg.

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 indicators and standard definitions 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!

When operating an electrical device, certain parts of the device inevitably have dangerous voltages.

Death, severe personal injury or substantial property damage can result if the device is not handled properly.

Only qualified personnel shall work on and around this equipment. It must be 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.

Of particular importance are the general installation and safety regulations for work in a high-voltage environment (for example, ANSI, IEC, EN, DIN, or other national and international regulations). These regulations must be observed.

Definition

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 Graphical Conventions

To designate terms which refer in the text to information of the device or for the device, the following fonts are used:

`Parameter names`

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

`1234A`

Parameter addresses have the same character style as parameter names. Parameter addresses in overview tables contain the suffix **A**, if the parameter is only available using the option **Display additional settings**.

`Parameter Conditions`

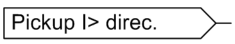
Possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI), are additionally written in italics. The same goes for the options of the menus.

`„Annunciations“`

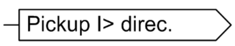
Designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotation marks.

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

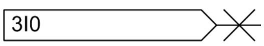
The following symbols are used in drawings:



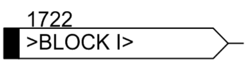
Device-internal logical input signal



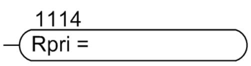
Device-internal (logical) output signal



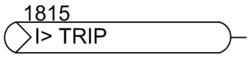
Internal input signal of an analog quantity



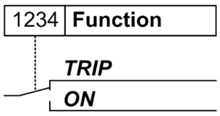
External binary input signal with number (binary input, input indication)



External binary output signal with number (device indication)

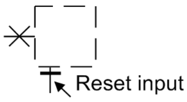


External binary output signal with number (device indication) used as input signal

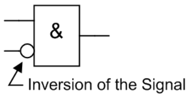


Example of a parameter switch designated **FUNCTION** with the address 1234 and the possible settings ON and OFF

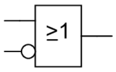
Besides these, graphical symbols are used according to IEC 60617-12 and IEC 60617-13 or symbols derived from these standards. Some of the most frequently used are listed below:



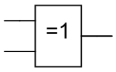
Input signal of an analog quantity



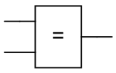
AND gate



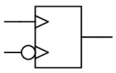
OR gate



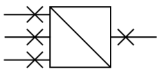
Exclusive OR (antivalence): output is active, if only **one** of the inputs is active



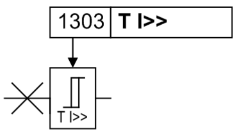
Coincidence gate (equivalence): output is active if **both** inputs are active or inactive at the same time



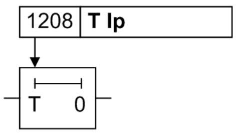
Dynamic inputs (edge–triggered) above with positive, below with negative edge



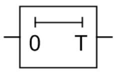
Formation of one analog output signal from a number of analog input signals



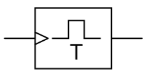
Limit stage with setting address and parameter designator (name)



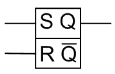
Timer (pickup delay T, example adjustable) with setting address and parameter designator (name)



Timer (dropout delay T, example non-adjustable)



Dynamic triggered pulse timer T (monoflop)



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

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Contents

Introduction 1

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

1.1 Overall Operation

The SIPROTEC 4 7SD610 line protection is equipped with a powerful microprocessor system. 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 ends of the protected area. Figure 1-1 shows the basic structure of the device.

Analog Inputs

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

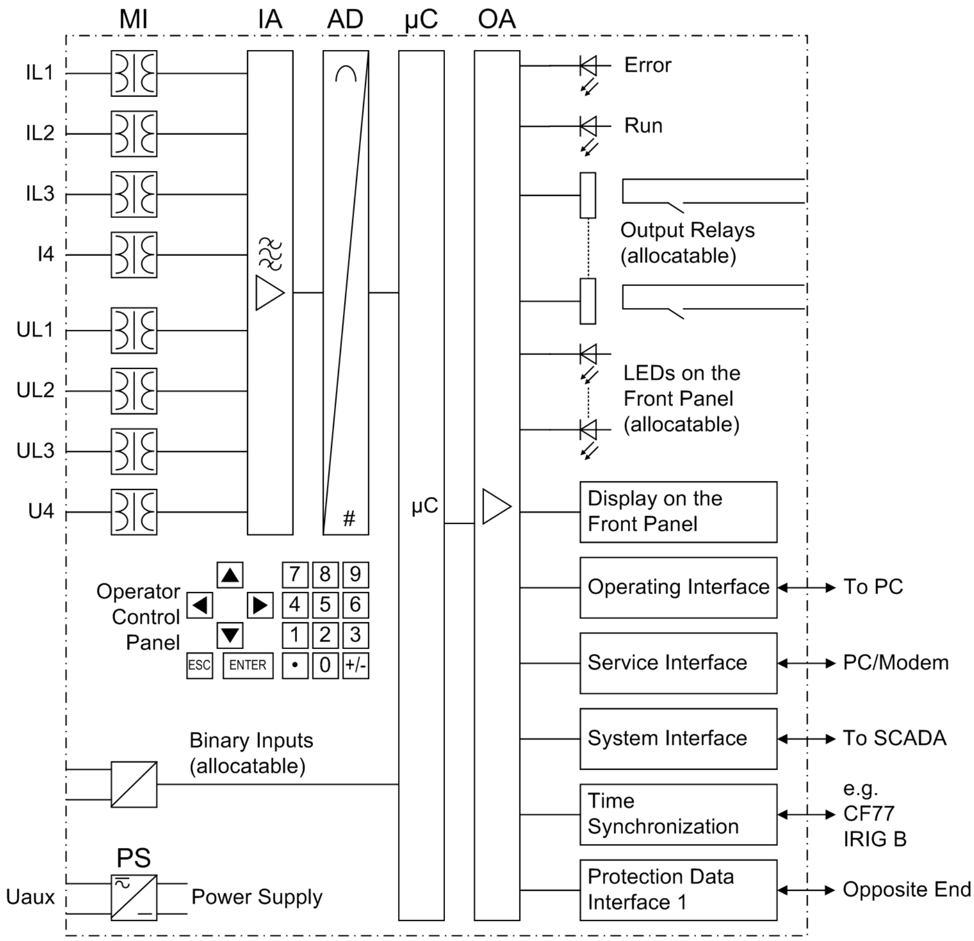


Figure 1-1 Hardware structure of the differential protection 7SD610

A voltage measuring input is provided for each phase-earth voltage. In principle, the differential protection does not require any measured voltage, however, for the directed overcurrent time protection the connection of the phase earth voltages U_{L1}, U_{L2} and U_{L3} is definitely required. Additionally voltages that allow to 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) or for any voltage U_x (for overcurrent protection). The analog values are transferred further to the IA input amplifier group.

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

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

Microcomputer System

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

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

The information is provided via output amplifier OA.

Binary Inputs and Outputs

Binary inputs and outputs from and to the computer system are routed via the I/O modules (inputs and outputs). The “μC” issues information to external equipment via the output contacts. Outputs are mainly commands that are issued to the switching devices and messages for remote signalling of events and states.

Front Elements

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

Integrated control and numeric keys in conjunction with the LCD facilitate local interaction with the local device. All information of the device can be accessed using the integrated control and numeric keys. This information includes protective and control settings, operating and fault indications, and measured values; setting parameters can be changed (see also Chapter 2 and SIPROTEC 4 System Description).

Devices with control functions also allow station control on the front panel.

Serial Interfaces

Via the serial operator interface in the front panel the communication with a personal computer using the operating program DIGSI is possible. This facilitates a comfortable handling of all device functions.

The service interface can also be used for communication with a personal computer using DIGSI. This is especially well suited for the central interrogation of the devices from a PC or for remote operation via a modem.

All device data can be transmitted to a central evaluating unit or control center through the serial system (SCADA) interface. This interface may be provided with various physical transmission modes and different protocols to suit the particular application.

A further interface is provided for time synchronization of the internal clock through external synchronization sources.

Further communication protocols can be realized via additional interface modules.

The operating or service interfaces allow the communication with both devices during commissioning, checking and also during operation of the device, via a communication network using a standard browser. For this a special tool, the WEB-Monitor, is provided, which has been optimized for differential protection.

Protection Data Interface

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

Power Supply

These described functional units are supplied by a power supply PS with the necessary power in the different voltage levels. Brief supply voltage dips which may occur on short circuits in the auxiliary voltage supply of the power system are usually bridged by a capacitor (see also Technical Data, Sub-section 4.1).

1.2 Application Scope

The numerical Differential Protection SIPROTEC 4 7SD610 is a selective short-circuit protection for overhead lines and cables with single- and multi-ended infeeds in radial, ring or any type of meshed systems of any 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 a power transformer is located within the protected zone (ordering option) whose starpoint(s) might also be isolated, earthed or provided with a Petersen coil.

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

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

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

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

Protection Functions

Recognition of short circuits in the protection zone — even of weak-current or high-resistive shorting — is the basic function of the device. Even complex multiphase faults are precisely detected, as the measured values are evaluated phase segregated. The protection system is restrained against inrush currents of power transformers. Subsequent to energizing the line onto a fault which may be located along the entire line length, it is possible to achieve a non-delayed trip signal.

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 overcurrent protection has three current-independent stages and one current-dependent stage. Furthermore, the device has a directional current-independent stage and a directional current-independent stage which enables an increased selectivity of the emergency function. For inverse time overcurrent protection stages, several curves of different standards are provided.

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

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

Depending on the order variant, the short-circuit protection functions may also trip single-pole, and may operate in co-operation with an integrated automatic reclosure (optionally). The automatic reclose function may be used on overhead lines for single-pole, three-pole or single- and three-pole automatic reclosure as well as multi-shot automatic reclosure.

Apart from the short-circuit protection functions mentioned, a thermal overload protection has been integrated which protects in particular cables and power transformers from undue heating through overload. Furthermore, multi-step over and undervoltage as well as frequency protection and restricted earth fault protection can be used (ordering variant). An optional circuit breaker failure protection provides rapid backup fault clearance instruction to the adjacent circuit breakers in case the local breaker fails to respond.

Control Functions

The device is equipped with control functions which operate, close and open, switchgear via the integrated operator panel, the system interface, binary inputs, and using a personal computer with DIGSI software. Using auxiliary contacts of the switch and binary inputs of the device, switching states feedbacks are issued. The current status (or position) of the primary equipment can be read out at the device, and used for interlocking or plausibility monitoring. The number of the devices to be switched is limited by the binary inputs and outputs available in the device or the binary inputs and outputs allocated for the switch position feedbacks. Depending on the resource one (single point indication) or two binary inputs (double point indication) can be used. The capability of switching primary equipment can be restricted by appropriate settings for the switching authority (remote or local), and by the operating mode (interlocked/non-interlocked, with or without password request). Interlocking conditions for switching (e.g. switchgear interlocking) can be established using the integrated user-defined logic.

Indications and Measured Values; Fault Recording

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

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

During a fault (power system fault) important events and changes in conditions are saved in fault logs (Event Log or Trip Log). Instantaneous fault values are also saved in the device and may be analyzed subsequently.

As a special feature the values are synchronized between the line terminals via the communication link.

Communication

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

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

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

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

The system interface is used for central communication between the device and a control centre. It can be operated through the RS232, RS485 or FO port. For data transmission there are several standardized protocols available. An EN100 module allows to integrate the devices into the 100 MBit Ethernet communication networks of the process control and automation systems using IEC 61850 protocols. In parallel to the link with the process control and automation system, this interface can also handle DIGSI communication and inter-relay communication using GOOSE.

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

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

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

1.3 Characteristics

General Features

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

Differential Protection

- Differential protection system for 2 ends with digital protection data transmission
- Protection for all types of short-circuits in systems with any starpoint conditioning
- Reliable differentiation between load and fault conditions also in high-resistant, current-weak faults by adaptive measuring procedures
- High sensitivity in case of weakly loaded system, extreme stability against load jumps and power swings
- Phase segregated measurement ensures that the pickup sensitivity is independent of the fault type
- Suited for transformers in the protected zone (order variant)
- Detection of high-resistant, weak-current faults due to high sensitivity of the protective functions
- Insensitive against inrush and charging currents – also for transformers in the protected zone – and against higher-frequency switching transients
- High stability also for different current transformer saturation
- Adaptive stabilisation that is automatically derived from the measured quantities and the configured current transformer data
- Fast, phase segregated tripping also on weak or zero infeed ends (breaker intertrip)
- low frequency dependency
- Digital protection data transmission; communication between devices via dedicated communication links (in general optical fibre) or a communication system
- Communication possible via a single copper wire pair (typically 15 km, max. 30 km, depending on used cable type)
- Synchronization via GPS possible. resulting in automatic correction of transmission time differences thus increasing once more the sensitivity
- Permanent monitoring of the protection data transmission concerning disturbance, failure or transfer time deviations in the transmission network with automatic transfer time correction
- Phase segregated tripping possible (for operation with single-pole or single-and three-pole auto-reclosure) (order variant)

Restricted Earth Fault Protection

- Earth fault protection for earthed transformer windings
- Short tripping time
- High sensitivity for earth faults
- High stability against external earth faults using the magnitude and phase relationship of through-flowing earth current

External Direct and Remote Tripping

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

Transmission of Information

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

Time Overcurrent Protection

- Selectable as emergency function during protection data communication failure or as back-up function or as both
- Maximally two definite time stages and one inverse time stage each for phase currents and earth current
- Two directional definite time stages (DT) and one directional inverse time stage (IDMT), each for phase currents and earth current
- for inverse time overcurrent protection a selection from various characteristics based on several standards is possible
- Blocking capability e.g. for reverse interlocking with any element
- Instantaneous tripping by any stage when switching onto a fault

High Current Switch-onto-Fault Protection

- Fast tripping for all faults on 100 % line length
- Selectable for manual closure or following each closure of the circuit breaker
- With integrated line energization detection.

Automatic Reclosure Function (optional)

- For reclosure after single-pole, three-pole or single-pole and three-pole tripping
- Single or multiple 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 the one device controls the automatic reclosure cycles whilst at the other line end the automatic reclosure solely depends on the one controlling device. The criteria used are voltage measurement and/or the transmitted CLOSE command (Remote-CLOSE)
- Automatic reclosure controlled optionally by protection start with separate dead times after single, two and three-pole starting

Voltage Protection (optional)

- Overvoltage and undervoltage detection with different stages
- Two overvoltage stages for the phase-earth voltages
- Two overvoltage stages for the phase-phase voltages
- Two overvoltage stages for the positive sequence voltage, optionally with compounding
- Two overvoltage stages for the negative sequence voltage
- Two overvoltage stages for the zero sequence voltage or any other single-phase voltage
- Settable drop-off to pick-up ratios
- Two undervoltage stages for the phase-earth voltages
- Two undervoltage stages for the phase-phase voltages
- Two undervoltage stages for the positive sequence voltage
- Settable current criterion for undervoltage protection functions

Frequency Protection (optional)

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

Circuit Breaker Failure Protection (optional)

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

Thermal Overload Protection

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

User-defined Logic Functions (CFC)

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

Commissioning; Operation; Maintenance

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

Command Processing

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

Monitoring Functions

- Availability of the device is greatly increased because of self-monitoring of the internal measurement circuits, power supply, hardware and software
- Monitoring of the current and voltage transformer secondary circuits by means of summation and symmetry checks
- Monitoring of communication with statistics showing the 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
- Check of local and remote measured values and comparison of both
- Broken wire supervision for the secondary CT circuits with fast phase segregated blocking of the differential protection system in order to avoid malfunction
- Supervision of measuring voltage failure using "Fuse Failure Monitor"

Further Functions

- Battery buffered real-time clock, which may be synchronized via a synchronization signal (e.g. DCF77, IRIG B, GPS via satellite receiver), binary input or system interface
- Automatic time synchronization between the devices at the ends of the protected object via the protection data transmission
- Continuous calculation and display of measured quantities on the front of the device. Indication of measured quantities of the remote end
- Fault event memory (trip log) for the last 8 network faults (faults in the power system), with real time stamps
- Fault recording memory and 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: Counter with the trip commands issued by the device, as well as record of the short-circuit current data and accumulation of the interrupted short-circuit currents
- Communication with central control and data storage equipment via serial interfaces through the choice of RS232, RS485, modem, or optical fibres, as an option

- Commissioning aids such as connection and direction checks as well as circuit breaker test functions
- The WEB-Monitor (installed on a PC or a laptop) widely supports the testing and commissioning procedure. The communication topology of the differential protection and communication system, phasor diagrams of all currents and (if applicable) voltages at both ends of the differential system are displayed as a graph

■

Functions 2

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

Additionally, on the basis of the following information, it may be defined which functions are to be used.

2.1 General

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

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

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

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

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

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

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

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

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

2.1.1 Functional Scope

2.1.1.1 Configuration of the Scope of Functions

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

Example for the configuration of scope of functions:

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

The available protection and supplementary functions can be configured as ***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 indications, and corresponding settings (functions, limit values) are not displayed during setting.

Note

The functions and default settings available depend on the order variant of the device.

2.1.1.2 Setting Notes

Configuring the functional scope

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

Most settings are self-explaining. The special cases are described below.

Special Cases

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

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

Note

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

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

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

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

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

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

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

The setting ***Trip with T-action / Trip without T-action ...*** (default setting = With trip command ...) is to be preferred if single-pole or single-pole/three-pole auto reclose cycles are provided for and possible. In this case, different dead times (for every AR cycle) are possible after single-pole tripping and after three-pole tripping. The protective function that issues the trip command determines the type of trip: Single-pole or three-pole. The dead time is controlled dependent on this.

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

The setting ***Trip with T-action*** provides an action time for each reclose cycle. The action time is started by a general pickup of all protective functions. If no trip command is present before the action time expires, the corresponding reclose cycle is not carried out. Section 2.10 provides detailed information on this topic. This setting is recommended for time-graded protection. If the protection function which is to operate with automatic reclosure does not have a general pickup signal for starting the action times, select ***... Trip without T-action***.

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

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

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

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

2.1.1.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip mode	3pole only 1-/3pole	3pole only	Trip mode
112	DIFF.PROTECTION	Enabled Disabled	Enabled	Differential protection
122	DTT Direct Trip	Disabled Enabled	Disabled	DTT Direct Transfer Trip
124	HS/SOTF-O/C	Disabled Enabled	Disabled	Instantaneous HighSpeed/SOTF Overcurrent
126	Back-Up O/C	Disabled TOC IEC TOC ANSI	TOC IEC	Backup overcurrent
133	Auto Reclose	1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles ADT Disabled	Disabled	Auto-Reclose Function
134	AR control mode	Pickup w/ Tact Pickup w/o Tact Trip w/ Tact Trip w/o Tact	Trip w/o Tact	Auto-Reclose control mode
136	FREQUENCY Prot.	Disabled Enabled	Disabled	Over / Underfrequency Protection
137	U/O VOLTAGE	Disabled Enabled Enabl. w. comp.	Disabled	Under / Overvoltage Protection
139	BREAKER FAILURE	Disabled Enabled enabled w/ 3I0>	Disabled	Breaker Failure Protection

Addr.	Parameter	Setting Options	Default Setting	Comments
140	Trip Cir. Sup.	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision
141	REF PROT.	Disabled Enabled	Disabled	Restricted earth fault protection
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
143	TRANSFORMER	NO YES	NO	Transformer inside protection zone
144	V-TRANSFORMER	Not connected connected	connected	Voltage transformers
148	GPS-SYNC.	Enabled Disabled	Disabled	GPS synchronization

2.1.2 General Power System Data (Power System Data 1)

The device requires some plant and power system data in order to be able to adapt its functions accordingly, 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. The Power System Data 1 can only be changed from a PC running DIGSI and are discussed in this section.

2.1.2.1 Setting Notes

Current Transformer Polarity

In address 201 **CT Starpoint** the polarity of the current transformers must be entered, in other words, the location of the CT star-point (Figure 2-1). The setting defines the measuring direction of the device (current in line direction is defined as positive at both line ends). The reversal of this parameter also reverses the polarity of the residual current input I_E.

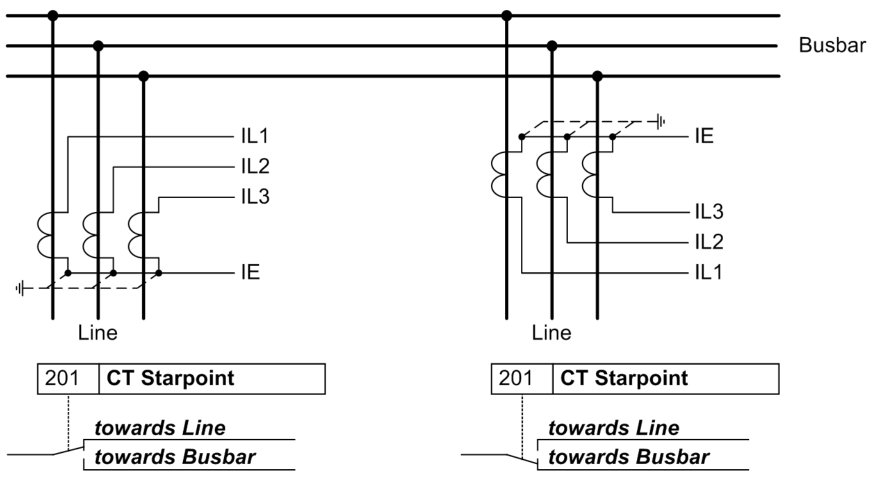


Figure 2-1 Polarity of current transformers

Nominal Values of Transformers

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

In addresses 203 **Unom PRIMARY** and 204 **Unom SECONDARY** the device obtains information on the primary and secondary rated voltage (phase-to-phase voltage) of the voltage transformers.

It is important to ensure that the rated secondary current of the current transformer matches the rated current of the device, otherwise the device will incorrectly calculate primary amperes.

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

Voltage Connection

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

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

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

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

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

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

- If the input U_4 is not required, set:

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

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

Connection of the Currents

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

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

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

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

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

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

<u>Example</u>:

Phase current transformers 500 A / 5 A

Earth current transformer 60 A / 1 A

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

- Connecting the I_4 input to the starpoint current of a transformator; this is used for the earth fault differential protection:

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

- If the input I_4 is not required, set:

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

  Address 221 **I4/Iph CT** is then irrelevant.

  In this case, the neutral current is calculated from the sum of the phase currents.

Rated frequency

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

System Starpoint

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

Distance Unit

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

Trip command duration

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

In address 241 the maximum close command duration **TMax CLOSE CMD** is set. It applies to all close commands issued by the device. It also determines the length of the close command pulse when a circuit breaker test cycle is issued via the device. It must be long enough to ensure that the circuit breaker has securely closed. There is no risk in setting this time too long, as the close command will in any event be terminated following a new trip command from a protective function. This parameter can only be altered using 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 using DIGSI. The duration of the trip command is set as explained above. Address 242 **T-CBtest-dead** determines the duration from the end of the trip command until the start of the close command for this test. It should not be less than 0.1 s.

Current transformer characteristic

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

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

The rated accuracy limit factor n of the current transformers and the rated power P_N are usually stated on the rating plate of the current transformers. The information stated refers to reference conditions (nominal current, nominal burden). For example (according to VDE 0414 / Part 1 or 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 these 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 overcurrent factor)
n =	rated accuracy limit factor of the current transformers (distinctive number behind P)
P_N =	rated burden of the current transformers [VA] at rated current
P_i =	internal burden of the current transformers [VA] at rated current
P' =	actually connected burden (devices + secondary lines) [VA] at rated current

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

$P_i \approx R_i \cdot I_N^2$

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

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

– 3 % for a 5P transformer,

– 5 % for a 10P transformer.

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

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

Table 2-1 Recommended settings for current transformer data

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

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

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

<u>Calculation example:</u>

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

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

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 nominal current I_N = 5 A is calculated

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

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

P' = 4.375 VA + 0.3 VA = 4.675 VA

Thus the ratio of the accuracy limit factors is as follows

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

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

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

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

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

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

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

Transformer with voltage control

If a power transformer with voltage control is located in the protected zone, a differential current may occur even during normal 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 the relay facing the regulated winding of the power transformer.

Calculation example:

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

This results in the following:

Rated current at rated voltage $I_N = 184$ A

Rated current at U_N + 10 % $I_{min} = 167$ A

Rated current at U_N – 10 % $I_{max} = 202$ A

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

The maximum deviation from this current is

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

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

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 requires a further correction of the data of the protected object as discussed in Section 2.1.4 under „Topological Data for Transformers (optional)".

2.1.2.2 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
201	CT Starpoint	towards Line towards Busbar	towards Line	CT Starpoint
203	Unom PRIMARY	0.4 .. 1200.0 kV	400.0 kV	Rated Primary Voltage
204	Unom SECONDARY	80 .. 125 V	100 V	Rated Secondary Voltage (Ph-Ph)
205	CT PRIMARY	10 .. 10000 A	1000 A	CT Rated Primary Current
206	CT SECONDARY	1A 5A	1A	CT Rated Secondary Current
207	SystemStarpoint	Solid Earthed Peterson-Coil Isolated	Solid Earthed	System Starpoint is
210	U4 transformer	Not connected Udelta transf. Ux transformer	Not connected	U4 voltage transformer is
211	Uph / Udelta	0.10 .. 9.99	1.73	Matching ratio Phase-VT To Open-Delta-VT
220	I4 transformer	Not connected In prot. line IY starpoint	In prot. line	I4 current transformer is
221	I4/Iph CT	0.010 .. 5.000	1.000	Matching ratio I4/Iph for CT's
230	Rated Frequency	50 Hz 60 Hz	50 Hz	Rated Frequency

Addr.	Parameter	Setting Options	Default Setting	Comments
236	Distance Unit	km Miles	km	Distance measurement unit
240A	TMin TRIP CMD	0.02 .. 30.00 sec	0.10 sec	Minimum TRIP Command Duration
241A	TMax CLOSE CMD	0.01 .. 30.00 sec	1.00 sec	Maximum Close Command Duration
242	T-CBtest-dead	0.00 .. 30.00 sec	0.10 sec	Dead Time for CB test-autoreclosure
251	K_ALF/K_ALF_N	1.00 .. 10.00	1.00	k_alf/k_alf nominal
253	E% ALF/ALF_N	0.5 .. 50.0 %	5.0 %	CT Error in % at k_alf/k_alf nominal
254	E% K_ALF_N	0.5 .. 50.0 %	15.0 %	CT Error in % at k_alf nominal

2.1.3 Change Group

2.1.3.1 Purpose of the Setting Groups

Up to four independent setting groups can be created for establishing the device's function settings. During operation, the user can locally switch between setting groups using the operator panel, binary inputs (if so configured), the operator and service interface per PC, 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*** during configuration (see Section 2.1.1.2). In 7SD610 devices, four independent setting groups (A to D) are available. Whereas setting values and options may vary, the selected scope of functions is the same for all groups.

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

2.1.3.2 Setting Notes

General

If multiple setting groups are not required. Group A is the default selection. Then, the rest of this section is not applicable.

If multiple setting groups are desired, the setting group change option must be set to **Grp Chge OPTION** = ***Enabled*** in the relay configuration of the functional scope (Section 2.1.1.2, address 103). For the setting of the function parameters, you can configure each of the required setting groups A to D, one after the other. A maximum of 4 is possible. To find out how to proceed, how to copy and to reset settings groups to the delivery state, and how to switch between setting groups during operation, please refer to the SIPROTEC 4 System Description.

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

2.1.3.3 Settings

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

2.1.3.4 Information List

No.	Information	Type of In-formation	Comments
-	Group A	IntSP	Group A
-	Group B	IntSP	Group B
-	Group C	IntSP	Group C
-	Group D	IntSP	Group D
7	>Set Group Bit0	SP	>Setting Group Select Bit 0
8	>Set Group Bit1	SP	>Setting Group Select Bit 1

2.1.4 General Protection Data (Power System Data 2)

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

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

2.1.4.1 Setting Notes

Rated values of protected lines

The information under this margin heading refers to protected lines (cables or overhead lines) if no power transformer is located within the protected zone, i.e. to models without transformer option or if address 143 **TRANSFORMER** = ***NO*** has been set to, Section 2.1.1.2).

With address 1103 **FullScaleVolt.** you inform the device on 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 nominal current is usually not defined; set the rated current of the current transformers (as set in address 205 **CT PRIMARY**, Section 2.1.2.1). If the current transformers have different rated currents at the ends of the protected object, set the highest rated current value for all ends.

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

General Performance Data

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

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

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

Topological Data for Transformers (optional)

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

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

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

In general, select the rated voltage of the transformer winding facing the device. However, 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 minimised.

Calculation example:

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

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

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

Voltage to be set (address 1103)

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

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

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

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

Example:

Transformer **Yy6d5**

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

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

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

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

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

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

for the **d** end is set: **VECTOR GROUP I** = **0** (5 - 5 = 0 = reference side).

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

If the vector group of the transformer is adapted with external means, e.g. because there are matching transformers in the measuring circuit that are still used, set **VECTOR GROUP I** = **0** at all ends. In this case the differential protection operates without proper matching computation. However, the measuring voltages transmitted via the transformer would not be adapted in the device and therefore not be calculated and displayed correctly. 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 calculation of the 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 grounded, 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 a ground fault outside of the protected zone.

Circuit Breaker Status

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

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

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

In address 1134 **Line Closure**, the criteria for the internal recognition of line energization are determined. ***Only with ManCl*** means that only the manual close signal via binary input or the integrated control is evaluated as closure. ***I OR U or ManCl*** means that additionally the measured currents or voltages are used to determine closure of the circuit breaker, whereas ***CB OR I or M/C*** implies that either the currents or the states of the circuit breaker auxiliary contacts are used to determine closure of the circuit breaker. If the voltage transformers are not arranged on the line side, the setting ***CB OR I or M/C*** must be used. In the case of ***I or Man.Close*** only the currents or the manual close signals are used to recognise closing of the circuit breaker.

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

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

While the time **SI Time all Cl.** (address 1132, see above) is activated following each recognition of line energization, **SI Time Man.Cl** (address 1150) is the time following manual closure during which special influence of the protection functions is activated (e.g. the switch-on pickup threshold for the differential protection). This parameter can only be altered in DIGSI at **Additional Settings**.

Note

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

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

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

For commands via the integrated control (on site, DIGSI, serial interface) address 1152 **Man.Clos. Imp.** determines whether a close command via the integrated control regarding the MANUAL CLOSE handling for the protective functions (like instantaneous re-opening when switching onto a fault) is to act like a MANUAL CLOSE command via binary input. This address also informs the device to which switchgear this applies. You can select from the switching devices which are available to the integrated control. Select the circuit breaker which operates for manual closure and, if required, for automatic reclosure (usually Q0). If ***none*** is set here, a CLOSE command via the control will not generate a MANUAL CLOSE impulse for the protective function.

Three-pole Coupling

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

Address 1155 **3pole coupling** determines whether any multi-phase pickup leads to a three-pole tripping command, or whether only multi-pole tripping decisions result in a three-pole tripping command. This setting is only relevant with one- and three-pole tripping and therefore only available in this version. 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 Section 2.16.1 Pickup Logic for the Entire Device.

With the setting ***with PICKUP*** every fault detection in more than one phase leads to three-pole coupling of the trip outputs, even if only a single-phase earth fault is situated within the tripping region, and a further fault, for example by overcurrent, is recognized. Even if a single-phase trip command has already been issued, each further fault detection will lead to three-pole coupling of the trip outputs.

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

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

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

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

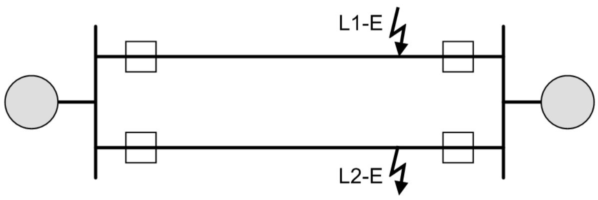


Figure 2-2 Multiple fault on a double-circuit line

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

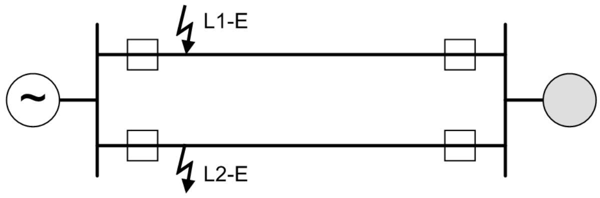


Figure 2-3 Multiple fault on a double-circuit line next to a generator

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

2.1.4.2 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1103	FullScaleVolt.		0.4 .. 1200.0 kV	400.0 kV	Measurement: Full Scale Voltage (100%)
1104	FullScaleCurr.		10 .. 10000 A	1000 A	Measurement: Full Scale Current (100%)
1105	Line Angle		10 .. 89 °	85 °	Line Angle
1106	OPERATION POWER		0.2 .. 5000.0 MVA	692.8 MVA	Operational power of protection zone
1107	P,Q sign		not reversed reversed	not reversed	P,Q operational measured values sign
1111	x'	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	x' - Line Reactance per length unit
		5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
1111	x'	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	x' - Line Reactance per length unit
		5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
1112	c'	1A	0.000 .. 100.000 µF/km	0.010 µF/km	c' - capacit. per unit line len. µF/km
		5A	0.000 .. 500.000 µF/km	0.050 µF/km	
1112	c'	1A	0.000 .. 160.000 µF/mi	0.016 µF/mi	c' - capacit. per unit line len. µF/mile
		5A	0.000 .. 800.000 µF/mi	0.080 µF/mi	
1113	Line Length		0.1 .. 1000.0 km	100.0 km	Line Length
1113	Line Length		0.1 .. 650.0 Miles	62.1 Miles	Line Length

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1130A	PoleOpenCurrent	1A	0.05 .. 1.00 A	0.10 A	Pole Open Current Threshold
		5A	0.25 .. 5.00 A	0.50 A	
1131A	PoleOpenVoltage		2 .. 70 V	30 V	Pole Open Voltage Threshold
1132A	SI Time all Cl.		0.01 .. 30.00 sec	0.10 sec	Seal-in Time after ALL closures
1133A	T DELAY SOTF		0.05 .. 30.00 sec	0.25 sec	minimal time for line open before SOTF
1134	Line Closure		only with ManCl I OR U or ManCl CB OR I or M/C I or Man.Close	I or Man.Close	Recognition of Line Closures with
1135	Reset Trip CMD		CurrentOpenPole Current AND CB Pickup Reset	CurrentOpenPole	RESET of Trip Command
1136	OpenPoleDetect.		OFF Current AND CB w/ measurement	w/ measurement	open pole detector
1150A	SI Time Man.Cl		0.01 .. 30.00 sec	0.30 sec	Seal-in Time after MANUAL closures
1151	SYN.MAN.CL		w/o Sync-check NO	NO	Manual CLOSE COMMAND generation
1152	Man.Clos. Imp.		(Setting options depend on configuration)	None	MANUAL Closure Impulse after CONTROL
1155	3pole coupling		with PICKUP with TRIP	with TRIP	3 pole coupling
1156A	Trip2phFlt		3pole 1pole leading Ø 1pole lagging Ø	3pole	Trip type with 2phase faults
1161	VECTOR GROUP U		0 .. 11	0	Vector group numeral for voltage
1162	VECTOR GROUP I		0 .. 11	0	Vector group numeral for current
1163	TRANS STP IS		Solid Earthed Not Earthed	Solid Earthed	Transformer starpoint is

2.1.4.3 Information List

No.	Information	Type of Information	Comments
301	Pow.Sys.Flt.	OUT	Power System fault
302	Fault Event	OUT	Fault Event
351	>CB Aux. L1	SP	>Circuit breaker aux. contact: Pole L1
352	>CB Aux. L2	SP	>Circuit breaker aux. contact: Pole L2
353	>CB Aux. L3	SP	>Circuit breaker aux. contact: Pole L3
356	>Manual Close	SP	>Manual close signal
357	>Blk Man. Close	SP	>Block manual close cmd. from external

No.	Information	Type of In-formation	Comments
361	>FAIL:Feeder VT	SP	>Failure: Feeder VT (MCB tripped)
366	>CB1 Pole L1	SP	>CB1 Pole L1 (for AR,CB-Test)
367	>CB1 Pole L2	SP	>CB1 Pole L2 (for AR,CB-Test)
368	>CB1 Pole L3	SP	>CB1 Pole L3 (for AR,CB-Test)
371	>CB1 Ready	SP	>CB1 READY (for AR,CB-Test)
378	>CB faulty	SP	>CB faulty
379	>CB 3p Closed	SP	>CB aux. contact 3pole Closed
380	>CB 3p Open	SP	>CB aux. contact 3pole Open
381	>1p Trip Perm	SP	>Single-phase trip permitted from ext.AR
382	>Only 1ph AR	SP	>External AR programmed for 1phase only
383	>Enable ARzones	SP	>Enable all AR Zones / Stages
385	>Lockout SET	SP	>Lockout SET
386	>Lockout RESET	SP	>Lockout RESET
410	>CB1 3p Closed	SP	>CB1 aux. 3p Closed (for AR, CB-Test)
411	>CB1 3p Open	SP	>CB1 aux. 3p Open (for AR, CB-Test)
501	Relay PICKUP	OUT	Relay PICKUP
502	Relay Drop Out	OUT	Relay Drop Out
503	Relay PICKUP L1	OUT	Relay PICKUP Phase L1
504	Relay PICKUP L2	OUT	Relay PICKUP Phase L2
505	Relay PICKUP L3	OUT	Relay PICKUP Phase L3
506	Relay PICKUP E	OUT	Relay PICKUP Earth
507	Relay TRIP L1	OUT	Relay TRIP command Phase L1
508	Relay TRIP L2	OUT	Relay TRIP command Phase L2
509	Relay TRIP L3	OUT	Relay TRIP command Phase L3
510	Relay CLOSE	OUT	Relay GENERAL CLOSE command
511	Relay TRIP	OUT	Relay GENERAL TRIP command
512	Relay TRIP 1pL1	OUT	Relay TRIP command - Only Phase L1
513	Relay TRIP 1pL2	OUT	Relay TRIP command - Only Phase L2
514	Relay TRIP 1pL3	OUT	Relay TRIP command - Only Phase L3
515	Relay TRIP 3ph.	OUT	Relay TRIP command Phases L123
530	LOCKOUT	IntSP	LOCKOUT is active
533	IL1 =	VI	Primary fault current IL1
534	IL2 =	VI	Primary fault current IL2
535	IL3 =	VI	Primary fault current IL3
536	Definitive TRIP	OUT	Relay Definitive TRIP
545	PU Time	VI	Time from Pickup to drop out
546	TRIP Time	VI	Time from Pickup to TRIP
560	Trip Coupled 3p	OUT	Single-phase trip was coupled 3phase
561	Man.Clos.Detect	OUT	Manual close signal detected
562	Man.Close Cmd	OUT	CB CLOSE command for manual closing
563	CB Alarm Supp	OUT	CB alarm suppressed
590	Line closure	OUT	Line closure detected
591	1pole open L1	OUT	Single pole open detected in L1
592	1pole open L2	OUT	Single pole open detected in L2
593	1pole open L3	OUT	Single pole open detected in L3

2.2 Protection Data Interfaces and Protection Data Topology

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

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

2.2.1 Functional Description

2.2.1.1 Protection Data Topology / Protection Data Communication

Protection Data Topology

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

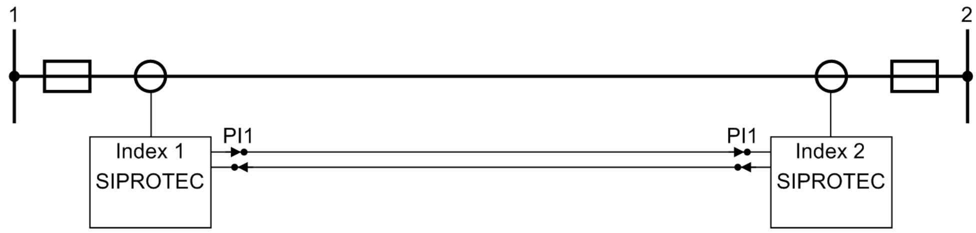


Figure 2-4 Differential protection for two ends with two 7SD610 devices, each of them having one protection data interface (transmitter/receiver)

Communication media

Communication can occur via different communication connections. Which kind of media is used depends on the distance and on the communication media available. For distances up to 100 km a direct connection via optical fibres having a transmission rate of 512 kbit/s is possible. Otherwise we recommend communication converters. A transmission via modems and communication networks can also be realized. Please note, however, that the tripping times of the differential protection devices depend on the transmission quality and that they are prolonged in case of a reduced transmission quality and /or an increased transmission time. Figure 2-5 shows examples of communication connections. In case of a direct connection the distance depends on the type of the optical fibre. Table 2-2 lists the options available. The modules in the device are replaceable. For ordering information see Appendix, under Accessories.

If a communication converter is used, the device and the communication converter are linked with a FO5 module via optical fibres. The converter itself is available in different versions allowing to connect it to communication networks (X.21, G703 64 kbit, G703 E1/T1) or connection via two-wire copper lines. For the Order No., please refer to the Appendix under Accessories.

Table 2-2 Communication via Direct Connection

Module in the Device	Connector Type	Fibre Type	Optical Wavelength	Perm. Path Attenuation	Distance, Typical
FO5	ST	Multimode 62.5/125 µm	820 nm	8 dB	1.5 km (0.94 miles)
FO6	ST	Multimode 62.5/125 µm	820 nm	16 dB	3.5 km (2.18 miles)
FO17	LC	Monomode 9/125 µm	1300 nm	13 dB	24 km (14.9 miles)
FO18	LC	Monomode 9/125 µm	1300 nm	29 dB	60 km (37.3 miles)
FO19	LC	Monomode 9/125 µm	1550 nm	29 dB	100 km (62 miles)

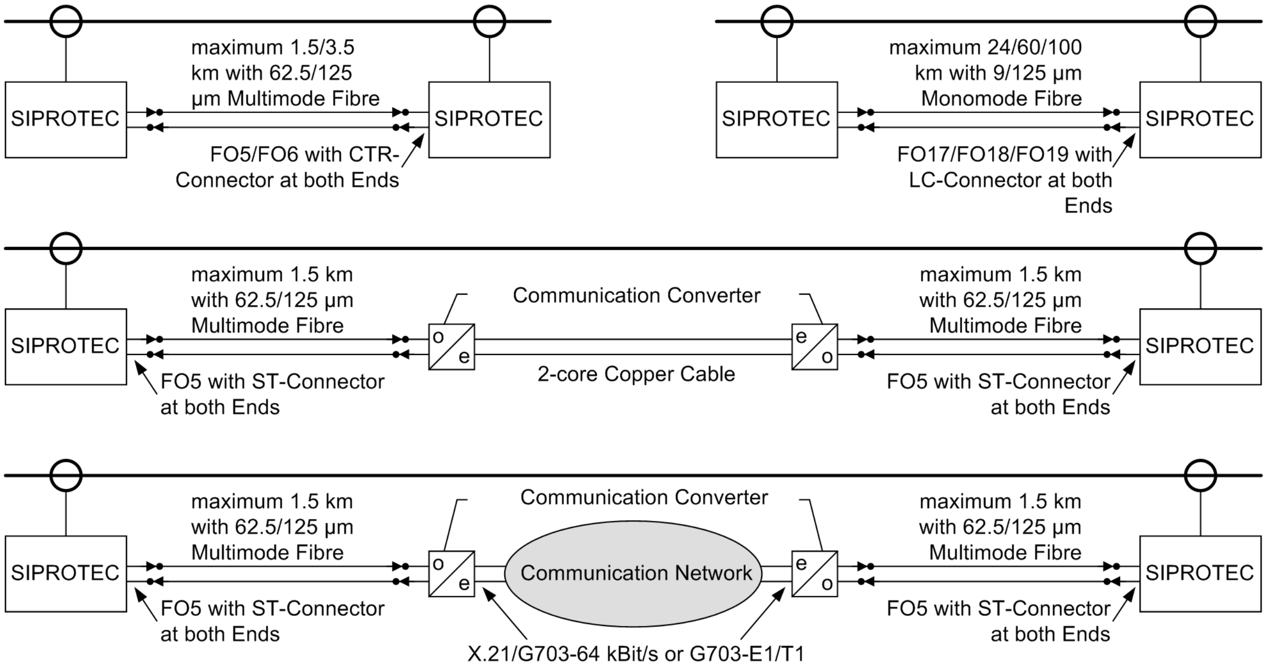


Figure 2-5 Examples for communication connections

Establishing the protection data communication

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

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

Monitoring the communication

The communication is permanently monitored by the devices.

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

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

If several faulty telegrams or no data telegrams at all are received, this is regarded as an Error 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“, No 3229). The differential protection is then out of operation. Both devices are affected by the disturbance, since the formation of differential currents and restraint currents is no longer possible at any of the ends. If the backup overcurrent protection is configured, it will be the only short-circuit protection still active. As soon as the data communication works fault-free again, the devices will automatically switch back to differential protection operation.

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

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

The maximum permissible unbalance of the operating times can be set. This has a direct influence on the sensitivity of the differential protection. The automatic self-restraint of the protection adapts the restraint quantities to this tolerance so that a spurious pickup of the differential protection by these influences is excluded. Thus, higher tolerance values reduce the sensitivity of the protection, which may be noticeable in case of very 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.“ (No 3250) will be issued.

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

2.2.2 Operating Modes of the Differential Protection

2.2.2.1 Mode: Log Out Device

General

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

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

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

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

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

Principle of function

Below, the logic is shown in a simplified way:

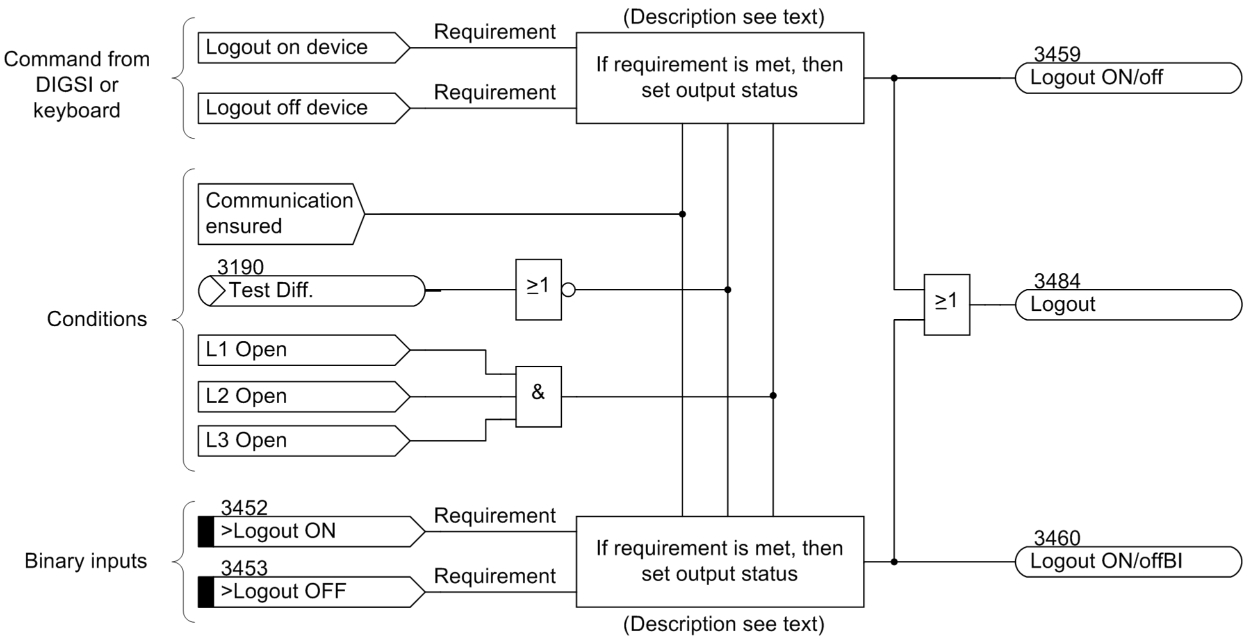


Figure 2-6 Logic diagram for switching the "Log out device" mode

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

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

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

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

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

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

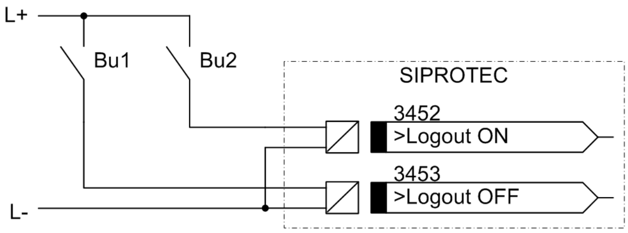


Figure 2-7 Preferred external button wiring for controlling in the "Log out device" mode

Bu1 Button „Log on device“

Bu2 Button „Log out device“

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

2.2.2.2 Differential Protection Test Mode

General

If differential protection test mode (test mode in the following) is activated, the differential protection is blocked in the entire system. Depending on the configuration, the overcurrent protection becomes effective as an emergency function.

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

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

The test mode can be activated/deactivated as follows:

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

The test mode status the another device of the line protection system is indicated on the local device by the indication „`TestDiff.remote`“ (No. 3192).

Principle of function

Below, the logic is shown in a simplified way:

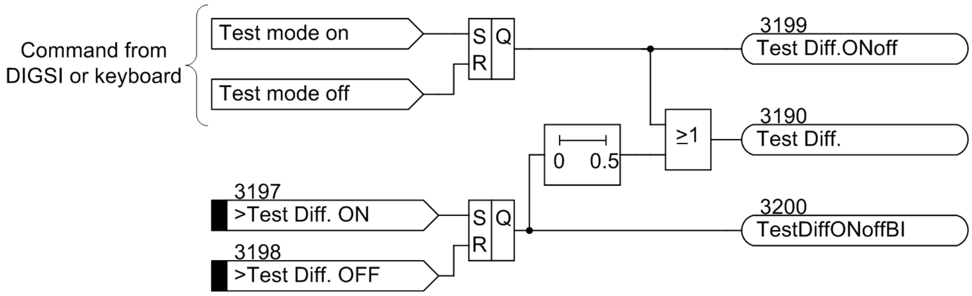


Figure 2-8 Logic diagram of the test mode

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

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

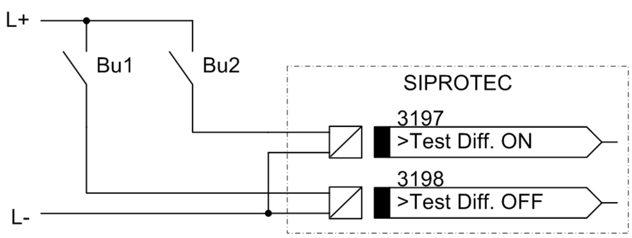


Figure 2-9 External button wiring for controlling the differential protection test mode

Bu1 Button „Deactivating differential protection test mode“

Bu2 Button „Activating differential protection test mode“

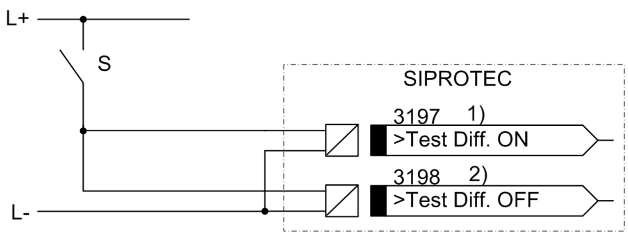


Figure 2-10 External switch wiring for controlling the differential protection test mode

S Switch „Activating/deactivating differential protection test mode“

1) Binary input as NO contact

2) Binary input as NC contact

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

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

2.2.2.3 Differential Protection Commissioning Mode

General

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

The commissioning mode is activated on a device of the protective device constellation and also affects the other device (indication No. 3193 „`Comm.Diff act.`“). The commissioning mode has to be deactivated on the device on which it was activated.

The commissioning mode can be activated/deactivated as follows:

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

Principle of function

Below, the logic is shown in a simplified way:

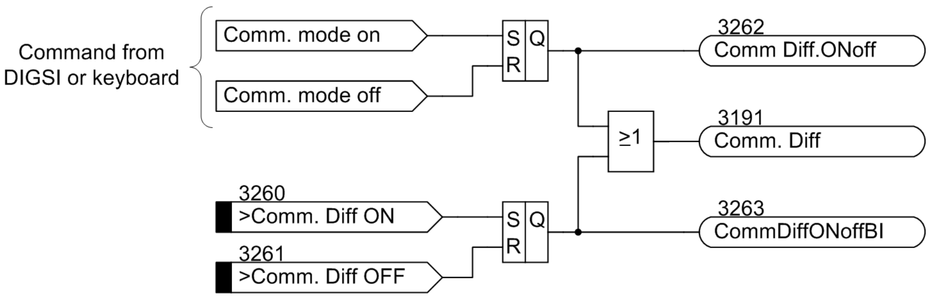


Figure 2-11 Logic diagram of the commissioning mode

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

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

The following figures show possible variants for controlling the binary inputs. If a switch is used for the control (Figure 2-13), it has to be observed that binary input „`>Comm. Diff ON`“ (No. 3260) has to be parameterised as NO contact and that binary input „`>Comm. Diff OFF`“ (No. 3261) has to be parameterised as NC contact.

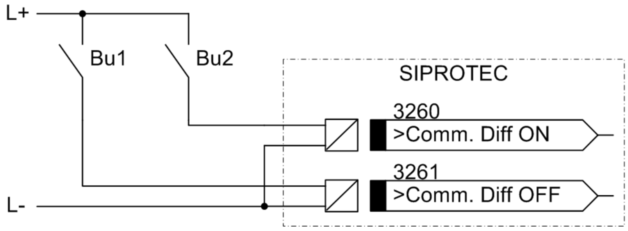


Figure 2-12 External button wiring for controlling the differential protection commissioning mode

Bu1 Button „Deactivating differential protection commissioning mode“

Bu2 Button „Activating differential protection commissioning mode“

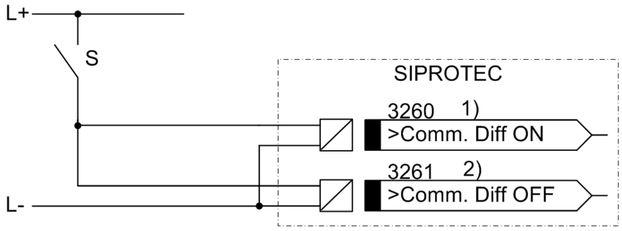


Figure 2-13 External switch wiring for controlling the differential protection commissioning mode

S Switch „Activating/deactivating differential protection commissioning mode“

1) Binary input as NO contact

2) Binary input as NC contact

2.2.3 Protection Data Interfaces

2.2.3.1 Setting Notes

General Information about Interfaces

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

Protection data interface 1

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

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

F.optic direct, i.e. 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 with 128 kbit/s (X.21, copper cable);

Com conv 512 kB, i.e. via communication converters 512 kbit/s (X.21) or communication converters for 2 Mbit/s (G703–E1/T1).

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 tripping 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 4505 and 4506 and can normally be left at their default values.

The maximum permissible transmission time at address 4505 **PROT 1 T-DELAY** is preset to a value that does not exceed the usual delay of communication networks. This parameter can only be altered in DIGSI at **Additional Settings**. If it is exceeded during operation (e.g. because of switchover to a different transmission path), the indication „PI1 TD alarm“ (No. 3239) 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 at address 4506 **PROT 1 UNSYM.**. This parameter can only be altered in DIGSI at **Additional Settings**. With a direct fibre-optic connection, this value should be set to **0**. For transmission via communication networks a higher value is needed. The standard value is 100 μs (default setting). The permissible transmission time difference has a direct influence on the sensitivity of the differential protection.

If GPS synchronisation (ordering option) is used, this value is relevant only in case the GPS signal is missing. As soon as the GPS synchronisation is restored, the transmission time differences are compensated again. As long as GPS synchronisation is intact, transmission time differences do **not** affect the sensitivity of the differential protection.

Address 4511 **PI1 SYNCMODE** is only relevant if GPS synchronisation is used. It determines the conditions for 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 put into service with the conventional method, the differential protection operates with increased self-restraint determined by the maximum transmission time difference without GPS (address 4506 **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 or if the running time is signalled via an external operation (binary input). If synchronization is established by the operator, the differential protection operates with the configured value at address 4506 **PROT 1 UNSYM.** until the 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).

At address 4513 you set a limit value **PROT1 max ERROR** for the permissible rate of faulty protection data telegrams. This parameter can only be altered in DIGSI at **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 4515 **PI1 BLOCK UNSYM** you can decide whether the differential protection shall be blocked in this case. Normal setting is ***YES*** (pre-setting). This parameter can only be altered with DIGSI under **Additional Settings**.

GPS synchronisation (optional)

If GPS synchronization (order option) is used, this synchronization mode can be switched ***ON*** or ***OFF*** in address 4801 **GPS-SYNC.**.

Address 4803 **TD GPS FAILD** is used to set the delay time after which an alarm is output „GPS loss“ (No 3247) after a GPS failure is detected.

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

2.2.3.2 Settings

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

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

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

2.2.3.3 Information List

No.	Information	Type of Information	Comments
3215	Wrong Firmware	OUT	Incompatible Firmware Versions
3217	PI1 Data reflec	OUT	Prot Int 1: Own Datas received
3227	>PI1 light off	SP	>Prot Int 1: Transmitter is switched off
3229	PI1 Data fault	OUT	Prot Int 1: Reception of faulty data
3230	PI1 Datafailure	OUT	Prot Int 1: Total receiption failure
3233	DT inconsistent	OUT	Device table has inconsistent numbers
3234	DT unequal	OUT	Device tables are unequal
3235	Par. different	OUT	Differences between common parameters
3239	PI1 TD alarm	OUT	Prot Int 1: Transmission delay too high
3243	PI1 with	VI	Prot Int 1: Connected with relay ID
3245	>GPS failure	SP	> GPS failure from external
3247	GPS loss	OUT	GPS: local pulse loss
3248	PI 1 GPS sync.	OUT	GPS: Prot Int 1 is GPS sychronized
3250	PI 1 PD unsym.	OUT	GPS:PI1 unsym.propagation delay too high
3252	>SYNC PI1 RESET	SP	> PI1 Synchronization RESET
3254	PI1 jump	OUT	Prot.1: Delay time change recognized
3256	PI1 unsym.	IntSP	Prot.1: Delay time unsymmetry to large
3258	PI1 Error	OUT	ProtInt1:Permissible error rate exceeded

2.2.4 Differential Protection Topology

2.2.4.1 Setting Notes

Protection data topology

First of all, define your protection data communication topology: Number the devices consecutively. This numbering is a serial device index that serves for your own overview. It starts for each distance differential protection system (i.e. for each protected object) with 1. For the differential protection system the device with index 1 is always the absolute-chronology master, i.e. the absolute time management of all devices which belong together depends on the absolute time management of this device, if synchronization is set to **Timing-Master**. As a result, the time information of all devices is comparable at all times. The device index is thus used for unique definition of the devices of a differential protection system (i.e. for one protected object).

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

If you work with different physical interfaces and communications links, please make sure that every protection data interface corresponds to the projected communication link.

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

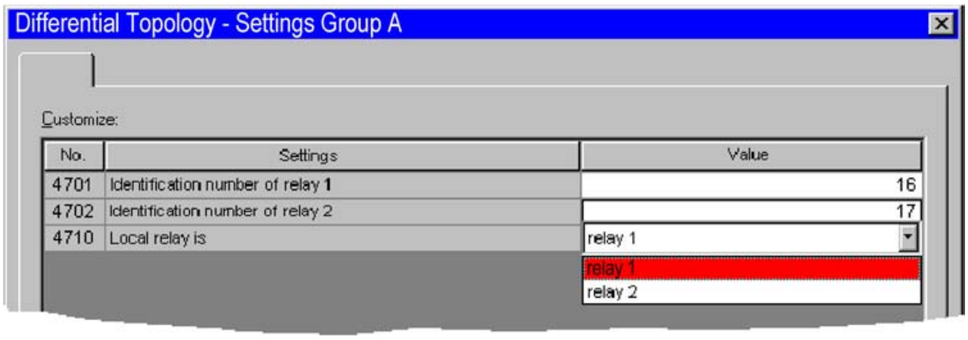


Figure 2-14 Differential protection topology for 2 ends with 2 devices — example

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

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

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

During startup of the protection system, the above listed conditions are checked. If one out of these conditions is still not fulfilled, no differential protection operation is possible.

The device then issues one of the following error messages

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

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

- Address 230 **Rated Frequency**
- Address 143 **TRANSFORMER** in the protected zone
- Address 1106 **OPERATION POWER** primary
- Address 112 **DIFF.PROTECTION** exists

2.2.4.2 Settings

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

2.2.4.3 Information List

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

2.3 Differential Protection

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

Apart from normal lines, 7SD610 also enables protecting lines with transformers switched en block (variant ordered). The protected zone is limited selectively by the current transformer sets.

2.3.1 Function Description

Basic principle with two ends

Differential protection is based on current comparison. It makes use of the fact that e.g. a line section L (Figure 2-15) 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 **I**; a measuring element **M** which is connected to the electrical balance point remains at zero current in healthy operation.

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

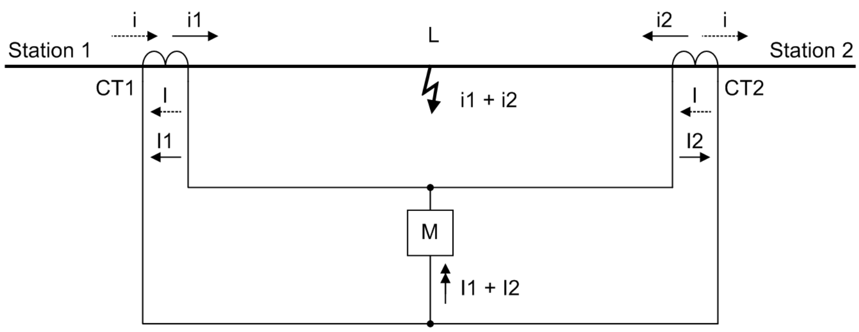


Figure 2-15 Basic principle of the differential protection for a line with two ends

Transmission Measured Value

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

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

Figure 2-16 shows this for a line with two ends. Each device measures the local current and sends the information on its intensity and phase relation to the opposite end. The interface for this communication between protection devices is called protection data interface. As a result, the currents can be added up and processed in each device.

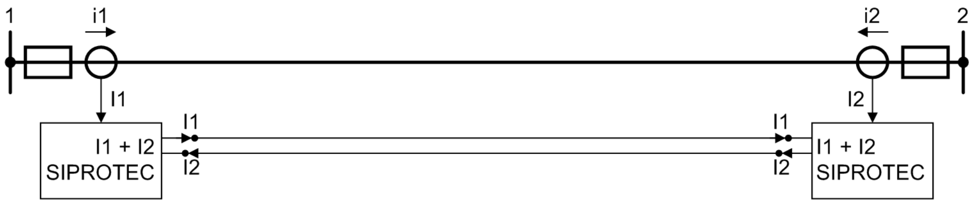


Figure 2-16 Differential protection for a line with two ends

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

Measured Value Synchronization

The devices measure the local currents in an asynchronous way. 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 or more 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 from the transmission and processing times related to the "timing master". With this "rough synchronization" the equality of the time bases with a precision of ± 0.5 ms is provided.

To reach 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 devices can carry out an optimized synchronization of the current comparisons based on the received time stamp and their own time management, i.e. they 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 data 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 with the calculation, 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 all devices work with the currently valid frequency.

Restraint

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

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

Charging Currents

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

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

Current transformer errors

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

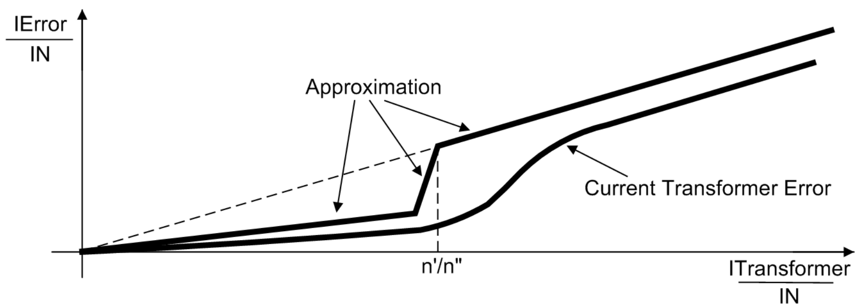


Figure 2-17 Approximation of the current transformer errors

Further influences

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

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

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

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

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

Inrush restraint

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

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

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

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

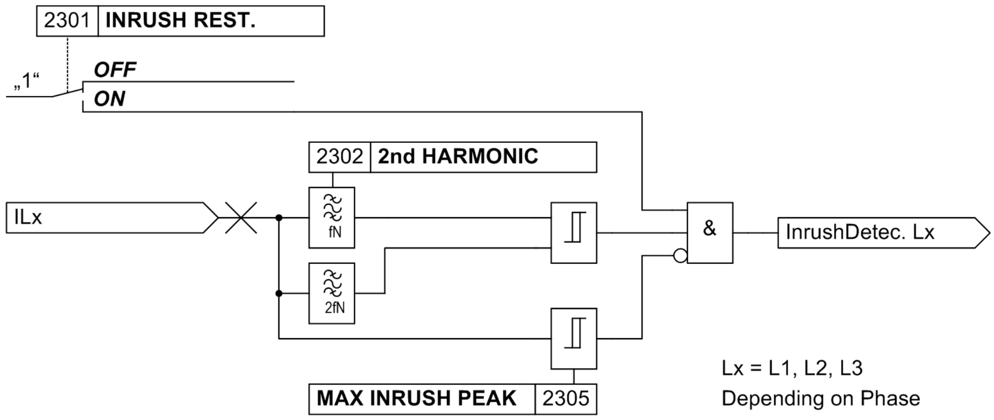


Figure 2-18 Logic diagram of the inrush restraint for one phase

Since the inrush restraint operates individually for each phase, the protection is fully operative when the transformer is switched onto a single-phase fault, whereby an inrush current may possibly flow through one of the undisturbed phases. It is, however, also possible to set the protection in such a way that when the permissible harmonic content in the current of only one single phase is exceeded, not only the phase with the inrush current but also the remaining phases of the differential stage are blocked. This cross-block function can be limited to a selectable duration. Figure 2-19 shows the logic diagram.

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

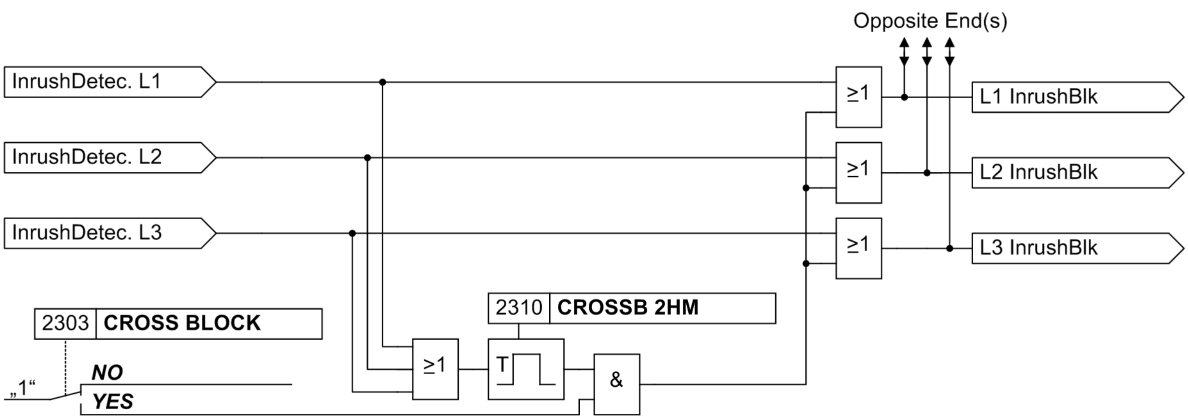


Figure 2-19 Logic diagram of the cross-block function for one end

Evaluation of the measured quantities

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

Each device calculates a differential current from the total of the current phasors that were formed at each end of the protected zone and transmitted to the other ends. The differential current value is equal to the value of the fault current that is 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 current measured quantities and power system parameters that were set. Therefore the highest possible error value of the current transformers within the nominal range and/or the short-circuit current range is multiplied with the current flowing through each end of the protected object. The total value, including the measured internal errors, is then transmitted to the other ends. 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 2-20) derives from the restraining characteristic $I_{diff} = I_{rest}$ (45°-curve), that is cut below the setting value **I-DIFF>**. It complies with the formula

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

If the calculated differential current exceeds the pickup limit and the greatest possible measurement error, the fault must be internal (shaded area in Figure 2-20).

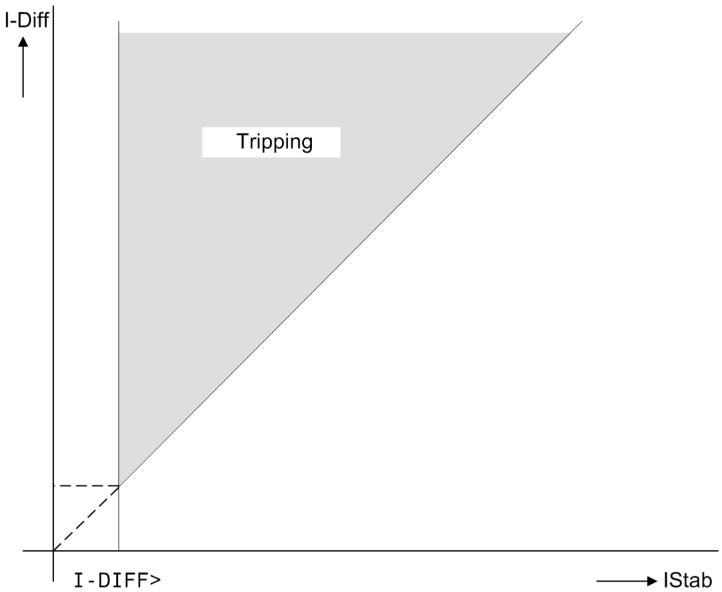


Figure 2-20 Differential protection pickup characteristic, I_{diff}> stage

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

High-speed charge comparison

The charge comparison protection function is a differential protection 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 of t_1 to t_2, which is selected in the 7SD610 device to period $^1/_4$.

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

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

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, a decision is taken before the saturation begins.

The charge difference of external faults is theoretically equal to zero at the beginning. The charge comparison protection function immediately detects the external fault and blocks its own function. If saturation begins in one or more current transformers which limit the protected zone, the before-mentioned function remains blocked. Thus possible differences resulting from the saturation are excluded. Generally it is assumed that an initial saturation of current transformers only takes place after the expiration of at least one integration interval ($^1/_4$ cycle) that commenced with the occurrence of a fault.

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

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

Blocking/interblocking

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

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

Pickup of the differential protection

Figure 2-21 illustrates the logic diagram of the breaker failure protection. The phase-selective indications of the stages are summarised to form general phase indications. Additionally the device provides information of which stage picked up.

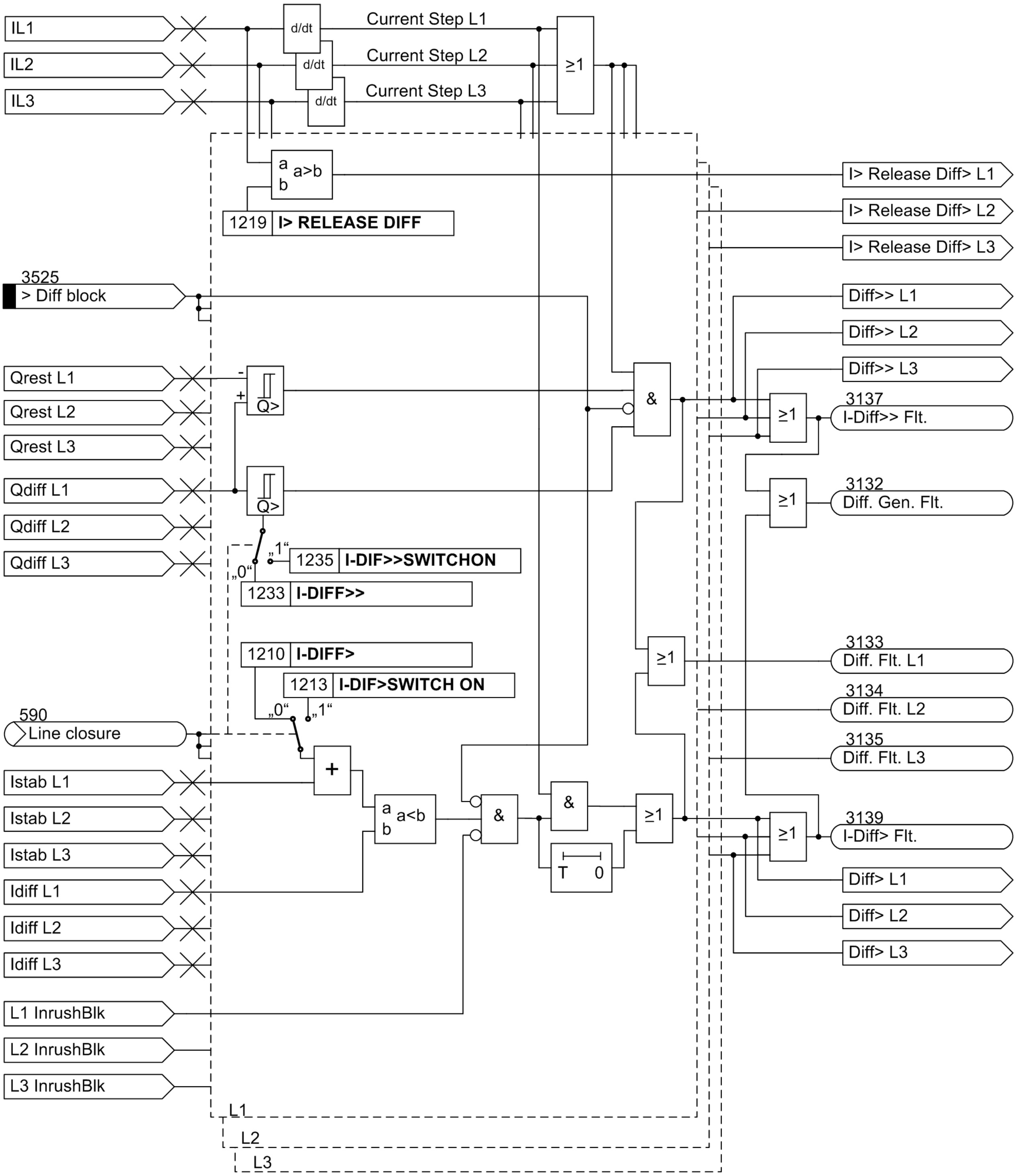


Figure 2-21 Pickup logic for the differential protection function

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

Tripping logic of the differential protection

The tripping logic of the differential protection combines all decisions of the differential stages and forms output signals which are also influenced by the central tripping logic of the entire device (Figure 2-22).

The pickup signals that identify the concerned stages of the differential protection stages can be delayed via the time stage **T-DELAY I-DIFF>**. Independently of this condition, a single-phase pickup can be blocked for a short time in order to bridge the transient oscillations on occurrence of a single earth fault in a resonant-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. The single-pole information implies that tripping will take place single-pole only. The actual generation of the commands for the tripping (output) relay is executed within the tripping logic of the entire device (see Section 2.16.1).

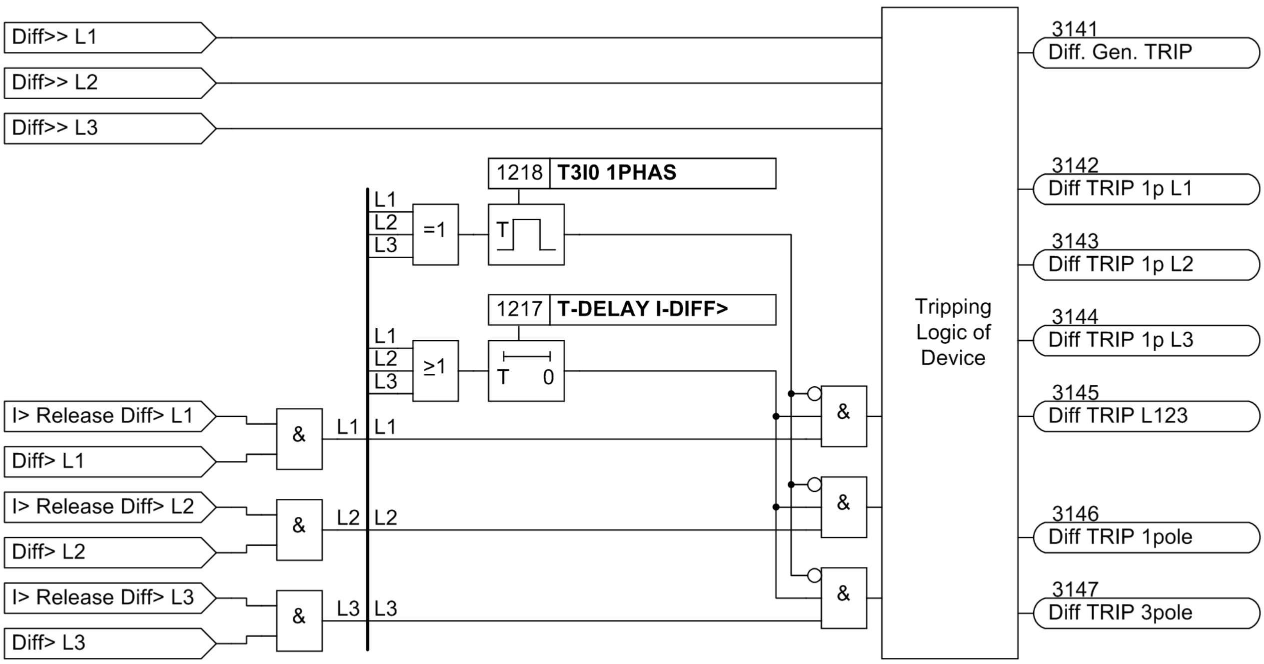


Figure 2-22 Tripping logic of the differential protection

2.3.2 Setting Notes

General

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

Pickup Value of the 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_{Nom}	Nominal voltage of the network in kV primary
f_N	Nominal 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 (as described in 2.1.4.1 under margin heading „topological data for transformers is described in the protection zone (optional)“, or from the addresses 1104 **FullScaleCurr.** according to Section 2.1.4.1 under margin heading „Rated Values of Protected Lines“. It must be equal at all ends of the protected object.

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

<u>Calculation Example:</u>

110 kV single-conductor oil-filled cable

Cross section = 240 mm^2

Rated frequency f_N = 50 Hz

Length s = 16 km

Service capacitance C_B' = 310 nF/km

Current transformer, transformer ratio 600 A/5 A

From that the steady-state charging current is calculated:

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

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

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

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

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

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. Please also refer to the notes in chapter

2.1.2.1 Setting information, Margin heading „Power Transformer with Voltage Regulation“.

Pickup value during switch-on

When switching on long, unloaded cables, overhead lines and arc-compensated lines, pronounced higher-frequency transient reactions may take place. These peaks are considerably damped by means of a digital filter in the differential protection. A pickup value **I-DIF>SWITCH ON** (address 1213) can be set to reliably prevent single-sided pickup of the protection. This pickup value is 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 in the general protection data at address 1132 (Section 2.1.4.1) all 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 margin heading „Inrush Restraint“).

Final checks will be carried out during commissioning. Further information can be found in chapter Installation and Commissioning.

Delays

In special cases of application it may be useful to delay the tripping of the differential protection with an additional timer, e.g. in case of reverse interlocking. The delay time **T-DELAY I-DIFF>** (address 1217) is only started upon detection of an internal fault. This parameter can only be altered with DIGSI 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 1218 **T3I0 1PHAS** the pickup to a single fault is therefore delayed for 0.04 s (presetting). For large resonant-earthed systems the time delay should be increased. By setting the address to ∞ the single-phase tripping is totally suppressed.

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

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

Pickup value 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 nominal values that must be equal (primary) at all ends of the protected object.

Since this stage reacts very fast, a pickup of capacitive charging currents (for lines) and inductive magnetising currents (for transformers or shunt 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 $I_{N\ Trafo}/u_{k\ Trafo}$.

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

Pickup value when switching on the charge comparison

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

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

Inrush restraint

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

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

However, if the local measured current exceeds a value set in address 2305 **MAX INRUSH PEAK**, there will be no inrush restraint. The peak value is decisive. The set value should be higher than the maximum inrush current peak value that can be expected. For transformers set the value above $\sqrt{2} \cdot I_{NTransf.}/u_{kTransf.}$. If a line ends on a transformer, a smaller value may be selected, considering the damping of the current by the line impedance.

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

2.3.3 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1201	STATE OF DIFF.		OFF ON	ON	State of differential protection
1210	I-DIFF>	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Pickup value
		5A	0.50 .. 100.00 A	1.50 A	
1213	I-DIF>SWITCH ON	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Value under switch on condition
		5A	0.50 .. 100.00 A	1.50 A	
1217A	T-DELAY I-DIFF>		0.00 .. 60.00 sec; ∞	0.00 sec	I-DIFF>: Trip time delay

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

2.3.4 Information List

No.	Information	Type of Information	Comments
3102	2nd Harmonic L1	OUT	Diff: 2nd Harmonic detected in phase L1
3103	2nd Harmonic L2	OUT	Diff: 2nd Harmonic detected in phase L2
3104	2nd Harmonic L3	OUT	Diff: 2nd Harmonic detected in phase L3
3120	Diff active	OUT	Diff: Active
3132	Diff. Gen. Flt.	OUT	Diff: Fault detection
3133	Diff. Flt. L1	OUT	Diff: Fault detection in phase L1
3134	Diff. Flt. L2	OUT	Diff: Fault detection in phase L2
3135	Diff. Flt. L3	OUT	Diff: Fault detection in phase L3
3136	Diff. Flt. E	OUT	Diff: Earth fault detection
3137	I-Diff>> Flt.	OUT	Diff: Fault detection of I-Diff>>
3139	I-Diff> Flt.	OUT	Diff: Fault detection of I-Diff>
3141	Diff. Gen. TRIP	OUT	Diff: General TRIP
3142	Diff TRIP 1p L1	OUT	Diff: TRIP - Only L1
3143	Diff TRIP 1p L2	OUT	Diff: TRIP - Only L2
3144	Diff TRIP 1p L3	OUT	Diff: TRIP - Only L3
3145	Diff TRIP L123	OUT	Diff: TRIP L123
3146	Diff TRIP 1pole	OUT	Diff: TRIP 1pole
3147	Diff TRIP 3pole	OUT	Diff: TRIP 3pole
3148	Diff block	OUT	Diff: Differential protection is blocked
3149	Diff OFF	OUT	Diff: Diff. protection is switched off
3176	Diff Flt. 1p.L1	OUT	Diff: Fault detection L1 (only)

No.	Information	Type of In-formation	Comments
3177	Diff Flt. L1E	OUT	Diff: Fault detection L1E
3178	Diff Flt. 1p.L2	OUT	Diff: Fault detection L2 (only)
3179	Diff Flt. L2E	OUT	Diff: Fault detection L2E
3180	Diff Flt. L12	OUT	Diff: Fault detection L12
3181	Diff Flt. L12E	OUT	Diff: Fault detection L12E
3182	Diff Flt. 1p.L3	OUT	Diff: Fault detection L3 (only)
3183	Diff Flt. L3E	OUT	Diff: Fault detection L3E
3184	Diff Flt. L31	OUT	Diff: Fault detection L31
3185	Diff Flt. L31E	OUT	Diff: Fault detection L31E
3186	Diff Flt. L23	OUT	Diff: Fault detection L23
3187	Diff Flt. L23E	OUT	Diff: Fault detection L23E
3188	Diff Flt. L123	OUT	Diff: Fault detection L123
3189	Diff Flt. L123E	OUT	Diff: Fault detection L123E
3190	Test Diff.	IntSP	Diff: Set Teststate of Diff. protection
3191	Comm. Diff	IntSP	Diff: Set Commissioning state of Diff.
3192	TestDiff.remote	OUT	Diff: Remote relay in Teststate
3193	Comm.Diff act.	OUT	Diff: Commissioning state is active
3197	>Test Diff. ON	SP	Diff: >Set Teststate of Diff. protection
3198	>Test Diff. OFF	SP	Diff: >Reset Teststate of Diff. protec.
3199	Test Diff.ONoff	IntSP	Diff: Teststate of Diff. prot. ON/OFF
3200	TestDiffONoffBI	IntSP	Diff: Teststate ON/OFF via BI
3260	>Comm. Diff ON	SP	Diff: >Commissioning state ON
3261	>Comm. Diff OFF	SP	Diff: >Commissioning state OFF
3262	Comm Diff.ONoff	IntSP	Diff: Commissioning state ON/OFF
3263	CommDiffONoffBI	IntSP	Diff: Commissioning state ON/OFF via BI
3525	> Diff block	SP	>Differential protection blocking signal
3526	Diffblk.rec PI1	OUT	Differential blocking received at PI1
3528	Diffblk.sen PI1	OUT	Differential blocking sending via PI1

2.4 Breaker Intertrip and Remote Tripping

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

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

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

2.4.1 Function Description

Transmission Circuit

The transmission signal can originate from two different sources (Figure 2-23). 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 interface and communication link.

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**.

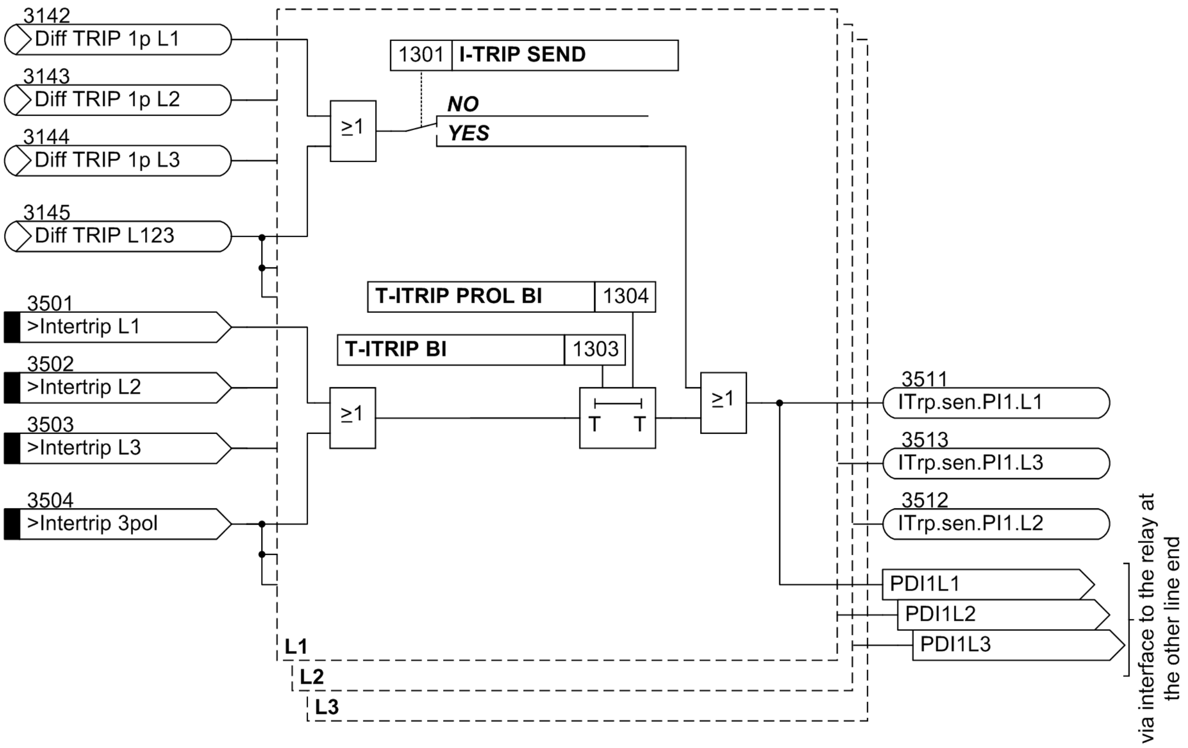


Figure 2-23 Logic diagram of the intertrip — transmission circuit

Receiving circuit

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

Figure 2-24 shows the logic diagram. If the received signal is to cause the trip, it will be forwarded to the tripping logic. The tripping logic of the entire device (see also Section 2.16.1) ensures, if necessary, that the conditions for single-pole tripping are fulfilled (e.g. single-pole tripping permissible, auto-reclosure function ready).

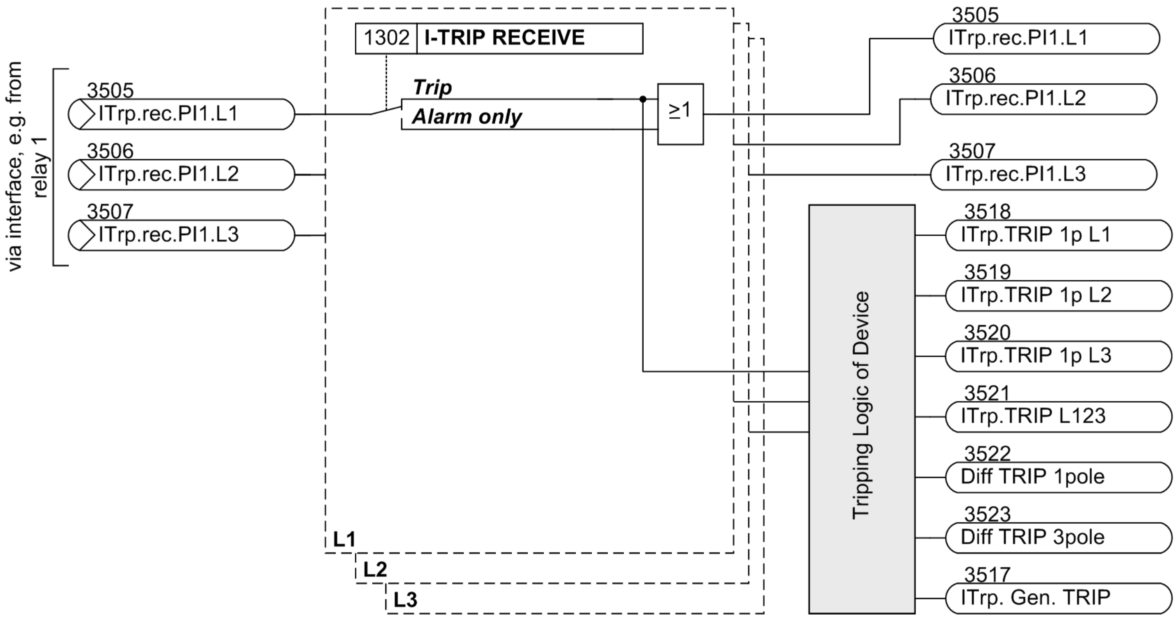


Figure 2-24 Logic diagram of the intertrip — receiving circuit

Ancillary Functions

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

It should be noted that for the transmission of remote alarms and remote commands another 4 fast transmission channels are optionally available (see also Section 2.7).

2.4.2 Setting Notes

General

The intertrip function for tripping caused by the differential protection can be activated (***YES***) or deactivated (***NO***) with address 1301 **I-TRIP SEND**. Since the differential protection devices theoretically operate with the same measured values at 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 both ends do not issue a tripping command due to inevitable device tolerances. For these cases **I-TRIP SEND** = ***YES*** ensures the tripping at all ends of the protected object.

Intertrip/Remote tripping

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

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

2.4.3 Settings

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

2.4.4 Information List

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

No.	Information	Type of Information	Comments
3519	ITrp.TRIP 1p L2	OUT	I.Trip: TRIP - Only L2
3520	ITrp.TRIP 1p L3	OUT	I.Trip: TRIP - Only L3
3521	ITrp.TRIP L123	OUT	I.Trip: TRIP L123
3522	Diff TRIP 1pole	OUT	I.Trip: TRIP 1pole
3523	Diff TRIP 3pole	OUT	I.Trip: TRIP 3pole

2.5 Restricted Earth Fault Protection (optional)

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

2.5.1 Application Examples

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

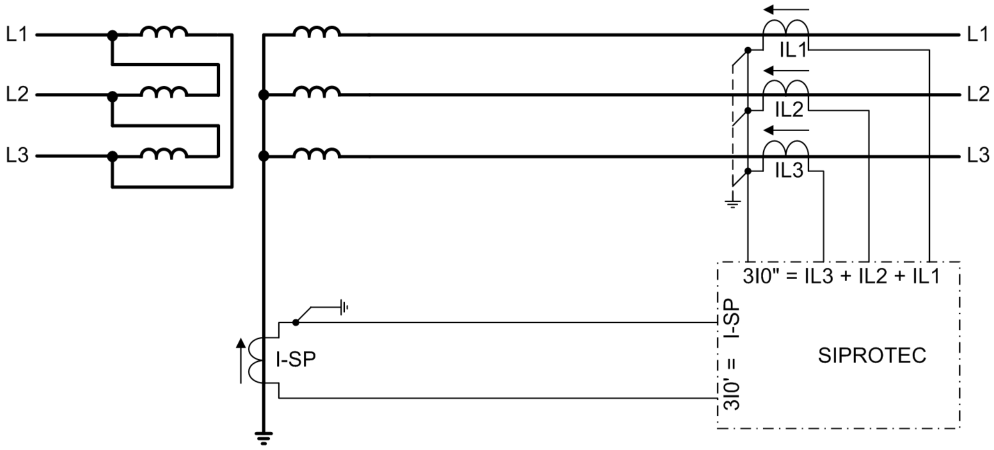


Figure 2-25 Restricted earth fault protection on an earthed transformer winding

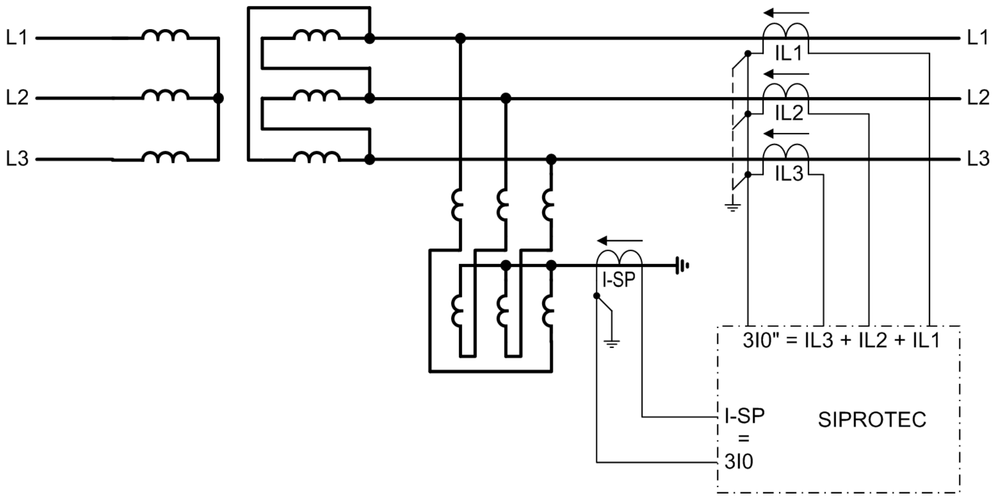


Figure 2-26 Restricted earth fault protection on a non-earthed transformer winding with neutral reactor (starpoint former) within the protected zone

2.5.2 Functional Description

Measuring principle

During healthy operation, no starpoint current ISP flows through the starpoint lead. The sum of the phase currents $3\underline{I}_0 = \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$ is also approximately zero.

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

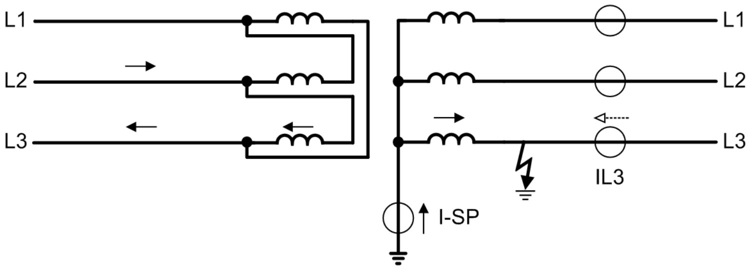


Figure 2-27 Example for an earth fault in a transformer with current distribution

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

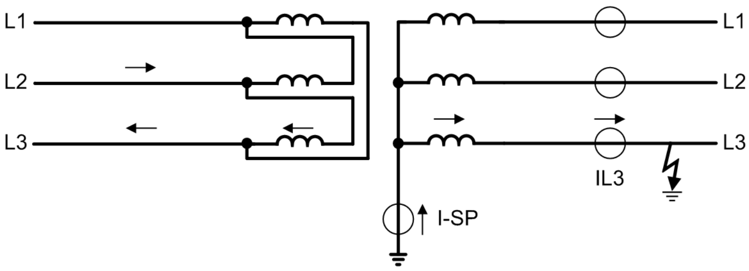


Figure 2-28 Example for an earth fault outside a transformer with current distribution

When a fault without earth connection occurs outside the protected zone, a residual current may occur in the residual current path of the phase current transformers which is caused by different saturation of the phase current transformers under strong through-current conditions. This current could simulate a fault in the protected zone. Measures must be taken to prevent this current from causing a trip. For this, the restricted earth fault protection provides stabilization methods which differ strongly from the usual stabilization methods of differential protection schemes since it uses, besides the magnitude of the measured currents, the phase relationship, too.

Evaluation of Measurement Quantities

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

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

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

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

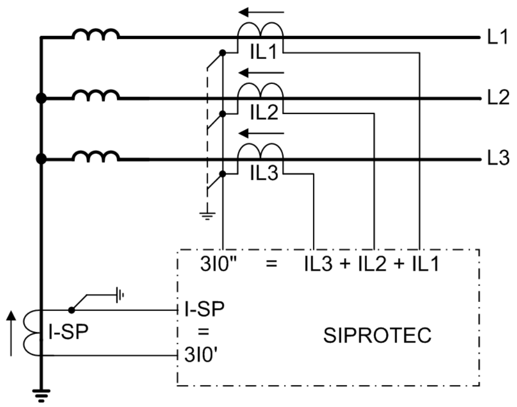


Figure 2-29 Principle of restricted earth fault protection

When an earth fault occurs outside the protected zone, another earth current flows though the phase current transformers. This is, on the primary side, in counter-phase with the starpoint current and has equal magnitude. The maximum information of the currents is evaluated for restraint: the magnitude of the currents and their phase position. The following is defined:

A tripping current

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

and a stabilisation or restraining current

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

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

To clarify the situation, three important operating conditions with ideal and matched measurement quantities are considered:

1. Through-fault current on an external earth fault:

   $3\underline{I}_0$" is in phase opposition with $3\underline{I}_0$', and of equal magnitude, i.e. $3\underline{I}_0" = -3\underline{I}_0'$

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

   $I_{Rest} = |3\underline{I}_0' + 3\underline{I}_0'| - |3\underline{I}_0' - 3\underline{I}_0'| = 2 \cdot |3\underline{I}_0'|$

   The tripping effect current (I_{Ref}) equals the starpoint current; restraint (I_{Rest}) corresponds to twice the tripping effect current.

2. Internal earth fault, fed only from the starpoint

   In this case $3\underline{I}_0" = 0$

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

   $I_{Rest} = |3\underline{I}_0' - 0| - |3\underline{I}_0' + 0| = 0$

   The tripping effect current (I_{Ref}) equals the starpoint current; restraint (I_{stab}) is zero, i.e. full sensitivity during internal earth fault.

3. Internal earth fault, fed from the starpoint and from the system, e.g. with equal earth current magnitude:

   In this case $3\underline{I}_0" = 3\underline{I}_0'$

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

   $I_{stab} = |3\underline{I}_0' - 3\underline{I}_0'| - |3\underline{I}_0' + 3\underline{I}_0'| = -2 \cdot |3\underline{I}_0'|$

   The tripping effect current (I_{Ref}) equals the starpoint current; the restraining quantity (I_{stab}) is negative and, therefore, set to zero, i.e. full sensitivity during internal earth fault.

This result shows that for an internal fault no restraint is effective since the restraining quantity is either zero or negative. Thus, small earth current can cause tripping. In contrast, strong restraint becomes effective for external earth faults. Figure 2-30 shows that the restraint is the strongest when the residual current from the phase current transformers is high (area with negative $3I_0"/3I_0'$). With ideal current transformers, the currents $3I_0$" and $3I_0$' would be inversely equal, i.e. $3I_0"/3I_0' = -1$.

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

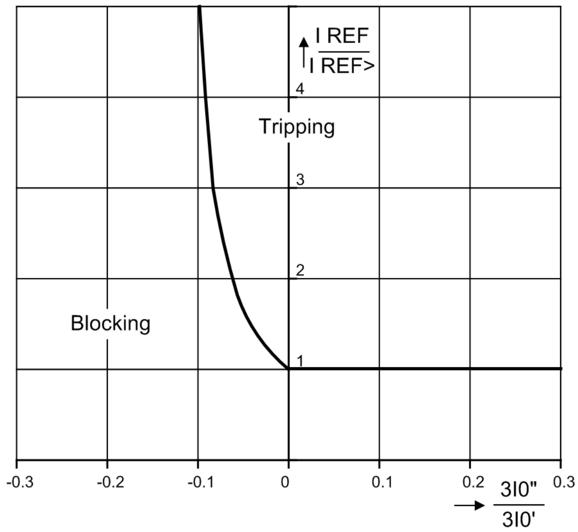


Figure 2-30 Tripping characteristic of the restricted earth fault protection depending on the earth current ratio $3I_0$"/$3I_0$' (both currents in phase + or counter-phase –); I_{REF}> = setting; I_{Trip} = tripping current

It was assumed in the above examples that the currents $3\underline{I}_0$" and $3\underline{I}_0$' are in counter-phase for external earth faults which is only true for the primary measured quantities. Current transformer saturation may cause phase shifting between the fundamental waves of the secondary currents which reduces the restraint quantity. If the phase displacement $\varphi(3\underline{I}_0"; 3\underline{I}_0') = 90°$ then the restraint quantity is zero. This corresponds to the conventional method of direction determination by use of the vectorial sum and difference comparison.

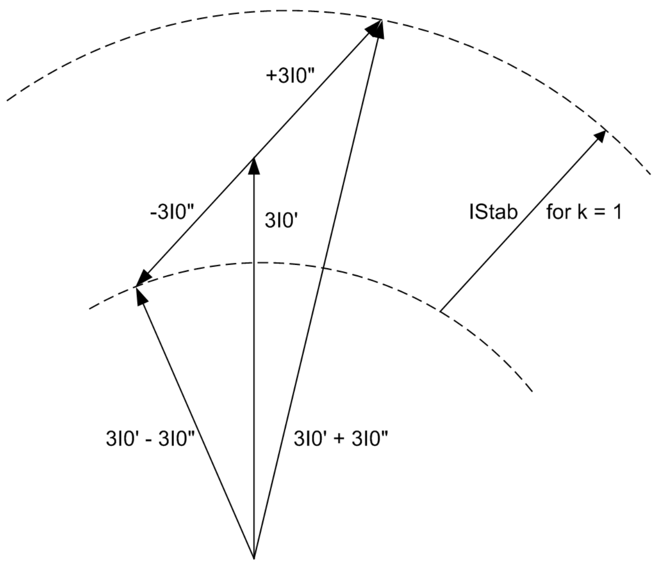


Figure 2-31 Phasor diagram of the restraint quantity during external fault

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

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

The restraint quantity I_{Rest} in the above example a) is quadrupled once more; it becomes thus 8 times the tripping effect quantity I_{Ref}.

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

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

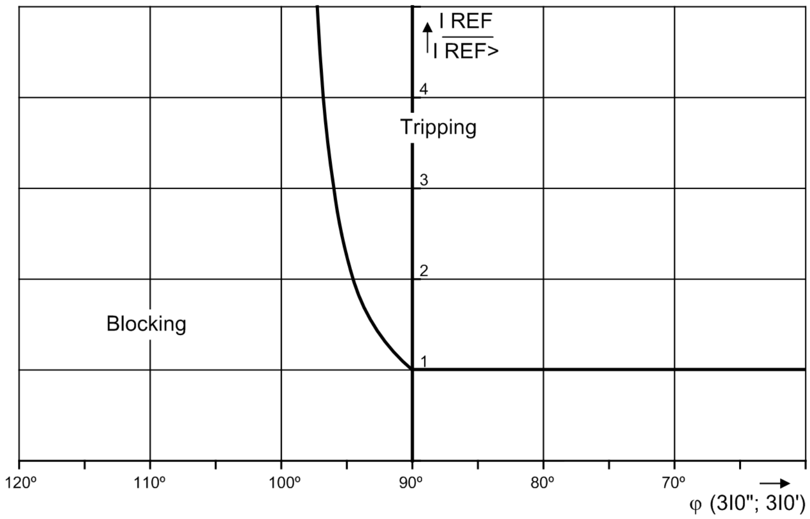


Figure 2-32 Tripping characteristic of the restricted earth fault protection depending on the phase displacement between $3I_0$” and $3I_0$' at $3I_0$” = $3I_0$' (180° = external fault)

It is also possible to increase the tripping value in the tripping area proportional to the arithmetic sum of all currents, In this case the pickup value with the arithmetic sum of all currents is stabilised, i.e. with„`IrestREF=`“ $\Sigma|I| = |I_{L1}| + |I_{L2}| + |I_{L3}| + |I_4|$ (Figure 2-33). The slope of this restraint characteristic can be set.

Pickup

Normally, a differential protection does not need a pickup or „fault detection“function, since the condition for a fault detection is identical to the trip condition. But the restricted earth fault protection provides like all protection functions a fault detection signal which forms an additional precondition for tripping and defines the fault inception instant for a number of further activities.

As soon as the fundamental wave of the differential current exceeds 85 % of the pickup value, fault detection is indicated. In this aspect, the differential current is represented by the sum of all in-flowing currents.

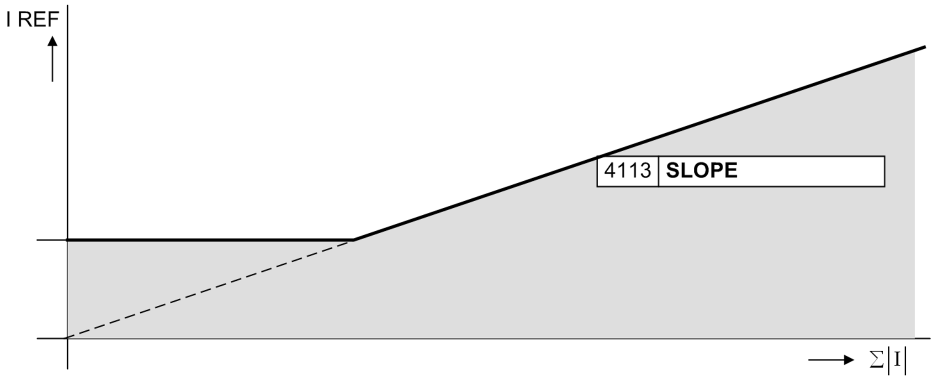


Figure 2-33 Increasing the pickup value

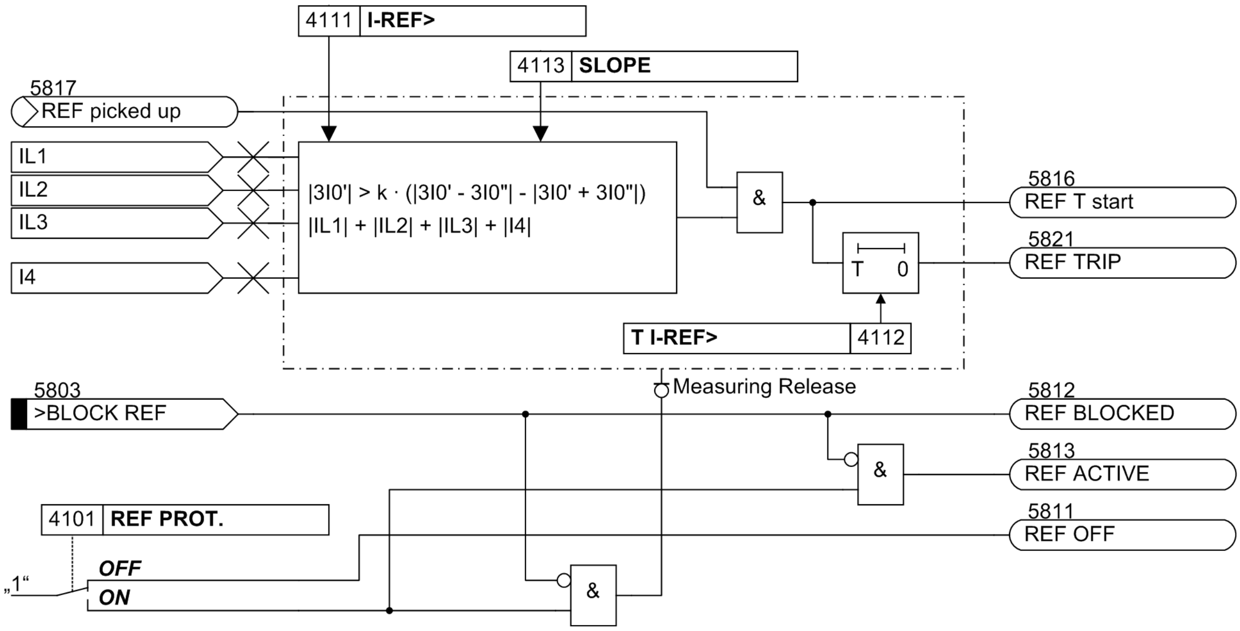


Figure 2-34 Logic diagram of the restricted earth fault protection (simplified)

2.5.3 Setting Notes

General

The restricted earth fault protection can only operate if this function has been set during configuration of the functional scope (Section 2.1.2) under address 141 **REF PROT.** on ***Enabled***. Operation requires the address 143 **TRANSFORMER** to be set on ***YES*** and the address 220 **I4 transformer** on ***IY starpoint***. The address 221 **I4/Iph CT** must be set under margin heading „Connection of the Currents“ as described in section 2.1.2.1.

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

Note

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

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

The set value can be increased in the tripping quadrant depending on the arithmetic sum of the currents (stabilization by the sum of all current magnitudes) which is set under address 4113 **SLOPE**. This parameter can only be altered in DIGSI at **Additional Settings**. The preset value 0 is normally adequate.

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

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

Value message 5826 „REF D:“ is the tripping value stabilized via the tripping curve. The reported values „REF S:“ and „REF D:“ refer to the time when the output message 5816 „REF T start“ is reported, i.e. the starting time of **T I-REF>** (address 4112).

The following relations apply for calculating the quantities (see section 2.5 margin heading „Evaluation of the measured quantities“):

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

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

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

2.5.4 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
4101	REF PROT.		OFF ON	OFF	Restricted Earth Fault Protection
4111	I-REF>	1A	0.05 .. 2.00 A	0.15 A	Pick up value I REF>
		5A	0.25 .. 10.00 A	0.75 A	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
4112A	T I-REF>		0.00 .. 60.00 sec; ∞	0.00 sec	T I-REF> Time Delay
4113A	SLOPE		0.00 .. 0.95	0.00	Slope of Charac. I-REF> = f(I-SUM)

2.5.5 Information List

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

2.6 Direct Local Trip

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

2.6.1 Method of Operation

External trip of the local circuit breaker

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

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

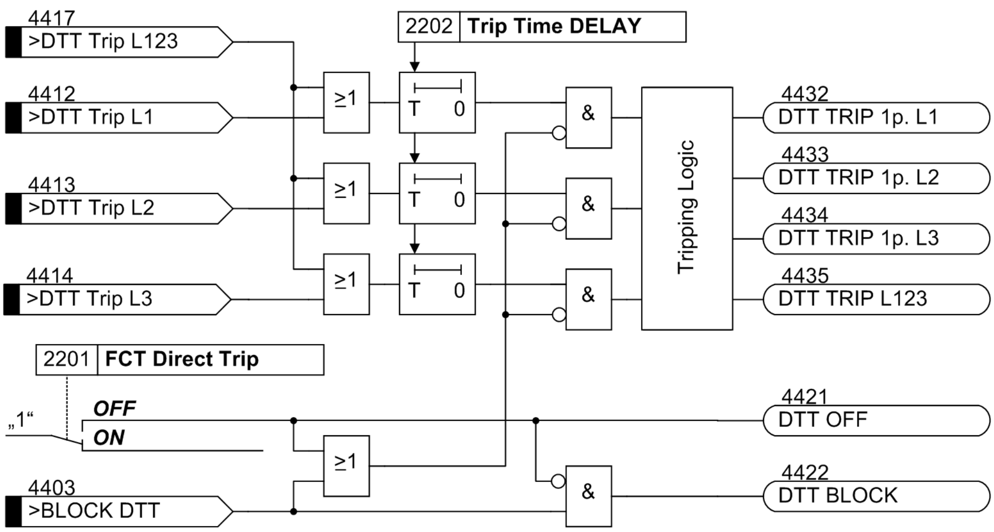


Figure 2-35 Logic diagram of the local external tripping

2.6.2 Setting Notes

General

A prerequisite for the application of the direct and remote tripping functions is that during the configuration of the scope of functions in address 122 **DTT Direct Trip** = ***Enabled*** was applied. At address 2201 **FCT Direct Trip** it can also be switched ***ON*** or ***OFF***.

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.

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

2.6.3 Settings

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

2.6.4 Information List

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

2.7 Direct Remote Trip and Transmission of Binary Information

2.7.1 Function Description

7SD610 allows the transmission of up to 4 items of binary information of any type from one device to the other via the communication link 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 other protection signals which are generated outside of 7SD610. They are suitable for information on the events taking place in a substation which may also be useful in other substations (see also the specifications in Chapter „Technical Data").

The information can be injected into the device via binary inputs and output at the other device via binary outputs. On both the transmitting and the receiving side the integrated user-defined CFC logic allows to perform logical operations on the signals and on other information from the protective and monitoring functions of the devices. Also an internal indication can be assigned via CFC to a transmission input and transmitted to the remote end(s).

The used binary inputs and the signal outputs must be allocated accordingly when configuring the input and output functions. The four high-priority signals are injected into the device via the binary inputs „>Remote Trip1" to „>Remote Trip4", are transmitted to the device of the other end and can be processed at each receiving side with the output functions „RemoteTrip1 rec" to „RemoteTrip4 rec".

When assigning the binary inputs and outputs using DIGSI, you can provide the information to be transmitted with your own designation. If, for example, a line has a unit connected power transformer at one end and you wish to transmit trip by the Buchholz protection as „>Remote Trip1" to the other end, you may use the input and designate it „Buchholz TRIP". At the other end, you designate the incoming information, „RemoteTrip1 rec" e.g. „Buchholz remote", and assign it to an output trip relay. In case of Buchholz protection trip the indications will then be given according to your designations.

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

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

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

No further settings are required for the transmission of binary information. The device sends the injected information to the device at the end of the protected object.

2.7.2 Information List

No.	Information	Type of Information	Comments
3541	>Remote Trip1	SP	>Remote Trip 1 signal input
3542	>Remote Trip2	SP	>Remote Trip 2 signal input
3543	>Remote Trip3	SP	>Remote Trip 3 signal input
3544	>Remote Trip4	SP	>Remote Trip 4 signal input
3545	RemoteTrip1 rec	OUT	Remote Trip 1 received
3546	RemoteTrip2 rec	OUT	Remote Trip 2 received
3547	RemoteTrip3 rec	OUT	Remote Trip 3 received
3548	RemoteTrip4 rec	OUT	Remote Trip 4 received

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

2.8.1 Function Description

General

The instantaneous high-current switch-onto-fault protection function is provided to disconnect immediately, and without delay, feeders that are switched onto a high-current fault. It serves, e.g. as a rapid protection for connecting a feeder with closed grounding disconnector. In order to function properly, the devices at all 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 to eliminate the DC component. DC current components in the fault current and in the CT secondary circuit following the switching off of large currents practically have no influence on this high-current pickup operation. If the setting value is exceeded by more than twice its value, the stage will automatically use the peak value of the unfiltered measured quantity 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 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 a different end) the stage is not effective. An indispensable precondition for the functioning of the I-STUB stage is that the auxiliary contacts of the circuit breakers are connected at all 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 Section 2.16.1).

Figure 2-36 shows the logic diagram. The I-STUB 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 2.16.1).

Tripping can also be enabled separately for each phase by the signals „SOTF enab. Lx“. This applies also, for example, to 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 2-36 shows the logic diagram in the upper part.

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

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.

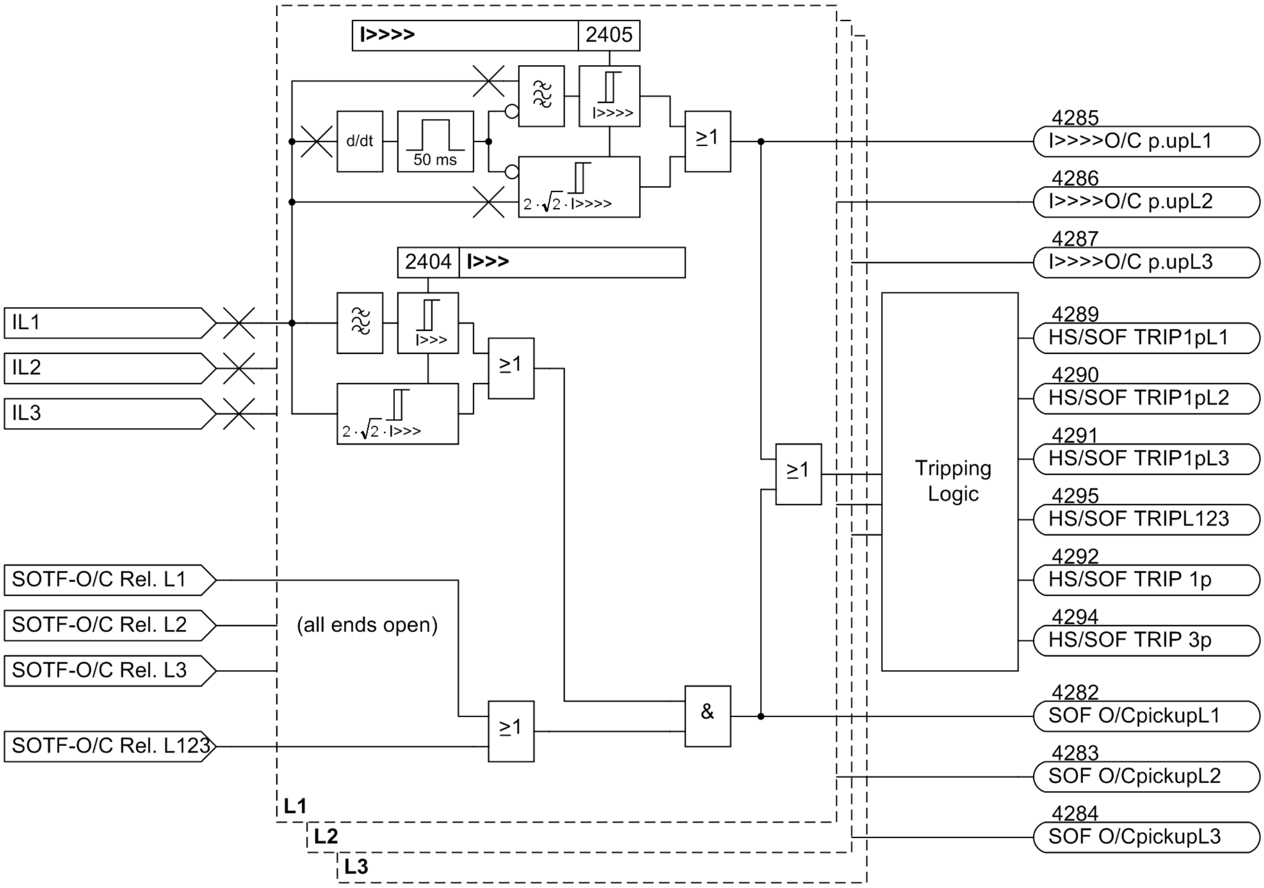


Figure 2-36 Logic diagram of the high current switch on to fault protection

2.8.2 Setting Notes

General

A prerequisite for the application of the direct and remote tripping functions is that during the configuration of the scope of functions (Section 2.1.1) in address 124 **HS/SOTF-O/C** = ***Enabled*** was applied. At address 2401 **FCT HS/SOTF-O/C** it can also be switched ***ON*** or ***OFF***.

I>>> Stage

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

When using a PC and DIGSI for the parameterisation, the values can be optionally entered as primary or secondary quantities. If secondary quantities are used, all currents must be converted to the secondary side of the current transformers.

I>>>>stage

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

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

Exemplary calculation:

110 kV overhead line 150 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_k'' = 3.5 GVA (subtransient, since the I>>>>stage can respond to the first peak value)

Current transformer 600 A/5 A

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

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

$Z_L = 0.46\ \Omega/\text{km} \cdot 60\ \text{km} = 27.66\ \Omega$

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

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

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

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

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

or the secondary settings value:

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

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. A complex calculation is only needed if the angles of the source impedance and the line impedance vary considerably.

2.8.3 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2401	FCT HS/SOTF-O/C		ON OFF	ON	Inst. High Speed/SOTF-O/C is
2404	I>>>	1A	0.10 .. 15.00 A; ∞	1.50 A	I>>> Pickup
		5A	0.50 .. 75.00 A; ∞	7.50 A	
2405A	I>>>>	1A	1.00 .. 25.00 A; ∞	∞ A	I>>>> Pickup
		5A	5.00 .. 125.00 A; ∞	∞ A	

2.8.4 Information List

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

2.9 Backup Time Overcurrent Protection

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

2.9.1 General

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

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

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

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

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

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

2.9.2 Function Description

Measured Values

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

If I_4 is connected to the starpoint of the current transformer set (address 220 **I4 transformer** = ***In prot. line***, see section2.1.2 of **P.System Data 1**), the earth current will be directly available as measured value. It is used considering the **I4/Iph CT** factor (address221).

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

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

The current phase earth voltage is used

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

The saved phase-earth voltage is used

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

The unfaulted current phase-earth voltage is used

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

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

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

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

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

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

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

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

Note

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

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

Directional Characteristic

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

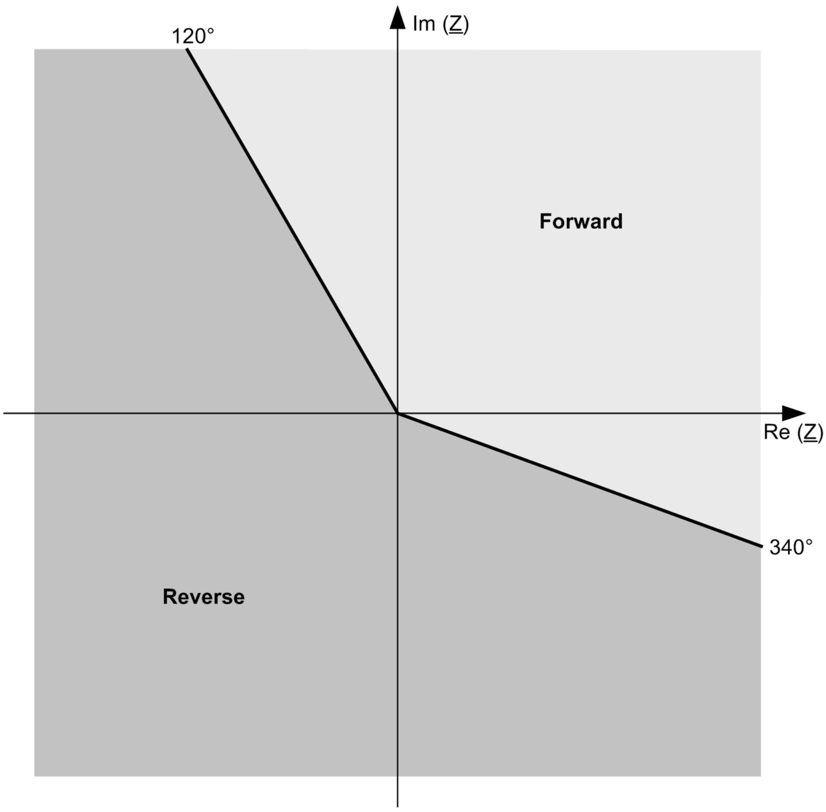


Figure 2-37   Directional characteristic of the time overcurrent protection

Definite Time High-set Current Stage I>>

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

Figure 2-38 shows the logic diagram of the I>> stages. The stages can be blocked via the binary input „`>BLOCK O/C I>>`“. Additionally, the earth current can be blocked separately via a binary input „`>BLOCK O/C Ie>>`“. During the single-pole pause, the earth current stage is always blocked to avoid a fault trigger.

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

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

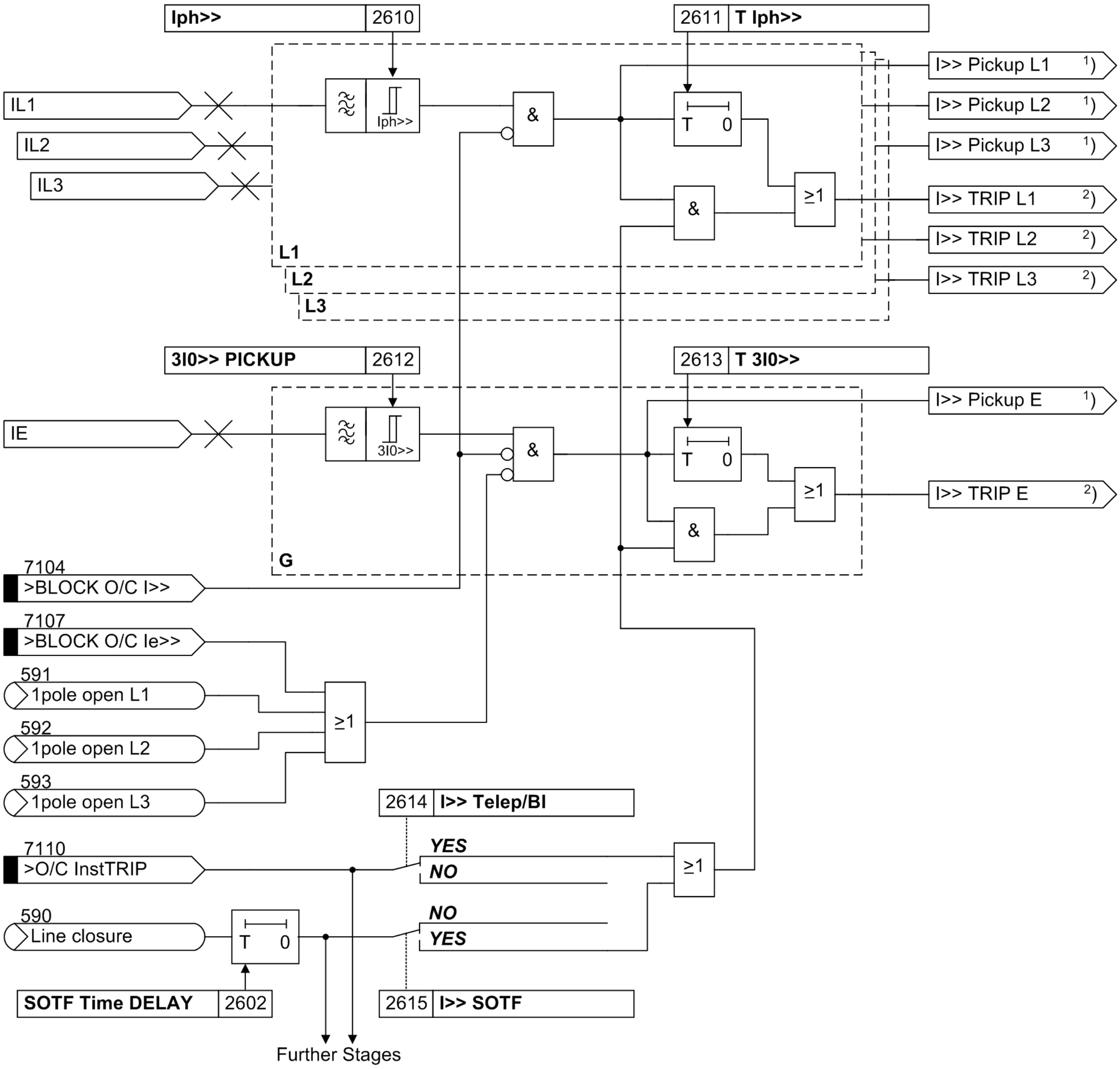


Figure 2-38 Logic diagram of the I>> stage

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

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

Definite time overcurrent stage I>

The logic of the overcurrent stage I> is the same as that of the I>> stages. In all references **`Iph>>`** must merely be replaced with **`Iph>`** or **`3I0>> PICKUP`** with **`3I0>`**. Parameter 2624 **`I> Telep/BI`** is default as ***NO***. In all other respects Figure 2-38 applies.

Additional Stage I>>>

The additional definite time or instantaneous overcurrent stage I>>> has an extra enable input (Figure 2-39) It 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>>> stage can, however, also be used as a standard additional and independent overcurrent stage, since it works independent of the other stages. In this case, the enable input „>I-STUB ENABLE“ must be activated permanently (via a binary input or CFC).

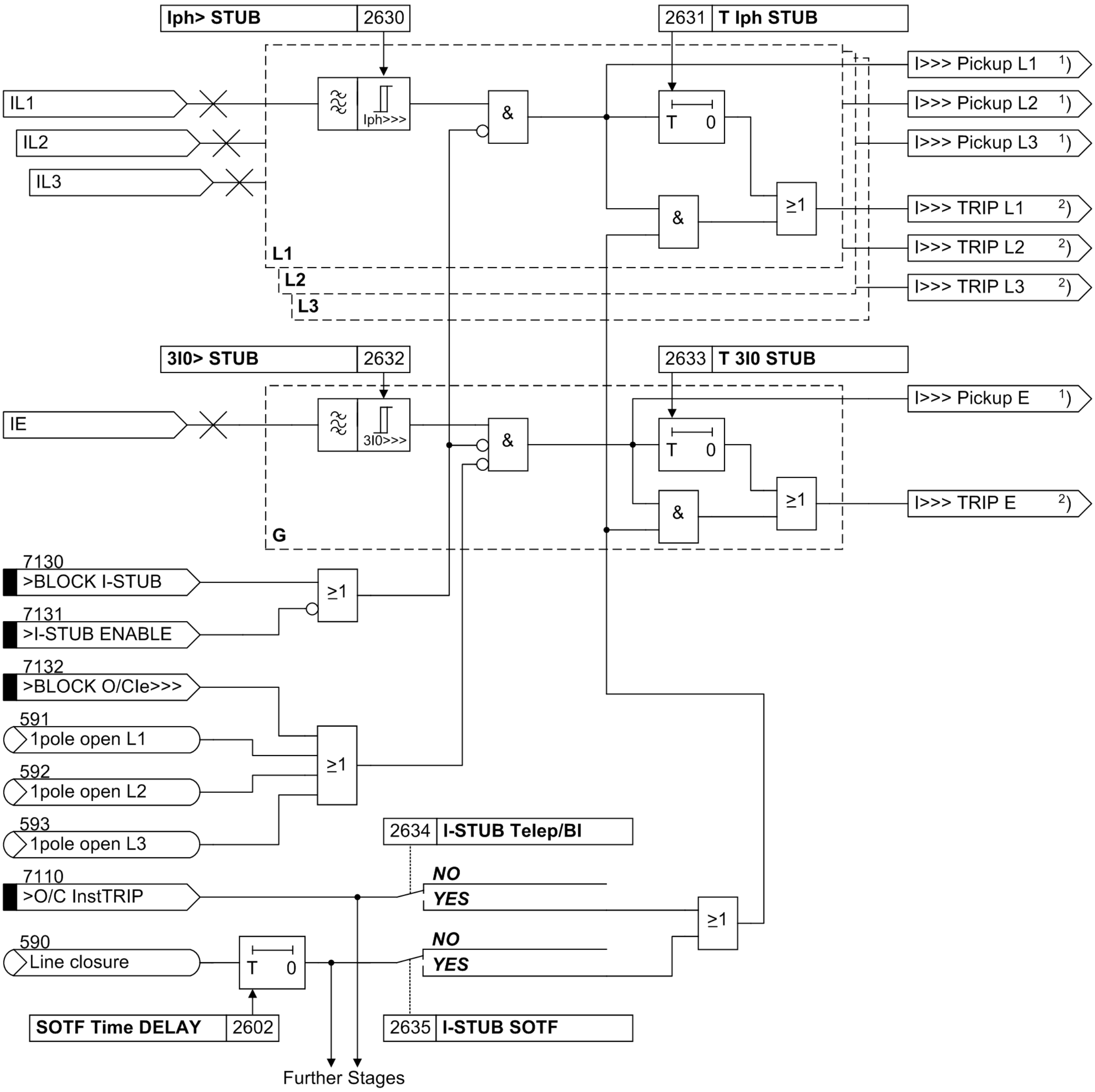


Figure 2-39 Logic diagram of the I>>> stage

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

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

Directional, Definite Time Overcurrent Stage I>

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

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

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

Figure 2-40 shows the logic diagram of the I>ger stages. The stages can be blocked via the binary input „>BLOCK Dir. I>“. Additionally, the earth current can be blocked separately via a binary input „>BLOCK Dir. Iep“.

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

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

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

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

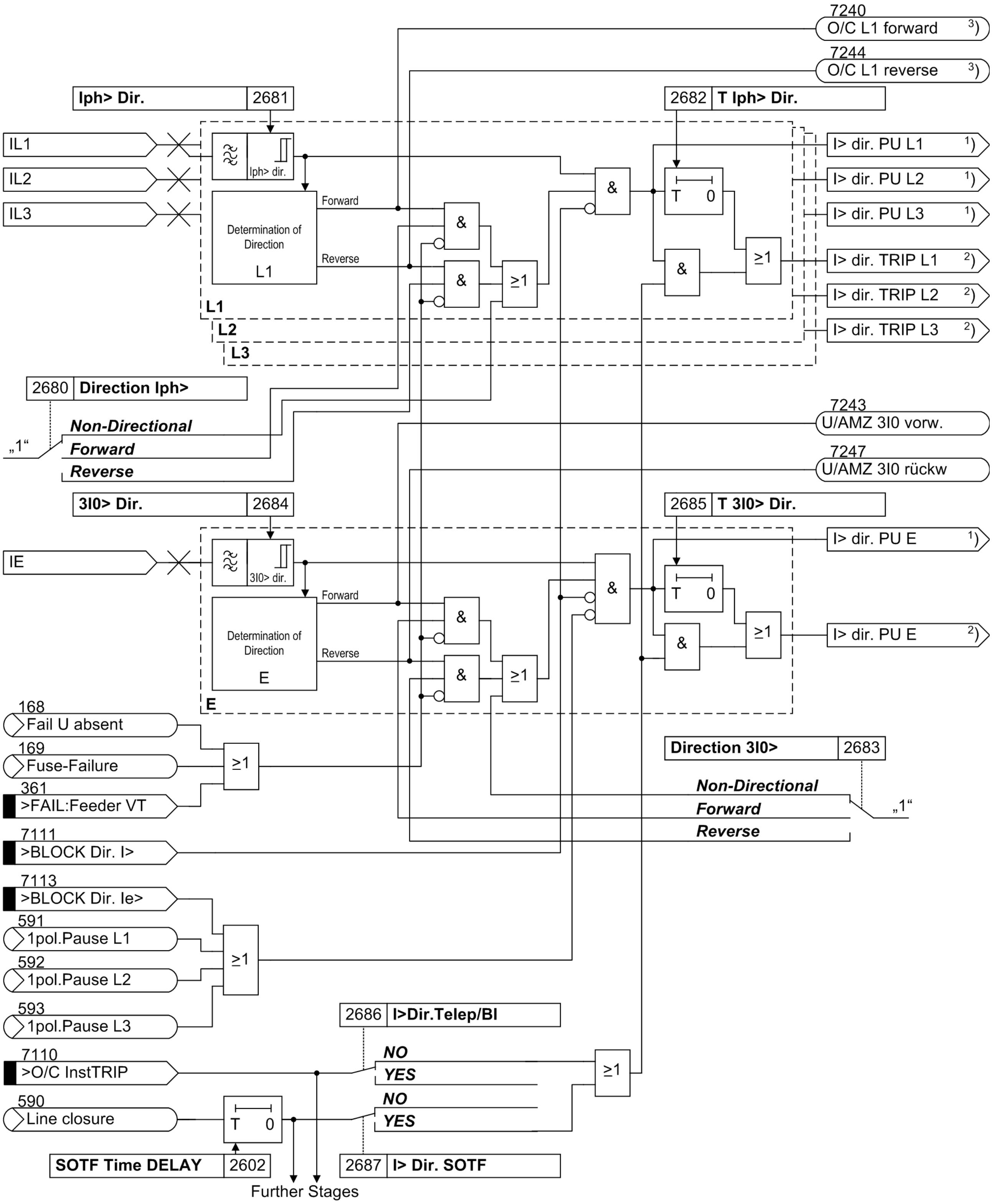


Figure 2-40 Logic diagram of the I> stage

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

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

[3]) The indications „`O/C L2 forward`“, „`O/C L3 forward`“, „`O/C L2 reverse`“, „`O/C L3 reverse`“ have not been represented in the Figure, however, they are reported if necessary.

Inverse time over-current stage I_P

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

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

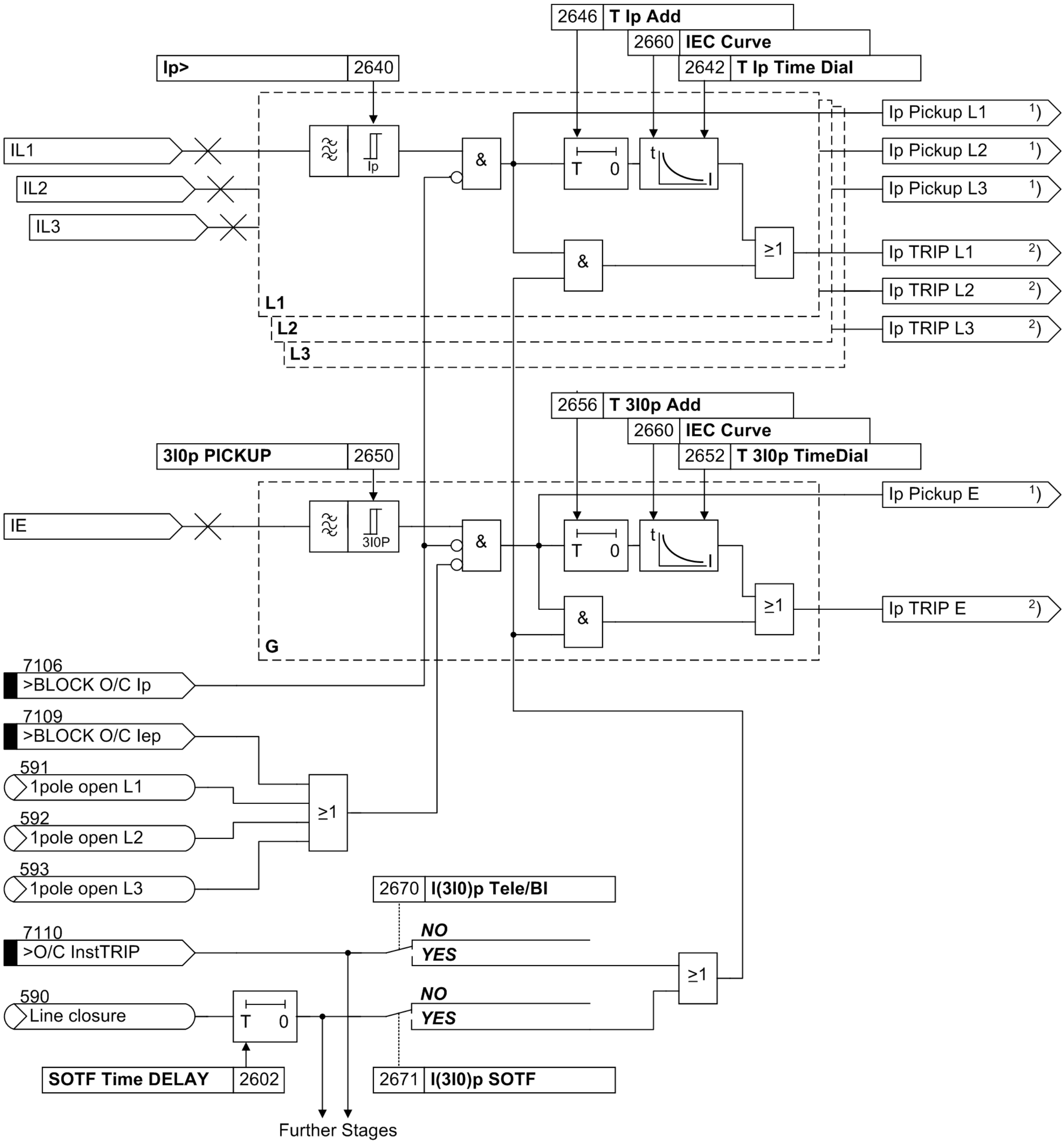


Figure 2-41 Logic diagram of the I_P stage (inverse time overcurrent protection) - example of IEC curve

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

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

Directional inverse time overcurrent stage I_P ger

The logic of the directional inverse overcurrent stage operates chiefly in the same way as the non-directional stages. However, triggering is not dependent on the result of the direction determination. Direction determination occurs via the measuring values and the respective directional characteristics.

However, the time delay is calculated here based on the type of the set characteristic, the intensity of the current and a time multiplier **`D Ip Dir.`** or **`D 3I0p Dir.`**. Furthermore, an additional constant time delay **`T Ip Add Dir.`** or **`T 3I0p Add Dir.`**

may be selected, which is added to the inverse time. The possible characteristics are shown in the Technical Data.

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

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

The directional and the non-directional inverse overcurrent stageI_P always uses the same characteristic parameterized via the parameter2660 (IEC) or 2661 (ANSI). Various inverse times and additional times can be configured.

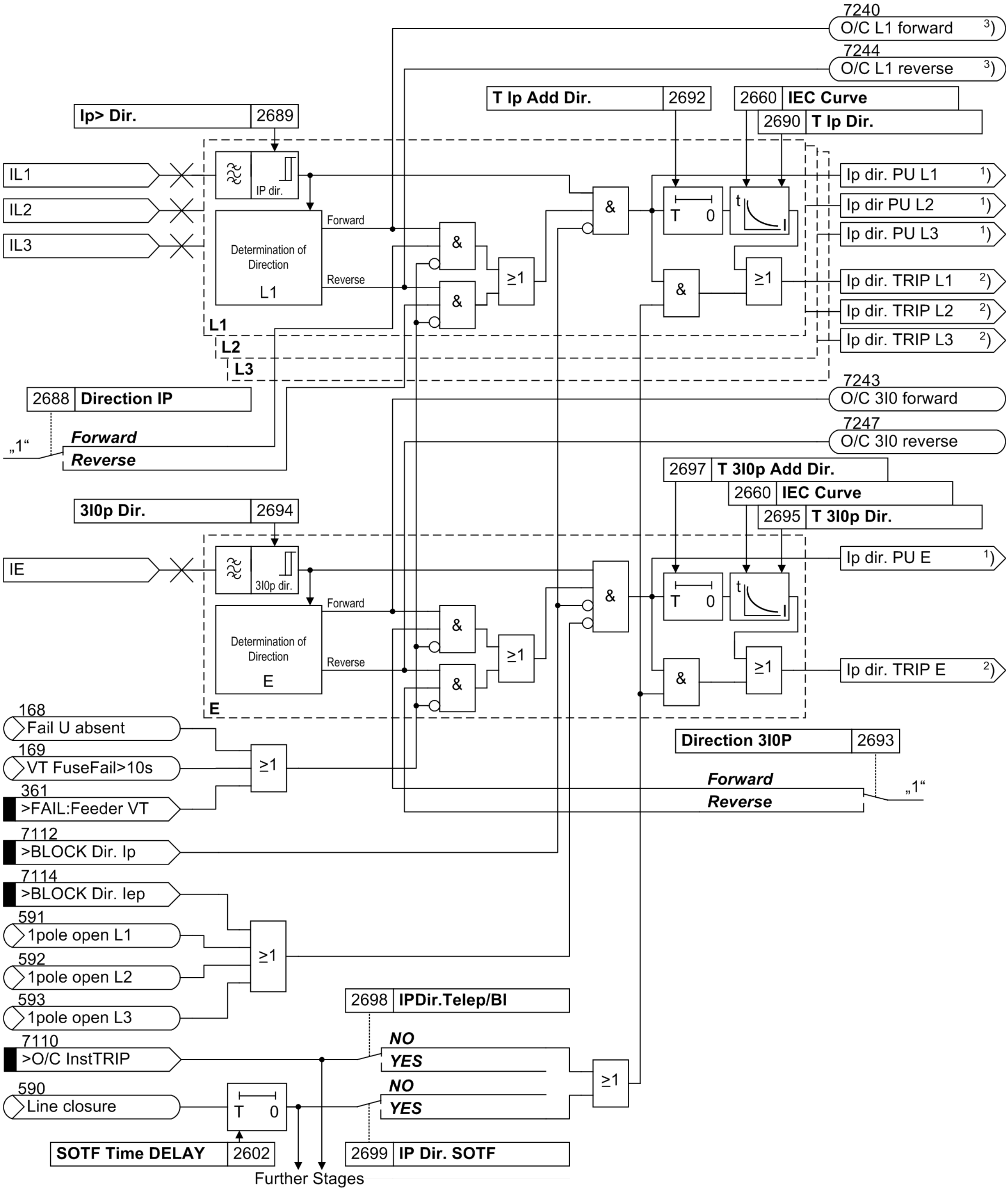


Figure 2-42 Logic diagram of the I_P stage (directional, inverse time overcurrent protection), for example IEC characteristics

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

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

3) The indications „`O/C L2 forward`“, „`O/C L3 forward`“, „`O/C L2 reverse`“, „`O/C L3 reverse`“ have not been represented in the Figure, however, they are reported if necessary.

Instantaneous tripping before automatic reclosure

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

Switching onto a fault

The internal line energization detection can be used to achieve quick tripping of the circuit breaker in case of an earth fault. The time overcurrent protection can then trip three-pole without delay or with a reduced delay. It can be determined via parameter setting for which stage(s) the instantaneous tripping following energization applies (refer also to the logic diagrams Figure 2-38, 2-41 and 2-39). This function is independent of the high-current instantaneous tripping described in Subsection 2.8.

Pickup logic and tripping logic

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

Table 2-3 Pickup signals of the single phases

Internal indication	Display	Output indication	No
I>> PU L1 I> PU L1 I>>> PU L1 I> ger PU L1 Ip PU L1 Ip ger PU L1	2-38 2-39 2-40 2-41 2-42	„O/C Pickup L1“	7162
I>> PU L2 I> PU L2 I>>> PU L2 I> ger PU L2 Ip PU L2 Ip ger PU L2	2-38 2-39 2-40 2-41 2-42	„O/C Pickup L2“	7163
I>> PU L3 I> PU L3 I>>> PU L3 I> ger PU L3 Ip PU L3 Ip ger PU L3	2-38 2-39 2-40 2-41 2-42	„O/C Pickup L3“	7164
I>> PU E I> PU E I>>> PU E I> ger PU E Ip PU E Ip ger PU E	2-38 2-39 2-40 2-41 2-42	„O/C Pickup E“	7165
I>> PU L1 I>> PU L2 I>> PU L3 I>> PU E	2-38 2-38 2-38 2-38	„O/C PICKUP I>>“	7191
I> PU L1 I> PU L2 I> PU L3 I> PU E		„O/C PICKUP I>“	7192

Internal indication	Display	Output indication	No
I>>> PU L1 I>>> PU L2 I>>> PU L3 I>>> PU E	2-39 2-39 2-39 2-39	„I-STUB PICKUP“	7201
I> ger PU L1 I> ger PU L2 I> ger PU L3 I> ger PU E	2-40 2-40 2-40 2-40	„O/C PICK. I>Dir“	7202
Ip PU L1 Ip PU L2 Ip PU L3 Ip PU E	2-41 2-41 2-41 2-41	„O/C PICKUP Ip“	7193
Ip ger PU L1 Ip ger PUL2 Ip ger PU L3 Ip ger PU E	2-42 2-42 2-42 2-42	„O/C PICK. IpDir“	7203
(All pickups)		„O/C PICKUP“	7161

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

Table 2-4 Trip signals of the single phases

Internal indication	Display	Output indication	No
I>> TRIP L1 I> TRIP L1 I>>> TRIP L1[1)] I> ger TRIP L1 Ip TRIP L1 Ip ger TRIP L1	2-38 2-39 2-40 2-41 2-42	„O/C TRIP 1p.L1“ or „O/C TRIP L123“	7212 or 7215
I>> TRIP L2 I> TRIP L2 I>>> TRIP L2[1)] I> ger TRIP L2 Ip TRIP L2 Ip ger TRIP L2	2-38 2-39 2-40 2-41 2-42	„O/C TRIP 1p.L2“ or „O/C TRIP L123“	7213 or 7215
I>> TRIP L3 I> TRIP L3 I>>> TRIP L3[1)] I> ger TRIP L3 Ip TRIP L3 Ip ger TRIP L3	2-38 2-39 2-40 2-41 2-42	„O/C TRIP 1p.L3“ or „O/C TRIP L123“	7214 or 7215
I>> TRIP E I> TRIP E I>>> TRIP E[2)] I> ger TRIP E Ip TRIP E Ip ger TRIP E	2-38 2-39 2-40 2-41 2-42	„O/C TRIP L123“	7215
I>> TRIP L1 I>> TRIP L2 I>> TRIP L3 I>> TRIP E	2-38 2-38 2-38 2-38	„O/C TRIP I>>“	7221
I> TRIP L1 I> TRIP L2 I> TRIP L3 I> TRIP E		„O/C TRIP I>“	7222
I>>> TRIP L1 I>>> TRIP L2 I>>> TRIP L3 I>>> TRIP E	2-39 2-39 2-39 2-39	„I-STUB TRIP“	7235
I> ger TRIP L1 I> ger AUS L2 I> ger AUS L3 I> ger AUS E	2-40 2-40 2-40 2-40	„O/C TRIP I>Dir.“	7236
Ip TRIP L1 Ip TRIP L2 Ip TRIP L3 Ip TRIP E	2-41 2-41 2-41 2-41	„O/C TRIP Ip“	7223
Ip ger TRIP L1 Ip ger TRIP L2 Ip ger TRIP L3 Ip ger TRIP E	2-42 2-42 2-42 2-42	„O/C TRIP IpDir.“	7237
(General TRIP)		„O/C TRIP“	7211

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

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

2.9.3 Setting Notes

General

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

Address 2601 is set according to the desired mode of operation of the overcurrent protection: **Operating Mode** = ***ON*** means that the time overcurrent protection operates independently of the other protection functions, i.e. as a backup time overcurrent protection. f it is intended to work only as an emergency function in case of a transmission failure, set ***Only Emer. prot***. Finally, it can also be set to ***OFF***.

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

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

One or several stages can be set as instantaneous tripping stages when switching onto a fault. This is chosen during the setting of the individual stages (see below). To avoid a spurious pickup due to transient overcurrents, the delay **SOTF Time DELAY** (address 2602) can be set. Typically, the presetting of **0** is correct. A short delay can be useful in case of long cables for which high inrush currents can be expected, or for transformers. The time delay depends on the severity and duration of the transient overcurrents as well as on which stages were selected for the fast switch onto fault clearance.

Directional Stages

The directional stages require additional settings.

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

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

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

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

In addition, at address 2680 **Direction Iph>** or 2683 **Direction 3I0>** set the pickup direction for the directional stages I>ger and 3I0ger. The settings ***Non-Directional*** (presetting), ***Forward***, and ***Reverse*** are possible.

In address2688**Direction IP** or 2693**Direction 3I0P** you set the pickup direction for the directional stages IPger and 3I0Pger. Settings ***Forward*** (default setting) and ***Reverse*** are possible.

High-current elements I_{ph}>>, $3I_0$>>

The I>> stages **Iph>>** (address 2610) and **3I0>> 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 one stage is not required, the pickup value has to be set to ∞. The I>> stages always operates with a defined delay time.

If the I>> stages are used for instantaneous tripping before the automatic reclosure (via CFC interconnection), the current setting corresponds to the I> or I_p stages (see below). In this case only the different delay times are of interest. The times **T Iph>>**(address 2611) and **T 3I0>>** (address 2613) can than be set to **0** 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** or to a small value.

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

Calculation Example:

110 kV overhead line 150 mm^2:

s (length) = 60 km

R_1/s = 0.19 Ω/km

X_1/s = 0.42 Ω/km

Short-circuit power at the beginning of the line:

S_k' = 2.5 GVA

Current Transformer 600 A / 5 A

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

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

$Z_L = 0.46\ \Omega/\text{km} \cdot 60\ \text{km} = 27.66\ \Omega$

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

The three-phase fault current at the line end is $I_{sc\ end}$:

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

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

Set value I>> = 1.1 · 2150 A = 2365 A

or the secondary setting value:

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

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

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

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

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

The parameter **I>> 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“ (No 7110) or by the operational automatic reclosure function. The binary input (if allocated) is applied to all stages of the time 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, when switching the line on to a fault, is to trip without delay or with a short delay, **SOTF Time DELAY** (address 2602, see above under margin heading „General“), the parameter **I>> SOTF** (address 2615) is set to ***YES***. Any other stage can be selected as well for this instantaneous tripping.

Time Overcurrent StagesI_{ph}>, $3I_0$>, I_{ph}>ger, $3I_0$>ger for Definite-time Overcurrent Protection

For the setting of the current pickup value, **Iph>** (address 2620), or **Iph> Dir.** (address 2681) 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. A pickup value setting equal to 10% is recommended for line protection, and a setting equal to 20 % of the expected peak load is recommended for transformers and motors.

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

Calculation Example:

110 kV overhead line 150 mm^2

maximum transmittable power

P_{max}	= 120 MVA

corresponding to

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

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

Set value I> = 1.1 · 630 A = 693 A

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

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

The earth current stage**3I0>** (address2622) or **3I0> Dir.** (address2684), should be set to detect the smallest earth fault current to be expected.

The delay time **T Iph>** (address2621) or**T Iph> Dir.** (address2682) results from the grading coordination chart defined for the network. If implemented as emergency overcurrent protection, shorter tripping times are advisable (one grading time step above the fast tripping stage), as this function is only activated in the case of the loss of the local measured voltage.

The time **T 3IO>** (address 2623) or**T 3IO> Dir.** (address2685) can normally be set shorter, according to a separate time grading schedule for ground currents.

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

The parameter **I> Telep/BI** (address2624) or**I>Dir.Telep/BI** (address2686) determines whether the delay times**T Iph>** (address2621) or**T Iph> Dir.** (address2682) and **T 3IO>** (address2623) or**T 3IO> Dir.** (address2685) can be bypassed via the binary input „>O/C InstTRIP“. The binary input (if allocated) is applied to all stages of the time-overcurrent protection. With **I> Telep/BI** = ***YES*** or **I>Dir.Telep/BI** = ***YES*** you define that the I>stages trip without delay after pickup if the binary input was activated. For **I> Telep/BI** = ***NO*** or **I>Dir.Telep/BI** = ***NO*** the set delays are always active.

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

If the I>stage, when switching the line on to a fault, is to trip without delay or with a short delay **SOTF Time DELAY** (address 2602, see above under margin heading „General“) the parameter **I> SOTF** (address 2625) or **I> Dir. SOTF** (address 2687) is set to ***YES***. We recommend, however, not to choose the sensitive setting for the switch on to a fault function as energizing of the line on to a fault should cause a large fault current. It is important to avoid that the selected stage picks up due to transients during line energization.

Time Overcurrent Stages I_P, $3I_{0P}$, $I_P$ger, $3I_{0P}$ger for inverse-time O/C protection with IEC characteristic

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

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

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

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

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

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

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

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

Primary: Set value IP = 630 A,

Secondary: Set value IP = 5.25 A, i.e. (630 A/600 A) X 5 A.

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

The time multiplicator**T 3I0p TimeDial** (address 2652) or**T 3I0p Dir.** (address2695) can normally be set shorter, according to a separate time grading schedule for ground currents. If only the phase currents are to be monitored, set the pickup value of the earth current stage to ∞.

In addition to the current-dependent delays, a fixed time delay can be set, if necessary. The setting **T Ip Add** (address2646) or **T Ip Add Dir.** (address 2692) for phase currents and **T 3I0p Add** (address 2656) or. **T 3I0p Add Dir.** (address 2697) for earth currents add to the times of the set characteristics.

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

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

If the IP>stage, when switching the line on to a fault, is to trip without delay or with a short delay **SOTF Time DELAY** (address 2602, see above under margin heading „General“) the parameter **I(3I0)p SOTF** (address 2671) or **IP Dir. SOTF** (address 2699) is set to ***YES***. We recommend, however, not to choose the sensitive setting for the switch on to a fault function as energizing of the line on to a fault should cause a large fault current. It is important to avoid that the selected stage picks up due to transients during line energization.

Time Overcurrent Stages I_P, $3I_{0P}$, $I_P$ger, $3I_{0P}$ger for inverse-time O/C protection with ANSI characteristic

In the case of the inverse overcurrent stages, various characteristics can be selected, depending on the ordering version of the device and the configuration (address 126), With the ANSI characteristics (address 126 **Back-Up O/C** = ***TOC ANSI***), the following options are available at address 2661 **ANSI Curve**:

Inverse,

Short Inverse,

Long Inverse,

Moderately Inv.,

Very Inverse,

Extremely Inv. and

Definite Inv..

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

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

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

Primary: Set value IP = 630 A,

Secondary: Setting value IP = 5.25 A, i.e. (630 A/600 A) X 5 A.

The set time multiplicator **Time Dial TD Ip** (address 2643) or **D Ip Dir.** (address 2691) results from the grading coordination chart defined for the network. For the use as emergency overcurrent protection shorter delay times make sense (one grading time step above instantaneous tripping), since this function is to work only in case of an interruption of the data communication for the differential protection.

The time multiplicator**TimeDial TD3I0p** (address 2653) or**D 3I0p Dir.** (address2696) can normally be set shorter, according to a separate time grading schedule for ground currents. If only the phase currents are to be monitored, set the pickup value of the earth current stage to ∞.

In addition to the current-dependent delays, a fixed time delay can be set, if necessary. The setting **T Ip Add** (address2646) or **T Ip Add Dir.** (address 2692) for phase currents and **T 3I0p Add** (address 2656) or. **T 3I0p Add Dir.** (address 2697) for earth currents add to the times of the set characteristics.

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

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

If the IP>stage, when switching the line on to a fault, is to trip without delay or with a short delay **SOTF Time DELAY** (address 2602, see above under margin heading „General“) the parameter **I(3I0)p SOTF** (address 2671) or **IP Dir. SOTF** (address 2699) is set to ***YES***. We recommend, however, not to choose the sensitive setting for the switch on to a fault function as energizing of the line on to a fault should cause a large fault current. It is important to avoid that the selected stage picks up due to transients during line energization.

Additional stage I_{ph}>>>

The I-STUB stage can be used as an additional definite time overcurrent stage since it operates independently of the other stages. In this case, the enable input „>I-STUB ENABLE“ (No. 7131) must be activated permanently (via a binary input or CFC).

Since the I-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 enable input „>I-STUB ENABLE“ (No. 7131) is then assigned the output signal „Emer. mode“ (No. 2054) (either via binary outputs and inputs or via the user-definable CFC logic functions).

The considerations for the use of the I>>> 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 grading time above the base time of the differential protection is sufficient.

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

The I-STUB stage can also be accelerated by the release signal „>O/C InstTRIP“ (No. 7110), e.g. before an auto-reclosure. This is defined with parameter **I-STUB Telep/BI** (address 2634). Set it to ***YES*** if the I-STUB stage is to trip without delay while the binary input „>O/C InstTRIP“ is activated or the internal automatic reclosure function is ready to operate.

Instantaneous tripping by the operational auto-reclosure should only be chosen if the I>>> 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 the parameter **I-STUB SOTF** (address 2635) to ***YES*** if instantaneous tripping is desired.

2.9.4 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2601	Operating Mode		ON Only Emer. prot OFF	ON	Operating mode
2602	SOTF Time DELAY		0.00 .. 30.00 sec	0.00 sec	Trip time delay after SOTF
2603A	Direct. 3I0		U0/I0 or U2/I0 with U0/I0 with U2/I2	U0/I0 or U2/I0	Measurement of direction for 3I0

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2610	Iph>>	1A	0.10 .. 25.00 A; ∞	2.00 A	Iph>> Pickup
		5A	0.50 .. 125.00 A; ∞	10.00 A	
2611	T Iph>>		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph>> Time delay
2612	3I0>> PICKUP	1A	0.05 .. 25.00 A; ∞	0.50 A	3I0>> Pickup
		5A	0.25 .. 125.00 A; ∞	2.50 A	
2613	T 3I0>>		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> Telep/BI		NO YES	YES	Instantaneous trip via Tele-prot./BI
2615	I>> SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2620	Iph>	1A	0.10 .. 25.00 A; ∞	1.50 A	Iph> Pickup
		5A	0.50 .. 125.00 A; ∞	7.50 A	
2621	T Iph>		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> Pickup
		5A	0.25 .. 125.00 A; ∞	1.00 A	
2623	T 3I0>		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Time delay
2624	I> Telep/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2625	I> SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2630	Iph> STUB	1A	0.10 .. 25.00 A; ∞	1.50 A	Iph> STUB Pickup
		5A	0.50 .. 125.00 A; ∞	7.50 A	
2631	T Iph STUB		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> STUB Pickup
		5A	0.25 .. 125.00 A; ∞	1.00 A	
2633	T 3I0 STUB		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0 STUB Time delay
2634	I-STUB Telep/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2635	I-STUB SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2640	Ip>	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> Pickup
		5A	0.50 .. 20.00 A; ∞	∞ A	
2642	T Ip Time Dial		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Time Dial
2643	Time Dial TD Ip		0.50 .. 15.00 ; ∞	5.00	Time Dial TD Ip
2646	T Ip Add		0.00 .. 30.00 sec	0.00 sec	T Ip Additional Time Delay
2650	3I0p PICKUP	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p Pickup
		5A	0.25 .. 20.00 A; ∞	∞ A	
2652	T 3I0p TimeDial		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Time Dial
2653	TimeDial TD3I0p		0.50 .. 15.00 ; ∞	5.00	Time Dial TD 3I0p

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2656	T 3I0p Add		0.00 .. 30.00 sec	0.00 sec	T 3I0p Additional Time Delay
2660	IEC Curve		Normal Inverse Very Inverse Extremely Inv. LongTimeInverse	Normal Inverse	IEC Curve
2661	ANSI Curve		Inverse Short Inverse Long Inverse Moderately Inv. Very Inverse Extremely Inv. Definite Inv.	Inverse	ANSI Curve
2670	I(3I0)p Tele/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2671	I(3I0)p SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2680	Direction Iph>		Non-Directional Forward Reverse	Non-Directional	Direction of stage Iph> Dir.
2681	Iph> Dir.	1A	0.10 .. 25.00 A; ∞	1.50 A	Iph> directional Pickup
		5A	0.50 .. 125.00 A; ∞	7.50 A	
2682	T Iph> Dir.		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Dir. Time delay
2683	Direction 3I0>		Non-Directional Forward Reverse	Non-Directional	Direction of stage 3I0> Dir.
2684	3I0> Dir.	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> directional Pickup
		5A	0.25 .. 125.00 A; ∞	1.00 A	
2685	T 3I0> Dir.		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Dir. Time delay
2686	I>Dir.Telep/BI		NO YES	NO	Instantaneous trip via Tele-prot./BI
2687	I> Dir. SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault
2688	Direction IP		Forward Reverse	Forward	Direction of stage Ip> Dir.
2689	Ip> Dir.	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> directional Pickup
		5A	0.50 .. 20.00 A; ∞	∞ A	
2690	T Ip Dir.		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Dir.: Inv.-Time delay for IEC-Char.
2691	D Ip Dir.		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2692	T Ip Add Dir.		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2693	Direction 3I0P		Forward Reverse	Forward	Direction of stage 3I0p

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2694	3I0p Dir.	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p directional Pickup
		5A	0.25 .. 20.00 A; ∞	∞ A	
2695	T 3I0p Dir.		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Dir.:Inv.-Time delay for IEC-Char
2696	D 3I0p Dir.		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2697	T 3I0p Add Dir.		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2698	IPDir.Telep/BI		NO YES	NO	Instantaneous trip via Teleprot./BI
2699	IP Dir. SOTF		NO YES	NO	Instantaneous trip after SwitchOnToFault

2.9.5 Information List

No.	Information	Type of Information	Comments
7104	>BLOCK O/C I>>	SP	>BLOCK Backup OverCurrent I>>
7105	>BLOCK O/C I>	SP	>BLOCK Backup OverCurrent I>
7106	>BLOCK O/C Ip	SP	>BLOCK Backup OverCurrent Ip
7107	>BLOCK O/C Ie>>	SP	>BLOCK Backup OverCurrent Ie>>
7108	>BLOCK O/C Ie>	SP	>BLOCK Backup OverCurrent Ie>
7109	>BLOCK O/C Iep	SP	>BLOCK Backup OverCurrent Iep
7110	>O/C InstTRIP	SP	>Backup OverCurrent InstantaneousTrip
7111	>BLOCK Dir. I>	SP	>BLOCK direct. Backup OverCurrent I>
7112	>BLOCK Dir. Ip	SP	>BLOCK direct. Backup OverCurrent Ip
7113	>BLOCK Dir. Ie>	SP	>BLOCK direct. Backup OverCurrent Ie>
7114	>BLOCK Dir. Iep	SP	>BLOCK direct. Backup OverCurrent Iep
7130	>BLOCK I-STUB	SP	>BLOCK I-STUB
7131	>I-STUB ENABLE	SP	>Enable I-STUB-Bus function
7132	>BLOCK O/CIe>>>	SP	>BLOCK Backup OverCurrent Ie>>>
7151	O/C OFF	OUT	Backup O/C is switched OFF
7152	O/C BLOCK	OUT	Backup O/C is BLOCKED
7153	O/C ACTIVE	OUT	Backup O/C is ACTIVE
7161	O/C PICKUP	OUT	Backup O/C PICKED UP
7162	O/C Pickup L1	OUT	Backup O/C PICKUP L1
7163	O/C Pickup L2	OUT	Backup O/C PICKUP L2
7164	O/C Pickup L3	OUT	Backup O/C PICKUP L3
7165	O/C Pickup E	OUT	Backup O/C PICKUP EARTH
7171	O/C PU only E	OUT	Backup O/C Pickup - Only EARTH
7172	O/C PU 1p. L1	OUT	Backup O/C Pickup - Only L1
7173	O/C Pickup L1E	OUT	Backup O/C Pickup L1E
7174	O/C PU 1p. L2	OUT	Backup O/C Pickup - Only L2
7175	O/C Pickup L2E	OUT	Backup O/C Pickup L2E
7176	O/C Pickup L12	OUT	Backup O/C Pickup L12

No.	Information	Type of In-formation	Comments
7177	O/C Pickup L12E	OUT	Backup O/C Pickup L12E
7178	O/C PU 1p. L3	OUT	Backup O/C Pickup - Only L3
7179	O/C Pickup L3E	OUT	Backup O/C Pickup L3E
7180	O/C Pickup L31	OUT	Backup O/C Pickup L31
7181	O/C Pickup L31E	OUT	Backup O/C Pickup L31E
7182	O/C Pickup L23	OUT	Backup O/C Pickup L23
7183	O/C Pickup L23E	OUT	Backup O/C Pickup L23E
7184	O/C Pickup L123	OUT	Backup O/C Pickup L123
7185	O/C PickupL123E	OUT	Backup O/C Pickup L123E
7191	O/C PICKUP I>>	OUT	Backup O/C Pickup I>>
7192	O/C PICKUP I>	OUT	Backup O/C Pickup I>
7193	O/C PICKUP Ip	OUT	Backup O/C Pickup Ip
7201	I-STUB PICKUP	OUT	O/C I-STUB Pickup
7202	O/C PICK. I>Dir	OUT	Backup O/C Pickup I> directional
7203	O/C PICK. IpDir	OUT	Backup O/C Pickup Ip directional
7211	O/C TRIP	OUT	Backup O/C General TRIP command
7212	O/C TRIP 1p.L1	OUT	Backup O/C TRIP - Only L1
7213	O/C TRIP 1p.L2	OUT	Backup O/C TRIP - Only L2
7214	O/C TRIP 1p.L3	OUT	Backup O/C TRIP - Only L3
7215	O/C TRIP L123	OUT	Backup O/C TRIP Phases L123
7221	O/C TRIP I>>	OUT	Backup O/C TRIP I>>
7222	O/C TRIP I>	OUT	Backup O/C TRIP I>
7223	O/C TRIP Ip	OUT	Backup O/C TRIP Ip
7235	I-STUB TRIP	OUT	O/C I-STUB TRIP
7236	O/C TRIP I>Dir.	OUT	Backup O/C TRIP I> directional
7237	O/C TRIP IpDir.	OUT	Backup O/C Pickup Ip directional
7240	O/C L1 forward	OUT	Backup O/C L1 forward direction
7241	O/C L2 forward	OUT	Backup O/C L2 forward direction
7242	O/C L3 forward	OUT	Backup O/C L3 forward direction
7243	O/C 3I0 forward	OUT	Backup O/C 3I0 forward direction
7244	O/C L1 reverse	OUT	Backup O/C L1 reverse direction
7245	O/C L2 reverse	OUT	Backup O/C L2 reverse direction
7246	O/C L3 reverse	OUT	Backup O/C L3 reverse direction
7247	O/C 3I0 reverse	OUT	Backup O/C 3I0 reverse direction
7248	O/C Dir.forward	OUT	Backup O/C forward direction
7249	O/C Dir.reverse	OUT	Backup O/C reverse direction

2.10 Automatic Reclosure Function (optional)

Experience shows that about 85% of the arc faults on overhead lines are extinguished automatically after being tripped by the protection. The line can therefore be re-energised. Reclosure is performed by an automatic reclose function (AR).

Automatic reclosure is only permitted on overhead lines because the option of automatic extinguishing of a fault arc only exists there. It should 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 directly connected to 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 automatic reclosure is usually initiated in the case of single-phase faults and a three-pole automatic reclosure in the case of multi-phase faults in the network with earthed system star point. If the fault still exists after reclosure (arc not extinguished or metallic short-circuit), the protection issues a final trip. In some systems several reclosing attempts are performed.

In the model with single-pole tripping the 7SD610 allows phase-selective single-pole tripping. A single- and three-pole, one- and multi-shot automatic reclosure is integrated depending on the order variant.

The 7SD610 can also operate in conjunction with an external automatic reclosure device. In this case, the signal exchange between 7SD610 and the external reclosure device must be effected via binary inputs and outputs.

It is also possible to initiate the integrated auto reclose function by an external protection device (e.g. a backup protection). The use of two 7SD610 with automatic reclosure function or the use of one 7SD610 with an automatic reclosure function and a second protection with its own automatic reclosure function is also possible.

2.10.1 Function Description

Reclosure is performed by an automatic reclosure circuit (ARC). An example of the normal time sequence of a double reclosure is shown in the figure below.

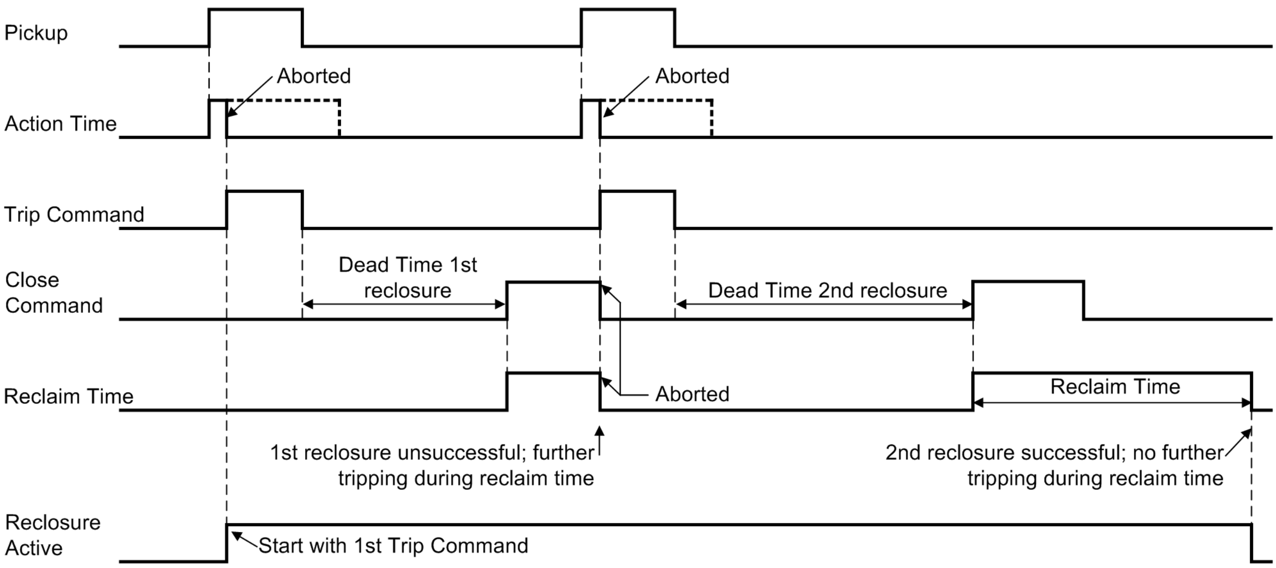


Figure 2-43 Timing diagram of a double-shot reclosure with action time (2nd reclosure successful)

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

Activation and deactivation

The automatic reclosure function can be switched on and off by means of the parameter 3401 **AUTO RECLOSE**, via the system interface (if available) and via binary inputs (if allocated). The switch states are saved internally (refer to Figure 2-44) and secured against loss of auxiliary supply. It is only possible to switch on from the source from where it had previously been switched off. 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 system interface is not possible during a running fault.

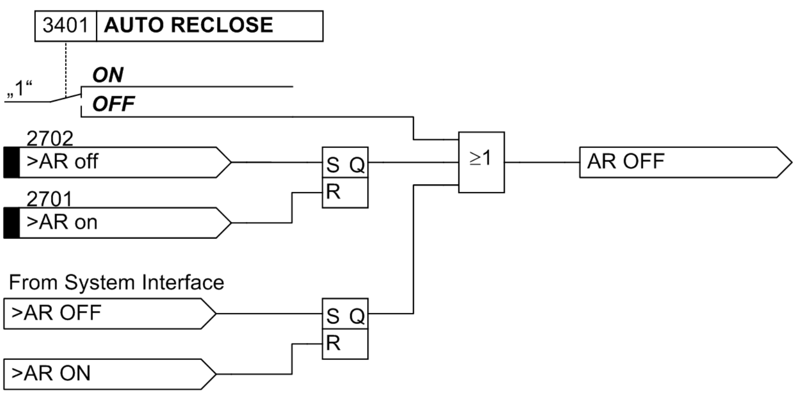


Figure 2-44 Activation and deactivation of the auto-reclosure function

Selectivity before Reclosure

In order for the automatic reclosure to be successful, all faults on the entire overhead line must be cleared at all line ends simultaneously — as fast as possible.

This is the usual case in differential protection schemes because the strict selective zone definition of the protected object by the current transformer sets always allows non-delayed tripping.

However, fast tripping of the protection may also be desired before reclosure after tripping by other short-circuit protection functions. For this purpose, every short-circuit protection which can start the automatic reclosure function has the possibility of initiating non-delayed tripping in at least one stage when the automatic reclosure function is ready for the first reclosure cycle. Please note, however, that fast, non-selective tripping should be avoided as long as the differential protection works properly: there should be no non-delayed tripping of the overcurrent time protection as the backup protection function, even if there is an automatic reclosure.

Fast tripping before reclosure is also possible with multiple reclosures. Appropriate links between the output signals (e.g. 2nd reclosure ready: „`AR 2.CycZoneRel`“) and the inputs for enabling/releasing non-delayed tripping of the protection functions can be established via the binary inputs and outputs or the integrated user-definable logic functions (CFC).

Initiation

Initiation of the automatic reclosure means storing the first trip signal of a power system fault that was generated by a protection function which operates with the automatic reclosure function. In case of multiple reclosure, initiation therefore only takes place once, with the first trip command. This storing of the first trip signal is the prerequisite for all subsequent activities of the automatic reclosure function. The starting is important when the first trip command has not appeared before expiry of an action time (see below under „Action times“).

Automatic reclosure is not started if the circuit breaker has not been ready for at least one OPEN-CLOSE-OPEN–cycle at the instant of the first trip command. This can be achieved by setting parameters. For further information, please refer to „Interrogation of Circuit Breaker Ready State“.

Each short-circuit protection function can be parameterized as to whether it should operate with the automatic reclose function or not, i.e. whether it should start the reclose function or not. The same goes for external trip commands applied via binary input and/or the trip commands generated by the teleprotection via permissive or intertrip signals.

Those protection and monitoring functions in the device which do not respond to short-circuits or similar conditions (e.g. an overload protection) do not initiate the automatic reclosure function because a reclosure will be of no use here. The breaker failure protection must not start the auto-reclosure either.

Action Times

It is often desirable to remove the ready-for-reclosure-state if the short-circuit condition was sustained for a certain time, e.g. because it is assumed that the arc has burned in to such an extent that there is no longer any chance of automatic arc extinction during the reclose dead time. Also for reasons of selectivity (see above), faults that are usually cleared after a time delay should not lead to reclosure.

The automatic reclosure function of the 7SD610 can be operated with or without action times (configuration parameter **`AR control mode`**, address `134`, see Section 2.1.1.2). No starting signal is necessary from the protection functions or external protection devices that operate without action time. Initiation takes place as soon as the first trip command appears.

When operating with action time, an action time is available for each reclose cycle. The action times are always started by the general starting signal (with logic OR combination of all internal and external protection functions which can start the automatic reclose function). If no trip command is present before the action time expires, the corresponding reclosure cycle is not carried out.

For each reclosure cycle, you may set whether or not it allows the initiation. Following the first general pickup, only the action times of those cycles that are set such that they may start off the recloser are considered since the other cycles are not allowed to be the first cycle under any circumstances. By means of the action times and the permission to start the recloser (permission to be the first cycle that is executed) it is possible to determine which reclose cycles are executed depending on the time used by the protection function to trip.

Example 1: 3 cycles are set. Starting of the auto-reclosure is allowed for at least the first cycle. The action times are set as follows:

- 1st Reclosure: T Action = 0.2 s;
- 2nd Reclosure: T Action = 0.8 s;
- 3rd Reclosure: 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 therefore started (the first cycle is initiated). After unsuccessful reclosure the 2nd cycle would then become active; but the time overcurrent protection would not trip in this example until after 1s 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 carried out now. If the trip command only appeared more than 1.2s after the 1st reclosure, there would have been no further reclosure.

Example 2: 3 cycles are set. Starting is only allowed for the first. The action times are set as in example 1. The first protection trip takes place 0.5 s after starting. Since the action time for the 1st cycle has already expired at this time, this cannot start the automatic reclose function. As the 2nd and 3rd cycles are not permitted to start the reclose function they will also not be initiated. Therefore no reclosure takes place as no starting took place.

Example 3: 3 cycles are set. At least the first two cycles are set such that they can start the recloser. The action times are set as in example 1. The first protection trip takes place 0.5 s after starting. Since the action time for the 1st cycle has already expired at this time, it cannot start the automatic reclosure function, but the 2nd cycle, for which initiating is allowed, is activated immediately. This 2nd cycle therefore starts the automatic reclosure circuit, the 1st cycle is practically skipped.

Operating 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 operating mode selected when determining the function scope and the resulting signals of the starting protective functions.

In control mode ***TRIP...*** (With TRIP command ...) single-pole or single-/three-pole reclose cycles are possible if the device and the circuit breaker are suitable. In this case, different dead times (for every AR cycle) are possible after single-pole tripping and after three-pole tripping. The protective function that issues the trip command determines the type of trip: Single-pole or three-pole. The dead time is controlled dependent on this.

In control mode ***PICKUP ...*** (With PICKUP...) different dead times can be set for every reclose cycle after single-, two- and three-phase faults. Here the decisive factor is the pickup diagram of the protective functions at the instant the trip command disappears. This mode enables to make the dead times dependent on the type of fault in the case of three-pole reclose cycles.

Blocking reclosure

Different conditions lead to blocking of the 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 blocking takes place (see below).

Each individual cycle may also be blocked via binary input. In this case the cycle concerned is declared as invalid and will be skipped in the sequence of permissible cycles. If blocking takes place while the cycle concerned is already running, this leads to aborting of the reclosure, i.e. no reclosure takes place even if other valid cycles have been parameterized.

Internal blocking signals, with a limited duration, arise during the course of the reclose cycles:

The blocking time **T-RECLAIM** (address 3403) is started with each automatic reclosure command. The only exception is the ADT mode where the blocking time can be disabled by setting it to 0 s. If the reclosure is successful, all functions of the automatic reclosure return to the idle state at the end of the blocking time; a fault after expiry of the blocking time is treated as a new fault in the power system. If the blocking time is disabled in ADT mode, each new trip after reclosing is considered as a new fault. If one of the protective functions causes another trip during the blocking time, the next reclosure cycle will be started if multiple reclosure has been set. If no further reclosure attempts are permitted, the last reclosure is regarded as unsuccessful in case of another trip during the blocking time. The automatic reclosure is blocked dynamically.

The dynamic lock-out locks the reclosure for the duration of the dynamic lock-out time (0.5 s). This occurs, for example, after a final tripping or other events which block the auto reclose function after it has been started. Restarting is locked out for this time. When this time expires, the automatic reclosure function returns to its quiescent state and is ready for a new fault in the network.

If the circuit breaker is closed manually (by the control discrepancy switch connected to a binary input, the local control functions or via one of the serial interfaces), the automatic reclosure is blocked for a manual-close-blocking time **T-BLOCK MC**, address 3404. If a trip command occurs during this time, it can be assumed that a metallic short-circuit is present (e.g. closed earth switch). Every trip command within this time is therefore final. With the user definable logic functions (CFC) further control functions can be processed in the same way as a manual–close command.

Interrogation of the Circuit Breaker Ready State

A precondition for automatic reclosure following clearance of a short-circuit is that the circuit breaker is ready for at least one OPEN-CLOSE-OPEN-cycle when the automatic reclosure circuit is started (i.e. at the time of the first trip command). The readiness of the circuit breaker is signalled to the device via the binary input „>CB1 Ready“ (No. 371). If no such signal is available, the circuit-breaker interrogation can be suppressed (presetting of address 3402) as automatic reclosure would otherwise not be possible at all.

In the event of a single cycle reclosure this interrogation is usually sufficient. Since, for example, the air pressure or the spring tension for the circuit breaker mechanism drops after the trip, no further interrogation should take place.

Especially when multiple reclosing attempts are programmed, it is recommended to monitor the circuit breaker condition not only prior to the first, but also before each following reclosing attempt. Reclosure will be blocked until the binary input indicates that the circuit breaker is ready to complete another CLOSE-TRIP cycle.

The time needed by the circuit breaker to regain the ready state can be monitored by the 7SD610. This monitoring time **CB TIME OUT** (address 3409) starts as soon as the CB indicates the not ready state. The dead time may be extended if the ready state is not indicated when it expires. However, if the circuit breaker does not indicate its ready status for a longer period than the monitoring time, reclosure is dynamically blocked (see also above under margin heading „Reclosure Blocking“).

Processing the circuit breaker auxiliary contacts

If the circuit breaker auxiliary contacts are connected to the device, the reaction of the circuit breaker is also checked for plausibility.

In the case of single-pole tripping this applies to each individual breaker pole. This assumes that the auxiliary contacts are connected to the appropriate binary inputs for each pole („`>CB1 Pole L1`“, No. 366; „`>CB1 Pole L2`“, No. 367; „`>CB1 Pole L3`“, No. 368).

If, instead of the individual pole auxiliary contacts, the series connections of the normally open and normally closed contacts are used, the CB is assumed to have all three poles open when the series connection of the normally closed contacts is closed (binary input „`>CB1 3p Open`“, No. 411). All three poles are assumed closed when the series connection of the normally open contacts is closed (binary input „`>CB1 3p Closed`“, No. 410). If none of these input indications is active, it is assumed that the breaker is open at one pole (even if this condition also exists theoretically when two poles are open).

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

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

If, after a **single-**pole trip command, the CB has opened **three-**pole, this is considered as a three-pole tripping. If three-pole reclose cycles are allowed, the dead time for three-pole tripping becomes active in the **operating mode with trip command** (see margin heading „Operating modes of the automatic reclosure“, above); in control by pickup the pickup diagram of the starting protective function(s) still applies. If three-pole cycles are not allowed, the reclosure is blocked dynamically. The trip command was final.

The latter also applies if the CB trips two poles following a single-pole trip command. The device can only detect this if the auxiliary contacts of each pole are connected individually. The device immediately initiates three pole coupling which results 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 reclose cycle is initiated with the dead time for three-pole reclosure provided that this is permitted. If the auxiliary contacts are connected for each pole individually, the device can detect a two-pole open CB. In this case the device immediately sends a three-pole trip command provided that the forced three-pole trip is activated (see Section 2.10.2 at margin heading „Forced three-pole trip“).

Sequence of a three-pole reclose cycle

If the automatic reclosure function is ready, the fault protection trips three-pole for all faults inside the stage selected for reclosure. The automatic reclosure function is started. When the trip command resets or the circuit breaker opens (auxiliary contact criterion) a(n) (adjustable) dead time starts. At the end of this dead time, the circuit breaker receives a close command. At the same time, the (adjustable) blocking time is started. If, when configuring the protective functions, at address 134 **`AR control`**

mode = ***with Pickup*** was set, different dead times can be parameterised depending on the type of fault recognised by the protection.

If the fault is cleared (successful reclosure), the reclaim time expires and all functions return to their quiescent state. The fault is cleared.

If the fault has not been eliminated (unsuccessful reclosure), the short-circuit protection initiates a final trip following a protection stage active without reclosure. Any fault during the reclaim time leads to a final trip.

After unsuccessful reclosure (final tripping) the automatic reclosure is blocked dynamically (see also margin heading „Reclose Block“, above).

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

Sequence of a single-pole reclose cycle

Single-pole reclose cycles are only possible with the appropriate device version and if this was selected during the configuration of the protective functions (address 110 **Trip mode**, see also Section 2.1.1.2). Of course, the circuit breaker must also be suitable for single-pole tripping.

If the automatic reclosure function is ready, the short-circuit protection trips single-pole for all single-phase faults inside the stage(s) selected for reclosure. Under the general settings (address 1156 **Trip2phFlt**, see also Section 2.1.4.1) it can also be selected that single-pole tripping takes place for two-phase faults without earth. Single-pole tripping is of course only possible by short-circuit protective functions which can determine the faulty phase.

If multiple-phase faults occur, the fault protection issues a final three-pole trip with the stage that is valid without reclosure. Any three-pole trip is final. The automatic reclosure function is blocked dynamically (see also margin heading „Blocking reclosure“, above).

The automatic reclosure is started in the case of single-pole tripping. The (adjustable) dead time for the single-pole reclose cycle starts with reset of the trip command or opening of the circuit breaker pole (auxiliary contact criterion). After expiry of the dead time, the circuit breaker receives a close command. At the same time, the (adjustable) blocking 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).

If the fault is cleared (successful reclosure), the reclaim time expires and all functions return to their quiescent state. The fault is cleared.

If the fault has not been eliminated (unsuccessful reclosure), the short-circuit protection initiates a final three-pole trip following the protection stage valid without reclosure. Any fault during the blocking time leads to a final three-pole trip.

After unsuccessful reclosure (final tripping) the automatic reclosure is blocked dynamically (see also margin heading „Reclose Block“, above).

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

Sequence of a single- and three-pole reclose cycle

This operating mode is only possible with the appropriate device version and if this was selected during configuration of the protective functions (address 110, see also Section 2.1.1.2). Of course, the circuit breaker must also be suitable for single-pole tripping.

If the automatic reclosure function is ready, the short-circuit protection trips single-pole for single-phase faults inside the stage(s) selected for reclosure, it trips three-pole for multiple-phase faults. In the general settings (address 1156 **Trip2phFlt**, see also Section 2.1.4.1) it can also be selected that single-pole tripping takes place for two-phase faults without earth. Single-pole tripping is of course only possible for short-circuit protective functions which can determine the faulty phase. The valid protection stage selected for reclosure ready state applies to 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 reclose cycle or the (separately adjustable) dead time for the three-pole reclose cycle starts following the reset of the trip command or opening of the circuit breaker (pole) (auxiliary contact criterion). After expiry of the dead time, the circuit breaker receives a close command. At the same time, the (adjustable) blocking 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).

If the fault is cleared (successful reclosure), the reclaim time expires and all functions return to their quiescent state. The fault is cleared.

If the fault has not been eliminated (unsuccessful reclosure), the short-circuit protection initiates a final three-pole trip with the protection stage valid without reclosure. Any fault during the blocking time leads to a final three-pole trip.

After unsuccessful reclosure (final tripping), the automatic reclosure is blocked dynamically (see also margin heading „Reclose Block“, above).

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

Multiple auto-reclosure

If a short-circuit still exists after a reclosure attempt, further reclosure attempts can be made. Up to 8 reclosure attempts are possible with the automatic reclosure function integrated in the 7SD610.

The first four reclose 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 to the fifth cycle and onwards.

The sequence is the same in principle as in the different reclosure programs described above. However, if the first reclosure attempt was unsuccessful, the reclosure function is not blocked, but instead the next reclose cycle is started. The appropriate dead time starts with the reset of the trip command or opening of the circuit breaker (pole) (auxiliary contact criterion). The circuit breaker receives a new close command after expiry of the dead time. At the same time the reclaim time is started.

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 reclosing attempts is successful, i.e. the fault disappeared after reclosure, the blocking time expires and the automatic reclosing system is reset. The fault is cleared.

If none of the cycles is successful, the short-circuit protection initiates a final three-pole trip after the last permissible reclosure, following a protection stage valid without auto-reclosure. The automatic reclosure function is blocked dynamically (see also margin heading „Blocking reclosure“, above).

Handling Evolving Faults

When single-pole or single-and three-pole reclose cycles are executed in the network, particular attention must be paid to sequential faults.

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

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

For the **Detection** of an evolving fault you can select whether the trip command of a protective function during the dead time or every further 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.

- **EV. FLT. MODE** ***Stops AutoRecl***:

  The reclosure is blocked as soon as a sequential fault is detected. The tripping by the sequential fault is always three-pole. This applies irrespective of whether three-pole cycles have been permitted or not. There are no further reclosure attempts; the automatic reclosure is blocked dynamically (see also margin heading „Blocking reclosure“, above).

- **EV. FLT. MODE** ***starts 3p AR***:

  As soon as a sequential fault is detected, the recloser switches to a three-pole cycle. Each trip command is three-pole. The separately settable dead time for sequential faults starts with the clearance of the sequential fault; after the dead time the circuit breaker receives a close command. The further sequence is the same as for 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 sequential fault plus the dead time for the sequential fault. This makes sense because the duration of the three-pole dead time is most important for the stability of the network.

If reclosure is blocked due to a sequential fault without the protection issuing a three-pole trip command (e.g. for sequential fault detection with starting), 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. By setting a parameter, you can achieve that the tripping logic of the device immediately sends 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 protective functions initiate a single-pole trip in different phases, the device will issue a three-pole trip command due to the tripping logic (Section 2.16.1), independent of this forced three-pole trip. This is also true for trip commands given via the direct local trip inputs (Section 2.6) or the reception of a remote trip (Section 2.7) since these signals directly affect the tripping logic of the device.

If the device trips single-pole and if an external trip command in another phase only reaches the device via one of the binary inputs, e.g. „>Trip L1 AR“ to the internal automatic reclosure function, this is not routed to the tripping logic. In this case, three-pole trip is ensured only if the forced three-pole trip is effective.

The forced three-pole trip is also activated when only three-pole cycles are allowed, but a single-pole trip is signalled externally via a binary input.

Dead Line Check (DLC)

If the voltage of a disconnected phase does not disappear following a trip, reclosure can be prevented. A prerequisite for this function is that the voltage transformers are connected on the line side of the circuit breaker. To select this function the dead line check must be activated. The automatic reclosure function then checks the disconnected line for no-voltage: the line must have been without voltage for at least an adequate measuring time during the dead time. If this was not the case, the reclosure is blocked dynamically.

This no-voltage check on the line is of advantage if a small generator (e.g. wind generator) is connected along the line.

Adaptive Dead Time (ADT)

In all the previous alternatives it was assumed that defined and equal dead times were set at both line ends, if necessary for different fault types and/or reclose cycles.

It is also possible to set the dead times (if necessary different for various fault types and/or reclose cycles) at one line end only and to configure the adaptive dead time at the other end. This can be done provided that the voltage transformers are located on the line side of the circuit breaker or that a means for transfer of a close command to the remote line end exists.

Figure 2-45 shows an example with voltage measurement. 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 at least fed from busbar A, i.e. the side with the defined dead times.

With the adaptive dead time, the automatic reclosure function at line end II decides independently if and when reclosure is sensible and allowed 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 apparent that voltage has been re-applied to the line from end I. All phase-to-phase and phase-to-earth voltages are monitored.

In the illustrated example, the lines are disconnected at positions I, and II. At 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 cleared.

If the fault has not been cleared after reclosure at I (unsuccessful reclosure), a switch on to fault occurs at I, no healthy voltage appears at II. The device there detects this and does not reclose.

In the case of multiple reclosure the sequence may be repeated several times following an unsuccessful reclosure until one of the reclosures attempts is successful or a final trip takes place.

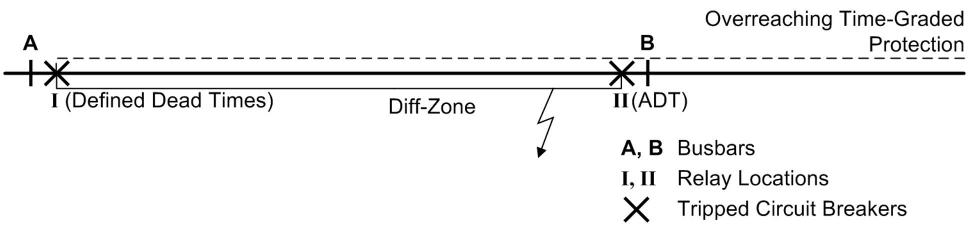


Figure 2-45 Example of adaptive dead time (ADT)

A, B Busbars

I, II Relay locations

As is shown by the example, the adaptive dead time has the following advantages:

- The circuit breaker at position II is not reclosed at all if the fault persists and is not unnecessarily stressed as a result.
- With non-selective tripping on an external fault by an overreaching time-graded protection, no further auto-reclosure attempts can be generated there because the fault current path via busbar B and position II remains interrupted even after several reclosure attempts.
- At position I overreach is allowed in the case of multiple reclosures and even in the event of final tripping because the line remains open at position II and therefore no actual overreach can occur at I.

CLOSE Command Transmission (Remote-CLOSE)

With close command transmission via the digital connection path the dead times are only set at one line end. The other end is set to "Adaptive Dead Time (ADT)". The latter only react to the received close commands from the transmitting end. An adaptive dead time is thus possible even without a voltage.

The transmission of the close command by the transmitting line end is delayed until it is sure that the local reclosure was successful. This means that after reclosure a possible local pickup is still waited for. This delay prevents unnecessary closing at the remote end on the one hand but also increases the time until reclosure takes place there. This is not critical for a single-pole reclosure or in radial or meshed networks if no stability problems are expected under these conditions.

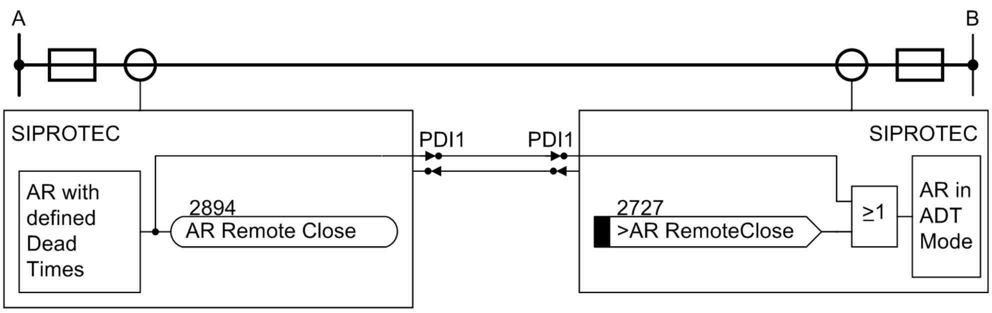


Figure 2-46 AR Remote-Close function via protection data interface

The close command can be transmitted by a teleprotection scheme using the protection data interfaces. When the indication „`AR Remote Close`“ is output, this information is transmitted at the same time to the remote end via the protection data interface. The information is OR-combined with the information of the binary input „`>AR RemoteClose`“ and made available to the automatic reclosure. (Figure 2-46).

Connecting an External Auto-Reclosure Device

If the 7SD610 has to work with an external reclosure device, the binary inputs and outputs provided for this purpose must be taken into consideration. The following inputs and outputs are recommended:

Binary inputs:

381 „>1p Trip Perm“	The external reclosure device allows one-pole tripping (logic inversion or three-pole coupling). If this input is not assigned or not routed (matrix), the protection functions trip three-pole for all faults. If the external reclosure device cannot supply this signal but supplies a „three-pole coupling“ signal instead, this must be taken into account in the allocation of the binary inputs: the signal must be inverted in this case (L-active = active without voltage).

Binary outputs:

501 „Relay PICKUP“	Start of protection device, general (if required by external recloser device).
512 „Relay TRIP 1pL1“	Trip of the device 1-pole L1.
513 „Relay TRIP 1pL2“	Trip of the device 1-pole L2.
514 „Relay TRIP 1pL3“	Trip of the device 1-pole L3.
515 „Relay TRIP 3ph.“	Trip protective device 3-pole.

In order to obtain a phase-segregated trip indication, the respective single-pole trip commands must be combined with the three-pole trip command on one output.

Figure, 2-47 for example, shows the interconnection between a 7SD610 and an external reclosure device with a mode selector switch.

Depending on the external reclosure device requirements, the three-pole indications (No. 512, 513, 514) can be combined to one „single-pole tripping“ output; No. 515 sends the „three-pole tripping“ signal to the external device.

In case of exclusively three-pole reclose cycles, the general pickup signal (No. 501, if required by the external reclosure device) and trip signal (No. 511) of 7SD610 (see Figure 2-48) are usually sufficient.

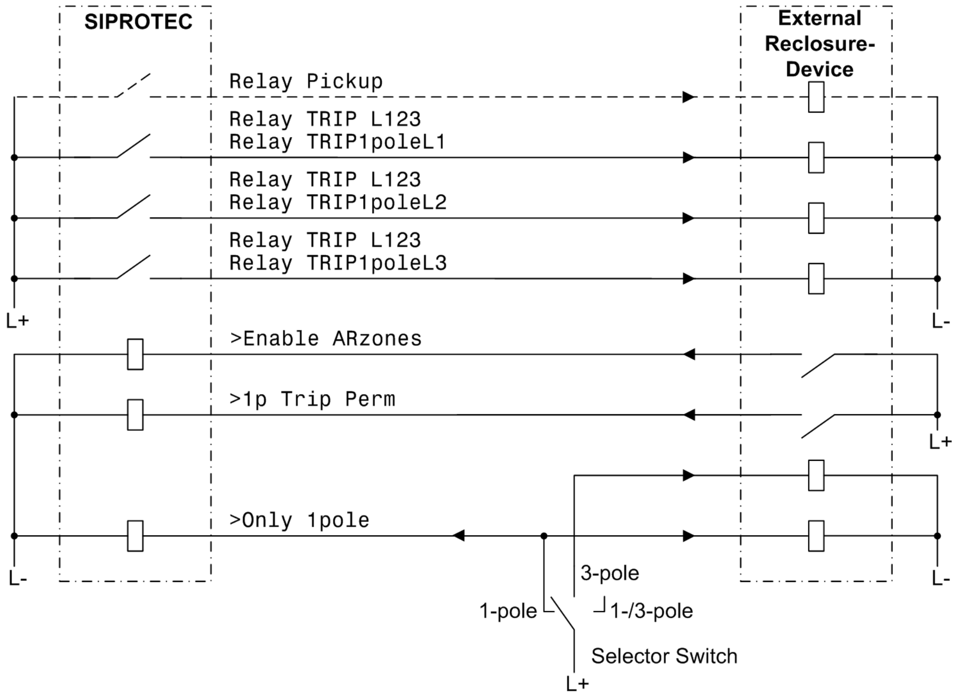


Figure 2-47 Connection example with external auto-reclosure device for 1-/3-pole AR with mode selector switch

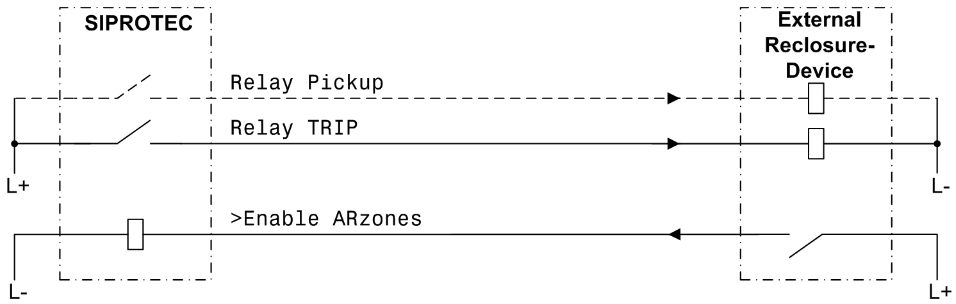


Figure 2-48 Connection example with external reclosure device for 3-pole AR

Control of the internal automatic reclosure by an external protection device

If the 7SD610 is equipped with the internal automatic reclosure function, it may also be controlled by an external protection device. This is of use, for example, on line ends with redundant protection or additional back-up protection when the second protection is used for the same line end and has to work with the automatic reclosure function integrated in the 7SD610.

The binary inputs and outputs provided for this functionality must be considered in this case. It must be decided whether the internal auto-reclosure is to be controlled by the starting (pickup) or by the trip command of the external protection (see also above under „Control Mode of the Automatic Reclosure“).

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

The automatic reclosure function is started via the Binary inputs:

2711 „`>AR Start`“	General fault detection for the automatic reclosure circuit (only required for action time),
2712 „`>Trip L1 AR`“	Trip command L1 for the automatic reclosure circuit,
2713 „`>Trip L2 AR`“	Trip command L2 for the automatic reclosure circuit,
2714 „`>Trip L3 AR`“	Trip command L3 for the automatic reclosure circuit.

The general fault detection determines the starting of the action times. It is also necessary if the automatic reclosure circuit is to detect sequential 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 reclose cycles is activated or whether the reclosure is blocked in three-pole tripping (depending on the parameterisation of dead times).

Figure 2-49 shows the interconnection between the internal automatic reclosure of 7SD610 and an external protection device, as a connection example for single-pole cylces.

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

2864 „`AR 1p Trip Perm`“	Internal automatic reclosure function ready for single-pole reclose cycle, i.e. allows single-pole tripping (logic inversion of the three-pole coupling).
2889 „`AR 1.CycZoneRel`“	Internal automatic reclosure function ready for the first reclose cycle, i.e. releases the stage of the external protection device for reclosure, the corresponding outputs can be used for other cycles. This output can be omitted if the external protection does not require an overreaching stage (e.g. differential protection).
2820 „`AR Program1pole`“	Internal automatic reclosure function is programmed for one pole, i.e. only recloses after single-pole tripping. This output can be omitted if no overreaching stage is required (e.g. differential protection).

Instead of the three phase-segregated trip commands, the single-pole and three-pole tripping may also be signalled to the internal automatic reclosure function - provided that the external protection device is capable of this -, i.e. assign the following binary inputs of the 7SD610:

2711 „`>AR Start`“	General fault detection for the internal automatic reclosure function (only required for action time),
2715 „`>Trip 1pole AR`“	Trip command single-pole for the internal automatic reclosure,
2716 „`>Trip 3pole AR`“	Trip command three-pole for the internal automatic reclosure function,

If only three-pole reclosure cycles are to be executed, it is sufficient to assign the binary input „`>Trip 3pole AR`“ (No. 2716) for the trip signal. Figure 2-50 shows an example. Any overreaching stages of the external protection are enabled again by „`AR 1.CycZoneRel`“ (No. 2889) and, if necessary, of further cycles.

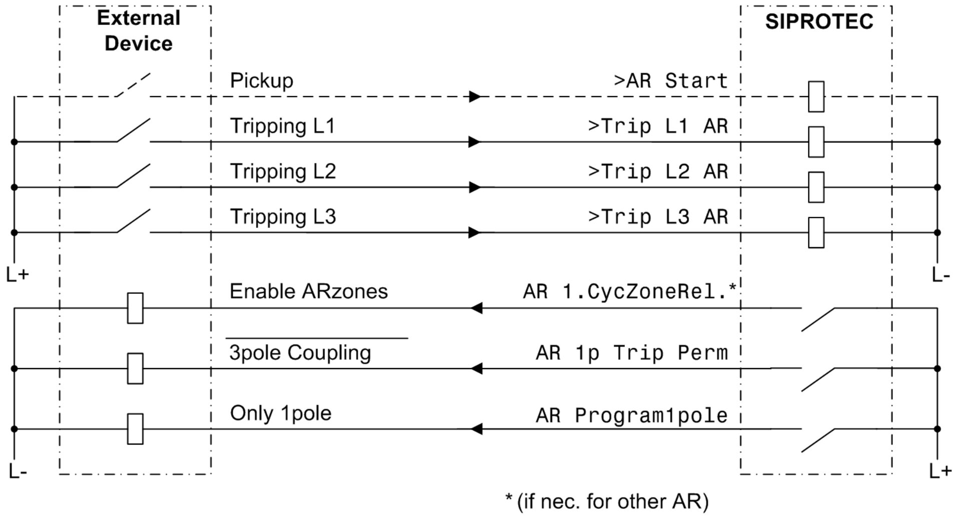


Figure 2-49 Connection example with external protection device for 1-/3-pole reclosure; AR control mode = with TRIP

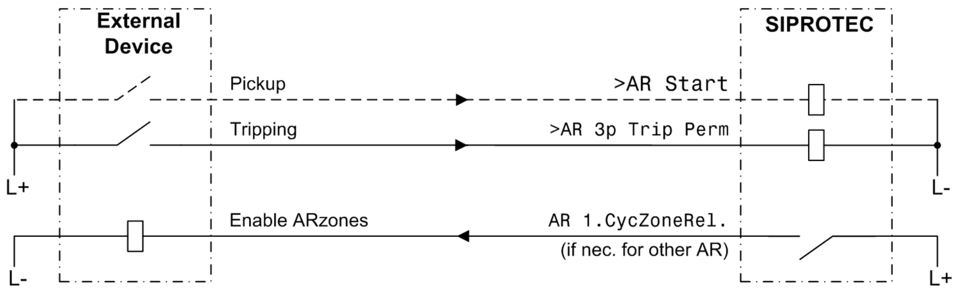
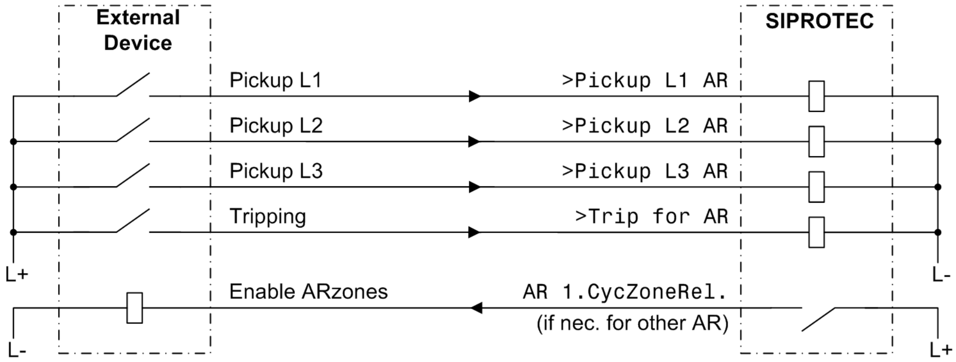
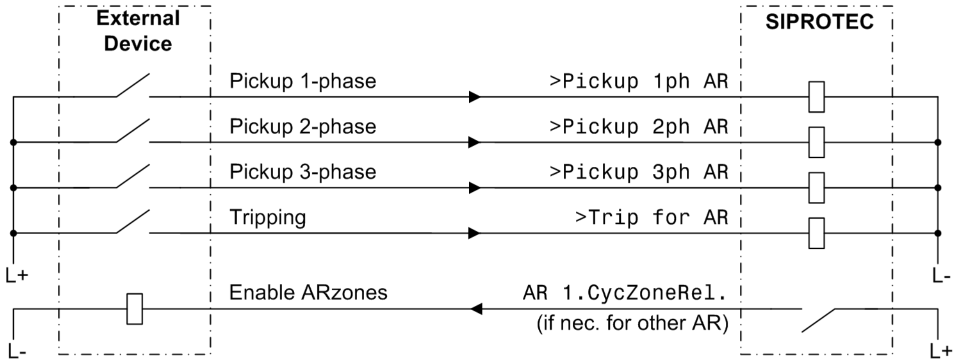


Figure 2-50 Connection example with external protection device for 3-pole reclosure; AR control mode = with TRIP

But if the internal automatic reclose function is controlled by the **pickup** (only possible for three-pole tripping: 110 **`Trip mode`** = ***`3pole only`***), 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 then suffices for tripping (No. 2746). Figure 2-51 shows a connection example.



Starting Signal for each Phase



Starting Signal 1-phase, 2-phase and 3-phase

Figure 2-51 Connection example with external protection device for fault detection dependent dead time — dead time control by pickup signals of the protection device; AR control mode = with PICKUP

2 Protection Relays with 2 Automatic Reclosure Circuits

If redundant protection is provided for a line and each protection operates with its own automatic reclosure function, a certain signal exchange between the two combinations is necessary. The connection example in Figure 2-52 shows the necessary cross-connections.

If phase segregated auxiliary contacts of the circuit breaker are connected, a three-pole coupling by the 7SD610 is ensured when more than one CB pole is tripped. This requires activation of the forced three-pole trip (see Section 2.10.2 at margin heading „Forced three-pole trip“). An external automatic three-pole coupling is therefore unnecessary if the above conditions are met. This prevents two-pole tripping under all circumstances.

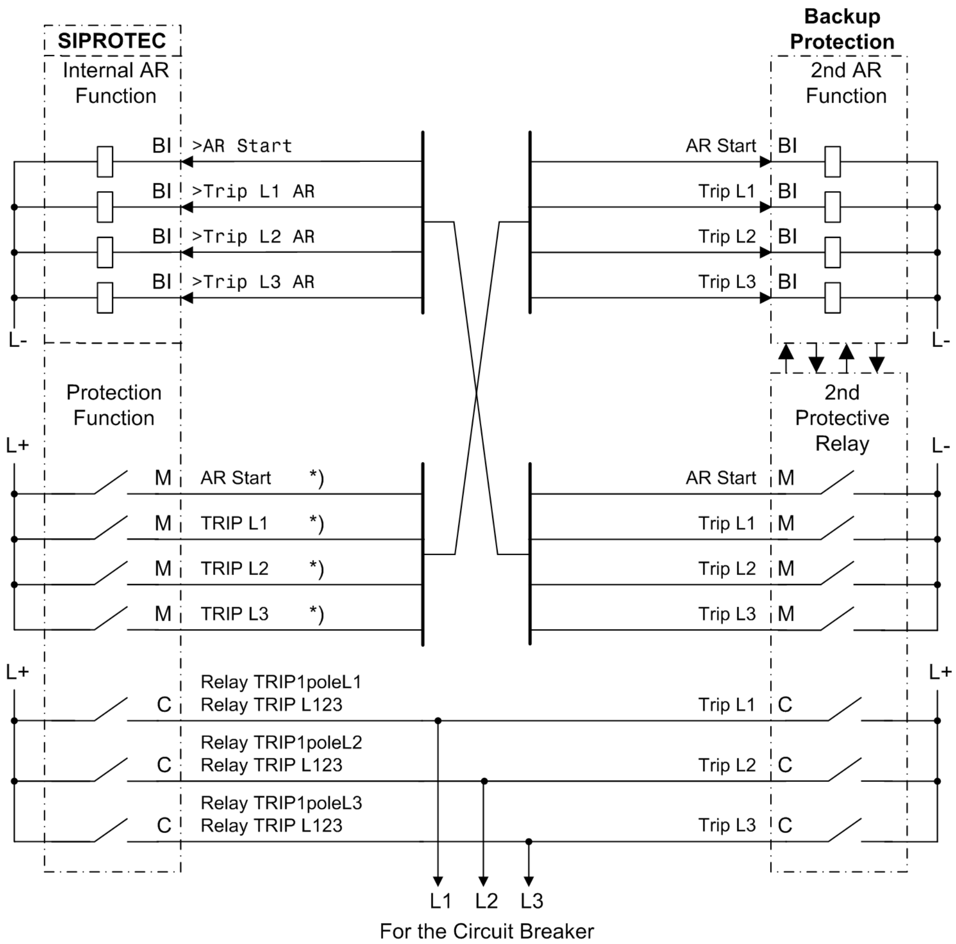


Figure 2-52 Connection example for 2 protection devices with 2 automatic reclosure functions

BI Binary inputs

M Signal output

K Command

*) for all protection functions operating with AR.

2.10.2 Setting Notes

General

If no reclosure is required on the feeder to which the 7SD610 differential protection is applied (e.g. for cables, transformers) the auto reclose function must be removed during configuration of the device (address 133, see Section 2.1.1.2). The auto reclose function is then fully disabled, i.e. the automatic reclosure is not processed in the 7SD610. No signals regarding the auto reclose function are generated, and the binary inputs for the auto reclose function are ignored. All parameters for setting the auto reclose function are inaccessible and of no significance.

If, on the other hand, the internal automatic reclosure function is to be used, the type of reclosure must be selected during the configuration of the functions (see Section 2.1.1.2) in address 133 **Auto Reclose** the AR control mode and in address 134 the **AR control mode**.

Up to 8 reclosure attempts are allowed with the integrated automatic reclosure function in the 7SD610. Whereas the settings in address 3401 to 3441 are common to all reclosure cycles, the individual settings of the cycles are made from address 3450 onwards. It is possible to set different individual parameters for the first four reclose cycles. From the fifth cycle on the parameters for the fourth cycle apply.

The automatic reclosing function can be turned ***ON*** or ***OFF*** under address 3401 **AUTO RECLOSE**.

A prerequisite for automatic reclosure taking place after a trip due to a short-circuit is that the circuit breaker is ready for at least one OPEN-CLOSE-OPEN cycle at the time the automatic reclosure circuit is started, i.e. at the time of the first trip command. The readiness of the circuit breaker is signalled to the device via the binary input „>CB1 Ready“ (No. 371). If no such signal is available, leave the setting under address 3402 **CB? 1.TRIP** = ***NO*** because no automatic reclosure would be possible at all otherwise. If circuit breaker interrogation is possible, you should set **CB? 1.TRIP** = ***YES***.

Furthermore, the circuit breaker ready state can also be interrogated prior to every reclosure. This is set when setting the individual reclose cycles (see below).

To check that the ready status of the circuit breaker is regained during the dead times, you can set a circuit breaker ready 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 is not ready again by the time this timer expires, no reclosure takes place, the automatic reclosure function is blocked dynamically.

Waiting for the circuit breaker to be ready can lead to an increase of the dead times. To avoid uncontrolled prolongation, it is possible to set a maximum prolongation of the dead time in this case in address 3411 **T-DEAD EXT.**. This prolongation is unlimited if the setting ∞ is applied. This parameter can only be altered with DIGSI under **Additional Settings**. Remember that longer dead times are only permissible after three-pole tripping when no stability problems occur.

The reclaim time **T-RECLAIM** (address 3403) defines the time that must elapse, after a successful reclosing attempt, before the auto reclose function is reset. Re-tripping by a protective function within this time initiates the next reclose cycle in the event of multiple reclosure; if no further reclosure is permitted, the last reclosure is treated as unsuccessful. The reclaim time must therefore be longer than the longest response time of a protective function which can start the automatic reclosure circuit. When operating the AR in ADT mode, it is possible to deactivate the reclaim time by setting it to 0 s.

A few seconds are generally sufficient. In areas with frequent thunderstorms or storms, a shorter blocking time may be necessary to avoid feeder lockout due to sequential lightning strikes or cable flashovers.

A longer reclaim time should be chosen where circuit breaker supervision is not possible (see above) during multiple reclosures, e.g. because of missing auxiliary contacts and information on the circuit breaker ready status. In this case, the reclaim time should be longer than the time required for the circuit breaker mechanism to be ready.

The blocking duration following manual-close detection **T-BLOCK MC** (address 3404) must ensure the circuit breaker to open and close reliably (0.5 s to 1 s). If a fault is detected by a protective function within this time after closing of the circuit breaker was detected, no reclosure takes place and a final three-pole trip command is issued. If this is not desired, address 3404 is set to **0**.

The options for handling evolving faults are described in Section 2.10 under margin heading „Handling Evolving Faults“. The treatment of sequential faults is not necessary on line ends where the adaptive dead time is applied (address 133 **Auto Reclose** = ***ADT***). The addresses 3406 and 3407 are then of no consequence and therefore not accessible.

The detection of an evolving fault can be defined under address 3406 **EV. FLT. RECOG.**. **EV. FLT. RECOG.** ***with PICKUP*** means that, during a dead time, every **pickup** of a 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** by a protection function. This may also include trip commands which are coupled in from external via a binary input or which have been transmitted from an opposite 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 from the external device is also connected to the 7SD610; otherwise an evolving fault can only be detected with the external trip command even if ***with PICKUP*** was set here.

The reaction in response to sequential faults can be selected at address 3407. **EV. FLT. MODE** ***Stops AutoRecl*** means that no reclosure is performed after detection of a sequential fault. This is always useful when only single-pole reclosure is to take place or when stability problems are expected due to the subsequent three-pole dead time. If a three-pole reclose cycle is to be initiated by tripping of the sequential fault, set **EV. FLT. MODE** = ***starts 3p AR***. In this case a separately adjustable three-pole dead time is started with the three-pole trip command due to the sequential 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 during this time (from the beginning of the trip command), the automatic reclosure is blocked dynamically. The criterion for circuit breaker opening is the position of the circuit breaker auxiliary contact or the disappearance of the trip command. If a circuit breaker failure protection (internal or external) is used on the feeder, this time should be shorter than the delay time of the circuit breaker failure protection so that no reclosure takes place if the circuit breaker fails.

Note

If the breaker failure protection (BF) is to perform a single-pole TRIP repetition, the time setting of parameter 3408 **T-Start MONITOR** must be longer than the time set for parameter 3903 **1p-RETRIP (T1)**.

To enable that the busbar is tripped by the breaker failure protection without preceding three-pole coupling of the trip command (by AR or BF), the time set for 3408 **T-Start MONITOR** also has to be longer than the time set for 3906 **T2**. In this case, the AR must be blocked by a signal from the BF to prevent the AR from reclosing after a busbar TRIP. It is recommended to connect the signal 1494 „BF T2-TRIP(bus)“ to the AR input 2703 „>AR block“ by means of CFC.

If the reclosure command is transmitted to the opposite end, this transmission can be delayed by the time setting in address 3410 **T RemoteClose**. This transmission is only possible if the device operates with adaptive dead time at the remote end (address 133 **Auto Reclose** = ***ADT***). This parameter is otherwise irrelevant. On the one hand, this delay serves to prevent the remote end device from reclosing unnecessarily when local reclosure is unsuccessful. On the other hand, it should be noted that the line is not available for energy transport until the remote end has also closed. This delay must therefore be added to the dead time for consideration of the network stability.

Configuration of auto-reclosure

This configuration concerns the interaction between the protection and supplementary functions of the device and the auto reclose function. The selection of device functions which are to start the automatic reclosure circuit and which are not to, is made here.

Address 3420	AR WITH DIFF, i.e. with differential protection
Address 3421	AR w/ SOTF-O/C, i.e. with high-current switch-onto-fault function
Address 3423	AR WITH I.TRIP, i.e. with permissive underreach transfer trip (PUTT)
Address 3424	AR w/ DTT, i.e. with direct transfer trip
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 other functions cannot start the automatic reclosure because reclosure is of little use here.

Forced three-pole trip

If a blocking of the auto-reclosure occurs during the dead time of a 1-pole cycle without a previous 3-pole trip command, the breaker remains open at one pole. With address 3430 **AR TRIP 3pole** it is possible to determine that the tripping logic of the device issues a three-pole trip command in this case (pole discrepancy prevention for the CB poles). Set this address to ***YES*** if the CB can be tripped single-pole and if it has no pole discrepancy protection. 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 (see also Section 2.10 at margin heading „Processing the circuit breaker auxiliary contacts“). The forced three-pole trip is also activated when only three-pole cycles are allowed, but a single-pole trip is signalled externally via a binary input.

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

Dead line check / reduced dead time

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 of the line voltage is used. This only enables reclosure after it becomes apparent that the line is 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 applied in Volts secondary. This value can be entered as a primary value when parameterising with a PC and DIGSI. Address 3438 **T U-stable** determines the measuring time available for determining the no-voltage condition. Address 3440 is irrelevant here.

Adaptive dead time (ADT)

When operating with adaptive dead time, it must be ensured in advance that **one** end per line operates with defined dead times and has an infeed. The other (or the others in multi-branch lines) may operate with adaptive dead time. It is essential that the voltage transformers are located on the line side of the circuit breaker. Details about this function can be found in Section 2.10 at margin heading „Adaptive Dead Time (ADT) and Close Command-transfer (Remote-CLOSE)“.

For the line end with defined dead times the number of desired reclose cycles must be set during the configuration of the protective functions (Section 2.1.1) in address 133 **Auto Reclose**. Additionally, the intertrip command of the differential protection should be activated (see Section 2.4, address 1301 **I-TRIP SEND** = ***YES***). For the devices operating with adaptive dead time, address 133 **Auto Reclose** must have been set to ***ADT*** during the configuration of the protective functions (Section 2.1.1). Only the parameters described below are interrogated in the latter case. No settings are then made for the individual reclosure cycles.

The adaptive dead time may be voltage-controlled or Remote–CLOSE–controlled. Both are possible at the same time. In the first case, reclosure takes place as soon as the returning voltage, after reclosure at the remote end, is detected. For this purpose the device must be connected to voltage transformers located on the line side. In the case of Remote-CLOSE, the autoreclosure waits until the Remote-CLOSE command is received from the remote end.

The action time **T-ACTION ADT** (address 3433) is the timeframe after initiation (fault detection) by any protective function which can start the automatic reclosure function within which the trip command must appear. If no trip command is issued until the action time has expired, there is no reclosure. Depending on the configuration of the protective functions (see Section 2.1.1.2), the action time may also be omitted; this applies especially when an initiating protective function has no fault detection signal.

The dead times are determined by the reclosure command of the device at the line end with the defined dead times. In cases where this reclosure command does not appear, e.g. because the reclosure was in the meantime blocked at this end, the readiness of the local device must return to the quiescent state at some time. This takes place after the maximum wait time **T-MAX ADT** (address 3434). This must be long enough to include the last reclosure of the remote end. In the case of single cycle reclosure, the sum total of maximum dead time plus reclaim time of the other device is sufficient. In the case of multiple reclosure the worst case is that all reclosures of the other end except the last one are unsuccessful. The time of all these cycles must be taken into account. To save having to make exact calculations, it is possible to use the sum of all dead times and all protection operating times plus one reclaim time.

At address 3435 **ADT 1p allowed** it can be determined whether single-pole tripping is allowed (provided that single-pole tripping is possible). If ***NO***, the protection trips three-pole for all fault types. If ***YES***, the actual trip signal of the starting protective functions is decisive. If the blocking time is unequal to 0 s and single-pole tripping is allowed, single-pole tripping will be prevented during the blocking time. Each fault is thus disconnected in three poles while the blocking time expires.

Address 3403 **T-RECLAIM** allows disabling the blocking time in ADT mode. In doing so, the ADT cycle including its settings and release conditions is restarted after unsuccessful automatic reclosing. If the blocking time is activated, the single-pole permission at address 3435 and the protection releases are disabled while the blocking time expires.

Under address 3436 **ADT CB? CLOSE** it can be determined whether circuit breaker ready is interrogated before reclosure after an adaptive dead time. With the setting ***YES***, the dead time may be extended if the circuit breaker is not ready for a CLOSE–OPEN–cycle when the dead time expires. The maximum extension that is possible is the circuit breaker monitoring time; this was set for all reclosure cycles under address 3409 (see above). Details about the circuit breaker monitoring can be found in the function description, Section 2.10, at margin heading „Interrogation of the Circuit Breaker Ready State“.

If there is a danger of stability problems in the network during a three-pole reclosure cycle, 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 feeder and busbar are sufficiently synchronous. This is only done on condition that either the internal synchronism and voltage check functions are available, or that an external device is available for synchronism and voltage check. If only single-pole reclose cycles are executed or if no stability problems are expected during three-pole dead times (e.g. due to closely meshed networks or in radial networks), set address 3437 to ***NO***.

Addresses 3438 and 3440 are only significant if the voltage-controlled adaptive dead time is used. 3440 **U-live>** is the phase-earth voltage limit above which the line is considered to be fault-free. The setting must be smaller than the lowest expected operating voltage. The setting is applied in Volts secondary. This value can be entered as a primary value when parameterising with a PC and DIGSI. Address 3438 **T U-stable** establishes the measuring time used to determine that the line is fault-free with this returning voltage. It should be longer than any transient oscillations resulting from line energization.

1st reclosure cycle

If working on a line with adaptive dead time, no further parameters are needed for the individual reclose cycles in this case. All the following parameters assigned to the individual cycles are then superfluous and inaccessible.

Address 3450 **1.AR: START** is only available if the automatic reclosure is configured with action time in the operating mode, i. e. if during configuration of the protective functions (see Section 2.1.1.2) address 134 **AR control mode** = ***Pickup w/ Tact*** or ***Trip w/ Tact*** was set (the first setting only applies to three-pole tripping). It determines whether automatic reclosure should be started at all with the first cycle. This address is included mainly due to the uniformity of the parameters for every reclosure attempt and is set to ***YES*** for the first cycle. If several cycles are performed, you can (at **AR control mode** = ***Pickup ...***) set this parameter and different action times to control the effectiveness of the individual cycles. Notes and examples are listed in Section 2.10 at margin heading „Action times“.

The action time **1.AR: T-ACTION** (address 3451) is the timeframe after initiation (fault detection) by any protective function which can start the automatic reclosure function within which the trip command must appear. If no trip command is issued until the action time has expired, there is no reclosure. Depending on the configuration of the protective functions, the action time may also be omitted; this applies especially when an initiating protective function has no fault detection signal.

Depending on the configured operating mode of the automatic reclosure (address 134 **AR control mode**) only address 3456 and 3457 (if **AR control mode** = ***with TRIP...***) are available or address 3453 to 3455 (if **AR control mode** = ***with PICKUP ...***).

In **AR control mode** = ***with TRIP ...*** you can set different dead times for single-pole and three-pole reclose cycles. Whether single-pole or three-pole tripping is triggered depends solely on the initiating protective functions. Single-pole tripping is of course only possible if the device and the corresponding protective function are also capable of single-pole tripping:

Table 2-5 AR control mode = **with TRIP...**

3456	1.AR Tdead1Trip	is the dead time after single-pole tripping,
3457	1.AR Tdead3Trip	is the dead time after three-pole tripping.

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

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

For three-pole tripping (address 3457 **1.AR Tdead3Trip**) the network stability is the main concern. Since the de-energized line cannot transfer synchronizing energy, only short dead times are allowed. The usual values are 0.3 s to 0.6 s. If the device is operating with a synchronism check device, a longer dead time may be tolerated under certain circumstances. Longer three-pole dead times are also possible in radial networks.

For **AR control mode** = ***with PICKUP ...*** it is possible to make the dead times dependent on the type of fault detected by the initiating protection function(s).

Table 2-6 AR control mode = **with PICKUP ...**

3453	1.AR Tdead 1Flt	is the dead time after single-phase pickup,
3454	1.AR Tdead 2Flt	is the dead time after two-phase pickup,
3455	1.AR Tdead 3Flt	is the dead time after three-phase pickup.

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

If, when setting the reaction to sequential faults (see above at „General“), you have set address 3407 **EV. FLT. MODE** ***starts 3p AR***, you can set a separate dead time for the three-pole dead time after clearance of the sequential fault **1.AR: Tdead EV.** (address 3458). Stability aspects are also decisive here. Normally the setting constraints are similar to address 3457 **1.AR Tdead3Trip**.

Under address 3459 **1.AR: CB? CLOSE** it can be determined whether the readiness of the circuit breaker ("circuit breaker ready") is interrogated before this first reclosure. With the setting ***YES***, the dead time may be extended if the circuit breaker is not ready for a CLOSE–TRIP–cycle when the dead time expires. The maximum extension that is possible is the circuit breaker monitoring time; this time was set for all reclosure cycles under address 3409 **CB TIME OUT** (see above). Details about the circuit breaker monitoring can be found in the function description, Section 2.10, at margin heading „Interrogation of the Circuit Breaker Ready State“.

If there is a danger of stability problems in the network during a three-pole reclosure cycle, set address 3460 **1.AR SynRequest** to ***YES***. In this case a check is made before each reclosure following a three-pole trip whether the voltages of feeder and busbar are sufficiently synchronous. This is only done on condition that either the internal synchronism and voltage check functions are available, or that an external device is available for synchronism and voltage check. If only single-pole reclose cycles are executed or if no stability problems are expected during three-pole dead times (e.g. due to closely meshed networks 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 scope of protection functions, you can set individual reclosure parameters for the 2nd to 4th cycles. The same options are available as for the first cycle. Again, only some of the parameters shown below will be available depending on the selections made during configuration of the scope of protection functions.

For the 2nd cycle:

3461	2.AR: START	Start in 2nd cycle generally allowed
3462	2.AR: T-ACTION	Action time for the 2nd cycle
3464	2.AR Tdead 1Flt	Dead time after single-phase pickup
3465	2.AR Tdead 2Flt	Dead time after two-phase pickup
3466	2.AR Tdead 3Flt	Dead time after three-phase pickup
3467	2.AR Tdead1Trip	Dead time after single-pole tripping

3468	2.AR Tdead3Trip	Dead time after three-pole tripping
3469	2.AR: Tdead EV.	Dead time after evolving fault
3470	2.AR: CB? CLOSE	CB ready interrogation before reclosing
3471	2.AR SynRequest	Sync. check after three-pole tripping

For the 3rd cycle:

3472	3.AR: START	Start in 3rd cycle generally allowed
3473	3.AR: T-ACTION	Action time for the 3rd cycle
3475	3.AR Tdead 1Flt	Dead time after single-phase pickup
3476	3.AR Tdead 2Flt	Dead time after two-phase pickup
3477	3.AR Tdead 3Flt	Dead time after three-phase pickup
3478	3.AR Tdead1Trip	Dead time after single-pole tripping
3479	3.AR Tdead3Trip	Dead time after three-pole tripping
3480	3.AR: Tdead EV.	Dead time after evolving fault
3481	3.AR: CB? CLOSE	CB ready interrogation before reclosing
3482	3.AR SynRequest	Sync. check after three-pole tripping

For the 4th cycle:

3483	4.AR: START	Start in 4th cycle generally allowed
3484	4.AR: T-ACTION	Action time for the 4th cycle
3486	4.AR Tdead 1Flt	Dead time after single-phase pickup
3487	4.AR Tdead 2Flt	Dead time after two-phase pickup
3488	4.AR Tdead 3Flt	Dead time after three-phase pickup
3489	4.AR Tdead1Trip	Dead time after single-pole tripping
3490	4.AR Tdead3Trip	Dead time after three-pole tripping
3491	4.AR: Tdead EV.	Dead time after evolving fault
3492	4.AR: CB? CLOSE	CB ready interrogation before reclosing
3493	4.AR SynRequest	Sync. check after three-pole tripping

5th to 8th reclosure cycle

If more than four cycles were set during configuration of the functional scope, the dead times preceding the fifth (5th) through the ninth (9th) reclosing attempts are equal to the open breaker time which precedes the fourth (4th) reclosing attempt.

Notes on the Information Overview

The most important information about automatic reclosure is briefly explained insofar as it was not mentioned in the following lists or described in detail in the preceding text.

„`>BLK 1.AR-cycle`“ (No. 2742) to „`>BLK 4.-n. AR`“ (No. 2745)

The respective auto-reclose cycle is blocked. If the blocking state already exists when the automatic reclosure function is initiated, the blocked cycle is not executed and may be skipped (if other cycles are permitted). The same applies if the automatic reclosure function is started (running), but not internally blocked. If the block signal of a cycle appears while this cycle is being executed (in progress), the automatic reclosure function is blocked dynamically; no further automatic reclosures cycles are then executed.

„`AR 1.CycZoneRel`“ (No. 2889) to „`AR 4.CycZoneRel`“ (No. 2892)

The automatic reclosure is ready for the respective reclosure cycle. This information indicates which cycle will be run next. For example, external protection functions can use this information to release accelerated or overreaching trip stages prior to the corresponding reclose cycle.

„AR is blocked“ (No. 2783)

The automatic reclosure is blocked (e.g. circuit breaker not ready). This information indicates to the operational information system that in the event of an upcoming system fault there will be a final trip, i.e. without reclosure. If the automatic reclosure has been started, this information does not appear.

„AR not ready“ (No. 2784)

The automatic reclosure is not ready for reclosure at the moment. In addition to the „AR is blocked“ (No. 2783) 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“. This information is particularly helpful during testing because no protection test cycle with reclosure may be initiated during this state.

„AR in progress“ (No. 2801)

This information appears with starting of the automatic reclosure function, i.e. with the first trip command which can start the automatic reclosure. If this reclosure was successful (or any in the case of multiple cycles), this information resets with the expiry of the last blocking time. If no reclosure was successful or if reclosure was blocked, it ends with the last – the final – trip command.

„AR Sync.Request“ (No. 2865)

Measuring request to an external synchronism check device. The information appears at the end of a dead time subsequent to three-pole tripping if a synchronism request was parameterised for the corresponding cycle. Reclosure only takes place when the synchronism check device has provided release signal „>Sync.release“ (No. 2731).

„>Sync.release“ (No. 2731)

Release of reclosure by an external synchronism check device if this was requested by the output information „AR Sync.Request“ (No. 2865).

2.10.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
3401	AUTO RECLOSE	OFF ON	ON	Auto-Reclose Function
3402	CB? 1.TRIP	YES NO	NO	CB ready interrogation at 1st trip

Addr.	Parameter	Setting Options	Default Setting	Comments
3403	T-RECLAIM	0.50 .. 300.00 sec	3.00 sec	Reclaim time after successful AR cycle
3403	T-RECLAIM	0.50 .. 300.00 sec; 0	3.00 sec	Reclaim time after successful AR cycle
3404	T-BLOCK MC	0.50 .. 300.00 sec; 0	1.00 sec	AR blocking duration after manual close
3406	EV. FLT. RECOG.	with PICKUP with TRIP	with TRIP	Evolving fault recognition
3407	EV. FLT. MODE	Stops AutoRecl starts 3p AR	starts 3p AR	Evolving fault (during the dead time)
3408	T-Start MONITOR	0.01 .. 300.00 sec	0.50 sec	AR start-signal monitoring time
3409	CB TIME OUT	0.01 .. 300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3410	T RemoteClose	0.00 .. 300.00 sec; ∞	0.20 sec	Send delay for remote close command
3411A	T-DEAD EXT.	0.50 .. 300.00 sec; ∞	∞ sec	Maximum dead time extension
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 overcur-rent ?
3423	AR WITH I.TRIP	YES NO	YES	AR with intertrip ?
3424	AR w/ DTT	YES NO	YES	AR with direct transfer trip ?
3425	AR w/ BackUpO/C	YES NO	YES	AR with back-up overcurrent ?
3430	AR TRIP 3pole	YES NO	YES	3pole TRIP by AR
3431	DLC / RDT	WITHOUT DLC	WITHOUT	Dead Line Check / Reduced Dead Time
3433	T-ACTION ADT	0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3434	T-MAX ADT	0.50 .. 3000.00 sec	5.00 sec	Maximum dead time
3435	ADT 1p allowed	YES NO	NO	1pole TRIP allowed
3436	ADT CB? CLOSE	YES NO	NO	CB ready interrogation before re-closing
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

Addr.	Parameter	Setting Options	Default Setting	Comments
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 re-closing
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 re-closing
3471	2.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3472	3.AR: START	YES NO	NO	AR start allowed in this cycle
3473	3.AR: T-ACTION	0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3475	3.AR Tdead 1Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3476	3.AR Tdead 2Flt	0.01 .. 1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3477	3.AR Tdead 3Flt	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3478	3.AR Tdead1Trip	0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3479	3.AR Tdead3Trip	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3480	3.AR: Tdead EV.	0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3481	3.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before re-closing
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

Addr.	Parameter	Setting Options	Default Setting	Comments
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 re-closing
3493	4.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR

2.10.4 Information List

No.	Information	Type of Information	Comments
127	AR ON/OFF	IntSP	Auto Reclose ON/OFF (via system port)
2701	>AR on	SP	>AR: Switch on auto-reclose function
2702	>AR off	SP	>AR: Switch off auto-reclose function
2703	>AR block	SP	>AR: Block auto-reclose function
2711	>AR Start	SP	>External start of internal Auto reclose
2712	>Trip L1 AR	SP	>AR: External trip L1 for AR start
2713	>Trip L2 AR	SP	>AR: External trip L2 for AR start
2714	>Trip L3 AR	SP	>AR: External trip L3 for AR start
2715	>Trip 1pole AR	SP	>AR: External 1pole trip for AR start
2716	>Trip 3pole AR	SP	>AR: External 3pole trip for AR start
2727	>AR RemoteClose	SP	>AR: Remote Close signal
2731	>Sync.release	SP	>AR: Sync. release from ext. sync.-check
2737	>BLOCK 1pole AR	SP	>AR: Block 1pole AR-cycle
2738	>BLOCK 3pole AR	SP	>AR: Block 3pole AR-cycle
2739	>BLK 1phase AR	SP	>AR: Block 1phase-fault AR-cycle
2740	>BLK 2phase AR	SP	>AR: Block 2phase-fault AR-cycle
2741	>BLK 3phase AR	SP	>AR: Block 3phase-fault AR-cycle
2742	>BLK 1.AR-cycle	SP	>AR: Block 1st AR-cycle
2743	>BLK 2.AR-cycle	SP	>AR: Block 2nd AR-cycle
2744	>BLK 3.AR-cycle	SP	>AR: Block 3rd AR-cycle
2745	>BLK 4.-n. AR	SP	>AR: Block 4th and higher AR-cycles
2746	>Trip for AR	SP	>AR: External Trip for AR start
2747	>Pickup L1 AR	SP	>AR: External pickup L1 for AR start
2748	>Pickup L2 AR	SP	>AR: External pickup L2 for AR start
2749	>Pickup L3 AR	SP	>AR: External pickup L3 for AR start
2750	>Pickup 1ph AR	SP	>AR: External pickup 1phase for AR start
2751	>Pickup 2ph AR	SP	>AR: External pickup 2phase for AR start
2752	>Pickup 3ph AR	SP	>AR: External pickup 3phase for AR start
2781	AR off	OUT	AR: Auto-reclose is switched off

No.	Information	Type of Information	Comments
2782	AR on	IntSP	AR: Auto-reclose is switched on
2783	AR is blocked	OUT	AR: Auto-reclose is blocked
2784	AR not ready	OUT	AR: Auto-reclose is not ready
2787	CB not ready	OUT	AR: Circuit breaker not ready
2788	AR T-CBreadyExp	OUT	AR: CB ready monitoring window expired
2796	AR on/off BI	IntSP	AR: Auto-reclose ON/OFF via BI
2801	AR in progress	OUT	AR: Auto-reclose in progress
2809	AR T-Start Exp	OUT	AR: Start-signal monitoring time expired
2810	AR TdeadMax Exp	OUT	AR: Maximum dead time expired
2818	AR evolving Flt	OUT	AR: Evolving fault recognition
2820	AR Program1pole	OUT	AR is set to operate after 1p trip only
2821	AR Td. evol.Flt	OUT	AR dead time after evolving fault
2839	AR Tdead 1pTrip	OUT	AR dead time after 1pole trip running
2840	AR Tdead 3pTrip	OUT	AR dead time after 3pole trip running
2841	AR Tdead 1pFlt	OUT	AR dead time after 1phase fault running
2842	AR Tdead 2pFlt	OUT	AR dead time after 2phase fault running
2843	AR Tdead 3pFlt	OUT	AR dead time after 3phase fault running
2844	AR 1stCyc. run.	OUT	AR 1st cycle running
2845	AR 2ndCyc. run.	OUT	AR 2nd cycle running
2846	AR 3rdCyc. run.	OUT	AR 3rd cycle running
2847	AR 4thCyc. run.	OUT	AR 4th or higher cycle running
2848	AR ADT run.	OUT	AR cycle is running in ADT mode
2851	AR CLOSE Cmd.	OUT	AR: Close command
2852	AR Close1.Cyc1p	OUT	AR: Close command after 1pole, 1st cycle
2853	AR Close1.Cyc3p	OUT	AR: Close command after 3pole, 1st cycle
2854	AR Close 2.Cyc	OUT	AR: Close command 2nd cycle (and higher)
2861	AR T-Recl. run.	OUT	AR: Reclaim time is running
2862	AR successful	OUT	AR successful
2864	AR 1p Trip Perm	OUT	AR: 1pole trip permitted by internal AR
2865	AR Sync.Request	OUT	AR: Synchro-check request
2871	AR TRIP 3pole	OUT	AR: TRIP command 3pole
2889	AR 1.CycZoneRel	OUT	AR 1st cycle zone extension release
2890	AR 2.CycZoneRel	OUT	AR 2nd cycle zone extension release
2891	AR 3.CycZoneRel	OUT	AR 3rd cycle zone extension release
2892	AR 4.CycZoneRel	OUT	AR 4th cycle zone extension release
2893	AR Zone Release	OUT	AR zone extension (general)
2894	AR Remote Close	OUT	AR Remote close signal send

2.11 Undervoltage and Overvoltage Protection (optional)

Voltage protection has the function of protecting electrical equipment against undervoltage and overvoltage. Both operational states are unfavourable as overvoltage may cause, for example, insulation problems or undervoltage may cause stability problems.

The overvoltage protection in the 7SD610 detects the phase voltages U_{L1-E}, U_{L2-E} and U_{L3-E}, the phase-to-phase voltages U_{L1-L2}, U_{L2-L3} and U_{L3-L1}, as well as the displacement voltage $3U_0$. Instead of the displacement voltage any other voltage that is connected to the fourth voltage input U_4 of the device can be detected. Furthermore, the device calculates the positive sequence system voltage and the negative sequence system voltage so that the symmetrical components are also monitored. Here compounding is also possible which calculates the voltage at the remote line end.

The undervoltage protection can also use the phase voltages U_{L1-E}, U_{L2-E} and U_{L3-E}, the phase-to-phase voltages U_{L1-L2}, U_{L2-L3} and U_{L3-L1}, as well as the positive sequence system.

These voltage protection functions can be combined according to the user's requirements. They can be switched on or off separately, or used for alarm purposes only. In the latter case the respective trip commands do not appear. Each voltage protection function is two-stage, i.e. it is provided with two threshold setting stages, each one with its respective time delay.

Abnormally high voltages often occur e.g. in low loaded, long distance transmission lines, in islanded systems when generator voltage regulation fails, or after full load shutdown of a generator with the generator disconnected from the system. Even if compensation reactors are used to avoid line overvoltages by compensation of the line capacitance and thus reduction of the overvoltage, the overvoltage will endanger the insulation if the reactors fail (e.g. due to fault clearance). The line must be de-energised within a very short time.

The undervoltage protection can be applied, for example, for disconnection or load shedding tasks in a system. Furthermore, this protection scheme can detect menacing stability problems. With induction machines undervoltages have an effect on the stability and permissible torque thresholds.

2.11.1 Overvoltage protection

Overvoltage Phase–Earth

Figure 2-53 depicts the logic diagram of the phase voltage stages. The fundamental frequency is numerically filtered from each of the three measuring voltages so that harmonics or transient voltage peaks are largely eliminated. Two threshold stages **Uph-e>** and **Uph-e>>** are compared with the voltages. If a phase voltage exceeds these thresholds it is indicated phase-segregated. Furthermore, a general pickup indication „Uph-e> Pickup“ „Uph-e>> Pickup“ is given. The drop-out to pickup ratio can be set (**Uph-e>(>) RESET**).

Every stage starts a time delay which is common to all phases. Expiry of the respective time delay **T Uph-e>** or **T Uph-e>>** is signalled and usually results in the trip command „Uph-e>(>) TRIP“.

The overvoltage protection phase–earth can be blocked via a binary input „>Uph-e>(>) BLK“.

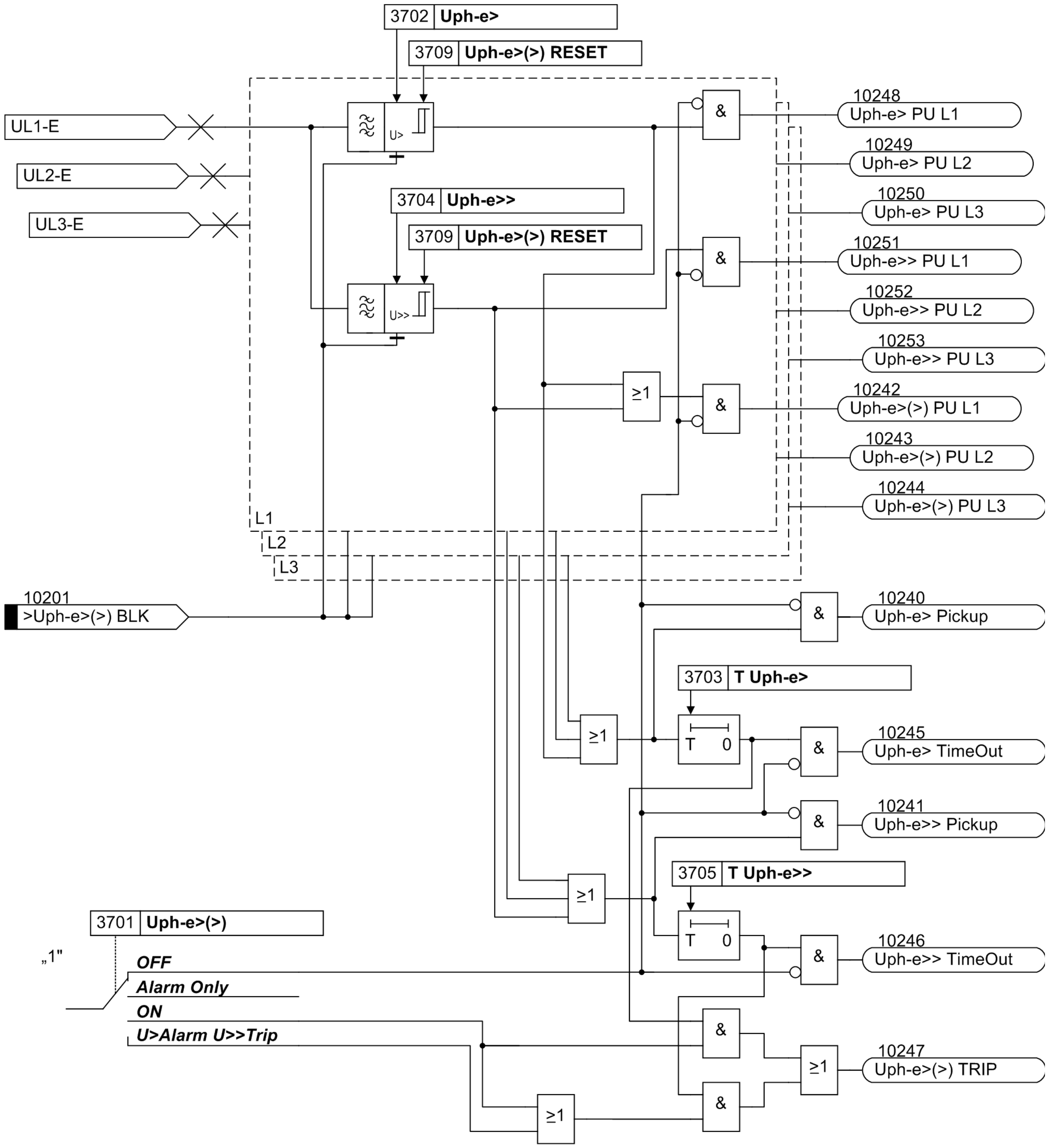


Figure 2-53 Logic diagram of the overvoltage protection for phase voltage

Phase-phase over-voltage

The phase–phase overvoltage protection operates just like the phase–earth protection except that it detects phase–to–phase voltages. Accordingly, phase–to–phase voltages which have exceeded one of the stage thresholds **`Uph-ph>`** or **`Uph-ph>>`**are also indicated. Beyond this, Figure 2-53 applies in principle.

The phase–phase overvoltage protection can also be blocked via a binary input „`>Uph-ph>(>) BLK`“.

Overvoltage positive sequence systemU_1

The device calculates the positive sequence system according to its defining equation

$$\underline{U}_1 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3})$$

where $\underline{a} = e^{j120°}$.

The resulting positive sequence voltage is fed to the two threshold stages **U1>** and **U1>>** (see Figure 2-54). Combined with the associated time delays **T U1>** and **T U1>>** these stages form a two-stage overvoltage protection for the positive sequence system. Here too, the drop-out to pickup ratio can be set.

The overvoltage protection for the positive sequence system can also be blocked via a binary input „>U1>(>) BLK".

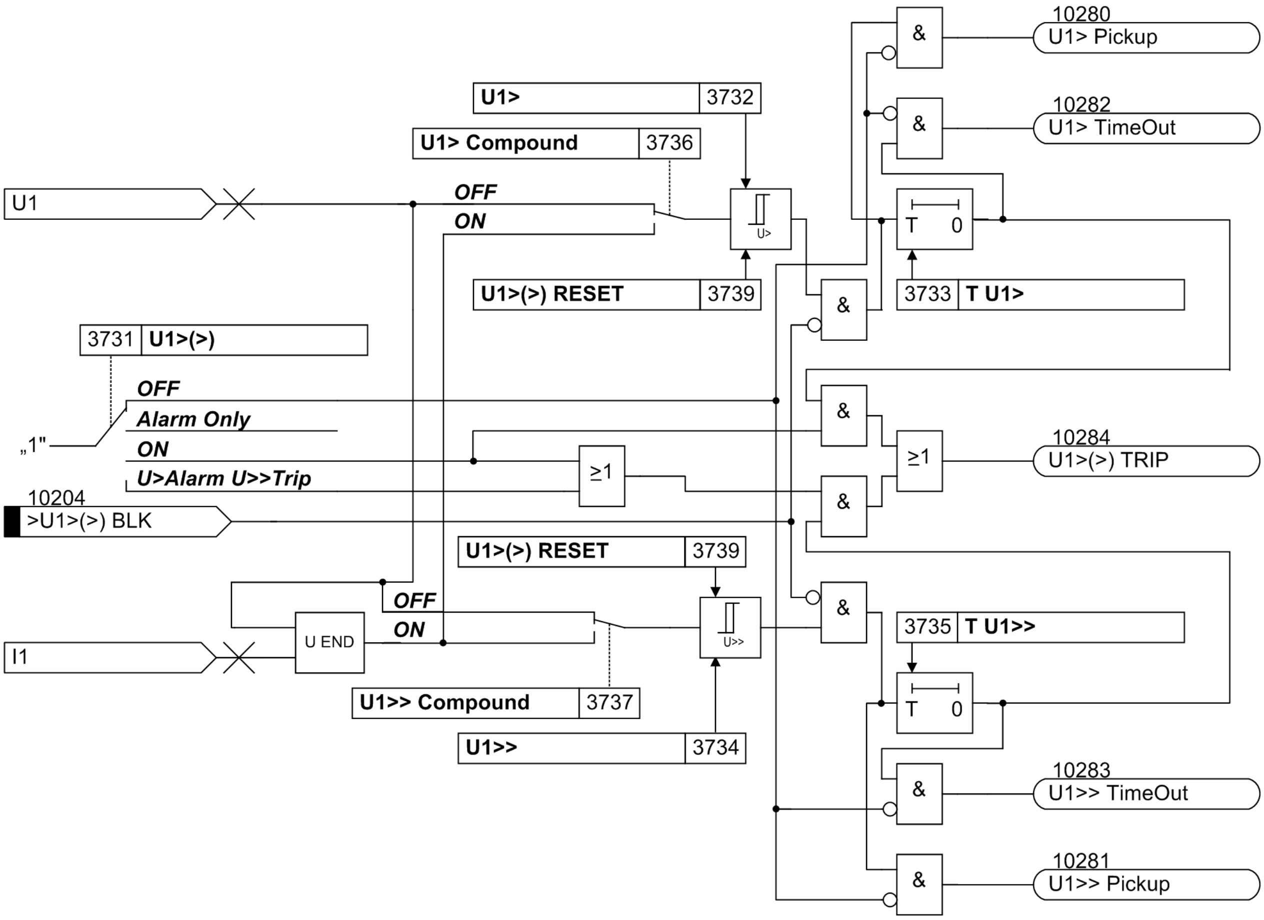


Figure 2-54 Logic diagram of the overvoltage protection for the positive sequence voltage system

Overvoltage protection U_1 with configurable compounding

The overvoltage protection for the positive sequence system may optionally operate with compounding. The compounding calculates the positive sequence system of the voltage at the remote line end. This option is thus particularly well suited for detecting a steady-state voltage increase caused by long transmission lines operating at weak load or no load due to the capacitance per unit length (Ferranti effect). In this case the overvoltage condition exists at the other line end but it can only be removed by switching off the local line end.

For calculating the voltage at the opposite line end, the device requires the line data (inductance per unit length, capacitance per unit length, line angle, line length) which were entered in the Power System Data 2 (Section 2.1.4.1) during configuration.

Compounding is only available if address 137 is set to ***`Enabl. w. comp.`***. In this case the calculated voltage at the other line end is also indicated in the operational measured values.

Note

Compounding is not suited for lines with series capacitors.

The voltage at the remote line end is calculated from the voltage measured at the local line end and the flowing current by means of a PI equivalent circuit diagram (refer also to Figure 2-55).

$$\underline{U}_{End} = \underline{U}_{Meas} - \left(\underline{I}_{Meas} - \frac{j\omega C_L}{2} \cdot \underline{U}_{Meas}\right) \cdot (R_L + j\omega L_L)$$

with

$\underline{U}_{End}$	the calculated voltage at the remote line end,
$\underline{U}_{Meas}$	the measured voltage at the local line end,
$\underline{I}_{Meas}$	the measured current at the local line end,
C_L	the service capacitance of the line,
R_L	the ohmic service resistance of the line,
L_L	the line inductance.

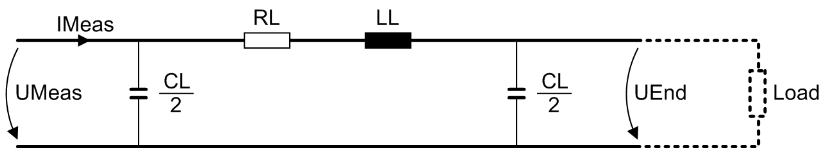


Figure 2-55 PI equivalent diagram for compounding

Overvoltage negative sequence system U_2

The device calculates the negative sequence system voltages according to its defining equation:

$$\underline{U}_2 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a}^2 \cdot \underline{U}_{L2} + \underline{a} \cdot \underline{U}_{L3})$$

where $\underline{a} = e^{j120°}$.

The resulting negative sequence voltage is fed to the two threshold stages **`U2>`** and **`U2>>`**. Figure 2-56 shows the logic diagram. By combining the associated time delays **`T U2>`** and **`T U2>>`** a two-stage overvoltage protection for the negative sequence system is formed. Here too, the drop-out to pickup ratio can be set.

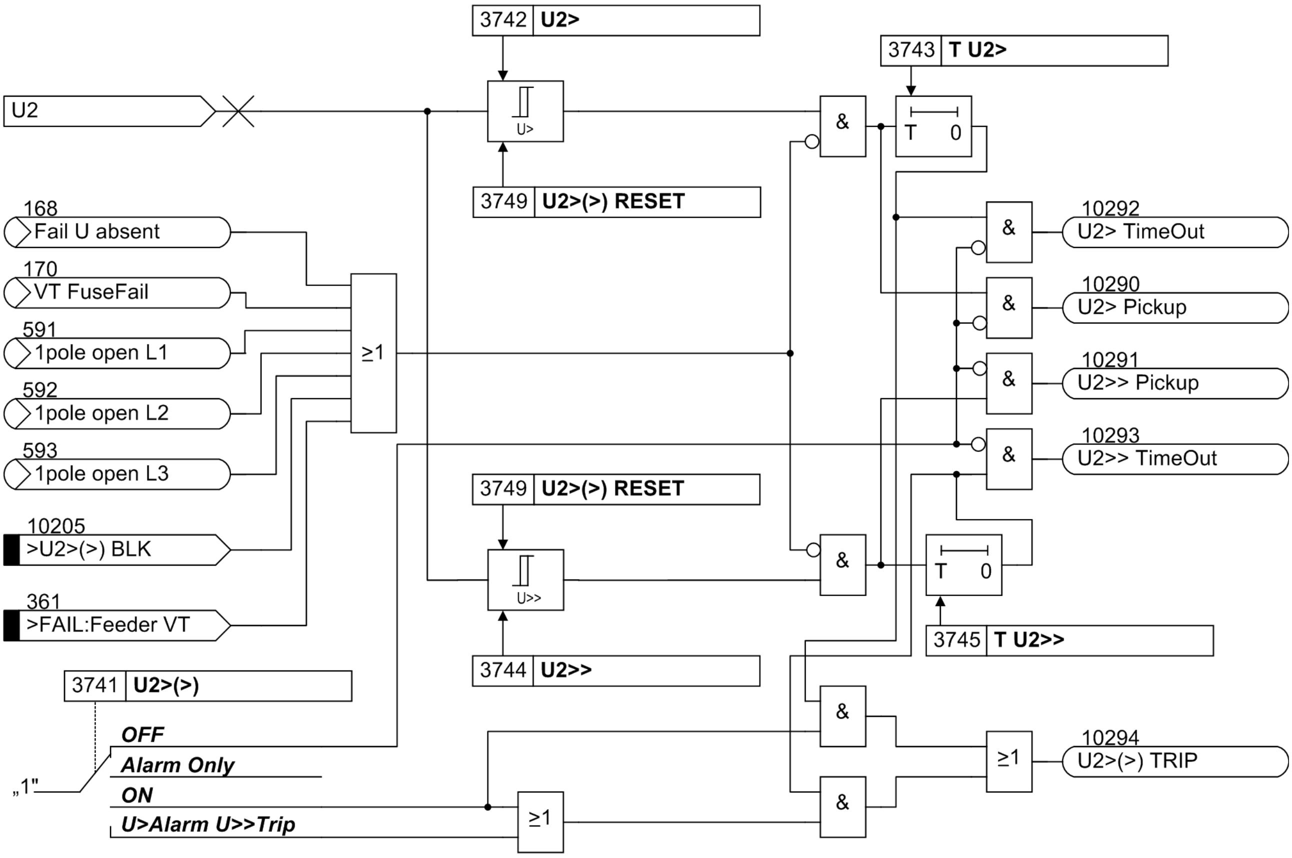


Figure 2-56 Logic diagram of the overvoltage protection for the negative sequence voltage system U_2

The overvoltage protection for the negative sequence system can also be blocked via a binary input „>U2>(>) BLK". The stages of the negative sequence voltage protection are automatically blocked as soon as an asymmetrical voltage failure was detected („Fuse–Failure–Monitor", also see Section 2.15.1, margin heading „Fuse Failure Monitor (Non-symmetrical Voltages))" or when the trip of the mcb for voltage transformers has been signalled via the binary input „>FAIL:Feeder VT" (internal indication „internal blocking").

During single-pole dead time the stages of the negative sequence overvoltage protection are automatically blocked since arising negative sequence values are only influenced by the asymmetrical power flow, not by the fault in the system. If the device cooperates with an external automatic reclosure function, or if a single-pole tripping can be triggered by a different protection system (working in parallel), the overvoltage protection for the negative sequence system must be blocked via a binary input during single-pole tripping.

Overvoltage zero sequence system $3U_0$

Figure 2-57 depicts the logic diagram of the zero sequence voltage stage. The fundamental frequency is numerically filtered from the measuring voltage so that the harmonics or transient voltage peaks remain largely harmless.

The triple zero sequence voltage $3{\cdot}U_0$ is fed to the two threshold stages **3U0>** and **3U0>>**. Combined with the associated time delays **T 3U0>** and **T 3U0>>** these stages form a two-stage overvoltage protection for the zero sequence system. Here too, the drop-off to pickup ratio can be set (**3U0>(>) RESET**). Furthermore, a restraint delay can be configured which is implemented by repeated measuring (approx. 3 periods).

The overvoltage protection for the zero sequence system can also be blocked via a binary input „>3U0>(>) BLK“. The stages of the zero sequence voltage protection are automatically blocked as soon as an asymmetrical voltage failure was detected („Fuse–Failure–Monitor“, also see Section 2.15.1, margin heading „Fuse Failure Monitor (Non-symmetrical Voltages))“ or when the trip of the mcb for voltage transformers has been signalled via the binary input „>FAIL:Feeder VT“ (internal indication „internal blocking“).

The stages of the zero sequence voltage protection are automatically blocked during single-pole automatic reclose dead time to avoid pickup with the asymmetrical power flow arising during this state. If the device cooperates with an external automatic reclosure function, or if a single-pole tripping can be triggered by a different protection system (working in parallel), the overvoltage protection for the zero sequence system must be blocked via a binary input during single-pole tripping.

According to Figure 2-57 the device calculates the voltage to be monitored:

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

This applies if no suitable voltage is connected to the fourth measuring input U_4.

However, if the displacement voltage U_{delta} of the voltage transformer set is directly connected to the fourth measuring input U_4 of the device and this information was entered during configuration, the device will automatically use this voltage and calculate the triple zero sequence voltage.

$$3 \cdot U_0 = \textbf{Uph / Udelta} \cdot U_4$$

Since the voltage transformation ratio of the voltage transformer set is usually

$$\frac{U_{N\ prim}}{\sqrt{3}} / \frac{U_{N\ sec}}{\sqrt{3}} / \frac{U_{N\ sec}}{3}$$

the factor is set to **Uph / Udelta** = $3/\sqrt{3} = \sqrt{3} = 1.73$. For more details, refer to **General Power System Data (Power System Data 1)** in Section 2.1.4.1 at margin heading „Voltage Connections“ via address 211.

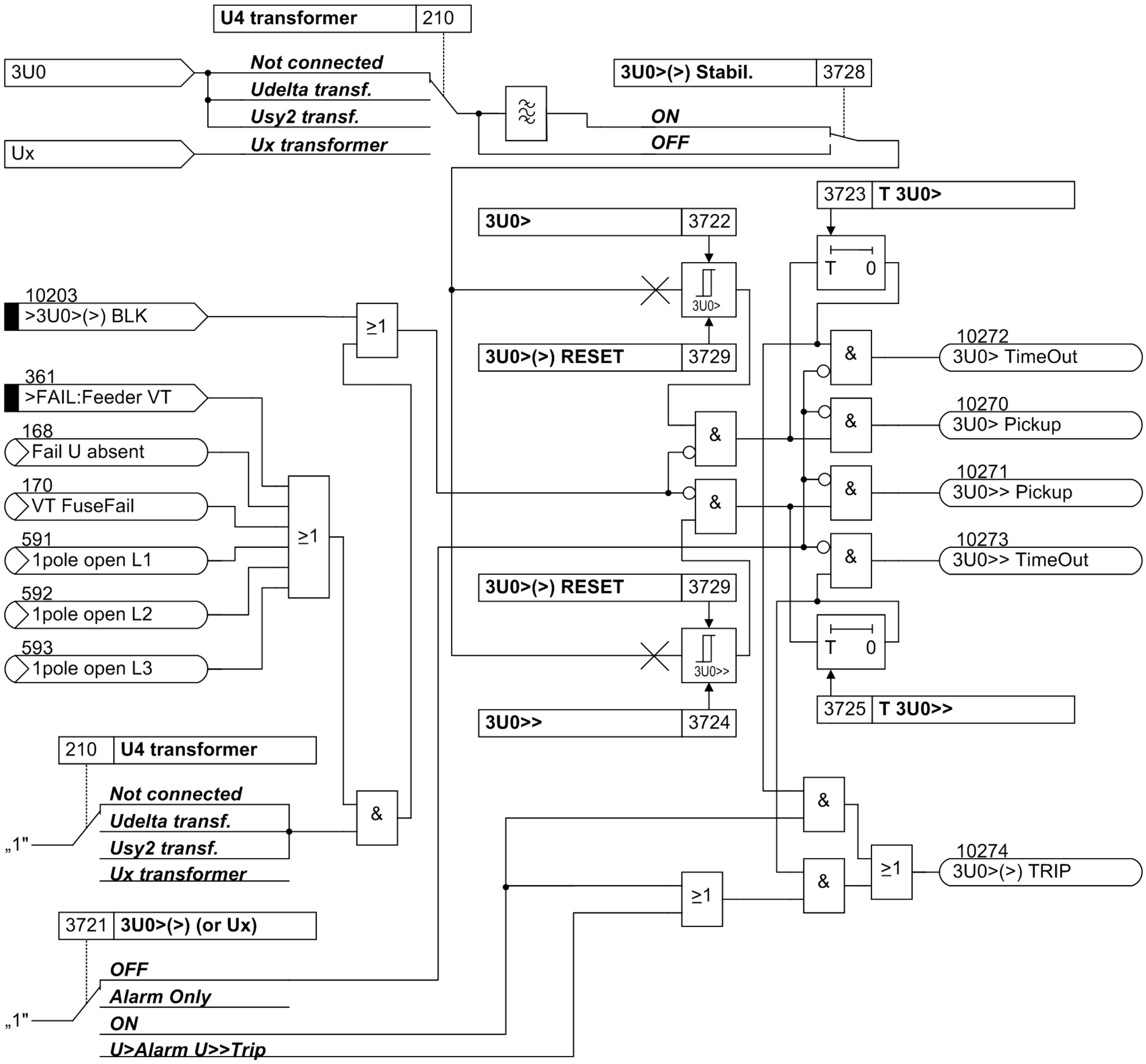


Figure 2-57 Logic diagram of the overvoltage protection for zero sequence voltage

Freely selectable single-phase voltage

As the zero sequence voltage stages operate separately and independent from the other protective overvoltage functions they can be used for any other single–phase voltage. Therefore the fourth voltage input U_4 of the device must be assigned accordingly (also see Section 2.1.2, „Voltage Transformer Connection“).

The stages can be blocked via a binary input „>3U0>(>) BLK“. Internal blocking is not accomplished in this application case.

2.11.2 Undervoltage protection

Undervoltage Phase–Earth

Figure 2-58 depicts the logic diagram of the phase voltage stages. The fundamental frequency is numerically filtered from each of the three measuring voltages so that harmonics or transient voltage peaks are largely harmless. Two threshold stages **Uph-e<** and **Uph-e<<** are compared with the voltages. If phase voltage falls below a threshold it is indicated phase-segregated. Furthermore, a general pickup indication „Uph-e< Pickup“ „Uph-e<< Pickup“ is given. The drop-out to pickup ratio can be set (**Uph-e<(<) RESET**).

Every stage starts a time delay which is common to all phases. Expiry of the respective time delay **T Uph-e<** or **T Uph-e<<** is signalled and results in the trip command „Uph-e<(<) TRIP“.

Depending on the configuration of the substations, the voltage transformers are located on the busbar side or on the outgoing feeder side. This results in a different behaviour of the undervoltage protection when the line is de-energised. While the voltage usually remains present or reappears on the busbar side after a trip command and opening of the circuit breaker, it becomes zero on the outgoing side. For the undervoltage protection this results in a pickup state being present if the voltage transformers are on the outgoing side. If this pickup must be reset, the current can be used as an additional criterion (current supervision **CURR.SUP. Uphe<**) to achieve this result. Undervoltage will then only be detected if, together with the undervoltage condition, the minimum current **PoleOpenCurrent** of the corresponding phase is also exceeded. This condition is communicated by the central function control of the device.

The undervoltage protection phase–earth can be blocked via a binary input „Uph-e<(<) BLK“. The stages of the undervoltage protection are then automatically blocked if a voltage failure is detected („Fuse–Failure–Monitor“, also see Section 2.15.1) or if the trip of the mcb of the voltage transformers is indicated (internal blocking) via the binary input „>FAIL:Feeder VT“.

Also during a single-pole automatic reclose dead time the stages of the undervoltage protection are automatically blocked in the pole open state. If necessary, the current criterion will be considered so that they do not respond to the undervoltage of the disconnected phase when voltage transformers are located on the outgoing side. Only such stages are blocked during the single-pole dead time that can actually generate a trip command according to their setting.

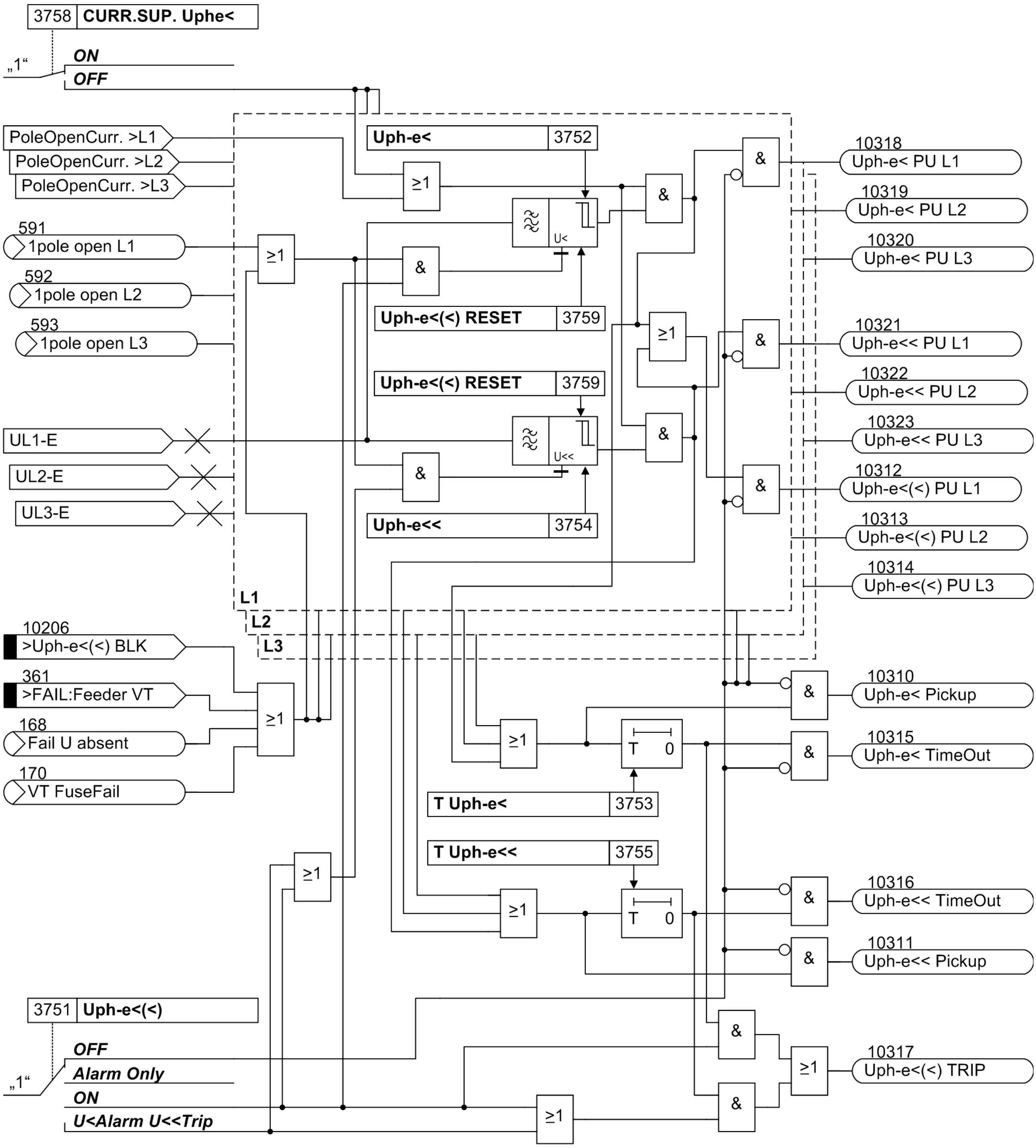


Figure 2-58 Logic diagram of the undervoltage protection for phase voltages

Phase-phase undervoltage

Basically, the phase-phase undervoltage protection operates like the phase-earth protection except that it detects phase-to-phase voltages. Accordingly, both phases are indicated during pickup of an undervoltage stage if one of the stage thresholds **Uph-ph<** or **Uph-ph<<** was undershot. Beyond this, Figure 2-58 applies in principle.

It is sufficient for the current criterion that current flow is detected in one of the involved phases.

The phase–phase undervoltage protection can also be blocked via a binary input „>Uphph<(<) BLK“. There is an automatic blocking if the measuring voltage failure was detected or voltage mcb tripping was indicated (internal blocking of the phases affected by the voltage failure).

During single-pole dead time for automatic reclosure the stages of the undervoltage protection are automatically blocked in the disconnected phase so that it does not respond to the undervoltage of the disconnected phase provided that the voltage transformers are located on the outgoing side. Only such stages are blocked during the single-pole dead time that can actually initiate tripping according to their setting.

Undervoltage positive sequence systemU$_1$

The device calculates the positive sequence system according to its defining equation

$$\underline{U}_1 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3})$$

where $\underline{a} = e^{j120°}$.

The resulting positive sequence voltage is fed to the two threshold stages **U1<** and **U1<<** (see Figure 2-59). Combined with the associated time delays **T U1<** and **T U1<<** these stages form a two-stage undervoltage protection for the positive sequence system.

Current can be used as an additional criterion for the undervoltage protection of the positive sequence system (current supervision **CURR.SUP.U1<**). An undervoltage is only detected if the current flow is detected in at least one phase together with the undervoltage criterion.

The undervoltage protection for the positive sequence system can be blocked via the binary input „>U1<(<) BLK“. The stages of the undervoltage protection are automatically blocked if voltage failure is detected („Fuse–Failure–Monitor“, also see Section 2.15.1) or, if the trip of the mcb for the voltage transformer is indicated via the binary input „>FAIL:Feeder VT“ (internal blocking).

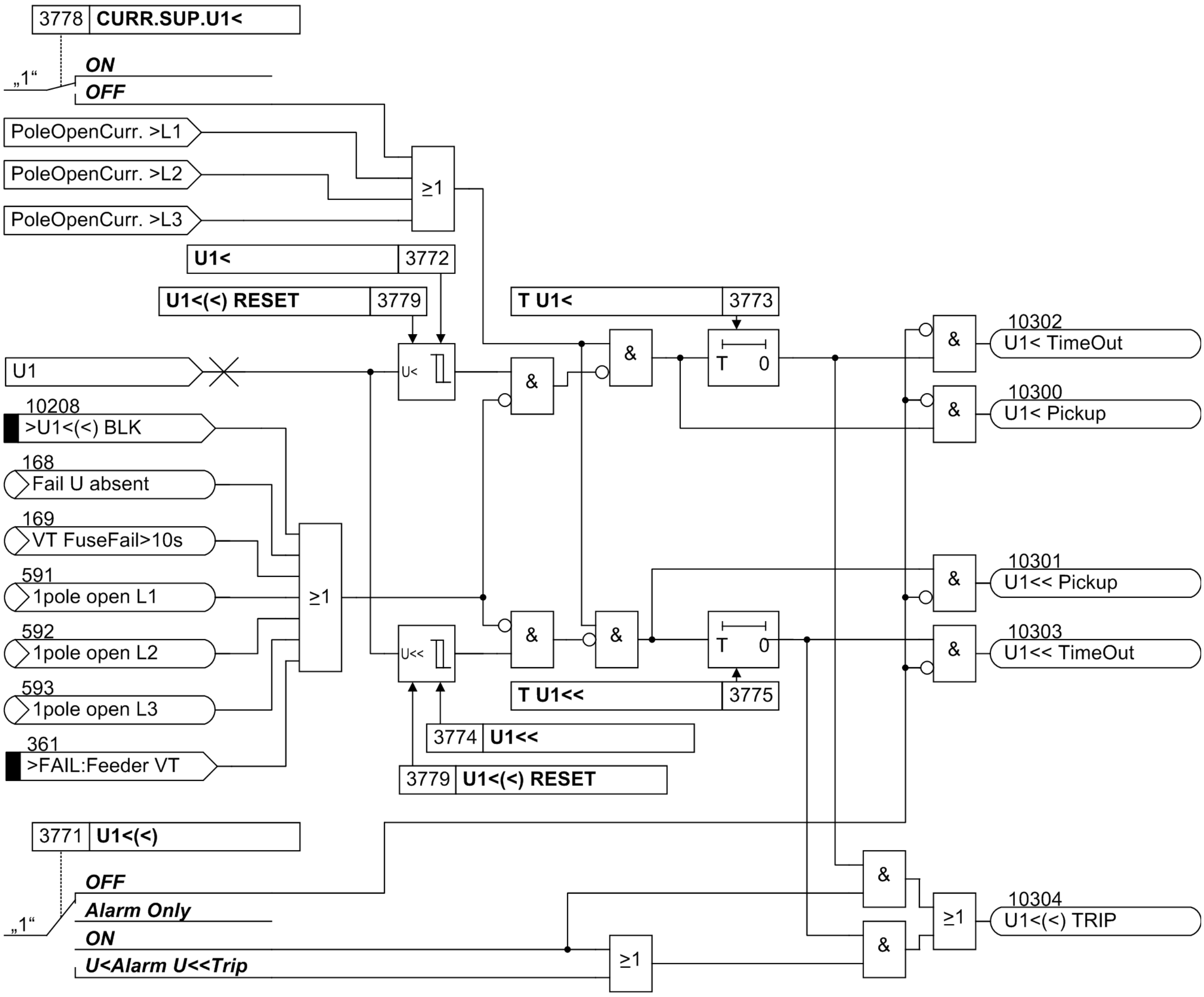


Figure 2-59 Logic diagram of the undervoltage protection for positive sequence voltage system

During single-pole dead time for automatic reclosure the stages of the undervoltage protection are automatically blocked in the positive sequence system so that they do not respond to the reduced voltage caused by the disconnected phase in case the voltage transformers are located on the outgoing side.

2.11.3 Setting Notes

General

The voltage protection can only operate if, when configuring the device scope (address 137), it has been set to ***Enabled***. Compounding is only available if (address 137) is set to ***Enabl. w. comp.***.

The overvoltage and undervoltage stages can detect phase-to-earth voltages, phase-to-phase voltages or the symmetrical positive sequence system of the voltages; for overvoltage also the symmetrical negative sequence system, zero sequence voltage or a different single-phase voltage can be used. Any combination is possible. Detection procedures that are not required are switched ***OFF***.

Note

For overvoltage protection it is particularly important to observe the setting hints: NEVER set an overvoltage stage (U_{L-E}, U_{L-L}, U_1) lower than an undervoltage stage. This would put the device immediately into a state of permanent pickup which cannot be reset by any measured value operation. As a result, operation via DIGSI or via the front display would be impossible due to the permanent pickup!

Phase-earth overvoltage

The phase voltage stages can be switched ***ON*** or ***OFF*** in address 3701 **Uph-e>(>)**. In addition to this, you can set ***Alarm Only***, i.e. these stages operate and send alarms but do not generate any trip command. The setting ***U>Alarm U>>Trip*** creates in addition also a trip command only for the U>> stage.

The settings of the voltage threshold and the timer values depend on the type of application. To detect steady-state overvoltages on long lines carrying no load, set the **Uph-e>** stage (address 3702) to at least 5 % above the maximum stationary phase-earth voltage expected during operation. Additionally, a high dropout to pickup ratio is required (address 3709 **Uph-e>(>) RESET** = 0.98 presetting). This parameter can only be altered in DIGSI at **Display Additional Settings**. The delay time **T Uph-e>** (address 3703) should be a few seconds so that overvoltages with short duration may not result in tripping.

The U_{ph}>> stage (address 3704) is provided for high overvoltages with short duration. Here an adequately high pickup value is set, e.g. the $1^1/_2$-fold of the nominal phase-earth voltage. 0.1 s to 0.2 s are sufficient for the delay time **T Uph-e>>** (address 3705).

Phase-phase overvoltage

Basically, the same considerations apply as for the phase voltage stages. These stages may be used instead of the phase voltage stages or be used additionally. Depending on your choice, set address 3711 **Uph-ph>(>)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U>Alarm U>>Trip***.

As phase–to–phase voltages are monitored, the phase–to–phase values are used for the settings **Uph-ph>** (address 3712) and **Uph-ph>>** (address 3714).

For the delay times **T Uph-ph>** (address 3713) and **T Uph-ph>>** (address 3715) the same considerations apply as above. The same is true for the dropout ratios (address 3719 **Uphph>(>) RESET**). The latter setting can only be altered in DIGSI at **Display Additional Settings**.

Overvoltage positive sequence systemU_1

You can use the positive sequence voltage stages instead of or in addition to previously mentioned overvoltage stages. Depending on your choice, set address 3731 **U1>(>)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U>Alarm U>>Trip***.

For symmetrical voltages an increase of the positive sequence system corresponds to an AND gate of the voltages. These stages are particularly suited to the detection of steady-state overvoltages on long, weak-loaded transmission lines (Ferranti effect). Here too, the **U1>** stage (address 3732) with a longer delay time **T U1>** (address 3733) is used for the detection of steady-state overvoltages (some seconds), the **U1>>** stage (address 3734) with the short delay time **T U1>>** (address 3735) is used for the detection of high overvoltages that may jeopardise insulation.

Note that the positive sequence system is established according to its defining equation $U_1 = {}^1/_3 \cdot |\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3}|$. For symmetrical voltages this is equivalent to a phase-to-earth voltage.

If you want the voltage at the remote line end to be decisive for overvoltage detection, you use the compounding feature. To do so, you must have set during the configuration of the protective functions (Section 2.1.1.2) address 137 **U/O VOLTAGE** to ***Enabl. w. comp.*** (enabled with compounding).

In addition, the compounding feature needs the line data, which have been set in the **General Protection Data (Power System Data 2)** (Section 2.1.4.1): Address 1111 **x'**, address 1112 **c'** and address 1113 **Line Length**, as well as address 1105 **Line Angle**. These data are vital for a correct compounding calculation. If the values provided here do not correspond to real conditions, the compounding may calculate a too high voltage at the remote end, which will cause immediate pickup as soon as the measured values are applied. In such a case, the pickup state can only be reset by switching off the measuring voltage.

Compounding can be switched ***ON*** or ***OFF*** separately for each of the U1 stages: for the **U1>** stage at address 3736 **U1> Compound** and for the **U1>>** stage at address 3737 **U1>> Compound**.

The dropout to pickup ratio (address 3739 **U1>(>) RESET**) is set as high as possible with regard to the detection of even small steady-state overvoltages. This parameter can only be altered in DIGSI at **Display Additional Settings**.

Overvoltage negative sequence system U_2

The negative sequence voltage stages detect asymmetrical voltages. If such voltages should cause tripping, set address 3741 **U2>(>)** to ***ON***. If you want only an alarm to be generated, set address 3741 **U2>(>)** to ***Alarm Only***. If you want only one stage to generate a trip command, choose the setting ***U>Alarm U>>Trip***. With this setting a trip command is output by the 2nd stage only. If negative sequence voltage protection is not required, set this parameter to ***OFF***.

This protective function also has two stages, one being **U2>** (address 3742) with a greater time delay **T U2>** (address 3743) for steady-state asymmetrical voltages and the other being **U2>>** (address 3744) with a short delay time **T U2>>** (address 3745) for high asymmetrical voltages.

Note that the negative sequence system is established according to its defining equation $U_2 = \mathbf{^1/_3} \cdot |\underline{U}_{L1} + \underline{a}^2 \cdot \underline{U}_{L2} + \underline{a} \cdot \underline{U}_{L3}|$. For symmetrical voltages and two swapped phases this is equivalent to the phase–to–earth voltage value.

The dropout to pickup ratio **U2>(>) RESET** can be set in address 3749. This parameter can only be altered in DIGSI at **Display Additional Settings**.

Overvoltage zero sequence system

The zero sequence voltage stages can be switched ***ON*** or ***OFF*** in address 3721 **3U0>(>) (or Ux)**. They can also be set to ***Alarm Only***, i.e. these stages operate and send alarms but do not generate any trip commands. If you want a trip command of the 2nd stage to be created anyway, the setting must be ***U>Alarm U>>Trip***. This protection function can be used for any other single-phase voltage which is connected to the fourth voltage measurement input U_4. Also refer to Section 2.1.2.1 and see margin heading „Voltage Transformer Connection“.

This protective function also has two stages. The settings of the voltage threshold and the timer values depend on the type of application. Here no general guidelines can be established. The stage **3U0>** (address 3722) is usually set with a high sensitivity and a longer delay time **T 3U0>** (address 3723). The **3U0>>** stage (address 3724) and its delay time **T 3U0>>** (address 3725) allow you to implement a second stage with less sensitivity and a shorter delay time.

Similar considerations apply if this voltage stage is used for a different voltage at the measuring input U_4.

The zero-voltage stages feature a special time stabilisation due to repeated measurements allowing them to be set rather sensitive. This stabilisation can be disabled in address 3728 **3U0>(>) Stabil.** if a shorter pickup time is required. This parameter can only be altered in DIGSI at **Display Additional Settings**. Please consider that sensitive settings combined with short pickup times are not recommended.

The dropout to pickup ratio **3U0>(>) RESET** can be set in address 3729. This parameter can only be altered in DIGSI at **Display Additional Settings**.

When setting the voltage values please observe the following:

- If the U_{en} voltage of the set of voltage transformers is connected to U_4 and if this was already set in the Power System Data 1 (refer also to Section 2.1.2.1 under margin heading „Voltage Connection", address 210 **U4 transformer** = ***Udelta transf.***), the device multiplies this voltage by the matching ratio **Uph / Udelta** (address 211), usually with 1.73. Therefore the voltage measured is $\sqrt{3} \cdot U_{en} = 3 \cdot U_0$. When the voltage triangle is fully displaced, the voltage will be $\sqrt{3}$ times the phase-to-phase voltage.
- If any other voltage is connected to U_4, which is not used for voltage protection, and if this was already set in the Power System Data 1 (refer also to Section 2.1.2.1 under margin heading „Voltage Connection", e.g. **U4 transformer** = or **U4 transformer** = ***Not connected***), the device calculates the zero sequence voltage from the phase voltages according to its definition $3 \cdot U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. When the voltage triangle is fully displaced, the voltage will be $\sqrt{3}$ times the phase-to-phase voltage.
- If any other voltage is connected to U_4 , which is used for voltage protection, and if this was already set in the Power System Data 1 (refer also to Section 2.1.2.1, under margin heading „Voltage Connection", **U4 transformer** = ***Ux transformer***), this voltage will be used for the voltage stages without any further factors. This „zero sequence voltage protection" then is, in reality, a single-phase voltage protection for any kind of voltage at U_4. Note that with a sensitive setting, i.e. close to operational values that are to be expected, not only the time delay **T 3U0>** (address 3723) must be greater, but also the reset ratio **3U0>(>) RESET** (address 3729) must be set as high as possible.

Phase-earth undervoltage

The phase voltage stages can be switched ***ON*** or ***OFF*** in address 3751 **Uph-e<(<)**. In addition to this, you can set ***Alarm Only***, i.e. these stages operate and send alarms but do not generate any trip command. You can generate a trip command for the 2nd stage only in addition to the alarm by setting ***U<Alarm U<<Trip***.

This undervoltage protection function has two stages. The **Uph-e<** stage (address 3752) with a longer setting of the time **T Uph-e<** (address 3753) operates in the case of minor undervoltages. However, the value set here must not be higher than the undervoltage permissible in operation. In the presence of higher voltage dips, the **Uph-e<<** stage (address 3754) with the delay **T Uph-e<<** (address 3755) becomes active.

The dropout to pickup ratio **Uph-e<(<) RESET** can be set in address 3759. This parameter can only be altered in DIGSI at **Display Additional Settings**.

The settings of the voltages and times depend on the intended use; therefore no general recommendations for the settings can be given. For load shedding, for example, the values are often determined by a priority grading coordination chart. In case of stability problems, the permissible levels and durations of overvoltages must be observed. With induction machines undervoltages have an effect on the permissible torque thresholds.

If the voltage transformers are located on the line side, the measuring voltages will be missing when the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP. Uphe<** (address 3758) is switched ***ON***. With busbar side voltage transformers it can be switched ***OFF***. However, if the busbar is dead, the undervoltage protection will pick up and expire and then remain in a picked-up state. It must therefore be ensured in such cases that the protection is blocked by a binary input.

Phase-phase undervoltage

Basically, the same considerations apply as for the phase voltage stages. These stages may replace the phase voltage stages or be used additionally. Depending on your choice, set address 3761 **Uph-ph<(<)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U<Alarm U<<Trip***.

As phase–to–phase voltages are monitored, the phase–to–phase values are used for the settings **Uph-ph<** (address 3762) and **Uph-ph<<** (address 3764).

The corresponding times delay are **T Uph-ph<** (address 3763) and **T Uphph<<** (address 3765).

The dropout to pickup ratio **Uphph<(<) RESET** can be set in address 3769. This parameter can only be altered in DIGSI at **Display Additional Settings**.

If the voltage transformers are located on the line side, the measuring voltages will be missing when the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP.Uphph<** (address 3768) is switched ***ON***. With busbar side voltage transformers it can be switched ***OFF***. However, if the busbar is dead, the undervoltage protection will pick up and expire and then remain in a picked-up state. It must therefore be ensured in such cases that the protection is blocked by a binary input.

Undervoltage positive sequence system U_1

The positive sequence undervoltage stages can be used instead of or in addition to previously mentioned undervoltage stages. Depending on your choice, set address 3771 **U1<(<)** to ***ON***, ***OFF***, ***Alarm Only*** or ***U<Alarm U<<Trip***.

Basically, the same considerations apply as for the other undervoltage stages. Especially in case of stability problems, the positive sequence system is advantageous, since the positive sequence system is relevant for the limit of the stable energy transmission.

To achieve the two-stage condition, the **U1<** stage (address 3772) is combined with a greater time delay **T U1<** (address 3773), and the **U1<<** stage (address 3774) with a shorter time delay **T U1<<** (address 3775).

Note that the positive sequence system is established according to its defining equation $U_1 = {}^1/_3 \cdot |\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3}|$. For symmetrical voltages this is equivalent to a phase-earth voltage.

The dropout to pickup ratio **U1<(<) RESET** can be set in address 3779. This parameter can only be altered in DIGSI at **Display Additional Settings**.

If the voltage transformers are located on the line side, the measuring voltages will be missing when the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP.U1<** (address 3778) is switched ***ON***. With busbar side voltage transformers it can be switched ***OFF***. However, if the busbar is dead, the undervoltage protection will pick up and expire and then remain in a picked-up state. It must therefore be ensured in such cases that the protection is blocked by a binary input.

2.11.4 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
3701	Uph-e>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-e overvoltage prot.
3702	Uph-e>	1.0 .. 170.0 V; ∞	85.0 V	Uph-e> Pickup
3703	T Uph-e>	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e> Time Delay
3704	Uph-e>>	1.0 .. 170.0 V; ∞	100.0 V	Uph-e>> Pickup
3705	T Uph-e>>	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e>> Time Delay
3709A	Uph-e>(>) RESET	0.30 .. 0.99	0.98	Uph-e>(>) Reset ratio
3711	Uph-ph>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-ph overvoltage prot.
3712	Uph-ph>	2.0 .. 220.0 V; ∞	150.0 V	Uph-ph> Pickup
3713	T Uph-ph>	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph> Time Delay
3714	Uph-ph>>	2.0 .. 220.0 V; ∞	175.0 V	Uph-ph>> Pickup
3715	T Uph-ph>>	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph>> Time Delay
3719A	Uphph>(>) RESET	0.30 .. 0.99	0.98	Uph-ph>(>) Reset ratio
3721	3U0>(>) (or Ux)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode 3U0 (or Ux) overvoltage
3722	3U0>	1.0 .. 220.0 V; ∞	30.0 V	3U0> Pickup (or Ux>)
3723	T 3U0>	0.00 .. 100.00 sec; ∞	2.00 sec	T 3U0> Time Delay (or T Ux>)
3724	3U0>>	1.0 .. 220.0 V; ∞	50.0 V	3U0>> Pickup (or Ux>>)
3725	T 3U0>>	0.00 .. 100.00 sec; ∞	1.00 sec	T 3U0>> Time Delay (or T Ux>>)
3728A	3U0>(>) Stabil.	ON OFF	ON	3U0>(>): Stabilization 3U0-Measurement
3729A	3U0>(>) RESET	0.30 .. 0.99	0.95	3U0>(>) Reset ratio (or Ux)
3731	U1>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U1 overvoltage prot.
3732	U1>	2.0 .. 220.0 V; ∞	150.0 V	U1> Pickup
3733	T U1>	0.00 .. 100.00 sec; ∞	2.00 sec	T U1> Time Delay
3734	U1>>	2.0 .. 220.0 V; ∞	175.0 V	U1>> Pickup
3735	T U1>>	0.00 .. 100.00 sec; ∞	1.00 sec	T U1>> Time Delay
3736	U1> Compound	OFF ON	OFF	U1> with Compounding

Addr.	Parameter	Setting Options	Default Setting	Comments
3737	U1>> Compound	OFF ON	OFF	U1>> with Compounding
3739A	U1>(>) RESET	0.30 .. 0.99	0.98	U1>(>) Reset ratio
3741	U2>(>)	OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U2 overvoltage prot.
3742	U2>	2.0 .. 220.0 V; ∞	30.0 V	U2> Pickup
3743	T U2>	0.00 .. 100.00 sec; ∞	2.00 sec	T U2> Time Delay
3744	U2>>	2.0 .. 220.0 V; ∞	50.0 V	U2>> Pickup
3745	T U2>>	0.00 .. 100.00 sec; ∞	1.00 sec	T U2>> Time Delay
3749A	U2>(>) RESET	0.30 .. 0.99	0.98	U2>(>) Reset ratio
3751	Uph-e<(<)	OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-e undervolt-age prot.
3752	Uph-e<	1.0 .. 100.0 V; 0	30.0 V	Uph-e< Pickup
3753	T Uph-e<	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e< Time Delay
3754	Uph-e<<	1.0 .. 100.0 V; 0	10.0 V	Uph-e<< Pickup
3755	T Uph-e<<	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e<< Time Delay
3758	CURR.SUP. Uphe<	ON OFF	ON	Current supervision (Uph-e)
3759A	Uph-e<(<) RESET	1.01 .. 1.20	1.05	Uph-e<(<) Reset ratio
3761	Uph-ph<(<)	OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-ph under-voltage prot.
3762	Uph-ph<	1.0 .. 175.0 V; 0	50.0 V	Uph-ph< Pickup
3763	T Uph-ph<	0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph< Time Delay
3764	Uph-ph<<	1.0 .. 175.0 V; 0	17.0 V	Uph-ph<< Pickup
3765	T Uphph<<	0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph<< Time Delay
3768	CURR.SUP.Uphph<	ON OFF	ON	Current supervision (Uph-ph)
3769A	Uphph<(<) RESET	1.01 .. 1.20	1.05	Uph-ph<(<) Reset ratio
3771	U1<(<)	OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode U1 undervoltage prot.
3772	U1<	1.0 .. 100.0 V; 0	30.0 V	U1< Pickup
3773	T U1<	0.00 .. 100.00 sec; ∞	2.00 sec	T U1< Time Delay
3774	U1<<	1.0 .. 100.0 V; 0	10.0 V	U1<< Pickup
3775	T U1<<	0.00 .. 100.00 sec; ∞	1.00 sec	T U1<< Time Delay

Addr.	Parameter	Setting Options	Default Setting	Comments
3778	CURR.SUP.U1<	ON OFF	ON	Current supervision (U1)
3779A	U1<(<) RESET	1.01 .. 1.20	1.05	U1<(<) Reset ratio

2.11.5 Information List

No.	Information	Type of Information	Comments
10201	>Uph-e>(>) BLK	SP	>BLOCK Uph-e>(>) Overvolt. (phase-earth)
10202	>Uph-ph>(>) BLK	SP	>BLOCK Uph-ph>(>) Overvolt (phase-phase)
10203	>3U0>(>) BLK	SP	>BLOCK 3U0>(>) Overvolt. (zero sequence)
10204	>U1>(>) BLK	SP	>BLOCK U1>(>) Overvolt. (positive seq.)
10205	>U2>(>) BLK	SP	>BLOCK U2>(>) Overvolt. (negative seq.)
10206	>Uph-e<(<) BLK	SP	>BLOCK Uph-e<(<) Undervolt (phase-earth)
10207	>Uphph<(<) BLK	SP	>BLOCK Uphph<(<) Undervolt (phase-phase)
10208	>U1<(<) BLK	SP	>BLOCK U1<(<) Undervolt (positive seq.)
10215	Uph-e>(>) OFF	OUT	Uph-e>(>) Overvolt. is switched OFF
10216	Uph-e>(>) BLK	OUT	Uph-e>(>) Overvolt. is BLOCKED
10217	Uph-ph>(>) OFF	OUT	Uph-ph>(>) Overvolt. is switched OFF
10218	Uph-ph>(>) BLK	OUT	Uph-ph>(>) Overvolt. is BLOCKED
10219	3U0>(>) OFF	OUT	3U0>(>) Overvolt. is switched OFF
10220	3U0>(>) BLK	OUT	3U0>(>) Overvolt. is BLOCKED
10221	U1>(>) OFF	OUT	U1>(>) Overvolt. is switched OFF
10222	U1>(>) BLK	OUT	U1>(>) Overvolt. is BLOCKED
10223	U2>(>) OFF	OUT	U2>(>) Overvolt. is switched OFF
10224	U2>(>) BLK	OUT	U2>(>) Overvolt. is BLOCKED
10225	Uph-e<(<) OFF	OUT	Uph-e<(<) Undervolt. is switched OFF
10226	Uph-e<(<) BLK	OUT	Uph-e<(<) Undervolt. is BLOCKED
10227	Uph-ph<(<) OFF	OUT	Uph-ph<(<) Undervolt. is switched OFF
10228	Uph-ph<(<) BLK	OUT	Uphph<(<) Undervolt. is BLOCKED
10229	U1<(<) OFF	OUT	U1<(<) Undervolt. is switched OFF
10230	U1<(<) BLK	OUT	U1<(<) Undervolt. is BLOCKED
10231	U</> ACTIVE	OUT	Over-/Under-Voltage protection is ACTIVE
10240	Uph-e> Pickup	OUT	Uph-e> Pickup
10241	Uph-e>> Pickup	OUT	Uph-e>> Pickup
10242	Uph-e>(>) PU L1	OUT	Uph-e>(>) Pickup L1
10243	Uph-e>(>) PU L2	OUT	Uph-e>(>) Pickup L2
10244	Uph-e>(>) PU L3	OUT	Uph-e>(>) Pickup L3
10245	Uph-e> TimeOut	OUT	Uph-e> TimeOut
10246	Uph-e>> TimeOut	OUT	Uph-e>> TimeOut
10247	Uph-e>(>) TRIP	OUT	Uph-e>(>) TRIP command
10248	Uph-e> PU L1	OUT	Uph-e> Pickup L1
10249	Uph-e> PU L2	OUT	Uph-e> Pickup L2
10250	Uph-e> PU L3	OUT	Uph-e> Pickup L3
10251	Uph-e>> PU L1	OUT	Uph-e>> Pickup L1

No.	Information	Type of Information	Comments
10252	Uph-e>> PU L2	OUT	Uph-e>> Pickup L2
10253	Uph-e>> PU L3	OUT	Uph-e>> Pickup L3
10255	Uphph> Pickup	OUT	Uph-ph> Pickup
10256	Uphph>> Pickup	OUT	Uph-ph>> Pickup
10257	Uphph>(>)PU L12	OUT	Uph-ph>(>) Pickup L1-L2
10258	Uphph>(>)PU L23	OUT	Uph-ph>(>) Pickup L2-L3
10259	Uphph>(>)PU L31	OUT	Uph-ph>(>) Pickup L3-L1
10260	Uphph> TimeOut	OUT	Uph-ph> TimeOut
10261	Uphph>> TimeOut	OUT	Uph-ph>> TimeOut
10262	Uphph>(>) TRIP	OUT	Uph-ph>(>) TRIP command
10263	Uphph> PU L12	OUT	Uph-ph> Pickup L1-L2
10264	Uphph> PU L23	OUT	Uph-ph> Pickup L2-L3
10265	Uphph> PU L31	OUT	Uph-ph> Pickup L3-L1
10266	Uphph>> PU L12	OUT	Uph-ph>> Pickup L1-L2
10267	Uphph>> PU L23	OUT	Uph-ph>> Pickup L2-L3
10268	Uphph>> PU L31	OUT	Uph-ph>> Pickup L3-L1
10270	3U0> Pickup	OUT	3U0> Pickup
10271	3U0>> Pickup	OUT	3U0>> Pickup
10272	3U0> TimeOut	OUT	3U0> TimeOut
10273	3U0>> TimeOut	OUT	3U0>> TimeOut
10274	3U0>(>) TRIP	OUT	3U0>(>) TRIP command
10280	U1> Pickup	OUT	U1> Pickup
10281	U1>> Pickup	OUT	U1>> Pickup
10282	U1> TimeOut	OUT	U1> TimeOut
10283	U1>> TimeOut	OUT	U1>> TimeOut
10284	U1>(>) TRIP	OUT	U1>(>) TRIP command
10290	U2> Pickup	OUT	U2> Pickup
10291	U2>> Pickup	OUT	U2>> Pickup
10292	U2> TimeOut	OUT	U2> TimeOut
10293	U2>> TimeOut	OUT	U2>> TimeOut
10294	U2>(>) TRIP	OUT	U2>(>) TRIP command
10300	U1< Pickup	OUT	U1< Pickup
10301	U1<< Pickup	OUT	U1<< Pickup
10302	U1< TimeOut	OUT	U1< TimeOut
10303	U1<< TimeOut	OUT	U1<< TimeOut
10304	U1<(<) TRIP	OUT	U1<(<) TRIP command
10310	Uph-e< Pickup	OUT	Uph-e< Pickup
10311	Uph-e<< Pickup	OUT	Uph-e<< Pickup
10312	Uph-e<(<) PU L1	OUT	Uph-e<(<) Pickup L1
10313	Uph-e<(<) PU L2	OUT	Uph-e<(<) Pickup L2
10314	Uph-e<(<) PU L3	OUT	Uph-e<(<) Pickup L3
10315	Uph-e< TimeOut	OUT	Uph-e< TimeOut
10316	Uph-e<< TimeOut	OUT	Uph-e<< TimeOut
10317	Uph-e<(<) TRIP	OUT	Uph-e<(<) TRIP command
10318	Uph-e< PU L1	OUT	Uph-e< Pickup L1
10319	Uph-e< PU L2	OUT	Uph-e< Pickup L2

No.	Information	Type of Information	Comments
10320	Uph-e< PU L3	OUT	Uph-e< Pickup L3
10321	Uph-e<< PU L1	OUT	Uph-e<< Pickup L1
10322	Uph-e<< PU L2	OUT	Uph-e<< Pickup L2
10323	Uph-e<< PU L3	OUT	Uph-e<< Pickup L3
10325	Uph-ph< Pickup	OUT	Uph-ph< Pickup
10326	Uph-ph<< Pickup	OUT	Uph-ph<< Pickup
10327	Uphph<(<)PU L12	OUT	Uphph<(<) Pickup L1-L2
10328	Uphph<(<)PU L23	OUT	Uphph<(<) Pickup L2-L3
10329	Uphph<(<)PU L31	OUT	Uphph<(<) Pickup L3-L1
10330	Uphph< TimeOut	OUT	Uphph< TimeOut
10331	Uphph<< TimeOut	OUT	Uphph<< TimeOut
10332	Uphph<(<) TRIP	OUT	Uphph<(<) TRIP command
10333	Uphph< PU L12	OUT	Uph-ph< Pickup L1-L2
10334	Uphph< PU L23	OUT	Uph-ph< Pickup L2-L3
10335	Uphph< PU L31	OUT	Uph-ph< Pickup L3-L1
10336	Uphph<< PU L12	OUT	Uph-ph<< Pickup L1-L2
10337	Uphph<< PU L23	OUT	Uph-ph<< Pickup L2-L3
10338	Uphph<< PU L31	OUT	Uph-ph<< Pickup L3-L1

2.12 Frequency Protection (optional)

The frequency protection function detects overfrequencies or underfrequencies in the system or in electrical machines. If the frequency is outside the permissible range, appropriate actions are initiated such as load shedding or separating the generator from the system.

Underfrequency is caused by increased real power demand of the loads or by a reduction of the generated power e.g. in the event of disconnection from the network, generator failure or faulty operation of the power frequency control. Underfrequency protection is also applied for generators which operate (temporarily) to an island network. This is due to the fact that the reverse power protection cannot operate in case of a drive power failure. The generator can be disconnected from the power system by means of the underfrequency protection. Underfrequency also results in increased reactive power demand of inductive loads.

Overfrequency is caused for instance by load shedding, system disconnection or malfunction of the power frequency control. There is also a risk of self-excitation for generators feeding long lines under no-load conditions.

2.12.1 Functional Description

Frequency stages

Frequency protection consists of the four frequency elements f1 to f4. Each element can be set as overfrequency stage (f>) or as underfrequency stage (f<) with individual thresholds and time delays. This ensures variable matching to the application purpose.

- If an element is set to a value above the rated frequency, it is automatically interpreted to be an overfrequency stage f>.
- If an element is set to a value below the rated frequency, it is automatically interpreted to be an underfrequency stage f<.
- If an element is set exactly to the rated frequency, it is inactive.

Each element can be blocked via binary input and also the entire frequency protection function can be blocked.

Frequency measurement

The largest of the 3 phase-to-phase voltages is used for frequency measurement. It must amount to at least 65 % of the nominal voltage set in parameter 204, **Unom SECONDARY**. Below that value frequency measurement will not take place.

Numerical filters are employed to calculate from the measured voltage a quantity that is proportional to the frequency which is virtually linear in the specified range (f_N ± 10 %). Filters and repeated measurements ensure that the frequency evaluation is virtually free from harmonic influences and phase jumps.

An accurate and quick measurement result is obtained by considering also the frequency change. When changing the frequency of the power system, the sign of the quotient $^{\Delta f}/_{dt}$ remains unchanged during several repeated measurements. If, however, a phase jump in the measured voltage temporarily simulates a frequency deviation, the sign of $^{\Delta f}/_{dt}$ will subsequently reverse. Thus the measurement results corrupted by a phase jump are quickly discarded.

The dropout value of each frequency element is approximately 20 mHz below (for f>) or above (for f<) of the pickup value.

Operating ranges

Frequency evaluation requires a measured quantity that can be processed. This implies that at least a sufficiently high voltage is available and that the frequency of this voltage is within the working range of the frequency protection.

The frequency protection automatically selects the largest of the phase-to-phase voltages. If all three voltages are below the operating range of 65 % · U_N (secondary), the frequency cannot be determined. In that case the indication 5215 „`Freq UnderV Blk`“ is displayed. If the voltage falls below this minimum value after a frequency stage has picked up, the picked up element will drop out. This implies also that all frequency stages will drop out after a line has been switched off (with voltage transformers on line side).

When connecting a measuring voltage with a frequency outside the configured threshold of a frequency element, the frequency protection is immediately ready to operate. Since the filters of the frequency measurement must first go through a transient state, the command output time may increase slightly (approx. 1 period). This is because a frequency element picks up only if the frequency has been detected outside the configured threshold in five consecutive measurements.

The frequency range is from 25 Hz to 70 Hz. If the frequency leaves this operating range, the frequency stages will drop out. If the frequency returns into the operating range, the measurement can be resumed provided that the measuring voltage is also inside the operating range. But if the measuring voltage is switched off, the picked up element will drop out immediately.

Power swings

In interconnected networks, frequency deviations may also be caused by power swings. Depending on the power swing frequency, the mounting location of the device and the setting of the frequency stages, power swings may cause the frequency protection to pickup and even to trip. In these cases it is reasonable to block the frequency protection once power swings are detected. This can be accomplished via binary inputs and binary outputs (e.g. power swing detection of an external distance protection) or by corresponding logic operations using the user-defined logic (CFC). If, however, the power swing frequencies are known, tripping of the frequency protection function can also be avoided by adapting the delay times of the frequency protection correspondingly.

Pickup/tripping

Figure 2-60 shows the logic diagram for the frequency protection function.

Once the frequency was reliably detected to be outside the configured thresholds of a stage (above the setting value for f> elements or below for f< elements), a pickup signal of the corresponding stage is generated. The decision is considered reliable if 5 measurements taken in intervals of $^1/_2$ period yield one frequency outside the set threshold.

After pickup, a delay time per element can be started. When the associated time has elapsed, one trip command per element is issued. A picked up element drops out if the pickup condition is no longer valid after 5 measurements or if the measuring voltage was switched off or the frequency is outside the operating range. When a frequency stage drops out, the tripping signal of of the corresponding frequency stage is immediately reset, but the trip command is maintained for at least the minimum command duration which was set for all tripping functions of the device.

Each of the four frequency elements can be blocked individually by binary inputs. The blocking takes immediate effect. It is also possible to block the entire frequency protection function via binary input.

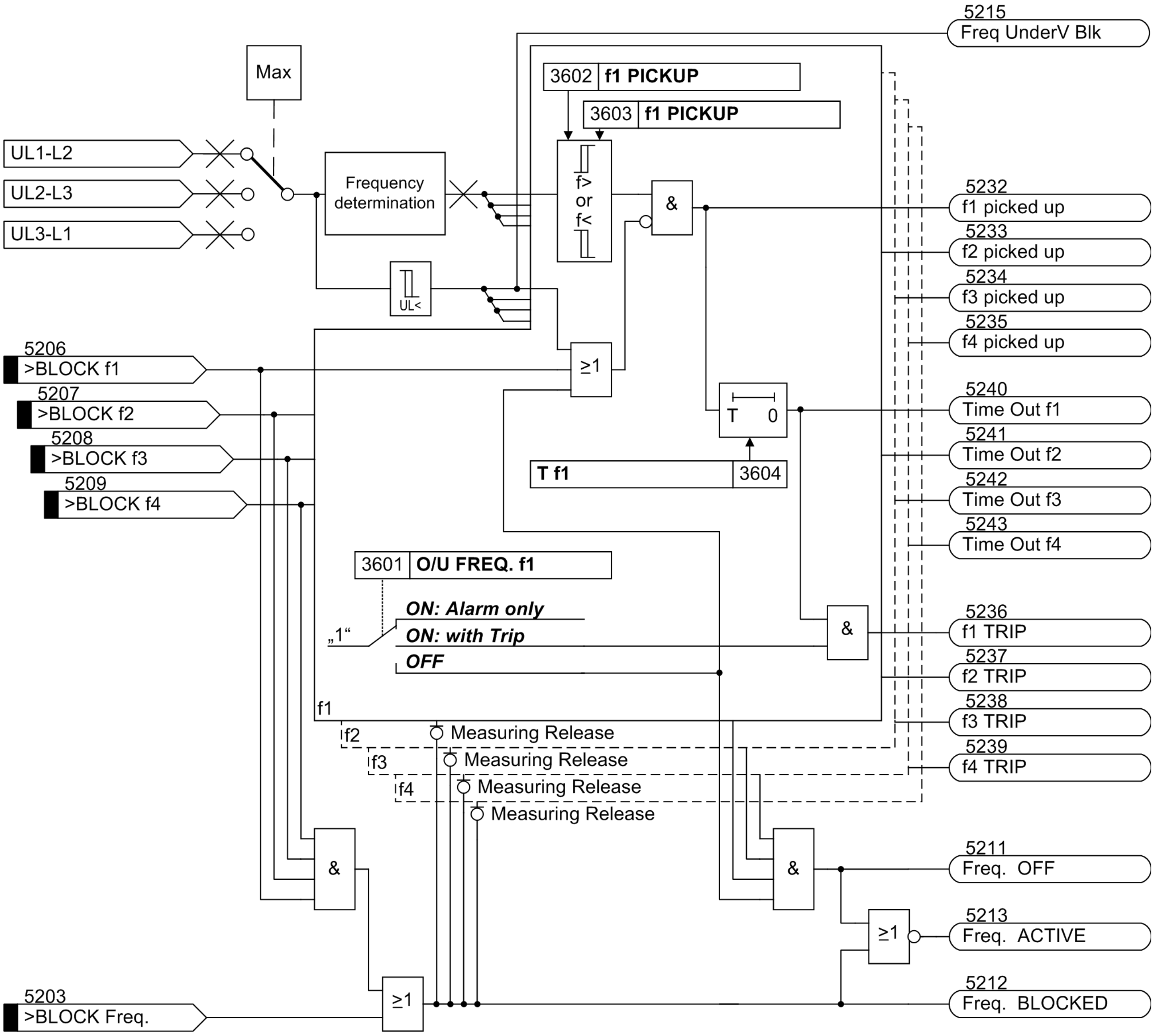


Figure 2-60 Logic diagram of the frequency protection

2.12.2 Setting Notes

General

Frequency protection is only in effect and accessible if address 136 **FREQUENCY Prot.** is set to ***Enabled*** during configuration of protective functions. If the function is not required, ***Disabled*** is to be set.

The frequency protection function features 4 frequency stages f1 to f4 each of which can function as overfrequency stage or underfrequency stage. Each stage can be set active or inactive. This is set in addresses:

- 3601 **O/U FREQ. f1** for frequency stage f1,
- 3611 **O/U FREQ. f2** for frequency stage f2,
- 3621 **O/U FREQ. f3** for frequency stage f3,
- 3631 **O/U FREQ. f4** for frequency stage f4,

The following 3 options are available:

- Stage ***OFF***: The stage is ineffective;
- Stage ***ON: with Trip***: The stage is effective and issues an alarm and a trip command (after time has expired) following irregular frequency deviations;
- Stage ***ON: Alarm only***: The stage is effective and issues an alarm but no trip command following irregular frequency deviations.

Pickup values, delay time

The configured pickup value determines whether a frequency element is to respond to overfrequency or underfrequency.

- If a stage is set to a value above the rated frequency, it is automatically interpreted to be an overfrequency stage f>.
- If a stage is set to a value below the rated frequency, it is automatically interpreted to be an underfrequency stage f<.
- If a stage is set exactly to the rated frequency, it is inactive.

A pickup value can be set for each stage according to above rules. The addresses and possible setting ranges are determined by the nominal frequency as configured in the Power System Data 1 (Section 2.1.2.1) in **Rated Frequency** (address 230).

Please note that none of the frequency stages is set to less than 30 mHz above (for f>) or below (for f<) of the nominal frequency. Since the frequency stages have a hysteresis of approx. 20 mHz, it may otherwise happen that the element does not drop out when returning to the nominal frequency.

Only those addresses are accessible that match the configured nominal frequency. For each element, a trip delay time can be set:

- Address 3602 **f1 PICKUP** pickup value for frequency stage f1 at f_N = 50 Hz,
  Address 3603 **f1 PICKUP** pickup value for frequency stage f1 at f_N = 60 Hz,
  Address 3604 **T f1** trip delay for frequency stage f1;
- Address 3612 **f2 PICKUP** pickup value for frequency stage f2 at f_N = 50 Hz,
  Address 3613 **f2 PICKUP** pickup value for frequency stage f2 at f_N = 60 Hz,
  Address 3614 **T f2** trip delay for frequency element f2;
- Address 3622 **f3 PICKUP** pickup value for frequency stage f3 at f_N = 50 Hz,
  Address 3623 **f3 PICKUP** pickup value for frequency stage f3 at f_N = 60 Hz,
  Address 3624 **T f3** trip delay for frequency stage f3;
- Address 3632 **f4 PICKUP** pickup value for frequency stage f4 at f_N = 50 Hz,
  Address 3633 **f4 PICKUP** pickup value for frequency stage f4 at f_N = 60 Hz,
  Address 3634 **T f4** trip delay for frequency element f4.

The set times are additional delay times not including the operating times (measuring time, dropout time) of the protective function.

If underfrequency protection is used for load shedding purposes, then the frequency settings relative to other feeder relays are generally based on the priority of the customers served by the protective relay. Normally, it is required for load shedding a frecuency / time grading that takes into account the importance of the consumers or consumer groups.

In interconnected networks, frequency deviations may also be caused by power swings. Depending on the power swing frequency, the mounting location of the device and the setting of the frequency stages, it is reasonable to block the entire frequency protection function or single stages once a power swing has been detected. The delay times must then be co-ordinated thus that a power swing is detected before the frequency protection trips.

Further application examples exist in the field of power stations. The frequency values to be set mainly depend, also in these cases, on the specifications of the power system/power station operator. In this context, the underfrequency protection also ensures the power station's own demand by disconnecting it from the power system on time. The turbo regulator regulates the machine set to the nominal speed. Consequently, the station's own demands can be continuously supplied at nominal frequency.

Since the dropout threshold is 20 mHz below or above the trip frequency, the resulting „minimum“ trip frequency is 30 mHz above or below the nominal frequency.

A frequency increase can, for example, occur due to a load shedding or malfunction of the speed regulation (e.g. in a stand-alone system). In this way, the frequency protection can, for example, be used as overspeed protection.

2.12.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
3601	O/U FREQ. f1	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f1
3602	f1 PICKUP	45.50 .. 54.50 Hz	49.50 Hz	f1 Pickup
3603	f1 PICKUP	55.50 .. 64.50 Hz	59.50 Hz	f1 Pickup
3604	T f1	0.00 .. 600.00 sec	60.00 sec	T f1 Time Delay
3611	O/U FREQ. f2	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f2
3612	f2 PICKUP	45.50 .. 54.50 Hz	49.00 Hz	f2 Pickup
3613	f2 PICKUP	55.50 .. 64.50 Hz	57.00 Hz	f2 Pickup
3614	T f2	0.00 .. 600.00 sec	30.00 sec	T f2 Time Delay
3621	O/U FREQ. f3	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f3
3622	f3 PICKUP	45.50 .. 54.50 Hz	47.50 Hz	f3 Pickup
3623	f3 PICKUP	55.50 .. 64.50 Hz	59.50 Hz	f3 Pickup
3624	T f3	0.00 .. 600.00 sec	3.00 sec	T f3 Time Delay
3631	O/U FREQ. f4	ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f4
3632	f4 PICKUP	45.50 .. 54.50 Hz	51.00 Hz	f4 Pickup
3633	f4 PICKUP	55.50 .. 64.50 Hz	62.00 Hz	f4 Pickup
3634	T f4	0.00 .. 600.00 sec	30.00 sec	T f4 Time Delay

2.12.4 Information List

No.	Information	Type of Information	Comments
5203	>BLOCK Freq.	SP	>BLOCK frequency protection
5206	>BLOCK f1	SP	>BLOCK frequency protection stage f1
5207	>BLOCK f2	SP	>BLOCK frequency protection stage f2
5208	>BLOCK f3	SP	>BLOCK frequency protection stage f3
5209	>BLOCK f4	SP	>BLOCK frequency protection stage f4
5211	Freq. OFF	OUT	Frequency protection is switched OFF
5212	Freq. BLOCKED	OUT	Frequency protection is BLOCKED
5213	Freq. ACTIVE	OUT	Frequency protection is ACTIVE
5215	Freq UnderV Blk	OUT	Frequency protection undervoltage Blk
5232	f1 picked up	OUT	Frequency protection: f1 picked up
5233	f2 picked up	OUT	Frequency protection: f2 picked up
5234	f3 picked up	OUT	Frequency protection: f3 picked up
5235	f4 picked up	OUT	Frequency protection: f4 picked up
5236	f1 TRIP	OUT	Frequency protection: f1 TRIP
5237	f2 TRIP	OUT	Frequency protection: f2 TRIP
5238	f3 TRIP	OUT	Frequency protection: f3 TRIP
5239	f4 TRIP	OUT	Frequency protection: f4 TRIP
5240	Time Out f1	OUT	Frequency protection: TimeOut Stage f1
5241	Time Out f2	OUT	Frequency protection: TimeOut Stage f2
5242	Time Out f3	OUT	Frequency protection: TimeOut Stage f3
5243	Time Out f4	OUT	Frequency protection: TimeOut Stage f4

2.13 Circuit Breaker Failure Protection

The circuit breaker failure protection provides rapid back-up fault clearance in the event that the circuit breaker fails to respond to a trip command from a protective function of the local circuit breaker.

2.13.1 Function Description

General

Whenever e.g. a short-circuit protection relay of a feeder issues a trip command to the circuit breaker, this is repeated to the breaker failure protection (Figure 2-61). 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.

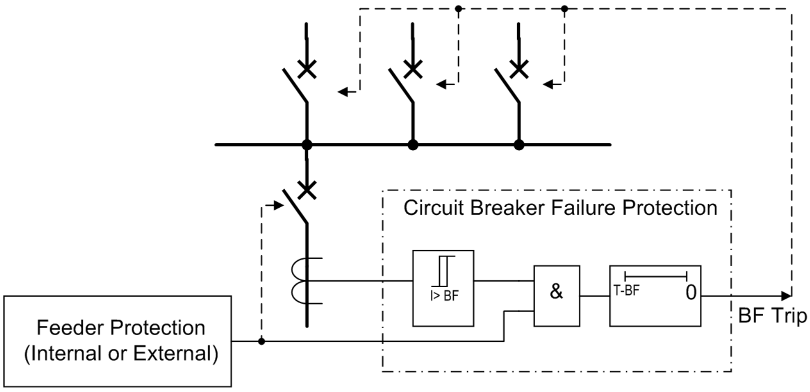


Figure 2-61 Simplified function diagram of circuit breaker failure protection with current flow monitoring

Normally, the breaker will open and interrupt the fault current. The current monitoring stage quickly resets (typical 10 ms) and stops the timer T–BF.

If the trip command is not carried out (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 back-up breakers and interrupt the fault current.

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

For protection functions where the tripping criterion is not dependent on current (e.g. Buchholz protection), current flow is not a reliable criterion for proper operation of the 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 2-62). For this purpose, the outputs from the auxiliary contacts must be fed to binary inputs on the relay (refer also to Section 2.16.1).

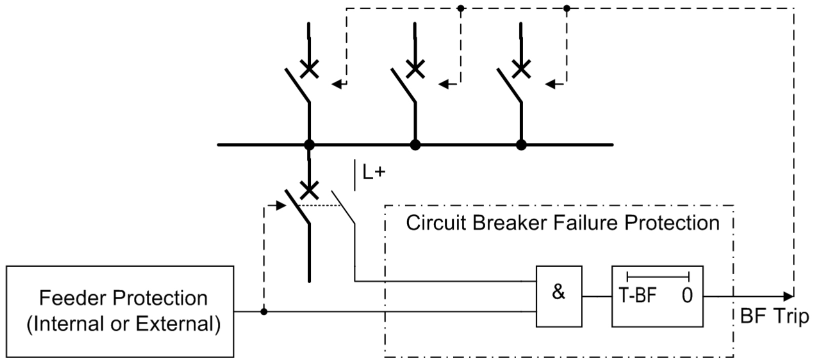


Figure 2-62 Simplified function diagram of circuit breaker failure protection controlled by circuit breaker auxiliary contact

Current flow monitoring

Each of the phase currents and an additional plausibility current (see below) are filtered by numerical filter algorithms so that only the fundamental component is used for further evaluation.

Special features recognize the instant of current interruption. In case of sinusoidal currents the current interruption is detected after approximately 10 ms. 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 limit value. Besides the three phase currents, two further current thresholds are provided in order to allow a plausibility check. If configured correspondingly, a separate threshold value can be used for this plausibility check (see Figure 2-63).

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 it is used. If the residual current is not available, the device calculates it with the formula:

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

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

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

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.

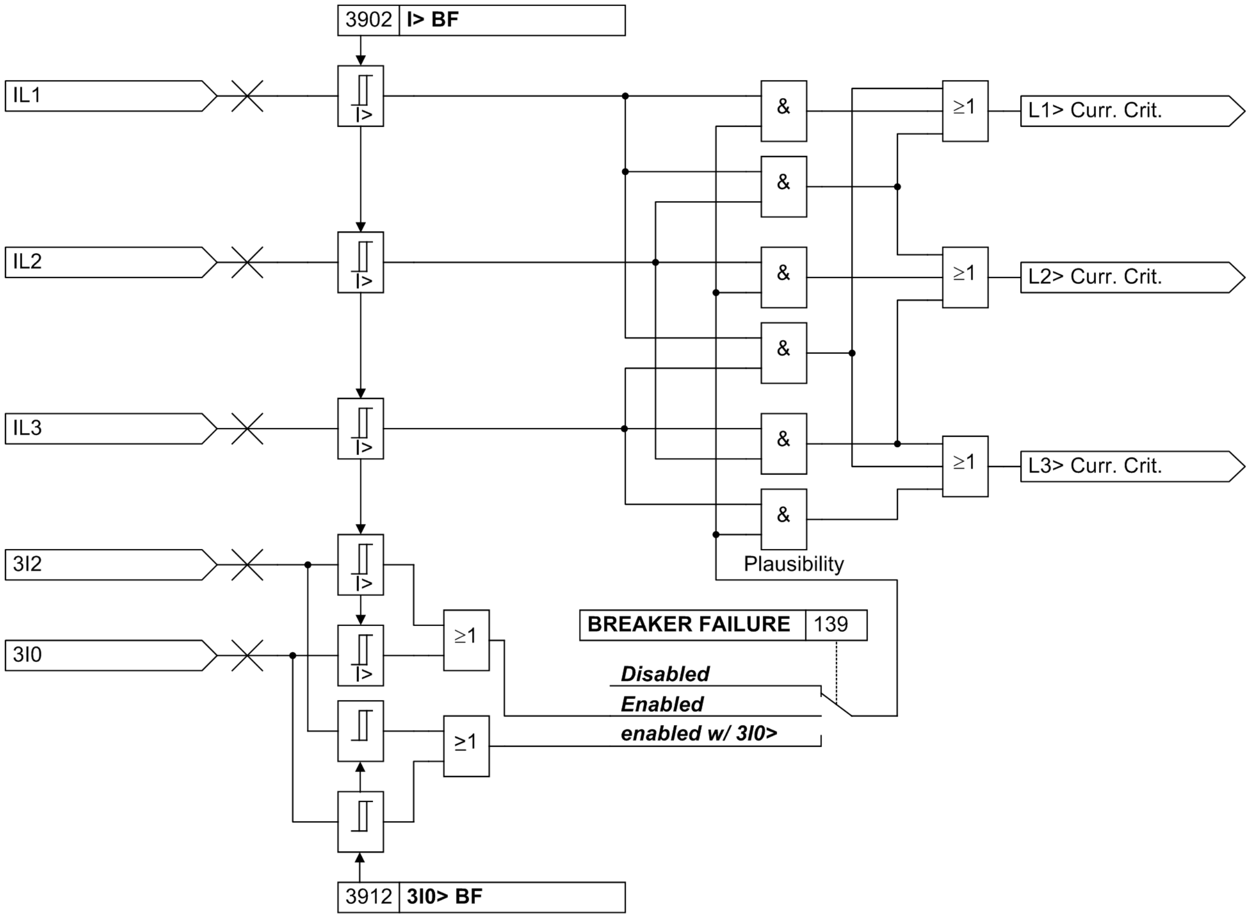


Figure 2-63 Current flow monitoring with plausibility currents $3{\cdot}I_0$ and $3{\cdot}I_2$

Monitoring the circuit breaker auxiliary contacts

It is the central function control of the device that informs the breaker failure protection on the position of the circuit breaker (refer also to Section 2.16.1). The 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 2-64). This gives preference to the more reliable current criterion and avoids overfunctioning due to a defect e.g. in the auxiliary contact mechanism or circuit. This interlock feature is provided for each individual phase as well as for three-pole tripping.

It is possible to disable the auxiliary contact criterion. If you set the parameter switch **Chk BRK CONTACT** (Figure 2-66 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.

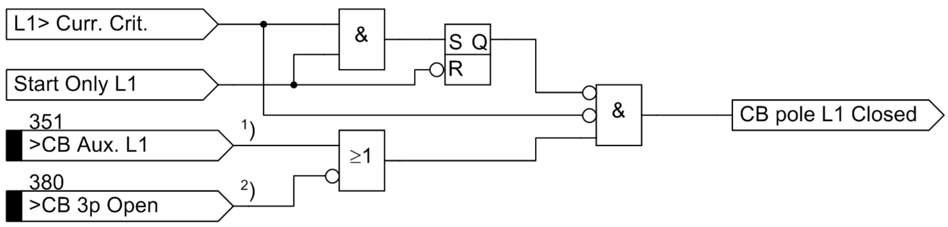


Figure 2-64 Interlock of the auxiliary contact criterion - example for phase L1

[1]) if phase-segregated auxiliary contacts are available

[2]) if series-connected NC contacts are available

On the other hand, current flow is not a reliable criterion for proper operation of the circuit breaker for faults which do not cause detectable current flow (e.g. Buchholz protection). Information regarding the position of the circuit breaker auxiliary contacts is required in these cases to check the correct response of the circuit breaker. For this purpose, the binary input „`>BF Start w/o I`“ No. 1439 is provided (Figure 2-66 left). This input initiates the breaker failure protection even if no current flow is detected.

Common phase initiation

Common phase initiation is used, for example, in systems with only three-pole tripping, for transformer feeders, or if the busbar protection trips. This is the only available initiation mode if the actual 7SD610 model can only trip three-pole.

If the breaker failure protection is intended to be initiated by further external protection devices, it is recommended, for security reasons, to connect two binary inputs to the device. Besides the trip command of the external protection to the binary input „`>BF Start 3pole`“ no. 1415 it is recommended to connect also the general device pickup to binary input „`>BF release`“ no. 1432. For Buchholz protection it is recommended that both inputs are connected to the device by two separate wire pairs.

Nevertheless, it is possible to initiate the breaker failure protection in single-channel mode should a separate release criterion not be available. The binary input „`>BF release`“ (No. 1432) must then not be assigned to any physical input of the device during configuration.

Figure 2-66 shows the operating principle. When the trip signal appears from any internal or external feeder protection and at least one current flow criterion according to Figure 2-63 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 can be queried as shown in Figure 2-65. If the circuit breaker poles have individual auxiliary contacts, the series connection of the three normally closed (NC) auxiliary contacts is used. After a three-pole trip command the circuit breaker has only operated correctly if current no longer flows over the poles or if all three NC auxiliary contacts are closed.

Figure 2-65 illustrates how the internal signal „CB pole ≥L1 closed“ is created (see Figure 2-66 left) if at least one circuit breaker pole is closed.

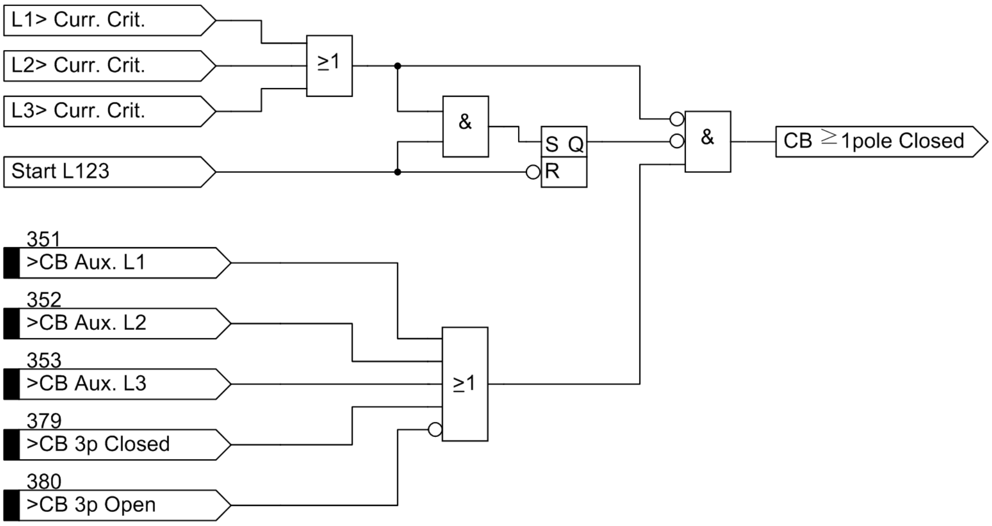


Figure 2-65 Creation of signal "CB ≥ any pole closed"

If an internal protection function or an external protection device trips without current flow, the breaker failure protection is initiated by the internal input „Start internal w/o I“, if the trip signal comes from the internal voltage protection or frequency protection, or by the external input „`>BF Start w/o I`“. In this case the start signal is maintained until the circuit breaker is reported to be open by the auxiliary contact criterion.

Initiation can be blocked via the binary input „`>BLOCK BkrFail`“ (e.g. during test of the feeder protection relay).

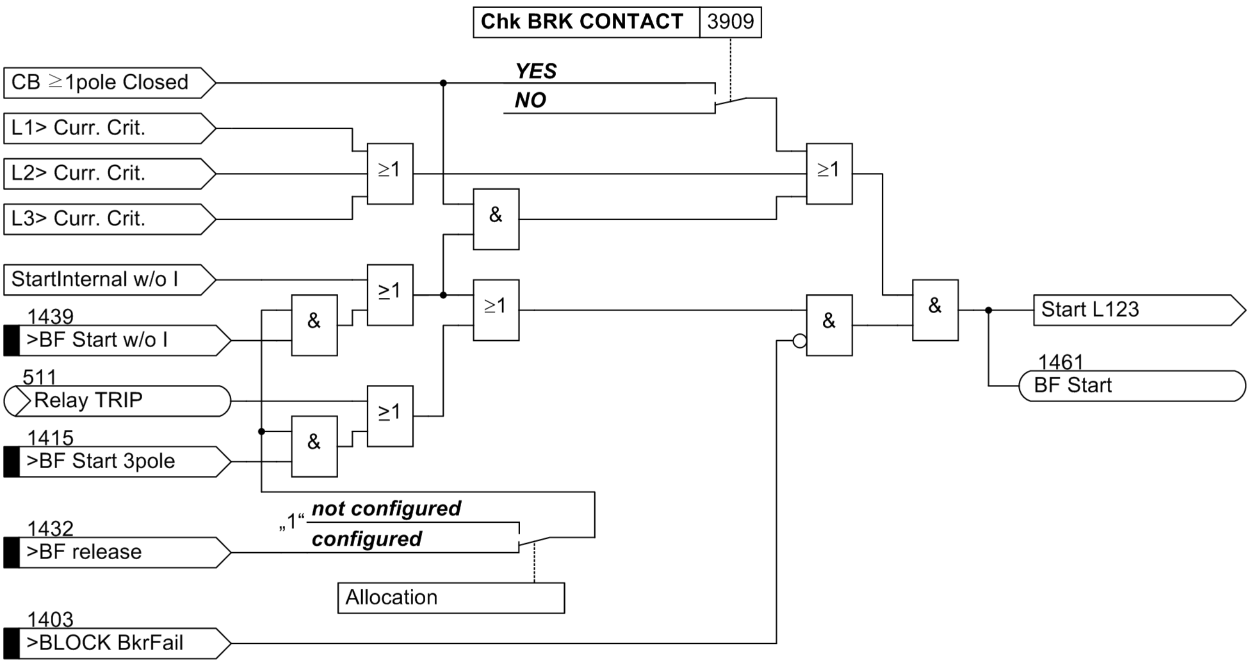


Figure 2-66 Breaker failure protection with common phase initiation

Phase-segregated initiation

Phase segregated initiation of the breaker failure protection is necessary if the circuit breaker poles are 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 two binary inputs to the device. Besides the three trip commands of the external relay to the binary input „`>BF Start L1`“, „`>BF Start L2`“ and „`>BF Start L3`“ it is recommended to connect also, for example, the general device pickup to binary input „`>BF release`“. Figure 2-67 shows this connection.

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`“ must then not be assigned to any physical input of the device during configuration.

If the external protection device does not provide a general fault detection signal, a general trip signal can be used instead. Alternatively, the parallel connection of a separate set of trip contacts can produce such a release signal as shown in Figure 2-68.

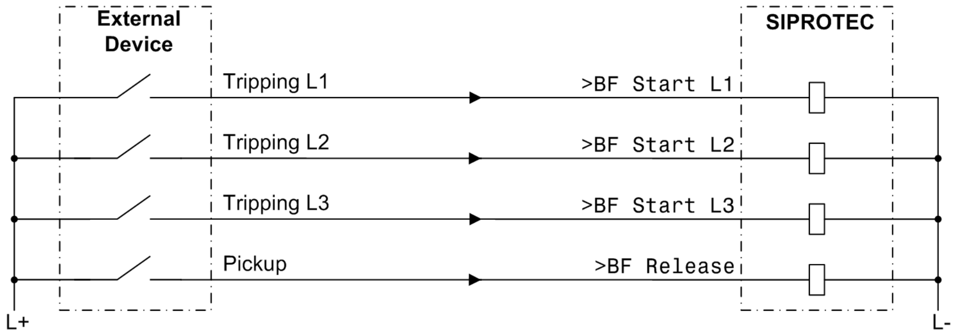


Figure 2-67 Breaker failure protection with phase segregated initiation — example for initiation by an external protection device with release by a fault detection signal

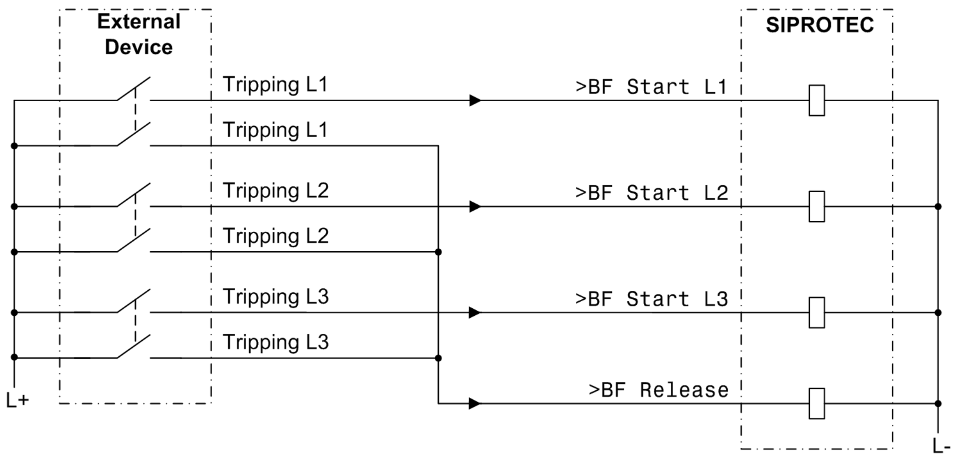


Figure 2-68 Breaker failure protection with phase segregated initiation — example for initiation by an external protection device with release by a separate set of trip contacts

The start condition logic for the delay time(s) is basically designed as in the common phase initiation, the difference is that this logic is designed separately for each phase

(Figure 2-69). Thus, current flow and initiation conditions are processed for each phase. In case of single-pole interruption before an automatic reclose cycle, current disappearance is reliably monitored for the tripped breaker pole only.

Initiation of an individual phase, e.g. „Start only L1“, is only valid if the starting signal (= tripping signal of the feeder protection) appears for exactly this phase and if the current criterion is met for at least this phase. If it is not met, the circuit breaker auxiliary contact can be interrogated according to Figure 2-64 – if parameterised (**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 executed only if the series connection of the normally open (NO) auxiliary contacts is interrupted. This information is provided to the breaker failure protection by the central function control of the device (refer to Section 2.16.1).

If there are starting signals of more than one phase, the common phase initiation „Start L123“ is used. Phase-segregated initiation is then blocked. The input "BF Start w/o I" (e.g. from Buchholz protection) operates only in three-phase mode. The function is the same as with common phase initiation.

The additional release-signal „>BF release“ (if assigned to a binary input) affects all initiation conditions. Initiation can be blocked via the binary input „>BLOCK BkrFail“ (e.g. during test of the feeder protection relay).

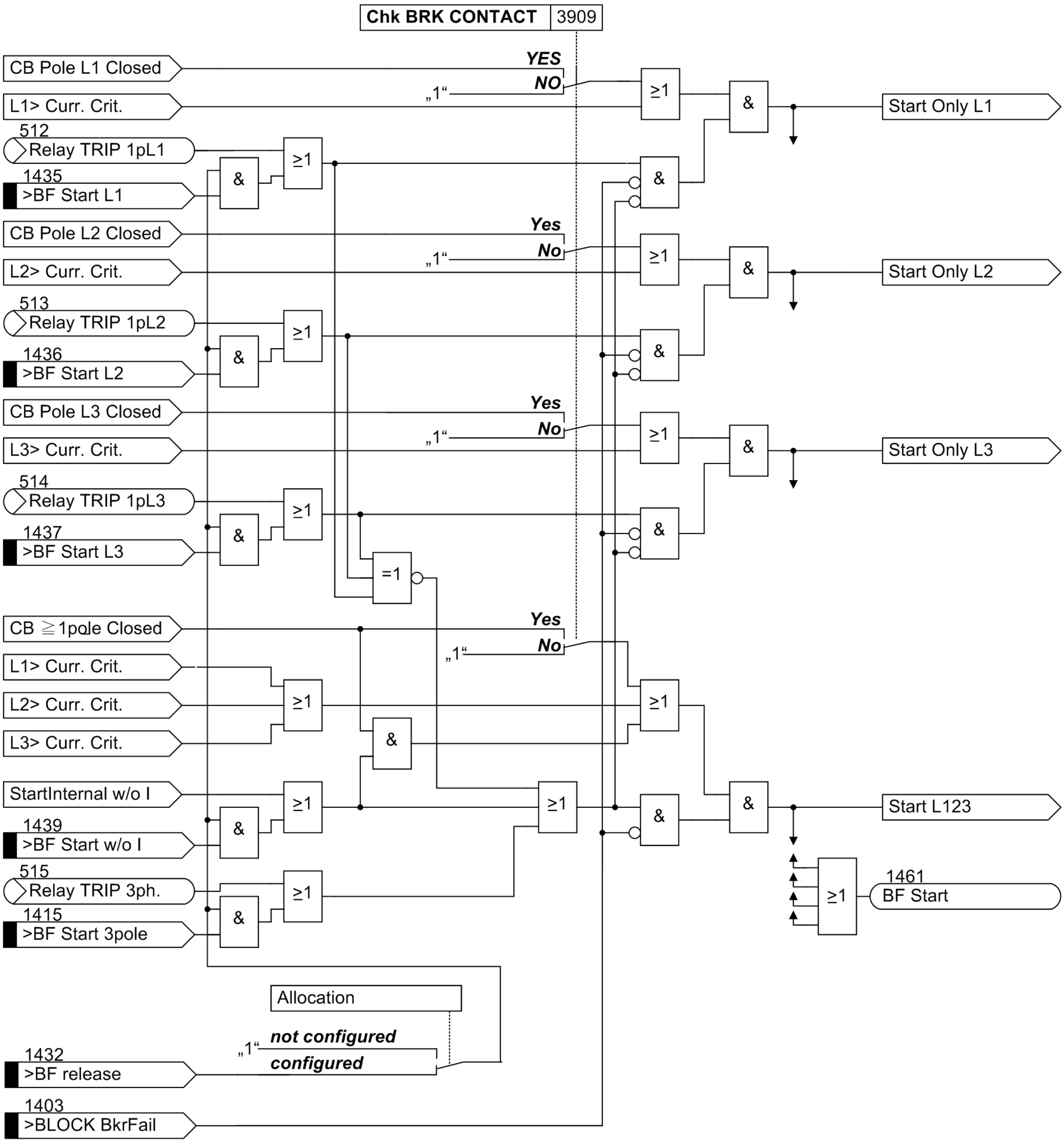


Figure 2-69 Initiation conditions for single-pole trip commands

Delay times

When the initiate conditions are fulfilled, the associated timers are started. The circuit breaker pole(s) must open before the associated time has elapsed.

Different delay times are possible for single-pole and three-pole initiation. An additional delay time 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 which then interrupt the fault current if the local feeder breaker fails (Figure 2-61 or Figure 2-62). Adjacent circuit breakers are the ones of the busbar or busbar section to which the considered feeder 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. The tripping by the breaker failure protection is always three-pole.

The simplest solution is to start the delay timer **T2** (Figure 2-70). The phase-segregated initiation signals are omitted 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 to be achieved after a single-pole trip or three-pole trip, the delay times **T1-1pole** and **T1-3pole** are used according to Figure 2-71.

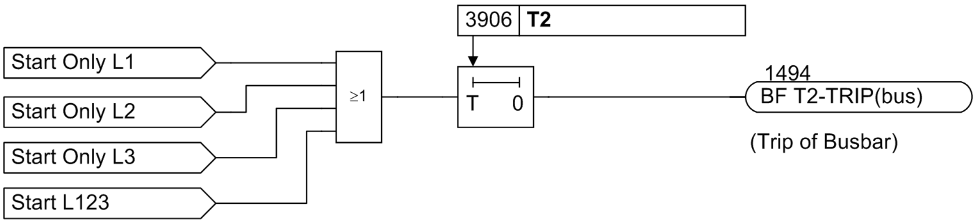


Figure 2-70 Single-stage breaker failure protection with common phase initiation

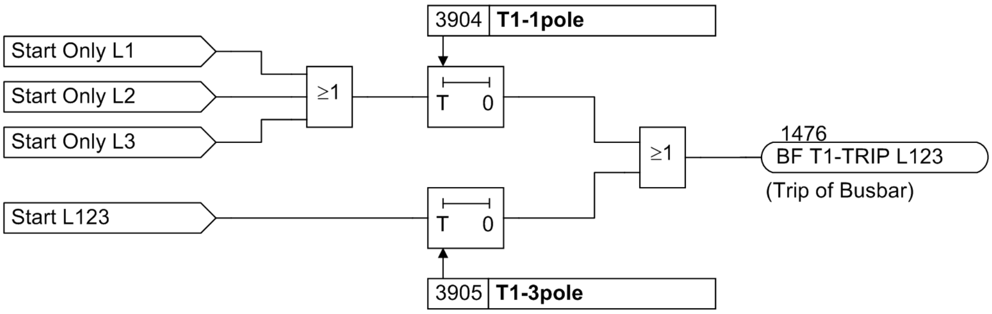


Figure 2-71 Single-stage breaker failure protection with different delay times

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

For the first stage a different delay **T1-1pole** can be set for single-pole trip than for three-pole trip by the feeder protection. In addition, you can use this setting (parameter **1p-RETRIP (T1)**) to define whether this repeated trip should be single-pole or three-pole.

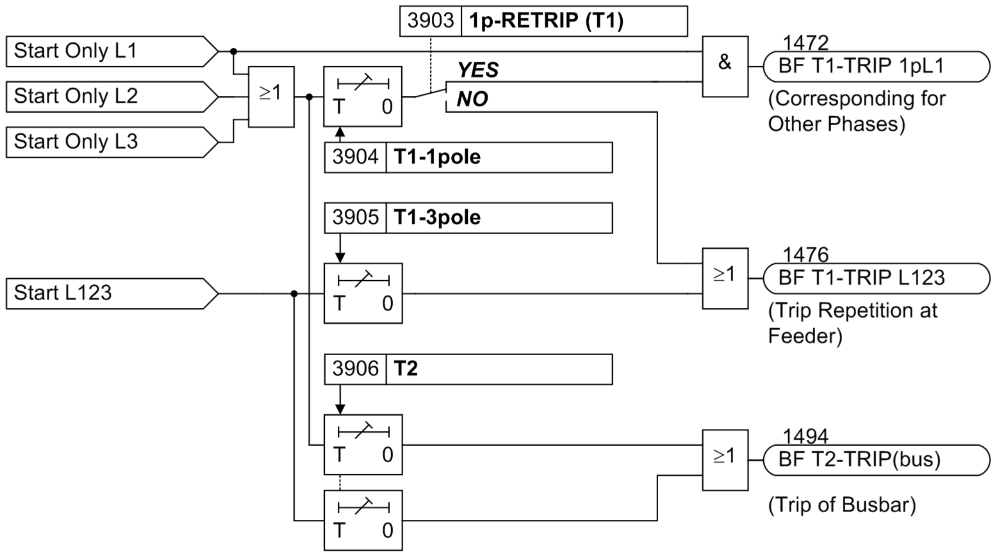


Figure 2-72 Two-stage breaker failure protection with phase segregated initiation

Circuit breaker not operational

There may be cases when it is already obvious that the circuit breaker associated with a feeder protection relay cannot clear a fault, e.g. when the tripping voltage or the tripping energy is not available.

In such a case it is not necessary to wait for the response of the feeder circuit breaker. If provision has been made for the detection of such a condition (e.g. control voltage monitor or air pressure monitor), the monitor alarm signal can be fed to the binary input „`>CB faulty`“ of the 7SD610. On occurrence of this alarm and a trip command by the feeder protection, a separate timer **`T3-BkrDefective`**, which is normally set to 0, is started (Figure 2-73). Thus, the adjacent circuit breakers (bus-bar) are tripped immediately in case the feeder circuit breaker is not operational.

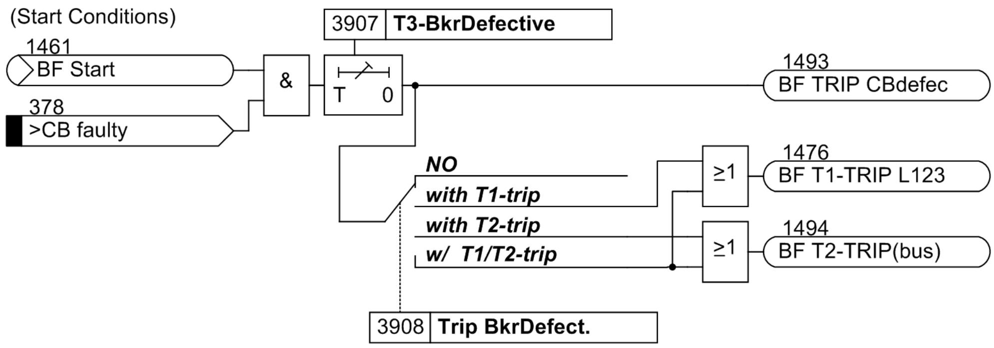


Figure 2-73 Circuit breaker not operational

Transfer trip to the remote end circuit breaker

The device 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. This requires the transmission of the command.

In case of 7SD610 the corresponding command — usually the trip command which is intended to trip the adjacent breakers — is assigned to the input function for intertrip of the devices. This can be achieved by external wiring: The command output is connected to the binary input „`>Intertrip 3pol`“ (No. 3504) (see also Section 2.4).

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 2-74. The fault is located — as seen from the current transformer (= measurement location) — on the busbar side, it will thus not be regarded as a feeder fault by the feeder protection relay. It can only be detected either by a reverse stage of the feeder protection or by the busbar protection. However, a trip command given to the feeder circuit breaker does not clear the fault since the opposite end continues to feed the fault. Thus, the fault current does not stop flowing even though the feeder circuit breaker has properly responded to the trip command.

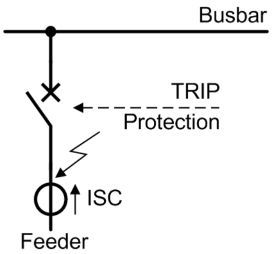


Figure 2-74 End fault between circuit breaker and current transformers

The end fault protection has the task to recognize this situation and to transmit a trip signal to the remote end(s) of the protected object to clear the fault. For this purpose, the output command „`BF EndFlt TRIP`“ (No. 1495) is available to trigger the intertrip input of the differential protection — if applicable, together with other commands that need to be transferred. This can be achieved by external wiring or via CFC.

The end fault is recognized when the current continues flowing although the circuit breaker auxiliary contacts indicate that the breaker is open. An additional criterion is the presence of any breaker failure protection initiate signal. Figure 2-75 illustrates the functional principle. If the breaker failure protection is initiated and current flow is detected (current criteria „L*> current criterion“ according to Figure 2-63), but no circuit breaker pole is closed (auxiliary contact criterion „ any pole closed“), then the timer **`T-EndFault`** is started. At the end of this time an intertrip signal is transmitted to the opposite end(s) of the protected object.

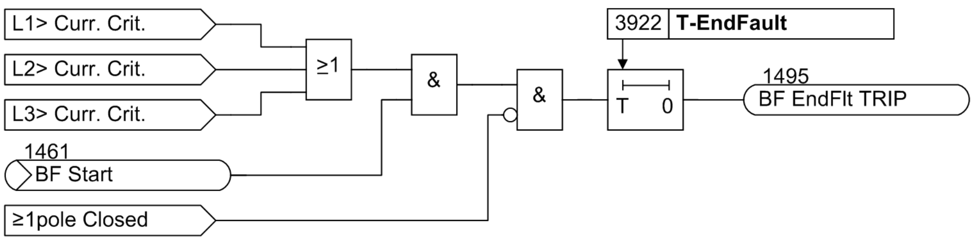


Figure 2-75 Operation scheme of end fault protection

Pole discrepancy supervision

The pole discrepancy supervision has the task to detect discrepancies in the position of the three circuit breaker poles. Under steady-state operating conditions, either all three poles of the 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 functionality is shown in Figure 2-76. 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 („ ≥ one pole closed“) and at the same time not all three poles are closed („ ≥ one pole open“).

Additionally, the current criteria (from Figure 2-63) are processed. Pole discrepancy can only be detected when current is not flowing through all three poles, i.e. through only one or two poles. When current is flowing through all three poles, all three poles must be closed even if the 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 before the trip command of the pole discrepancy supervision occurred.

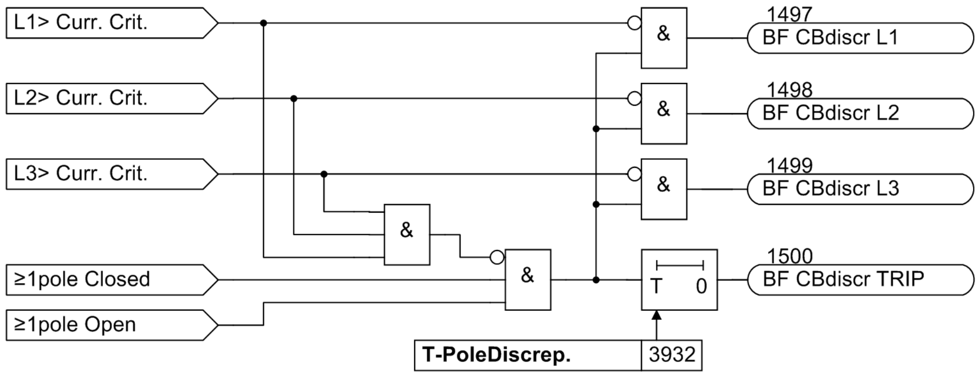


Figure 2-76 Function diagram of pole discrepancy supervision

2.13.2 Setting Notes

General

The circuit breaker failure protection and its ancillary functions (end fault protection, pole discrepancy supervision) can only operate if they were set during configuration of the scope of functions (address 139 **BREAKER FAILURE**, setting ***Enabled*** or ***enabled w/ 3I0>***).

Breaker failure protection

The breaker failure protection is switched ***ON*** or ***OFF*** at address 3901 **FCT BreakerFail**.

The current threshold **I> BF** (address 3902) should be selected such that the protection will operate with the smallest expected short-circuit current. A setting of 10 % below the minimum fault current for which breaker failure protection must operate is recommended. On the other hand, the value should not be set lower than necessary.

If the breaker failure is configured with zero sequence current threshold (address 139 = ***enabled w/ 3I0>***), the pickup threshold for the zero sequence current **3I0> BF** (address 3912) can be set independently of **I> BF**.

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***.

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 that single-pole trip is possible). This choice is made in address 3903 **1p-RETRIP (T1)**. Set this parameter to ***YES*** if the first stage is to trip single-pole, otherwise set it to ***NO***.

If the breaker does not respond to this trip repetition, the adjacent circuit breakers are tripped after T2, i.e. the circuit breakers of the busbar or of the concerned busbar section and, if necessary, also the circuit breaker at the remote end unless the fault has been cleared.

Separate delay times can be set

- for single- or three-pole trip repetition to the local feeder circuit breaker after a **1**-pole trip of the feeder protection **T1-1pole** at address 3904,
- for three-pole trip repetition to the local feeder circuit breaker after **3**-pole trip of the feeder protection **T1-3pole** (address 3905),
- for trip of the adjacent circuit breakers (busbar zone and remote end if applicable) **T2** at address 3906.

Note

If three-pole coupling is executed for a pending single-pole TRIP, the T2 delay is re-started with the three-pole coupling.

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. Figure 2-77 illustrates the timing of a typical breaker failure scenario. The dropout time for sinusoidal currents is ≤ 15 ms. If current transformer saturation is anticipated, the time should be set to 25 ms.

Note

If the breaker failure protection is to perform a single-pole TRIP repetition, the time set for the AR, address 3408 **T-Start MONITOR**, has to be longer than the time set for address 3903 **1p-RETRIP (T1)**.

To enable that the busbar is tripped by the breaker failure protection without preceding three-pole coupling of the trip command (by AR or BF), the time set for 3408 **T-Start MONITOR** also has to be longer than the time set for 3906 **T2**. In this case, the AR must be blocked by a signal from the BF to prevent the AR from reclosing after a busbar TRIP. It is recommended to connect the signal 1494 „BF T2-TRIP(bus)“ to the AR input 2703 „>AR block“.

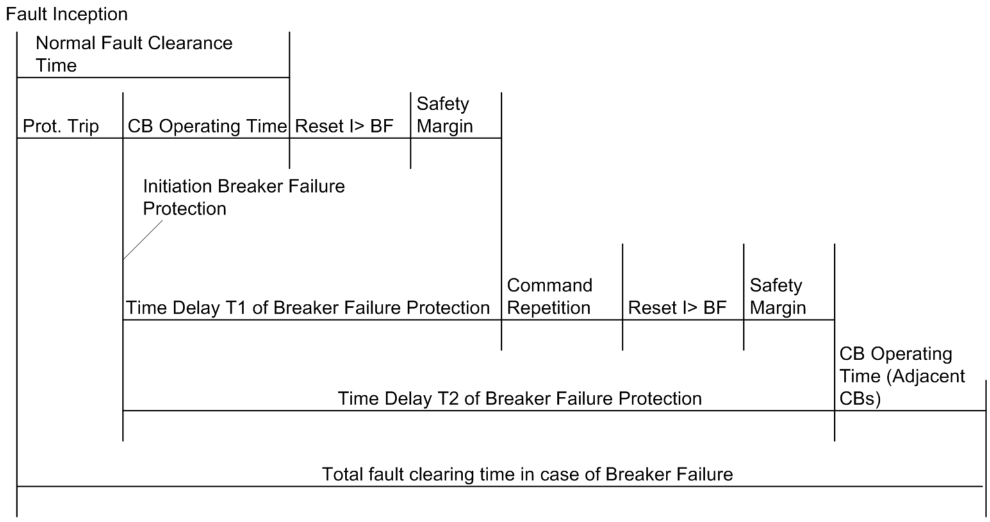


Figure 2-77 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using two-stage breaker failure protection

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.

But you may use the T1 timers for single-stage protection if you wish to utilise the facility of setting different delay times after single-pole trip and three-pole trip of the feeder protection. In this case set **T1-1pole** (address 3904) and **T1-3pole** (address 3905) separately, but address 3903 **1p-RETRIP (T1)** to ***NO*** to avoid a single-pole trip command 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 desired trip relay(s).

The delay time is determined from the maximum operating time of the feeder circuit breaker, the reset time of the current detectors of the breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. The time sequence is illustrated in Figure 2-78. The dropout time for sinusoidal currents is ≤ 15 ms. If current transformer saturation is anticipated, the time should be set to 25 ms.

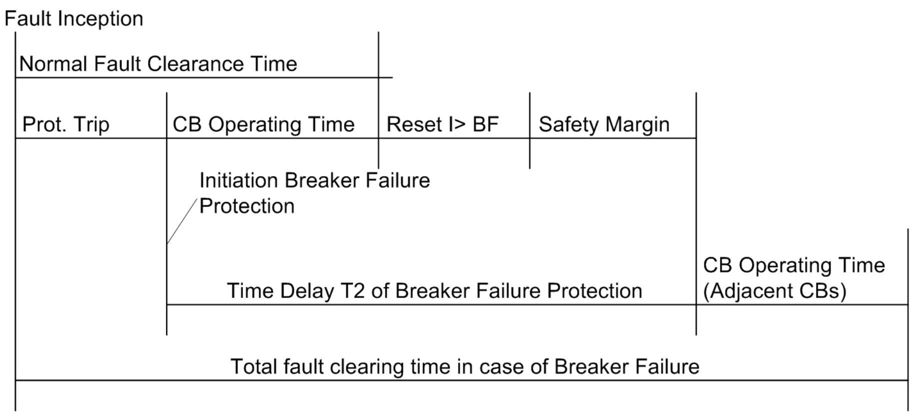


Figure 2-78 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using single-stage breaker failure protection

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 apparent that the local breaker cannot clear the fault. If the relay is informed about this disturbance (via the binary input „>CB faulty“), the adjacent circuit breakers (busbar and remote end if applicable) are tripped after the time **T3-BkrDefective** (address 3907) which is usually set to **0**.

Address 3908 **Trip BkrDefect.** determines to which output the trip command is routed in the event that the breaker is not operational when a feeder protection trip occurs. Select that output which is used to trip the adjacent breakers (bus-bar trip).

End fault protection

The end fault protection can be switched separately ***ON*** or ***OFF*** in 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 reverse stage of the feeder protection or by the busbar protection (the fault is a busbar fault as determined from the location of the current transformers), the fault current will continue to flow, because the fault is fed from the remote end of the feeder circuit.

The time **T-EndFault** (address 3922) is started when, during the time of pickup condition of the feeder protection, the circuit breaker auxiliary contacts indicate open poles and, at the same time, current flow is still detected (address 3902). The trip command of the end fault protection is intended for the transmission of an intertrip signal to the remote end circuit breaker.

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

Pole discrepancy supervision

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

The delay time **T-PoleDiscrep.** (address 3932) indicates how long a 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 be clearly longer than the duration of a single-pole automatic reclose cycle. The time should be less than the permissible duration of an unbalanced load condition which is caused by the unsymmetrical position of the circuit breaker poles. Conventional values are 2 s to 5 s.

2.13.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
3901	FCT BreakerFail		ON OFF	ON	Breaker Failure Protection
3902	I> BF	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold I>
		5A	0.25 .. 100.00 A	0.50 A	
3903	1p-RETRIP (T1)		NO YES	YES	1pole retrip with stage T1 (local trip)
3904	T1-1pole		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 1pole start (local trip)
3905	T1-3pole		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 3pole start (local trip)
3906	T2		0.00 .. 30.00 sec; ∞	0.15 sec	T2, Delay of 2nd stage (busbar trip)
3907	T3-BkrDefective		0.00 .. 30.00 sec; ∞	0.00 sec	T3, Delay for start with defective bkr.
3908	Trip BkrDefect.		NO with T1-trip with T2-trip w/ T1/T2-trip	NO	Trip output selection with defective bkr
3909	Chk BRK CONTACT		NO YES	YES	Check Breaker contacts
3912	3I0> BF	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold 3I0>
		5A	0.25 .. 100.00 A	0.50 A	
3921	End Flt. stage		ON OFF	OFF	End fault protection
3922	T-EndFault		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay of end fault protection
3931	PoleDiscrepancy		ON OFF	OFF	Pole Discrepancy supervision
3932	T-PoleDiscrep.		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay with pole discrepancy

2.13.4 Information List

No.	Information	Type of Information	Comments
1401	>BF on	SP	>BF: Switch on breaker fail protection
1402	>BF off	SP	>BF: Switch off breaker fail protection
1403	>BLOCK BkrFail	SP	>BLOCK Breaker failure
1415	>BF Start 3pole	SP	>BF: External start 3pole
1432	>BF release	SP	>BF: External release
1435	>BF Start L1	SP	>BF: External start L1
1436	>BF Start L2	SP	>BF: External start L2
1437	>BF Start L3	SP	>BF: External start L3
1439	>BF Start w/o I	SP	>BF: External start 3pole (w/o current)
1440	BkrFailON/offBI	IntSP	Breaker failure prot. ON/OFF via BI
1451	BkrFail OFF	OUT	Breaker failure is switched OFF
1452	BkrFail BLOCK	OUT	Breaker failure is BLOCKED
1453	BkrFail ACTIVE	OUT	Breaker failure is ACTIVE
1461	BF Start	OUT	Breaker failure protection started
1472	BF T1-TRIP 1pL1	OUT	BF Trip T1 (local trip) - only phase L1
1473	BF T1-TRIP 1pL2	OUT	BF Trip T1 (local trip) - only phase L2
1474	BF T1-TRIP 1pL3	OUT	BF Trip T1 (local trip) - only phase L3
1476	BF T1-TRIP L123	OUT	BF Trip T1 (local trip) - 3pole
1493	BF TRIP CBdefec	OUT	BF Trip in case of defective CB
1494	BF T2-TRIP(bus)	OUT	BF Trip T2 (busbar trip)
1495	BF EndFlt TRIP	OUT	BF Trip End fault stage
1496	BF CBdiscrSTART	OUT	BF Pole discrepancy pickup
1497	BF CBdiscr L1	OUT	BF Pole discrepancy pickup L1
1498	BF CBdiscr L2	OUT	BF Pole discrepancy pickup L2
1499	BF CBdiscr L3	OUT	BF Pole discrepancy pickup L3
1500	BF CBdiscr TRIP	OUT	BF Pole discrepancy Trip

2.14 Thermal Overload Protection

The thermal overload protection prevents damage to the protected object caused by thermal overloading, particularly in case of transformers, rotating machines, power reactors and cables. It is in general not necessary for overhead lines, since no meaningful overtemperature can be calculated because of the great variations in the environmental conditions (temperature, wind). In this case, however, a current-dependent alarm stage can signal an imminent overload.

2.14.1 Method of Operation

The unit computes the overtemperature according to a thermal single-body model as per the following thermal differential equation

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

with

Θ	–	Current overtemperature in per cent of the final overtemperature at the maximum permissible phase current kI_N
τ_{th}	–	Thermal time constant for the heating
I	–	Present rms current
k	–	k–factor indicating the maximum permissible constant current referred to the nominal current of the current transformers
I_N	–	Rated current of the device

In steady-state operation the solution of this equation is an e-function whose asymptote represents the final overtemperature Θ_{End}. After reaching the first settable threshold of overtemperature Θ_{alarm}, which is below the final overtemperature, a warning indication is issued in order to allow e.g. a preventive load reduction. When the second overtemperature threshold, i.e. the final overtemperature (= tripping temperature), is reached, the protected object is disconnected from the network. It is also possible, however, to set the overload protection to ***Alarm Only***. If this option is set, the device only outputs an indication even if the final temperature is reached.

The overtemperatures are calculated separately for each phase in a thermal replica from the square of the associated phase current. This guarantees a true RMS value measurement and also includes the effect of harmonic content. A choice can be made whether the maximum calculated overtemperature of the three phases, the average overtemperature, or the overtemperature calculated from the phase with maximum current should be decisive for evaluation of the thresholds.

The maximum permissible continuous thermal overload current I_{max} is described as a multiple of the nominal current I_N:

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

In addition to the k-factor, the time constant τ_{th} as well as the alarm temperature Θ_{alarm} must be entered as settings of the protection.

In addition to the temperature warning stage, the overload protection also features a current warning element I_{alarm}. It reports an overload current prematurely, even if the calculated overtemperature has not yet attained the warning or tripping temperature levels.

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

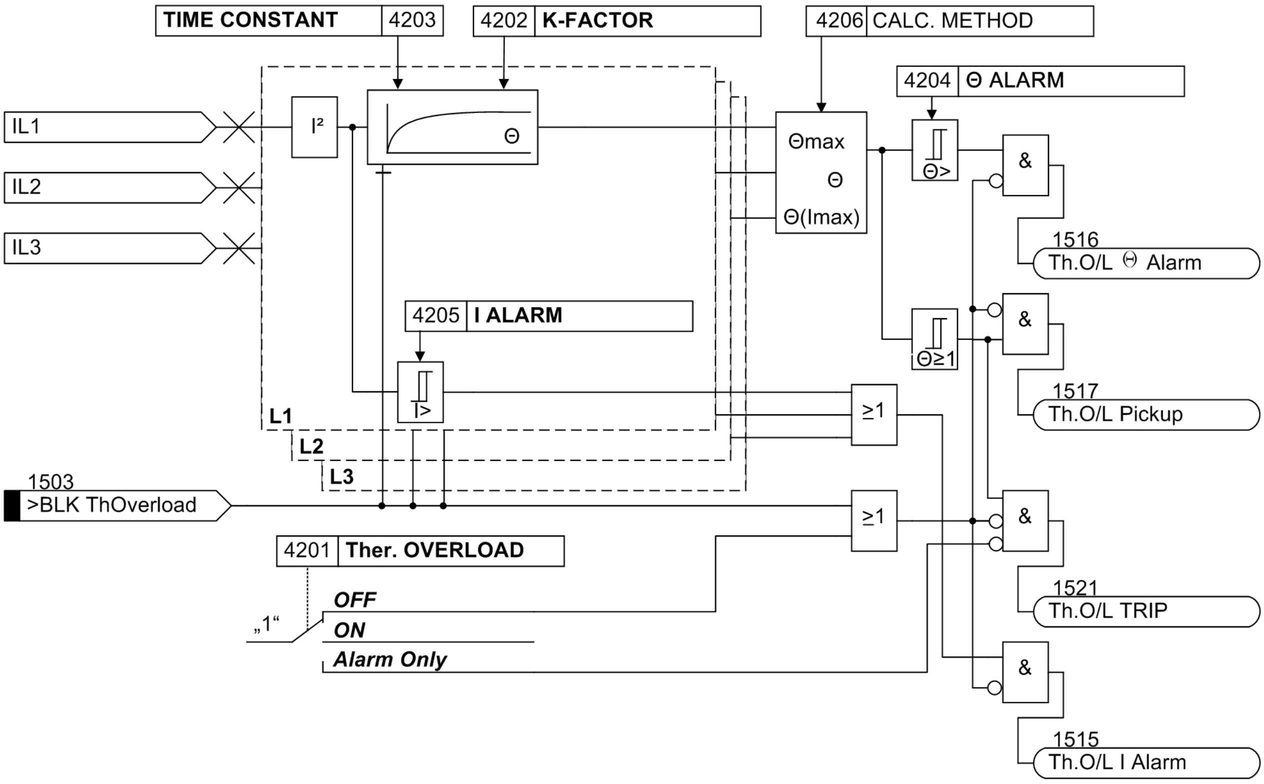


Figure 2-79 Logic diagram of the thermal overload protection

2.14.2 Setting Notes

General

A prerequisite for using the thermal overload protection is that during the configuration of the scope of functions at address 142 **Therm.Overload** = ***Enabled*** was applied. At address 4201 **Ther. OVERLOAD** the function can be turned ***ON*** or ***OFF***. Furthermore, ***Alarm Only*** can be set. With the latter setting the protective function is active but only outputs the indication „Th.O/L Pickup“ (address 1517) when the tripping temperature is reached. The indication „Th.O/L TRIP“ (address 1521) is not generated.

k-factor

The nominal device current is taken as a basis for overload detection. The setting factor k is set under address 4202 **K-FACTOR**. It is determined by the relation between the permissible thermal continuous current and this nominal current:

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

The permissible continuous current is at the same time the current at which the e-function of the overtemperature has its asymptote. It is not necessary to determine the tripping temperature since it results automatically from the final rise temperature at $k \cdot I_N$. Manufacturers of electrical machines usually state the permissible continuous current. If no data are available, k is set to 1.1 times the nominal current of the protected object. For cables, the permissible continuous current depends on the cross section, the insulation material, the design and the way they are laid, and can be derived from the relevant tables.

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

Example:

Belted cable 10 kV 150 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 at address 4203 **TIME CONSTANT**. This is also provided by the manufacturer. Please note that the time constant is set in minutes. Quite often other values for determining the time constant are stated which can be converted into the time constant as follows:

1-s current

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

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

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

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

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

Example:

Cable as above with

Permissible 1-s current 13.5 kA

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

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

Alarm levels

By setting a thermal alarm stage **Θ ALARM** (address 4204) an alarm can be provided before the tripping temperature is reached, so that a trip can be avoided by preventive load reduction or by switching over. The percentage is referred to the tripping temperature rise.

The current overload alarm 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 overtemperature

The thermal replica is calculated individually for each phase. Address 4206 **CALC. METHOD** decides whether the highest of the three calculated temperatures (Θ ***max***) or their arithmetic average (***Average*** **Θ**) or the temperature calculated from the phase with maximum current (Θ ***from Imax***) should be decisive for the thermal alarm and tripping stage.

Since 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.

2.14.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
4201	Ther. OVERLOAD		OFF ON Alarm Only	OFF	Thermal overload protection
4202	K-FACTOR		0.10 .. 4.00	1.10	K-Factor
4203	TIME CONSTANT		1.0 .. 999.9 min	100.0 min	Time Constant
4204	Θ ALARM		50 .. 100 %	90 %	Thermal Alarm Stage
4205	I ALARM	1A	0.10 .. 4.00 A	1.00 A	Current Overload Alarm Setpoint
		5A	0.50 .. 20.00 A	5.00 A	
4206	CALC. METHOD		Θ max Average Θ Θ from Imax	Θ max	Method of Acquiring Temperature

2.14.4 Information List

No.	Information	Type of Information	Comments
1503	>BLK ThOverload	SP	>BLOCK Thermal Overload Protection
1511	Th.Overload OFF	OUT	Thermal Overload Protection OFF
1512	Th.Overload BLK	OUT	Thermal Overload Protection BLOCKED
1513	Th.O/L ACTIVE	OUT	Thermal Overload Protection ACTIVE
1515	Th.O/L I Alarm	OUT	Th. Overload: Current Alarm (I alarm)
1516	Th.O/L Θ Alarm	OUT	Th. Overload Alarm: Near Thermal Trip
1517	Th.O/L Pickup	OUT	Th. Overload Pickup before trip
1521	Th.O/L TRIP	OUT	Th. Overload TRIP command

2.15 Monitoring Functions

The device incorporates extensive monitoring functions of both the device hardware and software; the measured values are also continually checked to ensure their plausibility; the current and voltage transformer secondary circuits are thereby substantially covered by the monitoring function. It is also possible to implement trip circuit monitoring, using appropriate binary inputs as available.

2.15.1 Measurement Supervision

2.15.1.1 Hardware Monitoring

The device is monitored from the measuring inputs up to the command relays. Monitoring circuits and the processor check the hardware for faults and inadmissible states.

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. On recovery of the voltage the processor system is restarted.

If the supply voltage is removed or switched off, the device is taken out of service, and an indication is immediately generated by a normally closed contact. Brief voltage interruptions of up to 50 ms do not disturb the operational readiness of the device (see for the Technical Data).

The processor monitors the reference voltage of the ADC (analog-to-digital converter). The protection is suspended if the voltages deviate outside an allowable range, and persistent deviations are reported.

Back-up Battery

The buffer battery, which ensures the operation of the internal clock and the storage of counters and indications if the auxiliary voltage fails, is periodically checked for charge status. On its undershooting a minimum admissible voltage, the indication „`Fail Battery`“ (no. 177) is issued.

If the device is not supplied with auxiliary voltage for more than 1 or 2 days, the internal clock is switched off automatically, i.e. the time is not registered any more. The data in the event and fault buffers, however, remain stored.

Memory Components

The main memory (RAM) is tested when the system starts up. If a fault is detected during this process, the startup is aborted. Error LED and LED 1 light up and the remaining LEDs start flashing simultaneously. During operation the memory is checked by means of its checksum.

A checksum of the program memory (EPROM) is cyclically generated and compared with the stored program checksum.

A checksum for the parameter memory (FLASH-EPROM) is cyclically generated and compared with the checksum which is computed after each change of the stored parameters.

If a malfunction occurs, the processor system is restarted.

Sampling Frequency

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

Measured Value Capturing Currents

There are four measurement inputs in the current paths. If the three phase currents and the earth current from the current transformer starpoint or a separated earth current transformer of the line to be protected are connected to the device, their digitised sum must be zero. A fault in the current circuit is detected when

$$I_F = |\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} + k_I \cdot \underline{I}_E| > \Sigma\mathbf{I\ THRESHOLD} \cdot I_N + \Sigma\mathbf{I\ FACTOR} \cdot \Sigma\,|\,I\,|$$

Factor k_I (address 221 **I4/Iph CT**) takes into account a possible different ratio of a separate I_E transformer (e.g. cable core balance current transformer). Σ**I THRESHOLD** and Σ**I FACTOR**. are setting parameters.

The component Σ**I FACTOR** $\Sigma\,|\,I\,|$ takes into account permissible current proportional ratio errors of the input transformers which are particularly prevalent during large fault currents (Figure 2-80). $\Sigma\,|\,I\,|$ is the sum of all currents:

$$\Sigma\,|\,I\,| = |\underline{I}_{L1}| + |\underline{I}_{L2}| + |\underline{I}_{L3}| + |k_I \cdot \underline{I}_E|$$

As soon as a summation current fault is detected after or before a system disturbance, the differential protection is blocked. This malfunction is signalled as „`Failure Σi`“ (No. 289). In order to avoid a blocking due to transformation errors (saturation) in case of high fault currents, this monitoring function is not effective during a system fault.

Note

Current sum monitoring can operate properly only when the ground current of the protected line is fed to the fourth current measuring input (I_4) of the relay. The I_4 transformer must have been configured with parameter **I4 transformer** (address 220) as ***In prot. line***.

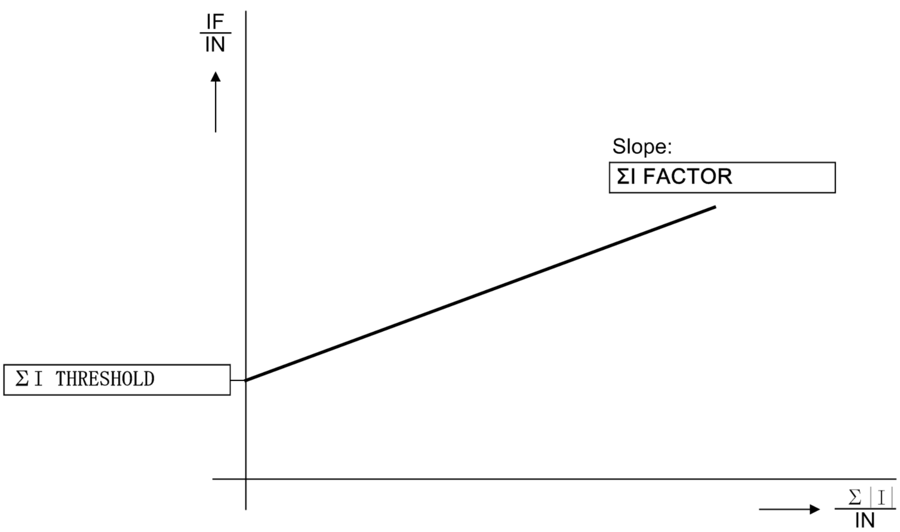


Figure 2-80 Current sum monitoring

Measured value acquisition voltages

Four measuring inputs are available in the voltage circuit: three for phase-to-earth voltages and one input for the displacement voltage (e-n voltage of open delta winding) or a busbar voltage. If the displacement voltage is connected to the device, the sum of the three digitized phase voltages must equal three times the zero sequence voltage. A fault in the voltage transformer circuits is detected when

$$U_F = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \cdot \underline{U}_{EN}| > 25\ \mathrm{V}.$$

The factor k_U allows for a difference of the transformation ratio between the displacement voltage input and the phase voltage inputs (address 211 **Uph / Udelta**).

This malfunction is signalled as „Fail Σ U Ph-E“ (no. 165).

Note

Voltage sum monitoring is only effective if an external displacement voltage is connected to the displacement voltage measuring input.

Voltage sum monitoring can operate properly only if the adaptation factor **Uph / Udelta** at address 211 has been correctly configured (see Subsection 2.1.2.1).

2.15.1.2 Software Monitoring

Watchdog

For continuous monitoring of the program sequences, a time monitor is provided in the hardware (watchdog for hardware) that expires upon failure of the processor or an internal program, and causes a reset of the processor system with complete restart.

An additional software watchdog ensures that malfunctions during the processing of programs are discovered. This also initiates a restart of the processor system.

If a fault is not removed by the restart of the processors, a new restart is attempted. 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 „life contact“.

2.15.1.3 Measurement Circuit Monitoring

Interruptions or short-circuits in the secondary circuits of the current and voltage transformers, as well as faults in the connections (important for commissioning!), are detected and reported by the device. To this end, the measured values are cyclically checked in the background as long as no fault detection is present.

Current Symmetry

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. The smallest phase current is compared with the largest. Non-symmetry is detected when

$|I_{min}| / |I_{max}|$ < **BAL. FACTOR I** as long as I_{max} / I_N > **BALANCE I LIMIT** / I_N

I_{max} is the highest, I_{min} the lowest of the three phase currents. The symmetry factor **BAL. FACTOR I** (address 2905) represents the allowable asymmetry of the phase currents while the limit value **BALANCE I LIMIT** (address 2904) is the lower limit of the operating range of this monitoring (see Figure 2-81). The dropout ratio is about 97%.

After a settable time (5-100 s) this malfunction is signaled as „`Fail I balance`" (no. 163).

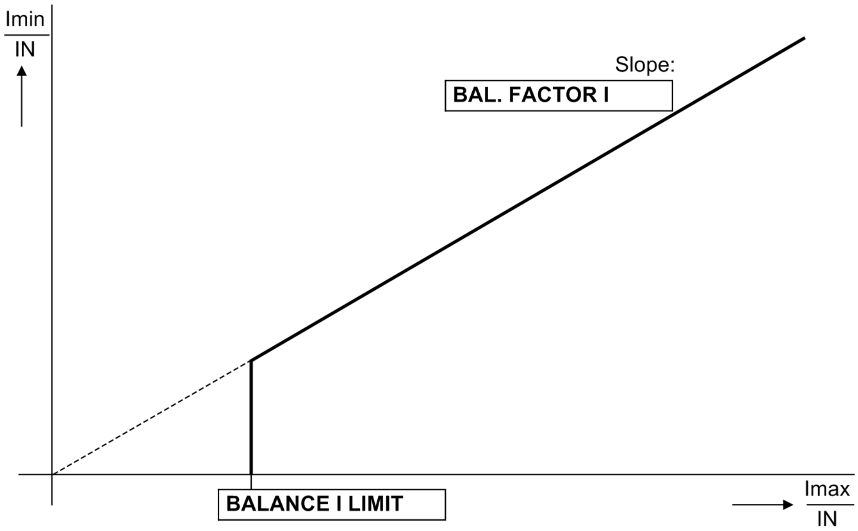


Figure 2-81 Current symmetry monitoring

Voltage Symmetry

In healthy network operation it can be expected that the voltages are nearly balanced. The monitoring of the measured values in the device checks this balance. The smallest phase voltage is compared to the largest. Non-symmetry is detected when

$|U_{min}| / |U_{max}| <$ **`BAL. FACTOR U`** as long as $|U_{max}| >$ **`BALANCE U-LIMIT`**

U_{max} is the largest of the three phase-to-phase voltages and U_{min} the smallest. The symmetry factor **`BAL. FACTOR U`** (address 2903) represents the allowable asymmetry of the voltages while the limit value **`BALANCE U-LIMIT`** (address 2902) is the lower limit of the operating range of this monitoring (see Figure 2-82). The dropout ratio is about 97%.

After a settable time, this malfunction is signaled as „`Fail U balance`" (no. 167).

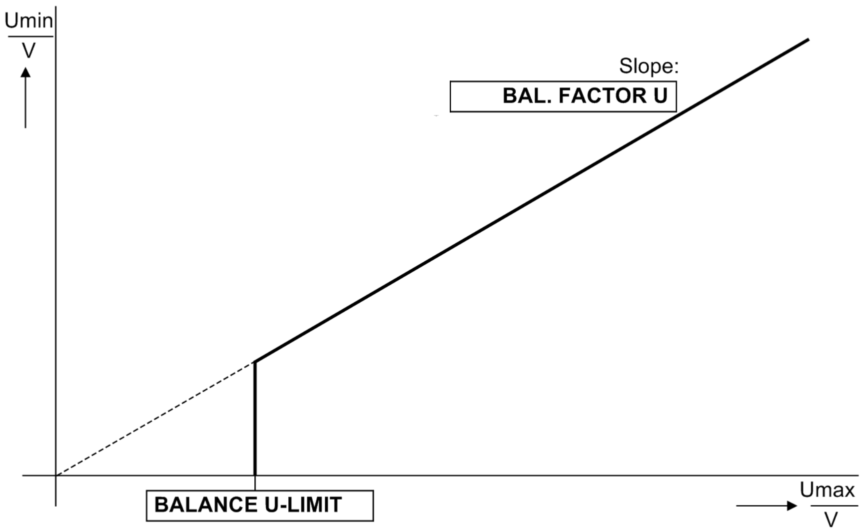


Figure 2-82 Voltage symmetry monitoring

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 hazardous 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 local currents of all three phases, as well as the differential and stabilization current values of the differential protection transferred from the devices to the other ends of the protected object. With these values, the device decides whether there is a broken wire or a network process.

The local wire break detection generates a „Suspected wire-break“ finformation for a phase when the current abruptly drops to zero during operation. This information continues to be used if currents and voltage (if connected) in the local device and the currents in the other devices do not change

In the local device, the „Wire break ILx“ (no. 290, 291, 292) message is generated and the differential protection is blocked. By transmitting the „Suspected wire-break “ information to the other devices, the differential protection is blocked also in these devices and the „Wire-break at the other end ILx“ (no. 297, 298, 299) message is generated.

If the communication between the devices is disturbed, the device operates in emergency operation. The differential protection is not active. The wire break detection then operates only with the locally available information. Multipole wire break is not indicated in emergency operation.

The blocking is cancelled as soon as the device is again supplied with current in the relevant phase. It is also suppressed when a high fault current is registered by any device at another end of the protected object.

It has to be observed that electronic test devices do not simulate the correct behaviour of broken wire so that pickup may occur.

Note

Broken wire monitoring can operate properly only when the fourth current input (I_4) of the relay is fed the residual current from a separate current transformer of the protected line, or no residual current at all.

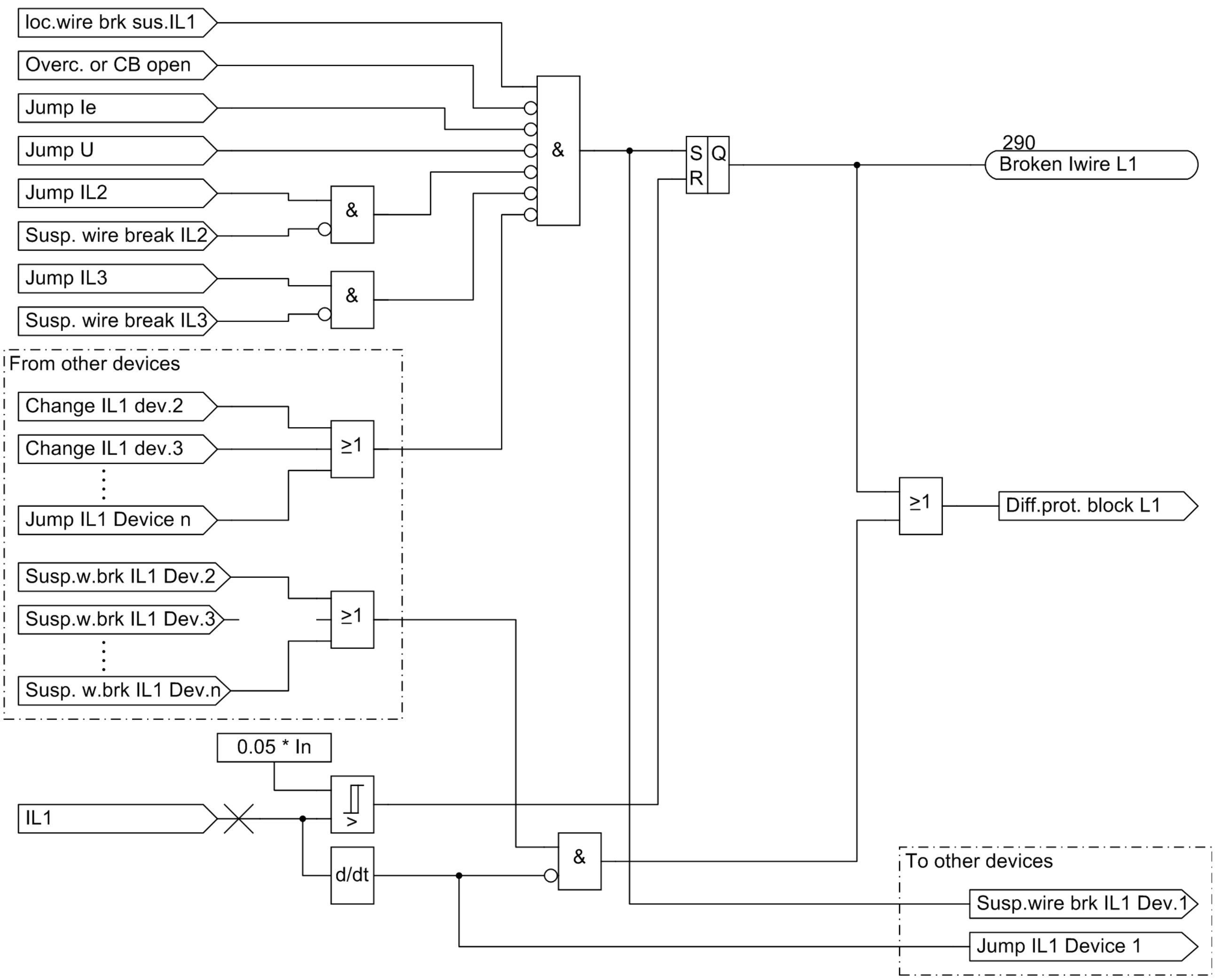


Figure 2-83 Broken-wire monitoring

Voltage Phase Sequence

The phase rotation of the measured voltages is checked by monitoring of the voltage phase sequence.

$\underline{U}_{L1}$ before $\underline{U}_{L2}$ before $\underline{U}_{L3}$

This check takes place if each measured voltage has a minimum magnitude of

$|U_{L1}|, |U_{L2}|, |U_{L3}| > 40 \text{ V}/\sqrt{3}$

In case of negative phase rotation, the indication „`Fail Ph. Seq.`“ (No. 171) is issued.

Asymmetrical Measuring Voltage Failure "Fuse Failure Monitor".

In the event of a measured voltage failure due to a short circuit fault or a broken conductor in the voltage transformer secondary circuit certain measuring loops may mistakenly see a voltage of zero. Simultaneously existing load currents may then cause a spurious pickup.

If fuses are used instead of a secondary miniature circuit breaker (VT mcb) with connected auxiliary contacts, then the („Fuse Failure Monitor“) can detect problems in the voltage transformer secondary circuit. Of course, the miniature circuit breaker and the „Fuse Failure Monitor“ can be used at the same time.

The asymmetrical measured voltage failure is characterized by its voltage asymmetry with simultaneous current symmetry. Figure 2-84 shows the logic diagram of the „Fuse Failure Monitor“ during asymmetrical failure of the measured voltage.

If there is substantial voltage asymmetry of the measured values, without asymmetry of the currents being registered at the same time, this indicates the presence of an asymmetrical failure in the voltage transformer secondary circuit.

The asymmetry of the voltage is detected by the fact that either the zero sequence voltage or the negative sequence voltage exceed a settable value **FFM U>(min)**. The current is assumed to be sufficiently symmetrical if both the zero sequence as well as the negative sequence current are below the settable threshold **FFM I< (max)** .

In non-earthed systems, the zero-sequence system quantities are no reliable criterion since a considerable zero sequence voltage occurs also in case of a simple earth fault where a significant zero sequence current does not necessarily flow. Therefore, the zero sequence voltage is not evaluated in these systems but only the negative sequence voltage (address207 **SystemStarpoint**).

As soon as this is detected, all functions that operate on the basis of undervoltage are blocked. The indication "„VT FuseFail“" (No. 170) is output. The immediate blocking demands that current flows in at least one of the phases. The differential protection can be switched to emergency operation, provided that these functions are parameterized accordingly (refer also to Sections 2.9).

The immediate blocking must not occur as long as one phase is without voltage due to single-pole dead time condition as the asymmetry of the measured values arising in this state is due to the switching state of the line and not due to a failure in the secondary circuit. Accordingly, the immediate blocking is disabled when the line is tripped single-pole (internal information „1 pole open“ in the logic diagram).

If a zero sequence or negative sequence current is detected within approximately 10 s after recognition of this criterion, the protection assumes a short-circuit and removes the blocking by the „fuse failure monitor“ for the duration of the fault. If on the other hand the voltage failure criterion is present for longer than approx. 10 s, the blocking is permanently activated (latching of the voltage criterion after 10 s). Only 10 s after the voltage criterion has been removed by correction of the secondary circuit failure, will the blocking automatically reset, thereby releasing the blocked protection functions again.

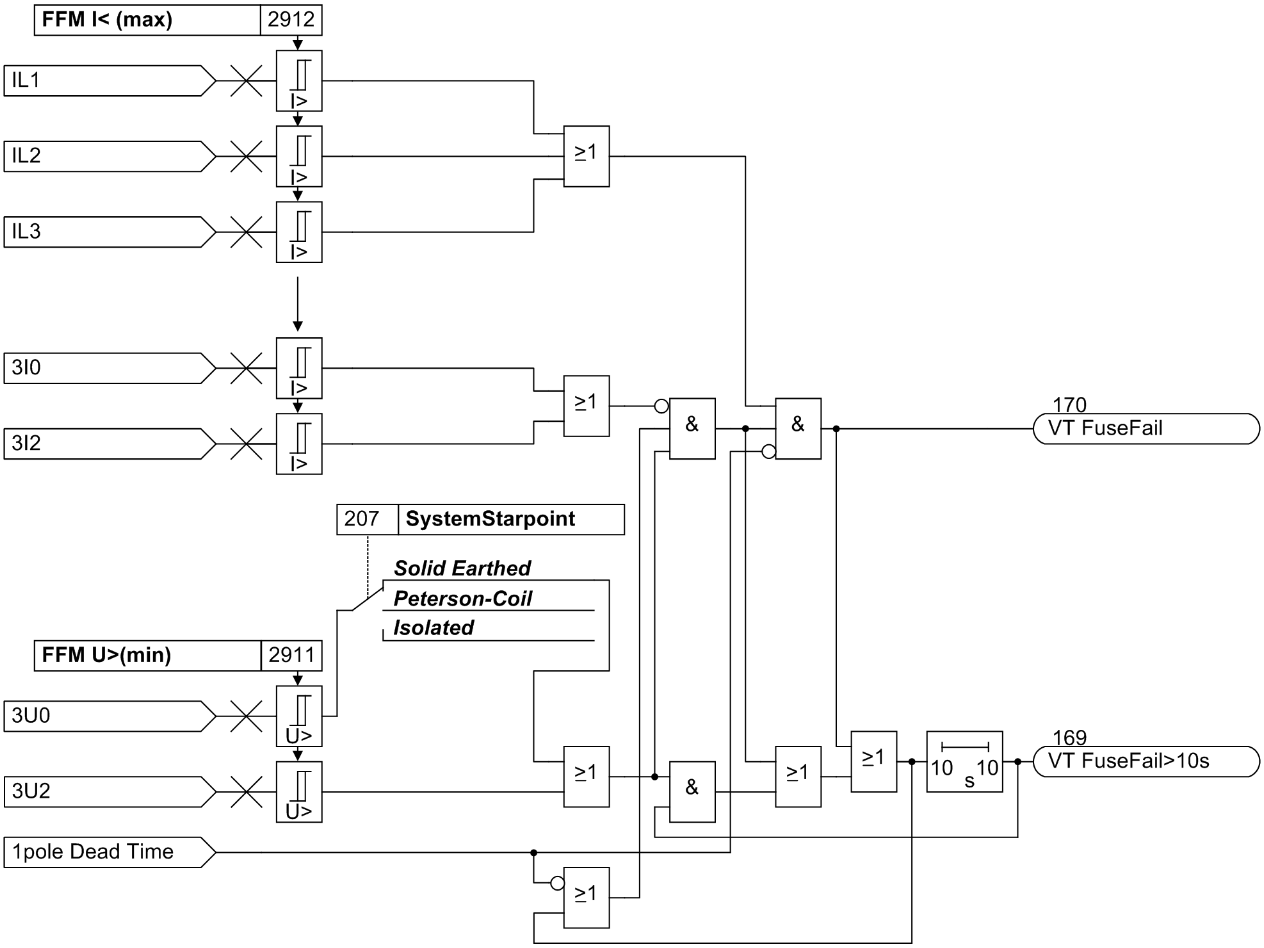


Figure 2-84 Logic diagram of the fuse failure monitor with zero and negative sequence system

Three-Phase Measuring Voltage Failure "Fuse Failure Monitor"

A three-phase failure of the secondary measured voltages can be distinguished from an actual system fault by the fact that the currents have no significant change in the event of a failure in the secondary measured voltage. For this reason, the current values are routed to a buffer so that the difference between present and stored current values can be analysed to recognise the magnitude of the current differential (current differential criterion). A three-pole measuring voltage failure is detected when

- All three phase-to-earth voltages are smaller than the threshold **FFM U<max (3ph)**,
- the current differential in all three phases is smaller than a threshold value **FFM Idelta (3p)** and

If no stored current values are present (yet), the current magnitude criterion is resorted to. Figure 2-85 shows the logic diagram of the 3-phase measured voltage failure monitoring. A three-pole measuring voltage failure is detected when

- All three phase-to-earth voltages are smaller than the threshold **FFM U<max (3ph)**,
- All three phase current amplitudes are greater than a fixed set noise threshold (40 mA).

If such a voltage failure is recognized, the protection functions that operate on the basis of undervoltage are blocked until the voltage failure is removed; afterwards the blocking is automatically removed. The O/C emergency operation is possible during the voltage failure, provided that the differential protection is parameterized accordingly (refer to Section 2.9).

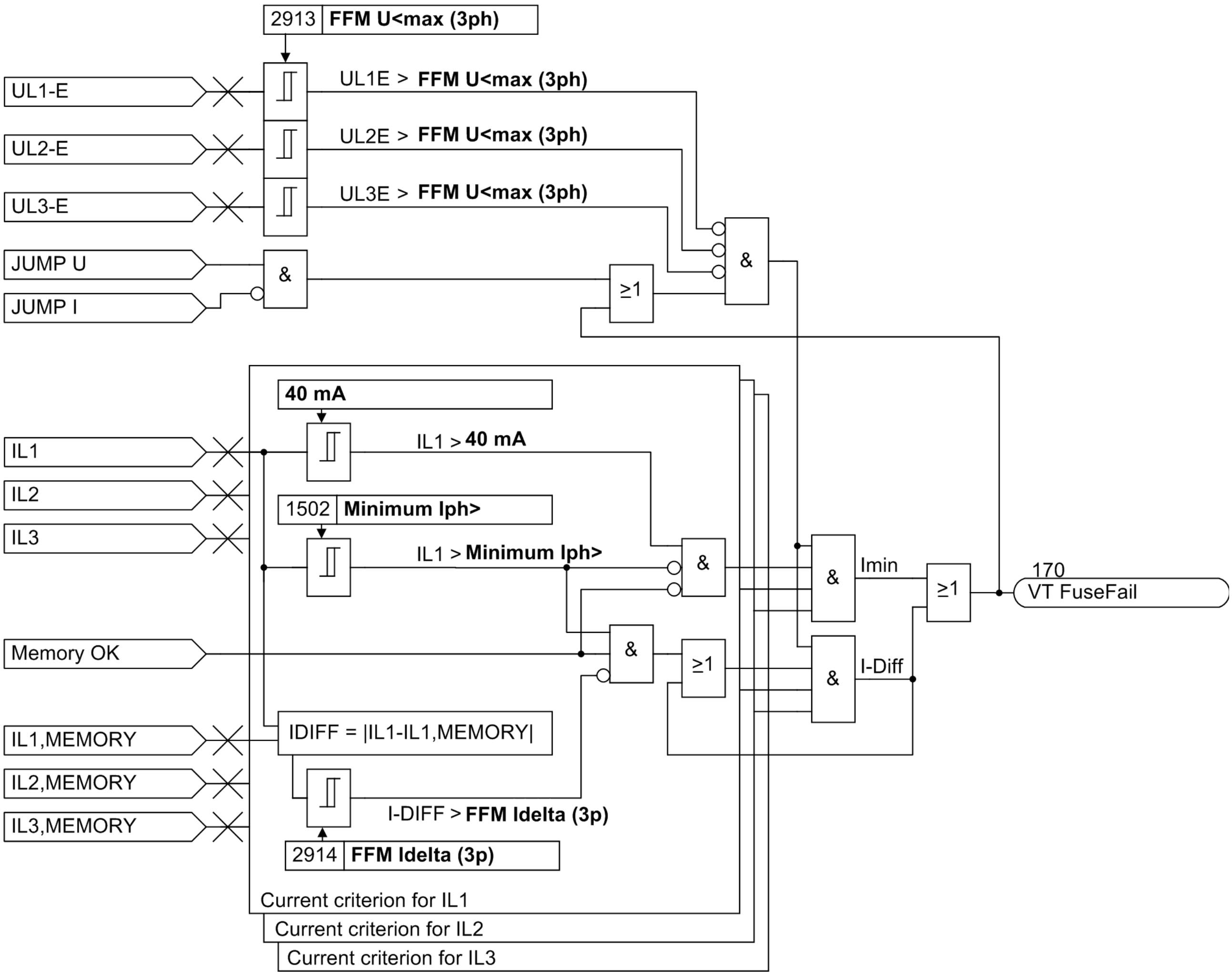


Figure 2-85 Logic diagram of the 3-phase measured voltage failure monitoring

Additional Measured Voltage Failure Monitoring

If no measuring voltage is available after power-on of the device (e.g. because the voltage transformers are not connected), the absence of the voltage can be detected and reported by an additional monitoring function. Where circuit breaker auxiliary contacts are used, they should be used for monitoring as well. Figure 2-86 shows the logic diagram of the measured voltage failure monitoring. A failure of the measured voltage is detected if the following conditions are met at the same time:

- All three phase-to-earth voltages are smaller than **FFM U<max (3ph)**,
- At least one phase current is larger than **PoleOpenCurrent** or at least one breaker pole is closed (can be set),
- No protection function has picked up,
- This condition persists for a settable time **T V-Supervision** (default setting: 3 s).

This time **T V-Supervision** is required to prevent that a voltage failure is detected before the protection picks up.

If a failure is detected by these criteria, the indication „`Fail U absent`“ (No. 168) is output, and the device switches to emergency operation (see Section 2.9).

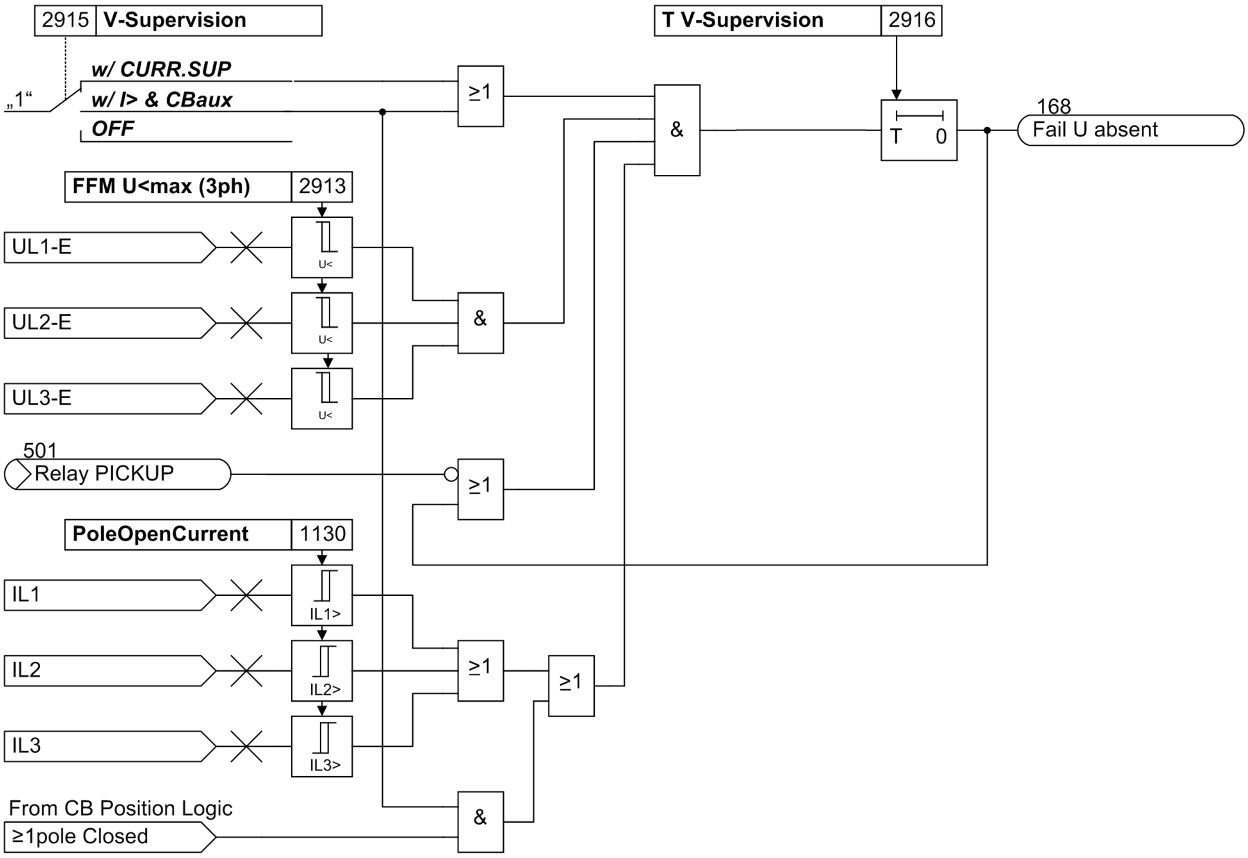


Figure 2-86 Logic diagram of the additional measured voltage failure monitoring

2.15.1.4 Monitoring the Phase Angle of the Positive Sequence Power

This monitoring function allows to determine the direction of power flow. You can monitor the phase angle of the complex power, and generate an indication when the power phasor is inside a settable segment.

One example of this application is the indication of capacitive reactive power. The monitoring indication can then be used to control the overvoltage protection function. For this purpose, two angles must be set, as shown in Figure 2-87. In this example, φA = 200° and φB = 340° has been set.

If the measured phase angle $\varphi(\underline{S}_1)$ of the positive sequence power is within the area of the P-Q plane delimited by the angles φA and φB, the indication „`φ(PQ Pos. Seq.)`“ (No. 130) is output. The angles φA and φB can be freely set in the range between 0° and 359°. The area starts at φA and extends in a mathematically positive sense as far as the angle φB. A hysteresis of 2° is provided to prevent erroneous indications which might emerge at the threshold limits.

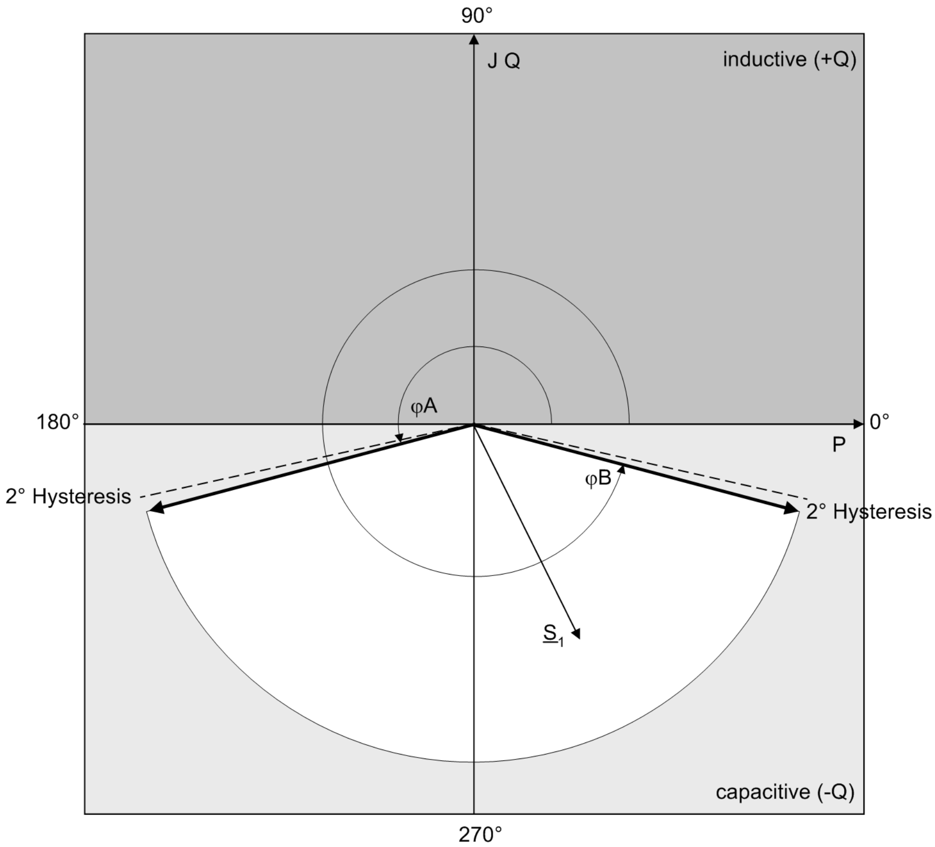


Figure 2-87 Characteristic of the Positive Sequence System Phase Angle Monitoring

The monitoring function can also be used for the display of negative active power. In this case the areas must be defined as shown in Figure 2-88.

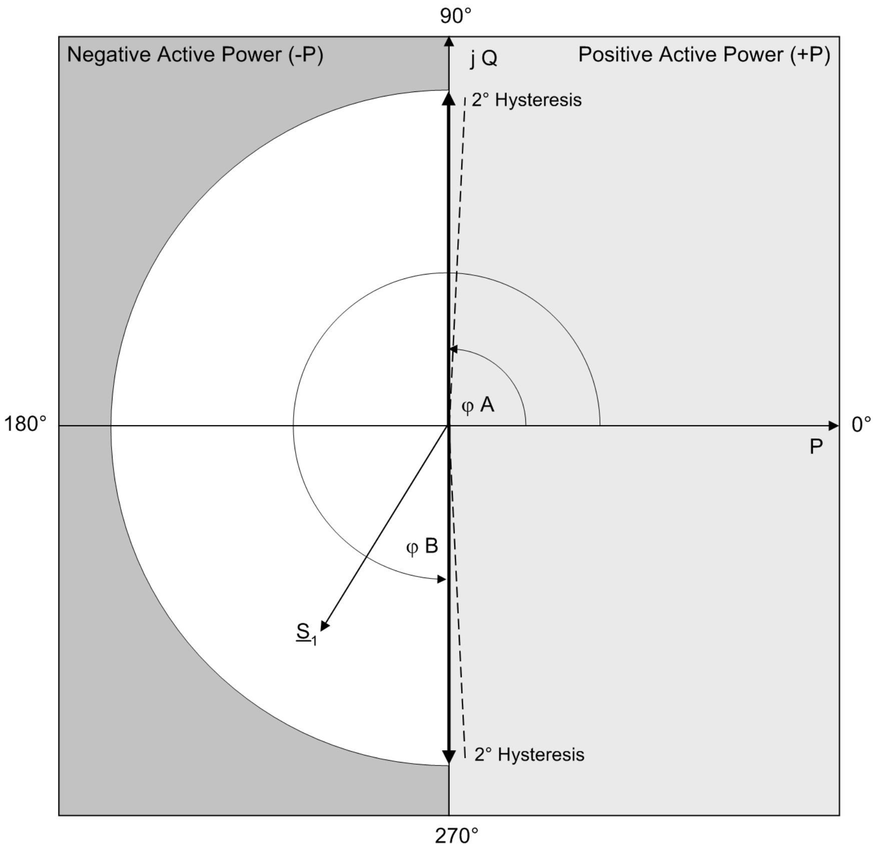


Figure 2-88 Phase Angle Monitoring for Negative Active Power

The two angles must be at least 3° apart; if this is not the case, monitoring is blocked and the indication „`φ Set wrong`“ (No. 132) is output.

The following conditions must be fulfilled for measurement to be enabled:

- The positive sequence current $\underline{I}_1$ is higher than the value set in parameter 2943 **`I1>`**.
- The positive sequence voltage $\underline{U}_1$ is higher than the value set in parameter 2944 **`U1>`**.
- The angles set in address 2941 φ**A** and 2942 φ**B** must be at least 3° apart. Incorrect parameter settings cause the indication 132 „`φ Set wrong`“ to be output.
- The „Fuse-Failure-Monitor“ and the measured voltage failure monitoring must not have responded, and binary input indication 361 „`>FAIL:Feeder VT`“ must not be present.

If monitoring is not active, this fact is signaled by the indication „`φ(PQ Pos) block`“ (No. 131).

Figure 2-89 shows the logic of the positive sequence system phase angle monitoring.

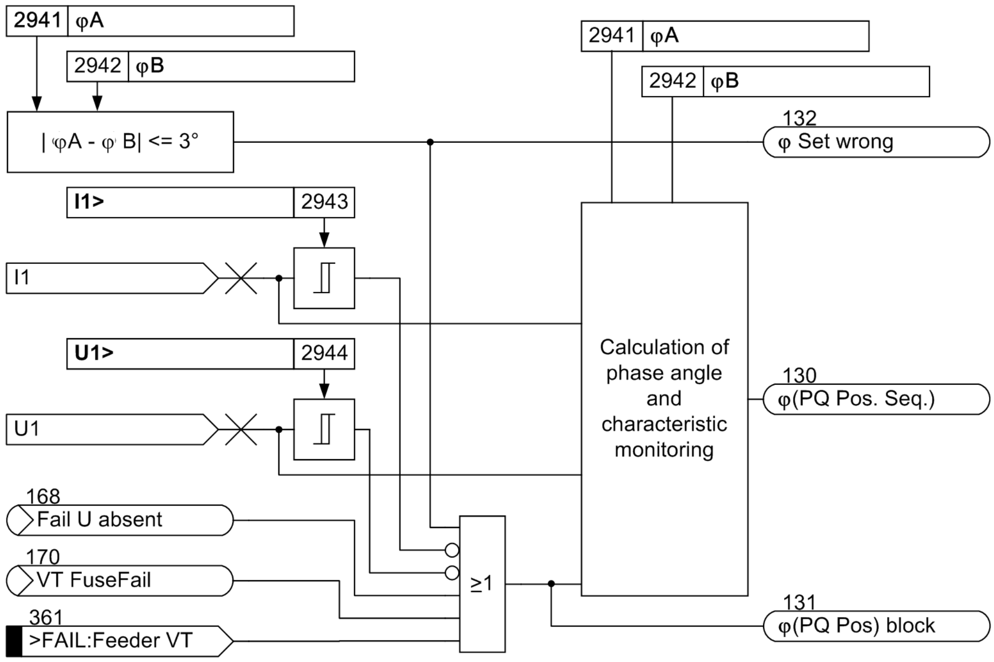


Figure 2-89 Logic of the Positive Sequence System Phase Angle Monitoring

2.15.1.5 Fault Reactions

Depending which kind of self supervision function is picked up, 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 device will take itself out of service and indicate this condition by dropout of the “Device OK” relay, thus indicating device failure. The red LED „ERROR“ on the device front lights up, provided the auxiliary voltage is available, and the green LED „RUN“ goes off. If the internal auxiliary voltage supply fails, all LEDs are dark. Table 2-7 shows a summary of the monitoring functions and the malfunction responses of the relay.

Table 2-7 Summary of malfunction responses of the device

Supervision	Possible Causes	Malfunction Response	Indication (No.)	Device
Auxiliary Supply Voltage Loss	External (aux. voltage) internal (converter)	Device out of operation or alarm	All LEDs dark „Error 5V“ (144)	DOK[2] drops out
Measured Value Acquisition	Internal (converter or reference voltage)	Protection out of operation, alarm	LED „ERROR“ „Error A/D-conv.“ (181)	DOK[2] drops out
Buffer battery	Internal (battery)	Indication	„Fail Battery“ (177)	As allocated
Hardware Watchdog	Internal (processor failure)	Device not in operation	LED „ERROR“	DOK[2] drops out
Software Watchdog	Internal (program sequence)	Restart attempt [1]	LED „ERROR“	DOK[2] drops out
RAM	Internal (RAM)	Restart attempt [1]), Restart abort Device not in operation	LED flashes	DOK[2] drops out
ROM	Internal (EPROM)	Restart attempt [1]	LED „ERROR“	DOK[2] drops out
Settings memory	internal (Flash-EPROM or RAM)	Restart attempt [1]	LED „ERROR“	DOK[2] drops out
Sampling frequency	Internal (clock generator)	Restart attempt [1]	LED „ERROR“	DOK[2] drops out
1 A/5 A setting	1/5 A jumper wrong	Messages: Protection out of operation	„Error1A/5Awrong“ (192) „Error A/D-conv.“ (181) LED „ERROR“	DOK[2] drops out
Adjustment values	Internal (EEPROM or RAM)	Indication: Using default values	„Alarm adjustm.“ (193)	As allocated
Modules	Module does not comply with ordering number (MLFB).	Messages: Protection out of operation	„Error Board BG1...7“ (183 ... 189) and if applicable „Error A/D-conv.“. (181)	DOK[2] drops out
Current sum	internal (measured value acquisition)	Message Total blocking of the differential protection	„Failure Σi“ (289)	as allocated
Current symmetry	External (power system or current transformer)	Indication	„Fail I balance“ (163)	As allocated
Broken Wire	External (power system or current transformer)	Indication Phase-selective blocking of the differential protection	„Broken Iwire L1“ (290), „Broken Iwire L2“ (291), „Broken Iwire L3“ (292)	As allocated
Voltage sum	Internal (measured value acquisition)	Indication	„Fail Σ U Ph-E“ (165)	As allocated
Voltage symmetry	External (power system or voltage transformer)	Indication	„Fail U balance“ (167)	As allocated
Voltage phase sequence	External (power system or connection)	Indication	„Fail Ph. Seq.“ (171)	As allocated
Voltage failure, 3-phase „Fuse Failure Monitor“	External (power system or connection)	Indication Undervoltage protection blocked, Frequency protection blocked	„VT FuseFail>10s“ (169), „VT FuseFail“ (170)	As allocated
Voltage failure, 1-/2-phase „Fuse Failure Monitor“	External (voltage transformers)	Indication Undervoltage protection blocked, Frequency protection blocked	„VT FuseFail>10s“ (169), „VT FuseFail“ (170)	As allocated

Supervision	Possible Causes	Malfunction Response	Indication (No.)	Device
Voltage failure, 3-phase	External (power system or connection)	Indication Undervoltage protection blocked, Frequency protection blocked	„Fail U absent“ (168)	As allocated
Trip Circuit Monitoring	external (trip circuit or control voltage)	Message	„FAIL: Trip cir.“ (6865)	as allocated

1) after three unsuccessful restarts, the device is taken out of service.

2) DOK = „Device OK“ = Break contact of the readiness relay = Life contact

2.15.1.6 Setting Notes

General

The sensitivity of the measured value monitoring can be changed. Experiential values set ex works are adequate in most cases. If particularly high operational asymmetries of the currents and/or voltages are expected, or if one or more monitoring functions pick up sporadically during normal operation, the sensitivity setting(s) should be reduced.

The measurement supervision can be switched ***ON*** or ***OFF*** in address 2901 **MEASURE. SUPERV**.

Current balance supervision

Address 2902 **BALANCE U-LIMIT** determines the limit voltage (phase-to-phase), above which the voltage symmetry monitoring is effective. Address 2903 **BAL. FACTOR U** is the associated balance factor, i.e. the gradient of the balance characteristic. The indication „Fail U balance“ (no. 167) can be delayed at address 2908 **T BAL. U LIMIT**. These settings can only be changed using DIGSI at **Additional Settings**.

Address 2904 **BALANCE I LIMIT** determines the limit current above which the current symmetry monitoring is effective. Address 2905 **BAL. FACTOR I** is the associated balance factor, i.e. the gradient of the balance characteristic. The indication „Fail I balance“ (no. 163) can be delayed at address 2909 **T BAL. I LIMIT**. These settings can only be changed using DIGSI at **Additional Settings**.

Summated current supervision

Address 2906 **ΣI THRESHOLD** determines the limit current above which the current sum monitoring is activated (absolute portion, only relative to I_N). The relative portion (relative to the maximum phase current) for activating the current sum monitoring is set at address 2907 **ΣI FACTOR**. These settings can only be changed using DIGSI at **Additional Settings**.

Note

Current sum monitoring can operate properly only when the ground current of the protected line is fed to the fourth current measuring input (I_4) of the relay. The I_4 transformer must have been configured as ***In prot. line*** via parameter **I4 transformer** (220).

Asymmetrical measuring voltage failure "Fuse Failure Monitor"

The settings of the „Fuse Failure Monitor“ for asymmetrical measured voltage failure must be selected so that on the one hand reliable pickup of the monitoring is ensured in the case of loss of a phase voltage (address 2911 **FFM U>(min)**), while on the other hand a pickup due to earth faults in an earthed system is avoided. In accordance with this requirement, address 2912 **FFM I< (max)** must be set sufficiently sensitive (below the smallest fault current due to earth faults). These settings can only be changed using DIGSI at **Additional Settings**.

In address 2910 **FUSE FAIL MON.**, the „Fuse Failure Monitor“, e.g. during asymmetrical testing, can be switched ***OFF***.

Three-phase measuring voltage failure "Fuse Failure Monitor"

The minimal voltage below which a three-phase measured voltage failure is detected, is set in address 2913 **FFM U<max (3ph)**, unless a current step takes place simultaneously which exceeds the limit according to address 2914 **FFM Idelta (3p)**. These settings can only be changed via DIGSI at **Display Additional Settings**.

In address 2910 **FUSE FAIL MON.**, the „Fuse Failure Monitor“, e.g. during asymmetrical testing, can be switched ***OFF***.

Measured voltage failure monitoring

In address 2915 **V-Supervision**, the measured voltage supervision can be switched to ***w/ CURR.SUP***, ***w/ I> & CBaux*** or ***OFF***. Address 2916 **T V-Supervision** is used to set the waiting time of the voltage failure supervision. This setting can only be changed in DIGSI at **Display Additional Settings**.

Circuit breaker for voltage transformers

If a circuit breaker for voltage transformers (VT mcb) is installed in the secondary circuit of the voltage transformers, the status is sent, via binary input, to the device informing it about the position of the VT mcb. If a short-circuit in the secondary circuit initiates the tripping of the VT mcb, the voltage protection function is blocked, as otherwise it would cause spurious tripping as a result of the absent measured voltage. The reaction time is set at address 2921 **T mcb**.

2.15.1.7 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2901	MEASURE. SUPERV		ON OFF	ON	Measurement Supervision
2902A	BALANCE U-LIMIT		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
2903A	BAL. FACTOR U		0.58 .. 0.95	0.75	Balance Factor for Voltage Monitor
2904A	BALANCE I LIMIT	1A	0.10 .. 1.00 A	0.50 A	Current Balance Monitor
		5A	0.50 .. 5.00 A	2.50 A	
2905A	BAL. FACTOR I		0.10 .. 0.95	0.50	Balance Factor for Current Monitor

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2906A	ΣI THRESHOLD	1A	0.10 .. 2.00 A	0.25 A	Summated Current Monitoring Threshold
		5A	0.50 .. 10.00 A	1.25 A	
2907A	ΣI FACTOR		0.00 .. 0.95	0.50	Summated Current Monitoring Factor
2908A	T BAL. U LIMIT		5 .. 100 sec	5 sec	T Balance Factor for Voltage Monitor
2909A	T BAL. I LIMIT		5 .. 100 sec	5 sec	T Current Balance Monitor
2910	FUSE FAIL MON.		ON OFF	ON	Fuse Failure Monitor
2911A	FFM U>(min)		10 .. 100 V	30 V	Minimum Voltage Threshold U>
2912A	FFM I< (max)	1A	0.10 .. 1.00 A	0.10 A	Maximum Current Threshold I<
		5A	0.50 .. 5.00 A	0.50 A	
2913A	FFM U<max (3ph)		2 .. 100 V	5 V	Maximum Voltage Threshold U< (3phase)
2914A	FFM Idelta (3p)	1A	0.05 .. 1.00 A	0.10 A	Delta Current Threshold (3phase)
		5A	0.25 .. 5.00 A	0.50 A	
2915	V-Supervision		w/ CURR.SUP w/ I> & CBaux OFF	w/ CURR.SUP	Voltage Failure Supervision
2916A	T V-Supervision		0.00 .. 30.00 sec	3.00 sec	Delay Voltage Failure Supervision
2921	T mcb		0 .. 30 ms	0 ms	VT mcb operating time
2931	BROKEN WIRE		ON OFF	OFF	Fast broken current-wire supervision
2933	FAST Σ i SUPERV		ON OFF	ON	State of fast current summation supervis
2941	φA		0 .. 359 °	200 °	Limit setting PhiA
2942	φB		0 .. 359 °	340 °	Limit setting PhiB
2943	I1>	1A	0.05 .. 2.00 A	0.05 A	Minimum value I1>
		5A	0.25 .. 10.00 A	0.25 A	
2944	U1>		2 .. 70 V	20 V	Minimum value U1>

2.15.1.8 Information List

No.	Information	Type of Information	Comments
130	φ(PQ Pos. Seq.)	OUT	Load angle Phi(PQ Positive sequence)
131	φ(PQ Pos) block	OUT	Load angle Phi(PQ) blocked
132	φ Set wrong	OUT	Setting error: |PhiA - PhiB| < 3°
161	Fail I Superv.	OUT	Failure: General Current Supervision
163	Fail I balance	OUT	Failure: Current Balance
164	Fail U Superv.	OUT	Failure: General Voltage Supervision

No.	Information	Type of Information	Comments
165	Fail Σ U Ph-E	OUT	Failure: Voltage summation Phase-Earth
167	Fail U balance	OUT	Failure: Voltage Balance
168	Fail U absent	OUT	Failure: Voltage absent
169	VT FuseFail>10s	OUT	VT Fuse Failure (alarm >10s)
170	VT FuseFail	OUT	VT Fuse Failure (alarm instantaneous)
171	Fail Ph. Seq.	OUT	Failure: Phase Sequence
196	Fuse Fail M.OFF	OUT	Fuse Fail Monitor is switched OFF
197	MeasSup OFF	OUT	Measurement Supervision is switched OFF
289	Failure Σi	OUT	Alarm: Current summation supervision
290	Broken Iwire L1	OUT	Alarm: Broken current-wire detected L1
291	Broken Iwire L2	OUT	Alarm: Broken current-wire detected L2
292	Broken Iwire L3	OUT	Alarm: Broken current-wire detected L3
295	Broken wire OFF	OUT	Broken wire supervision is switched OFF
296	Σi superv. OFF	OUT	Current summation superv is switched OFF
297	ext.Brk.Wire L1	OUT	Broken current-wire at other end L1
298	ext.Brk.Wire L2	OUT	Broken current-wire at other end L2
299	ext.Brk.Wire L3	OUT	Broken current-wire at other end L3

2.15.2 Trip Circuit Supervision

The line protection 7SD610 is equipped with an integrated trip circuit supervision function. Depending on the number of available binary inputs (not connected to a common potential), supervision with one or two binary inputs can be selected. If the routing of the binary inputs required for this does not comply with the selected supervision mode, an alarm is given („TripC1 ProgFAIL ...“, with identification of the non-compliant circuit). When using two binary inputs, malfunctions in the trip circuit can be detected under all circuit breaker conditions. When only one binary input is used, malfunctions in the circuit breaker itself cannot be detected. If single-pole tripping is possible, a separate trip circuit supervision can be implemented for each circuit breaker pole provided the required binary inputs are available.

2.15.2.1 Function Description

Supervision with Two Binary Inputs

When using two binary inputs, these are connected according to Figure 2-90 parallel to the associated trip contact on one side, and parallel to the circuit breaker auxiliary contacts on the other.

A precondition for the use of the trip circuit monitoring is that the control voltage for the circuit breaker is higher than the total of the minimum voltages drops at the two binary inputs ($U_{Ctrl} > 2 \cdot U_{BImin}$). Since at least 19 V are needed for each binary input, the monitoring function can only be used with a system control voltage of over 38 V.

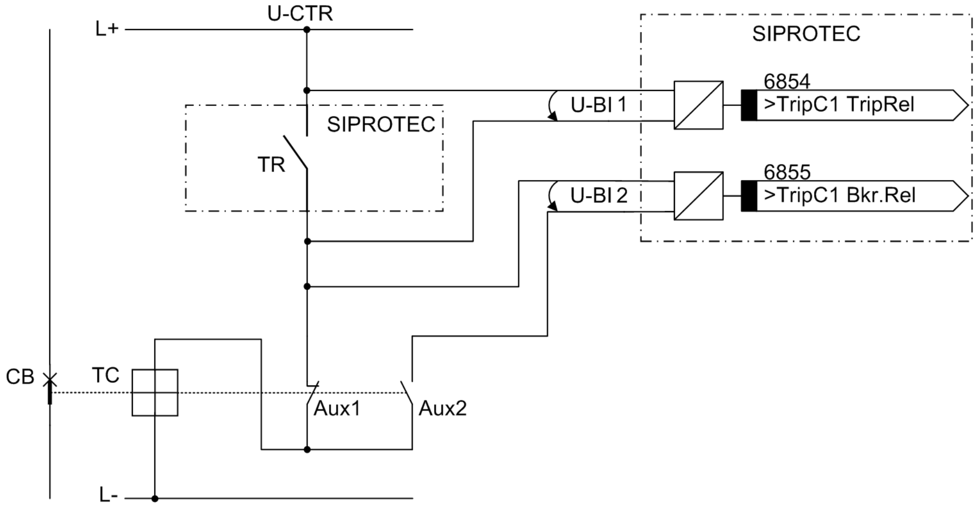


Figure 2-90 Principle of the trip circuit supervision with two binary inputs

TR	Trip relay contact
CB	Circuit breaker
TC	Circuit breaker trip coil
Aux1	Circuit breaker auxiliary contact (NC contact)
Aux2	Circuit breaker auxiliary contact (NO contact)
U-CTR	Control voltage (trip voltage)
U-BI1	Input voltage of 1st binary input
U-BI2	Input voltage of 2nd binary input

Monitoring with two binary inputs not only detects interruptions in the trip circuit and loss of control voltage, it also supervises the response of the circuit breaker using the position of the circuit breaker auxiliary contacts.

Depending on the conditions of the trip contact and the circuit breaker, the binary inputs are activated (logical condition „H“ in the following table), or short-circuited (logical condition „L“).

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

A continuous state of this condition is only possible when the trip circuit has been interrupted, a short-circuit exists in the trip circuit, a loss of battery voltage occurs, or malfunctions occur with the circuit breaker mechanism. Therefore, it is used as monitoring criterion.

Table 2-8 Condition table for binary inputs, depending on RTC and CB position

No.	Trip Contact	Circuit Breaker	Aux 1	Aux 2	BI 1	BI 2	Dynamic State	Static State
1	Open	ON	Closed	Open	H	L	Normal operation with circuit breaker closed	
2	Open	OFF	Open	Closed	H	H	Normal operation with circuit breaker open	
3	Closed	ON	Closed	Open	L	L	Transition or malfunction	Malfunction
4	Closed	OFF	Open	Closed	L	H	TR has tripped successfully	

The conditions of the two binary inputs are checked periodically. A query takes place about every 500 ms. If three consecutive conditional checks detect an abnormality, a fault indication is output (see Figure 2-91). The repeated measurements determine the delay of the alarm message and avoid that an alarm is output during short transition periods. After clearance of the failure in the trip circuit, the failure alarm automatically resets with the same time delay.

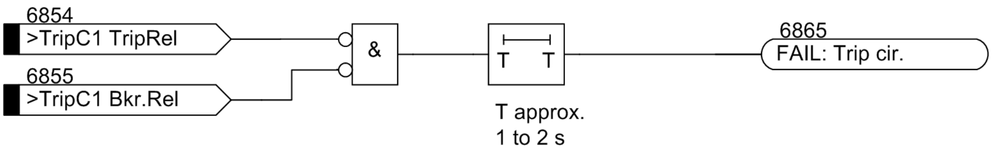


Figure 2-91 Logic diagram of the trip circuit monitoring with two binary inputs

Supervision with One Binary Input

According to Figure 2-92, the binary input is connected in parallel to the respective command relay contact of the protection device. The circuit breaker auxiliary contact is bridged with a high-resistance equivalent resistor R.

The control voltage for the circuit breaker should be at least twice as high as the minimum voltage drop at the binary input ($U_{Ctrl} > 2 \cdot U_{BImin}$). Since at least 19 V are needed for the binary input, the monitor can be used with a system control voltage of over 38 V.

A calculation example for the equivalent resistor R is shown in the configuration notes in Section „Mounting and Connections“, margin heading „Trip Circuit Supervision“.

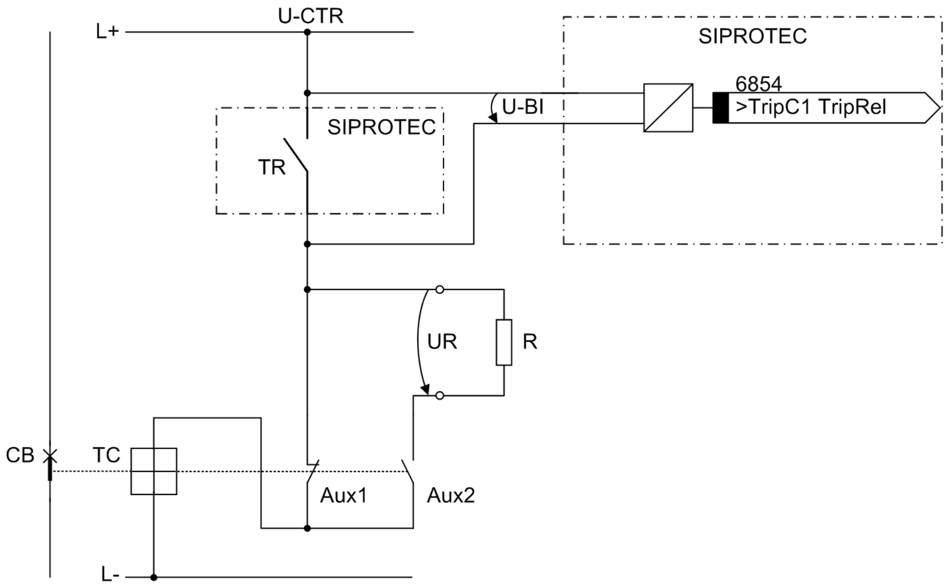


Figure 2-92 Principle of the trip circuit supervision with one binary input

TR	Trip relay contact
CB	Circuit breaker
TC	Circuit breaker trip coil
Aux1	Circuit breaker auxiliary contact (NC contact)
Aux2	Circuit breaker auxiliary contact (NO contact)
U-CTR	Control voltage for trip circuit
U-BI	Input voltage of binary input
R	Equivalent resistor
UR	Voltage across the equivalent resistor

During normal operation, the binary input is activated (logical condition „H“) when the trip contact is open and the trip circuit is intact, because the supervision circuit is closed either by the circuit breaker auxiliary contact (if the circuit breaker is closed) or through the equivalent resistor R. Only as long as the trip contact is closed, the binary input is short-circuited and thereby deactivated (logical condition „L“).

If the binary input is permanently deactivated during operation, an interruption in the trip circuit or a failure of the (trip) control voltage can be assumed.

The trip circuit monitoring does not operate during system faults. A momentary closed tripping contact does not lead to a fault indication. If, however, other trip relay contacts from different devices are connected in parallel in the trip circuit, the fault indication must be delayed by **`Alarm Delay`** (see also Figure 2-93). After clearance of the failure in the trip circuit, the fault message automatically resets with the same time delay.

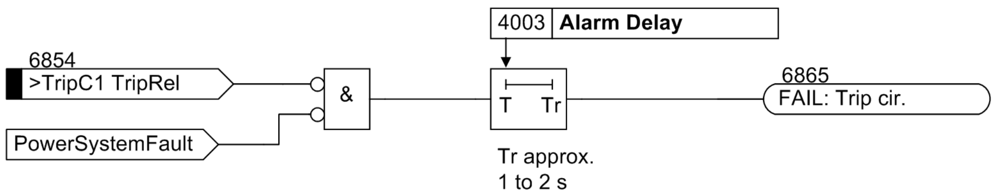


Figure 2-93 Logic diagram for trip circuit supervision with one binary input

2.15.2.2 Setting Notes

General

The number of circuits to be supervised was set during the configuration in address 140 **Trip Cir. Sup.** (Section 2.1.1.2). If the trip circuit supervision is not used at all, the setting ***Disabled*** must be applied there.

The trip circuit supervision can be switched ***ON*** or ***OFF*** in address 4001 **FCT TripSuperv.**. The number of binary inputs that shall be used in each of the supervised circuits is set in address 4002 **No. of BI**. If the routing of the binary inputs required for this does not comply with the selected supervision mode, an alarm is given („TripC1 ProgFAIL ...“, with identification of the non-compliant circuit).

Monitoring with one binary input

The alarm for supervision with two binary inputs is always delayed by approx. 1 s to 2 s, whereas the delay time of the alarm for supervision with one binary input can be set in address 4003 **Alarm Delay**. 1 s to 2 s are sufficient if only the 7SD610 device is connected to the trip circuits as the trip circuit supervision does not operate during a system fault. If, however, trip contacts from other devices are connected in parallel in the trip circuit, the alarm must be delayed such that the longest trip command duration can be reliably bridged.

2.15.2.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4001	FCT TripSuperv.	ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	1 .. 2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	1 .. 30 sec	2 sec	Delay Time for alarm

2.15.2.4 Information List

No.	Information	Type of Information	Comments
6854	>TripC1 TripRel	SP	>Trip circuit superv. 1: Trip Relay
6855	>TripC1 Bkr.Rel	SP	>Trip circuit superv. 1: Breaker Relay
6856	>TripC2 TripRel	SP	>Trip circuit superv. 2: Trip Relay
6857	>TripC2 Bkr.Rel	SP	>Trip circuit superv. 2: Breaker Relay
6858	>TripC3 TripRel	SP	>Trip circuit superv. 3: Trip Relay
6859	>TripC3 Bkr.Rel	SP	>Trip circuit superv. 3: Breaker Relay
6861	TripC OFF	OUT	Trip circuit supervision OFF
6865	FAIL: Trip cir.	OUT	Failure Trip Circuit
6866	TripC1 ProgFAIL	OUT	TripC1 blocked: Binary input is not set
6867	TripC2 ProgFAIL	OUT	TripC2 blocked: Binary input is not set
6868	TripC3 ProgFAIL	OUT	TripC3 blocked: Binary input is not set

2.16 Function Control and Circuit Breaker Test

2.16.1 Function Control

The function control is the control centre of the device. It coordinates the sequence of the protection and ancillary functions, processes their decisions and the information coming from the power system.

Applications

- Line energization recognition,
- Processing of the circuit breaker position,
- Open Pole Detector,
- Fault detection logic,
- Tripping logic.

2.16.1.1 Line energisation recognition

During energization of the protected object, several measures may be required or desirable. Following a manual closure onto a short-circuit, immediate trip of the circuit breaker is usually desired. This is done, e.g. in the overcurrent protection, by bypassing the delay time of specific stages. For every short-circuit protection function which can be delayed, at least one stage can be selected that will operate instantaneously in the event of a closing, as mentioned in the relevant sections. Also see Section 2.1.4.1 at margin heading „Circuit Breaker Status“.

The manual closing command must be indicated to the device via a binary input. In order to be independent of the duration that the switch is closed, the command is set to a defined length in the device (adjustable with the address `1150` **`SI Time Man.Cl`**). This setting can only be changed using DIGSI at **Additional Settings**. Figure 2-94 shows the logic diagram.

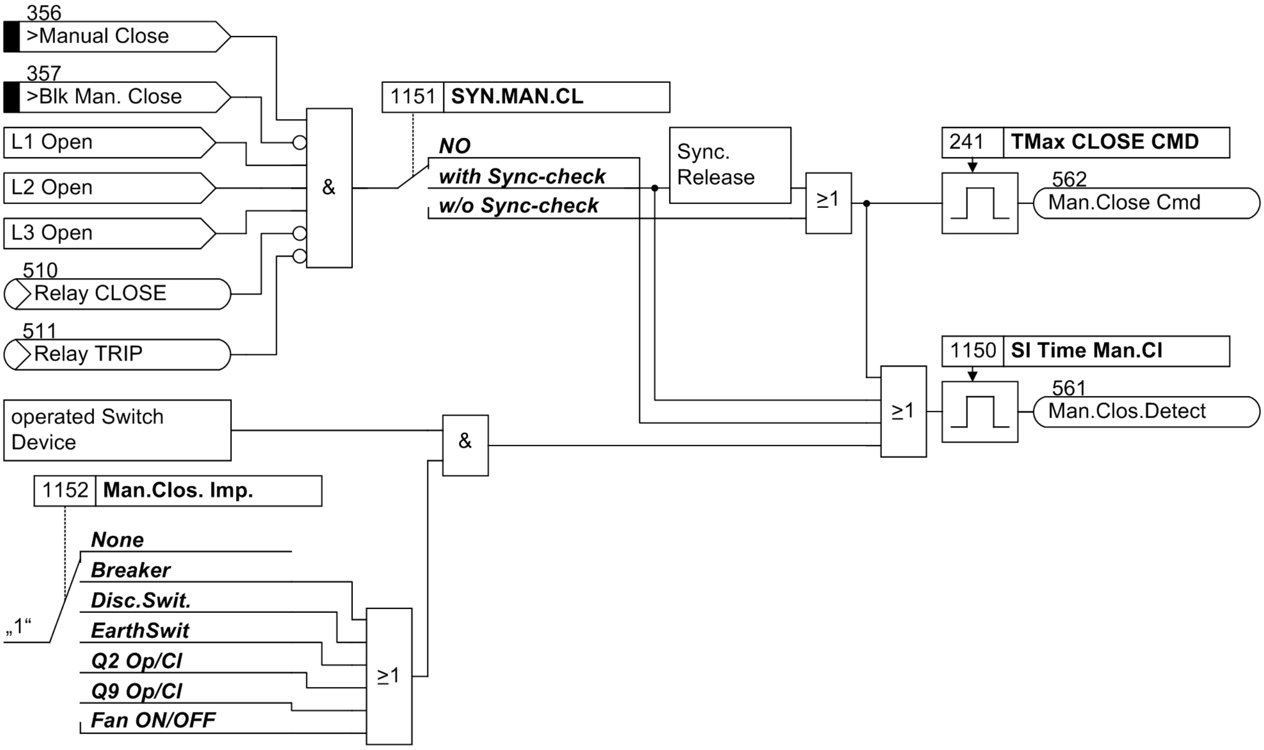


Figure 2-94 Logic diagram of the manual closing procedure

Reclosure via the integrated control functions - on-site control, control via DIGSI, control via serial interface - can have the same effect as manual reclosure, see parameter `1152` Chapter 2.1.4.1 at margin heading „Circuit Breaker Status“.

If the device has an integrated automatic reclosure, the integrated manual closure logic of the 7SD610 automatically distinguishes between an external control command via the binary input and an automatic reclosure by the internal automatic reclosure so that the binary input „`>Manual Close`“ can be connected directly to the control circuit of the close coil of the circuit breaker (Figure 2-95). Each reclosure that is not initiated by the internal automatic reclosure function is interpreted as a manual reclosure, even it has been initiated by a control command from the device.

With the user definable logic functions (CFC) further control functions can be processed in the same way as a manual–close command.

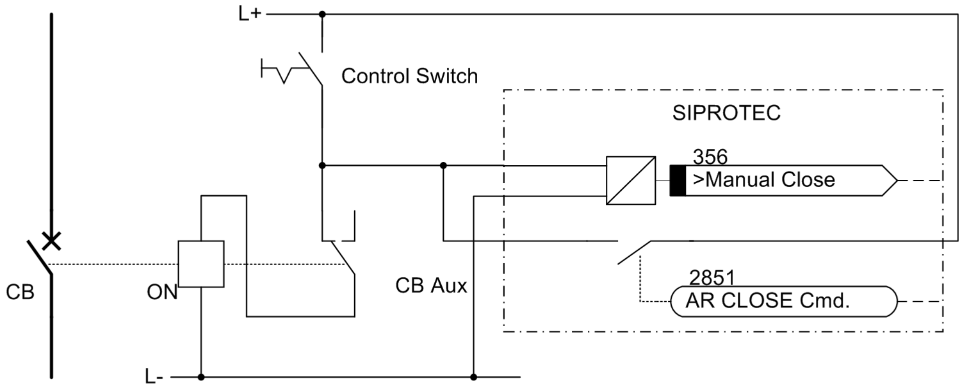


Figure 2-95 Manual closure with internal automatic reclosure

CB	Circuit breaker
ON	Circuit breaker close coil
CBaux	Circuit breaker auxiliary contact

If, however, external close commands which should not activate the manual close function are possible (e.g. external reclosure device), the binary input „`>Manual Close`“ must be triggered by a separate contact at the control discrepancy switch (Figure 2-96).

If in that latter case a manual close command can also be given by means of an internal control command from the device, such a command must be combined with the manual CLOSE function via parameter `1152` **`Man.Clos. Imp.`** (Figure 2-94).

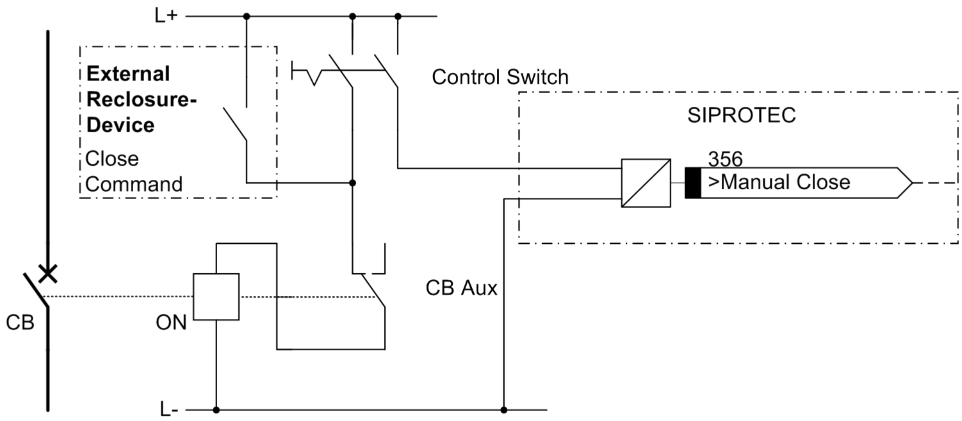


Figure 2-96 Manual closing with external automatic reclosure device

CB	Circuit breaker
ON	Circuit breaker close coil
CBaux	Circuit breaker auxiliary contact

Besides the manual CLOSE detection, the device records any energization of the line via the integrated line energization detection. This function processes a change-of-state of the measured quantities as well as the position of the breaker auxiliary contacts. The current status of the circuit breaker is detected, as described in the following Section at „Detection of the Circuit Breaker Position“. The criteria for the line energization detection change according to the local conditions of the measuring points and the setting of the parameter address 1134 **Line Closure** (see Section 2.1.4 at margin heading „Circuit Breaker Status“).

The phase currents and the phase-to-earth voltages are available as measuring quantities. A flowing current excludes that the circuit breaker is open (exception: A fault between current transformer and circuit breaker). If the circuit breaker is closed, it may, however, still occur that no current is flowing. The voltages can only be used as a criterion for the de-energized line if the voltage transformers are installed on the feeder side. Therefore, the device only evaluates those measuring quantities that provide information on the status of the line according to address 1134.

But a change-of-state, such as a voltage jump from zero to a considerable value (address 1131 **PoleOpenVoltage**) or the occurrence of a considerable current (address 1130 **PoleOpenCurrent**), can be a reliable indicator for line energization as such changes can neither occur during normal operation nor in case of a fault. These settings can only be changed via DIGSI at **Display Additional Settings**.

The position of the auxiliary contacts of the circuit breakers directly indicate the position of the circuit breaker. If the circuit breaker is controlled single-pole, energization takes place if at least one contact changes from open to closed.

The detected energization is signalled through the message „Line closure“ (No. 590). The parameter 1132 **SI Time all Cl.** is used to set the signal to a defined length. These settings can only be changed via DIGSI at **Display Additional Settings**. Figure 2-97 shows the logic diagram.

In order to avoid that an energization is detected mistakenly, the state „line open“, which precedes any energization, must apply for a minimum time (settable with the address 1133 **T DELAY. SOTF**). The default setting for this enable delay is 250 ms. This setting can only be changed using DIGSI at **Additional Settings**.

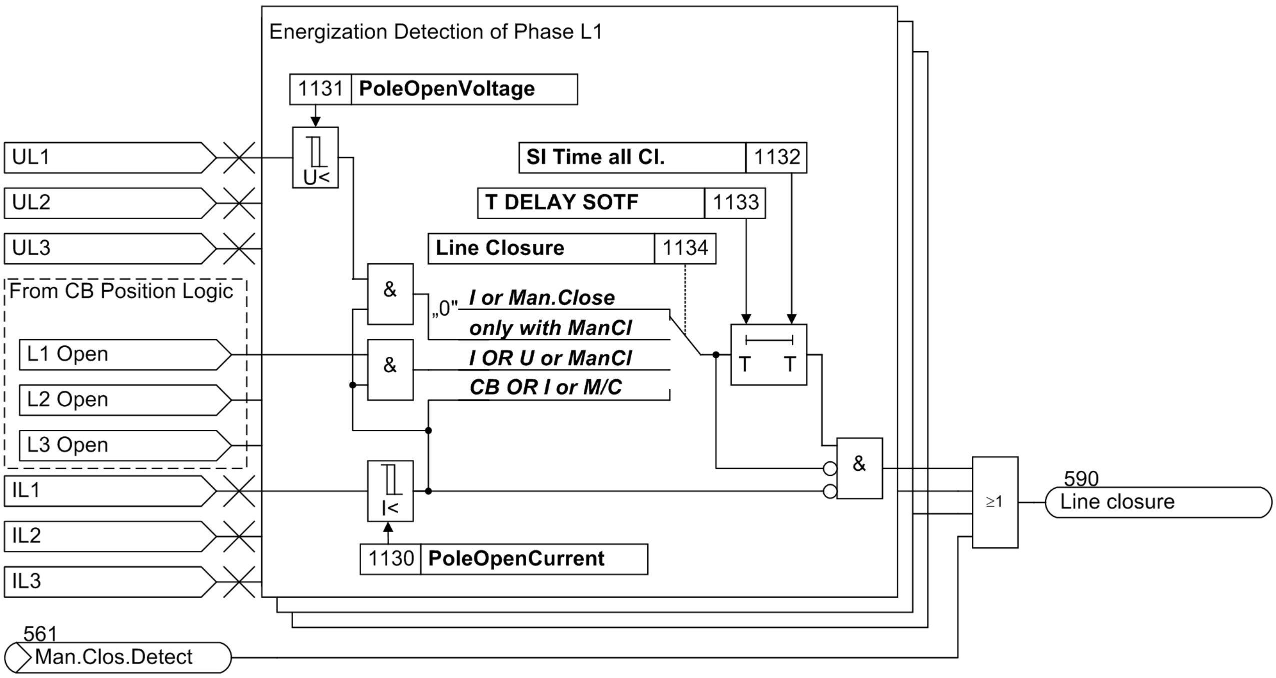


Figure 2-97 Generation of the energization signal

The line energization detection enables the time-overcurrent protection and high-current switch onto fault protection to trip without delay after energization of their line was detected.

2.16.1.2 Detection of the Circuit Breaker Position

For Protection Purposes

Information regarding the circuit breaker position is required by various protective and supplementary functions to ensure their optimal functionality. This is, for example, of assistance for

- The high-current instantaneous tripping (refer to Section 2.8),
- The circuit breaker failure protection (refer to Section 2.13),
- Verification of the dropout condition for the trip command (see Section „Terminating the Trip Signal“).

The device is equipped with a circuit breaker position logic (Figure 2-98) which offers different options depending on the type of auxiliary contacts provided by the circuit breaker and on how they are connected to the device.

In most cases it is sufficient to signal the position of the circuit breaker to the device with its auxiliary contact via a binary input. This always applies if the circuit breaker is only switched three-pole. Then the NO auxiliary contact of the circuit breaker is connected to a binary input which must be configured to the input function„`>CB 3p Closed`“ (No. 379). The other inputs are then not used and the logic is basically restricted to simply passing on this input information.

If the circuit breaker poles can be switched individually, and only a parallel connection of the NO individual pole auxiliary contacts is available, the relevant binary input (BI) is allocated to the function „`>CB 3p Open`“ (no. 380). The remaining inputs are not used in this case.

If the circuit breaker poles can be switched individually and if the individual auxiliary contacts are available, an individual binary input should be used for each auxiliary contact if this is possible and if the device can and is to trip single-pole. With this configuration, the device can process the maximum amount of information. Three binary inputs are used for this purpose:

- „`>CB Aux. L1`“ (No. 351) for the auxiliary contact of pole L1,
- „`>CB Aux. L2`“ (No. 352) for the auxiliary contact of pole L2,
- „`>CB Aux. L3`“ (No. 353) for the auxiliary contact of pole L3.

The inputs No. 379 and No. 380 are not used in this case.

If the circuit breaker can be switched individually, two binary inputs are sufficient if both the parallel as well as series connection of the auxiliary contacts of the three poles are available. In this case, the parallel connection of the auxiliary contacts is routed to the input function „`>CB 3p Closed`“ (No. 379) and the series connection is routed to the input function „`>CB 3p Open`“ (No. 380).

Please note that Figure 2-98 shows the complete logic for all connection alternatives. For each particular application, only a portion of the inputs is used as described above.

The eight output signals of the circuit breaker position logic can be processed by the individual protective and supplementary functions. The output signals are blocked if the signals transmitted from the circuit breaker are not plausible: for example, the circuit breaker cannot be open and closed at the same time. Furthermore, no current can flow over an open breaker contact.

The evaluation of the measuring quantities is according to the local conditions of the measuring points (see Section 2.1.4.1 at margin heading „Circuit Breaker Status“).

The phase currents are available as measuring quantities. A flowing current excludes that the circuit breaker is open (exception: A fault between current transformer and circuit breaker). If the circuit breaker is closed, it may, however, still occur that no current is flowing. The decisive setting for the evaluation of the measuring quantities is **PoleOpenCurrent** (address 1130) for the presence of the currents.

In 7SD610 the position of the circuit breaker poles detected by the device is also transmitted to the remote end device(s). This way the position of the circuit breaker poles is also recognized by at all other ends. The high-current switch-on-to-fault protection (see Section 2.8) makes use of this function.

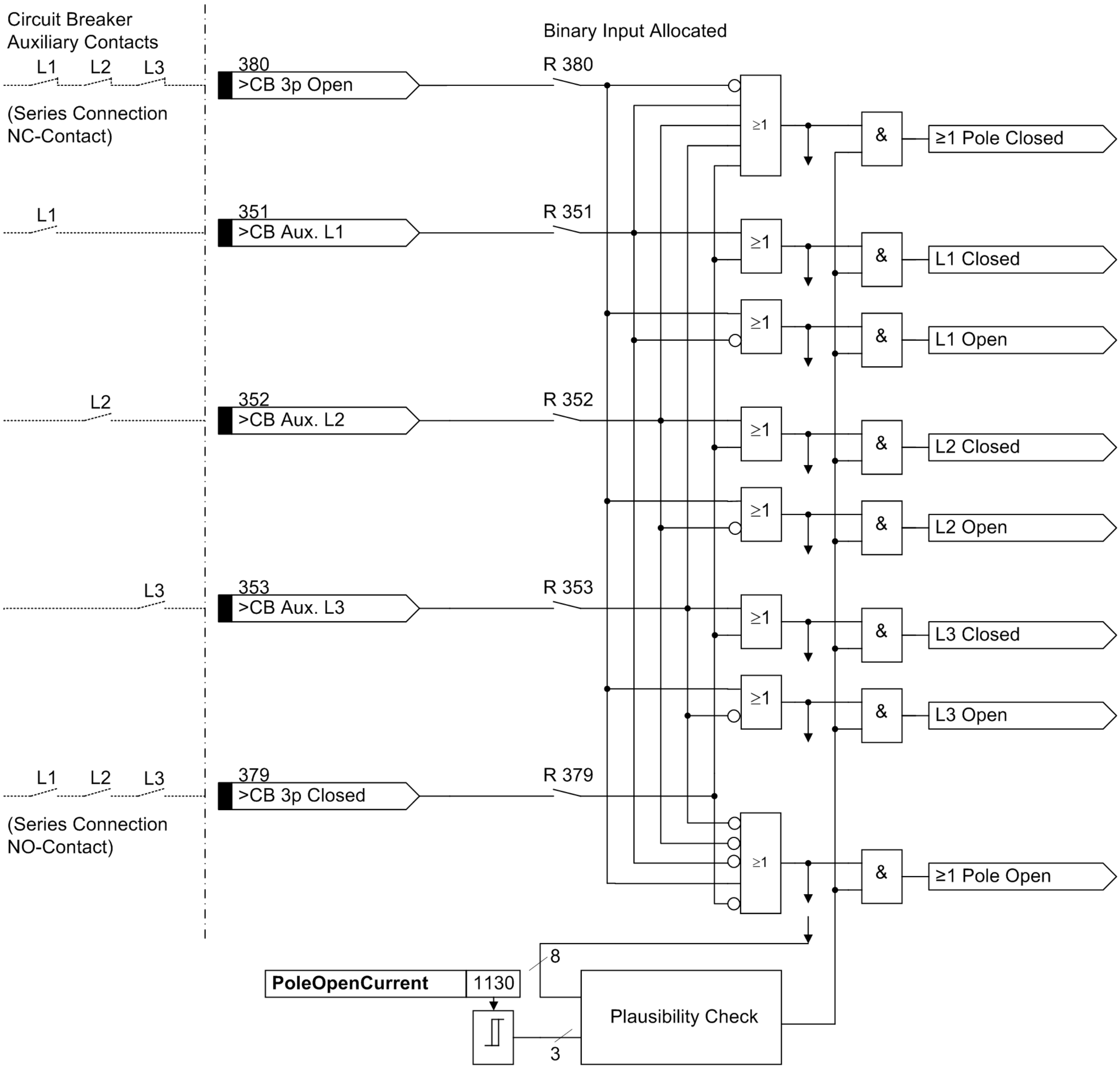


Figure 2-98 Circuit breaker position logic

For automatic reclosure and circuit breaker test

Separate binary inputs comprising information on the position of the circuit breaker are available for the automatic reclosure and the circuit breaker test. This is important for

- The plausibility check before automatic reclosure (refer to Section 2.10),
- The trip circuit check with the help of the TRIP–CLOSE–test cycle (refer to Section 2.16.2).

When using $1^1/_2$ or 2 circuit breakers in each feeder, the automatic reclosure function and the circuit breaker test refer to **one** circuit breaker. The feedback information of this circuit breaker can be connected separately to the device.

For this, separate binary inputs are available, which should be treated the same and configured additionally if necessary. These have a similar significance as the inputs described above for protection applications and are marked with „CB1 ...“ to distinguish them, i.e.:

- „`>CB1 3p Closed`“ (No. 410) for the series connection of the NO auxiliary contacts of the CB,
- „`>CB1 3p Open`“ (No. 411) for the series connection of the NC auxiliary contacts of the CB,
- „`>CB1 Pole L1`“ (No. 366) for the auxiliary contact of pole L1,
- „`>CB1 Pole L2`“ (No. 367) for the auxiliary contact of pole L2,
- „`>CB1 Pole L3`“ (No. 368) for the auxiliary contact of pole L3.

2.16.1.3 Open Pole Detector

Single-pole dead times can be detected and reported via the Open Pole Detector. The corresponding protective and monitoring functions can respond. The following figure shows the logic structure of an Open Pole Detector.

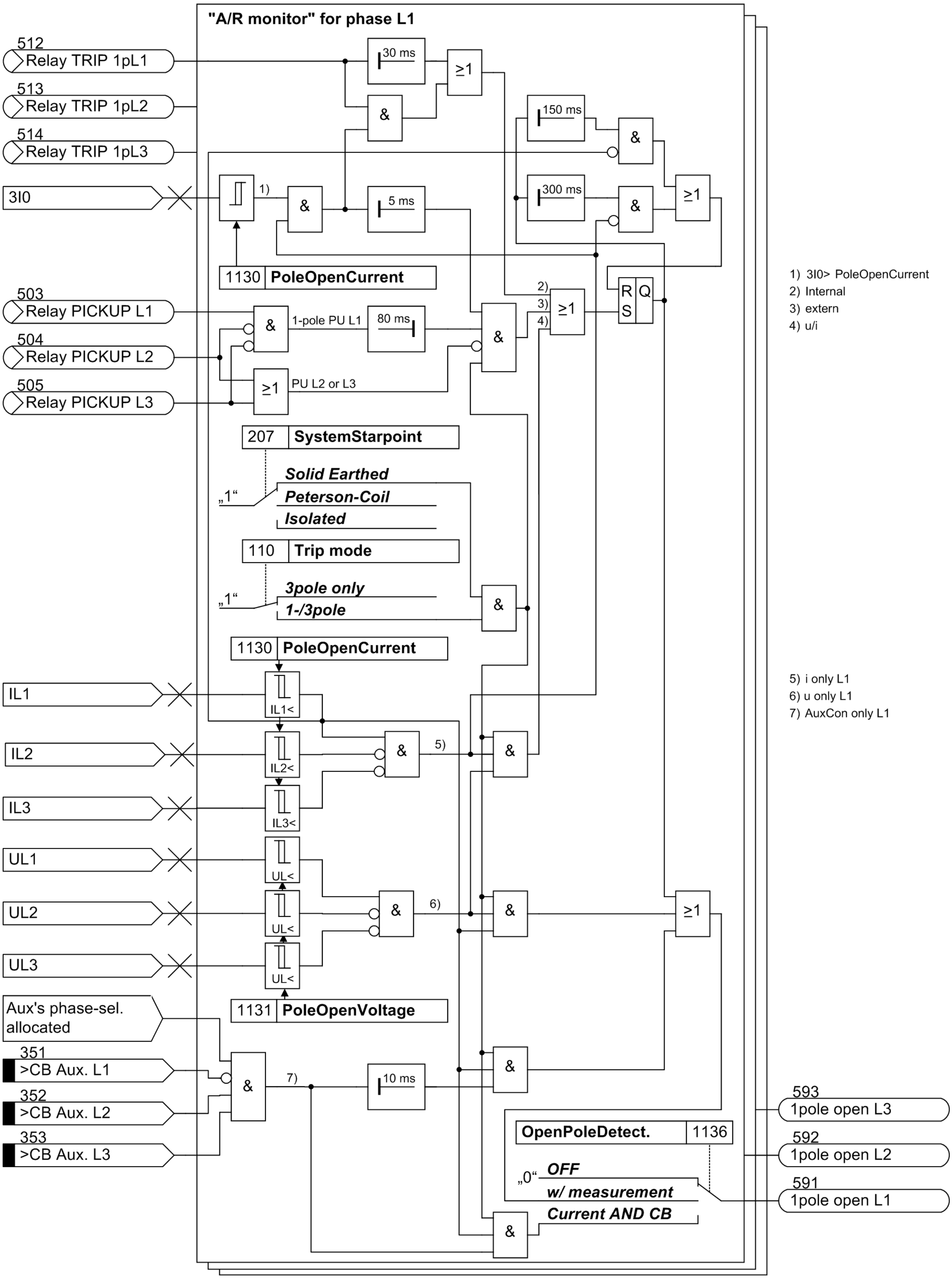


Figure 2-99 Open pole detector logic

1-pole dead time

During a 1-pole dead time, the load current flowing in the two healthy phases forces a current flow via earth which may cause undesired pickup. The developing zero sequence voltage may also prompt undesired responses of the protective functions.

The indications „1pole open L1“ (No. 591), „1pole open L2“ (No. 592) and „1pole open L3“ (No. 593) are additionally generated if the „Open Pole Detector“ detects that current and voltage are absent in one phase – however, it also detects that no current is flowing in the other phases. In this case, one of the indications will only be maintained while the condition is met. This enables a single-pole automatic reclosure to be detected on an unloaded line.

Specially for applications with busbar side voltage transformers the indication „1pole open Lx“ is additionally transmitted if the phase-selective CB auxiliary contacts clearly show a single-pole open circuit breaker, and the current of the affected phase falls below the parameter 1130 **PoleOpenCurrent**.

Depending on the setting of parameter 1136 **OpenPoleDetect.**, the Open Pole Detector evaluates all available measured values including the auxiliary contacts (default setting ***w/ measurement***) or it processes only the information from the auxiliary contacts including the phase current values (setting ***Current AND CB***). To disable the Open Pole Detector, set parameter 1136 to ***OFF***.

2.16.1.4 Pickup Logic of the Entire Device

Phase Segregated Fault Detection

The fault detection logic combines the fault detection (pickup) signals of all protection functions. In the case of those protection functions that allow for phase segregated pickup, the pickup is output in a phase segregated manner. If a protection function detects an earth fault, this is also output as a common device alarm. Thus, the alarms „Relay PICKUP L1“, „Relay PICKUP L2“, „Relay PICKUP L3“ and „Relay PICKUP E“ are available.

The above alarms can be allocated to LEDs or output relays. For the local display of fault event messages and for the transmission of event messages to a personal computer or a centralized control system, several protection functions provide the possibility to display the faulted phase information in a single message, e.g. „Diff Flt. L12E“ for a differential protection pickup L1-L2-E.

General Pickup

The pickup signals are combined with OR and lead to a general pickup of the device. It is signalled with „Relay PICKUP“. If no protective function of the device has picked up any longer, „Relay PICKUP“ disappears (indication „OFF“).

General device pickup is a precondition for a series of internal and external functions that occur subsequently. The following are among the internal functions controlled by general device pickup:

- Opening of fault case: from general device pickup to general device dropout, all fault indications are entered in the trip log.
- Initialization of fault storage: the storage and maintenance of fault values can also be made dependent on the occurrence of a trip command.
- Generation of spontaneous indications: Certain fault indications can be displayed as spontaneous indications (see margin heading „Spontaneous Indications“). In addition, this indication can be made dependent on the general device trip.
- Start action time of automatic reclosure (if available and used).

External functions may be controlled by this indication via an output contact. Examples are:

- Automatic reclose devices,
- Further additional devices or similar.

Spontaneous indications

Spontaneous indications are fault indications which appear in the display automatically following a general fault detection or trip command of the device. For the 7SD610, these indications include:

„Relay PICKUP“:	protective function that picked up;
„PU Time“:	Operating time from the general pickup to the dropout of the device, in ms;
„TRIP Time“:	the operating time from general pickup to the first trip command of the device, in ms;

2.16.1.5 Tripping Logic of the Entire Device

Three-pole tripping

In general, the device trips three-pole in the event of a fault. Depending on the version ordered (see Section A.1, „Ordering Information“), single-pole tripping is also possible. If, in general, single-pole tripping is not possible or desired, the output function „Relay TRIP“ is used for the trip command output to the circuit breaker. In these cases, the following sections regarding single-pole tripping are not of interest.

Single-pole tripping

Single-pole tripping only makes sense on overhead lines on which automatic reclosure is to be carried out and where the circuit breakers at both ends of the line are capable of single-pole tripping. Single-pole tripping with subsequent reclosure is then possible in the event of a single-phase fault in the faulted phase; three-pole tripping is generally performed in case of two-phase or three-phase faults with and without earth.

Device prerequisites for phase segregated tripping are:

- Phase segregated tripping is provided by the device (according to the ordering code);
- The tripping protective function is suitable for pole-segregated tripping (for example, not for frequency protection, overvoltage protection or overload protection),
- The binary input „>1p Trip Perm“ is configured and activated or the internal automatic reclosure function is ready for reclosure after single-pole tripping.

In all other cases tripping is always three-pole. The binary input „>1p Trip Perm“ is the logic inversion of a three-pole coupling and activated by an external auto-reclosure device as long as this is ready for a single-pole auto-reclosure cycle.

With the 7SD610, it is also possible to trip three-pole when only one phase is subjected to the trip conditions, but more than one phase indicates a fault detection. This can be the case e.g. if two faults occur in two different places of which only one is within the range of the differential protection. This is selected with the setting parameter **3pole coupling** (address 1155), which can be set to ***with PICKUP*** (every multiple-phase fault detection causes three-pole trip) or ***with TRIP*** (in the event of multiple-phase faults in the tripping area, the tripping is always three-pole).

The tripping logic combines the trip signals from all protective functions. The trip commands of those protective functions that allow single-pole tripping are phase segregated. The corresponding indications are named „Relay TRIP L1“, „Relay TRIP L2“ and „Relay TRIP L3“.

These indications can be allocated to LEDs or output relays. In the event of three-pole tripping all three indications are displayed. These alarms are also intended for the trip command output to the circuit breaker.

If single-pole tripping is possible, the protective functions generate a group signal for the local display of fault indications and for the transmission of the indications to a PC or a central control system, e.g. for single-pole tripping by differential protection „`Diff TRIP 1p L1`“, „`Diff TRIP 1p L2`“, „`Diff TRIP 1p L3`“ and „`Diff TRIP L123`“ for three-pole tripping; only one of these messages is displayed at a time.

Single-pole tripping for two-phase faults

Single-pole tripping for two-phase faults is a special feature. If a phase-to-phase fault without earth occurs in an earthed system, this fault can be cleared by single-pole trip and automatic reclosure in one of the faulted phases as the short-circuit path is interrupted in this manner. The phase selected for tripping must be the same at both line ends (and should be the same for the entire system).

The setting parameter **`Trip2phFlt`** (address `1156`) allows to select whether this tripping is to be ***`1pole leading Ø`***, i.e. single-pole tripping in the leading phase or ***`1pole lagging Ø`***, i.e. single-pole tripping in the lagging phase. Standard setting is ***`3pole`*** tripping in the event of two-phase faults (default setting).

Table 2-9 Single-pole and three-pole trip depending on fault type

Type of Fault (from Protection Function)				Parameter Trip2phFlt	Output signals for trip			
					TRIP 1p.L1	TRIP 1p.L2	TRIP 1p.L3	Relay TRIP 3ph.
L1				(any)	X			
	L2			(any)		X		
		L3		(any)			X	
L1			E	(any)	X			
	L2		E	(any)		X		
		L3	E	(any)			X	
L1	L2			3pole				X
L1	L2			1pole leading Ø	X			
L1	L2			1pole lagging Ø		X		
	L2	L3		3pole				X
	L2	L3		1pole leading Ø		X		
	L2	L3		1pole lagging Ø			X	
L1		L3		3pole				X
L1		L3		1pole leading Ø			X	
L1		L3		1pole lagging Ø	X			
L1	L2		E	(any)				X
	L2	L3	E	(any)				X
L1		L3	E	(any)				X
L1	L2	L3		(any)				X
L1	L2	L3	E	(any)				X
			E	(any)				X

General Trip

All trip signals for the protective functions are connected by OR and generate the message „`Relay TRIP`“. This can be allocated to LED or output relay.

Terminating the Trip Signal

Once a trip command is initiated, it is phase segregatedly latched (in the event of three-pole tripping for each of the three poles) (refer to Figure 2-100). At the same time, the minimum trip command duration **TMin TRIP CMD** is started. This ensures that the trip command is output to the circuit breaker for a sufficiently long time even if the tripping protective function resets very rapidly. The trip commands can only be reset after all tripping protective functions have dropped out and after the minimum trip command duration has elapsed.

A further condition for the reset of the trip command is that the circuit breaker has opened, in the event of single-pole tripping the relevant circuit breaker pole. In the function control of the device, this is checked by means of the circuit breaker position feedback (Section „Detection of the Circuit Breaker Position“) and the flow of current. In address 1130, the residual current **PoleOpenCurrent** is set which is certainly undershot when the circuit breaker pole is open. Address 1135 **Reset Trip CMD** determines under which conditions a trip command is reset. If ***CurrentOpenPole*** is set, the trip command is reset as soon as the current disappears. It is important that the value set in address 1130 **PoleOpenCurrent** (see above) is undershot. If ***Current AND CB*** is set, the circuit breaker auxiliary contact must send a message that the circuit breaker is open. It is a prerequisite for this setting that the position of the auxiliary contact is allocated via a binary input. If this additional condition is not required for resetting the trip command (e.g. if test sockets are used for protection testing), it can be switched off with the setting ***Pickup Reset***.

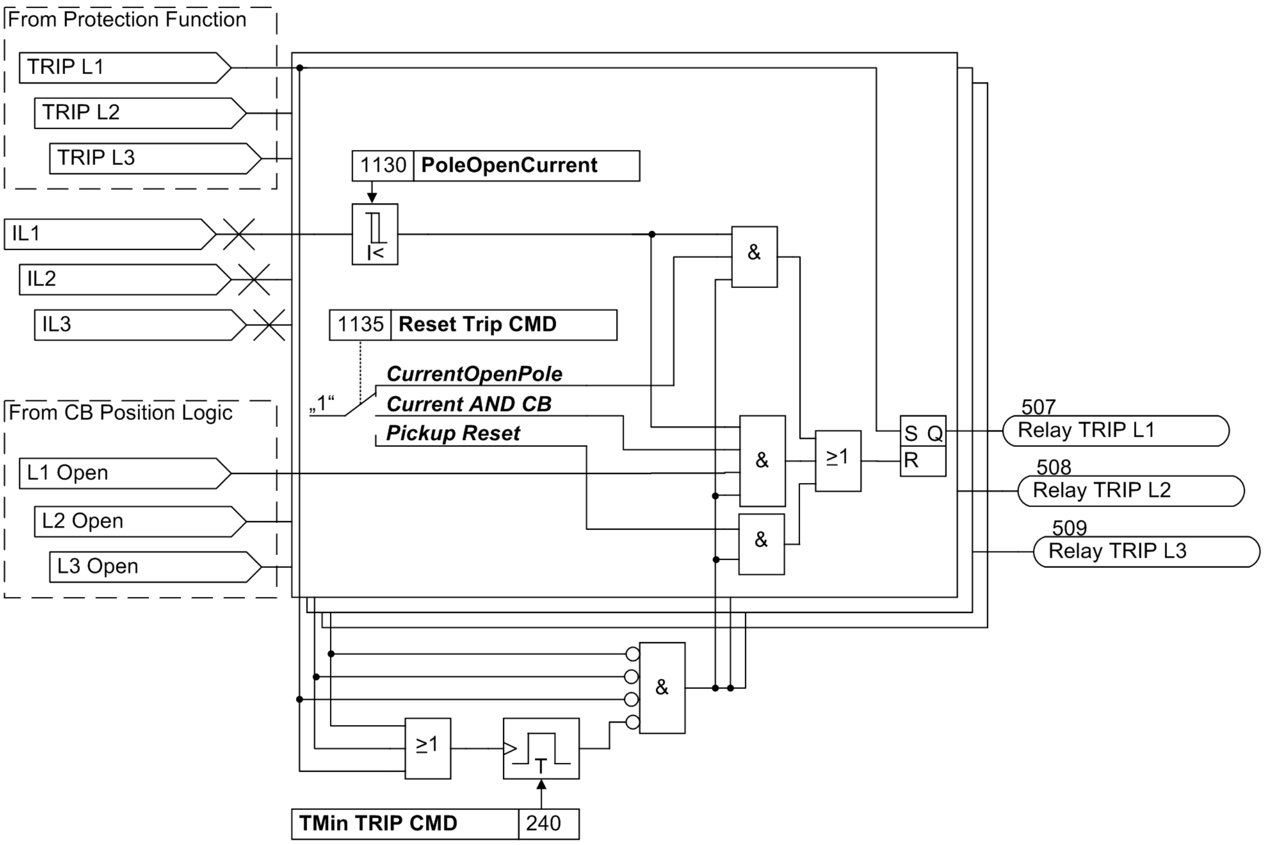


Figure 2-100 Storage and termination of the trip command

Reclosure Interlocking

When tripping the circuit breaker by a protection function the manual reclosure must often be blocked until the cause for the protection function operation is found. 7SD610 enables this via the integrated reclosure interlocking.

The interlocking state („LOCKOUT“) will be realized by an RS flipflop which is protected against auxiliary voltage failure (see Figure 2-101). The RS flipflop is set via binary input „`>Lockout SET`“ (no. 385). With the output alarm „`LOCKOUT`“ (no. 530), if interconnected correspondingly, a reclosure of the circuit breaker (e.g. for automatic reclosure, manual close signal, synchronization, closing via control) can be blocked. Only once the cause for the protection operation is known, should the interlocking be reset by a manual reset via binary input „`>Lockout RESET`“ (no. 386).

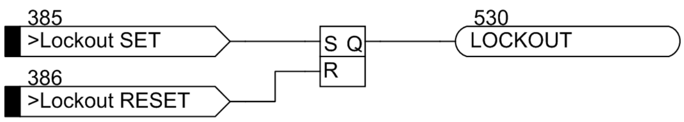


Figure 2-101 Reclosure Interlocking

Conditions which cause reclosure interlocking and control commands which have to be interlocked can be set individually. The two inputs and the output can be wired via the correspondingly allocated binary inputs and outputs or be linked via user-defined logic functions (CFC).

If, for example, each trip by the protection function has to cause a closing lockout, then combine the trip command „`Relay TRIP`“ (no. 511) with the interlocking input „`>Lockout SET`“. If automatic reclosure is applied, only the final trip of the protection function should activate reclosing lockout. Please bear in mind that the message „`Definitive TRIP`“ (no. 536) applies only for 500 ms. Then combine the output indication „`Definitive TRIP`“ (no. 536) with the interlocking input „`>Lockout SET`“, so that the interlocking function is not established when an automatic reclosure is still expected to come.

In the most simple case, the output indication „`LOCKOUT`“ (No. 530) can be allocated to the output which trips the circuit breaker without creating further links. Then the trip command is maintained until the interlock is reset via the 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 trip command is maintained.

The output indication „`LOCKOUT`“ can also be applied to interlock certain closing commands (externally or via CFC), e.g. by combining the output alarm with the binary input „`>Blk Man. Close`“ (no. 357) or by connecting the inverted alarm with the bay interlocking of the feeder.

The reset input „`>Lockout RESET`“ (no. 386) resets the interlocking state. This input is initiated by an external device which is protected against unauthorized or unintentional operation. The interlocking state can also be controlled by internal sources using CFC, e.g. a function key, operation of the device or using DIGSI on a PC.

For each case please make sure that 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. See also the SIPROTEC 4 System Description.

Breaker Tripping Alarm Suppression

While on feeders without automatic reclosure every trip command by a protection function is final, it is desirable, when using automatic reclosure, to prevent the operation detector of the circuit breaker (transient contact on the breaker) from sending an alarm if the trip of the breaker is not final (Figure 2-102).

For this purpose, the signal from the circuit breaker is routed via a correspondingly allocated output contact of the 7SD610 (output indication „CB Alarm Supp“, no. 563). In the idle state and when the device is turned off, this contact is closed. Therefore an output contact with a normally closed contact (NC contact) has to be allocated. Which contact is to be allocated depends on the device version. Refer to the general views in the Appendix.

Prior to the command, with the internal automatic reclosure in the ready state, the contact opens so that no signal from the circuit breaker is forwarded. This is only the case if the device is equipped with internal automatic reclosure and if the latter was taken into consideration when configuring the protective functions (address 133).

Also when closing the breaker via the binary input „>Manual Close“ (No 356) or via the integrated automatic reclosure the contact is interrupted so that the breaker alarm is inhibited.

Further optional closing commands which are not sent via the device cannot be taken into consideration. Closing commands for control can be linked to the alarm suppression via the user-defined logic functions (CFC).

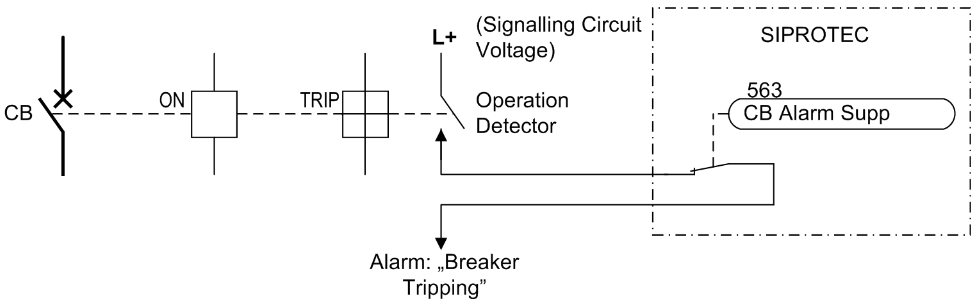


Figure 2-102 Breaker tripping alarm suppression

If the device issues a final trip command, the contact remains closed. This is the case, during the reclaim time of the automatic reclosure cycle, when the automatic reclosure is blocked or switched off or, due to other reasons is not ready for automatic reclosure (e.g. tripping only occurred after the action time expired).

Figure 2-103 shows time diagrams for manual trip and close as well as for short-circuit tripping with a single, failed automatic reclosure cycle.

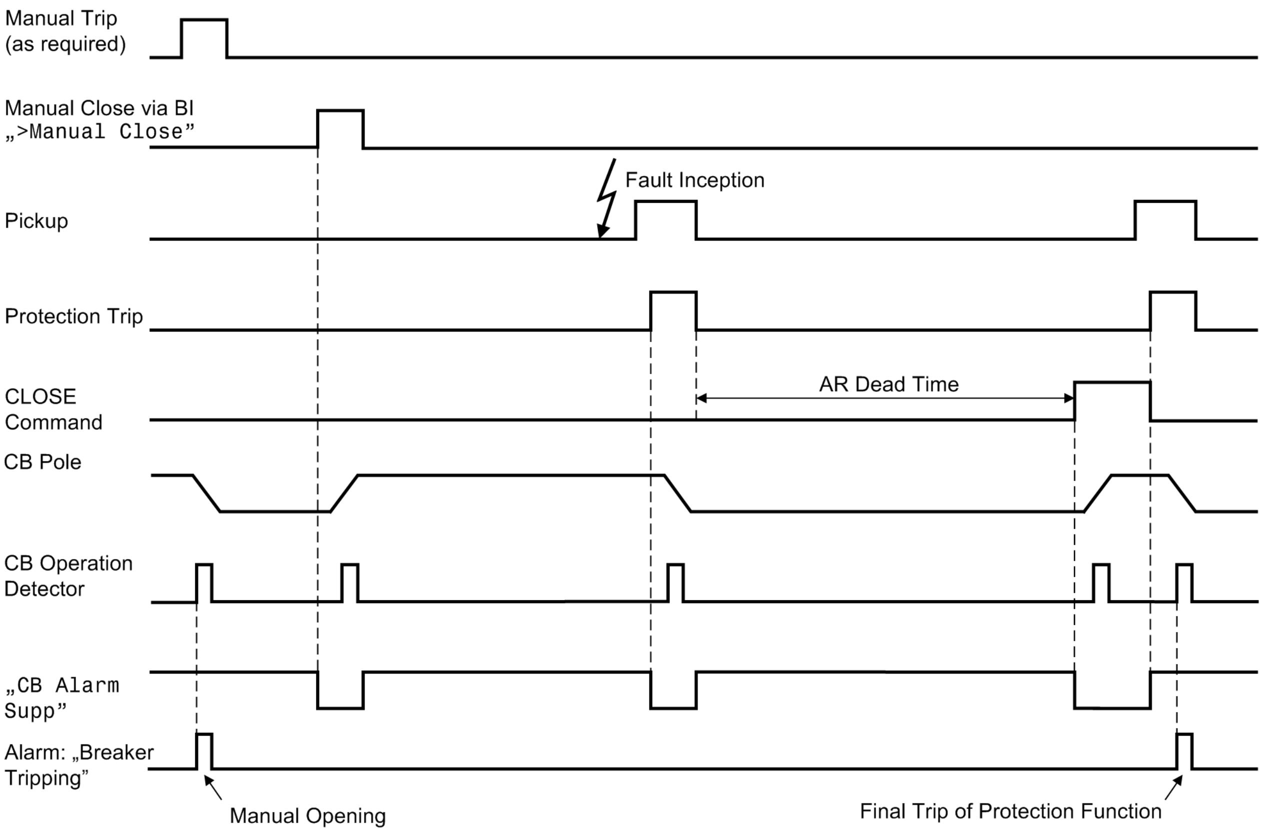


Figure 2-103 Breaker tripping alarm suppression — sequence examples

2.16.2 Circuit Breaker Test

The 7SD610 line protection relay allows for convenient testing of the trip circuits and the circuit breakers.

2.16.2.1 Functional Description

The test programs listed in Table 2-10 are available. The single-pole tests are naturally only available if the device at hand allows 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 using the operator panel on the front of the device or using the PC with DIGSI. The procedure is described in detail in the SIPROTEC 4 System Description. Figure 2-104 shows the chronological sequence of one TRIP–CLOSE test cycle. The set times are those stated in Section 2.1.2.1 for „Trip Command Duration“ and „Circuit Breaker Test“.

Where the circuit breaker auxiliary contacts indicate the status of the circuit breaker or of its poles to the device via binary inputs, the test cycle can only be initiated if the circuit breaker is closed.

The information regarding the position of the circuit breakers is not automatically derived from the position logic according to the above section. For the circuit breaker test function (auto recloser) there are separate binary inputs for the switching status feedback of the circuit breaker position. These must be taken into consideration when allocating the binary inputs as mentioned in the previous section.

The alarms of the device show the respective state of the test sequence.

Table 2-10 Circuit breaker test programs

Serial No.	Test Programs	Circuit Breaker	Output Indications (No.)
1	1-pole TRIP/CLOSE-cycle phase L1	CB 1	CB1-TESTtrip L1 (7325)
2	1-pole TRIP/CLOSE-cycle phase L2		CB1-TESTtrip L2 (7326)
3	1-pole TRIP/CLOSE-cycle phase L3		CB1-TESTtrip L3 (7327)
4	3-pole TRIP/CLOSE-cycle		CB1-TESTtrip 123 (7328)
	Associated close command		CB1-TEST CLOSE (7329)

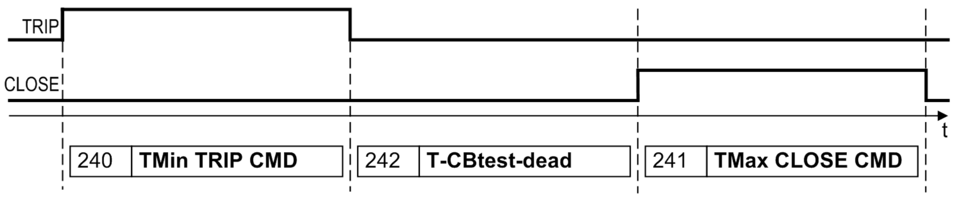


Figure 2-104 TRIP-CLOSE test cycle

2.16.2.2 Information List

No.	Information	Type of Information	Comments
-	CB1tst L1	-	CB1-TEST trip/close - Only L1
-	CB1tst L2	-	CB1-TEST trip/close - Only L2
-	CB1tst L3	-	CB1-TEST trip/close - Only L3
-	CB1tst 123	-	CB1-TEST trip/close Phases L123
7325	CB1-TESTtrip L1	OUT	CB1-TEST TRIP command - Only L1
7326	CB1-TESTtrip L2	OUT	CB1-TEST TRIP command - Only L2
7327	CB1-TESTtrip L3	OUT	CB1-TEST TRIP command - Only L3
7328	CB1-TESTtrip123	OUT	CB1-TEST TRIP command L123
7329	CB1-TEST close	OUT	CB1-TEST CLOSE command
7345	CB-TEST running	OUT	CB-TEST is in progress
7346	CB-TSTstop FLT.	OUT_Ev	CB-TEST canceled due to Power Sys. Fault
7347	CB-TSTstop OPEN	OUT_Ev	CB-TEST canceled due to CB already OPEN
7348	CB-TSTstop NOTr	OUT_Ev	CB-TEST canceled due to CB was NOT READY
7349	CB-TSTstop CLOS	OUT_Ev	CB-TEST canceled due to CB stayed CLOSED
7350	CB-TST .OK.	OUT_Ev	CB-TEST was successful

2.16.3 Device

The device requires some general information. This may be, for example, the type of indication to be issued in the event a power system fault occurs.

2.16.3.1 Trip-Dependent Indications

The storing of indications masked to local LEDs, and the maintenance of spontaneous indications, can be made dependent on whether the device has issued a trip signal. This information is then not output if one or more protection functions have picked up during a system disturbance, but no tripping by the 7SD610 resulted because the fault was cleared by a different device (e.g. on another line). These indications are then limited to faults on the line to be protected.

The figure below illustrates the generation of the reset command for stored indications. When the relay drops off, stationary conditions (fault display on every pickup/on trip only; trip/no trip) decide whether the new fault will be stored or reset.

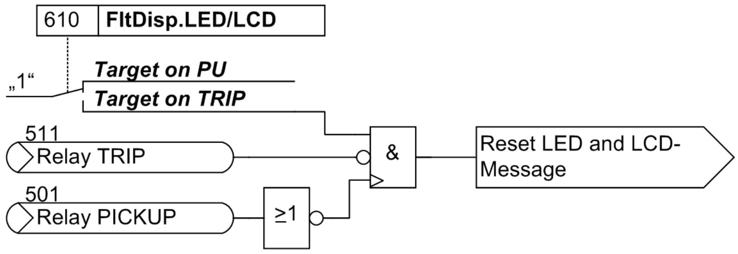


Figure 2-105 Creation of the reset command for the latched LED and LCD messages

2.16.3.2 Spontaneous Indications on the Display

You can select whether or not the most important data of a fault are displayed automatically after the fault has occurred (see also „Fault Indications“ in Section 2.17.2 „Processing of Messages“).

2.16.3.3 Switching Statistics

The number of trips initiated by the device 7SD610 are counted. If the device is capable of single-pole tripping, a separate counter for each circuit breaker pole is provided.

Furthermore, for each trip command the interrupted current for each pole is acquired, output in the trip log and accumulated in a memory. The maximum interrupted current is stored as well.

If the device is equipped with the integrated automatic reclosure, the automatic close commands are also counted, separately for reclosure after single-pole tripping, after three-pole tripping as well as separately for the first reclosure cycle and further reclosure cycles.

The counter and memory levels are secured against loss of auxiliary voltage. They can be set to zero or to any other initial value. For more details, refer to the SIPROTEC 4 System Description.

2.16.3.4 Setting Notes

Fault Messages

Pickup of a new protective function generally turns off any previously lit LEDs, so that only the latest fault is displayed at any time. It can be selected whether the stored LED displays and the spontaneous indications on the display appear upon renewed pickup, or only after a renewed trip signal is issued. In order to enter the desired type of display, select the submenu Device in the SETTINGS menu. At address 610 **FltDisp.LED/LCD** the two alternatives ***Target on PU*** and ***Target on TRIP*** („No trip - no flag“) are offered.

After startup of a device featuring a 4-line display, measured values are displayed by default. Use the arrow keys on the device front to select the different represenations of the measured values for the so-called default display. The start page of the default display, which is displayed by default after startup of the device, can be selected via parameter 640 **Start image DD**. The available representation types for the measured values are listed in the appendix .

2.16.3.5 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
610	FltDisp.LED/LCD	Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
640	Start image DD	image 1 image 2 image 3 image 4 image 5 image 6	image 1	Start image Default Display

2.16.3.6 Information List

No.	Information	Type of Information	Comments
-	Test mode	IntSP	Test mode
-	DataStop	IntSP	Stop data transmission
-	UnlockDT	IntSP	Unlock data transmission via BI
-	Reset LED	IntSP	Reset LED
-	SynchClock	IntSP_Ev	Clock Synchronization
-	>Light on	SP	>Back Light on
-	HWTestMod	IntSP	Hardware Test Mode
-	Distur.CFC	OUT	Disturbance CFC
-	Brk OPENED	IntSP	Breaker OPENED
-	FdrEARTHED	IntSP	Feeder EARTHED
3	>Time Synch	SP	>Synchronize Internal Real Time Clock
5	>Reset LED	SP	>Reset LED
11	>Annunc. 1	SP	>User defined annunciation 1
12	>Annunc. 2	SP	>User defined annunciation 2
13	>Annunc. 3	SP	>User defined annunciation 3
14	>Annunc. 4	SP	>User defined annunciation 4

No.	Information	Type of Information	Comments
15	>Test mode	SP	>Test mode
16	>DataStop	SP	>Stop data transmission
51	Device OK	OUT	Device is Operational and Protecting
52	ProtActive	IntSP	At Least 1 Protection Funct. is Active
55	Reset Device	OUT	Reset Device
56	Initial Start	OUT	Initial Start of Device
60	Reset LED	OUT_Ev	Reset LED
67	Resume	OUT	Resume
68	Clock SyncError	OUT	Clock Synchronization Error
69	DayLightSavTime	OUT	Daylight Saving Time
70	Settings Calc.	OUT	Setting calculation is running
71	Settings Check	OUT	Settings Check
72	Level-2 change	OUT	Level-2 change
73	Local change	OUT	Local setting change
110	Event Lost	OUT_Ev	Event lost
113	Flag Lost	OUT	Flag Lost
125	Chatter ON	OUT	Chatter ON
126	ProtON/OFF	IntSP	Protection ON/OFF (via system port)
140	Error Sum Alarm	OUT	Error with a summary alarm
144	Error 5V	OUT	Error 5V
160	Alarm Sum Event	OUT	Alarm Summary Event
177	Fail Battery	OUT	Failure: Battery empty
181	Error A/D-conv.	OUT	Error: A/D converter
183	Error Board 1	OUT	Error Board 1
184	Error Board 2	OUT	Error Board 2
185	Error Board 3	OUT	Error Board 3
186	Error Board 4	OUT	Error Board 4
187	Error Board 5	OUT	Error Board 5
188	Error Board 6	OUT	Error Board 6
189	Error Board 7	OUT	Error Board 7
190	Error Board 0	OUT	Error Board 0
191	Error Offset	OUT	Error: Offset
192	Error1A/5Awrong	OUT	Error:1A/5Ajumper different from setting
193	Alarm adjustm.	OUT	Alarm: Analog input adjustment invalid
194	Error neutralCT	OUT	Error: Neutral CT different from MLFB
320	Warn Mem. Data	OUT	Warn: Limit of Memory Data exceeded
321	Warn Mem. Para.	OUT	Warn: Limit of Memory Parameter exceeded
322	Warn Mem. Oper.	OUT	Warn: Limit of Memory Operation exceeded
323	Warn Mem. New	OUT	Warn: Limit of Memory New exceeded
2054	Emer. mode	OUT	Emergency mode

2.16.4 EN100-Modul 1

2.16.4.1 Function Description

An **EN100-Modul 1** allows to integrate the 7SD610 into 100 Mbit Ethernet communication networks used by process control and automation systems and running IEC 61850 protocols. This standard provides consistent inter-relay communication without gateways or protocol converters. This allows open and interoperable use of SIPROTEC 4 devices even in heterogeneous environments. In parallel to the process control integration of the device, this interface can also be used for communication with DIGSI and for inter-relay communication via GOOSE.

2.16.4.2 Setting Notes

Interface Selection

No settings are required for operation of the Ethernet system interface module (IEC 61850 **EN100-Modul 1**). If the device is equipped with such a module (see MLFB), the module is automatically configured to the interface available for it, namely ***Port B***.

2.16.4.3 Information List

No.	Information	Type of Information	Comments
009.0100	Failure Modul	IntSP	Failure EN100 Modul
009.0101	Fail Ch1	IntSP	Failure EN100 Link Channel 1 (Ch1)
009.0102	Fail Ch2	IntSP	Failure EN100 Link Channel 2 (Ch2)

2.17 Additional Functions

The additional functions of the 7SD610 differential protection relay include:

- Commissioning tool,
- Processing of messages,
- Processing of operational measured values,
- Storage of fault record data.

2.17.1 Commissioning aid

2.17.1.1 Function Description

There is a comprehensive commissioning and monitoring tool that checks the communication and the whole differential protection function. The WEB-Monitor is an integral part of the device. The respective online-help is available with DIGSI on CD-ROM or via the internet at www.siprotec.de.

To ensure a proper communication between the device and the PC browser, the transmission speed of both must be equal. Furthermore, the user must assign an IP address so that the browser can identify the device.

The WEB-Monitor also enables the user 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. The actual operation of the device can be now simulated with the mouse pointer. This possibility can be disabled.

If the device is equipped with an EN100 module, operation with DIGSI or the WEB-Monitor is also possible via Ethernet. All that has to be done is to set the IP configuration of the device accordingly. Parallel operation of DIGSI and WEB-Monitor via different interfaces is possible.

WEB-Monitor

The „WEB-Monitor“ is a comprehensive commissioning and monitoring tool which enables to clearly display the differential protection communication and the most important measured data using a PC with a web browser. Measured values and the values derived from them are graphically displayed as phasor diagrams. You can also view tripping diagrams, scalar values are shown in numerical form. For more details please refer to the online help for the „WEB-Monitor“.

This tool enables to graphically display, for instance, the currents, voltages (if connected to the system) and their phase angles for all devices of a differential protection system on a PC. In addition to phasor diagrams of the measured values, the numerical values as well as frequency and device addresses are indicated. Figure 2-106 shows an example.

Additionally the position of the differential and restraint values can be viewed in the tripping characteristic.

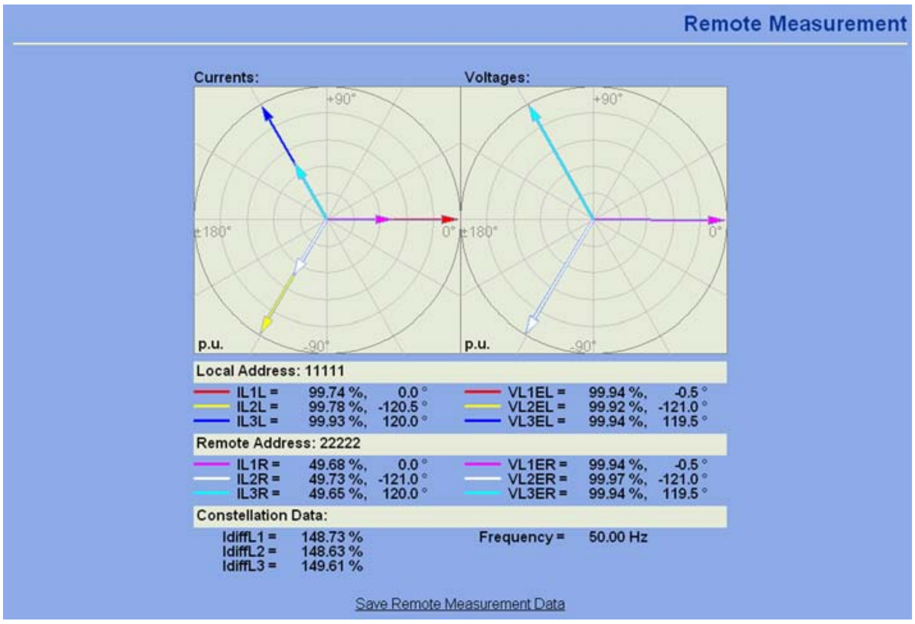
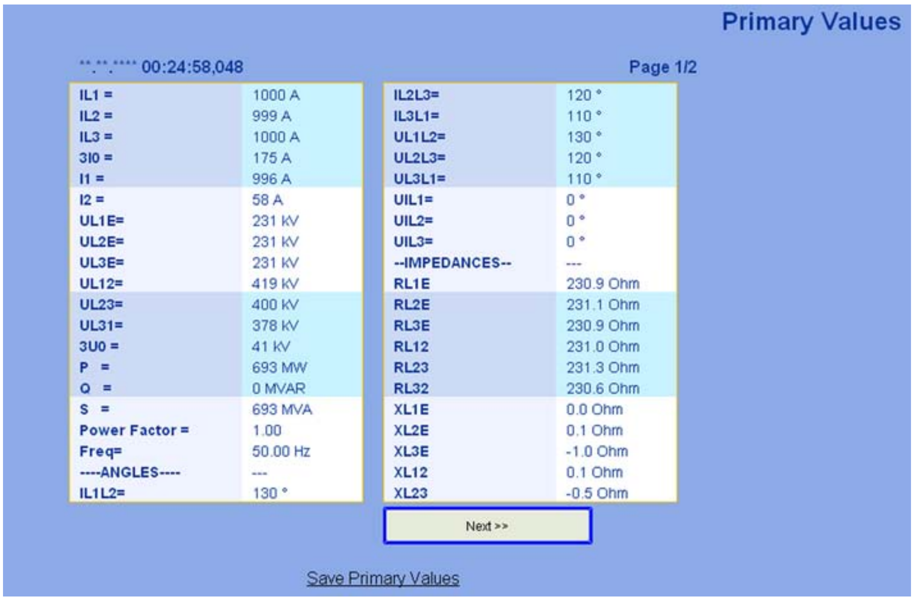


Figure 2-106 WEB-Monitor – Example of voltages and currents

Furthermore, the browser enables a clear display of the most important measured data. The measured values list can be selected from the navigation toolbar separately for the local and the remote device. In each case a list with the desired information is displayed (see Figures 2-106 and 2-108).


Primary Values

..**** 00:24:58,048 Page 1/2

IL1 =	1000 A	IL2L3=	120 °
IL2 =	999 A	IL3L1=	110 °
IL3 =	1000 A	UL1L2=	130 °
3I0 =	175 A	UL2L3=	120 °
I1 =	996 A	UL3L1=	110 °
I2 =	58 A	UIL1=	0 °
UL1E=	231 KV	UIL2=	0 °
UL2E=	231 KV	UIL3=	0 °
UL3E=	231 KV	--IMPEDANCES--	---
UL12=	419 KV	RL1E	230.9 Ohm
UL23=	400 KV	RL2E	231.1 Ohm
UL31=	378 KV	RL3E	230.9 Ohm
3U0 =	41 KV	RL12	231.0 Ohm
P =	693 MW	RL23	231.3 Ohm
Q =	0 MVAR	RL32	230.6 Ohm
S =	693 MVA	XL1E	0.0 Ohm
Power Factor =	1.00	XL2E	0.1 Ohm
Freq=	50.00 Hz	XL3E	-1.0 Ohm
----ANGLES----	---	XL12	0.1 Ohm
IL1L2=	130 °	XL23	-0.5 Ohm

Next >>

Save Primary Values

Figure 2-107 Local measured values in the WEB-Monitor — Examples for measured values

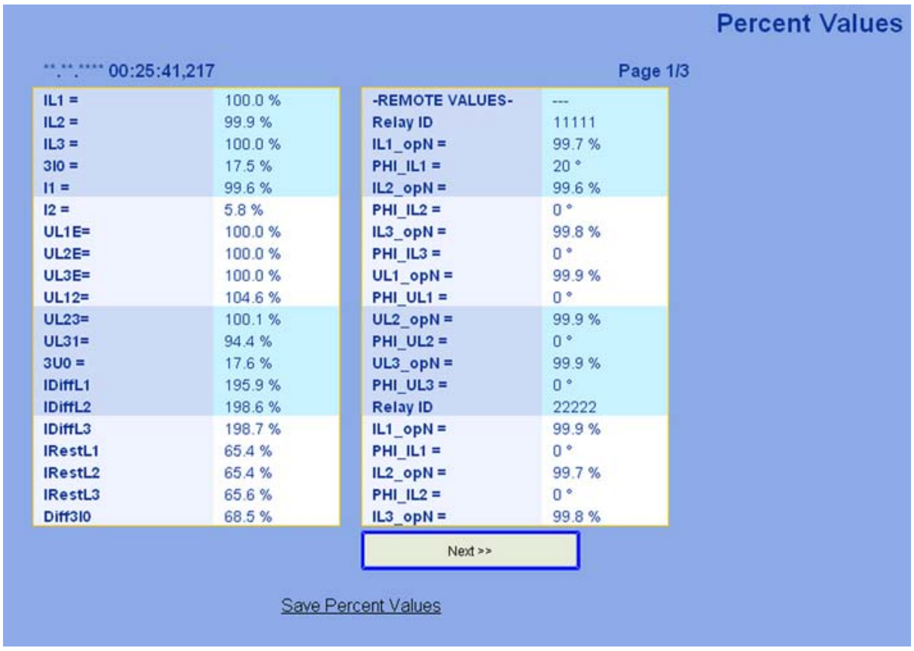


Figure 2-108 List of measured percentage values with given angle differences – Example

The following types of indications can be retrieved and displayed with the WEB-Monitor

- Operational indications (buffer: event log)
- Fault indications (buffer: trip log)
- Spontaneous Indications

You can print these lists with the „Print event buffer“ button.

2.17.1.2 Setting Notes

The parameters of the WEB-Monitor can be set separately for the front operator interface and the service interface. The relevant IP address of the interface is the one that is used for communication with the PC and the WEB-Monitor.

Make sure that the 12-digit IP address valid for the browser is set correctly via DIGSI in the format ***.***.***.***.

2.17.2 Processing of Messages

After the occurrence of a system fault, data regarding the response of the protective relay and the measured quantities should be saved for future analysis. For this reason message processing is done in three ways:

2.17.2.1 Function Description

Indicators and Binary Outputs (Output Relays)

Important events and states are displayed by LEDs on the front cover. The device also contains output relays for remote signaling. Most indications and displays can be configured differently from the delivery default settings (for information on the delivery default setting see Appendix). The SIPROTEC 4 System Description gives a detailed description of the configuration procedure.

The output relays and the LEDs may be operated in a latched or unlatched mode (each may be individually set).

The latched conditions are protected against loss of the auxiliary voltage. They are reset

- On site by pressing the LED key on the relay,
- Remotely using a binary input configured for that purpose,
- Using one of the serial interfaces,
- Automatically at the beginning of a new pickup.

Status messages should not be latched. Also, they cannot be reset until the criterion to be reported is remedied. This applies to, e.g., indications from monitoring functions, or the like.

A green LED displays operational readiness of the relay („RUN"); it cannot be reset. It extinguishes if the self-check feature of the microprocessor detects an abnormal occurrence, or if the auxiliary voltage fails.

When auxiliary voltage is present but the relay has an internal malfunction, the red LED („ERROR") lights up and the processor blocks the relay.

DIGSI enables you to selectively control each output relay and LED of the device and, in doing so, check the correct connection to the system. In a dialog box, you can, for instance, cause each output relay to pick up, and thus test the wiring between the 7SD610 and the system without having to create the indications masked to it.

Information on the Integrated Display (LCD) or to a Personal Computer

Events and conditions can be read out on the display on the front panel of the relay. Using the front operator interface or the rear service interface, for instance, a personal computer can be connected, to which the information can be sent.

In the quiescent state, i.e. as long as no system fault is present, the LCD can display selectable operational information (overview of the operational measured values) (default display). In the event of a system fault, information regarding the fault, the spontaneous displays, are displayed instead. After the fault indications have been acknowledged, the quiescent data are shown again. Acknowledgement can be performed by pressing the LED buttons on the front panel (see above).

Figure 2-109 shows the default display in a 4-line display as preset.

Various default displays can be selected via the arrow keys. Parameter 640 can be set to change the default setting for the default display page shown in idle state. Two examples of possible default display selections are given below.

1	345A	12	121kV
2	341A	23	118kV
3	346A	31	119kV
E	4.7A	U0	2kV

Example:

IL1	= 345 A	UL1-L2	= 121 kV
IL2	= 341 A	UL2-L3	= 118 kV
IL3	= 346 A	UL3-L1	= 119 kV
IE (3I0)	= 4.7 A	U0	= 2 kV

Figure 2-109 Operational measured values in the default display

Default display 3 shows the measured power values and the measured values U_{L1-L2} and I_{L2}.

```
S:  227MVA  U: 400kV
P:    71MW   I:  401A
Q:  268MVAR
f:50.00Hz cosφ: 0.25
```

Example:

S	= 227 MVA	UL1-L2	= 400 kV
P	= 71 MW	IL2	= 401 A
Q	= 268 MVAR		
f	= 50.00 Hz	cos φ	= 0.25

Figure 2-110 Operational measured values in the default display

Moreover, the device has several event buffers for operational indications, fault indications, switching statistics, etc., which are protected against loss of auxiliary supply by means of a backup battery. These indications can be displayed on the LCD at any time by selection using the keypad or transferred to a personal computer via the serial service or operator interface. Reading out indications during operation is described in detail in the SIPROTEC 4 System Description.

After a fault on the system, for example, important information about the progression of the fault can be retrieved, such as the pickup of a protective element or the initiation of a trip signal. The start of the fault is time stamped with the absolute time of the internal system clock. The progress of the fault is output with a relative time referred to the instant of fault detection, so that the duration of a fault until tripping and up to reset of the trip command can be ascertained. The resolution of the time information is 1 ms.

With a PC and the DIGSI protection data processing software it is also possible to retrieve and display the events with the convenience of visualisation on a monitor and a menu-guided dialog. The data may either be printed or stored for evaluation at a later time and place.

A system fault starts with the detection of the fault by the fault detection of any protection function and ends with the reset of the fault detection of the last protection function or after the expiry of the auto-reclose reclaim time, so that several unsuccessful reclose cycles are also stored cohesively. Accordingly a system fault may contain several individual fault events (from fault detection up to reset of fault detection).

Information to a Control Centre

If the device has a serial system interface, stored information may additionally be transferred via this interface to a centralized control and storage device. Several communication protocols are available for the transfer of this information.

You may test whether the indications are transmitted correctly with DIGSI.

Also the information transmitted to the control centre can be influenced during operation or tests. The IEC 60870-5-103 protocol allows to identify all indications and measured values transferred to the central control system with an added indication „test mode“ while the device is being tested on site (test mode). This identification prevents the indications from being incorrectly interpreted as resulting from an actual power system disturbance or event. Alternatively, you may disable the transmission of indications to the system interface during tests („Transmission Block“).

To influence information at the system interface during test mode („test mode“ and „transmission block“), a CFC logic is required. Default settings already include this logic (see Appendix).

The SIPROTEC 4 System Description describes in detail how to activate and deactivate test mode and blocked data transmission.

Classification of Indications

Indications are classified as follows:

- Operational indications: messages generated while the device is in operation: They include information about the status of device functions, measurement data, system data, and similar information.
- Fault indications: messages from the last eight system faults that were processed by the device..
- Indications on Statistics: they include counters for the switching actions of the circuit breakers initiated by the device, maybe reclose commands as well as values of interrupted currents and accumulated fault currents.

A complete list of all message and output functions that can be generated by the device, with the associated information number (no), can be found in the Appendix. There it is also indicated to which destination the indication can be reported. If functions are not present in the specific version of the , or if they are set to disable, then the associated indications cannot appear.

Operational Indications

Operational indications contain information that the device generates during operation and about operational conditions.

Up to 200 operational indications are stored in chronological order in the device. Newly generated indications are added to those already there. When the maximum capacity of the memory is exhausted, the oldest indication is lost.

Operational indications arrive automatically and can be read out from the device display or a personal computer at any time. Faults in the power system are indicated with „Network Fault“ and the present fault number. The fault indications contain detailed information on the behaviour of the system faults.

Trip Logs

Following a system fault, it is possible for example to 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 fault is output with a relative time referred to the instant of fault detection, so that the duration of a 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 a fault by the fault detection, i.e. first pickup of any protection function, and ends with the reset of the fault detection, i.e. dropout of the last protection function. Where a fault causes several protective functions to pick up, the fault is considered to include all that occurred between pickup of the first protective function and dropout of the last protective function.

If auto-reclosing occurs, then the network fault ends after the last reclosing shot, which means after a successful reclosing or lockout. Therefore the entire clearing process, including the reclosing shot (or all reclosing shots) occupies only one fault record. Within a network fault, several fault records can occur (from the first pickup of a protective function to the last dropout of a protective function). Without auto-reclosing each fault record represents a network fault.

Spontaneous annunciations

After a fault, automatically and without operator action, the most important fault data from the general device pickup appear on the display in the sequence shown in the following figure.

```
S/E/F PICKUP
PU - Time
TRIP Time
```

Protective Function that Tripped Last;
Operating Time from General Pickup to Dropout;
Operating Time from General Pickup to the First Trip Command;

Figure 2-111 Spontaneous fault indication display

Retrievable Indications

The indications of the last eight system faults can be retrieved and read out. A total of 600 indications can be stored. The oldest indications are erased for the newest fault indications when the buffer is full.

Spontaneous Indications

Spontaneous indications contain information that new indications have arrived. Each new incoming indication appears immediately, i.e. the user does not have to wait for an update or initiate one. This can be a useful help during operation, testing and commissioning.

Spontaneous indications can be read out via DIGSI. For more information see the SIPROTEC 4 System Description.

General Interrogation

The present condition of the SIPROTEC 4 device can be retrieved via DIGSI by viewing the contents of the General Interrogation. It shows all indications that are subject to general interrogation with their current value.

2.17.3 Statistics

Counting includes the number of trips initiated by 7SD610, the accumulated breaking currents resulting from trips initiated by protection functions, the number of close commands initiated by the auto-reclosure function.

2.17.3.1 Function Description

Counters and memories

The counters and memories of the statistics are saved by the device. Therefore, the information will not get lost in case the auxiliary voltage supply fails. The counters, however, can be reset to zero or to any value within the setting range.

Switching statistics can be viewed on the LCD of the device, or on a PC running DIGSI and connected to the operating or service interface.

A password is not required to read switching statistics; however, a password is required to change or delete the statistics. For more information see the SIPROTEC 4 System Description.

Number of trips

The number of trips initiated by the device 7SD610 is counted. If the device is capable of single-pole tripping, a separate counter for each circuit breaker pole is provided.

Number of automatic reclosing commands

If the device is equipped with the integrated automatic reclosure, the automatic close commands are also counted, separately for reclosure after single-pole tripping, after three-pole tripping as well as separately for the first reclosure cycle and other reclosure cycles.

Interrupted currents

Furthermore, for each trip command the interrupted current for each pole is acquired, output in the trip log and accumulated in a memory. The maximum interrupted current is stored as well. The indicated measured values are indicated in primary values.

Transmission Statistics

In 7SD610 the protection communication is registered in statistics. The 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 enables an evaluation of the transmission quality.

If GPS synchronization is configured, the transmission times for each direction and each protection data interface are regularly measured and indicated as long as GPS synchronization is intact.

2.17.3.2 Information List

No.	Information	Type of Information	Comments
1000	# TRIPs=	VI	Number of breaker TRIP commands
1001	TripNo L1=	VI	Number of breaker TRIP commands L1
1002	TripNo L2=	VI	Number of breaker TRIP commands L2
1003	TripNo L3=	VI	Number of breaker TRIP commands L3
1027	Σ IL1 =	VI	Accumulation of interrupted current L1
1028	Σ IL2 =	VI	Accumulation of interrupted current L2
1029	Σ IL3 =	VI	Accumulation of interrupted current L3
1030	Max IL1 =	VI	Max. fault current Phase L1
1031	Max IL2 =	VI	Max. fault current Phase L2
1032	Max IL3 =	VI	Max. fault current Phase L3
2895	AR #Close1./1p=	VI	No. of 1st AR-cycle CLOSE commands,1pole
2896	AR #Close1./3p=	VI	No. of 1st AR-cycle CLOSE commands,3pole
2897	AR #Close2./1p=	VI	No. of higher AR-cycle CLOSE commands,1p
2898	AR #Close2./3p=	VI	No. of higher AR-cycle CLOSE commands,3p
7751	PI1 TD	MV	Prot.Interface 1:Transmission delay
7753	PI1A/m	MV	Prot.Interface 1: Availability per min.
7754	PI1A/h	MV	Prot.Interface 1: Availability per hour
7875	PI1 TD R	MV	Prot.Interface 1:Transmission delay rec.
7876	PI1 TD S	MV	Prot.Interface 1:Transmission delay send

2.17.4 Measurement During Operation

2.17.4.1 Function Description

A series of measured values and the values derived from them are available for on-site retrieval or for data transfer.

A precondition for the correct display of primary and percentage values is the complete and correct entry of the nominal values of the instrument transformers and the power system as well as the transformation ratio of the current and voltage transformers in the earth paths.

Display of measured values

Operational measured values and metered values are determined in the background by the processor system. They can be called up on the front of the device, read out via the operator interface using a PC with DIGSI, or transferred to a control centre via the system interface.

Table 2-11 shows a survey of the measured values of the local device. Depending on the version ordered, the connection of the device, and the configured protection functions, only a part of the measured operating values listed in Table   is available.

Phase-to-earth voltages can only be measured if the phase-to-earth voltage inputs are connected. The displacement voltage $3U_0$ is e-n-voltage multiplied by $\sqrt{3}$ — if U_{en} is connected — or calculated from the phase-to-earth voltages $3U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. All three voltage inputs must be phase-earth connected for this.

Both devices connected via the protection interface form a joint frequency value (constellation frequency). This value is displayed as the operational measured value „Frequency“. It allows to display a frequency even in devices in which local frequency measurement is not possible. The constellation frequency is also used by the differential protection for synchronizing the measured values. Locally operating functions always use the locally measured frequency.

If the device is in „Log out device“ ON mode, in differential protection test mode or if there is no protection data interface connection, the locally measured frequency is displayed.

For the thermal overload protection, the calculated overtemperatures are indicated in relation to the trip overtemperature. Overload measured values can appear only if the overload protection was configured ***Enabled***.

The power and operating values upon delivery are set such that power in line direction is positive. Active components in line direction and inductive reactive components in line direction are also positive. The same applies for the power factor cosφ.

It is occasionally desired to define the power drawn from the line (e.g. as seen from the consumer) positively. Using parameter 1107 **P,Q sign** the signs for these components can be inverted.

The computation of the operational measured values is also executed during an existent system fault in intervals of approx. 0.5s.

Table 2-11 Operational measured values of the local device

Measured Values		Primary	Second-ary	% Referred to
I_{L1}; I_{L2}; I_{L3}	Phase currents	A	A	Nominal operational current 1)
$3I_0$	Earth current	A	A	Nominal operational current 1)
$\varphi(I_{L1}-I_{L2})$, $\varphi(I_{L2}-I_{L3})$, $\varphi(I_{L3}-I_{L1})$	Phase angle of the phase currents towards each other	°	–	–
I_1, I_2	component of the currents	A	A	Nominal operational current 1)
I_Y	Transformer starpoint current of the parallel line	A	A	Nominal operational current 1) 1)3)
U_{L1-L2}, U_{L2-L3}, U_{L3-L1}	Phase-to-phase voltages	kV	V	Nominal operational voltage 2)
U_{L1-E}, U_{L2-E}, U_{L3-E}	Phase-earth voltage	kV	V	Rated operational voltage / v3 2)
$3U_0$	Displacement Voltage	kV	V	Rated operational voltage / v3 2)
$\varphi(U_{L1}-U_{L2})$, $\varphi(U_{L2}-U_{L3})$, $\varphi(U_{L3}-U_{L1})$	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	Rated operational voltage / v3 2)
U_X, U_{EN}	Voltage at measuring input U_4	–	V	–
$U_{1compound}$	Positive sequence component of voltages at the remote end (if compounding is active in voltage protection)	kV	V	Operational rated voltage / $\sqrt{3}$ 2)
S, PA, Qt	Apparent, active and reactive power	VA, NW, MARK	–	$\sqrt{3}\cdot U_N\cdot I_N$ Nominal operational quantities 1)2)
cos f	Power factor	(abs)	(abs)	–
f	Frequency (constellation frequency)	Hz	Hz	Nominal Frequency
T_{L1}/T_{TRIP}, T_{L2}/T_{TRIP}, T_{L3}/T_{TRIP}	Thermal value of each phase, referred to the tripping value	%	–	Trip overtemperature
T/T_{TRIP}	Resulting thermal value, referred to the tripping value, calculated according to the set method	%	–	Trip overtemperature

1) according to address 1104
2) according to address 1103
3) considering factor 221 I4/Iph CT

2.17.4.2 Information List

No.	Information	Type of Information	Comments
601	IL1 =	MV	I L1
602	IL2 =	MV	I L2
603	IL3 =	MV	I L3
610	3I0 =	MV	3I0 (zero sequence)
612	IY =	MV	IY (star point of transformer)
619	I1 =	MV	I1 (positive sequence)
620	I2 =	MV	I2 (negative sequence)
621	UL1E=	MV	U L1-E
622	UL2E=	MV	U L2-E

No.	Information	Type of Information	Comments
623	UL3E=	MV	U L3-E
624	UL12=	MV	U L12
625	UL23=	MV	U L23
626	UL31=	MV	U L31
627	Uen =	MV	Uen
631	3U0 =	MV	3U0 (zero sequence)
633	Ux =	MV	Ux (separate VT)
634	U1 =	MV	U1 (positive sequence)
635	U2 =	MV	U2 (negative sequence)
641	P =	MV	P (active power)
642	Q =	MV	Q (reactive power)
643	PF =	MV	Power Factor
644	Freq=	MV	Frequency
645	S =	MV	S (apparent power)
679	U1co=	MV	U1co (positive sequence, compounding)
684	U0 =	MV	U0 (zero sequence)
801	Θ/Θtrip =	MV	Temperat. rise for warning and trip
802	Θ/ΘtripL1=	MV	Temperature rise for phase L1
803	Θ/ΘtripL2=	MV	Temperature rise for phase L2
804	Θ/ΘtripL3=	MV	Temperature rise for phase L3
7731	Φ IL1L2=	MV	PHI IL1L2 (local)
7732	Φ IL2L3=	MV	PHI IL2L3 (local)
7733	Φ IL3L1=	MV	PHI IL3L1 (local)
7734	Φ UL1L2=	MV	PHI UL1L2 (local)
7735	Φ UL2L3=	MV	PHI UL2L3 (local)
7736	Φ UL3L1=	MV	PHI UL3L1 (local)
7737	Φ UIL1=	MV	PHI UIL1 (local)
7738	Φ UIL2=	MV	PHI UIL2 (local)
7739	Φ UIL3=	MV	PHI UIL3 (local)

2.17.5 Differential Protection Values

2.17.5.1 Measured values of the differential protection

The differential and restraint current values of the differential protection which are listed in the following table can be called up at the front of the device, read out via the operating interface using a PC with DIGSI or transferred to a control centre via the system interface.

Table 2-12 Measured values of the differential protection

Measured Values		% Referred to
$IDiff_{L1}$, $IDiff_{L2}$, $IDiff_{L3}$	Calculated differential currents of the three phases	Nominal operational current [1)]
$IRest_{L1}$, $IRest_{L2}$, $IRest_{L3}$	Calculated restraining currents of the three phases	Nominal operational current [1)]
$IDiff_{3I0}$	Calculated differential current of the zero sequence system	Nominal operational current [1)]

[1)] for lines according to address (see section 2.1.4), for transformers calculated from address (see Section 2.1.4) $I_N = S_N/(v3 \cdot U_N)$

2.17.5.2 Information List

No.	Information	Type of Information	Comments
7742	IDiffL1=	MV	IDiffL1(% Operational nominal current)
7743	IDiffL2=	MV	IDiffL2(% Operational nominal current)
7744	IDiffL3=	MV	IDiffL3(% Operational nominal current)
7745	IRestL1=	MV	IRestL1(% Operational nominal current)
7746	IRestL2=	MV	IRestL2(% Operational nominal current)
7747	IRestL3=	MV	IRestL3(% Operational nominal current)
7748	Diff3I0=	MV	Diff3I0 (Differential current 3I0)
30654	IdiffREF=	MV	Idiff REF(% Operational nominal current)
30655	IrestREF=	MV	Irest REF(% Operational nominal current)

2.17.6 Remote Measured Values

2.17.6.1 Function Description

During communication, the data from the other end of the protected object can also be read out. For both devices, 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 and polarity at both line ends. Furthermore, the device addresse of the other device is transmitted so that all important data of both ends are available in a substation. All possible data are listed in Table 2-13.

Table 2-13 Operational measured values transmitted from the other ends and compared to the local values

Data		Primary value
Device ADDR	Device address of the remote device	(absolute)
I_{L1}, I_{L2}, I_{L3} remote	Phase currents of the remote device	A
I_{L1}, I_{L2}, I_{L3} local	Phase currents of the local device	A
$\varphi(I_{L1})$, $\varphi(I_{L2})$, $\varphi(I_{L3})$ remote	Phase angles between the remote and the local phase currents	°
U_{L1}, U_{L2}, U_{L3} remote	Voltages of the remote device	kV
U_{L1}, U_{L2}, U_{L3} local	Voltages of the local device	kV
$\varphi(U_{L1})$, $\varphi(U_{L2})$ $\varphi(U_{L3})$ remote	Phase angles between the remote and the local voltages	°

The information overviews below show you which information is available for each device.

2.17.7 Measured values constellation

2.17.7.1 Functional Description

The measured values constellation of both possible devices are showed here by evaluating the device (see table 2-14). Information on the second device is given in the Appendix.

The computation of this measured values constellation is also performed during an existing system fault at an interval of approx. 2 s.

Table 2-14 Measured values constellation for device 1

No.	Information	Type of Information	Description
7761	„Relay ID“	MW	Device address of the device
7762	„IL1_opN=“	MW	IL1 (% of operational rated current)
7763	„ΦI L1=“	MW	Angle IL1_remote <-> IL1_local
7764	„IL2_opN=“	MW	IL2 (% of operational rated current)
7765	„ΦI L2=“	MW	Angle IL2_remote <-> IL2_local
7766	„IL3_opN=“	MW	IL3 (% of operational rated current)
7767	„ΦI L3=“	MW	Angle IL3_remote <-> IL3_local
7769	„UL1_opN=“	MW	UL1 (% of operational rated voltage)
7770	„ΦU L1=“	MW	Angle UL1_remote <-> UL1_local
7771	„UL2_opN=“	MW	UL2 (% of operational rated voltage)
7772	„ΦU L2=“	MW	Angle UL2_remote <-> UL2_local
7773	„UL3_opN=“	MW	UL3 (% of operational rated voltage)
7774	„ΦU L3=“	MW	Angle UL3_remote <-> UL3_local

2.17.8 Oscillographic Fault Records

2.17.8.1 Function Description

The 7SD610 differential protection is equipped with a fault recording function. The instantaneous values of measured values

i_{L1}, i_{L2}, i_{L3}, 3_{i0}, u_{L1}, u_{L2}, u_{L3}, 3 u_0 or u_{en} or u_x as well asI_{diffL1}, I_{diffL2}, I_{diffL3}, I_{stabL1}, I_{stabL2}, I_{stabL3}

(voltages depending on the connection) are sampled at intervals of 1 ms (for 50 Hz) and stored in a circulating buffer (20 samples per cycle). For a fault, the data are stored for an adjustable period of time, but no more than 5 seconds per fault. A total of 8 faults can be saved during a total time of 15s. The fault record memory is automatically updated with every new fault, so that no acknowledgment is required. The storage of fault values can be started by pickup of a protective function, as well as via binary input and via the serial interface.

For the differential protection system of a protected object all fault records of all ends are synchronized by time management features. This ensures that all fault records operate with exactly the same time basis. Therefore equal measured values are coincident at all ends.

The data can be retrieved via the serial interfaces by means of a personal computer and evaluated with the operating software DIGSI and the graphic analysis software SIGRA 4. The latter graphically represents the data recorded during the system fault and calculates additional information such as the impedance or r.m.s. values from the measured values. A selection may be made as to whether the currents and voltages are represented as primary or secondary values. Binary signal traces (marks) of particular events, e.g. „fault detection“, „tripping“ are also represented.

If the device has a serial system interface, the fault recording data can be passed on to a central device via this interface. Data are evaluated by appropriate programs in the central device. Currents and voltages are referred to their maximum values, scaled to their rated values and prepared for graphic presentation. Binary signal traces (marks) of particular events e.g. „fault detection“, „tripping“ are also represented.

In the event of transfer to a central device, the request for data transfer can be executed automatically and can be selected to take place after each fault detection by the protection, or only after a trip.

2.17.8.2 Setting Notes

General

Other settings pertaining to fault recording (waveform capture) are found in the submenu **Oscillographic Fault Records** submenu of the **Settings** menu. Waveform capture makes a distinction between the trigger instant for an oscillographic record and the criterion to save the record (address 402 **WAVEFORMTRIGGER**). This parameter can only be altered using DIGSI at **Additional Settings**. Normally the trigger instant is the device pickup, i.e. the pickup of an arbitrary protective function is assigned the time. The criterion for saving may be both the device pickup (***Save w. Pickup***) or the device trip (***Save w. TRIP***). A trip command issued by the device can also be used as trigger instant (***Start w. TRIP***), in this case it is also the saving criterion.

An oscillographic fault record includes data recorded prior to the time of trigger, and data after the dropout of the recording criterion. Usually this is also the extent of a fault recording (address 403 **WAVEFORM DATA** = ***Fault event***). If automatic reclosure is implemented, the entire system disturbance — possibly with several reclose attempts — up to the ultimate fault clearance can be stored (address 403 **WAVEFORM DATA** = ***Pow.Sys.Flt.***). This facilitates the representation of the entire system fault history, but also consumes storage capacity during the auto reclosure dead time(s). This parameter can only be altered with DIGSI under **Additional Settings**.

The actual storage time begins at the pre-fault time **PRE. TRIG. TIME** (address 411) ahead of the reference instant, and ends at the post-fault time **POST REC. TIME** (address 412) after the storage criterion has reset. The maximum recording duration to each fault **MAX. LENGTH** is set at address 410.

The fault recording can also be triggered via a binary input, via the keypad on the front of the device or with a PC via the operation or service interface. The storage is then dynamically triggered. The length of the fault recording is set in address 415 **BinIn CAPT.TIME** (maximum length however is **MAX. LENGTH**, address 410). Pre-fault and post-fault times will be included. If the binary input time is set for ∞, then the length of the record equals the time that the binary input is activated (static), or the **MAX. LENGTH** setting in address 410, whichever is shorter.

2.17.8.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
402A	WAVEFORMTRIGGE R	Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403A	WAVEFORM DATA	Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
410	MAX. LENGTH	0.30 .. 5.00 sec	2.00 sec	Max. length of a Waveform Capture Record
411	PRE. TRIG. TIME	0.05 .. 0.50 sec	0.25 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input

2.17.8.4 Information List

No.	Information	Type of Information	Comments
-	FltRecSta	IntSP	Fault Recording Start
4	>Trig.Wave.Cap.	SP	>Trigger Waveform Capture
30053	Fault rec. run.	OUT	Fault recording is running

2.17.9 Energy

Metered values for active and reactive power are determined in the background by the processor system. They can be called up at the front of the device, read out via the operating interface using a PC with DIGSI, or transferred to a central master station via the system interface.

2.17.9.1 Energy Metering

7SD610 integrates the calculated power which is then made available with the measured values. The components as listed in table 2-15 can be read out. The signs of the operating values depend on the setting at address 1107 **P,Q sign** (see Section 2.17.4 under margin heading „Display of Measured Values“).

Please consider that 7SD610 is primarily a protection device. The accuracy of the metered values depends on the instrument transformers (normally protection core) and the device tolerances. The metering is therefore not suited for billing metering.

The counters can be reset to zero or any initial value (see also SIPROTEC 4 System Description).

Table 2-15 Operational metered values

Measured values		Primary
W_p+	Active power, output	kWh, MWh, GWh
W_p–	Active power, input	kWh, MWh, GWh
W_q+	Reactive power, output	kVARh, MVARh, GVARh
W_q–	Reactive power, input	kVARh, MVARh, GVARh

2.17.9.2 Setting Notes

Retrieving parameters

The SIPROTEC® System Description describes in detail how to read out the statistical counters via the device front panel or DIGSI. The values are added up in direction of the protected object, provided the direction was set as „forward“ (address 201).

2.17.9.3 Information List

No.	Information	Type of Information	Comments
-	Meter res	IntSP_Ev	Reset meter
888	Wp(puls)	PMV	Pulsed Energy Wp (active)
889	Wq(puls)	PMV	Pulsed Energy Wq (reactive)
916	WpΔ=	-	Increment of active energy
917	WqΔ=	-	Increment of reactive energy
924	Wp+=	MVMV	Wp Forward
925	Wq+=	MVMV	Wq Forward
928	Wp-=	MVMV	Wp Reverse
929	Wq-=	MVMV	Wq Reverse

2.18 Command Processing

The SIPROTEC 4 7SD610 includes a command editing for initiating switching operations in the system. Control can originate from four command sources:

- Local operation using the keypad on the local user interface of the device,
- Operation using DIGSI,
- Remote operation using a substation automation and control system (e.g. SICAM),
- Automatic functions (e.g. using binary inputs, CFC).

The number of switchgear devices that can be controlled is solely limited by the number of available and required binary inputs and outputs. For the output of control commands it has to be ensured that all the required binary inputs and outputs are configured and provided with the correct properties.

If specific interlocking conditions are needed for the execution of commands, the user can program the device with bay interlocking by means of the user-defined logic functions (CFC). The interlocking conditions of the system can be injected via the system interface and must be allocated accordingly.

The procedure for switching resources is described in the SIPROTEC 4 System Description under Control of Switchgear.

2.18.1 Control Authorization

2.18.1.1 Type of Commands

Commands to the Process

This type of commands are directly output to the switchgear to change their process state:

- Commands for the operation of circuit breakers as well as commands for the control of isolators and earthing disconnectors,
- Step commands, e.g. for raising and lowering transformer taps,
- Setpoint commands with configurable time settings, e.g. to control Petersen coils.

Device-internal Commands

These commands do not directly operate binary outputs. They serve for initiating internal functions, communicating the detection of status changes to the device or for acknowledging them.

- Manual override commands for „manual update“ of information on process-dependent objects such as annunciations and switching states, e.g. if the communication with the process is interrupted. Manually overidden objects are marked as such in the information status and can be displayed accordingly.
- Flagging commands (for „setting“) the data value of internal objects, e.g. switching authority (remote/local), parameter switchovers, transmission blockages and deletion and presetting of metered values.
- Acknowledgment and resetting commands for setting and resetting internal buffers or data stocks.
- Information status commands to set/delete the additional „Information Status“ item of a process object, such as
  - Acquisition blocking,
  - Output blocking.

2.18.1.2 Sequence in the Command Path

Safety mechanisms in the command sequence ensure that a 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.

Checking a Command Path

Please observe the following:

- Command entry, e.g. using the keypad on the local user interface of the device
  – Check password → access rights;
  – Check switching mode (interlocking activated/deactivated) → selection of deactivated interlocking status.
- User configurable interlocking checks:
  – Switching authority;
  – Device position check (set vs. actual comparison);
  – Zone controlled / bay interlocking (logic using CFC);
  – System interlocking (centrally via SICAM);
  – Double operation (interlocking against parallel switching operation);
  – Protection blocking (blocking of switching operations by protection functions);
- Fixed commands:
  – Internal process time (software watch dog which checks the time for processing the control action between initiation of the control and final close of the relay contact);
  – Configuration in process (if setting modification is in process, commands are rejected or delayed);
  – Equipment present as output;
  – Output block (if an output block has been programmed for the circuit breaker, and is active at the moment the command is processed, then the command is rejected);
  – Component hardware malfunction;
  – Command in progress (only one command can be processed at a time for each circuit breaker or switch);
  – 1–of–n check (for multiple allocations such as common contact relays or multiple protection commands configured to the same contact it is checked if a command procedure was already initiated for the output relays concerned or if a protection command is present. Superimposed commands in the same switching direction are tolerated).

Command Execution Monitoring

The following is monitored:

- Interruption of a command because of a cancel command,
- Running time monitor (feedback monitoring time).

2.18.1.3 Interlocking

Interlocking can be executed by the user-defined logic (CFC). Switchgear interlocking checks in a SICAM/SIPROTEC 4 system are normally divided in the following groups:

- System interlocking checked by a central control system (for interbay interlocking),
- Zone controlled / bay interlocking checked in the bay device (for the feeder).
- Cross-bay interlocking via GOOSE messages directly between bay controllers and protection relays (with rollout of IEC 61850; inter-relay communication by GOOSE is performed via the EN100 module)

System interlocking is based on the process image in the central device. Zone controlled / bay interlocking relies on the object database (feedback information) of the bay unit (here the SIPROTEC 4 relay) as was determined during configuration (see SIPROTEC 4 System Description).

The extent of the interlocking checks is determined by the configuration and interlocking logic of the relay. For more information on GOOSE, please refer to the SIPROTEC 4 System Description.

Switching objects that require system interlocking in a central control system are marked by a specific parameter inside the bay unit (via configuration matrix).

For all commands, operation with interlocking (normal mode) or without interlocking (test mode) can be selected:

- For local commands by reprogramming the settings with password check,
- For automatic commands, via command processing by CFC and Deactivated Interlocking Recognition,
- For local / remote commands, using an additional interlocking disable command via PROFIBUS.

Interlocked/non-interlocked Switching

The configurable command checks in the SIPROTEC 4 devices are also called „standard interlocking“. These checks can be activated via DIGSI (interlocked switching/tagging) or deactivated (non-interlocked).

De-interlocked or non-interlocked switching means that the configured interlock conditions are not tested.

Interlocked switching means that all configured interlocking conditions are checked within the command processing. If a condition could not be fulfilled, the command will be rejected by an indication with a minus added to it, e.g. „CO–“, followed by an operation response information. Table 2-16 shows the types of possible commands to switchgear, and the associated annunciations. The indications marked with *) are displayed only in the event logs on the device display; for DIGSI they appear in spontaneous indications.

Table 2-16 Command types and corresponding indications

Type of Command	Control	Cause	Indication
Control issued	Switching	CO	CO+/–
Manual tagging (positive / negative)	Manual tagging	MT	MT+/–
Information state command, Input blocking	Input blocking	ST	ST+/– *)
Information state command, Output blocking	Output blocking	ST	ST+/– *)
Cancel command	Cancel	CA	CA+/–

The plus sign indicated in the message is a confirmation of the command execution: The command output has a positive result, as expected. A minus sign means a negative, i.e. an unexpected result; the command was rejected. Figure 2-112 shows an example in the operational indications command and feedback of a positively run switching action 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 overriding or abort are not tested, i.e. are executed independently of the interlockings.

```
EVENT LOG
---------------------
19.06.01 11:52:05,625
Q0           CO+ Close

19.06.01 11:52:06,134
Q0           FB+ Close
```

Figure 2-112 Example of an operational indication for switching circuit breaker 52

Standard Interlocking

The standard interlocking includes the checks for each switchgear which were set during the configuration of inputs and outputs, see SIPROTEC 4 System Description.

An overview for processing the interlocking conditions in the relay is shown in Figure 2-113.

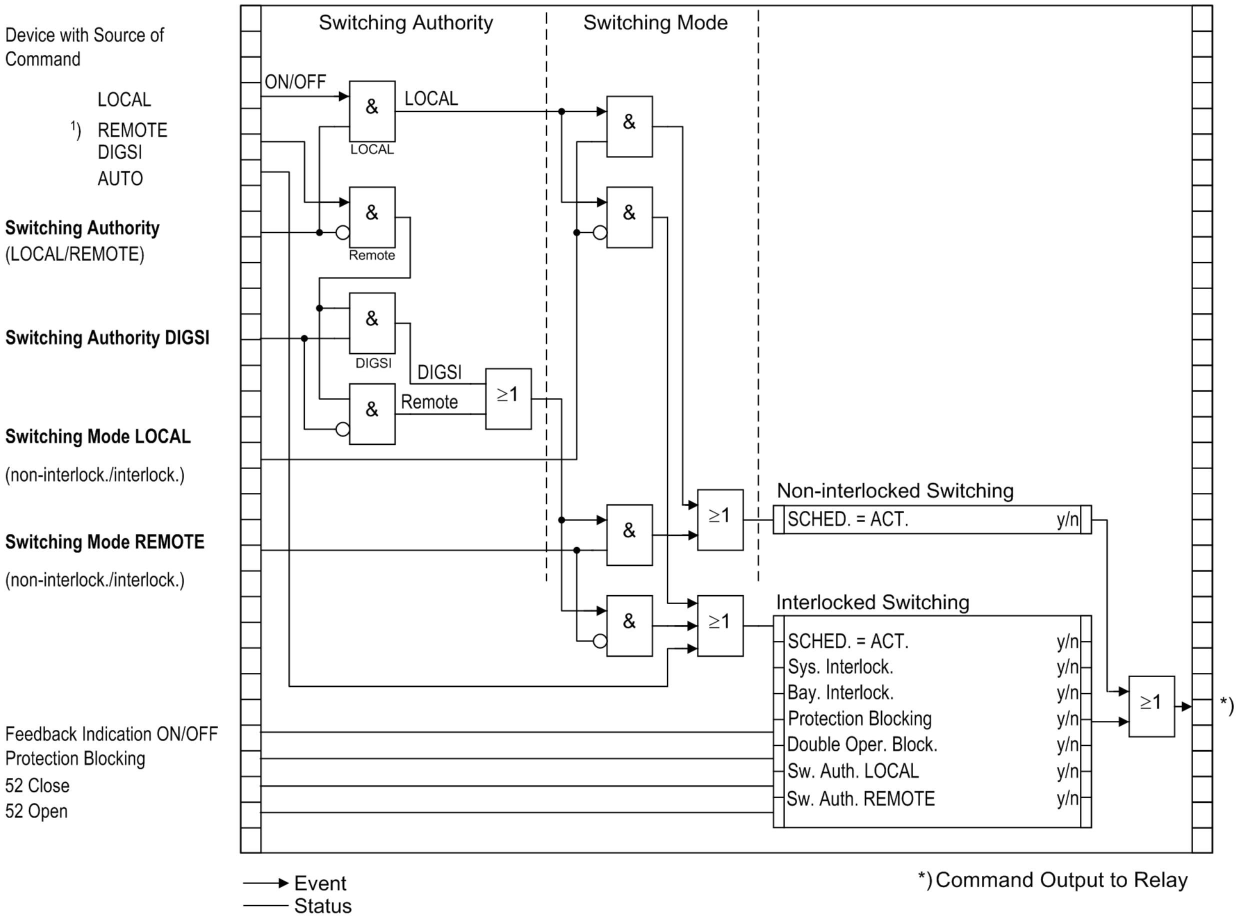


Figure 2-113 Standard interlockings

1) Source of Command REMOTE includes LOCAL.

LOCAL Command using substation controller

REMOTE Command via telecontrol station to power system management and from power system management to the device)

The display shows the configured interlocking reasons. The are marked by letters as explained in Table 2-17.

Table 2-17 Interlocking Commands

Interlocking Commands	Command	Display
Switching Authority	L	L
System Interlocking	S	S
Bay Interlocking	Z	Z
SET = ACTUAL (switch direction check)	P	P
Protection Blockage	B	B

Figure 2-114 shows all interlocking conditions (which usually appear in the display of the device) for three switchgear items with the relevant abbreviations explained in Table 2-17. All parameterised interlocking conditions are indicated.

```
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 2-114 Example of configured interlocking conditions

Control Logic via CFC

For the bay interlocking, an enabling logic can be structured using the CFC. Via specific release conditions the information „released“ or „bay interlocked“ are available, e.g. object „52 Close“ and „52 Open“ with the data values: ON/OFF).

2.18.1.4 Information List

No.	Information	Type of Information	Comments
-	ModeREMOTE	IntSP	Controlmode REMOTE
-	Cntrl Auth	IntSP	Control Authority
-	ModeLOCAL	IntSP	Controlmode LOCAL

2.18.2 Control Device

2.18.2.1 Information List

No.	Information	Type of Information	Comments
-	Breaker	CF_D12	Breaker
-	Breaker	DP	Breaker
-	Disc.Swit.	CF_D2	Disconnect Switch
-	Disc.Swit.	DP	Disconnect Switch
-	EarthSwit	CF_D2	Earth Switch
-	EarthSwit	DP	Earth Switch
-	Brk Open	IntSP	Interlocking: Breaker Open
-	Brk Close	IntSP	Interlocking: Breaker Close
-	Disc.Open	IntSP	Interlocking: Disconnect switch Open
-	Disc.Close	IntSP	Interlocking: Disconnect switch Close
-	E Sw Open	IntSP	Interlocking: Earth switch Open
-	E Sw Cl.	IntSP	Interlocking: Earth switch Close
-	Q2 Op/Cl	CF_D2	Q2 Open/Close
-	Q2 Op/Cl	DP	Q2 Open/Close
-	Q9 Op/Cl	CF_D2	Q9 Open/Close
-	Q9 Op/Cl	DP	Q9 Open/Close
-	Fan ON/OFF	CF_D2	Fan ON/OFF
-	Fan ON/OFF	DP	Fan ON/OFF
31000	Q0 OpCnt=	VI	Q0 operationcounter=
31001	Q1 OpCnt=	VI	Q1 operationcounter=
31002	Q2 OpCnt=	VI	Q2 operationcounter=

No.	Information	Type of Information	Comments
31008	Q8 OpCnt=	VI	Q8 operationcounter=
31009	Q9 OpCnt=	VI	Q9 operationcounter=

2.18.3 Process Data

During the processing of commands, independently of the further allocation and processing of indications, command and process feedbacks are sent to the indication processing. These indications contain information on the cause. With the corresponding allocation (configuration) these indications are entered in the event log, thus serving as a report.

A listing of possible operational indications and their meaning, as well as the command types needed for tripping and closing the switchgear or for raising and lowering transformer taps and detailed information are described in the SIPROTEC 4 System Description.

2.18.3.1 Method of Operation

Acknowledgement of Commands to the Device Front

All indications with the source of command LOCAL are transformed into a corresponding response and shown in the display of the device.

Acknowledgement of commands to local/remote/DIGSI

The acknowledgement of indications which relate to commands with the origin “Command Issued = Local/ Remote/DIGSI” are sent back to the initiating point independent of the routing (configuration on the serial digital interface).

The acknowledgement of commands is therefore not executed by a response indication as it is done with the local command but by ordinary command and feedback information recording.

Feedback monitoring

Command processing time monitors all commands with feedback. Parallel to the command, a monitoring time period (command runtime monitoring) is started which checks whether the switchgear has achieved the desired final state within this period. The monitoring time is stopped as soon as the feedback information arrives. If no feedback information arrives, a response „`Time Limit Expired`“ appears and the process is terminated.

Commands and their feedbacks are also recorded as operational indications. Normally the execution of a command is terminated as soon as the feedback information (**FB+**) of the relevant switchgear arrives or, in case of commands without process feedback information, the command output resets.

In the feedback, the plus sign means that a command has been positively completed. The command was as expected, in other words positive. The "minus" is a negative confirmation and means that the command was not executed as expected.

Command output/switching relays

The command types needed for tripping and closing of the switchgear or for raising and lowering transformer taps have been defined during the configuration, see also SIPROTEC 4 System Description.

2.18.3.2 Information List

No.	Information	Type of Information	Comments
-	>Door open	SP	>Cabinet door open
-	>CB wait	SP	>CB waiting for Spring charged
-	>Err Mot U	SP	>Error Motor Voltage
-	>ErrCntrlU	SP	>Error Control Voltage
-	>SF6-Loss	SP	>SF6-Loss
-	>Err Meter	SP	>Error Meter
-	>Tx Temp.	SP	>Transformer Temperature
-	>Tx Danger	SP	>Transformer Danger

2.18.4 Protocol

2.18.4.1 Information List

No.	Information	Type of Information	Comments
-	SysIntErr.	IntSP	Error Systeminterface

■

Mounting and Commissioning 3

This chapter is primarily intended for experienced commissioning engineers. The commissioning engineer must be familiar with the commissioning of protection and control systems, with the management of power systems and with the relevant safety rules and guidelines. Under certain circumstances adaptations of the hardware to the particular power system data may be necessary. The primary tests require the protected object (line, transformer etc.) to carry load.

3.1 Mounting and Connections

General

WARNING!

Warning of improper transport, storage, installation, and application of the device.

Non-observance can result in death, personal injury or substantial property damage.

Trouble free and safe use of this device depends on proper transport, storage, installation, and application of the device according to the warnings in this instruction manual.

Of particular importance are the general installation and safety regulations for work in a high-voltage environment (for example, VDE, IEC, EN, DIN, or other national and international regulations). These regulations must be observed.

3.1.1 Configuration Information

Prerequisites

For installation and connections the following conditions must be met:

The rated device data has been tested as recommended in the SIPROTEC 4 System Description and their compliance with the Power System Data is verified.

Connection Variants

General Diagrams are shown in Appendix A.2. Connection examples for current transformer and voltage transformer circuits are provided in Appendix A.3. It must be checked that the setting of the **P.System Data 1**, Section 2.1.2.1 2.1.2.1, was made in accordance to the device connections.

Currents

In Appendix A.3 examples for the possibilities of the current transformer connections in dependence on network conditions are displayed.

For normal connection, address 220 **I4 transformer** = ***In prot. line*** must be set and furthermore, address 221 **I4/Iph CT** = ***1.000***.

When using separate earth current transformers, address 220 **I4 transformer** = ***In prot. line*** must be set. The settings value of the address 221 **I4/Iph CT** may deviated from ***1***. For information on the calculation, please refer to section 2.1.2.1.

Voltages

This Section is only relevant if the measured voltages are connected to the device, a condition which was already set during the configuration (address 144 **V-TRANSFORMER**, see Section 2.1.1.2).

Connection examples for current and voltage transformer circuits are provided in Appendix A.3.

For the normal connection the 4th voltage measuring input is not used; correspondingly the address must be set to 210 **U4 transformer** = ***Not connected***.

For an additional connection of an e-n-winding of a set of voltage transformers, the address 210 **U4 transformer** = ***Udelta transf.*** must be set. The setting value of the address 211 **Uph / Udelta** depends on the transformation ratio of the e–n-winding. For additional hints, please refer to Section 2.1.2.1 under “Transformation Ratio“.

Binary Inputs and Outputs

The connections to the power plant depend on the possible allocation of the binary inputs and outputs, i.e. how they are assigned to the power equipment. The preset allocation can be found in the tables in Section A.4 of the Appendix. Check also whether the labelling corresponds to the allocated indication functions.

It is also very important that the feedback components (auxiliary contacts) of the circuit breaker monitored are connected to the correct binary inputs which are assigned for this purpose.

Changing Setting Group

If binary inputs are used to change setting groups, please observe the following:

- To enable the control of 4 possible setting groups 2 binary inputs have to be available. One binary input must be set for „>Set Group Bit0“, the other input for „>Set Group Bit1“.
- To control two setting groups, one binary input set for „>Set Group Bit0“ is sufficient since the binary input „>Set Group Bit1“, which is not assigned, is considered to be not controlled.
- The status of the signals controlling the binary inputs to activate a particular setting group must remain constant as long as that particular group is to remain active.

The following Table shows the relationship between binary inputs and the setting groups A to D. Principal connection diagrams for the two binary inputs are illustrated in the following Figure 3-1. The Figure illustrates an example in which both Set Group Bits 0 and 1 are configured to be controlled (actuated) when the associated binary input is energized (high).

Table 3-1 Changing setting groups with binary inputs

Binary Input		Active settings group
>Set Group Bit 0	**>Set Group Bit 1**	
Not energized	Not energized	Group A
Energized	Not energized	Group B
Not energized	Energized	Group C
Energized	Energized	Group D

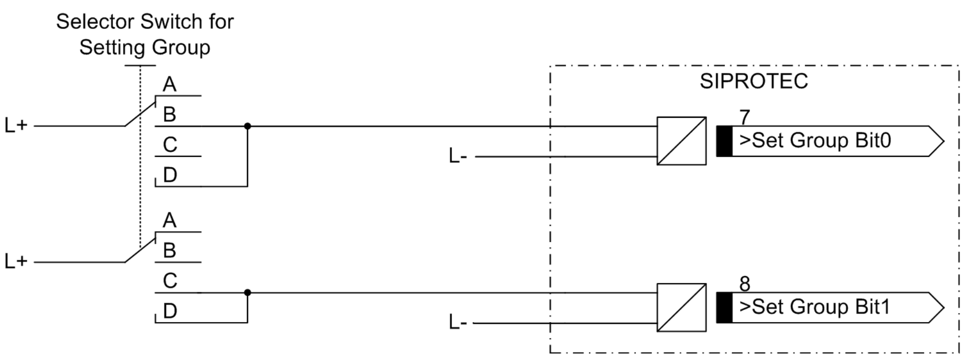


Figure 3-1 Connection diagram (example) for setting group switching with binary inputs

Trip Circuit Monitoring

It must be noted that two binary inputs or one binary input and one substitute resistor R must be connected in series. The pickup threshold of the binary inputs must therefore be substantially below half the rated control DC voltage.

If two binary inputs are used for the trip circuit supervision, these binary inputs must be isolated, i.o.w. not be communed with each other or with another binary input.

If one binary input is used, a bypass resistor R must be used (refer to Figure 2-92). The resistor R is inserted into the circuit of the second circuit breaker auxiliary contact (Aux2), to facilitate the detection of a malfunction also when the first circuit breaker auxiliary contact (Aux1) is open and the trip contact has dropped out. 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.

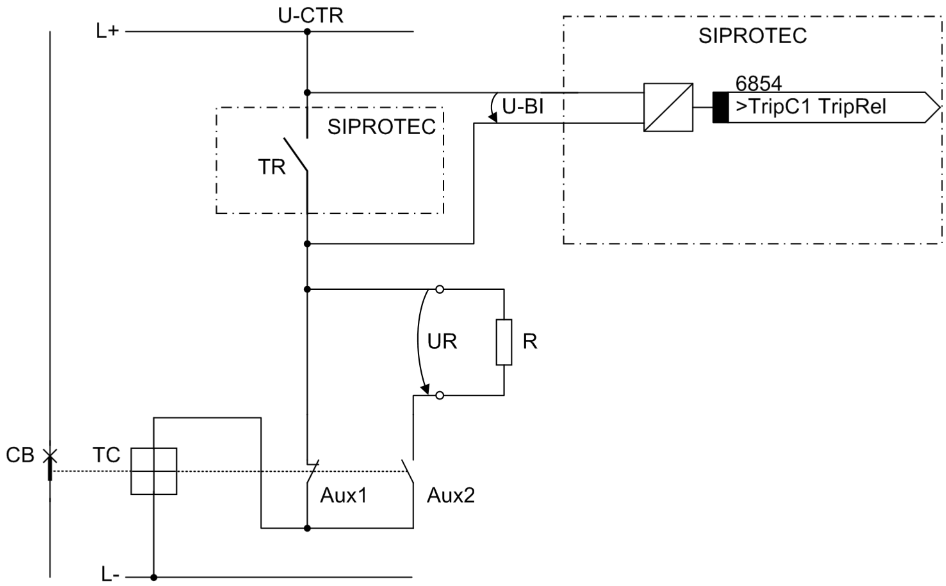


Figure 3-2 Principle of the trip circuit supervision with one binary input

TR	Trip relay contact
CB	Circuit breaker
TC	Circuit breaker trip coil
Aux1	Circuit breaker auxiliary contact (NC contact)
Aux2	Circuit breaker auxiliary contact (NO contact)
U-CTR	Control voltage for trip circuit
U-BI	Input voltage of binary input
R	Equivalent resistor
UR	Voltage across the equivalent resistor

This results in an upper limit for the resistance dimension, R_{max}, and a lower limit R_{min}, from which the optimal value of the arithmetic mean R should be selected:

$$R = \frac{R_{max} + R_{min}}{2}$$

In order that the minimum voltage for controlling the binary input is ensured, R_{max} is derived as:

$$R_{max} = \left(\frac{U_{CTR} - U_{BI\ min}}{I_{BI\ (High)}}\right) - R_{TC}$$

To keep the circuit breaker trip coil not energized in the above case, R_{min} is derived as:

$$R_{min} = R_{TC} \cdot \left(\frac{U_{CTR} - U_{TC\ (LOW)}}{U_{TC\ (LOW)}}\right)$$

$I_{BI\ (HIGH)}$	Constant current with activated BI (= 1.8 mA)
$U_{BI\ min}$	Minimum control voltage for BI 17 V for delivery setting for nominal voltages of 24/48/60 V; 73 V for delivery setting for nominal voltages of 110/125/220/250 V; 154 V for delivery setting for nominal voltages of 220/250 V
U_{CTR}	Control voltage for trip circuit
R_{TC}	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 jumpers (see Section „Hardware Modifications“).

For the power consumption of the resistance the following applies:

$$P_R = I^2 \cdot R = \left(\frac{U_{CTR}}{R + R_{CBTC}}\right)^2 \cdot R$$

Example:

$I_{BI\ (HIGH)}$	1.8 mA (SIPROTEC 4 7SD610)
$U_{BI\ min}$	17 V for delivery setting for nominal voltages of 24/48/60 V (from the device 7SD610); 73 V for delivery setting for nominal voltages110/125/220/250 V (from the device 7SD610); 154 V for delivery setting for nominal voltages 220/250 V (from the device 7SD610)
U_{ST}	110 V (system / trip circuit)
R_{CBTC}	500 Ω (system / trip circuit)
$U_{CBTC\ (LOW)}$	2 V (system / trip circuit)

$$R_{max} = \left(\frac{110\ V - 17\ V}{1.8\ mA}\right) - 500\ \Omega = 51.17\ \Omega$$

$$R_{min} = 500\ \Omega \cdot \left(\frac{110\ V - 2\ V}{2\ V}\right) = 27\ k\Omega$$

$$R = \frac{R_{max} + R_{min}}{2} = 39.1\ k\Omega$$

The closest standard value of 39 kΩ is selected; the power is:

$$P_R = \left(\frac{110\ V}{39\ k\Omega + 0.5\ k\Omega}\right)^2 \cdot 39\ k\Omega \geq 0.3\ W$$

3.1.2 Hardware Modifications

3.1.2.1 General

A subsequent adaptation of hardware to the power system conditions can be necessary for example with regard to the control voltage for binary inputs or termination of bus-capable interfaces. Follow the procedure described in this section, whenever hardware modifications are carried out.

Auxiliary Voltage

There are different ranges of input voltage for the auxiliary voltage (refer to the Ordering Information in Appendix A.1). The power supplies of the variants for 60/110/125 VDC and 110/125/220/250 VDC, 115 VAC are largely interchangeable by modifying the position of the jumpers. The assignment of these jumpers to the nominal voltage ranges and their spatial arrangement on the PCB are described further below at „Processor Board C-CPU-2“ Location and ratings of the miniature fuse and the buffer battery are also shown. When the device is delivered, these jumpers are set according to the name-plate sticker. Generally, they do not need to be altered.

Live Contact

The life contact of the device is a changeover contact from which either the NC contact or the NO contact can be connected to the device terminals via a plug-in jumper (X40). Assignments of the jumpers to the contact type and the spatial layout of the jumpers are described in the following Section at margin heading „Processor Board C-CPU-2“.

Rated Currents

The input transformers of the device are set to a nominal current of 1 A or 5 A with jumpers. The jumpers are factory set according to the name-plate sticker. The assignment of the jumpers to the nominal current and the spatial arrangement of the jumpers are described in the following section under the margin heading „Input/Output Board C-I/O-11“. All jumpers must be set for one nominal current, i.e. one jumper (X61 to X64) for each input transformer and additionally the common jumper X60.

Note

If nominal current ratings are changed exceptionally, then the new ratings must be registered in address 206 **CT SECONDARY** in the power system data (see Section 2.1.2.1).

Control Voltage for Binary Inputs

When the device is delivered the binary inputs are set to operate with a voltage that corresponds to the nominal voltage of the power supply. If the nominal values differ from the power system control voltage, it may be necessary to change the switching threshold of the binary inputs.

To change the switching threshold of a binary input, a jumper must be reallocated in each case. The physical arrangement of the binary input jumpers in relation to the pickup voltages is explained in the sections below under margin headings „Processor Board C-CPU-2“ and „Input/Output Board C-I/O-11“.

Note

If binary inputs are used for trip circuit supervision, note that two binary inputs (or a binary input and a substitute resistor) are connected in series. The switching threshold must lie clearly below half of the nominal control voltage.

Replacing Interfaces

The serial interfaces can be exchanged in the versions for panel flush mounting and cubicle mounting. The following section under margin heading „Rreplacing Interface Modules“ describes which interfaces can be exchanged, and how this is done.

Terminating interfaces with bus capability

If the device is equipped with a serial RS485 port, the RS485 bus must be terminated with resistors at the last device on the bus to ensure reliable data transmission. For this purpose terminating resistors are provided on the PCB of the C-CPU-2 processor modules and on the interface module which can be connected via jumpers. The spatial arrangement of the jumpers on the PCB of the processor module C-CPU-2 is described in the following sections under „Processor module C-CPU-2“ and on the interface modules under „RS485 interface“ and „Profibus/DNP-/MODBUS interface“. Both jumpers must always have the same setting.

The termination resistors are disabled on delivery.

Spare Parts

Spare parts can be the battery for storage of data in the battery-buffered RAM in case of a power failure, and the internal power supply miniature fuse. Their spatial arrangement is shown in the figure of the processor board. The ratings of the fuse are printed on the board next to the fuse itself. When replacing the fuse, please observe the guidelines given in the SIPROTEC 4 System Description in the chapter „Maintenance“ and „Corrective Maintenance“.

3.1.2.2 Disassembly

Work on the Printed Circuit Boards

Note

It is assumed for the following steps that the device is not operative.

Caution!

Caution when changing jumper settings that affect nominal values of the device:

As a consequence, the ordering number (MLFB) and the ratings on the name plate no longer match the actual device properties.

Where such changes are necessary in exceptional cases, they MUST be marked clearly and visibly on the device. Self-adhesive stickers are available that can be used as supplementary name plate.

To perform work on the printed circuit boards, such as checking or moving switching elements or exchanging modules, proceed as follows:

- Prepare your workplace: prepare a suitable underlay for electrostatically sensitive devices (ESD). Also the following tools are required:
  – screwdriver with a 5 to 6 mm wide tip,
  – a crosstip screwdriver for Pz size 1,
  – a 5 mm socket wrench.
- Unfasten the screw-posts of the D-subminiature connectors on the back panel at location „A“ and „C“. This activity does not apply if the device is for surface mounting.
- If the device features additional interfaces besides those at location „A“ and „C“, the screws located diagonally to the interfaces must be removed. This activity does not apply if the device is for surface mounting.
- Remove the covers on the front panel and loosen the screws which can then be accessed.
- Carefully take off the front cover.

Work on the Plug Connectors

Caution!

Mind electrostatic discharges:

Non-observance can result in minor personal injury or property damage.

In order to avoid electrotrastic discharges when handling with plug connectors first touch an earthed metal surface .

Do not plug or unplug interface connectors under voltage!

The order of the boards is shown in Figure 3-3.

- Release the connector of the ribbon cable between processor module C-CPU-2 and front cover at the front cover itself. To do this, spread the latches on the upper and lower end of the plug connector to release the plug connector of the ribbon cable.
- Disconnect the ribbon cables between the processor board C-CPU-2 (No. 1 in Figure 3-3) and the input/output board I/O-11 (No. 2 in Figure 3-3).
- Remove the boards and set them on the grounded mat to protect them from ESD damage. In the case of the device variant for panel surface mounting, please be aware of the fact that a certain amount of force is required in order to remove the C-CPU-2 module due to the existing plug connectors.
- Check the jumpers according to Figures 3-4 to 3-10 and the following information. Change or remove the jumpers if necessary.

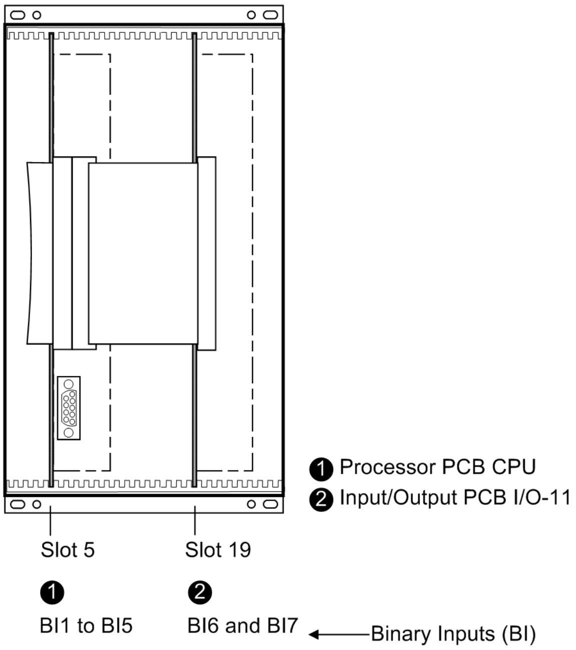


Figure 3-3 Front view after removal of the front cover (simplified and with minimized zoom)

3.1.2.3 Switching Elements on Printed Circuit Boards

C-CPU-2 processor board

The layout of the printed circuit board for the processor board C-CPU-2 is illustrated in the following figure. The set nominal voltage of the integrated supply is checked according to Table 3-2, the quiescent state of the life contact according to Table 3-3 and the selected control voltages of the binary inputs BI1 to BI5 according to Table 3-4 and the integrated interface RS232 / RS485 according to Table 3-5 to 3-7. The location and ratings of the miniature fuse (F1) and the buffer battery (G1) are shown in the following figure.

Before checking the integrated RS232/RS485 interface it may be necessary to remove the interface modules placed above.

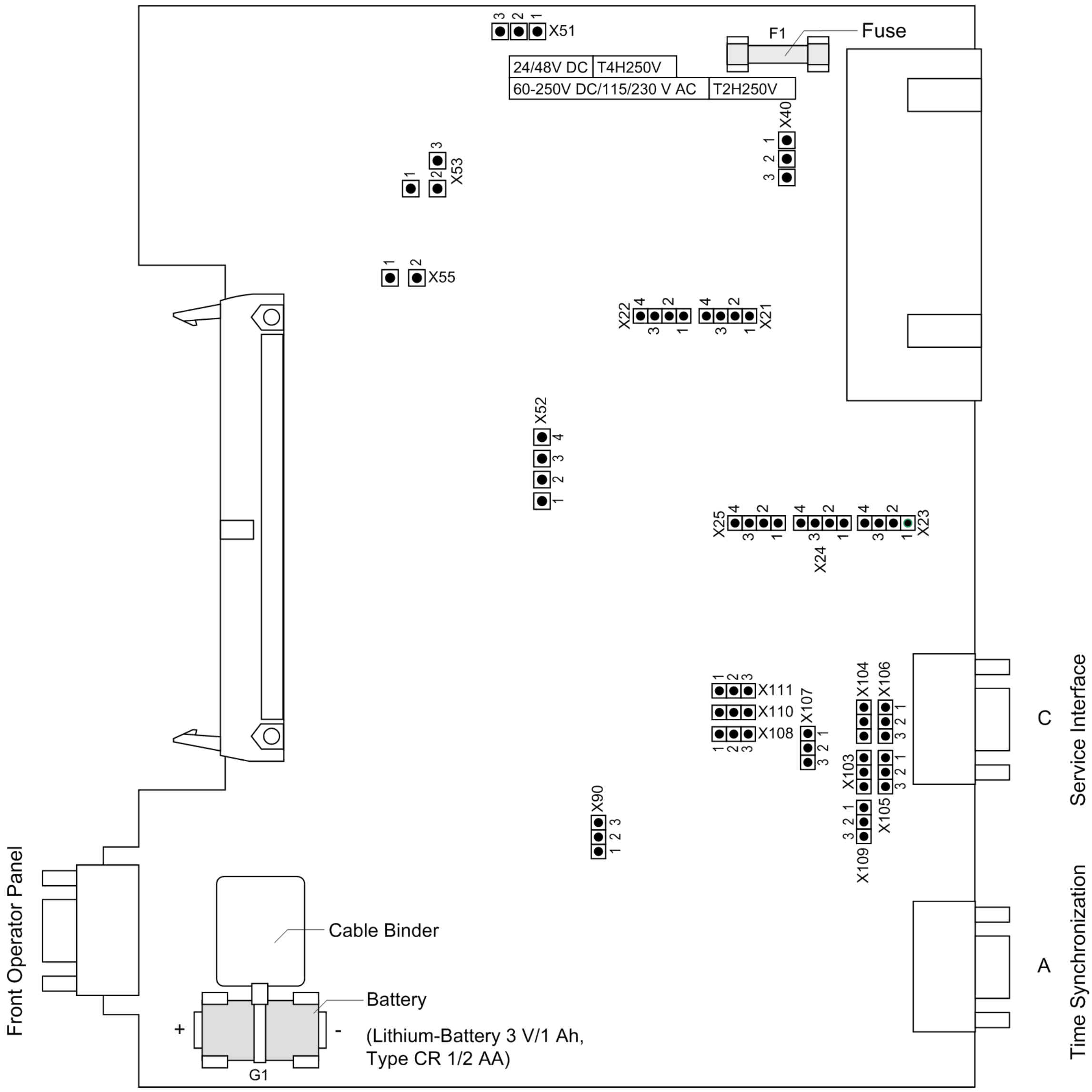


Figure 3-4 Processor printed circuit board C-CPU-2 with jumpers settings required for the board configuration

Table 3-2 Jumper setting of the rated voltage of the integrated **Power Supply** on the C-CPU-2 processor board

Jumper	Nominal voltage		
	24 to 48 VDC	**60 to 125 VDC**	**110 to 250 VDC, 115/230 VAC**
X51	Not used	1-2	2-3
X52	Not used	1-2 and 3-4	2-3
X53	Not used	1-2	2-3
X55	Not used	Not used	1-2
Fuse	T4H250V	T2H250V	

Table 3-3 Jumper setting of the quiescent state of the **Life Contact** on the processor board C-CPU-2

Jumper	Open in the quiescent state	Closed in the quiescent state	Presetting
X40	1-2	2-3	2-3

Table 3-4 Jumper setting of the **Control Voltages** of the binary inputs BI1 to BI5 on the C-CPU-2 processor board

Binary Inputs	Jumper	17 V Threshold [1)]	73 V Threshold [2)]	154 V Threshold [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)] Use only with control voltages 220 or 250 VDC and 250 VAC

By repositioning jumpers the interface RS485 can be modified into a RS232 interface and vice versa.

Jumpers X105 to X110 must be set to the same position.

Table 3-5 Jumper settings of the integrated **RS232/RS485 Interface** on the C-CPU-2 processor board

Jumper	RS232	RS485
X103 and X104	1-2	1-2
X105 to X110	1-2	2-3

The jumpers are preset at the factory according to the configuration ordered.

With interface RS232 jumper X111 is needed to activate CTS which enables the communication with the modem.

Table 3-6 Jumper setting for **CTS** (**C**lear **T**o **S**end, flow control) on the C-CPU-2 processor board

Jumper	/CTS from Interface RS232	/CTS Controlled by /RTS
X111	1-2	2-3

Jumper setting 2-3: The connection to the modem is usually established with a star coupler or fibre-optic converter. Therefore the modem control signals according to RS232 standard DIN 66020 are not available. Modem signals are not required since the connection to the SIPROTEC 4 devices is always operated in the half-duplex mode. Please use the connection cable with order number 7XV5100-4.

Jumper setting 1-2: This setting makes the modem signals available, i. e. for a direct RS232-connection between the SIPROTEC 4 device and the modem this setting can be selected optionally. We recommend to use a standard RS232 modem connection cable (converter 9-pin to 25-pin).

Note

For a direct connection to DIGSI with interface RS232 jumper X111 must be plugged in position 2-3.

If there are no external terminating resistors in the system, the last devices on a RS485 bus must be configured via jumpers X103 and X104.

Table 3-7 Jumper settings of the **Terminating Resistors** of the RS485 interface on the C-CPU-2 processor board

Jumper	Terminating resistor closed	Terminating resistor open	Presetting
X103	2-3	1-2	1-2
X104	2-3	1-2	1-2

Note: Both jumpers must always be plugged in the same way!

Jumper X90 has no function. The factory setting is 1-2.

Terminating resistors can also be connected externally (e.g. to the terminal block). In this case, the terminating resistors located on the RS485 or PROFIBUS interface module or directly on the PCB of the processor board C-CPU-2 must be de-energized.

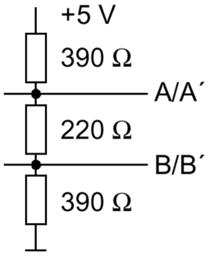


Figure 3-5 Termination of the RS485 interface (external)

Input/Output Board C-I/O-11

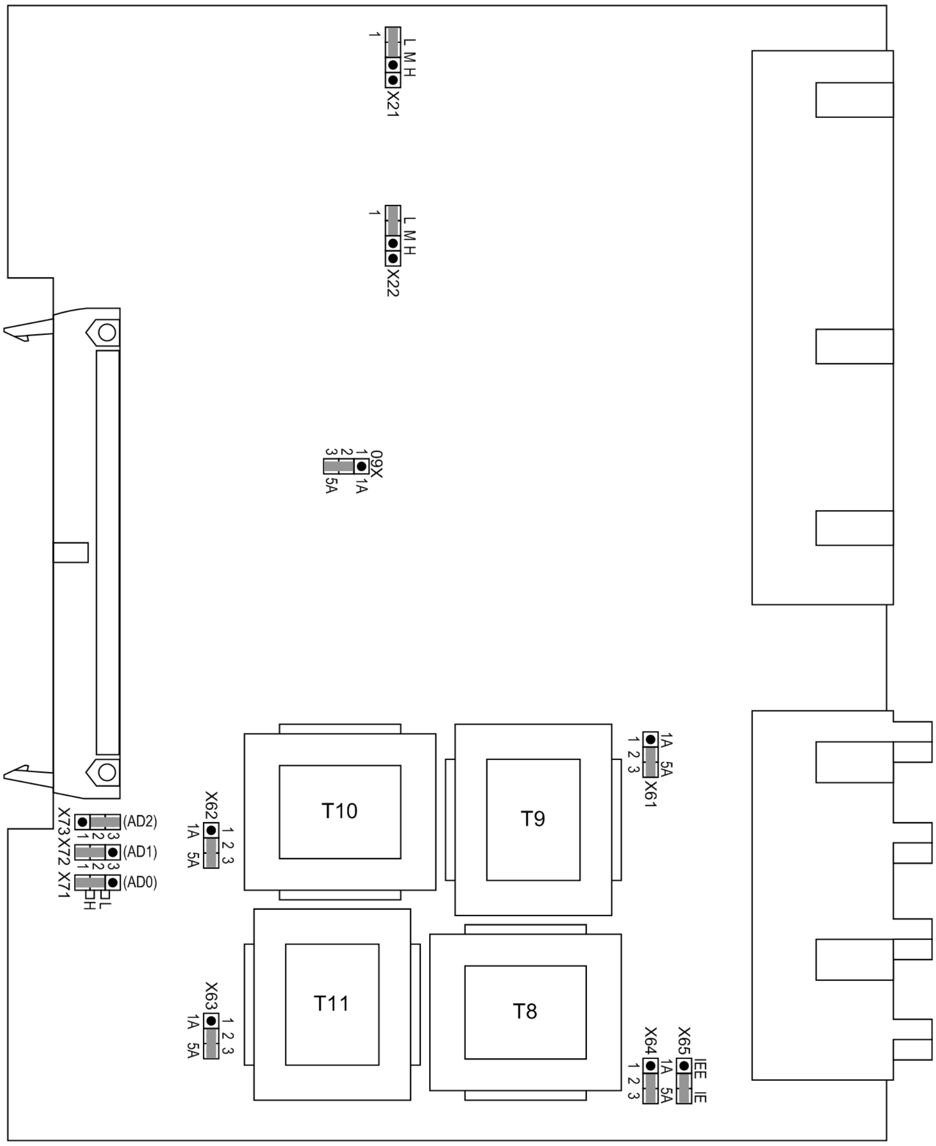


Figure 3-6 C-I/O-11 input/output board with representation of jumper settings required for checking configuration settings

Table 3-8 Jumper settings for **Control Voltages** of the binary inputs BI6 and BI7 on the input/output board C-I/O-11

Binary input	Jumper	17 V Threshold 1)	73 V Threshold 2)	154 V Threshold 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
3) Use only with control voltages 220 to 250 VDC and 250 VAC

The set nominal current of the current input transformers are checked on the input/output board C-I/O-11. The jumpers X60 to X64 must all be set to the same rated current, i.e. one jumper (X61 to X64) for each input transformer of the phase currents and in addition the common jumper X60.

Jumper X64 is plugged in position „IE“.

Jumpers X71, X72 and X73 on the input/output board C-I/O-11 are used for setting the bus address and must not be changed. The following Table lists the jumper presettings.

Table 3-9 Jumper settings of **Bus Address** of the input/output board C-I/O-11

Jumper	Presetting
X71	1-2(H)
X72	1-2 (H)
X73	2-3 (L)

Slot of input/output board C-I/O-11: No. 2 in Figure 3-3.

3.1.2.4 Interface Modules

Exchanging Interface Modules

The interface modules are located on the processor board C-CPU-2 (No. 1 in Figure 3-3).

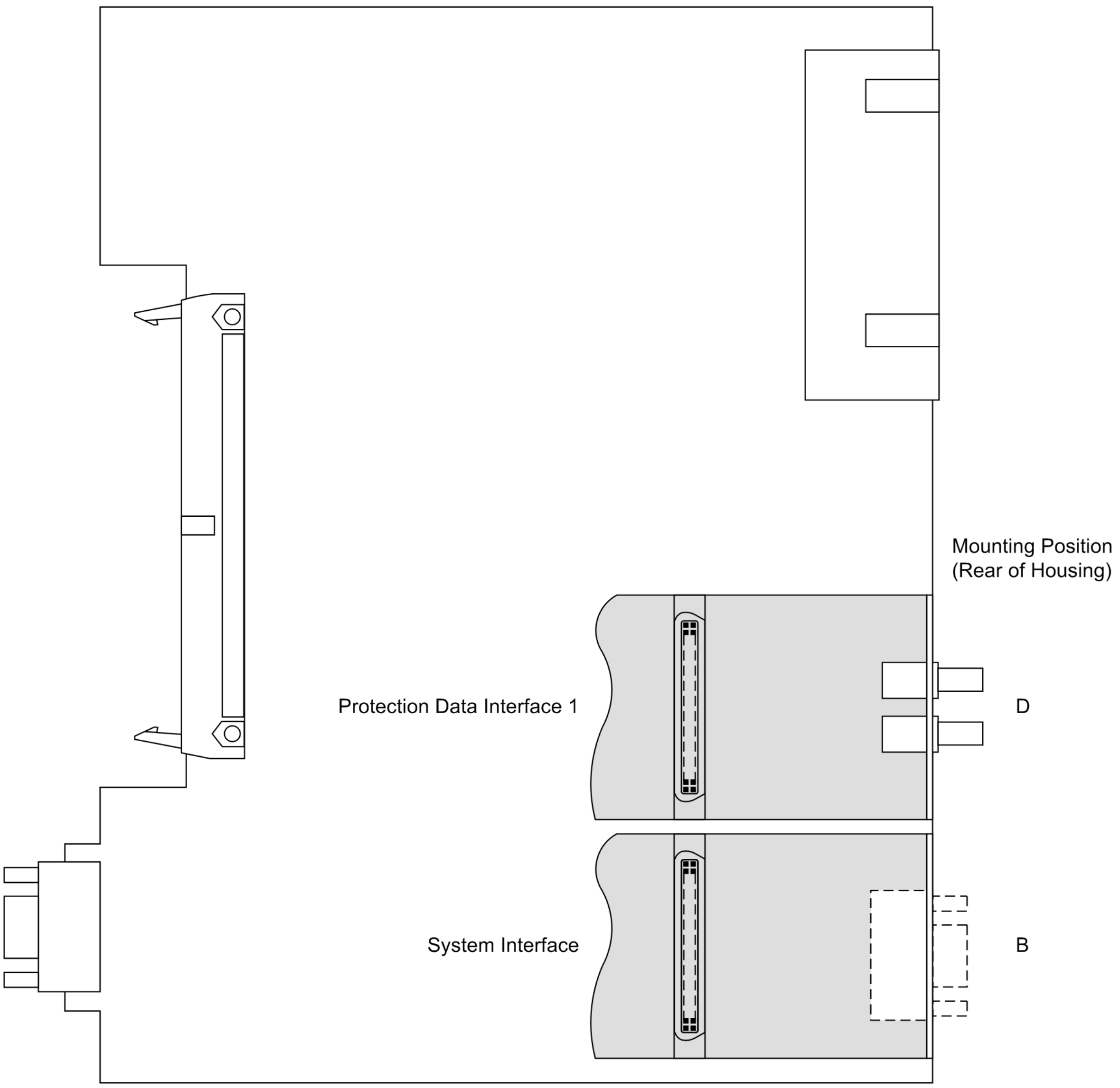


Figure 3-7 C-CPU-2 board with interface modules

Please observe the following:

- The interface modules can only be exchanged in devices in flush-mounted housing. Interface modules for devices with surface mounting housing must be retrofitted in our manufacturing centre.
- Use only interface modules that can be ordered ex-factory via the ordering code (see also Appendix, Section A.1).
- You may have to ensure the termination of the interfaces featuring bus capability according to the margin heading „RS485 Interface“.

Table 3-10 Replacement modules for interfaces

Interface	Mounting location / port	Exchange Module
System interface	B	Only interface modules that can be ordered in our facilities via the order key (see Appendix, Section A.1).
Service Interface	C	RS232
		RS485
Protection Data Interface	D	FO5, FO6; FO17 to FO19

The ordering numbers of the exchange modules are listed in Appendix A.1.

RS232 Interface

Interface RS232 can be modified to interface RS485 and vice versa (see Figures 3-8 and 3-9).

Figure 3-7 shows the C-CPU-2 PCB with the layout of the modules.

The following figure shows the location of the jumpers of interface RS232 on the interface module.

Surface-mounted devices with fibre optics connection have their fibre optics module fitted in the console housing on the case bottom. The fibre optics module is controlled via an RS232 interface module at the associated CPU interface slot. For this application type the jumpers X12 and X13 on the RS232 module are plugged in position 2-3.

Jumper	Terminating Resistors Disconnected
X3	1-2 *)
X4	1-2 *)

*) Default Setting

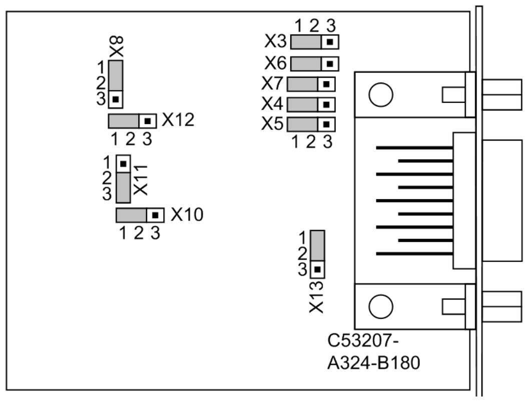


Figure 3-8 Location of the jumpers for configuration of RS232

Terminating resistors are not required for RS232. They are disconnected.

Jumper X11 is used to activate the flow control which is important for the modem communication.

Table 3-11 Jumper setting for **CTS** (**C**lear **T**o **S**end, flow control) on the interface module

Jumper	/CTS from Interface RS232	/CTS controlled by /RTS
X11	1-2	2-3 [1)]

[1)] Default Setting

Jumper setting 2-3: The connection to the modem is usually established with a star coupler or fibre-optic converter. Therefore the modem control signals according to RS232 standard DIN 66020 are not available. Modem signals are not required since the connection to the SIPROTEC 4 devices is always operated in the half-duplex mode. Please use the connection cable with order number 7XV5100-4.

Jumper setting 1-2: This setting makes the modem signals available, i. e. for a direct RS232-connection between the SIPROTEC 4 device and the modem this setting can be selected optionally. We recommend to use a standard RS232 modem connection cable (converter 9-pin to 25-pin).

Note

For a direct connection to DIGSI with interface RS232 jumper X11 must be plugged in position 2-3.

RS485 Interface

The following figure shows the location of the jumpers of interface RS485 on the interface module.

Interface RS485 can be modified to interface RS232 and vice versa, according to Figure 3-8.

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	2-3	1-2 *)
X4	2-3	1-2 *)

*) Default Setting

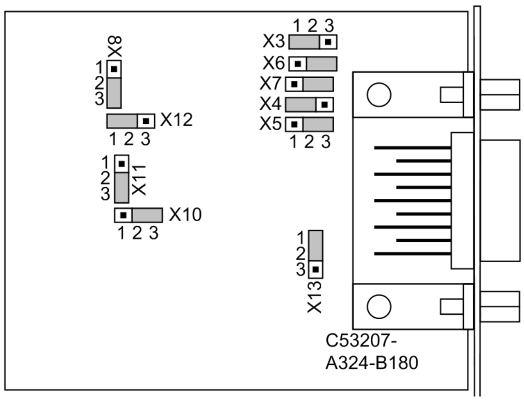


Figure 3-9 Position of terminating resistors and the plug-in jumpers for configuration of the RS485 interface

Profibus/DNP/MODBUS Interface

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	1-2	2-3 *)
X4	1-2	2-3 *)

*) Default Setting

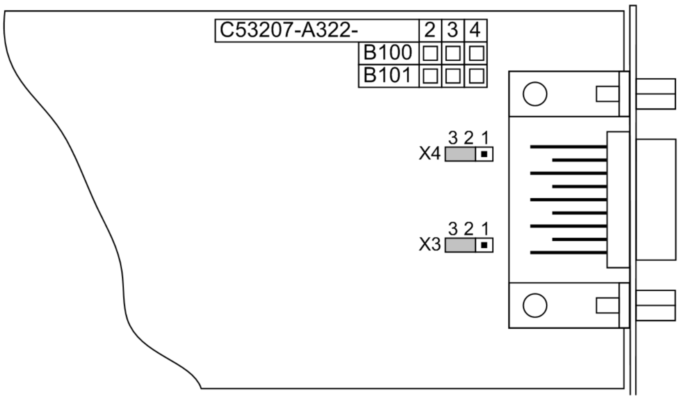


Figure 3-10 Location of the jumpers for configuring the terminating resistors (PROFIBUS, DNP and MODBUS interface)

EN100 Ethernet Module (IEC 61850)

The Ethernet interface module has no jumpers. No hardware modifications are required to use it.

Termination

Bus-capable interfaces always require a termination at the last device on the bus, i.e. terminating resistors must be connected. On the 7SD610 device, this concerns the variants with RS485 or PROFIBUS7/DNP/MODBUS interfaces.

The terminating resistors are located on the interface module which is on the processor module C-CPU-2 (no.1 in Figure 3-3) or directly on the PCB of the processor module C-CPU-2 (see Section „Processor module C-CPU-2“, Table 3-7).

The interface modules are displayed in Figure 3-9 and in Figure3-10.

For the configuration of the terminating resistors both jumpers have to be plugged in the same way.

On delivery the jumpers are set so that the terminating resistors are disconnected.

The terminating resistors can also be implemented outside the device (e.g. at the terminal block), see Figure 3-11. In this case, the terminating resistors located on the interface module or directly on the PCB of the processor board C-CPU-2 must be disconnected.

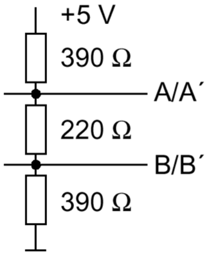


Figure 3-11 Termination of the RS485 Interface (External)

3.1.2.5 Reassembly

The assembly of the device is done in the following steps:

- Insert the modules carefully in the housing. The mounting locations are shown in figure 3-3. For the model of the device designed for surface mounting, use the metal lever to insert the C-CPU-2 board. The installation is easier with the lever.
- First insert the plug connectors of the ribbon cable on the input/output boards C-I/O–11 and then on the processor board C-CPU-2. Do not bend any connector pins! Don´t use force!
- Connect the plug connectors of the ribbon cable between the processor board C-CPU-2 and the front panel to the front panel plug connector.
- Press plug connector interlocks together.
- Put on the front cover and screw it onto the housing.
- Put the covers back on.
- Re-fasten the interfaces on the rear of the device housing. This activity is not necessary if the device is designed for surface mounting.

3.1.3 Mounting

3.1.3.1 Panel Flush Mounting

For 7SD610 (Picture 3-12) 4 covers and 4 holes exist.

- Remove the 4 covers at the corners of the front cover. Thus, 4 elongated holes are revealed in the mounting bracket and can be accessed.
- Insert the device into the control panel section and tighten it with 4 screws. For dimensions refer to Section 4.17.
- Replace the 4 covers.
- Connect the earth on the rear plate of the device to the protective earth of the panel. Use at least one M4 screw for the device earth. The cross-sectional area of the earth wire must be equal to the cross-sectional area of any other control conductor connected to the device. The cross-section of the earth wire must be at least 2.5 mm ^{2}.
- Connections are realized via the plug terminals or screw terminals on the rear side of the device according to the circuit diagram.

  For screw connections with forked lugs or direct connection, before inserting wires the screws must be tightened so that the screw heads are flush with the outer edge of the connection block.

  A ring lug must be centred in the connection chamber, in such a way that the screw thread fits in the hole of the lug.

  The SIPROTEC 4 System Description has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.

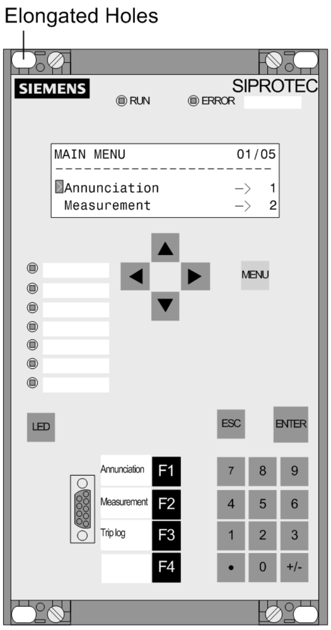


Figure 3-12 Example of panel flush mounting of a device (housing size $^1/_3$)

3.1.3.2 Rack and Cubicle Mounting

To install the device in a rack or cubicle, a pair of mounting rails; one for top, one for bottom are required. The ordering codes are stated in Appendix, Section A.1

For 7SD610 (Picture 3-13) 4 covers and 4 holes exist.

- Screw on loosely the two angle brackets in the rack or cabinet, each with four screws.
- Remove the 4 covers at the corners of the front cover. Thus, 4 elongated holes are revealed in the mounting bracket and can be accessed.
- Fasten the device to the a pair of mounting rails; one for top, one for bottom with 4 screws.
- Replace the 4 covers.
- Tighten fast the eight screws of the angle brackets in the rack or cabinet.
- Screw down a robust low-ohmic protective earth or station earth to the rear of the device using at least an M4 screw. The cross-sectional area of the earth wire must be equal to the cross-sectional area of any other conductor connected to the device. The cross-section of the earth wire must be at least 2.5 mm^2.
- Connections use the plug terminals or screw terminals on the rear side of the device in accordance the wiring diagram.

  For screw connections with forked lugs or direct connection, before inserting wires the screws must be tightened so that the screw heads are flush with the outer edge of the connection block.

  A ring lug must be centred in the connection chamber so that the screw thread fits in the hole of the lug.

  The SIPROTEC 4 System Description has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.

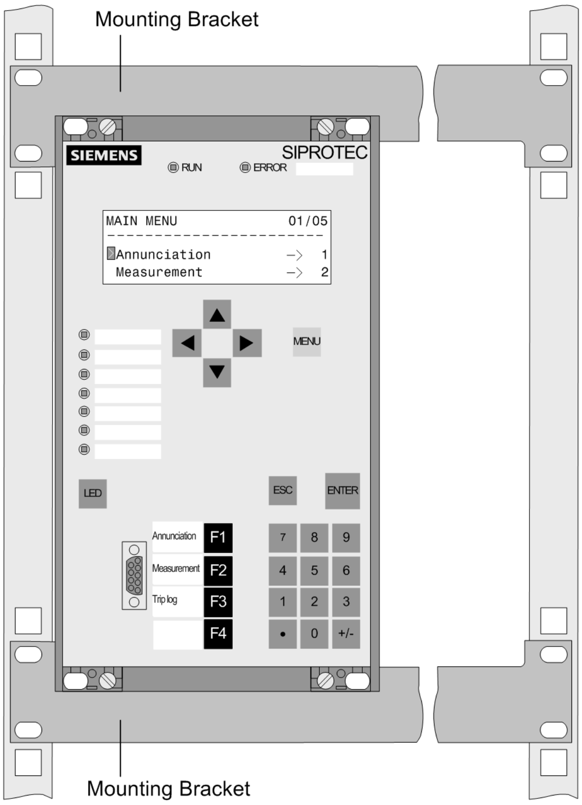


Figure 3-13 Example of rack or cubicle mounting of a device (housing size $^1/_3$)

3.1.3.3 Panel Mounting

For mounting proceed as follows:

- Secure the device to the panel with four screws. For dimensions see the Technical Data in Section 4.17.
- Connect the low-resistance operational and protective earth to the ground terminal of the device. The cross-sectional area of the ground wire must be equal to the cross-sectional area of any other control conductor connected to the device. It must thus be at least 2.5 mm^2.
- Alternatively, there is the possibility to connect the aforementioned earthing to the lateral grounding surface with at least one M4 screw.
- Connections according to the circuit diagram via screw terminals, connections for optical fibres and electrical communication modules via the console housing. The SIPROTEC 4 System Description has pertinent information regarding wire size, lugs, bending radii, etc. Installation notes are also given in the brief reference booklet attached to the device.

3.2 Checking Connections

3.2.1 Checking Data Connections of Serial Interfaces

The tables of the following margin headings list the pin assignments for the different serial interfaces, the time synchronization interface and the Ethernet interface of the device. The position of the connections can be seen in the following figures.

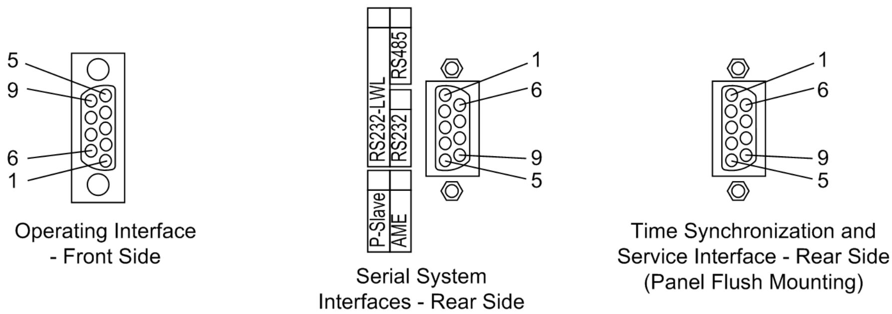


Figure 3-14 9-pin D-subminiature female connectors

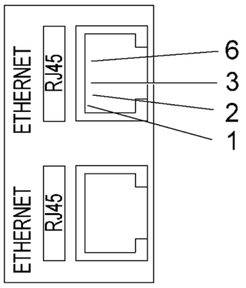


Figure 3-15 Ethernet connector

Operator Interface

When the recommended communication cable is used, correct connection between the SIPROTEC 4 device and the PC is automatically ensured. See the Appendix A.1 for an ordering description of the cable.

Service interface

Check the data connection if the service interface (Interface C) for communicating with the device is via fix wiring or a modem.

System interface

For versions equipped with a serial interface to a control center, the user must check the data connection. The visual check of the assignment of the transmission and reception channels is of particular importance. With RS232 and fibre optic interfaces, each connection is dedicated to one transmission direction. Therefore the output of one device must be connected to the input of the other device and vice versa.

With data cables, the connections are designated according to DIN 66020 and ISO 2110:

- TxD = Data Transmit
- RxD = Data Receive

- $\overline{\text{RTS}}$ = Request to Send
- $\overline{\text{CTS}}$ = Clear to Send
- GND = Signal / Chassis Ground

The cable shield is to be earthed at **both** line ends. For extremely EMC-prone environments, the earth may be connected via a separate individually shielded wire pair to improve immunity to interference.

Table 3-12 The assignments of the D-subminiature and RJ45 connector for the various interfaces

Pin No.	Operating Interface	RS232	RS485	PROFIBUS DP Slave, RS485	DNP3.0/MOD-BUS, RS485	Ethernet EN100
1	Shield (with shield ends electrically connected)					Tx+
2	RxD	RxD	-	-	-	Tx-
3	TxD	TxD	A/A’ (RxD/TxD-N)	B/B’ (RxD/TxD-P)	A	Rx+
4	-	-	-	CNTRA-(TTL)	RTS (TTL level)	-
5	GND	GND	C/C’ (GND)	C/C’ (GND)	GND1	-
6	-	-	-	+5 V (max. load < 100 mA)	VCC1	Rx-
7	$\overline{\text{RTS}}$	$\overline{\text{RTS}}$	- [1)]	-	-	-
8	$\overline{\text{CTS}}$	$\overline{\text{CTS}}$	B/B’ (RxD/TxD-P)	A/A’ (RxD/TxD-N)	B	-
9	-	-	-	-	-	Disabled

[1)] Pin 7 may also carry the RS232 RTS signal on an RS485 interface. Pin 7 must therefore not be connected!

RS485 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' (GND). It is necessary to check that the terminating resistors are connected to the bus only at the last unit, and not at other devices on the bus. The jumpers for the terminating resistors are on the interface module (see Figure3-8 or Figure 3-9) or directly on the C-CPU-2 (see Figure 3-4 and Table 3-7). Terminating resistors can also be implemented outside the device (e.g. in the plug connectors) as shown in Figure 3-5. In this case, the terminating resistors located on the module must be disabled.

If the bus is extended, make sure again that only terminating resistors at the last device to the bus are switched in.

Time Synchronisation Interface

It is optionally possible to process 5 V, 12 V or 24 V time synchronization signals, provided that these are connected to the inputs named in the following table.

Table 3-13 D-subminiature connector assignment of the time synchronization interface

Pin No.	Designation	Signal significance
1	P24_TSIG	Input 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return line
4	M_TSYNC [1)]	Return line [1)]
5	SCREEN	Screen potential
6	-	-
7	P12_TSIG	Input 12 V
8	P_TSYNC [1)]	Input 24 V [1)]
9	SCREEN	Screen potential

[1)] only for PPS signal (GPS)

Optical Fibres

WARNING!

Do not look directly into the fibre-optic elements, not even with optical devices! Laser class 1 according to EN 60825-1.

For the protection data communication, refer to the following section.

The transmission via fiber optics is particularly insensitive to electromagnetic interference and thus ensures galvanic isolation of the connection. Transmit and receive connections are shown with the symbols ▪⟶ for transmit and ⟶• for receive.

The character idle state for the optical fibre interface is „Light off". If the character idle state is to be changed, use the operating program DIGSI, as described in the SIPROTEC 4 System Description.

3.2.2 Checking the Protection Data Communication

The protection data communication is conducted either directly from device to device via optical fibres or via communication converters and a communication network or a dedicated transmission medium.

Optical Fibres, Directly

WARNING!

Warning of Laser rays

Do not look directly into the fibre-optic elements, not even with optical devices! Laser class 1 according to EN 60825-1.

The direct optical fibre connection is visually inspected by means of an optical fibre connector. There is one connection for each direction. The data output of one device must be connected to the data input of the other device and vice versa. Transmission and receiving connections are identified with the symbols ▪⟶ for transmit and ⟶• for receive. The visual check of the assignment of the transmission and reception channels is important.

For short distances, laser class 1 is fulfilled if FO5 modules and the recommended fibres are used. In other cases, the laser output may be higher.

Communication Converter

Optical fibres are usually used for the connections between the devices and communication converters. These are checked as the direct optical fibre connections.

Make sure that under the address 4502 **CONNEC. 1 OVER** the right connection type is parameterized.

Further Connections

For further connections a visual inspection is sufficient for the time being. Electrical and functional controls are performed during commissioning (see the following main section).

3.2.3 Checking the System Connections

WARNING!

Warning of dangerous voltages

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Therefore, only qualified people who are familiar with and adhere to the safety procedures and precautionary measures shall perform the inspection steps.

Caution!

Be careful when operating the device on a battery charger without a battery

Non-observance of the following measure can lead to unusually high voltages and consequently, the destruction of the device.

Do not operate the device on a battery charger without a connected battery. (For limit values see also Technical Data, Section 4.1).

Before the device is energized for the first time, it should be in the final operating environment for at least 2 hours to equalize the temperature, to minimize humidity and avoid condensation. Connections are checked with the device at its final location. The plant must first be switched off and earthed.

Connection examples for current transformer connections are provided in the Appendix A.3. Please observe the plant diagrams, too.

Proceed as follows in order to check the system connections:

- Protective switches for the power supply and the measured voltages must be switched off.
- Check the continuity of all current and voltage transformer connections against the system and connection diagrams:
  - Are the current transformers earthed properly?
  - Are the polarities of the current transformers the same?
  - Is the phase relationship of the current transformers correct?
  - Are the voltage transformers earthed properly (if used)?
  - Are the polarities of the voltage transformers correct (if used)?
  - Is the phase relationship of the voltage transformers correct (if used)?

- Is the polarity for current input I_4 correct (if used)?
- Is the polarity for voltage input U_4 correct (if used, e.g. with broken delta winding)?

- Check the functions of all test switches that are installed for the purposes of secondary testing and isolation of the device. Of particular importance are test switches in current transformer circuits. Be sure these switches short-circuit the current transformers when they are in the „test mode“.
- The short-circuiters of the plug connectors for the current circuits must be checked. This may be performed with secondary test equipment or other test equipment for checking continuity. Make sure that terminal continuity is not wrongly simulated in reverse direction via current transformers or their short-circuiters.
  - Remove the front panel of the device (see Figure 3-3).
  - Remove the ribbon cable connected to the I/O board (viewed from the front side it is the respective circuit board on the right, see Figure 3-3). Then remove the printed circuit board so that there is no longer any contact with the plug-in terminal of the housing.
  - At the terminals of the device, check continuity for each pair of terminals that receives current from the CTs.
  - Firmly re-insert the I/O board. Carefully connect the ribbon cable. Be careful that no connector pins are bent! Don't apply force!
  - At the terminals of the device, again check continuity for each pair of terminals that receives current from the CTs.
  - Attach the front panel and tighten the screws.
- Connect an ammeter in the supply circuit of the power supply. A range of about 2.5 A to 5 A for the meter is appropriate.
- Switch on m.c.b. for auxiliary voltage (supply protection), check the voltage level and, if applicable, the polarity of the voltage at the device terminals or at the connection modules.
- The measured steady-state current should correspond to the quiescent power consumption of the device. Transient movement of the ammeter merely indicates the charging current of capacitors.
- Remove the voltage from the power supply by opening the protective switches.
- Disconnect the measuring test equipment; restore the normal power supply connections.
- Apply voltage to the power supply.
- Close the protective switches for the voltage transformers.
- Verify that the voltage phase rotation at the device terminals is correct.
- Open the miniature circuit breakers for the transformer voltage (VT mcb) and the power supply.
- Check tripping circuits to the circuit breakers.
- Check the close circuits to the power system circuit breakers.
- Verify that the control wiring to and from other devices is correct.
- Check the signalling connections.
- Close the protective switches.
- If communication converters are used: check the auxiliary voltages for the communication converters.

- If the communication converter is connected to the communication network, its device-ready relay (DOK = „Device Ok“) picks up. This also signalizes that the clock pulse of the communication network is recognized.

  Further checks are performed according to Section „Checking the Protection Data Topology“.
- Please also observe carefully the documentation on the communication converters.

3.3 Commissioning

WARNING!

Warning of dangerous voltages when operating an electrical device

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Only qualified people shall work on and around this device. They must be thoroughly familiar with all warnings and safety notices in this instruction manual as well as with the applicable safety steps, safety regulations, and precautionary measures.

Before making any connections, the device must be earthed at the protective conductor terminal.

Hazardous voltages can exist in the power supply and at the connections to current transformers, voltage transformers, and test circuits.

Hazardous voltages can be present in the device even after the power supply voltage has been removed (capacitors can still be charged).

After removing voltage from the power supply, wait a minimum of 10 seconds before re-energizing the power supply. This wait allows the initial conditions to be firmly established before the device is re-energized.

The limit values given in Technical Data must not be exceeded, neither during testing nor during commissioning.

For tests with a secondary test equipment ensure that no other measurement voltages are connected and the trip and close commands to the circuit breakers are blocked, unless otherwise specified.

DANGER!

Hazardous voltages during interruptions in secondary circuits of current transformers

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Short-circuit the current transformer secondary circuits before current connections to the device are opened.

During the commissioning procedure, switching operations must be carried out. The tests described require that they can be done without danger. They are accordingly not meant for operational checks.

WARNING!

Warning of dangers evolving from improper primary tests

Non-observance of the following measure can result in death, personal injury or substantial property damage.

Primary tests may only be carried out by qualified persons who are familiar with commissioning protection systems, with managing power systems and the relevant safety rules and guidelines (switching, earthing etc.).

3.3.1 Test Mode / Transmission Block

Activation and Deactivation

If the device is connected to a central control system or a server via the SCADA interface, then the information that is transmitted can be modified with some of the protocols available (see Table „Protocol-dependent functions“ in the Appendix A.5).

If **Test mode** is set ON, then a message sent by a SIPROTEC 4 device to the main system has an additional test bit. This bit allows the message to be recognized as resulting from testing and not an actual fault or power system event. Furthermore it can be determined by activating the **Transmission block** that no indications at all are transmitted via the system interface during test mode.

The SIPROTEC 4 System Description describes how to activate and deactivate test mode and blocked data transmission. Note that when DIGSI is being used, the program must be in the **Online** operating mode for the test features to be used.

3.3.2 Test Time Synchronisation Interface

If external time synchronization sources are used, the data of the time source (antenna system, time generator) are checked (see Section 4 under „Time Synchronization“). A correct function (IRIG B, DCF77) is recognized in such a way that 3 minutes after the startup of the device the clock status is displayed as „`synchronized`“, accompanied by the indication „`Alarm Clock OFF`“. For further information please refer to the SIPROTEC System Description.

Table 3-14 Time status

No.	Status text	Status
1	–– –– –– ––	synchronized
2	–– –– –– ST	
3	–– –– ER ––	not synchronized
4	–– –– ER ST	
5	–– NS ER ––	
6	–– NS –– ––	
Legend: –– NS –– –– –– –– ER –– –– –– –– ST		time invalid time fault summertime

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 failure`“ „OFF“ appears.

3.3.3 Testing the System Interface

Prefacing Remarks

If the device features a system interface and uses it to communicate with the control centre, the DIGSI device operation can be used to test if messages are transmitted correctly. This test option should however definitely „not“ be used while the device is in service on a live system.

DANGER!

The sending or receiving of indications via the system interface by means of the test function is a real information exchange between the SIPROTEC 4 device and the control centre. Connected operating equipment such as circuit breakers or disconnectors can be switched in this way!

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during „real“ operation performing transmission and reception of messages via the system interface.

Note

After termination of the hardware test, the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be extracted with DIGSI prior to the test.

The interface test is carried out using DIGSI in the Online operating mode:

- Open the **Online** directory by double-clicking; the operating functions for the device appear.
- Click on **Test**; the function selection appears in the right half of the window.
- Double-click on **Testing Messages for System Interface** shown in the list view. The dialog box **Generate Indications** is opened (see Figure 3-16).

Structure of the Dialog Box

In the column **Indication**, all message texts that were configured for the system interface in the matrix will then appear. In the column **Setpoint** you determine a value for the indications that shall be tested. Depending on the type of message different entering fields are available (e.g. ***`message ON`*** / ***`message OFF`***). By clicking on one of the buttons you can select the desired value from the pull-down menu.

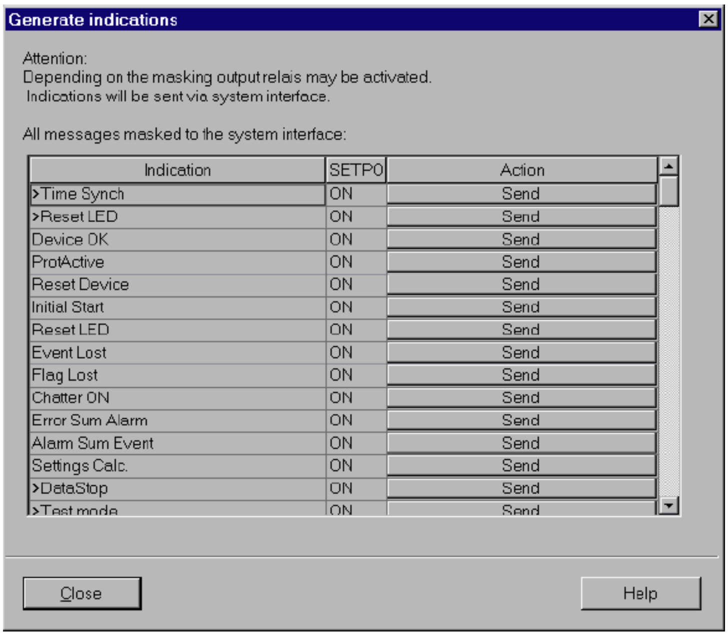


Figure 3-16 System interface test with dialog box: Generating indications – Example

Changing the Operating State

On clicking one of the buttons in the column **Action** you will be prompted for the password No. 6 (for hardware test menus). After correct entry of the password, individual annunciations can be initiated. To do so, click on the button **Send** in the corresponding line. The corresponding message is issued and can be read out either from the event log of the SIPROTEC 4 device or from the substation control center.

Further tests remain enabled until the dialog box is closed.

Test in Indication Direction

For all information that is transmitted to the central station, test in **Setpoint** the desired options in the list which appears:

- Make sure that each checking process is carried out carefully without causing any danger (see above and refer to DANGER!)
- Click on Send and check whether the transmitted information reaches the control centre and shows the desired reaction. Data which are normally linked via binary inputs (first character „>“) are likewise indicated to the control centre with this procedure. The function of the actual binary inputs is tested separately.

Exiting the Test Mode

To end the System Interface Test, click on **Close**. The dialog box closes. The processor system is restarted, then the device is ready for operation.

Test in Command Direction

Data which are normally linked via binary inputs (first character „>“) are likewise checked with this procedure. The information transmitted in command direction must be indicated by the central station. Check whether the reaction is correct.

3.3.4 Checking the switching states of the binary Inputs/Outputs

Prefacing Remarks

The binary inputs, outputs, and LEDs of a SIPROTEC 4 device can be individually and precisely controlled in DIGSI. This feature is used to verify control wiring from the device to plant equipment (operational checks) during commissioning. This test option should however definitely „not" be used while the device is in service on a live system.

DANGER!

A changing of switching states by means of the test function causes a real change of the operating state at the SIPROTEC 4 device. Connected operating equipment such as circuit breakers or disconnectors will be switched in this way!

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during „real" operation performing transmission and reception of messages via the system interface.

Note

After termination of the hardware test the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be extracted with DIGSI prior to the test.

The hardware test can be carried out using DIGSI in the Online operating mode:

- Open the **Online** directory by double-clicking; the operating functions for the device appear.
- Click on **Test**; the function selection appears in the right half of the window.
- Double-click in the list view on **Device inputs and outputs**. The dialog box with this name is opened (see Figure 3-17).

Structure of the Dialog Box

The dialog box is divided into three groups: **BI** for binary inputs, **BO** for binary outputs and **LED** for LEDs. An accordingly labelled button is on the left of each group. By double-clicking a button, information regarding the associated group can be shown or hidden.

In the column **Status** the present (physical) state of the hardware component is displayed. Indication is displayed symbolically. The physical actual states of the binary inputs and outputs are indicated by an open or closed switch symbol, the LEDs by switched on or switched off symbol.

The opposite state of each element is displayed in the column **Scheduled**. The display is in plain text.

The right-most column indicates the commands or messages that are configured (masked) to the hardware components.

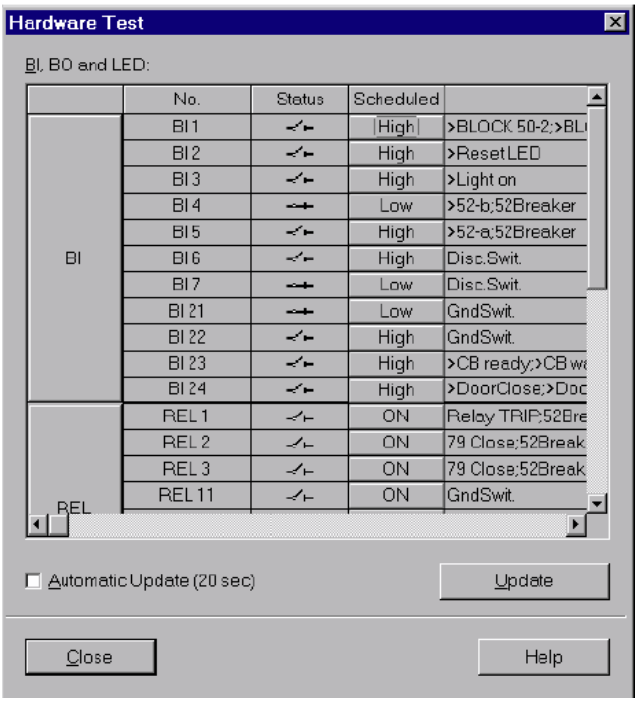


Figure 3-17 Test of the Binary Inputs and Outputs — Example

Changing the operating state

To change the operating state of a hardware component, click on the associated switching field in the **Scheduled** column.

Before executing the first change of the operating state the password No. 6 will be requested (if activated during configuration). After entry of the correct password a condition change will be executed. Further state changes remain enabled until the dialog box is closed.

Test of the Output Relays

Each individual output relay can be energized allowing a check of the wiring between the output relay of the 7SD610 and the plant, without having to generate the message that is assigned to the relay. As soon as the first change of state for any of the output relays is initiated, all output relays are separated from the internal device functions, and can only be operated by the hardware test function. This means, that e.g. a TRIP command coming from a protection function or a control command from the operator panel to an output relay cannot be executed.

Proceed as follows in order to check the output relay:

- Make sure that the switching operations caused by the output relays can be executed without any danger (see above under DANGER!).
- Each output relay must be tested via the corresponding **Scheduled** field of the dialog box.
- Finish the testing (see margin heading below „Exiting the Procedure“), so that during further testings no unwanted switchings are initiated.

Test of the Binary Inputs

To test the wiring between the plant and the binary inputs of the 7SD610 the condition in the system which initiates the binary input must be generated and the response of the device checked.

To do so, open the dialog box **Hardware Test** again to view the physical position of the binary input. The password is not yet required.

Proceed as follows in order to check the binary inputs:

- Each state in the system which causes a binary input to pick up must be generated.
- Check the reaction in the **Status** column of the dialog box. To do this, the dialog box must be updated. The options may be found below under the margin heading „Updating the Display“.
- Finish the test sequence (see margin heading below „Exiting the Procedure“).

If, however, the effect of a binary input must be checked without carrying out any switching in the system, it is possible to trigger individual binary inputs with the hardware test function. As soon as the first state change of any binary input is triggered and the password No. 6 has been entered, all binary inputs are separated from the system and can only be activated via the hardware test function.

Test of the LEDs

The light-emitting diodes (LEDs) may be tested in a similar manner to the other input/output components. As soon as the first state change of any LED has been triggered, all LEDs are separated from the internal device functionality and can only be controlled via the hardware test function. This means e.g. that no LED is illuminated anymore by a protective function or by pressing the LED reset button.

Updating the Display

When the dialog box **Hardware Test** is opened, the present conditions of the hardware components at that moment are read in and displayed.

An update is made:

- For the particular hardware component, if a command for change to another state was successful,
- For all hardware components if the **Update** button is clicked,
- For all hardware components with cyclical updating (cycle time is 20 sec) if the **Automatic Update (20 sec)** field is marked.

Exiting the Procedure

To end the hardware test, click on **Close**. The dialog box closes. Thus, all the hardware components are set back to the operating state specified by the plant states. The processor system is restarted, then the device is ready for operation.

3.3.5 Checking the Protection Data Topology

General

The communication topology can either be checked from the PC using DIGSI or with a „ WEB-Monitor“. If you choose to work with the „WEB-Monitor“, please note the Help files referring to the „WEB-Monitor“.

You can either connect the PC to the device locally using the operator interface at the front, or the service interface at the back of the PC (Figure 3-18). Or you can log into the device using a modem via the service interface (example in Figure 3-19).

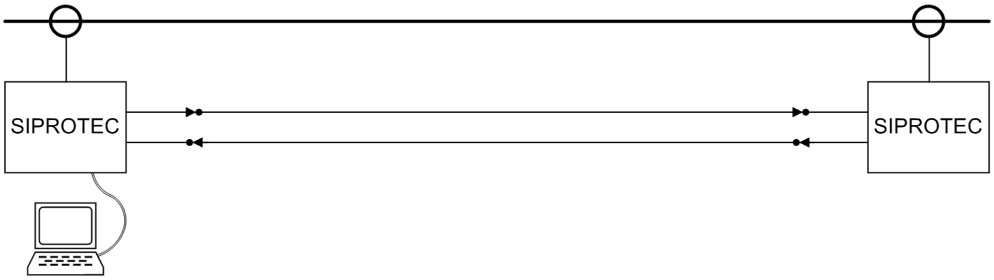


Figure 3-18 PC interfacing directly to the device - example

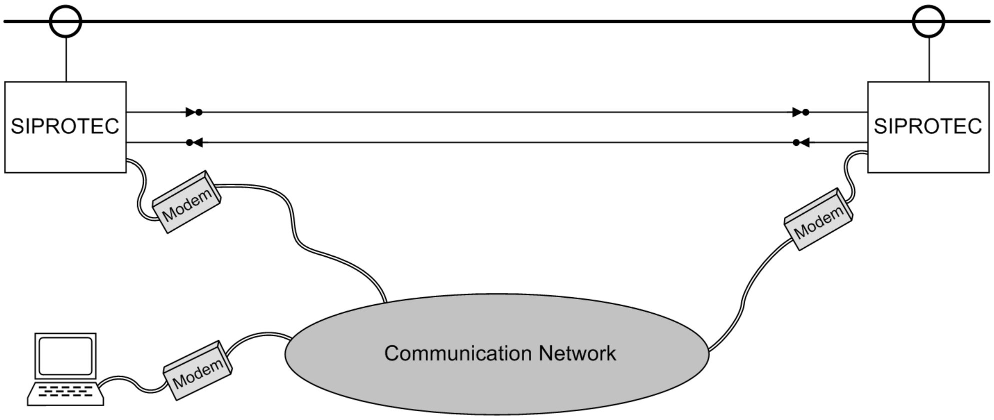


Figure 3-19 PC interfacing via modem — schematic example

Checking a Connection using Direct Link

For two devices linked with fibre optical cables (as in Figure 3–18 or 3–19), this connection is checked as follows.

- Both devices at the link ends have to be switched on.
- Check in the operating indications or in the spontaneous indications:
  – If the indication „`PI1 with`“ (protection data interface 1 connected with no. 3243) is provided with the device index of the other device, a link has been established and one device has detected the other.
  – The device also indicates the device index of the device which communicates correctly (e.g. annunciation „`Rel2 Login`“, No. 3492, when relay 2 has been contacted).
- In case of an incorrect communication link, you see the message „`PI1 Data fault`“ (No 3229). In this case, recheck the fibre optical cable link.
  – Have the devices been linked correctly and no cables been mixed up?
  – Are the cables free from mechanical damage, intact and the connectors locked?
  – Otherwise repeat check.

Continue with the margin heading „Consistency of Topology and Parameterization“.

Checking a Link with a Communication Converter

If a communication converter is used, please note the instructions enclosed with the device. The communication converter has a test setting where its outputs are looped back to the inputs.

Links via the communication converter are tested by means of local loop-back (Figure 3-20, left).

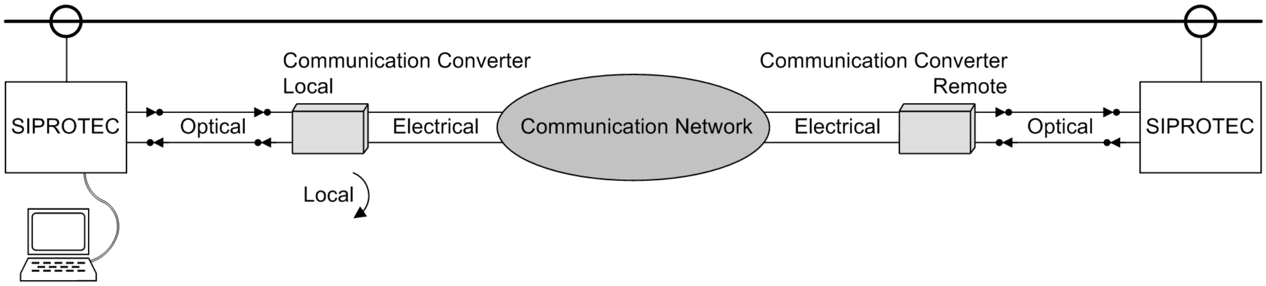


Figure 3-20 Protection data communication via communication converter and communication network — schematic example

DANGER!

Opening the Communication Converter

There is danger to life by energized parts.

Before opening the communication converter, it is absolutely necessary to isolate it from the auxiliary supply voltage at all poles!

- Both devices at the link ends have to be switched on.
- First configure the communication converter CC-1:
  - Disconnect the auxiliary supply voltage from both poles.
  - Open the communication converter.
  - Set the jumpers to the matching position for the correct interface type and transmission rate; they must be identical with the parameterization of the 7SD610 (address 4502 **CONNEC. 1 OVER** for protection data interface 1, see also Subsection 2.2.3.1).
  - Move the communication converter into test position (jumper X32 in position 2-3).
  - Close the communication converter housing.
- Reconnect the auxiliary supply voltage for the communication converter.
- The system interface (X.21 or G703.1) must be active and connected to the communication converter. Check this by means of the "device ready"-contact of the communication converter (continuity at the NO contact).
  - If the "device ready"-contact of the communication converter doesn't close, check the connection between the communication converter and the net (communication device). The communication device must emit the correct transmitter clock to the communication converter.
- Change the interface parameters at the 7SD610 (at the device front or via DIGSI):
  - Address 4502 **CONNEC. 1 OVER** = ***F.optic direct*** when you are testing protection data interface 1,

- Check the operating indications or in the spontaneous annunciations:
  - Message 3217 „`PI1 Data reflec`“ (Protection interface 1 data reflection ON) when you test protection data interface 1,
  - If the indication is not transmitted check for the following:
  - Has the 7SD610 fibre optical transmitting terminal output been correctly linked with the fibre optical receiving terminal input of the communication converter and vice versa (No erroneous interchanging)?
  - Does the 7SD610 device have the correct interface module and is it working correctly?
  - Are the fibre optic cables intact?
  - Are the parameter settings for interface type and transmission rate at the communication converter correct (see above; note the DANGER instruction!)?
  - Repeat the check after correction, if necessary.
- Reset the interface parameters at the 7SD610 correctly:
  - Address 4502 **`CONNEC. 1 OVER`** = required setting, when you have tested protection data interface 1,
- Disconnect the auxiliary supply voltage of the communication converter at both poles. Note the above DANGER instruction!
- Reset the communication converter to normal position (X32 in position 1-2) and close the housing again.
- Reconnect the supply voltage of the communication converter.

Perform the above check at the other end with the device being connected there and its corresponding communication converter.

Continue with the margin heading „Consistency of Topology and Parameterization“.

Consistency of Topology and Parameterisation

Having performed the above checks, the linking of a device pair, including their communication converters, has been completely tested and connected to the auxiliary supply voltage. Now the devices communicate by themselves.

- Check now the Event Log or in the spontaneous annunciations of the device where you are working:
  - Message No. 3243 „`PI1 with`“ (protection data interface 1 linked with) followed by the device index of the other device, if interface 1 is applying.
  - If the devices are at least connected once, the message No. 3458 „`Chaintopology`“ will appear.
  - If no other devices are involved in the topology as an entity, the message No. 3464 „`Topol complete`“ will then be displayed, too.
  - And if the device configuration is also consistent, i.e. the prerequisites for setting the function scope (Section 2.1.1),Power System Data 1 (2.1.2.1), Power System Data 2 (2.1.4.1) topology and protection data interface parameters (Section 2.2.3.1) have been considered, the fault message, i.e. No. 3229 „`PI1 Data fault`“, for the interface just checked will disappear. The communication and consistency test has now been completed.
  - If the fault message of the interface being checked does not disappear, however, the fault must be found and eliminated. Table lists messages that indicate such faults.

Table 3-15 Annunciations on inconsistencies

No	Short Text	State	Meaning / Measures
3233	„DT inconsistent“	ON	„Device table inconsistent“: the indexing of the devices is inconsistent (missing numbers or one number used twice, see Section 2.2.3.1)
3234	„DT unequal“	ON	„Device table unequal“: the ID-numbers of the devices are unequal (see Section 2.2.3.1)
3235	„Par. different“	ON	„Parameterization inconsistent“: 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)
3487	„Equal IDs“	ON	„Same device address:“: The parameter 4710 LOCAL RELAY has been set for several devices.

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 of the device.

Check the following information:

- Indication No. 7753 „PI1A/m“ (availability per minute) and indication No. 7754 „PI1A/h“ (availability per hour) indicate the availability of protection data interface 1. The value of No. 7753 „PI1A/m“ should attain a minimum per-minute-availability of 99.85% after two minutes of operation. The value for No. 7754 „PI1A/h“ should attain a minimum per-hour-availability of 99.85 % after one hour of operation.

If these values are not attained, the protection communication should be checked.

If GPS synchronisation is used, the transmission times can be retrieved separately for each direction:

- Concerning protection data interface 1, indication No. 7876 „PI1 TD S“ indicates the transmission time in sending direction, No. 7875 „PI1 TD R“ in receiving direction.

In all other cases, the mean value for both directions will be indicated:

- Indication No. 7751 „PI1 TD“ indicates the transmission time for protection data interface 1.

WEB-Monitor

The topology and the statistics of the protection data interfaces can be graphically displayed on the screen using the WEB-Monitor. This requires a personal computer with web browser. Figure 3-21 shows the general information of the communication topology.

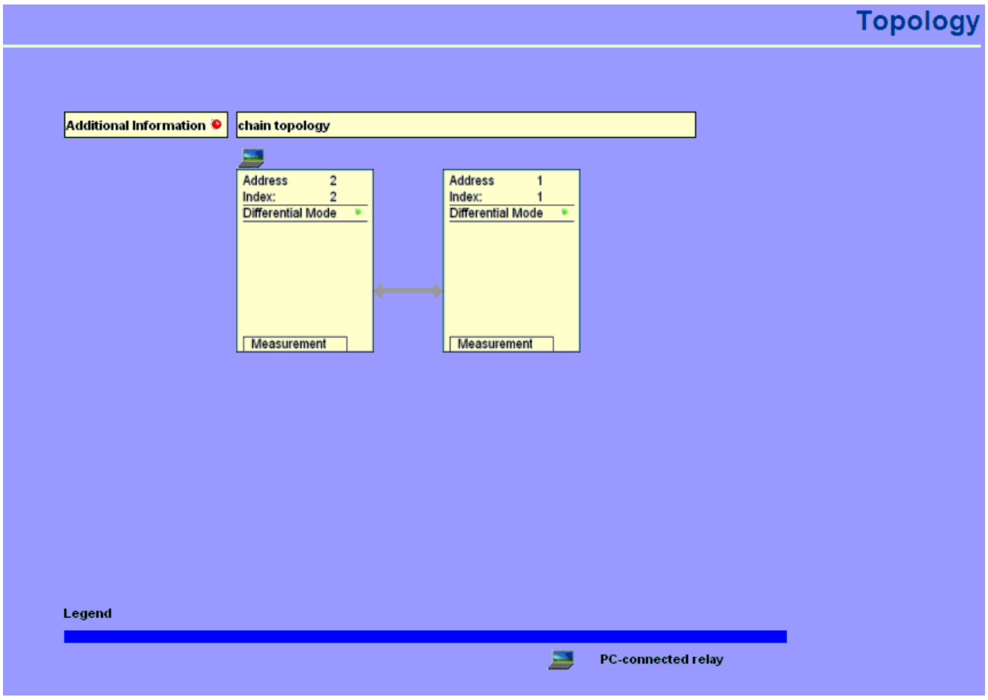


Figure 3-21 Communication topology – Limited representation

The „Additional Information“ button extends the representation by the following information:

The timing master is indicated by a clock icon in the communication topology display.

In the event of an incorrect parameterisation or faulty wiring, the indications „Communication topology not complete“ (topol complete OFF), „Communication topology invalid“ and „Protection topology invalid“ are displayed in a red bar.

The display of the circuit breaker positions is integrated into the topology display. Closed circuit breakers are displayed in green, opened circuit breakers are displayed in red and circuit breakers in an undefined state are displayed in grey.

An LED is used to select whether the communication topology or the protection topology is to be displayed for the participating device. The display of the connections changes correspondingly.

To get an overview of the quality of the individual communication paths, a connection status is displayed for each connection. The statuses can be „OK“, „asynchronous connection“, „high fault rate“.

The status is displayed directly in the communication path display, i.e. in the display of the arrows symbolising the connection. The colour of the connection indicates its status, a legend at the lower screen edge explains the colouration. If a connection fails completely, the connection is no longer displayed.

Table 3-16 Connection status

Status	Colour of the connection display	Remark
OK	green	The connection is OK.
failed	is not displayed	

Status	Colour of the connection display	Remark
asynchro-nous	red	The connection cannot be used for protective functions.
unknown	grey	

The following figure shows a topology example with additional information.

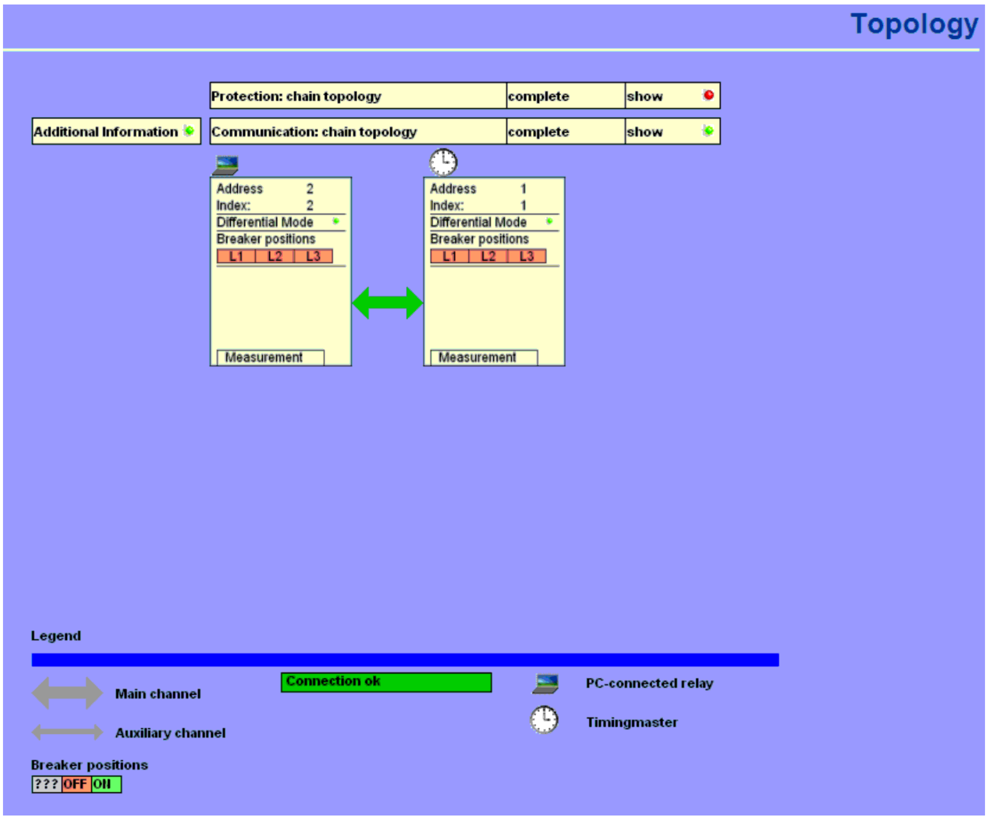


Figure 3-22 Communication topology – Additional representation

Figure 3-23 shows an example of the protection data interface statistics of the device. The values for the transfer times and the availability are displayed. Both RX and TX direction of the transmission delay times are displayed, symmetric conditions are assumed if there is no GPS synchronisation. In this case, the values displayed for the transfer time are identical.

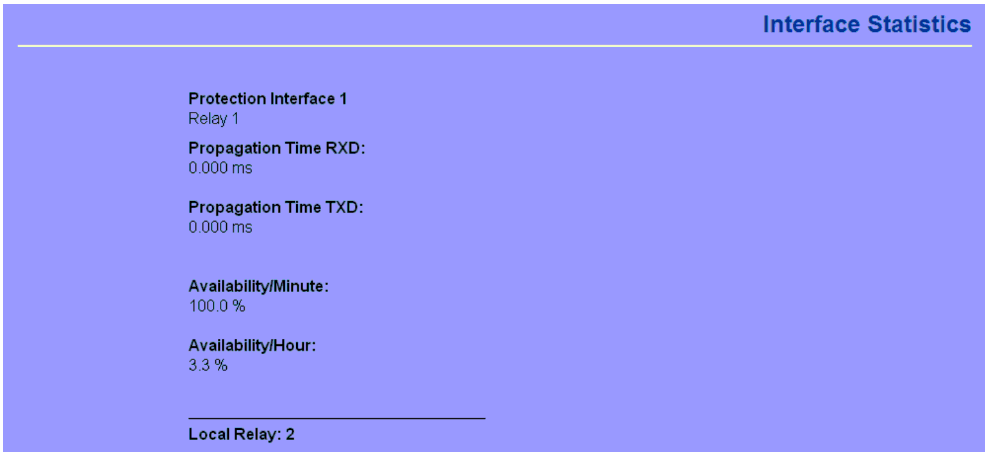


Figure 3-23 Example of viewing the transmission times and availability of the protection data interface

3.3.6 Checking for Breaker Failure Protection

General

If the device is equipped with the breaker failure protection and this function is used, the integration of this protection function into the system must be tested under practical conditions.

Because of the manifold applications and various configuration possibilities of the plant it is not possible to give a detailed description of the necessary test steps. It is important to consider the local conditions and the protection and plant drawings.

Before starting the circuit tests it is recommended to isolate the circuit breaker of the feeder to be tested at both ends, i.e. line disconnectors and busbar disconnectors should be open so that the breaker can be operated without risk.

Caution!

Also for tests on the local circuit breaker of the feeder a trip command to the surrounding circuit breakers can be issued for the busbar.

Non-observance of the following measure can result in minor personal injury or property damage.

Therefore, primarily it is recommended to interrupt the tripping commands to the adjacent (busbar) breakers, e.g. by interrupting the corresponding pickup voltage supply.

Before the breaker is closed again for normal operation the trip command of the feeder protection routed to the circuit breaker must be disconnected so that the trip command can only be initiated by the breaker failure protection.

Although the following list does not claim to be complete, it may also contain points which are to be ignored in the current application.

Auxiliary Contacts of the CB

The circuit breaker auxiliary contact(s) form an essential part of the breaker failure protection system in case they have been connected to the device. Make sure the correct assignment has been checked.

External Initiation Conditions

If the breaker failure protection can also be started by external protection devices, the external start conditions are checked. Depending on the device version and the setting of the breaker failure protection, single-pole or three-pole trip are possible. The pole discrepancy check of the device or the actual breaker may lead to three-pole tripping after single-pole tripping. Therefore check first how the parameters of the breaker failure protection are set. See also Section 2.13.2, addresses `3901` onwards.

In order for the breaker failure protection to be started, a current must flow at least through the monitored phase and the earth. This may be a secondary injected current.

After every start the indication „`BF Start`“ (no. 1461) must appear in the spontaneous or fault indications.

If only single-pole initiation is possible:

- Start by single-pole trip command of the external protection `L1`:

  Binary input functions „`>BF Start L1`“ and, if necessary, „`>BF release`“ (in spontaneous or fault indications). Trip command (depending on settings).
- Start by single-pole trip command of the external protection `L2`:

  Binary input functions „`>BF Start L2`“ and, if necessary, „`>BF release`“ (in spontaneous or fault indications). Trip command (depending on settings).
- Start by single-pole trip command of the external protection `L3`:

  Binary input functions „`>BF Start L3`“ and, if necessary, „`>BF release`“ (in spontaneous or fault indications). Trip command (dependent on settings).
- Start by three-pole trip command of the external protection via all three binary inputs `L1`, `L2` and `L3`:

  Binary input functions „`>BF Start L1`“, „`>BF Start L2`“ and „`>BF Start L3`“ and, if necessary, „`>BF release`“ (in spontaneous or fault indications). Three-pole trip command.

For three-pole initiation:

- Start by three-pole trip command of the external protection :

  Binary input functions „`>BF Start 3pole`“ and, if necessary, „`>BF release`“ (in spontaneous or fault indications). Trip command (dependent on settings).

Switch off test current.

If start is possible without current flow:

- Starting by trip command of the external protection without current flow:

  Binary input functions „`>BF Start w/o I`“ and, if necessary, „`>BF release`“ (in spontaneous or fault indications). Trip command (dependent on settings).

Busbar Tripping

The most important thing is the check of the correct distribution of the trip commands to the adjacent circuit breakers in case of breaker failure.

The adjacent circuit breakers are those of all feeders which must be tripped in order to ensure interruption of the fault current should the local breaker fail. These are therefore the circuit breakers of all feeders which feed the busbar or busbar section to which the feeder with the fault is connected.

A general detailed test guide cannot be specified because the layout of the adjacent circuit breakers largely depends on the system topology.

In particular with multiple busbars the trip distribution logic for the surrounding circuit breakers must be checked. Here check for every busbar section that all circuit breakers which are connected to the same busbar section as the feeder circuit breaker under observation are tripped, and no other breakers.

Tripping of the Remote End

If the trip command of the circuit breaker failure protection must also trip the circuit breaker at the remote end of the feeder under observation, the transmission channel for this remote trip must also be checked. This is done together with transmission of other signals according to Sections „Testing of the Teleprotection Scheme with ...“ further below.

Termination of the Checks

All temporary measures taken for testing must be undone, e.g. especially switching states, interrupted trip commands, changes to setting values or individually switched off protection functions.

3.3.7 Checking the Instrument Transformer Connections of One Line End

If secondary test equipment is connected to the device, it is to be removed or, if applying, test switches should be in normal operation position.

Note

It must be taken into consideration that tripping can occur even at the opposite end of the protected object if connections were made wrong.

Before energizing the object to be protected at one end, short-circuit protection must be ensured at least at the feeding ends. If a separate backup protection (e.g. time overcurrent protection) is available, this has to be put into operation and switched to alert first.

Voltage and phase rotation check

If the device has been connected to voltage transformers, these connections are checked using primary values. For devices without voltage transformer connection the rest of this margin heading may be skipped.

The voltage transformer connections are individually tested at either end of the object to be protected. At the other end, the circuit breaker initially remains open.

- Having closed the circuit breaker, none of the measurement monitoring functions in the device must respond.
  - If there was a fault indication, however, the Event Log or spontaneous indications could be checked to investigate the reason for it.
  - 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 Section 2.15.1 under margin heading „Symmetry Monitoring“).

  The voltages can be read as primary and secondary values on the display at the front, or called up in the PC via the operator or service interface, and compared with the actual measured quantities. Besides the magnitudes of the phase-to-earth and the phase-to-phase voltages, the phase differences of the voltages are also displayed so that the correct phase sequence and polarity of individual transformers can also be seen. The voltages can also be read with the „WEB-Monitor“ (see below, „Current test“).
- The voltages have to be almost equal. All three angles φ (U_{Lx}–U_{Ly}) must be approximately 120°.
  - If the measured quantities are not plausible, the connections must be checked and corrected after switching off the line. If the phase difference between two voltages is 60° instead of 120°, one voltage must be polarity-reversed. The same applies if there are phase-to-phase voltages which are almost equal to the phase-to-earth voltages instead of having a value that is $\sqrt{3}$ larger. The measurements are to be repeated after correcting the connections.
  - In general, the phase rotation is a clockwise phase rotation. If the system has an anti-clockwise phase rotation, this must be identical at all ends of the protected object. The phase assignment of the measured quantities has to be checked and , if required, corrected after the line has been isolated. Subsequently the measurement has to be repeated.
- Open the circuit breaker for voltage transformers of the feeder. The measured voltages in the operational measured values appear with a value close to zero (small measured voltages are of no consequence).
  - Check the Event Log and the spontaneous indications to make sure that the VT mcb trip was noticed (indication „`>FAIL:Feeder VT`“ „ON“, No. 361). This requires that the position of the circuit breaker for voltage transformers is connected to the device via a binary input.
- Close the circuit breaker for voltage transformers: The above indication is displayed in the spontaneous indications as „OFF“, i.e. „`>FAIL:Feeder VT`“ „OFF“.
  - If one of the indications does not appear, the connection and allocation of these signals must be checked.
  - If „ON“ state and „OFF“ state are swapped, the contact type (H–active or L–active) must be checked and corrected.
- The protected object is switched off.
- This check must be performed at both ends.

3.3.8 Checking the Instrument Transformer Connections of Two Line Ends

Current Test

The connections of the current transformers are tested with primary values. A load current of at least 5% of the rated operational current is required. Any direction is possible.

This test cannot replace the visual inspection of the correct current transformer connections. Therefore, the inspection according to Section „Checking the System Connections“ is a prerequisite.

- The current transformer connections are tested at each end of the protected object. The current flows through the protected object.
- After closing the circuit breakers, none of the measured value monitoring functions in the 7SD610 must respond. If there was a fault indication, however, the Event Log or spontaneous indications can be checked to investigate the reason for it.
  - If current summation errors occur, check the matching factors (see Section 2.1.2 under margin heading „Connection of the currents“).
  - Indications from the symmetry monitoring could occur because there actually are asymmetrical conditions in the primary system. If they are part of normal operation, the corresponding monitoring function is set less sensitive (see Section 2.15.1 under margin heading „Symmetry Monitoring“).

  The currents can be read as primary and secondary values on the display at the front, or called up in the PC via the operator or service interface, and compared with the actual measured quantities. The phase differences of the currents are indicated in addition to the absolute values so that the correct phase sequence and polarity of individual transformers can also be seen.

  The „WEB-Monitor“ allows convenient readout of all measured values with visualization by means of phasor diagrams (Figure 3-24).
- The current amplitudes must be approximately the same. All three angles φ (I_{Lx}–I_{Ly}) must be approximately 120°.
  - If the measured values are not plausible, the connections must be checked and corrected after switching off the protected object and short-circuiting the current transformers. If, for example, the phase difference between two currents is 60° instead of 120°, one of the currents must have a reversed polarity. The same applies if a substantial earth current 3 I_0 occurs:

    3 $I0 \approx$ phase current $\rightarrow$ one or two phase currents are missing;

    3 $I0 \approx$ twice the phase current $\rightarrow$ one or two phase currents have a reversed polarity.
- The measurements are to be repeated after correcting the connections.
- The above described tests of the measured quantities also have to be performed at the other end of the tested current path. The current value of the other end can also be read out locally as percentage values as well as the phase angles.

In the „WEB-Monitor“ the local and remote measured values can be displayed graphically. The following figures show an example.

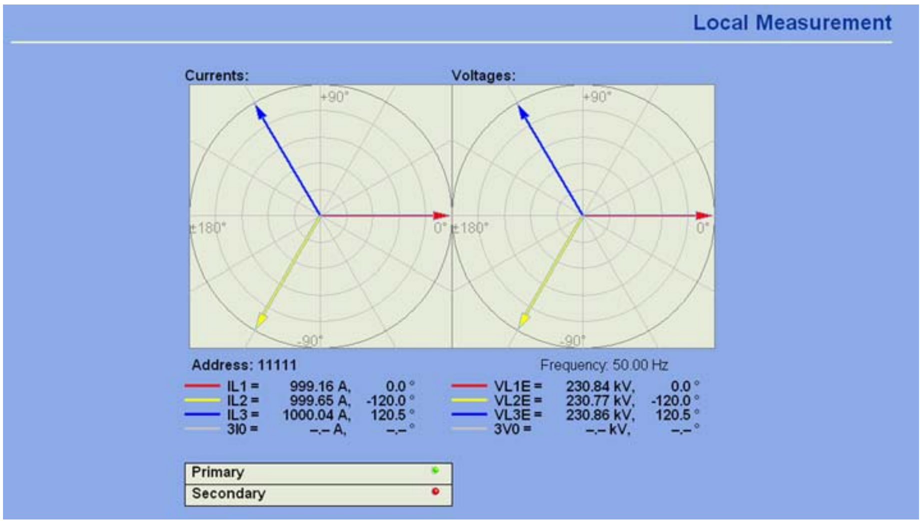


Figure 3-24 Local measured values in the WEB-Monitor - Examples of plausible measured values

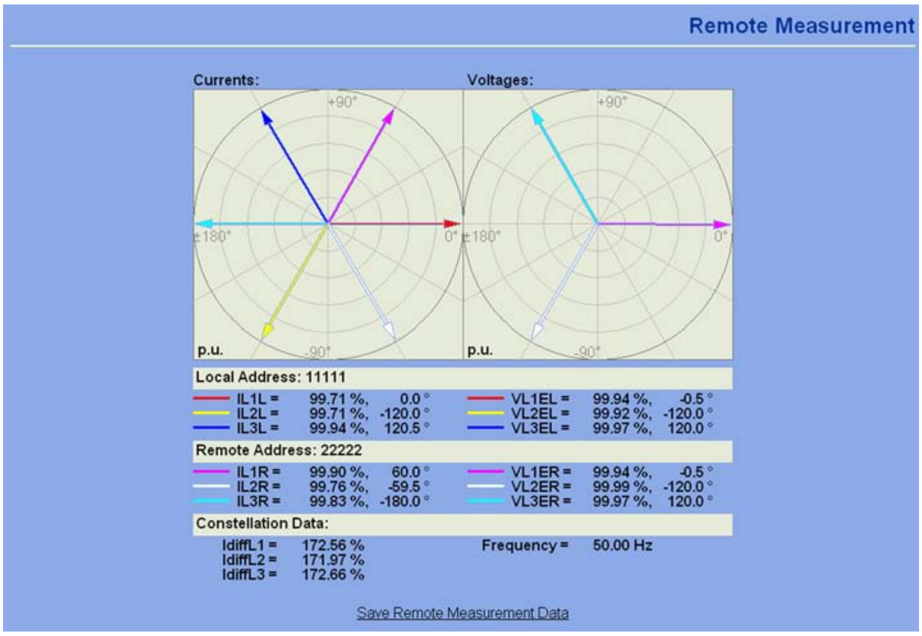


Figure 3-25 Remote measured values in the WEB-Monitor - Examples of plausible measured values

Polarity check

If the device is connected to voltage transformers, the local measured values already allow a polarity check.

A load current of at least 5% of the rated operational current is still required. Any direction is possible but must be known.

- With closed circuit breakers, the power values are viewed as primary and secondary values on the front display panel or via the operator or service interface with a personal computer.

  Here, again, the „WEB-Monitor“ is a convenient help since the vector diagrams also show the allocation between the currents and voltages (Figure 3-25). Cyclically and acyclically swapped phases can easily be detected.

- The measured power values on the actual device or in DIGSI enable you to verify that they correspond to the load direction (Figure 3-26):

  P positive if active power flows into the protected object,

  P negative if active power flows toward the busbar,

  Q positive if reactive power flows into the protected object,

  Q negative if reactive power flows toward the busbar.

  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 obtain unambiguous results, you should increase the load current if necessary.

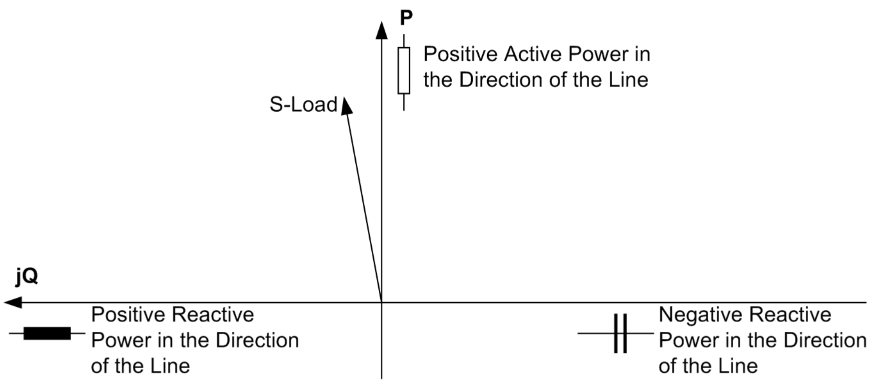


Figure 3-26 Apparent load power

- The power measurement provides an initial indication as to whether the measured values of one end have the correct polarity.
  - If the direction of the reactive power is correct but the sign of the active power is incorrect, cyclic phase swapping of the currents (right) or of the voltages (left) might be the cause;
  - If the direction of the active power is correct but the reactive power has an incorrect sign, cyclic phase swapping of the currents (left) or of the voltages (right) might be the cause;
  - if the signs of both active and reactive power are incorrect, the polarity in address 201 **CT Starpoint** has to be checked and corrected.

  The phase angles between currents and voltages must also be conclusive. All three phase angles φ (U_{Lx}–I_{Lx}) must be approximately the same and represent the operating status. In the event of power in the direction of the protected object, they correspond to the current phase displacement (cos φ positive); in the event of power in the direction of the busbar they are higher by 180° (cos φ negative). However, charging currents might have to be considered (see above).
- The measurements may have to be repeated after correcting the connections.
- The above described tests of the measured quantities also have to be performed at the other end of the tested current path. The current and voltage values as well as the phase angles of the other end can also be read out locally as percentage values. Please observe that currents flowing through the object (without charging currents) ideally have opposite signs at both ends, i.e. they are turned by 180°. In the „WEB-Monitor“, the local and remote measured values can be shown graphically. An example is shown in Figure 3-25.
- The protected object is now switched off, i.e. the circuit breakers are opened.

Polarity check for the current measuring input I_4

If the standard connection of the device is used whereby current input I_4 is connected in the starpoint of the set of current transformers (refer also to the connection circuit diagram in the Appendix 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 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 situations that may occur in practice, the non-symmetry of measured values may cause the measured value monitoring to pickup. This must therefore be ignored during such tests.

DANGER!

Hazardous voltages during interruptions in secondary circuits of current transformers

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Short-circuit the current transformer secondary circuits before current connections to the device are opened.

I_4 from Own Line

To generate a displacement voltage, the e–n winding of one phase in the voltage transformer set (e.g. L1) is bypassed (see Figure 3-27). 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 resistive-inductive load, the protection is basically subjected to the same conditions that exist during an earth fault in the direction of the line.

The voltages can be read on the display at the front, or called up in the PC via the operator or service interface, and compared with the actual measured quantities as primary or secondary values. The absolute values as well as the phase differences of the voltages are indicated so that the correct phase sequence and polarity of individual transformers can also be seen. The voltages can also be read out with the Web-Monitor.

The same manipulation is carried out with the current and voltage transformers at the other end.

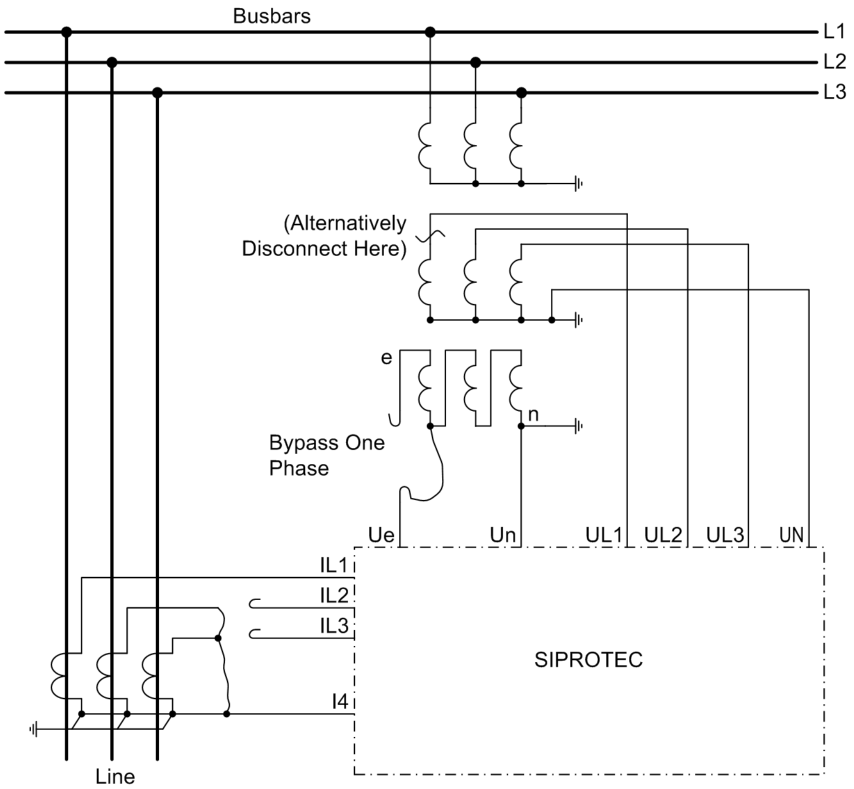


Figure 3-27 Polarity check for I_4, example with current transformer configured in a Holmgreen connection

If the current flows towards the protected object according to the circuit in Figure 3-27, the currents I_{L2} and I_{L3} are virtually zero. An earth current $3I_0$ of the approximately same level as I_{L1} occurs. Accordingly, the voltage U_{L1E} is missing and a zero sequence voltage $3U_0$ appears.

In the event of a polarity fault, $3I_0$ is in opposite phase with I_{L1} or the zero voltage $3U_0$ supplements the other two voltages to a voltage star. Open the circuit breakers, short-circuit current transformers and set current and voltage transformer connections right and repeat the check.

Note

If parameters were changed for this test, they must be returned to their original state after completion of the test!

Measuring the differential and restraint currents

The test for two ends is terminated with the reading of the differential, restraint and load currents. It is simultaneously checked that the current transformer connections have been correctly restored after the I_4 test (if performed).

- Read out the differential, restraint and load currents. They are available for every phase on the device display or in DIGSI in the measured values.
  - The differential currents must be low, at least one scale less than the currents flowing through. If high charging currents are to be expected in long overhead lines or cables, these are additionally included in the differential currents.
  - The maximum values of the read measured values for the charging current (3 values) are converted to Ampere and entered in **I-DIFF>**. The recommended setting for the pickup threshold is $1 \cdot I_{cN}$.
  - The restraint currents result from the pickup value **I-DIFF>** (address 1210, see Section 2.3.2) plus the sum of the fault currents to be tolerated: Such as the locally permissible current transformer errors according to address 253 **E% ALF/ALF_N** (see Section 2.1.2), the permissible current transformer errors at the other ends according to the respective setting, as well as the internal estimation of the system errors (frequency, synchronisation and delay time difference errors). With the default values for **I-DIFF>** (0.3 I_N) and **E% ALF/ALF_N** (5.0 % = 0.05) the following ensues:

$$\frac{I_{Rest}}{I_{NB}} = \underbrace{0.3 \cdot \frac{I_{N1}}{I_{NB}}}_{\substack{\text{Setting Value}\\ \textbf{IDIFF>}}} + \underbrace{0.05 \cdot \frac{I}{I_{N1}}}_{\substack{\text{Adm. Local}\\ \text{Tranformer}\\ \text{Error}}} + \underbrace{0.05 \cdot \frac{I}{I_{N2}}}_{\substack{\text{Adm. Remote}\\ \text{Transformer}\\ \text{Eror}}} + \text{System Error}$$

With

I	the actually flowing current,
I_{NB}	the rated operational current (as parameterised),
I_{N1}	the primary nominal current of the local current transformers,
I_{N2}	the primary nominal current of the current transformers of the remote end.

In the „WEB-Monitor“ the differential and restraint currents are graphically displayed in a characteristics diagram. An example is shown in Figure 3-28.

- If there is a differential current in the size of twice the through-flowing current, you may assume a polarity reversal of the current transformer(s) at one line end. Again check the polarity and set it right after short-circuiting all the three current transformers. If you have modified these current transformers, also perform a power or angle test.
- Finally, open the circuit breaker again.
- If parameter settings have been changed for the tests, reset them to the values necessary for operation.

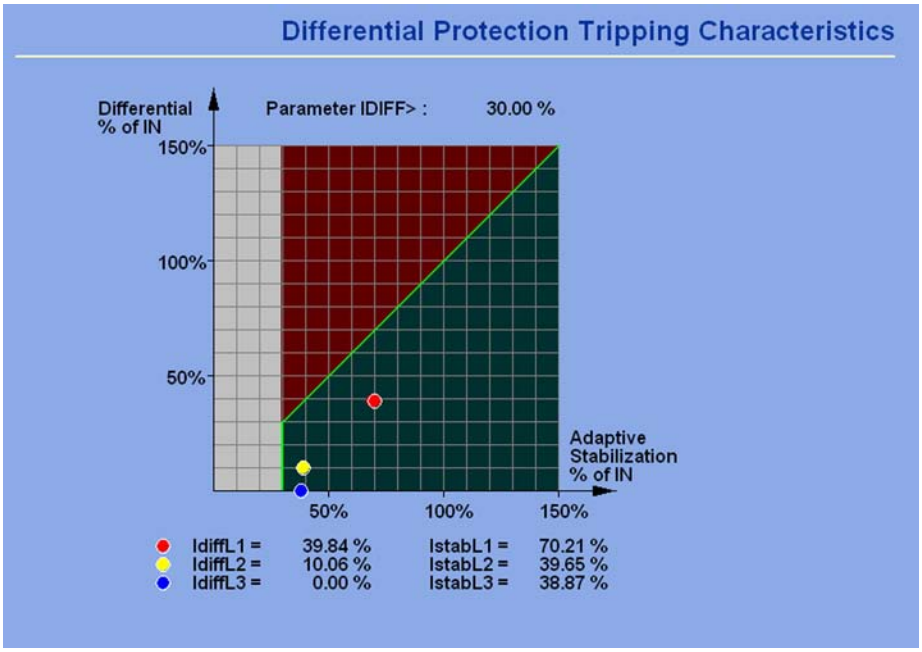


Figure 3-28 Differential and restraint currents - Example of plausible measurements

3.3.9 Check of the Signal Transmission for Internal and External Remote Tripping

The 7SD610 provides the possibility to transmit a remote trip signal to the opposite line end if a signal transmission path is available for this purpose. This remote trip signal may be derived from both an internally generated trip signal as well as from any signal coming from an external protection or control device.

If an internal signal is used, the initiation of the transmitter must be checked. If the signal transmission path is the same and has already been checked as part of the previous sections, it need not be checked again here. Otherwise the initiating event is simulated and the response of the circuit breaker at the opposite line end is verified.

For the remote transmission, the external command input is employed on the receiving line end; it is therefore a prerequisite that: **DTT Direct Trip** is set in address 122 ***Enabled*** and **FCT Direct Trip** is set in address 2201 ***ON***. If the signal transmission path is the same and has already been checked as part of the previous sections, it need not be checked again here. A function check is sufficient, whereby the externally derived command is executed. For this purpose the external tripping event is simulated and the response of the circuit breaker at the opposite line end is verified.

3.3.10 Testing User-defined Functions

The device has a vast capability for allowing functions to be defined by the user, especially with the CFC logic. Any special function or logic added to the device must be checked.

A general procedure cannot in the nature of things be specified. Configuration of these functions and the set value conditions must be actually known beforehand and tested. Especially, possible interlocking conditions of the switching devices (circuit breakers, isolators, grounding electrodes) must be observed and checked.

3.3.11 Trip and Close Test with the Circuit Breaker

The circuit breaker and tripping circuits can be conveniently tested by the device 7SD610.

The procedure is described in detail in the SIPROTEC 4 System Description.

If the check does not produce the expected results, the cause may be established from the text in the display of the device or the PC. If necessary, the connections of the circuit breaker auxiliary contacts must be checked:

It must be noted that the binary inputs used for the circuit breaker auxiliary contacts must be assigned separately for the CB test. This means it is not sufficient that the auxiliary contacts are allocated to the binary inputs No. 351 to 353, 379 and 380 (according to the possibilities of the auxiliary contacts); additionally, the corresponding No. 366 to 368 or 410 and/or 411 must be allocated (according to the possibilities of the auxiliary contacts). In the CB test only the latter ones are analyzed. See also Section 2.16.2. Furthermore, the ready state of the circuit breaker for the CB test must be indicated to the binary input with No. 371.

3.3.12 Trip / Close Tests for the Configured Operating Devices

Control by Local Command

If the configured operating devices were not switched sufficiently in the hardware test already described, all configured switching devices must be switched on and off from the device via the integrated control element. The feedback information of the circuit breaker position injected using binary inputs is read out at the device and compared with the actual breaker position.

The switching procedure is described in the SIPROTEC 4 System Description. The switching authority must be set in correspondence with the source of commands used. With the switching mode, you can choose between locked and unlocked switching. In this case, you must be aware that unlocked switching is a safety risk.

Switching from a Remote Control Centre

If the device is connected to a remote substation via a system (SCADA) interface, the corresponding switching tests may also be checked from the substation. Please also take into consideration that the switching authority is set in correspondence with the source of commands used.

3.3.13 Triggering Oscillographic Recording for Test

In order to be able to test the stability of the protection during switchon procedures also, switchon trials can also be carried out at the end. Oscillographic records obtain the maximum information about the behaviour of the protection.

Prerequisite

Along with the capability of storing fault recordings via pickup of the protection function, the 7SD610 also has the capability of capturing the same data when commands are given to the device via the service program DIGSI, the serial interface, or a binary input. For the latter, event „`>Trig.Wave.Cap.`“ must be allocated to a binary input. Triggering of the recording then occurs, for example, via the binary input when the protection object is energized.

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 oscillographic recording, and has a number for establishing a sequence. However, these recordings are not displayed in the fault indication buffer, as they are not fault events.

Start Test Measurement Recording

To trigger test measurement recording with DIGSI, click on **Test** in the left part of the window. Double click in the list view the **Test fault recording** entry (see Figure 3-29).

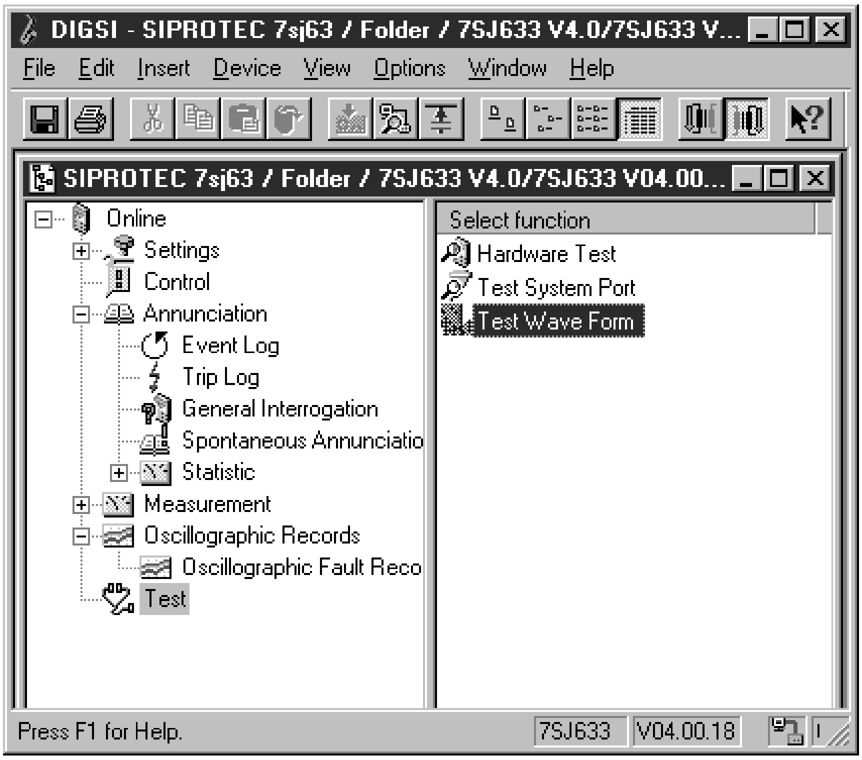


Figure 3-29 Triggering oscillographic recording with DIGSI — example

Oscillographic recording is immediately started. During the recording, an annunciation is output in the left area of the status line. Bar segments additionally indicate the progress of the procedure.

The SIGRA or the Comtrade Viewer program is required to view and analyse the oscillographic data.

3.4 Final Preparation of the Device

The used terminal screws must be tightened, including those that are not used. All the plug connectors must be correctly inserted.

Caution!

Do not apply force!

The tightening torques must not be exceeded as the threads and terminal chambers may otherwise be damaged!

The setting values should be checked again if they were changed during the tests. Check if protection, control and auxiliary functions to be found with the configuration parameters are set correctly (Section 2.1.1, Functional Scope). All desired functions must be switched ***ON***. Ensure that a copy of the setting values is stored on the PC.

Check the internal clock of the device. If necessary, set the clock or synchronize the clock if the element is not automatically synchronized. Further details on this subject are described in /1/.

The indication buffers are deleted under **Main Menu** → **Annunciation** → ***Set/Reset***, so that in the future they only contain information on actual events and states. The numbers in the switching statistics should be reset to the values that were existing prior to the testing.

The counters of the operational measured values (e.g. operation counter, if available) are reset under **Main Menu** → **Measurement** → ***Reset***.

Press the ESC key, several times if necessary, to return to the default display.

Clear the LEDs on the front panel by pressing the LED key, so that they only show real events and states. In this context, saved output relays are reset, too. Pressing the LED key also serves as a test for the LEDs on the front panel because they should all light when the button is pressed. If the LEDs display states relevant by that moment, these LEDs, of course, stay lit.

The green „RUN“ LED must light up, whereas the red „ERROR“ must not light up.

Close the protective switches. If test switches are available, then these must be in the operating position.

The device is now ready for operation.

■

Technical Data 4

This chapter presents the technical data of SIPROTEC 4 7SD610 device and its individual functions, including the limit values that must not be exceeded under any circumstances. The electrical and functional data of fully equipped devices are followed by the mechanical data, with dimensional drawings.

4.1 General

4.1.1 Analog Inputs

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_{Nom} = 1 A		Approx. 0.05 VA
- at I_{Nom} = 5 A		Approx. 0.3 VA
Current Path Loadability		
- thermal (RMS)		$100 \cdot I_{Nom}$ for 1 s $30 \cdot I_{Nom}$ for 10 s $4 \cdot I_N$ continuous
- dynamic (pulse)		$250 \cdot I_N$ (half-cycle)

Requirements for current transformers

1. Condition: for maximum fault current, current transformers must not be saturated stationary	$n' \geq \frac{I_{kd\ max}}{I_{N\ prim}}$
2. Condition: The operational accuracy limit factor must at least be 30 or a non-saturated period t'_{AL} of at least $^1/_4$ must be ensured	$n' \geq 30$ **or** $t'_{AL} \geq {}^1/_4$ AC cycle
3. 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)
Measuring range		0 V to 218.5 V (rms)
Power consumption per phase	At 100 V	≤ 0.1 VA
Voltage overload capability per phase		
- thermal (RMS)		230 V continuous

4.1.2 Auxiliary voltage

Direct Voltage

Voltage supply via integrated AC/DC converter			
Nominal auxiliary voltage U_H–	24/48 VDC	60/110/125 VDC	110/125/220/250 VDC
Admissible voltage ranges	19 to 58 VDC	48 to 150 VDC	88 to 300 VDC
Superimposed AC ripple voltage, Peak to peak IEC60255–11	≤ 15 % of the nominal auxiliary voltage		
Power Input			
- Quiescent	Approx. 6.5 W		
- Energized	Approx. 10 W		
Plus approx. 1.5 W per interface module			
Bridging time for failure / short circuit of DC auxiliary voltage	≥ 50 ms at U_{Aux} = 48 V and U_{Aux} ≥110 V		
	≥ 20 ms at U_{Aux} = 24 V and U_{Aux} ≥60 V		

AC Voltage

Voltage supply via integrated AC/DC converter	
Nominal Auxiliary Voltage AC U_{Aux} 230 V~ (release /CC and higher) 1)	115/230 V~
Admissible voltage ranges 184 to 265 V~	92 to 265 V~
Power Input	
- Quiescent	Approx. 10 VA
- Energized	Approx. 17 VA
Plus approx. 1.5 VA per interface module	
Bridging time for failure/short circuit of alternating auxiliary voltage	≥ 50 ms

1) Max. permissible ambient temperature +55 °C when operated with 230 V~

4.1.3 Binary Inputs and Outputs

Binary inputs

Number	7 (configurable)	
Rated Voltage Range	24 VDC to 250 VDC, in 3 ranges, bipolar	
Pick-up threshold	Changeable via jumpers	
- For nominal voltages	24/48 VDC and 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	
Impulse filter on input	220 nF coupling capacitance at 220 V with recovery time > 60 ms	

Binary Outputs

Signalling/Trip Relays (see also terminal assignments in Appendix A.2))			
Number and information	**(allocatable)**		
UL Listed	**NO Contact (normal)[1])**	**NO Contact (fast)[1])**	**NO/NC (switch selectable)[1])**
x	5	-	1
Switching capability MAKE	1000 W/VA		
Switching capability OFF	30 VA 40 W ohmic 25 W/VA for L/R ≤ 50ms		
Switching voltage			
DC	250 V		
AC	250 V		
Admissible current per contact (continuous)	5 A		
Permissible current per contact (close and hold)	30 A for 0.5 s (NO contact)		
Permissible total current on common path contacts	5 A continuous 30 A for 0.5 s		
Permissible relative closing time	-		
Operating time, approx.	8 ms	5 ms	8 ms
Alarm relay [1])		With 1 NC contact or 1 NO contact (switchable)	
Switching capacity	MAKE	1000 W/VA	
	OPEN	30 VA 40 W ohmic 25 VA at L/R ≤ 50 ms	
Switching voltage		250 V	
Permissible Current per Contact		5 A continuous 30 A for 0.5 s	

Signalling/Trip Relays (see also terminal assignments in Appendix A.2))			
Number and information	**(allocatable)**		
UL Listed	**NO Contact (normal)[1])**	**NO Contact (fast)[1])**	**NO/NC (switch selectable)[1])**
[1]) UL-listed 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 Communication Interfaces

Protection data interfaces

See Section 4.2 „Protection Data Interfaces and Communication Topology“

Operator Interface

Connection	Front side, non-isolated, RS232, 9-pin D-subminiature female connector for connection of a PC
Operation	With DIGSI
Transmission speed	Min. 4800 Baud; max. 115200 Baud; Factory Setting: 38400 Baud; Parity: 8E1
Transmission distance	15 m / 50 feet

Service/Modem Interface (optional)

	RS232/RS485/FO Acc. to ordered version	Isolatede interface for data transfer
	Operation	with DIGSI
RS232/RS485		RS232/RS485 according to ordered variant
	Connection for flush mounting housing	Rear panel, mounting location „C“, 9-pole D-subminiature female connector Shielded data cable
	For Panel Surface-Mounted Case	Shielded data cable at the terminal at the case bottom
		in console housing at the case bottom; 9-pole D-subminiature female connector
	Test Voltage	500 V; 50 Hz
	Transmission speed	Min. 4800 Baud; max. 115200 Baud Factory setting 38400 Baud
RS232		
	Maximum Distance of Transmission	15 m (50 ft)
RS485		
	Maximum Distance of Transmission	1,000 m (3280 ft)

System Interface (optional)

RS232/RS485/FO Profibus DP RS485/ Profibus DP FO DNP3.0/MODBUS RS485 DNP3.0/MODBUS FO Ethernet EN100 Acc. to ordered variant	Isolated interface for data transfer to a master terminal	
RS232		
	Connection for flush mounting housing	Rear panel, slot „B“, 9-pole D-subminiature female connector
	For Panel Surface-Mounted Case	in console housing at case bottom 9-pole D-subminiature female connector
	Test voltage	500 V; 50 Hz
	Transmission speed	Min. 4800 Baud; max. 38400 Baud Factory setting 19200 Baud
	Maximum Distance of Transmission	Max. 15 m
RS485		
	Connection for flush mounting housing	Rear panel, slot „B“, 9-pole D-subminiature female connector
	For Panel Surface-Mounted Case	in console housing at case bottom 9-pole D-subminiature female connector
	Test voltage	500 V; 50 Hz
	Transmission speed	min. 4800 Baud; max. 38400 Baud; Factory setting 19200 Bd
	Bridgeable distance	Max. 1 km
Fibre optic cable (FO)		
	FOC connector type	ST connector
	Connection for flush mounting housing	rear panel, mounting location „B“
	For Panel Surface-Mounted Case	in console housing at case bottom
	Optical wavelength	λ = 820 nm
	Laser Class I according to EN 60825-1/-2	Using glass fibre 50/125 μm or Using glass fibre 62.5/125 μm
	Permissible path attenuation	Max. 8 dB, with glass fibre 62.5/125 μm
	Maximum Distance of Transmission	Max. 1.5 km
	Character Idle State	Selectable, factory setting „Light off“
Profibus DP RS485		
	Connection for flush mounting housing	Rear panel, slot „B“, 9-pole D-subminiature female connector
	For Panel Surface-Mounted Case	in console housing at case bottom 9-pole D-subminiature female connector
	Test voltage	500 V; 50 Hz
	Transmission speed	up to 12 MBd
	Maximum Distance of Transmission	1,000 m (1640 ft.) at ≤ 93.75 kBd 500 m (1640 ft.) at ≤ 187.5 kBd 200 m (328 ft.) at ≤ 1.5 MBaud 100 m (328 ft.) at ≤ 12 MBaud

Profibus DP Fibre Optical Link		
	FOC connector type	ST connector; double ring
	Connection for flush mounting housing	Rear panel, mounting location „B“
	Connection for surface mounting housing	please use version with Profibus RS485 in the console housing as well as separate electrical/optical converter.
	Transmission speed	Conversion by means of external OLM up to 1.5 MBaud ≥ 500 kBaud for normal version ≤ 57600 Baud with detached operator panel
	Recommended speed:	> 500 kBaud
	Optical Wavelength	λ = 820 nm
	Laser Class I according to EN 60825-1/-2	Using glass fibre 50/125 μm or Using glass fibre 62.5/125 μm
	Permissible path attenuation	Max. 8 dB, with glass fibre 62.5/125 μm
	Transmission distance between two modules with redundant optical ring topology and optical fibre 62.5/125 m	2 m (6.6 ft.) with plastic fibre 500 Kbits/s max. 1.6 km (5,250 ft.) 1500 Kbits/s 530 m (1,760 ft.)
	Character idle state (status for "No character")	Light OFF
	Max. number of modules in optical rings with 500 kB/s or 1500 kB/s	41
DNP3.0 / MODBUS RS485		
	Connection for flush mounting housing	Rear panel, slot „B“, 9-pole D-subminiature female connector
	Connection for surface mounting housing	in console housing
	Test voltage	500 V; 50 Hz
	Transmission speed	Up to 19200 Baud
	Bridgeable distance	Max. 1 km
DNP3.0 / MODBUS FO		
	FOC connector type	ST connector receiver/transmitter
	Connection for flush mounting housing	Rear panel, mounting location „B“
	Connection for surface mounting housing	in console housing
	Transmission rate	Up to 19200 Baud
	Optical Wavelength	λ = 820 nm
	Laser class 1 according to EN60825-1/-2	Using glass fibre 50/125 μm or Using glass fibre 62.5/125 μm
	Permissible path attenuation	Max. 8 dB, with glass fibre 62.5/125 μm
	Bridgeable distance	Max. 1.5 km
Ethernet electrical (EN 100) for IEC 61850 and DIGSI		
	Connection for flush-mounted housing	Rear panel, mounting location „B“ 2 x RJ45 female connector 100BaseT according to IEEE802.3
	Connection for surface mounting housing	In console housing on bottom
	Test voltage (female connector)	500 V; 50 Hz
	Transmission speed	100 Mbits/s
	Bridgeable distance	20 m

<table>
<tr><td rowspan="9">Ethernet electrical (EN 100) for IEC 61850 and DIGSI</td><td colspan="2"></td></tr>
<tr><td>FOC connector type</td><td>ST connector receiver/transmitter</td></tr>
<tr><td>Connection for flush mounting housing</td><td>Rear panel, mounting location „B“</td></tr>
<tr><td>Connection for surface mounting housing</td><td>Not deliverable</td></tr>
<tr><td>Optical Wavelength</td><td>λ = 1350 nm</td></tr>
<tr><td>Transmission rate</td><td>100 Mbit/s</td></tr>
<tr><td>Laser class 1 according to
EN 60825-1/-2</td><td>Using glass fibre 50/125 μm
or
Using glass fibre 62,5/125 μm</td></tr>
<tr><td>Permissible path attenuation</td><td>Max. 5 dB, with glass fibre 62,5/125 μm</td></tr>
<tr><td>Bridgeable distance</td><td>Max. 800 m</td></tr>
</table>

Time synchronization interface

<table>
<tr><td colspan="2">Time synchronisation</td><td colspan="2">DCF 77/IRIG-B-Signal (telegram format IRIG-B000)/GPS</td></tr>
<tr><td colspan="2">Connection for flush mounting housing</td><td colspan="2">rear panel, mounting location „A“
9-pole D-subminiature female connector</td></tr>
<tr><td colspan="2">for surface-mounting case</td><td colspan="2">at two-tier terminals on the case bottom</td></tr>
<tr><td colspan="2">Nominal signal voltages
DCF77/IRIG B</td><td colspan="2">Selectable 5 V, 12 V or 24 V</td></tr>
<tr><td colspan="2">Nominal signal voltages
GPS</td><td colspan="2">24 V</td></tr>
<tr><td colspan="2">Test voltage</td><td colspan="2">500 V; 50 Hz</td></tr>
<tr><td colspan="4">Signal levels and burdens DCF77/IRIG-B:</td></tr>
<tr><td rowspan="2"></td><td colspan="3">Nominal signal input voltage</td></tr>
<tr><td>5 V</td><td>12 V</td><td>24 V</td></tr>
<tr><td>U_{IHigh}</td><td>6.0 V</td><td>15.8 V</td><td>31 V</td></tr>
<tr><td>U_{ILow}</td><td>1.0 V at I_{ILow} = 0.25 mA</td><td>1.4 V at I_{ILow} = 0.25 mA</td><td>1.9 V at I_{ILow} = 0.25 mA</td></tr>
<tr><td>I_{IHigh}</td><td>4.5 mA to 9.4 mA</td><td>4.5 mA to 9.3 mA</td><td>4.5 mA to 8.7 mA</td></tr>
<tr><td rowspan="2">R_I</td><td>890 Ω at U_I = 4 V</td><td>1930 Ω at U_I = 8.7 V</td><td>3780 Ω at U_I = 17 V</td></tr>
<tr><td>640 Ω at U_I = 6 V</td><td>1700 Ω at U_I = 15.8 V</td><td>3560 Ω at U_I = 31 V</td></tr>
<tr><td colspan="4">PPS signal for GPS</td></tr>
<tr><td colspan="2">ON-/OFF pulse duty factor</td><td colspan="2">1/999 to 1/1</td></tr>
<tr><td colspan="2">max. rise/fall time deviation of all receivers</td><td colspan="2">$\pm$3 μs</td></tr>
<tr><td colspan="4">For GPS receiver, antenna and power supply unit please refer to Appendix A1.2, Accessories.</td></tr>
</table>

4.1.5 Electrical Tests

Specifications

Standards:	IEC 60255 (product standards) IEEE Std C37.90.0/.1/.2 UL 508 VDE 0435 For more standards see also individual functions

Insulation test

Standards:	IEC 60255-5 and IEC 60870-2-1
High voltage test (routine test) all circuits except power supply, binary inputs, and communication / time sync. interfaces	2.5 kV (rms), 50 Hz
High voltage test (routine test) auxiliary voltage, binary inputs and outputs	3.5 kV–
High voltage test (routine test) only isolated communication and time synchronisation interfaces	500 V (rms), 50 Hz
Impulse voltage test (type test) all circuits except communication and time synchronisation interfaces, Class III	5 kV (peak), 1.2/50 μs, 0.5 Ws, 3 positive and 3 negative impulses at intervals of 5 s

EMC Tests for Immunity (type tests)

Standards:	IEC 60255-6 and -22, (product standards) EN 61000-6-2 (generic standard) VDE 0435 part 301DIN VDE 0435-110
High frequency test IEC 60255-22-1, Class III and VDE 0435 Section 303, Class III	2,5 kV (peak); 1 MHz; τ = 15 μs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2, Class IV and IEC 61000-4-2, Class IV	8 kV contact discharge; 15 kV air discharge, both polarities; 150 pF; R_i = 330 Ω
Irradiation with HF field, frequency sweep IEC 60255-22-3, Class III IEC 61000-4-3, Class III IEEE Std C37.90.2-2004	10 V/m and 20 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz 10 V/m; 800 MHz to 960 MHz; 80 % AM; 1 kHz 10 V/m; 1,4 GHz to 2,7 GHz; 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-3, IEC 61000-4-3, Class III, IEEE Std C37.90.2 –amplitude-modulated –pulse-modulated	20 V/m; 80; 160; 450; 900 MHz; 80 % AM; 1kHz; duty cycle > 10 s 35 V/m; 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbances / Burst IEC 60255-22-4 and IEC 61000-4-4, Class IV	4 kV; 5/50 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 - Auxiliary voltage - Analog measuring inputs, binary inputs, relay outputs	Impuls: 1,2/50 μs Common mode: 2 kV; 12 Ω; 9 μF Diff. mode: 1 kV; 2 Ω; 18 μF Common mode: 2 kV; 42 Ω; 0,5 μF Diff. mode: 1 kV; 42 Ω; 0,5 μF

Line conducted HF, amplitude modulated IEC 61000-4-6, Class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field IEC 60255-6 IEC 61000-4-8, Class IV	0,5 mT; 50 Hz, 30 A/m continuous; 300 A/m for 3 s; 50 Hz
Oscillatory Surge Withstand Capability IEEE Std C37.90.1	2,5 kV (peak); 1 MHz; τ = 15 µs; 400 Surges per s; test duration 2 s; R_i = 200 Ω
Fast Transient Surge Withstand Cap. IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities: R_i = 50 Ω; test duration 1 min
Radiated Electromagnetic Interference IEEE Std C37.90.2-2004	35 V/m; 80 MHz to 1000 MHz; key ring test
Damped oscillations IEC 60694, IEC 61000-4-12	2,5 kV (peak value), polarity alternating 100 kHz, 1 MHz, R_i = 200 Ω

EMC tests for noise emission (type test)

Standard:	EN 61000-6-3 (generic standard)
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B [1)]
Interference field strength IEC-CISPR 22	30 MHz to 1000 MHz Limit class B [1)]
Harmonic currents on the network lead at 230 VAC IEC 61000-3-2	Class A limits are observed
Voltage fluctuations and flicker on the network incoming feeder at 230 VAC IEC 61000-3-3	Limits are observed

[1)] From production series /EE, limit class A to IEC-CISPR 11

4.1.6 Mechanical Tests

Vibration and Shock Resistance during Stationary Operation

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	Sinusoidal 10 Hz to 60 Hz: ± 0.075 mm amplitude; 60 Hz to 150 Hz: 1 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal 5 g acceleration, duration 11 ms, each 3 shocks (in both directions of the 3 axes)
Seismic vibration IEC 60255-21-3, Class 1 IEC 60068-3-3	Sinusoidal 1 Hz to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 Hz to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 Hz to 35 Hz: 1 g acceleration (horizontal axis) 8 Hz to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

Vibration and Shock Resistance during Transport

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm Amplitude; 8 Hz to 150 Hz: 2 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal 15 g acceleration, duration 11 ms, each 3 shocks (in both directions of the 3 axes)
Continuous shock IEC 60255-21-2, Class 1 IEC 60068-2-29	Semi-sinusoidal 10 g acceleration, duration 16 ms, 1000 shocks each in both directions of the 3 axes

4.1.7 Climatic stress tests

Climatic tests

Standards:	IEC 60255-6
Type tested (acc. to IEC 60068-2-1 and -2, Test Bd for 16 h)	-25 °C to +85 °C
Permissible temporary operating temperature (tested for 96 h)	-20 °C to +70 °C (legibility of display may be restricted from +131 °F (+55 °C))
Recommended for permanent operation (according to IEC 60255-6)	-5 °C to +55 °C when max. half of the inputs and outputs are subjected to the max. permissible values
Limit Temperatures for Storage	-25 °C to +55 °C
Limit Temperatures during Transport	-25 °C to +70 °C
Storage and transport of the device with factory packaging!	
[1] Limit temperature for normal operation (i.e. output relays not energized)	-20 °C to +70 °C
[1] Limit temperature with maximum load (max. cont. permissible input and output quantities)	–23 °F to +40 °C (–5 °C to +55 °C)

[1] UL–certified according to standard 508 (Industrial Control Equipment)

Humidity

Admissible humidity	Annual average ≤ 75 % relative humidity; On 56 days of the year up to 93% relative humidity. Condensation must be avoided in operation!
It is recommended that all devices be installed so that they are not exposed to direct sunlight nor subject to large fluctuations in temperature that may cause condensation to occur.	

4.1.8 Deployment Conditions

The protection device is designed for installation in normal relay rooms and plants, so that electromagnetic immunity is ensured if installation is done properly.

In addition the following is recommended:

- Contacts and relays operating within the same cabinet or on the same relay board with digital protection equipment, should be in principle provided with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables shall be shielded with a conductive shield earthed at both ends. For substations with lower operating voltages, no special measures are normally required.
- For substations with lower operating voltages, no special measures are normally required. When removed, many components are electrostatically endangered; when handling the EEC standards (standards for **E**lectrostatically **E**ndangered **C**omponents) must be observed. The modules, boards, and device are not endangered when the device is completely assembled.

4.1.9 Constructive versions

Housing		7XP20
Dimensions		See dimensional drawings, Section 4.17

Housing	**Weight** **(for maximum number of components)**
in flush mounting housing	5 kg (11.02 lb)
In panel surface mounting housing	9.5 kg (20.94 lb)

Degree of protection according to IEC 60529		
For surface mounting housing equipment		IP 51
For the device in flush-mounted housing		
	Front	IP 51
	Rear	IP 50
for personell protection		IP 2x with closed protection cover
UL-certification conditions		Type 1 for front panel mounting Surrounding air temperature: tsurr: max. 70 ^{o}C, normal operation

4.2 Protection Data Interfaces and differential protection topology

Differential Protection Topology

Number of devices for one protected object (=number of ends delimited by the current transformer)	2

Protection Data Interfaces

Number	1
Connection optical fibre	Mounting location „D“
For flush mounting housing	On the rear side
for surface-mounting case	In console housing at device bottom
Connection modules for protection data interface, depending on the order variant:	

Module in the Device	Connector Type	Fibre Type	Optical Wavelength	Perm. path attenuation	Distance, maximum
FO5 1)	ST	Multimode 62.5/125 µm	820 nm	8 dB	1.5 km (0.93 miles)
FO6 1)	ST	Multimode 62.5/125 µm	820 nm	16 dB	3.5 km (2.2 miles)
FO17 2)	LC	Monomode 9/125 µm	1300 nm	13 dB	24 km (15.0 miles)
FO18 2)	LC	Monomode 9/125 µm	1300 nm	29 dB	60 km (37.5 miles)
FO19 2)	LC	Monomode 9/125 µm	1550 nm	29 dB	100 km (62.5 miles)

1) Laser class 1 acc. to EN 60825-1/ -2 using glass fibre 62.5/125 µm
2) Laser class 1 acc. to EN 60285-1/-2 when using glass fibre 9/125 µm

Protection Data Communication

Direct connection:		
Transmission rate	512 kbit/s	
Fibre Type	see Table above	
Optical wavelength		
Permissible path attenuation		
Bridgeable distance		
Connection via communication networks:		
Communication converter	see Appendix A.1, Section Accessories	
Supported network interfaces	G703.1 with 64 kbit/s G703-T1 with 1.455 Mbit/s G703-E1 with 2.048 Mbit/s	
	X.21 with 64 or 128 or 512 kbit/s	
	Pilot wires with 128 Kbits/s;	
Connection to communication converter	see Table above under module FO5	
Transmission rate	64 kbit/s with G703.1 1.455 Mbit/s for G703-T1 2.048 Mbit/s for G703-E1	
	512 kbit/s or 128 kBit/s or 64 kbit/s with X.21	
	128 kBit/s with pilot wires	
Max. transmission delay	0.1 ms to 30 ms	Increments 0.1 ms
Max. transmission delay difference	0.000 ms to 3.000 ms	Increments 0.001 ms

4.3 Differential Protection

Pickup Values

Differential current, I-DIFF>	I_N = 1 A	0.10 to 20.00 A	Increment 0.01 A
	I_N = 5 A	0.50 to 100.00 A	
Differential current when switching onto a fault; I-DIF>SWITCH ON	I_N = 1 A	0.10 to 20.00 A	Increment 0.01 A
	I_N = 5 A	0.50 to 100.00 A	
Differential current, high set differential current I-DIFF>>	I_N = 1 A	0.8 to 100.0 A or 8 (stage disabled)	Increment 0.01 A
	I_N = 5 A	4.0 to 500.00 A or 8 (stage disabled)	
Differential current, high set differential current when Switching; I-DIF>>SWITCHON	I_N = 1 A	0.8 to 100.0 A or ∞ (stage disabled)	Increment 0.01 A
	I_N = 5 A	4.0 to 500.00 A or ∞ (stage disabled)	
Tolerances		5 % of set value or 1% I_N per end	

Tripping Times

The operating times depend on the communication speed. The following data require a transfer rate of 512 kbit/s.		
Pickup / trip times of the I-DIFF>> stages at 50 or 60 Hz approx.	minimum	9 ms
	typical	12 ms
Dropout time of the I-DIFF>> stages approx.	typical	35 ms to 50 ms
Pickup / trip times of the I-DIFF> stages approx.	minimum (50/60 Hz)	27/24 ms
	typical (50/60 Hz)	29/26 ms
Dropout time of the I-DIFF> stages approx.	typical	35 ms to 50 ms

Delay times

Delay of I-DIFF stage	T-DELAY I-DIFF>	0.00 s to 60.00 s or ∞ (no trip)	Increments 0.01 s
Delay of I-DIFF stage for 1-phase pickup	T3I0 1PHAS	0.00 s to 60.00 s or ∞ (stage disabled for 1-phase pickup)	Increments 0.01 s
Expiry tolerances		1 % of setting value or 10 ms	
The set times are pure delay times with definite time protection.			

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 to 10.00	Increment 0.01
Transformer error at n'/n	0.5 % to 50.0 %	Steps 0.1 %

Transformer error at $n \cdot I_N$ (class)	0.5 % to 50.0 %	Steps 0.1 %
Further restraint quantities (adaptive self-restraint)	Frequency deviations, delay time differences, harmonics, synchronous quality, jitter	

Inrush stabilization

Restraint ratio 2. Inrush stabilization I_{2fN}/I_{fN}		0 % to 45 %	Steps 1 %
Max. current for restraint	I_N = 1 A	1.1 A to 25.0 A	Increment 0.1 A
	I_N = 5 A	5.5 A to 125.0 A	
Crossblock Function		Can be switched on/off	
Max. action time for crossblock CROSSB 2HM		0.00 s to 60.00 s or 0 (crossblock disabled) or ∞ (active until dropout)	Increments 0.01 s

Conditioning for Transformers (optional)

Matching of Vector Group	0 to 11 (x 30°)	Increment 1
Star-point conditioning	earthed or non-earthed (for each winding)	

Emergency operation

Communication failure	see section „Time Overcurrent Protection“

Frequency

Operating range	$0.8 \leq f/f_N \leq 1.2$ stable when starting machine

Standard precision of operational measured values

The standard precision of the operational measured values of the differential protection from ± 0.5% of the rated operational current is ensured up to a transformer error adjustment of 2:1.

4.4 Restricted Earth Fault Protection

Setting ranges

Differential current I_{REF}>	for I_N = 1 A	0.05 A to 2.00 A	Increment 0.01
	for I_N = 5 A	0.25 A to 10.00 A	
Threshold angle φ_{Limit}		100° (fixed)	
Trip Characteristic		see Figure	
Pickup tolerance for $\varphi(3\bar{I}_0'', 3\bar{I}_0') < 90°$ and address 221 I4/Iph CT = 1.000 and address 4113 SLOPE = 0.00			
Delay time T_{EDS}		0.00 s to 60.00 s or ∞ (no trip)	Increments 0.01 s
Expiry tolerances		1 % of set value or 10 ms	
The set times are pure delay times			

Operating Time

Pickup time at frequency	50 Hz	60 Hz
at 1.5 · set value I_{REF}> approx.	35 ms	34 ms
at 2.5 · set value I_{REF}> approx.	35 ms	34 ms
Dropout time, approx.	30 ms	30 ms
Drop-off to pickup ratio	approx. 0.7	

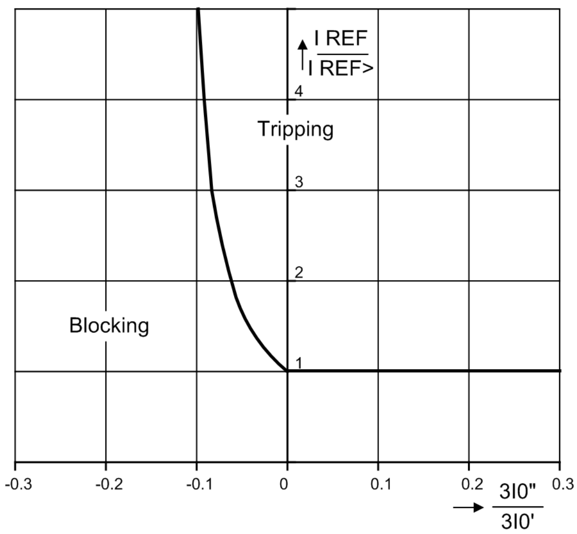


Figure 4-1 Tripping characteristic of the restricted earth fault protection depending on the earth current ratio $3I_0''/3I_0'$ (both currents in phase + or counter-phase –); I_{REF}> = setting; I_{Trip} = tripping current

4.5 Breaker Intertrip and Remote Tripping- Direct Local Trip

Breaker Intertrip and Remote Tripping

Intertripping of all opposite ends when single-end tripping	can be switched on/off

External direct trip

Operating time, total	Approx. 6 ms	
Trip time delay Trip Time DELAY	0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Time tolerance	1 % of setting value or 10 ms	
The set times are pure delay times.		

Remote Tripping

Tripping of remote ends by a command that is coupled into a binary input The operating times depend on the communication speed. The following data require a transmission rate of 512 kBit/s.			
Operating times, total approx.	minimum		7 ms
	typical		12 ms
Dropout times, total approx.	typical		19 ms
Trip time delay	T-ITRIP BI	0.00 s to 30.00 s	Increments 0.01 s
Trip time prolongation	T-ITRIP PROL BI	0.00 s to 30.00 s	Increments 0.01 s
Expiry tolerances		1 % of setting value or 10 ms	
The set times are pure delay times.			

4.6 Transmission of Binary Information (optional)

Remote commands

Number of possible remote commands		4
The operating times depend on the communication speed. The following data require a transmission rate of 512 kBit/s. The operating times refer to the entire signal path from entry via binary inputs until output of commands via output relays.		
Operating times, total approx.	minimum	8 ms
	typical	12 ms
Dropout times, total approx.	typical	19 ms

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

Pickup

High current pickup I>>>	for I_N = 1 A	0.10 A to 15.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 75.00 A or ∞ (disabled)	
High current pickup I>>>>	for I_N = 1 A	1.00 A to 25.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	5.00 A to 125.00 A or ∞ (disabled)	
Dropout to pickup ratio		Approx. 90 %	
Pickup tolerance		3 % of setting value or 1 % of I_N	

Times

Shortest trip time	approx. 10 ms

4.8 Backup Time Overcurrent Protection

Operating Modes

As emergency overcurrent protection or back-up overcurrent protection	
Backup time overcurrent protection	Effective when the differential protection system is blocked (e.g. because of a failure of the device communication)
Backup overcurrent protection	operates independent of any events

Characteristics

Definite time stages (definite)	I_{Ph}>, $3I_0$>, I_{Ph}>>, $3I_0$>>, I_{Ph}>>>, $3I_0$>>>, $I_{Ph}>_{ger}$, $3I_0>_{ger}$
Inverse time stages (IDMT)	I_P, $3I_{0P}$; I_{Pger}, $3I_{0Pger}$; one of the characteristics according to 4-2 to Figure 4-4 can be selected

High set current stages

Pickup value Iph>> (phases)	for I_N = 1 A	0.10 A to 25.00 A or ∞ (ineffective)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 125.00 A or ∞ (ineffective)	
Pickup value 3I0>> PICKUP (earth)	for I_N = 1 A	0.05 A to 25.00 A or ∞ (ineffective)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 125.00 A or ∞ (ineffective)	
Delay T Iph>> (Phases)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Delay T 3I0>> (earth)		0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Dropout ratio		Approx. 0,93 for $I/I_N \geq 0,5$	
Pick-up times		Approx. 25 ms	
Dropout times		Approx. 30 ms	
Tolerances	Currents	3 % of setting value or 1 % nominal current	
	Times	1 % of setting value or 10 ms	
The set times are pure delay times			

Overcurrent stages

Pickup value Iph> (phases)	for I_N = 1 A	0.10 A to 25.00 A or ∞ (ineffective)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 125.00 A or ∞ (ineffective)	
Pickup value 3I0> (earth)	for I_N = 1 A	0.05 A to 25.00 A or ∞ (ineffective)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 125.00 A or ∞ (ineffective)	
Delays	T Iph>	0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
	T 3I0>	0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s

Pickup value Iph> STUB (phases)	for I_N = 1 A	0.10 A to 25.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 125.00 A or ∞ (disabled)	
Pickup value 3I0> STUB (earth)	for I_N = 1 A	0.05 A to 25.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 125.00 A or ∞ (disabled)	
Delays	T Iph STUB	0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
	T 3I0 STUB	0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Pickup thresholdIph> Dir. (directional phases)	for I_N = 1 A	0.10 A to 25.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 125.00 A or ∞ (disabled)	
Pickup threshold3I0> Dir. (Earth directional)	for I_N = 1 A	0.05 A to 25.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 125.00 A or ∞ (disabled)	
Time Delays (directional stages)	T Iph> Dir.	0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
	T 3I0> Dir.	0.00 s to 30.00 s or ∞ (ineffective)	Increments 0.01 s
Dropout ratio		Approx . 0,93 for $I/I_N \geq 0{,}5$	
Pick-up times		Approx. 25 ms	
Dropout times		Approx. 30 ms	
Tolerances	Currents	3 % of setting value or 1 % nominal current	
	Times	1 % of setting value or 10 ms	
The set times are pure delay times			

Inverse Current Stage (IEC)

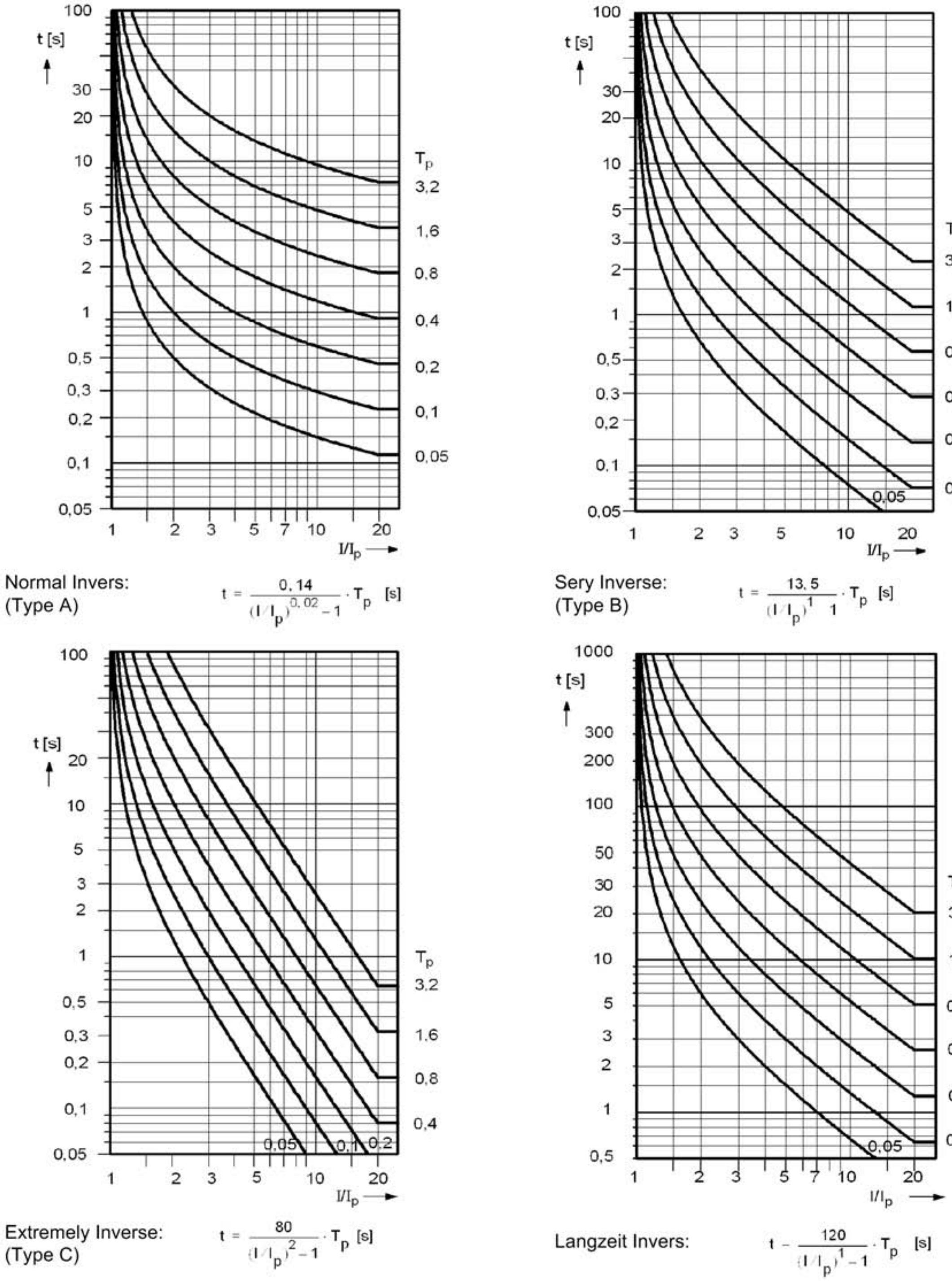
Pickup value Ip>I (phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (ineffective)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (ineffective)	
(earth) Pickup value3I0p PICKUP	for I_N = 1 A	0.05 A to 4.00 A or ∞ (ineffective)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 20.00 A or ∞ (ineffective)	
Time factors	T Ip Time Dial (Phases)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
	T 3I0p TimeDial (Earth)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays	T Ip Add (Phases)	0.00 s to 30.00 s	Increments 0.01 s
	T 3I0p Add (Earth)	0.00 s to 30.00 s	Increments 0.01 s
Tolerances currents		Pickup at $1.05 \leq I/I_P \leq 1.15$ or $1.05 \leq I/3I_{0P} \leq 1.15$	
Tolerances times		5 % ± 15 ms for $2 \leq I/I_P \leq 20$ and $0.1 \leq T_{IP}/s \leq 2$ or $2 \leq I/3I_{0P} \leq 20$ and $0.1 \leq T_{3I0P}/s \leq 2$	

Pickup value Ip> Dir.I (directional phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (disabled)	
Pickup threshold3I0p Dir. (Earth directional)	for I_N = 1 A	0.05 A to 4.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 20.00 A or ∞ (disabled)	
Time factors (directional stages)	T Ip Dir. (Phases)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
	T 3I0p Dir. (Earth)	0.05 s to 3.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays (directional stages)	T Ip Add Dir. (Phases)	0.00 s to 30.00 s	Increments 0.01 s
	T 3I0p Add Dir. (Earth)	0.00 s to 30.00 s	Increments 0.01 s
Tolerances currents (directional stages)		Pickup at $1.05 \leq I/I_{Pger} \leq 1.15$ or $1.05 \leq I/3I_{0Pgeer} \leq 1.15$	
Tolerances times (directional stages)		5 % ± 15 ms for $2 \leq I/I_{Pger} \leq 20$ and $0.1 \leq T_{IPger}/s \leq 2$ or $2 \leq I/3I_{0Pger} \leq 20$ and $0.1 \leq T_{3I0Pger}/s \leq 2$	
Characteristics		See Figure 4-2	
Defined times		1 % of setting value or 10 ms	

Inverse Current Stage (ANSI)

Pickup value Ip>I (phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (disabled)	
Pickup threshold3I0p PICKUP (Earth)	for I_N = 1 A	0.05 A to 4.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 20.00 A or ∞ (disabled)	
Time factors	Time Dial TD Ip (Phases)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
	TimeDial TD3I0p (Earth)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays	T Ip Add (Phases)	0.00 s to 30.00 s	Increments 0.01 s
	T 3I0p Add (Earth)	0.00 s to 30.00 s	Increments 0.01 s
Tolerances currents		Pickup at $1.05 \leq I/I_P \leq 1.15$ or $1.05 \leq I/3I_{0P} \leq 1.15$	
Tolerances times		5 % ± 15 ms for $2 \leq I/I_P \leq 20$ and $D_{IP}/s \geq 1$ or $2 \leq I/3I_{0P} \leq 20$ and $D_{3I0P}/s \geq 1$	
Pickup value Ip> Dir.I (directional phases)	for I_N = 1 A	0.10 A to 4.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A or ∞ (disabled)	
Pickup value 3I0p Dir.I (directional earth)	for I_N = 1 A	0.05 A to 4.00 A or ∞ (disabled)	Increment 0.01 A
	for I_N = 5 A	0.25 A to 20.00 A or ∞ (disabled)	

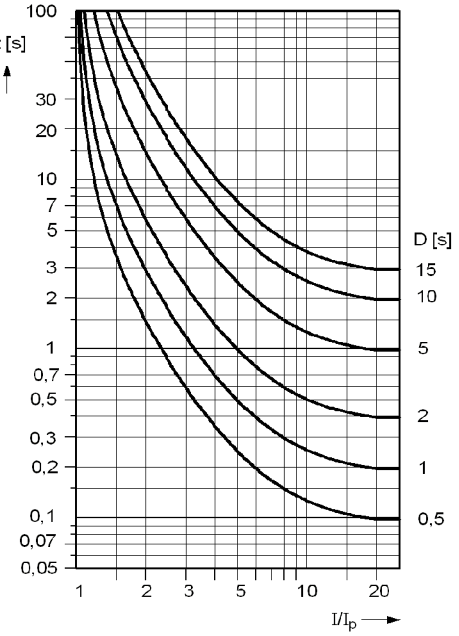
Time factors (directional stages)	D Ip Dir. (Phases)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
	D 3I0p Dir. (Earth)	0.50 s to 15.00 s or ∞ (ineffective)	Increments 0.01 s
Additional time delays (directional stages)	T Ip Add Dir. (Phases)	0.00 s to 30.00 s	Increments 0.01 s
	T 3I0p Add Dir. (Earth)	0.00 s to 30.00 s	Increments 0.01 s
Tolerances currents (directional stages)		Pickup at $1.05 \leq I/I_P \leq 1.15$ or $1.05 \leq I/3I_{0P} \leq 1.15$	
Tolerances times (directional stages)		5 % ± 15 ms for $2 \leq I/I_{Pger} \leq 20$ and $D_{IPger}/s \geq 1$ or $2 \leq I/3I_{0Pger} \leq 20$ and $D_{3I0Pger}/s \geq 1$	
Characteristics		See Figure 4-3 and 4-4	
Defined times		1 % of set value or 10 ms	

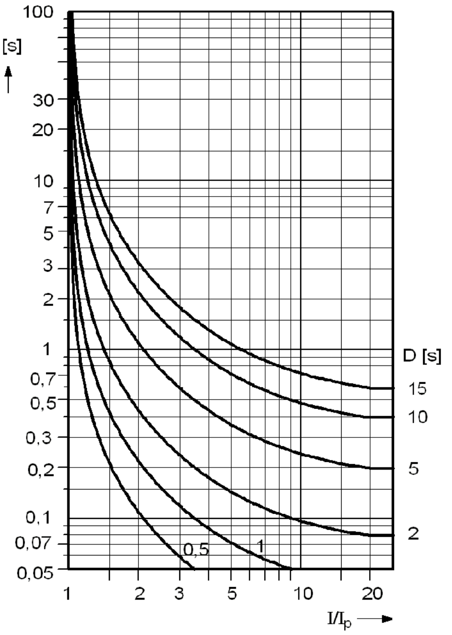


t Trip Time
T_p Setting Value of the Time Factor
I Fault current
I_p Setting value current

Note:
For earth fault read 3I0p instead of Ip and T3I0p instead of Tp.

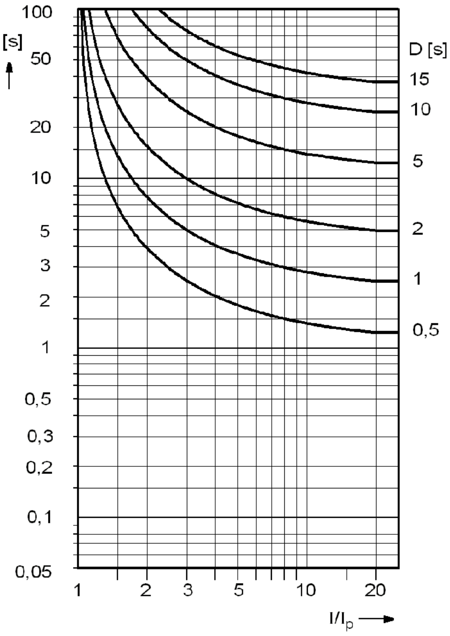
Figure 4-2 Trip time characteristics of inverse time overcurrent stage, acc. IEC (phases and earth)

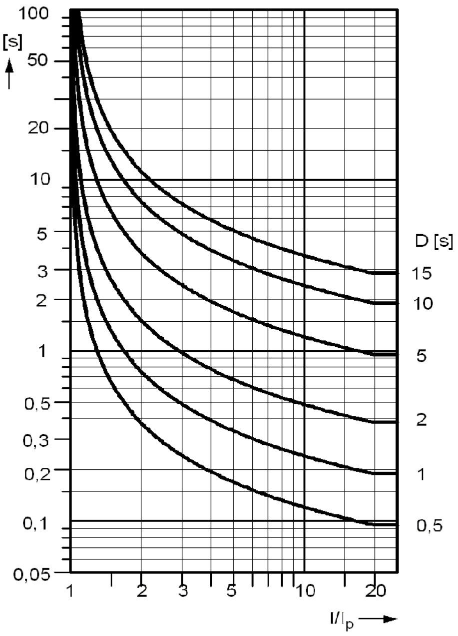




INVERSE $t = \left(\frac{8,9341}{(I/I_p)^{2,0938} - 1} + 0,17966\right) \cdot D$ [s]

SHORT INVERSE $t = \left(\frac{0,2663}{(I/I_p)^{1,2969} - 1} + 0,03393\right) \cdot D$ [s]

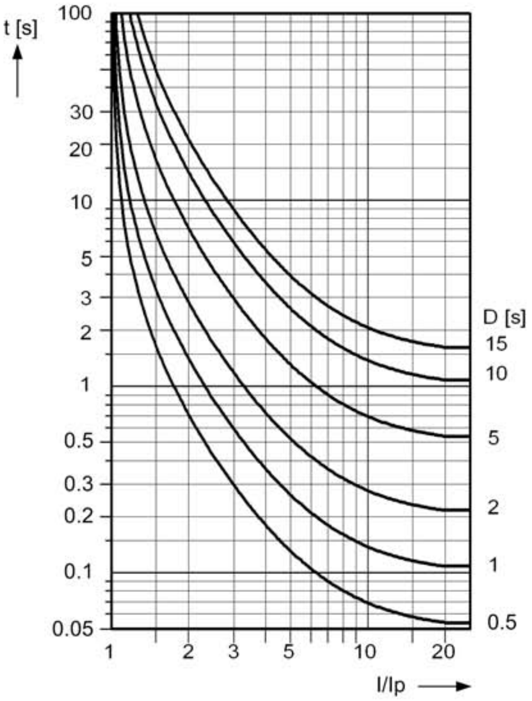




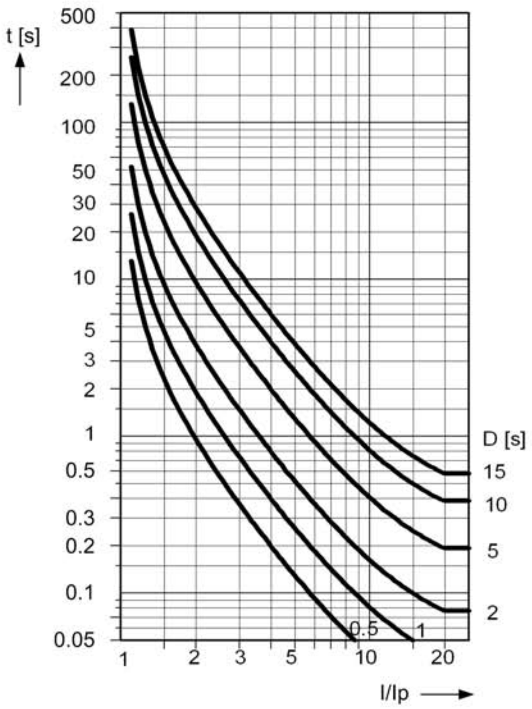
LONG INVERSE $t = \left(\frac{5,6143}{(I/I_p) - 1} + 2,18592\right) \cdot D$ [s]

MODERATELY INVERSE $t = \left(\frac{0,0103}{(I/I_p)^{0,02} - 1} + 0,0228\right) \cdot D$ [s]

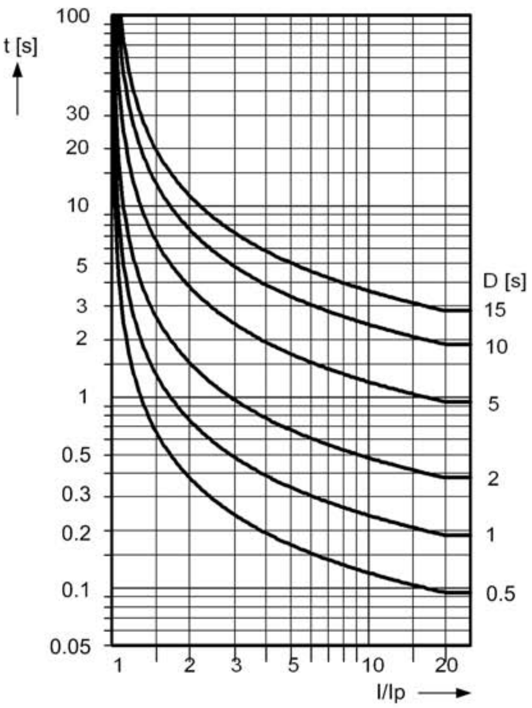
Figure 4-3 Trip time characteristics of inverse time overcurrent stage, acc. ANSI/IEEE (phases and earth)



VERY INVERSE: $t = \left(\frac{3{,}922}{(I/I_p)^2 - 1} + 0{,}0982 \right) \cdot D[s]$



EXTREMELY INVERSE: $t = \left(\frac{5{,}64}{(I/I_p)^2 - 1} + 0{,}02434 \right) \cdot D[s]$



DEFINITE INVERSE: $t = \left(\frac{0{,}4797}{(I/I_p)^{1{,}5625} - 1} + 0{,}21359 \right) \cdot D[s]$

t Trip Time
D Setting value time multiplier
I Fault current
Ip Setting value current

Note:
For earth fault read 3I0p instead of Ip and D3I0p instead of D.

Figure 4-4 Trip time characteristics of inverse time overcurrent stage, acc. ANSI/IEEE (phases and earth)

4.9 Automatic Reclosure (optional)

Automatic Reclosures

Number of reclosures	Max. 8, first 4 with individual settings	
Type (depending on ordered version)	1-pole, 3-pole or 1-/3-pole	
Control	With pickup or trip command	
Action times Initiation possible without pickup and action time	0.01 s to 300.00 s; ∞	Increments 0.01 s
Different dead times before reclosure can be set for all operating modes and cycles	0.01 s to 1800.00 s; ∞	Increments 0.01 s
Dead times after evolving fault recognition	0.01 s to 1800.00 s	Increments 0.01 s
Reclaim time after reclosure	0.50 s to 300.00 s	Increments 0.01 s
Blocking time after dynamic blocking	0.5 s	
Blocking time after manual closing	0.50 s to 300.00 s; 0	Increments 0.01 s
Start signal monitoring time	0.01 s to 300.00 s	Increments 0.01 s
Circuit breaker monitoring time	0.01 s to 300.00 s	Increments 0.01 s

Adaptive Dead Time/Reduced Dead Time/Dead Line Check

Adaptive dead time	With voltage measurement or with close command transmission	
Action times Initiation possible without pickup and action time	0.01 s to 300.00 s; ∞	Increments 0.01 s
Maximum dead time	0.50 s to 3000.00 s	Increments 0.01 s
Voltage measurement dead line or bus	2 V to 70 V (Ph-E)	Increments 1 V
Voltage measurement live or bus	30 V to 90 V (Ph-E)	Increments 1 V
Voltage measuring time	0.10 s to 30.00 s	Increments 0.01 s
Time delay for close command transmission	0.00 s to 300.00 s; ∞	Increments 0.01 s

4.10 Voltage Protection (optional)

Phase-earth overvoltages

Overvoltage U_{Ph}>>		1.0 V to 170.0 V; ∞	Increments 0.1 V
Delay $T_{UPh>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Overvoltage U_{Ph}>		1.0 V to 170.0 V; ∞	Increments 0.1 V
Delay $T_{UPh>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		0.30 to 0.99	Increment 0.01
Pickup time		approx. 40 ms	
Dropout time		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

Phase-phase overvoltages

Overvoltage U_{PhPh}>>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay T_{UPhPh}		0.00 s to 100.00 s; ∞	Increments 0.01 s
Overvoltage U_{PhPh}>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{UPhPh>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		0.30 to 0.99	Increment 0.01
Pickup time		approx. 40 ms	
Dropout time		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

Overvoltage positive sequence systemU_1

Overvoltage U_1>>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{U1>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Overvoltage U_1>>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{U1>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		0.30 to 0.99	Increment 0.01
Compounding		Can be switched on/off	
Pickup time		approx. 40 ms	
Dropout time		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

Overvoltage negative sequence system U_2

Overvoltage U_2>>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{U2>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Overvoltage U_2>>		2.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{U2>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		0.30 to 0.99	Increment 0.01
Pickup time		approx. 40 ms	
Dropout time		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

Overvoltage zero sequence system $3U_0$ or any single-phase voltage U_X

Overvoltage U_0>>		1.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{3U0>>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Overvoltage U_0>		1.0 V to 220.0 V; ∞	Increments 0.1 V
Delay $T_{3U0>}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		0.30 to 0.99	Increment 0.01
Pickup time			
With repeated measurement		approx. 75 ms	
Without repeated measurement		approx. 40 ms	
Dropout time			
With repeated measurement		approx. 75 ms	
Without repeated measurement		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

Phase-earth undervoltages

Undervoltage U_{Ph}<<		1.0 V to 100.0 V	Increments 0.1 V
Delay $T_{UPh<<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Undervoltage U_{Ph}<		1.0 V to 100.0 V	Increments 0.1 V
Delay $T_{UPh<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		1,01-1,20	Increment 0.01
Current criterion		Can be switched on/off	
Pickup time		ca. 40 ms	
Dropout time		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

Phase-phase undervoltages

Undervoltage U_{PhPh}<<		1.0 V to 175.0 V	Increments 0.1 V
Delay $T_{UPhPh<<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Undervoltage U_{PhPh}<		1.0 V to 175.0 V	Increments 0.1 V
Delay $T_{UPhPh<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		1,01-1,20	Increment 0.01
Current criterion		Can be switched on/off	
Pickup time		approx. 40 ms	
Dropout time		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

Undervoltage positive sequence systemU_1

Undervoltage U_1<<		1.0 V to 100.0 V	Increments 0.1 V
Delay $T_{U1<<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Undervoltage U_1<		1.0 V to 100.0 V	Increments 0.1 V
Delay $T_{U1<}$		0.00 s to 100.00 s; ∞	Increments 0.01 s
Drop-off to pickup ratio		1,01-1,20	Increment 0.01
Current criterion		Can be switched on/off	
Pickup time		approx. 40 ms	
Dropout time		approx. 35 ms	
Tolerances	Voltages	3 % of setting value or 1 V	
	Times	1 % of set value or 10 ms	

4.11 Frequency Protection (optional)

Frequency Elements

Quantity	4, depending on setting effective on f< or f>

Pick-up Values

f> or f< adjustable for each element		
For f_N = 50 Hz	45.50 Hz to 54.50 Hz	Increments 0.01 Hz
For f_N = 60 Hz	55.50 Hz to 64.50 Hz	Increments 0.01 Hz

Times

Pickup times f>, f<	Approx. 85 ms	
Dropout times f>, f<	Approx. 30 ms	
Delay times T	0.00 s to 600.00 s	Increments 0.01 s
The set times are pure delay times. Note on dropout times: Dropout was enforced by current = 0 A and voltage = 0 V. Enforcing the dropout by means of a frequency change below the dropout threshold extends the dropout times.		

Dropout Frequency

Δf = | pickup value – dropout value |	Approx. 20 mHz

Operating Range

In voltage range	approx. 0.65 · U_N up to 230 V (phase-phase)
In frequency range	25 Hz to 70 Hz

Tolerances

Frequencies f>, f< in specific range (f_N ± 10 %)	15 mHz in range U_{LL}: 50 V to 230 V
Time delays T(f<, f>)	1 % of setting value or 10 ms

4.12 Circuit Breaker Failure Protection (optional)

Circuit breaker monitoring

Current flow monitoring	for I_N = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 100.00 A	
Zero sequence current monitoring	for I_N = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 100.00 A	
Dropout to pickup ratio		Approx. 0.95	
Tolerance		5 % of setting value or 1 % of nominal current	
Monitoring of circuit breaker auxiliary contact position			
- for three-pole tripping		Binary input for circuit breaker auxiliary contact	
- for single-pole tripping		1 binary input for auxiliary contact per pole or 1 binary input for series connection NO contact and NC contact	
Note: The circuit breaker failure protection can also operate without the indicated circuit breaker auxiliary contacts, but the function range is then reduced. Auxiliary contacts are necessary for the circuit breaker failure protection for tripping without or with a very low current flow (e.g. Buchholz protection) and for end fault protection and circuit breaker pole discrepancy supervision.			

Initiation conditions

For circuit breaker failure protection	Internal or external single-pole trip [1)] Internal or external three-pole trip [1)] Internal or external three-pole trip without current [1)]

[1)] Via binary inputs

Times

Pickup time	Approx. 5 ms with measured quantities present Approx. 20 ms after switch-on of measured quantities	
Dropout time, internal (overshoot time)	≤ 15 ms at sinusoidal measured values, ≤ 25 ms maximal	
Delay times for all stages	0.00 s to 30.00 s; ∞	Increments 0.01 s
Tolerance	1 % of setting value or 10 ms	

End fault protection

With signal transmission to the opposite line end		
Time delay	0.00 s to 30.00 s; ∞	Increments 0.01 s
Tolerance	1 % of setting value or 10 ms	

Pole discrepancy supervision

Initiation criterion	Not all poles are closed or open	
Monitoring time	0.00 s to 30.00 s; ∞	Increments 0.01 s
Tolerance	1 % of setting value or 10 ms	

4.13 Thermal Overload Protection

Setting Ranges

Factor k according to IEC 60255-8		0.10 to 4.00	Increments 0.01
Time Constant τ_{th}		1.0 min to 999.9 min	Increments 0.1 min
Thermal Alarm $\Theta_{Alarm}/\Theta_{Trip}$		50 % to 100 % of the trip over-temperature	Increments 1 %
Current Overload I_{Alarm}	for I_N = 1 A	0.10 A to 4.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A	

Calculation Method

Calculation method temperature rise	Maximum temperature rise of 3 phases Average of temperature rise of 3 phases Temperature rise from maximum current

Tripping Characteristic

Tripping characteristic for $(I/k \cdot I_N) \leq 8$

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

Meaning of abbreviations:

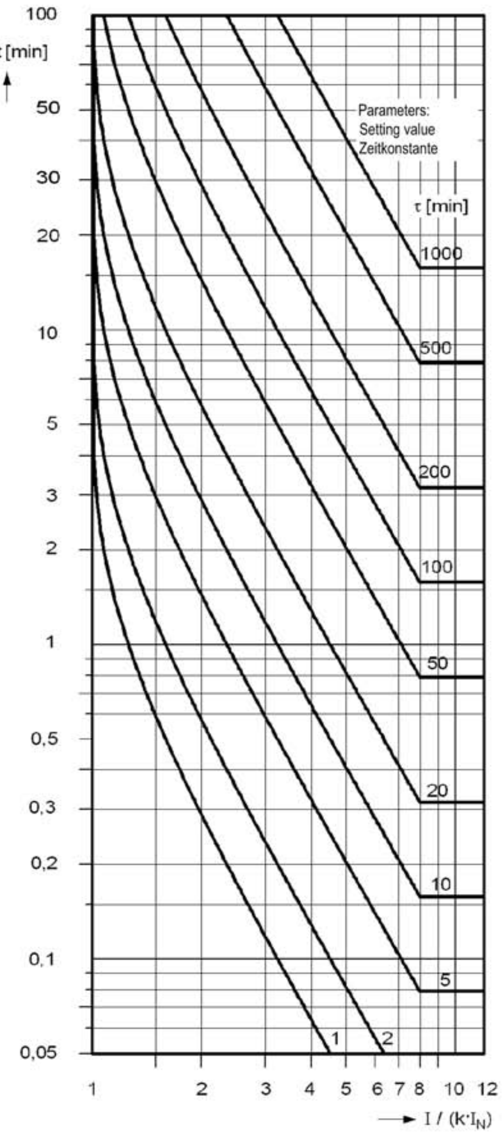
t	Tripping time
τ	Temperature rise time factor
I	Load current
I_{pre}	Previous load current
k	Setting factor according to IEC 60255-8
I_N	Rated current of protected object

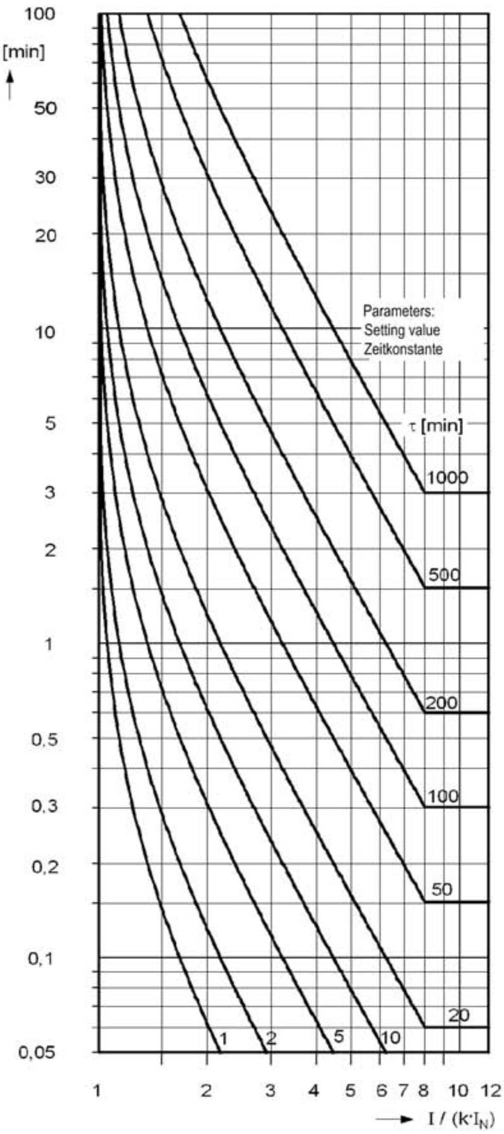
Dropout to Pickup Ratio

Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97

Tolerances

Referring to $k \cdot I_N$	2 % or 1 % of nominal current; Class 2 % according to IEC 60255-8
Referring to tripping time	3 % or 1 s for $I/(k \cdot I_N) > 1.25$; class 3 % per IEC 60255-8





without pre-load:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [\text{min}]$$

with 90 % pre-load:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{vor}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [\text{min}]$$

Figure 4-5 Trip time characteristics of the overload protection

4.14 Monitoring Functions

Measured Values

Current sum		$I_F = \mid \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} + k_I \cdot \underline{I}_E \mid >$ SUM.I Threshold $\cdot I_N$ + SUM.FactorI $\cdot \Sigma \mid I \mid$	
- SUM.ILimit	for I_N = 1 A	0.10 A to 2.00 A	Increment 0.01 A
	for I_N = 5 A	0.50 A to 10.00 A	Increment 0.01 A
- SUM.FACTOR I		0.00 to 0.95	Increment 0.01
Voltage sum		$U_F = \mid \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \cdot \underline{U}_{EN} \mid > 25$ V	
Current Symmetry		$\mid I_{min} \mid / \mid I_{max} \mid <$ BAL.FACTOR.I as long as $I_{max}/I_N >$ BAL.ILIMIT/I_N	
- BAL.FACTOR.I		0.10 to 0.95	Increment 0.01
- BAL.ILIMIT	for I_N = 1 A	0.10 A to 1.00 A	Increment 0.01 A
	for I_N = 5 A	0.50 A to 5.00 A	Increment 0.01 A
- T BAL.ILIMIT		5 s to 100 s	Increments 1 s
Broken wire		one conductor without current, the others with current (monitoring of current transformer circuits on current step change in one phase without residual current)	
Voltage balance		$\mid U_{min} \mid / \mid U_{max} \mid <$ BAL.FACTOR.U as long as $\mid U_{max} \mid >$ BAL.ULIMIT	
- BAL.FACTOR.U		0.58 to 0.95	Increment 0.01
- BAL.ULIMIT		10 V to 100 V	Increment 1 V
- T BAL.ULIMIT		5 s to 100 s	Increments 1 s
Voltage phase sequence		$\underline{U}_{L1}$ leads $\underline{U}_{L2}$ leads $\underline{U}_{L3}$ as long as $\mid \underline{U}_{L1} \mid, \mid \underline{U}_{L2} \mid, \mid \underline{U}_{L3} \mid > 40 \text{ V}/\sqrt{3}$	
Asymmetrical measuring voltage failure (Fuse Failure Monitor)		$3 \cdot U_0 >$ FFM U> OR $3 \cdot U_2 >$ FFM U> AND simultaneously $3 \cdot I_0 <$ FFM I< AND $3 \cdot I_2 <$ FFM I<	
- FFM U>		10 V to 100 V	Increments 1 V
- FFM I<	for I_N = 1 A	0.10 A to 1.00 A	Increment 0.01 A
	for I_N = 5 A	0.50 A to 5.00 A	Increment 0.01 A
Three-phase measuring voltage failure (Fuse Failure Monitor)		all $U_{Ph-E} <$ FFM UMEAS < AND simultaneously all $\Delta I_{Ph} <$ FFM I_{delta} AND all $I_{Ph} > (I_{Ph}>$ (Dist.)) OR all $U_{Ph-E} <$ FFM UMEAS < AND simultaneously all $I_{Ph} < (I_{Ph}>$ (Dist.)) AND all $I_{Ph} > 40$ mA	
- FFM UMEAS <		2 V to 100 V	Increments 1 V
- FFM I_{delta}	for I_N = 1 A	0.05 A to 1.00 A	Increment 0.01 A
	for I_N = 5 A	0.25 A to 5.00 A	Increment 0.01 A
- T U Monitoring (waiting time for additional measured voltage failure monitoring)		0.00 s to 30.00 s	Increments 0.01 s
- T U T mcb		0 ms to 30 ms	Increments 1 ms

Trip Circuit Monitoring

Number of supervised trip circuits	1 to 3	
Operation of each trip circuit	With 1 binary input or with 2 binary inputs	
Pickup and dropout time	approx. 1 to 2 s	
Settable delay time for operation with 1 binary input	1 s to 30 s	Increments 1 s

4.15 User defined functions (CFC)

Function Blocks and their Possible Allocation to the Priority Classes

Function Module	Explanation	Task Level			
		MW_BEARB	PLC1_BEARB	PLC_BEARB	SFS_BEARB
ABSVALUE	Magnitude Calculation	X	–	–	–
ADD	Addition	X	X	X	X
ALARM	Alarm clock	X	X	X	X
AND	AND - Gate	X	X	X	X
BLINK	Flash block	X	X	X	X
BOOL_TO_CO	Boolean to Control (conversion)	–	X	X	–
BOOL_TO_DI	Boolean to Double Point (conversion)	–	X	X	X
BOOL_TO_IC	Bool to Internal SI, Conversion	–	X	X	X
BUILD_DI	Create Double Point Annunciation	–	X	X	X
CMD_CANCEL	Cancel command	X	X	X	X
CMD_CHAIN	Switching Sequence	–	X	X	–
CMD_INF	Command Information	–	–	–	X
COMPARE	Measured value comparison	X	X	X	X
CONNECT	Connection	–	X	X	X
COUNTER	Counter	X	X	X	X
CV_GET_STATUS	Information status of the metered value, decoder	X	X	X	X
D_FF	D- Flipflop	–	X	X	X
D_FF_MEMO	Status Memory for Restart	X	X	X	X
DI_GET_STATUS	Information status double point indication, decoder	X	X	X	X
DI_SET_STATUS	Double point indication with status, encoder	X	X	X	X
DI_TO_BOOL	Double Point to Boolean (conversion)	–	X	X	X
DINT_TO_REAL	DoubleInt after real, adapter	X	X	X	X
DIST_DECODE	Double point indication with status, decoder	X	X	X	X
DIV	Division	X	X	X	X
DM_DECODE	Decode Double Point	X	X	X	X
DYN_OR	Dynamic OR	X	X	X	X
LIVE_ZERO	Live zero monitoring, non-linear characteristic	X	–	–	–
LONG_TIMER	Timer (max.1193h)	X	X	X	X
LOOP	Feedback Loop	X	X	X	X
LOWER_SETPOINT	Lower Limit	X	–	–	–
MUL	Multiplication	X	X	X	X
MV_GET_STATUS	Information status measured value, decoder	X	X	X	X

MV_SET_STATUS	Measured value with status, encoder	X	X	X	X
NAND	NAND - Gate	X	X	X	X
NEG	Negator	X	X	X	X
NOR	NOR - Gate	X	X	X	X
OR	OR - Gate	X	X	X	X
REAL_TO_DINT	Real after DoubleInt, adapter	X	X	X	X
REAL_TO_UINT	Real after U-Int, adapter	X	X	X	X
RISE_DETECT	Rising edge detector	X	X	X	X
RS_FF	RS- Flipflop	–	X	X	X
RS_FF_MEMO	Status memory for restart	X	X	X	X
SI_GET_STATUS	Information status single point indication, decoder	X	X	X	X
SI_SET_STATUS	Single point indication with status, encoder	X	X	X	X
SQUARE_ROOT	Root Extractor	X	X	X	X
SR_FF	SR- Flipflop	–	X	X	X
SR_FF_MEMO	Status memory for restart	X	X	X	X
ST_AND	AND gate with status	X	X	X	X
ST_NOT	Negator with status	X	X	X	X
ST_OR	OR gate with status	X	X	X	X
SUB	Substraction	X	X	X	X
TIMER	Timer	–	X	X	–
TIMER_SHORT	Simple timer	–	X	X	–
UINT_TO_REAL	U-Int to real, adapter	X	X	X	X
UPPER_SETPOINT	Upper Limit	X	–	–	–
X_OR	XOR - Gate	X	X	X	X
ZERO_POINT	Zero Supression	X	–	–	–

General limits

Description	Limit	Comments
Maximum number of all CFC charts considering all task levels	32	When the limit is exceeded, an error message is output by the device. Consequently, the device is put into monitoring mode. The red ERROR-LED lights up.
Maximum number of all CFC charts considering one task level	16	Only error message (evolving error in processing procedure)
Maximum number of all CFC inputs considering all charts	400	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

Description	Limit	Comments
Maximum number of inputs of one chart for each task level (number of unequal information items of the left border per task level)	400	Only error message; here the number of elements of the left border per task level is counted. Since the same information is indicated at the border several times, only unequal information is to be counted.
Maximum number of reset-resistant flipflops D_FF_MEMO, RS_FF_MEMO, SR_FF_MEMO	350	When the limit is exceeded, an error indication is output by the device. Consequently, the device is put into monitoring mode. The red ERROR-LED lights up.

Device-specific Limits

Description	Limit	Comments
Maximum number of concurrent changes to planned inputs per task level	50	When the limit is exceeded, an error message is output by the device. Consequently, the device is put into monitoring mode. The red ERROR-LED lights up.
Maximum number of chart outputs per task level	150	

Additional Limits

<table>
<tr><th colspan="5">Additional limits 1) for the following 4 CFC blocks:</th></tr>
<tr><th>Task Level</th><th colspan="4"></th></tr>
<tr><td></td><td>TIMER 2) 3)</td><td>TIMER_SHORT 2) 3)</td><td>CMD_CHAIN</td><td>D_FF_MEMO</td></tr>
<tr><td>MW_BEARB</td><td></td><td></td><td></td><td rowspan="4">350</td></tr>
<tr><td>PLC1_BEARB</td><td rowspan="2">15</td><td rowspan="2">30</td><td rowspan="2">20</td></tr>
<tr><td>PLC_BEARB</td></tr>
<tr><td>SFS_BEARB</td><td></td><td></td><td></td></tr>
</table>

1) When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

2) TIMER and TIMER_SHORT share the available timer resources. The relation is TIMER = 2 · system timer and TIMER_SHORT = 1 · system timer. For the maximum used timer number the following side conditions are valid: (2 · number of TIMERs + number of TIMER_SHORTs) < 20. The LONG_TIMER is not subject to this condition.

3) The time values for the blocks TIMER and TIMER_SHORT must not be smaller than the time resolution of the device, i.e. 5 ms, otherwise the blocks will not start with the starting impulse issued.

Maximum Number of TICKS in the Task Levels

Task Level	Limit in TICKS 1)
MW_BEARB (Measured Value Processing)	10 000
PLC1_BEARB (Slow PLC Processing)	1 900
PLC_BEARB (Fast PLC Processing)	200
SFS_BEARB (switchgear interlocking)	10 000

1) When the sum of TICKS of all blocks exceeds the limits before-mentioned, an error message is output by CFC.

Processing Times in TICKS required by the Individual Elements

Individual Element		Number of TICKS
Block, basic requirement		5
Each input more than 3 inputs for generic modules		1
Connection to an input signal		6
Connection to an output signal		7
Additional for each chart		1
Operating sequence module	CMD_CHAIN	34
Flipflop	D_FF_MEMO	6
Loop module	LOOP	8
Decoder	DM_DECODE	8
Dynamic OR	DYN_OR	6
Addition	ADD	26
Subtraction	SUB	26
Multiplication	MUL	26
Division	DIV	54
Square root	SQUARE_ROOT	83
Timer	TIMER_SHORT	8
Timer	LONG_TIMER	11
Blinker lamp	BLINK	11
Counter	COUNTER	6
Adaptor	REAL_TO_DINT	10
Adaptor	REAL_TO_UINT	10
Alarm clock	ALARM	21
Comparison	COMPARE	12
Decoder	DIST_DECODE	8

4.16 Auxiliary functions

Operational measured values

Operational measured values of currents	I_{L1}; I_{L2}; I_{L3}; $3I_0$; I_1; I_2; I_Y in A primary and secondary and in % $I_{NOperation}$;
Tolerance	0.5 % of measured value, or 0.5 % of I_N
Phase angles of currents	f(I_{L1}-I_{L2}); f(I_{L2}-I_{L3}); f(I_{L3}-I_{L1}) in °
Tolerance	1° at nominal current
Operational measured values for voltages	U_{L1-E}, U_{L2-E}, U_{L3-E}; $3U_0$, U_0, U_1, U_2, U_{1Ko} in kV primary, in V secondary or in % $U_{NOp}/\sqrt{3}$
Tolerance	0.5 % of measured value, or 0.5 % of IU_{Nom}
Operational measured values of voltages	U_{EN}; U_X in V secondary
Tolerance	0.5 % of measured value, or 0.5 % of U_N
Operational measured values for voltages	U_{L1-L2}, U_{L2-L3}, U_{L3-L1} in kV primary, in V secondary or in % U_{NOp}
Tolerance	0.5 % of measured value, or 0.5 % of U_N
Phase angle of voltages	f(U_{L1}-U_{L2}); f(U_{L2}-U_{L3}); f(U_{L3}-U_{L1}) in °
Tolerance	1 ° at nominal voltage
Phase angle for voltages and currents	f(U_{L1}-I_{L1}); f(U_{L2}-I_{L2}); f(U_{L3}-I_{L3}) in °
Tolerance	1° at nominal voltage and nominal current
Operational Measured Values for Powers	S; P; Q (apparent, active and reactive power) in MVA; MW; Mvar primary and % S_N (operational nominal power) = $\sqrt{3} \cdot U_N \cdot I_N$
Tolerance for S	1 % of S_N at I/I_N and U/U_N in range 50 to 120 %
Tolerance for P	1 % of P_N at I/I_N and U/U_N in range 50 to 120 % and ABS(cos φ) in range ≥ 0.7
Tolerance for Q	1 % of Q_N at I/I_N and U/U_N in range 50 to 120 % and ABS(cos φ) in range ≥ 0.7
Operating measured value for power factor	cos φ
Tolerance	0,02
Counter values for energy	W_p+, W_q+; W_p-; W_q- (active and reactive energy) In kWh (MWh or GWh) and In kVARh (MVARh or GVARh)
Tolerance at nominal frequency	5 % for $I > 0.5\ I_N$, $U > 0.5\ U_N$ and $\lvert \cos\varphi \rvert \geq 0.707$
Operating measured values for frequency	f in Hz and % f_N
Range	10 Hz to 75 Hz
Tolerance	20 mHz in range f_N ± 10 % at nominal values
Measured values of the differential protection	I_{DIFFL1}; I_{DIFFL2}; I_{DIFFL3}; I_{RESTL1}; I_{RESTL2}; I_{RESTL3}; $I_{DIFF3I0}$ in % $I_{NOperation}$
Thermal measured values	Θ_{L1}/Θ_{AUS}; Θ_{L2}/Θ_{AUS}; Θ_{L3}/Θ_{AUS}; Θ/Θ_{AUS} related to tripping temperature rise
Remote measured values for currents	I_{L1}; I_{L2}; I_{L3} of the remote end in A primary φ(I_{L1}); φ(I_{L2}); φ(I_{L3}), (remote versus local) in °
Remote measured values for currents	U_{L1}; U_{L2}; U_{L3} of the remote end in kV primary φ(U_{L1}); φ(U_{L2}); φ(U_{L3}) (remote versus local) in °

Telegram

Capacity	200 records

Fault Logging

Capacity	8 faults with a total of max. 600 messages

Fault recording

Number of stored faults	Max. 8.
Storage time	maximum of 5 s per fault total of approx. 30 s
Sampling rate at f_N = 50 Hz	1 ms
Sampling rate at f_N = 60 Hz	0.83 ms

Statistics (serial protection data interface)

Availability of transmission for applications with protection data interface	Availability in %/min and %/h
Delay time of transmission	Resolution 0.01 ms

Switching statistics

Number of trip events caused by the device	Separately for each breaker pole (if single-pole tripping is possible)
Number of automatic reclosures initiated by the device	Separate for 1-pole and 3-pole AR; Separately for 1st AR cycle and for all further cyles
Total of interrupted currents	Pole segregated
Maximum interrupted current	Pole segregated

Real Time Clock and Buffer Battery

Resolution for operational messages	1 ms
Resolution for fault messages	1 ms
Back-up battery	Type: 3 V/1 Ah, Type CR 1/2 AA Self-discharging time approx. 10 years

Commissioning Aids

Operational measured values Switching device test

Clock

Time synchronisation		DCF 77/IRIG-B-Signal (telegram format IRIG-B000) Binary Inputs Communication
Operating modes of the clock management		
No.	Operating mode	Description
1	**Internal**	Internal synchronization via RTC (default)
2	**IEC 60870-5-103**	External synchronization using system interface (IEC 60870-5-103)
3	**GPS synchronization**	External synchronisation via GPS signal
4	**Time signal IRIG B**	External synchronisation via IRIG B (telegram format IRIG-B000)
5	**Time signal DCF 77**	External synchronization via DCF 77
6	**Time signal synchro-box**	External synchronization using SIMEAS Sync. box
7	**Pulse via binary input**	External synchronisation with pulse via binary input

4.17 Dimensions

4.17.1 Housing for Panel Flush Mounting or Cubicle Installation

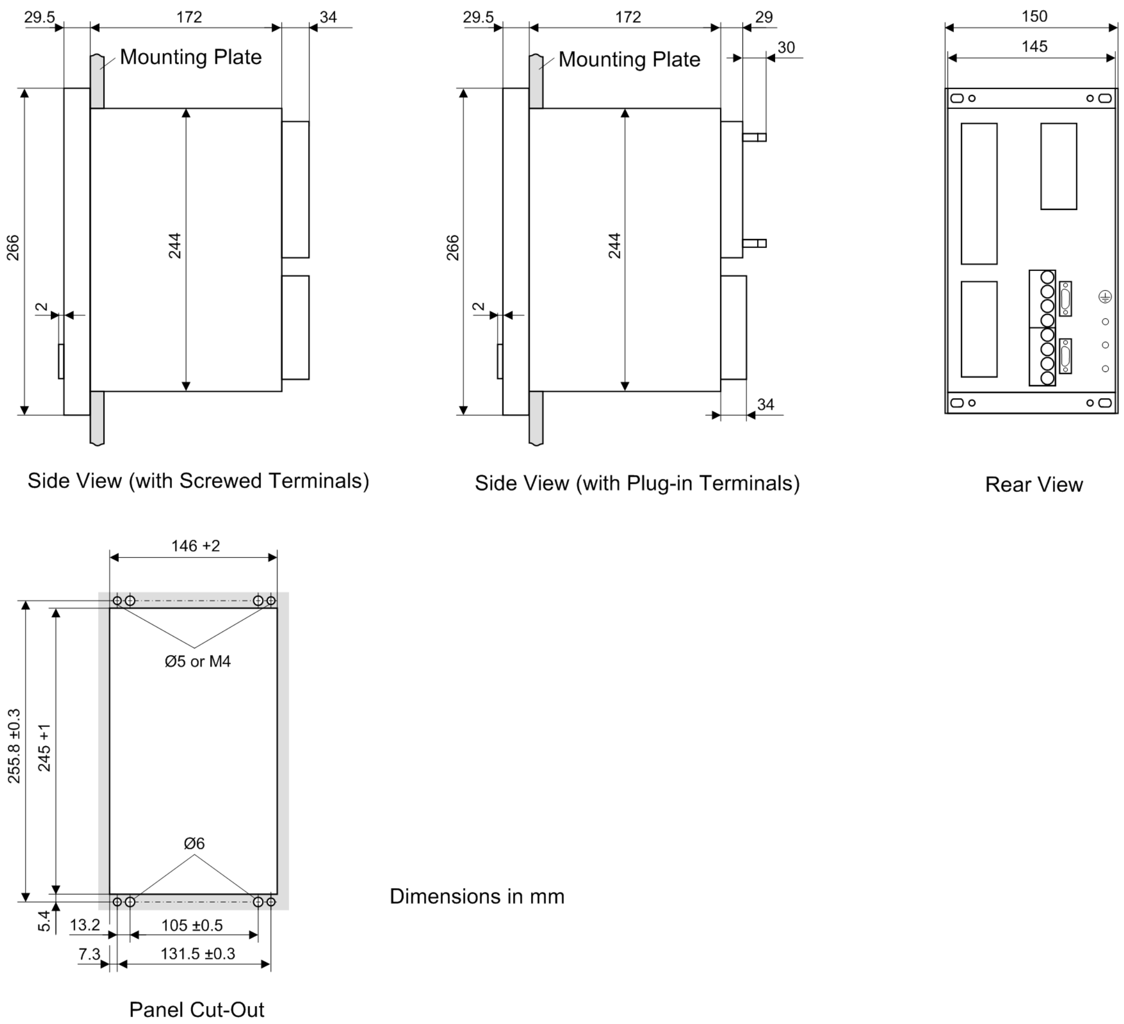


Figure 4-6 Dimensions of a device for panel flush mounting or cubicle installation (size $^1/_3$)

4.17.2 Panel Surface Mounting

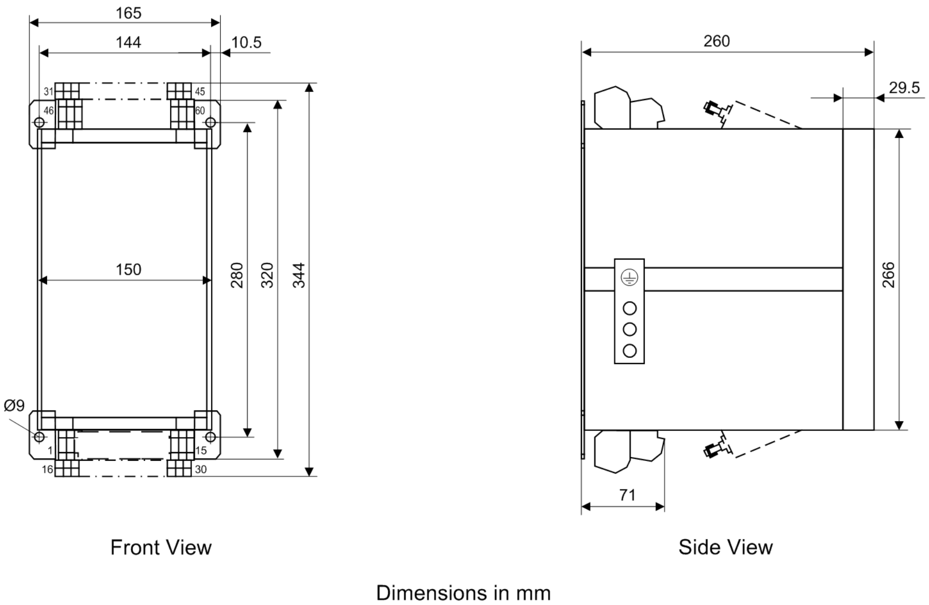


Figure 4-7 Dimensions of a device for panel surface mounting (size $^{1}/_{3}$)

■

Appendix A

This appendix is primarily a reference for the experienced user. This section provides ordering information for the models of this device. Connection diagrams for indicating the terminal connections of the models of this device are included. Following the general diagrams are diagrams that show the proper connections of the devices to primary equipment in many typical power system configurations. Tables with all settings and all information available in this device equipped with all options are provided. Default settings are also given.

A.1 Ordering Information and Accessories

A.1.1 Ordering Information

A.1.1.1 Ordering Code (MLFB)

Line Differential Protection						7		8	9	10	11	12		13	14	15	16		
7	S	D	6	1	0		—						—					+	L/M/N

Measurement Input	**Pos. 7**
I_{Ph} = 1 A, I_E = 1 A	1
I_{Ph} = 5 A, I_E = 5 A	5

Auxiliary Voltage (Power Supply, Pickup Threshold of Binary Inputs)	**Pos. 8**
24 to 48 VDC, binary input threshold 17 V [2)]	2
60 to 125 VDC [1)], binary input threshold 17 V [2)]	4
110 to 250 VDC[1)], 115 VAC, binary input threshold 73 V [2)]	5
220 to 250 VDC, 230 VAC , binary input threshold 154 V [2)]	6

1) With plug-in jumper one of the 2 voltage ranges can be selected
2) For each binary input one of 3 pickup threshold ranges can be selected with plug-in jumper

Mechanical Design: Housing, Number of Binary Inputs and Outputs **BI: Binary Inputs, BO: Output Relays**	**Pos. 9**
Flush mounting housing with screw terminals, $^1/_3$ x 19”, 7 BI, 6 BO, 1 life contact	B
Surface mounting housing with two-tier terminals, $^1/_3$ x 19”, 7 BI, 6 BO, 1 life contact	F
Flush mounting housing with plug-in terminals, $^1/_3$ x 19”, 7 BI, 6 BO, 1, life contact	K

Region-specific Default / Language Settings and Function Versions	**Pos. 10**
Region DE, 50 Hz, IEC, German language (language can be changed)	A
Region World, 50/60 Hz, IEC/ANSI, English language (language can be changed)	B
Region USA, 60/50 Hz, ANSI, language American English (language can be changed)	C
Region World, 50/60 Hz, IEC/ANSI, French language (language can be changed)	D
Region World, 50 / 60 Hz, IEC / ANSI, Spanish language (language can be changed)	E

System Interfaces (Port B)	**Pos. 11**
No system interface	0
IEC 60870-5-103 protocol, electrical RS232	1
IEC 60870-5-103 protocol, electrical RS485	2
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3
For more interface options see Additional Specification **L**	9

Additional Specification L for Further System Interfaces (Port B) (only if Pos. 11 = 9)	**Pos. 21**	**Pos. 22**
Profibus DP Slave, electrical RS485	0	A
Profibus DP Slave, optical, 820 nm, double ring, ST connector [1)]	0	B
MODBUS, electrical RS 485	0	D
MODBUS, 820 nm, optical, ST connector [1)]	0	E
DNP 3.0, electrical RS485	0	G
DNP 3.0, optical, 820 nm, double ring, ST connector [1)]	0	H
IEC61850, 100Mbit Ethernet, double electrical, RJ45 connector	0	R
IEC61850, 100Mbit Ethernet, optical 820 nm, double ring, ST connector 2)[2)]	0	S

[1)] Not possible with surface mounting housing (position 9 = F). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and accessories as stated in Appendix A.1.2 „External converters".

[2)] Not possible with surface mounting housing (position 9 = F).

Function Interface (Port C and D)	**Pos. 12**
see Additional Specification **M**	9

Additional Specification M for DIGSI/modem interface and protection data interface 1 (device rear, port C and D)	**Pos. 23**	**Pos. 24**
Port C: DIGSI/Modem/Browser, electrical RS232	1	
Port C: DIGSI/Modem/Browser, electrical RS485	2	
Port D: optical, 820 nm, 2 ST connectors, length of optical fibre up to 1.5 km, FO5 for direct connection or communication networks using multimode fibre		A
Port D: optical, 820 nm, 2 ST connectors, length of optical fibre up to 3.5 km, FO6 for direct connection using multimode fibre		B
Port D: optical, 1300 nm, 2 LC duplex connectors, length of optical fibre up to 24 km, F017 for direct connection using monomode fibre [1)]		G
Port D: optical 1300 nm, 2 LC duplex connectors, optical fibre up to a length of 60 km, FO18 for direct connection via monomode fibre[1)]		H
Port D: optical 1550 nm, 2 LC duplex connectors, optical fibre up to a length of 100 km, FO19 for direct connection via monomode fibre[1)]		J

[1)] for surface-mounted case, delivery with external repeater

Functions 1	**Pos. 13**
Three-pole tripping, without automatic reclosure	0
Three-pole tripping, with automatic reclosure	1
1-/3-pole tripping without automatic reclosure	2
1-/3-pole tripping with automatic reclosure	3

Function 2	**Pos. 14**
with backup time delay overcurrent protection / emergency overcurrent protection	B
with backup time delay overcurrent protection / emergency overcurrent protection with breaker failure protection	C
with directional backup time delay overcurrent protection / emergency overcurrent protection	R
with directional backup time delay overcurrent protection / emergency overcurrent protection with breaker failure protection	S

Function 3				Pos. 15
4 remote commands	Transformer inside protection zone	Voltage/ frequency protection	Restricted Earth Fault Protection	
without	without	without	without	A
without	without	With	without	B
without	With	without	without	E
without	with	with	without	F
with	without	without	without	J
with	without	with	without	K
with	with	without	without	N
with	with	with	without	P
with	with	without	with	S
with	with	with	with	T

Function 4	Pos. 16
External GPS synchronization of the differential protection	
Without	0
With	1

A.1.2 Accessories

Communication converter

Converter for the serial connection of the 7SD610 line protection system to synchronous communication interfaces X.21 G703.1 (64 kbit/s), G703–T1 (1.1455 Mbit/s), G703–E1 (2.048 Mbit/s) or symmetrical communication cables.

Name	Order No.r
Optical-electrical communication converter CC-X/G with synchronous interface (X.21 / G703.1)	7XV5662-0AA00
Optical–electrical communication converter CC-CU with synchronous interface	7XV5662-0AC00
Optical-electrical communication converter CC-2M with synchronous interface (G703-E1, G703-T1)	7XV5662-0AD00

Optical Repeater

Fibre optical repeater for long-distance transmission of serial signals (up to 100 km / 62.5 miles)

Name	Order No.r
Wide-area fibre optical repeater (24 km / 15 miles)	7XV5461-0BG00
Wide-area fibre optical repeater (60 km / 37.5 miles)	7XV5461-0BH00
Wide-area fibre optical repeater (100 km / 62.5 miles)	7XV5461-0BJ00

Isolating Transformers

Isolating transformers are needed on copper lines if the longitudinal voltage induced in the pilot wires can result in more than 60 % of the test voltage at the communication converter (i.e. 3 kV for CC-CU). They are connected between the communication converter and the communication line.

Name	Order Number
Isolation transformer, test voltage 20 kV	7XR9516

GPS

Name	Order No.r
GPS receiver with antenna and cable	7XV5664-0AA00
Power supply	7XV5810-0BA00

External Converters

Optical interfaces for Profibus and DNP 3.0 are not possible with surface mounted housings. Please order in this case a device with the appropriate electrical RS485 interface, and the additional OLM converters listed below . **Note**: The OLM converter 6GK1502-3CB10 requires an operating voltage of 24 VDC. If the operating voltage is > 24 V DC the additional power supply 7XV5810-0BA00 is required.

Interface used	Order device with additional module/OLM converter
Profibus DP double ring	Profibus DP RS485 / 6GK1502-3CB10
DNP 3.0 820 nm	DNP 3.0 RS485/ 7XV5650-0BA00

Exchangeable interface modules

Name	Order No.
RS232	C53207-A351-D641-1
RS485	C73207-A351-D642-1
FO 820 nm	C53207-A351-D643-1
Profibus DP RS485	C53207-A351-D611-1
Profibus DP double ring	C53207-A351-D613-1
Modbus RS 485	C53207-A351-D621-1
Modbus 820 nm	C53207-A351-D623-1
DNP 3.0 RS485	C53207-A351-D631-3
DNP 3.0 820 nm	C53207-A351-D633-3
FO5 with ST connector; 820 nm; multimode optical fibre - maximum length: 1.5 km (0.94 miles)1)	C53207-A351-D651-1
FO5 with ST connector; 820 nm; multimode optical fibre - maximum length: 1.5 km; for surface mounting housing 1)	C53207-A406-D49-1
FO6 with ST-connector; 820 nm; multimode optical fibre - maximum length: 3.5 km (2.2 miles)	C53207-A351-D652-1
FO6 with ST connector; 820 nm; multimode optical fibre - maximum length: 3.5 km; for surface mounting housing	C53207–A406–D50–1
FO17 with LC duplex connector; 1300 nm; monomode optical fibre - maximum length: 24 km (15 miles)	C53207-A351-D655-1
FO18 with LC duplex connector; 1300 nm; monomode optical fibre - maximum length: 60 km (37.5 miles)	C53207-A351-D656-1
FO19 with LC duplex connector; 1550 nm; monomode optical fibre - maximum length: 100 km (62.5 miles)	C53207-A351-D657-1
Ethernet electrical (EN100)	C53207-A351-D675-2
Ethernet optical (EN100)	C53207-A351-D676-1

1) also used for connection to the optical-electrical communication converter

Terminal Block Covering Caps

Terminal Block Covering Cap for Block Type	Order No.
18 terminal voltage, 12 terminal current block	C73334-A1-C31-1
12 terminal voltage, 8 terminal current block	C73334-A1-C32-1

Short-Circuit Links

Short-circuit Links as Jumper Kit	Order No.
3 pcs for current terminals + 6 pcs for voltage terminals	C73334-A1-C40-1

Plug-in Connector

Plug-in Connector	Order No.
2-pin	C73334-A1-C35-1
3-pin	C73334-A1-C36-1

Mounting Brackets for 19" Racks

Name	Order No.
a pair of mounting rails; one for top, one for bottom	C73165-A63-D200-1

Battery

Lithium battery 3 V/1 Ah, type CR 1/2 AA	Order No.
VARTA	6127 101 501

Interface Cable

An interface cable and the DIGSI operating software are required for the communication between the SIPROTEC 4 device and a PC or laptop: The PC or laptop must run MS-WINDOWS 95, MS-WINDOWS 98, MS-WINDOWS NT 4, MS-WINDOWS 2000, MS-WINDOWS ME or MS-WINDOWS XP PRO

Name	Order No.
Interface cable between PC and SIPROTEC, Cable with 9-pin male/female connectors	7XV5100-4

DIGSI Operating Software

Software for setting and operating SIPROTEC 4 devices

Name	Order No.
DIGSI, basic version with licenses 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)

Name	Order No.
SIGRA graphical analysis program, full version with license for 10 computers	7XS5410-0AA00

DIGSI REMOTE 4

Name	Order No.
Software for remotely operating protection devices via a modem (and possibly a star coupler) using DIGSI (option package of the complete version of DIGSI)	7XS5440-0AA00

A.2 Terminal Assignments

A.2.1 Housing for Panel Flush and Cubicle Mounting

7SD610*-*B/K

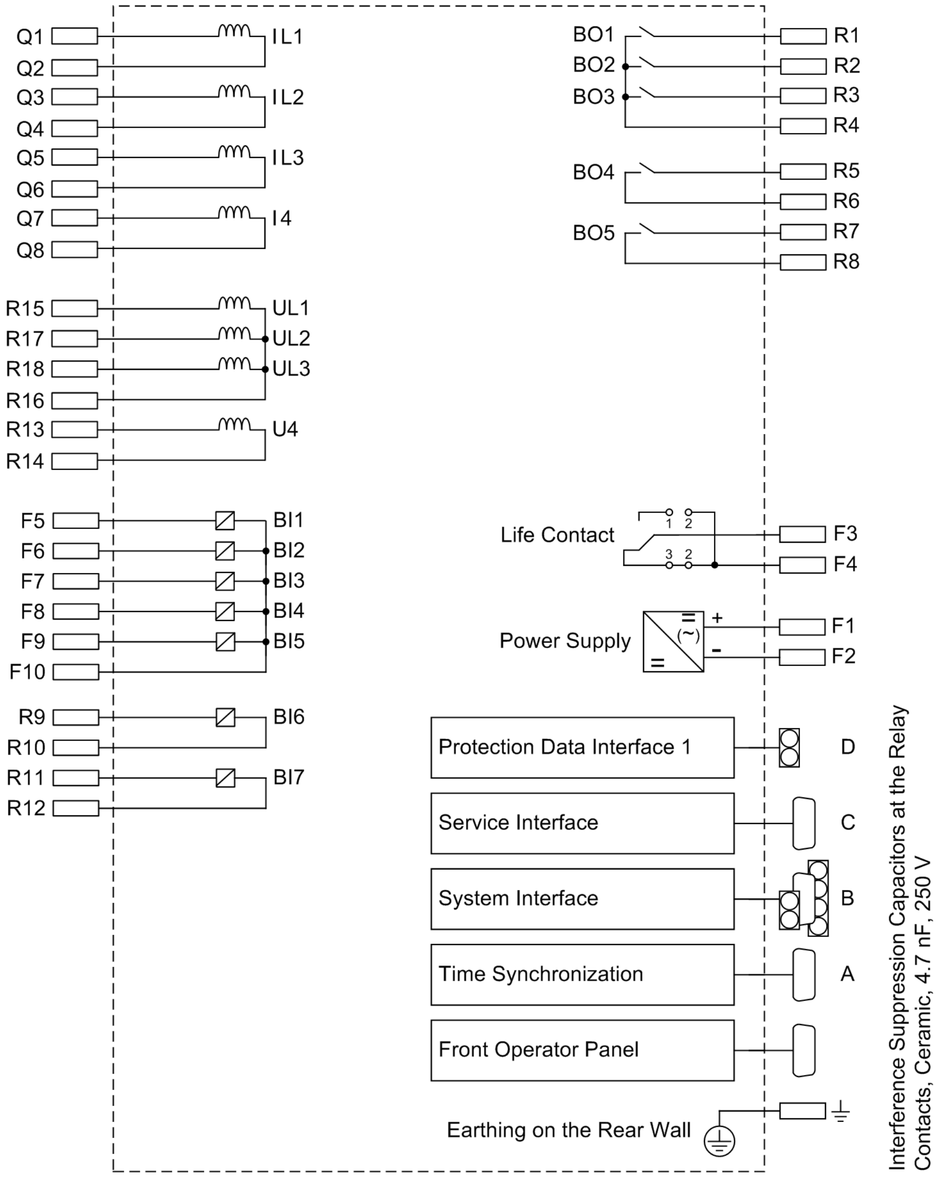


Figure A-1 General diagram for 7SD610*-*B/K (panel flush mounted or cubicle mounted)

A.2.2 Housing for panel surface mounting

7SD610*-*F

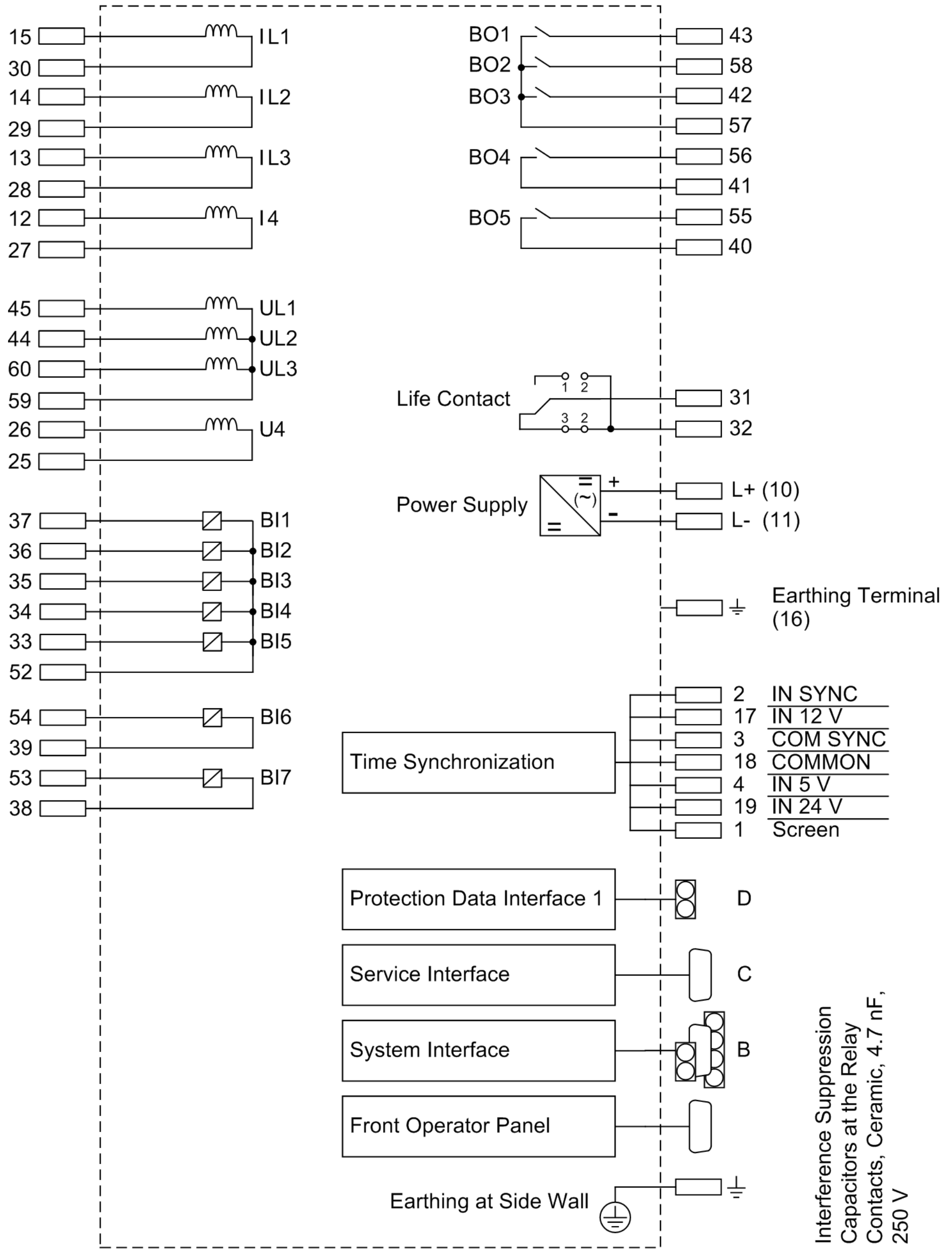


Figure A-2 Connection diagram for 7SD610*-*F (panel surface mounted)

A.3 Connection Examples

A.3.1 Current Transformer Connection Examples

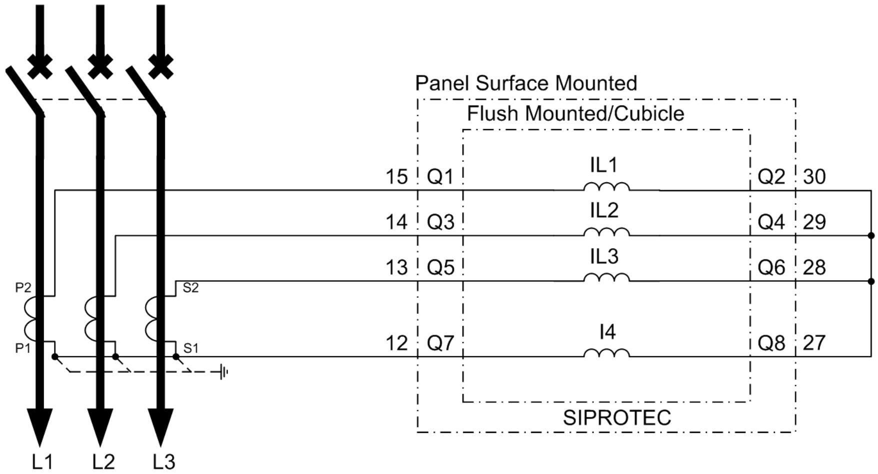
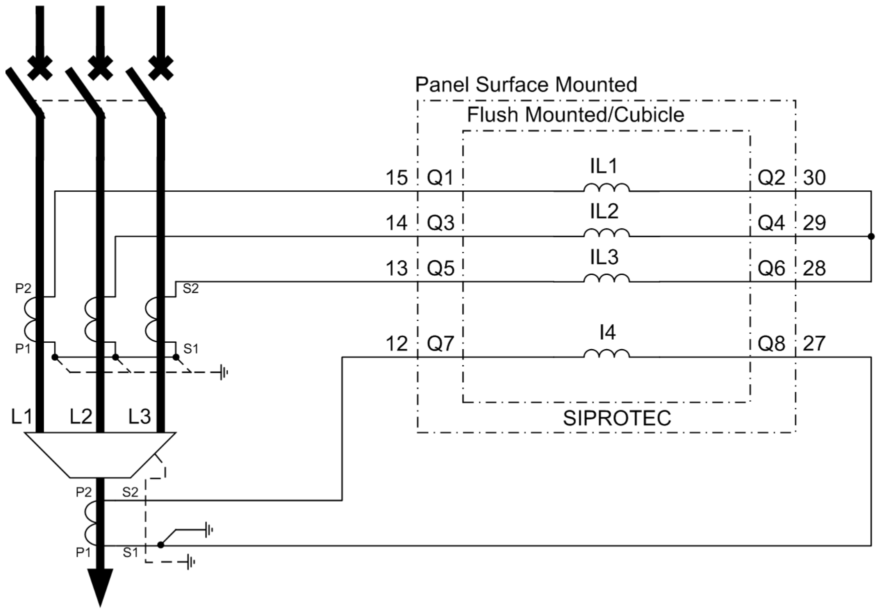


Figure A-3 Current connections to three current transformers with a starpoint connection for earth current (residual 3I0 neutral current), normal circuit layout



Important! Note: Cable Shield Grounding must be done on the Cable Side!

Change of Adress 0201 Setting Change Polarity of I4 Current Input!

Figure A-4 Current connections to three current transformers with separate earth current transformer (summation current transformer or toroidal current transformer)

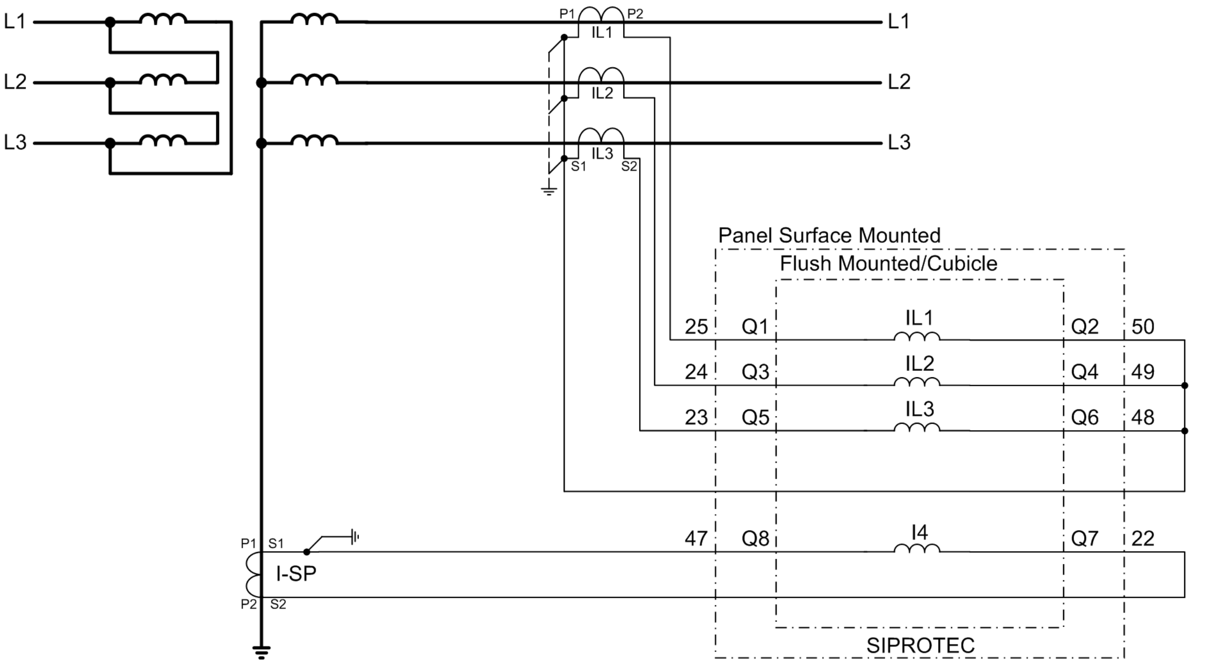


Figure A-5 Restricted earth fault protection on an earthed transformer winding

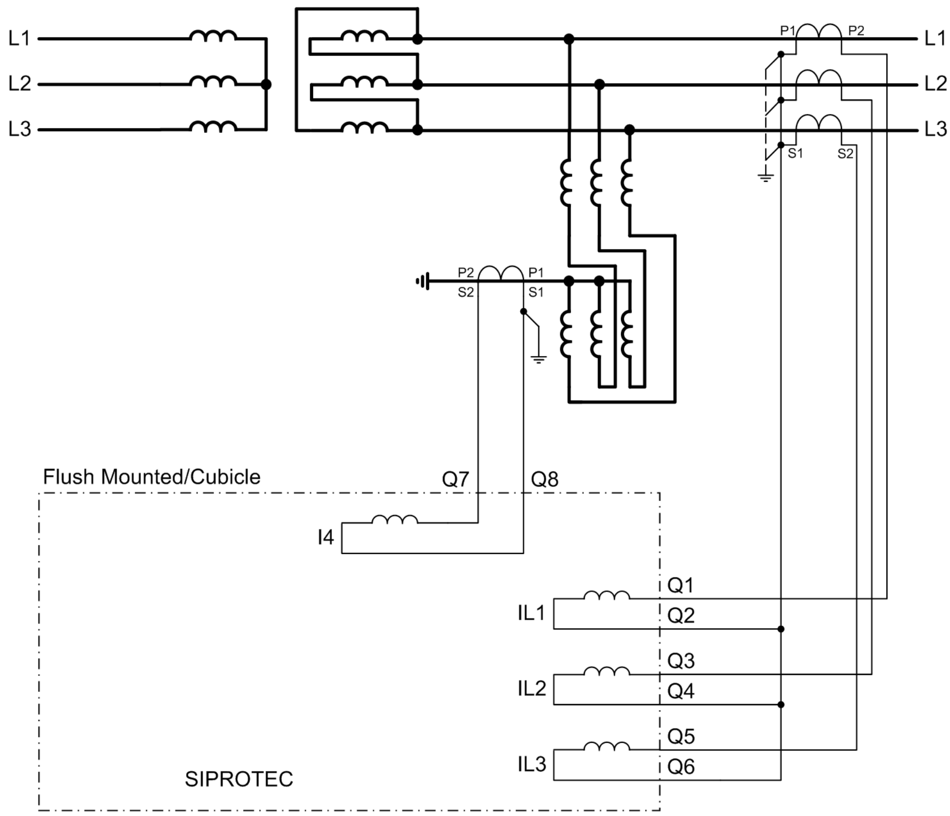


Figure A-6 Restricted earth fault protection on a non-earthed transformer winding with neutral reactor

A.3.2 Voltage Transformer Examples

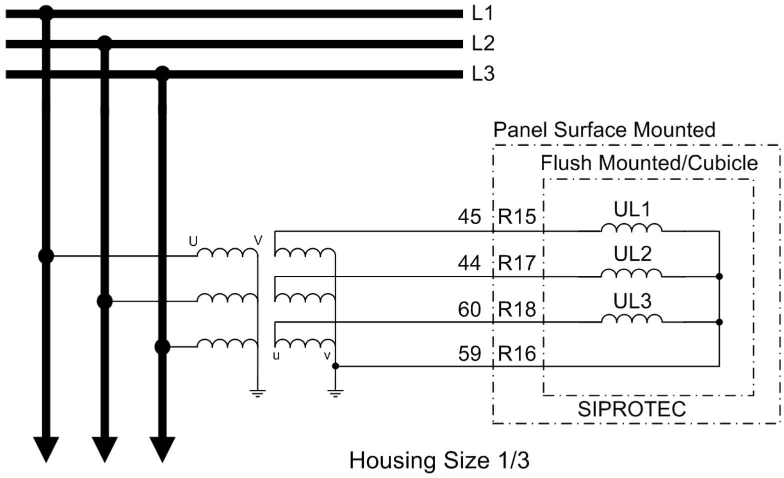


Figure A-7 Voltage connections to three wye-connected voltage transformers (normal circuit layout)

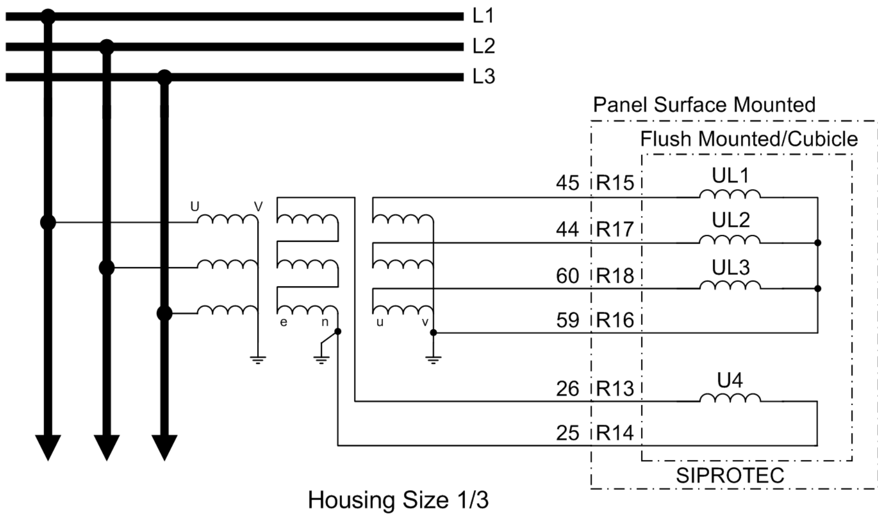


Figure A-8 Voltage connections to three wye-connected voltage transformers with additional broken delta windings (da–dn–winding)

A.4 Default Settings

A.4.1 LEDs

Table A-1 LED Indication Presettings

LEDs	Allocated Function	Function No.	Description
LED1	Relay TRIP	511	Relay GENERAL TRIP command
LED2	Relay PICKUP L1	503	Relay PICKUP Phase L1
LED3	Relay PICKUP L2	504	Relay PICKUP Phase L2
LED4	Relay PICKUP L3	505	Relay PICKUP Phase L3
LED5	Par. different	3235	Differences between common parameters
LED6	PI1 Data fault	3229	Prot Int 1: Reception of faulty data
LED7	DT inconsistent DT unequal Equal IDs	3233 3234 3487	Device table has inconsistent numbers Device tables are unequal Equal IDs in constellation

A.4.2 Binary Input

Table A-2 Binary input presettings for all devices and ordering variants

Binary Input	Allocated Function	Function No.	Description
BI1	>Intertrip 3pol	3504	I.Trip: >Intertrip 3 pole signal input
BI2	>Reset LED	5	>Reset LED
BI3	> Diff block	3525	>Differential protection blocking signal
BI4	>DTT Trip L123	4417	>Direct Transfer Trip INPUT 3ph L123
BI5	>BLOCK O/C I>> >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>>> >BLOCK Dir. I> >BLOCK Dir. Ip	7104 7105 7106 7107 7108 7109 7130 7132 7111 7112	>BLOCK Backup OverCurrent I>> >BLOCK Backup OverCurrent I> >BLOCK Backup OverCurrent Ip >BLOCK Backup OverCurrent Ie>> >BLOCK Backup OverCurrent Ie> >BLOCK Backup OverCurrent Iep >BLOCK I-STUB >BLOCK Backup OverCurrent Ie>>> >BLOCK direct. Backup OverCurrent I> >BLOCK direct. Backup OverCurrent Ip
BI7	>CB1 Ready	371	>CB1 READY (for AR,CB-Test)

A.4.3 Binary Output

Table A-3 Output relay presettings for all devices and ordering variants

Binary Output	Allocated Function	Function No.	Description
BO1	Relay PICKUP L1	503	Relay PICKUP Phase L1
BO2	Relay PICKUP L2	504	Relay PICKUP Phase L2
BO3	Relay PICKUP L3	505	Relay PICKUP Phase L3
BO4	Relay TRIP	511	Relay GENERAL TRIP command
BO5	Relay TRIP	511	Relay GENERAL TRIP command

A.4.4 Function Keys

Table A-4 Applies to all devices and ordered variants

Function Keys	Predefined Function
F1	Display of Operational Annunciations
F2	Operating Measured Values, Primary
F3	An overview of the last eight network faults
F4	Not pre-assigned

A.4.5 Default Display

4-line Display

Table A-5 This selection is available as start page which may be configured.

Page 1	1▮ 1000A 12▮ 400kV 2▮ 999A 23▮ 400kV 3▮ 1000A 31▮ 400kV E▮ 0A U0▮ 0kV
Page 2	% IL ULE ULL L1▮ 78.4 99.6 99.5 L2▮ 78.1 99.4 99.3 L3▮ 78.9 99.8 99.7
Page 3	S: 0.0MVA U: 0kV P: 0.0MW I: 0A Q: 0.0MVAR f: --- PF: ---
Page 4	Diff Rest L1▮ 0.0% 31.6% L2▮ 0.0% 31.6% L3▮ 0.0% 31.6%
Page 5	L1▮ 78.4A L2▮ 78.1A L3▮ 78.9A E ▮ 0.0A

A.4.6 Pre-defined CFC Charts

Device and System Logic

A negator block of the slow logic (PLC1-BEARB) is created from the binary input „>MMSperr“ into the internal single point indication „EntrMMSp“.

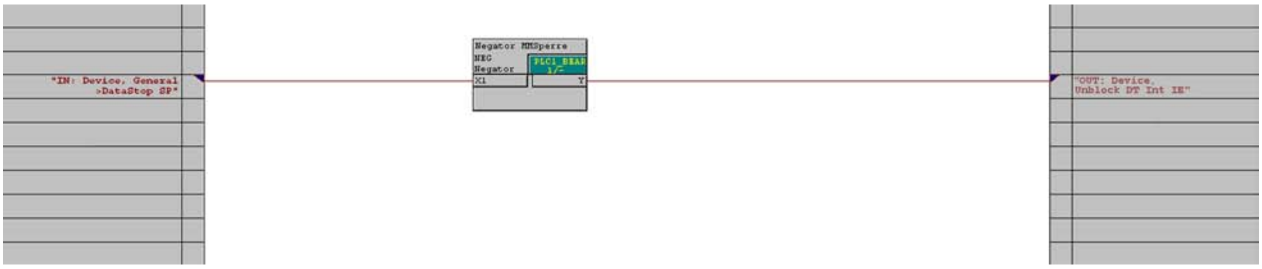


Figure A-9 Logical Link between Input and Output

A.5 Protocol-dependent Functions

Protocol → Function ↓	IEC 60870-5-103	IEC 61850 Ethernet (EN100)	Profibus DP	DNP 3.0 MODBUS
Operational measured values	Yes	Yes	Yes	Yes
Metered values	Yes	Yes	Yes	Yes
Fault recording	Yes	Yes	No, only via additional service interface	No, only via additional service interface
Remote relay setting	No, only via additional service interface	Yes with DIGSI via Ethernet	No, only via additional service interface	No, only via additional service interface
User-defined annunciations and switching objects	Yes	Yes	Pre-defined „User-defined messages“ in CFC	Pre-defined „User-defined messages“ in CFC
Time synchronisation	Via protocol; DCF77/IRIG B/GPS; interface; binary input	Via protocol (NTPT); DCF77/IRIG B; Interface; Binary input	Via DCF77/IRIG B/GPS; interface; binary input	Via protocol; DCF77/IRIG B/GPS; interface; binary input
Messages with time stamp	Yes	Yes	Yes	Yes
Commissioning aids				
Message / measured value blocking	Yes	Yes	No	No
Creating test messages	Yes	Yes	No	No
Physical Mode	Asynchronous	Synchronous	Asynchronous	Asynchronous
Transmission mode	Cyclical/event	Cyclically/Event	Cyclic	Cyclically/Event Cyclical (MODBUS)
Baud rate	4800 to 38400	Up to 100 MBaud	up to 1.5 Mbaud	2400 to 19200
Type	RS232, RS485 Fibre-optic cable	Ethernet TP	RS485 Fiber-optic cables Double ring	RS485 Fiber-optic cables

A.6 Functional Scope

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip mode	3pole only 1-/3pole	3pole only	Trip mode
112	DIFF.PROTECTION	Enabled Disabled	Enabled	Differential protection
122	DTT Direct Trip	Disabled Enabled	Disabled	DTT Direct Transfer Trip
124	HS/SOTF-O/C	Disabled Enabled	Disabled	Instantaneous HighSpeed/SOTF Overcurrent
126	Back-Up O/C	Disabled TOC IEC TOC ANSI	TOC IEC	Backup overcurrent
133	Auto Reclose	1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles ADT Disabled	Disabled	Auto-Reclose Function
134	AR control mode	Pickup w/ Tact Pickup w/o Tact Trip w/ Tact Trip w/o Tact	Trip w/o Tact	Auto-Reclose control mode
136	FREQUENCY Prot.	Disabled Enabled	Disabled	Over / Underfrequency Protection
137	U/O VOLTAGE	Disabled Enabled Enabl. w. comp.	Disabled	Under / Overvoltage Protection
139	BREAKER FAILURE	Disabled Enabled enabled w/ 3I0>	Disabled	Breaker Failure Protection
140	Trip Cir. Sup.	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision
141	REF PROT.	Disabled Enabled	Disabled	Restricted earth fault protection
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
143	TRANSFORMER	NO YES	NO	Transformer inside protection zone
144	V-TRANSFORMER	Not connected connected	connected	Voltage transformers
148	GPS-SYNC.	Enabled Disabled	Disabled	GPS synchronization

A.7 Settings

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

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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
201	CT Starpoint	P.System Data 1		towards Line towards Busbar	towards Line	CT Starpoint
203	Unom PRIMARY	P.System Data 1		0.4 .. 1200.0 kV	400.0 kV	Rated Primary Voltage
204	Unom SECONDARY	P.System Data 1		80 .. 125 V	100 V	Rated Secondary Voltage (Ph-Ph)
205	CT PRIMARY	P.System Data 1		10 .. 10000 A	1000 A	CT Rated Primary Current
206	CT SECONDARY	P.System Data 1		1A 5A	1A	CT Rated Secondary Current
207	SystemStarpoint	P.System Data 1		Solid Earthed Peterson-Coil Isolated	Solid Earthed	System Starpoint is
210	U4 transformer	P.System Data 1		Not connected Udelta transf. Ux transformer	Not connected	U4 voltage transformer is
211	Uph / Udelta	P.System Data 1		0.10 .. 9.99	1.73	Matching ratio Phase-VT To Open-Delta-VT
220	I4 transformer	P.System Data 1		Not connected In prot. line IY starpoint	In prot. line	I4 current transformer is
221	I4/Iph CT	P.System Data 1		0.010 .. 5.000	1.000	Matching ratio I4/Iph for CT's
230	Rated Frequency	P.System Data 1		50 Hz 60 Hz	50 Hz	Rated Frequency
236	Distance Unit	P.System Data 1		km Miles	km	Distance measurement unit
240A	TMin TRIP CMD	P.System Data 1		0.02 .. 30.00 sec	0.10 sec	Minimum TRIP Command Duration
241A	TMax CLOSE CMD	P.System Data 1		0.01 .. 30.00 sec	1.00 sec	Maximum Close Command Duration
242	T-CBtest-dead	P.System Data 1		0.00 .. 30.00 sec	0.10 sec	Dead Time for CB test-autoreclosure
251	K_ALF/K_ALF_N	P.System Data 1		1.00 .. 10.00	1.00	k_alf/k_alf nominal
253	E% ALF/ALF_N	P.System Data 1		0.5 .. 50.0 %	5.0 %	CT Error in % at k_alf/k_alf nominal
254	E% K_ALF_N	P.System Data 1		0.5 .. 50.0 %	15.0 %	CT Error in % at k_alf nominal
301	ACTIVE GROUP	Change Group		Group A Group B Group C Group D	Group A	Active Setting Group is
302	CHANGE	Change Group		Group A Group B Group C Group D Binary Input Protocol	Group A	Change to Another Setting Group
402A	WAVEFORMTRIGGER	Osc. Fault Rec.		Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403A	WAVEFORM DATA	Osc. Fault Rec.		Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
410	MAX. LENGTH	Osc. Fault Rec.		0.30 .. 5.00 sec	2.00 sec	Max. length of a Waveform Capture Record
411	PRE. TRIG. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.25 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	Osc. Fault Rec.		0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
610	FltDisp.LED/LCD	Device		Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
640	Start image DD	Device		image 1 image 2 image 3 image 4 image 5 image 6	image 1	Start image Default Display
1103	FullScaleVolt.	P.System Data 2		0.4 .. 1200.0 kV	400.0 kV	Measurement: Full Scale Voltage (100%)
1104	FullScaleCurr.	P.System Data 2		10 .. 10000 A	1000 A	Measurement: Full Scale Current (100%)
1105	Line Angle	P.System Data 2		10 .. 89 °	85 °	Line Angle
1106	OPERATION POWER	P.System Data 2		0.2 .. 5000.0 MVA	692.8 MVA	Operational power of protection zone
1107	P,Q sign	P.System Data 2		not reversed reversed	not reversed	P,Q operational measured values sign
1111	x'	P.System Data 2	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	x' - Line Reactance per length unit
			5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
1111	x'	P.System Data 2	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	x' - Line Reactance per length unit
			5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
1112	c'	P.System Data 2	1A	0.000 .. 100.000 µF/km	0.010 µF/km	c' - capacit. per unit line len. µF/km
			5A	0.000 .. 500.000 µF/km	0.050 µF/km	
1112	c'	P.System Data 2	1A	0.000 .. 160.000 µF/mi	0.016 µF/mi	c' - capacit. per unit line len. µF/mile
			5A	0.000 .. 800.000 µF/mi	0.080 µF/mi	
1113	Line Length	P.System Data 2		0.1 .. 1000.0 km	100.0 km	Line Length
1113	Line Length	P.System Data 2		0.1 .. 650.0 Miles	62.1 Miles	Line Length
1130A	PoleOpenCurrent	P.System Data 2	1A	0.05 .. 1.00 A	0.10 A	Pole Open Current Threshold
			5A	0.25 .. 5.00 A	0.50 A	
1131A	PoleOpenVoltage	P.System Data 2		2 .. 70 V	30 V	Pole Open Voltage Threshold
1132A	SI Time all Cl.	P.System Data 2		0.01 .. 30.00 sec	0.10 sec	Seal-in Time after ALL closures
1133A	T DELAY SOTF	P.System Data 2		0.05 .. 30.00 sec	0.25 sec	minimal time for line open before SOTF
1134	Line Closure	P.System Data 2		only with ManCl I OR U or ManCl CB OR I or M/C I or Man.Close	I or Man.Close	Recognition of Line Closures with
1135	Reset Trip CMD	P.System Data 2		CurrentOpenPole Current AND CB Pickup Reset	CurrentOpenPole	RESET of Trip Command
1136	OpenPoleDetect.	P.System Data 2		OFF Current AND CB w/ measurement	w/ measurement	open pole detector
1150A	SI Time Man.Cl	P.System Data 2		0.01 .. 30.00 sec	0.30 sec	Seal-in Time after MANUAL clo-sures
1151	SYN.MAN.CL	P.System Data 2		w/o Sync-check NO	NO	Manual CLOSE COMMAND generation
1152	Man.Clos. Imp.	P.System Data 2		(Setting options depend on configuration)	None	MANUAL Closure Impulse after CONTROL
1155	3pole coupling	P.System Data 2		with PICKUP with TRIP	with TRIP	3 pole coupling
1156A	Trip2phFlt	P.System Data 2		3pole 1pole leading Ø 1pole lagging Ø	3pole	Trip type with 2phase faults
1161	VECTOR GROUP U	P.System Data 2		0 .. 11	0	Vector group numeral for voltage
1162	VECTOR GROUP I	P.System Data 2		0 .. 11	0	Vector group numeral for current
1163	TRANS STP IS	P.System Data 2		Solid Earthed Not Earthed	Solid Earthed	Transformer starpoint is
1201	STATE OF DIFF.	Diff. Prot		OFF ON	ON	State of differential protection
1210	I-DIFF>	Diff. Prot	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Pickup value
			5A	0.50 .. 100.00 A	1.50 A	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1213	I-DIF>SWITCH ON	Diff. Prot	1A	0.10 .. 20.00 A	0.30 A	I-DIFF>: Value under switch on condition
			5A	0.50 .. 100.00 A	1.50 A	
1217A	T-DELAY I-DIFF>	Diff. Prot		0.00 .. 60.00 sec; ∞	0.00 sec	I-DIFF>: Trip time delay
1218	T3I0 1PHAS	Diff. Prot		0.00 .. 0.50 sec; ∞	0.04 sec	Delay 1ph-faults (comp/isol. star-point)
1219A	I> RELEASE DIFF	Diff. Prot	1A	0.10 .. 20.00 A; 0	0.00 A	Min. local current to release DIFF-Trip
			5A	0.50 .. 100.00 A; 0	0.00 A	
1233	I-DIFF>>	Diff. Prot	1A	0.8 .. 100.0 A; ∞	1.2 A	I-DIFF>>: Pickup value
			5A	4.0 .. 500.0 A; ∞	6.0 A	
1235	I-DIF>>SWITCHON	Diff. Prot	1A	0.8 .. 100.0 A; ∞	1.2 A	I-DIFF>>: Value under switch on cond.
			5A	4.0 .. 500.0 A; ∞	6.0 A	
1301	I-TRIP SEND	Intertrip		YES NO	NO	State of transmit. the intertrip command
1302	I-TRIP RECEIVE	Intertrip		Alarm only Trip	Trip	Reaction if intertrip command is receiv.
1303	T-ITRIP BI	Intertrip		0.00 .. 30.00 sec	0.02 sec	Delay for intertrip via binary input
1304	T-ITRIP PROL BI	Intertrip		0.00 .. 30.00 sec	0.00 sec	Prolongation for intertrip via bin.input
2201	FCT Direct Trip	DTT Direct Trip		ON OFF	OFF	Direct Transfer Trip (DTT)
2202	Trip Time DELAY	DTT Direct Trip		0.00 .. 30.00 sec; ∞	0.01 sec	Trip Time Delay
2301	INRUSH REST.	Diff. Prot		OFF ON	OFF	Inrush Restraint
2302	2nd HARMONIC	Diff. Prot		10 .. 45 %	15 %	2nd. harmonic in % of fundamen-tal
2303	CROSS BLOCK	Diff. Prot		NO YES	NO	Cross Block
2305	MAX INRUSH PEAK	Diff. Prot	1A	1.1 .. 25.0 A	15.0 A	Maximum inrush-peak value
			5A	5.5 .. 125.0 A	75.0 A	
2310	CROSSB 2HM	Diff. Prot		0.00 .. 60.00 sec; ∞	0.00 sec	Time for Crossblock with 2nd harmonic
2401	FCT HS/SOTF-O/C	SOTF Overcurr.		ON OFF	ON	Inst. High Speed/SOTF-O/C is
2404	I>>>	SOTF Overcurr.	1A	0.10 .. 15.00 A; ∞	1.50 A	I>>> Pickup
			5A	0.50 .. 75.00 A; ∞	7.50 A	
2405A	I>>>>	SOTF Overcurr.	1A	1.00 .. 25.00 A; ∞	∞ A	I>>>> Pickup
			5A	5.00 .. 125.00 A; ∞	∞ A	
2601	Operating Mode	Back-Up O/C		ON Only Emer. prot OFF	ON	Operating mode
2602	SOTF Time DELAY	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	Trip time delay after SOTF
2603A	Direct. 3I0	Back-Up O/C		U0/I0 or U2/I0 with U0/I0 with U2/I2	U0/I0 or U2/I0	Measurement of direction for 3I0
2610	Iph>>	Back-Up O/C	1A	0.10 .. 25.00 A; ∞	2.00 A	Iph>> Pickup
			5A	0.50 .. 125.00 A; ∞	10.00 A	
2611	T Iph>>	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph>> Time delay
2612	3I0>> PICKUP	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.50 A	3I0>> Pickup
			5A	0.25 .. 125.00 A; ∞	2.50 A	
2613	T 3I0>>	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> Telep/BI	Back-Up O/C		NO YES	YES	Instantaneous trip via Tele-prot./BI
2615	I>> SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after Switch-OnToFault
2620	Iph>	Back-Up O/C	1A	0.10 .. 25.00 A; ∞	1.50 A	Iph> Pickup
			5A	0.50 .. 125.00 A; ∞	7.50 A	
2621	T Iph>	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> Pickup
			5A	0.25 .. 125.00 A; ∞	1.00 A	
2623	T 3I0>	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Time delay

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2624	I> Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Tele-prot./BI
2625	I> SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after Switch-OnToFault
2630	Iph> STUB	Back-Up O/C	1A	0.10 .. 25.00 A; ∞	1.50 A	Iph> STUB Pickup
			5A	0.50 .. 125.00 A; ∞	7.50 A	
2631	T Iph STUB	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> STUB Pickup
			5A	0.25 .. 125.00 A; ∞	1.00 A	
2633	T 3I0 STUB	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0 STUB Time delay
2634	I-STUB Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Tele-prot./BI
2635	I-STUB SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after Switch-OnToFault
2640	Ip>	Back-Up O/C	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> Pickup
			5A	0.50 .. 20.00 A; ∞	∞ A	
2642	T Ip Time Dial	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Time Dial
2643	Time Dial TD Ip	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	Time Dial TD Ip
2646	T Ip Add	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T Ip Additional Time Delay
2650	3I0p PICKUP	Back-Up O/C	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p Pickup
			5A	0.25 .. 20.00 A; ∞	∞ A	
2652	T 3I0p TimeDial	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Time Dial
2653	TimeDial TD3I0p	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	Time Dial TD 3I0p
2656	T 3I0p Add	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T 3I0p Additional Time Delay
2660	IEC Curve	Back-Up O/C Back-Up O/C		Normal Inverse Very Inverse Extremely Inv. LongTimeInverse	Normal Inverse	IEC Curve
2661	ANSI Curve	Back-Up O/C Back-Up O/C		Inverse Short Inverse Long Inverse Moderately Inv. Very Inverse Extremely Inv. Definite Inv.	Inverse	ANSI Curve
2670	I(3I0)p Tele/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Tele-prot./BI
2671	I(3I0)p SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after Switch-OnToFault
2680	Direction Iph>	Back-Up O/C		Non-Directional Forward Reverse	Non-Directional	Direction of stage Iph> Dir.
2681	Iph> Dir.	Back-Up O/C	1A	0.10 .. 25.00 A; ∞	1.50 A	Iph> directional Pickup
			5A	0.50 .. 125.00 A; ∞	7.50 A	
2682	T Iph> Dir.	Back-Up O/C		0.00 .. 30.00 sec; ∞	0.50 sec	T Iph> Dir. Time delay
2683	Direction 3I0>	Back-Up O/C		Non-Directional Forward Reverse	Non-Directional	Direction of stage 3I0> Dir.
2684	3I0> Dir.	Back-Up O/C	1A	0.05 .. 25.00 A; ∞	0.20 A	3I0> directional Pickup
			5A	0.25 .. 125.00 A; ∞	1.00 A	
2685	T 3I0> Dir.	Back-Up O/C		0.00 .. 30.00 sec; ∞	2.00 sec	T 3I0> Dir. Time delay
2686	I>Dir.Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Tele-prot./BI
2687	I> Dir. SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after Switch-OnToFault
2688	Direction IP	Back-Up O/C		Forward Reverse	Forward	Direction of stage Ip> Dir.
2689	Ip> Dir.	Back-Up O/C	1A	0.10 .. 4.00 A; ∞	∞ A	Ip> directional Pickup
			5A	0.50 .. 20.00 A; ∞	∞ A	
2690	T Ip Dir.	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T Ip Dir.: Inv.-Time delay for IEC-Char.

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2691	D Ip Dir.	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2692	T Ip Add Dir.	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2693	Direction 3I0P	Back-Up O/C		Forward Reverse	Forward	Direction of stage 3I0p
2694	3I0p Dir.	Back-Up O/C	1A	0.05 .. 4.00 A; ∞	∞ A	3I0p directional Pickup
			5A	0.25 .. 20.00 A; ∞	∞ A	
2695	T 3I0p Dir.	Back-Up O/C		0.05 .. 3.00 sec; ∞	0.50 sec	T 3I0p Dir.:Inv.-Time delay for IEC-Char
2696	D 3I0p Dir.	Back-Up O/C		0.50 .. 15.00 ; ∞	5.00	D 3I0p Dir.:Inv.-Time delay for ANSI-Ch.
2697	T 3I0p Add Dir.	Back-Up O/C		0.00 .. 30.00 sec	0.00 sec	T 3I0p Dir.: additional time delay
2698	IPDir.Telep/BI	Back-Up O/C		NO YES	NO	Instantaneous trip via Tele-prot./BI
2699	IP Dir. SOTF	Back-Up O/C		NO YES	NO	Instantaneous trip after Switch-OnToFault
2901	MEASURE. SUPERV	Measurem.Superv		ON OFF	ON	Measurement Supervision
2902A	BALANCE U-LIMIT	Measurem.Superv		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
2903A	BAL. FACTOR U	Measurem.Superv		0.58 .. 0.95	0.75	Balance Factor for Voltage Monitor
2904A	BALANCE I LIMIT	Measurem.Superv	1A	0.10 .. 1.00 A	0.50 A	Current Balance Monitor
			5A	0.50 .. 5.00 A	2.50 A	
2905A	BAL. FACTOR I	Measurem.Superv		0.10 .. 0.95	0.50	Balance Factor for Current Monitor
2906A	ΣI THRESHOLD	Measurem.Superv	1A	0.10 .. 2.00 A	0.25 A	Summated Current Monitoring Threshold
			5A	0.50 .. 10.00 A	1.25 A	
2907A	ΣI FACTOR	Measurem.Superv		0.00 .. 0.95	0.50	Summated Current Monitoring Factor
2908A	T BAL. U LIMIT	Measurem.Superv		5 .. 100 sec	5 sec	T Balance Factor for Voltage Monitor
2909A	T BAL. I LIMIT	Measurem.Superv		5 .. 100 sec	5 sec	T Current Balance Monitor
2910	FUSE FAIL MON.	Measurem.Superv		ON OFF	ON	Fuse Failure Monitor
2911A	FFM U>(min)	Measurem.Superv		10 .. 100 V	30 V	Minimum Voltage Threshold U>
2912A	FFM I< (max)	Measurem.Superv	1A	0.10 .. 1.00 A	0.10 A	Maximum Current Threshold I<
			5A	0.50 .. 5.00 A	0.50 A	
2913A	FFM U<max (3ph)	Measurem.Superv		2 .. 100 V	5 V	Maximum Voltage Threshold U< (3phase)
2914A	FFM Idelta (3p)	Measurem.Superv	1A	0.05 .. 1.00 A	0.10 A	Delta Current Threshold (3phase)
			5A	0.25 .. 5.00 A	0.50 A	
2915	V-Supervision	Measurem.Superv		w/ CURR.SUP w/ I> & CBaux OFF	w/ CURR.SUP	Voltage Failure Supervision
2916A	T V-Supervision	Measurem.Superv		0.00 .. 30.00 sec	3.00 sec	Delay Voltage Failure Supervi-sion
2921	T mcb	Measurem.Superv		0 .. 30 ms	0 ms	VT mcb operating time
2931	BROKEN WIRE	Measurem.Superv		ON OFF	OFF	Fast broken current-wire supervi-sion
2933	FAST Σ i SUPERV	Measurem.Superv		ON OFF	ON	State of fast current summation supervis
2941	φA	Measurem.Superv		0 .. 359 °	200 °	Limit setting PhiA
2942	φB	Measurem.Superv		0 .. 359 °	340 °	Limit setting PhiB
2943	I1>	Measurem.Superv	1A	0.05 .. 2.00 A	0.05 A	Minimum value I1>
			5A	0.25 .. 10.00 A	0.25 A	
2944	U1>	Measurem.Superv		2 .. 70 V	20 V	Minimum value U1>
3401	AUTO RECLOSE	Auto Reclose		OFF ON	ON	Auto-Reclose Function
3402	CB? 1.TRIP	Auto Reclose		YES NO	NO	CB ready interrogation at 1st trip

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3403	T-RECLAIM	Auto Reclose		0.50 .. 300.00 sec	3.00 sec	Reclaim time after successful AR cycle
3403	T-RECLAIM	Auto Reclose		0.50 .. 300.00 sec; 0	3.00 sec	Reclaim time after successful AR cycle
3404	T-BLOCK MC	Auto Reclose		0.50 .. 300.00 sec; 0	1.00 sec	AR blocking duration after manual close
3406	EV. FLT. RECOG.	Auto Reclose		with PICKUP with TRIP	with TRIP	Evolving fault recognition
3407	EV. FLT. MODE	Auto Reclose		Stops AutoRecl starts 3p AR	starts 3p AR	Evolving fault (during the dead time)
3408	T-Start MONITOR	Auto Reclose		0.01 .. 300.00 sec	0.50 sec	AR start-signal monitoring time
3409	CB TIME OUT	Auto Reclose		0.01 .. 300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3410	T RemoteClose	Auto Reclose		0.00 .. 300.00 sec; ∞	0.20 sec	Send delay for remote close command
3411A	T-DEAD EXT.	Auto Reclose		0.50 .. 300.00 sec; ∞	∞ sec	Maximum dead time extension
3420	AR WITH DIFF	Auto Reclose		YES NO	YES	AR with differential protection ?
3421	AR w/ SOTF-O/C	Auto Reclose		YES NO	YES	AR with switch-onto-fault over-current ?
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 overcurrent ?
3430	AR TRIP 3pole	Auto Reclose		YES NO	YES	3pole TRIP by AR
3431	DLC / RDT	Auto Reclose		WITHOUT DLC	WITHOUT	Dead Line Check / Reduced Dead Time
3433	T-ACTION ADT	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Action time
3434	T-MAX ADT	Auto Reclose		0.50 .. 3000.00 sec	5.00 sec	Maximum dead time
3435	ADT 1p allowed	Auto Reclose		YES NO	NO	1pole TRIP allowed
3436	ADT CB? CLOSE	Auto Reclose		YES NO	NO	CB ready interrogation before re-closing
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 re-closing
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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3466	2.AR Tdead 3Flt	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3467	2.AR Tdead1Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3468	2.AR Tdead3Trip	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3469	2.AR: Tdead EV.	Auto Reclose		0.01 .. 1800.00 sec	1.20 sec	Dead time after evolving fault
3470	2.AR: CB? CLOSE	Auto Reclose		YES NO	NO	CB ready interrogation before re-closing
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 re-closing
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 re-closing
3493	4.AR SynRequest	Auto Reclose		YES NO	NO	Request for synchro-check after 3pole AR
3601	O/U FREQ. f1	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f1
3602	f1 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	49.50 Hz	f1 Pickup
3603	f1 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	59.50 Hz	f1 Pickup
3604	T f1	Frequency Prot.		0.00 .. 600.00 sec	60.00 sec	T f1 Time Delay
3611	O/U FREQ. f2	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f2
3612	f2 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	49.00 Hz	f2 Pickup
3613	f2 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	57.00 Hz	f2 Pickup
3614	T f2	Frequency Prot.		0.00 .. 600.00 sec	30.00 sec	T f2 Time Delay
3621	O/U FREQ. f3	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f3
3622	f3 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	47.50 Hz	f3 Pickup
3623	f3 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	59.50 Hz	f3 Pickup
3624	T f3	Frequency Prot.		0.00 .. 600.00 sec	3.00 sec	T f3 Time Delay
3631	O/U FREQ. f4	Frequency Prot.		ON: Alarm only ON: with Trip OFF	ON: Alarm only	Over/Under Frequency Protection stage f4
3632	f4 PICKUP	Frequency Prot.		45.50 .. 54.50 Hz	51.00 Hz	f4 Pickup
3633	f4 PICKUP	Frequency Prot.		55.50 .. 64.50 Hz	62.00 Hz	f4 Pickup
3634	T f4	Frequency Prot.		0.00 .. 600.00 sec	30.00 sec	T f4 Time Delay

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3701	Uph-e>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-e overvolt-age prot.
3702	Uph-e>	Voltage Prot.		1.0 .. 170.0 V; ∞	85.0 V	Uph-e> Pickup
3703	T Uph-e>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e> Time Delay
3704	Uph-e>>	Voltage Prot.		1.0 .. 170.0 V; ∞	100.0 V	Uph-e>> Pickup
3705	T Uph-e>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e>> Time Delay
3709A	Uph-e>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	Uph-e>(>) Reset ratio
3711	Uph-ph>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode Uph-ph over-voltage prot.
3712	Uph-ph>	Voltage Prot.		2.0 .. 220.0 V; ∞	150.0 V	Uph-ph> Pickup
3713	T Uph-ph>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph> Time Delay
3714	Uph-ph>>	Voltage Prot.		2.0 .. 220.0 V; ∞	175.0 V	Uph-ph>> Pickup
3715	T Uph-ph>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph>> Time Delay
3719A	Uphph>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	Uph-ph>(>) Reset ratio
3721	3U0>(>) (or Ux)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode 3U0 (or Ux) ov-ervoltage
3722	3U0>	Voltage Prot.		1.0 .. 220.0 V; ∞	30.0 V	3U0> Pickup (or Ux>)
3723	T 3U0>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T 3U0> Time Delay (or T Ux>)
3724	3U0>>	Voltage Prot.		1.0 .. 220.0 V; ∞	50.0 V	3U0>> Pickup (or Ux>>)
3725	T 3U0>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T 3U0>> Time Delay (or T Ux>>)
3728A	3U0>(>) Stabil.	Voltage Prot.		ON OFF	ON	3U0>(>): Stabilization 3U0-Mea-surement
3729A	3U0>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.95	3U0>(>) Reset ratio (or Ux)
3731	U1>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U1 overvoltage prot.
3732	U1>	Voltage Prot.		2.0 .. 220.0 V; ∞	150.0 V	U1> Pickup
3733	T U1>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T U1> Time Delay
3734	U1>>	Voltage Prot.		2.0 .. 220.0 V; ∞	175.0 V	U1>> Pickup
3735	T U1>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T U1>> Time Delay
3736	U1> Compound	Voltage Prot.		OFF ON	OFF	U1> with Compounding
3737	U1>> Compound	Voltage Prot.		OFF ON	OFF	U1>> with Compounding
3739A	U1>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	U1>(>) Reset ratio
3741	U2>(>)	Voltage Prot.		OFF Alarm Only ON U>Alarm U>>Trip	OFF	Operating mode U2 overvoltage prot.
3742	U2>	Voltage Prot.		2.0 .. 220.0 V; ∞	30.0 V	U2> Pickup
3743	T U2>	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T U2> Time Delay
3744	U2>>	Voltage Prot.		2.0 .. 220.0 V; ∞	50.0 V	U2>> Pickup
3745	T U2>>	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T U2>> Time Delay
3749A	U2>(>) RESET	Voltage Prot.		0.30 .. 0.99	0.98	U2>(>) Reset ratio
3751	Uph-e<(<)	Voltage Prot.		OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-e under-voltage prot.
3752	Uph-e<	Voltage Prot.		1.0 .. 100.0 V; 0	30.0 V	Uph-e< Pickup
3753	T Uph-e<	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-e< Time Delay
3754	Uph-e<<	Voltage Prot.		1.0 .. 100.0 V; 0	10.0 V	Uph-e<< Pickup
3755	T Uph-e<<	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-e<< Time Delay
3758	CURR.SUP. Uphe<	Voltage Prot.		ON OFF	ON	Current supervision (Uph-e)
3759A	Uph-e<(<) RESET	Voltage Prot.		1.01 .. 1.20	1.05	Uph-e<(<) Reset ratio

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3761	Uph-ph<(<)	Voltage Prot.		OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode Uph-ph under-voltage prot.
3762	Uph-ph<	Voltage Prot.		1.0 .. 175.0 V; 0	50.0 V	Uph-ph< Pickup
3763	T Uph-ph<	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T Uph-ph< Time Delay
3764	Uph-ph<<	Voltage Prot.		1.0 .. 175.0 V; 0	17.0 V	Uph-ph<< Pickup
3765	T Uphph<<	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T Uph-ph<< Time Delay
3768	CURR.SUP.Uphph<	Voltage Prot.		ON OFF	ON	Current supervision (Uph-ph)
3769A	Uphph<(<) RESET	Voltage Prot.		1.01 .. 1.20	1.05	Uph-ph<(<) Reset ratio
3771	U1<(<)	Voltage Prot.		OFF Alarm Only ON U<Alarm U<<Trip	OFF	Operating mode U1 undervolt-age prot.
3772	U1<	Voltage Prot.		1.0 .. 100.0 V; 0	30.0 V	U1< Pickup
3773	T U1<	Voltage Prot.		0.00 .. 100.00 sec; ∞	2.00 sec	T U1< Time Delay
3774	U1<<	Voltage Prot.		1.0 .. 100.0 V; 0	10.0 V	U1<< Pickup
3775	T U1<<	Voltage Prot.		0.00 .. 100.00 sec; ∞	1.00 sec	T U1<< Time Delay
3778	CURR.SUP.U1<	Voltage Prot.		ON OFF	ON	Current supervision (U1)
3779A	U1<(<) RESET	Voltage Prot.		1.01 .. 1.20	1.05	U1<(<) Reset ratio
3901	FCT BreakerFail	Breaker Failure		ON OFF	ON	Breaker Failure Protection
3902	I> BF	Breaker Failure	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold I>
			5A	0.25 .. 100.00 A	0.50 A	
3903	1p-RETRIP (T1)	Breaker Failure		NO YES	YES	1pole retrip with stage T1 (local trip)
3904	T1-1pole	Breaker Failure		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 1pole start (local trip)
3905	T1-3pole	Breaker Failure		0.00 .. 30.00 sec; ∞	0.00 sec	T1, Delay after 3pole start (local trip)
3906	T2	Breaker Failure		0.00 .. 30.00 sec; ∞	0.15 sec	T2, Delay of 2nd stage (busbar trip)
3907	T3-BkrDefective	Breaker Failure		0.00 .. 30.00 sec; ∞	0.00 sec	T3, Delay for start with defective bkr.
3908	Trip BkrDefect.	Breaker Failure		NO with T1-trip with T2-trip w/ T1/T2-trip	NO	Trip output selection with defec-tive bkr
3909	Chk BRK CONTACT	Breaker Failure		NO YES	YES	Check Breaker contacts
3912	3I0> BF	Breaker Failure	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold 3I0>
			5A	0.25 .. 100.00 A	0.50 A	
3921	End Flt. stage	Breaker Failure		ON OFF	OFF	End fault protection
3922	T-EndFault	Breaker Failure		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay of end fault protection
3931	PoleDiscrepancy	Breaker Failure		ON OFF	OFF	Pole Discrepancy supervision
3932	T-PoleDiscrep.	Breaker Failure		0.00 .. 30.00 sec; ∞	2.00 sec	Trip delay with pole discrepancy
4001	FCT TripSuperv.	TripCirc.Superv		ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	TripCirc.Superv		1 .. 2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	TripCirc.Superv		1 .. 30 sec	2 sec	Delay Time for alarm
4101	REF PROT.	REF		OFF ON	OFF	Restricted Earth Fault Protection
4111	I-REF>	REF	1A	0.05 .. 2.00 A	0.15 A	Pick up value I REF>
			5A	0.25 .. 10.00 A	0.75 A	
4112A	T I-REF>	REF		0.00 .. 60.00 sec; ∞	0.00 sec	T I-REF> Time Delay
4113A	SLOPE	REF		0.00 .. 0.95	0.00	Slope of Charac. I-REF> = f(I-SUM)

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
4201	Ther. OVERLOAD	Therm. Overload		OFF ON Alarm Only	OFF	Thermal overload protection
4202	K-FACTOR	Therm. Overload		0.10 .. 4.00	1.10	K-Factor
4203	TIME CONSTANT	Therm. Overload		1.0 .. 999.9 min	100.0 min	Time Constant
4204	Θ ALARM	Therm. Overload		50 .. 100 %	90 %	Thermal Alarm Stage
4205	I ALARM	Therm. Overload	1A	0.10 .. 4.00 A	1.00 A	Current Overload Alarm Setpoint
			5A	0.50 .. 20.00 A	5.00 A	
4206	CALC. METHOD	Therm. Overload		Θ max Average Θ Θ from Imax	Θ max	Method of Acquiring Tempera-ture
4501	STATE PROT I 1	Prot. Interface		ON OFF	ON	State of protection interface 1
4502	CONNEC. 1 OVER	Prot. Interface		F.optic direct Com conv 64 kB Com conv 128 kB Com conv 512 kB	F.optic direct	Connection 1 over
4505A	PROT 1 T-DELAY	Prot. Interface		0.1 .. 30.0 ms	30.0 ms	Prot 1: Maximal permissible delay time
4506A	PROT 1 UNSYM.	Prot. Interface		0.000 .. 3.000 ms	0.100 ms	Prot 1: Diff. in send and receive time
4509	T-DATA DISTURB	Prot. Interface		0.05 .. 2.00 sec	0.10 sec	Time delay for data disturbance alarm
4510	T-DATAFAIL	Prot. Interface		0.0 .. 60.0 sec	6.0 sec	Time del for transmission failure alarm
4511	PI1 SYNCMODE	Prot. Interface		TEL and GPS TEL or GPS GPS SYNC OFF	TEL and GPS	PI1 Synchronizationmode
4512	Td ResetRemote	Prot. Interface		0.00 .. 300.00 sec; ∞	0.00 sec	Remote signal RESET DELAY for comm.fail
4513A	PROT1 max ERROR	Prot. Interface		0.5 .. 20.0 %	1.0 %	Prot 1: Maximal permissible error rate
4515A	PI1 BLOCK UNSYM	Prot. Interface		YES NO	YES	Prot.1: Block. due to unsym. delay time
4701	ID OF RELAY 1	Diff.-Topo		1 .. 65534	1	Identification number of relay 1
4702	ID OF RELAY 2	Diff.-Topo		1 .. 65534	2	Identification number of relay 2
4710	LOCAL RELAY	Diff.-Topo		relay 1 relay 2	relay 1	Local relay is
4801	GPS-SYNC.	Prot. Interface		ON OFF	OFF	GPS synchronization
4803A	TD GPS FAILD	Prot. Interface		0.5 .. 60.0 sec	2.1 sec	Delay time for local GPS-pulse loss

A.8 Information List

Indications for IEC 60 870-5-103 are always reported ON / OFF if they are subject to general interrogation for IEC 60 870-5-103. If not, they are reported only as ON.

The function type of Differential Protection 7SD610 regarding IEC 60 870-5-103 refers to as “compatible function type 192” (Differential Protection).

New user-defined indications or such newly allocated to IEC 60 870-5-103 are set to ON / OFF and subjected to general interrogation if the information type is not a spontaneous event („.._Ev“). Further information on indications can be found in detail in the SIPROTEC 4 System Description, Order No. E50417-H1100-C151.

In columns „Event Log“, „Trip Log“ and „Ground Fault Log“ the following applies:

UPPER CASE NOTATION “ON/OFF”: definitely set, not allocatable

lower case notation “on/off”: preset, allocatable

*: not preset, allocatable

<blank>: neither preset nor allocatable

In column „Marked in Oscill.Record“ the following applies:

UPPER CASE NOTATION “M”: definitely set, not allocatable

lower case notation “m”: preset, allocatable

*: not preset, allocatable

<blank>: neither preset nor allocatable

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
-	Test mode (Test mode)	Device	IntSP	ON OFF	*		*	LED			BO		192	21	1	Yes
-	Stop data transmission (DataStop)	Device	IntSP	ON OFF	*		*	LED			BO		192	20	1	Yes
-	Unlock data transmission via BI (UnlockDT)	Device	IntSP				*									
-	Reset LED (Reset LED)	Device	IntSP	ON	*		*	LED			BO		192	19	1	No
-	Clock Synchronization (SynchClock)	Device	IntSP_Ev	*	*		*	LED			BO					
-	>Back Light on (>Light on)	Device	SP	ON OFF	*				BI							
-	Hardware Test Mode (HWTestMod)	Device	IntSP	ON OFF	*		*	LED			BO					
-	Disturbance CFC (Distur.CFC)	Device	OUT	on off	*			LED			BO					
-	Breaker OPENED (Brk OPENED)	Device	IntSP	*	*		*	LED			BO					
-	Feeder EARTHED (FdrEARTHED)	Device	IntSP	*	*		*	LED			BO					
-	Group A (Group A)	Change Group	IntSP	ON OFF	*		*	LED			BO		192	23	1	Yes
-	Group B (Group B)	Change Group	IntSP	ON OFF	*		*	LED			BO		192	24	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
-	Group C (Group C)	Change Group	IntSP	ON OFF	*		*	LED			BO		192	25	1	Yes
-	Group D (Group D)	Change Group	IntSP	ON OFF	*		*	LED			BO		192	26	1	Yes
-	Fault Recording Start (FltRecSta)	Osc. Fault Rec.	IntSP	on off	*		m	LED			BO					
-	CB1-TEST trip/close - Only L1 (CB1tst L1)	Testing	-		*											
-	CB1-TEST trip/close - Only L2 (CB1tst L2)	Testing	-		*											
-	CB1-TEST trip/close - Only L3 (CB1tst L3)	Testing	-		*											
-	CB1-TEST trip/close Phases L123 (CB1tst 123)	Testing	-		*											
-	Controlmode REMOTE (ModeR-EMOTE)	Cntrl Authority	IntSP	on off	*			LED			BO					
-	Control Authority (Cntrl Auth)	Cntrl Authority	IntSP	on off	*			LED			BO		101	85	1	Yes
-	Controlmode LOCAL (ModeLO-CAL)	Cntrl Authority	IntSP	on off	*			LED			BO		101	86	1	Yes
-	Breaker (Breaker)	Control Device	CF_D 12	on off	*						BO		240	160	20	
-	Breaker (Breaker)	Control Device	DP	on off	*				BI			CB	240	160	1	Yes
-	Disconnect Switch (Disc.Swit.)	Control Device	CF_D 2	on off	*						BO		240	161	20	
-	Disconnect Switch (Disc.Swit.)	Control Device	DP	on off	*				BI			CB	240	161	1	Yes
-	Earth Switch (EarthSwit)	Control Device	CF_D 2	on off	*						BO		240	164	20	
-	Earth Switch (EarthSwit)	Control Device	DP	on off	*				BI			CB	240	164	1	Yes
-	Interlocking: Breaker Open (Brk Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Breaker Close (Brk Close)	Control Device	IntSP	*	*		*									
-	Interlocking: Disconnect switch Open (Disc.Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Disconnect switch Close (Disc.Close)	Control Device	IntSP	*	*		*									
-	Interlocking: Earth switch Open (E Sw Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Earth switch Close (E Sw Cl.)	Control Device	IntSP	*	*		*									
-	Q2 Open/Close (Q2 Op/Cl)	Control Device	CF_D 2	on off	*						BO		240	162	20	
-	Q2 Open/Close (Q2 Op/Cl)	Control Device	DP	on off	*				BI			CB	240	162	1	Yes
-	Q9 Open/Close (Q9 Op/Cl)	Control Device	CF_D 2	on off	*						BO		240	163	20	
-	Q9 Open/Close (Q9 Op/Cl)	Control Device	DP	on off	*				BI			CB	240	163	1	Yes
-	Fan ON/OFF (Fan ON/OFF)	Control Device	CF_D 2	on off	*						BO		240	175	20	
-	Fan ON/OFF (Fan ON/OFF)	Control Device	DP	on off	*				BI			CB	240	175	1	Yes

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
-	>Cabinet door open (>Door open)	Process Data	SP	on off	*		*	LED	BI		BO	CB	101	1	1	Yes
-	>CB waiting for Spring charged (>CB wait)	Process Data	SP	on off	*		*	LED	BI		BO	CB	101	2	1	Yes
-	>Error Motor Voltage (>Err Mot U)	Process Data	SP	on off	*		*	LED	BI		BO	CB	240	181	1	Yes
-	>Error Control Voltage (>ErrCntr-lU)	Process Data	SP	on off	*		*	LED	BI		BO	CB	240	182	1	Yes
-	>SF6-Loss (>SF6-Loss)	Process Data	SP	on off	*		*	LED	BI		BO	CB	240	183	1	Yes
-	>Error Meter (>Err Meter)	Process Data	SP	on off	*		*	LED	BI		BO	CB	240	184	1	Yes
-	>Transformer Temperature (>Tx Temp.)	Process Data	SP	on off	*		*	LED	BI		BO	CB	240	185	1	Yes
-	>Transformer Danger (>Tx Danger)	Process Data	SP	on off	*		*	LED	BI		BO	CB	240	186	1	Yes
-	Reset meter (Meter res)	Energy	IntSP _Ev	ON	*											
-	Error Systeminterface (SysIn-tErr.)	Protocol	IntSP	on off				LED			BO					
-	Threshold Value 1 (ThreshVal1)	Thresh.-Switch	IntSP	ON OFF	*		*	LED	BI	FC TN	BO	CB				
3	>Synchronize Internal Real Time Clock (>Time Synch)	Device	SP	*	*		*	LED	BI		BO					
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Osc. Fault Rec.	SP	on	*		m	LED	BI		BO					
5	>Reset LED (>Reset LED)	Device	SP	*	*		*	LED	BI		BO					
7	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	SP	*	*		*	LED	BI		BO					
8	>Setting Group Select Bit 1 (>Set Group Bit1)	Change Group	SP	*	*		*	LED	BI		BO					
009.0100	Failure EN100 Modul (Failure Modul)	EN100-Modul 1	IntSP	on off			*	LED			BO					
009.0101	Failure EN100 Link Channel 1 (Ch1) (Fail Ch1)	EN100-Modul 1	IntSP	on off			*	LED			BO					
009.0102	Failure EN100 Link Channel 2 (Ch2) (Fail Ch2)	EN100-Modul 1	IntSP	on off			*	LED			BO					
11	>User defined annunciation 1 (>Annunc. 1)	Device	SP	*	*	*	*	LED	BI		BO		192	27	1	Yes
12	>User defined annunciation 2 (>Annunc. 2)	Device	SP	*	*	*	*	LED	BI		BO		192	28	1	Yes
13	>User defined annunciation 3 (>Annunc. 3)	Device	SP	*	*	*	*	LED	BI		BO		192	29	1	Yes
14	>User defined annunciation 4 (>Annunc. 4)	Device	SP	*	*	*	*	LED	BI		BO		192	30	1	Yes
15	>Test mode (>Test mode)	Device	SP	ON OFF	*		*	LED	BI		BO		135	53	1	Yes
16	>Stop data transmission (>DataStop)	Device	SP	*	*		*	LED	BI		BO		135	54	1	Yes
51	Device is Operational and Pro-tecting (Device OK)	Device	OUT	ON OFF	*		*	LED			BO		135	81	1	Yes
52	At Least 1 Protection Funct. is Active (ProtActive)	Device	IntSP	ON OFF	*		*	LED			BO		192	18	1	Yes
55	Reset Device (Reset Device)	Device	OUT	*	*		*	LED			BO					
56	Initial Start of Device (Initial Start)	Device	OUT	ON	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
60	Reset LED (Reset LED)	Device	OUT_Ev	ON	*		*	LED			BO					
67	Resume (Resume)	Device	OUT	ON	*		*	LED			BO		135	97	1	No
68	Clock Synchronization Error (Clock SyncError)	Device	OUT	ON OFF	*		*	LED			BO					
69	Daylight Saving Time (DayLight-SavTime)	Device	OUT	ON OFF	*		*	LED			BO					
70	Setting calculation is running (Settings Calc.)	Device	OUT	ON OFF	*		*	LED			BO		192	22	1	Yes
71	Settings Check (Settings Check)	Device	OUT	*	*		*	LED			BO					
72	Level-2 change (Level-2 change)	Device	OUT	ON OFF	*		*	LED			BO					
73	Local setting change (Local change)	Device	OUT	*	*											
110	Event lost (Event Lost)	Device	OUT_Ev	ON	*		*	LED			BO		135	130	1	No
113	Flag Lost (Flag Lost)	Device	OUT	ON	*		m	LED			BO		135	136	1	Yes
125	Chatter ON (Chatter ON)	Device	OUT	ON OFF	*		*	LED			BO		135	145	1	Yes
126	Protection ON/OFF (via system port) (ProtON/OFF)	Device	IntSP	ON OFF	*		*	LED			BO					
127	Auto Reclose ON/OFF (via system port) (AR ON/OFF)	Auto Reclose	IntSP	ON OFF	*		*	LED			BO					
130	Load angle Phi(PQ Positive sequence) (φ(PQ Pos. Seq.))	Measurem.Superv	OUT	*	*		*	LED			BO					
131	Load angle Phi(PQ) blocked (φ(PQ Pos) block)	Measurem.Superv	OUT	*	*		*	LED			BO					
132	Setting error: |PhiA - PhiB| < 3° (φ Set wrong)	Measurem.Superv	OUT	*	*		*	LED			BO					
140	Error with a summary alarm (Error Sum Alarm)	Device	OUT	ON OFF	*		*	LED			BO		192	47	1	Yes
144	Error 5V (Error 5V)	Device	OUT	ON OFF	*		*	LED			BO		135	164	1	Yes
160	Alarm Summary Event (Alarm Sum Event)	Device	OUT	*	*		*	LED			BO		192	46	1	Yes
161	Failure: General Current Supervision (Fail I Superv.)	Measurem.Superv	OUT	*	*		*	LED			BO		192	32	1	Yes
163	Failure: Current Balance (Fail I balance)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	183	1	Yes
164	Failure: General Voltage Supervision (Fail U Superv.)	Measurem.Superv	OUT	*	*		*	LED			BO		192	33	1	Yes
165	Failure: Voltage summation Phase-Earth (Fail Σ U Ph-E)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	184	1	Yes
167	Failure: Voltage Balance (Fail U balance)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	186	1	Yes
168	Failure: Voltage absent (Fail U absent)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	187	1	Yes
169	VT Fuse Failure (alarm >10s) (VT FuseFail>10s)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	188	1	Yes
170	VT Fuse Failure (alarm instantaneous) (VT FuseFail)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO					
171	Failure: Phase Sequence (Fail Ph. Seq.)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		192	35	1	Yes
177	Failure: Battery empty (Fail Battery)	Device	OUT	ON OFF	*		*	LED			BO		135	193	1	Yes

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
181	Error: A/D converter (Error A/D-conv.)	Device	OUT	ON OFF	*		*	LED			BO		135	178	1	Yes
183	Error Board 1 (Error Board 1)	Device	OUT	ON OFF	*		*	LED			BO		135	171	1	Yes
184	Error Board 2 (Error Board 2)	Device	OUT	ON OFF	*		*	LED			BO		135	172	1	Yes
185	Error Board 3 (Error Board 3)	Device	OUT	ON OFF	*		*	LED			BO		135	173	1	Yes
186	Error Board 4 (Error Board 4)	Device	OUT	ON OFF	*		*	LED			BO		135	174	1	Yes
187	Error Board 5 (Error Board 5)	Device	OUT	ON OFF	*		*	LED			BO		135	175	1	Yes
188	Error Board 6 (Error Board 6)	Device	OUT	ON OFF	*		*	LED			BO		135	176	1	Yes
189	Error Board 7 (Error Board 7)	Device	OUT	ON OFF	*		*	LED			BO		135	177	1	Yes
190	Error Board 0 (Error Board 0)	Device	OUT	ON OFF	*		*	LED			BO		135	210	1	Yes
191	Error: Offset (Error Offset)	Device	OUT	ON OFF	*		*	LED			BO					
192	Error:1A/5Ajumper different from setting (Error1A/5Awrong)	Device	OUT	ON OFF	*		*	LED			BO		135	169	1	Yes
193	Alarm: Analog input adjustment invalid (Alarm adjustm.)	Device	OUT	ON OFF	*		*	LED			BO		135	181	1	Yes
194	Error: Neutral CT different from MLFB (Error neutralCT)	Device	OUT	ON OFF	*		*	LED			BO		135	180	1	Yes
196	Fuse Fail Monitor is switched OFF (Fuse Fail M.OFF)	Measurem.Superv	OUT		*		*	LED			BO		135	196	1	Yes
197	Measurement Supervision is switched OFF (MeasSup OFF)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	197	1	Yes
285	Power factor alarm (cosφ alarm)	Set Points(MV)	OUT	on off	*		*	LED			BO					
289	Alarm: Current summation super-vision (Failure Σi)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	250	1	Yes
290	Alarm: Broken current-wire de-tected L1 (Broken Iwire L1)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	137	1	Yes
291	Alarm: Broken current-wire de-tected L2 (Broken Iwire L2)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	138	1	Yes
292	Alarm: Broken current-wire de-tected L3 (Broken Iwire L3)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO		135	139	1	Yes
295	Broken wire supervision is switched OFF (Broken wire OFF)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO					
296	Current summation superv is switched OFF (Σi superv. OFF)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO					
297	Broken current-wire at other end L1 (ext.Brk.Wire L1)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO					
298	Broken current-wire at other end L2 (ext.Brk.Wire L2)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO					
299	Broken current-wire at other end L3 (ext.Brk.Wire L3)	Measurem.Superv	OUT	ON OFF	*		*	LED			BO					
301	Power System fault (Pow.Sys.Flt.)	P.System Data 2	OUT	ON OFF	ON		*						135	231	2	Yes
302	Fault Event (Fault Event)	P.System Data 2	OUT	*	ON		*						135	232	2	No
320	Warn: Limit of Memory Data ex-ceeded (Warn Mem. Data)	Device	OUT	on off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
321	Warn: Limit of Memory Parameter exceeded (Warn Mem. Para.)	Device	OUT	on off	*		*	LED			BO					
322	Warn: Limit of Memory Operation exceeded (Warn Mem. Oper.)	Device	OUT	on off	*		*	LED			BO					
323	Warn: Limit of Memory New exceeded (Warn Mem. New)	Device	OUT	on off	*		*	LED			BO					
351	>Circuit breaker aux. contact: Pole L1 (>CB Aux. L1)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	1	1	Yes
352	>Circuit breaker aux. contact: Pole L2 (>CB Aux. L2)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	2	1	Yes
353	>Circuit breaker aux. contact: Pole L3 (>CB Aux. L3)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	3	1	Yes
356	>Manual close signal (>Manual Close)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	6	1	Yes
357	>Block manual close cmd. from external (>Blk Man. Close)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		150	7	1	Yes
361	>Failure: Feeder VT (MCB tripped) (>FAIL:Feeder VT)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		192	38	1	Yes
366	>CB1 Pole L1 (for AR,CB-Test) (>CB1 Pole L1)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	66	1	Yes
367	>CB1 Pole L2 (for AR,CB-Test) (>CB1 Pole L2)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	67	1	Yes
368	>CB1 Pole L3 (for AR,CB-Test) (>CB1 Pole L3)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	68	1	Yes
371	>CB1 READY (for AR,CB-Test) (>CB1 Ready)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	71	1	Yes
378	>CB faulty (>CB faulty)	P.System Data 2	SP	*	*		*	LED	BI		BO					
379	>CB aux. contact 3pole Closed (>CB 3p Closed)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	78	1	Yes
380	>CB aux. contact 3pole Open (>CB 3p Open)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	79	1	Yes
381	>Single-phase trip permitted from ext.AR (>1p Trip Perm)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO					
382	>External AR programmed for 1phase only (>Only 1ph AR)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO					
383	>Enable all AR Zones / Stages (>Enable ARzones)	P.System Data 2	SP	ON OFF	ON OFF		*	LED	BI		BO					
385	>Lockout SET (>Lockout SET)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		150	35	1	Yes
386	>Lockout RESET (>Lockout RESET)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		150	36	1	Yes
410	>CB1 aux. 3p Closed (for AR, CB-Test) (>CB1 3p Closed)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	80	1	Yes
411	>CB1 aux. 3p Open (for AR, CB-Test) (>CB1 3p Open)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	81	1	Yes
501	Relay PICKUP (Relay PICKUP)	P.System Data 2	OUT	*	*		M	LED			BO		192	84	2	Yes
502	Relay Drop Out (Relay Drop Out)	P.System Data 2	OUT													
503	Relay PICKUP Phase L1 (Relay PICKUP L1)	P.System Data 2	OUT	*	*		m	LED			BO		192	64	2	Yes
504	Relay PICKUP Phase L2 (Relay PICKUP L2)	P.System Data 2	OUT	*	*		m	LED			BO		192	65	2	Yes
505	Relay PICKUP Phase L3 (Relay PICKUP L3)	P.System Data 2	OUT	*	*		m	LED			BO		192	66	2	Yes
506	Relay PICKUP Earth (Relay PICKUP E)	P.System Data 2	OUT	*	*		m	LED			BO		192	67	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
507	Relay TRIP command Phase L1 (Relay TRIP L1)	P.System Data 2	OUT	*	*		m	LED			BO		192	69	2	No
508	Relay TRIP command Phase L2 (Relay TRIP L2)	P.System Data 2	OUT	*	*		m	LED			BO		192	70	2	No
509	Relay TRIP command Phase L3 (Relay TRIP L3)	P.System Data 2	OUT	*	*		m	LED			BO		192	71	2	No
510	Relay GENERAL CLOSE command (Relay CLOSE)	P.System Data 2	OUT	*	*		*	LED			BO					
511	Relay GENERAL TRIP command (Relay TRIP)	P.System Data 2	OUT	*	OFF		M	LED			BO		192	68	2	No
512	Relay TRIP command - Only Phase L1 (Relay TRIP 1pL1)	P.System Data 2	OUT	*	*		*	LED			BO					
513	Relay TRIP command - Only Phase L2 (Relay TRIP 1pL2)	P.System Data 2	OUT	*	*		*	LED			BO					
514	Relay TRIP command - Only Phase L3 (Relay TRIP 1pL3)	P.System Data 2	OUT	*	*		*	LED			BO					
515	Relay TRIP command Phases L123 (Relay TRIP 3ph.)	P.System Data 2	OUT	*	*		*	LED			BO					
530	LOCKOUT is active (LOCKOUT)	P.System Data 2	IntSP	ON OFF	*		*	LED			BO					
533	Primary fault current IL1 (IL1 =)	P.System Data 2	VI	*	ON OFF								150	177	4	No
534	Primary fault current IL2 (IL2 =)	P.System Data 2	VI	*	ON OFF								150	178	4	No
535	Primary fault current IL3 (IL3 =)	P.System Data 2	VI	*	ON OFF								150	179	4	No
536	Relay Definitive TRIP (Definitive TRIP)	P.System Data 2	OUT	ON	ON			LED			BO		150	180	2	Yes
545	Time from Pickup to drop out (PU Time)	P.System Data 2	VI													
546	Time from Pickup to TRIP (TRIP Time)	P.System Data 2	VI													
560	Single-phase trip was coupled 3phase (Trip Coupled 3p)	P.System Data 2	OUT	*	ON		*	LED			BO		150	210	2	No
561	Manual close signal detected (Man.Clos.Detect)	P.System Data 2	OUT	ON	*		*	LED			BO		150	211	1	No
562	CB CLOSE command for manual closing (Man.Close Cmd)	P.System Data 2	OUT	*	*		*	LED			BO		150	212	1	No
563	CB alarm suppressed (CB Alarm Supp)	P.System Data 2	OUT	*	*		*	LED			BO					
590	Line closure detected (Line closure)	P.System Data 2	OUT	ON OFF	ON OFF		*	LED			BO					
591	Single pole open detected in L1 (1pole open L1)	P.System Data 2	OUT	ON OFF	ON OFF		*	LED			BO					
592	Single pole open detected in L2 (1pole open L2)	P.System Data 2	OUT	ON OFF	ON OFF		*	LED			BO					
593	Single pole open detected in L3 (1pole open L3)	P.System Data 2	OUT	ON OFF	ON OFF		*	LED			BO					
916	Increment of active energy (WpΔ=)	Energy	-													
917	Increment of reactive energy (WqΔ=)	Energy	-													
1000	Number of breaker TRIP commands (# TRIPs=)	Statistics	VI													
1001	Number of breaker TRIP commands L1 (TripNo L1=)	Statistics	VI													

No.	Description	Function	Type of Information	Log Buffers: 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: Relay	Configurable in Matrix: Chatter Suppression	IEC 60870-5-103: Type	IEC 60870-5-103: Information Number	IEC 60870-5-103: Data Unit	IEC 60870-5-103: General Interrogation
1002	Number of breaker TRIP commands L2 (TripNo L2=)	Statistics	VI													
1003	Number of breaker TRIP commands L3 (TripNo L3=)	Statistics	VI													
1027	Accumulation of interrupted current L1 (Σ IL1 =)	Statistics	VI													
1028	Accumulation of interrupted current L2 (Σ IL2 =)	Statistics	VI													
1029	Accumulation of interrupted current L3 (Σ IL3 =)	Statistics	VI													
1030	Max. fault current Phase L1 (Max IL1 =)	Statistics	VI													
1031	Max. fault current Phase L2 (Max IL2 =)	Statistics	VI													
1032	Max. fault current Phase L3 (Max IL3 =)	Statistics	VI													
1401	>BF: Switch on breaker fail protection (>BF on)	Breaker Failure	SP	*	*		*	LED	BI		BO					
1402	>BF: Switch off breaker fail protection (>BF off)	Breaker Failure	SP	*	*		*	LED	BI		BO					
1403	>BLOCK Breaker failure (>BLOCK BkrFail)	Breaker Failure	SP	ON OFF	*		*	LED	BI		BO		166	103	1	Yes
1415	>BF: External start 3pole (>BF Start 3pole)	Breaker Failure	SP	ON OFF	*		*	LED	BI		BO					
1432	>BF: External release (>BF release)	Breaker Failure	SP	ON OFF	*		*	LED	BI		BO					
1435	>BF: External start L1 (>BF Start L1)	Breaker Failure	SP	ON OFF	*		*	LED	BI		BO					
1436	>BF: External start L2 (>BF Start L2)	Breaker Failure	SP	ON OFF	*		*	LED	BI		BO					
1437	>BF: External start L3 (>BF Start L3)	Breaker Failure	SP	ON OFF	*		*	LED	BI		BO					
1439	>BF: External start 3pole (w/o current) (>BF Start w/o I)	Breaker Failure	SP	ON OFF	*		*	LED	BI		BO					
1440	Breaker failure prot. ON/OFF via BI (BkrFailON/offBI)	Breaker Failure	IntSP	ON OFF	*		*	LED			BO					
1451	Breaker failure is switched OFF (BkrFail OFF)	Breaker Failure	OUT	ON OFF	*		*	LED			BO		166	151	1	Yes
1452	Breaker failure is BLOCKED (BkrFail BLOCK)	Breaker Failure	OUT	ON OFF	ON OFF		*	LED			BO		166	152	1	Yes
1453	Breaker failure is ACTIVE (BkrFail ACTIVE)	Breaker Failure	OUT	*	*		*	LED			BO		166	153	1	Yes
1461	Breaker failure protection started (BF Start)	Breaker Failure	OUT	*	ON OFF		*	LED			BO		166	161	2	Yes
1472	BF Trip T1 (local trip) - only phase L1 (BF T1-TRIP 1pL1)	Breaker Failure	OUT	*	ON		*	LED			BO					
1473	BF Trip T1 (local trip) - only phase L2 (BF T1-TRIP 1pL2)	Breaker Failure	OUT	*	ON		*	LED			BO					
1474	BF Trip T1 (local trip) - only phase L3 (BF T1-TRIP 1pL3)	Breaker Failure	OUT	*	ON		*	LED			BO					
1476	BF Trip T1 (local trip) - 3pole (BF T1-TRIP L123)	Breaker Failure	OUT	*	ON		*	LED			BO					
1493	BF Trip in case of defective CB (BF TRIP CBdefec)	Breaker Failure	OUT	*	ON		*	LED			BO					
1494	BF Trip T2 (busbar trip) (BF T2-TRIP(bus))	Breaker Failure	OUT	*	ON		*	LED			BO		192	85	2	No

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
1495	BF Trip End fault stage (BF EndFlt TRIP)	Breaker Failure	OUT	*	ON		*	LED			BO					
1496	BF Pole discrepancy pickup (BF CBdiscrSTART)	Breaker Failure	OUT	*	ON OFF		*	LED			BO					
1497	BF Pole discrepancy pickup L1 (BF CBdiscr L1)	Breaker Failure	OUT	*	ON OFF		*	LED			BO					
1498	BF Pole discrepancy pickup L2 (BF CBdiscr L2)	Breaker Failure	OUT	*	ON OFF		*	LED			BO					
1499	BF Pole discrepancy pickup L3 (BF CBdiscr L3)	Breaker Failure	OUT	*	ON OFF		*	LED			BO					
1500	BF Pole discrepancy Trip (BF CBdiscr TRIP)	Breaker Failure	OUT	*	ON		*	LED			BO					
1503	>BLOCK Thermal Overload Protection (>BLK ThOverload)	Therm. Overload	SP	*	*		*	LED	BI		BO		167	3	1	Yes
1511	Thermal Overload Protection OFF (Th.Overload OFF)	Therm. Overload	OUT	ON OFF	*		*	LED			BO		167	11	1	Yes
1512	Thermal Overload Protection BLOCKED (Th.Overload BLK)	Therm. Overload	OUT	ON OFF	ON OFF		*	LED			BO		167	12	1	Yes
1513	Thermal Overload Protection ACTIVE (Th.O/L ACTIVE)	Therm. Overload	OUT	ON OFF	*		*	LED			BO		167	13	1	Yes
1515	Th. Overload: Current Alarm (I alarm) (Th.O/L I Alarm)	Therm. Overload	OUT	ON OFF	*		*	LED			BO		167	15	1	Yes
1516	Th. Overload Alarm: Near Thermal Trip (Th.O/L Θ Alarm)	Therm. Overload	OUT	ON OFF	*		*	LED			BO		167	16	1	Yes
1517	Th. Overload Pickup before trip (Th.O/L Pickup)	Therm. Overload	OUT	ON OFF	*		*	LED			BO		167	17	1	Yes
1521	Th. Overload TRIP command (Th.O/L TRIP)	Therm. Overload	OUT	*	ON		*	LED			BO		167	21	2	Yes
2054	Emergency mode (Emer. mode)	Device	OUT	ON OFF	ON OFF		*	LED			BO		192	37	1	Yes
2701	>AR: Switch on auto-reclose function (>AR on)	Auto Reclose	SP	*	*		*	LED	BI		BO		40	1	1	Yes
2702	>AR: Switch off auto-reclose function (>AR off)	Auto Reclose	SP	*	*		*	LED	BI		BO		40	2	1	Yes
2703	>AR: Block auto-reclose function (>AR block)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	3	1	Yes
2711	>External start of internal Auto reclose (>AR Start)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	11	2	Yes
2712	>AR: External trip L1 for AR start (>Trip L1 AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	12	2	Yes
2713	>AR: External trip L2 for AR start (>Trip L2 AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	13	2	Yes
2714	>AR: External trip L3 for AR start (>Trip L3 AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	14	2	Yes
2715	>AR: External 1pole trip for AR start (>Trip 1pole AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	15	2	Yes
2716	>AR: External 3pole trip for AR start (>Trip 3pole AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	16	2	Yes
2727	>AR: Remote Close signal (>AR RemoteClose)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	22	2	Yes
2731	>AR: Sync. release from ext. sync.-check (>Sync.release)	Auto Reclose	SP	*	*		*	LED	BI		BO		40	31	2	Yes
2737	>AR: Block 1pole AR-cycle (>BLOCK 1pole AR)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	32	1	Yes
2738	>AR: Block 3pole AR-cycle (>BLOCK 3pole AR)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	33	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
2739	>AR: Block 1phase-fault AR-cycle (>BLK 1phase AR)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	34	1	Yes
2740	>AR: Block 2phase-fault AR-cycle (>BLK 2phase AR)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	35	1	Yes
2741	>AR: Block 3phase-fault AR-cycle (>BLK 3phase AR)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	36	1	Yes
2742	>AR: Block 1st AR-cycle (>BLK 1.AR-cycle)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	37	1	Yes
2743	>AR: Block 2nd AR-cycle (>BLK 2.AR-cycle)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	38	1	Yes
2744	>AR: Block 3rd AR-cycle (>BLK 3.AR-cycle)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	39	1	Yes
2745	>AR: Block 4th and higher AR-cycles (>BLK 4.-n. AR)	Auto Reclose	SP	ON OFF	*		*	LED	BI		BO		40	40	1	Yes
2746	>AR: External Trip for AR start (>Trip for AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	41	2	Yes
2747	>AR: External pickup L1 for AR start (>Pickup L1 AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	42	2	Yes
2748	>AR: External pickup L2 for AR start (>Pickup L2 AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	43	2	Yes
2749	>AR: External pickup L3 for AR start (>Pickup L3 AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	44	2	Yes
2750	>AR: External pickup 1phase for AR start (>Pickup 1ph AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	45	2	Yes
2751	>AR: External pickup 2phase for AR start (>Pickup 2ph AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	46	2	Yes
2752	>AR: External pickup 3phase for AR start (>Pickup 3ph AR)	Auto Reclose	SP	*	ON		*	LED	BI		BO		40	47	2	Yes
2781	AR: Auto-reclose is switched off (AR off)	Auto Reclose	OUT	ON OFF	*		*	LED			BO		40	81	1	Yes
2782	AR: Auto-reclose is switched on (AR on)	Auto Reclose	IntSP	*	*		*	LED			BO		192	16	1	Yes
2783	AR: Auto-reclose is blocked (AR is blocked)	Auto Reclose	OUT	ON OFF	*		*	LED			BO		40	83	1	Yes
2784	AR: Auto-reclose is not ready (AR not ready)	Auto Reclose	OUT	*	ON		*	LED			BO		192	130	1	Yes
2787	AR: Circuit breaker not ready (CB not ready)	Auto Reclose	OUT	*	*		*	LED			BO		40	87	1	Yes
2788	AR: CB ready monitoring window expired (AR T-CBreadyExp)	Auto Reclose	OUT	*	ON		*	LED			BO		40	88	2	Yes
2796	AR: Auto-reclose ON/OFF via BI (AR on/off BI)	Auto Reclose	IntSP	*	*		*	LED			BO					
2801	AR: Auto-reclose in progress (AR in progress)	Auto Reclose	OUT	*	ON		*	LED			BO		40	101	2	Yes
2809	AR: Start-signal monitoring time expired (AR T-Start Exp)	Auto Reclose	OUT	*	ON		*	LED			BO		40	174	2	Yes
2810	AR: Maximum dead time expired (AR TdeadMax Exp)	Auto Reclose	OUT	*	ON		*	LED			BO		40	175	2	Yes
2818	AR: Evolving fault recognition (AR evolving Flt)	Auto Reclose	OUT	*	ON		*	LED			BO		40	118	2	Yes
2820	AR is set to operate after 1p trip only (AR Program1pole)	Auto Reclose	OUT	*	*		*	LED			BO		40	143	1	Yes
2821	AR dead time after evolving fault (AR Td. evol.Flt)	Auto Reclose	OUT	*	ON OFF		*	LED			BO		40	197	2	Yes
2839	AR dead time after 1pole trip running (AR Tdead 1pTrip)	Auto Reclose	OUT	*	ON		*	LED			BO		40	148	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
2840	AR dead time after 3pole trip running (AR Tdead 3pTrip)	Auto Reclose	OUT	*	ON		*	LED			BO		40	149	2	Yes
2841	AR dead time after 1phase fault running (AR Tdead 1pFlt)	Auto Reclose	OUT	*	ON		*	LED			BO		40	150	2	Yes
2842	AR dead time after 2phase fault running (AR Tdead 2pFlt)	Auto Reclose	OUT	*	ON		*	LED			BO		40	151	2	Yes
2843	AR dead time after 3phase fault running (AR Tdead 3pFlt)	Auto Reclose	OUT	*	ON		*	LED			BO		40	154	2	Yes
2844	AR 1st cycle running (AR 1stCyc. run.)	Auto Reclose	OUT	*	ON		*	LED			BO		40	155	2	Yes
2845	AR 2nd cycle running (AR 2ndCyc. run.)	Auto Reclose	OUT	*	ON		*	LED			BO		40	157	2	Yes
2846	AR 3rd cycle running (AR 3rdCyc. run.)	Auto Reclose	OUT	*	ON		*	LED			BO		40	158	2	Yes
2847	AR 4th or higher cycle running (AR 4thCyc. run.)	Auto Reclose	OUT	*	ON		*	LED			BO		40	159	2	Yes
2848	AR cycle is running in ADT mode (AR ADT run.)	Auto Reclose	OUT	*	ON		*	LED			BO		40	130	2	Yes
2851	AR: Close command (AR CLOSE Cmd.)	Auto Reclose	OUT	*	ON		m	LED			BO		192	128	2	No
2852	AR: Close command after 1pole, 1st cycle (AR Close1.Cyc1p)	Auto Reclose	OUT	*	*		*	LED			BO		40	152	1	Yes
2853	AR: Close command after 3pole, 1st cycle (AR Close1.Cyc3p)	Auto Reclose	OUT	*	*		*	LED			BO		40	153	1	Yes
2854	AR: Close command 2nd cycle (and higher) (AR Close 2.Cyc)	Auto Reclose	OUT	*	*		*	LED			BO		192	129	1	No
2861	AR: Reclaim time is running (AR T-Recl. run.)	Auto Reclose	OUT	*	*		*	LED			BO		40	161	1	Yes
2862	AR successful (AR successful)	Auto Reclose	OUT	*	*		*	LED			BO		40	162	1	Yes
2864	AR: 1pole trip permitted by internal AR (AR 1p Trip Perm)	Auto Reclose	OUT	*	*		*	LED			BO		40	164	1	Yes
2865	AR: Synchro-check request (AR Sync.Request)	Auto Reclose	OUT	*	*		*	LED			BO		40	165	2	Yes
2871	AR: TRIP command 3pole (AR TRIP 3pole)	Auto Reclose	OUT	*	ON		*	LED			BO		40	171	2	Yes
2889	AR 1st cycle zone extension release (AR 1.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	160	1	Yes
2890	AR 2nd cycle zone extension release (AR 2.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	169	1	Yes
2891	AR 3rd cycle zone extension release (AR 3.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	170	1	Yes
2892	AR 4th cycle zone extension release (AR 4.CycZoneRel)	Auto Reclose	OUT	*	*		*	LED			BO		40	172	1	Yes
2893	AR zone extension (general) (AR Zone Release)	Auto Reclose	OUT	*	*		*	LED			BO		40	173	1	Yes
2894	AR Remote close signal send (AR Remote Close)	Auto Reclose	OUT	*	ON		*	LED			BO		40	129	2	Yes
2895	No. of 1st AR-cycle CLOSE commands,1pole (AR #Close1./1p=)	Statistics	VI													
2896	No. of 1st AR-cycle CLOSE commands,3pole (AR #Close1./3p=)	Statistics	VI													
2897	No. of higher AR-cycle CLOSE commands,1p (AR #Close2./1p=)	Statistics	VI													
2898	No. of higher AR-cycle CLOSE commands,3p (AR #Close2./3p=)	Statistics	VI													

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
3102	Diff: 2nd Harmonic detected in phase L1 (2nd Harmonic L1)	Diff. Prot	OUT	*	*		*	LED			BO		92	89	1	Yes
3103	Diff: 2nd Harmonic detected in phase L2 (2nd Harmonic L2)	Diff. Prot	OUT	*	*		*	LED			BO		92	90	1	Yes
3104	Diff: 2nd Harmonic detected in phase L3 (2nd Harmonic L3)	Diff. Prot	OUT	*	*		*	LED			BO		92	91	1	Yes
3120	Diff: Active (Diff active)	Diff. Prot	OUT	ON OFF	*		m	LED			BO		92	92	1	Yes
3132	Diff: Fault detection (Diff. Gen. Flt.)	Diff. Prot	OUT	*	ON OFF		m	LED			BO					
3133	Diff: Fault detection in phase L1 (Diff. Flt. L1)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	93	2	Yes
3134	Diff: Fault detection in phase L2 (Diff. Flt. L2)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	94	2	Yes
3135	Diff: Fault detection in phase L3 (Diff. Flt. L3)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	95	2	Yes
3136	Diff: Earth fault detection (Diff. Flt. E)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	96	2	Yes
3137	Diff: Fault detection of I-Diff>> (I-Diff>> Flt.)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	97	2	Yes
3139	Diff: Fault detection of I-Diff> (I-Diff> Flt.)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	98	2	Yes
3141	Diff: General TRIP (Diff. Gen. TRIP)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	99	2	Yes
3142	Diff: TRIP - Only L1 (Diff TRIP 1p L1)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	100	2	Yes
3143	Diff: TRIP - Only L2 (Diff TRIP 1p L2)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	101	2	Yes
3144	Diff: TRIP - Only L3 (Diff TRIP 1p L3)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	102	2	Yes
3145	Diff: TRIP L123 (Diff TRIP L123)	Diff. Prot	OUT	*	ON OFF		m	LED			BO		92	103	2	Yes
3146	Diff: TRIP 1pole (Diff TRIP 1pole)	Diff. Prot	OUT	*	ON OFF		*	LED			BO					
3147	Diff: TRIP 3pole (Diff TRIP 3pole)	Diff. Prot	OUT	*	ON OFF		*	LED			BO					
3148	Diff: Differential protection is blocked (Diff block)	Diff. Prot	OUT	ON OFF	*		*	LED			BO		92	104	1	Yes
3149	Diff: Diff. protection is switched off (Diff OFF)	Diff. Prot	OUT	ON OFF	*		*	LED			BO		92	105	1	Yes
3176	Diff: Fault detection L1 (only) (Diff Flt. 1p.L1)	Diff. Prot	OUT	*	*		*	LED			BO					
3177	Diff: Fault detection L1E (Diff Flt. L1E)	Diff. Prot	OUT	*	*		*	LED			BO					
3178	Diff: Fault detection L2 (only) (Diff Flt. 1p.L2)	Diff. Prot	OUT	*	*		*	LED			BO					
3179	Diff: Fault detection L2E (Diff Flt. L2E)	Diff. Prot	OUT	*	*		*	LED			BO					
3180	Diff: Fault detection L12 (Diff Flt. L12)	Diff. Prot	OUT	*	*		*	LED			BO					
3181	Diff: Fault detection L12E (Diff Flt. L12E)	Diff. Prot	OUT	*	*		*	LED			BO					
3182	Diff: Fault detection L3 (only) (Diff Flt. 1p.L3)	Diff. Prot	OUT	*	*		*	LED			BO					
3183	Diff: Fault detection L3E (Diff Flt. L3E)	Diff. Prot	OUT	*	*		*	LED			BO					

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				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
3184	Diff: Fault detection L31 (Diff Flt. L31)	Diff. Prot	OUT	*	*		*	LED			BO					
3185	Diff: Fault detection L31E (Diff Flt. L31E)	Diff. Prot	OUT	*	*		*	LED			BO					
3186	Diff: Fault detection L23 (Diff Flt. L23)	Diff. Prot	OUT	*	*		*	LED			BO					
3187	Diff: Fault detection L23E (Diff Flt. L23E)	Diff. Prot	OUT	*	*		*	LED			BO					
3188	Diff: Fault detection L123 (Diff Flt. L123)	Diff. Prot	OUT	*	*		*	LED			BO					
3189	Diff: Fault detection L123E (Diff Flt. L123E)	Diff. Prot	OUT	*	*		*	LED			BO					
3190	Diff: Set Teststate of Diff. protection (Test Diff.)	Diff. Prot	IntSP	ON OFF	*		*	LED		FC TN	BO		92	106	1	Yes
3191	Diff: Set Commissioning state of Diff. (Comm. Diff)	Diff. Prot	IntSP	ON OFF	*		*	LED		FC TN	BO		92	107	1	Yes
3192	Diff: Remote relay in Teststate (TestDiff.remote)	Diff. Prot	OUT	ON OFF	*		*	LED			BO		92	108	1	Yes
3193	Diff: Commissioning state is active (Comm.Diff act.)	Diff. Prot	OUT	ON OFF	*		*	LED			BO		92	109	1	Yes
3197	Diff: >Set Teststate of Diff. protection (>Test Diff. ON)	Diff. Prot	SP	ON OFF	*		*	LED	BI		BO					
3198	Diff: >Reset Teststate of Diff. protec. (>Test Diff. OFF)	Diff. Prot	SP	ON OFF	*		*	LED	BI		BO					
3199	Diff: Teststate of Diff. prot. ON/OFF (Test Diff.ONoff)	Diff. Prot	IntSP	ON OFF	*		*	LED			BO					
3200	Diff: Teststate ON/OFF via BI (TestDiffONoffBI)	Diff. Prot	IntSP	ON OFF	*		*	LED			BO					
3215	Incompatible Firmware Versions (Wrong Firmware)	Prot. Interface	OUT	ON	*			LED			BO					
3217	Prot Int 1: Own Datas received (PI1 Data reflec)	Prot. Interface	OUT	ON OFF	*			LED			BO					
3227	>Prot Int 1: Transmitter is switched off (>PI1 light off)	Prot. Interface	SP	ON OFF	*		*	LED	BI		BO					
3229	Prot Int 1: Reception of faulty data (PI1 Data fault)	Prot. Interface	OUT	ON OFF	*		*	LED			BO		93	135	1	Yes
3230	Prot Int 1: Total receiption failure (PI1 Datafailure)	Prot. Interface	OUT	ON OFF	*		*	LED			BO		93	136	1	Yes
3233	Device table has inconsistent numbers (DT inconsistent)	Prot. Interface	OUT	ON OFF	*			LED			BO					
3234	Device tables are unequal (DT unequal)	Prot. Interface	OUT	ON OFF	*			LED			BO					
3235	Differences between common parameters (Par. different)	Prot. Interface	OUT	ON OFF	*			LED			BO					
3239	Prot Int 1: Transmission delay too high (PI1 TD alarm)	Prot. Interface	OUT	ON OFF	*			LED			BO		93	139	1	Yes
3243	Prot Int 1: Connected with relay ID (PI1 with)	Prot. Interface	VI	ON OFF	*											
3245	> GPS failure from external (>GPS failure)	Prot. Interface	SP	ON OFF	*		*	LED	BI		BO					
3247	GPS: local pulse loss (GPS loss)	Prot. Interface	OUT	ON OFF	*		*	LED			BO					
3248	GPS: Prot Int 1 is GPS sychronized (PI 1 GPS sync.)	Prot. Interface	OUT	ON OFF	*		*	LED			BO					
3250	GPS:PI1 unsym.propagation delay too high (PI 1 PD unsym.)	Prot. Interface	OUT	ON OFF	*		*	LED			BO					

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				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
3252	> PI1 Synchronization RESET (>SYNC PI1 RESET)	Prot. Interface	SP	on off	*		*	LED	BI		BO					
3254	Prot.1: Delay time change recog-nized (PI1 jump)	Prot. Interface	OUT	on off	*		*	LED			BO					
3256	Prot.1: Delay time unsymmetry to large (PI1 unsym.)	Prot. Interface	IntSP	ON OFF	*			LED			BO					
3258	ProtInt1:Permissible error rate exceeded (PI1 Error)	Prot. Interface	OUT	on off	*		*	LED			BO					
3260	Diff: >Commissioning state ON (>Comm. Diff ON)	Diff. Prot	SP	ON OFF	*		*	LED	BI		BO					
3261	Diff: >Commissioning state OFF (>Comm. Diff OFF)	Diff. Prot	SP	ON OFF	*		*	LED	BI		BO					
3262	Diff: Commissioning state ON/OFF (Comm Diff.ONoff)	Diff. Prot	IntSP	ON OFF	*		*	LED			BO					
3263	Diff: Commissioning state ON/OFF via BI (CommDiffONoff-BI)	Diff. Prot	IntSP	ON OFF	*		*	LED			BO					
3452	> Logout state ON (>Logout ON)	Diff.-Topo	SP	ON OFF	*		*	LED	BI		BO					
3453	> Logout state OFF (>Logout OFF)	Diff.-Topo	SP	ON OFF	*		*	LED	BI		BO					
3458	System operates in a open Chaintopology (Chaintopology)	Diff.-Topo	OUT	ON OFF	*		*	LED			BO		93	142	1	Yes
3459	Logout state ON/OFF (Logout ON/off)	Diff.-Topo	IntSP	ON OFF	*		*	LED			BO					
3460	Logout state ON/OFF via BI (Logout ON/offBI)	Diff.-Topo	IntSP	ON OFF	*		*	LED			BO					
3464	Communication topology is com-plete (Topol complete)	Diff.-Topo	OUT	ON OFF	*		*	LED			BO					
3475	Relay 1 in Logout state (Rel1Logout)	Diff.-Topo	IntSP	ON OFF	*		*	LED		FC TN	BO		93	143	1	Yes
3476	Relay 2 in Logout state (Rel2Logout)	Diff.-Topo	IntSP	ON OFF	*		*	LED		FC TN	BO		93	144	1	Yes
3484	Local activation of Logout state (Logout)	Diff.-Topo	IntSP	ON OFF	*		*	LED		FC TN	BO		93	149	1	Yes
3487	Equal IDs in constellation (Equal IDs)	Diff.-Topo	OUT	ON OFF	*		*	LED			BO					
3491	Relay 1 in Login state (Rel1 Login)	Diff.-Topo	OUT	ON OFF	*		*	LED			BO		93	191	1	Yes
3492	Relay 2 in Login state (Rel2 Login)	Diff.-Topo	OUT	ON OFF	*		*	LED			BO		93	192	1	Yes
3501	I.Trip: >Intertrip L1 signal input (>Intertrip L1)	Intertrip	SP	ON OFF	*		*	LED	BI		BO					
3502	I.Trip: >Intertrip L2 signal input (>Intertrip L2)	Intertrip	SP	ON OFF	*		*	LED	BI		BO					
3503	I.Trip: >Intertrip L3 signal input (>Intertrip L3)	Intertrip	SP	ON OFF	*		*	LED	BI		BO					
3504	I.Trip: >Intertrip 3 pole signal input (>Intertrip 3pol)	Intertrip	SP	ON OFF	*		*	LED	BI		BO					
3505	I.Trip: Received at Prot.Interface 1 L1 (ITrp.rec.PI1.L1)	Intertrip	OUT	on off	*		*	LED			BO					
3506	I.Trip: Received at Prot.Interface 1 L2 (ITrp.rec.PI1.L2)	Intertrip	OUT	on off	*		*	LED			BO					
3507	I.Trip: Received at Prot.Interface 1 L3 (ITrp.rec.PI1.L3)	Intertrip	OUT	on off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
3511	I.Trip: Sending at Prot.Interface 1 L1 (ITrp.sen.PI1.L1)	Intertrip	OUT	ON OFF	*		*	LED			BO					
3512	I.Trip: Sending at Prot.Interface 1 L2 (ITrp.sen.PI1.L2)	Intertrip	OUT	ON OFF	*		*	LED			BO					
3513	I.Trip: Sending at Prot.Interface 1 L3 (ITrp.sen.PI1.L3)	Intertrip	OUT	ON OFF	*		*	LED			BO					
3517	I.Trip: General TRIP (ITrp. Gen. TRIP)	Intertrip	OUT	*	ON OFF		m	LED			BO					
3518	I.Trip: TRIP - Only L1 (ITrp.TRIP 1p L1)	Intertrip	OUT	*	ON OFF		m	LED			BO		93	150	2	Yes
3519	I.Trip: TRIP - Only L2 (ITrp.TRIP 1p L2)	Intertrip	OUT	*	ON OFF		m	LED			BO		93	151	2	Yes
3520	I.Trip: TRIP - Only L3 (ITrp.TRIP 1p L3)	Intertrip	OUT	*	ON OFF		m	LED			BO		93	152	2	Yes
3521	I.Trip: TRIP L123 (ITrp.TRIP L123)	Intertrip	OUT	*	ON OFF		m	LED			BO		93	153	2	Yes
3522	I.Trip: TRIP 1pole (Diff TRIP 1pole)	Intertrip	OUT	*	ON OFF		*	LED			BO					
3523	I.Trip: TRIP 3pole (Diff TRIP 3pole)	Intertrip	OUT	*	ON OFF		*	LED			BO					
3525	>Differential protection blocking signal (> Diff block)	Diff. Prot	SP	ON OFF	*		*	LED	BI		BO					
3526	Differential blocking received at PI1 (Diffblk.rec PI1)	Diff. Prot	OUT	ON OFF	*		*	LED			BO					
3528	Differential blocking sending via PI1 (Diffblk.sen PI1)	Diff. Prot	OUT	ON OFF	*		*	LED			BO					
3541	>Remote Trip 1 signal input (>Remote Trip1)	Remote Signals	SP	on off	*		*	LED	BI		BO					
3542	>Remote Trip 2 signal input (>Remote Trip2)	Remote Signals	SP	on off	*		*	LED	BI		BO					
3543	>Remote Trip 3 signal input (>Remote Trip3)	Remote Signals	SP	on off	*		*	LED	BI		BO					
3544	>Remote Trip 4 signal input (>Remote Trip4)	Remote Signals	SP	on off	*		*	LED	BI		BO					
3545	Remote Trip 1 received (RemoteTrip1 rec)	Remote Signals	OUT	on off	*		*	LED			BO		93	154	1	Yes
3546	Remote Trip 2 received (RemoteTrip2 rec)	Remote Signals	OUT	on off	*		*	LED			BO		93	155	1	Yes
3547	Remote Trip 3 received (RemoteTrip3 rec)	Remote Signals	OUT	on off	*		*	LED			BO		93	156	1	Yes
3548	Remote Trip 4 received (RemoteTrip4 rec)	Remote Signals	OUT	on off	*		*	LED			BO		93	157	1	Yes
4253	>BLOCK Instantaneous SOTF Overcurrent (>BLOCK SOTF-O/C)	SOTF Overcurr.	SP	*	*		*	LED	BI		BO					
4271	SOTF-O/C is switched OFF (SOTF-O/C OFF)	SOTF Overcurr.	OUT	ON OFF	*		*	LED			BO		25	71	1	Yes
4272	SOTF-O/C is BLOCKED (SOTF-O/C BLOCK)	SOTF Overcurr.	OUT	ON OFF	ON OFF		*	LED			BO		25	72	1	Yes
4273	SOTF-O/C is ACTIVE (SOTF-O/C ACTIVE)	SOTF Overcurr.	OUT	*	*		*	LED			BO		25	73	1	Yes
4281	SOTF-O/C PICKED UP (SOTF-O/C PICKUP)	SOTF Overcurr.	OUT	*	OFF		m	LED			BO		25	81	2	Yes
4282	SOTF-O/C Pickup L1 (SOF O/CpickupL1)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	82	2	Yes

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
4283	SOTF-O/C Pickup L2 (SOF O/CpickupL2)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	83	2	Yes
4284	SOTF-O/C Pickup L3 (SOF O/CpickupL3)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	84	2	Yes
4285	High Speed-O/C Pickup I>>>> L1 (I>>>>O/C p.upL1)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	85	2	Yes
4286	High Speed-O/C Pickup I>>>> L2 (I>>>>O/C p.upL2)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	86	2	Yes
4287	High Speed-O/C Pickup I>>>> L3 (I>>>>O/C p.upL3)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	87	2	Yes
4289	High Speed/SOTF-O/C TRIP - Only L1 (HS/SOF TRIP1pL1)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	89	2	Yes
4290	High Speed/SOTF-O/C TRIP - Only L2 (HS/SOF TRIP1pL2)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	90	2	Yes
4291	High Speed/SOTF-O/C TRIP - Only L3 (HS/SOF TRIP1pL3)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	91	2	Yes
4292	High Speed/SOTF-O/C TRIP 1pole (HS/SOF TRIP 1p)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	94	2	No
4293	High Speed/SOTF-O/C General TRIP (HS/SOF Gen.TRIP)	SOTF Overcurr.	OUT	*	ON		*	LED			BO					
4294	High Speed/SOTF-O/C TRIP 3pole (HS/SOF TRIP 3p)	SOTF Overcurr.	OUT	*	ON		*	LED			BO					
4295	High Speed/SOTF-O/C TRIP command L123 (HS/SOF TRIPL123)	SOTF Overcurr.	OUT	*	ON		*	LED			BO		25	95	2	Yes
4403	>BLOCK Direct Transfer Trip function (>BLOCK DTT)	DTT Direct Trip	SP	*	*		*	LED	BI		BO					
4412	>Direct Transfer Trip INPUT Phase L1 (>DTT Trip L1)	DTT Direct Trip	SP	ON OFF	*		*	LED	BI		BO					
4413	>Direct Transfer Trip INPUT Phase L2 (>DTT Trip L2)	DTT Direct Trip	SP	ON OFF	*		*	LED	BI		BO					
4414	>Direct Transfer Trip INPUT Phase L3 (>DTT Trip L3)	DTT Direct Trip	SP	ON OFF	*		*	LED	BI		BO					
4417	>Direct Transfer Trip INPUT 3ph L123 (>DTT Trip L123)	DTT Direct Trip	SP	ON OFF	*		*	LED	BI		BO					
4421	Direct Transfer Trip is switched OFF (DTT OFF)	DTT Direct Trip	OUT	ON OFF	*		*	LED			BO		51	21	1	Yes
4422	Direct Transfer Trip is BLOCKED (DTT BLOCK)	DTT Direct Trip	OUT	ON OFF	ON OFF		*	LED			BO		51	22	1	Yes
4432	DTT TRIP command - Only L1 (DTT TRIP 1p. L1)	DTT Direct Trip	OUT	*	ON		*	LED			BO		51	32	2	No
4433	DTT TRIP command - Only L2 (DTT TRIP 1p. L2)	DTT Direct Trip	OUT	*	ON		*	LED			BO		51	33	2	No
4434	DTT TRIP command - Only L3 (DTT TRIP 1p. L3)	DTT Direct Trip	OUT	*	ON		*	LED			BO		51	34	2	No
4435	DTT TRIP command L123 (DTT TRIP L123)	DTT Direct Trip	OUT	*	ON		*	LED			BO		51	35	2	No
5203	>BLOCK frequency protection (>BLOCK Freq.)	Frequency Prot.	SP	ON OFF	*		*	LED	BI		BO		70	176	1	Yes
5206	>BLOCK frequency protection stage f1 (>BLOCK f1)	Frequency Prot.	SP	ON OFF	*		*	LED	BI		BO		70	177	1	Yes
5207	>BLOCK frequency protection stage f2 (>BLOCK f2)	Frequency Prot.	SP	ON OFF	*		*	LED	BI		BO		70	178	1	Yes
5208	>BLOCK frequency protection stage f3 (>BLOCK f3)	Frequency Prot.	SP	ON OFF	*		*	LED	BI		BO		70	179	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5209	>BLOCK frequency protection stage f4 (>BLOCK f4)	Frequency Prot.	SP	ON OFF	*		*	LED	BI		BO		70	180	1	Yes
5211	Frequency protection is switched OFF (Freq. OFF)	Frequency Prot.	OUT	ON OFF	*		*	LED			BO		70	181	1	Yes
5212	Frequency protection is BLOCKED (Freq. BLOCKED)	Frequency Prot.	OUT	ON OFF	ON OFF		*	LED			BO		70	182	1	Yes
5213	Frequency protection is ACTIVE (Freq. ACTIVE)	Frequency Prot.	OUT	ON OFF	*		*	LED			BO		70	183	1	Yes
5215	Frequency protection undervoltage Blk (Freq UnderV Blk)	Frequency Prot.	OUT	on off	on off		*	LED			BO		70	238	1	Yes
5232	Frequency protection: f1 picked up (f1 picked up)	Frequency Prot.	OUT	*	ON OFF		*	LED			BO		70	230	2	Yes
5233	Frequency protection: f2 picked up (f2 picked up)	Frequency Prot.	OUT	*	ON OFF		*	LED			BO		70	231	2	Yes
5234	Frequency protection: f3 picked up (f3 picked up)	Frequency Prot.	OUT	*	ON OFF		*	LED			BO		70	232	2	Yes
5235	Frequency protection: f4 picked up (f4 picked up)	Frequency Prot.	OUT	*	ON OFF		*	LED			BO		70	233	2	Yes
5236	Frequency protection: f1 TRIP (f1 TRIP)	Frequency Prot.	OUT	*	ON		*	LED			BO		70	234	2	Yes
5237	Frequency protection: f2 TRIP (f2 TRIP)	Frequency Prot.	OUT	*	ON		*	LED			BO		70	235	2	Yes
5238	Frequency protection: f3 TRIP (f3 TRIP)	Frequency Prot.	OUT	*	ON		*	LED			BO		70	236	2	Yes
5239	Frequency protection: f4 TRIP (f4 TRIP)	Frequency Prot.	OUT	*	ON		*	LED			BO		70	237	2	Yes
5240	Frequency protection: TimeOut Stage f1 (Time Out f1)	Frequency Prot.	OUT	*	*		*	LED			BO					
5241	Frequency protection: TimeOut Stage f2 (Time Out f2)	Frequency Prot.	OUT	*	*		*	LED			BO					
5242	Frequency protection: TimeOut Stage f3 (Time Out f3)	Frequency Prot.	OUT	*	*		*	LED			BO					
5243	Frequency protection: TimeOut Stage f4 (Time Out f4)	Frequency Prot.	OUT	*	*		*	LED			BO					
5803	>BLOCK restricted earth fault prot. (>BLOCK REF)	REF	SP	*	*		*	LED	BI		BO					
5811	Restricted earth fault is switched OFF (REF OFF)	REF	OUT	ON OFF	*		*	LED			BO		76	11	1	Yes
5812	Restricted earth fault is BLOCKED (REF BLOCKED)	REF	OUT	ON OFF	ON OFF		*	LED			BO		76	12	1	Yes
5813	Restricted earth fault is ACTIVE (REF ACTIVE)	REF	OUT	ON OFF	*		*	LED			BO		76	13	1	Yes
5816	Restr. earth flt.: Time delay started (REF T start)	REF	OUT	*	ON OFF		*	LED			BO		76	16	2	Yes
5817	Restr. earth flt.: picked up (REF picked up)	REF	OUT	*	ON OFF		m	LED			BO		76	17	2	Yes
5821	Restr. earth flt.: TRIP (REF TRIP)	REF	OUT	*	ON		m	LED			BO		76	21	2	No
5826	REF: Value D at trip (without Tdelay) (REF D:)	REF	VI	*	ON OFF								76	26	4	No
5827	REF: Value S at trip (without Tdelay) (REF S:)	REF	VI	*	ON OFF								76	27	4	No
6854	>Trip circuit superv. 1: Trip Relay (>TripC1 TripRel)	TripCirc.Superv	SP	ON OFF	*		*	LED	BI		BO					
6855	>Trip circuit superv. 1: Breaker Relay (>TripC1 Bkr.Rel)	TripCirc.Superv	SP	ON OFF	*		*	LED	BI		BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
6856	>Trip circuit superv. 2: Trip Relay (>TripC2 TripRel)	TripCirc.Superv	SP	ON OFF	*		*	LED	BI		BO					
6857	>Trip circuit superv. 2: Breaker Relay (>TripC2 Bkr.Rel)	TripCirc.Superv	SP	ON OFF	*		*	LED	BI		BO					
6858	>Trip circuit superv. 3: Trip Relay (>TripC3 TripRel)	TripCirc.Superv	SP	ON OFF	*		*	LED	BI		BO					
6859	>Trip circuit superv. 3: Breaker Relay (>TripC3 Bkr.Rel)	TripCirc.Superv	SP	ON OFF	*		*	LED	BI		BO					
6861	Trip circuit supervision OFF (TripC OFF)	TripCirc.Superv	OUT	ON OFF	*		*	LED			BO		170	53	1	Yes
6865	Failure Trip Circuit (FAIL: Trip cir.)	TripCirc.Superv	OUT	ON OFF	*		*	LED			BO		192	36	1	Yes
6866	TripC1 blocked: Binary input is not set (TripC1 ProgFAIL)	TripCirc.Superv	OUT	ON OFF	*		*	LED			BO					
6867	TripC2 blocked: Binary input is not set (TripC2 ProgFAIL)	TripCirc.Superv	OUT	ON OFF	*		*	LED			BO					
6868	TripC3 blocked: Binary input is not set (TripC3 ProgFAIL)	TripCirc.Superv	OUT	ON OFF	*		*	LED			BO					
7104	>BLOCK Backup OverCurrent I>> (>BLOCK O/C I>>)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	4	1	Yes
7105	>BLOCK Backup OverCurrent I> (>BLOCK O/C I>)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	5	1	Yes
7106	>BLOCK Backup OverCurrent Ip (>BLOCK O/C Ip)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	6	1	Yes
7107	>BLOCK Backup OverCurrent Ie>> (>BLOCK O/C Ie>>)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	7	1	Yes
7108	>BLOCK Backup OverCurrent Ie> (>BLOCK O/C Ie>)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	8	1	Yes
7109	>BLOCK Backup OverCurrent Iep (>BLOCK O/C Iep)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	9	1	Yes
7110	>Backup OverCurrent Instanta-neousTrip (>O/C InstTRIP)	Back-Up O/C	SP	ON OFF	ON OFF		*	LED	BI		BO		64	10	1	Yes
7111	>BLOCK direct. Backup Over-Current I> (>BLOCK Dir. I>)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	11	1	Yes
7112	>BLOCK direct. Backup Over-Current Ip (>BLOCK Dir. Ip)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	12	1	Yes
7113	>BLOCK direct. Backup Over-Current Ie> (>BLOCK Dir. Ie>)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	13	1	Yes
7114	>BLOCK direct. Backup Over-Current Iep (>BLOCK Dir. Iep)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	14	1	Yes
7130	>BLOCK I-STUB (>BLOCK I-STUB)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	30	1	Yes
7131	>Enable I-STUB-Bus function (>I-STUB ENABLE)	Back-Up O/C	SP	ON OFF	ON OFF		*	LED	BI		BO		64	31	1	Yes
7132	>BLOCK Backup OverCurrent Ie>>> (>BLOCK O/CIe>>>)	Back-Up O/C	SP	ON OFF	*		*	LED	BI		BO		64	32	1	Yes
7151	Backup O/C is switched OFF (O/C OFF)	Back-Up O/C	OUT	ON OFF	*		*	LED			BO		64	51	1	Yes
7152	Backup O/C is BLOCKED (O/C BLOCK)	Back-Up O/C	OUT	ON OFF	ON OFF		*	LED			BO		64	52	1	Yes
7153	Backup O/C is ACTIVE (O/C ACTIVE)	Back-Up O/C	OUT	*	*		*	LED			BO		64	53	1	Yes
7161	Backup O/C PICKED UP (O/C PICKUP)	Back-Up O/C	OUT	*	OFF		m	LED			BO		64	61	2	Yes
7162	Backup O/C PICKUP L1 (O/C Pickup L1)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	62	2	Yes

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: Relay	Configurable in Matrix: Chatter Suppression	IEC 60870-5-103: Type	IEC 60870-5-103: Information Number	IEC 60870-5-103: Data Unit	IEC 60870-5-103: General Interrogation
7163	Backup O/C PICKUP L2 (O/C Pickup L2)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	63	2	Yes
7164	Backup O/C PICKUP L3 (O/C Pickup L3)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	64	2	Yes
7165	Backup O/C PICKUP EARTH (O/C Pickup E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	65	2	Yes
7171	Backup O/C Pickup - Only EARTH (O/C PU only E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	71	2	No
7172	Backup O/C Pickup - Only L1 (O/C PU 1p. L1)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	72	2	No
7173	Backup O/C Pickup L1E (O/C Pickup L1E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	73	2	No
7174	Backup O/C Pickup - Only L2 (O/C PU 1p. L2)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	74	2	No
7175	Backup O/C Pickup L2E (O/C Pickup L2E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	75	2	No
7176	Backup O/C Pickup L12 (O/C Pickup L12)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	76	2	No
7177	Backup O/C Pickup L12E (O/C Pickup L12E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	77	2	No
7178	Backup O/C Pickup - Only L3 (O/C PU 1p. L3)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	78	2	No
7179	Backup O/C Pickup L3E (O/C Pickup L3E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	79	2	No
7180	Backup O/C Pickup L31 (O/C Pickup L31)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	80	2	No
7181	Backup O/C Pickup L31E (O/C Pickup L31E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	81	2	No
7182	Backup O/C Pickup L23 (O/C Pickup L23)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	82	2	No
7183	Backup O/C Pickup L23E (O/C Pickup L23E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	83	2	No
7184	Backup O/C Pickup L123 (O/C Pickup L123)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	84	2	No
7185	Backup O/C Pickup L123E (O/C PickupL123E)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	85	2	No
7191	Backup O/C Pickup I>> (O/C PICKUP I>>)	Back-Up O/C	OUT	*	ON		m	LED			BO		64	91	2	Yes
7192	Backup O/C Pickup I> (O/C PICKUP I>)	Back-Up O/C	OUT	*	ON		m	LED			BO		64	92	2	Yes
7193	Backup O/C Pickup Ip (O/C PICKUP Ip)	Back-Up O/C	OUT	*	ON		m	LED			BO		64	93	2	Yes
7201	O/C I-STUB Pickup (I-STUB PICKUP)	Back-Up O/C	OUT	*	ON OFF		m	LED			BO		64	101	2	Yes
7202	Backup O/C Pickup I> directional (O/C PICK. I>Dir)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	102	2	Yes
7203	Backup O/C Pickup Ip directional (O/C PICK. IpDir)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	103	2	Yes
7211	Backup O/C General TRIP command (O/C TRIP)	Back-Up O/C	OUT	*	*		*	LED			BO		64	111	2	No
7212	Backup O/C TRIP - Only L1 (O/C TRIP 1p.L1)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	112	2	No
7213	Backup O/C TRIP - Only L2 (O/C TRIP 1p.L2)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	113	2	No
7214	Backup O/C TRIP - Only L3 (O/C TRIP 1p.L3)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	114	2	No

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: Relay	Configurable in Matrix: Chatter Suppression	IEC 60870-5-103: Type	IEC 60870-5-103: Information Number	IEC 60870-5-103: Data Unit	IEC 60870-5-103: General Interrogation
7215	Backup O/C TRIP Phases L123 (O/C TRIP L123)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	115	2	No
7221	Backup O/C TRIP I>> (O/C TRIP I>>)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	121	2	No
7222	Backup O/C TRIP I> (O/C TRIP I>)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	122	2	No
7223	Backup O/C TRIP Ip (O/C TRIP Ip)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	123	2	No
7235	O/C I-STUB TRIP (I-STUB TRIP)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	135	2	No
7236	Backup O/C TRIP I> directional (O/C TRIP I>Dir.)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	136	2	No
7237	Backup O/C Pickup Ip directional (O/C TRIP IpDir.)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	137	2	No
7240	Backup O/C L1 forward direction (O/C L1 forward)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	140	2	No
7241	Backup O/C L2 forward direction (O/C L2 forward)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	141	2	No
7242	Backup O/C L3 forward direction (O/C L3 forward)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	142	2	No
7243	Backup O/C 3I0 forward direction (O/C 3I0 forward)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	143	2	No
7244	Backup O/C L1 reverse direction (O/C L1 reverse)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	144	2	No
7245	Backup O/C L2 reverse direction (O/C L2 reverse)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	145	2	No
7246	Backup O/C L3 reverse direction (O/C L3 reverse)	Back-Up O/C	OUT	*	ON		*	LED			BO		64	146	2	No
7247	Backup O/C 3I0 reverse direction (O/C 3I0 reverse)	Back-Up O/C	OUT	*	on		*	LED			BO		64	147	2	No
7248	Backup O/C forward direction (O/C Dir.forward)	Back-Up O/C	OUT	*	*		*	LED			BO					
7249	Backup O/C reverse direction (O/C Dir.reverse)	Back-Up O/C	OUT	*	*		*	LED			BO					
7325	CB1-TEST TRIP command - Only L1 (CB1-TESTtrip L1)	Testing	OUT	ON OFF	*		*	LED			BO		153	25	1	Yes
7326	CB1-TEST TRIP command - Only L2 (CB1-TESTtrip L2)	Testing	OUT	ON OFF	*		*	LED			BO		153	26	1	Yes
7327	CB1-TEST TRIP command - Only L3 (CB1-TESTtrip L3)	Testing	OUT	ON OFF	*		*	LED			BO		153	27	1	Yes
7328	CB1-TEST TRIP command L123 (CB1-TESTtrip123)	Testing	OUT	ON OFF	*		*	LED			BO		153	28	1	Yes
7329	CB1-TEST CLOSE command (CB1-TEST close)	Testing	OUT	ON OFF	*		*	LED			BO		153	29	1	Yes
7345	CB-TEST is in progress (CB-TEST running)	Testing	OUT	ON OFF	*		*	LED			BO		153	45	1	Yes
7346	CB-TEST canceled due to Power Sys. Fault (CB-TSTstop FLT.)	Testing	OUT_Ev	ON	*											
7347	CB-TEST canceled due to CB already OPEN (CB-TSTstop OPEN)	Testing	OUT_Ev	ON	*											
7348	CB-TEST canceled due to CB was NOT READY (CB-TSTstop NOTr)	Testing	OUT_Ev	ON	*											
7349	CB-TEST canceled due to CB stayed CLOSED (CB-TSTstop CLOS)	Testing	OUT_Ev	ON	*											

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
7350	CB-TEST was successful (CB-TST .OK.)	Testing	OUT_Ev	ON	*											
10201	>BLOCK Uph-e>(>) Overvolt. (phase-earth) (>Uph-e>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10202	>BLOCK Uph-ph>(>) Overvolt (phase-phase) (>Uph-ph>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10203	>BLOCK 3U0>(>) Overvolt. (zero sequence) (>3U0>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10204	>BLOCK U1>(>) Overvolt. (positive seq.) (>U1>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10205	>BLOCK U2>(>) Overvolt. (negative seq.) (>U2>(>) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10206	>BLOCK Uph-e<(<) Undervolt (phase-earth) (>Uph-e<(<) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10207	>BLOCK Uphph<(<) Undervolt (phase-phase) (>Uphph<(<) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10208	>BLOCK U1<(<) Undervolt (positive seq.) (>U1<(<) BLK)	Voltage Prot.	SP	*	*		*	LED	BI		BO					
10215	Uph-e>(>) Overvolt. is switched OFF (Uph-e>(>) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	15	1	Yes
10216	Uph-e>(>) Overvolt. is BLOCKED (Uph-e>(>) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	16	1	Yes
10217	Uph-ph>(>) Overvolt. is switched OFF (Uph-ph>(>) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	17	1	Yes
10218	Uph-ph>(>) Overvolt. is BLOCKED (Uph-ph>(>) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	18	1	Yes
10219	3U0>(>) Overvolt. is switched OFF (3U0>(>) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	19	1	Yes
10220	3U0>(>) Overvolt. is BLOCKED (3U0>(>) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	20	1	Yes
10221	U1>(>) Overvolt. is switched OFF (U1>(>) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	21	1	Yes
10222	U1>(>) Overvolt. is BLOCKED (U1>(>) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	22	1	Yes
10223	U2>(>) Overvolt. is switched OFF (U2>(>) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	23	1	Yes
10224	U2>(>) Overvolt. is BLOCKED (U2>(>) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	24	1	Yes
10225	Uph-e<(<) Undervolt. is switched OFF (Uph-e<(<) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	25	1	Yes
10226	Uph-e<(<) Undervolt. is BLOCKED (Uph-e<(<) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	26	1	Yes
10227	Uph-ph<(<) Undervolt. is switched OFF (Uph-ph<(<) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	27	1	Yes
10228	Uphph<(<) Undervolt. is BLOCKED (Uph-ph<(<) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	28	1	Yes
10229	U1<(<) Undervolt. is switched OFF (U1<(<) OFF)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	29	1	Yes
10230	U1<(<) Undervolt. is BLOCKED (U1<(<) BLK)	Voltage Prot.	OUT	ON OFF	ON OFF		*	LED			BO		73	30	1	Yes
10231	Over-/Under-Voltage protection is ACTIVE (U</> ACTIVE)	Voltage Prot.	OUT	ON OFF	*		*	LED			BO		73	31	1	Yes
10240	Uph-e> Pickup (Uph-e> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	40	2	Yes

No.	Description	Function	Type of Information	Log Buffers: Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	Configurable in Matrix: LED	Binary Input	Function Key	Relay	Chatter Suppression	IEC 60870-5-103: Type	Information Number	Data Unit	General Interrogation
10241	Uph-e>> Pickup (Uph-e>> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	41	2	Yes
10242	Uph-e>(>) Pickup L1 (Uph-e>(>) PU L1)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	42	2	Yes
10243	Uph-e>(>) Pickup L2 (Uph-e>(>) PU L2)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	43	2	Yes
10244	Uph-e>(>) Pickup L3 (Uph-e>(>) PU L3)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	44	2	Yes
10245	Uph-e> TimeOut (Uph-e> Time-Out)	Voltage Prot.	OUT	*	*		*	LED			BO					
10246	Uph-e>> TimeOut (Uph-e>> Tim-eOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10247	Uph-e>(>) TRIP command (Uph-e>(>) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	47	2	Yes
10248	Uph-e> Pickup L1 (Uph-e> PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO					
10249	Uph-e> Pickup L2 (Uph-e> PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO					
10250	Uph-e> Pickup L3 (Uph-e> PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO					
10251	Uph-e>> Pickup L1 (Uph-e>> PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO					
10252	Uph-e>> Pickup L2 (Uph-e>> PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO					
10253	Uph-e>> Pickup L3 (Uph-e>> PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO					
10255	Uph-ph> Pickup (Uphph> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	55	2	Yes
10256	Uph-ph>> Pickup (Uphph>> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	56	2	Yes
10257	Uph-ph>(>) Pickup L1-L2 (Uph-ph>(>)PU L12)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	57	2	Yes
10258	Uph-ph>(>) Pickup L2-L3 (Uph-ph>(>)PU L23)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	58	2	Yes
10259	Uph-ph>(>) Pickup L3-L1 (Uph-ph>(>)PU L31)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	59	2	Yes
10260	Uph-ph> TimeOut (Uphph> Time-Out)	Voltage Prot.	OUT	*	*		*	LED			BO					
10261	Uph-ph>> TimeOut (Uphph>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10262	Uph-ph>(>) TRIP command (Up-hph>(>) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	62	2	Yes
10263	Uph-ph> Pickup L1-L2 (Uphph> PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO					
10264	Uph-ph> Pickup L2-L3 (Uphph> PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO					
10265	Uph-ph> Pickup L3-L1 (Uphph> PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO					
10266	Uph-ph>> Pickup L1-L2 (Uph-ph>> PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO					
10267	Uph-ph>> Pickup L2-L3 (Uph-ph>> PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO					
10268	Uph-ph>> Pickup L3-L1 (Uph-ph>> PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO					
10270	3U0> Pickup (3U0> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	70	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
10271	3U0>> Pickup (3U0>> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	71	2	Yes
10272	3U0> TimeOut (3U0> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10273	3U0>> TimeOut (3U0>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10274	3U0>(>) TRIP command (3U0>(>) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	74	2	Yes
10280	U1> Pickup (U1> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	80	2	Yes
10281	U1>> Pickup (U1>> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	81	2	Yes
10282	U1> TimeOut (U1> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10283	U1>> TimeOut (U1>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10284	U1>(>) TRIP command (U1>(>) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	84	2	Yes
10290	U2> Pickup (U2> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	90	2	Yes
10291	U2>> Pickup (U2>> Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	91	2	Yes
10292	U2> TimeOut (U2> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10293	U2>> TimeOut (U2>> TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10294	U2>(>) TRIP command (U2>(>) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	94	2	Yes
10300	U1< Pickup (U1< Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	100	2	Yes
10301	U1<< Pickup (U1<< Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	101	2	Yes
10302	U1< TimeOut (U1< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10303	U1<< TimeOut (U1<< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10304	U1<(<) TRIP command (U1<(<) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	104	2	Yes
10310	Uph-e< Pickup (Uph-e< Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	110	2	Yes
10311	Uph-e<< Pickup (Uph-e<< Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	111	2	Yes
10312	Uph-e<(<) Pickup L1 (Uph-e<(<) PU L1)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	112	2	Yes
10313	Uph-e<(<) Pickup L2 (Uph-e<(<) PU L2)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	113	2	Yes
10314	Uph-e<(<) Pickup L3 (Uph-e<(<) PU L3)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	114	2	Yes
10315	Uph-e< TimeOut (Uph-e< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10316	Uph-e<< TimeOut (Uph-e<< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10317	Uph-e<(<) TRIP command (Uph-e<(<) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	117	2	Yes
10318	Uph-e< Pickup L1 (Uph-e< PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO					
10319	Uph-e< Pickup L2 (Uph-e< PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO					
10320	Uph-e< Pickup L3 (Uph-e< PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO					
10321	Uph-e<< Pickup L1 (Uph-e<< PU L1)	Voltage Prot.	OUT	*	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
10322	Uph-e<< Pickup L2 (Uph-e<< PU L2)	Voltage Prot.	OUT	*	*		*	LED			BO					
10323	Uph-e<< Pickup L3 (Uph-e<< PU L3)	Voltage Prot.	OUT	*	*		*	LED			BO					
10325	Uph-ph< Pickup (Uph-ph< Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	125	2	Yes
10326	Uph-ph<< Pickup (Uph-ph<< Pickup)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	126	2	Yes
10327	Uphph<(<) Pickup L1-L2 (Uph-ph<(<)PU L12)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	127	2	Yes
10328	Uphph<(<) Pickup L2-L3 (Uph-ph<(<)PU L23)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	128	2	Yes
10329	Uphph<(<) Pickup L3-L1 (Uph-ph<(<)PU L31)	Voltage Prot.	OUT	*	ON OFF		*	LED			BO		73	129	2	Yes
10330	Uphph< TimeOut (Uphph< Time-Out)	Voltage Prot.	OUT	*	*		*	LED			BO					
10331	Uphph<< TimeOut (Uphph<< TimeOut)	Voltage Prot.	OUT	*	*		*	LED			BO					
10332	Uphph<(<) TRIP command (Uph-ph<(<) TRIP)	Voltage Prot.	OUT	*	ON		*	LED			BO		73	132	2	Yes
10333	Uph-ph< Pickup L1-L2 (Uphph< PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO					
10334	Uph-ph< Pickup L2-L3 (Uphph< PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO					
10335	Uph-ph< Pickup L3-L1 (Uphph< PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO					
10336	Uph-ph<< Pickup L1-L2 (Uph-ph<< PU L12)	Voltage Prot.	OUT	*	*		*	LED			BO					
10337	Uph-ph<< Pickup L2-L3 (Uph-ph<< PU L23)	Voltage Prot.	OUT	*	*		*	LED			BO					
10338	Uph-ph<< Pickup L3-L1 (Uph-ph<< PU L31)	Voltage Prot.	OUT	*	*		*	LED			BO					
30053	Fault recording is running (Fault rec. run.)	Osc. Fault Rec.	OUT	*	*		*	LED			BO					
31000	Q0 operationcounter= (Q0 OpCnt=)	Control Device	VI													
31001	Q1 operationcounter= (Q1 OpCnt=)	Control Device	VI													
31002	Q2 operationcounter= (Q2 OpCnt=)	Control Device	VI													
31008	Q8 operationcounter= (Q8 OpCnt=)	Control Device	VI													
31009	Q9 operationcounter= (Q9 OpCnt=)	Control Device	VI													

A.9 Group Alarms

No.	Description	Function No.	Description
140	Error Sum Alarm	144 192 181	Error 5V Error1A/5Awrong Error A/D-conv.
160	Alarm Sum Event	289 163 165 167 168 169 170 171 177 190 191 193 183 184 185 186 187 188 189	Failure Σi Fail I balance Fail Σ U Ph-E Fail U balance Fail U absent VT FuseFail>10s VT FuseFail Fail Ph. Seq. Fail Battery Error Board 0 Error Offset Alarm adjustm. Error Board 1 Error Board 2 Error Board 3 Error Board 4 Error Board 5 Error Board 6 Error Board 7
161	Fail I Superv.	289 163	Failure Σi Fail I balance
164	Fail U Superv.	165 167 168	Fail Σ U Ph-E Fail U balance Fail U absent

A.10 Measured Values

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
-	Lower setting limit for Power Factor (PF<)	Set Points(MV)	-	-	-	-	-	CFC	CD	DD
601	I L1 (IL1 =)	Measurement	134	129	No	9	1	CFC	CD	DD
602	I L2 (IL2 =)	Measurement	134	129	No	9	2	CFC	CD	DD
603	I L3 (IL3 =)	Measurement	134	129	No	9	3	CFC	CD	DD
610	3I0 (zero sequence) (3I0 =)	Measurement	134	129	No	9	14	CFC	CD	DD
612	IY (star point of transformer) (IY =)	Measurement	-	-	-	-	-	CFC	CD	DD
619	I1 (positive sequence) (I1 =)	Measurement	-	-	-	-	-	CFC	CD	DD
620	I2 (negative sequence) (I2 =)	Measurement	-	-	-	-	-	CFC	CD	DD
621	U L1-E (UL1E=)	Measurement	134	129	No	9	4	CFC	CD	DD
622	U L2-E (UL2E=)	Measurement	134	129	No	9	5	CFC	CD	DD
623	U L3-E (UL3E=)	Measurement	134	129	No	9	6	CFC	CD	DD
624	U L12 (UL12=)	Measurement	134	129	No	9	10	CFC	CD	DD
625	U L23 (UL23=)	Measurement	134	129	No	9	11	CFC	CD	DD
626	U L31 (UL31=)	Measurement	134	129	No	9	12	CFC	CD	DD
627	Uen (Uen =)	Measurement	-	-	-	-	-	CFC	CD	DD
631	3U0 (zero sequence) (3U0 =)	Measurement	-	-	-	-	-	CFC	CD	DD
633	Ux (separate VT) (Ux =)	Measurement	-	-	-	-	-	CFC	CD	DD
634	U1 (positive sequence) (U1 =)	Measurement	-	-	-	-	-	CFC	CD	DD
635	U2 (negative sequence) (U2 =)	Measurement	-	-	-	-	-	CFC	CD	DD
641	P (active power) (P =)	Measurement	134	129	No	9	7	CFC	CD	DD
642	Q (reactive power) (Q =)	Measurement	134	129	No	9	8	CFC	CD	DD
643	Power Factor (PF =)	Measurement	134	129	No	9	13	CFC	CD	DD
644	Frequency (Freq=)	Measurement	134	129	No	9	9	CFC	CD	DD
645	S (apparent power) (S =)	Measurement	-	-	-	-	-	CFC	CD	DD
679	U1co (positive sequence, compounding) (U1co=)	Measurement	-	-	-	-	-	CFC	CD	DD
684	U0 (zero sequence) (U0 =)	Measurement	-	-	-	-	-	CFC	CD	DD
801	Temperat. rise for warning and trip (Θ/Θtrip =)	Measurement	-	-	-	-	-	CFC	CD	DD
802	Temperature rise for phase L1 (Θ/ΘtripL1=)	Measurement	-	-	-	-	-	CFC	CD	DD
803	Temperature rise for phase L2 (Θ/ΘtripL2=)	Measurement	-	-	-	-	-	CFC	CD	DD
804	Temperature rise for phase L3 (Θ/ΘtripL3=)	Measurement	-	-	-	-	-	CFC	CD	DD
888	Pulsed Energy Wp (active) (Wp(puls))	Energy	133	55	No	205	-	CFC	CD	DD
889	Pulsed Energy Wq (reactive) (Wq(puls))	Energy	133	56	No	205	-	CFC	CD	DD
924	Wp Forward (Wp+=)	Energy	133	51	No	205	-	CFC	CD	DD
925	Wq Forward (Wq+=)	Energy	133	52	No	205	-	CFC	CD	DD
928	Wp Reverse (Wp-=)	Energy	133	53	No	205	-	CFC	CD	DD
929	Wq Reverse (Wq-=)	Energy	133	54	No	205	-	CFC	CD	DD
7731	PHI IL1L2 (local) (Φ IL1L2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7732	PHI IL2L3 (local) (Φ IL2L3=)	Measurement	-	-	-	-	-	CFC	CD	DD
7733	PHI IL3L1 (local) (Φ IL3L1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7734	PHI UL1L2 (local) (Φ UL1L2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7735	PHI UL2L3 (local) (Φ UL2L3=)	Measurement	-	-	-	-	-	CFC	CD	DD
7736	PHI UL3L1 (local) (Φ UL3L1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7737	PHI UIL1 (local) (Φ UIL1=)	Measurement	-	-	-	-	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
7738	PHI UIL2 (local) (Φ UIL2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7739	PHI UIL3 (local) (Φ UIL3=)	Measurement	-	-	-	-	-	CFC	CD	DD
7742	IDiffL1(% Operational nominal current) (IDiffL1=)	IDiff/IRest	134	122	No	9	1	CFC	CD	DD
7743	IDiffL2(% Operational nominal current) (IDiffL2=)	IDiff/IRest	134	122	No	9	2	CFC	CD	DD
7744	IDiffL3(% Operational nominal current) (IDiffL3=)	IDiff/IRest	134	122	No	9	3	CFC	CD	DD
7745	IRestL1(% Operational nominal current) (IRestL1=)	IDiff/IRest	134	122	No	9	4	CFC	CD	DD
7746	IRestL2(% Operational nominal current) (IRestL2=)	IDiff/IRest	134	122	No	9	5	CFC	CD	DD
7747	IRestL3(% Operational nominal current) (IRestL3=)	IDiff/IRest	134	122	No	9	6	CFC	CD	DD
7748	Diff3I0 (Differential current 3I0) (Diff3I0=)	IDiff/IRest	-	-	-	-	-	CFC	CD	DD
7751	Prot.Interface 1:Transmission delay (PI1 TD)	Statistics	134	122	No	9	7	CFC	CD	DD
7753	Prot.Interface 1: Availability per min. (PI1A/m)	Statistics	-	-	-	-	-	CFC	CD	DD
7754	Prot.Interface 1: Availability per hour (PI1A/h)	Statistics	134	122	No	9	8	CFC	CD	DD
			134	121	No	9	3			
7761	Relay ID of 1. relay (Relay ID)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7762	IL1(% of Operational nominal current) (IL1_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7763	Angle IL1_rem <-> IL1_loc (ΦI L1=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7764	IL2(% of Operational nominal current) (IL2_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7765	Angle IL2_rem <-> IL2_loc (ΦI L2=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7766	IL3(% of Operational nominal current) (IL3_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7767	Angle IL3_rem <-> IL3_loc (ΦI L3=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7769	UL1(% of Operational nominal voltage) (UL1_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7770	Angle UL1_rem <-> UL1_loc (ΦU L1=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7771	UL2(% of Operational nominal voltage) (UL2_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7772	Angle UL2_rem <-> UL2_loc (ΦU L2=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7773	UL3(% of Operational nominal voltage) (UL3_opN=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7774	Angle UL3_rem <-> UL3_loc (ΦU L3=)	Measure relay1	-	-	-	-	-	CFC	CD	DD
7781	Relay ID of 2. relay (Relay ID)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7782	IL1(% of Operational nominal current) (IL1_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7783	Angle IL1_rem <-> IL1_loc (ΦI L1=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7784	IL2(% of Operational nominal current) (IL2_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7785	Angle IL2_rem <-> IL2_loc (ΦI L2=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7786	IL3(% of Operational nominal current) (IL3_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7787	Angle IL3_rem <-> IL3_loc (ΦI L3=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7789	UL1(% of Operational nominal voltage) (UL1_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7790	Angle UL1_rem <-> UL1_loc (ΦU L1=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7791	UL2(% of Operational nominal voltage) (UL2_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7792	Angle UL2_rem <-> UL2_loc (ΦU L2=)	Measure relay2	-	-	-	-	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
7793	UL3(% of Operational nominal voltage) (UL3_opN=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7794	Angle UL3_rem <-> UL3_loc (ΦU L3=)	Measure relay2	-	-	-	-	-	CFC	CD	DD
7875	Prot.Interface 1:Transmission delay rec. (PI1 TD R)	Statistics	134	121	No	9	1	CFC	CD	DD
7876	Prot.Interface 1:Transmission delay send (PI1 TD S)	Statistics	134	121	No	9	2	CFC	CD	DD
30654	Idiff REF(% Operational nominal current) (IdiffREF=)	IDiff/IRest	-	-	-	-	-	CFC	CD	DD
30655	Irest REF(% Operational nominal current) (IrestREF=)	IDiff/IRest	-	-	-	-	-	CFC	CD	DD

■

Literature

/1/ SIPROTEC 4 System Description; E50417-H1176-C151-A2

/2/ SIPROTEC DIGSI, Start Up; E50417-G1176-C152-A2

/3/ DIGSI CFC, Manual; E50417-H1176-C098-A4

/4/ SIPROTEC SIGRA 4, Manual; E50417-H1176-C070-A2

Glossary

Battery — The buffer battery ensures that specified data areas, flags, timers and counters are retained retentively.

Bay controllers — Bay controllers are devices with control and monitoring functions without protective functions.

Bit pattern indication — Bit pattern indication is a processing function by means of which items of digital process information applying across several inputs can be detected together in parallel and processed further. The bit pattern length can be specified as 1, 2, 3 or 4 bytes.

BP_xx — → Bit pattern indication (Bitstring Of x Bit), x designates the length in bits (8, 16, 24 or 32 bits).

C_xx — Command without feedback

CF_xx — Command with feedback

CFC — Continuous Function Chart. CFC is a graphical editor with which a program can be created and configured by using ready-made blocks.

CFC blocks — Blocks are parts of the user program delimited by their function, their structure or their purpose.

Chatter blocking — A rapidly intermittent input (for example, due to a relay contact fault) is switched off after a configurable monitoring time and can thus not generate any further signal changes. The function prevents overloading of the system when a fault arises.

Combination devices — Combination devices are bay devices with protection functions and a control display.

Combination matrix — From DIGSI V4.6 onward, up to 32 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination (IRC combination). Which device exchanges which information is defined with the help of the combination matrix.

Communication branch — A communications branch corresponds to the configuration of 1 to n users that communicate by means of a common bus.

Communication reference CR — The communication reference describes the type and version of a station in communication by PROFIBUS.

Component view In addition to a topological view, SIMATIC Manager offers you a component view. The component view does not offer any overview of the hierarchy of a project. It does, however, provide an overview of all the SIPROTEC 4 devices within a project.

COMTRADE Common Format for Transient Data Exchange, format for fault records.

Container If an object can contain other objects, it is called a container. The object Folder is an example of such a container.

Control display The display which is displayed on devices with a large (graphic) display after you have pressed the control key is called the control display. It contains the switchgear that can be controlled in the feeder with status display. It is used to perform switching operations. Defining this display is part of the configuration.

Data pane → The right-hand area of the project window displays the contents of the area selected in the → navigation window, for example indications, measured values, etc. of the information lists or the function selection for the device configuration.

DCF77 The extremely precise official time is determined in Germany by the "Physikalisch-Technische-Bundesanstalt PTB" in Braunschweig. The atomic clock station of the PTB transmits this time via the long-wave time-signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 1,500 km from Frankfurt/Main.

Device container In the Component View, all SIPROTEC 4 devices are assigned to an object of type Device container. This object is a special object of DIGSI Manager. However, since there is no component view in DIGSI Manager, this object only becomes visible in conjunction with STEP 7.

Double command Double commands are process outputs which indicate 4 process states at 2 outputs: 2 defined (for example ON/OFF) and 2 undefined states (for example intermediate positions)

Double-point indication Double-point indications are items of process information which indicate 4 process states at 2 inputs: 2 defined (for example ON/OFF) and 2 undefined states (for example intermediate positions).

DP → Double-point indication

DP_I → Double point indication, intermediate position 00

Drag and drop Copying, moving and linking function, used at graphics user interfaces. Objects are selected with the mouse, held and moved from one data area to another.

Earth The conductive earth whose electric potential can be set equal to zero at every point. In the area of earth electrodes the earth can have a potential deviating from zero. The term "Earth reference plane" is often used for this state.

Earth (verb)	This term means that a conductive part is connected via an earthing system to the → earth.
Earthing	Earthing is the total of all means and measures used for earthing.
Electromagnetic compatibility	Electromagnetic compatibility (EMC) is the ability of an electrical apparatus to function fault-free in a specified environment without influencing the environment unduly.
EMC	→ Electromagnetic compatibility
ESD protection	ESD protection is the total of all the means and measures used to protect electrostatic sensitive devices.
ExBPxx	External bit pattern indication via an ETHERNET connection, device-specific → Bit pattern indication
ExC	External command without feedback via an ETHERNET connection, device-specific
ExCF	External command with feedback via an ETHERNET connection, device-specific
ExDP	External double point indication via an ETHERNET connection, device-specific → Double point indication
ExDP_I	External double point indication via an ETHERNET connection, intermediate position 00, device-specific → Double point indication
ExMV	External metered value via an ETHERNET connection, device-specific
ExSI	External single point indication via an ETHERNET connection, device-specific → Single point indication
ExSI_F	External single point indication via an ETHERNET connection, device-specific → Transient information, → Single point indication
Field devices	Generic term for all devices assigned to the field level: Protection devices, combination devices, bay controllers.
Floating	→ Without electrical connection to the → Earth.
FMS communication branch	Within an FMS communication branch, the users communicate on the basis of the PROFIBUS FMS protocol via a PROFIBUS FMS network.
Folder	This object type is used to create the hierarchical structure of a project.
General interrogation (GI)	During the system start-up the state of all the process inputs, of the status and of the fault image is sampled. This information is used to update the system-end process

image. The current process state can also be sampled after a data loss by means of a GI.

GOOSE message GOOSE messages (Generic Object Oriented Substation Event) are data packets which are transferred event-controlled via the Ethernet communication system. They serve for direct information exchange among the relays. This mechanism implements cross-communication between bay units.

GPS Global Positioning System. Satellites with atomic clocks on board orbit the earth twice a day on different paths in approx. 20,000 km. They transmit signals which also contain the GPS universal time. The GPS receiver determines its own position from the signals received. From its position it can derive the delay time of a satellite signal and thus correct the transmitted GPS universal time.

Hierarchy level Within a structure with higher-level and lower-level objects a hierarchy level is a container of equivalent objects.

HV field description The HV project description file contains details of fields which exist in a ModPara-project. The actual field information of each field is stored in a HV field description file. Within the HV project description file, each field is allocated such a HV field description file by a reference to the file name.

HV project description All the data is exported once the configuration and parameterization of PCUs and submodules using ModPara has been completed. This data is split up into several files. One file contains details about the fundamental project structure. This also includes, for example, information detailing which fields exist in this project. This file is called a HV project description file.

ID Internal double point indication → Double point indication

ID_S Internal double point indication, intermediate position 00 → Double point indication

IEC International Electrotechnical Commission, international standardisation body

IEC address Within an IEC bus a unique IEC address has to be assigned to each SIPROTEC 4 device. A total of 254 IEC addresses are available for each IEC bus.

IEC communication branch Within an IEC communication branch the users communicate on the basis of the IEC60-870-5-103 protocol via an IEC bus.

IEC61850 International communication standard for communication in substations. The objective of this standard is the interoperability of devices from different manufacturers on the station bus. An Ethernet network is used for data transfer.

Initialization string An initialization string comprises a range of modem-specific commands. These are transmitted to the modem within the framework of modem initialization. The commands can, for example, force specific settings for the modem.

Inter relay communication → IRC combination

IRC combination Inter Relay Communication, IRC, is used for directly exchanging process information between SIPROTEC 4 devices. You require an object of type IRC combination to configure an inter relay communication. Each user of the combination and all the necessary communication parameters are defined in this object. The type and scope of the information exchanged between the users is also stored in this object.

IRIG-B Time signal code of the Inter-Range Instrumentation Group

IS Internal single point indication → Single point indication

IS_F Internal indication transient → Transient information, → Single point indication

ISO 9001 The ISO 9000 ff range of standards defines measures used to assure the quality of a product from the development stage to the manufacturing stage.

Link address The link address gives the address of a V3/V2 device.

List view The right pane of the project window displays the names and icons of objects which represent the contents of a container selected in the tree view. Because they are displayed in the form of a list, this area is called the list view.

LV Limit value

LVU Limit value, user-defined

Master Masters may send data to other users and request data from other users. DIGSI operates as a master.

Metered value Metered values are a processing function with which the total number of discrete similar events (counting pulses) is determined for a period, usually as an integrated value. In power supply companies the electrical work is usually recorded as a metered value (energy purchase/supply, energy transportation).

MLFB MLFB is the abbreviation for "MaschinenLesbare FabrikateBezeichnung" (machine-readable product designation). This is the equivalent of an order number. The type and version of a SIPROTEC 4 device are coded in the order number.

Modem connection This object type contains information on both partners of a modem connection, the local modem and the remote modem.

Modem profile A modem profile consists of the name of the profile, a modem driver and may also comprise several initialization commands and a user address. You can create several modem profiles for one physical modem. To do so you need to link various initialization commands or user addresses to a modem driver and its properties and save them under different names.

Modems	Modem profiles for a modem connection are stored in this object type.
MV	Measured value
MVMV	Metered value which is formed from the measured value
MVT	Measured value with time
MVU	Measured value, user-defined
Navigation pane	The left pane of the project window displays the names and symbols of all containers of a project in the form of a folder tree.
Object	Each element of a project structure is called an object in DIGSI.
Object properties	Each object has properties. These might be general properties that are common to several objects. An object can also have specific properties.
Off-line	In offline mode a connection to a SIPROTEC 4 device is not required. You work with data which are stored in files.
OI_F	Output Indication Transient → Transient information
On-line	When working in online mode, there is a physical connection to a SIPROTEC 4 device. This connection can be implemented as a direct connection, as a modem connection or as a PROFIBUS FMS connection.
OUT	Output indication
Parameter set	The parameter set is the set of all parameters that can be set for a SIPROTEC 4 device.
Phone book	User addresses for a modem connection are saved in this object type.
PMV	Pulse metered value
Process bus	Devices with a process bus interface allow direct communication with SICAM HV modules. The process bus interface is equipped with an Ethernet module.
PROFIBUS	PROcess FIeld BUS, the German process and field bus standard, as specified in the standard EN 50170, Volume 2, PROFIBUS. It defines the functional, electrical, and mechanical properties for a bit-serial field bus.
PROFIBUS address	Within a PROFIBUS network a unique PROFIBUS address has to be assigned to each SIPROTEC 4 device. A total of 254 PROFIBUS addresses are available for each PROFIBUS network.

Project Content-wise, a project is the image of a real power supply system. Graphically, a project is represented as a number of objects which are integrated in a hierarchical structure. Physically, a project consists of a number of directories and files containing project data.

Protection devices All devices with a protective function and no control display.

Reorganizing Frequent addition and deletion of objects results in memory areas that can no longer be used. By reorganizing projects, you can release these memory areas again. However, a cleanup also reassigns the VD addresses. The consequence is that all SIPROTEC 4 devices have to be reinitialized.

RIO file Relay data Interchange format by Omicron.

RSxxx-interface Serial interfaces RS232, RS422/485

SCADA Interface Rear serial interface on the devices for connecting to a control system via IEC or PROFIBUS.

Service port Rear serial interface on the devices for connecting DIGSI (for example, via modem).

Setting parameters General term for all adjustments made to the device. Parameterization jobs are executed by means of DIGSI or, in some cases, directly on the device.

SI → Single point indication

SI_F → Single point indication transient → Transient information, → Single point indication

SICAM SAS Modularly structured station control system, based on the substation controller → SICAM SC and the SICAM WinCC operator control and monitoring system.

SICAM SC Substation Controller. Modularly structured substation control system, based on the SIMATIC M7 automation system.

SICAM WinCC The SICAM WinCC operator control and monitoring system displays the state of your network graphically, visualizes alarms, interrupts and indications, archives the network data, offers the possibility of intervening manually in the process and manages the system rights of the individual employee.

Single command Single commands are process outputs which indicate 2 process states (for example, ON/OFF) at one output.

Single point indication Single indications are items of process information which indicate 2 process states (for example, ON/OFF) at one output.

SIPROTEC The registered trademark SIPROTEC is used for devices implemented on system base V4.

SIPROTEC 4 device This object type represents a real SIPROTEC 4 device with all the setting values and process data it contains.

SIPROTEC 4 variant This object type represents a variant of an object of type SIPROTEC 4 device. The device data of this variant may well differ from the device data of the original object. However, all variants derived from the original object have the same VD address as the original object. For this reason they always correspond to the same real SIPROTEC 4 device as the original object. Objects of type SIPROTEC 4 variant have a variety of uses, such as documenting different operating states when entering parameter settings of a SIPROTEC 4 device.

Slave A slave may only exchange data with a master after being prompted to do so by the master. SIPROTEC 4 devices operate as slaves.

Time stamp Time stamp is the assignment of the real time to a process event.

Topological view DIGSI Manager always displays a project in the topological view. This shows the hierarchical structure of a project with all available objects.

Transformer Tap Indication Transformer tap indication is a processing function on the DI by means of which the tap of the transformer tap changer can be detected together in parallel and processed further.

Transient information A transient information is a brief transient → single-point indication at which only the coming of the process signal is detected and processed immediately.

Tree view The left pane of the project window displays the names and symbols of all containers of a project in the form of a folder tree. This area is called the tree view.

TxTap → Transformer Tap Indication

User address A user address comprises the name of the user, the national code, the area code and the user-specific phone number.

Users From DIGSI V4.6 onward , up to 32 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination. The individual participating devices are called users.

VD A VD (Virtual Device) includes all communication objects and their properties and states that are used by a communication user through services. A VD can be a physical device, a module of a device or a software module.

VD address The VD address is assigned automatically by DIGSI Manager. It exists only once in the entire project and thus serves to identify unambiguously a real SIPROTEC 4 device. The VD address assigned by DIGSI Manager must be transferred to the SIPROTEC 4 device in order to allow communication with DIGSI Device Editor.

VFD A VFD (Virtual Field Device) includes all communication objects and their properties and states that are used by a communication user through services.

WM A WD (Wertmeldung) designates value indication.

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