SIEMENS

SIPROTEC

Feeder Automation Controller 7SC80

V4.0

Manual

E50417-G1140-C486-A1

Note

For safety purposes, please note instructions and warnings in the Preface.

Disclaimer of Liability

We have checked the contents 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 suggested improvements.

We reserve the right to make technical improvements without notice.

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Preface

Purpose of this Manual

This manual describes the functions, operation, installation, and commissioning of 7SC80 devices. In particular, one will find:

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

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

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.

Applicability of this Manual

This manual applies to: SIPROTEC 4 Feeder Automation Controller 7SC80; firmware version V4.0.

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

UL approval according standard UL 508 is pending.

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Additional Support

Should further information on the System SIPROTEC 4 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.

Our Customer Support Center provides a 24-hour service.

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Training Courses

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

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Internet: www.siemens.com/energy/power-academy

Email: power-academy.energy@siemens.com

Safety Information

This manual does not constitute a complete index of all required safety measures for operation of the equipment (module, device), as special operational conditions may require additional measures. However, it comprises important information that should be noted for purposes of personal safety as well as avoiding material damage. Information that is highlighted by means of a warning triangle and according to the degree of danger, is illustrated as follows.

DANGER!

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

WARNING!

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

Caution!

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

Note

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

WARNING!

Qualified Personnel

Commissioning and operation of the equipment (module, device) as set out in this manual may only be carried out by qualified personnel. Qualified personnel in terms of the technical safety information as set out in this manual are persons who are authorized to commission, activate, to ground and to designate devices, systems and electrical circuits in accordance with the safety standards.

Use as prescribed

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

The successful and safe operation of the device is dependent on proper handling, storage, installation, operation, and maintenance.

When operating an electrical equipment, certain parts of the device are inevitably subject to dangerous voltage. Severe personal injury or property damage may result if the device is not handled properly.

Before any connections are made, the device must be grounded to the ground terminal.

All circuit components connected to the voltage supply may be subject to dangerous voltage.

Dangerous voltage may be present in the device even after the power supply voltage has been removed (capacitors can still be charged).

Operational equipment with exposed current transformer circuits may not be operated.

The limit values as specified in this manual or in the operating instructions may not be exceeded. This aspect must also be observed during testing and commissioning.

Typographic and Symbol Conventions

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

`Parameter Names`

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

`1234A`

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

`Parameter Options`

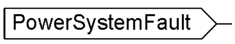
Possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI), are additionally written in italics. This also applies to header bars for selection menus.

`„Messages“`

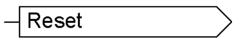
Designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotation marks.

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

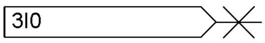
The following symbols are used in drawings:



Device-internal logical input signal

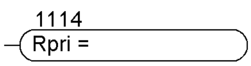


Device-internal logical output signal



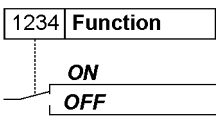
Internal input signal of an analog quantity

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



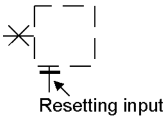
External binary input signal with number (example of a value indication)

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

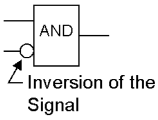


Example of a parameter switch designated **FUNCTION** with address 1234 and the possible settings ON and OFF

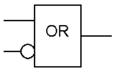
Besides these, graphical symbols are used according to IEC 60617-12 and IEC 60617-13 or symbols derived from these standards. Some of the most frequently used are listed below:



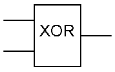
Analog input variable



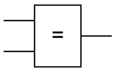
AND operation of input variables



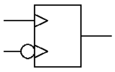
OR operation of input variables



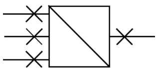
Exclusive OR (antivalence): output is active if only **one** of the inputs is active



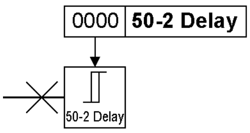
Coincidence: output is active if **both** inputs are active or inactive at the same time



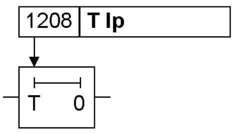
Dynamic input signals (edge-triggered) above with positive, below with negative edge



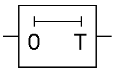
Formation of one analog output signal from a number of analog input signals



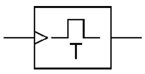
Threshold element with setting address and parameter names



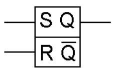
Timer (pickup delay T adjustable) with setting address and parameter names



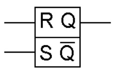
Timer (dropout delay T not adjustable)



Edge-triggered time element with action time T



Static memory (SR flipflop) with setting input (S), resetting input (R), output (Q) and inverted output (Q̄), setting input dominant



Static memory (RS-flipflop) with resetting input (R) setting input (S), output (Q) and inverted output (Q̄), resetting input dominant

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Contents

Introduction 1

This chapter introduces the SIPROTEC Feeder Automation Controller 7SC80 and gives an overview of the device's application, properties and functions.

1.1 Overall Operation

This chapter introduces the SIPROTEC Feeder Automation Controller 7SC80 and gives an overview of the device's application, properties and functions.

Analog Inputs

The measuring inputs (MI) convert the currents and voltages coming from the measuring transformers and adapt them to the level appropriate for the internal processing of the device. The device provides 4 current transformers, 1 voltage transformer, and – depending on the model – 3 additional voltage transformers. Three current inputs serve for the input of the phase currents, another current input (I_N) can be used for measuring the ground fault current I_N (current transformer neutral point).

The optional voltage transformers can either be used to input three phase-to-ground voltages or for two phase-to-phase voltages and the displacement voltage (open delta voltage). It is also possible to connect two phase-to-phase voltages in an open delta connection.

The voltage input Vx which is always available can be used for single-phase measurements of any voltages.

The analog input quantities are passed on to the input amplifiers (IA). The input amplifier IA element provides a high-resistance termination for the input quantities. It consists of filters that are optimized for measured-value processing with regard to bandwidth and processing speed.

The analog-to-digital (AD) transformer group consists of an analog-to-digital converter and memory components for the transmission of data to the microcomputer.

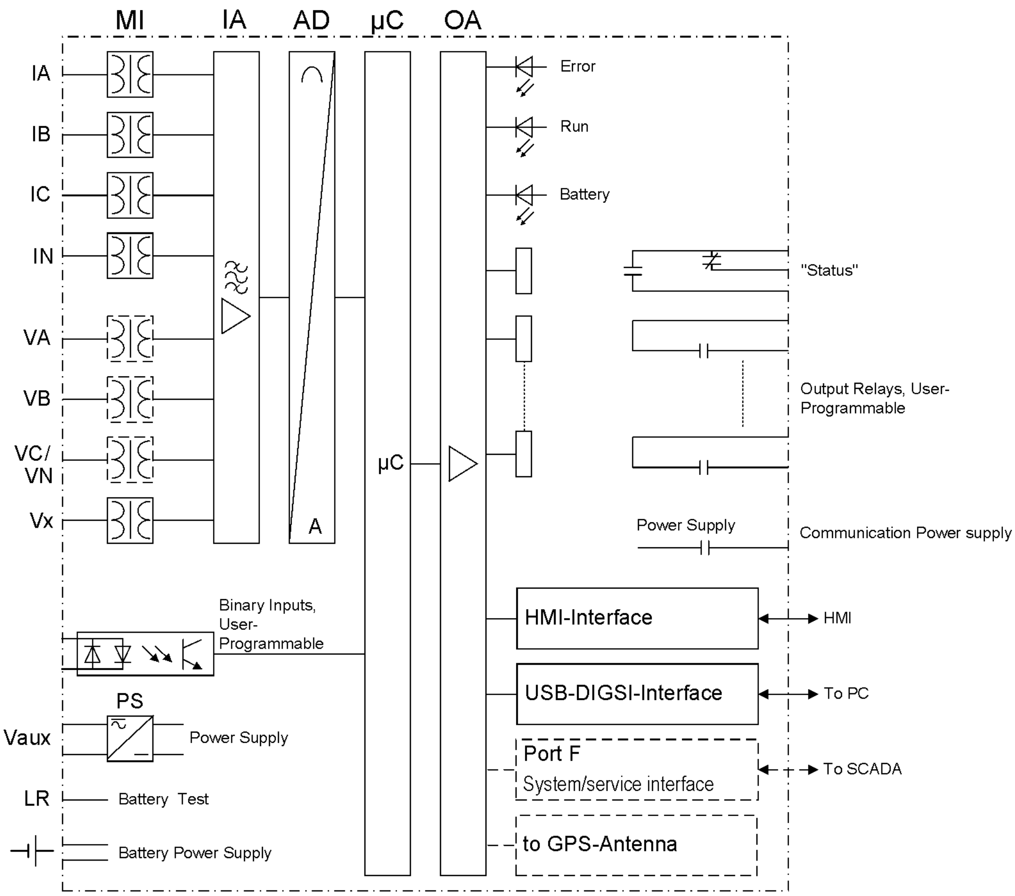

Figure 1-1 Hardware structure Feeder Automation Controller 7SC80

Microcomputer System

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

- Filtering and preparation of the measured quantities
- Continuous monitoring of the measured quantities
- Monitoring of the pickup conditions for the individual protective functions
- Interrogation of limit values and sequences in time
- Control of signals for the logic functions
- Output of control commands for switching devices
- Recording of messages, fault data and fault values for analysis
- Management of the operating system and the associated functions such as data recording, real-time clock, communication, interfaces, etc.
- The information is distributed via output amplifiers (OA).

Binary Inputs and Outputs

The computer system obtains external information through the binary input/output boards (inputs and outputs). The computer system obtains information from the system (e.g remote resetting) or from external equipment (e.g. blocking commands). These outputs include, in particular, trip commands to circuit breakers and signals for the remote indication of important events and conditions.

Front Elements

LEDs on the device front indicate the device's readiness for operation and signal the states of the integrated battery controller.

Interfaces

Communication with DIGSI can be effected via the **USB-DIGSI interface** or via **port F** (system/service interface). This allows for all device functions to be easily executed.

In addition to the device communication via DIGSI, **port F** can also be used to transmit all device data to a central evaluator or a control center. This interface may be provided with various protocols and physical transmission schemes to suit the particular application.

Power Supply

A power supply unit (Vaux or PS) delivers power to the functional units using the different voltage levels. Voltage dips may occur if the voltage supply system (substation battery) becomes short-circuited. Usually, they are bridged by a capacitor (see also Technical Data).

A replaceable buffer battery is located on the side of the device.

Communication Power Supply

The Feeder Automation Controller 7SC80 can supply external communication components (only order variant 24/48V). The supply is effected via the auxiliary power supply connection or via the battery and can be cut off by the Feeder Automation Controller 7SC80, e.g. in the case of low battery voltage.

1.2 Application Scope

The Feeder Automation Controller 7SC80 can be used as protection, control and monitoring unit for line protection in networks with grounded or low-resistance grounded neutral point structure. It is suitable for networks that are radial and supplied from a single source, open or closed looped networks, and for lines with sources at both ends.

The Feeder Automation Controller 7SC80 includes the functions that are usually necessary for protection, monitoring of circuit breaker positions and control of circuit breakers; therefore, the device can be employed universally. The device also provides excellent backup protection of differential protective schemes of any kind.

The Feeder Automation Controller is particularly suitable for the use in distribution network automation outside the substation. It covers the special requirements as to the temperature range, the remote control feature, and remote access. The 24/48V batteries typically used in distribution networks are charged and monitored by the integrated battery management.

The optional GPS module enables time synchronization of the Feeder Automation Controller 7SC80 exact to the millisecond.

Protection Functions

Non-directional and directional overcurrent protection are the basic functions of the device. These feature definite-time overcurrent elements for phase currents and ground current.

Depending on the order variant, further protective functions such as frequency protection, undervoltage and overvoltage protection, as well as a breaker failure protection are included.

Control Functions

The device provides a control function with which the switchgear can be activated and deactivated via the Web Monitor, port F, binary inputs and the USB interface using DIGSI.

The status of the primary equipment can be transmitted to the device via auxiliary contacts connected to binary inputs. The present status (or position) of the primary equipment can be displayed on the device, and used for interlocking or alarm condition monitoring. The number of operating equipments 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 indications. Depending on the primary equipment being controlled, one binary input (single point indication) or two binary inputs (double point indication) may be used for this process.

The capability of switching primary equipment can be restricted by a setting associated with switching authority (Remote or Local), and by the operating mode (interlocked/non-interlocked, with or without password request).

Processing of interlocking conditions for switching (e.g. switchgear interlocking) can be established with the aid of integrated, user-configurable logic functions.

Indications and Measured Values; Fault Recording

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

Device indications can be processed externally via output contacts (allocatable), linked with user-definable logic functions, and/or issued via various interfaces. Furthermore, indications can be output to a number of virtual LEDs (allocatable) and displayed with the help of the Web Monitor.

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

Communication

The following interfaces are available for communication with external operating, control and memory systems.

Local communication with a PC is possible via the USB-DIGSI interface on the front. The DIGSI 4 operating software enables you to perform all operational and evaluation tasks, for example entering and modifying configuration and setting parameters, configuring user-specific logic functions, reading out operational indications, fault indications and measured values, reading out and displaying fault records, retrieving device conditions and measured values, issuing control commands.

Depending on the order variant, additional interfaces are located on the side of the device. They serve for establishing extensive communication with other digital operating, control and memory components:

Port F serves for central communication between the device and a control center. It can be operated via copper lines or fiber optic cables. Standard protocols are available for data transfer, e.g. IEC61850. These protocols are also used to integrate the devices into substation control systems such as SICAM PAS.

1.3 Characteristics

General Properties

- Powerful 32-bit microprocessor system
- Complete digital measured value processing and control, from sampling and digitalization of the measured quantities to close and trip decisions for the switchgear component
- Complete galvanic and interference-free isolation of the internal processing circuits of the measurement, control and supply circuits of the system using instrument transformers, binary input and output modules, and DC and AC voltage converters.
- Complete functional scope required for protection and control of a line section
- Easy device operation using the Web Monitor or a connected PC running DIGSI
- Continuous calculation and displaying of measured values and count values
- Storage of min./max. measured values (slave pointer function) and storage of long-term mean values
- Storing fault indications for the last 8 power system faults (faults in the power system) with real-time assignment and instantaneous values for fault recording for a maximum time period of approx. 18 s
- Continuous monitoring of the measured quantities and of the device hardware and software
- Communication with central control and data storage equipment
- Battery-buffered clock which can be synchronized via a synchronization signal at the binary input, or via a protocol or GPS
- Switching statistics: Counting the number of trip commands initiated by the device, logging the currents of the last switch-off operation initiated by the device, and accumulating the eliminated short-circuit currents of each breaker pole
- Operating hours counter: Counting the operating hours of the protected object under load
- Commissioning aids such as connection and direction check, status indication of all binary inputs and outputs, easy testing of port F, and influencing of information at port F during test operation.

Non-directional Overcurrent Protection

- Three definite-time overcurrent protection elements each for phase currents and ground current I_N or summation current $3I_0$
- Two-phase operation of the overcurrent protection (I_A, I_C) is possible.
- Blocking is possible, e.g. for reverse interlocking with any Element.
- Instantaneous tripping by any Element is possible when switching onto a fault.
- In-rush restraint with second harmonic current quantities.

Directional Overcurrent Protection

- Two definite-time overcurrent protection elements for the phase operate in parallel to the non-directional overcurrent elements. Their pickup values and time delays can be set independently of these.
- Direction determination with cross-polarized voltages and voltage memory and dynamically unlimited direction sensitivity
- Fault direction is calculated phase-selectively and separately for phase faults, ground faults and summation current faults.

Voltage Protection

- 2-element undervoltage detection via the positive-sequence system of the voltages, phase-to-phase or phase-to-ground voltages
- Phase-specific undervoltage detection
- The current criterion can optionally be activated as an additional release criterion.
- Separate two-element overvoltage detection of the largest voltages applied or detection of the positive or negative sequence component of the voltages
- Phase-specific overvoltage detection
- Settable dropout ratio for all elements of the undervoltage and overvoltage protection.

Voltage protection for Vx

- Two-element undervoltage and overvoltage protection for single-phase voltage connection to Vx
- Settable dropout ratio for all elements of the single-phase undervoltage and overvoltage protection Vx

Frequency Protection

- Monitoring of falling below (f<) and/or exceeding (f>) with 4 frequency limits and time delays that are independently adjustable
- Insensitive to harmonics and abrupt phase angle changes
- Adjustable undervoltage threshold.

Monitoring Functions

- Increased reliability due to monitoring of the internal measurement circuits as well as the hardware and software
- Fuse failure monitor with protection function blocking
- Monitoring of the current transformer and voltage transformer secondary circuits using sum and symmetry supervision with optional protection function blocking
- Phase rotation check.

Fault Location

- Initiation by trip command, external command or dropout of pickup
- Configuration of up to three line sections possible
- Calculation of the fault distance and output of the fault point in ohms (primary and secondary) and in kilometers or miles

Breaker Failure Protection

- By checking the current and/or evaluating the circuit breaker auxiliary contacts
- Started by any integrated protection function that trips
- Initiation possible via a binary input from an external protective device.

Flexible Protection Functions

- Up to 20 customizable protection functions with three-phase or single-phase operation
- Any calculated or directly measured quantity can be evaluated on principle.
- Standard protection logic with a constant (i.e. definite-time) characteristic curve
- Internal and configurable pickup and dropout delay
- Modifiable message texts.

Phase Sequence Reversal

- Selectable ABC or ACB by setting (static) or binary input (dynamic).

User-Defined Functions

- Freely programmable linking of internal and external signals in order to implement user-defined logic functions.
- All standard logic functions (AND, OR, NOT, EXCLUSIVE-OR, etc.)
- Time delays and limit value interrogations
- Processing of measured values, including zero suppression, adding a knee curve for a transducer input, and live-zero monitoring.

Switchgear Control

- Switching devices can be opened and closed manually via the Web Monitor, port F (e.g. of SICAM), or via the user interface (using the DIGSI operating software)
- Feedback of switching states via the switch auxiliary contacts
- Plausibility monitoring of the circuit breaker position and check of interlocking conditions.

Device Operation

- Device operation via the Web Monitor

Battery Charger

- Charging and monitoring of the charge state of an external battery with 24 V or 48 V power connection

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Functions 2

This chapter describes the numerous functions available on the SIPROTEC 4 device 7SC80. It shows the setting possibilities for each function in maximum configuration. Information with regard to the determination of setting values as well as formulas, if required, are also provided.

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

2.1 General

The settings associated with the various device functions may be modified by using the operator interface in DIGSI. Some parameters may also be changed using the Web Monitor. The procedure is set out in the SIPROTEC System Description /1/.

2.1.1 Functions Overview

The 7SC80 relay comprises protection functions and additional functions. The hardware and firmware are designed for this scope of functions. Additionally, the control functions can be matched to the system requirements. Individual functions can be activated or deactivated during the configuration procedure or the interaction of functions be modified.

2.1.1.1 Description

Setting the Scope of Functions

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

Functions configured as ***Disabled*** are not processed in the 7SC80. There are no messages issued and the corresponding settings (functions, limit values) are not queried during configuration.

Note

Available functions and default settings depend on the ordered variant of the relay (see A.1 for details).

2.1.1.2 Setting Notes

Setting the Functional Scope

Your protection device is configured using the DIGSI software. Connect your personal computer either to the USB interface on the device front or to port F or on the side of the device, depending on the device version (order variant). Operation using DIGSI is explained in the SIPROTEC 4 System Description.

The **Device Configuration** dialog box allows you to adjust your device to the specific system conditions.

Password no. 7 is required (for parameter set) for changing configuration parameters in the device. Without the password the settings can only be read but not edited and transmitted to the device.

Special Features

Most settings are self-explanatory. The special cases are described in the following.

If you want to use the setting group change function, set address 103 **Grp Chge OPTION** to ***Enabled***. In this case, you can select up to four different groups of function parameters between which you can switch quickly and conveniently during operation. Only **one** setting group can be used when selecting the option ***Disabled***.

The relay elements associated with non-directional overcurrent protection (both for phase and ground) are activated at addresses 112 **Charac. Phase** and 113 **Charac. Ground**. The setting ***Disabled*** deactivates overcurrent protection. With the setting ***Definite Time***, overcurrent protection operates with a definite-time characteristic.

The directional overcurrent protection is set at addresses 115 **67/67-TOC** and 116 **67N/67N-TOC**. Here, the same options are available as for non-directional overcurrent protection (except for the 50-3 element).

At address 170, you can set the breaker failure protection to ***Enabled*** or ***Disabled***. The setting option ***enabled w/ 3I0>*** subjects the ground current and the negative sequence current to a plausibility check. With the setting option ***Enabled w/o I>***, only the circuit breaker auxiliary contacts are evaluated.

In address 181, you can enter how many line sections (maximum of three) are taken into account by the fault locator.

At address 350, you define whether to use a **Battery Charger** to protect the power supply via an external battery.

The flexible protection functions can be configured via parameter **FLEXIBLE FUNC.**. You can create up to 20 flexible functions by setting a checkmark in front of the desired function. When the checkmark of a function is removed, all previously made settings and configurations get lost. After re-selecting the function, all settings and configurations are in default setting. The flexible function can be configured in DIGSI at „Settings“, „Additional Functions“ and „Settings“. Configuration is done, as usual, under „Settings“ and „Configuration“.

2.1.1.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
104	OSC. FAULT REC.	Disabled Enabled	Enabled	Oscillographic Fault Records
112	Charac. Phase	Disabled Definite Time	Definite Time	50/51
113	Charac. Ground	Disabled Definite Time	Definite Time	50N/51N
115	67/67-TOC	Disabled Definite Time	Definite Time	67, 67-TOC
116	67N/67N-TOC	Disabled Definite Time	Definite Time	67N, 67N-TOC
122	InrushRestraint	Disabled Enabled	Disabled	2nd Harmonic Inrush Restraint
140	46	Disabled TOC ANSI TOC IEC Definite Time	Disabled	46 Negative Sequence Protection
150	27/59	Disabled Enabled	Disabled	27, 59 Under/Overvoltage Protection
154	81 O/U	Disabled Enabled	Disabled	81 Over/Underfrequency Protection
170	50BF	Disabled Enabled enabled w/ 3I0> Enabled w/o I>	Disabled	50BF Breaker Failure Protection
180	Fault Locator	Disabled Enabled	Disabled	Fault Locator
181	L-sections FL	1 Section 2 Sections 3 Sections	1 Section	Line sections for fault locator
350	Battery Charger	Disabled Enabled	Enabled	Battery Charger

Addr.	Parameter	Setting Options	Default Setting	Comments
370	27/59 Vx	Enabled Disabled	Disabled	27/59 Over/under volt. Prot. for Vx
-	FLEXIBLE FUNC. 1...20	Flex. Function 01 Flex. Function 02 Flex. Function 03 Flex. Function 04 Flex. Function 05 Flex. Function 06 Flex. Function 07 Flex. Function 08 Flex. Function 09 Flex. Function 10 Flex. Function 11 Flex. Function 12 Flex. Function 13 Flex. Function 14 Flex. Function 15 Flex. Function 16 Flex. Function 17 Flex. Function 18 Flex. Function 19 Flex. Function 20	Please select	Flexible Functions

2.1.2 Device, General Settings

To assure a correct functioning of the device, some general information is required, e.g. the form in which messages on power system faults are to be output.

If the device features a battery charger (ordering option), configure the respective data in the device data, too.

2.1.2.1 General Device Functions

Command-Dependent Messages "No Trip – No Flag"

The storage of indications assigned to local LEDs and the availability of spontaneous indications can be made dependent on whether the device has issued a trip command. This information is then not issued if during a system disturbance one or more protection functions have picked up but the 7SC80 did not trip because the fault was cleared by another device (e.g. on another line). These messages are then limited to faults in the line to be protected.

The following figure illustrates the creation of the reset command for stored messages. By the moment of the device dropout, the presetting of the parameter 610 **FltDisp.LED/LCD** decides, whether the new fault is stored or reset.

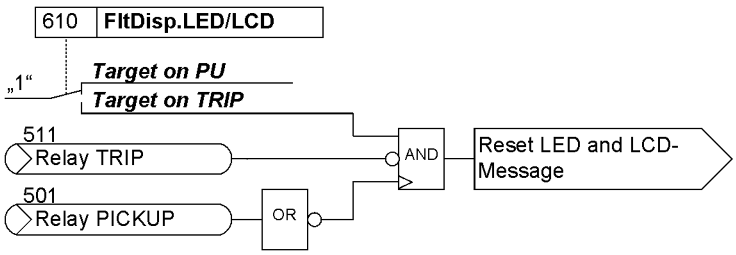


Figure 2-1 Creation of the reset command for the latched LED and LCD messages

Spontaneous Indications

You can determine whether or not the most important data of a fault event are to be displayed automatically after the fault has occurred (see also Subsection "Fault Indications" in Section "Auxiliary Functions").

2.1.2.2 Battery Charger

General

The Feeder Automation Controller 7SC80 in the 24 V/48 V connection variant is equipped with a battery charging control and a battery charger. Batteries with a voltage of 24 V or 48 V may only be connected in these device variants. Other batteries are rejected.

If the power supply of the 7SC80 Feeder Automation Controller fails, the battery supplies the Feeder Automation Controller and the communication device, via which the Feeder Automation Controller is connected to a control center. Furthermore, the battery supplies the power for operating a local switching device, e.g. a circuit breaker.

The charge state of the battery is monitored. If the charge state falls below a settable value, the battery charging control cuts off the Feeder Automation Controller as well as the communication power supply. The residual voltage can be used for the manual operation of the local switching device.

During normal operation, conservation charging ensures the optimal charge state of the battery. This charge state is achieved when the charging current has reached a settable value.

The charging process is permissible only within a settable temperature range. The charging voltage and the maximum permissible charging time are settable.

When the battery voltage has reached a settable minimum voltage, the battery charger changes to recovery mode. In that, the battery is charged in fast mode over the maximum permissible charging time.

A power loss is signaled after a settable time delay.

The battery is tested every day. The test mode is only possible if no hardware faults are pending and the power supply of the 7SC80 is available. If the power supply of the 7SC80 fails during the battery test, the test mode is exited. The battery takes on the power supply of the 7SC80. The duration of the battery test and the maximum voltage drop during the test discharge are settable.

The individual operating modes and any occurring faults are signaled, e.g. „`Bat. charging`“, „`Bat.Load low`“, „`Battery testing`“, „`Battery recover`“, „`Temp Meas.Err`“, or „`No charging`“.

Operating State of the Battery

The operating state of the battery is displayed via an LED on the housing of the 7SC80. The operating state can also be routed to an LED of the display via DIGSI and displayed in the Web Monitor. The associated indications are entered in the event log. The display depends on the operating state of the battery and the operating state of the power supply of the 7SC80. The operating states and their effects are described in the following.

The LED is off in the following states:

- No or impermissible battery connected.

  Indication„Battery invalid“
- The battery has reached the settable battery voltage at which it is regarded as being empty. The device is switched off within 5 seconds.

  Indication „Battery empty“

The LED lights up or flashes green if the following conditions apply:

- The battery is operating and supplied with the conservation charging.

  Indication „Battery charged“
- The battery is in test mode (LED flashes).

  Indication „Battery testing“

The LED lights up or flashes yellow if the following conditions apply:

- The battery is charged (LED flashes).

  Indication „Bat. charging“
- The battery is used as power supply and is in a good charge state.

  Indication „Bat.Load good“
- The battery test was successful, the battery is charged via conservation charging (LED flashes).

  Indication „Bat. charging“

The LED lights up or flashes red if the following conditions apply:

- The maximum permissible battery charging time has been exceeded. The battery is bad or defective (LED flashes).

  Indication „Battery bad“
- The battery can still be used to supply power to the local switching device. The 7SC80 and the communication power supply are cut off.

  Indication „Bat.Load low“
- Bad battery state detected during the battery test (LED flashes).

  Indication „Battery bad“
- The battery is not charged because the temperature is outside the permissible range (LED flashes).

  Indication „Temp > Range“

The LED flashes yellow/red if the following conditions apply:

- The battery voltage is below the set battery voltage for recovery mode. The battery charger operates with the maximum charging voltage.

  Indication „Battery recover“

2.1.2.3 Setting Notes

Fault Indications

A new pickup by a protection element generally turns off any previously lit LEDs in the Web Monitor so that only the latest fault is displayed. For this fault, you can select whether the stored LED displays and the spontaneous fault indications appear after the new pickup or only after a new trip command has been issued. In order to select the desired display mode, select the DEVICE submenu 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 provided.

Use parameter 611 **Spont. FltDisp.** to specify whether or not a spontaneous fault indication should appear automatically (***YES***) or not (***NO***).

Default Display Selection

The start page of the default display appearing in the Web Monitor after startup of the device can be selected in the device data via parameter 640 **Start image DD**. The available image pages are listed in Appendix A.5.

Battery Charger

To activate the battery charger, set address 350 **Battery Charger** in the functions to ***Enabled***.

At address 351 **Battery Charger** the battery charger is set ***ON*** or ***OFF***.

At address 352 **I bat. charged** you set the charging current of the battery, which has to flow for full charging.

At address 353 **V bat. crit.** you set the battery voltage from which on the device as well as the communication power supply are cut off. The residual voltage is available for the operation of the local switching device.

At address 354 **V bat. empty** you set the battery voltage at which the battery is to be regarded as empty.

At address 355 **Min.T.charge** you set the minimum permissible ambient temperate for the charging process in °C, at address 359 in °F.

At address 356 **Max.T.charge** you set the maximum permissible ambient temperate for the charging process in °C, at address 360 in °F.

At address 357 **Min.T.discharge** you set the minimum permissible ambient temperate in °C for the discharging of the battery, at address 361 in °F.

At address 358 **Max.T.discharge** you set the maximum permissible ambient temperate in °C for the discharging of the battery, at address 362 in °F.

At address 363 **Bat. ChTime Max** you set the maximum permissible charging time of the battery.

At address 364 **V bat. recover** you set the battery voltage from which on the battery charger changes to recovery mode.

At address 365 **T Voltage loss** you set the message time delay in the case of power loss.

At address 366 **BattTest durat.** you set the maximum duration of the battery test.

At address 367 **V drop bat test** you set the maximum voltage difference which may occur during the battery test.

2.1.2.4 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
351	Battery Charger	OFF ON	OFF	Battery Charger
352	I bat. charged	20 .. 100 mA	40 mA	Battery full charged current
353	V bat. crit.	22.0 .. 24.0 V	23.0 V	Battery critical voltage level
354	V bat. empty	20.0 .. 22.0 V	21.0 V	Battery discharged voltage level
355	Min.T.charge	-50 .. 0 °C	-23 °C	Min. allowed charging temperature °C
356	Max.T.charge	0 .. 80 °C	48 °C	Max. allowed charging temperature °C
357	Min.T.discharge	-50 .. 0 °C	-40 °C	Min. allowed discharging temperature °C
358	Max.T.discharge	0 .. 80 °C	71 °C	Max. allowed discharging temperature °C
359	Min.T.charge	-58 .. 32 °F	9 °F	Min. allowed charging temperature °F
360	Max.T.charge	32 .. 176 °F	118 °F	Max. allowed charging temperature °F
361	Min.T.discharge	-58 .. 32 °F	-40 °F	Min. allowed discharging temperature °F
362	Max.T.discharge	32 .. 176 °F	160 °F	Max. allowed discharging temperature °F
363	Bat. ChTime Max	6 .. 72 hour	48 hour	Max. allowed high voltage charge hours
364	V bat. recover	21.0 .. 24.0 V	22.5 V	Battery recover voltage level
365	T Voltage loss	0 .. 600 sec	60 sec	No voltage detection message timeout
366	BattTest durat.	2 .. 8 sec	5 sec	Duration of battery test
367	V drop bat test	1.0 .. 5.0 V	3.0 V	Max. of battery voltage drop during test
610	FltDisp.LED/LCD	Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
611	Spont. FltDisp.	YES NO	NO	Spontaneous display of flt.annunciations
620	Remote FwUpdate	Disabled Enabled	Enabled	Remote firmware update
640	Start image DD	image 1 image 2 image 3 image 4 image 5 image 6	image 1	Start image Default Display

2.1.2.5 Information List

No.	Information	Type of In-formation	Comments
-	>Light on	SP	>Back Light on
-	Reset LED	IntSP	Reset LED
-	DataStop	IntSP	Stop data transmission
-	Test mode	IntSP	Test mode
-	Feeder gnd	IntSP	Feeder GROUNDED
-	Brk OPENED	IntSP	Breaker OPENED
-	HWTestMod	IntSP	Hardware Test Mode
-	SynchClock	IntSP_Ev	Clock Synchronization
1	Not configured	SP	No Function configured
2	Non Existent	SP	Function Not Available
3	>Time Synch	SP_Ev	>Synchronize Internal Real Time Clock
5	>Reset LED	SP	>Reset LED
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
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
140	Error Sum Alarm	OUT	Error with a summary alarm
160	Alarm Sum Event	OUT	Alarm Summary Event
177	Fail Battery	OUT	Failure: Battery empty
178	I/O-Board error	OUT	I/O-Board Error
181	Error A/D-conv.	OUT	Error: A/D converter
191	Error Offset	OUT	Error: Offset
193	Alarm NO calibr	OUT	Alarm: NO calibration data available
194	Error neutralCT	OUT	Error: Neutral CT different from MLFB
301	Pow.Sys.Flt.	OUT	Power System fault
302	Fault Event	OUT	Fault Event
303	sens Gnd flt	OUT	sensitive Ground fault
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
502	Relay Drop Out	SP	Relay Drop Out

No.	Information	Type of Information	Comments
510	Relay CLOSE	SP	General CLOSE of relay
545	PU Time	VI	Time from Pickup to drop out
546	TRIP Time	VI	Time from Pickup to TRIP
2150	Ext.V. invalid	OUT	Invalid external voltage
2151	Ext.Volt. valid	OUT	Valid external voltage
2152	Battery invalid	OUT	Invalid external battery connected
2153	Bat. charging	OUT	External battery charging
2154	Battery charged	OUT	External battery is fully charged
2155	Bat.Load good	OUT	External battery load is good
2156	Bat.Load low	OUT	External battery load is low
2157	Battery empty	OUT	External battery load is insufficient
2158	Battery testing	OUT	External battery is under test
2159	Battery bad	OUT	External battery bad or defect
2160	Temp > Range	OUT	Temperature out of range
2163	Battery recover	OUT	External battery in recovery mode
2164	HW Err Charger	OUT	Hardware charger defect
2165	LIN defect	OUT	LIN detection defect
2166	No charging	OUT	Charging not possible
2167	High current	OUT	Charging current too high
2168	Float Chg.Err	OUT	Float charge mode defect
2169	Bat. Test Error	OUT	Error during external battery test
2170	Temp Meas.Err	OUT	Temperature measurement error
2172	GPS ModuleError	OUT	GPS Module Error
2186	Error IO board	OUT	Error occurred on IO board
2234	MANUAL BAT TST	IntSP	Manual Battery Test
2240	Multi. routing	OUT	Several indications routed
17566	Dist.CFC Src	VI	Disturbance CFC Source

2.1.3 Power System Data 1

2.1.3.1 Description

The device requires certain data regarding the network and substation so that it can adapt its functions to this data depending on the application. This may be, for instance, nominal data of the substation and measuring transformers, polarity and connection of the measured quantities, breaker properties (where applicable), etc. There are also certain parameters that are common to all functions, i.e. not associated with a specific protection, control or monitoring function. The following section discusses this data.

2.1.3.2 Setting Notes

General

In DIGSI, double-click **Settings** to open the corresponding dialog box. In doing so, a dialog box with tabs opens under **P.System Data 1**, in which individual parameters can be configured. The following descriptions are therefore structured according to these tabs.

Nominal Frequency (Power System)

The nominal frequency of the system is set at address 214 **Rated Frequency**. The model-dependent factory pre-setting only needs to be changed if the device is to be used for a purpose different than the one planned when ordering. In US device versions (MLFB position 10 = C), parameter 214 is preset to 60 Hz.

Phase Rotation (Power System)

Address 209 **PHASE SEQ.** is used to change the default phase sequence (***A B C*** for clockwise rotation) if your power system permanently has an anti-clockwise phase sequence (***A C B***). A temporary reversal of rotation is also possible using binary inputs (see Section 2.11.2).

Polarity of Current Transformers (Power System)

At address 201 **CT Starpoint**, you enter the polarity of the current transformers, that is, the location of the CT neutral point (the following figure applies correspondingly for two current transformers). This setting determines the measuring direction of the device (forward = line direction). The reversal of this parameter also reverses the polarity of the ground current inputs I_N.

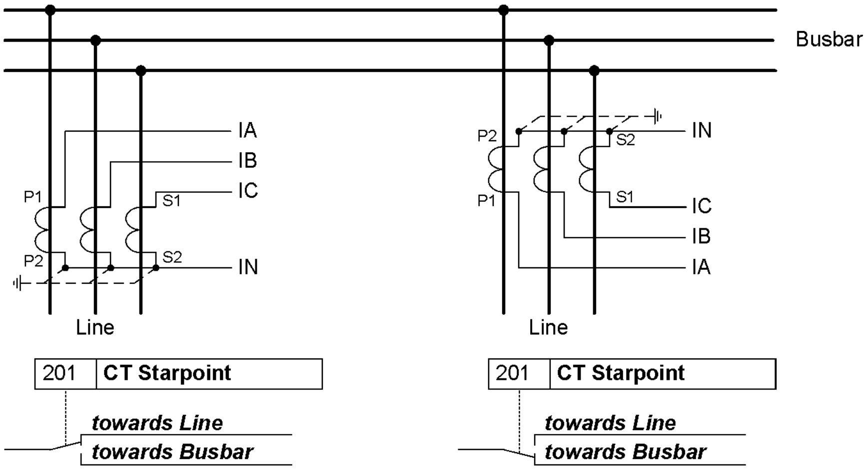


Figure 2-2 Polarity of current transformers

Current Connection I4 (Power System)

Here, the device gets the information whether the ground current of the current transformer neutral point is connected to the fourth current input (I_4). This corresponds with the Holmgreen connection (see connection example in Appendix A.3, Figure). In this case, parameter 280 **Holmgr. for Σi** is set to ***YES***. In all other cases, even if the ground current of the own line is measured via a separate ground current transformer, the setting ***NO*** has to be made. This setting exclusively affects the function „Total Current Monitoring“ (see Chapter 2.8.1).

Voltage Connection (Power System)

Address 213 specifies how the voltage transformers are connected.

VT Connect. 3ph = ***Van, Vbn, Vcn*** means that the three phase voltages are wye connected, i.e. the three phase-to-ground voltages are measured.

VT Connect. 3ph = ***Vab, Vbc, VGnd*** means that two phase-to-phase voltages (open delta voltage) and the displacement voltage V_{GND} are connected.

VT Connect. 3ph = ***Vab, Vbc*** means that two phase-to-phase voltages (open delta voltage) are connected. The third voltage transformer of the device is not used.

The selection of the voltage transformer connection affects the operation of all device functions that require voltage input.

The settings ***Vab, Vbc*** do not allow to determine the zero voltage. Protection functions working with the zero voltage are inactive in this case.

Table 2-1 Connection Types of the Voltage Transformers

Connection type	Functions			
	Directional definite-time/inverse-time overcurrent protection phase	Directional definite-time/inverse-time overcurrent protection ground	Fault locator	Fuse failure monitor
Van, Vbn, Vcn	Yes	Yes	Yes	Yes
Vab, Vbc, VGnd	Yes	Yes	Yes	Yes
Vab, Vbc	Yes	Yes[1)]	No	No

[1)] Direction determination is only possible by evaluating the negative sequence system (otherwise selection of zero sequence system or negative sequence system)

Measured values, which due to the chosen voltage connection cannot be calculated, will be displayed as dots.

The Appendix provides some connection examples for all connection types at A.3.

Distance Unit (Power System)

Address 215 **Distance Unit** allows you to specify the distance unit (***km*** or ***Miles***) for the fault locator. In the absence of a fault locator or if this function has been removed, this parameter is of no importance. Changing the distance unit does not imply an automatic conversion of the setting values that are dependent on the distance unit. These have to be re-entered at the respective addresses.

Nominal Values of Current Transformers (CTs)

At addresses 204 **CT PRIMARY** and 205 **CT SECONDARY** information is entered regarding the primary and secondary ampere ratings of the current 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 calculate incorrect primary data. At addresses 217 **Ignd-CT PRIM** and 218 **Ignd-CT SEC**, information is entered regarding the primary and secondary ampere rating of the current transformers. In case of a normal connection (starpoint current connected to I_N transformer), 217 **Ignd-CT PRIM** and 204 **CT PRIMARY** must be set to the same value.

For US device models (order item 10= C) parameters 205 and 218 are set by default to 5 A.

Nominal Values of Voltage Transformers (VTs)

At addresses 202 **Vnom PRIMARY** and 203 **Vnom SECONDARY**, information is entered regarding the primary nominal voltage and secondary nominal voltage (phase-to-phase) of the connected voltage transformers.

Transformation Ratio of Voltage Transformers (VTs)

Address 206 **Vph/Vdelta** informs the device of the adjustment factor between the phase voltage and the displacement voltage. This information is relevant for the processing of ground faults (in grounded systems and ungrounded systems), for the operational measured value V_N and measured-variable monitoring.

If the voltage transformer set provides open delta windings and if these windings are connected to the device, this must be specified accordingly in address 213 (see above margin heading "Voltage Connection"). Since the voltage transformer ratio is normally as follows:

$$\frac{V_{nomPrimary}}{\sqrt{3}} / \frac{V_{nomSecondary}}{\sqrt{3}} / \frac{V_{nomSecondary}}{3}$$

the factor V_{ph}/V_N (secondary voltage, address 206 **Vph/Vdelta**) must be set to $3/\sqrt{3} = \sqrt{3} = 1.73$ which must be used if the V_N voltage is connected. For other transformation ratios, i.e. the formation of the displacement voltage via an interconnected transformer set, the factor must be corrected accordingly.

Please take into consideration that also the calculated secondary V_0-voltage is divided by the value set in address 206. Thus, even if the V_0-voltage is not connected, address 206 has an impact on the secondary operational measured value V_N.

If ***Vab, Vbc, VGnd*** is selected as voltage connection type, parameter **Vph/Vdelta** is used to calculate the phase-to-ground voltages and is therefore important for the protection function. With voltage connection type ***Van, Vbn, Vcn***, this parameter is used only to calculate the operational measured value of the „secondary voltage V_N".

Trip and Close Command Duration (Breaker)

In address 210 the minimum trip command duration **TMin TRIP CMD** is set. This setting applies to all protection functions that can initiate tripping.

Current Flow Monitoring (Breaker)

Address 212 **BkrClosed I MIN** corresponds to the threshold value of the integrated current flow monitoring system. This parameter is used by several protection functions (e.g. voltage protection with current criterion). If the set threshold current is exceeded, the circuit breaker is considered closed.

The threshold value setting applies to all three phases, and must take into consideration all used protection functions.

The pickup threshold for the breaker failure protection is set separately (see 2.10.2).

Two-phase Time Overcurrent Protection (Protection Operating Quantities)

The two-phase overcurrent protection functionality is used in grounded or compensated systems where interaction of three-phase devices with existing two-phase protection equipment is required. Via parameter 250 **50/51 2-ph prot** the time overcurrent protection can be configured to two or three-phase operation. If the parameter is set to ***ON***, the value 0 A instead of the measured value for I_B is used permanently for the threshold comparison so that no pickup is possible in phase B. All other functions, however, operate in three phases.

Ground Fault (Protection Parameters)

With parameter 613 **Gnd O/Cprot. w.**, you define whether breaker failure protection or fuse failure monitor operate with measured values (***Ignd (measured)***) or with the quantities calculated from the 3 phase currents (***3I0 (calcul.)***). In the first case, the quantity measured at the fourth current input is evaluated. In the latter case, the summation current is calculated from the 3 phase current inputs.

Voltage Protection (Protection Operating Quantities)

Parameters 614 **OP. QUANTITY 59** and 615 **OP. QUANTITY 27** define the quantities used by the voltage protection.

In a three-phase connection, overvoltage protection optionally uses the following quantities:

- Fundamental harmonic of the largest of the phase-to-phase voltages (***Vphph***)
- Fundamental harmonic of the largest of the phase-to-ground voltages (***Vph-n***)
- Positive sequence voltage (***V1***)
- Negative sequence voltage (***V2***)
- Phase-selectively with the fundamental harmonic of the individual phase-to-phase voltages (***Vphph selective***)
- Phase-selectively with the fundamental harmonic of the individual phase-to-ground voltages (***Vph-n selective***)

In a three-phase connection, undervoltage protection optionally uses the following quantities:

- Fundamental harmonic of the smallest of the phase-to-phase voltages (***Vphph***)
- Fundamental harmonic of the smallest of the phase-to-ground voltages (***Vph-n***)
- Positive sequence voltage (***V1***)
- Phase-selectively with the fundamental harmonic of the individual phase-to-phase voltages (***Vphph selective***)
- Phase-selectively with the fundamental harmonic of the individual phase-to-ground voltages (***Vph-n selective***)

Note

If parameter 213 **VT Connect. 3ph** is set to ***Vab, Vbc***, the setting options ***Vph-n*** and ***Vph-n selective*** are not available for parameters 614 and 615.

In a single-phase voltage transformer connection, the measured quanities are directly compared to the threshold values and the parameterization of and the parameterization of the characteristic quantity switchover is ignored.

2.1.3.3 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
201	CT Starpoint		towards Line towards Busbar	towards Line	CT Starpoint
202	Vnom PRIMARY		0.10 .. 800.00 kV	20.00 kV	Rated Primary Voltage
203	Vnom SECONDARY		34 .. 400 V	100 V	Rated Secondary Voltage (L-L)
204	CT PRIMARY		10 .. 50000 A	400 A	CT Rated Primary Current
205	CT SECONDARY		1A 5A	1A	CT Rated Secondary Current
206A	Vph/Vdelta		1.00 .. 3.00	1.73	Matching ratio Phase-VT To Open-Delta-VT
209	PHASE SEQ.		A B C A C B	A B C	Phase Sequence
210A	TMin TRIP CMD		0.01 .. 32.00 sec	0.15 sec	Minimum TRIP Command Duration
211A	TMax CLOSE CMD		0.01 .. 32.00 sec	1.00 sec	Maximum Close Command Duration
212	BkrClosed I MIN	1A	0.04 .. 1.00 A	0.04 A	Closed Breaker Min. Current Threshold
		5A	0.20 .. 5.00 A	0.20 A	
213	VT Connect. 3ph		Van, Vbn, Vcn Vab, Vbc, VGnd Vab, Vbc	Van, Vbn, Vcn	VT Connection, three-phase
214	Rated Frequency		50 Hz 60 Hz	50 Hz	Rated Frequency
215	Distance Unit		km Miles	km	Distance measurement unit
217	Ignd-CT PRIM		1 .. 50000 A	60 A	Ignd-CT rated primary current
218	Ignd-CT SEC		1A 5A	1A	Ignd-CT rated secondary current
250A	50/51 2-ph prot		OFF ON	OFF	50, 51 Time Overcurrent with 2ph. prot.
280	Holmgr. for Σi		NO YES	NO	Holmgreen conn. (for fast sum-i-monit.)
325	Vnom sec Vx		34 .. 230 V	100 V	Rated Secondary Voltage Vx
330	Iph-prim nom		10 .. 50000 A	400 A	Primary nominal phase current for prot.
331	Iph-LPS prim		10 .. 50000 A	400 A	Rated primary phase current LPS

Addr.	Parameter	C	Setting Options	Default Setting	Comments
332	Vph-LPS I sec		0.50 .. 20.00 V	10.00 V	Rated secondary voltage for current LPS
333	Vnom prim Vx		0.10 .. 800.00 kV	20.00 kV	Rated Primary Voltage Vx
368	Battery Volt.		24 V 48 V	24 V	Battery voltage type
613A	Gnd O/Cprot. w.		Ignd (measured) 3I0 (calcul.)	Ignd (measured)	Ground Overcurrent protection with
614A	OP. QUANTITY 59		Vphph Vphph selective Vph-n Vph-n selective V1 V2	Vphph	Opera. Quantity for 59 Overvolt. Prot.
615A	OP. QUANTITY 27		V1 Vphph Vphph selective Vph-n Vph-n selective	V1	Opera. Quantity for 27 Undervolt. Prot.

2.1.3.4 Information List

No.	Information	Type of Information	Comments
5145	>Reverse Rot.	SP	>Reverse Phase Rotation
5147	Rotation ABC	OUT	Phase rotation ABC
5148	Rotation ACB	OUT	Phase rotation ACB

2.1.4 Oscillographic Fault Records

The Multifunctional Protection with Control 7SC80 is equipped with a fault record memory. The instantaneous values of the measured values

i_A, i_B, i_C, i_N and v_A, v_B, v_C, v_{AB}, v_{BC}, v_{CA}, v_N, v_X

(voltages depending on connection) are sampled at intervals of 1.0 ms (at 50 Hz) and stored in a revolving buffer (20 samples per cycle). In the event of a fault, the data is stored for a set period of time, but not for more than 6 seconds. Up to 8 fault events can be recorded in this buffer. The fault record memory is automatically updated with every new fault so that there is no acknowledgment for previously recorded faults required. In addition to protection pickup, the recording of the fault event data can also be started via a binary input or via the serial interface.

2.1.4.1 Description

The data of a fault event can be read out via the device interface and evaluated with the help of the SIGRA 4 graphic analysis software. SIGRA 4 graphically represents the data recorded during the fault event and also calculates additional information from the measured values. Currents and voltages can be presented either as primary or as secondary values. Signals are additionally recorded as binary tracks (marks), e.g. "pickup", "trip".

If port F of the device has been configured correspondingly, the fault record data can be imported by a central controller via this interface and evaluated. Currents and voltages are prepared for a graphic representation. Signals are additionally recorded as binary tracks (marks), e.g. "pickup", "trip".

The retrieval of the fault data by the central controller takes place automatically either after each protection pickup or after a tipping.

Depending on the selected type of connection of the voltage transformers (address 213 **VT Connect. 3ph**), the following measured values are recorded in the fault record:

	Voltage connection		
	Van, Vbn, Vcn	Vab, Vbc, VGnd	Vab, Vbc
V_{AB}	Yes	Yes	Yes
V_{BC}	Yes	Yes	Yes
V_{CA}	Yes	Yes	Yes
V_A	Yes	Yes	
V_B	Yes	Yes	
V_C	Yes	Yes	

The voltage connection Vx is always available.

Note

The signals used for the binary tracks can be allocated in DIGSI.

2.1.4.2 Setting Notes

Configuration

Fault recording (waveform capture) will only take place if address 104 **OSC. FAULT REC.** is set to ***Enabled***. Other settings pertaining to fault recording (waveform capture) are found in the OSC. FAULT REC. 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 401 **WAVEFORMTRIGGER**). Normally, the trigger is the pickup of a protection element, i.e. the time 0 is defined as the instant the first protection function picks up. 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.

A fault event starts with the pickup by any protection function and ends when the last pickup of a protection function has dropped out. Usually this is also the extent of a fault recording (address 402 **WAVEFORM DATA** = ***Fault event***). If automatic reclosing is performed, the entire system fault — with several reclosing attempts if necessary — can be recorded until the fault has been cleared for good (address 402 **WAVEFORM DATA** = ***Pow.Sys.Flt.***). This facilitates the representation of the entire system fault history, but also consumes storage capacity during the automatic reclosing dead time(s).

The actual storage time begins at the pre-fault time **PRE. TRIG. TIME** (address 404) ahead of the reference instant, and ends at the post-fault time **POST REC. TIME** (address 405) after the storage criterion has reset. The maximum storage time for each fault recording (**MAX. LENGTH**) is entered in address 403. Recording per fault must not exceed 6 seconds. A total of 8 records can be saved. However, the total length of time of all fault records in the buffer must not exceed 18 seconds.

An oscillographic record can be triggered by a status change of a binary input, or from a PC via the operator interface. Storage is then triggered dynamically. The length of the fault recording is set in address 406 **BinIn CAPT.TIME** (but not longer than **MAX. LENGTH**, address 403). Pre-fault and post-fault times will add to this. If the binary input time is set to ∞, the length of the record equals the time that the binary input is activated (static), but not longer than the **MAX. LENGTH** (address 403).

2.1.4.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
401	WAVEFORMTRIGGE R	Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
402	WAVEFORM DATA	Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
403	MAX. LENGTH	0.30 .. 6.00 sec	2.00 sec	Max. length of a Waveform Capture Record
404	PRE. TRIG. TIME	0.05 .. 0.50 sec	0.25 sec	Captured Waveform Prior to Trigger
405	POST REC. TIME	0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
406	BinIn CAPT.TIME	0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input

2.1.4.4 Information List

No.	Information	Type of Information	Comments
-	FltRecSta	IntSP	Fault Recording Start
4	>Trig.Wave.Cap.	SP	>Trigger Waveform Capture
203	Wave. deleted	OUT_Ev	Waveform data deleted
30053	Fault rec. run.	OUT	Fault recording is running

2.1.5 Settings Groups

Up to four different setting groups can be created for establishing the device's function settings.

2.1.5.1 Description

Changing Setting Groups

The setting groups can be changed locally during operation via the Web Monitor, via binary inputs (if routed correspondingly) or via the interfaces. For safety reasons, it is not possible to change between setting groups during a power system fault.

A setting group includes the parameter values for all functions that have been selected as ***Enabled*** during configuration (see Section 2.1.1.2). In 7SC80 devices, four independent setting groups (A to D) are supported. Whereas setting values may vary, the selected functions of each setting group remain the same.

2.1.5.2 Setting Notes

General

If setting group change option is not required, Group A is the default selection. Then, the rest of this section is not applicable.

If the changeover option is desired, group changeover must be set to **Grp Chge OPTION** = ***Enabled*** (address 103) when the function extent is configured. For the setting of the function parameters, each of the required setting groups A to D (a maximum of 4) must be configured in sequence. The SIPROTEC 4 System Description gives further information on how to copy setting groups or reset them to their status at delivery and also how to change from one setting group to another.

Subsection 3.1 of this manual tells you how to change between several setting groups externally via binary inputs.

2.1.5.3 Settings

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

2.1.5.4 Information List

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

2.1.6 Power System Data 2

2.1.6.1 Description

The general protection data (**P.System Data 2**) include parameters common to all functions, i.e. not associated with a specific protection or monitoring function. In contrast to the **P.System Data 1** discussed before, they can be changed with the parameter group.

If the primary reference voltage and the primary reference current of the protected object are specified, the device can calculate and issue the percentage operational measured values.

2.1.6.2 Setting Notes

Definition of Nominal Rated Values

At addresses 1101 **FullScaleVolt.** and 1102 **FullScaleCurr.**, the primary reference voltage (phase-to-phase) and reference current (phase) of the protected equipment is entered (e.g. motors). If these reference sizes match the primary nominal values of the VTs and CTs, they correspond to the settings in address 202 and 204 (Section 2.1.3.2). They are generally used to show values referenced to full scale.

Ground Impedance Ratios (only for Fault Location)

The adjustment of the ground impedance ratio is only important for the utilization of the line fault location function. This is done by entering the resistance ratio **RE/RL** and the reactance ratio **XE/XL**.

The values under addresses 1103 and 1104 apply if only one line section is available and to all faults that occur outside the defined line sections.

If several line sections are set, the following shall apply:

- for line section 1, addresses 6001 and 6002
- for line section 2, addresses 6011 and 6012
- for line section 3, the addresses 6021 and 6022.

Resistance ratio **RE/RL** and reactance ratio **XE/XL** are calculated formally and do not correspond to the real and imaginary components of $\underline{Z}_E/\underline{Z}_L$. No complex calculation is required! The ratios can be obtained from the line data using the following formulas:

$$\frac{R_G}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right) \qquad \frac{X_G}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right)$$

Where

R_0	– Zero sequence resistance of the line
X_0	– Zero sequence reactance of the line
R_1	– Positive sequence resistance of the line
X_1	– Positive sequence reactance of the line

This data can be used for the entire line or line section, or as distance-related values, since the quotients are independent of the distance.

Calculation example:

20 kV free line 120 mm^2 with the following data:

R_0/s = 0.88 Ω/km (1.42 Ω/mile) Zero sequence resistance

X_0/s = 1.26 Ω/km (2.03 Ω/mile) Zero sequence reactance

R_1/s = 0.24 Ω/km (0.39 Ω/mile) Positive sequence resistance

X_1/s = 0.34 Ω/km (0.55 Ω/mile) Positive sequence reactance

For ground impedance ratios, the following results:

$$\frac{R_G}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{1.42\ \Omega/\text{mile}}{0.39\ \Omega/\text{mile}} - 1\right) = 0.89$$

$$\frac{X_G}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{2.03\ \Omega/\text{mile}}{0.55\ \Omega/\text{mile}} - 1\right) = 0.90$$

Reactance per Unit Length (only for Fault Location)

The setting of the reactance per unit length is only important for the utilization of the line fault location function. The reactance setting enables the protective relay to indicate the fault location in terms of distance.

The reactance value X' is entered as a reference value **x'**, i.e. in Ω/mile if set to distance unit ***Miles*** (address 215, see Section 2.1.3.2 under "Distance Unit") or in Ω/km if set to distance unit ***km***. If, after having entered the reactance per unit length, the distance unit is changed under address 215, the reactance per unit length must be reconfigured in accordance with the new distance unit.

The values under address 1106 (***km***) or 1105 (***Miles***) apply if only one line section is available and to all faults that occur outside the defined line sections.

If several line sections are set, the following shall apply:

- for line section 1, addresses 6004 (***km***) or 6003 (***Miles***)
- for line section 2, addresses 6014 (***km***) or 6013 (***Miles***)
- for line section 3, addresses 6024 (***km***) or 6023 (***Miles***).

When setting the parameters in DIGSI, the values can also be entered as primary values. In that case the following conversion to secondary values is not required.

For the conversion of primary values to secondary values the following applies in general:

$$Z_{\text{secondary}} = \frac{\text{Current-Transformer-Ratio}}{\text{Voltage-Transformer - Ratio}} \cdot Z_{\text{primary}}$$

Likewise, the following applies to the reactance per unit length of a line:

$$X'_{\text{sec}} = \frac{N_{\text{CTR}}}{N_{\text{VTR}}} \cdot X'_{\text{prim}}$$

with

N_{CTR} – Transformation ratio of the current transformer

N_{VTR} – Transformation ratio of the voltage transformer

Calculation example:

In the following, the same line as illustrated in the example for ground impedance ratios (above) and additional data on the voltage transformers will be used:

Current Transformers	500 A/5 A
Voltage Transformers	20 kV/0.1 kV

The secondary reactance per unit length is calculated as follows:

$$X'_{sec} = \frac{N_{CTR}}{N_{VTR}} \cdot X'_{prim} = \frac{500\ A/5\ A}{20\ kV/0.1\ kV} \cdot 0.55\ \Omega/mile = 0.275\ \Omega/mile$$

Line Angle (only for Fault Location)

The setting of the line angle is only important for the utilization of the line fault location function. The line angle can be derived from the line constants. The following applies:

$$\tan\varphi = \frac{X_L}{R_L} \quad \text{or} \quad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

with R_L being the ohmic resistance and X_L being the reactance of the line.

The value under address 1109 applies if only one line section is available and to all faults that occur outside the defined line sections.

If several line sections are set, the following shall apply:

- for line section 1, address 6005
- for line section 2, address 6015
- for line section 3, address 6025

This data can be used for the entire line or line section, or as distance-related values, since the quotients are independent of the distance. It is also irrelevant whether the quotients were derived from primary or secondary values.

Calculation Example:

110 kV free line 150 mm^2 with the following data:

R'_1 = 0.31 Ω/mile

X'_1 = 0.69 Ω/mile

The line angle is calculated as follows:

$$\tan\varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.69\ \Omega/mile}{0.31\ \Omega/mile} = 2.21 \qquad \varphi = 65.7°$$

The respective address must be set to **`Line angle`** = **66°**.

Line Length (only for Fault Location)

The setting of the line length is only important for the utilization of the line fault location function. The line length is required so that the fault location can be given as a reference value (in %). Furthermore, when using several line sections, the respective length of the individual sections is defined.

The values under address 1110 (***km***) or 1111 (***Miles***) apply if only one line section is available and to all faults that occur outside the defined line sections.

If several line sections are set, the following shall apply:

- for line section 1, addresses 6007 (***km***) or 6006 (***Miles***)
- for line section 2, addresses 6017 (***km***) or 6016 (***Miles***)
- for line section 3, addresses 6027 (***km***) or 6026 (***Miles***)

The length set for the entire line must correspond to the sum of lengths configured for the line sections. A deviation of 10% max. is admissible.

Inversion of Measured Power Values / Metered Values

The directional values (power, power factor, work and related min., max., mean and setpoint values), calculated in the operational measured values, are usually defined a positive in the direction of 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). But it is also possible to make different settings for the "forward" direction" for the protection functions and the positive direction for the power etc., e.g. to have the active power supply (from the line to the busbar) displayed positively. To do so, set address 1108 **P,Q sign** to ***reversed***. If the setting is ***not reversed*** (default), the positive direction for the power etc. corresponds to the "forward" direction for the protection functions. Section 4 provides a detailed list of the values in question.

2.1.6.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1101	FullScaleVolt.		0.10 .. 800.00 kV	20.00 kV	Measurem:FullScaleVoltage(Equipm.rating)
1102	FullScaleCurr.		10 .. 50000 A	400 A	Measurem:FullScaleCurrent(Equipm.rating)
1103	RE/RL		-0.33 .. 7.00	1.00	Zero seq. compensating factor RE/RL
1104	XE/XL		-0.33 .. 7.00	1.00	Zero seq. compensating factor XE/XL
1105	x'	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	feeder reactance per mile: x'
		5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
1106	x'	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	feeder reactance per km: x'
		5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
1108	P,Q sign		not reversed reversed	not reversed	P,Q operational measured values sign
1109	Line angle		10 .. 89 °	85 °	Line angle
1110	Line length		0.1 .. 1000.0 km	100.0 km	Line length in kilometer
1111	Line length		0.1 .. 650.0 Miles	62.1 Miles	Line length in miles
6001	S1: RE/RL		-0.33 .. 7.00	1.00	S1: Zero seq. compensating factor RE/RL
6002	S1: XE/XL		-0.33 .. 7.00	1.00	S1: Zero seq. compensating factor XE/XL
6003	S1: x'	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	S1: feeder reactance per mile: x'
		5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
6004	S1: x'	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	S1: feeder reactance per km: x'
		5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
6005	S1: Line angle		10 .. 89 °	85 °	S1: Line angle
6006	S1: Line length		0.1 .. 650.0 Miles	62.1 Miles	S1: Line length in miles
6007	S1: Line length		0.1 .. 1000.0 km	100.0 km	S1: Line length in kilometer
6011	S2: RE/RL		-0.33 .. 7.00	1.00	S2: Zero seq. compensating factor RE/RL
6012	S2: XE/XL		-0.33 .. 7.00	1.00	S2: Zero seq. compensating factor XE/XL
6013	S2: x'	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	S2: feeder reactance per mile: x'
		5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
6014	S2: x'	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	S2: feeder reactance per km: x'
		5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
6015	S2: Line angle		10 .. 89 °	85 °	S2: Line angle
6016	S2: Line length		0.1 .. 650.0 Miles	62.1 Miles	S2: Line length in miles

Addr.	Parameter	C	Setting Options	Default Setting	Comments
6017	S2: Line length		0.1 .. 1000.0 km	100.0 km	S2: Line length in kilometer
6021	S3: RE/RL		-0.33 .. 7.00	1.00	S3: Zero seq. compensating factor RE/RL
6022	S3: XE/XL		-0.33 .. 7.00	1.00	S3: Zero seq. compensating factor XE/XL
6023	S3: x'	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	S3: feeder reactance per mile: x'
		5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
6024	S3: x'	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	S3: feeder reactance per km: x'
		5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
6025	S3: Line angle		10 .. 89 °	85 °	S3: Line angle
6026	S3: Line length		0.1 .. 650.0 Miles	62.1 Miles	S3: Line length in miles
6027	S3: Line length		0.1 .. 1000.0 km	100.0 km	S3: Line length in kilometer

2.1.6.4 Information List

No.	Information	Type of Information	Comments
126	ProtON/OFF	IntSP	Protection ON/OFF (via system port)
356	>Manual Close	SP	>Manual close signal
501	Relay PICKUP	OUT	Relay PICKUP
511	Relay TRIP	OUT	Relay GENERAL TRIP command
533	Ia =	VI	Primary fault current Ia
534	Ib =	VI	Primary fault current Ib
535	Ic =	VI	Primary fault current Ic
561	Man.Clos.Detect	OUT	Manual close signal detected
2720	>Enable ANSI#-2	SP	>Enable 50/67-(N)-2 (override 79 blk)
4601	>52-a	SP	>52-a contact (OPEN, if bkr is open)
4602	>52-b	SP	>52-b contact (OPEN, if bkr is closed)

2.1.7 EN100-Module

2.1.7.1 Description

The EN100-Module enables integration of the 7SC80 in 100-Mbit communication networks in control and automation systems with the protocols according to IEC 61850 standard. This standard permits uniform communication of the devices without gateways and protocol converters. Even when installed in heterogeneous environments, SIPROTEC 4 relays therefore provide for open and interoperable operation. 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.

2.1.7.2 Description

The EN100-Module enables integration of the 7SC80 in 100-Mbit communication networks in control and automation systems with the protocols according to IEC 61850 standard. This standard permits uniform communication of the devices without gateways and protocol converters. Even when installed in heterogeneous environments, SIPROTEC 4 relays therefore provide for open and interoperable operation. 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.

The Feeder Automation Controller 7SC80 can be used with an **EN100-Module** with 2 IEC 61850 channels.

2.1.7.3 Information List

No.	Information	Type of Information	Comments
009.0100	Failure Module	IntSP	Failure EN100 Module
009.0101	Fail Ch1	IntSP	Failure EN100 Link Channel 1 (Ch1)
009.0102	Fail Ch2	IntSP	Failure EN100 Link Channel 2 (Ch2)

2.2 Overcurrent Protection 50, 51, 50N, 51N

Overcurrent protection is the main protection function of the 7SC80 relay. Each phase current and the ground current is provided with four elements. All elements are independent from each other and can be combined as desired.

If it is desired in grounded or compensated systems that three-phase devices should work together with two-phase protection equipment, the overcurrent protection can be configured in such a way that it allows two-phase operation besides three-phase mode (see Section 2.1.3.2).

The high-current elements 50-3 and 50-2 as well as the overcurrent element 50-1 always operate with a definite tripping time.

Applications

- Non-directional overcurrent protection is suitable for networks that are radial and supplied from a single source, or open looped networks, and for backup protection of differential protective schemes of all kinds.

2.2.1 General

Depending on the parameter 613 **Gnd O/Cprot. w.**, the overcurrent protection for the ground current can either operate with measured values I_N or with the quantities 3I0 calculated from the three phase currents.

The timer for each Element can be blocked via binary input, thus suppressing the trip command. If the blocking is canceled during pickup, the timer will be restarted. The Manual Close signal is an exception. If a circuit breaker is manually closed onto a fault, it can be re-opened immediately. For overcurrent elements or high-current elements, the delay may be bypassed via a Manual Close pulse, thus resulting in instantaneous tripping after pickup. This pulse is extended up to at least 300 ms.

Pickup of the definite-time elements can be stabilized by setting the dropout times. This protection is used in systems where intermittent faults occur. Combined with electromechanical relays, it allows different dropout responses to be adjusted and a time grading of digital and electromechanical relays to be implemented.

Utilizing the inrush restraint feature, tripping by the 50-1 elements in the phases and ground path may be blocked when inrush current is detected.

The following table gives an overview of the interconnections to other functions of 7SC80.

Table 2-2 Interconnection to Other Functions

Overcurrent protection elements	Manual CLOSE	Inrush current restraint
50-1	•	•
50-2	•	
50-3	•	
50N-1	•	•
50N-2	•	
50N-3	•	

2.2.2 Definite Time, High-set Elements 50-3, 50-2, 50N-3, 50N-2

For each Element, an individual pickup value **50-3 PICKUP**, **50-2 PICKUP** or **50N-3 PICKUP**, **50N-2 PICKUP** is set. For **50-3 PICKUP** and **50N-3 PICKUP**, it is possible to measure the ***Instantaneous*** in addition to ***Fundamental*** and ***True RMS***. If set to ***Instantaneous***, the element picks up at 2 · √2 · setting value (rms). Each phase and ground current is compared separately per Element with the common pickup values **50-3 PICKUP**, **50-2 PICKUP** or **50N-3 PICKUP**, **50N-2 PICKUP**. If the respective pickup value is exceeded, this is signaled. After the user-defined time delays **50-3 DELAY**, **50-2 DELAY** or **50N-3 DELAY**, **50N-2 DELAY** have elapsed, trip commands are issued which are available for each Element. The dropout value is roughly equal to 95% of the pickup value for currents > 0.3 I_{Nom}. If the measurement of the instantaneous values has been parameterized for the **50-3 PICKUP** or 50N-3 Element, the dropout ratio is set to 90 %.

Pickup can be stabilized by setting dropout times 1215 **50 T DROP-OUT** or 1315 **50N T DROP-OUT**. This time is started and maintains the pickup condition if the current falls below the threshold. Therefore, the function does not drop out at high speed. The trip delay time **50-3 DELAY**, **50-2 DELAY** or **50N-3 DELAY**, **50N-2 DELAY** continues running in the meantime. After the dropout delay time has elapsed, the pickup is reported OFF and the trip delay time is reset unless the threshold **50-3 PICKUP**, **50-2 PICKUP** or **50N-3 PICKUP**, **50N-2 PICKUP** has been exceeded again. If the threshold is exceeded again during the dropout delay time, the time is canceled. The trip delay time **50-3 DELAY**, **50-2 DELAY** or **50N-3 DELAY**, **50N-2 DELAY** continues running in the meantime. If the threshold value is exceeded after this time has elapsed, the trip command is issued immediately. If the threshold value is not exceeded at this time, there is no reaction. If the threshold value is exceeded again after expiry of the trip command delay time while the dropout delay time is still running, tripping is initiated immediately.

The pickup values of each 50-2, 50-3 Element for phase currents and 50N-2, 50N-3 Element for the ground current and the element-specific time delays can be set individually.

The following figures show the logic diagrams for the 50-2 and 50N-2 high-set elements as an example. They also apply analogously to the high-set elements 50-3 and 50N-3.

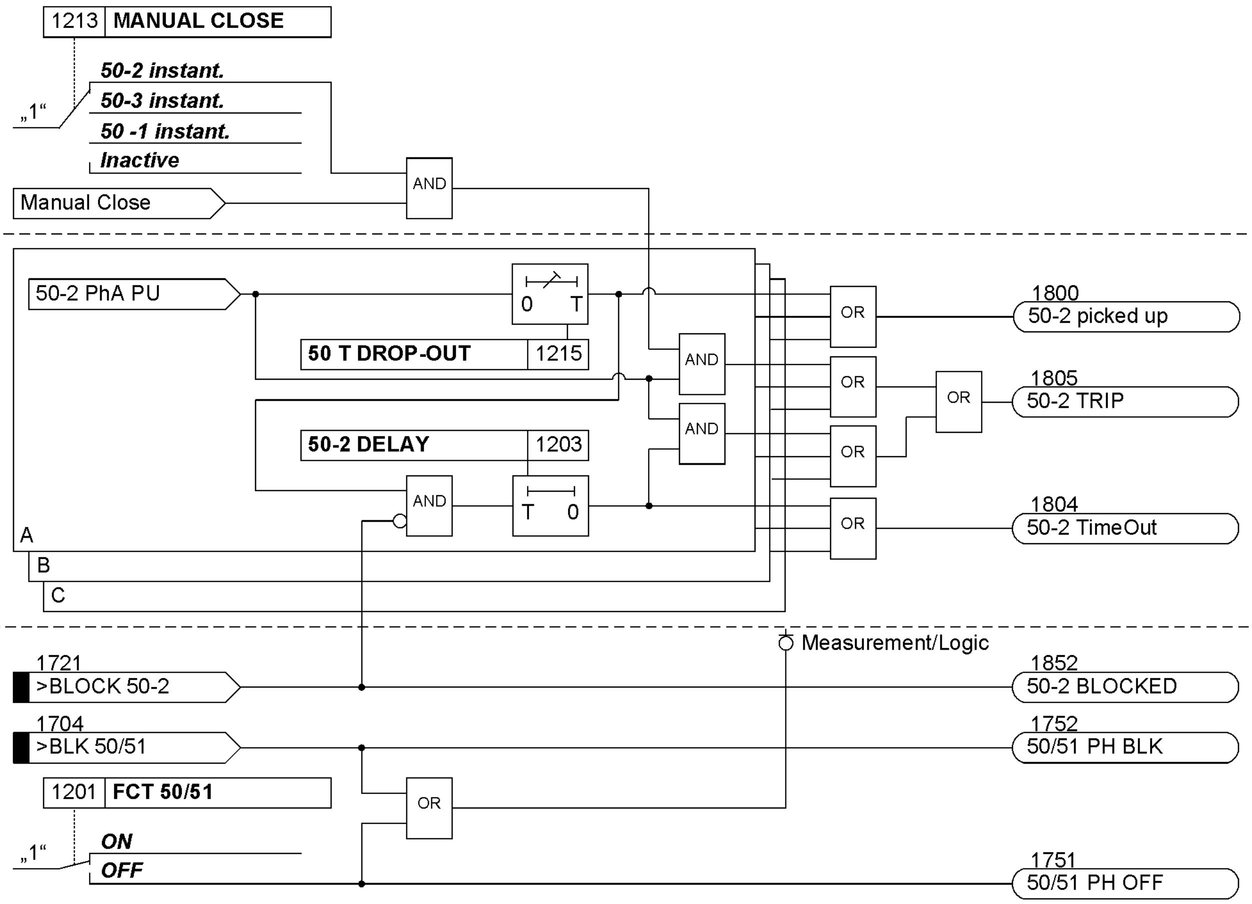


Figure 2-3 Logic diagram for the high-current element 50-2 for phases

If parameter 1213 **MANUAL CLOSE** is set to ***50-2 instant.*** or ***50-3 instant.*** and manual close detection is used, a pickup causes instantaneous tripping even if the Element is blocked via a binary input.

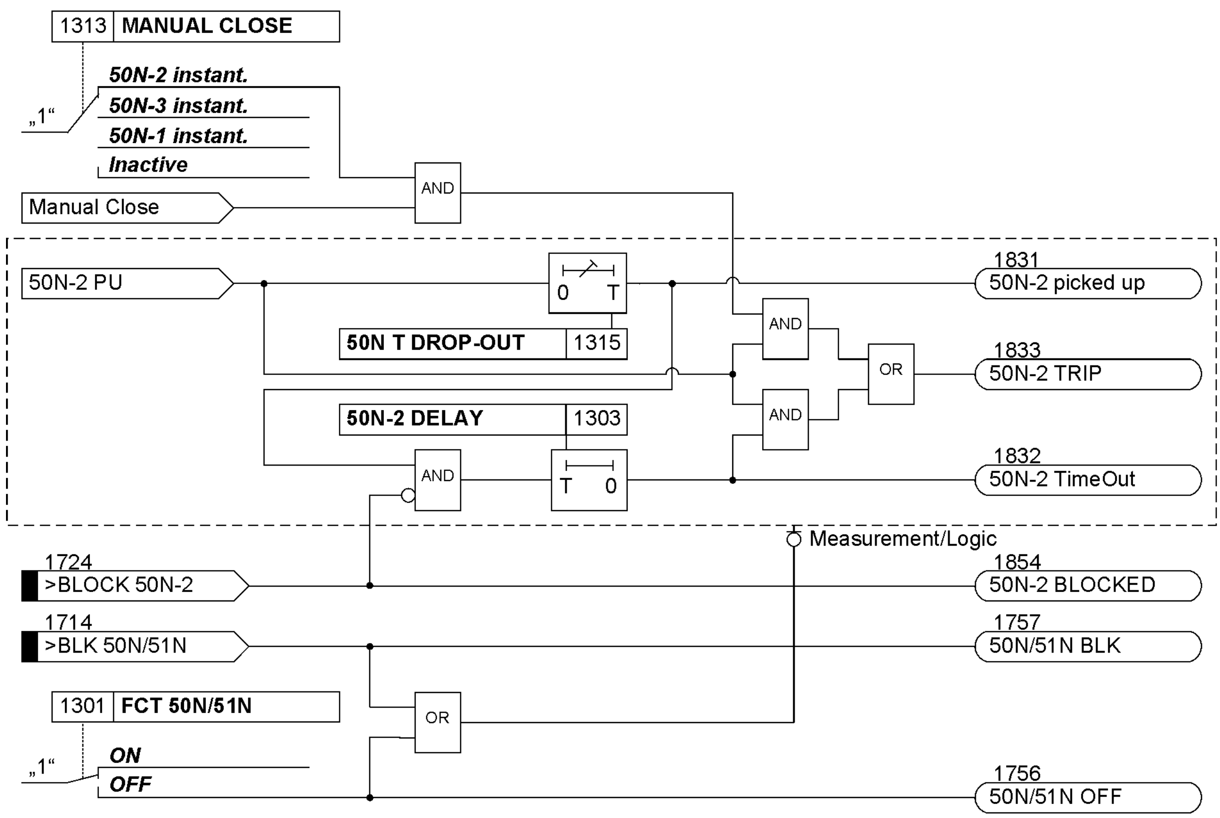


Figure 2-4 Logic diagram for the high-current element 50N-2

If parameter 1313 **MANUAL CLOSE** is set to ***50N-2 instant.*** or ***50N-3 instant.*** and manual close detection is used, a pickup causes instantaneous tripping even if the Element is blocked via a binary input.

2.2.3 Definite Time Overcurrent Elements 50-1, 50N-1

For each Element an individual pickup value **50-1 PICKUP** or **50N-1 PICKUP** is set. Apart from ***Fundamental***, the ***True RMS*** can also be measured. Each phase and ground current is compared separately with the setting value 50-1 or 50N-1 for each Element. If the respective value is exceeded, this is signaled. If the inrush restraint feature (see below) is applied, either the normal pickup signals or the corresponding inrush signals are output as long as inrush current is detected. After user-configured time delays **50-1 DELAY** or **50N-1 DELAY** have elapsed, a trip signal is issued if no inrush current is detected or inrush restraint is disabled. If the inrush restraint feature is enabled and an inrush condition exists, no tripping takes place but a message is recorded and displayed indicating when the overcurrent element time delay elapses. Trip signals and signals on the expiration of time delay are available separately for each Element. The dropout value is approximately 95% of the pickup value for currents > 0.3 I_{Nom}.

Pickup can be stabilized by setting dropout times 1215 **50 T DROP-OUT** or 1315 **50N T DROP-OUT**. This time is started and maintains the pickup condition if the current falls below the threshold. Therefore, the function does not drop out at high speed. The trip-command delay time **50-1 DELAY** or **50N-1 DELAY** continues running in the meantime. After the dropout delay time has elapsed, the pickup is reported OFF and the trip delay time is reset unless the threshold 50-1 or 50N-1 has been exceeded again. If the threshold is exceeded again during the dropout delay time, the time is canceled. However, the trip-command delay time **50-1 DELAY** or **50N-1 DELAY** continues running. If the threshold value is exceeded after its expiry, the trip command is issued immediately. If the threshold value is not exceeded at this time, there is no reaction. If the threshold value is exceeded again after expiry of the trip-command delay time, while the dropout delay time is still running, tripping occurs immediately.

Pickup stabilization of the overcurrent elements 50-1 or 50N-1 by means of settable dropout time is deactivated if an inrush pickup is present since an inrush does not represent an intermittent fault.

The pickup values of each 50-1 Element for phase currents and 50N-1 Element for the ground current and the element-specific time delays can be set individually.

The following figures show the logic diagrams for the current elements 50-1 and 50N-1.

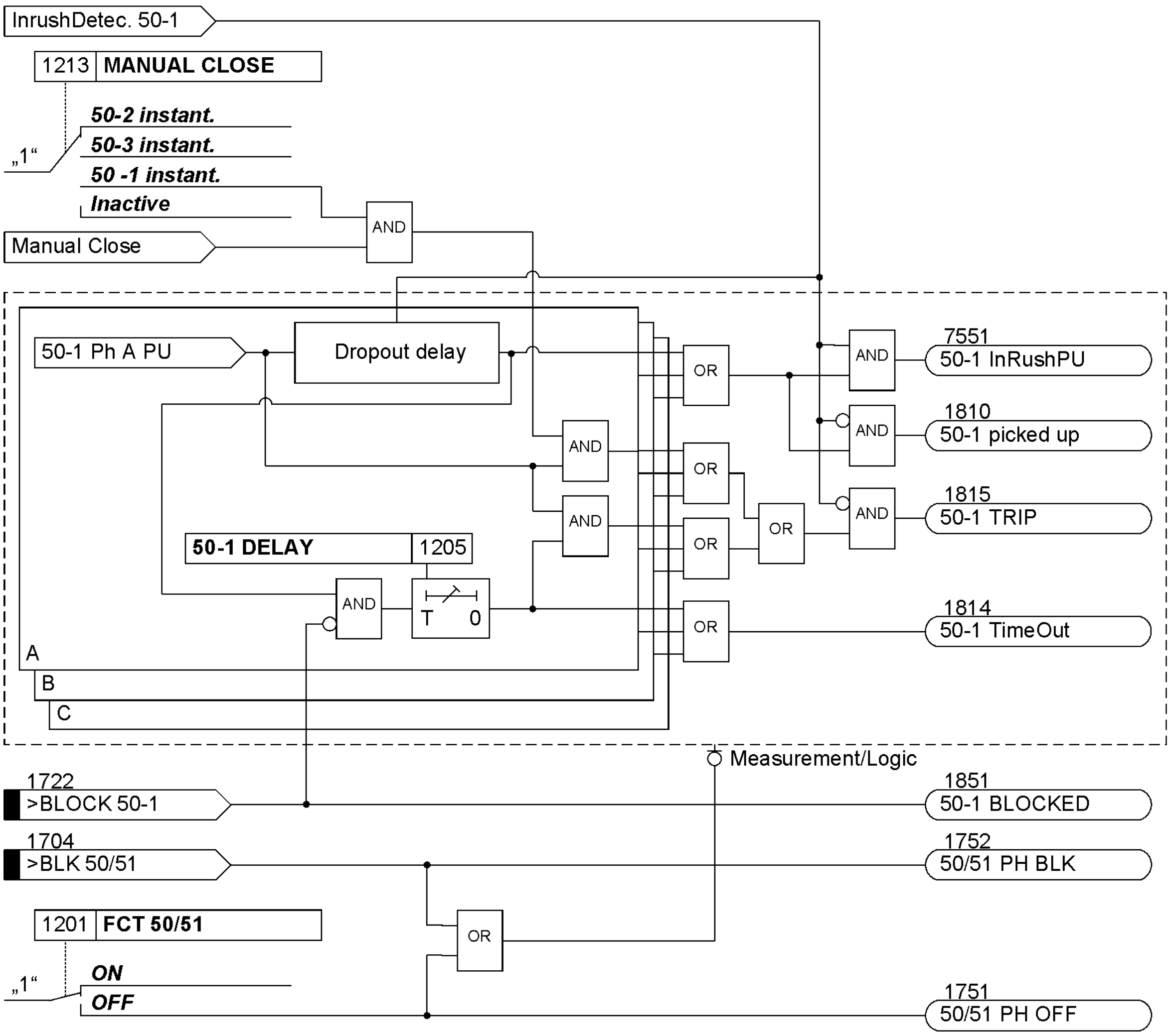


Figure 2-5 Logic diagram for the overcurrent element 50-1 for phases

If parameter 1213 **MANUAL CLOSE** is set to ***50 -1 instant.*** and manual close detection is used, a pickup causes instantaneous tripping even if theElement is blocked via a binary input.

The dropout delay only operates when no inrush was detected. An incoming inrush resets an already running dropout time delay.

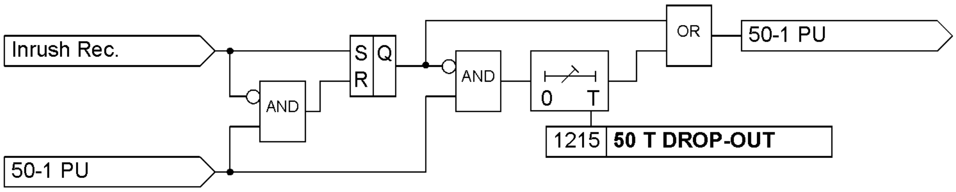


Figure 2-6 Logic diagram of the dropout delay for 50-1

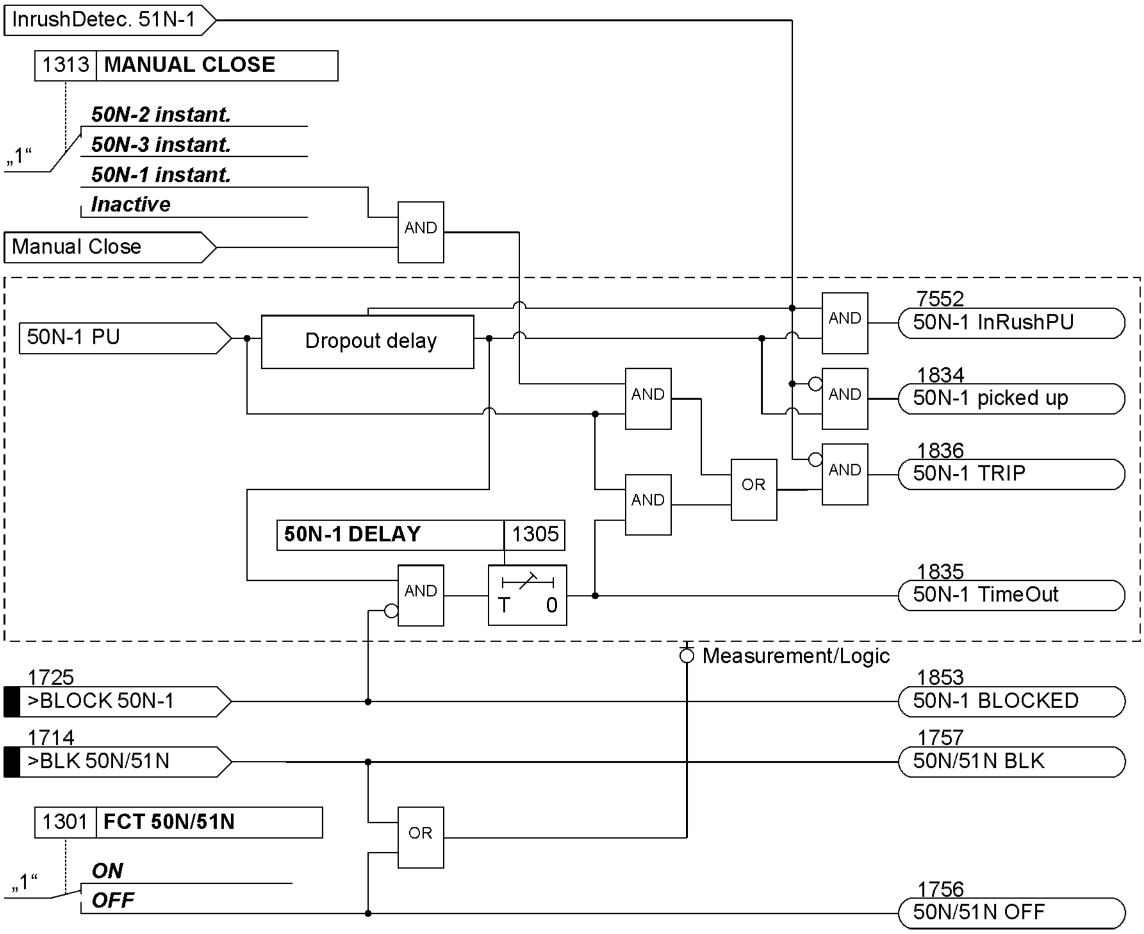


Figure 2-7 Logic diagram for the overcurrent element 50N-1

If parameter 1313 **MANUAL CLOSE** is set to ***50N-1 instant.*** and manual close detection is used, a pickup causes instantaneous tripping even if the Element is blocked via a binary input.

The pickup values of each 50-1, 50-2 Element for the phase currents and 50N-1, 50N-2 Element for the ground current and the valid delay times for each element can be set individually.

The dropout delay only operates when no inrush was detected. An incoming inrush resets an already running dropout time delay.

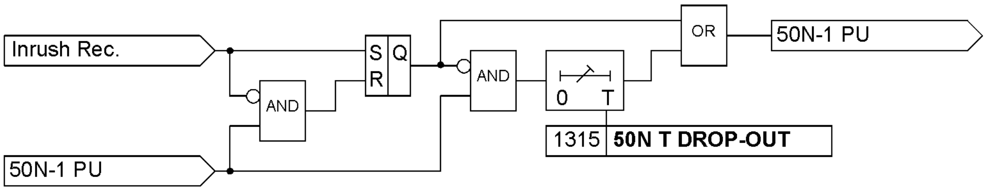


Figure 2-8 Logic of the dropout delay for 50N-1

2.2.4 Inrush Restraint

When the Feeder Automation Controller 7SC80 is installed, for instance, to protect a power transformer feeder, high inrush currents will flow when the transformer is energized. These inrush currents may be several times the nominal transformer current, and may last from several 10 milliseconds to several seconds, depending on the transformer size and design.

Although pickup of the relay elements is based only on the fundamental harmonic component of the measured currents, false device pickup due to inrush is still a potential problem since, depending on the transformer size and design, the inrush current also comprises a large component of the fundamental.

The Feeder Automation Controller 7SC80 therefore features an integrated inrush restraint function. It avoids the „normal“ pickup of the 50-1 relay elements (not 50-2 and 50-3) in the phases and ground path of all directional and non-directional overcurrent relay elements. After detection of inrush currents, special inrush signals are generated. These signals also initiate a fault record and start the associated trip delay. If inrush conditions are still present after the tripping time delay has elapsed, a corresponding indication („....Timeout“) is issued, but the overcurrent tripping is blocked (see also logic diagrams of time overcurrent elements, Figures 2-5 to 2-8).

Inrush current contains a relatively large second harmonic component (twice the nominal frequency) which is nearly absent during a fault current. The inrush restraint is based on the evaluation of the 2nd harmonic present in the inrush current. For frequency analysis, digital filters are used to conduct a Fourier analysis of all three phase currents and the ground current.

Inrush current is recognized if the following conditions are fulfilled at the same time:

- The harmonic content is larger than the setting value 2202 **2nd HARMONIC** (minimum 0.025 * $I_{Nom,sec}$);
- the currents do not exceed an upper limit value 2205 **I Max**;
- an exceeding of a threshold value via an inrush restraint of the blocked Element takes place.

In this case an inrush in the affected phase is recognized (annunciations 1840 to 1842 and 7558 „InRush Gnd Det“, see Figure) and its blocking being carried out.

Since quantitative analysis of the harmonic components cannot be completed until a full line period has been measured, pickup will generally be blocked by then. Therefore, assuming the inrush restraint feature is enabled, a pickup message will be delayed by a full line period if no closing process is present. On the other hand, trip delay times of the time overcurrent protection feature are started immediately even with the inrush restraint being enabled. Time delays continue running with inrush currents present. If inrush blocking drops out after the time delay has elapsed, tripping will occur immediately. Therefore, utilization of the inrush restraint feature will not result in any additional tripping delays. If a relay element drops out during inrush blocking, the associated time delay will reset.

Cross Blocking

Since inrush restraint operates individually for each phase, protection is ideal where a power transformer is energized into a single-phase fault and inrush currents are detected on a different healthy phase. However, the protection feature can be configured to allow that not only this phase element but also the remaining elements (including ground) are blocked (the so-called **CROSS BLOCK** function, address 2203) if the permissible harmonic component of the current is exceeded for only one phase.

Please take into consideration that inrush currents flowing in the ground path will not cross-block tripping by the phase elements.

Cross blocking is reset if there is no more inrush in any phase. Furthermore, the cross blocking function may also be limited to a particular time interval (address 2204 **CROSS BLK TIMER**). After expiry of this time interval, the cross blocking function will be disabled, even if inrush current is still present.

The inrush restraint has an upper limit: Above this (via adjustable parameter 2205 **I Max**) current blocking is suppressed since a high-current fault is assumed in this case.

The following figure shows the inrush restraint influence on the time overcurrent elements including cross-blocking.

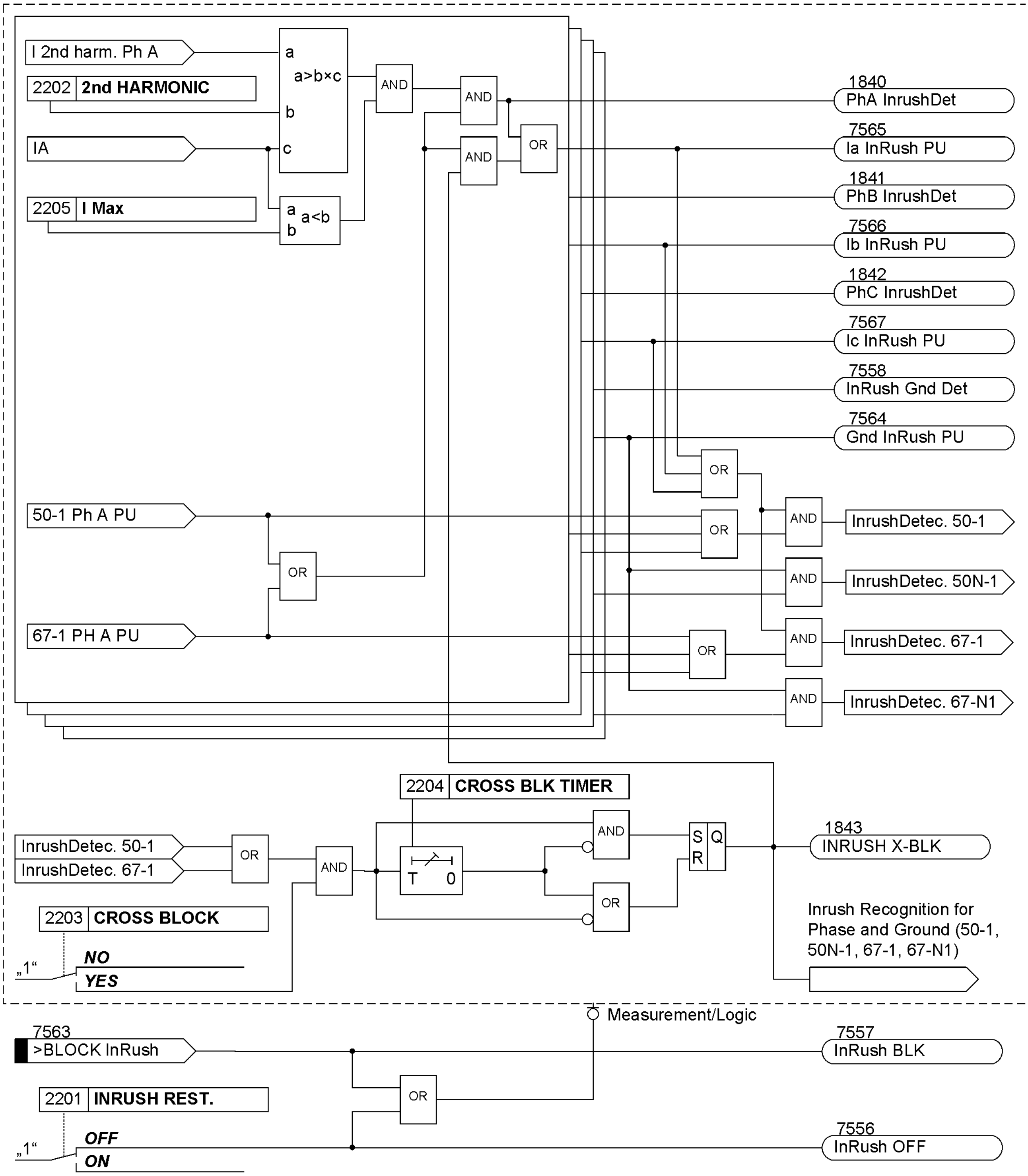


Figure 2-9 Logic diagram for inrush restraint

2.2.5 Pickup Logic and Tripping Logic

The pickup annunciations of the individual phases (or ground) and the individual elements are combined with each other in such a way that the phase information and the Element that has picked up are issued:

Table 2-3 Pickup Indications of Overcurrent Protection

Internal indication	Figure	Output indication	FNo.
PU 50-3 A PU 50-2 A PU 50-1 A	 2-3 2-5	„50/51 Ph A PU“	1762
PU 50-3 B PU 50-2 B PU 50-1 B	 2-3 2-5	„50/51 Ph B PU“	1763
PU 50-3 C PU 50-2 C PU 50-1 C	 2-3 2-5	„50/51 Ph C PU“	1764
PU 50N-3 PU 50N-2 PU 50N-1	 2-4 2-7	„50N/51NPickedup“	1765
PU 50-3 A PU 50-3 B PU 50-3 C PU 50N-3		„50-3 picked up“	1767
PU 50-2 A PU 50-2 B PU 50-2 C	2-3 2-3 2-3	„50-2 picked up“	1800
PU 50N-2	2-4	„50N-2 picked up“	1831
PU 50-1 A PU 50-1 B PU 50-1 C	2-5 2-5 2-5	„50-1 picked up“	1810
PU 50N-1	2-7	„50N-1 picked up“	1834
(All pickups)		„50(N)/51(N) PU“	1761

In the trip signals, the Element which initiated the tripping is also indicated.

2.2.6 Setting Notes

General

When selecting overcurrent protection in DIGSI, a dialog box appears with several tabs for setting the individual parameters. The number of tabs can vary, depending on the functional scope specified during configuration of the protective functions in addresses 112 **Charac. Phase** and 113 **Charac. Ground**. If **FCT 50/51** was set to ***Definite Time***, or **Charac. Ground** to ***Definite Time***, then the settings for the definite-time elements are available.

Parameter 250 **50/51 2-ph prot** can also be set to activate two-phase overcurrent protection.

Under address 1201 **FCT 50/51**, overcurrent protection for phases and under address 1301 **FCT 50N/51N**, the ground overcurrent protection can be switched ***ON*** or ***OFF***.

Pickup values and time delays for ground protection can be set separately from those for phase. Because of this, an independent grading for ground faults is often possible with shorter times and more sensitive settings.

Depending on the setting of parameter , the device can also be used in specific system configuration with regard to current connections. Further information can be found under Section 2.1.3.2, „Current Connections“.

Measurement Methods

The comparison values to be used for the respective element can be set in the setting sheets for the elements.

- Measurement of the **fundamental harmonic** (standard method):

  This measurement method processes the sampled values of the current and filters in numerical order the fundamental harmonic so that the higher harmonics or transient peak currents remain largely unconsidered.

- Measurement of the **true RMS value**

  The current amplitude is derived from the sampled values in accordance with the definition equation of the true RMS value. This measurement method should be selected when higher harmonics are to be considered by the function (e.g. in capacitor banks).

- Measurement with **instantaneous values**

  This procedure compares the instantaneous values to the set threshold. The element picks up at 2 · √2 · setting value (rms). It does not perform a mean-value calculation and is thus sensitive with regard to disturbances. This measurement method should only be selected if an especially short pickup time of the element is required. In this measurement procedure, the operating time of the element is reduced compared to the measurement of effective values or fundamental harmonics (see „Technical Data“).

The type of reference values can be set at the following addresses:

50-3 Element	Address 1219 **50-3 measurem.**
50-2 Element	Address 1220 **50-2 measurem.**
50-1 Element	Address 1221 **50-1 measurem.**
50N-3 Element	Address 1319 **50N-3 measurem.**
50N-2 Element	Address 1320 **50N-2 measurem.**
50N-1 Element	Address 1321 **50N-1 measurem.**

High-set Current Elements 50-2, 50-3 (phases)

The pickup currents of the high-current elements **50-2 PICKUP** or **50-3 PICKUP** can be set either at address 1202 or at address 1217. The corresponding time delay **50-2 DELAY** or **50-3 DELAY** can be configured at address 1203 or at address 1218. It is usually used for the purpose of current grading intended for large impedances that are prevalent in transformers. It is specified such that it picks up for faults up to this impedance.

Example of the high-set current element **50-2 PICKUP**: Transformer used for busbar supply with the following data:

Rated apparent power	S_{NomT} = 16 MVA
Transformer impedance	ZT = 10 %
Primary nominal voltage	V_{Nom1} = 110 kV
Secondary nominal voltage	V_{Nom2} = 20 kV
Vector groups	Dy 5
Neutral point	Grounded
Fault power on 110 kV-side	1 GVA

Based on the data above, the following fault currents are calculated:

Three-Phase High Voltage Side Fault Current	at 110 kV = 5250 A
Three-Phase Low Voltage Side Fault Current	at 20 kV = 3928 A
On the High Voltage Side Flowing	at 110 kV = 714 A

The nominal current of the transformer is:

$I_{NomT, 110}$ = 84 A (High Voltage Side)	$I_{NomT, 20}$ = 462 A (Low Voltage Side)
Current Transformer (High Voltage Side)	100 A/1 A
Current Transformer (Low Voltage Side)	500 A/1 A

Due to the following definition

High-set Element 50-2 PICKUP $$\frac{50\text{-}2}{I_{Nom}} > \frac{1}{V_{kTransf}} \cdot \frac{I_{NomTransf}}{I_{NomCT}}$$

the following setting applies to the protection device: The 50-2 high-set current element must be set higher than the maximum fault current which is detected during a low side fault on the high side. To reduce fault probability as much as possible even when fault power varies, the following setting is selected in primary values: 50-2 /I_{Nom} = 10, i.e. 50-2 = 1000 A. The same applies analogously when using the high-set element 50-3.

Increased inrush currents, if their fundamental component exceeds the setting value, are rendered harmless by delay times (address 1203 **50-2 DELAY** or 1218 **50-3 DELAY**).

The principle of "reverse interlocking" utilizes the multi-element function of overcurrent protection: The element **50-2 PICKUP** is applied as a fast busbar protection with a shorter safety time delay **50-2 DELAY** (e.g., 100 ms). For faults at the outgoing feeders, the element 50-2 is blocked. The element 50-1 serves as backup protection here. The pickup values of both elements (50-1 and 50-2) are set equal. The time delay **50-1 DELAY** is set such that it overgrades the delay for the outgoing feeders.

The selected time is an additional delay time and does not include the operating time (measuring time, dropout time). The delay can also be set to ∞. In this case, the Element will not trip after pickup. However, pickup, will be signaled. If the 50-2 Element or the 50-3 Element is not required at all, the pickup threshold 50-2 or 50-3 is set to ∞. This setting prevents tripping and the generation of a pickup message.

High-set Current Elements 50N-2, 50N-3 (ground)

The pickup currents of the high-set elements **50N-2 PICKUP** or **50N-3 PICKUP** are set under address 1302 or 1317. The corresponding delay time **50N-2 DELAY** or **50N-3 DELAY** can be configured under address 1303 or 1318. The same considerations apply to these settings as they did for phase currents discussed earlier.

The selected time is an additional delay time and does not include the operating time (measuring time, dropout time). The delay can also be set to ∞. In this case, the Element will not trip after pickup. However, pickup, will be signaled. If the 50N-2 Element or 50N-3 Element is not required at all, the pickup threshold 50N-2 or 50N-3 should be set to ∞. This setting prevents tripping and the generation of a pickup message.

50-1 Element (phases)

For setting the 50-1 element, the maximum anticipated load current must be considered. Pickup due to overload must never occur since in this mode, the device operates as fault protection with correspondingly short tripping times and not as overload protection. For this reason, lines are set to approx. 20 % above the maximum expected (over)load and transformers to approx. 40 %.

The settable time delay (address 1205 **50-1 DELAY**) results from the grading coordination chart defined for the system.

The selected time is an additional delay time and does not include the operating time (measuring time, dropout time). The delay can also be set to ∞. In this case, the Element will not trip after pickup. However, pickup, will be signaled. If the 50-1 Element is not required at all, then the pickup threshold 50-1 should be set to ∞. This setting prevents tripping and the generation of a pickup message.

50N-1 Element (ground)

The 50N-1 element is normally set based on minimum ground fault current.

If you expect large inrush currents when using the protection device on transformers, the inrush restraint feature of 7SC80 may be used for the 50N-1 element. It can be enabled or disabled for both the phase current and the ground current at address 2201 **INRUSH REST.**. The characteristic values of the inrush restraint are listed in subsection "Inrush Restraint".

The settable delay time (address 1305 **50N-1 DELAY**) results from the time coordination chart defined for the system. For ground currents in a grounded system a separate coordination timer with short time delays can be applied.

The selected time is an additional delay time and does not include the operating time (measuring time, dropout time). The delay can also be set to ∞. In this case, the Element will not trip after pickup. However, pickup, will be signaled. If the 50N-1 Element is not required at all, the pickup threshold 50N-1 PICKUP should be set to ∞. This setting prevents tripping and the generation of a pickup message.

Pickup Stabilization (Definite Time)

The configurable dropout times 1215 **50 T DROP-OUT** or 1315 **50N T DROP-OUT** can be set to implement a uniform dropout behavior when using electromechanical relays. This is necessary for a time grading. The dropout time of the electromechanical relay must be known to this end. Subtract the dropout time of the device (see Technical Data) from this value and enter the result in the parameters.

Inrush Restraint

When applying the protection device to transformers where high inrush currents are to be expected, the 7SC80 can make use of an inrush restraint function for the overcurrent elements 50–1, 51, 50N-1 and 51N.

Inrush restraint is only effective and accessible if address 122 **InrushRestraint** was set to ***Enabled*** during configuration. If this function is not required, then ***Disabled*** is set. At address 2201 **INRUSH REST.**, the function is switched ***ON*** or ***OFF*** jointly for the overcurrent elements **50-1 PICKUP** and **50N-1 PICKUP**.

The inrush restraint is based on the evaluation of the 2nd harmonic present in the inrush current. Upon delivery from the factory, a ratio I_{2f}/I_f of 15 % is set. Under normal circumstances, this setting will not need to be changed. The setting value is identical for all phases and ground. However, the component required for restraint may be adjusted to system conditions in address 2202 **2nd HARMONIC**. To provide more restraint in exceptional cases, where energizing conditions are particularly unfavorable, a smaller value can be set in the aforementioned address, e.g. 12 %. Irrespective of parameter 2202 **2nd HARMONIC**, rush blocking will only occur if the absolute value of the 2nd harmonic is at least 0.025 * $I_{Nom,sec}$.

The effective duration of the cross-blocking 2203 **CROSS BLK TIMER** can be set to a value between 0 s (harmonic restraint active for each phase individually) and a maximum of 180 s (harmonic restraint of a phase blocks also the other phases for the specified duration).

If the current exceeds the value set in address 2205 **I Max**, no further restraint will take place for the 2nd harmonic.

Manual Close Mode (phases,ground)

When a circuit breaker is closed onto a faulted line, a high-speed trip by the circuit breaker is usually desired. For overcurrent or high-set Element the delay may be bypassed via a Manual Close pulse, thus resulting in instantaneous tripping. This pulse is prolonged by at least 300 ms. To enable the device to react properly on occurrence of a fault in the phase elements, address 1213 **MANUAL CLOSE** has to be set accordingly. Correspondingly, address 1313 **MANUAL CLOSE** is considered for the ground path address. Thus, the user determines for both elements, the phase and the ground element, what pickup value is active with what delay when the circuit breaker is closed manually.

External Control Command

If the manual closing signal is not sent from a 7SC80 device but directly from a control acknowledgment switch, this signal must be passed to a 7SC80 binary input and configured accordingly („>Manual Close“), so that the Element selected for **MANUAL CLOSE** will be effective. Its alternative ***Inactive*** means that all elements operate as per configuration, even with manual close, and do not get special treatment.

Internal Control Function

If the manual close signal is sent via the internal control function of the device, an internal connection of information has to be established via CFC (interlocking task level) using the CMD_Information block (see Figure 2-10).

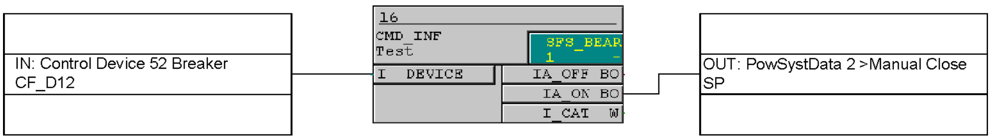


Figure 2-10 Example for the generation of a manual close signal using the internal control function

2.2.7 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1201	FCT 50/51		ON OFF	ON	50, 51 Phase Time Overcurrent
1202	50-2 PICKUP	1A	0.10 .. 35.00 A; ∞	4.00 A	50-2 Pickup
		5A	0.50 .. 175.00 A; ∞	20.00 A	
1203	50-2 DELAY		0.00 .. 60.00 sec; ∞	0.00 sec	50-2 Time Delay
1204	50-1 PICKUP	1A	0.10 .. 35.00 A; ∞	1.00 A	50-1 Pickup
		5A	0.50 .. 175.00 A; ∞	5.00 A	
1205	50-1 DELAY		0.00 .. 60.00 sec; ∞	0.50 sec	50-1 Time Delay
1213A	MANUAL CLOSE		50-3 instant. 50-2 instant. 50 -1 instant. Inactive	50-2 instant.	Manual Close Mode
1214A	50-2 active		Always	Always	50-2 active
1215A	50 T DROP-OUT		0.00 .. 60.00 sec	0.00 sec	50 Drop-Out Time Delay
1216A	50-3 active		Always	Always	50-3 active
1217	50-3 PICKUP	1A	1.00 .. 35.00 A; ∞	∞ A	50-3 Pickup
		5A	5.00 .. 175.00 A; ∞	∞ A	
1218	50-3 DELAY		0.00 .. 60.00 sec; ∞	0.00 sec	50-3 Time Delay
1219A	50-3 measurem.		Fundamental True RMS Instantaneous	Fundamental	50-3 measurement of
1220A	50-2 measurem.		Fundamental True RMS	Fundamental	50-2 measurement of
1221A	50-1 measurem.		Fundamental True RMS	Fundamental	50-1 measurement of
1301	FCT 50N/51N		ON OFF	ON	50N, 51N Ground Time Overcurrent
1302	50N-2 PICKUP	1A	0.05 .. 35.00 A; ∞	0.50 A	50N-2 Pickup
		5A	0.25 .. 175.00 A; ∞	2.50 A	
1303	50N-2 DELAY		0.00 .. 60.00 sec; ∞	0.10 sec	50N-2 Time Delay
1304	50N-1 PICKUP	1A	0.05 .. 35.00 A; ∞	0.20 A	50N-1 Pickup
		5A	0.25 .. 175.00 A; ∞	1.00 A	
1305	50N-1 DELAY		0.00 .. 60.00 sec; ∞	0.50 sec	50N-1 Time Delay
1313A	MANUAL CLOSE		50N-3 instant. 50N-2 instant. 50N-1 instant. Inactive	50N-2 instant.	Manual Close Mode
1314A	50N-2 active		Always	Always	50N-2 active

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1315A	50N T DROP-OUT		0.00 .. 60.00 sec	0.00 sec	50N Drop-Out Time Delay
1316A	50N-3 active		Always	Always	50N-3 active
1317	50N-3 PICKUP	1A	0.25 .. 35.00 A; ∞	∞ A	50N-3 Pickup
		5A	1.25 .. 175.00 A; ∞	∞ A	
1318	50N-3 DELAY		0.00 .. 60.00 sec; ∞	0.05 sec	50N-3 Time Delay
1319A	50N-3 measurem.		Fundamental True RMS Instantaneous	Fundamental	50N-3 measurement of
1320A	50N-2 measurem.		Fundamental True RMS	Fundamental	50N-2 measurement of
1321A	50N-1 measurem.		Fundamental True RMS	Fundamental	50N-1 measurement of
2201	INRUSH REST.		OFF ON	OFF	Inrush Restraint
2202	2nd HARMONIC		10 .. 45 %	15 %	2nd. harmonic in % of fundamental
2203	CROSS BLOCK		NO YES	NO	Cross Block
2204	CROSS BLK TIMER		0.00 .. 180.00 sec	0.00 sec	Cross Block Time
2205	I Max	1A	0.30 .. 25.00 A	7.50 A	Maximum Current for Inrush Restraint
		5A	1.50 .. 125.00 A	37.50 A	

2.2.8 Information List

No.	Information	Type of Information	Comments
1704	>BLK 50/51	SP	>BLOCK 50/51
1714	>BLK 50N/51N	SP	>BLOCK 50N/51N
1718	>BLOCK 50-3	SP	>BLOCK 50-3
1719	>BLOCK 50N-3	SP	>BLOCK 50N-3
1721	>BLOCK 50-2	SP	>BLOCK 50-2
1722	>BLOCK 50-1	SP	>BLOCK 50-1
1724	>BLOCK 50N-2	SP	>BLOCK 50N-2
1725	>BLOCK 50N-1	SP	>BLOCK 50N-1
1751	50/51 PH OFF	OUT	50/51 O/C switched OFF
1752	50/51 PH BLK	OUT	50/51 O/C is BLOCKED
1753	50/51 PH ACT	OUT	50/51 O/C is ACTIVE
1756	50N/51N OFF	OUT	50N/51N is OFF
1757	50N/51N BLK	OUT	50N/51N is BLOCKED
1758	50N/51N ACT	OUT	50N/51N is ACTIVE
1761	50(N)/51(N) PU	OUT	50(N)/51(N) O/C PICKUP
1762	50/51 Ph A PU	OUT	50/51 Phase A picked up
1763	50/51 Ph B PU	OUT	50/51 Phase B picked up
1764	50/51 Ph C PU	OUT	50/51 Phase C picked up

No.	Information	Type of Information	Comments
1765	50N/51NPickedup	OUT	50N/51N picked up
1767	50-3 picked up	OUT	50-3 picked up
1768	50N-3 picked up	OUT	50N-3 picked up
1769	50-3 TRIP	OUT	50-3 TRIP
1770	50N-3 TRIP	OUT	50N-3 TRIP
1787	50-3 TimeOut	OUT	50-3 TimeOut
1788	50N-3 TimeOut	OUT	50N-3 TimeOut
1791	50(N)/51(N)TRIP	OUT	50(N)/51(N) TRIP
1800	50-2 picked up	OUT	50-2 picked up
1804	50-2 TimeOut	OUT	50-2 Time Out
1805	50-2 TRIP	OUT	50-2 TRIP
1810	50-1 picked up	OUT	50-1 picked up
1814	50-1 TimeOut	OUT	50-1 Time Out
1815	50-1 TRIP	OUT	50-1 TRIP
1831	50N-2 picked up	OUT	50N-2 picked up
1832	50N-2 TimeOut	OUT	50N-2 Time Out
1833	50N-2 TRIP	OUT	50N-2 TRIP
1834	50N-1 picked up	OUT	50N-1 picked up
1835	50N-1 TimeOut	OUT	50N-1 Time Out
1836	50N-1 TRIP	OUT	50N-1 TRIP
1840	PhA InrushDet	OUT	Phase A inrush detection
1841	PhB InrushDet	OUT	Phase B inrush detection
1842	PhC InrushDet	OUT	Phase C inrush detection
1843	INRUSH X-BLK	OUT	Cross blk: PhX blocked PhY
1851	50-1 BLOCKED	OUT	50-1 BLOCKED
1852	50-2 BLOCKED	OUT	50-2 BLOCKED
1853	50N-1 BLOCKED	OUT	50N-1 BLOCKED
1854	50N-2 BLOCKED	OUT	50N-2 BLOCKED
7551	50-1 InRushPU	OUT	50-1 InRush picked up
7552	50N-1 InRushPU	OUT	50N-1 InRush picked up
7556	InRush OFF	OUT	InRush OFF
7557	InRush BLK	OUT	InRush BLOCKED
7558	InRush Gnd Det	OUT	InRush Ground detected
7559	67-1 InRushPU	OUT	67-1 InRush picked up
7560	67N-1 InRushPU	OUT	67N-1 InRush picked up
7563	>BLOCK InRush	SP	>BLOCK InRush
7564	Gnd InRush PU	OUT	Ground InRush picked up
7565	Ia InRush PU	OUT	Phase A InRush picked up
7566	Ib InRush PU	OUT	Phase B InRush picked up
7567	Ic InRush PU	OUT	Phase C InRush picked up
10034	50-3 BLOCKED	OUT	50-3 BLOCKED
10035	50N-3 BLOCKED	OUT	50N-3 BLOCKED

2.3 Directional Overcurrent Protection 67, 67N

Directional overcurrent protection includes two elements each for the phase currents and the ground current. All elements operate with a definite tripping time, they are independent of each other and can be combined as desired.

Applications

- The directional overcurrent protection allows the application of Feeder Automation Controller 7SC80 also in systems where selectivity depends on both the overcurrent criterion and the direction of power flow to the fault location.
- The non-directional overcurrent protection described in Section 2.2 may operate as overlapping backup protection or may be disabled. Additionally, individual elements (e.g. 67-2 and/or 67N-2) may be interconnected with the directional overcurrent protection.
- For parallel lines or transformers supplied from a single source, only directional overcurrent protection allows selective fault detection.
- For line sections supplied from two sources or in ring-operated lines, the overcurrent protection has to be supplemented by the element-specific directional criterion.

2.3.1 General

For parallel lines or transformers supplied from a single source (Figure 2-11), the second feeder (II) is opened on occurrence of a fault in the first feeder (I) if tripping of the breaker in the parallel feeder is not prevented by a directional measuring element (at B). Therefore, where indicated with an arrow (Figure 2-11), directional overcurrent protection is applied. Please ensure that the "forward" direction of the protection element is in the direction of the line (or object to be protected). This is not necessarily identical with the direction of the normal load flow, as shown in Figure 2-11.

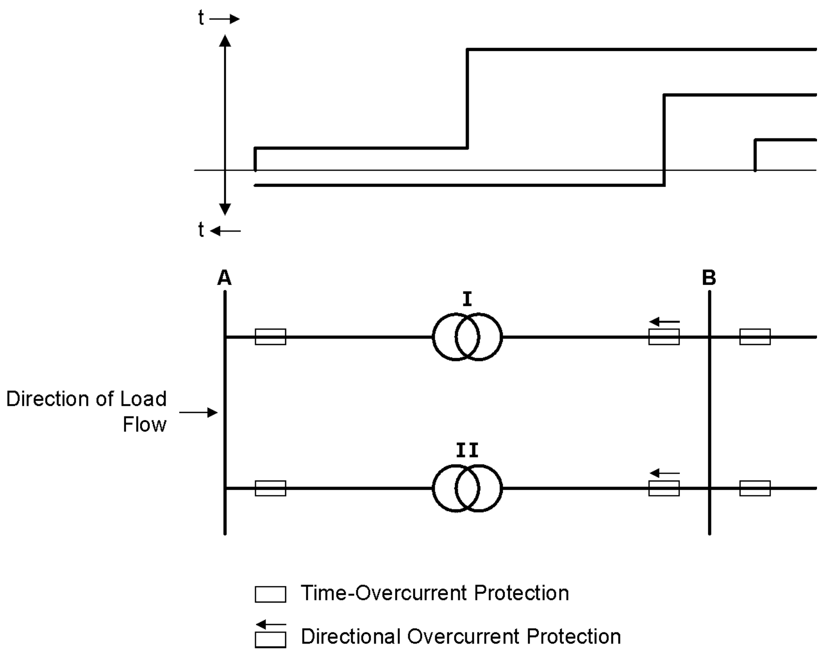


Figure 2-11 Overcurrent protection for parallel transformers

For line sections supplied from two sources or in ring-operated lines, the overcurrent protection has to be supplemented by the directional criterion. Figure 2-12 shows a ring system where both energy sources are merged to one single source.

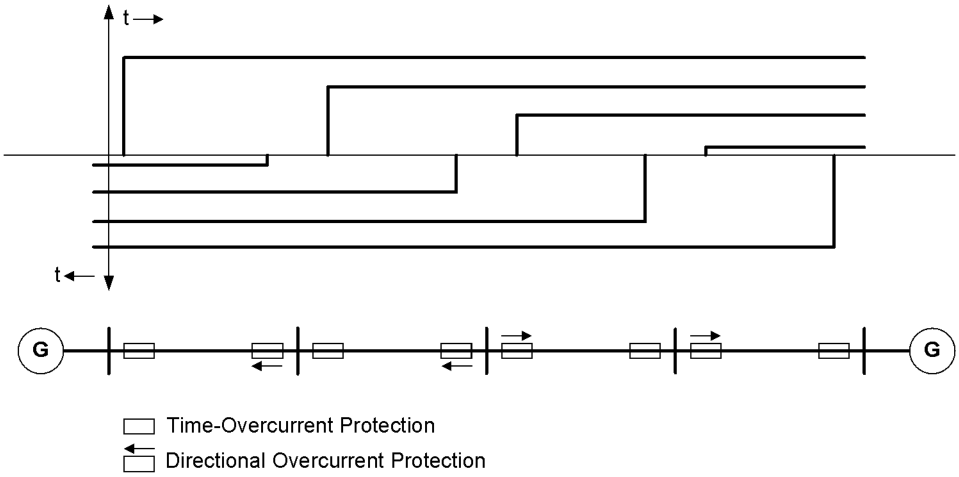


Figure 2-12 Transmission lines with sources at both ends

Depending on the setting of parameter 613 **Gnd O/Cprot. w.**, the ground current element can operate either with measured values I_N or with the values 3I0 calculated from the three phase currents.

For each element the time can be blocked via binary input or automatic reclosing (cycle-dependent), thus suppressing the trip command. Removal of blocking during pickup will restart time delays. The Manual Close signal is an exception. If a circuit breaker is manually closed onto a fault, it can be re-opened immediately. For overcurrent elements or high-set elements the delay may be bypassed via a Manual Close pulse, thus resulting in high-speed tripping.

Pickup stabilization for the 67/67N elements of the directional overcurrent protection can be accomplished by means of settable dropout times. This protection comes into use in systems where intermittent faults occur. Combined with electromechanical relays, it allows different dropout responses to be adjusted and a time grading of digital and electromechanical relays to be implemented.

Utilizing the inrush restraint feature tripping may be blocked by the 67-1, 67-TOC, 67N-1, and 67N-TOC elements in phases and ground path when inrush current is detected.

The following table gives an overview of these interconnections to other functions of the 7SC80 devices.

Table 2-4 Interconnection to Other Functions

Directional overcurrent protection elements	Manual CLOSE	Inrush current restraint
67-1	•	•
67-2	•	
67N-1	•	•
67N-2	•	

2.3.2 Definite Time, Directional High-set Elements 67-2, 67N-2

For each element an individual pickup value 67-2 PICKUP or 67N-2 PICKUP is set which can be measured as *Fundamental* or *True RMS*. Phase and ground current are compared separately with the pickup values of the 67-2 PICKUP and 67N-2 PICKUP relay elements. Currents above the setting values are recognized separately when fault direction is equal to the direction configured. After the appropriate delay times 67-2 DELAY, 67N-2 DELAY have elapsed, trip signals are issued which are available for each element. The dropout value is approximately 95% of the pickup value for currents > 0.3 I_{Nom}.

Pickup can be stabilized by setting dropout times 1518 **67 T DROP-OUT** or 1618 **67N T DROP-OUT**. This time is started and maintains the pickup condition if the current falls below the threshold. Therefore, the function does not drop out at high speed. The trip-command delay time **50-2 DELAY** or **50N-2 DELAY** continues in the meantime. After the dropout delay time has elapsed, the pickup is reported OFF and the trip delay time is reset unless the threshold **50-2 PICKUP** or **50N-2 PICKUP** has been exceeded again. If the threshold is exceeded again during the dropout delay time, the time is canceled. The trip-command delay time **50-2 DELAY** or **50N-2 DELAY** continues in the meantime. Should the threshold value be exceeded after its expiry, the trip command is issued immediately. If the threshold value is not exceeded at this time, there will be no reaction. If the threshold value is exceeded again after expiry of the trip-command delay time, while the dropout delay time is still running, tripping occurs immediately.

Each of these elements can be directional or non-directional.

The following figure gives an example of the logic diagram for the high-set element 67-2.

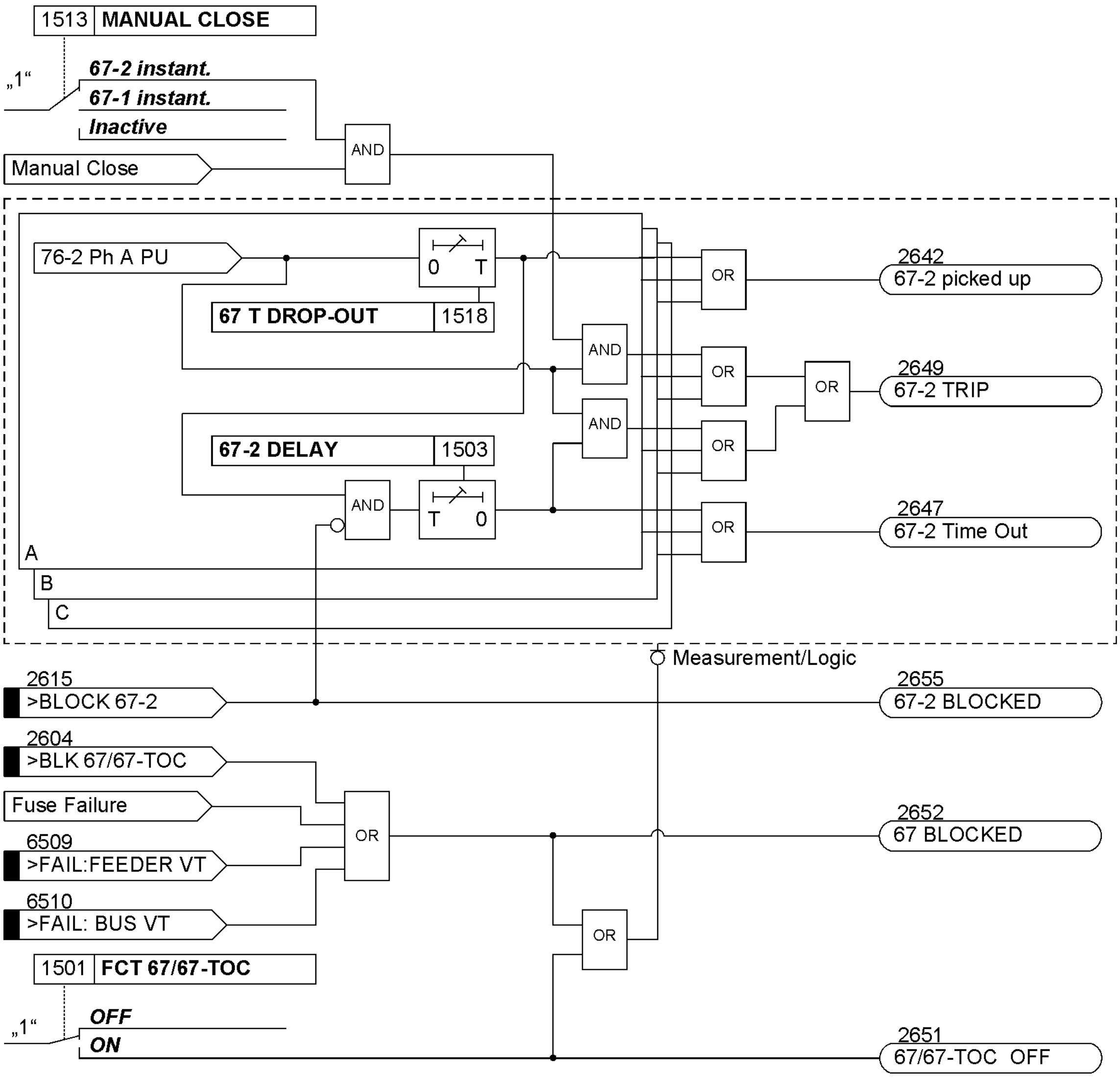


Figure 2-13 Logic diagram for directional high-current element 67-2 for phases

If parameter 1513 **MANUAL CLOSE** is set to ***67-2 instant.*** and manual close detection applies, the trip is initiated as soon as the pickup conditions arrive, even if the element is blocked via a binary input.

2.3.3 Definite Time, Directional Time Overcurrent Elements 67-1, 67N-1

For each element an individual pickup value **67-1 PICKUP** or **67N-1 PICKUP** is set which can be measured as ***Fundamental*** or ***True RMS***. Phase and ground currents are compared separately with the common setting value **67-1 PICKUP** or **67N-1 PICKUP**. Currents above the setting values are recognized separately when fault direction is equal to the configured direction. If the inrush restraint feature is used, either the normal pickup signals or the corresponding inrush signals are issued as long as inrush current is detected. When the relevant delay times **67-1 DELAY**, **67N-1 DELAY** have expired, a tripping command is issued unless an inrush has been recognized or inrush restraint is active. If the inrush restraint feature is enabled, and an inrush condition exists, no tripping takes place, but a message is recorded and displayed indicating when the overcurrent element time delay elapses. Trip signals and other flags for each element are issued when the element times out. The dropout value is roughly equal to 95% of the pickup value for currents > 0.3 I_{Nom}.

Pickup can be stabilized by setting dropout times 1518 **67 T DROP-OUT** or 1618 **67N T DROP-OUT**. This time is started and maintains the pickup condition if the current falls below the threshold. Therefore, the function does not drop out at high speed. The trip-command delay time **50-1 DELAY** or **50N-1 DELAY** continues in the meantime. After the dropout delay time has elapsed, the pickup is reported OFF and the trip delay time is reset unless the threshold **50-1 PICKUP** or **50N-1 PICKUP** has been exceeded again. If the threshold is exceeded again during the dropout delay time, the time is canceled. The trip-command delay time **50-1 DELAY** or **50N-1 DELAY** continues in the meantime. Should the threshold value be exceeded after its expiry, the trip command is issued immediately. If the threshold value is not exceeded at this time, there will be no reaction. If the threshold value is exceeded again after expiry of the trip-command delay time, while the dropout delay time is still running, tripping occurs immediately.

The inrush restraint of the overcurrent elements **50-1 PICKUP** or **50N-1 PICKUP** is disabled via configurable dropout times if an inrush pickup occurs, because the occurrence of an inrush does not constitute an intermittent fault.

Each of these elements can be directional or non-directional.

The following figure shows by way of an example the logic diagram for the directional overcurrent element 67-1.

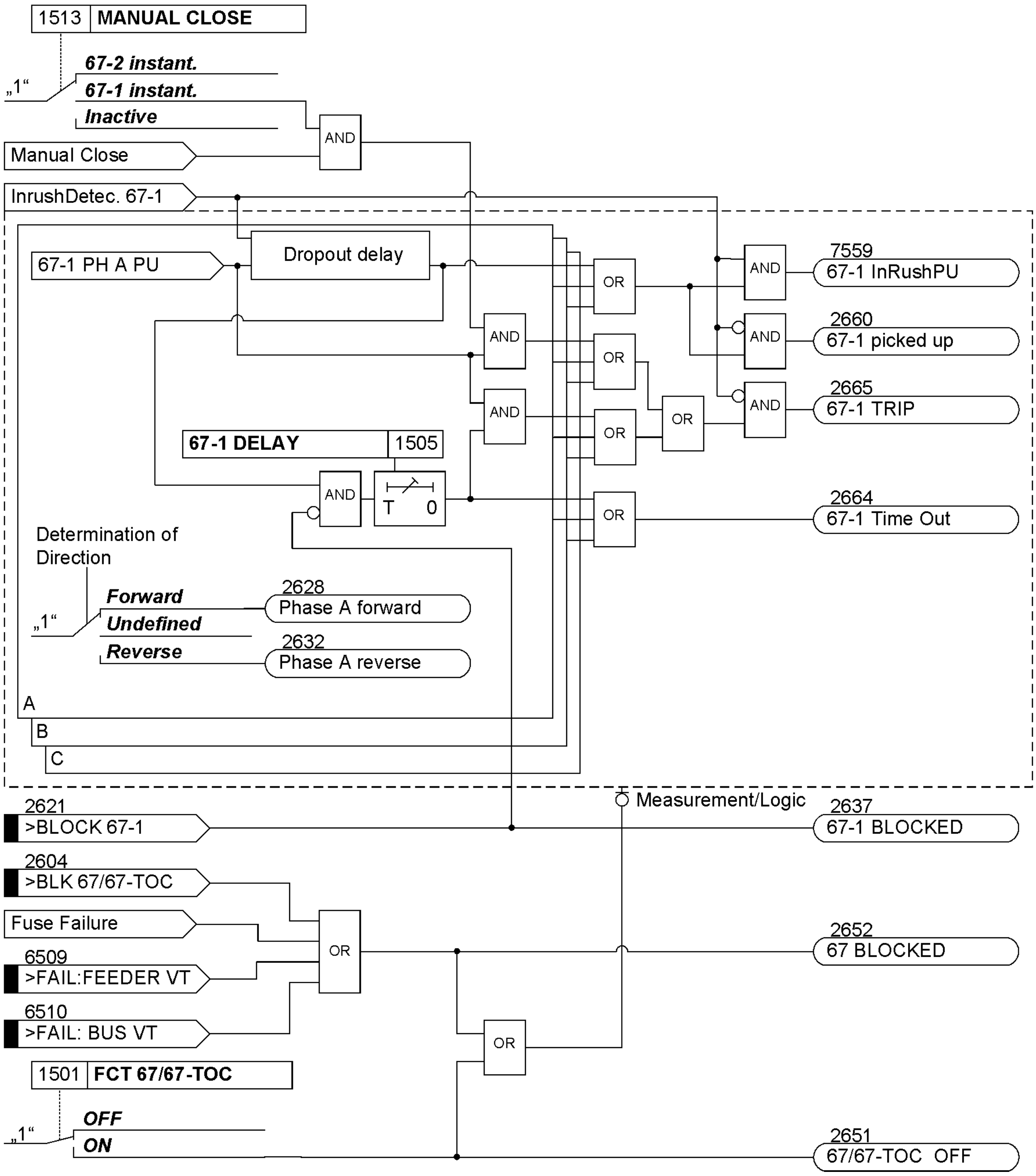


Figure 2-14 Logic diagram for directional overcurrent element 67-1 for phases

If parameter 1513 **MANUAL CLOSE** is set to ***67-1 instant.*** and manual close detection applies, the trip is initiated as soon as the pickup conditions arrive, even if the element is blocked via a binary input.

The dropout delay does only function if no inrush was detected. An approaching inrush resets an already running dropout time delay.

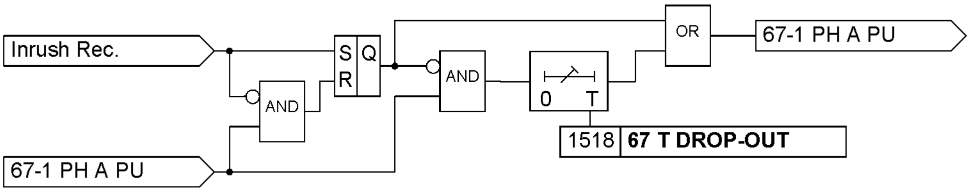


Figure 2-15 Logic of the dropout delay for 67-1

2.3.4 Interaction with Fuse Failure Monitor (FFM)

Spurious tripping might be caused by a measuring voltage failure due to a short circuit, a phase failure in the voltage transformer secondary system, or a pickup of the voltage transformer mcb (fuse). In the event of a single-phase or two-phase failure of the measuring voltage, it is possible to recognize this condition and block the directional overcurrent protection elements (phase and ground) (see logic diagrams).

For additional information on the operation of the fuse failure monitor, see Section 2.8.1 Measured Value Supervision.

2.3.5 Inrush Restraint

The 7SC80 features an integrated inrush restraint function. It prevents the "normal" pickup of all directional and non-directional overcurrent relay elements in the phases and ground path, but not the high-set elements. The same is true for the alternative pickup thresholds of the dynamic cold load pickup function. After detection of inrush currents above a pickup value, special inrush signals are generated. These signals also initiate fault annunciations and start the associated trip delay time. If inrush conditions are still present after the tripping time delay has elapsed, a corresponding message ("....TimeOut ") is output, but the overcurrent tripping is blocked (for further information see "Inrush Restraint" in Section 2.2).

2.3.6 Determination of Direction

The determination of the fault direction for the phase directional element and the ground directional element is performed independently.

Basically, the direction determination is performed by determining the phase angle between the fault current and a reference voltage.

Method of Directional Measurement

For the phase directional element the fault current of the corresponding phase and the unfaulted phase-to-phase voltage are used as reference voltage. The unfaulted voltage also allows for a correct direction determination even if the fault voltage has collapsed entirely (short-line fault). In phase-to-ground voltage connections, the phase-to-phase voltages are calculated. In a connection of two phase-to-phase voltages and V_N, the third phase-to-phase voltage is also calculated.

With three-phase short-line faults, memory voltage values are used to clearly determine the direction if the measurement voltages are not sufficient.Upon the expiration of the storage time period (2 s), the detected direction is saved, as long as no sufficient measuring voltage is available. When closing onto a fault, if no memory voltage values exist in the buffer, the relay element will trip. In all other cases the voltage magnitude will be sufficient for determining the direction.

For each directional ground element there are two possibilities of direction determination:

Direction Determination with Zero Sequence Calculated or Measured Quantities

For the directional ground fault elements, direction can be determined by comparing the zero sequence system quantities. In the current path, the I_N current is valid, when the transformer neutral current is connected to the device. Otherwise, the device calculates the ground current from the sum of the three phase currents. In the voltage path, the displacement voltage V_N is used as reference voltage, if it is connected. Otherwise the device calculates as reference voltage the zero sequence voltage $3 \cdot V_0$ from the sum of the three phase voltages. If the magnitude of V_0 or $3 \cdot V_0$ is not sufficient to determine direction, the direction is undefined. Then the directional ground element will not initiate a trip signal. If the current I0 cannot be determined, e.g. because only two current transformers are utilized or the current transformers are connected in an open delta configuration, then the directional ground elements will not be able to function. The latter is only permitted in ungrounded systems.

Direction Determination with Negative Sequence System

Here, the negative sequence current and as reference voltage the negative sequence voltage are used for the direction determination. This is advantageous if the zero sequence is influenced via a parallel line or if the zero voltage becomes very small due to unfavorable zero impedances. The negative sequence system is calculated from the individual voltages and currents. As with the use of the zero sequence values, a direction determination is carried out if the values necessary for the direction determination have exceeded a minimum threshold. Otherwise the direction is undetermined.

Cross-Polarized Reference Voltages for Direction Determination

The direction of a phase-directional element is detected by means of a cross-polarized voltage. In a phase-to-ground fault, the cross-polarized voltage (reference voltage) is 90° out of phase with the fault voltages (see Figure 2-16). With phase-to-phase faults, the position of the reference voltages changes, depending on the degree of collapse of the fault voltages, up to 30°.

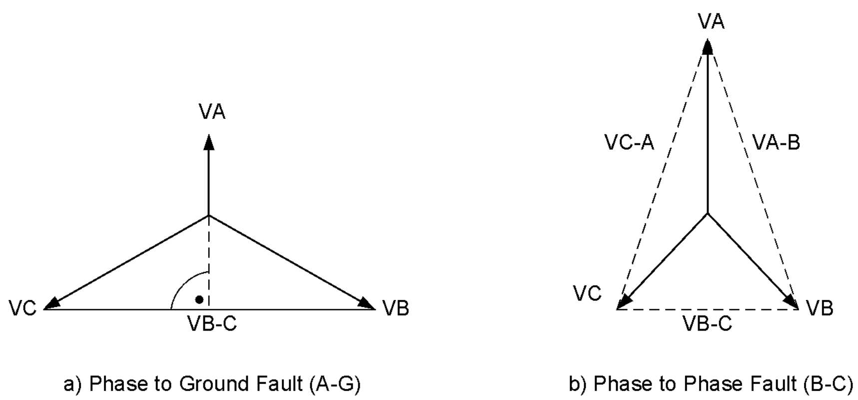


Figure 2-16 Cross-polarized voltages for direction determination

Measured Values for the Determination of Fault Direction

Each phase has its own phase measuring element. The fourth measuring element is used as directional ground element. If the current exceeds the pickup threshold of a phase or that of the ground path, the direction determination is started by the associated measuring element. In the event of a multi-phase fault, all phase measuring elements involved conduct an independent direction determination. If one of the directions determined coincides with the direction set, the function picks up.

The following table shows the allocation of measured values for the determination of fault direction for various causes of pickup.

Table 2-5 Measured Values for the Determination of Fault Direction

Pickup	**Measuring element**							
	A		**B**		**C**		**ground**	
	Current	**Voltage**	**Current**	**Voltage**	**Current**	**Voltage**	**Current**	**Voltage**
A	I_A	$V_B - V_C$	—	—	—	—	—	—
B	—	—	I_B	$V_C - V_A$	—	—	—	—
C	—	—	—	—	I_C	$V_A - V_B$	—	—
N	—	—	—	—	—	—	I_N	V_N 1)
A, N		$V_B - V_C$	—	—	—	—	I_N	V_N 1)
B, N	—	—	I_B	$V_C - V_A$	—	—	I_N	V_N 1)
C, N	—	—	—	—	I_C	$V_A - V_B$	I_N	V_N 1)
A, B	I_A	$V_B - V_C$	I_B	$V_C - V_A$	—	—	—	—
B, C	—	—	I_B	$V_C - V_A$	I_C	$V_A - V_B$	—	—
AC	I_A	$V_B - V_C$	—	—	I_C	$V_A - V_B$	—	—
A, B, N	I_A	$V_B - V_C$	I_B	$V_C - V_A$	—	—	I_N	V_N 1)
B, C, N	—	—	I_B	$V_C - V_A$	I_C	$V_A - V_B$	I_N	V_N 1)
A, C, N	I_A	$V_B - V_C$	—	—	I_C	$V_A - V_B$	I_N	V_N 1)
A, B, C	I_A	$V_B - V_C$	I_B	$V_C - V_A$	I_C	$V_A - V_B$	—	—
A, B, C, N	I_A	$V_B - V_C$	I_B	$V_C - V_A$	I_C	$V_A - V_B$	I_N	V_N 1)

1) or $3 \cdot V_0 = |V_A + V_B + V_C|$, depending on the connection type of voltages

Direction Determination of Directional Phase Elements

As already mentioned, the direction determination is performed by determining the phase angle between the fault current and the reference voltage. In order to satisfy different network conditions and applications, the reference voltage can be rotated by an adjustable angle. In this way, the vector of the rotated reference voltage can be closely adjusted to the vector of the fault current in order to provide the best possible result for the direction determination. Figure 2-17 clearly shows the relationship for the directional phase element based on a single-phase ground fault in Phase A. The fault current I_{scA} follows the fault voltage by fault angle φ_{sc}. The reference voltage, in this case V_{BC} for the directional phase element A, is rotated by the setting value 1519 **ROTATION ANGLE**, positively counter-clockwise. In this case, a rotation by +45°.

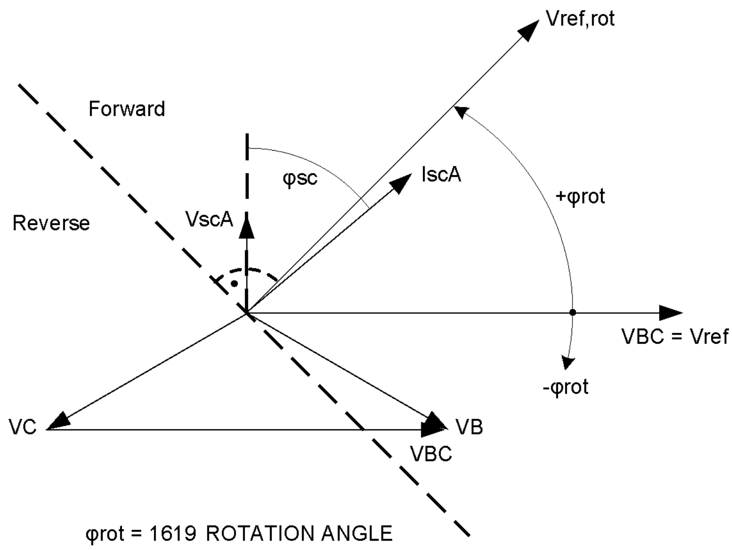


Figure 2-17 Rotation of the reference voltage, directional phase element

The rotated reference voltage defines the forward and reverse area, see Figure 2-18. The forward area is a range of ±86° around the rotated reference voltage $V_{ref,rot}$ If the vector of the fault current is in this area, the device detects forward direction. In the mirrored area, the device detects reverse direction. In the intermediate area, the direction result is undefined.

In a network, the vector of the fault current is usually in the forward or reverse area. If the vector moves out of one these areas, e.g. the forward area, in direction of the undefined area, it leaves the forward area at $V_{ref,rot}$ ±86° and reaches the undefined area. If the vector leaves the undefined area in direction of the forward area (or reverse area), a hysteresis of 2° is added. This hysteresis prevents chattering of the directional result. The current vector reaches the forward area at ±84° (= 86°-2° hysteresis).

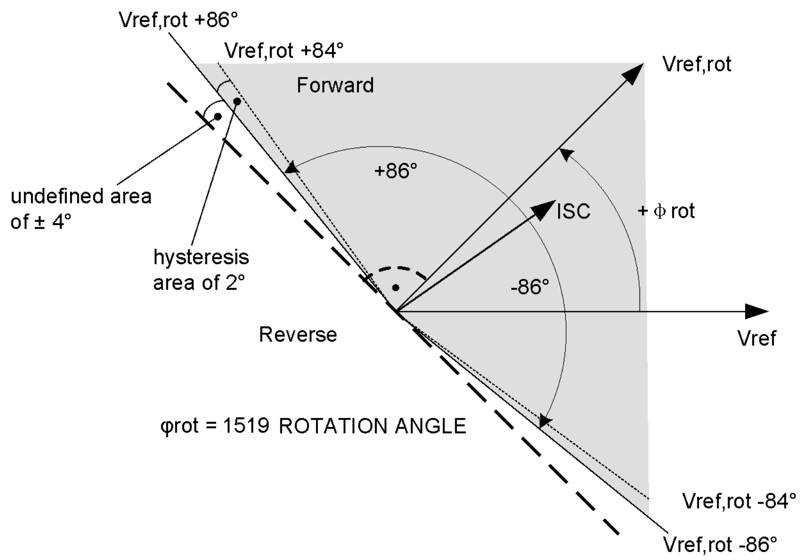


Figure 2-18 Forward characteristic of the directional function, directional phase element

Direction Determination of Directional Ground Element with Ground Values

Figure 2-19 shows the treatment of the reference voltage for the directional ground element, also based on a single-phase ground fault in phase A. Contrary to the directional phase elements, which work with the unfaulted voltage as reference voltage, the fault voltage itself is the reference voltage for the directional ground element. Depending on the connection of the voltage transformer, this is the voltage $3V_0$ (as shown in Figure 2-19) or V_N. The fault current $-3I_0$ is phase offset by 180° to the fault current I_{scA} and follows the fault voltage $3V_0$ by fault angle φ_{sc}. The reference voltage is rotated by the setting value 1619 **ROTATION ANGLE**. In this case, a rotation by -45°.

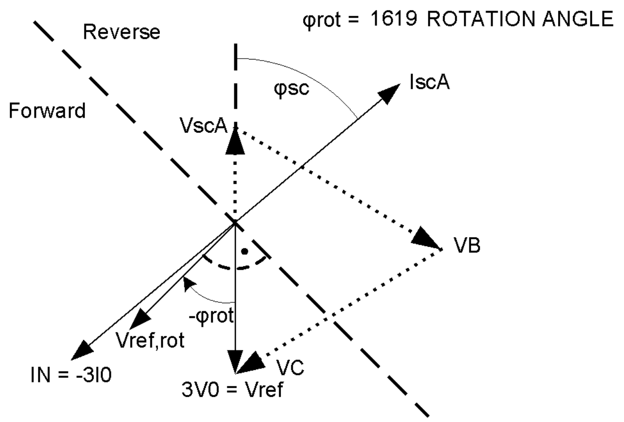


Figure 2-19 Rotation of the reference voltage, directional ground element with zero sequence values

The forward area is also a range of ±86° around the rotated reference voltage $V_{ref, rot}$. If the vector of the fault current $-3I_0$ (or I_N) is in this area, the device detects forward direction.

Direction Determination of Directional Ground Element with Negative Sequence Values

Figure 2-20 shows the treatment of the reference voltage for the directional ground element using the negative sequence values based on a single-phase ground fault in phase A. As reference voltage, the negative sequence voltage is used, as current for the direction determination, the negative sequence system in which the fault current is displayed. The fault current $-3I_2$ is in phase opposition to the fault current I_{scA} and follows the voltage $3V_2$ by the fault angle φ_{sc}. The reference voltage is rotated through the setting value 1619 **ROTATION ANGLE**. In this case, a rotation of -45°.

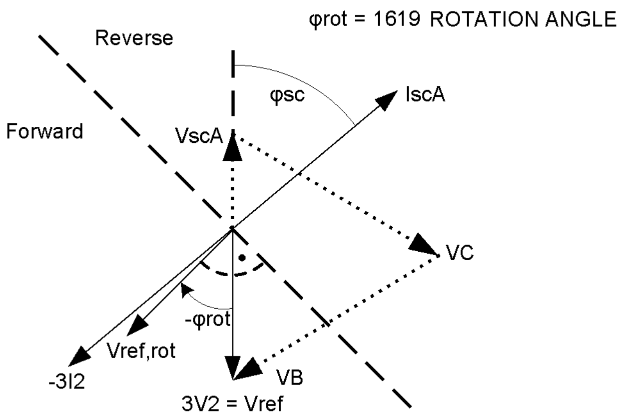


Figure 2-20 Rotation of the reference voltage, directional ground element with negative sequence values

The forward area is a range of ±86° around the rotated reference voltage $V_{ref, rot}$. If the vector of the negative sequence system current $-3I_2$ is in this area, the device detects forward direction.

2.3.7 Setting Notes

General

When selecting the directional time overcurrent protection in DIGSI, a dialog box appears with several tabs for setting the associated parameters. Depending on the functional scope specified during configuration of the protective functions in addresses 115 **67/67-TOC** and 116 **67N/67N-TOC**, the number of tabs can vary.

If **67/67-TOC** or **67N/67N-TOC** = ***Definite Time*** is set, the settings for the definite-time elements are available.

At address 1501 **FCT 67/67-TOC**, directional phase overcurrent protection may be switched ***ON*** or ***OFF***.

Pickup values and time delays for ground protection can be set separately from those for phase protection. Because of this, an independent grading for ground faults is often possible with shorter times and more sensitive settings. Thus, at address 1601 **FCT 67N/67N-TOC**, the directional ground current element may be switched ***ON*** or ***OFF*** independent of the overcurrent protection for phase currents.

Depending on the parameter 613 **Gnd O/Cprot. w.**, the device can operate using either measured values IN or the quantities 3I0 calculated from the three phase currents.

The directional orientation of the function is influenced by parameter 201 **CT Starpoint** (see Chapter 2.1.3).

Measurement Methods

The comparison values to be used for the respective element can be set in the setting sheets for the elements.

- Measurement of the **Fundamental Harmonic** (standard method):

  This measurement method processes the sampled values of the current and filters in numerical order the fundamental harmonic so that the higher harmonics or transient peak currents are rejected.

- Measurement of the **True RMS Value**

  The current amplitude is derived from the sampled value in accordance with the definition equation of the true RMS value. This measurement method should be selected when higher harmonics are to be considered by the function (e.g. in capacitor bank).

The type of reference values can be set at the following addresses:

67-2 Element	Address 1520 **67-2 MEASUREM.**
67-1 Element	Address 1521 **67-1 MEASUREM.**
67N-2 Element	Address 1620 **67N-2 MEASUREM.**
67N-1 Element	Address 1621 **67N-1 MEASUREM.**

Direction Characteristic

The direction characteristic, i.e. the position of the ranges „forward“ and „reverse“ is set for the phase directional elements under address 1519 **ROTATION ANGLE** and for the ground directional element under address 1619 **ROTATION ANGLE**. The short-circuit angle is generally inductive in a range of 30° to 60°. This means that usually the default settings of +45° for the phase directional elements and -45° for the ground directional element can be maintained for the adjustment of the reference voltage, as they guarantee a safe direction result.

Nevertheless, the following contains some setting examples for special applications (Table 2-6). The following must be observed: With the phase directional elements, the reference voltage (fault-free voltage) for phase-ground-faults is vertical on the short-circuit voltage. For this reason, the resulting setting of the angle of rotation is (see also Section 2.3.8):

Ref. volt. angle of rotation = 90 - φ_k Phase directional element (phase-to-ground fault).

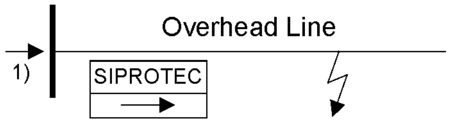
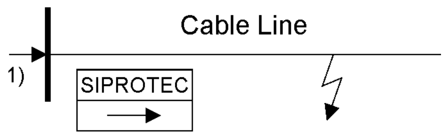
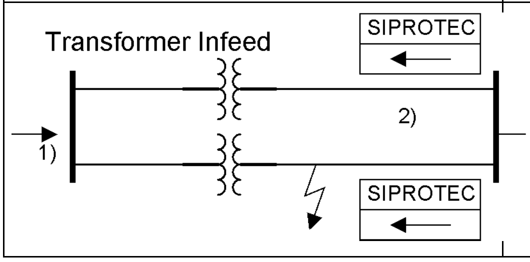
With the ground directional element, the reference voltage is the short-circuit voltage itself. The resulting setting of the angle of rotation is then:

Ref. volt. angle of rotation = -φ_k Directional ground element (phase-to-ground fault).

It should also be noted for phase directional elements that with phase-to-phase faults, the reference voltage is rotated between 0° (remote fault) and 30° (close-up fault) depending on the collapse of the faulty voltage. This can be taken into account with a mean value of 15°:

Ref. volt. angle of rotation = 90 - φ_k -15° Phase directional element (phase-to-phase fault).

Table 2-6 Setting examples

Application	**φ_{sc} typical**	**Setting** **Directional Phase Element** **1519 ROTATION ANGLE**	**Setting** **Directional Ground Element** **1619 ROTATION ANGLE**
	60°	Range 30°..0.0° → 15°	–60°
	30°	Range 60°...30° → 45°	–30°
	30°	Range 60°...30° → 45°	–30°

1) Power flow direction

2) With the assumption that these are cable lines

Directional Orientation

The directional orientation can be changed for the directional phase elements at address 1516 **67 Direction** and for the directional ground element at address 1616 **67N Direction**, to either ***Forward*** or ***Reverse*** or ***Non-Directional***. Directional overcurrent protection normally operates in the direction of the protected object (line, transformer).

Note

When the 67-1 Element or the 67N-1 Element picks up, the phase-specific directional indications „forward" or „reverse" are generated (indications 2628 to 2636).

Pickup of the 67-2 Element or the 67N-2 Element lies within the parameterized directional range without directional indication.

Quantity Selection for Direction Determination for the Directional Ground Element

Parameter 1617 **67N POLARIZAT.** can be set to specify whether direction determination is accomplished from the zero sequence quantities or ground quantities (***with VN and IN***) or from the negative sequence quantities (***with V2 and I2***). The first option is the preferential setting, the latter is to be selected in case of danger that the zero voltage be too small due to unfavorable zero impedance or that a parallel line influences the zero system.

Note

If parameter 213 **VT Connect. 3ph** is set to ***Vab, Vbc*** the direction is always determined using the negative sequence values V2/I2. For these voltage connection types, the zero sequence voltage (VN or 3V0) is not available.

67-2 Directional High-set Element (phases)

The pickup and delay of element **67-2** are set at addresses 1502 and 1503. For setting, the same considerations apply as did for the non-directional time overcurrent protection in Section 2.2.6.

The selected time is only an additional time delay and does not include the operating time (measuring time, dropout time). The delay can be set to ∞. After pickup the Element will then not trip. Pickup, however, will be signaled. If the 67-2 Element is not required at all, the pickup value **67-2 PICKUP** should be set to ∞. For this setting, there is neither a pickup signal generated nor a trip.

67N-2 Directional High-set Element (Ground)

The pickup and delay of element **67N-2** are set at addresses 1602 and 1603. The same considerations apply for these settings as did for phase currents discussed earlier.

The selected time is only an additional time delay and does not include the operating time (measuring time, dropout time). The delay can be set to ∞. After pickup the Element will then not trip. Pickup, however, will be signaled. If the 67N-2 Element is not required at all, then the pickup value **67N-2 PICKUP** should be set to ∞. This setting prevents from tripping and the generation of a pickup message.

67-1 Directional Overcurrent Element (phases)

The maximum appearing load current is very important for the setting of the overcurrent element 1504 **67-1 PICKUP**. Pickup due to overload must never occur since in this mode, the device operates as fault protection with correspondingly short tripping times and not as overload protection. For this reason, lines are set to approx. 20 % above the maximum expected (over)load and transformers to approx. 40 %.

If the relay is used to protect transformers with large inrush currents, the inrush restraint feature of 7SC80 may be used for the **67-1 PICKUP** element (for more information, see margin heading "Inrush Restraint").

The delay for directional Elements (address 1505 **67-1 DELAY**) is usually set shorter than the delay for non-directional Elements (address 1205) since the non-directional Elements overlap the directional elements as backup protection. It should be based on the system coordination requirements for directional tripping.

For parallel transformers supplied from a single source (see "Applications"), the delay of elements **67-1 DELAY** located on the load side of the transformers may be set to 0 without provoking negative impacts on selectivity.

The selected time is only an additional time delay and does not include the operating time (measuring time, dropout time). The delay can be set to ∞. After pickup the Element will then not trip. Pickup, however, will be signaled. If the 67-1 Element is not required at all, the pickup value **67-1 PICKUP** should be set to ∞. This setting prevents from tripping and the generation of a pickup message.

67N-1 Directional Relay Element (ground)

The pickup value of the **67N-1** relay element should be set below the minimum anticipated ground fault current.

If you expect large inrush currents when using the protection device on transformers, the inrush restraint feature of 7SC80 may be used for the **67N-1 PICKUP** element (for more information, see margin heading "Inrush Restraint").

The delay is set at address 1605 **67N-1 DELAY** and should be based on system coordination requirements for directional tripping. For ground currents in a grounded system a separate coordination chart with short time delays is often used.

The selected time is only an additional time delay and does not include the operating time (measuring time, dropout time). The delay can be set to ∞. After pickup the Element will then not trip. Pickup, however, will be signaled. If the 67N-1 Element is not required at all, the pickup value **67N-1 PICKUP** should be set to ∞. This setting prevents from tripping and the generation of a pickup message.

Pickup Stabilization (67/67N Directional)

The pickups can also be stabilized via parameterizable dropout times under address 1518 **67 T DROP-OUT** or 1618 **67N T DROP-OUT**.

Inrush Restraint

If you expect large inrush currents when using the protection device on transformers, the inrush restraint feature of 7SC80 can be used for the directional overcurrent elements **67-1 PICKUP** and **67N-1 PICKUP** as well as for the non-directional overcurrent elements. The inrush restraint option is enabled or disabled at 2201 **INRUSH REST.** (in the settings option **non-directional** overcurrent protection). The characteristic values of the inrush restraint are already listed in the section discussing the non-directional overcurrent protection (Section 2.2.6).

Manual Close Mode (phases, ground)

When a circuit breaker is closed onto a faulted line, a high speed trip by the circuit breaker is often desired. For overcurrent or high-set Element the delay may be bypassed via a Manual Close pulse, thus resulting in instantaneous tripping. This pulse is prolonged by at least 300 ms. To enable the device to react properly on occurrence of a fault in the phase elements after manual close, address 1513 **MANUAL CLOSE** has to be set accordingly. Accordingly, address 1613 **MANUAL CLOSE** is considered for the ground path address. Thus, the user determines for both elements, the phase and the ground element, what pickup value is active with what delay when the circuit breaker is closed manually.

External Control Switch

If the manual close signal is not from the 7SC80 device, that is, neither sent via the built-in operator interface nor via a serial port but directly from a control acknowledgment switch, this signal must be passed to a 7SC80 binary input, and configured accordingly („>Manual Close“), so that the Element selected for **MANUAL CLOSE** can become effective. ***Inactive*** means that all Elements (phase and ground) operate with the configured trip times even with manual close.

Internal Control Function

The manual closing information must be allocated via CFC (interlocking task-level) using the CMD_Information block, if the internal control function is used.

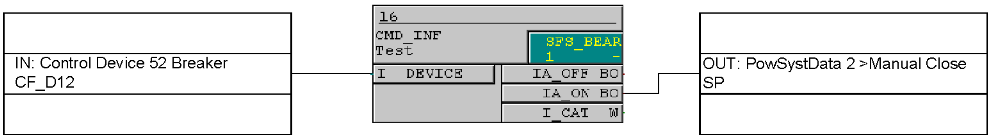


Figure 2-21 Example for the generation of a manual close signal using the internal control function

2.3.8 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1501	FCT 67/67-TOC		OFF ON	OFF	67, 67-TOC Phase Time Overcurrent
1502	67-2 PICKUP	1A	0.10 .. 35.00 A; ∞	2.00 A	67-2 Pickup
		5A	0.50 .. 175.00 A; ∞	10.00 A	
1503	67-2 DELAY		0.00 .. 60.00 sec; ∞	0.10 sec	67-2 Time Delay
1504	67-1 PICKUP	1A	0.10 .. 35.00 A; ∞	1.00 A	67-1 Pickup
		5A	0.50 .. 175.00 A; ∞	5.00 A	
1505	67-1 DELAY		0.00 .. 60.00 sec; ∞	0.50 sec	67-1Time Delay
1513A	MANUAL CLOSE		67-2 instant. 67-1 instant. Inactive	67-2 instant.	Manual Close Mode
1514A	67-2 active		always	always	67-2 active
1516	67 Direction		Forward Reverse Non-Directional	Forward	Phase Direction
1518A	67 T DROP-OUT		0.00 .. 60.00 sec	0.00 sec	67 Drop-Out Time Delay
1519A	ROTATION ANGLE		-180 .. 180 °	45 °	Rotation Angle of Reference Voltage
1520A	67-2 MEASUREM.		Fundamental True RMS	Fundamental	67-2 measurement of
1521A	67-1 MEASUREM.		Fundamental True RMS	Fundamental	67-1 measurement of
1601	FCT 67N/67N-TOC		OFF ON	OFF	67N, 67N-TOC Ground Time Overcurrent
1602	67N-2 PICKUP	1A	0.05 .. 35.00 A; ∞	0.50 A	67N-2 Pickup
		5A	0.25 .. 175.00 A; ∞	2.50 A	
1603	67N-2 DELAY		0.00 .. 60.00 sec; ∞	0.10 sec	67N-2 Time Delay

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1604	67N-1 PICKUP	1A	0.05 .. 35.00 A; ∞	0.20 A	67N-1 Pickup
		5A	0.25 .. 175.00 A; ∞	1.00 A	
1605	67N-1 DELAY		0.00 .. 60.00 sec; ∞	0.50 sec	67N-1 Time Delay
1613A	MANUAL CLOSE		67N-2 instant. 67N-1 instant. Inactive	67N-2 instant.	Manual Close Mode
1614A	67N-2 active		always	always	67N-2 active
1616	67N Direction		Forward Reverse Non-Directional	Forward	Ground Direction
1617	67N POLARIZAT.		with VN and IN with V2 and I2	with VN and IN	Ground Polarization
1618A	67N T DROP-OUT		0.00 .. 60.00 sec	0.00 sec	67N Drop-Out Time Delay
1619A	ROTATION ANGLE		-180 .. 180 °	-45 °	Rotation Angle of Reference Voltage
1620A	67N-2 MEASUREM.		Fundamental True RMS	Fundamental	67N-2 measurement of
1621A	67N-1 MEASUREM.		Fundamental True RMS	Fundamental	67N-1 measurement of

2.3.9 Information List

No.	Information	Type of Information	Comments
2604	>BLK 67/67-TOC	SP	>BLOCK 67/67-TOC
2614	>BLK 67N/67NTOC	SP	>BLOCK 67N/67N-TOC
2615	>BLOCK 67-2	SP	>BLOCK 67-2
2616	>BLOCK 67N-2	SP	>BLOCK 67N-2
2621	>BLOCK 67-1	SP	>BLOCK 67-1
2623	>BLOCK 67N-1	SP	>BLOCK 67N-1
2628	Phase A forward	OUT	Phase A forward
2629	Phase B forward	OUT	Phase B forward
2630	Phase C forward	OUT	Phase C forward
2632	Phase A reverse	OUT	Phase A reverse
2633	Phase B reverse	OUT	Phase B reverse
2634	Phase C reverse	OUT	Phase C reverse
2635	Ground forward	OUT	Ground forward
2636	Ground reverse	OUT	Ground reverse
2637	67-1 BLOCKED	OUT	67-1 is BLOCKED
2642	67-2 picked up	OUT	67-2 picked up
2646	67N-2 picked up	OUT	67N-2 picked up
2647	67-2 Time Out	OUT	67-2 Time Out
2648	67N-2 Time Out	OUT	67N-2 Time Out
2649	67-2 TRIP	OUT	67-2 TRIP
2651	67/67-TOC OFF	OUT	67/67-TOC switched OFF
2652	67 BLOCKED	OUT	67/67-TOC is BLOCKED
2653	67 ACTIVE	OUT	67/67-TOC is ACTIVE
2655	67-2 BLOCKED	OUT	67-2 is BLOCKED
2656	67N OFF	OUT	67N/67N-TOC switched OFF
2657	67N BLOCKED	OUT	67N/67N-TOC is BLOCKED
2658	67N ACTIVE	OUT	67N/67N-TOC is ACTIVE
2659	67N-1 BLOCKED	OUT	67N-1 is BLOCKED
2660	67-1 picked up	OUT	67-1 picked up
2664	67-1 Time Out	OUT	67-1 Time Out
2665	67-1 TRIP	OUT	67-1 TRIP
2668	67N-2 BLOCKED	OUT	67N-2 is BLOCKED
2679	67N-2 TRIP	OUT	67N-2 TRIP
2681	67N-1 picked up	OUT	67N-1 picked up
2682	67N-1 Time Out	OUT	67N-1 Time Out
2683	67N-1 TRIP	OUT	67N-1 TRIP
2691	67/67N pickedup	OUT	67/67N picked up
2692	67 A picked up	OUT	67/67-TOC Phase A picked up
2693	67 B picked up	OUT	67/67-TOC Phase B picked up
2694	67 C picked up	OUT	67/67-TOC Phase C picked up
2695	67N picked up	OUT	67N/67N-TOC picked up
2696	67/67N TRIP	OUT	67/67N TRIP

2.4 Voltage Protection 27, 59

Voltage protection has the task to protect electrical equipment against undervoltage and overvoltage. Both operational states are abnormal as overvoltage may cause for example insulation problems or undervoltage may cause stability problems.

There are two elements each available for overvoltage protection and undervoltage protection. The pickup voltages and time delays can be set per element or phase-specifically.

Applications

- Higher voltages often occur, e.g. on long transmission lines under low load conditions.
- The undervoltage protection function detects voltage dips on transmission lines and prevents inadmissible operating states and a possible loss of stability.

2.4.1 Measurement Principle

Connection/Measured Values

The voltages supplied to the device can be either the three phase-to-ground voltages V_{A-N}, V_{B-N}, V_{C-N} or two phase-to-phase voltages (V_{A-B}, V_{B-C}), and the displacement voltage (ground voltage V_N). The connection type has been specified during the configuration in parameter 213 **VT Connect. 3ph** (see 2.1.3.2).

The following table indicates which voltages can be evaluated by the function. The settings for this are made in the **P.System Data 1** (see Section 2.1.3.2). Furthermore, it is indicated to which value the threshold must be set. All voltages are fundamental frequency values.

Table 2-7 Voltage Protection, Selectable Voltages

Function	Three-phase connection (parameter 213)	Selectable voltage (parameter 614/615)	Threshold to be set as
Overvoltage	Van, Vbn, Vcn	Vphph (largest phase-to-phase voltage)	Phase-to-phase voltage
		Vph-n (largest phase-to-ground voltage)	Phase-to-ground voltage
		V1 (positive sequence voltage)	Positive sequence voltage calculated from phase-to-ground voltage or phase-to-phase voltage / $\sqrt{3}$
		V2 (negative sequence voltage)	Negative sequence voltage
		Vphph selective (phase-specific phase-to-phase voltage)	Phase-specific phase-to-phase pickup voltage
		Vph-n selective (phase-specific phase-to-ground voltage)	Phase-specific phase-to-ground pickup voltage
	Vab, Vbc, VGnd Vab, Vbc	Vphph (largest phase-to-phase voltage)	Phase-to-phase voltage
		V1 (positive sequence voltage)	Positive sequence voltage
		V2 (negative sequence voltage)	Negative sequence voltage
		Vphph selective	Phase-specific phase-to-phase pickup voltage
Undervoltage	Van, Vbn, Vcn	Vphph (smallest phase-to-phase voltage)	Phase-to-phase voltage
		Vph-n (smallest phase-to-ground voltage)	Phase-to-ground voltage
		V1 (positive sequence voltage)	Positive sequence voltage · $\sqrt{3}$
		Vphph selective (phase-specific phase-to-phase voltage)	Phase-specific phase-to-phase pickup voltage
		Vph-n selective (phase-specific phase-to-ground voltage)	Phase-specific phase-to-ground pickup voltage
	Vab, Vbc, VGnd Vab, Vbc	Vphph (smallest phase-to-phase voltage)	Phase-to-phase voltage
		V1 (positive sequence voltage)	Positive sequence voltage · $\sqrt{3}$
		Vphph selective (phase-specific phase-to-phase voltage)	Phase-specific phase-to-phase pickup voltage

The positive and negative sequence voltages stated in the table are calculated from the phase-to-ground voltages.

Current Criterion

Depending on the system, the primary voltage transformers are arranged either on the supply side or the load side of the associated circuit breaker. These different arrangements lead to different behaviour of the voltage protection function when a fault occurs. When a tripping command is issued and a circuit breaker is opened, full voltage remains on the supply side while the load side voltage becomes zero. When voltage supply is suppressed, undervoltage protection, for instance, will remain picked up. If pickup is to drop out, the current can be used as an additional criterion for pickup of undervoltage protection (current supervision CS). Undervoltage pickup can only be maintained when the undervoltage criterion satisfied and a settable minimum current level (**BkrClosed I MIN**) are exceeded. Here, the largest of the three phase currents is used. When the current decreases below the minimum current setting after the circuit breaker has opened, undervoltage protection drops out.

Note

If parameter **CURRENT SUPERV.** is set to disabled in address 5120, the device picks up immediately without measurement voltage and the undervoltage protection function in pickup. Apply measuring voltage or block the voltage protection to continue with configuration. Moreover you have the option of setting a flag via device operation for blocking the voltage protection. This initiates the reset of the pickup and device configuration can be resumed.

2.4.2 Overvoltage Protection 59

Function

The overvoltage protection has two elements. In case of a high overvoltage, tripping switch off is performed with a short-time delay, whereas in case of less severe overvoltages, the tripping is performed with a longer time delay. When one of the adjustable settings is exceeded, the 59 element picks up and trips after an adjustable time delay has elapsed. The time delay is not dependent on the magnitude of the overvoltage.

The dropout ratio for the two overvoltage elements (= $V_{dropout\ value}/V_{pickup\ value}$) can be set.

The pickup voltages and time delays can also be set phase-specifically.

The following figure shows the logic diagram of the overvoltage protection function.

The logic diagram also applies for overvoltage protection which can be set phase-specifically (***Vphph selective*** or ***Vph-n selective***). The thresholds and time delays are to be replaced with the phase-specific values.

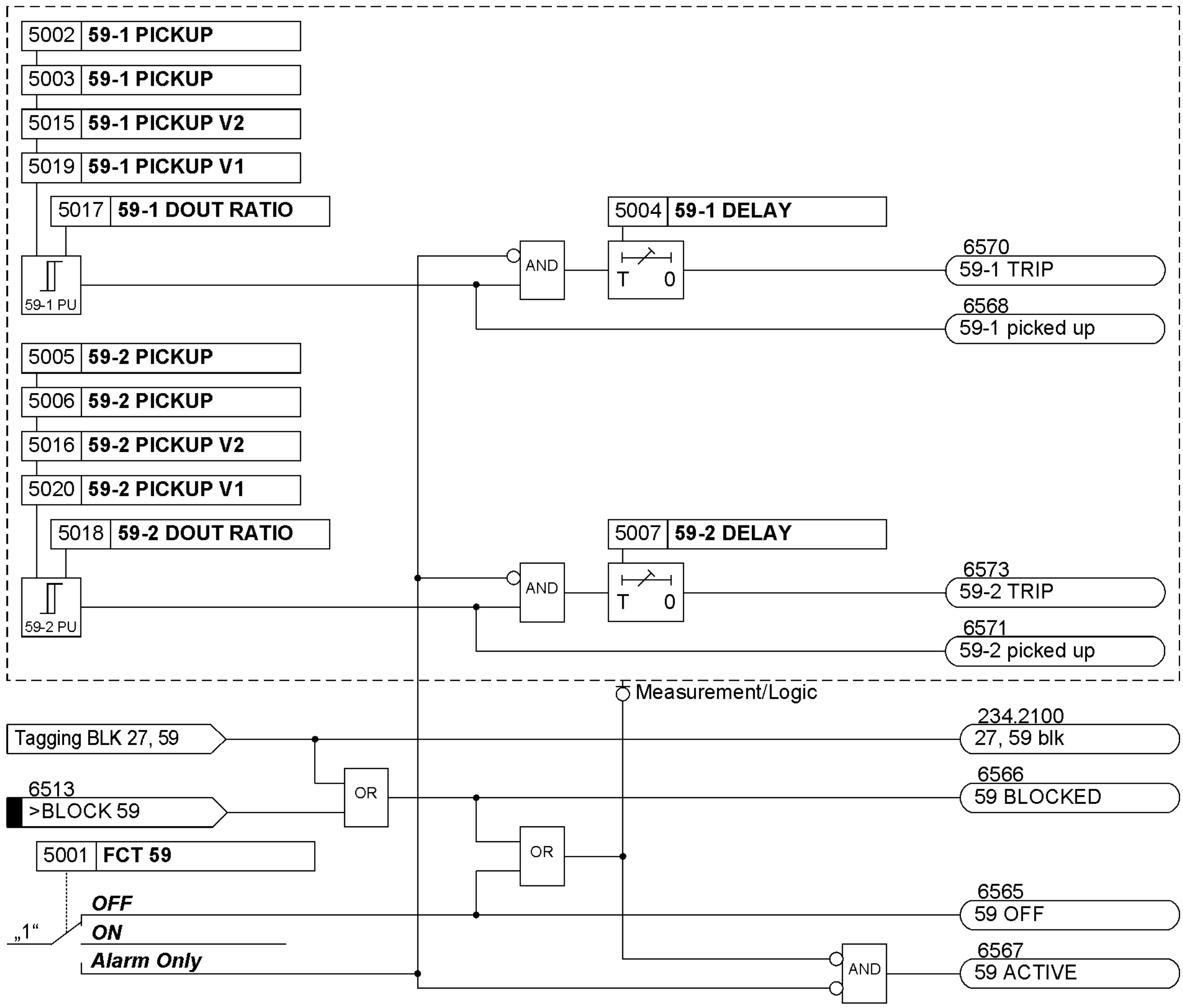


Figure 2-22 Logic diagram of the overvoltage protection

2.4.3 Undervoltage Protection 27

Function

Undervoltage protection consists of two definite time elements (**27-1 PICKUP** and **27-2 PICKUP**). Therefore, tripping can be time-coordinated depending on how severe voltage collapses are. Voltage thresholds and time delays can be set individually for both elements.

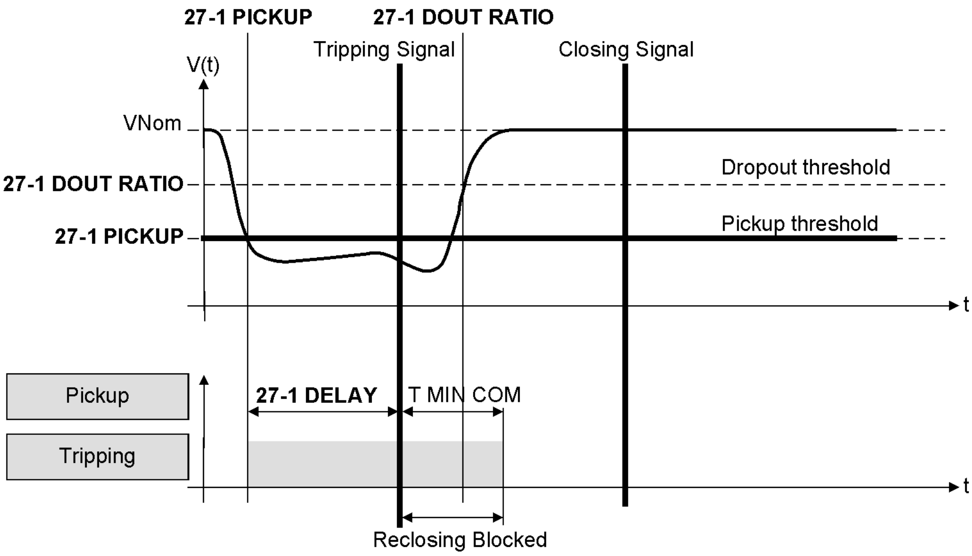
The pickup voltages and time delays can also be set phase-specifically.

The dropout ratio for the two undervoltage elements (= $V_{dropout\ value}/V_{pickup\ value}$) can be set.

Undervoltage protection works in an expanded frequency range. The RMS value of the positive voltage component is considered too small when the frequency deviates considerably so that the device tends to overfunction. If you expect applications in which the frequency range of f_{Nom} ± 10 % will be exceeded, the current criterion will not return a correct result and must be switched off.

Figure 2-23 shows a typical voltage profile during a fault for source side connection of the voltage transformers. Because full voltage is present after the circuit breaker has been opened, current supervision CS described above is not necessary in this case. After the voltage has dropped below the pickup setting, tripping is initiated after time delay **27-1 DELAY**. As long as the voltage remains below the dropout setting, reclosing is blocked.

Only after the fault has been cleared, i.e. when the voltage increases above the dropout level, the element drops out and allows reclosing of the circuit breaker.



T MIN COM = Minimum Command Line

Figure 2-23 Typical fault profile for source side connection of the voltage transformer (without current supervision)

Figure 2-24 shows a fault profile for a load side connection of the voltage transformers. When the circuit breaker is open, the voltage disappears (the voltage remains below the pickup setting), and current supervision is used to ensure that pickup drops out after the circuit breaker has opened (**BkrClosed I MIN**).

After the voltage has dropped below the pickup setting, tripping is initiated after time delay **27-1 DELAY**. When the circuit breaker opens, voltage decreases to zero and undervoltage pickup is maintained. The current value also decreases to zero so that current criterion is reset as soon as the release threshold (**BkrClosed I MIN**) is exceeded. Pickup of the protection function is also reset by the action of the AND-combination of voltage and current. As a consequence, energization is admitted anew when the minimum command time elapsed.

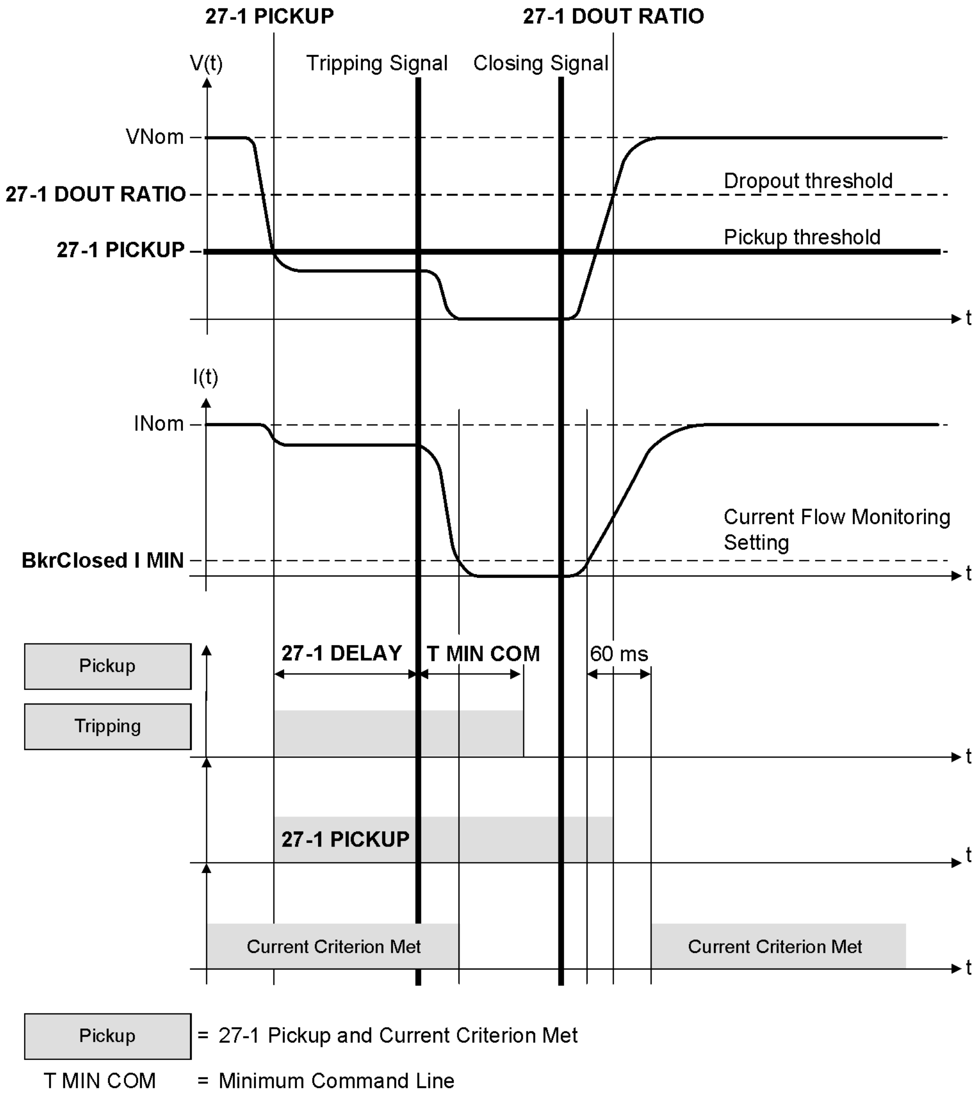


Figure 2-24 Typical fault profile for load side connection of the voltage transformers (with current supervision)

Upon the closing of the circuit breaker, current criterion is delayed for a short period of time. If the voltage criterion drops out during this time period (about 60 ms), the protection function does not pick up. Therefore no fault record is created when voltage protection is activated in a healthy system. It is important to understand, however, that if a low voltage condition exists on the load after the circuit breaker is closed (unlike Figure 2-24), the desired pickup of the element will be delayed by 60 ms.

The following figure shows the logic diagram of the undervoltage protection function.

The logic diagram also applies for undervoltage protection which can be set phase-specifically (***Vphph selective*** or ***Vph-n selective***). The thresholds and time delays are to be replaced with the phase-specific values.

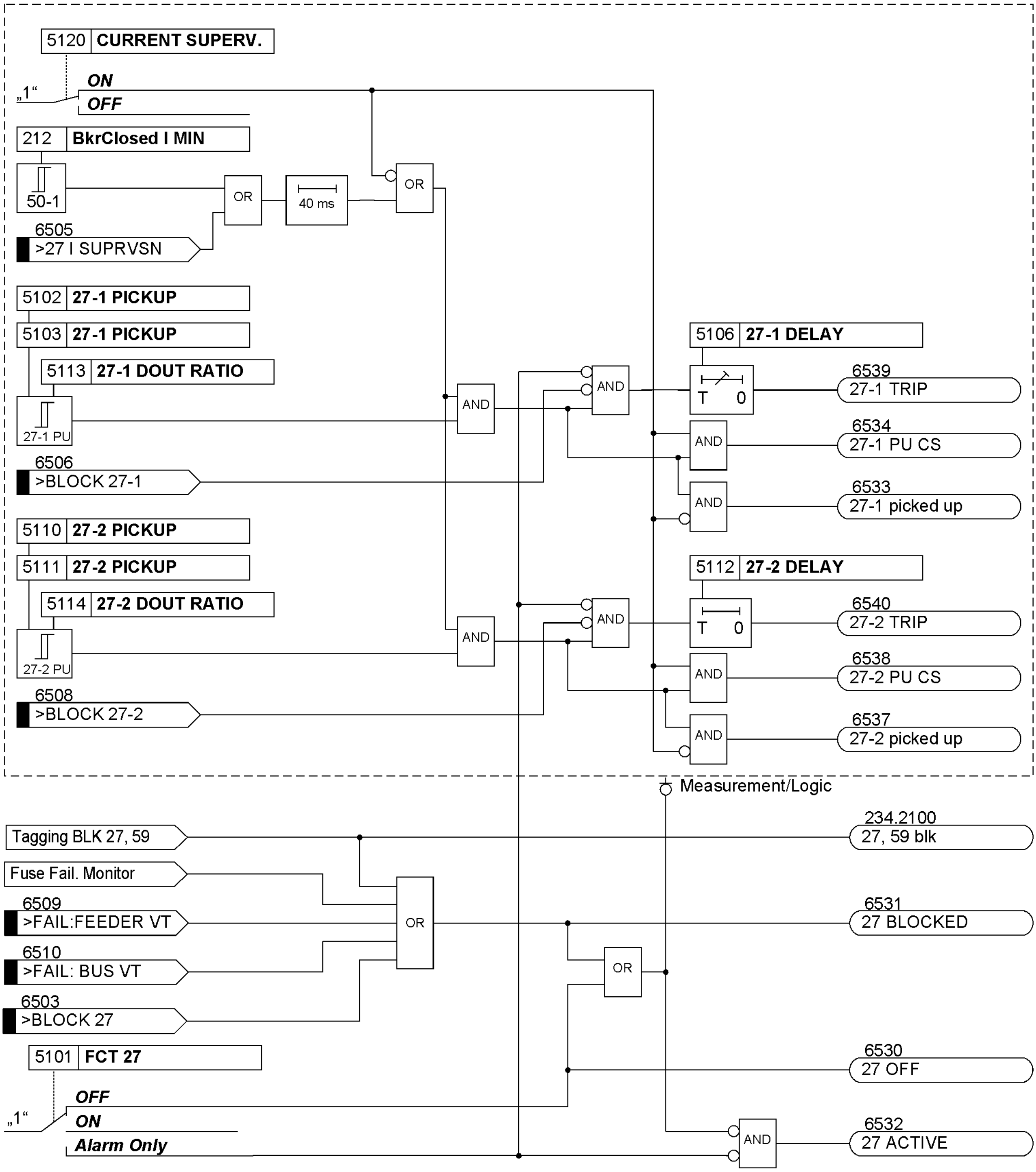


Figure 2-25 Logic diagram of the undervoltage protection

2.4.4 Setting Notes

General

Voltage protection is only effective and accessible if address 150 **27/59** is set to ***Enabled*** during configuration of protection functions. If this function is not required, then ***Disabled*** is set.

The voltage to be evaluated is selected in **Power System Data 1** (see Chapter 2.4, Table 2-7).

Overvoltage protection can be turned ***ON*** or ***OFF***, or set to ***Alarm Only*** at address 5001 **FCT 59**.

Undervoltage protection can be turned ***ON*** or ***OFF*** or set to ***Alarm Only*** at address 5101 **FCT 27**.

With the protection function ***ON***, tripping, the clearing of a fault and fault recording are initiated when the thresholds are exceeded and the set time delays have expired.

When setting ***Alarm Only***, no trip command is given, no trip log is initiated, and no spontaneous fault indication is issued.

Overvoltage Protection with Phase-to-phase or Phase-to-ground Voltages

The largest of the applied voltages is evaluated for the phase-to-phase or phase-to-ground overvoltage protection.

The threshold values are set in the value to be evaluated (see Chapter 2.4, Table 2-7).

The overvoltage protection has two elements. The pickup value of the lower threshold (address 5002 or 5003, **59-1 PICKUP**, depending on the phase-to-ground or the phase-to-phase voltages, can be assigned a longer time delay (address 5004, **59-1 DELAY**) and the upper threshold Element (address 5005 or 5006, **59-2 PICKUP**) a shorter (address 5007, **59-2 DELAY**) time delay. There are no specific procedures on how the pickup values are set. However, as the function is mainly used to prevent high insulation damage to system components and users, the threshold value 5002 , 5003 **59-1 PICKUP** lies generally between 110 % and 115 % of the nominal voltage and setting value 5005 , 5006 **59-2 PICKUP** at approximately 130 %.

The time delays of the overvoltage elements are entered at addresses 5004 **59-1 DELAY** and 5007 **59-2 DELAY**, and should be selected in such manner that they make allowance for brief voltage peaks that are generated during switching operations and also enable clearance of stationary overvoltages in due time.

The choice between phase-to-ground and phase-to-phase voltage allows voltage asymmetries (e.g. caused by a ground fault) to be taken into account (phase-to-ground) or to remain unconsidered (phase-to-phase) during evaluation.

Overvoltage Protection - Positive Sequence System V1

In a three-phase voltage transformer connection the positive sequence system can be evaluated for the overvoltage protection by means of configuring parameter 614 **OP. QUANTITY 59** to ***V1***. In this case, the threshold values of the overvoltage protection must be set in parameters 5019 **59-1 PICKUP V1** or 5020 **59-2 PICKUP V1**.

Overvoltage Protection - Negative Sequence System V2

In a three-phase transformer connection, parameter 614 **OP. QUANTITY 59** can determine that the negative sequence system ***V2*** can be evaluated as a measured value for the overvoltage protection. The negative sequence system detects voltage unbalance and can be used for the stabilization of the time overcurrent protection. In backup protection of transformers or generators, the fault currents lie, in some cases, only slightly above the load currents. In order to obtain a pickup threshold of the time overcurrent protection that is as sensitive as possible, its stabilization via the voltage protection is necessary to avoid false tripping.

Overvoltage protection comprises two elements. Thus, with configuration of the negative system, a longer time delay (address 5004, **59-1 DELAY**) may be assigned to the lower Element (address 5015, **59-1 PICKUP V2** and a shorter time delay (address 5007, **59-2 DELAY**) may be assigned to the upper Element (address 5016, **59-2 PICKUP V2**). There are not clear cut procedures on how to set the pickup values **59-1 PICKUP V2** or **59-2 PICKUP V2** as they depend on the respective station configuration.

The time delays of the overvoltage elements are entered at addresses 5004 **59-1 DELAY** and 5007 **59-2 DELAY**, and should be selected in such manner that they make allowance for brief voltage peaks that are generated during switching operations and also enable clearance of stationary overvoltages in due time.

Dropout Threshold of the Overvoltage Protection

The dropout thresholds of the 59-1 Element and the 59-2 Element can be configured via the dropout ratio $r = V_{Dropout}/V_{Pickup}$ at addresses 5017 **59-1 DOUT RATIO** or 5018 **59-2 DOUT RATIO**. The following marginal condition applies to r:

r · (configured pickup threshold) ≤ 150 V with connection of phase-to-phase voltages and phase-to-ground voltages or

r · (configured pickup threshold) ≤ 260 V with calculation of the measured values from the connected voltages (e.g. phase-to-phase voltages calculated from the connected phase-to-ground voltages).

The minimum hysteresis is 0.6 V.

Phase-specific Pickup Voltages Overvoltage Protection

The phase-specific pickup voltages of the two overvoltage protection elements are set at the following addresses:

59-1 PhA Pickup	Address 5030 or 5031
59-1 PhB Pickup	Address 5032 or 5033
59-1 PhC Pickup	Address 5034 or 5035
59-2 PhA Pickup	Address 5036 or 5037
59-2 PhB Pickup	Address 5038 or 5039
59-2 PhC Pickup	Address 5040 or 5041

The selectable voltage range depends on the type of connection phase-to-phase voltage or phase-to-ground voltage (parameter 213).

Phase-specific Time Delays Overvoltage Protection

The phase-specific times for tripping delay of the two overvoltage protection elements are set at the following addresses:

59-1 PhA Delay	Address 5042
59-1 PhB Delay	Address 5043
59-1 PhC Delay	Address 5044
59-2 PhA Delay	Address 5045
59-2 PhB Delay	Address 5046
59-2 PhC Delay	Address 5047

Undervoltage Protection - Positive Sequence System V1

The positive sequence component (***V1***) can be evaluated for the undervoltage protection. Especially in case of stability problems, their acquisition is advantageous because the positive sequence system is relevant for the limit of the stable energy transmission. Concerning the pickup values there are no specific notes on how to set them. However, because the undervoltage protection function is primarily intended to protect induction machines from voltage dips and to prevent stability problems, the pickup values will usually be between 60% and 85 % of the nominal voltage.

The threshold value is multiplied as positive sequence voltage and set to $\sqrt{3}$, thus realizing the reference to the nominal voltage.

Undervoltage protection comprises two elements. The pickup value of the lower threshold is set at address 5110 or 5111, **27-2 PICKUP** (depending on the voltage transformer connection, phase-to-ground or phase-to-phase), while time delay is set at address 5112, **27-2 DELAY** (short time delay). The pickup value of the upper Element is set at address 5102 or 5103, **27-1 PICKUP**, while the time delay is set at address 5106, **27-1 DELAY** (a somewhat longer time delay). Setting these elements in this way allows the undervoltage protection function to closely follow the stability behavior of the system.

The time settings should be selected such that tripping occurs in response to voltage dips that lead to unstable operating conditions. On the other hand, the time delay should be long enough to avoid tripping on short-term voltage dips.

Undervoltage Protection with Phase-to-phase or Phase-to-ground Voltages

In parameter 615 **OP. QUANTITY 27** you can determine for undervoltage protection in a three-phase connection that instead of the positive-sequence system ***V1***, the smallest of the phase-to-phase voltages ***Vphph*** or the smallest phase-to-ground voltage ***Vph-n*** is configured as a measured quantity. The threshold values are set in the quantity to be evaluated (see Section 2.4, table 2-7).

Undervoltage protection comprises two elements. The pickup value of the lower threshold is set at address 5110 or 5111, **27-2 PICKUP** (depending on the voltage transformer connection, phase-to-ground or phase-to-phase), while time delay is set at address 5112, **27-2 DELAY** (short time delay). The pickup value of the upper Element is set at address 5102 or 5103, **27-1 PICKUP**, while the time delay is set at address 5106, **27-1 DELAY** (a somewhat longer time delay). Setting these elements in this way allows the undervoltage protection function to closely follow the stability behavior of the system.

The time settings should be selected such that tripping occurs in response to voltage dips that lead to unstable operating conditions. On the other hand, the time delay should be long enough to avoid tripping on short-term voltage dips.

Dropout Threshold of the Undervoltage Protection

The dropout thresholds of the 27-1 and the 27-2 element can be configured via the dropout ratio $r = V_{dropout}/V_{pickup}$ (5113 **27-1 DOUT RATIO** or 5114 **27-2 DOUT RATIO**). The following marginal condition applies to r:

r · (configured pickup threshold) ≤ 120 V with connection of phase-to-phase voltages and phase-to-ground voltages) or

r· (configured pickup threshold) ≤ 210 V with calculation of the measured values from the connected voltages (e.g. calculated phase-to-phase voltages from the connected phase-to-ground voltages).

The minimum hysteresis is 0.6 V.

Note

If a setting is selected such that the dropout threshold (= pickup threshold · dropout ratio) results in a greater value than 120 V/210 V, it will be limited automatically. No error message occurs.

Phase-specific Pickup Voltages Undervoltage Protection

The phase-specific pickup voltages of the two undervoltage protection elements are set at the following addresses:

27-1 PhA Pickup	Address 5130 or 5131
27-1 PhB Pickup	Address 5132 or 5133
27-1 PhC Pickup	Address 5134 or 5135
27-2 PhA Pickup	Address 5136 or 5137
27-2 PhB Pickup	Address 5138 or 5139
27-2 PhC Pickup	Address 5140 or 5141

The selectable voltage range depends on the type of connection phase-to-phase voltage or phase-to-ground voltage (parameter 213).

Phase-specific Time Delays Undervoltage Protection

The phase-specific times for tripping delay of the two undervoltage protection elements are set at the following addresses:

27-1 PhA Delay	Address 5142
27-1 PhB Delay	Address 5143
27-1 PhC Delay	Address 5144
27-2 PhA Delay	Address 5145
27-2 PhB Delay	Address 5146
27-2 PhC Delay	Address 5147

Current Criterion for Undervoltage Protection

The 27-1 Element and the 27-2 Element can be supervised by the current flow monitoring setting. If the **CURRENT SUPERV.** is switched ON at address 5120 (factory setting), the release condition of the current criterion must be fulfilled in addition to the corresponding undervoltage condition, which means that a configured minimum current (**BkrClosed I MIN**, address 212) must be present to make sure that this protective function can pick up. Thus it can be achieved that pickup of the undervoltage protection drops out when the line is disconnected from voltage supply. Furthermore, this feature prevents an immediate general pickup of the device when the device is powered-up without measurement voltage being present.

Note

If parameter **CURRENT SUPERV.** is set to disabled at address 5120, the device picks up immediately if the measuring-circuit voltage fails and the undervoltage protection is enabled. Furthermore, configuration can be performed by pickup of measuring-circuit voltage or blocking of the voltage protection. The latter can be initiated via device operation in DIGSI and via communication from the control center by means of a tagging command for blocking the voltage protection. This causes the dropout of the pickup and parameterization can be resumed.

2.4.5 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
5001	FCT 59	OFF ON Alarm Only	OFF	59 Overvoltage Protection
5002	59-1 PICKUP	20 .. 415 V	110 V	59-1 Pickup
5003	59-1 PICKUP	20 .. 240 V	110 V	59-1 Pickup
5004	59-1 DELAY	0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Time Delay
5005	59-2 PICKUP	20 .. 260 V	120 V	59-2 Pickup
5006	59-2 PICKUP	20 .. 240 V	120 V	59-2 Pickup
5007	59-2 DELAY	0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Time Delay
5015	59-1 PICKUP V2	2 .. 240 V	30 V	59-1 Pickup V2
5016	59-2 PICKUP V2	2 .. 240 V	50 V	59-2 Pickup V2
5017A	59-1 DOUT RATIO	0.90 .. 0.99	0.95	59-1 Dropout Ratio
5018A	59-2 DOUT RATIO	0.90 .. 0.99	0.95	59-2 Dropout Ratio
5019	59-1 PICKUP V1	20 .. 240 V	110 V	59-1 Pickup V1
5020	59-2 PICKUP V1	20 .. 240 V	120 V	59-2 Pickup V1
5030	59-1 PhA Pickup	20 .. 415 V	110 V	59-1 Phase A Pickup
5031	59-1 PhA Pickup	20 .. 240 V	110 V	59-1 Phase A Pickup
5032	59-1 PhB Pickup	20 .. 415 V	110 V	59-1 Phase B Pickup
5033	59-1 PhB Pickup	20 .. 240 V	110 V	59-1 Phase B Pickup
5034	59-1 PhC Pickup	20 .. 415 V	110 V	59-1 Phase C Pickup
5035	59-1 PhC Pickup	20 .. 240 V	110 V	59-1 Phase C Pickup
5036	59-2 PhA Pickup	20 .. 415 V	120 V	59-2 Phase A Pickup
5037	59-2 PhA Pickup	20 .. 240 V	120 V	59-2 Phase A Pickup
5038	59-2 PhB Pickup	20 .. 415 V	120 V	59-2 Phase B Pickup
5039	59-2 PhB Pickup	20 .. 240 V	120 V	59-2 Phase B Pickup
5040	59-2 PhC Pickup	20 .. 415 V	120 V	59-2 Phase C Pickup
5041	59-2 PhC Pickup	20 .. 240 V	120 V	59-2 Phase C Pickup
5042	59-1 PhA Delay	0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Phase A Time Delay
5043	59-1 PhB Delay	0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Phase B Time Delay
5044	59-1 PhC Delay	0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Phase C Time Delay
5045	59-2 PhA Delay	0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Phase A Time Delay
5046	59-2 PhB Delay	0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Phase B Time Delay
5047	59-2 PhC Delay	0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Phase C Time Delay
5101	FCT 27	OFF ON Alarm Only	OFF	27 Undervoltage Protection
5102	27-1 PICKUP	10 .. 385 V	75 V	27-1 Pickup

Addr.	Parameter	Setting Options	Default Setting	Comments
5103	27-1 PICKUP	10 .. 200 V	45 V	27-1 Pickup
5106	27-1 DELAY	0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Time Delay
5110	27-2 PICKUP	10 .. 385 V	70 V	27-2 Pickup
5111	27-2 PICKUP	10 .. 200 V	40 V	27-2 Pickup
5112	27-2 DELAY	0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Time Delay
5113A	27-1 DOUT RATIO	1.01 .. 3.00	1.20	27-1 Dropout Ratio
5114A	27-2 DOUT RATIO	1.01 .. 3.00	1.20	27-2 Dropout Ratio
5120A	CURRENT SUPERV.	OFF ON	ON	Current Supervision
5130	27-1 PhA Pickup	10 .. 385 V	75 V	27-1 Phase A Pickup
5131	27-1 PhA Pickup	10 .. 200 V	45 V	27-1 Phase A Pickup
5132	27-1 PhB Pickup	10 .. 385 V	75 V	27-1 Phase B Pickup
5133	27-1 PhB Pickup	10 .. 200 V	45 V	27-1 Phase B Pickup
5134	27-1 PhC Pickup	10 .. 385 V	75 V	27-1 Phase C Pickup
5135	27-1 PhC Pickup	10 .. 200 V	45 V	27-1 Phase C Pickup
5136	27-2 PhA Pickup	10 .. 385 V	70 V	27-2 Phase A Pickup
5137	27-2 PhA Pickup	10 .. 200 V	40 V	27-2 Phase A Pickup
5138	27-2 PhB Pickup	10 .. 385 V	70 V	27-2 Phase B Pickup
5139	27-2 PhB Pickup	10 .. 200 V	40 V	27-2 Phase B Pickup
5140	27-2 PhC Pickup	10 .. 385 V	70 V	27-2 Phase C Pickup
5141	27-2 PhC Pickup	10 .. 200 V	40 V	27-2 Phase C Pickup
5142	27-1 PhA Delay	0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Phase A Time Delay
5143	27-1 PhB Delay	0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Phase B Time Delay
5144	27-1 PhC Delay	0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Phase C Time Delay
5145	27-2 PhA Delay	0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Phase A Time Delay
5146	27-2 PhB Delay	0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Phase B Time Delay
5147	27-2 PhC Delay	0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Phase C Time Delay

2.4.6 Information List

No.	Information	Type of Information	Comments
234.2100	27, 59 blk	IntSP	27, 59 blocked via operation
2203	27-1 PhA pickup	OUT	27-1 Phase A Undervoltage pickup
2204	27-1 PhB pickup	OUT	27-1 Phase B Undervoltage pickup
2205	27-1 PhC pickup	OUT	27-1 Phase C Undervoltage pickup
2206	27-1 PhA PU CS	OUT	27-1 Phase A PICKUP w/curr. Supervision
2207	27-1 PhB PU CS	OUT	27-1 Phase B PICKUP w/curr. Supervision
2208	27-1 PhC PU CS	OUT	27-1 Phase C PICKUP w/curr. Supervision
2209	27-2 PhA pickup	OUT	27-2 Phase A Undervoltage pickup

No.	Information	Type of Information	Comments
2210	27-2 PhB pickup	OUT	27-2 Phase B Undervoltage pickup
2211	27-2 PhC pickup	OUT	27-2 Phase C Undervoltage pickup
2212	27-2 PhA PU CS	OUT	27-2 Phase A PICKUP w/curr. Supervision
2213	27-2 PhB PU CS	OUT	27-2 Phase B PICKUP w/curr. Supervision
2214	27-2 PhC PU CS	OUT	27-2 Phase C PICKUP w/curr. Supervision
2215	27-1 PhA TRIP	OUT	27-1 Phase A Undervoltage TRIP
2216	27-1 PhB TRIP	OUT	27-1 Phase B Undervoltage TRIP
2217	27-1 PhC TRIP	OUT	27-1 Phase C Undervoltage TRIP
2218	27-2 PhA TRIP	OUT	27-2 Phase A Undervoltage TRIP
2219	27-2 PhB TRIP	OUT	27-2 Phase B Undervoltage TRIP
2220	27-2 PhC TRIP	OUT	27-2 Phase C Undervoltage TRIP
2221	59-1 PhA pickup	OUT	59-1 Phase A picked up
2222	59-1 PhB pickup	OUT	59-1 Phase B picked up
2223	59-1 PhC pickup	OUT	59-1 Phase C picked up
2224	59-1 Ph A TRIP	OUT	59-1 Phase A TRIP
2225	59-1 Ph B TRIP	OUT	59-1 Phase B TRIP
2226	59-1 Ph C TRIP	OUT	59-1 Phase C TRIP
2227	59-2 PhA pickup	OUT	59-2 Phase A picked up
2228	59-2 PhB pickup	OUT	59-2 Phase B picked up
2229	59-2 PhC pickup	OUT	59-2 Phase C picked up
2230	59-2 Ph A TRIP	OUT	59-2 Phase A TRIP
2231	59-2 Ph B TRIP	OUT	59-2 Phase B TRIP
2232	59-2 Ph C TRIP	OUT	59-2 Phase C TRIP
6503	>BLOCK 27	SP	>BLOCK 27 undervoltage protection
6505	>27 I SUPRVSN	SP	>27-Switch current supervision ON
6506	>BLOCK 27-1	SP	>BLOCK 27-1 Undervoltage protection
6508	>BLOCK 27-2	SP	>BLOCK 27-2 Undervoltage protection
6513	>BLOCK 59	SP	>BLOCK 59 overvoltage protection
6530	27 OFF	OUT	27 Undervoltage protection switched OFF
6531	27 BLOCKED	OUT	27 Undervoltage protection is BLOCKED
6532	27 ACTIVE	OUT	27 Undervoltage protection is ACTIVE
6533	27-1 picked up	OUT	27-1 Undervoltage picked up
6534	27-1 PU CS	OUT	27-1 Undervoltage PICKUP w/curr. superv
6537	27-2 picked up	OUT	27-2 Undervoltage picked up
6538	27-2 PU CS	OUT	27-2 Undervoltage PICKUP w/curr. superv
6539	27-1 TRIP	OUT	27-1 Undervoltage TRIP
6540	27-2 TRIP	OUT	27-2 Undervoltage TRIP
6565	59 OFF	OUT	59-Overvoltage protection switched OFF
6566	59 BLOCKED	OUT	59-Overvoltage protection is BLOCKED
6567	59 ACTIVE	OUT	59-Overvoltage protection is ACTIVE
6568	59-1 picked up	OUT	59-1 Overvoltage V> picked up
6570	59-1 TRIP	OUT	59-1 Overvoltage V> TRIP
6571	59-2 picked up	OUT	59-2 Overvoltage V>> picked up
6573	59-2 TRIP	OUT	59-2 Overvoltage V>> TRIP

2.5 27/59 Under/Over Voltage for Vx

The Feeder Automation Controller 7SC80 features a voltage input Vx which is provided in all device variants. This voltage can be used for single-phase voltage protection.

2.5.1 Function Description

Overvoltage Protection

Single-phase overvoltage protection includes two elements. In case of a high overvoltage, tripping switch off is performed with a short-time delay, whereas in case of less severe overvoltages, the switch off is performed with a longer time delay. When one of the adjustable thresholds is exceeded, the 59 element picks up and trips after an adjustable time delay has elapsed. The time delay is not dependent on the magnitude of the overvoltage.

The dropout ratio for the two overvoltage elements (= $V_{dropout\ value}/V_{pickup\ value}$) can be set.

The following figure shows the logic diagram of the single-phase overcurrent protection function.

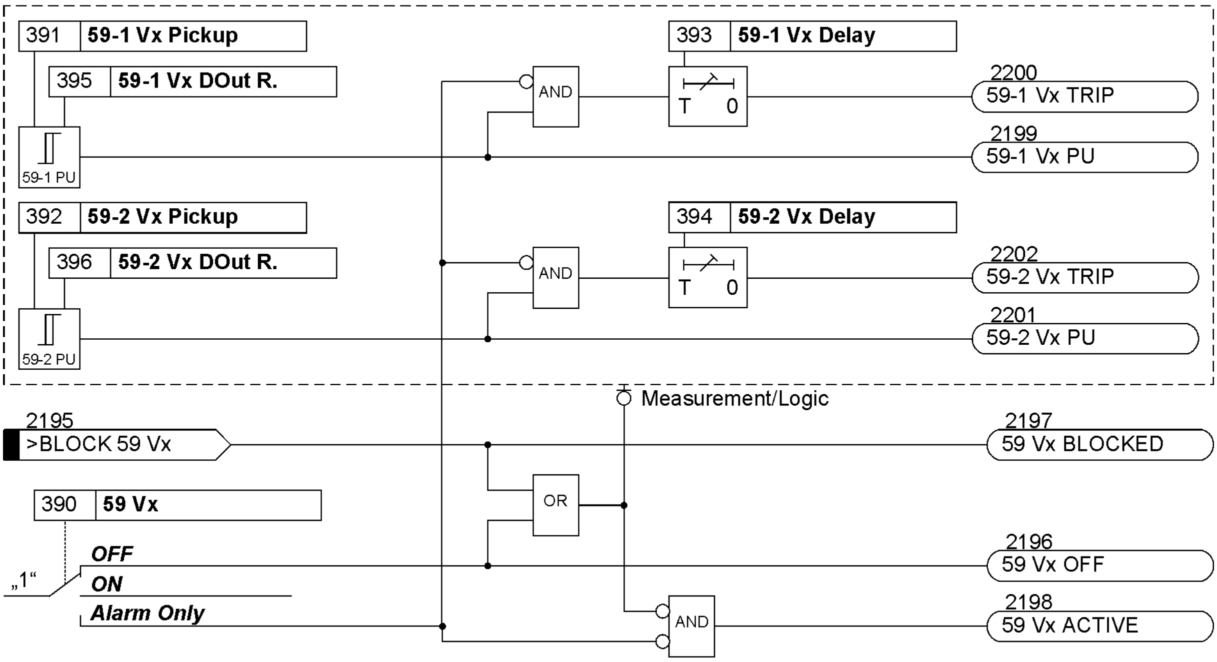


Figure 2-26 Logic diagram for single-phase overvoltage protection

Undervoltage Protection

Undervoltage protection includes two elements (**`27-1 PICKUP`** and **`27-2 PICKUP`**). Therefore, tripping can be time-graded depending on how severe voltage collapses are. Voltage thresholds and time delays can be set individually for both elements.

The dropout ratio for the two undervoltage elements (= $V_{dropout\ value}/V_{pickup\ value}$) can be set.

After the voltage has dropped below the pickup threshold, tripping is initiated after the time delay. As long as the voltage remains below the dropout threshold, reclosing is blocked. Only after the fault has been cleared, i.e. when the voltage increases above the dropout threshold, the element drops out and allows reclosing of the circuit breaker.

Single-phase undervoltage protection works without any current criterion. Please keep this in mind during parameterization and commissioning.

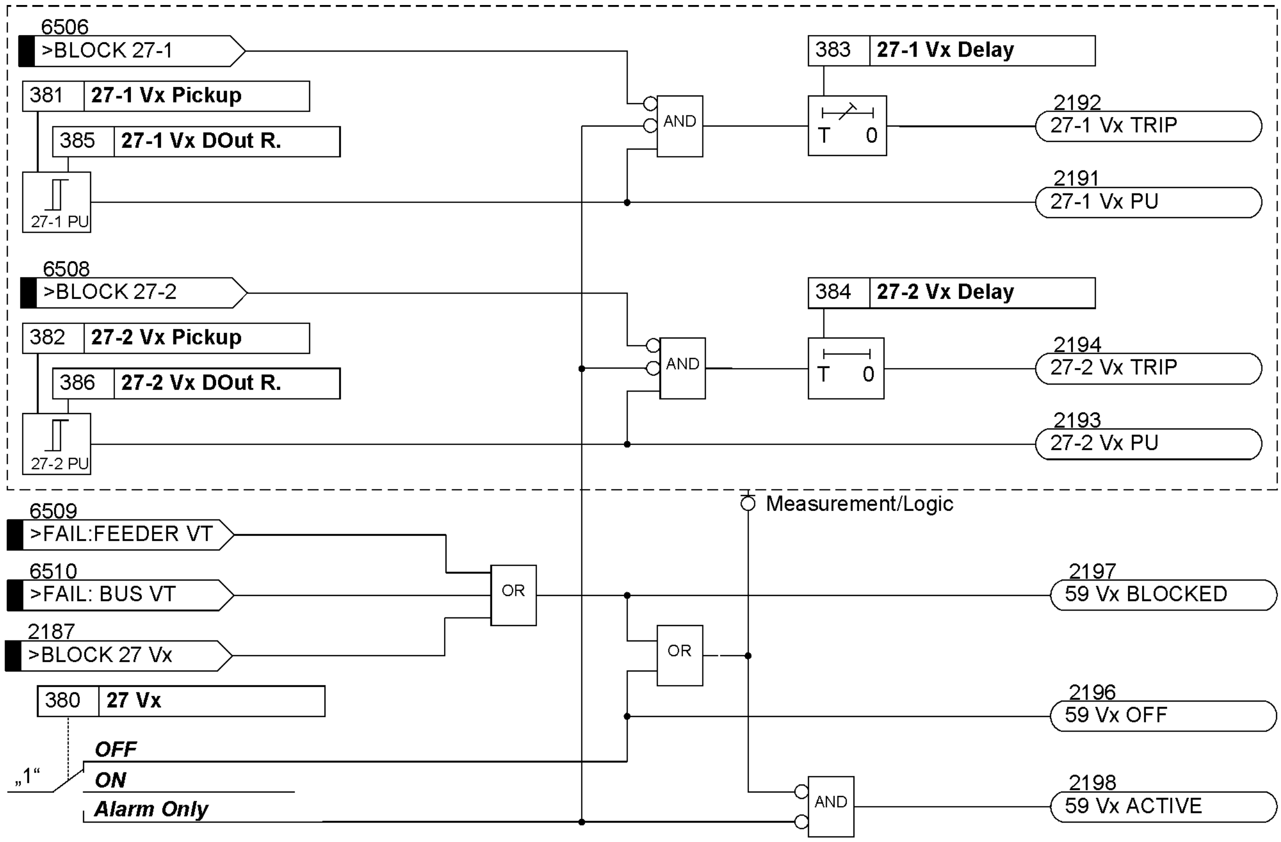


Figure 2-27 Logic diagram for single-phase undervoltage protection

2.5.2 Setting Notes

General

The single-phase voltage protection via Vx is set at address 370 **27/59 Vx** = ***Enabled***. If this function is not required, select ***Disabled***.

Overvoltage protection can be switched ***ON*** or ***OFF***, or set to ***Alarm Only*** at address 390 **59 Vx**.

Undervoltage protection can be switched ***ON*** or ***OFF***, or set to ***Alarm Only*** at address 380 **27 Vx**.

If the protection function is ***ON***, tripping, trip log and fault recording will occur when limit values have been exceeded and after time delays have expired.

When setting ***Alarm Only***, no trip command is given, no trip log is initiated, and no spontaneous fault indication is issued in the Web Monitor.

Overvoltage Protection

Overvoltage protection includes two elements.

You can set the pickup thresholds at the following addresses:

59-1 Vx Pickup	Address 391
59-2 Vx Pickup	Address 392

The times for tripping delay are set at the following addresses:

59-1 Vx Delay	Address 393
59-2 Vx Delay	Address 394

Select the time settings in such a way that admissible brief voltage peaks generated during switching operations do not generate a tripping and that stationary overvoltages can be tripped in time.

The dropout thresholds are set at the following addresses:

59-1 Vx DOut R.	Address 395
59-2 Vx DOut R.	Address 396

The minimum hysteresis is 0.6 V.

Undervoltage Protection

Undervoltage protection includes two elements.

You can set the pickup thresholds at the following addresses:

27-1 Vx Pickup	Address 381
27-2 Vx Pickup	Address 382

The times for tripping delay are set at the following addresses:

27-1 Vx Delay	Address 383
27-2 Vx Delay	Address 384

The time settings should be selected in such a way that tripping occurs in case of voltage dips that lead to unstable operating conditions. On the other hand, time delays should be long enough to avoid tripping due to momentary voltage dips.

The dropout thresholds are set at the following addresses:

27-1 Vx DOut R.	Address 385
27-2 Vx DOut R.	Address 386

The minimum hysteresis is 0.6 V.

2.5.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
380	27 Vx	OFF ON Alarm Only	OFF	27 Undervoltage prot. for Vx
381	27-1 Vx Pickup	10 .. 210 V	35 V	Undervoltage Vx< pickup
382	27-2 Vx Pickup	10 .. 210 V	30 V	Undervoltage Vx<< pickup
383	27-1 Vx Delay	0.00 .. 60.00 sec; ∞	0.50 sec	Undervoltage Vx< delay time
384	27-2 Vx Delay	0.00 .. 60.00 sec; ∞	0.50 sec	Undervoltage Vx<< delay time
385A	27-1 Vx DOut R.	1.01 .. 3.00	1.20	27-1 Vx Dropout Ratio
386A	27-2 Vx DOut R.	1.01 .. 3.00	1.20	27-2 Vx Dropout Ratio
390	59 Vx	OFF ON Alarm Only	OFF	59 Overvoltage prot. for Vx
391	59-1 Vx Pickup	60 .. 260 V	140 V	Overvoltage Vx> pickup
392	59-2 Vx Pickup	60 .. 260 V	145 V	Overvoltage Vx>> pickup
393	59-1 Vx Delay	0.00 .. 60.00 sec; ∞	0.50 sec	Overvoltage Vx> delay time
394	59-2 Vx Delay	0.00 .. 60.00 sec; ∞	0.50 sec	Overvoltage Vx>> delay time
395A	59-1 Vx DOut R.	0.90 .. 0.99	0.95	59-1 Vx Dropout Ratio
396A	59-2 Vx DOut R.	0.90 .. 0.99	0.95	59-2 Vx Dropout Ratio

2.5.4 Information List

No.	Information	Type of In-formation	Comments
2187	>BLOCK 27 Vx	SP	>BLOCK 27 under voltage prot. Vx
2188	27 Vx OFF	OUT	27 under volt. Vx switched OFF
2189	27 Vx BLOCKED	OUT	27 under volt. Vx is BLOCKED
2190	27 Vx ACTIVE	OUT	27 under volt. Vx is ACTIVE
2191	27-1 Vx PU	OUT	27-1 under volt. Vx PICKUP
2192	27-1 Vx TRIP	OUT	27-1 under volt. Vx TRIP
2193	27-2 Vx PU	OUT	27-2 under volt. Vx PICKUP
2194	27-2 Vx TRIP	OUT	27-2 under volt. Vx TRIP
2195	>BLOCK 59 Vx	SP	>BLOCK 59 over voltage prot. Vx
2196	59 Vx OFF	OUT	59 over volt prot. Vx switched OFF
2197	59 Vx BLOCKED	OUT	59 over voltage Vx is BLOCKED
2198	59 Vx ACTIVE	OUT	59 over voltage Vx is ACTIVE
2199	59-1 Vx PU	OUT	59-1 over voltage Vx PICKUP
2200	59-1 Vx TRIP	OUT	59-1 over voltage Vx TRIP
2201	59-2 Vx PU	OUT	59-2 over voltage Vx PICKUP
2202	59-2 Vx TRIP	OUT	59-2 over voltage Vx TRIP

2.6 Negative Sequence Protection 46

Negative sequence protection detects unbalanced loads on the system.

Applications

- This protection function can be used to detect interruptions, short-circuits and polarity problems in the connections to the current transformers.
- It also allows to detect single-phase and two-phase faults with fault currents smaller than the maximum load current.

Prerequisites

The unbalanced load protection becomes effective when:

a minimum phase current is larger than 0.1 x I_{Nom} and

all phase currents are smaller than 10 x I_{Nom}.

2.6.1 Definite Time Characteristic

The definite time characteristic consists of two elements. As soon as the first settable threshold `46-1 PICKUP` is reached, a pickup message is output and time element `46-1 DELAY` is started. When the second Element `46-2 PICKUP` is started, another message is output and time element `46-2 DELAY` is initiated. Once either time delay elapses, a trip signal is initiated.

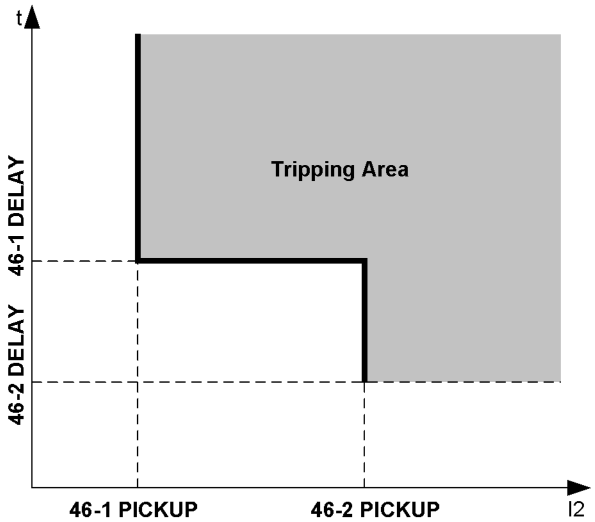


Figure 2-28 Definite time characteristic for negative sequence protection

Settable Dropout Times

Pickup stabilization for the definite-time tripping characteristic 46-1, 46-2 can be accomplished by means of settable dropout times. This facility is used in power systems with possible intermittent faults. Used together with electromechanical relays, it allows different dropout responses to be adjusted and a time grading of numerical and electromechanical relays to be implemented.

2.6.2 Inverse Time Characteristic 46-TOC

The inverse time Element is dependent on the ordered device version. It operates with IEC or ANSI characteristic tripping curves. The curves and associated formulas are given in the Technical Data. When programming the inverse time characteristic also definite time elements `46-2 PICKUP` and `46-1 PICKUP` are available (see a foregoing paragraph).

Pickup and Tripping

The negative sequence current I2 is compared to the setting value **`46-TOC PICKUP`**. When the negative sequence current exceeds 1.1 times the setting value, a pickup annunciation is generated. The tripping time is calculated from the negative sequence current according to the characteristic selected. When tripping time is reached, a tripping command is issued. The characteristic curve is illustrated in the following Figure.

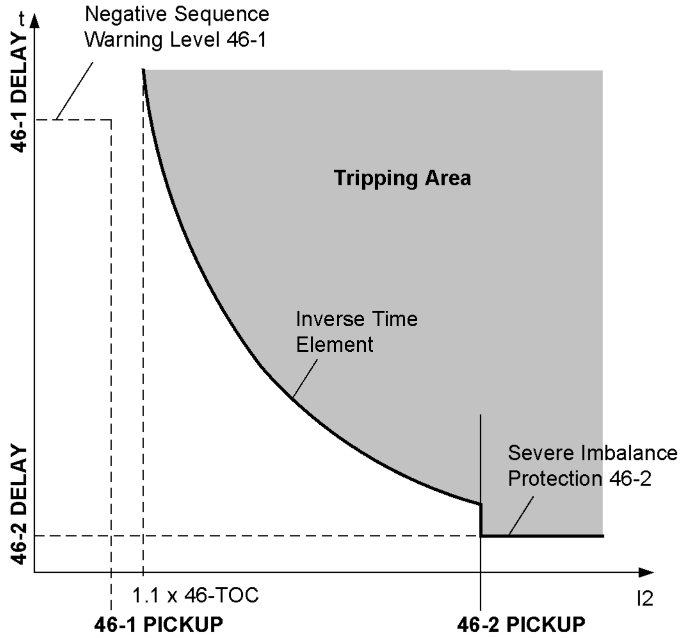


Figure 2-29 Inverse time characteristic for negative sequence protection

Dropout for IEC Curves

The Element drops out when the negative sequence current decreases to approx. 95% of the pickup setting. The time delay resets immediately to be ready for another pickup operation.

Dropout for ANSI Curves

When using an ANSI curve it can be selected whether the dropout of the element is to occur instantaneously or whether dropout is to be performed by means of the disk emulation mechanism. „Instantaneous“ means that the drop out will occur when a 95 % of the pickup value is reached. For a new pickup the time counter starts at zero.

The disk emulation evokes a dropout process (timer counter is decrementing) which begins after de-energization. This process corresponds to the reset of a Ferraris-disk (explaining its denomination "disk emulation"). In case several faults occur in succession, the "history" is taken into consideration due to the inertia of the Ferraris-disk, and the time response is adapted. This ensures a proper simulation of the temperature rise of the protected object even for extremely fluctuating unbalanced load values. Reset begins as soon as 90 % of the setting value is reached, in accordance with the dropout curve of the selected characteristic. In the range between the dropout value (95 % of the pickup value) and 90 % of the setting value, the incrementing and decrementing process is in idle state.

Disk emulation offers advantages when the behavior of the negative sequence protection must be coordinated with other relays in the system based on electromagnetic measuring principles.

Logic

The following figure shows the logic diagram for the negative sequence protection function. The protection may be blocked via a binary input. This resets pickup and time elements and clears measured values.

When the negative sequence protection criteria are no longer satisfied (i.e. all phase currents below 0.1 x I_{Nom} or at least one phase current is greater than 10 x I_{Nom}) all pickups issued by the negative sequence protection function are reset.

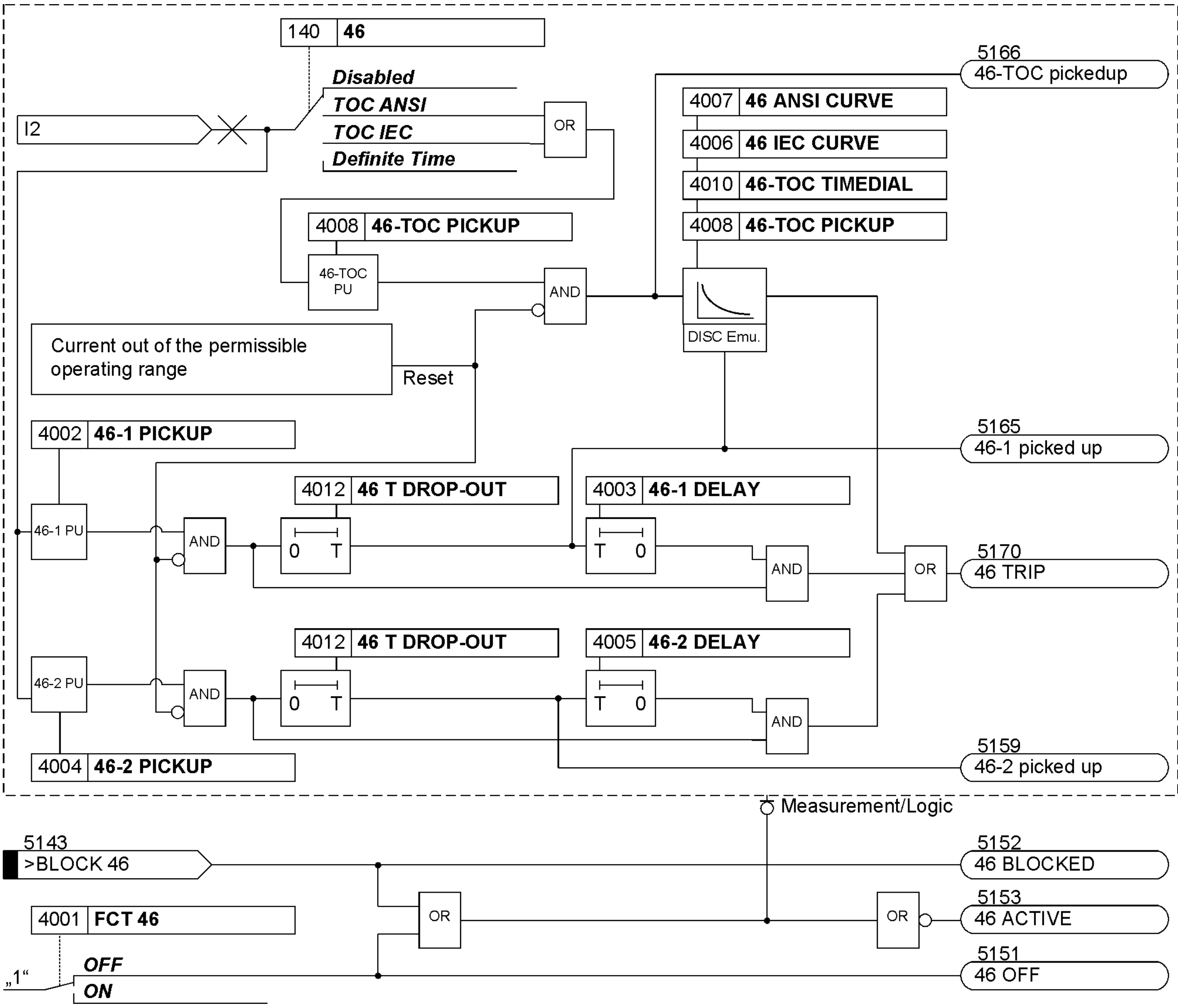


Figure 2-30 Logic diagram of the unbalanced load protection

The pickup of the definite time overcurrent protection can be stabilized by the configured dropout time 4012 **46 T DROP-OUT**. This time is started and maintains the pickup condition if the current falls below the threshold. Therefore, the function does not drop out at high speed. The trip command delay time continues running. After the dropout delay time has elapsed, the pickup is reported OFF and the trip delay time is reset unless the threshold has been exceeded again. If the threshold is exceeded again during the dropout delay time, the time is canceled. The trip command delay time continues running. Should the threshold value be exceeded after its expiry, the trip command is issued immediately. If the threshold value is not exceeded at this time, there will be no reaction. If the threshold value is exceeded again after expiry of the trip-command delay time, while the dropout delay time is still running, tripping occurs immediately.

The configured dropout times do not influence the tripping times of the inverse time elements as these depend dynamically on the measured current value. For purposes of dropout coordination, disc emulation is used with electro-mechanical relays.

2.6.3 Setting Notes

General

The function type has been specified during configuration of the protection functions (see Section 2.1.1.2, address 140, **46**). If only the definite time elements are desired, the address **46** should be set to ***Definite Time***. Selecting **46** = ***TOC IEC*** or ***TOC ANSI*** in address 140 will additionally make all parameters available that are relevant for the inverse time characteristics. If this function is not required, then ***Disabled*** is set.

The function can be turned ***ON*** or ***OFF*** in address 4001 **FCT 46**.

The default pickup settings and delay settings are generally sufficient for most applications. If data is available from the manufacturer regarding the allowable long-term load imbalance and the allowable load imbalance per unit of time, this data should be used preferentially. It is important to note that the manufacturer's data relate to the primary values of the machine, for example, the maximum permissible permanent inverse current is referred to the nominal machine current. For the setting values at the protection device, this information is converted to the secondary inverse current. The following applies

Pickup Setting $$I_2 = \left(\frac{I_{2perm\ prim}}{I_{NomMotor}}\right) \cdot I_{NomMotor} \cdot \frac{I_{CT\ sec}}{I_{CT\ prim}}$$

with

$I_{2\ perm\ prim}$	permissible thermal inverse current of the motor
$I_{Nom\ Motor}$	Nominal Motor Current
$I_{CT\ sec}$	Secondary Nominal Current of the Current Transformer
$I_{CT\ prim}$	Primary nominal current of the current transformer

Definite Time Elements

The unbalanced load protection function comprises two elements. Therefore, the upper Element (address 4004 **46-2 PICKUP**) can be set to a short time delay4005 **46-2 DELAY**) and the lower Element (address 4002 **46-1 PICKUP**) can be set to a somewhat longer time delay (address 4003 **46-1 DELAY**). This allows the lower Element to act, e.g. as an alarm, while the upper Element will cut the inverse time characteristic as soon as high inverse currents are present. If **46-2 PICKUP** is set to about 60%, tripping is always performed with the thermal characteristic. On the other hand, with more than 60% of unbalanced load, a two-phase fault can be assumed. The delay time **46-2 DELAY** must be coordinated with the system grading of phase-to-phase faults. If power supply with current I is provided via just two phases, the following applies to the inverse current:

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

Examples:

Motor with the following data:

Nominal current	$I_{Nom\ Motor}$ = 545 A
Continuously permissible negative sequence current	$I_{2\ dd\ prim} / I_{Nom\ Motor}$ = 0.11 continuous
Briefly permissible negative sequence current	$I_{2\ long\text{-}term\ prim} / I_{Nom\ Motor}$= 0.55 for T max = 1 s
Current transformer	$I_{Nomprim}/I_{Nomsec}$ = 600 A/1 A
Setting value	46-1 Pickup = 0.11 · 545 A · (1/600 A) = 0.10 A
Setting value	46-2 Pickup = 0.55 · 545 A · (1/600 A) = 0.50 A

When protecting feeder or cable systems, unbalanced load protection may serve to identify low magnitude unsymmetrical faults below the pickup values of the directional and non-directional overcurrent elements.

Here, the following must be observed:

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

A phase-to-ground fault with current I corresponds to the following negative sequence current:

$$I_2 = \frac{1}{3} \cdot I = 0.33 \cdot I$$

On the other hand, with more than 60% of unbalanced load, a phase-to-phase fault can be assumed. The delay time **46-2 DELAY** must be coordinated with the system grading of phase-to-phase faults.

For a power transformer, unbalanced load protection may be used as sensitive protection for low magnitude phase-to-ground and phase-to-phase faults. In particular, this application is well suited for delta-wye transformers where low side phase-to-ground faults do not generate high side zero sequence currents (e.g. vector group Dy).

Since transformers transform symmetrical currents according to the transformation ratio "CTR", the relationship between negative sequence currents and total fault current for phase-to-phase faults and phase-to-ground faults are valid for the transformer as long as the turns ratio "CTR" is taken into consideration.

Consider a transformer with the following data:

Base Transformer Rating	S_{NomT} = 16 MVA	
Primary Nominal Voltage	V_{Nom} = 110 kV	
Secondary Nominal Voltage	V_{Nom} = 20 kV	(TR_V = 110/20)
Vector Groups	Dy5	
High Side CT	100 A / 1 A	(CT_I = 100)

The following fault currents may be detected at the low side:

If **46-1 PICKUP** on the high side of the devices is set to = 0.1, then a fault current of $I = 3 \cdot TR_V \cdot TR_I \cdot$ **46-1 PICKUP** = 3 · 110/20 · 100 · 0.1 A = 165 A for single-phase faults and $\sqrt{3} \cdot TR_V \cdot TR_I \cdot$**46-1 PICKUP** = 95 A can be detected for two-phase faults at the low side. This corresponds to 36% and 20% of the transformer nominal current respectively. It is important to note that load current is not taken into account in this simplified example.

As it cannot be recognized reliably on which side the thus detected fault is located, the delay time **46-1 DELAY** must be coordinated with other downstream relays in the system.

Pickup Stabilization (definite-time overcurrent protection)

Pickup of the definite time elements can be stabilized by means of a configurable dropout time. This dropout time is set in 4012 **46 T DROP-OUT**.

IEC Curves (Inverse Time Tripping Curve)

The thermal behavior of a machine can be closely replicated due to negative sequence by means of an inverse time tripping curve. In address 4006 **46 IEC CURVE**, select out of three IEC curves provided by the device the curve which is most similar to the thermal unbalanced load curve provided by the manufacturer. The tripping curves of the protective relay, and the formulas on which they are based, are given in the Technical Data.

It must be noted that a safety factor of about 1.1 has already been included between the pickup value and the setting value when an inverse time characteristic is selected. This means that a pickup will only occur if an unbalanced load of about 1.1 times the setting value **46-TOC PICKUP** is present (address 4008). The dropout is performed as soon as the value falls below 95% of the pickup value.

The associated time multiplier is entered at address 4010, **46-TOC TIMEDIAL**.

The time multiplier can also be set to ∞. After pickup the Element will then not trip. Pickup, however, will be signaled. If the inverse time Element is not required at all, address 140 **46** should be set to ***Definite Time*** during the configuration of protection functions (Section 2.1.1.2).

ANSI Curves (Inverse Time Tripping Curve)

Behavior of a machine due to negative sequence current can be closely replicated by means of an inverse time tripping curve. In address 4007 the **46 ANSI CURVE**, select out of four ANSI curves provided by the device the curve which is most similar to the thermal unbalanced load curve provided by the manufacturer. The tripping curves of the protective relay, and the formulas on which they are based, are given in the Technical Data.

It must be noted that a safety factor of about 1.1 has already been included between the pickup value and the setting value when an inverse time characteristic is selected. This means that a pickup will only occur if an unbalanced load of about 1.1 times the setting value is present. If ***Disk Emulation*** was selected at address 4011 **46-TOC RESET**, reset will occur in accordance with the reset curve as described in the Functional Description.

The unbalanced load value is set at address 4008 **46-TOC PICKUP**. The corresponding time multiplier is accessible via address 4009 **46-TOC TIMEDIAL**.

The time multiplier can also be set to ∞. In this case, the Element will not trip after pickup. However, pickup, will be signaled. If the inverse time Element is not required at all, address 140 **46** should be set to ***Definite Time*** during configuration of the protection functions (Section 2.1.1.2).

2.6.4 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
4001	FCT 46		OFF ON	OFF	46 Negative Sequence Protection
4002	46-1 PICKUP	1A	0.10 .. 3.00 A	0.10 A	46-1 Pickup
		5A	0.50 .. 15.00 A	0.50 A	
4003	46-1 DELAY		0.00 .. 60.00 sec; ∞	1.50 sec	46-1 Time Delay
4004	46-2 PICKUP	1A	0.10 .. 3.00 A	0.50 A	46-2 Pickup
		5A	0.50 .. 15.00 A	2.50 A	
4005	46-2 DELAY		0.00 .. 60.00 sec; ∞	1.50 sec	46-2 Time Delay
4006	46 IEC CURVE		Normal Inverse Very Inverse Extremely Inv.	Extremely Inv.	IEC Curve
4007	46 ANSI CURVE		Extremely Inv. Inverse Moderately Inv. Very Inverse	Extremely Inv.	ANSI Curve
4008	46-TOC PICKUP	1A	0.10 .. 2.00 A	0.90 A	46-TOC Pickup
		5A	0.50 .. 10.00 A	4.50 A	
4009	46-TOC TIMEDIAL		0.50 .. 15.00 ; ∞	5.00	46-TOC Time Dial
4010	46-TOC TIMEDIAL		0.05 .. 3.20 sec; ∞	0.50 sec	46-TOC Time Dial
4011	46-TOC RESET		Instantaneous Disk Emulation	Instantaneous	46-TOC Drop Out
4012A	46 T DROP-OUT		0.00 .. 60.00 sec	0.00 sec	46 Drop-Out Time Delay

2.6.5 Information List

No.	Information	Type of Information	Comments
5143	>BLOCK 46	SP	>BLOCK 46
5151	46 OFF	OUT	46 switched OFF
5152	46 BLOCKED	OUT	46 is BLOCKED
5153	46 ACTIVE	OUT	46 is ACTIVE
5159	46-2 picked up	OUT	46-2 picked up
5165	46-1 picked up	OUT	46-1 picked up
5166	46-TOC pickedup	OUT	46-TOC picked up
5170	46 TRIP	OUT	46 TRIP
5171	46 Dsk pickedup	OUT	46 Disk emulation picked up

2.7 Frequency Protection 81 O/U

The frequency protection function detects overfrequencies and underfrequencies in the power system. If the frequency lies outside the permissible range, appropriate switching actions are initiated.

Applications

- Underfrequency is caused by an increased real power demand of the power system or faulty operation of the frequency regulation.
- Overfrequency is caused, e.g. by load shedding (island network) or malfunction of the frequency regulation.

2.7.1 Description

Detection of Frequency

The frequency is detected preferably from the positive sequence voltage. If this voltage is too low, the phase-to-phase voltage V_{A-B} at the device is used. If the amplitude of this voltage is too small, one of the other phase-to-phase voltages is used instead.

Through the use of filters and repeated measurements, the frequency evaluation is free from harmonic influences and very accurate.

Frequency Increase and Decrease

Frequency protection consists of four frequency elements. To make protection flexible for different power system conditions, theses elements can be used alternatively for frequency decrease or increase separately, and can be independently set to perform different control functions.

Operating Range

The frequency can be determined as long as in a three-phase voltage transformer connection the positive-sequence system of the voltages, or alternatively, in a single-phase voltage transformer connection, the respective voltage is present and of sufficient magnitude. If the measured voltage drops below a settable value **Vmin**, the frequency protection is blocked because no precise frequency values can be calculated from the signal.

Time Delays / Logic

Each frequency element has an associated settable time delay. When the time delay elapses, a trip signal is generated. When a frequency element drops out, the tripping command is immediately terminated, but not before the minimum command duration has elapsed.

Each of the four frequency elements can be blocked individually via binary inputs.

The following figure shows the logic diagram for the frequency protection function.

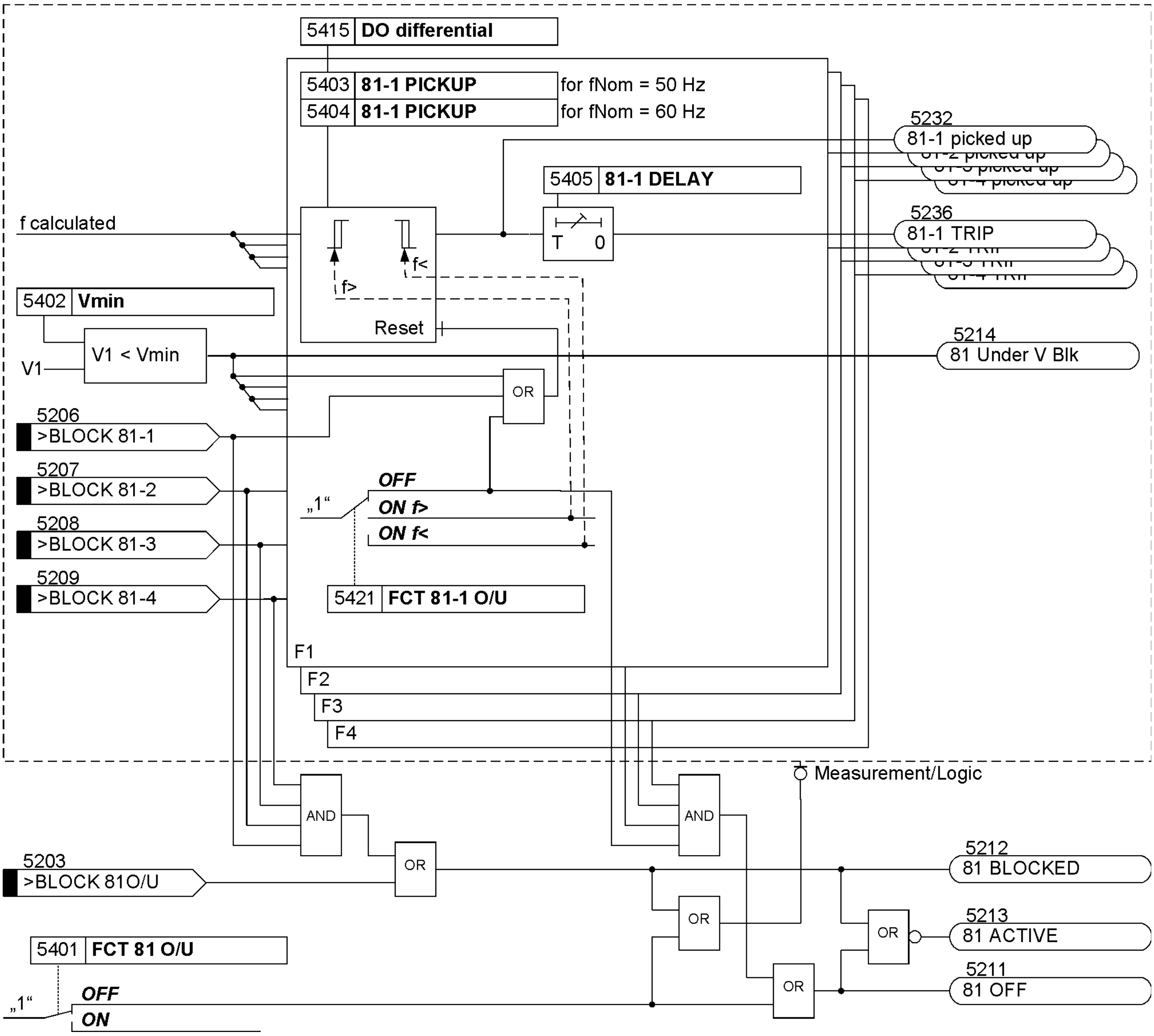


Figure 2-31 Logic diagram of the frequency protection

2.7.2 Setting Notes

General

Frequency protection is only in effect and accessible if address 154 **81 O/U** is set to ***Enabled*** during configuration of protective functions. If the function is not required ***Disabled*** is set. The function can be turned ***ON*** or ***OFF*** under address 5401 **FCT 81 O/U**.

By setting the parameters 5421 to 5424, the function of each of the elements **81-1 PICKUP** to **81-4 PICKUP** is set individually as overfrequency or underfrequency protection or set to ***OFF***, if the element is not required.

Minimum Voltage

Address 5402 **Vmin** is used to set the minimum voltage. Frequency protection is blocked as soon as the minimum voltage is undershot.

On all three-phase connections and single-phase connections of a phase-to-phase voltage, the threshold must be set as a phase-to-phase value. With a single phase-to-ground connection the threshold must be set as a phase voltage.

Pickup Values

The setting as overfrequency or underfrequency element does not depend on the parameter threshold values of the respective element. An element can also function, for example, as an overfrequency element if its threshold value is set below the nominal frequency and vice versa.

If frequency protection is used for load shedding purposes, the setting values depend on the actual power system conditions. Normally, a time coordinated load shedding is required that takes into account the importance of the consumers or consumer groups.

Further application examples exist in the field of power stations. Here too, the frequency values to be set mainly depend on the specifications of the power system / power station operator. The underfrequency protection safeguards the power station's own demand by disconnecting it from the power system on time. The turbo governor regulates the machine set to the nominal speed. Consequently, the station's own demands can be continuously supplied at nominal frequency.

Under the assumption that the apparent power is reduced by the same degree, turbine-driven generators can, as a rule, be continuously operated down to 95% of the nominal frequency. However, for inductive consumers, the frequency reduction not only means an increased current input, but also endangers stable operation. For this reason, only a short-term frequency reduction down to about 48 Hz (for f_N = 50 Hz) or 58 Hz (for f_N = 60 Hz) is permissible.

A frequency increase can, for example, occur due to a load shedding or malfunction of the speed regulation (e.g. in an island network). In this way, the frequency increase protection can, for example, be used as overspeed protection.

Dropout Thresholds

The dropout threshold is defined via the adjustable dropout-difference address 5415 **DO differential**. It can thus be adjusted to the network conditions. The dropout difference is the absolute-value difference between pickup threshold and dropout threshold. The default value of 0.02 Hz can usually remain. Should, however, frequent minor frequency fluctuations be expected, this value should be increased.

Time Delays

The delay times **81-1 DELAY** to **81-4 DELAY** (addresses 5405, 5408, 5411 and 5414) allow the frequency elements to be time coordinated, e.g. for load shedding equipment. The set times are additional delay times not including the operating times (measuring time, dropout time) of the protection function.

2.7.3 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
5401	FCT 81 O/U		OFF ON	OFF	81 Over/Under Frequency Protection
5402	Vmin		10 .. 150 V	65 V	Minimum required voltage for operation
5402	Vmin		20 .. 150 V	35 V	Minimum required voltage for operation
5403	81-1 PICKUP		40.00 .. 60.00 Hz	49.50 Hz	81-1 Pickup
5404	81-1 PICKUP		50.00 .. 70.00 Hz	59.50 Hz	81-1 Pickup
5405	81-1 DELAY		0.00 .. 100.00 sec; ∞	60.00 sec	81-1 Time Delay
5406	81-2 PICKUP		40.00 .. 60.00 Hz	49.00 Hz	81-2 Pickup
5407	81-2 PICKUP		50.00 .. 70.00 Hz	59.00 Hz	81-2 Pickup
5408	81-2 DELAY		0.00 .. 100.00 sec; ∞	30.00 sec	81-2 Time Delay
5409	81-3 PICKUP		40.00 .. 60.00 Hz	47.50 Hz	81-3 Pickup
5410	81-3 PICKUP		50.00 .. 70.00 Hz	57.50 Hz	81-3 Pickup
5411	81-3 DELAY		0.00 .. 100.00 sec; ∞	3.00 sec	81-3 Time delay
5412	81-4 PICKUP		40.00 .. 60.00 Hz	51.00 Hz	81-4 Pickup
5413	81-4 PICKUP		50.00 .. 70.00 Hz	61.00 Hz	81-4 Pickup
5414	81-4 DELAY		0.00 .. 100.00 sec; ∞	30.00 sec	81-4 Time delay
5415A	DO differential		0.02 .. 1.00 Hz	0.02 Hz	Dropout differential
5416	81 Imin	1A	0.30 .. 5.00 A	0.80 A	Minimum required current for operation
		5A	1.50 .. 25.00 A	4.00 A	
5421	FCT 81-1 O/U		OFF ON f> ON f<	OFF	81-1 Over/Under Frequency Protection
5422	FCT 81-2 O/U		OFF ON f> ON f<	OFF	81-2 Over/Under Frequency Protection
5423	FCT 81-3 O/U		OFF ON f> ON f<	OFF	81-3 Over/Under Frequency Protection
5424	FCT 81-4 O/U		OFF ON f> ON f<	OFF	81-4 Over/Under Frequency Protection

2.7.4 Information List

No.	Information	Type of Information	Comments
5203	>BLOCK 81O/U	SP	>BLOCK 81O/U
5206	>BLOCK 81-1	SP	>BLOCK 81-1
5207	>BLOCK 81-2	SP	>BLOCK 81-2
5208	>BLOCK 81-3	SP	>BLOCK 81-3
5209	>BLOCK 81-4	SP	>BLOCK 81-4
5211	81 OFF	OUT	81 OFF
5212	81 BLOCKED	OUT	81 BLOCKED
5213	81 ACTIVE	OUT	81 ACTIVE
5214	81 Under V Blk	OUT	81 Under Voltage Block
5232	81-1 picked up	OUT	81-1 picked up
5233	81-2 picked up	OUT	81-2 picked up
5234	81-3 picked up	OUT	81-3 picked up
5235	81-4 picked up	OUT	81-4 picked up
5236	81-1 TRIP	OUT	81-1 TRIP
5237	81-2 TRIP	OUT	81-2 TRIP
5238	81-3 TRIP	OUT	81-3 TRIP
5239	81-4 TRIP	OUT	81-4 TRIP

2.8 Monitoring Functions

The device features comprehensive monitoring functions which cover both device hardware and software. The measured values, too, are continuously checked for plausibility so that the current and voltage transformer circuits are largely included into the monitoring system.

2.8.1 Measurement Supervision

2.8.1.1 General

The device monitoring extends from the measuring inputs to the binary outputs. Monitoring checks the hardware for malfunctions and abnormal conditions.

Hardware and software monitoring described in the following are enabled continuously. Settings (including the possibility to activate and deactivate the monitoring function) refer to the monitoring of external transformer circuits.

2.8.1.2 Hardware Monitoring

Auxiliary and Reference Voltages

The processor voltage of 5 V DC is monitored by the hardware since the processor will no longer be functional if the voltage falls below the minimum value. In that case, the device is put out of operation. When the supply voltage returns, the processor system is restarted.

Failure of or switching off the supply voltage removes the device from operation and a message is immediately generated by a normally closed contact. Brief auxiliary voltage interruptions of less than 50 ms do not disturb the readiness of the device (for nominal auxiliary voltage > 110 VDC).

The processor monitors the offset and reference voltage of the ADC (analog-digital converter). The protection is suspended if the voltages deviate outside an allowable range, and lengthy deviations are reported.

Buffer Battery

The buffer battery, which ensures operation of the internal clock and storage of counters and messages if the auxiliary voltage fails, is periodically checked for charge status. If it is less than an allowed minimum voltage, then the „`Fail Battery`“ message is issued.

Memory Components

All working memories (RAMs) are checked during startup. If a malfunction occurs then, the starting sequence is interrupted and an LED blinks. During operation the memories are checked with the help of their checksum. For the program memory, the cross sum is formed cyclically and compared to the stored program cross sum.

For the settings memory, the cross sum is formed cyclically and compared to the cross sum that is freshly generated each time a setting process takes place.

If a fault occurs the processor system is restarted.

Scanning

Scanning and the synchronization between the internal buffer components are constantly monitored. If any deviations cannot be removed by renewed synchronization, then the processor system is restarted.

Measurement Value Acquisition – Currents

The monitoring of the device-internal measured-value acquisition of the currents can be effected via the current sum monitoring.

Up to four input currents are measured by the device. If the three phase currents and the ground current from the current transformer neutral point are connected with the device, the sum of the four digitized currents must be zero. This also applies in the event of a possible transformer saturation. For that reason – in order to eliminate pickup upon transformer saturation – this function is only available in a Holmgreen-connection (see also Section 2.1.3.2). Faults in the current circuits are recognized if

$I_F = | i_A + i_B + i_C + i_E | > \Sigma$ **I THRESHOLD** + Σ **I FACTOR** $\Sigma | I |$

Σ **I THRESHOLD** (address 8106) and Σ **I FACTOR** (address 8107) are programmable settings. The component Σ **I FACTOR** $\cdot \Sigma | I |$ takes into account the permissible current proportional ratio errors of the input transformer which are particularly prevalent during large short-circuit currents (Figure 2-32). The dropout ratio is about 97 %.

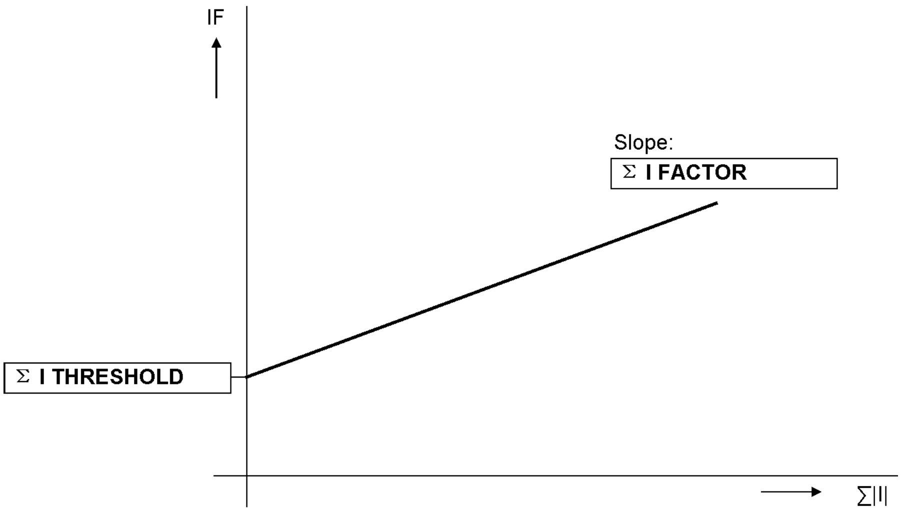


Figure 2-32 Current sum monitoring

An error in the current sum results in the message „Failure Σ I“ (No. 162) and blocking of the protection function. Furthermore, a fault log is initiated for a period of 100 ms.

The monitoring can be switched off.

The monitoring is available subject to the following conditions:

- The ground current of the current transformer neutral point is connected to the fourth current input (I_4) (Holmgreen-connection). This is communicated to the device in the **Power System Data 1** via address 280 ***YES***.
- The settings **CT PRIMARY** (address 204) and **Ignd-CT PRIM** (address 217) must be the same.
- The settings **CT SECONDARY** (address 205) and **Ignd-CT SEC** (address 218) must be the same.

The following logic diagram illustrates the operational mode of the current sum monitoring.

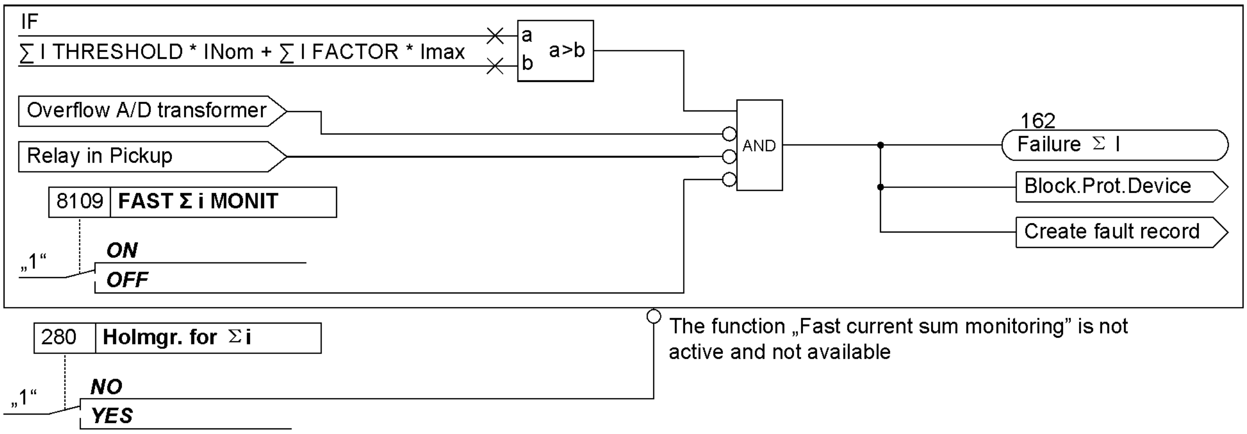


Figure 2-33 Logic diagram for the fast current sum monitoring

AD Transformer Monitoring

The digitized sampled values are being monitored in respect of their plausibility. If the result is not plausible, message 181 „`Error A/D-conv.`“ is issued. The protection is blocked, thus preventing unwanted operation. Furthermore, a fault record is generated for recording of the internal fault.

2.8.1.3 Software Monitoring

Watchdog

For continuous monitoring of the program sequences, a time monitor is provided in the hardware (hardware watchdog) that expires upon failure of the processor or an internal program, and causes a complete restart of the processor system.

An additional software watchdog ensures that malfunctions during the processing of programs are discovered. This also initiates a restart of the processor system.

If such a malfunction is not cleared by the restart, an additional restart attempt is begun. After three unsuccessful restarts within a 30 second window of time, the device automatically removes itself from service and the red „Error“ LED lights up. The readiness relay drops out and indicates „device malfunction“ with its normally closed contact.

Offset Monitoring

This monitoring function checks all ring buffer data channels for corrupt offset replication of the analog/digital transformers and the analog input paths using offset filters. Possible offset errors are detected using DC filters, and the associated sampled values are corrected up to a specific limit. If this limit is exceeded, an indication is generated (191 „`Error Offset`“) and integrated into the warning group indication (160). As increased offset values impair the measurements, we recommend sending the device to the OEM plant for corrective action should this indication persist.

2.8.1.4 Monitoring of the Transformer Circuits

Open circuits or short circuits in the secondary circuits of the current and voltage transformers, as well as faults in the connections (important during commissioning!), are detected and reported by the device. The measured quantities are periodically checked in the background for this purpose, as long as no system fault is present.

Current Symmetry

During normal system operation, symmetry among the input currents is expected. The monitoring of the measured values in the device checks this balance. The smallest phase current is compared to the largest phase current. Asymmetry is detected if | Imin | / | Imax | < **BAL. FACTOR I** as long as Imax > **BALANCE I LIMIT** is valid.

Thereby Imax is the largest of the three phase currents and Imin the smallest. The symmetry factor **BAL. FACTOR I** (address 8105) represents the allowable asymmetry of the phase currents while the limit value (address 8104) is the lower limit of the operating range of this monitoring (see Figure 2-34). Both parameters can be set. The dropout ratio is about 97%.

This failure is therefore located below the curve for all values and is reported as „Fail I balance“.

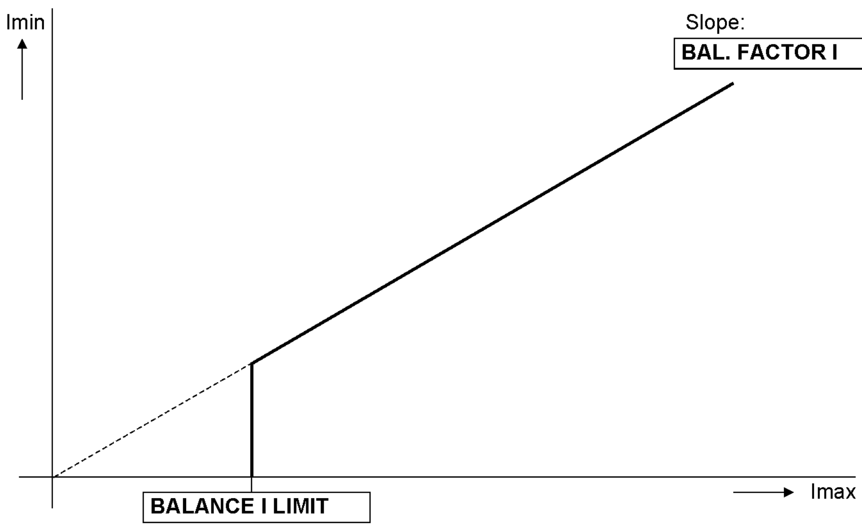


Figure 2-34 Current symmetry monitoring

Voltage Symmetry

During normal system operation, balance among the voltages is expected. Since the phase-to-phase voltages are insensitive to ground faults, the phase-to-phase voltages are used for balance monitoring. If the device is connected to the phase-to-ground voltages, then the phase-to-phase voltages are calculated accordingly, whereas, if the device is connected to phase-to-phase voltages and the displacement voltage V_0, then the third phase-to-phase voltage is calculated accordingly. From the phase-to-phase voltages, the device generates the rectified average values and checks the balance of their absolute values. The smallest phase voltage is compared with the largest phase voltage.

Asymmetry is recognized if

$| V_{min} | / | V_{max} |$ < **BAL. FACTOR V** as long as $| V_{max} |$ > **BALANCE V-LIMIT**. Where V_{max} is the highest of the three voltages and V_{min} the smallest. The symmetry factor **BAL. FACTOR V** (address 8103) represents the allowable asymmetry of the conductor voltages while the limit value **BALANCE V-LIMIT** (address 8102) is the lower limit of the operating range of this monitoring (see Figure 2-35). Both parameters can be set. The dropout ratio is about 97%.

This failure is therefore located below the curve for all values and is reported as „`Fail V balance`“.

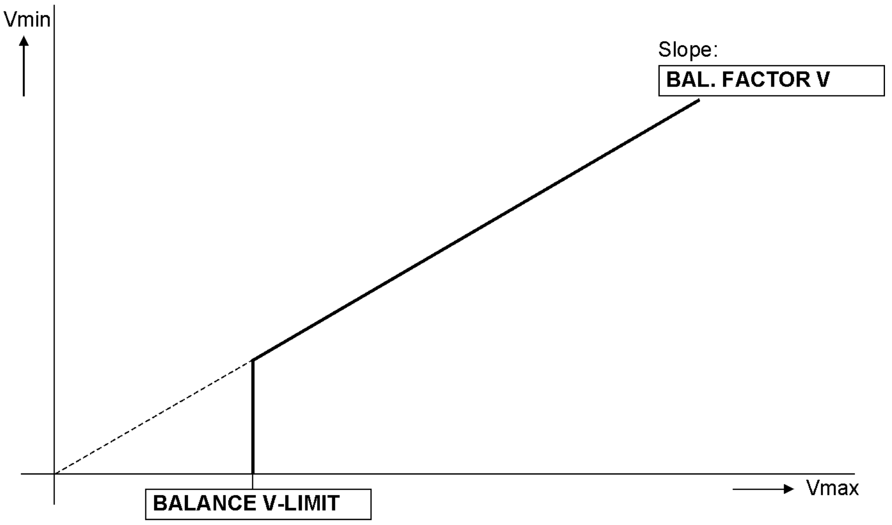


Figure 2-35 Voltage symmetry monitoring

Phase Sequence of Voltage and Current

To detect swapped phase connections in the voltage and current input circuits, the phase sequence of the phase-to-phase measured voltages and the phase currents are checked by monitoring the sequence of same polarity zero crossing of the voltages.

Direction measurement with normal voltages, path selection for fault location, and negative sequence detection all assume a phase sequence of "abc". Phase rotation of measurement quantities is checked by verifying the phase sequences. For that purpose, the phase-sequence monitoring uses the phase-to-phase voltages V_{AB}, V_{BC}, V_{CA}.

Voltages: $\underline{V}_{AB}$ before $\underline{V}_{BC}$ before $\underline{V}_{CA}$ and

Currents: $\underline{I}_A$ before $\underline{I}_B$ before $\underline{I}_C$.

Verification of the voltage phase rotation is done when each measured voltage is at least

$|\underline{V}_{AB}|, |\underline{V}_{BC}|, |\underline{V}_{CA}| > 40$ V.

Verification of the current phase rotation is done when each measured current is at least:

$|\underline{I}_A|, |\underline{I}_B|, |\underline{I}_C| > 0.5\ I_{Nom}$.

For abnormal phase sequences, the messages „`Fail Ph. Seq. V`“ or „`Fail Ph. Seq. I`“ are issued, along with the switching of this message „`Fail Ph. Seq.`“.

For applications in which an opposite phase sequence is expected, the protective relay should be adjusted via a binary input or the respective parameter **`PHASE SEQ.`** (address 209). If the phase sequence is changed in the relay, phases B and C internal to the relay are reversed, and the positive and negative sequence currents are thereby exchanged (see also Section 2.11.2). The phase-related messages, malfunction values, and measured values are not affected by this.

2.8.1.5 Measurement Voltage Failure Detection

Requirements

The measurement voltage failure detection function, referred to as „Fuse Failure Monitor" (FFM), only operates under the following condition:

- Three phase-to-ground voltages are connected; with phase-to-phase voltages and V_N or single-phase connection, the function is disabled.

Purpose of the Fuse Failure Monitor

In the event of a measuring 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. Directional overcurrent protection and undervoltage protection may thereby acquire incorrect measuring results.

Of course, supervision of the miniature circuit breaker and the Fuse Failure Monitor can be used at the same time.

Mode of Operation - Grounded System

The device is informed of the application of the FFM in a grounded system via address 5301 **FUSE FAIL MON.** ***Solid grounded***.

Note

On systems where the ground fault current is very small or absent (e.g. ungrounded supply transformers), fuse failure monitoring must be disabled or set to ***Coil.gnd./isol.***.

The logic diagram for the mode of operation in a grounded system is illustrated in Figure 2-36. Depending on the configuration and MLFB, the FFM operates with measured or calculated values V_N or I_N. If a zero voltage occurs without a ground fault current being registered simultaneously, this suggests an asymmetrical fault in the secondary voltage transformer circuit. Directional overcurrent protection (phase and ground function) and undervoltage protection are blocked if parameter 5310 **BLOCK PROT.** is set to ***YES***.

The FFM picks up if the ground voltage V_N is higher than the set limit value under address 5302 **FUSE FAIL 3Vo** and if the ground current IN lies below the set limit value under address 5303 **FUSE FAIL RESID**.

Pickup occurs in accordance with the configured values. A hysteresis of 105% for the dropout is integrated for I_N or 95% for V_N. In case of low-current asymmetrical faults in systems with week infeed, the ground current caused by the fault could lie below the pickup threshold of the Fuse Failure Monitor. Overfunctioning of the Fuse Failure Monitor can, however, cause the feeder protection device to underfunction since all protection functions that use voltage signals are blocked. In order to prevent overfunctioning of the FFM, the phase currents are also checked. If at least one phase current lies above the pickup threshold of 5303 **FUSE FAIL RESID**, it can be assumed that the zero current created by a fault will equally exceed this threshold.

In order to immediately detect an existing fault after switching in, the following applies: If a ground current I_N is detected within 10 seconds after recognition of the Fuse Failure criterion, the protection assumes a fault 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. After this time has elapsed, it can be assumed that a fuse failure has actually occurred. 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.

The generation of an internal signal „Alarm FFM isol. N." for the mode of operation in an isolated system is illustrated in Figure 2-37.

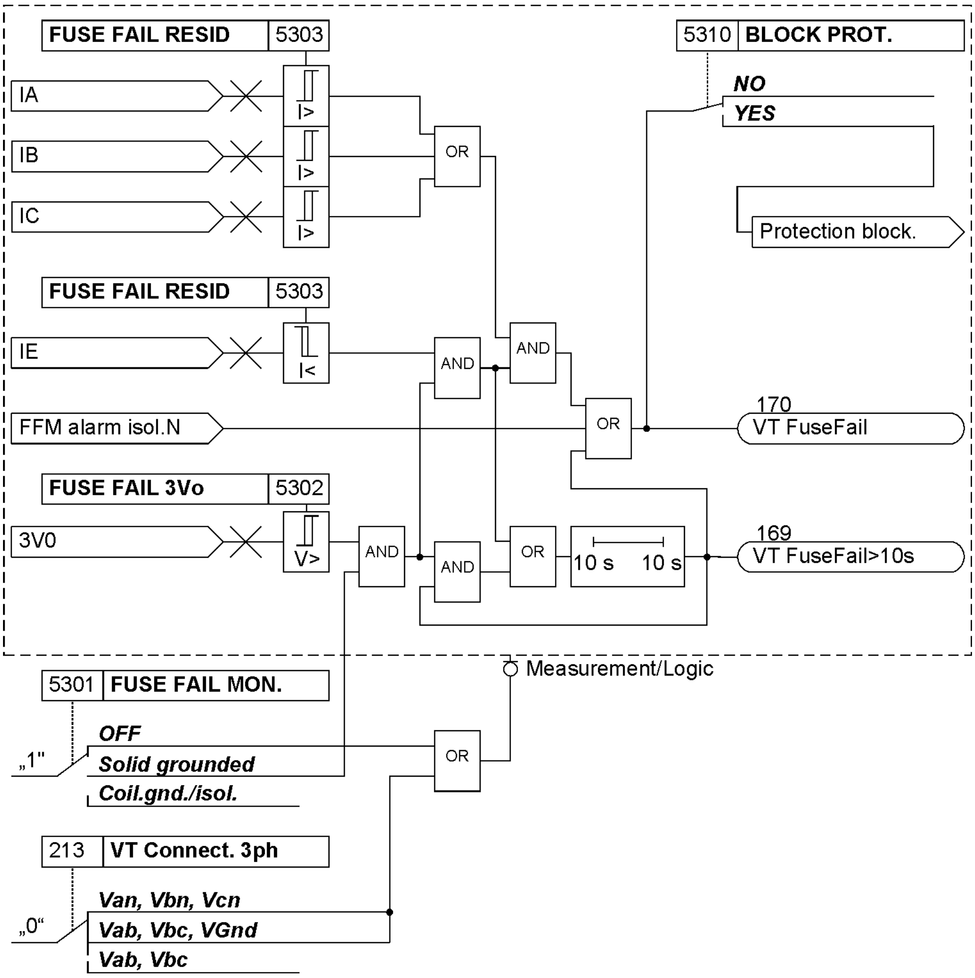


Figure 2-36 Logic diagram for the fuse failure monitor for grounded systems

Mode of Operation - Isolated System

The FFM can also function in isolated and compensated (grounded) systems where only low ground currents are expected. This is indicated to the device via address 5301 **FUSE FAIL MON.**.

The logic diagram on the mode of operation in an isolated system is illustrated in Figure 2-37. The following is a description of the principles for single-, two- and three-phase faults in a voltage transformer secondary system. If this part of the FFM logic picks up, the internal signal „Alarm FFM isol. N. “ is initiated, further processing of which is indicated in Figure 2-36.

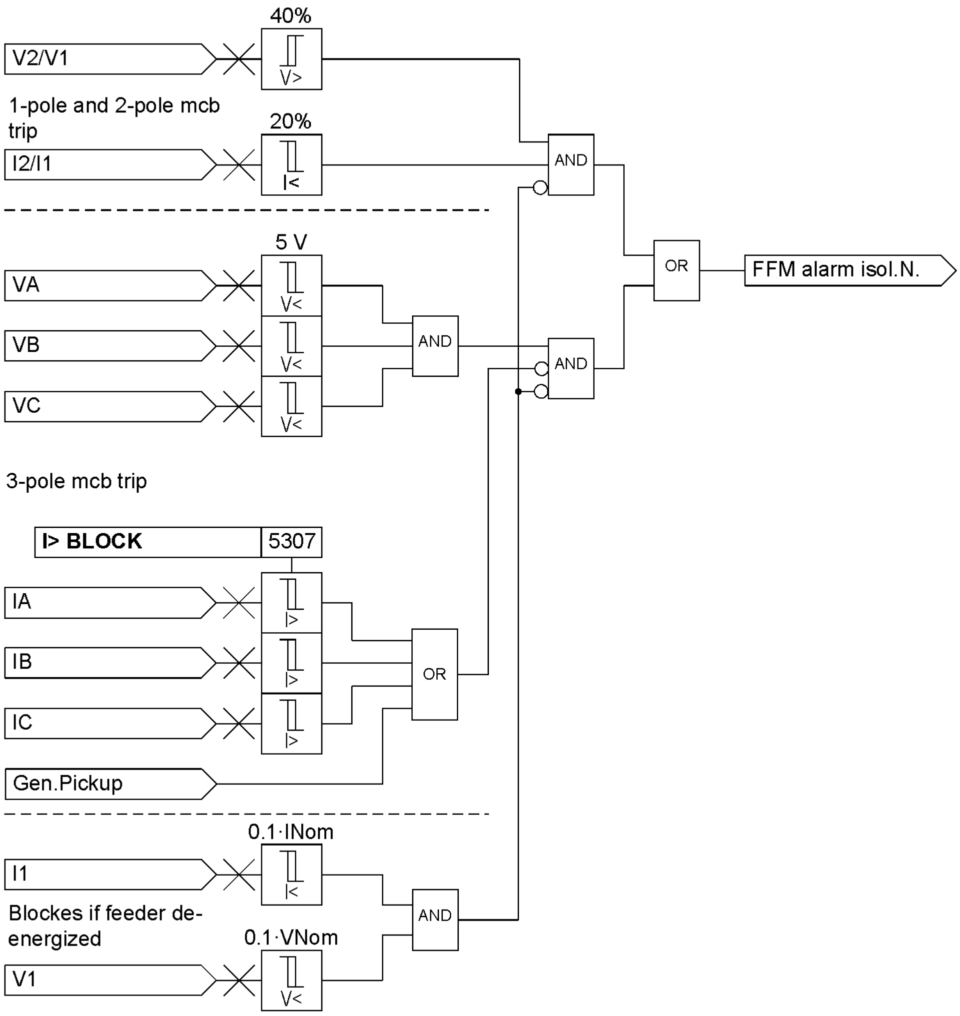


Figure 2-37 Logic diagram of the Fuse Failure Monitor for ungrounded networks

Single- and Two-phase Faults in Voltage Transformer Circuits

The measuring voltage failure detection is based on the fact that a significant negative sequence system is formed in the voltage during single- or two-phase voltage failure, however without influencing the current. This enables a clear distinction from asymmetries impressed by the power system. If the negative sequence system is related to the current positive sequence system, the following rules apply to the **Fault-free Case**:

$$\frac{V_2}{V_1} = 0 \quad \text{and} \quad \frac{I_2}{I_1} = 0$$

If a fault occurs in the voltage transformer secondary system, the following rules apply to the **Single-phase Failure**:

$$\frac{V_2}{V_1} = \frac{0.33}{0.66} = 0.5 \quad \text{and} \quad \frac{I_2}{I_1} = 0 \quad \left(\frac{V_2}{V_1} > \frac{I_2}{I_1}\right)$$

If a fault occurs in the voltage transformer secondary system, the following rules apply to the **Two-phase Failure**:

$$\frac{V_2}{V_1} = \frac{0.33}{0.33} = 1 \quad \text{and} \quad \frac{I_2}{I_1} = 0 \quad \left(\frac{V_2}{V_1} > \frac{I_2}{I_1}\right)$$

In case of a failure of one or two phases of the primary system, the current also shows a negative sequence system of 0.5 or 1. Consequently, the voltage monitoring does not respond since no voltage transformer fault can be present. In order to avoid occurrence of an overfunctioning of the measuring voltage failure detection due to inaccuracy, the function is blocked below a minimum threshold of the positive sequence systems of voltage ($V_1 < 0.1\ V_{Nom}$) and current ($I_1 < 0.1\ I_{Nom}$).

Three-phase Faults in Voltage Transformer Circuits

A three-phase failure in the voltage transformer secondary system cannot be detected via the positive- and negative sequence system as described above. The monitoring of the progress of current and voltage in respect of time is required here. If a voltage dip to almost zero occurs (or if the voltage is zero), and the current remains unchanged, a three-phase failure in the voltage transformer secondary system can be concluded. The exceeding of an overcurrent threshold (parameter 5307 **I> BLOCK**) is used here. This threshold value should be identical to the definite time overcurrent protection. If the threshold value is exceeded the measuring-circuit voltage failure monitoring is blocked. This function is also blocked if a pickup by an (overcurrent) protection function has already occurred.

2.8.1.6 Setting Notes

Measured Value Monitoring

The sensitivity of measured value monitor can be modified. Default values which are sufficient in most cases are preset. If especially high operating asymmetries in the currents and/or voltages are to be expected during operation, or if it becomes apparent during operation that certain monitoring functions activate sporadically, then the setting should be less sensitive.

Address 8102 **BALANCE V-LIMIT** determines the limit voltage (phase-to-phase) above which the voltage symmetry monitor is effective. Address 8103 **BAL. FACTOR V** is the associated symmetry factor; that is, the slope of the symmetry characteristic curve.

Address 8104 **BALANCE I LIMIT** determines the limit current above which the current symmetry monitor is effective. Address 8105 **BAL. FACTOR I** is the associated symmetry factor; that is, the slope of the symmetry characteristic curve.

Address 8106 **Σ I THRESHOLD** determines the limit current above which the current sum monitor is activated (absolute portion, only relative to I_{Nom}). The relative portion (relative to the maximum conductor current) for activating the current sum monitor is set at address 8107 **Σ I FACTOR**.

Note

Current sum monitoring can operate properly only when the three phase currents and at the fourth current measuring input (I_N) for ground current the ground current of the protected line are connected (see **Power System Data 1**).

Note

The connections of the ground paths and their adaption factors were set when configuring the general Power System Data. These settings must be correct for the measured values monitoring to function properly.

Measured value monitoring can be set to ***ON*** or ***OFF*** at address 8101 **MEASURE. SUPERV**.

Fuse Failure Monitor (FFM)

Via address 5301 **FUSE FAIL MON.** you select under which system conditions the FFM works. Depending on that, make the required settings in the grounded system via the parameters 5302, 5303 and 5307. In a grounded/isolated system, only the parameter 5307 is relevant.

The settings for the fuse failure monitor must be selected in such manner that reliable activation occurs if a phase voltage fails, but that false activation does not occur during ground faults in a grounded network. Address 5303 **FUSE FAIL RESID** must be set as sensitive as required (with ground faults, below the smallest fault current).

The FFM picks up if the ground voltage V_N is higher than the set limit value under address 5302 **FUSE FAIL 3Vo** and if the ground current IN lies below the set limit value under address 5303 **FUSE FAIL RESID**.

In order to detect a three-phase failure, the progress in time of current and voltage is monitored. If the voltage sinks below the threshold value without a change in the current value, a three-phase failure is detected. This threshold value of the current element must be set under address 5307 **I> BLOCK**. The threshold value should be identical with the definite time overcurrent protection.

Under address 5310 **BLOCK PROT.** it can be determined whether the protection functions should be blocked upon pickup by the FFM.

Note

The setting under address 5310 **BLOCK PROT.** has no effect on the flexible protection functions. A separate blocking can be selected for that purpose.

The function may be disabled in address 5301 **FUSE FAIL MON.**, e.g. when performing asymmetrical tests.

2.8.1.7 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
5301	FUSE FAIL MON.		OFF Solid grounded Coil.gnd./isol.	OFF	Fuse Fail Monitor
5302	FUSE FAIL 3Vo		10 .. 100 V	30 V	Zero Sequence Voltage
5303	FUSE FAIL RESID	1A	0.10 .. 1.00 A	0.10 A	Residual Current
		5A	0.50 .. 5.00 A	0.50 A	
5307	I> BLOCK	1A	0.10 .. 35.00 A; ∞	1.00 A	I> Pickup for block FFM
		5A	0.50 .. 175.00 A; ∞	5.00 A	
5310	BLOCK PROT.		NO YES	YES	Block protection by FFM
8101	MEASURE. SUPERV		OFF ON	ON	Measurement Supervision
8102	BALANCE V-LIMIT		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
8103	BAL. FACTOR V		0.58 .. 0.90	0.75	Balance Factor for Voltage Monitor
8104	BALANCE I LIMIT	1A	0.10 .. 1.00 A	0.50 A	Current Threshold for Balance Monitoring
		5A	0.50 .. 5.00 A	2.50 A	
8105	BAL. FACTOR I		0.10 .. 0.90	0.50	Balance Factor for Current Monitor
8106	Σ I THRESHOLD	1A	0.05 .. 2.00 A; ∞	0.10 A	Summated Current Monitoring Threshold
		5A	0.25 .. 10.00 A; ∞	0.50 A	
8107	Σ I FACTOR		0.00 .. 0.95	0.10	Summated Current Monitoring Factor
8109	FAST Σ i MONIT		OFF ON	ON	Fast Summated Current Monitoring

2.8.1.8 Information List

No.	Information	Type of Information	Comments
161	Fail I Superv.	OUT	Failure: General Current Supervision
162	Failure Σ I	OUT	Failure: Current Summation
163	Fail I balance	OUT	Failure: Current Balance
167	Fail V balance	OUT	Failure: Voltage Balance
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
175	Fail Ph. Seq. I	OUT	Failure: Phase Sequence Current
176	Fail Ph. Seq. V	OUT	Failure: Phase Sequence Voltage
197	MeasSup OFF	OUT	Measurement Supervision is switched OFF
6509	>FAIL:FEEDER VT	SP	>Failure: Feeder VT
6510	>FAIL: BUS VT	SP	>Failure: Busbar VT

2.8.2 Malfunction Responses of Monitoring Equipment

The malfunction responses of monitoring equipment are summarized in the following.

2.8.2.1 Description

Malfunction Responses

Depending on the type of malfunction discovered, an indication is sent, a restart of the processor system is initiated, or the device is shut down. After three unsuccessful restart attempts, the device is also shut down. The readiness relay opens and indicates with its NC contact that the device is malfunctioning. Moreover, the red "ERROR" LED lights up and the green "RUN" LED goes out. If the internal auxiliary voltage also fails, all LEDs are dark. Table 2-8 shows a summary of the monitoring functions and the malfunction responses of the device.

Table 2-8 Summary of the Device's Malfunction Responses

Monitoring	Possible causes	Malfunction response	Indication (No.)	Output
Auxiliary voltage failure	External (auxiliary voltage) Internal (converter)	Device shutdown	All LEDs dark	DOK[2] drops out
Buffer battery	Internal (buffer battery)	Indication	„Fail Battery“ (177)	
Hardware watchdog	Internal (processor failure)	Restart attempt[1]	LED "ERROR"	DOK[2] drops out
Software watchdog	Internal (processor failure)	Restart attempt [1]	LED "ERROR"	DOK[2] drops out
Working memory ROM	Internal (hardware)	Abortion of restart, device shutdown	LED flashes	DOK[2] drops out
Program memory RAM	Internal (hardware)	During boot sequence	LED "ERROR"	DOK[2] drops out
		During operation: Device shutdown [1]	LED "ERROR"	
Parameter memory	Internal (hardware)	Device shutdown [1]	LED "ERROR"	DOK[2] drops out
Sampling frequency	Internal (hardware)	Device shutdown	LED "ERROR"	DOK[2] drops out
Error in the I/O board	Internal (hardware)	Device shutdown	„I/O-Board error“ (178), LED "ERROR"	DOK[2] drops out
Offset monitoring	Internal (hardware)	Device shutdown	„Error Offset“ (191)	DOK[2] drops out
Current sum	Internal (measure value acquisition)	Indication	„Failure Σ I“ (162)	As allocated
Current symmetry	External (system or current transformer)	Indication	„Fail I balance“ (163)	As allocated
Voltage symmetry	External (system or voltage transformer)	Indication	„Fail V balance“ (167)	As allocated
Voltage phase sequence	External (system or connection)	Indication	„Fail Ph. Seq. V“ 176)	As allocated
Current phase sequence	External (system or connection)	Indication	„Fail Ph. Seq. I“ (175)	As allocated
Fuse failure monitor	External (voltage transformer)	Indication	„VT FuseFail>10s“ (169) „VT FuseFail“ (170)	As allocated
Adjustment data error	Internal (hardware)	Indication	„Alarm NO calibr“ (193)	As allocated

[1] Following three unsuccessful restarting attempts, the device is put out of operation.

[2] DOK = "Device OK" = readiness relay drops out; protection and control functions are blocked.

Group Indications

Certain indications of the monitoring functions are already combined to group indications. These group indications and their composition are stated in the Appendix A.10. Keep in mind that the indication 160 „`Alarm Sum Event`“ is only issued when the measured value monitoring functions (8101 **MEASURE. SUPERV**) are activated.

2.9 Fault Locator

The measurement of the distance to a short-circuit fault is a supplement to the protection functions. Power transmission within the system can be increased when the fault is located and cleared faster.

2.9.1 Description

General

The fault locator is a stand-alone and independent function which uses the line and power system parameters set in other functions. In the event of a fault, it is addressed by the protection functions provided in the 7SC80 device.

The protected object can e.g. be an inhomogeneous line. For calculation purposes, the line can be divided into different sections, for example, a short cable followed by an overhead line. In such protected objects, you can configure each section individually. Without this information, the fault locator uses the general line data (see Section 2.1.6.2).

The fault locator also calculates double ground faults with different base points, reverse faults and faults that are located behind the configured sections. For faults that are not located within the configured sections, the fault locator uses the general line data.

The fault locator can be triggered by the trip command of the non-directional or directional time overcurrent protection, or by each fault detection. In the latter case, fault location calculations is even possible if another protection relay cleared the fault. Additionally, the fault location can be initiated via a binary input. However, it is a prerequisite that pickup of the time overcurrent protection is performed at the same time (directional or non-directional).

Note

Depending on the type of voltage connection (see **`Power System Data 1`**, Table 2-1), the fault locator is disabled.

Fault Location Determination

The measurement principle of the fault locator is based on the calculation of impedances.

Sampled value pairs of short-circuit current and short-circuit voltage are stored in a buffer (at a sampling rate of 1/20 cycle) shortly after the trip command. To date, even with very fast circuit breakers, no errors in the measured values have occurred during the shutdown procedure. Measured value filtering and the number of impedance calculations are adjusted automatically to the number of stable measured value pairs in the determined data window. If no sufficient data windows with reliable values could be determined for fault location, message „`Flt.Loc.invalid`“ is issued.

The fault locator evaluates the short-circuit loops and uses the loops with the lowest fault impedance (see margin heading „Loop Selection“).

Loop Selection

Using the pickup of the time overcurrent protection (directional or non-directional), the valid measurement loops for the calculation of fault impedance are selected.

Table 2-9 shows the assignment of the evaluated loops to the possible pickup scenarios of the protection elements.

Table 2-9 Assignment of Pickup - Evaluated Loops

Pickup by				fault type	measured loop	signaled loop
A	B	C	N			
x				A	A-N	A-N
	x			B	B-N	B-N
		x		C	C-N	C-N
			x	N	A-N, B-N, C-N	lowest impedance
x			x	A-N	A-N	A-N
	x		x	B-N	B-N	B-N
		x	x	C-N	C-N	C-N
x	x			A-B	A-B	A-B
x		x		A-C	A-C	A-C
	x	x		B-C	B-C	B-C
x	x		x	A-B-N	A-B, A-N, B-N	Lowest impedance
x		x	x	A-C-N	C-A, A-N, B-N	Lowest impedance
	x	x	x	B-C-N	B-C, B-N, C-N	Lowest impedance
x	x	x		A-B-C	A-B, B-C, C-A	lowest impedance
x	x	x	x	A-B-C-N	A-B, B-C, C-A, A-N, B-N, C-N	lowest impedance

Output of Fault Location

The following information is output as result of the fault location:

- the short-circuit loop from which the fault reactance was determined,
- the fault reactance X in Ω primary and Ω secondary,
- the fault resistance R in Ω primary and Ω secondary,
- the distance to fault d in kilometers or miles of the line proportional to the reactance, converted on the basis of the set line reactance per unit line length,
- the distance to fault d in % of the line length, calculated on the basis of the set reactance per unit length and the set line length.

Line Sections

The line type is determined by the line section settings. If, for instance, the line includes a cable and an overhead line, two different sections must be configured. The system can distinguish between up to three different line types. When configuring this line data, please note that the different tabs for setting the line sections will only be displayed if more than one line section has been configured under the functional scope (address 181). The parameters for a line section are entered in the Setting tab .

2.9.2 Setting Notes

General

The fault location is only enabled if address 180 was set to ***Enabled*** during configuration of the function extent.

Under address 181 **L-sections FL** the number of line section must be selected, which is required for the accurate description of the line. If the number is set to ***2 Sections*** or ***3 Sections***, further setting sheets appear in the **Power System Data 2** in DIGSI. Default setting is ***1 Section***.

Line Data

To calculate the fault distance in kilometers or miles, the device needs the per distance reactance of the line in Ω/kilometer or Ω/mile. Furthermore, the line length in km or miles, the angle of the line impedance, and resistance and reactance ratios are required. These parameters have already been set in the **Power System Data 2** for a maximum of 3 line sections (see Section 2.1.6.2 under„Ground Impedance Ratios“ and „Reactance per Unit Length“).

Initiation of Measurement

Normally the fault location calculation is started when a directional or non-directional time overcurrent protection initiates a trip signal (address 8001 **START** = ***TRIP***). However, it may also be initiated when pickup drops out (address 8001 **START** = ***Pickup***), e.g. when another protection element clears the fault. Irrespective of this fact, calculation of the fault location can be triggered externally via a binary input. (FNo. 1106 „>Start Flt. Loc“) provided the device has picked up.

2.9.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8001	START	Pickup TRIP	Pickup	Start fault locator with

2.9.4 Information List

No.	Information	Type of Information	Comments
1106	>Start Flt. Loc	SP	>Start Fault Locator
1114	Rpri =	VI	Flt Locator: primary RESISTANCE
1115	Xpri =	VI	Flt Locator: primary REACTANCE
1117	Rsec =	VI	Flt Locator: secondary RESISTANCE
1118	Xsec =	VI	Flt Locator: secondary REACTANCE
1119	dist =	VI	Flt Locator: Distance to fault
1120	d[%] =	VI	Flt Locator: Distance [%] to fault
1122	dist =	VI	Flt Locator: Distance to fault
1123	FL Loop AG	OUT	Fault Locator Loop AG
1124	FL Loop BG	OUT	Fault Locator Loop BG
1125	FL Loop CG	OUT	Fault Locator Loop CG
1126	FL Loop AB	OUT	Fault Locator Loop AB
1127	FL Loop BC	OUT	Fault Locator Loop BC
1128	FL Loop CA	OUT	Fault Locator Loop CA
1132	Flt.Loc.invalid	OUT	Fault location invalid

2.10 Breaker Failure Protection 50BF

The breaker failure protection function monitors proper tripping of the relevant circuit breaker.

2.10.1 Description

General

If after a programmable time delay, the circuit breaker has not opened, breaker failure protection issues a trip signal to isolate the failure breaker by tripping other surrounding backup circuit breaker (see example in the figure below).

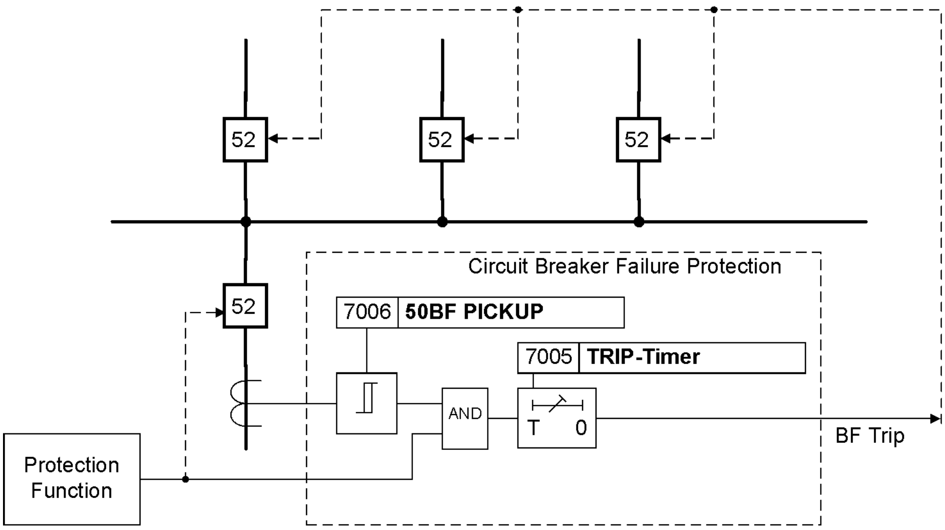


Figure 2-38 Function principle of the breaker failure protection

Initiation

The breaker failure protection function can be initiated by two different sources:

- Trip signals of internal protective functions of the 7SC80,
- external trip signals via binary inputs („>50BF ext SRC“).

For each of the two sources, a unique pickup message is generated, a unique time delay is initiated, and a unique trip signal is generated. The setting values of current threshold and delay time apply to both sources.

Criteria

There are two criteria for breaker failure detection:

- Check whether the current flow has effectively disappeared after a tripping command was issued,
- Evaluate the circuit breaker's auxiliary contacts.

The criteria used to determine if the circuit breaker has operated are selectable and also depend on the protection function that initiated the breaker failure function. On tripping without fault current, e.g. via voltage protection, the current below the threshold **50BF PICKUP** is not a reliable indication of the proper functioning of the circuit breaker. In such cases, pickup exclusively depends on the auxiliary contact criterion. In protection functions based on the measurement of currents (including all short-circuit protection functions), the current flow is a preferential criterion, i.e. it is given priority, as opposed to the auxiliary contacts. If current flows above the set threshold or thresholds (***enabled w/ 3I0>***) are detected, the breaker failure protection trips even if the auxiliary criterion indicates „Breaker Open“.

Monitoring of the Current Flow

At Address 170 **50BF**, you can set whether the current criterion can already be met by a single phase current (setting ***Enabled***) or whether another current is taken into consideration for the plausibility check (setting ***enabled w/ 3I0>***), see following Figure. With the setting ***Enabled w/o I>***, only the circuit breaker auxiliary contacts are evaluated. The current criterion **CB Icrit.closed** is not included in the logic.

The currents are filtered through numerical filters to evaluate the fundamental harmonic. They are monitored and compared to the set limit value. Besides the three phase currents, two further current thresholds are provided in order to allow a plausibility check. For purposes of the plausibility check, a configuration of a separate threshold value can be applied accordingly. (see Figure 2-39).

The ground current I_N ($3 \cdot I_0$) is preferably used as plausibility current. Via the parameters 613 you decide whether the measured (***Ignd (measured)***) or the calculated (***3I0 (calcul.)***) values are to be used. In case of system faults not involving ground currents, no increased ground currents/residual currents are flowing, and therefore the calculated triple negative sequence current $3 \cdot I_2$ or a second phase current is used as plausibility current.

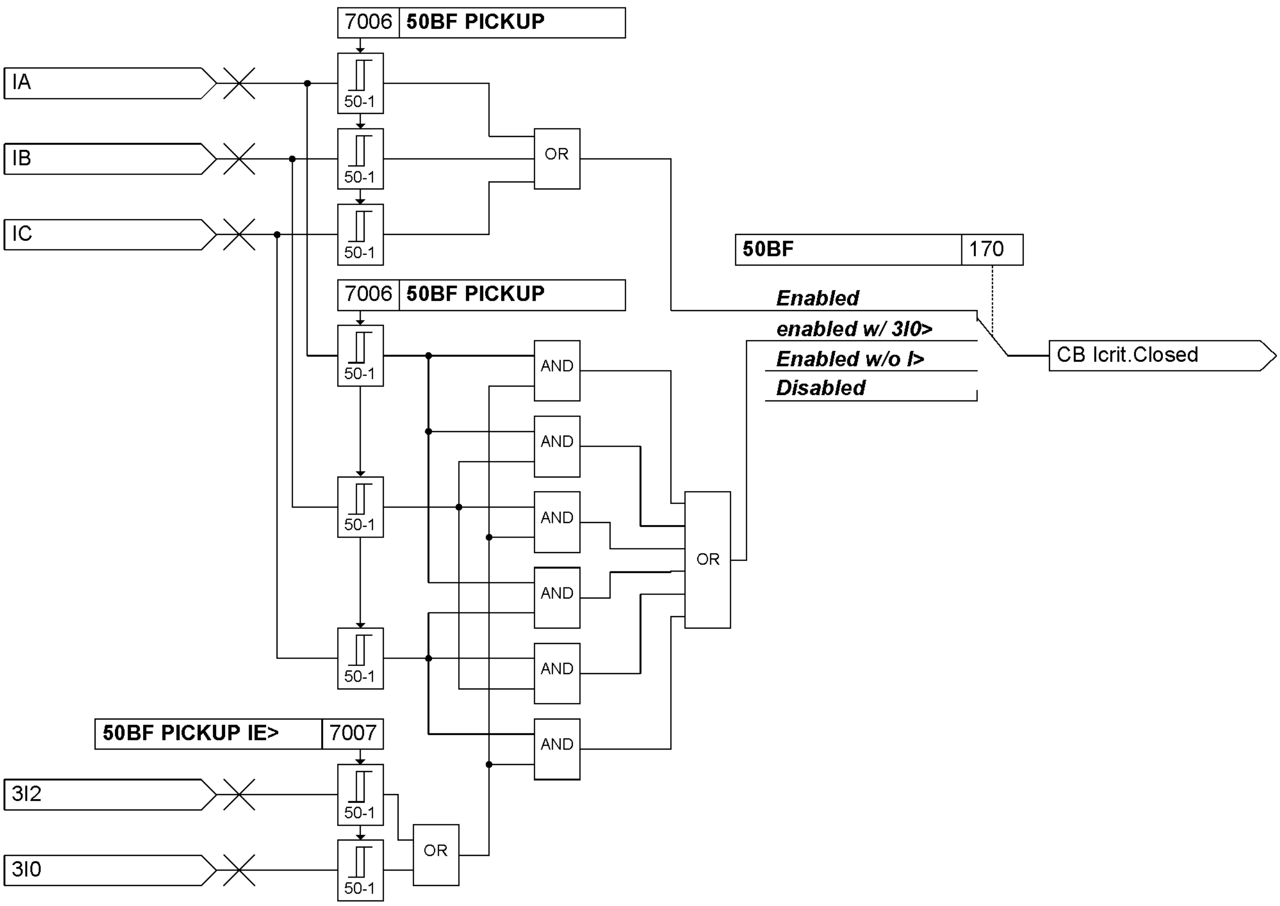


Figure 2-39 Monitoring of the current flow

Monitoring of the Circuit Breaker Auxiliary Contacts

Evaluation of the circuit breaker's auxiliary contacts depends on the type of contacts, and how they are connected to the binary inputs:

- the auxiliary contacts for circuit breaker "open" (4602 „>52-b“) and "closed" (4601 „>52-a“) are configured,
- only the auxiliary contact for circuit breaker "open" is configured(4602 „>52-b“),
- only the auxiliary contact for circuit breaker "closed" is configured (4601 „>52-a“),
- none of the two auxiliary contacts is configured.

Feedback information of the auxiliary status of the circuit breaker is evaluated, depending on the allocation of binary inputs and auxiliary contacts. After a trip command has been issued it is the aim to detect — if possible — by means of the feedback of the circuit breaker's auxiliary contacts whether the breaker is open or in intermediate position. If valid, this information can be used for a proper initiation of the breaker failure protection function.

The logic diagram illustrates the monitoring of the circuit breaker's auxiliary contacts.

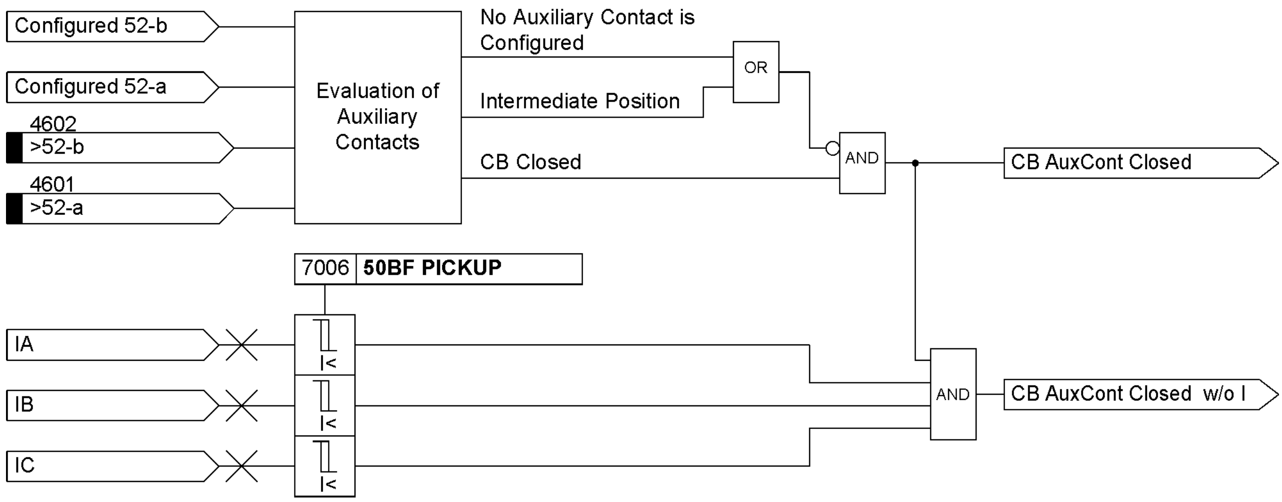


Figure 2-40 Logic diagram for breaker failure protection, monitoring of the circuit-breaker auxiliary contacts

Logic

If breaker failure protection is initiated, an alarm message is generated and a settable delay time is started. If once the time delay has elapsed, criteria for a pickup are still met, a trip signal is issued to a superordinate circuit breaker. Therefore, the trip signal issued by the breaker failure protection is configured to one of the output relays.

The following figure shows the logic diagram for the breaker failure protection function. The entire breaker failure protection function may be turned on or off, or it can be blocked dynamically via binary inputs.

If the criteria that led to the pickup are no longer met when the time delay has elapsed, such pickup thus drops out and no trip signal is issued by the breaker failure protection function.

To protect against nuisance tripping due to excessive contact bounce, a stabilization of the binary inputs for external trip signals takes place. This external signal must be present during the entire period of the delay time, otherwise the timer is reset and no trip signal is issued.

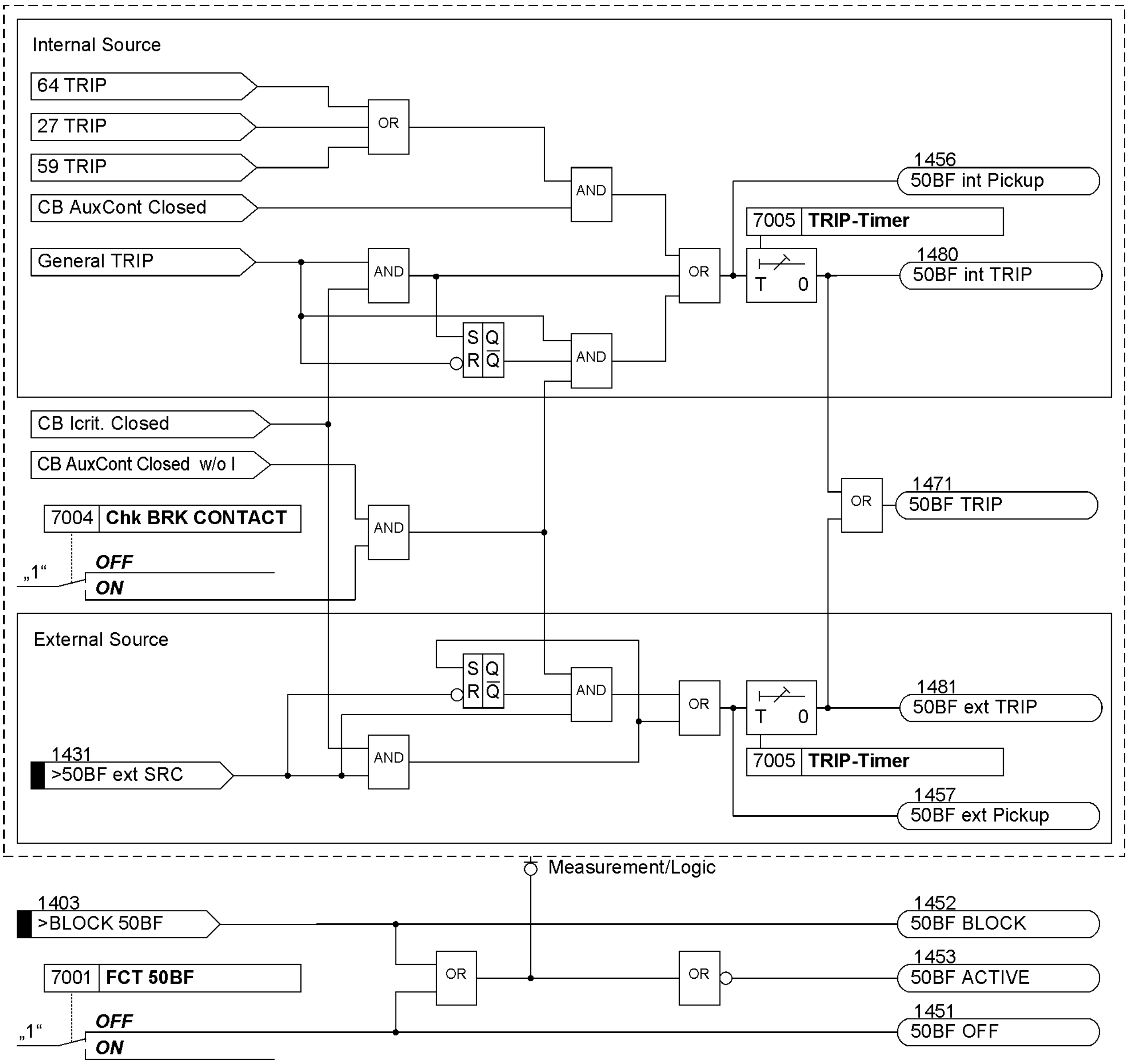


Figure 2-41 Logic diagram of the breaker failure protection

2.10.2 Setting Notes

General

Breaker failure protection is only effective and accessible if address 170 **50BF** is set to ***Enabled*** or ***enabled w/ 3I0>***. Setting ***Enabled*** considers the three phase currents for total current monitoring. Setting ***enabled w/ 3I0>*** additionally evaluates the ground current or the negative sequence system when only one phase current occurs.

With the setting ***Enabled w/o I>***, only the circuit breaker auxiliary contacts are evaluated. The current criterion **CB Icrit.closed** is not included in the logic (see Figure).

If this function is not required, then ***Disabled*** is set. The function can be set to ***ON*** or ***OFF*** under address 7001 **FCT 50BF**.

Criteria

Address 7004 **Chk BRK CONTACT** establishes whether or not the breaker auxiliary contacts connected via binary inputs are to be used as a criterion for pickup. If this address is set to ***ON***, then current criterion and/or the auxiliary contact criterion apply. This setting must be selected if the breaker failure protection is started by functions, which do not always have a certain criterion for detection of an open circuit breaker, e.g. voltage protection.

Time Delay

The time delay is entered at address 7005 **TRIP-Timer**. This setting should be based on the maximum circuit breaker operating time plus the dropout time of the current flow monitoring element plus a safety margin which takes into consideration the tolerance of the time delay. Figure 2-42 illustrates the time sequences.

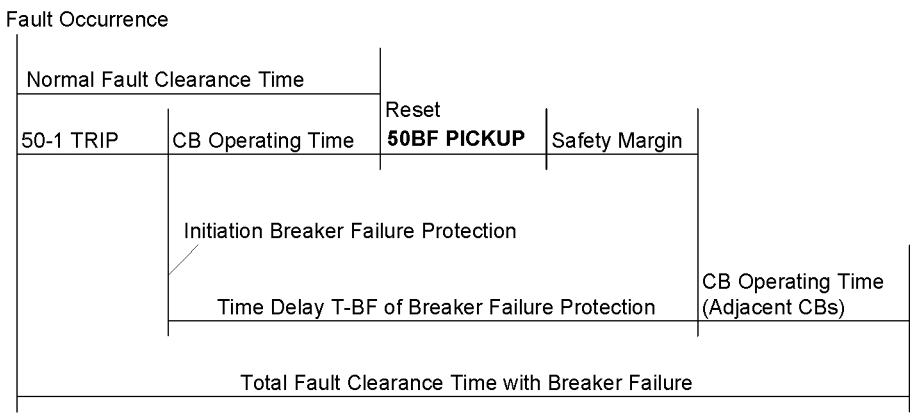


Figure 2-42 Time sequence example for normal clearance of a fault, and with circuit breaker failure

Pickup Values

The pickup value of the current flow monitoring is set under address 7006 **50BF PICKUP**, and the pickup value of the ground current monitoring under address 7007 **50BF PICKUP IE>**. The threshold values must be set at a level below the minimum fault current for which the total current monitoring must operate. A setting of 10% below the minimum fault current for which breaker failure protection must operate is recommended. The pickup value should not be set too low since otherwise there is a risk that transients in the current transformer secondary circuit may lead to extended dropout times if extremely high currents are switched off.

2.10.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
7001	FCT 50BF		OFF ON	OFF	50BF Breaker Failure Protection
7004	Chk BRK CONTACT		OFF ON	OFF	Check Breaker contacts
7005	TRIP-Timer		0.06 .. 60.00 sec; ∞	0.25 sec	TRIP-Timer
7006	50BF PICKUP	1A	0.05 .. 20.00 A	0.10 A	50BF Pickup current threshold
		5A	0.25 .. 100.00 A	0.50 A	
7007	50BF PICKUP IE>	1A	0.05 .. 20.00 A	0.10 A	50BF Pickup earth current threshold
		5A	0.25 .. 100.00 A	0.50 A	

2.10.4 Information List

No.	Information	Type of Information	Comments
1403	>BLOCK 50BF	SP	>BLOCK 50BF
1431	>50BF ext SRC	SP	>50BF initiated externally
1451	50BF OFF	OUT	50BF is switched OFF
1452	50BF BLOCK	OUT	50BF is BLOCKED
1453	50BF ACTIVE	OUT	50BF is ACTIVE
1456	50BF int Pickup	OUT	50BF (internal) PICKUP
1457	50BF ext Pickup	OUT	50BF (external) PICKUP
1471	50BF TRIP	OUT	50BF TRIP
1480	50BF int TRIP	OUT	50BF (internal) TRIP
1481	50BF ext TRIP	OUT	50BF (external) TRIP

2.11 Phase Sequence Reversal

A phase rotation function via binary input and parameter is implemented in 7SC80 devices.

Applications

- Phase rotation ensures that all protective and monitoring functions operate correctly even with anti-clock-wise rotation, without the need for two phases to be reversed.

2.11.1 Description

General

Various functions of the 7SC80 only operate correctly if the phase rotation of the voltages and currents is known. Among these functions are the undervoltage protection (based on positive sequence voltages), the directional overcurrent protection (direction with cross-polarized voltages), and several measured value supervision functions.

If an "acb" phase rotation is normal, the appropriate setting is made during configuration of the Power System Data.

If the phase rotation can change during operation, a reversal signal at the binary input configured for this purpose is sufficient to inform the protection device of the phase sequence reversal.

Logic

Phase rotation is permanently established at address 209 **PHASE SEQ.** (Power System Data). Via the exclusive-OR gate the binary input „>Reverse Rot.“ inverts the sense of the phase rotation applied with setting.

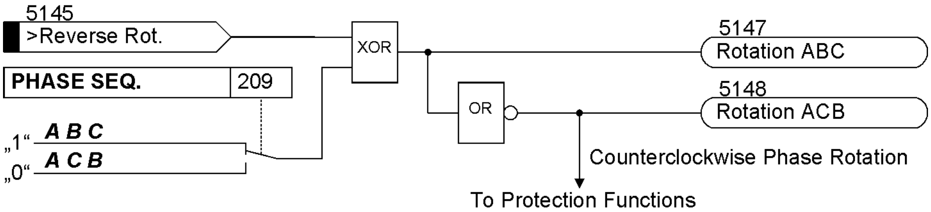


Figure 2-43 Message logic of the phase rotation reversal

Influence on Protection and Monitoring Functions

The swapping of the phases affects only the calculation of the positive and negative sequence quantities and the calculation of phase-to-phase quantities by subtracting two phase-to-ground voltages and vice versa so that the phase-selective indications, fault values and operational measured values are not distorted. This function thus influences the directional overcurrent protection, voltage protection, flexible protection functions, and some of the monitoring functions that generate indications if the defined and the calculated phase rotations do not match.

2.11.2 Setting Notes

Setting the Function Parameter

The normal phase sequence is set at 209 (see Section 2.1.3). If, on the system side, phase rotation is reversed temporarily, then this is communicated to the protective device using the binary input „>Reverse Rot.“ (5145).

2.12 Flexible Protection Functions

The flexible protection function is applicable for a variety of protection principles. The user can create up to 20 flexible protection functions and configure them according to their function. Each function can be used either as an autonomous protection function, as an additional protective element of an existing protection function or as a universal logic, e.g. for monitoring tasks.

2.12.1 Description

General

The function is a combination of a standard protection logic and a characteristic (measured quantity or derived quantity) that is adjustable via parameters. The characteristics listed in table 2-10 and the derived protection functions are available.

Please note that the power values are not available if you have selected the setting ***Vab, Vbc*** or as connection type for the voltage transformers in address 213 **VT Connect. 3ph**.

Table 2-10 Possible Protection Functions

Characteristic Group	Characteristic / Measured Quantity		Protective Function	ANSI No.	Mode of Operation	
					Three-phase	Single-phase
Current	I	RMS value of fundamental component	Overcurrent protection Undercurrent monitoring	50, 50G 37	X	X
	I_{rms}	True RMS (RMS value)	Overcurrent protection Thermal overload protection Undercurrent monitoring	50, 50G 49 37	X	X
	$3I_0$	Zero sequence system	Time overcurrent protection, ground	50N	X	
	I1	Positive-sequence component			X	
	I2	Negative-sequence component	Negative sequence protection	46	X	
	I2/I1	Positive/negative sequence component ratio			X	
Frequency	f	Frequency	Frequency protection	81U/O	without phase reference	
	df/dt	Frequency change	Frequency change protection	81R		
Voltage	V	RMS value of fundamental component	Voltage protection Displacement voltage	27, 59, 59G	X	X
	V_{rms}	True RMS (RMS value)	Voltage protection Displacement voltage	27, 59, 59G	X	X
	$3V_0$	Zero sequence system	Displacement voltage	59N	X	
	V_1	Positive-sequence component	Voltage protection	27, 59	X	
	V_2	Negative-sequence component	Voltage asymmetry	47	X	
Power	P	Real power	Reverse power protection Power protection	32R, 32, 37	X	X
	Q	Reactive power	Power protection	32	X	X
	cos φ	Power factor	Power factor	55	X	X
Binary input	–	Binary input	Direct coupling		without phase reference	

The maximum 20 configurable protection functions operate independently of each other. The following description concerns one function; it can be applied accordingly to all other flexible functions. The logic diagram 2-44 illustrates the description.

Functional Logic

The function can be switched ***ON*** and ***OFF*** or, it can be set to ***Alarm Only***. In this status, a pickup condition will neither initiate fault recording nor start the trip time delay. Tripping is thus not possible.

Changing the Power System Data 1 after flexible functions have been configured may cause these functions to be set incorrectly. Message (FNo.235.2128 „$00 inval.set“) reports this condition. The function is inactive in this case and function's setting has to be modified.

Blocking Functions

The function can be blocked via binary input (FNo. 235.2110 „>BLOCK $00“) or via local operating terminal („Control“ -> „Tagging“ -> „Set“). Blocking will reset the function's entire measurement logic as well as all running times and indications. Blocking via the local operating terminal may be useful if the function is in a status of permanent pickup which does not allow the function to be reset. In context with voltage-based characteristics, the function can be blocked if one of the measuring voltages fails. Recognition of this status is either accomplished by the relay's internal „Fuse-Failure-Monitor“ (FNo. 170 „VT FuseFail“; see section 2.8.1) or via auxiliary contacts of the voltage transformer CB (FNo. 6509 „>FAIL:FEEDER VT“ and FNo. 6510 „>FAIL: BUS VT“). This blocking mechanism can be enabled or disabled in the according parameters. The associated parameter **BLK.by Vol.Loss** is only available if the characteristic is based on a voltage measurement.

When using the flexible function for power protection or power monitoring, it will be blocked if currents fall below 0.03 I_{Nom}.

Operating Mode, Measured Quantity, Measurement Method

The flexible function can be tailored to assume a specific protective function for a concrete application in parameters **OPERRAT. MODE**, **MEAS. QUANTITY**, **MEAS. METHOD** and **PICKUP WITH**. Parameter **OPERRAT. MODE** can be set to specify whether the function works ***3-phase***, ***1-phase*** or ***no reference***, i.e. without a fixed phase reference. The three-phase method evaluates all three phases in parallel. This implies that threshold evaluation, pickup indications and trip time delay are accomplished selectively for each phase and parallel to each other. This may be for example the typical operating principle of a three-phase time overcurrent protection. When operating single-phase, the function employs either a phase's measured quantity, which must be stated explicitly, (e.g. evaluating only the current in phase ***Ib***), the measured ground current ***In*** or the measured displacement voltage ***Vn***. If the characteristic relates to the frequency or if external trip commands are used, the operating principle is without (fixed) phase reference. Additional parameters can be set to specify the used **MEAS. QUANTITY** and the **MEAS. METHOD**. The **MEAS. METHOD** determines for current and voltage measured values whether the function uses the RMS value of the fundamental component or the normal RMS value (true RMS) that evaluates also harmonics. All other characteristics use always the rms value of the fundamental component. Parameter **PICKUP WITH** moreover specifies whether the function picks up on exceeding the threshold (>-Element) or on falling below the threshold (<-Element).

Characteristic Curve

The function's characteristic curve is always „definite time“; this means that the time delay is not affected by the measured quantity.

Function Logic

Figure 2-44 shows the logic diagram of a three-phase function. If the function operates on one phase or without phase reference, phase selectivity and phase-specific indications are not relevant.

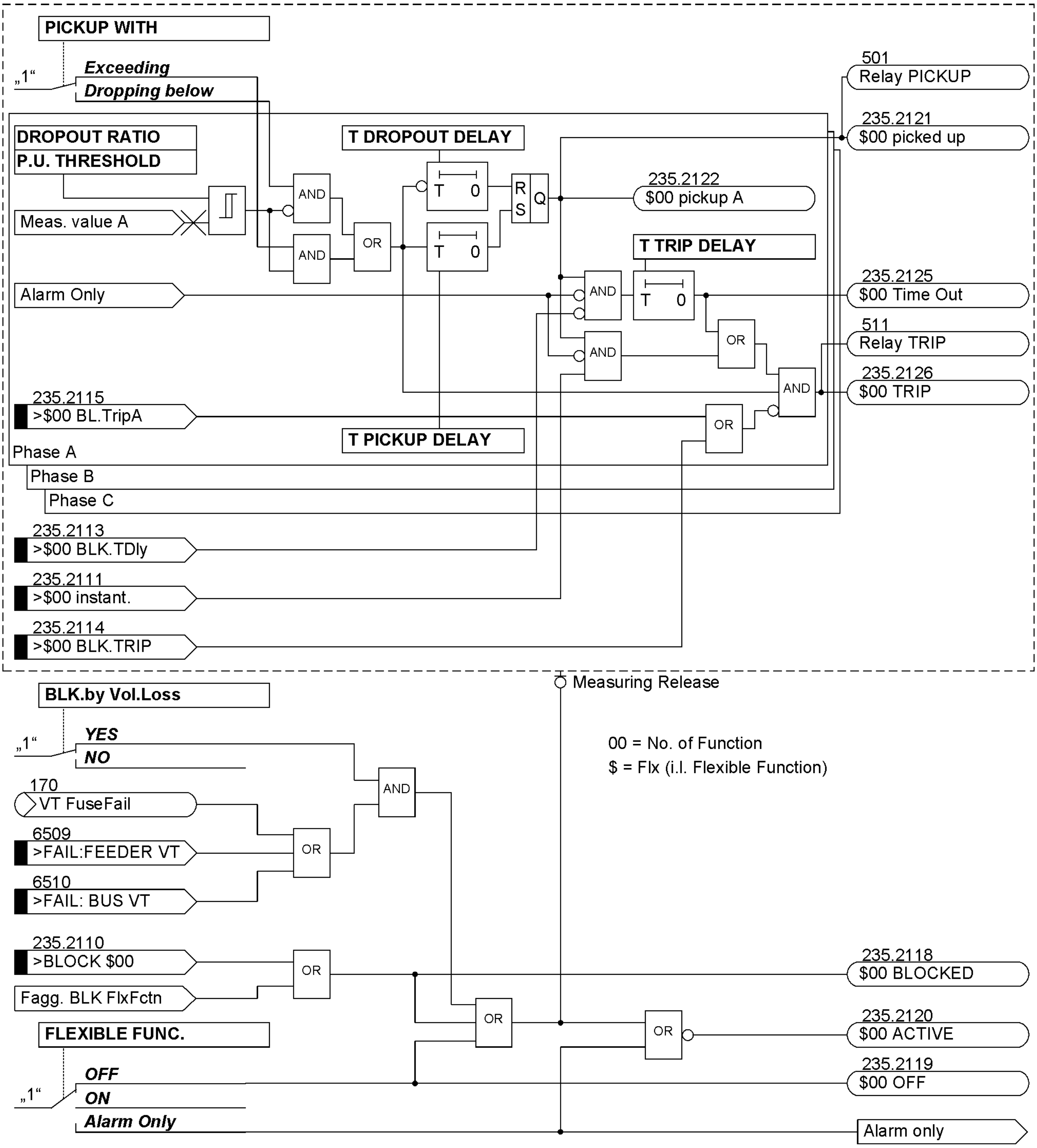


Figure 2-44 Logic diagram of the flexible protection functions

The parameters can be set to monitor either exceeding or dropping below of the threshold. The configurable pickup time delay will be started once the threshold (>-Element) has been exceeded. When the time delay has elapsed and the threshold is still violated, the pickup of the phase (e.g. no. 235.2122 „$00 pickup A“)and of the function (no. 235.2121 „$00 picked up“) is reported. If the pickup delay is set to zero, the pickup will occur simultaneously with the detection of the threshold violation. If the function is enabled, the pickup will start the trip time delay and the fault log. This is not the case if set to "Alarm only". If the threshold violation persists after the trip time delay has elapsed, the trip will be initiated upon its expiration (no. 235.2126 „$00 TRIP“). The timeout is reported via (no. 235.2125 „$00 Time Out“). Expiry of the trip time delay can be blocked via binary input (no. 235.2113 „>$00 BLK.TDly“). The time delay will not be started as long as the binary input is active; a trip can thus be initiated. The time delay is started after the binary input has dropped out and the pickup is still present. It is also possible to bypass the expiration of the time delay by activating binary input (no. 235.2111 „>$00 instant.“). The trip will be launched immediately when the pickup is present and the binary input has been activated. The trip command can be blocked via binary inputs (no. 235.2115 „>$00 BL.TripA“) and (no. 235.2114 „>$00 BLK.TRIP“). The phase-selective blocking of the trip command is required for interaction with the inrush restraint (see „Interaction with other functions“). The function's dropout ratio can be set. If the threshold (>-Element) is undershot after the pickup, the dropout time delay will be started. The pickup is maintained during that time, a started trip delay time continues to count down. If the trip time delay has elapsed while the dropout time delay is still during, the trip command will only be given if the current threshold is exceeded. The element will only drop out when the dropout time delay has elapsed. If the time is set to zero, the dropout will be initiated immediately once the threshold is undershot.

External Trip Commands

The logic diagram does not explicitly depict the external trip commands since their functionality is analogous. If the binary input is activated for external trip commands (no. 235.2112 „>$00 Dir.TRIP“), it will be logically treated as threshold overshooting, i.e. once it has been activated, the pickup time delay is started. If the pickup time delay is set to zero, the pickup condition will be reported immediately starting the trip time delay. Otherwise, the logic is the same as depicted in Figure 2-44.

Interaction with Other Functions

The flexible protection functions interact with a number of other functions such as the

- Breaker failure protection:

  The breaker failure protection is started automatically if the function initiates a trip. The trip will, however, only take place if the current criterion is met at this time, i.e. the set minimum current threshold 212 **BkrClosed I MIN** (Power System Data 1) has been exceeded.

- Fuse-Failure-Monitor (see description at „Blocking Functions“).

- Inrush restraint:

  Direct interaction with the inrush restraint is not possible. In order to block a flexible function by the inrush restraint, the blocking must be carried out in CFC. The flexible function provides three binary inputs for blocking trip commands selectively for each phase (no. 235.2115 to 235.2117). They have to be linked with the phase-selective indications for detecting the inrush (no. 1840 to 1842). Activating a crossblock function requires the phase-selective inrush indications to be logically combined with the binary input for blocking the function trip command (no. 235.2114 „>$00 BLK.TRIP“). The flexible function also needs to be delayed by at least 20 ms to make sure that the inrush restraint picks up before the flexible function.

- Entire relay logic:

  The pickup signal of the flexible function is added to the general device pickup, the trip signal is added to the general device trip (see also Chapter 2.13). All functions associated with general device pickup and tripping are thus also applied to the flexible function.

  After the picked up element has dropped out, the trip signals of the flexible protection functions are held up at least for the specified minimum trip command time 210 T TRIPCOM MIN.

2.12.2 Setting Notes

The setting of the functional scope determines the number of flexible protection functions to be used (see Chapter 2.1.1). If a flexible function in the functional scope is disabled (by removing the checkmark), this will result in losing all settings and configurations of this function or its settings will be reset to their default settings.

General

In the DIGSI setting dialog „General“, parameter **FLEXIBLE FUNC.** can be set to ***OFF***, ***ON*** or ***Alarm Only***. If the function is enabled in operational mode ***Alarm Only***, no faults are recorded, no „Effective“-indication is generated, no trip command issued and neither will the circuit-breaker protection be affected. Therefore, this operational mode is preferred when a flexible function is not required to operate as a protection function. Furthermore, the **OPERRAT. MODE** can be configured:

Three-phase – functions evaluate the three-phase measuring system, i.e. all three phases are processed simultaneously. A typical example is the three-phase operating time overcurrent protection.

Single-phase – functions evaluate only the individual measuring value. This can be an individual phase value (e.g. V_B) or a ground variable (V_N or I_N).

Setting ***no reference*** determines the evaluation of measured variables irrespective of a single or three-phase connection of current and voltage. Table 2-10 provides an overview regarding which variables can be used in which mode of operation.

Measured Variable:

In the setting dialog „Measured Variable“ the measured variables to be evaluated by the flexible protection functions can be selected, which may be a calculated or a directly measured variable. The setting options that can be selected here are dependent on the mode of measured-value processing as predefined in parameter **OPERRAT. MODE** (see the following table).

Table 2-11 Parameters “Operating Mode” and “Measured Quantity”

Parameter **OPERRAT. MODE** Setting	Parameter **MEAS. QUANTITY** Setting options
Single-phase Three-phase	Current Voltage P forward P reverse Q forward Q reverse Power factor
Without reference	Frequency df/dt rising df/dt falling Binray Input

If at address 213 **VT Connect. 3ph** you selected ***Vab, Vbc*** as type of connection of the voltage transformers, the power values are not available.

Measurement Procedures

The measurement procedures as set out in the following table can be configured for the measured variables - current, voltage and power. The dependencies of the available measurement procedures of configurable modes of operation and the measured variable are also indicated.

Table 2-12 Parameter in the Settings Dialog "Measurement Procedure", Mode of Operation three-phase

Mode of operation	**Measured Variable**		**Notes**
Three-phase	Current, Voltage	Parameter **MEAS. METHOD** Setting Options	
		Fundamental Harmonic	Only the fundamental harmonic is evaluated, higher harmonics are suppressed. This is the standard measurement procedure of the protection functions. Important: The voltage threshold value is always parameterized as phase-to-phase voltage independent of parameter VOLTAGE SYSTEM.
		True RMS	The "true" RMS value is determined, i.e. higher harmonics are evaluated. This procedure is applied, for example, if a simple overload protection is to be implemented on the basis of a current measurement, as the higher harmonics contribute to thermal heating. Important: The voltage threshold value is always parameterized as phase-to-phase voltage independent of parameter VOLTAGE SYSTEM.
		Positive sequence system, Negative sequence system, Zero sequence system	In order to implement certain applications, the positive sequence system or negative sequence system can be configured as measurement procedure. Examples are: - I2 (tripping monitoring system) - U2 (voltage asymmetry) Selecting the selection zero-sequence system enables additional zero-sequence current or zero-sequence voltage functions to be implemented that operate independently of the ground variables IN and VN, which are measured directly via transformers. Important: The voltage threshold value is always parameterized according to the definition of the symmetrical components independent of parameter VOLTAGE SYSTEM.
	Current	Ratio I2/I1	The ratio negative/positive sequence current is evaluated
	Voltage	Parameter **VOLTAGE SYSTEM** Setting Options	
		Phase-to-phase Phase-to-ground	If you have configured address 213 VT Connect. 3ph to Van, Vbn, Vcn or Vab, Vbc, VGnd, you can select whether a three-phase voltage function will evaluate the phase-to-ground voltage or the phase-to-phase voltages. When selecting phase-to-phase, these variables are derived from the phase-to-ground voltages. The selection is, for example, important for single-pole faults. If the faulty voltage drops to zero, the affected phase-to-ground voltage is zero, whereas the affected phase-to-phase voltages collapse to the size of a phase-to-ground voltage. With phase-to-phase voltage connections the parameter is hidden.

Note

With regard to the phase-selective pickup messages, a special behavior is observed in the three-phase voltage protection with phase-to-phase variables, because the phase-selective pickup message "Flx01 Pickup Lx" is allocated to the respective measured-value channel "Lx".

Single-phase faults:

If, for example, voltage V_A drops to such degree that voltages V_{AB} and V_{CA} exceed their threshold values, the device indicates pickups “Flx01 Pickup A” and “Flx01 Pickup C”, because the undershooting was detected in the first and third measured-value channel.

Two-phase faults:

If, for example, voltage V_{AB} drops to such degree that its threshold value is reached, the device then indicates pickup "Flx01 Pickup A", because the undershooting was detected in the first measured-value channel.

Table 2-13 Parameters in the Setting Dialog "Measurement Procedure", Operating Mode: Single-phase

Mode of operation	Measurand		Notes
Single-phase	Current, voltage	Parameter **MEAS. METHOD** setting options	
		Fundamental compo-nent	Only the fundamental harmonic is evaluated, higher harmonics are suppressed. This is the standard measurement procedure of the protection functions.
		True RMS	The „True“ RMS value is determined, i.e. higher harmonics are evaluated. This procedure is applied, for example, if a simple overload protection is to be implemented on the basis of a current measurement, as the higher harmonics contribute to thermal heating.
	Current	Parameter **CURRENT** setting options	
		IA IB IC IN	The current measuring channel that is to be evaluated by the function is determined.
	Voltage	Parameter **VOLTAGE** setting options	
		VAB VBC VCA VAN VBN VCN VN	The voltage measuring channel that is to be evaluated by the function is determined. When selecting a phase-to-phase volt-age, the threshold value must be set as a phase-to-phase value, when selecting a phase-to-ground variable as phase-to-ground voltage. The extent of the setting texts depends on the connec-tion of the voltage transformers (see address 213 VT Connect. 3ph).
	P forward, P reverse, Q forward, Q reverse	Parameter **POWER** setting options	
		IA VAN IB VBN IC VCN	The power measuring channel (current and voltage) that is to be evaluated by the function is determined. The extent of the setting texts depends on the connection of the voltage transformers (see address 213 VT Connect. 3ph). When selecting Vab, Vbc, VGnd, the phase-to-ground voltages will be calculated if „phase-to-ground“ is configured. When selecting „phase-to-phase“, the connected phase-to-phase voltages are used and VCA is calcu-lated from VAB and VBC.

The forward direction of power (P forward, Q reverse) is the direction of the line. Parameter (1108 **P,Q sign**) for sign inversion of the power display in the operating measured values is ignored by the flexible functions.

In single-phase voltage protection, the configured voltage threshold is always interpreted as voltage at the terminal. The parameterization in 213 **VT Connect. 3ph** (see Power System Data 1) is ignored here.

Via parameter **PICKUP WITH** it is determined whether the function must be triggered on exceeding or undershooting of the set threshold value.

Settings

The pickup thresholds, time delays and dropout ratios of the flexible protection function are set in the „Settings“ dialog box in DIGSI.

The pickup threshold of the function is configured via parameter **P.U. THRESHOLD**. The OFF-command time delay is set via parameter **T TRIP DELAY**. Both setting values must be selected according to the required application.

The pickup can be delayed via parameter **T PICKUP DELAY**. This parameter is usually set to zero (default setting) in protection applications, because a protection function should pick up as quickly as possible. A setting deviating from zero may be appropriate if a trip log is not desired to be started upon each short-term exceeding of the pickup threshold, for example, with power protection or when a function is not used as a protection, but as a monitoring function.

When setting the power threshold values, it is important to take into consideration that a minimum current of 0.03 I_N is required for power calculation. The power calculation is blocked for lower currents.

The dropout of pickup can be delayed via parameter **T DROPOUT DELAY**. This setting is also set to zero by default (standard setting) A setting deviating from zero may be required if the device is utilized together with electro-magnetic devices with considerably longer dropout ratios than the digital protection device (see Chapter 2.2 for more information). When utilizing the dropout time delay, it is recommended to set it to a shorter time than the OFF-command time delay in order to avoid both times to "race".

Parameter **BLK.by Vol.Loss** determines whether a function whose measured variable is based on a voltage measurement (measured quantities voltage, P forward, P reverse, Q forward, Q reverse and power factor), should be blocked in case of a measured voltage failure (set to ***YES***) or not (set to ***NO***).

The dropout ratio of the function can be selected in parameter **DROPOUT RATIO**. The standard dropout ratio of protection functions is 0.95 (default setting). If the function is used as power protection, a dropout ratio of at least 0.9 should be set. The same applies to the utilization of the symmetrical components of current and voltage. If the dropout ratio is decreased, it would be sensible to test the pickup of the function regarding possible "chatter".

The dropout difference of the frequency elements is set under parameter **DO differential**. Usually, the default setting of 0.02 Hz can be retained. A higher dropout difference should be set in weak systems with larger, short-term frequency fluctuations to avoid chattering of the message.

A permanent dropout difference of 0.1 Hz/s is used for the frequency change (df/dt) measurand. The same applies to the voltage change (dU/dt) measurand. The permanent dropout difference here is 3 V/s.

Renaming Messages, Checking Configurations

After parameterization of a flexible function, the following steps should be noted:

- Open matrix in DIGSI
- Rename the neutral message texts in accordance with the application.
- Check configurations on contacts and in operation and fault buffer, or set them according to the requirements.

Further Information

The following instruction should be noted:

- As the power factor does not differentiate between capacitive and inductive, the sign of the reactive power may be used with CFC-help as an additional criterion.

2.12.3 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
0	FLEXIBLE FUNC.		OFF ON Alarm Only	OFF	Flexible Function
0	OPERRAT. MODE		3-phase 1-phase no reference	3-phase	Mode of Operation
0	MEAS. QUANTITY		Please select Current Voltage P forward P reverse Q forward Q reverse Power factor Frequency df/dt rising df/dt falling Binray Input	Please select	Selection of Measured Quantity
0	MEAS. METHOD		Fundamental True RMS Positive seq. Negative seq. Zero sequence Ratio I2/I1	Fundamental	Selection of Measurement Method
0	PICKUP WITH		Exceeding Dropping below	Exceeding	Pickup with
0	CURRENT		Ia Ib Ic In In sensitive In2	Ia	Current
0	VOLTAGE		Please select Van Vbn Vcn Vab Vbc Vca Vn	Please select	Voltage

Addr.	Parameter	C	Setting Options	Default Setting	Comments
0	POWER		Ia Van Ib Vbn Ic Vcn	Ia Van	Power
0	VOLTAGE SYSTEM		Phase-Phase Phase-Ground	Phase-Phase	Voltage System
0	P.U. THRESHOLD	1A	0.05 .. 40.00 A	2.00 A	Pickup Threshold
		5A	0.25 .. 200.00 A	10.00 A	
0	P.U. THRESHOLD	1A	0.05 .. 40.00 A	2.00 A	Pickup Threshold
		5A	0.25 .. 200.00 A	10.00 A	
0	P.U. THRESHOLD	1A	0.001 .. 1.500 A	0.100 A	Pickup Threshold
		5A	0.005 .. 7.500 A	0.500 A	
0	P.U. THRESHOLD		2.0 .. 260.0 V	110.0 V	Pickup Threshold
0	P.U. THRESHOLD		2.0 .. 200.0 V	110.0 V	Pickup Threshold
0	P.U. THRESHOLD		40.00 .. 60.00 Hz	51.00 Hz	Pickup Threshold
0	P.U. THRESHOLD		50.00 .. 70.00 Hz	61.00 Hz	Pickup Threshold
0	P.U. THRESHOLD		0.10 .. 20.00 Hz/s	5.00 Hz/s	Pickup Threshold
0	P.U. THRESHOLD	1A	2.0 .. 10000.0 W	200.0 W	Pickup Threshold
		5A	10.0 .. 50000.0 W	1000.0 W	
0	P.U. THRESHOLD		-0.99 .. 0.99	0.50	Pickup Threshold
0	P.U. THRESHOLD		15 .. 100 %	20 %	Pickup Threshold
0	P.U. THRESHOLD		2.0 .. 260.0 V	110.0 V	Pickup Threshold
0	T TRIP DELAY		0.00 .. 3600.00 sec	1.00 sec	Trip Time Delay
0A	T PICKUP DELAY		0.00 .. 60.00 sec	0.00 sec	Pickup Time Delay
0	T PICKUP DELAY		0.00 .. 28800.00 sec	0.00 sec	Pickup Time Delay
0A	T DROPOUT DELAY		0.00 .. 60.00 sec	0.00 sec	Dropout Time Delay
0A	BLK.by Vol.Loss		NO YES	YES	Block in case of Meas.-Voltage Loss
0A	DROPOUT RATIO		0.70 .. 0.99	0.95	Dropout Ratio
0A	DROPOUT RATIO		1.01 .. 3.00	1.05	Dropout Ratio
0	DO differential		0.02 .. 1.00 Hz	0.03 Hz	Dropout differential

2.12.4 Information List

No.	Information	Type of Information	Comments
235.2110	>BLOCK $00	SP	>BLOCK Function $00
235.2111	>$00 instant.	SP	>Function $00 instantaneous TRIP
235.2112	>$00 Dir.TRIP	SP	>Function $00 Direct TRIP
235.2113	>$00 BLK.TDly	SP	>Function $00 BLOCK TRIP Time Delay
235.2114	>$00 BLK.TRIP	SP	>Function $00 BLOCK TRIP
235.2115	>$00 BL.TripA	SP	>Function $00 BLOCK TRIP Phase A
235.2116	>$00 BL.TripB	SP	>Function $00 BLOCK TRIP Phase B
235.2117	>$00 BL.TripC	SP	>Function $00 BLOCK TRIP Phase C
235.2118	$00 BLOCKED	OUT	Function $00 is BLOCKED
235.2119	$00 OFF	OUT	Function $00 is switched OFF
235.2120	$00 ACTIVE	OUT	Function $00 is ACTIVE
235.2121	$00 picked up	OUT	Function $00 picked up
235.2122	$00 pickup A	OUT	Function $00 Pickup Phase A
235.2123	$00 pickup B	OUT	Function $00 Pickup Phase B
235.2124	$00 pickup C	OUT	Function $00 Pickup Phase C
235.2125	$00 Time Out	OUT	Function $00 TRIP Delay Time Out
235.2126	$00 TRIP	OUT	Function $00 TRIP
235.2128	$00 inval.set	OUT	Function $00 has invalid settings
236.2127	BLK. Flex.Fct.	IntSP	BLOCK Flexible Function

2.13 Function Control

The function logic coordinates the execution of protection and auxiliary functions, it processes the resulting decisions and information received from the system. This includes in particular:

– Fault Detection / Pickup Logic

– Processing Tripping Logic

2.13.1 Pickup Logic of the Entire Device

General Device Pickup

The pickup signals for all protection functions in the device are connected via an OR logic and lead to the general device pickup. 4 It is initiated by the first function to pick up and drop out when the last function drops out. As a consequence, the following message is reported: 501 „Relay PICKUP“.

The general pickup is a prerequisite for a number of internal and external consequential functions. The following are among the internal functions controlled by general device pickup:

- Start of a trip log: From general device pickup to general device dropout, all fault messages are entered in the trip log.
- Initialization of Oscillographic Records: The storage and maintenance of oscillographic values can also be made dependent on the general device pickup.

Exception: Some protection functions cannot only be set to ***ON*** or ***OFF*** but also to ***Alarm Only***. When setting ***Alarm Only***, no trip command is given, no trip log is initiated, fault recording is not initiated, and no spontaneous fault indication is issued.

External functions may be controlled via an output contact. Examples are:

- Automatic reclosing devices,
- Starting of additional devices, or similar.

2.13.2 Tripping Logic of the Entire Device

General Tripping

The trip signals for all protective functions are connected by OR and generate the message 511 „Relay TRIP“.

This message can be configured to an LED or binary output, just as the individual tripping messages can.

Terminating the Trip Signal

Once the trip command is output by the protection function, it is recorded as message „Relay TRIP“ (see figure 2-45). At the same time, the minimum trip command duration **TMin TRIP CMD** is started. This ensures that the command is transmitted to the circuit breaker for a sufficient amount of time, even if the function which issued the trip signal drops out quickly. The trip commands can be terminated first when the last protection function has dropped out (no function is in pickup mode) AND the minimum trip signal duration has expired.

Finally, it is possible to latch the trip signal until it is manually reset (lockout function). This allows the circuit-breaker to be locked against reclosing until the cause of the fault has been clarified and the lockout has been manually reset. The reset takes place either by pressing the LED reset key or by activating an appropriately allocated binary input („>Reset LED“). A precondition, of course, is that the circuit-breaker close coil – as usual – remains blocked as long as the trip signal is present, and that the trip coil current is interrupted by the auxiliary contact of the circuit breaker.

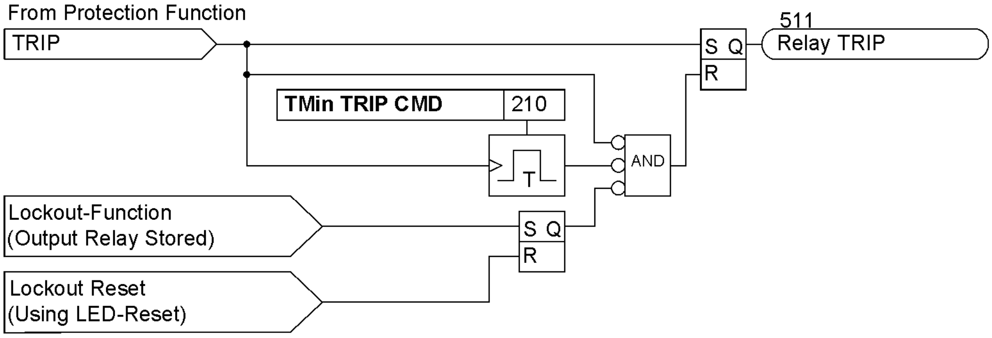


Figure 2-45 Terminating the Trip Signal

2.14 Additional Functions

The general functions of the device are described in the Additional Functions chapter.

2.14.1 Message Processing

After the occurrence of a system fault, information regarding the response of the protective relay and the measured values is important for a detailed analysis. An information processing function in the device takes care of this.

The procedure for allocating information is described in the SIPROTEC 4 System Description.

Applications

- LEDs and binary outputs
- Information via the Web Monitor
- Information to a control center

Prerequisites

The SIPROTEC 4 System Description provides a detailed description of the configuration procedure (see /1/).

2.14.1.1 LEDs and Binary Outputs (Output Relays)

Important events and conditions are indicated via LEDs on the device or via the Web Monitor. The device furthermore features output relays for remote signaling. Most of the indications and displays can be allocated, i.e. configured differently from the delivery condition. The Appendix of this manual deals in detail with the delivery condition and the allocation options.

The output relays and LEDs may be operated in a latched or unlatched mode (each may be set individually).

The latched conditions are protected against loss of the auxiliary voltage. They are reset

- via the Web Monitor by pressing the button Reset targets,
- via a correspondingly configured binary input,
- automatically at the beginning of a new pickup.

Condition indications should not be latched. They also cannot be reset until the criterion to be reported has been canceled. This applies, for example, to indications from monitoring functions or similar.

A green LED indicates operational readiness of the relay ("RUN"); it cannot be reset. It goes out if the self-check feature of the microprocessor detects a fault or if the auxiliary voltage fails.

When auxiliary voltage is present but the relay has an internal malfunction, then the red LED ("ERROR") lights up and the device is blocked.

An LED on the device and in the Web Monitor indicates the battery state.

2.14.1.2 Information via Display Panel or PC

Events and conditions can be read at the display panel of the Web Monitor. A PC to which the information is then sent can be connected via the USB interface or port F of the device.

The device is equipped with several event buffers for operational indications, circuit breaker statistics etc., which are protected against loss of the auxiliary voltage by a buffer battery. Reading indications indications during operation is described in the Web Monitor section and in the SIPROTEC 4 System Description.

Classification of Messages

The messages are categorized as follows:

- Operational messages (event log); messages generated while the device is operating: Information regarding the status of device functions, measured data, power system data, control command logs etc.
- Fault messages (trip log): messages from the last 8 network faults that were processed by the device.
- Messages of "statistics"; they include a counter for the trip commands initiated by the device and possibly 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 maximum functional scope can be found in the appendix. All functions are associated with an information number (FNo). There is also an indication of where each message can be sent to. If functions are not present in a not fully equipped version of the device, or are configured to ***Disabled***, then the associated indications cannot appear.

Operational Messages (Buffer: Event Log)

The operational messages contain information that the device generates during operation and about operational conditions. Up to 200 operational messages are recorded in chronological order in the device. New messages are appended at the end of the list. If the memory is used up, then the oldest message is scrolled out of the list by a new message.

Fault Messages (Buffer: Trip Log)

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 disturbance is output with a relative time referred to the instant of fault detection, so that the duration of the fault until tripping and up to reset of the trip command can be ascertained. The resolution of the time information is 1 ms

Retrievable Messages

The messages for the last eight network faults can be retrieved and read out. The definition of a network fault is such that the time period from fault detection up to final clearing of the disturbance is considered to be one network fault. 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 all reclosing shots, occupies only one trip log buffer. Within a network fault, several fault messages can occur (from the first pickup of a protective function to the last dropout of a protective function). Without auto-reclosing each fault event represents a network fault.

In total 600 indications can be recorded. Oldest data are erased for newest data when the buffer is full.

General Interrogation

The general interrogation which can be retrieved via DIGSI enables the current status of the SIPROTEC 4 device to be read out. All messages requiring general interrogation are displayed with their present value.

Spontaneous Messages

The spontaneous messages displayed using DIGSI reflect the present status of incoming information. Each new incoming message appears immediately, i.e. the user does not have to wait for an update or initiate one.

2.14.1.3 Information to a Substation Control Center

If the device has a serial system interface, stored information may additionally be transferred via this interface to a centralized control and storage device. Transmission is possible via different transmission protocols.

2.14.2 Statistics

The number of trips initiated by the 7SC80 and the operating hours under load are counted. An additional counter allows to determine the number of hours in which the switching device is in the „open“ condition.

The counter and memory levels are protected against loss of auxiliary voltage.

During the first start of the device, the statistical values are pre-defined to zero.

2.14.2.1 Description

Number of Trips

In order to count the number of trips initiated by the 7SC80, the position of the circuit breaker auxiliary contacts must be communicated to the 7SC80 via binary inputs. As to that, the internal pulse counter „`#of TRIPs=`“ must be allocated in the matrix to a binary input that is controlled by the switching device OPEN position. The pulse count value "Number of TRIPs CB" can be found in the "Statistics" group if the option "Measured and Metered Values Only" was enabled in the configuration matrix.

Operating Hours

The operating hours under load are also stored (= the current value in at least one phase is greater than the limit value **`BkrClosed I MIN`** set under address 212).

Hours Meter "CB open"

A meter can be realized as CFC application if it adds up the number of hours in state „CB open“ similarly to the operating hours meter. The universal hours meter is connected to a respective binary input and counts if this binary input is active. Alternatively, the fact that the value falls below the parameter value 212 **`BkrClosed I MIN`** may be used as a criterion for starting the meter. The meter can be set or reset. A CFC application example for such a meter is available on the Internet (SIPROTEC Download Area).

2.14.2.2 Setting Notes

Reading/Setting/Resetting the Counters

The counters can be read via the Web Monitor or using DIGSI. The procedure using DIGSI is explained in the SIPROTEC 4 System Description. Setting or resetting of these statistical counters takes place under the menu item **MESSAGES** —> **STATISTICS** by overwriting the counter values displayed.

2.14.2.3 Information List

No.	Information	Type of In-formation	Comments
-	#of TRIPs=	PMV	Number of TRIPs=
409	>BLOCK Op Count	SP	>BLOCK Op Counter
1020	Op.Hours=	VI	Counter of operating hours
1021	Σ Ia =	VI	Accumulation of interrupted current Ph A
1022	Σ Ib =	VI	Accumulation of interrupted current Ph B
1023	Σ Ic =	VI	Accumulation of interrupted current Ph C

2.14.3 Measurement

A series of measured values and values derived from these are constantly available for call-up by the Web Monitor, or for data transfer.

Applications

- Information on the actual status of the system
- Conversion of secondary values to primary values and percentages

Prerequisites

Except for secondary values, the device is able to indicate the primary values and percentages of the measured values.

A precondition correct display of the primary and percentage values is the complete and correct entry of the nominal values for the instrument transformers and the protected equipment as well as current and voltage transformer ratios in the ground paths when configuring the device. The following table shows the formulas which are the basis for the conversion of secondary values to primary values and percentages.

When using the ***Vab, Vbc*** type of connection for the voltage transformers (address 213 **VT Connect. 3ph**), the measured values for power P, Q, S, power factor, energy, and the values derived from these, e.g. mean values, etc., are not available.

Measured values which cannot be calculated due to the selected voltage connection are shown as dots.

2.14.3.1 Display of Measured Values

Measured values	Second-ary	Primary	%
I_A, I_B, I_C, I_1, I_2	$I_{sec.}$	$\frac{\text{CT PRIM}}{\text{CT SEC}} \cdot I_{sec}$	$\frac{I_{prim}}{\text{FullScaleCurr.}}$
$I_N = 3 \cdot I_0$ (calculated)	$I_{N\ sec.}$	$\frac{\text{CT PRIM}}{\text{CT SEC}} \cdot I_{n\ sec}$	$\frac{I_{Nom\ prim}}{\text{FullScaleCurr.}}$
I_N = measured value from the I_N input	$I_{N\ sec.}$	$\frac{\text{IN CT PRIM}}{\text{IN CT SEC}} \cdot I_{N\ sec}$	$\frac{I_{Nom\ prim}}{\text{FullScaleCurr.}}$
V_A, V_B, V_C, V_0, V_1, V_2	$V_{ph-n\ sec.}$	$\frac{\text{Vnom PRIMARY}}{\text{Vnom SECONDARY}} \cdot U_{PhNsec}$	$\frac{V_{prim}}{\text{FullScaleVolt.} / (\sqrt{3})}$
V_{A-B}, V_{B-C}, $V_{ph-ph\ sec.C-A}$	$V_{ph-ph\ sec.}$	$\frac{\text{Vnom PRIMARY}}{\text{Vnom SECONDARY}} \cdot V_{Ph-Ph\ sec}$	$\frac{V_{prim}}{\text{FullScaleVolt.}}$
P, Q, S (P and Q phase-segregat-ed)	No secondary measured values		$\frac{Power_{prim}}{\sqrt{3} \cdot (\text{Full.Scal.Volt.}) \cdot (\text{Full.Scal.Curr.})}$
Power factor (phase-segre-gated)	cos φ	cos φ	cos φ · 100 in %
Frequency	f in Hz	f in Hz	$\frac{f \text{ in Hz}}{f_{Nom}} \cdot 100$

Table 2-14 Legend for the conversion formulae

Parameter	Address	Parameter	Address
Vnom PRIMARY	202	Ignd-CT PRIM	217
Vnom SECONDARY	203	Ignd-CT SEC	218
CT PRIMARY	204	FullScaleVolt.	1101
CT SECONDARY	205	FullScaleCurr.	1101
Vph/Vdelta	206		

Depending on the type of device ordered and the device connections, some of the operational measured values listed below may not be available. The phase–to–ground voltages are either measured directly, if the voltage inputs are connected phase–to–ground, or they are calculated from the phase–to–phase voltages V_{A-B} and V_{B-C} and the displacement voltage V_N.

The displacement voltage V_N is either measured directly or calculated from the phase-to-ground voltages:

$$V_N = \frac{3 \cdot V_0}{V_{ph} / V_{delta}}$$

with $3\underline{V}_0 = (\underline{V}_{A-G} + \underline{V}_{B-G} + \underline{V}_{C-G})$
V_{ph}/V_{delta} = Transformation adjustment for ground input voltage (setting 0206A)

Please note that value V_0 is indicated in the operational measured values.

The ground current I_N is either measured directly or calculated from the conductor currents.

$$I_N = \frac{3 \cdot I_0}{I_{gnd-CT} / (CT)}$$

with $3\underline{I}_0 = (\underline{I}_A + \underline{I}_B + \underline{I}_C)$
$I_{gnd\text{-}CT}$ = setting 0217 or 0218
CT = setting 0204 or 0205)

Upon delivery, the power and operating values are set in such manner 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 to 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 1108 **P,Q sign** the signs for these components can be inverted.

The calculation of the operational measured values also takes place while a fault is running. The values are updated at intervals of > 0.3 s and < 1 s.

2.14.3.2 Transmitting Measured Values

Measured values can be transmitted to a central control and storage device via port F.

The measuring range in which these values are transmitted depends on the protocol and additional settings, if applicable.

Protocol	Transmittable measuring range, format
IEC 61850	The primary operational measured values are transmitted. The measured values as well as their unit format are described in detail in the PIXIT document of the 7SC80 device. The measured values are transmitted in „Float“ format. The transmittable measuring range is not limited and corresponds to that of the operational measurement.

2.14.3.3 Information List

No.	Information	Type of In-formation	Comments
601	Ia =	MV	Ia
602	Ib =	MV	Ib
603	Ic =	MV	Ic
604	In =	MV	In
605	I1 =	MV	I1 (positive sequence)
606	I2 =	MV	I2 (negative sequence)
621	Va =	MV	Va
622	Vb =	MV	Vb
623	Vc =	MV	Vc
624	Va-b=	MV	Va-b
625	Vb-c=	MV	Vb-c
626	Vc-a=	MV	Vc-a
627	VN =	MV	VN
629	V1 =	MV	V1 (positive sequence)
630	V2 =	MV	V2 (negative sequence)
641	P =	MV	P (active power)
642	Q =	MV	Q (reactive power)
644	Freq=	MV	Frequency
645	S =	MV	S (apparent power)
680	Phi A =	MV	Angle Va-Ia
681	Phi B =	MV	Angle Vb-Ib
682	Phi C =	MV	Angle Vc-Ic
831	3Io =	MV	3Io (zero sequence)
832	Vo =	MV	Vo (zero sequence)
901	PF =	MV	Power Factor
2161	Vbat =	MV	External battery voltage
2162	SysTemp =	MV	System temperature
2171	Ibat =	MV	External battery current
2233	Vx =	MV	Vx =
30701	Pa =	MV	Pa (active power, phase A)
30702	Pb =	MV	Pb (active power, phase B)
30703	Pc =	MV	Pc (active power, phase C)
30704	Qa =	MV	Qa (reactive power, phase A)
30705	Qb =	MV	Qb (reactive power, phase B)
30706	Qc =	MV	Qc (reactive power, phase C)
30707	PFa =	MV	Power Factor, phase A
30708	PFb =	MV	Power Factor, phase B
30709	PFc =	MV	Power Factor, phase C

2.14.4 Average Measurements

The long-term averages are calculated and output by the 7SC80.

2.14.4.1 Description

Long-Term Averages

The long-term averages of the three phase currents I_x, the positive sequence components I_1 for the three phase currents, and the real power P, reactive power Q, and apparent power S are calculated within a set period of time and indicated in primary values.

For the long-term averages mentioned above, the length of the time window for averaging and the frequency with which it is updated can be set.

2.14.4.2 Setting Notes

Average Calculation

The selection of the time period for measured value averaging is set with parameter 8301 **DMD Interval** in the corresponding setting group from A to D under **MEASUREMENT**. The first number specifies the averaging time window in minutes while the second number gives the frequency of updates within the time window. ***15 Min., 3 Subs***, for example, means: Time average is generated for all measured values with a window of 15 minutes. The output is updated every 15/3 = 5 minutes.

With address 8302 **DMD Sync.Time**, the starting time for the averaging window set under address 8301 is determined. This setting specifies if the window should start on the hour (***On The Hour***) or 15 minutes later (***15 After Hour***) or 30 minutes / 45 minutes after the hour (***30 After Hour***, ***45 After Hour***).

If the settings for averaging are changed, then the measured values stored in the buffer are deleted, and new results for the average calculation are only available after the set time period has passed.

2.14.4.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8301	DMD Interval	15 Min., 1 Sub 15 Min., 3 Subs 15 Min.,15 Subs 30 Min., 1 Sub 60 Min., 1 Sub 60 Min.,10 Subs 5 Min., 5 Subs	60 Min., 1 Sub	Demand Calculation Intervals
8302	DMD Sync.Time	On The Hour 15 After Hour 30 After Hour 45 After Hour	On The Hour	Demand Synchronization Time

2.14.4.4 Information List

No.	Information	Type of In-formation	Comments
833	I1 dmd=	MV	I1 (positive sequence) Demand
834	P dmd =	MV	Active Power Demand
835	Q dmd =	MV	Reactive Power Demand
836	S dmd =	MV	Apparent Power Demand
963	Ia dmd=	MV	I A demand
964	Ib dmd=	MV	I B demand
965	Ic dmd=	MV	I C demand

2.14.5 Min/Max Measurement Setup

Minimum and maximum values are calculated by the 7SC80. Time and date of the last update of the values can also be read out.

2.14.5.1 Description

Minimum and Maximum Values

The minimum and maximum values for the three phase currents I_x, the three phase voltages $V_{x\text{-}N}$, the phase-to-phase voltages V_{xy}, the positive sequence components I_1 and V_1, the voltage V_N, the active power P, the reactive power Q, and the apparent power S, the frequency, and the power factor cos φ are formed as primary values, including the date and time of their last update.

The minimum and maximum values of the long-term averages listed in the previous section are also calculated.

The minimum and maximum values can be reset at any time via binary input or by using the Web Monitor or the DIGSI software. Additionally, the reset can be carried out cyclically, starting at a preset point of time.

2.14.5.2 Setting Notes

Minimum and Maximum Values

The tracking of minimum and maximum values can be reset automatically at a programmable point in time. To select this feature, address 8311 **MinMax cycRESET** should be set to ***YES***. The point in time when reset is to take place (the minute of the day in which reset will take place) is set at address 8312 **MiMa RESET TIME**. The reset cycle in days is entered at address 8313 **MiMa RESETCYCLE**, and the beginning date of the cyclical process, from the time of the setting procedure (in days), is entered at address 8314 **MinMaxRES.START**.

2.14.5.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8311	MinMax cycRESET	NO YES	YES	Automatic Cyclic Reset Function
8312	MiMa RESET TIME	0 .. 1439 min	0 min	MinMax Reset Timer
8313	MiMa RESETCYCLE	1 .. 365 Days	7 Days	MinMax Reset Cycle Period
8314	MinMaxRES.START	1 .. 365 Days	1 Days	MinMax Start Reset Cycle in

2.14.5.4 Information List

No.	Information	Type of Information	Comments
-	ResMinMax	IntSP_Ev	Reset Minimum and Maximum counter
395	>I MinMax Reset	SP	>I MIN/MAX Buffer Reset
396	>I1 MiMaReset	SP	>I1 MIN/MAX Buffer Reset
397	>V MiMaReset	SP	>V MIN/MAX Buffer Reset
398	>VphphMiMaRes	SP	>Vphph MIN/MAX Buffer Reset
399	>V1 MiMa Reset	SP	>V1 MIN/MAX Buffer Reset
400	>P MiMa Reset	SP	>P MIN/MAX Buffer Reset
401	>S MiMa Reset	SP	>S MIN/MAX Buffer Reset
402	>Q MiMa Reset	SP	>Q MIN/MAX Buffer Reset
403	>Idmd MiMaReset	SP	>Idmd MIN/MAX Buffer Reset
404	>Pdmd MiMaReset	SP	>Pdmd MIN/MAX Buffer Reset
405	>Qdmd MiMaReset	SP	>Qdmd MIN/MAX Buffer Reset
406	>Sdmd MiMaReset	SP	>Sdmd MIN/MAX Buffer Reset
407	>Frq MiMa Reset	SP	>Frq. MIN/MAX Buffer Reset
408	>PF MiMaReset	SP	>Power Factor MIN/MAX Buffer Reset
412	> Θ MiMa Reset	SP	>Theta MIN/MAX Buffer Reset
837	IAdmdMin	MVT	I A Demand Minimum
838	IAdmdMax	MVT	I A Demand Maximum
839	IBdmdMin	MVT	I B Demand Minimum
840	IBdmdMax	MVT	I B Demand Maximum
841	ICdmdMin	MVT	I C Demand Minimum
842	ICdmdMax	MVT	I C Demand Maximum
843	I1dmdMin	MVT	I1 (positive sequence) Demand Minimum
844	I1dmdMax	MVT	I1 (positive sequence) Demand Maximum
845	PdMin=	MVT	Active Power Demand Minimum
846	PdMax=	MVT	Active Power Demand Maximum
847	QdMin=	MVT	Reactive Power Minimum
848	QdMax=	MVT	Reactive Power Maximum
849	SdMin=	MVT	Apparent Power Minimum
850	SdMax=	MVT	Apparent Power Maximum
851	Ia Min=	MVT	Ia Min
852	Ia Max=	MVT	Ia Max
853	Ib Min=	MVT	Ib Min
854	Ib Max=	MVT	Ib Max
855	Ic Min=	MVT	Ic Min
856	Ic Max=	MVT	Ic Max
857	I1 Min=	MVT	I1 (positive sequence) Minimum
858	I1 Max=	MVT	I1 (positive sequence) Maximum
859	VanMin=	MVT	Van Min
860	VanMax=	MVT	Van Max
861	VbnMin=	MVT	Vbn Min
862	VbnMax=	MVT	Vbn Max
863	VcnMin=	MVT	Vcn Min
864	VcnMax=	MVT	Vcn Max

No.	Information	Type of Information	Comments
865	VabMin=	MVT	Vab Min
867	VabMax=	MVT	Vab Max
868	VbcMin=	MVT	Vbc Min
869	VbcMax=	MVT	Vbc Max
870	VcaMin=	MVT	Vca Min
871	VcaMax=	MVT	Vca Max
872	Vn Min =	MVT	V neutral Min
873	Vn Max =	MVT	V neutral Max
874	V1 Min =	MVT	V1 (positive sequence) Voltage Minimum
875	V1 Max =	MVT	V1 (positive sequence) Voltage Maximum
876	Pmin=	MVT	Active Power Minimum
877	Pmax=	MVT	Active Power Maximum
878	Qmin=	MVT	Reactive Power Minimum
879	Qmax=	MVT	Reactive Power Maximum
880	Smin=	MVT	Apparent Power Minimum
881	Smax=	MVT	Apparent Power Maximum
882	fmin=	MVT	Frequency Minimum
883	fmax=	MVT	Frequency Maximum
884	PF Max=	MVT	Power Factor Maximum
885	PF Min=	MVT	Power Factor Minimum

2.14.6 Set Points for Measured Values

SIPROTEC devices facilitate the setting of limit values for some measured and metered values. If any of these limit values is reached, exceeded or fallen below during operation, the device issues an alarm which is indicated in the form of an operational message. This can be allocated to LEDs and/or binary outputs, transferred via the interfaces and linked in DIGSI CFC. The limit values can be configured via DIGSI CFC and allocated via the DIGSI device matrix.

Applications

- This monitoring program works with multiple measurement repetitions and a lower priority than the protection functions. Therefore, it may not pick up if measured values are changed spontaneously in the event of a fault, before a pickup or tripping of the protection function occurs. This monitoring program is therefore absolutely unsuitable for blocking protection functions.

2.14.6.1 Setting Notes

Setpoints for Measured Values

Setting is performed in the DIGSI configuration Matrix under **Settings**, **Masking I/O (Configuration Matrix)**. Apply the filter "Measured and Metered Values Only" and select the configuration group "Set Points (MV)".

Here you can insert new limit values via the Information Catalog which are subsequently linked to the measured value to be monitored using CFC.

This view also allows you to change the default settings of the limit values under **Properties**.

The settings for limit values must be in percent and usually refer to nominal values of the device.

For more details, see the SIPROTEC 4 System Description and the DIGSI CFC Manual.

2.14.7 Set Points for Statistic

2.14.7.1 Description

For the statistical counters, limit values may be entered so that a message is generated as soon as they are reached. These messages can be allocated to both output relays and LEDs.

2.14.7.2 Setting Notes

Limit Values for the Statistics Counter

The limit values for the statistics counters can be set in DIGSI under **Annunciation** → **Statistic** in the submenu **Statistics**. Double-click to display the corresponding contents in new window. By overwriting the previous value, a new value can be entered (see also SIPROTEC 4 System Description).

2.14.7.3 Information List

No.	Information	Type of In-formation	Comments
-	OpHour>	LV	Operating hours greater than
272	SP. Op Hours>	OUT	Set Point Operating Hours

2.14.8 Energy Metering

Count values for active and reactive energy are determined by the device. They can be output via the Web Monitor, read using DIGSI via the USB interface, or transmitted to a control center via port F.

2.14.8.1 Description

Metered Values for Active and Reactive Energy

Metered values of the real power W_p and reactive power (W_q) are acquired in kilowatt, megawatt or gigawatt hours primary or in kVARh, MVARh or GVARh primary, separately according to the input (+) and output (–), or capacitive and inductive. The measured-value resolution can be configured. The signs of the measured values appear as configured in address 1108 **P,Q sign** (see Section „Display of Measured Values“).

2.14.8.2 Setting Notes

Setting of parameter for meter resolution

Parameter 8315 **MeterResolution** can be used to maximize the resolution of the metered energy values by ***Factor 10*** or ***Factor 100*** compared to the ***Standard*** setting.

2.14.8.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8315	MeterResolution	Standard Factor 10 Factor 100	Standard	Meter resolution

2.14.8.4 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	WpForward	MVMV	Wp Forward
925	WqForward	MVMV	Wq Forward
928	WpReverse	MVMV	Wp Reverse
929	WqReverse	MVMV	Wq Reverse

2.14.9 Commissioning Aids

In test mode or during commissioning, the device information transmitted to a central or storage device can be influenced. There are tools available for testing the system interface (port F) and the binary inputs and outputs of the device.

Applications

- Test Mode
- Commissioning

Prerequisites

In order to be able to use the commissioning aids described in the following, the device must be connected to a control center via port F.

2.14.9.1 Description

Influencing Information to the Control Center During Test Mode

Some of the available protocols allow for identifying all messages and measured values transmitted to the control center with "test mode" as the message cause while the device is tested on site. This identification prevents the message from being incorrectly interpreted as resulting from an actual fault. Moreover, a transmission block can be set during the test so that no messages are transferred to the control center.

This can be accomplished via binary inputs or using DIGSI via the USB interface.

The SIPROTEC 4 System Description states in detail how to activate and deactivate test mode and blocked data transmission.

Testing the Connection to a Control Center

Via the DIGSI device control it can be tested whether messages are transmitted correctly.

A dialog box shows the texts of all indications which were allocated to the system interface (port F) in the DIGSI matrix. In another column of the dialog box, you can define a value for the indications to be tested (e.g. indication ON/indication OFF). After having entered password no. 6 (for hardware test menus), the corresponding indication is issued and can be read in the event log of the SIPROTEC 4 device and in the substation control center.

The procedure is described in detail in Chapter "Mounting and Commissioning".

Creating Oscillographic Recordings for Tests

During commissioning, energization sequences should be carried out to check the stability of the protection also during closing operations. Oscillographic event recordings contain the maximum information on the behavior of the protection.

Along with the capability of storing fault recordings via pickup of the protection function, the 7SC80 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 for the oscillographic recording then occurs, for instance, via the binary input when the protection object is energized.

Fault records that are triggered externally (that is, without a protective element pickup) are processed by the device as a normal oscillographic records. For each oscillographic record a fault record is created, with an individual number to ensure that assignment can be made properly. However, these oscillographic records are not displayed in the trip log as they are not a fault event.

The procedure is described in detail in Chapter "Mounting and Commissioning".

2.15 Command Processing

A control command function is integrated in the SIPROTEC 4 7SC80 device to coordinate the the switching operations in the substation.

Control commands can originate from four command sources:

- Operation using the Web Monitor
- Operation using DIGSI
- Remote control via a substation control system (e.g. SICAM)
- Automatic functions (e.g. via binary input)

Switchgear with single and multiple busbars are supported. The number of switchgear devices to be controlled is limited only by the number of available binary inputs and outputs. Interlocking checks ensure high security against maloperation, and a multitude of switchgear types and operating modes are available.

2.15.1 Control Device

Switchgear can also be controlled via the Web Monitor or via a connection to the substation control system.

Applications

- Switchgear with single and double busbars

Prerequisites

The number of switchgear devices to be controlled is limited by the the

– existing binary inputs

– existing binary outputs

2.15.1.1 Description

Operation Using Web Monitor

The Web Monitor features two buttons below the LED displays for the control.

Password and security prompts prevent unintended switching operations. The entries are confirmed using ENTER.

Cancellation is possible at any time before the control command is issued or during switch selection via the ESC key.

Command end, feedback, or any violation of the interlocking conditions are indicated.

For further information on the device operation, please refer to Section 2.16.

Operation Using DIGSI

When using DIGSI, switchgear can be controlled via the USB interface. The procedure for that is described in the SIPROTEC 4 System Description (Control of Switchgear).

Operation Using an Interface

Switchgear can also be controlled using a connection to the substation control system. For that, the required periphery must exist in the device and in the substation. Furthermore, certain settings for the interface need to be made in the device (see SIPROTEC 4 System Description).

2.15.1.2 Information List

No.	Information	Type of Information	Comments
-	52Breaker	CF_D12	52 Breaker
-	52Breaker	DP	52 Breaker
-	Disc.Swit.	CF_D2	Disconnect Switch
-	Disc.Swit.	DP	Disconnect Switch
-	GndSwit.	CF_D2	Ground Switch
-	GndSwit.	DP	Ground Switch
31000	Q0 OpCnt=	VI	Q0 operationcounter=
31001	Q1 OpCnt=	VI	Q1 operationcounter=
31008	Q8 OpCnt=	VI	Q8 operationcounter=

2.15.2 Command Types

In conjunction with the power system control several command types can be distinguished for the device:

2.15.2.1 Description

Commands to the Process

These are all commands that are directly output to the switchgear to change their process state:

- Switching commands for controlling the circuit breakers (not synchronized), disconnectors and ground electrodes
- Step commands, e.g. raising and lowering transformer LTCs
- Set-point commands with configurable time settings, e.g. to control Petersen coils

Internal / Pseudo Commands

They do not directly operate binary outputs. They serve to initiate internal functions, simulate changes of state, or to acknowledge changes of state.

- Manual overriding commands to manually update information on process-dependent objects such as annunciations and switching states, e.g. if the communication with the process is interrupted. Manually overridden objects are flagged as such in the information status and can be displayed accordingly.
- Tagging commands are issued to establish internal settings, e.g. deleting / presetting the switching authority (remote vs. local), a parameter set changeover, data transmission block to the SCADA interface, and measured value setpoints.

- Acknowledgment and resetting commands for setting and resetting internal buffers or data states.
- Information status command to set/reset the additional information "information status" of a process object, such as:
  - Input blocking
  - Output blocking

2.15.3 Command Sequence

Safety mechanisms in the command sequence ensure that a command can only be released after a thorough check of preset criteria has been successfully concluded. Standard Interlocking checks are provided for each individual control command. Additionally, user-defined interlocking conditions can be programmed separately for each command. The actual execution of the command is also monitored afterwards. The overall command task procedure is described in brief in the following list:

2.15.3.1 Description

Check Sequence

Please observe the following:

- Command input, e.g. via the Web Monitor
  - Check Password → Access Rights
  - Check Switching Mode (interlocking activated/deactivated) → Selection of Deactivated interlocking Recognition.
- User configurable interlocking checks
  - Switching Authority
  - Device Position Check (set vs. actual comparison)
  - Interlocking, Zone Controlled (logic using CFC)
  - System Interlocking (centrally, using SCADA system or substation controller)
  - Double Operation (interlocking against parallel switching operation)
  - Protection Blocking (blocking of switching operations by protective functions).
- Fixed Command Checks
  - 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)
  - Setting Modification in Process (if setting modification is in process, commands are denied or delayed)
  - Operating equipment enabled as output (if an operating equipment component was configured, but not configured to a binary input, the command is denied)
  - Output Block (if an output block has been programmed for the circuit breaker, and is active at the moment the command is processed, then the command is denied)
  - Board Hardware Error
  - Command in Progress (only one command can be processed at a time for one operating equipment, object-related Double Operation Block)
  - 1-of-n-check (for schemes with multiple assignments, such as relays contact sharing a common terminal a check is made if a command is already active for this set of output relays).

Monitoring the Command Execution

The following is monitored:

- Interruption of a command because of a Cancel Command
- Runtime Monitor (feedback message monitoring time)

2.15.4 Switchgear Interlocking

System interlocking is executed by the user-defined logic (CFC).

2.15.4.1 Description

Interlocking checks in a SICAM / SIPROTEC 4 system are normally divided in the following groups:

- System interlocking relies on the system data base in the substation or central control system.
- Bay interlocking relies on the object data base (feedbacks) of the bay unit.
- cross-bay interlocking via GOOSE messages directly between bay units and protection relays (with IEC61850: The inter-relay communication with GOOSE is performed via the EN100 module)

The extent of the interlocking checks is determined by the configuration of the relay. To obtain more information about GOOSE, please refer to the SIPROTEC 4 System Description /1/.

Switching objects that require system interlocking in a central control system are assigned to a specific parameter inside the bay unit (via configuration matrix).

For all commands, operation with interlocking (normal mode) or without interlocking (Interlocking OFF) can be selected:

- For local commands, by activation of "Normal/Test"-key switch,
- 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).

Deactivated interlock switching means the configured interlocking conditions are not checked in the relay.

Interlocked switching means that all configured interlocking conditions are checked within the command processing. If a condition is not fulfilled, the command will be rejected by a message with a minus added to it (e.g. "„CO–“"), immediately followed by a message.

The following table shows the possible types of commands in a switching device and their corresponding indications. The indications designated with *) are displayed in the shown form in the Web Monitor in the event logs, for DIGSI they appear in the spontaneous indications.

Type of Command	Command	Cause	Message
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" appearing in the message is a confirmation of the command execution. The command execution was as expected, in other words positive. The minus sign means a negative confirmation, the command was rejected. Possible command feedbacks and their causes are dealt with in the SIPROTEC 4 System Description. The following figure shows operational indications relating to command execution and operation response information for successful switching of the circuit breaker.

The check of interlocking can be programmed separately for all switching devices and tags that were set with a tagging command. Other internal commands such as manual entry or abort are not checked, i.e. carried out independent of the interlocking.

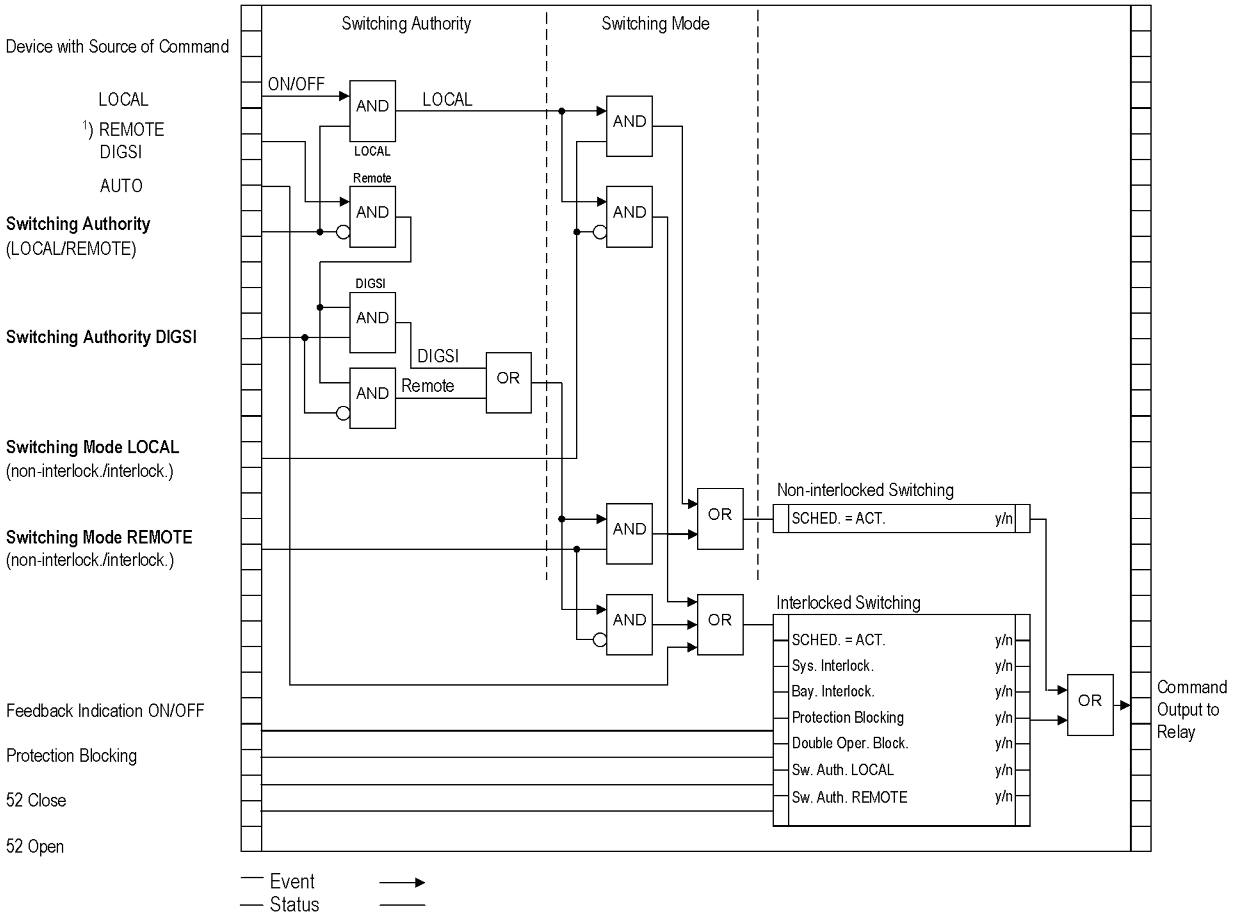
```
EVENT LOG
---------------------
19.06.01 11:52:05,625
Q0          CO+ Close

19.06.01 11:52:06,134
Q0          FB+ Close
```

Figure 2-46 Example of an operational annunciation for switching circuit breaker 52 (Q0)

Standard Interlocking (default)

The standard interlockings contain the following fixed programmed tests for each switching device, which can be individually enabled or disabled using parameters:

- Device Status Check (set = actual): The switching command is rejected, and an error indication is displayed if the circuit breaker is already in the set position. (If this check is enabled, then it works whether interlocking, e.g. zone controlled, is activated or deactivated.) This condition is checked in both interlocked and non-interlocked status modes.
- System Interlocking: To check the power system interlocking, a local command is transmitted to the central unit with Switching Authority = LOCAL. A switching device that is subject to system interlocking cannot be switched by DIGSI.
- Zone Controlled / Bay Interlocking: Logic links in the device which were created via CFC are interrogated and considered during interlocked switching.
- Protection blocking: Switch-ON commands are rejected in the case of interlocked switches as soon as one of the protection functions of the unit has initiated a trip log. However, trip commands can always be executed.
- Double Operation Block: Parallel switching operations are interlocked against one another; while one command is processed, a second cannot be carried out.
- Switching Authority LOCAL: A control command from the user interface of the device (command with command source LOCAL) is only allowed if the Key Switch (for devices without key switch via configuration) is set to LOCAL.
- Switching authority DIGSI: Switching commands that are issued locally or remotely via DIGSI (command with source DIGSI) are only allowed if remote control is enabled at the device (by configuration). If a DIGSI computer logs on to the device, it leaves a Virtual Device Number (VD). Only commands with this VD (when switching authority = REMOTE) are accepted by the device. Remote switching commands are rejected.
- Switching authority REMOTE: A remote switching command (command with source REMOTE) is only allowed if remote control is enabled at the device (by configuration).



¹) Source REMOTE also includes SAS.
(LOCAL Command using substation controller
REMOTE Command using remote source such as SCADA through controller to device.)

Figure 2-47 Standard interlockings

The following figure shows the configuration of the interlocking conditions using DIGSI.

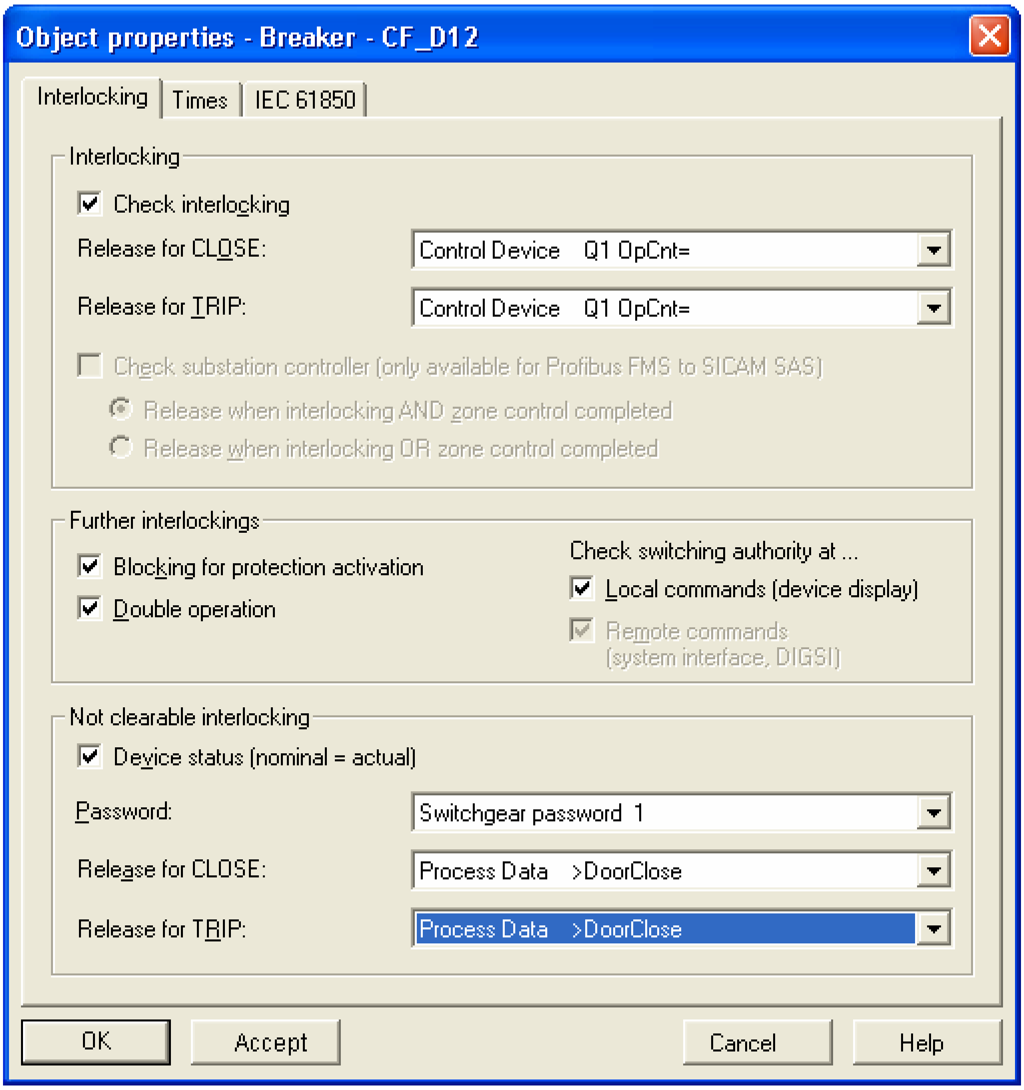


Figure 2-48 DIGSI dialog box 'Object properties' for setting the interlocking conditions

With the Web Monitor, configured interlocking causes are output on the device display. They are marked by letters explained in the following table.

Table 2-15 Command types and corresponding messages

Interlocking Commands	Abbrev.	Display
Switching Authority	L	L
System interlocking	S	A
Zone controlled	Z	Z
SET = ACTUAL (switch direction check)	P	P
Protection blocking	B	B

Control Logic using CFC

For the bay interlocking a control logic can be structured via 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).

Switching Authority

The interlocking condition "Switching authority" serves for determining the switching authority. It enables the user to select the authorized command source. The following switching authority ranges are defined in the following priority sequence:

- LOCAL
- DIGSI
- REMOTE

The "Switching authority" object serves for interlocking or unlocking LOCAL control, but not REMOTE or DIGSI commands. With a 7SC80, the switching authority can be changed between "REMOTE" and "LOCAL" on the operator panel after having entered the password, or by means of CFC also via binary inputs and a function key.

The "Switching authority DIGSI" is used for interlocking and allows commands to be initiated using DIGSI. This allows for local as well as remote DIGSI connections. When a (local or remote) DIGSI PC logs on to the device, it enters its Virtual Device Number (VD). Only commands with this VD (when switching authority = OFF or REMOTE) are accepted by the device. When the DIGSI PC logs off again, the VD is canceled.

Commands are checked for their source CS and the device settings and compared to the current status set in the objects "Switching authority" and "Switching authority DIGSI".

Configuration

Switching authority available	Y/N (create appropriate object)
Switching authority DIGSI available	Y/N (create appropriate object)
Specific device (e.g. switchgear)	Switching authority LOCAL (check for LOCAL status): Y/N
Specific device (e.g. switchgear)	Switching authority REMOTE (check for LOCAL, REMOTE or DIGSI commands): Y/N

Table 2-16 Interlocking Logic

Current switching authority status	Switching authority DIGSI	Command issued with CS[3] = LOCAL	Command issued with CS = LOCAL or REMOTE	Command issued with CS = DIGSI
LOCAL (ON)	Not registered	Enabled	Interlocked [2] - "Switching authority LOCAL"	Interlocked - "DIGSI not registered"
LOCAL (ON)	Registered	Enabled	Interlocked [2] - "Switching authority LOCAL"	Interlocked [2] - "Switching authority LOCAL"
REMOTE (OFF)	Not registered	Interlocked [1] - "Switching authority REMOTE"	Enabled	Interlocked - "DIGSI not registered"
REMOTE (OFF)	Registered	Interlocked [1] - "Switching authority DIGSI"	Interlocked [2] - "Switching authority DIGSI"	Enabled

[1] also "Enabled" for: "Switching Authority LOCAL (check for LOCAL status): n"

[2] also "Enabled" for: "Switching authority REMOTE (check for LOCAL, REMOTE or DIGSI commands): n"

[3] CS = command source

CS = Auto:

Commands that are initiated internally (command processing in the CFC) are not subject to the switching authority and are therefore always "enabled".

Switching Mode

The switching mode serves for activating or deactivating the configured interlocking conditions at the time of the switching operation.

The following (local) switching modes are defined:

- For local commands (CS = LOCAL)
  - interlocked (normal) or
  - unlocked (non-interlocked)

With a 7SC80, the switching mode can be changed between "interlocked" and "unlocked" in the Web Monitor after having entered the password, or by means of CFC also via binary inputs and a function key.

The following (remote) switching modes are defined:

- For remote or DIGSI commands (CS = LOCAL, REMOTE or DIGSI)
  - interlocked or
  - unlocked (non-interlocked). Here, bypassing the interlocking is accomplished via a separate unlocking command.
  - For commands from CFC (CS = Auto), please observe the notes in the CFC manual (component: BOOL to command).

Zone Controlled / Field Interlocking

Zone controlled / field interlocking (e.g. via CFC) includes the verification that predetermined switchgear position conditions are satisfied to prevent switching errors (e.g. disconnector vs. ground switch, ground switch only if no voltage applied) as well as verification of the state of other mechanical interlocking in the switchgear bay (e.g. High Voltage compartment doors).

Interlocking conditions can be programmed separately, for each switching device, for device control CLOSE and/or OPEN.

The enable information with the data "switching device is interlocked (OFF/NV/FLT) or enabled (ON)" can be set up,

- directly, using a single point or double point indication, key-switch, or internal indication (marking), or
- by means of a control logic via CFC.

When a switching command is initiated, the actual status is scanned cyclically. The assignment is done via "Release object CLOSE/OPEN".

System Interlocking

Substation Controller (System interlocking) involves switchgear conditions of other bays evaluated by a central control system.

Double Activation Blockage

Parallel switching operations are interlocked. As soon as the command has arrived all command objects subject to the interlocking are checked to know whether a command is being processed. While the command is being executed, interlocking is enabled for other commands.

Blocking by Protection

The pickup of protective elements blocks switching operations. Protective elements are configured, separately for each switching component, to block specific switching commands sent in CLOSE and TRIP direction.

When enabled, "Block CLOSE commands" blocks CLOSE commands, whereas "Block TRIP commands" blocks TRIP signals. Switching operations in progress will immediately be aborted by the pickup of a protective element.

Device Status Check (set = actual)

For switching commands, a check takes place whether the selected switching device is already in the set/desired position (set/actual comparison). This means, if a circuit breaker is already in the CLOSED position and an attempt is made to issue a closing command, the command will be refused, with the operating message "set condition equals actual condition". If the circuit breaker / switchgear device is in the intermediate position, then this check is not performed.

Bypassing Interlocking

Bypassing configured interlockings at the time of the switching action happens device-internally via interlocking recognitions in the command job or globally via so-called switching modes.

- CS=LOCAL
  - The switching modes "interlocked" or "unlocked" (non-interlocked) can be set in housing sizes $^1/_2$ or $^1/_1$ via the key switch. The position "Interlocking OFF" corresponds to unlocked switching and serves the special purpose of unlocking the standard interlockings. For devices in housings of size $^1/_3$, the switching mode can be changed between "interlocked" and "unlocked" on the operator panel after having entered the password, or by means of CFC also via binary inputs and a function key.
- REMOTE and DIGSI
  - Commands issued by SICAM or DIGSI are unlocked via a global switching mode REMOTE. A separate request must be sent for unlocking. Unlocking applies for one switching operation only and only for commands caused by the same source.
  - Job order: command to object "Switching mode REMOTE", ON
  - Job order: switching command to "switching device"
- Derived commands via CFC (automatic command, CS=Auto SICAM):
  - Behavior configured in the CFC block ("BOOL to command").

2.15.5 Command Logging

During the processing of the commands, independent of the further message routing and processing, command and process feedback information are sent to the message processing center. These messages contain information on the cause. With the corresponding allocation (configuration) these messages are entered in the event list, thus serving as a report.

Prerequisites

A listing of possible operating messages and their meaning as well as the command types needed for tripping and closing of the switchgear or for raising and lowering of transformer taps are described in the SIPROTEC 4 System Description.

2.15.5.1 Description

Acknowledgment of Commands to the Device Front

All indications with the source of command LOCAL are transformed into a corresponding response and shown in the text field of the Web Monitor.

Acknowledgment of Commands to LOCAL/REMOTE/DIGSI

The acknowledgment of indications with source of command LOCAL/REMOTE/DIGSI are sent back to the initiating point independent of the routing (configuration on the interface).

The acknowledgment of commands is thus not effected via a response as in the case of a local command but via the normal command and feedback logging.

Monitoring of Feedback Information

The processing of commands monitors the command execution and timing of feedback information for all commands. At the same time the command is sent, the monitoring time is started (monitoring of the command execution). This time controls whether the device achieves the required final result within the monitoring time. The monitoring time is stopped as soon as the feedback information arrives. If no feedback information arrives, a response "Timeout command monitoring time" appears and the process is terminated.

Commands and information feedback are also recorded in the event list. Normally the execution of a command is terminated as soon as the feedback information (**FB+**) of the relevant switchgear arrives or, in case of commands without process feedback information, the command output resets and a message is output.

The "plus" sign appearing in a feedback information confirms that the command was successful. The command was as expected, in other words positive. The "minus" is a negative confirmation and means that the command was not executed as expected.

Command Output and Switching Relays

The command types needed for tripping and closing of the switchgear or for raising and lowering of transformer taps are described in the configuration section of the SIPROTEC 4 System Description /1/ .

2.16 Device Operation

The Web Monitor facilitates the displaying of parameters, indications and measuring values for 7SC80 devices during operation or commissioning. The Web Monitor is called via a web browser such as the Internet Explorer.

Apart from general information regarding installation, this manual provides a description of specific functions of the Web Monitor for 7SC80 only. The general functions are described in the Help file of the DIGSI CD (from DIGSI V4.60 on).

Prerequisites

The Web Monitor runs on the operator PC and requires only standard software. The following software / operating systems must be installed:

Operating system: Microsoft Windows XP or Windows 7

Internet browser: Microsoft Internet Explorer from Version 7.0 on or other browsers which can start JNLP files, e.g. Mozilla Firefox.

Java Runtime Environment (JRE) from Version 6 on must be installed and activated.

Network adapter: The required software component is included in Microsoft Windows. This component is only required if the device is connected via an Ethernet interface (possible for devices with EN100 interface).

2.16.1 Web Monitor

General

To run the Web Monitor, the operator PC must be connected to the Feeder Automation Controller 7SC80 via the Ethernet interface. If you want to use the USB interface, a data communication connection is required. Information on configuring the data communication connection is available on the Internet at www.siprotec.de.

An Internet browser must be installed on the operator PC (see paragraph on system requirements). DIGSI 4 is usually also installed on the operator PC.

Note that DIGSI 4 and the Web Monitor do not work on the same interface at the same time.Before the Web Monitor is started, the settings and routings on the device should have been completed with DIGSI 4.

The Web Monitor is included in the Feeder Automation Controller 7SC80 delivery. It consists of HTML pages and a Java web start application, which are stored in the 7SC80. It forms an integral part of the firmware and therefore does not need to be installed separately.

To start the Web Monitor:

- Open the Internet browser.
- Enter the IP address of the used interface of the 7SC80 in the address bar of the browser.

The basic window of the Web Monitor is displayed. It shows the following areas:

- Navigation tree for selecting the output of indications and measured values
- Control and display panel

Via the menu bar, you can select all logs and measured values displayed in the navigation tree.

The menu item **Options** is used for diagnostic purposes and can be activated by Siemens experts only.

Control and Display Panel

The control and display panel is structured into various function and display areas.

- 32 LEDs to display operating states or indications
- OPEN and CLOSE key to activate/deactivate assigned operational equipment
- 6-line field to display operational indications and measured values
- ESC key to cancel entries made in the display panel, scroll keys and ENTER key to confirm entries made in the text field.
- LEDs Run, Error and Battery to display the operating state of the 7SC80 and the connected external battery (see also Section 2.1.2, Battery Charger)
- 10 function keys to select functions directly
- NUM LOCK key to switch the functions of the function keys. When this key is not pressed, the function keys work as labeled. When this key is pressed, the function keys can be used to enter digits.
- The RESET TARGETS key resets the LED displays.
- The LOCK PB key locks the other keys.

The assignment and labeling of the LEDs and function keys corresponds to the allocation made with DIGSI. For further information, please refer to the system description /1/. The allocation is automatically displayed next to the LEDs and function keys in the Web Monitor.

The description of the navigation and the setting options in the text field can be found in the System Description /1/.

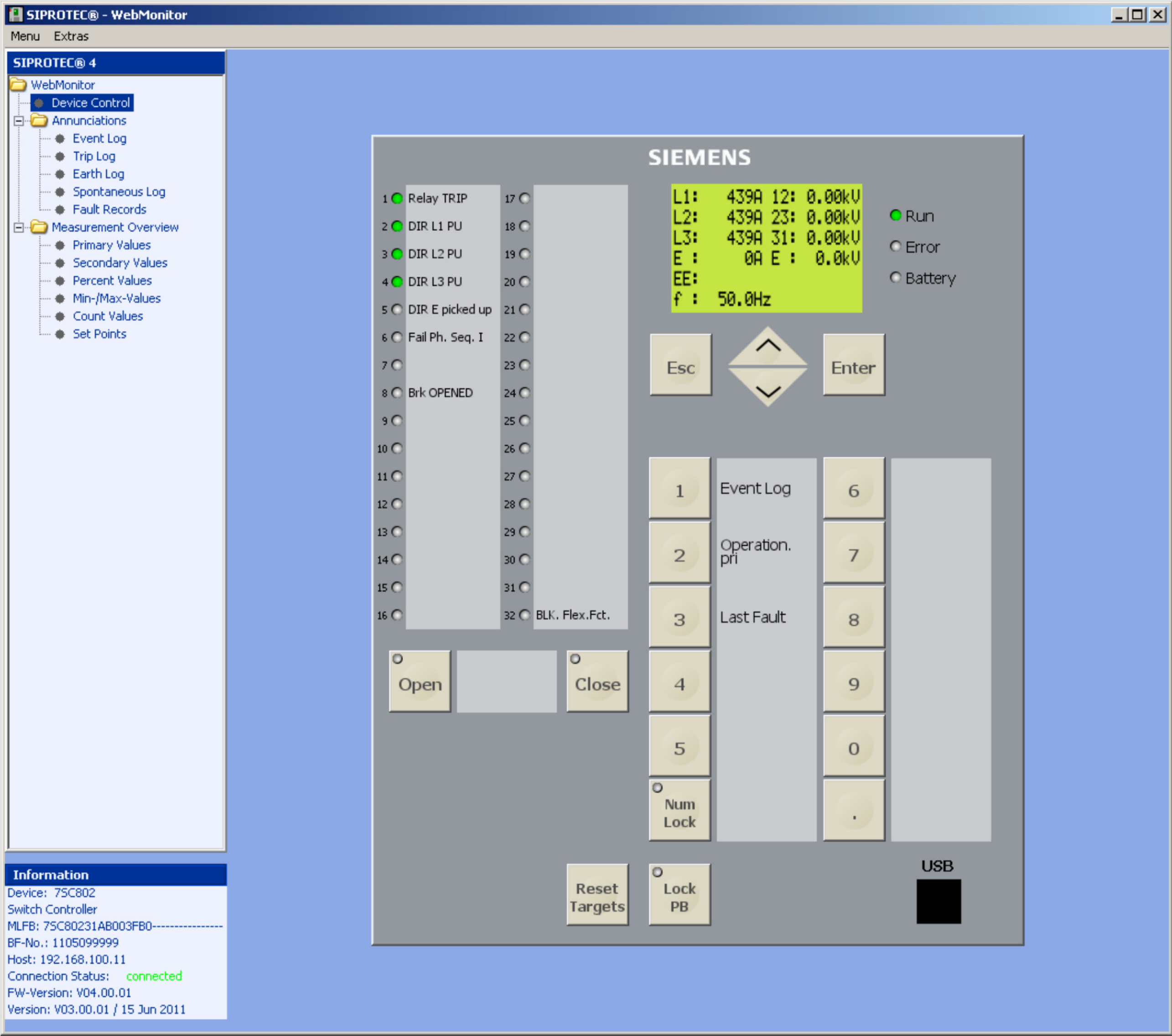


Figure 2-49 Web Monitor – Device Control

Displaying of Indications

In the Web Monitor, the indications of the 7SC80 are displayed in different logs depending on their type and allocation.

- Event Log (event list)
- Trip Log (alarm list)
- Earth Log (ground fault indications)
- Spontaneous Log (spontaneous indications)
- Fault Records

The list selected in the navigation tree is shown in the display area. The logs are continuously updated. Further information on the type and content of the logs can be found in the System Description /1/.

Some examples are given in the following.

The following editing options are available for the displayed content of the selected log:

- Saving via **Save**.

  The indications are saved in a text file from the selection time of a page on.

  The file name must have the ending .TXT.

  If you save another page of the list, this page is saved beginning at the selection time.

  Examples of the displaying of a text file can be found in the following Section **Logging**.

- Printing via **Print**.

  The indications are printed beginning at the selection time of a page. Examples can be found in the following Section **Logging**.

- Deleting via **Delete**.

  The device password is required to delete the displayed content of a log. Further information on the device password can be found in the System Description /1/.

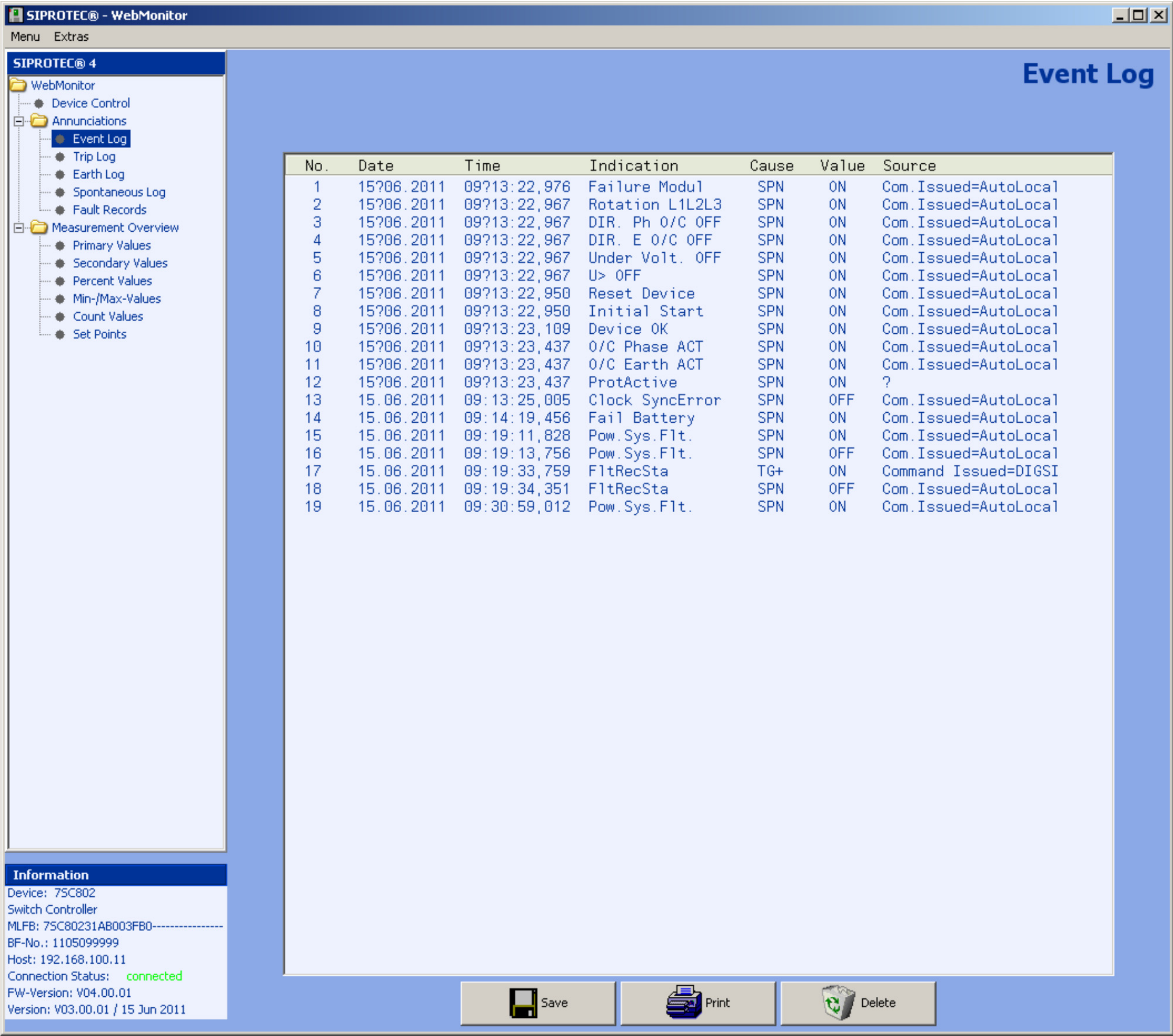


Figure 2-50 Web Monitor – Event Log

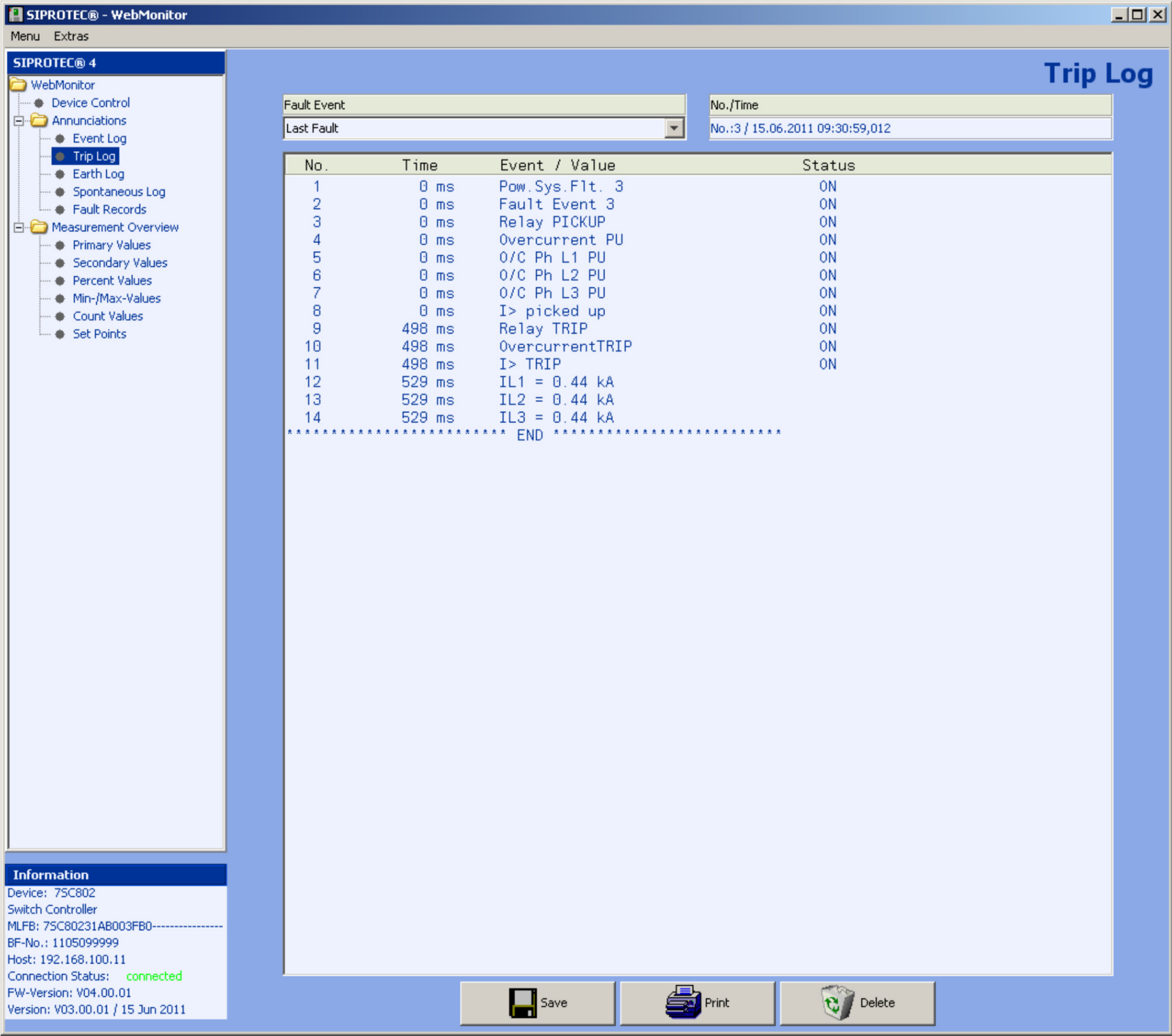


Figure 2-51 Web Monitor – Trip Log

The **Fault Records** log indicates all pending fault records.

With the VIEW key, the fault record is opened with the SIGRA evaluation program. SIGRA must be installed on your system. This program is not included in the Web Monitor.

Figure 2-52 Web Monitor – Fault Records

Displaying Measured Values

In the Web Monitor, the measured values and count values of the 7SC80 are displayed in various lists.

- Primary values

  Measured values of the primary side
- Secondary values

  Measured values of the secondary side
- Percent values

  Percentage indication of the values, referred to the nominal values
- MinMax values

  Minimum and maximum values
- Count values

  Metered energy values
- Set points

  Statistic values

The list selected in the navigation tree is shown in the display area. Some examples are given in the following. Further information on the type and content of the measurement logs can be found in the System Description /1/.

With the SAVE key, a list is saved with the values displayed last. Up to 1000 entries can be saved for each page.

The NEXT and PREVIOUS keys can be used to browse forward and backward.

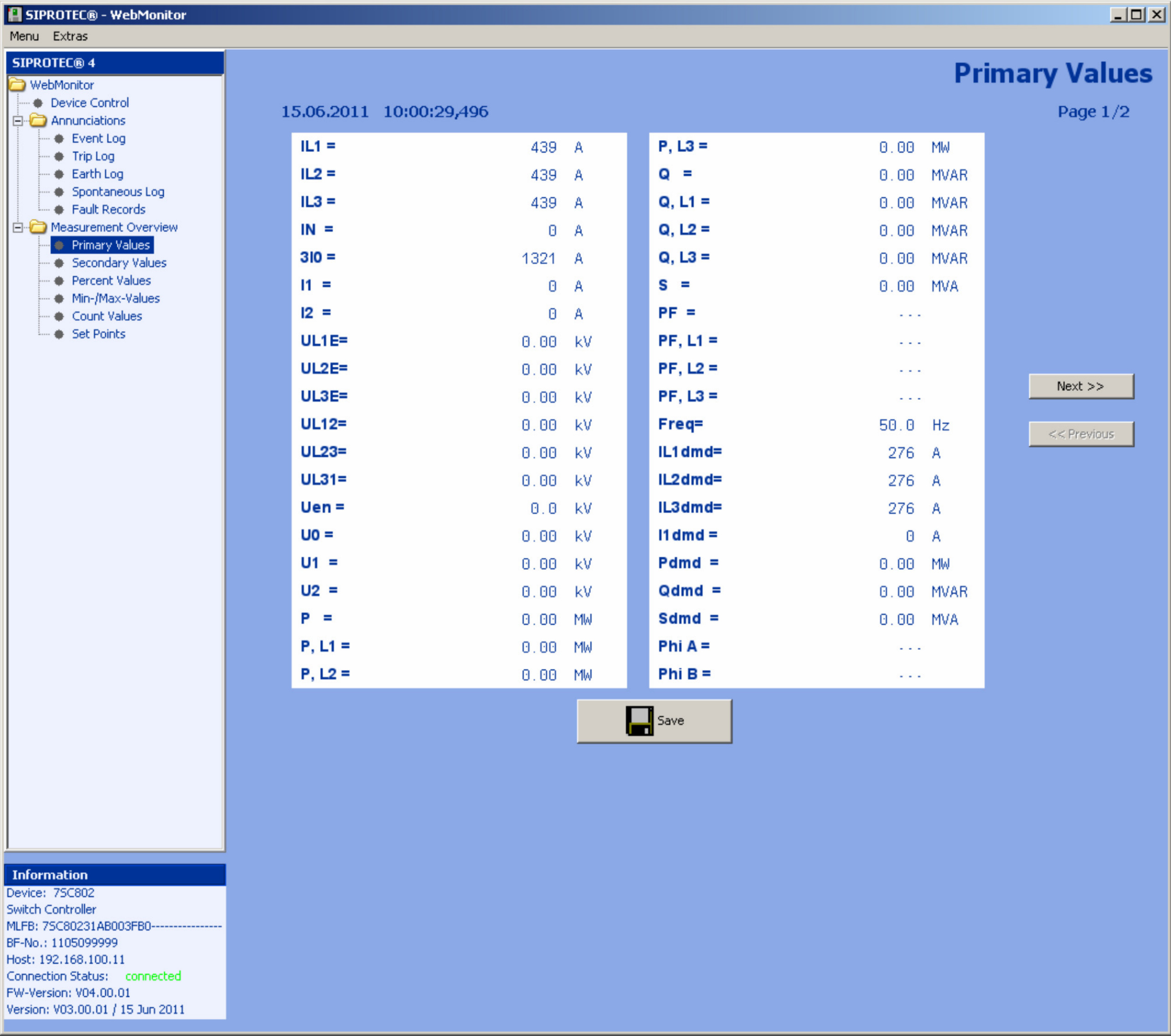


Figure 2-53 Web Monitor – Primary Values

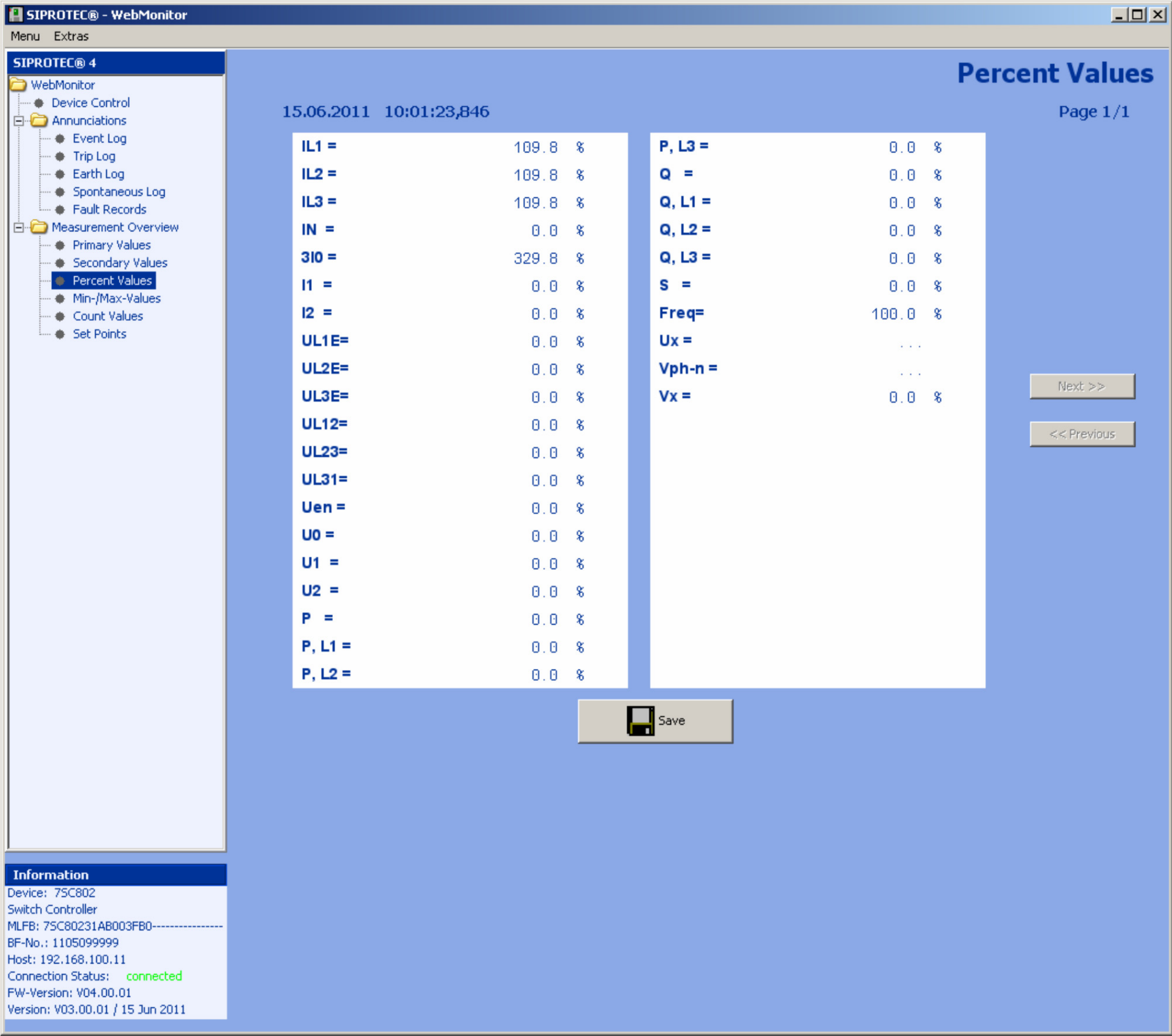


Figure 2-54 Web Monitor – Percent Values

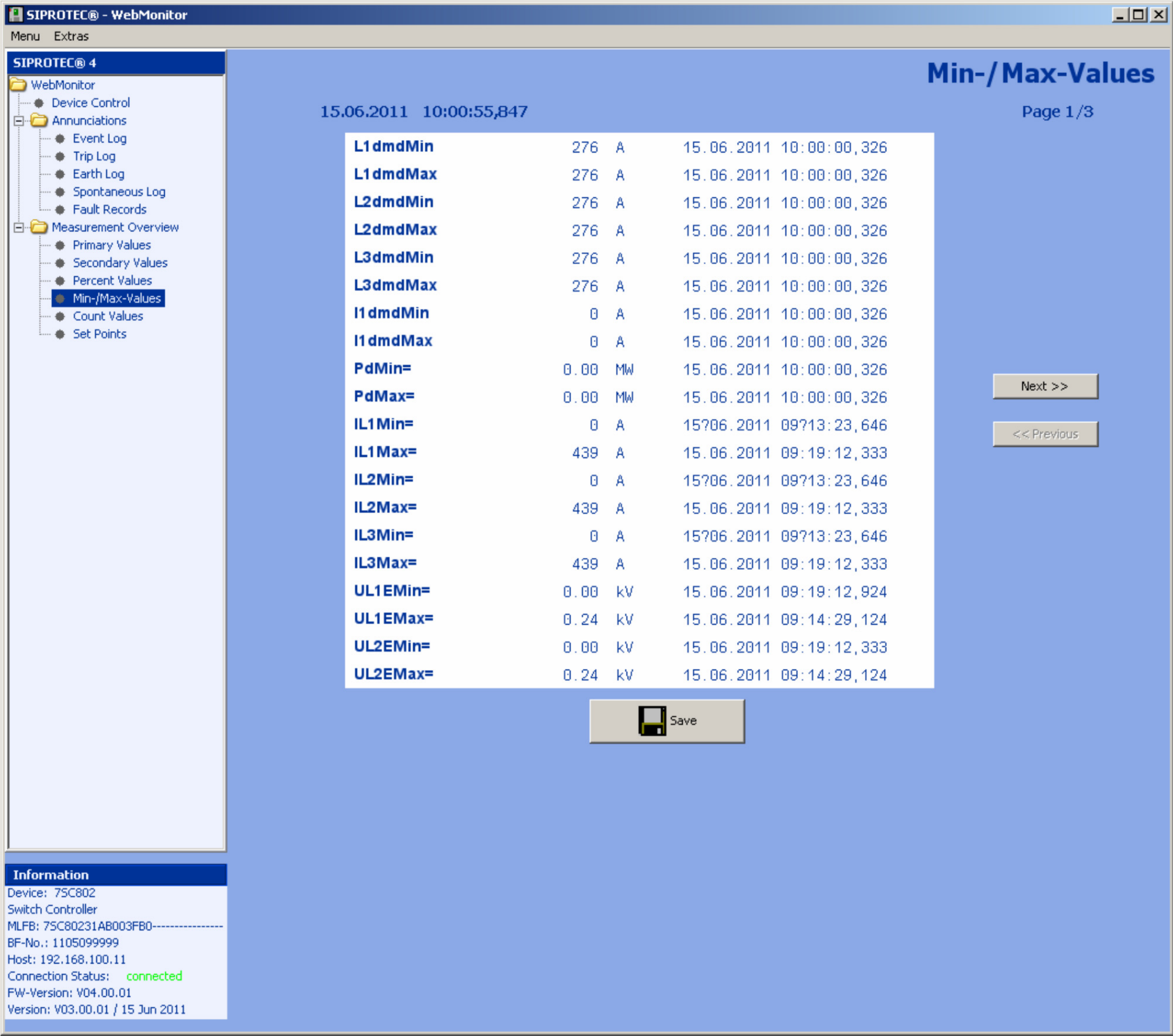


Figure 2-55 Web Monitor – Min-/Max-Values

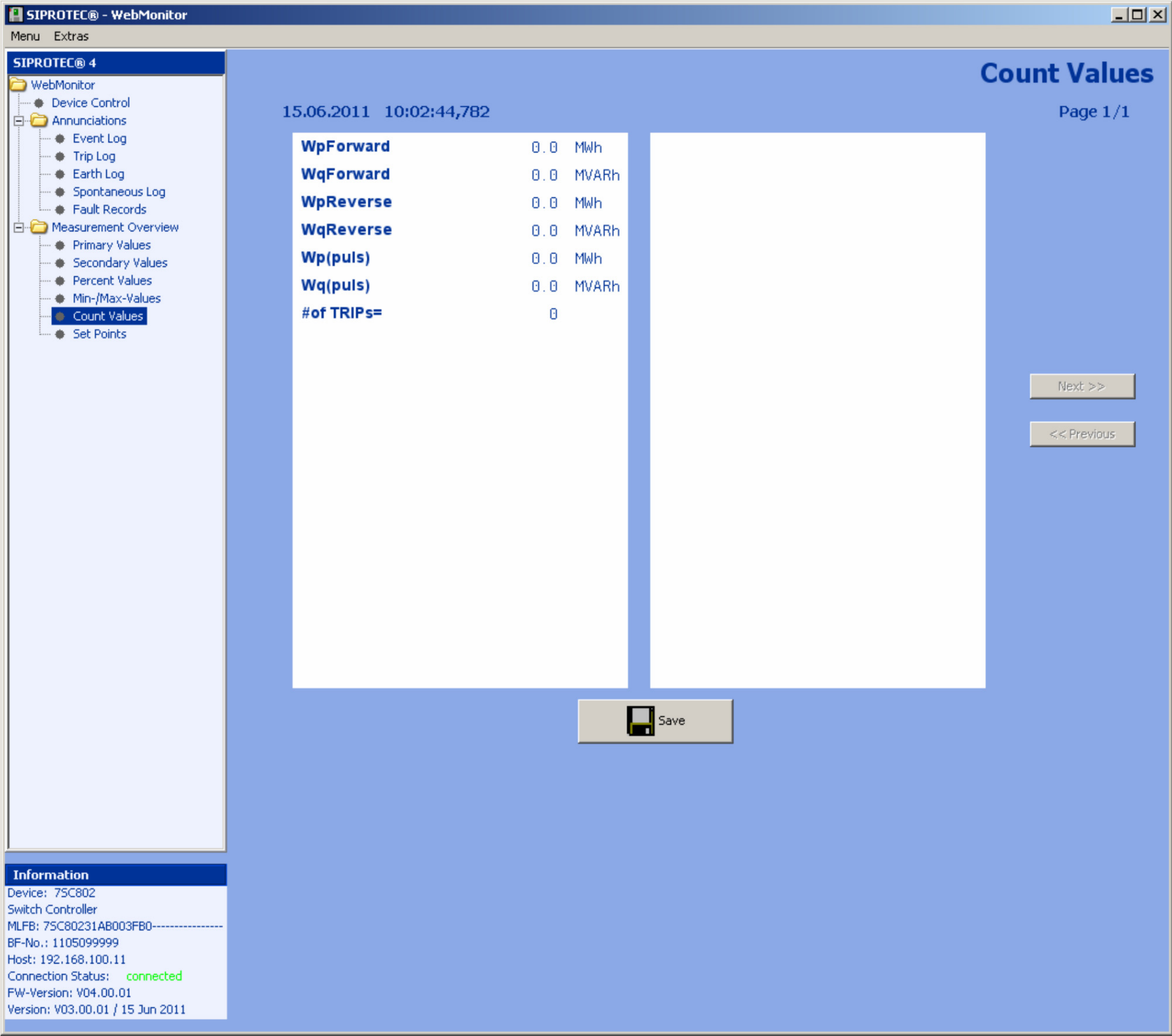
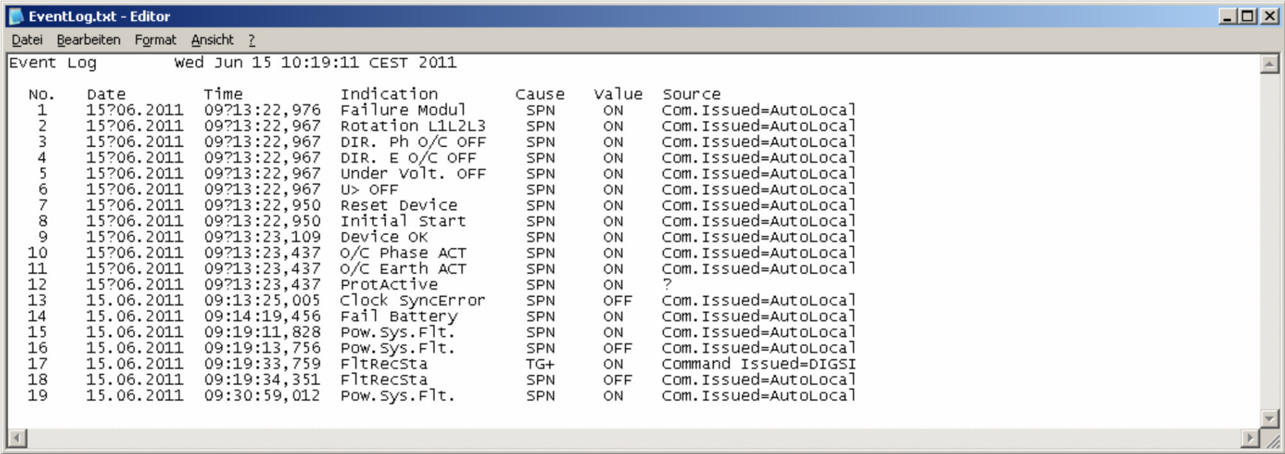


Figure 2-56 Web Monitor – Count Values

Logging

The following figures are examples of the displaying of an event log saved as text file and a measurement log.

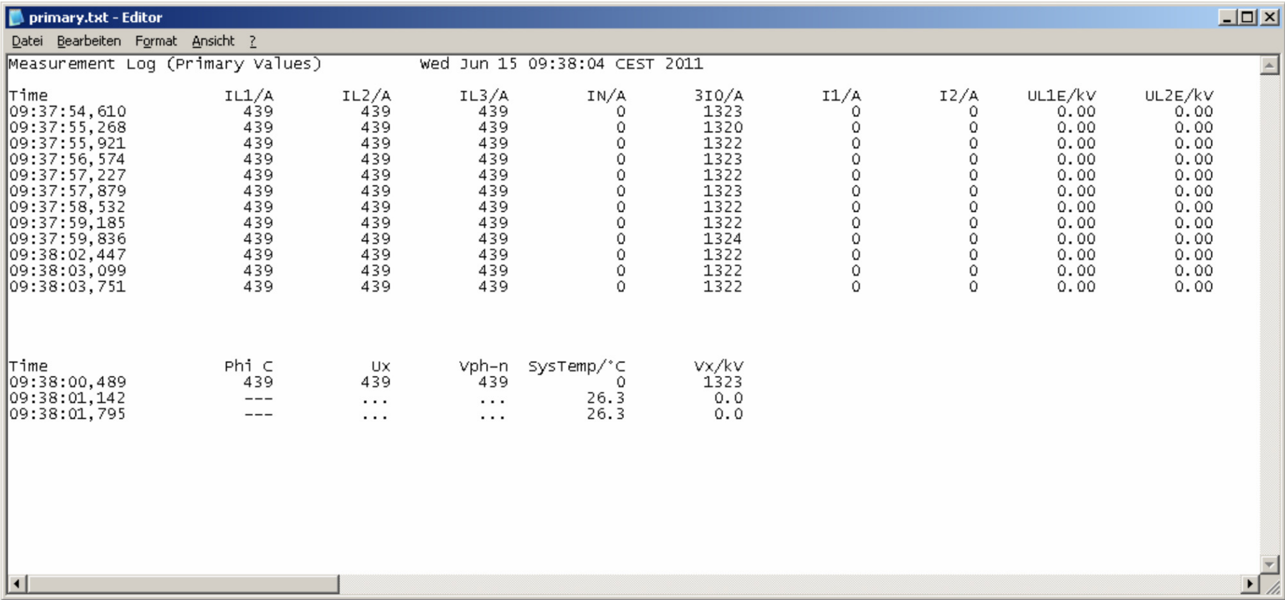


EventLog.txt - Editor

Datei Bearbeiten Format Ansicht ?

```
Event Log        Wed Jun 15 10:19:11 CEST 2011

 No.   Date        Time          Indication        Cause   Value  Source
  1    15?06.2011  09?13:22,976  Failure Modul      SPN     ON    Com.Issued=AutoLocal
  2    15?06.2011  09?13:22,967  Rotation L1L2L3    SPN     ON    Com.Issued=AutoLocal
  3    15?06.2011  09?13:22,967  DIR. Ph O/C OFF    SPN     ON    Com.Issued=AutoLocal
  4    15?06.2011  09?13:22,967  DIR. E O/C OFF     SPN     ON    Com.Issued=AutoLocal
  5    15?06.2011  09?13:22,967  Under Volt. OFF    SPN     ON    Com.Issued=AutoLocal
  6    15?06.2011  09?13:22,967  U> OFF             SPN     ON    Com.Issued=AutoLocal
  7    15?06.2011  09?13:22,950  Reset Device       SPN     ON    Com.Issued=AutoLocal
  8    15?06.2011  09?13:22,950  Initial Start      SPN     ON    Com.Issued=AutoLocal
  9    15?06.2011  09?13:23,109  Device OK          SPN     ON    Com.Issued=AutoLocal
 10    15?06.2011  09?13:23,437  O/C Phase ACT      SPN     ON    Com.Issued=AutoLocal
 11    15?06.2011  09?13:23,437  O/C Earth ACT      SPN     ON    Com.Issued=AutoLocal
 12    15?06.2011  09?13:23,437  ProtActive         SPN     ON    ?
 13    15.06.2011  09:13:25,005  Clock SyncError    SPN     OFF   Com.Issued=AutoLocal
 14    15.06.2011  09:14:19,456  Fail Battery       SPN     ON    Com.Issued=AutoLocal
 15    15.06.2011  09:19:11,828  Pow.Sys.Flt.       SPN     ON    Com.Issued=AutoLocal
 16    15.06.2011  09:19:13,756  Pow.Sys.Flt.       SPN     OFF   Com.Issued=AutoLocal
 17    15.06.2011  09:19:33,759  FltRecSta          TG+     ON    Command Issued=DIGSI
 18    15.06.2011  09:19:34,351  FltRecSta          SPN     OFF   Com.Issued=AutoLocal
 19    15.06.2011  09:30:59,012  Pow.Sys.Flt.       SPN     ON    Com.Issued=AutoLocal
```

Figure 2-57 Event log text file example



primary.txt - Editor

Datei Bearbeiten Format Ansicht ?

```
Measurement Log (Primary Values)         Wed Jun 15 09:38:04 CEST 2011

Time               IL1/A     IL2/A     IL3/A       IN/A      3I0/A       I1/A       I2/A    UL1E/kV    UL2E/kV
09:37:54,610         439       439       439          0       1323          0          0       0.00       0.00
09:37:55,268         439       439       439          0       1320          0          0       0.00       0.00
09:37:55,921         439       439       439          0       1322          0          0       0.00       0.00
09:37:56,574         439       439       439          0       1323          0          0       0.00       0.00
09:37:57,227         439       439       439          0       1322          0          0       0.00       0.00
09:37:57,879         439       439       439          0       1323          0          0       0.00       0.00
09:37:58,532         439       439       439          0       1322          0          0       0.00       0.00
09:37:59,185         439       439       439          0       1322          0          0       0.00       0.00
09:37:59,836         439       439       439          0       1324          0          0       0.00       0.00
09:38:02,447         439       439       439          0       1322          0          0       0.00       0.00
09:38:03,099         439       439       439          0       1322          0          0       0.00       0.00
09:38:03,751         439       439       439          0       1322          0          0       0.00       0.00



Time               Phi C        Ux     Vph-n SysTemp/°C       Vx/kV
09:38:00,489         439       439       439          0        1323
09:38:01,142         ---       ...       ...       26.3         0.0
09:38:01,795         ---       ...       ...       26.3         0.0
```

Figure 2-58 Measurement log example

■

Mounting and Commissioning 3

This chapter is intended for experienced commissioning staff. The staff must be familiar with the commissioning of protection and control systems, with power systems management and with the relevant safety rules and guidelines. Under certain circumstances, it may become necessary to adapt parts of the power system hardware. Some of the primary tests require the protected line or equipment to carry load.

3.1 Mounting and Connections

General

WARNING!

Warning of improper transport, storage, installation or assembly of the device.

Failure to observe these precautions can result in death, personal injury, or serious material damage.

Trouble-free and safe use of this device depends on proper transport, storage, installation, and assembly of the device according to the warnings in this device 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.

3.1.1 Configuration Information

Prerequisites

For installation and connections the following conditions must be met:

The rated device data have been checked as recommended in the SIPROTEC 4 System Description. It has been verified that these data comply with the power system data.

General Diagrams

Block diagrams for the terminal assignment of the 7SC80 are shown in Appendix A.2. Connection examples for the current and voltage transformer circuits are provided in Appendix A.3.

Voltage Connection Examples

Connection examples for voltage transformers are provided in Appendix A.3. It must be checked that the configuration of the **Power System Data 1** (Section 2.1.3.2) corresponds with the connections.

The normal connection is set at address 213 **VT Connect. 3ph** = ***Van, Vbn, Vcn***.

When connecting an open delta winding of the voltage transformer set, address 213 **VT Connect. 3ph** must be set to ***Vab, Vbc, VGnd***.

Binary Inputs and Outputs

The configuration options of the binary in- and outputs, i.e. the procedure for the individual adaptation to the plant conditions, are described in the SIPROTEC 4 System Description. The connections to the plant are dependent on this configuration. The presettings of the device are listed in Appendix A.5. Please also check that the labeling strips on the front panel correspond to the configured message functions.

Setting Group Change

If binary inputs are used to switch setting groups, please observe the following:

- Two binary inputs must be dedicated to the purpose of changing setting groups when four groups are to be switched. One binary input must be set for „>Set Group Bit0“, the other input for „>Set Group Bit1“. If either of these input functions is not assigned, then it is considered as not controlled.
- For the control of 2 setting groups one binary input is sufficient, namely „>Set Group Bit0“, since the non-assigned binary input „>Set Group Bit1“ is then regarded as not connected.
- The control signals must be permanently active so that the selected setting group is and remains active.

The following table shows the allocation of the binary inputs to the setting groups A to D and a simplified connection diagram for the two binary inputs is illustrated in the following figure. The figure illustrates an example in which both Set Group Bits 0 and 1 are configured to be controlled (actuated) when the associated binary input is energized (high).

Where:

no = not energized or not connected

yes = energized

Table 3-1 Changing setting groups using binary inputs

Binary Input		Active Group
>Set Group Bit 0	**>Set Group Bit 1**	
No	No	Group A
Yes	No	Group B
No	Yes	Group C
Yes	Yes	Group D

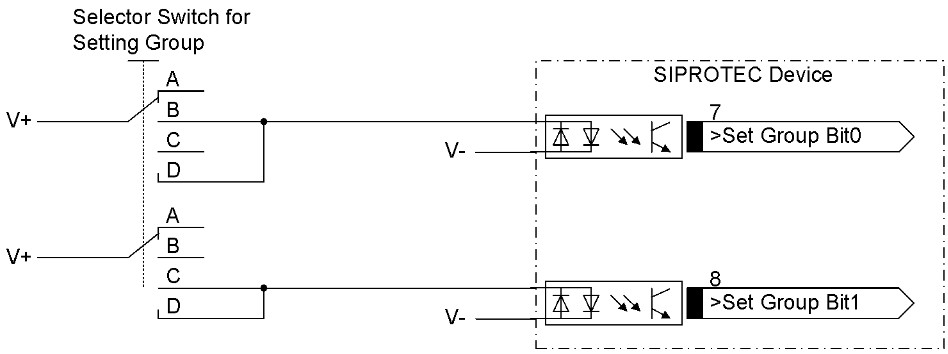


Figure 3-1 Connection diagram (example) for setting group switching using binary inputs

3.1.2 Hardware Modifications

3.1.2.1 Disassembly

Replacing the Buffer Battery

The battery is located in a battery compartment which is accessible from outside. The battery compartment can be found on the side of the device. When replacing the battery, it is not necessary to open the device. In the case of a failure of the auxiliary voltage, the battery ensures operation of the internal clock and storage of all process data for at least half a year. The device parameterization is always stored in a failsafe way in a non-volatile memory. The device cyclically checks the charge state of the battery.

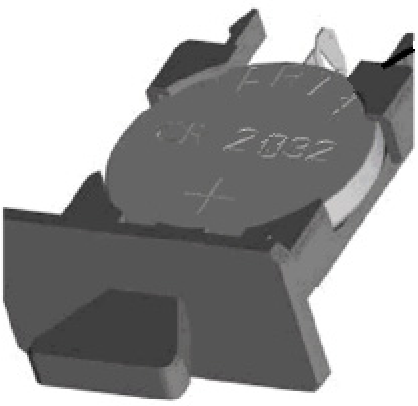


Figure 3-2 Battery compartment

Replacing the Battery

- The battery must only be replaced with one of the similar type:
  Lithium battery CR2032, 3 V and 230 mAh
- Withdraw the battery compartment.
- Remove the battery.
- Insert the new battery in the battery compartment, the positive pole facing upward.
- Slide in the battery compartment again.

Caution!

Take care when replacing and disposing of the battery.

Non-observance of the stated measures might result in property damage.

The battery contains lithium. The legal requirements for the disposal of batteries also apply to lithium batteries.

Observe the national and international regulations when disposing of the battery. Bring the battery to an approved collection place or throw the battery into a collecting box intended for that!

Working on the Device

Note

Before carrying out the following steps, make sure that the device is not operative.

Note

Apart from the communication modules and the fuse, there are no further components that can be configured or operated by the user inside the device. Any service activities exceeding the installation or exchange of communication modules must only be carried out by Siemens personnel.

For preparing the workplace, a pad suitable for electrostatic sensitive devices (ESD) is required.

Additionally, the following tools are required:

- a screwdriver with a 5 mm to 6 mm (0.20 – 0.24 in) wide blade,
- a Philips screwdriver size 1,
- a 5 mm (0.20 in) socket or nut driver

In order to disassemble the device, first remove it from the substation installation. Remove the mounting brackets from the device for that.

Note

The following must absolutely be observed:

Disconnect all communication connections from the device. If this is not observed, the communication lines and/or the device might be destroyed.

Note

To use the device, all terminal blocks must be plugged in.

Caution!

Mind electrostatic discharges

Failure to observe these precautions can result in personal injury or material damage.

Any electrostatic discharges while working at the electronics block are to be avoided. We recommend ESD protective equipment (grounding strap, conductive grounded shoes, ESD-suitable clothing, etc.). Alternatively, an electrostatic charge is to be discharged by touching grounded metal parts.

Note

In order to minimize the expenditure for reconnecting the device, remove the completely wired terminal blocks from the device. Mark the terminal blocks to prevent inadvertent swapping when connecting them again. To do so, open the elastic holders of the current terminal blocks in pairs with a flat screwdriver and remove the block and the other connectors. When reinstalling the device, insert the terminal blocks back into the device like assembled terminals.

Note

Withdraw the battery compartment from the device before disassembly. When removing the battery compartment, the device buffer and the fault records are deleted. You may want to save the device buffer and fault records first.

In order to install or exchange communication modules or to replace the fuse, proceed as follows:

Unscrew all screws with which the cover is fixed to the device. Remove the protective cap of the GPS antenna, if any. Now carefully remove the housing.

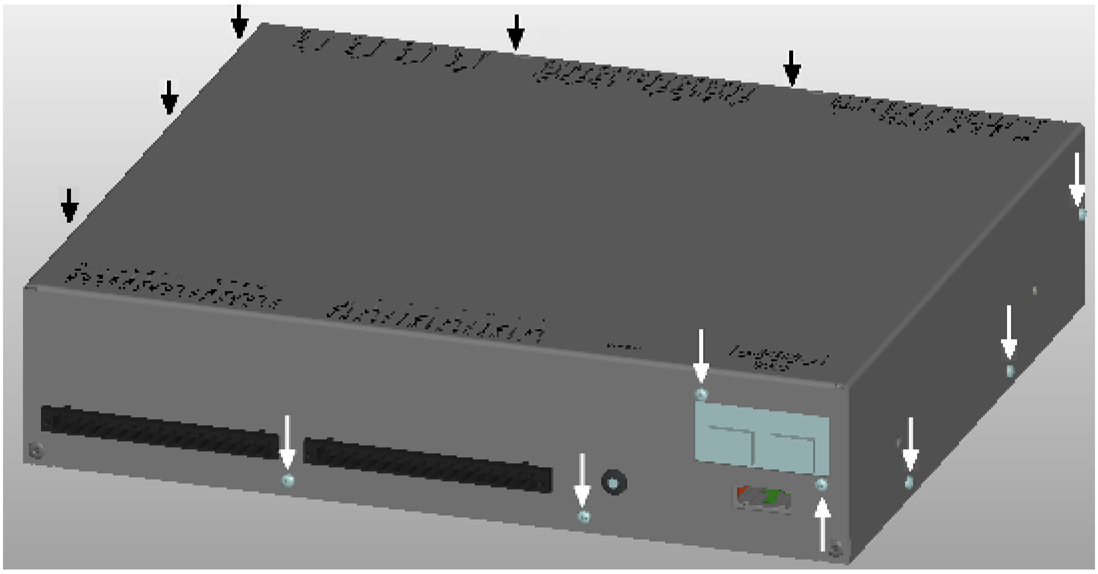


Figure 3-3 Housing

Replacing the Fuse

The position of the fuses on the module is shown in the following figure. The F200 fuse is for the auxiliary voltage and the F300 fuse for the battery input.

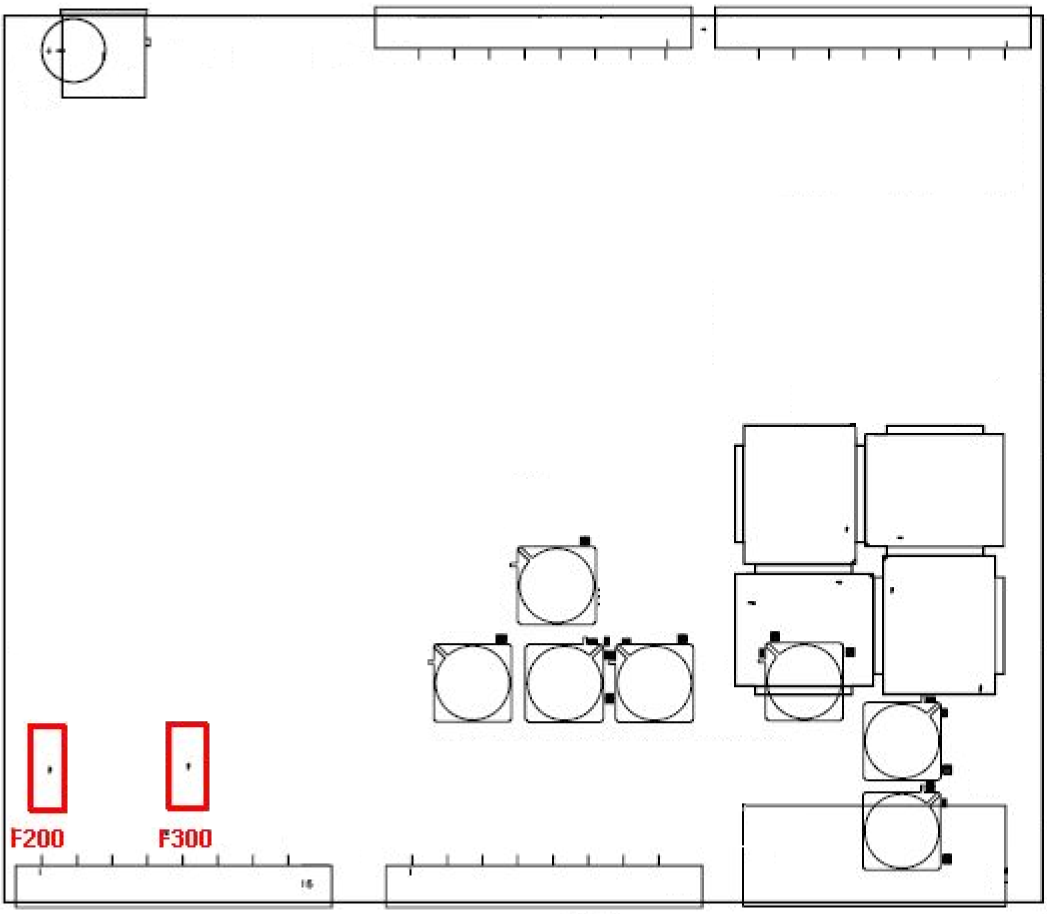


Figure 3-4 Placing the fuses

Remove the defective fuse. Insert the new fuse with the following technical data into the fuse holder:

5 mm x 20 mm (0.20 * 0.79 in) safety fuse

T characteristic

Nominal current 2.0 A for F200 and 4.0 A for F300

250 V nominal voltage

Switching capacity 1500 A/300 VDC

Only UL-approved fuses may be used.

The data for F200 apply to all device types (24 V/48 V and 60 V to 250 V).

The data for F300 only apply to the device types (24 V/48 V) with battery charging control.

Make sure that the defective fuse has not left any obvious damage on the device. If the fuse trips again after reconnection of the device, refrain from any further repairs and send the device to Siemens for repair.

The device can now be reassembled again (see Section Reassembly).

3.1.2.2 Current Terminal Connections

Stop Elements and Cable Cross-Sections

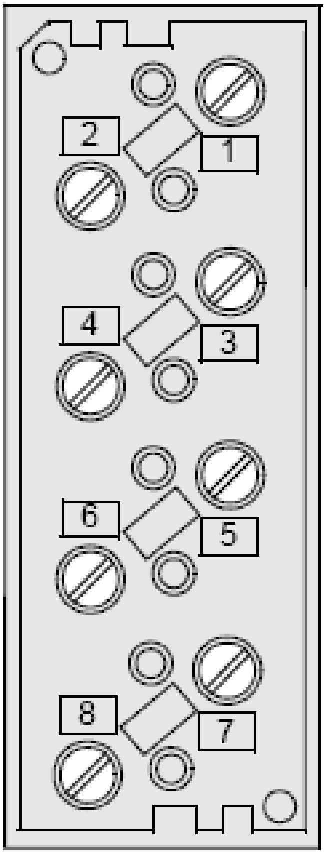


Figure 3-5 8-pin current terminal

Ring and fork-type lugs can be used for the connection. For complying with the required insulation clearances, insulated lugs have to be used. Otherwise, the crimp zone has to be insulated with corresponding means (e.g. by pulling a shrink-on sleeve over).

When connecting single cables, the following cross-sections are allowed:

Cable cross-sections: when using lugs	AWG 14-12 (2.6 mm^2 to 3.3 mm^2) AWG 14-10 (2.6 mm^2 to 6.6 mm^2)
Permissible tightening torque	2.7 Nm
Stripping length: (for solid conductor)	10 mm to 11 mm Use copper conductors only.

Note

When using current terminals, the mounting brackets must be used in the outmost setting to observe the stipulated bending radius.

Note

In the connection diagrams in the Appendix, terminal connection "1" of the current terminal corresponds to pin number "72".

Further information with regard to the current terminals can be found in the SIPROTEC 4 System Description, Order No. E50417-H1100-C151.

3.1.2.3 Process Terminal Connections

Fixing Elements

The process terminals feature integrated fixing elements. The head shape of the terminal screw allows for using a simple flat screwdriver (4.0 x 0.8).

Stop Elements and Cable Cross-sections

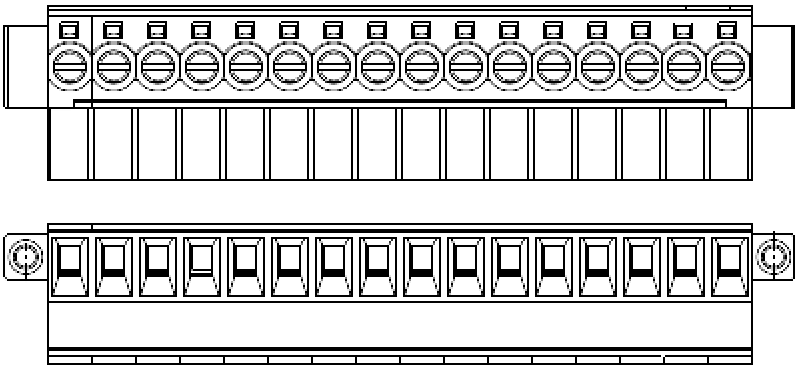


Figure 3-6 16-pin process terminal (type 360° for cabinet surface mounting)

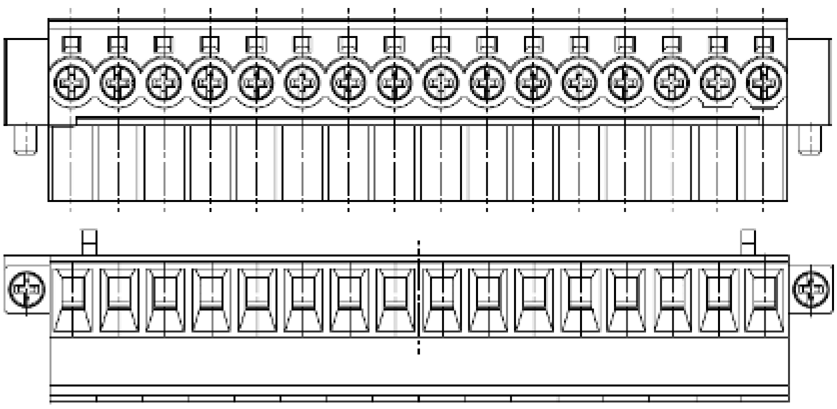


Figure 3-7 16-pin process terminal (type 180° for cabinet flush mounting)

Use the corresponding appropriate terminals, depending on the type of installation - cabinet flush mounting (180°) or cabinet surface mounting. Ordering data can be found in Appendix A1.

Solid conductors as well as stranded conductors with or without conductor sleeves can be used as single cables. Siemens recommends using twin cable end sleeves when connecting two single cables.

Cable cross-sections:	AWG 26-12 (0.2 mm^2 to 2.5 mm^2)
Permissible voltages:	400 V (IEC)/300 V (UL)
Permissible currents:	19 A (IEC)/15 A (UL) Use copper conductors only!

Mechanical Requirements

The fixing elements and the connected components are designed for the following mechanical requirements:

Permissible tightening torque at the terminal screw	0.4 Nm to 0.5 Nm
Stripping length	7 mm

3.1.2.4 Interface Modules

General

The 7SC80 device is supplied with preconfigured interfaces in accordance with the MLFB. You do not have to make any adaptations to the hardware (e.g. plugging in jumpers) yourself, except for the installation or replacement of communication modules.

Replacing the Communication Module or GPS Module

First, unscrew all screws with which the base is fixed to the device. Carefully remove the base.

Now unscrew the screws with which the communication module or GPS module is fixed. Pay attention to any plug connectors when removing the module.

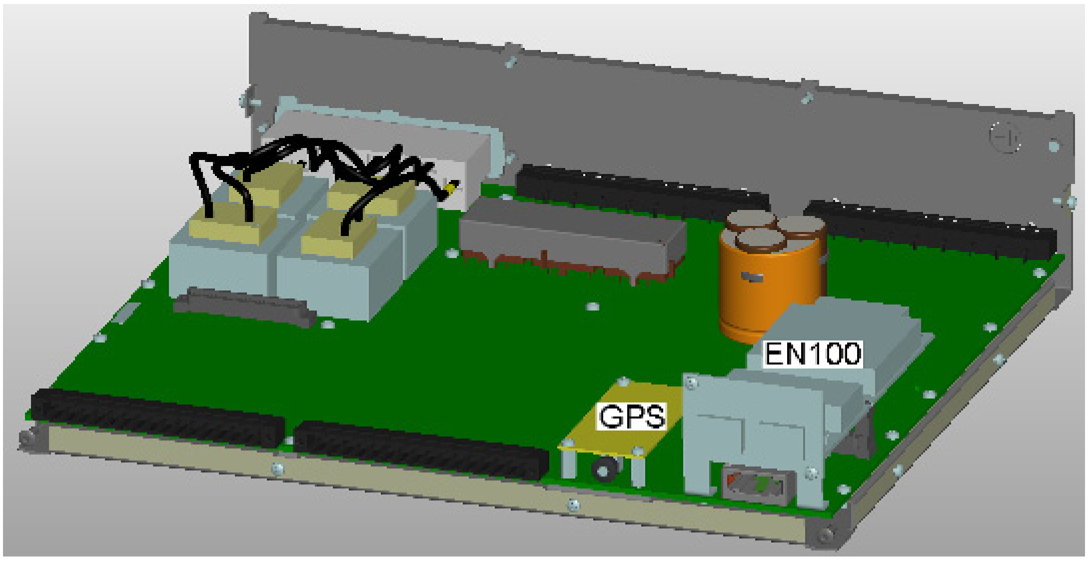


Figure 3-8 Module fixing

Only use original spare parts to replace the modules. If you have replaced an optical EN100 module, subsequently fasten it with a cable tie (203 mm x 2.5 mm).

3.1.2.5 Reassembly

For assembly, perform the steps of the disassembly section in reverse order.

Install the device in the substation again. Slide the battery compartment back into the device.

Please observe the following:

Note

Insert the current and voltage terminal blocks again and lock them in place!

Additionally fix the process terminals with the fixing elements or screws.

3.1.3 Installation

3.1.3.1 General

To install the 7SC80 device in a rack or cabinet, the two mounting brackets included in the delivery are required.

Figure 3-9   Device view

Housing Assembly

- Fix the device to the mounting brackets with 4 screws.
- Loosely screw the two mounting brackets into the rack or cabinet with 4 screws each.
- Tighten the 8 screws of the mounting brackets in the rack or cabinet.
- Connect a solid low-ohmic protective and operational ground to the grounding terminal of the device. The cross-section of the cable used must correspond to the maximum connected cross-section but must be at least 2.5 mm^2.
- Establish the connections according to the circuit diagram via the screwed connections. The details on the connection technique for the communication modules in accordance with the SIPROTEC 4 System Description and the details on the connection technique for the current and voltage terminals on the rear of the device in the Sections „Current Terminal Connections“ and „Voltage Terminal Connections“ must be strictly observed.

Note

When using current terminals, the mounting brackets must be used in the outmost setting to observe the stipulated bending radius.

3.2 Checking Connections

3.2.1 Checking the Data Connections of the Interfaces

Pin Assignment

The following tables show the pin assignment of the various interfaces. The position of the connections can be seen in the following figures.

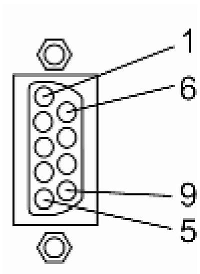


Figure 3-10 9-pin D-sub socket (HMI)

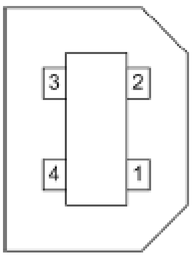


Figure 3-11 USB interface

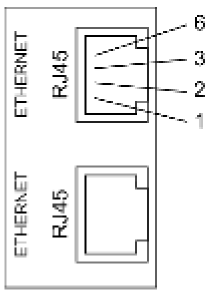


Figure 3-12 Ethernet ports 2 x RJ45

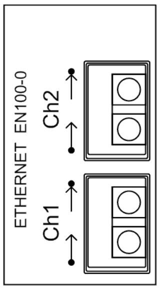


Figure 3-13 Ethernet EN100 O SM 24 km

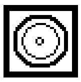


Figure 3-14 SMB socket (SubMiniature B) for connecting a GPS antenna

HMI

In a later version, the operator panel will be connected via the 9-pin DSUB socket.

Table 3-2 Socket Assignment

Pin No.	Function
1	VCC
2	RxD
3	TxD
4	USB D+
5	GND
6	GND
7	RS232 high
8	DET_HMI
9	USB D-

USB Interface

The USB interface can be used to establish a connection between the protection device and your PC. For the communication, the Microsoft Windows USB driver is used which is installed together with DIGSI (as of version V4.82). The interface is installed as a virtual serial COM port. We recommend the use of standard USB cables with a maximum length of 5 m/16 ft.

Table 3-3 Assignment of the USB socket

Pin No.	1	2	3	4	Housing
USB	VBUS (unused)	D-	D+	GND	Shield

Ethernet Connections at RJ45

If the interface is used for communication with the device, the data connection is to be checked.

Table 3-4 Socket Assignment

Pin No.	Ethernet interface
1	Tx+
2	Tx-
3	Rx+
4	—
5	—
6	Rx-
7	—
8	—

GPS Interface

Via the SMB socket, an active GPS antenna (5 V max. 50 mA) can be connected.

If no GPS interface is available, there is a cover instead.

Checking the Time Synchronization Interface

When connecting the time signal transmitter (GPS), the specified technical data must be observed (see Chapter 4 Technical Data, „Time Synchronization Interface“). The GPS module supplies UTC time, irrespective of time zone and switchover to/from daylight-saving time. You can adapt your time zone to the time signal by entering an offset time (in minutes) on the device or via DIGSI. Proper functioning is indicated by the fact that 20 minutes max. after device startup or selection of GPS as time source, the time status is indicated as „`synchronized`“ accompanied by the operational indication „`Clock SyncError (OFF)`“.

If the time is still indicated as faulted after 20 minutes, check the operational log. If there is no indication "GPS Module Error ON", check the antenna connection.

In continuous operation, with GPS as time signal transmitter, it might happen that the time management issues the operational indication "Clock SyncError (ON)" although the time was correct before. This might be caused by one of the following conditions:

- If the indication: "GPS Module Error ON" was issued in the operational log and has been pending for a longer period of time, please send the device in for a check.
- The GPS module does not have enough satellites in view and is therefore not able to determine the correct time. The cyclic synchronization can be absent for up to 10 minutes before the time is considered faulted. As soon as a valid satellite signal is received, the clock error is reset: "Clock SyncError (OFF)".

Further information can be found in the SIPROTEC 4 System Description.

Table 3-5 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

3.2.2 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 should perform the inspection steps.

Caution!

Take care when operating the device without a battery on a battery charger.

Non-observance of the following measures 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).

If undervoltage protection is configured and enabled in the device and if, at the same time, the current criterion is disabled, the device picks up right after auxiliary voltage has been connected, since no measuring voltage is available. To make the device configurable, pickup is to be stopped, i.e. the measuring voltage is connected or voltage protection is blocked. This can be performed by operation.

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 to avoid condensation. Connections are checked with the device at its final location. The plant must first be switched off and grounded.

Proceed as follows for checking the system connections:

- Circuit breakers for the auxiliary power supply and the measuring voltage must be opened.
- Check the continuity of all current and voltage transformer connections against the system and connection diagrams:
  - Are the current transformers grounded properly?
  - Are the polarities of the current transformer connections the same?
  - Is the phase assignment of the current transformers correct?
  - Are the voltage transformers grounded properly?
  - Are the polarities of the voltage transformer connections the same and correct?
  - Is the phase assignment of the voltage transformers correct?
  - Is the polarity for current input I_N correct (if used)?
  - Is the polarity for the voltage input V_3 correct (if used e.g. for broken delta winding or busbar voltage)?
- If test switches are used for the secondary testing of the device, their functions must also be checked, in particular that in the „Check“ position the current transformer secondary lines are automatically short-circuited.
- 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 current input should correspond to the power input in neutral position of the device. The measured steady state current should be insignificant. Transient movement of the ammeter merely indicates the charging current of capacitors.
- Check the polarity of the cabinet battery connections.
- 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 protective switches for the voltage transformers and the power supply.
- Check the trip and close circuits to the power system circuit breakers.
- Verify that the control wiring to and from other devices is correct.
- Check the signaling connections.
- Switch the mcb back on.

3.2.3 Battery Charging Function

Feeder Automation Controller 7SC80 with battery charging control/battery charging function (MLFB position 8 must be a 2) can be connected to external batteries. These are used to secure the own power supply and are also charged via the Feeder Automation Controller 7SC80.

For initial and replacement installation, only use charged cabinet batteries and replace these cyclically.

For further information on the "Battery Charger", please refer to Chapter 2 Functions.

Caution!

Battery Charger

To reduce risk of injury, charge only Power-Sonic (No. PS-12120F2) or Hawker Energy (No. 0770-2007 EONO) type rechargeable batteries.

Other types of batteries may burst causing personal injury and damage.

Other acid batteries are suitable, but not UL-tested.

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 grounded at the protective conductor terminal.

Hazardous voltages can exist in all switchgear components connected to the power supply and to measurement 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 switching off the auxiliary voltage, wait a minimum of 10 seconds before reconnecting this voltage so that steady conditions can be established.

The limit values given in Technical Data (Chapter 4) must not be exceeded, neither during testing nor during commissioning.

When testing the device with secondary test equipment, make sure that no other measurement quantities are connected and that the trip and close circuits to the circuit breakers and other primary switches are disconnected from the device.

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.

Switching operations have to be carried out during commissioning. A prerequisite for the prescribed tests is that these switching operations can be executed without danger. They are accordingly not intended for operational checks.

WARNING!

Warning of dangers evolving from improper primary tests

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Primary tests are only allowed to be carried out by qualified personnel, who are familiar with the commissioning of protection systems, the operation of the plant and the safety rules and regulations (switching, grounding, etc.).

3.3.1 Test Mode and Transmission Block

Activation and Deactivation

If the device is connected to a central or main computer system via the SCADA interface, then the information that is transmitted can be influenced. This is only possible with some of the protocols available (see Table „Protocol-dependent functions“ in the Appendix A.6).

If the **test mode** is switched on, the messages sent by a SIPROTEC 4 device to the main system has an additional test bit. This bit allows the messages to be recognized as not resulting from actual faults. Furthermore, it can be determined by activating the **transmission block** that no annunciations are transmitted via the system interface during test mode.

The SIPROTEC 4 System Manual describes in detail how to activate and deactivate the test mode and blocked data transmission. Please note that when DIGSI is being used for device editing, the program must be in the **online** operating mode for the test features to be used.

3.3.2 Testing the System Interface (at Port F)

Prefacing Remarks

If the device features a system interface and this is used to communicate with the control center, 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„real“ operation.

DANGER!

Danger evolving from operating the equipment (e.g. circuit breakers, disconnectors) by means of the test function

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 test function during real operation by transmitting or receiving messages via the system interface.

Note

After termination of the system interface 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 screen.
- Double-click **Generate Indications** in the list view. The **Generate Indications** dialog box opens (see following figure).

Structure of the Test Dialog Box

In the column **Indication** the display texts of all indications are displayed which were allocated to the system interface in the matrix. In the column **SETPOINT Status** the user has to define the value for the messages to be tested. Depending on annunciation type, several input fields are offered (e.g. message „ON“ / message „OFF“). By clicking on one of the fields you can select the desired value from the pull-down menu.

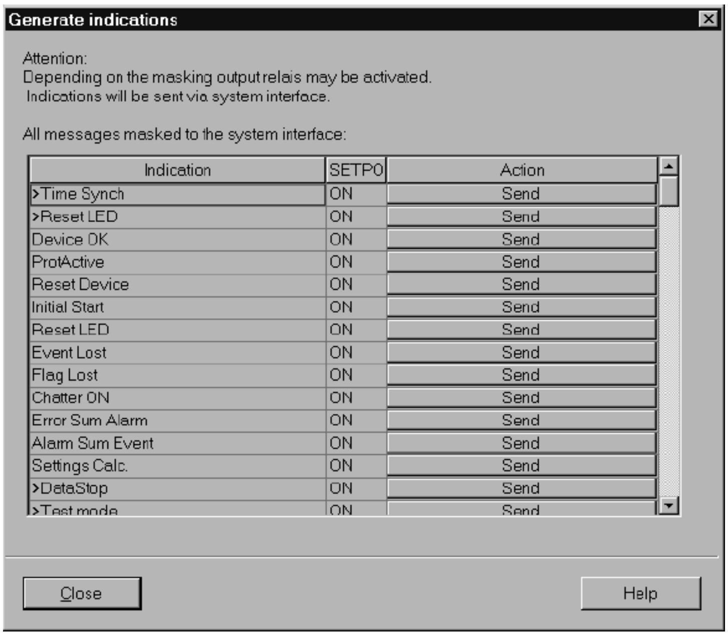


Figure 3-15 System interface test with the dialog box: Creating messages - example

Changing the Operating State

When clicking one of the buttons in the column **Action** for the first time, 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** on 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 system.

As long as the window is open, further tests can be performed.

Test in Message Direction

For all information that is transmitted to the central station, test the options in the list which appears in **SET-POINT Status**:

- Make sure that each checking process is carried out carefully without causing any danger (see above and refer to DANGER!)
- Click on Send in the function to be tested and check whether the transmitted information reaches the central station and shows the desired reaction. Data which are normally linked via binary inputs (first character „>“) are likewise indicated to the central power system with this procedure. The function of the binary inputs itself is tested separately.

Exiting the Test Mode

To end the System Interface Test, click on **Close**. The device is briefly out of service while the start-up routine is executed. The dialog box closes.

Test in Command Direction

The information transmitted in command direction must be indicated by the central station. Check whether the reaction is correct.

3.3.3 Communication Module Configuration

Required Settings in DIGSI 4

The following applies in general:

In the case of a first-time installation or replacement of a communication module, the ordering number (MLFB) does not need to be changed. The ordering number can be retained. Thus, all previously created parameter sets remain valid for the device.

Changes in the DIGSI Manager

In order that the protection device can access the new communication module, a change has to be made in the parameter set within the DIGSI Manager.

In **DIGSI 4 Manager**, select the SIPROTEC device in your project and select the menu item "Edit" - "Object properties..." to open the `"Properties - SIPROTEC 4 Device"` dialog box (see following Figure). In the `"Communication modules"` tab, select the type of communication module or the protocol for `"11. Port F"` using the "L: ..." button.

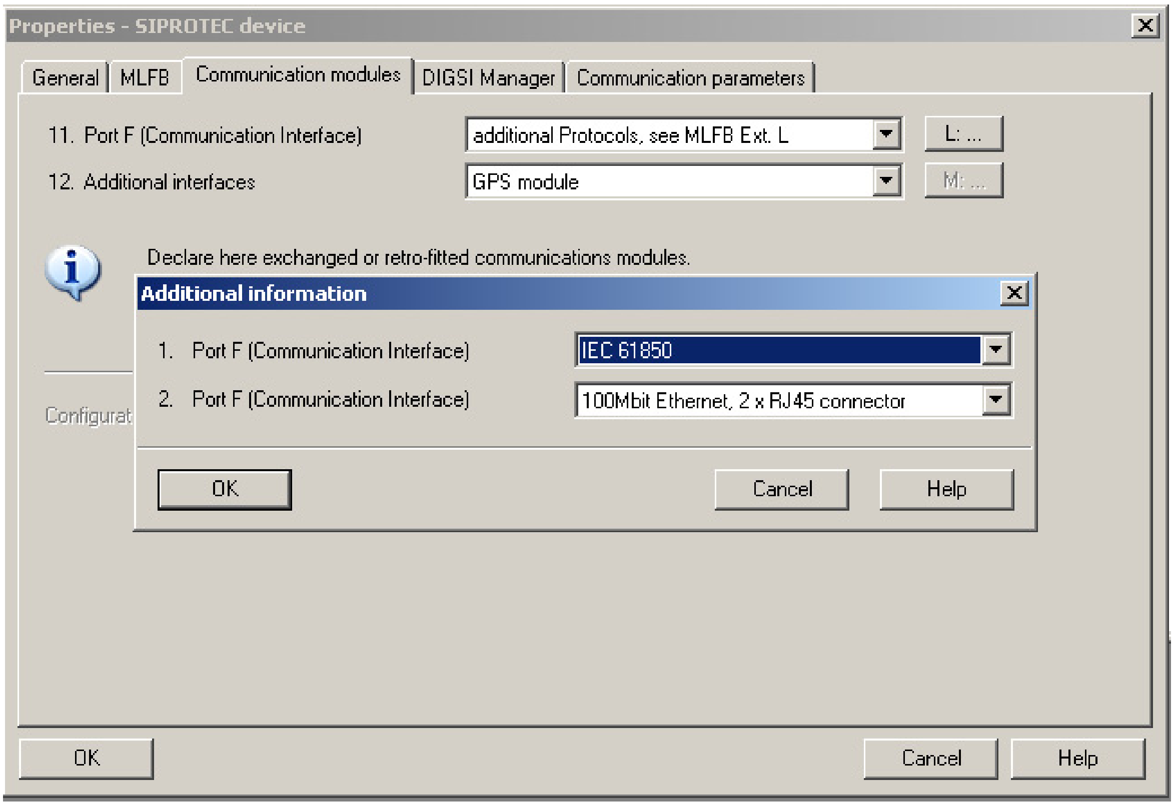


Figure 3-16 DIGSI 4: protocol selection (example)

3.3.4 Checking the Status of Binary Inputs and 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„real“ operation.

DANGER!

Danger evolving from operating the equipment (e.g. circuit breakers, disconnectors) by means of the test function

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 test function during real operation by transmitting or receiving messages via the system interface.

Note

After finishing the hardware tests, the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be read out with DIGSI and saved 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 screen.
- Double-click in the list view on **Hardware Test**. The dialog box of the same name opens (see the following figure).

Structure of the Test Dialog Box

The dialog box is classified into three groups: **BI** for binary inputs, **REL** for output relays, and **LED** for light-emitting diodes. On the left of each of these groups is an accordingly labeled button. 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 made by symbols. The physical actual states of the binary inputs and outputs are indicated by an open or closed switch symbol, the LEDs by a dark or illuminated LED symbol.

The opposite state of each element is displayed in the column **Scheduled**. The display is made in plain text.

The right-most column indicates the commands or messages that are configured (masked) to the hardware components.

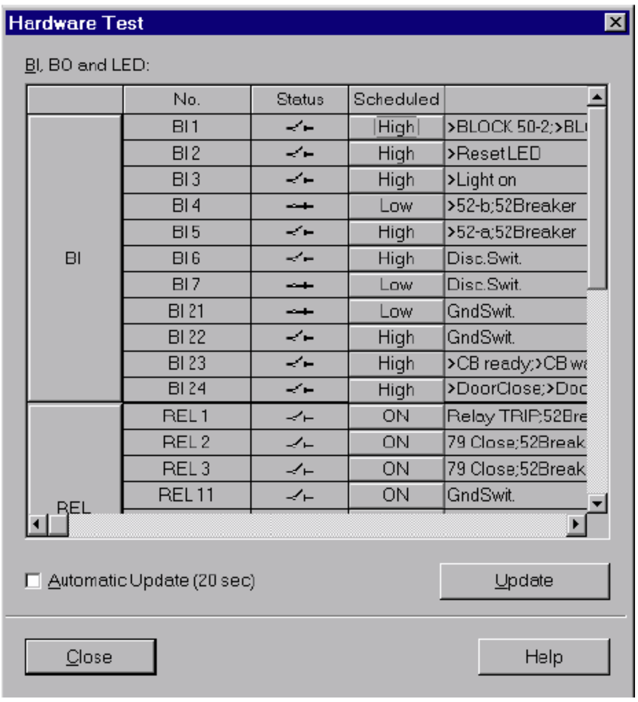


Figure 3-17 Test of the binary inputs/outputs — example

Changing the Operating State

To change the status of a hardware component, click on the associated button in the **Scheduled** column.

Password No. 6 (if activated during configuration) will be requested before the first hardware modification is allowed. After entry of the correct password a status change will be executed. Further status changes remain possible while the dialog box is open.

Test of the Output Relays

Each individual output relay can be energized allowing to check the wiring between the output relay of the 7SC80 and the system, without having to generate the message that is assigned to the relay. As soon as the first status change for any one of the output relays is initiated, all output relays are separated from the internal device functions, and can only be operated by the hardware test function. This for example means that a switching 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:

- Ensure that the switching of the output relay can be executed without danger (see above under DANGER!).
- Each output relay must be tested via the corresponding **Scheduled**-cell in the dialog box.
- Finish the testing (see margin title below „Exiting the Test Mode“), 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 7SC80 the condition in the plant which initiates the binary input must be generated and the response of the device checked.

To do so, the dialog box **Hardware Test** must be opened again to view the physical state of the binary inputs. The password is not yet required.

Proceed as follows in order to check the binary inputs:

- Activate each of function in the system which causes a binary input to pick up.
- Check the reaction in the **Status** column of the dialog box. To do so, the dialog box must be updated. The options may be found below under the margin heading „Updating the Display".
- Finish the testing (see margin heading below „Exiting the Test Mode").

If ,however, the effect of a binary input must be checked without carrying out any switching in the plant, it is possible to trigger individual binary inputs with the hardware test function. As soon as the first state change of any binary input is triggered and the password No. 6 has been entered, all binary inputs are separated from the plant and can only be activated via the hardware test function.

Updating the Display

As the **Hardware Test** dialog opens, the operating states of the hardware components which are current at this time are read in and displayed.

An update is made:

- for each hardware component, if a command to change the condition is successfully performed,
- for all hardware components if the **Update** button is clicked,
- for all hardware components with cyclical updating (cycle time is 20 seconds) if the **Automatic Update (20 sec)** field is marked.

Exiting the Test Mode

To end the hardware test, click on **Close**. The dialog box is closed. The device becomes unavailable for a brief start-up period immediately after this. Then all hardware components are returned to the operating conditions determined by the plant settings.

3.3.5 Tests for Breaker Failure Protection

General

If the device provides a breaker failure protection and if this is used, the integration of this protection function in the system must be tested under practical conditions.

Due to the variety of application options and the available system configurations, it is not possible to make a detailed description of the necessary tests. It is important to observe local conditions and protection and system drawings.

Before starting the circuit breaker tests it is recommended to isolate the circuit breaker of the tested feeder at both ends, i.e. line isolators and busbar isolators 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 voltages.

Before the breaker is finally closed 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 lists do not claim to be complete, they 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 be started by external protection devices, the external start conditions must be checked.

In order for the breaker failure protection to be started, a current must flow at least via the monitored phase. This may be a secondary injected current.

- Start by trip command of the external protection: binary input functions „>50BF ext SRC“ (FNo 1431) (in spontaneous or fault annunciations).
- After every start, the message „50BF ext Pickup“ (FNo 1457) must appear in the spontaneous or fault annunciations.
- After time expiration **TRIP-Timer** (address 7005) tripping command of the breaker failure protection.

Switch off test current.

If start is possible without current flow:

- Closing the circuit breaker to be monitored to both sides with the disconnector switches open.
- Start by trip command of the external protection: Binary input functions „>50BF ext SRC“ (FNo 1431) (in spontaneous or fault annunciations).
- After every start, the message „50BF ext Pickup“ (FNo 1457) must appear in the spontaneous or fault annunciations.
- After time expiration **TRIP-Timer** (address 7005) tripping command of the breaker failure protection.

Open the circuit breaker again.

Busbar Tripping

For testing the distribution of the trip commands in the substation in the case of breaker failures it is important to check that the trip commands to the adjacent circuit breakers are correct.

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 adjacent circuit breakers must be checked. Here it should be checked 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.

Termination

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.

3.3.6 Testing User-Defined Functions

CFC Logic

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.

Of course, general test procedures cannot be given. Configuration of these functions and the target conditions must be actually known beforehand and tested. Possible interlocking conditions of switching devices (circuit breakers, disconnectors, ground switch) are of particular importance. They must be observed and tested.

3.3.7 Current, Voltage, and Phase Rotation Testing

Preliminary Remark

Note

The voltage and phase rotation test is only relevant for devices with voltage transformers.

≥ 10 % of Load Current

The connections of the current and voltage transformers are tested using primary quantities. Secondary load current of at least 10 % of the nominal current of the device is necessary. The line is energized and will remain in this state during the measurements.

With proper connections of the measuring circuits, none of the measured-values supervision elements in the device should pick up. If an element detects a problem, the causes which provoked it may be viewed in the Event Log. If current or voltage summation errors occur, then check the matching factors.

Messages from the symmetry monitoring could occur because there actually are asymmetrical conditions in the network. If these asymmetrical conditions are normal service conditions, the corresponding monitoring functions should be made less sensitive.

Current and Voltage Values

Currents and voltages can be read via a PC using the Web-Monitor or the operator interface, and compared with the actual measured quantities, as primary and secondary quantities.

If the measured values are not plausible, the connection must be checked and corrected after the line has been isolated and the current transformer circuits have been short-circuited. The measurements must then be repeated.

Phase Rotation

The phase rotation must correspond to the configured phase rotation, in general a clockwise phase rotation. If the system has an anti-clockwise phase rotation, this must have been considered when the power system data was set (address 209 **PHASE SEQ.**). If the phase rotation is incorrect, the alarm „Fail Ph. Seq.“ (FNo 171) is generated. The measured value phase allocation must be checked and corrected, if required, after the line has been isolated and current transformers have been short-circuited. The measurement must then be repeated.

Voltage Transformer Miniature Circuit Breaker (VT mcb)

The VT mcb of the feeder (if used) must be opened. The measured voltages in the operational measured values appear with a value close to zero (small measured voltages are of no consequence).

Check in the spontaneous annunciations that the VT mcb trip was entered (annunciation „>FAIL:FEEDER VT“ „ON“ in the spontaneous annunciations). Beforehand it has to be assured that the position of the VT mcb is connected to the device via a binary input.

Close the VT mcb again: The above messages appear under the spontaneous messages as „OFF“, i.e. „>FAIL:FEEDER VT“ „OFF“.

If one of the events does not appear, the connection and allocation of these signals must be checked.

If the „ON“-state and „OFF“–state are swapped, the contact type (H–active or L–active) must be checked and remedied.

3.3.8 Testing the Reverse Interlocking Scheme

(only if used)

Testing reverse interlocking is available if at least one of the binary inputs available is configured for this purpose (e.g. presetting of binary input BI1 „>BLOCK 50-2“ and „>BLOCK 50N-2“ to open circuit system). Tests can be performed with phase currents or ground current. For ground current the corresponding ground current settings apply.

Please note that the blocking function can either be configured for the pickup current connected (open circuit system) or the pickup current missing (closed circuit system). For open circuit system the following tests are to be proceeded:

The feeder protection relays of all associated feeders must be in operation. At the beginning no auxiliary voltage is fed to the reverse interlocking system.

A test current higher than the pickup values of **50-2 PICKUP** and **50-1 PICKUP** or is set. As a result of the missing blocking signal, the protection function trips after (short) time delay **50-2 DELAY**.

Caution!

Test with currents above 20 A continuous current

cause an overload of the input circuits.

Perform the test only for a short time (see Technical Data, Section 4.1). Afterwards, the device has to cool off!

The direct voltage for reverse interlocking is now switched on to the line. The precedent test is repeated, the result will be the same.

Subsequently, a pickup is simulated at each of the protection devices of the feeders. Meanwhile, another fault is simulated for the protection function of the infeed, as described before. Tripping is now effected in the (longer set) time **50-1 DELAY** (in the case of definite-time overcurrent protection).

These tests also check the proper functioning of the wiring for reverse interlocking.

3.3.9 Direction Check with Load Current

Preliminary Remark

Note

The direction check is only relevant for devices with voltage transformers.

≥ 10 % of Load Current

The correct connection of the current and voltage transformers is tested via the protected line using the load current. For this purpose, connect the line. The load current the line carries must be at least 0.1 · I_{Nom}. The load current should be in-phase or lagging the voltage (resistive or resistive-inductive load). The direction of the load current must be known. If there is any doubt, network or ring loops should be opened. The line remains energized during the test.

The direction can be derived directly from the operational measured values. Initially the correlation of the measured load direction with the actual direction of load flow is checked. In this case the normal situation is assumed whereby the forward direction (measuring direction) extends from the busbar towards the line

P positive, if active power flows into the line,

P negative, if active power flows towards the busbar,

Q positive, if reactive power flows into the line,

Q negative, if reactive power flows toward the busbar.

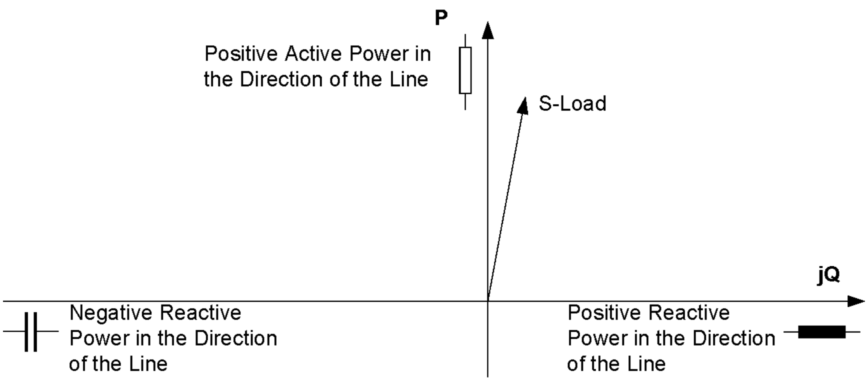


Figure 3-18 Apparent Load Power

All signs of powers may be inverted deliberately. Check whether polarity is inverted in address 1108 **P,Q sign** in the **P.System Data 2**. In that case the signs for active and reactive power are inverse as well.

The power measurement provides an initial indication as to whether the measured values have the correct polarity. If both the active power and the reactive power have the wrong sign and 1108 **P,Q sign** is set to ***not reversed***, the polarity according to address 201 **CT Starpoint** must be checked and corrected.

However, power measurement itself is not able to detect all connection errors. For this reason, directional messages should be generated by means of the directional overcurrent protection. Therefore, pickup thresholds must be reduced so that the available load current causes a continuous pickup of the element. The direction reported in the messages, such as „Phase A forward“ or „Phase A reverse“ must correspond to the actual power flow. Be careful that the „Forward“ direction of the protective element is in the direction of the line (or object to be protected). This is not necessarily identical with the direction of the normal the power flow. For all three phases, the directional messages to the power flow must be reported properly.

If all directions differ from each other, individual phases in current or voltage transformer connections are interchanged, not connected properly or phase assignment is incorrect. After isolation of the line and short-circuiting of the current transformers the connections must be checked and corrected. The measurements must then be repeated.

Finally, switch off the protected power line.

Note

Reset the pickup values changed for the check to valid values.

3.3.10 Polarity Check for Current Input I_N

General

If the standard connection of the device is used with current input I_N connected in the neutral point of the set of current transformers (see also connection circuit diagram in Appendix A.3), then the correct polarity of the ground current path usually occurs automatically.

If, however, current I_N is derived from a separate summation CT (see e.g. a connection circuit diagram in the Appendix A.3), an additional direction check with this current is necessary.

If the device features the sensitive current input for I_N and if it is used in an isolated or resonant-grounded system, the polarity check for I_N was already carried out with the ground fault check according to the previous section. Then this section is not relevant.

Otherwise 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 pick up. 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.

Directional Testing for Grounded Systems

The test can be performed with the „Directional ground fault protection“ function (address 116).

In the following the check is described using the „directional ground fault protection“ function (address 116) as an example.

To generate a displacement voltage, the e–n winding of one phase in the voltage transformer set (e.g. A) is bypassed (see Figure 3-19). If no connection on the e–n windings of the voltage transformer is provided, the corresponding phase is disconnected on the secondary side (see Figure 3-20). Only the current of the transformer which is not provided with voltage in its voltage path is fed into the current path. If the line carries resistive-inductive load, the protection is subject to the same conditions as exist during a ground fault in line direction.

Directional ground fault protection must be configured as enabled and activated (address 116). Its pickup threshold must be below the load current of the line; if necessary, the pickup threshold must be reduced. The parameters that have been changed must be noted.

After switching the line on and off again, the direction indication must be checked: In the fault log the messages „67N picked up“ and „Ground forward“ must at least be present. If the directional pickup is not present, either the ground current connection or the displacement voltage connection is incorrect. If the wrong direction is indicated, either the direction of load flow is from the line toward the busbar or the ground current path has a swapped polarity. In the latter case, the connection must be rectified after the line has been isolated and the current transformers short-circuited.

If the pickup message is missing, the measured ground (residual) current or the displacement voltage emerged may be too small. This can be checked via operational measured values.

Important! If parameters were changed for this test, they must be returned to their original state after completion of the test !

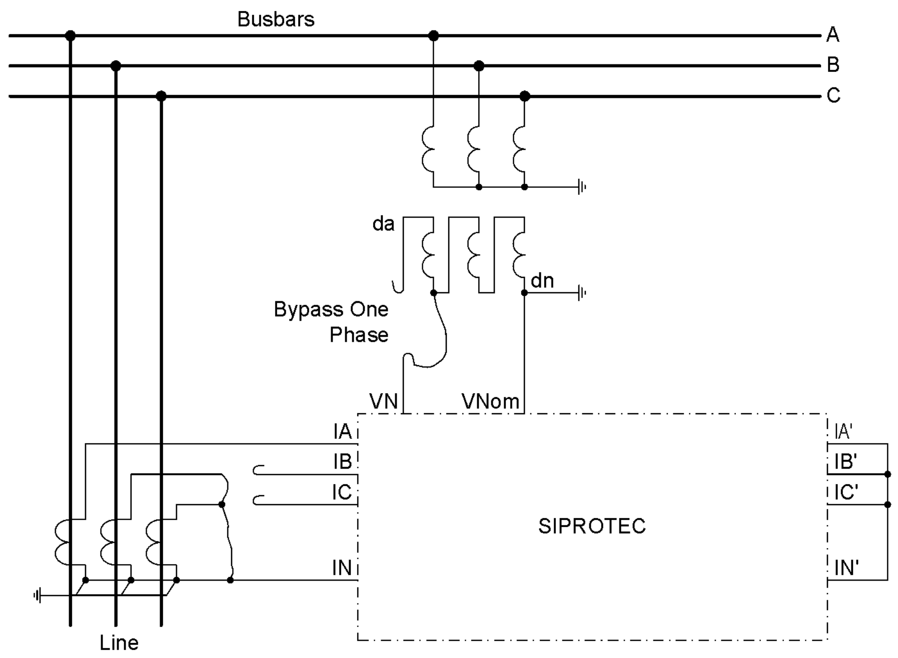


Figure 3-19 Polarity testing for I_N, example with current transformers configured in a Holmgreen-connection (VTs with broken delta connection -- e-n winding)

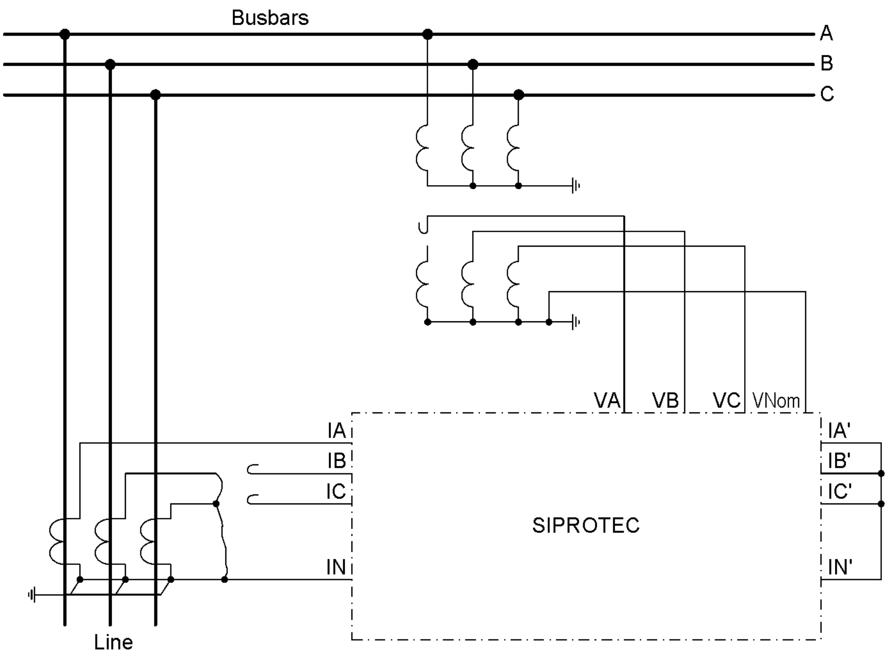


Figure 3-20 Polarity testing for I_N, example with current transformers configured in a Holmgreen-connection (VTs Wye-connected)

3.3.11 Switching Test for Configured Equipment

Switching via Command Input

If the configured equipment was not switched sufficiently in the hardware test already described, configured equipment must be switched on and off from the device via the integrated control element. The feedback information on the circuit breaker position injected via binary inputs is to be 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 according to the command source used. The switching mode can be selected from interlocked and non-interlocked switching. Please note that non-interlocked switching can be a safety hazard.

Control from a Remote Control Center

If the device is connected to a remote substation via a system 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.

3.3.12 Creating A Test Fault Record

In order to test the stability of the protection during switch-on procedures also, switch-on 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 possibility of storing fault records via pickup of the protection function, the 7SC80 also has the capability of capturing the same data when commands are given to the device via the operating program DIGSI, the serial interface, or via binary input. In the latter case, „`>Trig.Wave.Cap.`“ must be allocated to a binary input. The recording is then triggered, e.g. via binary input when the protected 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.

Starting Test Fault Recording

In order to start a test fault record via DIGSI, select the **Test** function in the left part of the window. Double-click the entry **Test Wave Form** in the list view (see Figure 3-21).

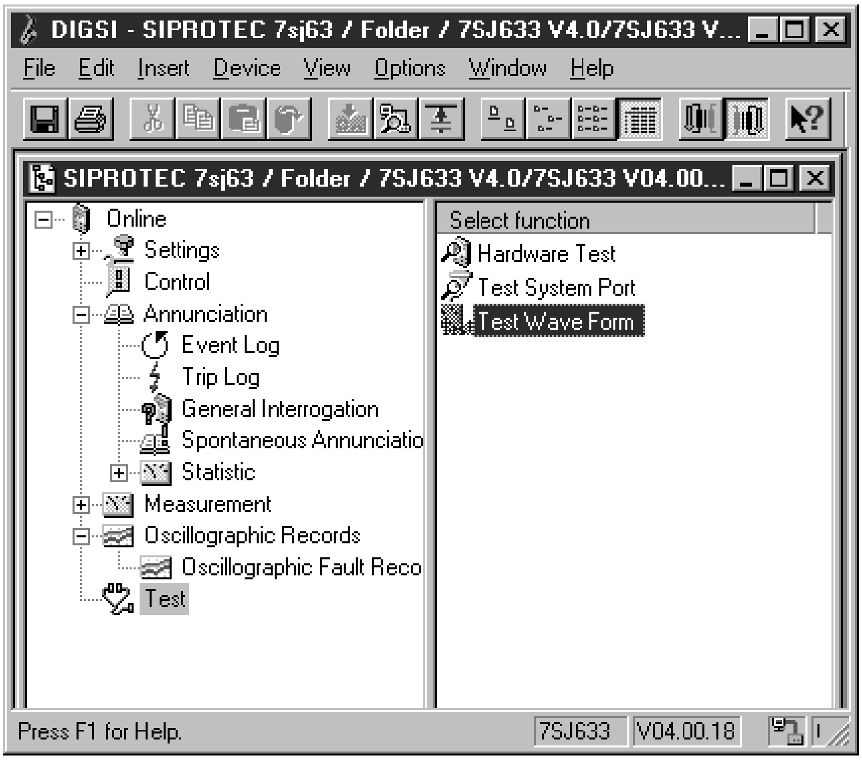


Figure 3-21 Test Wave Form window in DIGSI - Example

Oscillographic recording is immediately started. During the recording, an annunciation is output in the left area of the status line. Bar segments additionally indicate the progress of the procedure.

The SIGRA or the Comtrade Viewer program is required to view and analyze the oscillographic data.

3.4 Final Preparation of the Device

The used terminal screws must be tightened, including all screws that are not used. All plug connectors must be inserted correctly.

Caution!

Do not use force!

The permissible tightening torques must not be exceeded as otherwise the threads and terminal chambers may be damaged!

The setting values should be checked again if they were changed during the tests. Check in particular whether all protection, control and auxiliary functions in the configuration parameters are set correctly (Section 2.1.1, Functional Scope) and that all desired functions have been set to ***ON***. Make sure that a backup copy of all setting values is stored on the PC.

Check the internal clock of the device. If necessary, set the clock or synchronize the clock if it is not synchronized automatically. Further details on this subject are described in /1/.

The indication buffers are deleted under **Main Menu** → **Annunciations** → ***Set/Reset*** so that they only contain information on actual events and states in the future. The counters of the switching statistics should be reset to the values 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. The default display appears in the display (e.g. display of operational measured values).

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 pushed. 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“ LED 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 provides the technical data of the device SIPROTEC 7SC80 and its individual functions, including the limit values that may not be exceeded under any circumstances. The electrical and functional data for the maximum functional scope are followed by the mechanical specifications with dimensioned drawings.

4.1 General Device Data

4.1.1 Analog Inputs

Current Inputs

Nominal frequency	f_{Nom}	50 Hz or 60 Hz	(adjustable)
Frequency operating range (independent of the nominal frequency)		25 Hz to 70 Hz	
Nominal current	I_{Nom}	1 A or 5 A	
Consumption per phase and ground path - for I_{Nom} = 1 A - for I_{Nom} = 5 A		 ≤ 0.1 VA ≤ 0.5 VA	
Current overload capability - thermal (rms) - dynamic (peak value)		 500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half-cycle)	

Voltage Inputs

Measuring range		0 V to 250 V
Consumption	at 100 V	approx. 0.005 VA
Voltage overload capability		
– thermal (rms)		230 V continuous

4.1.2 Auxiliary Voltage

Direct Voltage

Power supply via integrated converter		
Rated auxiliary direct voltage V_{PS}	DC 24 V to 48 V	DC 60 V to 250 V
Permissible voltage ranges	DC 19 V to 60 V	DC 48 V to 300 V
Overvoltage category, IEC 60255-27	III	
Permissible AC ripple voltage, peak to peak, IEC 60255-11	15 % of the auxiliary voltage	

Power consumption	quiescent	energized
7SC80	approx. 5 W	approx. 12 W
Bridging time for failure/short circuit, IEC 60255-11 (if cabinet battery is not connected)	≥ 50 ms	

Alternating Voltage

Power supply via integrated converter		
Rated auxiliary alternating voltage V_{PS}	AC 115 V	AC 230 V
Permissible voltage ranges	AC 92 V to 132 V	AC 184 V to 265 V
Overvoltage category, IEC 60255-27	III	

Power consumption (for AC 115 V/230 V)	< 15 VA
Bridging time for failure/short circuit	≥ 100 ms

4.1.3 Binary Inputs and Outputs

Binary Inputs

Variant	Quantity
7SC80	12 (routable)
Range of rated direct voltage	DC 0 V to 300 V, AC 0 V to 200 V
Current consumption, energized (independent of operating voltage)	approx. 0.4 mA
Pickup time Response time of binary output after trigger signal from binary input	approx. 3 ms approx. 9 ms
Dropout time Response time of binary output after trigger signal from binary input	approx. 4 ms approx. 5 ms
Secured switching thresholds	V high > DC 17 V V low < DC 12 V
Maximum admissible voltage	DC 300 V
Input pulse suppression	220 V induced above 220 nF at a recovery time between two switching operations ≥ 60 ms

Output Relays

Signal/command relay, alarm relay		
Quantity and data	depending on the order variant (routable)	
7SC80	8 BO	
Switching capability CLOSE	1000 W/1000 VA	
Switching capability TRIP	40 W or 30 VA at L/R ≤ 40 ms	
Switching voltage AC and DC	250 V	
Permissible current per contact (continuous)	8 A	
Permissible current per contact (close and hold)	30 A for 0.5 s (make contact)	
Interference suppression capacitor at the relay outputs 2.2 nF, 250 V, ceramic	Frequency	Impedance
	50 Hz	$1.4 \cdot 10^6\ \Omega \pm 20\ \%$
	60 Hz	$1.2 \cdot 10^6\ \Omega \pm 20\ \%$

4.1.4 Communication Interfaces

User Interface

Connection	At the front, non-isolated, USB type B socket for connecting a personal computer operation for DIGSI V4.82 and higher via USB 2.0 full speed
Operation	with DIGSI
Transmission speed	up to 12 Mbit/s max.
Bridgeable distance	5 m

Port F

Ethernet electrical (EN 100) for IEC61850 and DIGSI		
	Connection	At housing, 2 x RJ45 connector socket 100BaseT in acc. with IEEE802.3
	Test voltage (for socket)	500 V; 50 Hz
	Transmission speed	100 Mbit/s
	Bridgeable distance	20 m
Ethernet optical (EN 100 SM) for IEC61850 and DIGSI		
	Connection	At housing, duplex-LC, 100BaseF in acc. with IEEE802.3
	Transmission speed	100 Mbit/s
	Optical wavelength	1300 nm
	Bridgeable distance	max. 24 km

GPS Connection

Connection	SMB socket (subminiature B) at device
	Active GPS antenna 5 V, max. 50 mA

4.1.5 Electrical Tests

Regulations

Standards: see also individual tests	
Protection devices	Bay units
IEC 60255 EN 60255/EN 50263 DIN 57435/DIN EN 50263 IEC TS 61000-6-5 IEC/EN 61000-4 IEC 60694 IEC 61850-3 ANSI/IEEE Std C37.90 IEC 61010-1 VDE 0435	IEC 60870 EN 60870 DIN EN 60870 IEC TS 61000-6-5 IEC/EN 61000-4 IEC 60694 IEC 61850-3

Insulation Test

Standards:	IEC 60255-27 and IEC 60870-2-1
Voltage test (component test) all circuits except for auxiliary voltage, binary inputs and communication interfaces	2.5 kV; 50 Hz
Voltage test (component test) auxiliary voltage and binary inputs	DC 3.5 kV
Voltage test (component test) only isolated communication interfaces (A and B)	500 V; 50 Hz
Impulse voltage test (type test), all process circuits (except for communication interfaces) against internal electronics	6 kV (peak value); 1.2 µs/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 1 s
Impulse voltage test (type test), all process circuits (except for communication interfaces) against each other and against the grounding terminal category III	5 kV (peak value); 1.2 µs/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 1 s

EMC Tests for Immunity (Type Tests)

Standards:		IEC 60255-6 and -22, (product standards) IEC/EN 61000-6-2 VDE 0435 For additional standards, see the individual tests
1 MHz test, class III IEC 60255-22-1, IEC 61000-4-18, IEEE C37.90.1		2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge, class IV IEC 60255-22-2, IEC 61000-4-2		8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with amplitude-modulated HF field, class III IEC 60255-22-3, IEC 61000-4-3		10 V/m; 80 MHz to 2.7 GHz 80 % AM; 1 kHz
Fast transient disturbance variables/burst, class IV IEC 60255-22-4, IEC 61000-4-4, IEEE C37.90.1		4 kV; 5 ns/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages installation class III IEC 60255-22-5, IEC 61000-4-5 [1)]		Pulse: 1.2 µs/50 µs
	Auxiliary voltage	common mode: 4 kV; 12 Ω; 9 µF diff. mode:1 kV; 2 Ω; 18 µF
	Measuring inputs, binary inputs and relay outputs	common mode: 4 kV; 42 Ω; 0.5 µF diff. mode: 1 kV; 42 Ω; 0.5 µF
[1)] For the device variants 24 V/48 V, provide a protection for a possible surge dissipation (for example, in case of lightning strokes) by external measures.		
Line-conducted HF, amplitude-modulated, class III IEC 60255-22-6, IEC 61000-4-6		10 V; 150 kHz to 80 MHz: 80 % AM; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV;		30 A/m; continuous; 300 A/m for 3 s;
Radiated electromagnetic interference IEEE Std C37.90.2		20 V/m; 80 MHz to 1 GHz; 80 % AM; 1 kHz For an irradiation in the range of 500 MHz, a higher measured-value deviation can occur. The maximum measured deviation is 6 %.
Damped oscillations IEC 61000-4-18		2.5 kV (peak); 100 kHz; 40 pulses per s; test duration 2 s; Ri = 200 Ω

EMC Tests for Noise Emission (Type Test)

Standard:	IEC/EN 61000-6-4
Radio noise voltage on lines, only auxiliary voltage IEC-CISPR 11	150 kHz to 30 MHz limit class A
Radio noise field strength IEC-CISPR 11	30 MHz to 1000 MHz limit class A
Harmonic currents on the network lead at AC 230 V IEC 61000-3-2	Device is to be assigned to class D (applies only to devices with > 50 VA power consumption)
Voltage variations and flickers on the network lead at AC 230 V IEC 61000-3-3	Limit values are observed.

4.1.6 Mechanical Tests

Vibration and Shock Stress during Steady-State Operation

Standards:	IEC 60255-21 IEC 60068 IEC 60721	IEC 60870
Vibration IEC 60255-21-1, class 1; IEC 60068-2-6	sinusoidal 10 Hz to 60 Hz: ± 0.075 mm amplitude; 60 Hz to 150 Hz: 1 g acceleration frequency sweep rate 1 octave/min, 20 cycles in 3 orthogonal axes	
Shock IEC 60255-21-2, class 1; IEC 60068-2-27	semi-sinusoidal 15 g acceleration, duration 11 ms, 3 shocks in each direction of the 3 axes	
Seismic vibration IEC 60255-21-3, class 2 IEC 60068-3-3	sinusoidal 1 Hz to 8 Hz: ± 8.0 mm amplitude (horizontal axis) 1 Hz to 8 Hz: ± 4.0 mm amplitude (vertical axis) 8 Hz to 35 Hz: 2 g acceleration (horizontal axis) 8 Hz to 35 Hz: 1 g acceleration (vertical axis) frequency sweep rate 1 octave/min, 1 cycle in 3 orthogonal axes	

Vibration and Shock Stress during Transport

Standards:	IEC 60255-21 IEC 60068 IEC 60721	IEC 60870
Vibration IEC 60255-21-1, class 1; IEC 60068-2-6	sinusoidal 5 Hz to 8 Hz: ±3.5 mm amplitude; 8 Hz to 150 Hz: 1 g acceleration frequency sweep rate 1 octave/min, 20 cycles in 3 orthogonal axes	
Shock IEC 60255-21-2, class 1; IEC 60068-2-27	semi-sinusoidal acceleration 15 g, duration 11 ms, 3 shocks in each direction of the 3 orthogonal axes	
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	semi-sinusoidal acceleration 10 g, duration 16 ms, 1000 shocks in each direction of the 3 orthogonal axes	

4.1.7 Climatic Stress Tests

Temperatures

Standards:	IEC 60255-6 and IEC 60870
Type test (in acc. with IEC 60086-2-1 and -2, test Bd for 16 h)	–50 °C to +85 °C
temporarily admissible during operation (tested for 96 h)	–40°C bis +70 °C[1)]
recommended for permanent operation (in acc. with IEC 60255-6)	–40 °C to +55 °C[1)]
Limit temperatures for storage	–25 °C to +55 °C
Limit temperatures during transport	–20 °C to +70 °C
Storage and transport in factory packaging	
[1)] The lithium battery CR2032 mounted by default is admitted for –30°C to +70°C.	

Humidity

Permissible humidity	Mean value per year ≤ 75 % relative humidity; on 30 days of the year up to 95 % relative humidity; condensation must be avoided!
Siemens recommends installing the devices in a place where they are not exposed to direct sunlight or great temperature variations that could lead to condensation. **If condensation is anticipated, the control cabinet into which the 7SC80 is installed must be equipped with a cabinet heating.**	

4.1.8 Service Conditions

The device is designed for installation in standard relay rooms and compartments so that the electromagnetic compatibility (EMC) is ensured when the device is installed correctly.

Siemens also recommends:

- All contactors and relays that operate in the same cabinet or on the same relay panel as the digital protection devices must generally be equipped with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables must be shielded with a conductive shield grounded at both ends. For substations with lower operating voltages no special measures are normally required.
- Do not withdraw or insert individual modules while the protection device is energized. When handling modules outside the housing, the standards for components sensitive to electrostatic discharge (**E**lectrostatically **S**ensitive **D**evices) must be observed. There is no risk in the installed condition.

4.1.9 Constructive Design

Dimensions	See dimensional drawings, Section 4.16

Device	Housing	Weight
7SC80	For panel flush mounting and panel surface mounting	4.5 kg

Degree of protection in acc. with IEC 60529	
For equipment in surface-mounting housing or flush-mounting housing	IP 40
For operator protection	IP 2x for current terminal IP 1x for voltage terminal
Degree of pollution, IEC 60255-27	2

4.1.10 UL certification conditions

Output relays	DC 24 V	5 A general purpose
	DC 48 V	0.8 A general purpose
	DC 240 V	0.1 A general purpose
	AC 240 V	5 A general purpose
	AC 120 V	1/3 hp
	AC 250 V	1/2 hp
	B300, R300	
Voltage inputs	Input voltage range	300 V
Battery	Servicing of the circuitry involving the batteries and replacement of the lithium batteries shall be done by a trained technician. Replace battery with type CR2032 lithium battery; 3 V, 230 mAh only. Use of another battery may present a risk of fire or explosion. See the manual for safety instructions. Caution: The battery used in this device may present a fire or chemical burn hazard if handled incorrectly. Do not recharge, disassemble, heat above 100 °C (212 °F) or incinerate. Dispose of used battery promptly. Keep away from children.	
Climatic stress	Surrounding air temperature	tsurr: max. 70 °C (158 °F), normal operation
Constructive design	Field wires of control circuits must be separated from other circuits with respect to the end use requirements!	
	Type 1 if mounted into a door or front cover of an enclosure.	

4.2 Definite-time overcurrent protection 50, 50N

Operating Modes

Three-phase	Standard
Two-phase	Phases A and C

Method of Measurement

All elements	Fundamental wave, true RMS value
50-3, 50N-3	Additional instantaneous values

Setting Ranges/Increments

Current pickup 50-1, 50-2 (phases)	for I_{Nom} = 1 A	0.10 A to 35.00 A or ∞ (disabled)	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 175.00 A or ∞ (disabled)	
Current pickup 50-3 (phases)	for I_{Nom} = 1 A	1.0 A to 35.00 A or ∞ (disabled)	
	for I_{Nom} = 5 A	5.0 A to 175.00 A or ∞ (disabled)	
Current pickup 50N-1, 50N-2 (ground)	for I_{Nom} = 1 A	0.05 A to 35.00 A or ∞ (disabled)	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 175.00 A or ∞ (disabled)	
Current pickup 50N-3 (ground)	for I_{Nom} = 1 A	0.25 A to 35.00 A or ∞ (disabled)	
	for I_{Nom} = 5 A	1.25 A to 175.00 A or ∞ (disabled)	
Delay times T		0.00 s to 60.00 s or ∞ (disabled)	Increments 0.01 s
Dropout delay times 50 T DROP-OUT, 50N T DROP-OUT		0.00 s to 60.00 s	Increments 0.01 s

Times

Pickup times (without inrush restraint, with inrush restraint + 1 cycle)	
Fundamental component, RMS value - for setting value x 2 - for setting value x 10 Instantaneous value - for setting value x 2 - for setting value x 10	 approx. 30 ms approx. 20 ms approx. 16 ms approx. 16 ms
Dropout times Fundamental component, RMS value Instantaneous value	 approx. 30 ms approx. 40 ms

Dropout Ratio

Dropout ratio for - fundamental component, RMS value - instantaneous value	 approx. 0.95 for $I/I_{Nom} \geq 0.3$ approx. 0.90 for $I/I_{Nom} \geq 0.3$

Tolerances

Current pickup	3 % of setting value or 15 mA at I_{Nom} = 1 A or 75 mA at I_{Nom} = 5 A
Delay times T	1 % or 10 ms

Influencing Variables for Pickup and Dropout Values

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequencies outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic for instantaneous values of 50-3/50N-3 elements	 1 % 1 % increased tolerances
Transient overreaction for τ > 100 ms (with full displacement)	<5 %

4.3 Directional Overcurrent Protection 67, 67N

Overcurrent Elements

The same specifications apply as for non-directional overcurrent protection of the elements 50-1, 50-2, 50N-1 and 50N-2 (see previous sections).

Determination of Direction

Moreover, the following data apply for determining the fault direction:

For Phase Faults

Type	with cross-polarized voltages; with voltage memory (memory depth 2 seconds) for measuring voltages that are too small
Forward range	$V_{ref,rot} \pm 86°$
Rotation of the reference voltage $V_{ref,rot}$	–180° to +180° increments 1°
Dropout difference	3°
Directional sensitivity	unlimited for single-phase and two-phase faults for three-phase faults dynamically unlimited, steady-state approx. 7 V phase-to-phase

For Ground Faults

Type	with zero-sequence system quantities $3V_0$, $3I_0$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of the reference voltage $V_{ref,rot}$	–180° to +180° increments 1°
Dropout difference	3°
Directional sensitivity	$V_{Gnd} \approx 2.5$ V displacement voltage, measured $3V_0 \approx 5$ V displacement voltage, calculated

Type	with negative-sequence system quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of the reference voltage $V_{ref,rot}$	–180° to +180° increments 1°
Dropout difference	3°
Directional sensitivity	$3V_2 \approx 5$ V negative-sequence voltage $3I_2 \approx 45$ mA negative-sequence current for $I_{Nom} = 1$ A $3I_2 \approx 225$ mA negative-sequence current for $I_{Nom} = 5$ A

Times

Pickup times (without inrush restraint, with inrush restraint + 1 cycle)	
67-1, 67-2, 67N-1, 67N-2 - for setting value x 2 - for setting value x 10	 approx. 45 ms approx. 40 ms
Dropout times 67-1, 67-2, 67N-1, 67N-2	 approx. 40 ms

Tolerances

Angle error for phase and ground faults	±3° electrical

Influencing Variables

Frequency influence - without memory voltage	 approx. 1° in the range from 25 Hz to 50 Hz

4.4 Inrush Restraint

Influenceable Functions

Overcurrent elements	50-1, 50N-1, 67-1, 67N-1

Setting Ranges/Increments

Restraining factor I_{2f}/I	10 % to 45 %	Increments 1 %

Function Limits

Lower function limit phases	for I_{Nom} = 1 A	at least one phase current (50 Hz and 100 Hz) ≥ 50 mA	
	for I_{Nom} = 5 A	at least one phase current (50 Hz and 100 Hz) ≥ 125 mA	
Lower function limit ground	for I_{Nom} = 1 A	Ground current (50 Hz and 100 Hz) ≥ 50 mA	
	for I_{Nom} = 5 A	Ground current (50 Hz and 100 Hz) ≥ 125 mA	
Upper function limit, configurable	for I_{Nom} = 1 A	0.30 A to 25.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	1.50 A to 125.00 A	Increments 0.01 A

Crossblock

Crossblock I_A, I_B, I_C	ON/OFF

4.5 Voltage Protection 27, 59

Setting Ranges/Increments

Undervoltages 27-1, 27-2 phase-specific phase x 27-1, phase x 27-2			
Measured quantity used with three-phase connection		- Positive-sequence system of voltages - Smallest phase-to-phase voltage - Smallest phase-to-ground voltage	
Connection of phase-to-ground voltages: - Evaluation of phase-to-ground voltages - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system		 10 V to 200 V 10 V to 385 V 10 V to 385 V	 Increments 1 V Increments 1 V Increments 1 V
Connection of phase-to-phase voltages		10 V to 385 V	Increments 1 V
Dropout ratio r for 27-1, 27-2 [1)]		1.01 to 3.00	Increments 0.01
Dropout threshold for (r · 27-1) or (r · 27-2)		max. 130 V for phase-to-phase voltage max. 225 V for phase-to-ground voltage Minimum hysteresis 0.6 V	
Time delays 27-1, 27-2		0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s
Current criterion BkrClosed I MIN	for I_{Nom} = 1 A	0.04 A to 1.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.20 A to 5.00 A	
Overvoltages 59-1, 59-2 phase-specific phase x 59-1, phase x 59-2			
Measured quantity used with three-phase connection		- Positive sequence system of voltages - Negative sequence system of voltages - Largest phase-to-phase voltage - Largest phase-to-ground voltage	
Connection of phase-to-ground voltages: - Evaluation of phase-to-ground voltages - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system - Evaluation of negative sequence system		 20 V to 240 V 20 V to 415 V 20 V to 240 V 2 V to 240 V	 Increments 1 V Increments 1 V Increments 1 V Increments 1 V
Connection of phase-to-phase voltages: - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system - Evaluation of negative sequence system		 20 V to 240 V 20 V to 240 V 2 V to 240 V	 Increments 1 V Increments 1 V Increments 1 V
Dropout ratio r for 59-1, 59-2[1)]		0.90 to 0.99	Increments 0.01
Dropout threshold for (r · 59-1) or (r · 59-2)		max. 240 V for phase-to-phase voltage max. 415 V for phase-to-ground voltage Minimum hysteresis 0.6 V	
Time delay 59-1, 59-2 Phase-specific delay time Phx 59-1		0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s

[1)] $r = V_{dropout}/V_{pickup}$

Times

Pickup times	
- Undervoltage 27-1, 27-2, 27-1 V_1, 27-2 V_1 - Overvoltage 59-1, 59-2 - Overvoltage 59-1 V_1, 59-2 V_1, 59-1 V_2, 59-2 V_2 - Undervoltage phase x 27-1, phase x 27-2 - Overvoltage phase x 59-1, phase x 59-2	approx. 50 ms approx. 50 ms approx. 60 ms
Dropout times	
- Undervoltage 27-1, 27-2, 27-1 V_1, 27-2 V_1 - Overvoltage 59-1, 59-2 - Overvoltage 59-1 V_1, 59-2 V_1, 59-1 V_2, 59-2 V_2 - Undervoltage phase x 27-1, phase x 27-2 - Overvoltage phase x 59-1, phase x 59-2	approx. 50 ms approx. 50 ms approx. 60 ms

Tolerances

Voltage limit values	3 % of setting value or 1 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.6 Voltage Protection for Vx

Setting Ranges/Increments

Undervoltages 27-1, 27-2		
Measured quantity used	Connected single-phase phase-to-ground voltage	
Connection: single-phase	10 V to 200 V	Increments 1 V
Dropout ratio r for 27-1, 27-2 [1)]	1.01 to 3.00	Increments 0.01
Dropout threshold for (r · 27-1) or (r · 27-2)	max. 225 V Minimum hysteresis 0.6 V	
Time delays 27-1 Delay, 27-2 Delay	0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s
Overvoltages 59-1, 59-2		
Measured quantity used with single-phase connection	Connected single-phase phase-to-ground voltage	
Connection: single-phase	20 V to 240 V	Increments 1 V
Dropout ratio r for 59-1, 59-2[1)]	0.90 to 0.99	Increments 0.01
Dropout threshold for (r · 59-1) or (r · 59-2)	max. 260 V for phase-to-ground voltage Minimum hysteresis 0.6 V	
Time delay 59-1 Delay, 59-2 Delay Phase-specific Ph x 59-1 Delay, Ph x 59-2 Delay	0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s

1) $r = V_{dropout}/V_{pickup}$

Times

Pickup times	
- Undervoltage 27-1, 27-2 - Overvoltage 59-1, 59-2	approx. 50 ms approx. 50 ms
Dropout times	
- Undervoltage 27-1, 27-2 - Overvoltage 59-1, 59-2	approx. 50 ms approx. 50 ms

Tolerances

Voltage limit values	3 % of setting value or 1 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.7 Negative Sequence Protection 46-1, 46-2 (Definite Time Characteristic)

Setting Ranges/Increments

Unbalanced load elements 46-1, 46-2	for I_{Nom} = 1 A	0.10 A to 3.00 A or ∞ (disabled)	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 15.00 A or ∞ (disabled)	
Delay times 46-1 Delay, 46-2 Delay		0.00 s to 60.00 s or ∞ (disabled)	Increments 0.01 s
Dropout time delays 46 T DROP-OUT		0.00 s to 60.00 s	Increments 0.01 s

Functional Limit

Functional limit	for I_{Nom} = 1 A	All phase currents ≤ 10 A
	for I_{Nom} = 5 A	All phase currents ≤ 50 A

Times

Pickup times Dropout times	approx. 35 ms approx. 35 ms

Dropout Ratio

Element characteristic 46-1, 46-2	approx. 0.95 for $I_2/I_{Nom} \geq 0.3$

Tolerances

Pickup values 46-1, 46-2	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA for I_{Nom} = 5 A
Time delays	1 % or 10 ms

Influencing Variables for Pickup Values

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Transient overreaction for τ > 100 ms (with full displacement)	<5 %

4.8 Negative Sequence Protection 46-TOC (Inverse Time Characteristic)

Setting Ranges/Increments

Pickup value 46-TOC PICKUP	for I_{Nom} = 1 A	0.10 A to 2.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 10.00 A	
Time Multiplier 46-TOC TIMEDIAL (IEC)		0.05 s to 3.20 s or ∞ (disabled)	Increments 0.01 s
Time Multiplier 46-TOC TIMEDIAL (ANSI)		0.50 s to 15.00 s or ∞ (disabled)	Increments 0.01 s

Functional Limit

Functional limit	for I_{Nom} = 1 A	All phase currents ≤ 10 A
	for I_{Nom} = 5 A	All phase currents ≤ 50 A

Trip Time Curves acc. to IEC

See also Figure 4-1

INVERSE

$$t_{TRIP} = \frac{0.14}{(I_2/I_{2p})^{0.02} - 1} \cdot T_{I2p} \qquad [s]$$

VERY INVERSE

$$t_{TRIP} = \frac{13.5}{(I_2/I_{2p})^{1} - 1} \cdot T_{I2p} \qquad [s]$$

EXTREMELY INV.

$$t_{TRIP} = \frac{80}{(I_2/I_{2p})^{2} - 1} \cdot T_{I2p} \qquad [s]$$

Where:
t_{TRIP} Trip Time
T_{I2p} Setting Value of the Time Multiplier
I_2 Negative Sequence Current
I_{2p} Setting Value of the Pickup Current

The trip times for $I_2/I_{2p} \geq 20$ are identical to those for $I_2/I_{2p} = 20$.

Pickup Threshold	Approx. 1.10· I_{2p}

Trip Time Curves acc. to ANSI

It can be selected one of the represented trip time characteristic curves in the figures 4-2 and 4-3 each on the right side of the figure.	
INVERSE	$t_{TRIP} = \left(\frac{8.9341}{(I_2/I_{2p})^{2.0938} - 1} + 0.17966\right) \cdot D_{I2p} \quad [s]$
MODERATELY INVERSE	$t_{TRIP} = \left(\frac{0.0103}{(I_2/I_{2p})^{0.02} - 1} + 0.0228\right) \cdot D_{I2p} \quad [s]$
VERY INVERSE	$t_{TRIP} = \left(\frac{3.922}{(I_2/I_{2p})^{2} - 1} + 0.0982\right) \cdot D_{I2p} \quad [s]$
EXTREMELY INV.	$t_{TRIP} = \left(\frac{5.64}{(I_2/I_{2p})^{2} - 1} + 0.02434\right) \cdot D_{I2p} \quad [s]$
	Where: t_{TRIP} Trip Time D_{I2p} Setting Value of the Time Multiplier I_2 Negative Sequence Currents I_{2p} Setting Value of the Pickup Current
The trip times for $I_2/I_{2p} \geq 20$ are identical to those for $I_2/I_{2p} = 20$.	
Pickup Threshold	Approx. 1.10· I_{2p}

Tolerances

Pickup thresholds 46-TOC PICKUP	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA at I_{Nom} = 5 A
Time for 2 £ I/46-TOC PICKUP £ 20	5 % of set point value + 2 % current tolerance, or 30 ms

Dropout Time Curves with Disk Emulation acc. to ANSI

Representation of the possible dropout time curves, see figure 4-2 and 4-3 each on the left side of the figure	
INVERSE	$t_{Reset} = \left(\frac{8.8}{1 - (I_2/I_{2p})^{2.0938}}\right) \cdot D_{I2p} \quad [s]$
MODERATELY INV.	$t_{Reset} = \left(\frac{0.97}{1 - (I_2/I_{2p})^{2}}\right) \cdot D_{I2p} \quad [s]$
VERY INVERSE	$t_{Reset} = \left(\frac{4.32}{1 - (I_2/I_{2p})^{2}}\right) \cdot D_{I2p} \quad [s]$
EXTREMELY INV.	$t_{Reset} = \left(\frac{5.82}{1 - (I_2/I_{2p})^{2}}\right) \cdot D_{I2p} \quad [s]$
	Where: t_{Reset} Reset Time D_{I2p} Setting Value of the Time Multiplier I_2 Negative Sequence Current I_{2p} Setting Value of the Pickup Current
The dropout time constants apply to $(I_2/I_{2p}) \leq 0.90$	

Dropout Value

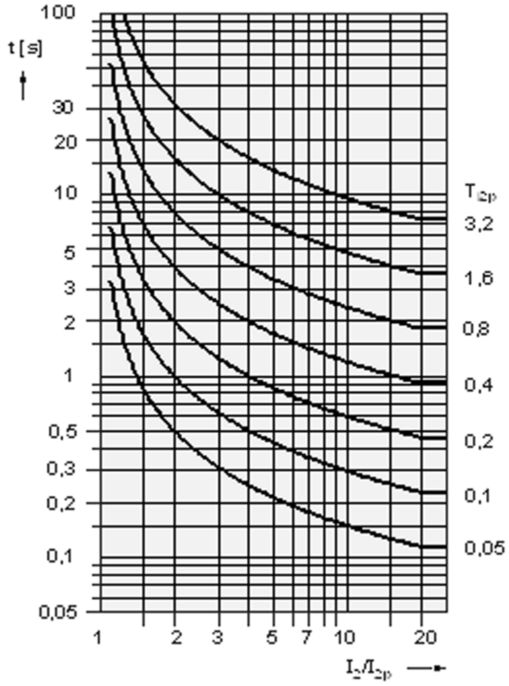
IEC and ANSI (without Disk Emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold I_2
ANSI with Disk Emulation	Approx. 0.90 · I_{2p} setting value

Tolerances

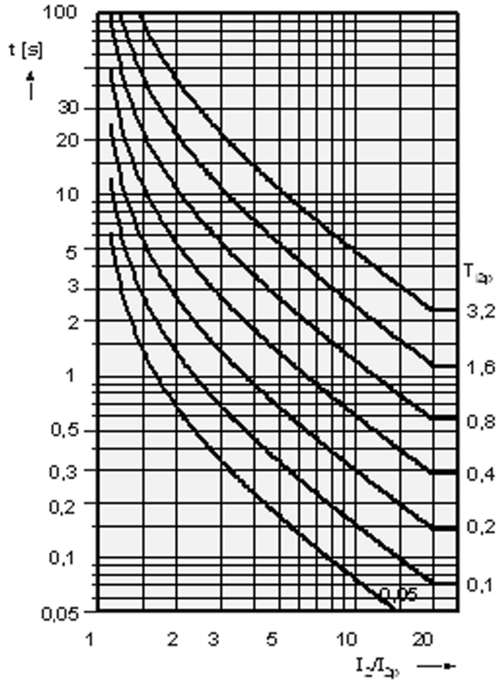
Dropout value 46-TOC Drop-Out	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA for I_{Nom} = 5 A
Time for 46/46-TOC ≤ 0.90	5 % of set point value + 2 % current tolerance or 30 ms

Influencing Variables for Pickup Values

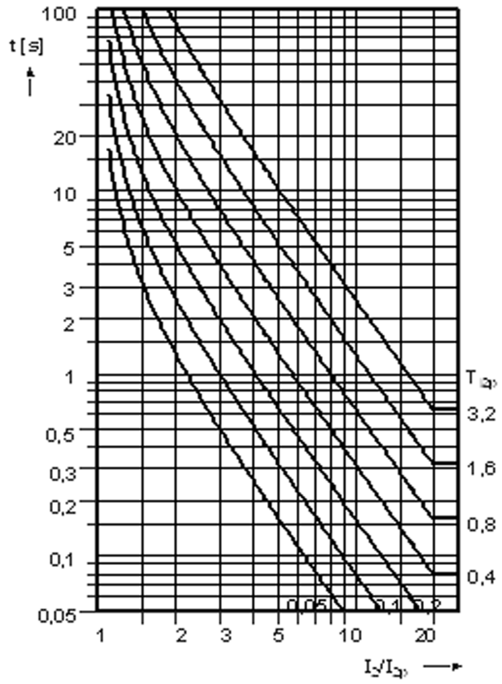
Power supply direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequencies outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Transient overreaction for τ > 100 ms (with full displacement)	<5 %



IEC INVERSE: $t = \frac{0,14}{(I_2/I_{2p})^{0,02}-1} \cdot T_{I2p}$ [s]



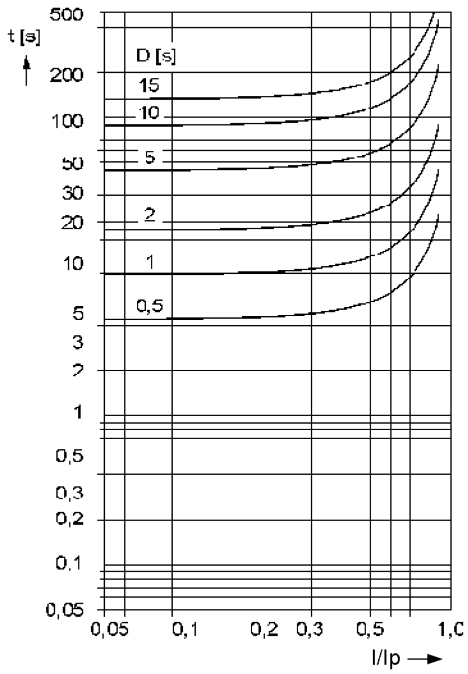
IEC VERY INVERSE: $t = \frac{13,5}{(I_2/I_{2p})^{1}-1} \cdot T_{I2p}$ [s]



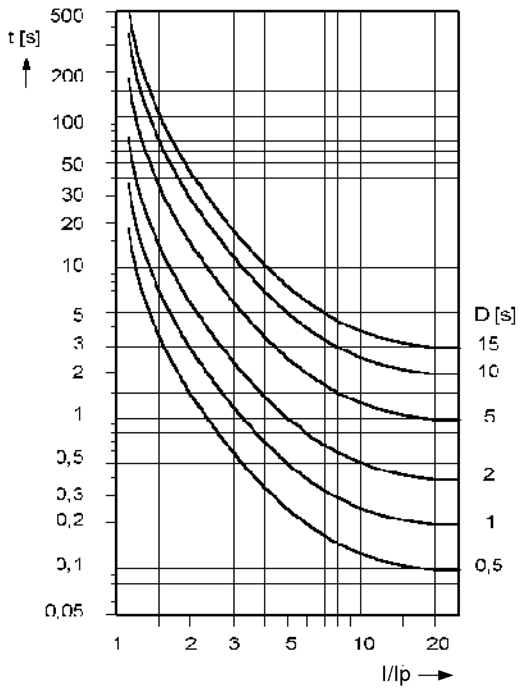
IEC EXTREMELY INVERSE: $t = \frac{80}{(I_2/I_{2p})^{2}-1} \cdot T_{I2p}$ [s]

t	Tripping Time
T_{I2p}	Setting Value of the Time Factor
I_2	Inverse current
I_{2p}	Pickup current of unbalanced load protection

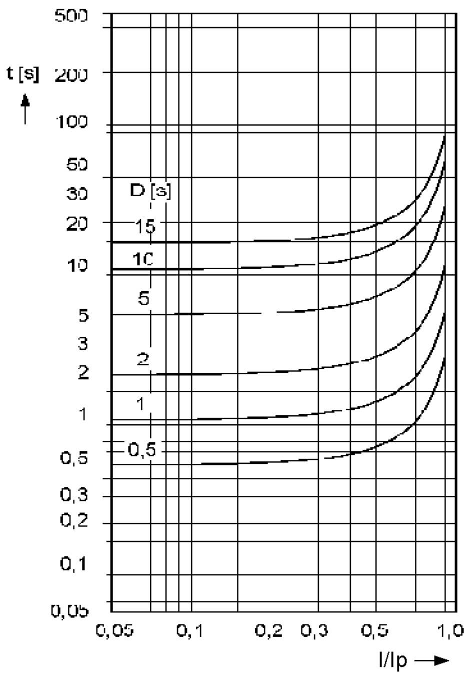
Figure 4-1 Trip time characteristics of the inverse time negative sequence element 46-TOC, acc. to IEC



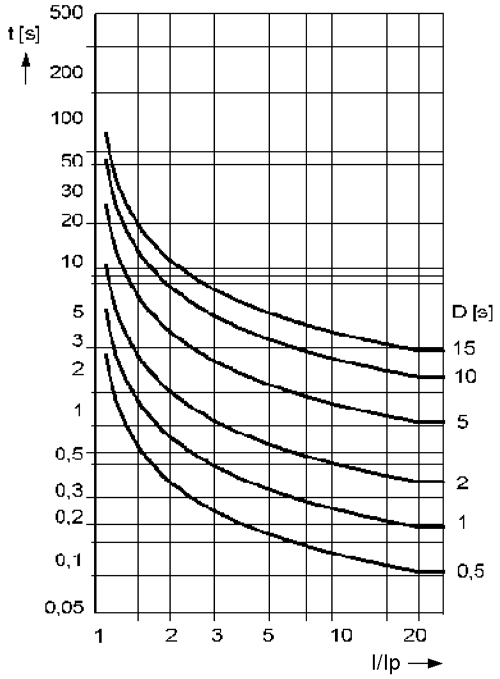
RESET INVERSE $t = \left(\frac{8.8}{1-(I_2/I_{2p})^{2.0938}}\right)\cdot D\ [s]$



INVERSE $t = \left(\frac{8.9341}{(I_2/I_{2p})^{2.0938}-1}+0.17966\right)\cdot D\ [s]$

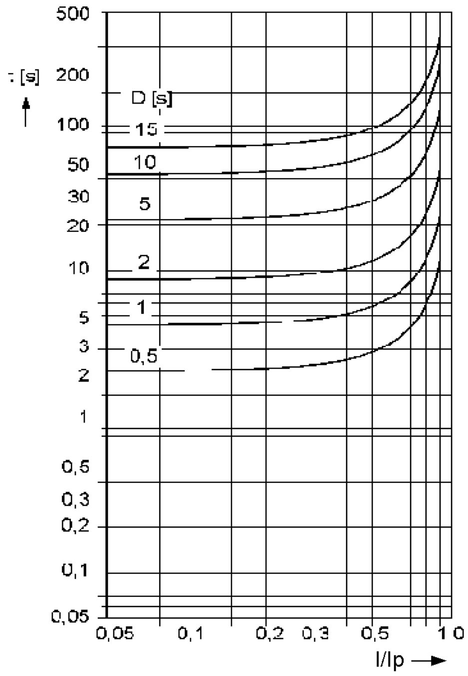


RESET MODERATELY INVERSE $t = \left(\frac{0.97}{1-(I_2/I_{2p})^{2}}\right)\cdot D\ [s]$

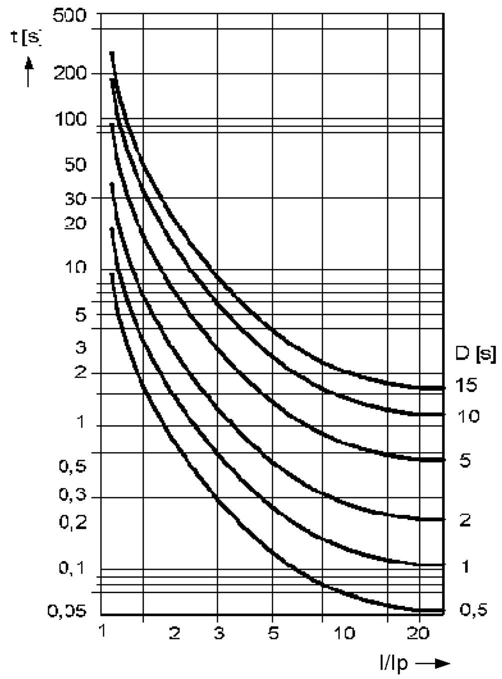


MODERATELY INVERSE $t = \left(\frac{0.0103}{(I_2/I_{2p})^{0.02}-1}+0.0228\right)\cdot D\ [s]$

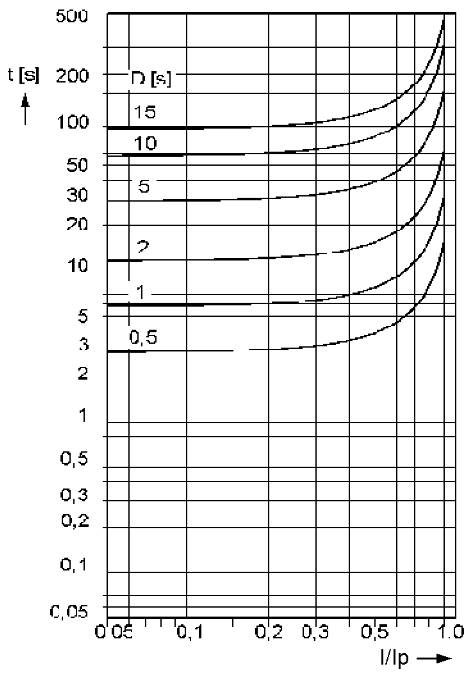
Figure 4-2 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI



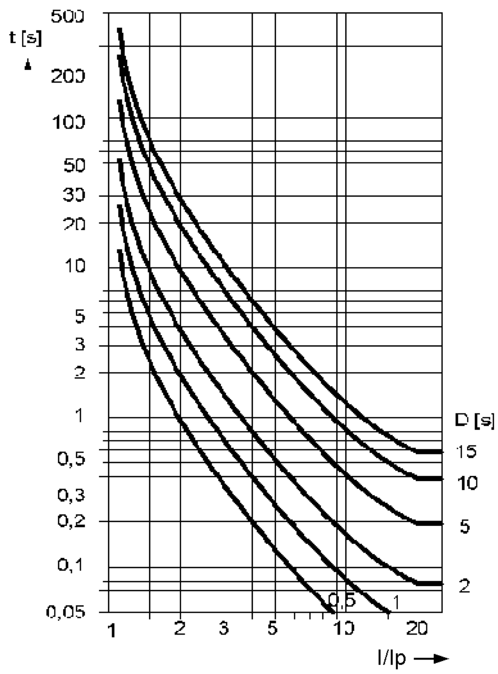
RESET VERY INVERSE $t = \left(\frac{4.32}{1-(I_2/I_{2p})^2}\right) \cdot D \ [s]$



VERY INVERSE: $t = \left(\frac{3.922}{(I_2/I_{2p})^2 - 1} + 0.0982\right) \cdot D \ [s]$



RESET EXTREMELY INVERSE $t = \left(\frac{5.82}{1-(I_2/I_{2p})^2}\right) \cdot D \ [s]$



EXTREMELY INVERSE $t = \left(\frac{5.64}{(I_2/I_{2p})^2 - 1} + 0.02434\right) \cdot D \ [s]$

Figure 4-3 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI

4.9 Frequency Protection 81

Setting Ranges/Increments

Number of frequency elements	4; each can be set to f> or f<	
Pickup values f> or f< for f_{Nom} = 50 Hz	40.00 Hz to 60.00 Hz	Increments 0.01 Hz
Pickup values f> or f< for f_{Nom} = 60 Hz	50.00 Hz to 70.00 Hz	Increments 0.01 Hz
Dropout threshold = |pickup threshold – dropout threshold|	0.02 Hz to 1.00 Hz	Increments 0.01 Hz
Delay times T	0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s
Undervoltage blocking with three-phase connection: Positive-sequence component V_1	10 V to 150 V	Increments 1 V

Times

Pickup times f>, f<	approx. 100 ms for f_{Nom} = 50 Hz approx. 80 ms for f_{Nom} = 60 Hz
Dropout times f>, f<	approx. 100 ms for f_{Nom} = 50 Hz approx. 80 ms for f_{Nom} = 60 Hz

Dropout Difference

Δf = I pickup value - dropout value I	0.02 Hz to 1 Hz

Dropout Ratio

Dropout ratio for undervoltage blocking	approx. 1.05

Tolerances

Frequencies f>, f< Undervoltage blocking Delay times T(f>, f<)	approx. 20 mHz (for V = V_{Nom}, f = f_{Nom} ± 5 Hz) 3 % of setting value or 1 V 1 % of setting value or 10 ms

Influencing Variables

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.10 Fault Locator

Output of the fault distance		in Ω primary and secondary in km or miles of line length or in % of the line length [1)]	
Trigger		with tripping, with dropout or from an external source via binary input	
Reactance per unit length setting (secondary)	for I_{Nom} = 1 A	0.0050 to 9.5000 Ω/km	Increments 0.0001
		0.0050 to 15.0000 Ω/mile	Increments 0.0001
	for I_{Nom} = 5 A	0.0010 to 1.9000 Ω/km	Increments 0.0001
		0.0010 to 3.0000 Ω/mile	Increments 0.0001
For the remaining parameters refer to the Power System Data 2.			
When configuring mixed lines, the reactance per unit length value must be set for each line section (A1 to A3).			
Measurement tolerance as per VDE 0435, Part 303 for sinusoidal measured quantities		2.5 % fault location (without intermediate infeed) $30° \leq \varphi_K \leq 90°$ and $V_K/V_{Nom} \geq 0.1$ and $I_K/I_{Nom} \geq 1.0$	

[1)] Homogeneous lines or correctly configured line sections are assumed when the fault distance is given in km, miles or %!

4.11 Breaker Failure Protection 50BF

Setting Ranges/Increments

Pickup threshold 50BF Pickup	for I_{Nom} = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 100.00 A	
Pickup threshold 50NBF Pickup	for I_{Nom} = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 100.00 A	
Time delay 50 BF TRIP Timer		0.06 s to 60.00 s or ∞	Increments 0.01 s

Times

Pickup times - for internal start - for external start dropout time dropout ratio	 is included in the delay time is included in the delay time approx. 25 ms [1)] = 0.95 (minimum hysteresis between pickup and tripping ≥ 32.5 mA)

Tolerances

Pickup threshold 50BF Pickup, 50NBF Pickup	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA for I_{Nom} = 5 A
Time delay 50 BF TRIP Timer	1 % or 20 ms

Influencing Variables for Pickup Values

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

1) A further delay for the current may be caused by compensation in the secondary CT circuit.

4.12 Flexible Protection Functions

Measured Values/Modes of Operation

Three-phase	I, $3I_0$, $I1$, $I2$, $I2/I1$, V, $3V_0$, V1, V2, P forward, P reverse, Q forward, Q reverse, cosφ
Single-phase	I, I_N, I_{N2}, V, V_N, P forward, P reverse, Q forward, Q reverse, cosφ
without fixed phase reference	f, df/dt, binary input
Method of measurement for I, V	Fundamental component, true RMS value, positive-sequence system, negative-sequence system, zero-sequence system
Pickup when	exceeding threshold value or falling below threshold value

Setting Ranges/Increments

Pickup thresholds:			
Current I, I_1, I_2, $3I_0$, I_N	for I_{Nom} = 1 A	0.05 A to 40.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 200.00 A	
Ratio I_2/I_1		15 % to 100 %	Increments 1%
Voltage V, V_1, V_2, $3V_0$		2.0 V to 260.0 V	Increments 0.1 V
Displacement voltage V_N		2.0 V to 200.0 V	Increments 0.1 V
Power P, Q	for I_{Nom} = 1 A	2.0 W to 10000 W	Increments 0.1 W
	for I_{Nom} = 5 A	10 W to 50000 W	
Power factor cosφ		-0.99 to +0.99	Increments 0.01
Frequency	for f_{nom} = 50 Hz for f_{nom} = 60 Hz	40.0 Hz to 60.0 Hz 50.0 Hz to 70.0 Hz	Increments 0.01 Hz Increments 0.01 Hz
Frequency change df/dt		0.10 Hz/s to 20.00 Hz/s	Increments 0.01 Hz/s
Dropout ratio > element		1.01 to 3.00	Increments 0.01
Dropout ratio < element		0.70 to 0.99	Increments 0.01
Dropout difference f		0.02 Hz to 1.00 Hz	Increments 0.01 Hz
Pickup delay (standard)		0.00 s to 60.00 s	Increments 0.01 s
Pickup delay for I_2/I_1		0.00 s to 28800.00 s	Increments 0.01 s
Command delay time		0.00 s to 3600.00 s	Increments 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments 0.01 s

Function Limits

Power measurement three-phase	for I_{Nom} = 1 A	Positive-sequence current > 0.03 A
	for I_{Nom} = 5 A	Positive-sequence current > 0.15 A
Power measurement single-phase	for I_{Nom} = 1 A	Phase current > 0.03 A
	for I_{Nom} = 5 A	Phase current > 0.15 A
Ratio I_2/I_1 measurement	for I_{Nom} = 1 A	Positive-sequence current or negative-sequence current > 0.1 A
	for I_{Nom} = 5 A	Positive-sequence current or negative-sequence current > 0.5 A

Times

Pickup times:	
Current, voltage (phase quantities) 2 times pickup value 10 times pickup value	 approx. 30 ms approx. 20 ms
Current, voltage (symmetrical components) 2 times pickup value 10 times pickup value	 approx. 40 ms approx. 30 ms
Power typical maximum (small signals and thresholds)	 approx. 120 ms approx. 350 ms
Power factor	300 to 600 ms
Frequency	approx. 100 ms
Frequency change for 1.25 times the setting value	approx. 220 ms
Binary input	approx. 20 ms
Dropout times:	
Current, voltage (phase quantities)	< 20 ms
Current, voltage (symmetrical components)	< 30 ms
Power typical maximum	 < 50 ms < 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Frequency change	< 200 ms
Binary input	< 10 ms

Tolerances

Pickup thresholds:		
Current	for I_{Nom} = 1 A	3% of setting value or 15 mA
	for I_{Nom} = 5 A	3% of setting value or 75 mA
Current (symmetrical components)	for I_{Nom} = 1 A	4% of setting value or 20 mA
	for I_{Nom} = 5 A	4% of setting value or 100 mA
Current (I_2/I_1)		4% of setting value
Voltage		3% of setting value or 0.2 V
Voltage (symmetrical components)		4% of setting value or 0.2 V
Power	for I_{Nom} = 1 A	3% of setting value or 0.5 W
	for I_{Nom} = 5 A	3% of setting value or 2.5 W
Power factor		3°
Frequency		approx. 15 mHz
Frequency change		5% of setting value or approx. 0.05 Hz/s
Times		1% of setting value or 10 ms

Influencing Variables for Pickup Values

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.13 User-defined Functions (CFC)

Function Blocks and Their Possible Assignments to Task Levels

Function block	Explanation	Task level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
ABSVALUE	Magnitude Calculation	X	—	—	—
ADD	Addition	X	X	X	X
ALARM	Alarm	X	X	X	X
AND	AND - Gate	X	X	X	X
BLINK	Blink 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
CMD_INF_EXE	Command information in real-time	—	—	—	X
COMPARE	Metered value comparison	X	X	X	X
CONNECT	Connection	—	X	X	X
COUNTER	Counter	X	X	X	X
DI_GET_STATUS	Decode status of double-point indication	X	X	X	X
DI_SET_STATUS	Generate double-point indication with status	X	X	X	X
D_FF	D- Flipflop	—	X	X	X
D_FF_MEMO	Status Memory for Restart	X	X	X	X
DI_TO_BOOL	Double Point to Boolean (conversion)	—	X	X	X
DINT_TO_REAL	Adaptor	X	X	X	X
DIST_DECODE	Convert double-point indication with status into four single-point indications with status	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
INT_TO_REAL	Conversion	X	X	X	X
LIVE_ZERO		X	—	—	—
LONG_TIMER	Timer (max.1193h)	X	X	X	X
LOOP	Feedback Loop	X	X	—	X

Function block	Explanation	Task level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
LOWER_SETPOINT	Lower Limit	X	—	—	—
MUL	Multiplication	X	X	X	X
MV_GET_STATUS	Decode status of a value	X	X	X	X
MV_SET_STATUS	Set status of a value	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	Adaptor	X	X	X	X
REAL_TO_INT	Conversion	X	X	X	X
REAL_TO_UINT	Conversion	X	X	X	X
RISE_DETECT	Edge detector	X	X	X	X
RS_FF	RS- Flipflop	—	X	X	X
RS_FF_MEMO	RS- Flipflop with status memory	—	X	X	X
SQUARE_ROOT	Root Extractor	X	X	X	X
SR_FF	SR- Flipflop	—	X	X	X
SR_FF_MEMO	SR- Flipflop with status memory	—	X	X	X
ST_AND	AND gate with status	X	X	X	X
ST_NOT	Inverter 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	Conversion	X	X	X	X
UPPER_SETPOINT	Upper Limit	X	—	—	—
X_OR	XOR - Gate	X	X	X	X
ZERO_POINT	Zero Supression	X	—	—	—

Device-Specific CFC Blocks

Table 4-1 ASWITCH – This block is used to switch between two REAL inputs (RMS values).

<table>
<tr><th></th><th>Name</th><th>Type</th><th>Description</th><th>Default function</th></tr>
<tr><td>Input</td><td>SWITCH</td><td>BOOL</td><td>Analog value selection</td><td>FALSE</td></tr>
<tr><td></td><td>IN1</td><td>REAL</td><td>Analog value</td><td>0.0</td></tr>
<tr><td></td><td>IN2</td><td>REAL</td><td>Analog value</td><td>0.0</td></tr>
<tr><td>Output</td><td>OUT</td><td>REAL</td><td>Selected analog value</td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="2">Task levels:</td><td colspan="3">Recommendation: Into task levels PLC1_BEARB and PLC_BEARB, because these levels are directly triggered.
Note: If you use thi block in the task levels MW_BEARB and SFS_BEARB, a change of the SWITCH signal is only recognized if the signal lasts longer than the processing cycle of the task level.</td></tr>
<tr><td colspan="2">Behavior of inputs and out-puts:</td><td colspan="3"><table><tr><th>SWITCH</th><th>OUT</th></tr><tr><td>0</td><td>IN1</td></tr><tr><td>1</td><td>IN2</td></tr></table></td></tr>
</table>

General Limits

Description	Limit	Comment
Maximum number of all CFC charts considering all task levels	32	If the limit is exceeded, the device rejects the parameter set with an error message, restores the last valid parameter set and restarts using that parameter set.
Maximum number of all CFC charts considering one task level	16	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
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.
Maximum number of reset-resistant flipflops D_FF_MEMO	350	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

Device-Specific Limits

Description	Limit	Comment
Maximum number of synchronous changes of chart inputs per task level	165	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of chart outputs per task level	150	

Additional Limits

<table>
<tr><th colspan="3">Additional limits [1] for the following CFC blocks:</th></tr>
<tr><th>Task Level</th><th colspan="2">Maximum Number of Modules in the Task Levels</th></tr>
<tr><td></td><td>TIMER[2][3]</td><td>TIMER_SHORT[2][3]</td></tr>
<tr><td>MW_BEARB</td><td>—</td><td>—</td></tr>
<tr><td>PLC1_BEARB</td><td rowspan="2">15</td><td rowspan="2">30</td></tr>
<tr><td>PLC_BEARB</td></tr>
<tr><td>SFS_BEARB</td><td>—</td><td>—</td></tr>
</table>

1) When the limit is exceeded, an error message is iisued by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

2) The following condition applies for the maximum number of timers: (2 · number of TIMER + number of TIMER_SHORT) < 30. TIMER and TIMER_SHORT hence share the available timer resources within the frame of this inequation. The limit does not apply to the LONG_TIMER.

3) The time values for the blocks TIMER and TIMER_SHORT must not be selected shorter than the time resolution of the device of 10 ms, as then, the blocks will not then start with the starting pulse.

Maximum Number of TICKS on the Task Levels

Task level	Limit in TICKS [1]
MW_BEARB (measured value processing)	10000
PLC1_BEARB (slow PLC processing)	6000
PLC_BEARB (fast PLC processing)	500
SFS_BEARB (switchgear interlocking)	10000

1) When the sum of TICKS of all blocks exceeds the above-mentioned limits, an error message is output in the CFC.

Processing Times in TICKS for the Individual Elements

Individual element		Number of TICKS
Block, basic requirement		5
Each input more than 3 inputs for generic modules		1
Combination with input signal border		6
Combination with output signal border		7
Additionally for each chart		1
Arithmetic	ABS_VALUE	5
	ADD	26
	SUB	26
	MUL	26
	DIV	54
	SQUARE_ROOT	83
Base logic	AND	5
	CONNECT	4
	DYN_OR	6
	NAND	5
	NEG	4
	NOR	5
	OR	5
	RISE_DETECT	4
	X_OR	5
Information status	SI_GET_STATUS	5
	CV_GET_STATUS	5
	DI_GET_STATUS	5
	MV_GET_STATUS	5
	SI_SET_STATUS	5
	DI_SET_STATUS	5
	MV_SET_STATUS	5
	ST_AND	5
	ST_OR	5
	ST_NOT	5
Memory	D_FF	5
	D_FF_MEMO	6
	RS_FF	4
	RS_FF_MEMO	4
	SR_FF	4
	SR_FF_MEMO	4
Control commands	BOOL_TO_CO	5
	BOOL_TO_IC	5
	CMD_INF	4
	CMD_INF_EXE	4
	CMD_CHAIN	34
	CMD_CANCEL	3
	LOOP	8

Individual element		Number of TICKS
Type converter	BOOL_TO_DI	5
	BUILD_DI	5
	DI_TO_BOOL	5
	DM_DECODE	8
	DINT_TO_REAL	5
	DIST_DECODE	8
	UINT_TO_REAL	5
	REAL_TO_DINT	10
	REAL_TO_UINT	10
Comparison	COMPARE	12
	LOWER_SETPOINT	5
	UPPER_SETPOINT	5
	LIVE_ZERO	5
	ZERO_POINT	5
Integrated total	COUNTER	6
Time and clock pulse	TIMER	5
	TIMER_LONG	5
	TIMER_SHORT	8
	ALARM	21
	BLINK	11

Routable in Matrix

In addition to the defined preassignments, indications and measured values can be freely routed to buffers, preconfigurations can be removed.

4.14 Additional Functions

Operational Measured Values

Currents I_A; I_B; I_C Positive sequence component I_1 Negative sequence component I_2 I_N or 3I0	in A (kA) primary and in A secondary or in % I_{Nom}
Range Tolerance[1)]	10 % to 150 % I_{Nom} 1.5 % of measured value or 1 % I_{Nom} and from 151 % to 200 % I_{Nom} 3 % of measured value
Voltages (phase-to-ground) V_{A-N}, V_{B-N}, V_{C-N} Voltages (phase-to-phase) V_{A-B}, V_{B-C}, V_{C-A}, V_{SYN} V_{delta}, V_{ph-gnd}, V_x or V_0 positive sequence component V_1 negative sequence component V_2	in kV primary, in V secondary or in % V_{Norm}
Range Tolerance[1)]	10 % to 120 % of V_{Nom} 1.5 % of measured value or 0.5 % V_{Nom}
S, apparent power	in kVAr (MVAR or GVAR) primary and in % of S_{Nom}
Range Tolerance[1)]	0 % to 120 % S_{Nom} 1.5 % of S_{Nom} for V/V_{Nom} and I/I_{Nom} = 50 to 120 %
P, active power	with sign, total and phase-segregated in kW (MW or GW) primary and in % S_{Nom}
Range Tolerance[1)]	0 % to 120 % S_{Nom} 2 % of S_{Nom} for V/V_{Nom} and I/I_{Nom} = 50 to 120 % and | cos φ | = 0.707 to 1 with $S_{Nom} = \sqrt{3} \cdot V_{Nom} \cdot I_{Nom}$
Q, reactive power	with sign, total and phase-segregated in kVAr (MVAr or GVAr) primary and in % S_{Nom}
Range Tolerance[1)]	0 % to 120 % S_{Nom} 2 % of S_{Nom} for V/V_{Nom} and I/I_{Nom} = 50 to 120 % and | sin φ | = 0.707 to 1 with $S_{Nom} = \sqrt{3} \cdot V_{Nom} \cdot I_{Nom}$
cos φ, power factor[2)]	total and phase-segregated
Range Tolerance[1)]	–1 to +1 2 % for | cos φ | $\geq$ 0.707
Angle φ_A; φ_B; φ_C,	in degrees (°)
Range Tolerance[1)]	0 to 180° 0.5°
Frequency f	in Hz
Range Tolerance[1)]	$f_{Nom} \pm 5$ Hz 20 mHz

1) for nominal frequency

2) display of cos φ from I/I_{Nom} and V/V_{Nom} greater than 10 %

Long-Term Mean Values

Time Window	5, 15, 30 or 60 minutes
Frequency of Updates	adjustable
Long-Term Averages	
of Currents of Real Power of Reactive Power of Apparent Power	I_{Admd}; I_{Bdmd}; I_{Cdmd}; I_{1dmd} in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAr (kVAr, MVAr) S_{dmd} in VAr (kVAr, MVAr)

Min./Max. Memory

Storage of Measured Values	with date and time
Reset automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Manual Reset	Using binary input Using keypad Via communication
Min/Max Values for Current	I_A; I_B; I_C; I_1 (positive sequence component)
Min/Max Values for Voltages	V_{A-N}; V_{B-N}; V_{C-N}; V_1 (Positive Sequence Component); V_{A-B}; V_{B-C}; V_{C-A}
Min/Max Values for Power	S, P; Q, cos φ; frequency
Min/Max Values for Overload Protection	Θ/Θ_{Trip}
Min/Max Values for Mean Values	I_{Admd}; I_{Bdmd}; I_{Cdmd}; I_1 (positive sequence component); S_{dmd}; P_{dmd}; Q_{dmd}

Fuse Failure Monitor

Setting range of the displacement voltage 3V0 above which voltage failure is detected	10 - 100 V
Setting range of the ground current above which no voltage failure is assumed	0.1 - 1 A for I_{Bdmd} = 1 A 0.5 - 5A for I_{Bdmd} = 5A
Setting range of the pickup threshold I> above which no voltage failure is assumed	0.1 - 35 A for I_{Bdmd} = 1 A 0.5 - 175 A for I_{Bdmd} = 5A
Operation of the fuse failure monitor	depends on the MLFB and configuration with measured or calculated values V_N and I_N

Local Measured Value Monitoring

Current unbalance	I_{max}/I_{min} > balance factor, for $I > I_{balance\ limit}$
Voltage unbalance	V_{max}/V_{min} > symmetry factor, for $V > V_{limit}$
Current sum	$\lvert i_A + i_B + i_C + k_I \cdot i_E \rvert$ > limit value, with $k_I = \frac{\text{Ignd-CT PRIM} / \text{Ignd-CT SEC}}{\text{CT PRIMARY} / \text{CT SECONDARY}}$
Current phase sequence	Clockwise/counter-clockwise phase sequence
Voltage phase sequence	Clockwise/counter-clockwise phase sequence

Fault Logging

Recording of indications of the last 8 power system faults
Recording of indications of the last 3 ground faults

Time Allocation

Resolution for operational indications	1 ms
Resolution for fault indications	1 ms
Maximum time deviation (internal clock)	0,01 %
Buffer battery	Lithium battery type CR2032, 3 V, 230 mAh indication „Fail Battery“ if the battery is not charged sufficiently

Fault Recording

max. 8 fault records saved by buffer battery also in the event of auxiliary voltage failure	
Storage period	6 s per fault record, in total up to 18 s at 50 Hz (max. 15 s at 60 Hz)
Sampling rate at 50 Hz Sampling rate at 60 Hz	each 1 instantaneous value per 1.0 ms each 1 instantaneous value per 0.83 ms

Energy Counter

Meter Values for Energy Wp, Wq (real and reactive energy)	in kWh (MWh or GWh) and in kVARh (MVARh or GVARh)
Range Tolerance [1]	28 bit or 0 to 2 68 435 455 decimal for IEC 60870-5-103 (VDEW protocol) 31 bit or 0 to 2 147 483 647 decimal for other protocols (other than VDEW) $\leq$ 2 % for $I > 0.1\ I_{Nom}$, $V > 0.1\ V_{Nom}$ and $\lvert \cos \varphi \rvert \geq 0.707$

[1] At nominal frequency

Switching Statistics

Stored number of trips	up to 9 decimal places

Operating Hours Counter

Display range	up to 7 decimal places
Criterion	Exceeding an adjustable current threshold (CB I>)

Commissioning Aids

- Phase-sequence check - Operational measured values - Circuit breaker test via control - Creating a test fault record - Generating indications

Clock

Time synchronization		Binary input Communication
Operating modes of the clock management		
No.	Operating mode	Comments
1	Internal	Internal synchronization via RTC (default)
3	Pulse via binary input	External synchronization with pulse via binary input
5	NTP (IEC 61850)	External synchronization via port F (IEC 61850)
6	GPS	External synchronization via GPS

Setting Group Change Option of the Functional Settings

Number of available setting groups	4 (setting group A, B, C and D)
The change can be performed via	operation panel at the device DIGSI via user interface protocol via port F binary input

IEC 61850 GOOSE (inter-device communication)

The GOOSE communication service of IEC 61850 is qualified for switchgear interlocking. Since the transmission time of GOOSE messages depends on both the number of IEC 61850 clients and the pickup condition of the device, GOOSE is not generally qualified for protection-relevant applications. The protection application must be checked with regard to the required transmission times and coordinated with the manufacturer.

4.15 Switching Device Control

Number of switching devices	Depends on the number of binary inputs and outputs available
Interlocking	Freely programmable interlocking
Messages	Feedback messages, closed, open, intermediate position
Control commands	Single command/double command
Switching command to circuit breaker	1-pole, 1½-pole and 2-pole
Programmable Logic Controller	PLC logic, graphic input tool
Local control	Control via menu Assignment of function keys
Remote control	via communication interfaces via systems control (e.g. SICAM) via DIGSI (e.g. via modem)

4.16 Dimensions

4.16.1 Feeder Automation Controller 7SC80

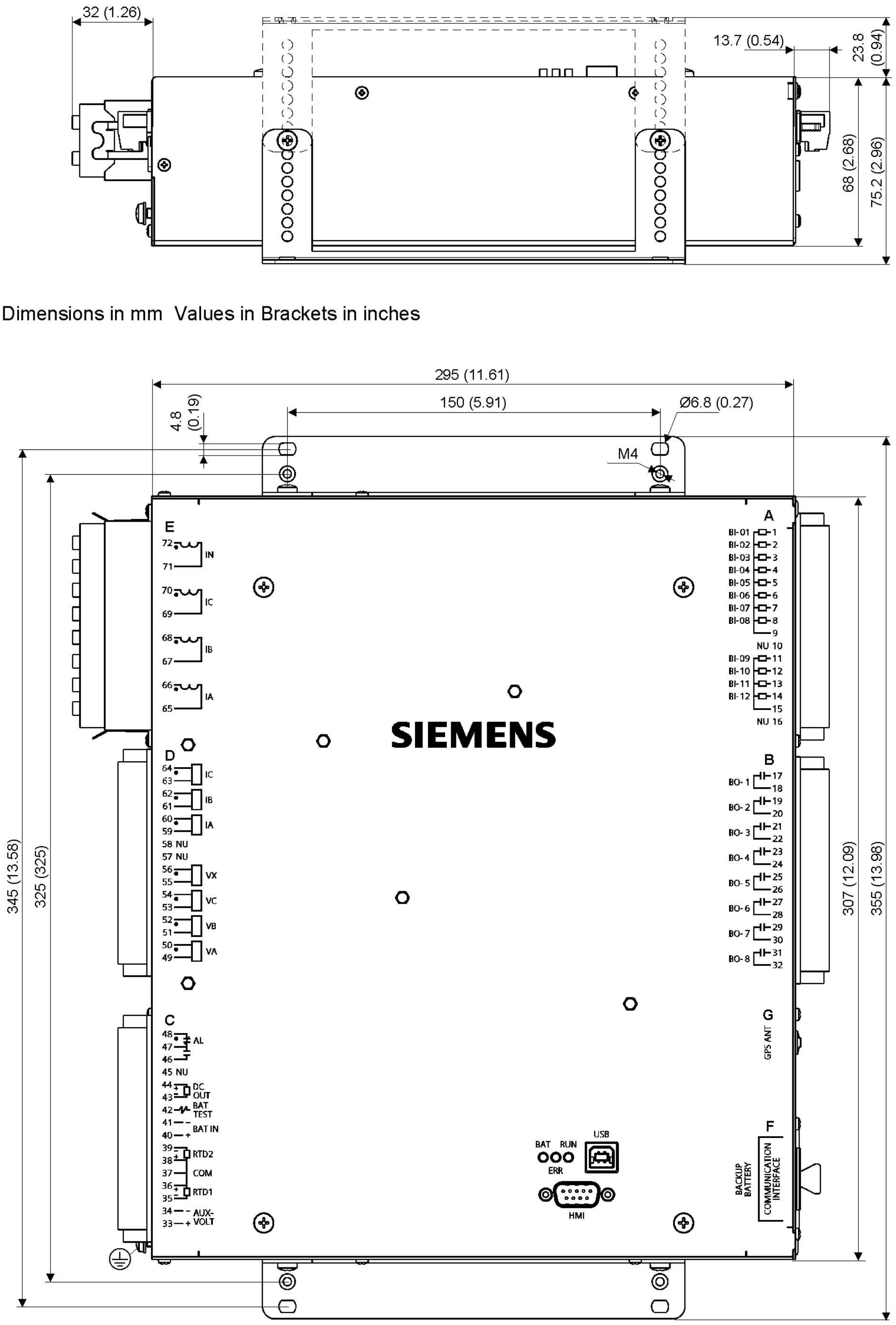


Figure 4-4 Dimensional drawing Feeder Automation Controller 7SC80

■

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 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 7SC80 V4.6

Differential protection						6	7		8	9	10	11	12		13	14	15	16		Suffix		
	7	**S**	**C**	**8**	**0**			–						–	3	F		0	+			

Basic functions, BO/BI	Pos. 6
Housing 12 BI, 8 BO, 1 life status contact, 1 x 120 V input for line detection	2

Current and voltage inputs, default settings (BOLD)	Pos. 7
4 x I_{ph} = **1 A** / 5 A , I_e = **1 A** / 5 A	2
4 x I_{ph} = **1 A** / 5 A , I_e = **1 A** / 5 A, 3 x V	4

Auxiliary voltage (power supply)	Pos. 8
DC 60 V to 250 V, AC 115 V, AC 230 V	1
DC 24 V/ 48 V including battery charger / battery charging control	2

Construction	Pos. 9
Surface-mounted housing, screw-type terminals, without operator panel	A

Region-specific language default settings and function versions	Pos. 10
Region DE, IEC, language German (language can be changed)	A
Region world, IEC/ANSI, language English (language can be changed)	B
Region US, ANSI, language English (US) (language can be changed)	C

System interfaces	Pos. 11
Not equipped	0
For further interface options, see Additional Information in the following	9

Additional information for additional interfaces	Suffix
100 Mbit Ethernet, 2 x RJ45 connector	+ L x R
100 Mbit Ethernet, optical 2 x LC single-mode 24 km	+ L x T

Protocol for system interface	Suffix x
IEC 61850	0

Additional interfaces	Pos. 12
Not equipped	0
GPS module	7

Protection functions			Pos. 15
Designation	ANSI No.	Description	
Basic function (included in all versions)	50	Overcurrent protection phase 50-1, 50-2, 50-3	A
	50N	Overcurrent protection ground 50N-1, 50N-2, 50N-3	
	50BF	Breaker failure protection	
	46	Negative sequence overcurrent protection	
	81 U/O	Flexible protection functions (parameters from current): Underfrequency / overfrequency, f<, f>	
	—	Cold load pickup (dynamic setting changes) Monitoring functions Circuit breaker control Inrush current restraint Fault recording, average values, min/max values	
Basic version [1] + direction determination overcurrent, phase and ground + voltage protection	67	Direction determination for the overcurrent protection phase elements 67-1, 67-2	B
	67N	Direction determination for the overcurrent protection ground elements 67N-1, 67N-2	
	27/59	Undervoltage / overvoltage	
	64/59N	Displacement voltage	
	32/55/81R	Flexible protection functions (parameters from current and voltage): voltage, power, power factor, frequency change protection	
	81 U/O	Underfrequency / overfrequency (f<, f>)	

[1] MLFB position 7 must be a 4 (voltage transformer)

Additional functions			Pos. 16
		without	0
	21FL	With fault locator [1]	2

[1] MLFB position 7 must be a 4 (voltage transformer)

A.1.2 Accessories

Replacement modules for interfaces

GPS module	W73089-U7
EN100 module electrical, 2 x RJ45, IEC 61850	C53207-A351-D675-2

Terminals

Current terminal (set of 10 pieces)	C53207-A406-D237-1
Process terminal 16-pin, type 360° (set of 18 pieces for cabinet surface mounting)	C53207-A406-D238-1
Process terminal 16-pin, type 180° rotated (set of 18 pieces for cabinet flush mounting)	C53207-A406-D239-1

Mounting brackets

Set of mounting brackets (2 pieces)	C53207-A406-D240-1

A.2 Terminal Assignments

A.2.1 7SC80 — Housing for cabinet flush mounting and cabinet surface mounting

7SC8022*

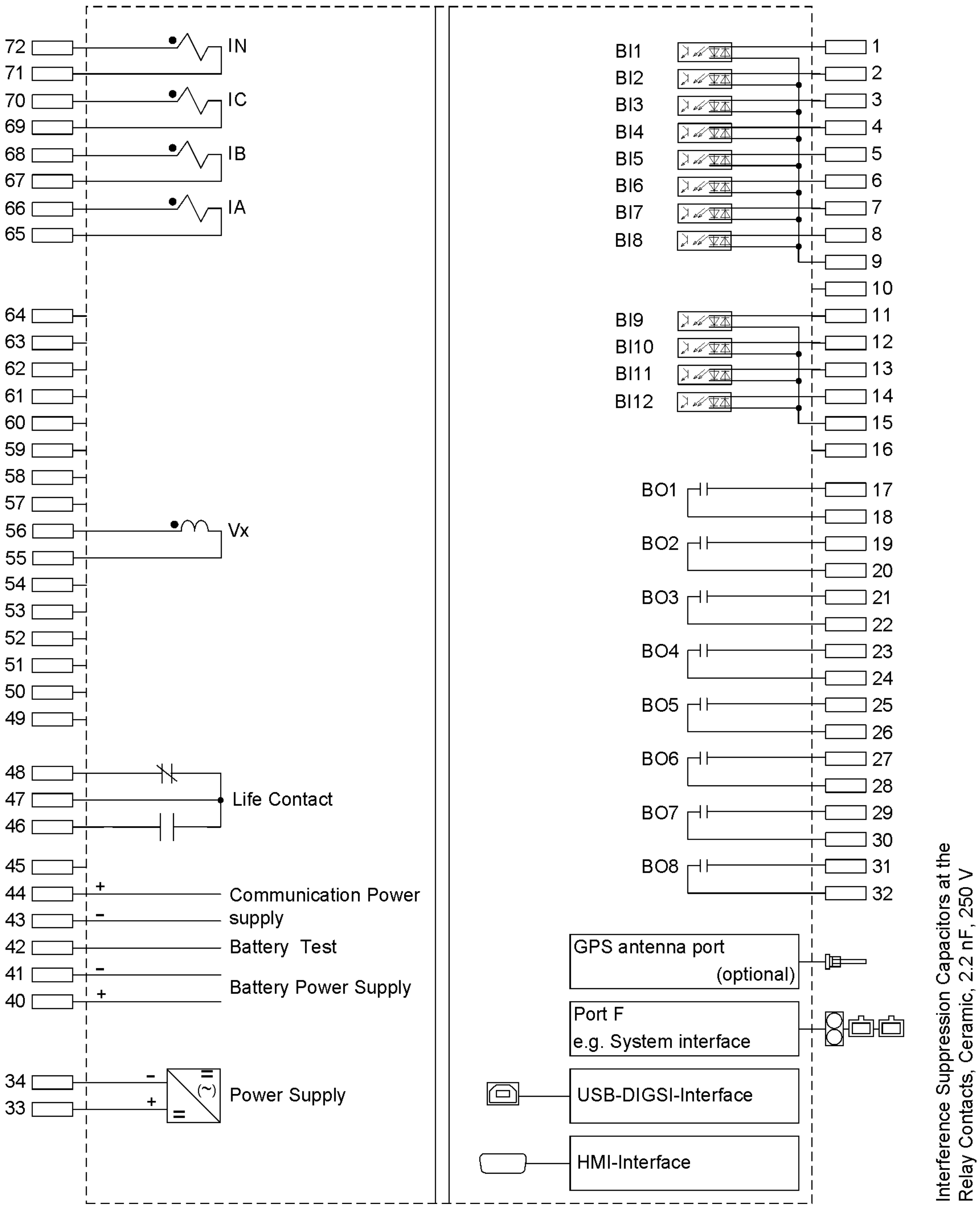


Figure A-1 Connection diagram 7SC8022*

In the 24 V/48 V device variant, the power connections 41 BAT IN- and 34 AUX- are connected inside the device.

7SC8024*

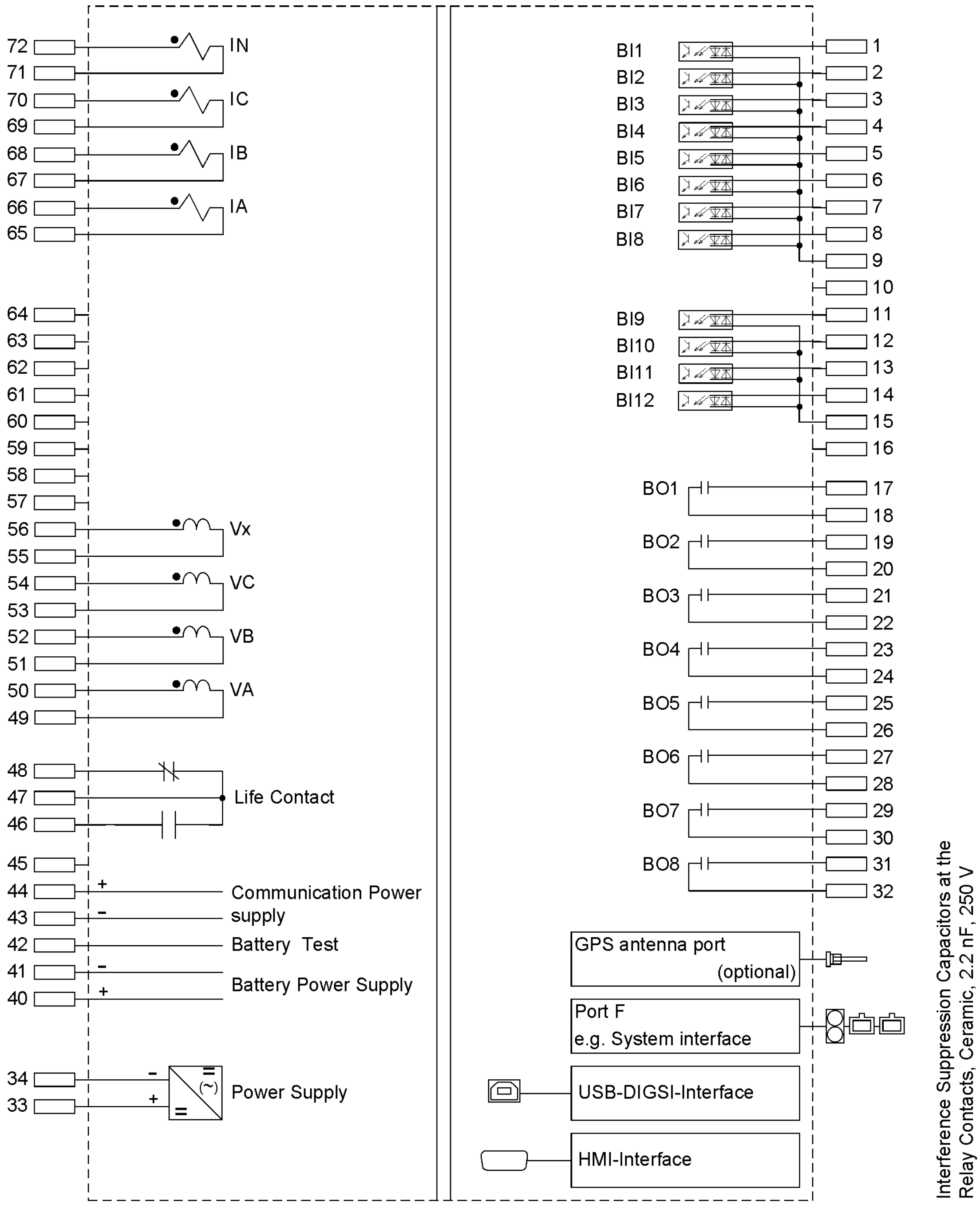


Figure A-2 Connection diagram 7SC8024*

In the 24 V/48 V device variant, the power connections 41 BAT IN- and 34 AUX- are connected inside the device.

A.3 Connection Examples

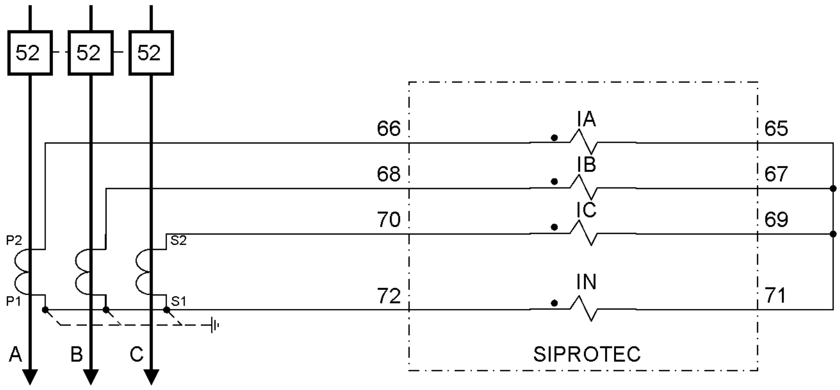


Figure A-3 Current transformer connections to three current transformers and neutral point current (ground current) (Holmgreen connection) – appropriate for all networks

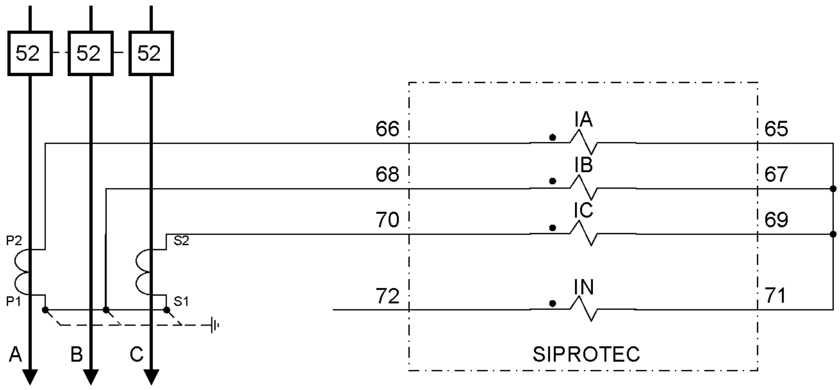


Figure A-4 Current transformer connections to two current transformers – only for isolated or resonant-grounded networks

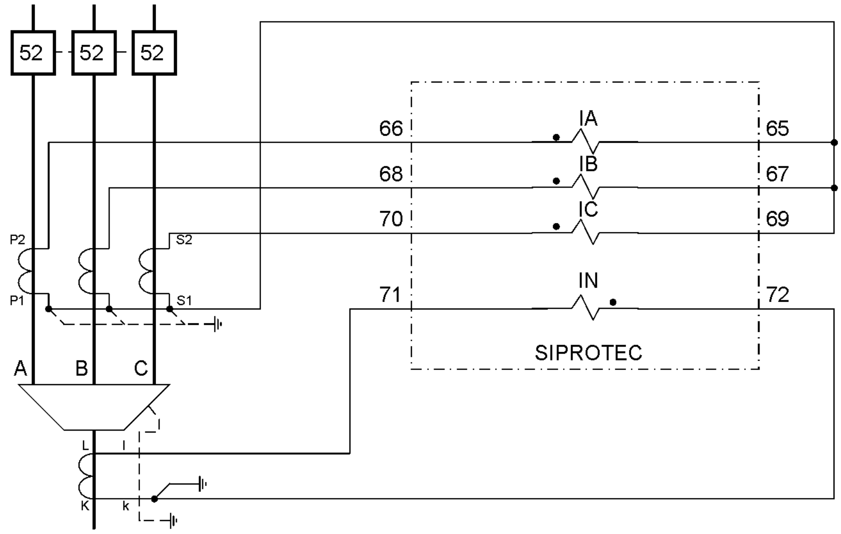


Figure A-5 Current transformer connections to three current transformers, ground current from an additional summation current transformer – preferably for effectively or low-resistance grounded networks

Important: Grounding of the cable shield must be effected at the cable side

Note: The switchover of the current polarity (address 201) also reverses the polarity of the current input IN!

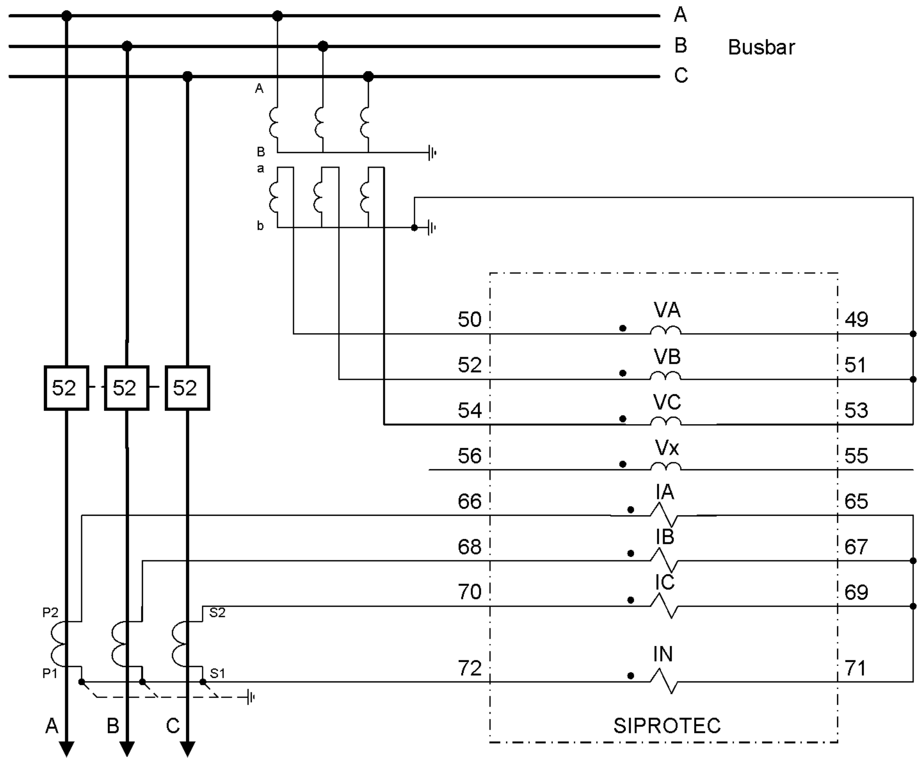


Figure A-6 Transformer connections to three current transformers and three voltage transformers (phase-to-ground voltages), normal circuit layout – appropriate for all networks

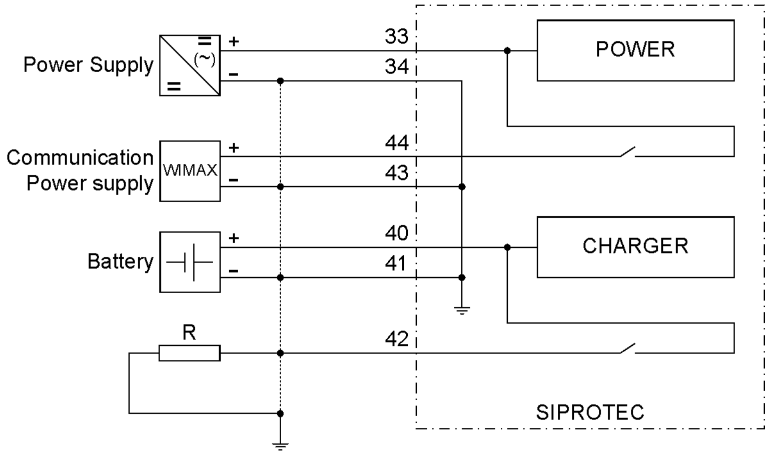


Figure A-7 Connection example for the external battery

A.4 Current Transformer Requirements

The requirements for phase current transformers are usually determined by the overcurrent time protection, particularly by the high-current element settings. Besides, there is a minimum requirement based on experience.

The recommendations are given according to the standard IEC 60044-1.

The standards IEC 60044-6, BS 3938 and ANSI/IEEE C 57.13 are referred to for converting the requirement into the knee-point voltage and other transformer classes.

A.4.1 Accuracy limiting factors

Effective and Rated Accuracy Limiting Factor

Required minimum effective accuracy limiting factor	$K_{ALF}' = \frac{50\text{-}2_{PU}}{I_{pNom}}$ but at least 20	
	with	
	$K_{ALF'}$	Minimum effective accuracy limiting factor
	$50\text{-}2_{PU}$	Primary pickup value of the high-current element
	I_{pNom}	Primary nominal transformer current
Resulting rated accuracy limiting factor	$K_{ALF} = \frac{R_{BC} + R_{Ct}}{R_{BN} + R_{Ct}} \cdot K_{ALF'}$	
	with	
	K_{ALF}	Rated accuracy limiting factor
	R_{BC}	Connected burden resistance (device and cables)
	R_{BN}	Nominal burden resistance
	R_{Ct}	Transformer internal burden resistance

Calculation example according to IEC 60044–1

I_{sNom} = 1 A $K_{ALF'}$ = 20 R_{BC} = 0.6 Ω (device and cables) R_{Ct} = 3 Ω R_{BN} = 5 Ω (5 VA)	$K_{ALF} = \frac{0.6 + 3}{5 + 3} \cdot 20 = 9$ K_{ALF} set to 10, so that: 5P10, 5 VA
with I_{sNom} = secondary transformer nominal current	

A.4.2 Class conversion

Table A-1 Conversion into other classes

British Standard BS 3938	$V_k = \frac{(R_{Ct} + R_{BN}) \cdot I_{sNom}}{1.3} \cdot K_{ALF}$	
ANSI/IEEE C 57.13, class C	$V_{s.t.max} = 20 \cdot I_{sNom} \cdot R_{BN} \cdot \frac{K_{ALF}}{20}$ I_{sNom} = 5 A (typical value)	
IEC 60044-6 (transient response), class TPS	$V_{al} = K \cdot k_{SSC} \cdot (R_{Ct} + R_{BN}) \cdot I_{sNom}$ $K \approx 1$ $K_{SSC} \approx K_{ALF}$	
Classes TPX, TPY, TPZ	Calculation See ChapterA.4.1 Accuracy limiting factors with: $K_{SSC} \approx K_{ALF}$ T_P depending on power system and specified closing sequence	
	with	
	V_k	Knee-point voltage
	R_{Ct}	Internal burden resistance
	R_{BN}	Nominal burden resistance
	I_{sNom}	Secondary nominal transformer current
	K_{ALF}	Rated accuracy limiting factor
	$V_{s.t.max}$	Sec. terminal voltage at 20 I_{pNom}
	V_{al}	Sec. magnetization limit voltage
	K	Dimensioning factor
	K_{SSC}	Factor symmetr. Rated fault current
	T_P	Primary time constant

A.5 Default Settings

When the device leaves the factory, many LED indications, binary inputs, binary outputs and function keys are already preset. They are summarized in the following table.

A.5.1 LEDs

Table A-2 LED display, e.g. via the Web-Monitor

LEDs	Default function	Function No.	Description
LED1	Not configured	1	No Function configured
LED2	Not configured	1	No Function configured
LED3	Not configured	1	No Function configured
LED4	Not configured	1	No Function configured
LED5	Not configured	1	No Function configured
LED6	Not configured	1	No Function configured
LED7	Not configured	1	No Function configured
LED8	Not configured	1	No Function configured
LED9	Not configured	1	No Function configured
LED10	Not configured	1	No Function configured
LED11	Not configured	1	No Function configured
LED12	Not configured	1	No Function configured
LED13	Not configured	1	No Function configured
LED14	Not configured	1	No Function configured
LED15	Not configured	1	No Function configured
LED16	Not configured	1	No Function configured
LED17	Relay TRIP	511	Relay GENERAL TRIP command
LED18	50/51 Ph A PU	1762	50/51 Phase A picked up
LED19	50/51 Ph B PU	1763	50/51 Phase B picked up
LED20	50/51 Ph C PU	1764	50/51 Phase C picked up
LED21	50N/51NPickedup	1765	50N/51N picked up
LED22	Failure Σ I Fail I balance Fail Ph. Seq. I	162 163 175	Failure: Current Summation Failure: Current Balance Failure: Phase Sequence Current
LED23	Brk OPENED		Breaker OPENED
LED24	Alarm Sum Event	160	Alarm Summary Event
LED25	Fail Battery	177	Failure: Battery empty
LED26	Not configured	1	No Function configured
LED27	Not configured	1	No Function configured
LED28	Not configured	1	No Function configured
LED29	Not configured	1	No Function configured
LED30	Not configured	1	No Function configured
LED31	Not configured	1	No Function configured
LED32	Not configured	1	No Function configured

A.5.2 Binary Input

Table A-3 Binary input presettings for all devices and ordering variants

Binary Input	Default function	Function No.	Description
BI1	>BLOCK 50-2 >BLOCK 50N-2	1721 1724	>BLOCK 50-2 >BLOCK 50N-2
BI2	>52-b 52Breaker	4602	>52-b contact (OPEN, if bkr is closed) 52 Breaker
BI3	>52-a 52Breaker	4601	>52-a contact (OPEN, if bkr is open) 52 Breaker
BI4	not pre-assigned	-	-
BI5	not pre-assigned	-	-
BI6	not pre-assigned	-	-
BI7	not pre-assigned	-	-
BI8	not pre-assigned	-	-
BI9	not pre-assigned	-	-
BI10	not pre-assigned	-	-
BI11	not pre-assigned	-	-
BI12	not pre-assigned	-	-

A.5.3 Binary Output

Table A-4 Output Relay Presettings for All Devices and Ordering Variants

Binary Output	Default function	Function No.	Description
BO1	Relay TRIP 52Breaker	511	Relay GENERAL TRIP command 52 Breaker
BO2	52Breaker		52 Breaker
BO3	52Breaker		52 Breaker
BO4	Failure Σ I Fail I balance Fail V balance Fail Ph. Seq. I Fail Ph. Seq. V	162 163 167 175 176	Failure: Current Summation Failure: Current Balance Failure: Voltage Balance Failure: Phase Sequence Current Failure: Phase Sequence Voltage
BO5	Relay PICKUP	501	Relay PICKUP
BO6	not pre-assigned	-	-
BO7	not pre-assigned	-	-
BO8	not pre-assigned	-	-

A.5.4 Function Keys

Table A-5 The called functions are executed directly, e.g. via the Web-Monitor, without any feedbacks (one-push-button).

Function Keys	Default function	Function No.	Description
F1	Display of the operational indications	-	-
F2	Display of the primary operational measured values	-	-
F3	not pre-assigned	-	-
F4	not pre-assigned	-	-
F5	not pre-assigned	-	-
F6	not pre-assigned	-	-
F7	not pre-assigned	-	-
F8	not pre-assigned	-	-
F9	not pre-assigned	-	-
F0	Overview of the last eight fault indications	-	-

A.5.5 Default Display

A number of pre-defined measured value pages are available depending on the device type. The start page of the default display appearing after startup of the device can be selected in the device data via parameter 640 **Start image DD**.

for the 6-line display of the 7SC80, e.g. via the Web Monitor

Side 1
```
A :400A    12:20.0kV
B :400A    23:20.0kV
C :400A    31:20.0kV
N :  0A    N : 0.0kV

f : 50.0Hz Vx: 0.0kV
```

Side 2
```
% :  IL   VPh-N VPh-Ph
A :100.0 100.0  100.0
B :100.0 100.0  100.0
C :100.0 100.0  100.0
Vx:100.0
f : 50.0Hz
```

Side 3
```
I1:400A
V1: 11.5kV
P : 13.8MV
Q :  0.0MVAR
S : 13.8MVA
cosφ: 1.00
```

Side 4
```
P:13.8MW    A12:20.0kV
Q:0.0MVAR   A23:20.0kV
S:13.8MVA   A31:20.0kV
cosφ:1.00   IA :400A
Vx:0.0kV    IB :400A
f:50.0Hz    IC :400A
```

Side 5
```
A :400A    MAX400A
B :400A    MAX400A
C :400A    MAX400A
N :  0A

f : 50.0Hz
```

Side 6
```
A :400A
B :400A
C :400A
N :  0A

f : 50.0Hz
```

Figure A-8 Default display of 7SC80 for models with V

```
Side 1
A :400A       100%
B :400A       100%
C :400A       100%
N :   0A      100%

f : 50.0Hz
```

```
Side 2
A :400A    MAX400A
B :400A    MAX400A
C :400A    MAX400A
N :   0A

f : 50.0Hz
```

Figure A-9 Default display of 7SC80 for models without V

Spontaneous Fault Display

After a fault has occurred, the most important fault data are automatically displayed after general device pickup in the order shown in the picture below.

50-1 PICKUP	Protective Function that Picked up First;
50-1 TRIP	Protective Function that Tripped Last;
T - Pickup	Operating Time from General Pickup to Dropout;
T - TRIP	Operating Time from General Pickup to the First Trip Command;

Figure A-10 Representation of spontaneous messages on the device display

A.6 Protocol-dependent Functions

Protocol →	IEC 61850 Ethernet
Function ↓	
Operational measured values	Yes
Count values	Yes
Fault recording	Yes
Remote protection setting	Yes
User-defined indications and switching objects	Yes
Time synchronization	Yes
Indications with time stamp	Yes
Commissioning aids	
Data transmission stop	Yes
Creation of test messages	Yes
Transmission mode	Cyclic / event
Baud rate	up to 100 MBaud
Type	Ethernet

A.7 Functional Scope

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
104	OSC. FAULT REC.	Disabled Enabled	Enabled	Oscillographic Fault Records
112	Charac. Phase	Disabled Definite Time	Definite Time	50/51
113	Charac. Ground	Disabled Definite Time	Definite Time	50N/51N
115	67/67-TOC	Disabled Definite Time	Definite Time	67, 67-TOC
116	67N/67N-TOC	Disabled Definite Time	Definite Time	67N, 67N-TOC
122	InrushRestraint	Disabled Enabled	Disabled	2nd Harmonic Inrush Restraint
140	46	Disabled TOC ANSI TOC IEC Definite Time	Disabled	46 Negative Sequence Protection
150	27/59	Disabled Enabled	Disabled	27, 59 Under/Overvoltage Protection
154	81 O/U	Disabled Enabled	Disabled	81 Over/Underfrequency Protection
170	50BF	Disabled Enabled enabled w/ 3I0> Enabled w/o I>	Disabled	50BF Breaker Failure Protection
180	Fault Locator	Disabled Enabled	Disabled	Fault Locator
181	L-sections FL	1 Section 2 Sections 3 Sections	1 Section	Line sections for fault locator
350	Battery Charger	Disabled Enabled	Enabled	Battery Charger

Addr.	Parameter	Setting Options	Default Setting	Comments
370	27/59 Vx	Enabled Disabled	Disabled	27/59 Over/under volt. Prot. for Vx
-	FLEXIBLE FUNC. 1...20	Flex. Function 01 Flex. Function 02 Flex. Function 03 Flex. Function 04 Flex. Function 05 Flex. Function 06 Flex. Function 07 Flex. Function 08 Flex. Function 09 Flex. Function 10 Flex. Function 11 Flex. Function 12 Flex. Function 13 Flex. Function 14 Flex. Function 15 Flex. Function 16 Flex. Function 17 Flex. Function 18 Flex. Function 19 Flex. Function 20	Please select	Flexible Functions

A.8 Settings

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

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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
0	FLEXIBLE FUNC.	Flx		OFF ON Alarm Only	OFF	Flexible Function
0	OPERRAT. MODE	Flx		3-phase 1-phase no reference	3-phase	Mode of Operation
0	MEAS. QUANTITY	Flx		Please select Current Voltage P forward P reverse Q forward Q reverse Power factor Frequency df/dt rising df/dt falling Binray Input	Please select	Selection of Measured Quantity
0	MEAS. METHOD	Flx		Fundamental True RMS Positive seq. Negative seq. Zero sequence Ratio I2/I1	Fundamental	Selection of Measurement Method
0	PICKUP WITH	Flx		Exceeding Dropping below	Exceeding	Pickup with
0	CURRENT	Flx		Ia Ib Ic In In sensitive In2	Ia	Current
0	VOLTAGE	Flx		Please select Van Vbn Vcn Vab Vbc Vca Vn	Please select	Voltage
0	POWER	Flx		Ia Van Ib Vbn Ic Vcn	Ia Van	Power
0	VOLTAGE SYSTEM	Flx		Phase-Phase Phase-Ground	Phase-Phase	Voltage System
0	P.U. THRESHOLD	Flx	1A	0.05 .. 40.00 A	2.00 A	Pickup Threshold
			5A	0.25 .. 200.00 A	10.00 A	
0	P.U. THRESHOLD	Flx	1A	0.05 .. 40.00 A	2.00 A	Pickup Threshold
			5A	0.25 .. 200.00 A	10.00 A	
0	P.U. THRESHOLD	Flx	1A	0.001 .. 1.500 A	0.100 A	Pickup Threshold
			5A	0.005 .. 7.500 A	0.500 A	
0	P.U. THRESHOLD	Flx		2.0 .. 260.0 V	110.0 V	Pickup Threshold
0	P.U. THRESHOLD	Flx		2.0 .. 200.0 V	110.0 V	Pickup Threshold
0	P.U. THRESHOLD	Flx		40.00 .. 60.00 Hz	51.00 Hz	Pickup Threshold
0	P.U. THRESHOLD	Flx		50.00 .. 70.00 Hz	61.00 Hz	Pickup Threshold
0	P.U. THRESHOLD	Flx		0.10 .. 20.00 Hz/s	5.00 Hz/s	Pickup Threshold
0	P.U. THRESHOLD	Flx	1A	2.0 .. 10000.0 W	200.0 W	Pickup Threshold
			5A	10.0 .. 50000.0 W	1000.0 W	
0	P.U. THRESHOLD	Flx		-0.99 .. 0.99	0.50	Pickup Threshold

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
0	P.U. THRESHOLD	Flx		15 .. 100 %	20 %	Pickup Threshold
0	P.U. THRESHOLD	Flx		2.0 .. 260.0 V	110.0 V	Pickup Threshold
0	T TRIP DELAY	Flx		0.00 .. 3600.00 sec	1.00 sec	Trip Time Delay
0A	T PICKUP DELAY	Flx		0.00 .. 60.00 sec	0.00 sec	Pickup Time Delay
0	T PICKUP DELAY	Flx		0.00 .. 28800.00 sec	0.00 sec	Pickup Time Delay
0A	T DROPOUT DELAY	Flx		0.00 .. 60.00 sec	0.00 sec	Dropout Time Delay
0A	BLK.by Vol.Loss	Flx		NO YES	YES	Block in case of Meas.-Voltage Loss
0A	DROPOUT RATIO	Flx		0.70 .. 0.99	0.95	Dropout Ratio
0A	DROPOUT RATIO	Flx		1.01 .. 3.00	1.05	Dropout Ratio
0	DO differential	Flx		0.02 .. 1.00 Hz	0.03 Hz	Dropout differential
201	CT Starpoint	P.System Data 1		towards Line towards Busbar	towards Line	CT Starpoint
202	Vnom PRIMARY	P.System Data 1		0.10 .. 800.00 kV	20.00 kV	Rated Primary Voltage
203	Vnom SECONDARY	P.System Data 1		34 .. 400 V	100 V	Rated Secondary Voltage (L-L)
204	CT PRIMARY	P.System Data 1		10 .. 50000 A	400 A	CT Rated Primary Current
205	CT SECONDARY	P.System Data 1		1A 5A	1A	CT Rated Secondary Current
206A	Vph/Vdelta	P.System Data 1		1.00 .. 3.00	1.73	Matching ratio Phase-VT To Open-Delta-VT
209	PHASE SEQ.	P.System Data 1		A B C A C B	A B C	Phase Sequence
210A	TMin TRIP CMD	P.System Data 1		0.01 .. 32.00 sec	0.15 sec	Minimum TRIP Command Duration
211A	TMax CLOSE CMD	P.System Data 1		0.01 .. 32.00 sec	1.00 sec	Maximum Close Command Duration
212	BkrClosed I MIN	P.System Data 1	1A	0.04 .. 1.00 A	0.04 A	Closed Breaker Min. Current Threshold
			5A	0.20 .. 5.00 A	0.20 A	
213	VT Connect. 3ph	P.System Data 1		Van, Vbn, Vcn Vab, Vbc, VGnd Vab, Vbc	Van, Vbn, Vcn	VT Connection, three-phase
214	Rated Frequency	P.System Data 1		50 Hz 60 Hz	50 Hz	Rated Frequency
215	Distance Unit	P.System Data 1		km Miles	km	Distance measurement unit
217	Ignd-CT PRIM	P.System Data 1		1 .. 50000 A	60 A	Ignd-CT rated primary current
218	Ignd-CT SEC	P.System Data 1		1A 5A	1A	Ignd-CT rated secondary current
250A	50/51 2-ph prot	P.System Data 1		OFF ON	OFF	50, 51 Time Overcurrent with 2ph. prot.
280	Holmgr. for Σi	P.System Data 1		NO YES	NO	Holmgreen conn. (for fast sum-i-monit.)
302	CHANGE	Change Group		Group A Group B Group C Group D Binary Input Protocol	Group A	Change to Another Setting Group
325	Vnom sec Vx	P.System Data 1		34 .. 230 V	100 V	Rated Secondary Voltage Vx
330	Iph-prim nom	P.System Data 1		10 .. 50000 A	400 A	Primary nominal phase current for prot.
331	Iph-LPS prim	P.System Data 1		10 .. 50000 A	400 A	Rated primary phase current LPS
332	Vph-LPS I sec	P.System Data 1		0.50 .. 20.00 V	10.00 V	Rated secondary voltage for current LPS
333	Vnom prim Vx	P.System Data 1		0.10 .. 800.00 kV	20.00 kV	Rated Primary Voltage Vx
351	Battery Charger	Device, General		OFF ON	OFF	Battery Charger
352	I bat. charged	Device, General		20 .. 100 mA	40 mA	Battery full charged current
353	V bat. crit.	Device, General		22.0 .. 24.0 V	23.0 V	Battery critical voltage level
354	V bat. empty	Device, General		20.0 .. 22.0 V	21.0 V	Battery discharged voltage level

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
355	Min.T.charge	Device, General		-50 .. 0 °C	-23 °C	Min. allowed charging temperature °C
356	Max.T.charge	Device, General		0 .. 80 °C	48 °C	Max. allowed charging temperature °C
357	Min.T.discharge	Device, General		-50 .. 0 °C	-40 °C	Min. allowed discharging temperature °C
358	Max.T.discharge	Device, General		0 .. 80 °C	71 °C	Max. allowed discharging temperature °C
359	Min.T.charge	Device, General		-58 .. 32 °F	9 °F	Min. allowed charging temperature °F
360	Max.T.charge	Device, General		32 .. 176 °F	118 °F	Max. allowed charging temperature °F
361	Min.T.discharge	Device, General		-58 .. 32 °F	-40 °F	Min. allowed discharging temperature °F
362	Max.T.discharge	Device, General		32 .. 176 °F	160 °F	Max. allowed discharging temperature °F
363	Bat. ChTime Max	Device, General		6 .. 72 hour	48 hour	Max. allowed high voltage charge hours
364	V bat. recover	Device, General		21.0 .. 24.0 V	22.5 V	Battery recover voltage level
365	T Voltage loss	Device, General		0 .. 600 sec	60 sec	No voltage detection message timeout
366	BattTest durat.	Device, General		2 .. 8 sec	5 sec	Duration of battery test
367	V drop bat test	Device, General		1.0 .. 5.0 V	3.0 V	Max. of battery voltage drop during test
368	Battery Volt.	P.System Data 1		24 V 48 V	24 V	Battery voltage type
380	27 Vx	27/59 Vx		OFF ON Alarm Only	OFF	27 Undervoltage prot. for Vx
381	27-1 Vx Pickup	27/59 Vx		10 .. 210 V	35 V	Undervoltage Vx< pickup
382	27-2 Vx Pickup	27/59 Vx		10 .. 210 V	30 V	Undervoltage Vx<< pickup
383	27-1 Vx Delay	27/59 Vx		0.00 .. 60.00 sec; ∞	0.50 sec	Undervoltage Vx< delay time
384	27-2 Vx Delay	27/59 Vx		0.00 .. 60.00 sec; ∞	0.50 sec	Undervoltage Vx<< delay time
385A	27-1 Vx DOut R.	27/59 Vx		1.01 .. 3.00	1.20	27-1 Vx Dropout Ratio
386A	27-2 Vx DOut R.	27/59 Vx		1.01 .. 3.00	1.20	27-2 Vx Dropout Ratio
390	59 Vx	27/59 Vx		OFF ON Alarm Only	OFF	59 Overvoltage prot. for Vx
391	59-1 Vx Pickup	27/59 Vx		60 .. 260 V	140 V	Overvoltage Vx> pickup
392	59-2 Vx Pickup	27/59 Vx		60 .. 260 V	145 V	Overvoltage Vx>> pickup
393	59-1 Vx Delay	27/59 Vx		0.00 .. 60.00 sec; ∞	0.50 sec	Overvoltage Vx> delay time
394	59-2 Vx Delay	27/59 Vx		0.00 .. 60.00 sec; ∞	0.50 sec	Overvoltage Vx>> delay time
395A	59-1 Vx DOut R.	27/59 Vx		0.90 .. 0.99	0.95	59-1 Vx Dropout Ratio
396A	59-2 Vx DOut R.	27/59 Vx		0.90 .. 0.99	0.95	59-2 Vx Dropout Ratio
401	WAVEFORMTRIGGER	Osc. Fault Rec.		Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
402	WAVEFORM DATA	Osc. Fault Rec.		Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
403	MAX. LENGTH	Osc. Fault Rec.		0.30 .. 6.00 sec	2.00 sec	Max. length of a Waveform Capture Record
404	PRE. TRIG. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.25 sec	Captured Waveform Prior to Trigger
405	POST REC. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
406	BinIn CAPT.TIME	Osc. Fault Rec.		0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input
610	FltDisp.LED/LCD	Device, General		Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
611	Spont. FltDisp.	Device, General		YES NO	NO	Spontaneous display of flt.annunciations
613A	Gnd O/Cprot. w.	P.System Data 1		Ignd (measured) 3I0 (calcul.)	Ignd (measured)	Ground Overcurrent protection with

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
614A	OP. QUANTITY 59	P.System Data 1		Vphph Vphph selective Vph-n Vph-n selective V1 V2	Vphph	Opera. Quantity for 59 Overvolt. Prot.
615A	OP. QUANTITY 27	P.System Data 1		V1 Vphph Vphph selective Vph-n Vph-n selective	V1	Opera. Quantity for 27 Undervolt. Prot.
620	Remote FwUpdate	Device, General		Disabled Enabled	Enabled	Remote firmware update
640	Start image DD	Device, General		image 1 image 2 image 3 image 4 image 5 image 6	image 1	Start image Default Display
1101	FullScaleVolt.	P.System Data 2		0.10 .. 800.00 kV	20.00 kV	Measurem:FullScaleVolt-age(Equipm.rating)
1102	FullScaleCurr.	P.System Data 2		10 .. 50000 A	400 A	Measurem:FullScaleCur-rent(Equipm.rating)
1103	RE/RL	P.System Data 2		-0.33 .. 7.00	1.00	Zero seq. compensating factor RE/RL
1104	XE/XL	P.System Data 2		-0.33 .. 7.00	1.00	Zero seq. compensating factor XE/XL
1105	x'	P.System Data 2	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	feeder reactance per mile: x'
			5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
1106	x'	P.System Data 2	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	feeder reactance per km: x'
			5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
1108	P,Q sign	P.System Data 2		not reversed reversed	not reversed	P,Q operational measured values sign
1109	Line angle	P.System Data 2		10 .. 89 °	85 °	Line angle
1110	Line length	P.System Data 2		0.1 .. 1000.0 km	100.0 km	Line length in kilometer
1111	Line length	P.System Data 2		0.1 .. 650.0 Miles	62.1 Miles	Line length in miles
1201	FCT 50/51	50/51 Overcur.		ON OFF	ON	50, 51 Phase Time Overcurrent
1202	50-2 PICKUP	50/51 Overcur.	1A	0.10 .. 35.00 A; ∞	4.00 A	50-2 Pickup
			5A	0.50 .. 175.00 A; ∞	20.00 A	
1203	50-2 DELAY	50/51 Overcur.		0.00 .. 60.00 sec; ∞	0.00 sec	50-2 Time Delay
1204	50-1 PICKUP	50/51 Overcur.	1A	0.10 .. 35.00 A; ∞	1.00 A	50-1 Pickup
			5A	0.50 .. 175.00 A; ∞	5.00 A	
1205	50-1 DELAY	50/51 Overcur.		0.00 .. 60.00 sec; ∞	0.50 sec	50-1 Time Delay
1213A	MANUAL CLOSE	50/51 Overcur.		50-3 instant. 50-2 instant. 50 -1 instant. Inactive	50-2 instant.	Manual Close Mode
1214A	50-2 active	50/51 Overcur.		Always	Always	50-2 active
1215A	50 T DROP-OUT	50/51 Overcur.		0.00 .. 60.00 sec	0.00 sec	50 Drop-Out Time Delay
1216A	50-3 active	50/51 Overcur.		Always	Always	50-3 active
1217	50-3 PICKUP	50/51 Overcur.	1A	1.00 .. 35.00 A; ∞	∞ A	50-3 Pickup
			5A	5.00 .. 175.00 A; ∞	∞ A	
1218	50-3 DELAY	50/51 Overcur.		0.00 .. 60.00 sec; ∞	0.00 sec	50-3 Time Delay
1219A	50-3 measurem.	50/51 Overcur.		Fundamental True RMS Instantaneous	Fundamental	50-3 measurement of
1220A	50-2 measurem.	50/51 Overcur.		Fundamental True RMS	Fundamental	50-2 measurement of
1221A	50-1 measurem.	50/51 Overcur.		Fundamental True RMS	Fundamental	50-1 measurement of
1301	FCT 50N/51N	50/51 Overcur.		ON OFF	ON	50N, 51N Ground Time Overcur-rent

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1302	50N-2 PICKUP	50/51 Overcur.	1A	0.05 .. 35.00 A; ∞	0.50 A	50N-2 Pickup
			5A	0.25 .. 175.00 A; ∞	2.50 A	
1303	50N-2 DELAY	50/51 Overcur.		0.00 .. 60.00 sec; ∞	0.10 sec	50N-2 Time Delay
1304	50N-1 PICKUP	50/51 Overcur.	1A	0.05 .. 35.00 A; ∞	0.20 A	50N-1 Pickup
			5A	0.25 .. 175.00 A; ∞	1.00 A	
1305	50N-1 DELAY	50/51 Overcur.		0.00 .. 60.00 sec; ∞	0.50 sec	50N-1 Time Delay
1313A	MANUAL CLOSE	50/51 Overcur.		50N-3 instant. 50N-2 instant. 50N-1 instant. Inactive	50N-2 instant.	Manual Close Mode
1314A	50N-2 active	50/51 Overcur.		Always	Always	50N-2 active
1315A	50N T DROP-OUT	50/51 Overcur.		0.00 .. 60.00 sec	0.00 sec	50N Drop-Out Time Delay
1316A	50N-3 active	50/51 Overcur.		Always	Always	50N-3 active
1317	50N-3 PICKUP	50/51 Overcur.	1A	0.25 .. 35.00 A; ∞	∞ A	50N-3 Pickup
			5A	1.25 .. 175.00 A; ∞	∞ A	
1318	50N-3 DELAY	50/51 Overcur.		0.00 .. 60.00 sec; ∞	0.05 sec	50N-3 Time Delay
1319A	50N-3 measurem.	50/51 Overcur.		Fundamental True RMS Instantaneous	Fundamental	50N-3 measurement of
1320A	50N-2 measurem.	50/51 Overcur.		Fundamental True RMS	Fundamental	50N-2 measurement of
1321A	50N-1 measurem.	50/51 Overcur.		Fundamental True RMS	Fundamental	50N-1 measurement of
1501	FCT 67/67-TOC	67 Direct. O/C		OFF ON	OFF	67, 67-TOC Phase Time Over-current
1502	67-2 PICKUP	67 Direct. O/C	1A	0.10 .. 35.00 A; ∞	2.00 A	67-2 Pickup
			5A	0.50 .. 175.00 A; ∞	10.00 A	
1503	67-2 DELAY	67 Direct. O/C		0.00 .. 60.00 sec; ∞	0.10 sec	67-2 Time Delay
1504	67-1 PICKUP	67 Direct. O/C	1A	0.10 .. 35.00 A; ∞	1.00 A	67-1 Pickup
			5A	0.50 .. 175.00 A; ∞	5.00 A	
1505	67-1 DELAY	67 Direct. O/C		0.00 .. 60.00 sec; ∞	0.50 sec	67-1Time Delay
1513A	MANUAL CLOSE	67 Direct. O/C		67-2 instant. 67-1 instant. Inactive	67-2 instant.	Manual Close Mode
1514A	67-2 active	67 Direct. O/C		always	always	67-2 active
1516	67 Direction	67 Direct. O/C		Forward Reverse Non-Directional	Forward	Phase Direction
1518A	67 T DROP-OUT	67 Direct. O/C		0.00 .. 60.00 sec	0.00 sec	67 Drop-Out Time Delay
1519A	ROTATION ANGLE	67 Direct. O/C		-180 .. 180 °	45 °	Rotation Angle of Reference Voltage
1520A	67-2 MEASUREM.	67 Direct. O/C		Fundamental True RMS	Fundamental	67-2 measurement of
1521A	67-1 MEASUREM.	67 Direct. O/C		Fundamental True RMS	Fundamental	67-1 measurement of
1601	FCT 67N/67N-TOC	67 Direct. O/C		OFF ON	OFF	67N, 67N-TOC Ground Time Overcurrent
1602	67N-2 PICKUP	67 Direct. O/C	1A	0.05 .. 35.00 A; ∞	0.50 A	67N-2 Pickup
			5A	0.25 .. 175.00 A; ∞	2.50 A	
1603	67N-2 DELAY	67 Direct. O/C		0.00 .. 60.00 sec; ∞	0.10 sec	67N-2 Time Delay
1604	67N-1 PICKUP	67 Direct. O/C	1A	0.05 .. 35.00 A; ∞	0.20 A	67N-1 Pickup
			5A	0.25 .. 175.00 A; ∞	1.00 A	
1605	67N-1 DELAY	67 Direct. O/C		0.00 .. 60.00 sec; ∞	0.50 sec	67N-1 Time Delay
1613A	MANUAL CLOSE	67 Direct. O/C		67N-2 instant. 67N-1 instant. Inactive	67N-2 instant.	Manual Close Mode
1614A	67N-2 active	67 Direct. O/C		always	always	67N-2 active
1616	67N Direction	67 Direct. O/C		Forward Reverse Non-Directional	Forward	Ground Direction

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1617	67N POLARIZAT.	67 Direct. O/C		with VN and IN with V2 and I2	with VN and IN	Ground Polarization
1618A	67N T DROP-OUT	67 Direct. O/C		0.00 .. 60.00 sec	0.00 sec	67N Drop-Out Time Delay
1619A	ROTATION ANGLE	67 Direct. O/C		-180 .. 180 °	-45 °	Rotation Angle of Reference Voltage
1620A	67N-2 MEASUREM.	67 Direct. O/C		Fundamental True RMS	Fundamental	67N-2 measurement of
1621A	67N-1 MEASUREM.	67 Direct. O/C		Fundamental True RMS	Fundamental	67N-1 measurement of
2201	INRUSH REST.	50/51 Overcur.		OFF ON	OFF	Inrush Restraint
2202	2nd HARMONIC	50/51 Overcur.		10 .. 45 %	15 %	2nd. harmonic in % of fundamental
2203	CROSS BLOCK	50/51 Overcur.		NO YES	NO	Cross Block
2204	CROSS BLK TIMER	50/51 Overcur.		0.00 .. 180.00 sec	0.00 sec	Cross Block Time
2205	I Max	50/51 Overcur.	1A	0.30 .. 25.00 A	7.50 A	Maximum Current for Inrush Restraint
			5A	1.50 .. 125.00 A	37.50 A	
4001	FCT 46	46 Negative Seq		OFF ON	OFF	46 Negative Sequence Protection
4002	46-1 PICKUP	46 Negative Seq	1A	0.10 .. 3.00 A	0.10 A	46-1 Pickup
			5A	0.50 .. 15.00 A	0.50 A	
4003	46-1 DELAY	46 Negative Seq		0.00 .. 60.00 sec; ∞	1.50 sec	46-1 Time Delay
4004	46-2 PICKUP	46 Negative Seq	1A	0.10 .. 3.00 A	0.50 A	46-2 Pickup
			5A	0.50 .. 15.00 A	2.50 A	
4005	46-2 DELAY	46 Negative Seq		0.00 .. 60.00 sec; ∞	1.50 sec	46-2 Time Delay
4006	46 IEC CURVE	46 Negative Seq		Normal Inverse Very Inverse Extremely Inv.	Extremely Inv.	IEC Curve
4007	46 ANSI CURVE	46 Negative Seq		Extremely Inv. Inverse Moderately Inv. Very Inverse	Extremely Inv.	ANSI Curve
4008	46-TOC PICKUP	46 Negative Seq	1A	0.10 .. 2.00 A	0.90 A	46-TOC Pickup
			5A	0.50 .. 10.00 A	4.50 A	
4009	46-TOC TIMEDIAL	46 Negative Seq		0.50 .. 15.00 ; ∞	5.00	46-TOC Time Dial
4010	46-TOC TIMEDIAL	46 Negative Seq		0.05 .. 3.20 sec; ∞	0.50 sec	46-TOC Time Dial
4011	46-TOC RESET	46 Negative Seq		Instantaneous Disk Emulation	Instantaneous	46-TOC Drop Out
4012A	46 T DROP-OUT	46 Negative Seq		0.00 .. 60.00 sec	0.00 sec	46 Drop-Out Time Delay
5001	FCT 59	27/59 O/U Volt.		OFF ON Alarm Only	OFF	59 Overvoltage Protection
5002	59-1 PICKUP	27/59 O/U Volt.		20 .. 415 V	110 V	59-1 Pickup
5003	59-1 PICKUP	27/59 O/U Volt.		20 .. 240 V	110 V	59-1 Pickup
5004	59-1 DELAY	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Time Delay
5005	59-2 PICKUP	27/59 O/U Volt.		20 .. 260 V	120 V	59-2 Pickup
5006	59-2 PICKUP	27/59 O/U Volt.		20 .. 240 V	120 V	59-2 Pickup
5007	59-2 DELAY	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Time Delay
5015	59-1 PICKUP V2	27/59 O/U Volt.		2 .. 240 V	30 V	59-1 Pickup V2
5016	59-2 PICKUP V2	27/59 O/U Volt.		2 .. 240 V	50 V	59-2 Pickup V2
5017A	59-1 DOUT RATIO	27/59 O/U Volt.		0.90 .. 0.99	0.95	59-1 Dropout Ratio
5018A	59-2 DOUT RATIO	27/59 O/U Volt.		0.90 .. 0.99	0.95	59-2 Dropout Ratio
5019	59-1 PICKUP V1	27/59 O/U Volt.		20 .. 240 V	110 V	59-1 Pickup V1
5020	59-2 PICKUP V1	27/59 O/U Volt.		20 .. 240 V	120 V	59-2 Pickup V1
5030	59-1 PhA Pickup	27/59 O/U Volt.		20 .. 415 V	110 V	59-1 Phase A Pickup
5031	59-1 PhA Pickup	27/59 O/U Volt.		20 .. 240 V	110 V	59-1 Phase A Pickup
5032	59-1 PhB Pickup	27/59 O/U Volt.		20 .. 415 V	110 V	59-1 Phase B Pickup
5033	59-1 PhB Pickup	27/59 O/U Volt.		20 .. 240 V	110 V	59-1 Phase B Pickup
5034	59-1 PhC Pickup	27/59 O/U Volt.		20 .. 415 V	110 V	59-1 Phase C Pickup

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
5035	59-1 PhC Pickup	27/59 O/U Volt.		20 .. 240 V	110 V	59-1 Phase C Pickup
5036	59-2 PhA Pickup	27/59 O/U Volt.		20 .. 415 V	120 V	59-2 Phase A Pickup
5037	59-2 PhA Pickup	27/59 O/U Volt.		20 .. 240 V	120 V	59-2 Phase A Pickup
5038	59-2 PhB Pickup	27/59 O/U Volt.		20 .. 415 V	120 V	59-2 Phase B Pickup
5039	59-2 PhB Pickup	27/59 O/U Volt.		20 .. 240 V	120 V	59-2 Phase B Pickup
5040	59-2 PhC Pickup	27/59 O/U Volt.		20 .. 415 V	120 V	59-2 Phase C Pickup
5041	59-2 PhC Pickup	27/59 O/U Volt.		20 .. 240 V	120 V	59-2 Phase C Pickup
5042	59-1 PhA Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Phase A Time Delay
5043	59-1 PhB Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Phase B Time Delay
5044	59-1 PhC Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-1 Phase C Time Delay
5045	59-2 PhA Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Phase A Time Delay
5046	59-2 PhB Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Phase B Time Delay
5047	59-2 PhC Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	59-2 Phase C Time Delay
5101	FCT 27	27/59 O/U Volt.		OFF ON Alarm Only	OFF	27 Undervoltage Protection
5102	27-1 PICKUP	27/59 O/U Volt.		10 .. 385 V	75 V	27-1 Pickup
5103	27-1 PICKUP	27/59 O/U Volt.		10 .. 200 V	45 V	27-1 Pickup
5106	27-1 DELAY	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Time Delay
5110	27-2 PICKUP	27/59 O/U Volt.		10 .. 385 V	70 V	27-2 Pickup
5111	27-2 PICKUP	27/59 O/U Volt.		10 .. 200 V	40 V	27-2 Pickup
5112	27-2 DELAY	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Time Delay
5113A	27-1 DOUT RATIO	27/59 O/U Volt.		1.01 .. 3.00	1.20	27-1 Dropout Ratio
5114A	27-2 DOUT RATIO	27/59 O/U Volt.		1.01 .. 3.00	1.20	27-2 Dropout Ratio
5120A	CURRENT SUPERV.	27/59 O/U Volt.		OFF ON	ON	Current Supervision
5130	27-1 PhA Pickup	27/59 O/U Volt.		10 .. 385 V	75 V	27-1 Phase A Pickup
5131	27-1 PhA Pickup	27/59 O/U Volt.		10 .. 200 V	45 V	27-1 Phase A Pickup
5132	27-1 PhB Pickup	27/59 O/U Volt.		10 .. 385 V	75 V	27-1 Phase B Pickup
5133	27-1 PhB Pickup	27/59 O/U Volt.		10 .. 200 V	45 V	27-1 Phase B Pickup
5134	27-1 PhC Pickup	27/59 O/U Volt.		10 .. 385 V	75 V	27-1 Phase C Pickup
5135	27-1 PhC Pickup	27/59 O/U Volt.		10 .. 200 V	45 V	27-1 Phase C Pickup
5136	27-2 PhA Pickup	27/59 O/U Volt.		10 .. 385 V	70 V	27-2 Phase A Pickup
5137	27-2 PhA Pickup	27/59 O/U Volt.		10 .. 200 V	40 V	27-2 Phase A Pickup
5138	27-2 PhB Pickup	27/59 O/U Volt.		10 .. 385 V	70 V	27-2 Phase B Pickup
5139	27-2 PhB Pickup	27/59 O/U Volt.		10 .. 200 V	40 V	27-2 Phase B Pickup
5140	27-2 PhC Pickup	27/59 O/U Volt.		10 .. 385 V	70 V	27-2 Phase C Pickup
5141	27-2 PhC Pickup	27/59 O/U Volt.		10 .. 200 V	40 V	27-2 Phase C Pickup
5142	27-1 PhA Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Phase A Time Delay
5143	27-1 PhB Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Phase B Time Delay
5144	27-1 PhC Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	1.50 sec	27-1 Phase C Time Delay
5145	27-2 PhA Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Phase A Time Delay
5146	27-2 PhB Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Phase B Time Delay
5147	27-2 PhC Delay	27/59 O/U Volt.		0.00 .. 100.00 sec; ∞	0.50 sec	27-2 Phase C Time Delay
5301	FUSE FAIL MON.	Measurem.Superv		OFF Solid grounded Coil.gnd./isol.	OFF	Fuse Fail Monitor
5302	FUSE FAIL 3Vo	Measurem.Superv		10 .. 100 V	30 V	Zero Sequence Voltage
5303	FUSE FAIL RESID	Measurem.Superv	1A	0.10 .. 1.00 A	0.10 A	Residual Current
			5A	0.50 .. 5.00 A	0.50 A	
5307	I> BLOCK	Measurem.Superv	1A	0.10 .. 35.00 A; ∞	1.00 A	I> Pickup for block FFM
			5A	0.50 .. 175.00 A; ∞	5.00 A	
5310	BLOCK PROT.	Measurem.Superv		NO YES	YES	Block protection by FFM
5401	FCT 81 O/U	81 O/U Freq.		OFF ON	OFF	81 Over/Under Frequency Protection

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
5402	Vmin	81 O/U Freq.		10 .. 150 V	65 V	Minimum required voltage for operation
5402	Vmin	81 O/U Freq.		20 .. 150 V	35 V	Minimum required voltage for operation
5403	81-1 PICKUP	81 O/U Freq.		40.00 .. 60.00 Hz	49.50 Hz	81-1 Pickup
5404	81-1 PICKUP	81 O/U Freq.		50.00 .. 70.00 Hz	59.50 Hz	81-1 Pickup
5405	81-1 DELAY	81 O/U Freq.		0.00 .. 100.00 sec; ∞	60.00 sec	81-1 Time Delay
5406	81-2 PICKUP	81 O/U Freq.		40.00 .. 60.00 Hz	49.00 Hz	81-2 Pickup
5407	81-2 PICKUP	81 O/U Freq.		50.00 .. 70.00 Hz	59.00 Hz	81-2 Pickup
5408	81-2 DELAY	81 O/U Freq.		0.00 .. 100.00 sec; ∞	30.00 sec	81-2 Time Delay
5409	81-3 PICKUP	81 O/U Freq.		40.00 .. 60.00 Hz	47.50 Hz	81-3 Pickup
5410	81-3 PICKUP	81 O/U Freq.		50.00 .. 70.00 Hz	57.50 Hz	81-3 Pickup
5411	81-3 DELAY	81 O/U Freq.		0.00 .. 100.00 sec; ∞	3.00 sec	81-3 Time delay
5412	81-4 PICKUP	81 O/U Freq.		40.00 .. 60.00 Hz	51.00 Hz	81-4 Pickup
5413	81-4 PICKUP	81 O/U Freq.		50.00 .. 70.00 Hz	61.00 Hz	81-4 Pickup
5414	81-4 DELAY	81 O/U Freq.		0.00 .. 100.00 sec; ∞	30.00 sec	81-4 Time delay
5415A	DO differential	81 O/U Freq.		0.02 .. 1.00 Hz	0.02 Hz	Dropout differential
5416	81 Imin	81 O/U Freq.	1A	0.30 .. 5.00 A	0.80 A	Minimum required current for operation
			5A	1.50 .. 25.00 A	4.00 A	
5421	FCT 81-1 O/U	81 O/U Freq.		OFF ON f> ON f<	OFF	81-1 Over/Under Frequency Protection
5422	FCT 81-2 O/U	81 O/U Freq.		OFF ON f> ON f<	OFF	81-2 Over/Under Frequency Protection
5423	FCT 81-3 O/U	81 O/U Freq.		OFF ON f> ON f<	OFF	81-3 Over/Under Frequency Protection
5424	FCT 81-4 O/U	81 O/U Freq.		OFF ON f> ON f<	OFF	81-4 Over/Under Frequency Protection
6001	S1: RE/RL	P.System Data 2		-0.33 .. 7.00	1.00	S1: Zero seq. compensating factor RE/RL
6002	S1: XE/XL	P.System Data 2		-0.33 .. 7.00	1.00	S1: Zero seq. compensating factor XE/XL
6003	S1: x'	P.System Data 2	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	S1: feeder reactance per mile: x'
			5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
6004	S1: x'	P.System Data 2	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	S1: feeder reactance per km: x'
			5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
6005	S1: Line angle	P.System Data 2		10 .. 89 °	85 °	S1: Line angle
6006	S1: Line length	P.System Data 2		0.1 .. 650.0 Miles	62.1 Miles	S1: Line length in miles
6007	S1: Line length	P.System Data 2		0.1 .. 1000.0 km	100.0 km	S1: Line length in kilometer
6011	S2: RE/RL	P.System Data 2		-0.33 .. 7.00	1.00	S2: Zero seq. compensating factor RE/RL
6012	S2: XE/XL	P.System Data 2		-0.33 .. 7.00	1.00	S2: Zero seq. compensating factor XE/XL
6013	S2: x'	P.System Data 2	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	S2: feeder reactance per mile: x'
			5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	
6014	S2: x'	P.System Data 2	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	S2: feeder reactance per km: x'
			5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
6015	S2: Line angle	P.System Data 2		10 .. 89 °	85 °	S2: Line angle
6016	S2: Line length	P.System Data 2		0.1 .. 650.0 Miles	62.1 Miles	S2: Line length in miles
6017	S2: Line length	P.System Data 2		0.1 .. 1000.0 km	100.0 km	S2: Line length in kilometer
6021	S3: RE/RL	P.System Data 2		-0.33 .. 7.00	1.00	S3: Zero seq. compensating factor RE/RL
6022	S3: XE/XL	P.System Data 2		-0.33 .. 7.00	1.00	S3: Zero seq. compensating factor XE/XL
6023	S3: x'	P.System Data 2	1A	0.0050 .. 15.0000 Ω/mi	0.2420 Ω/mi	S3: feeder reactance per mile: x'
			5A	0.0010 .. 3.0000 Ω/mi	0.0484 Ω/mi	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
6024	S3: x'	P.System Data 2	1A	0.0050 .. 9.5000 Ω/km	0.1500 Ω/km	S3: feeder reactance per km: x'
			5A	0.0010 .. 1.9000 Ω/km	0.0300 Ω/km	
6025	S3: Line angle	P.System Data 2		10 .. 89 °	85 °	S3: Line angle
6026	S3: Line length	P.System Data 2		0.1 .. 650.0 Miles	62.1 Miles	S3: Line length in miles
6027	S3: Line length	P.System Data 2		0.1 .. 1000.0 km	100.0 km	S3: Line length in kilometer
7001	FCT 50BF	50BF BkrFailure		OFF ON	OFF	50BF Breaker Failure Protection
7004	Chk BRK CONTACT	50BF BkrFailure		OFF ON	OFF	Check Breaker contacts
7005	TRIP-Timer	50BF BkrFailure		0.06 .. 60.00 sec; ∞	0.25 sec	TRIP-Timer
7006	50BF PICKUP	50BF BkrFailure	1A	0.05 .. 20.00 A	0.10 A	50BF Pickup current threshold
			5A	0.25 .. 100.00 A	0.50 A	
7007	50BF PICKUP IE>	50BF BkrFailure				50BF Pickup earth current threshold
			5A	0.25 .. 100.00 A	0.50 A	
1A	0.05 .. 20.00 A	0.10 A				
8001	START	Fault Locator		Pickup TRIP	Pickup	Start fault locator with
8101	MEASURE. SUPERV	Measurem.Superv		OFF ON	ON	Measurement Supervision
8102	BALANCE V-LIMIT	Measurem.Superv		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
8103	BAL. FACTOR V	Measurem.Superv		0.58 .. 0.90	0.75	Balance Factor for Voltage Monitor
8104	BALANCE I LIMIT	Measurem.Superv	1A	0.10 .. 1.00 A	0.50 A	Current Threshold for Balance Monitoring
			5A	0.50 .. 5.00 A	2.50 A	
8105	BAL. FACTOR I	Measurem.Superv		0.10 .. 0.90	0.50	Balance Factor for Current Monitor
8106	Σ I THRESHOLD	Measurem.Superv	1A	0.05 .. 2.00 A; ∞	0.10 A	Summated Current Monitoring Threshold
			5A	0.25 .. 10.00 A; ∞	0.50 A	
8107	Σ I FACTOR	Measurem.Superv		0.00 .. 0.95	0.10	Summated Current Monitoring Factor
8109	FAST Σ i MONIT	Measurem.Superv		OFF ON	ON	Fast Summated Current Monitor-ing
8301	DMD Interval	Demand meter		15 Min., 1 Sub 15 Min., 3 Subs 15 Min.,15 Subs 30 Min., 1 Sub 60 Min., 1 Sub 60 Min.,10 Subs 5 Min., 5 Subs	60 Min., 1 Sub	Demand Calculation Intervals
8302	DMD Sync.Time	Demand meter		On The Hour 15 After Hour 30 After Hour 45 After Hour	On The Hour	Demand Synchronization Time
8311	MinMax cycRESET	Min/Max meter		NO YES	YES	Automatic Cyclic Reset Function
8312	MiMa RESET TIME	Min/Max meter		0 .. 1439 min	0 min	MinMax Reset Timer
8313	MiMa RESETCYCLE	Min/Max meter		1 .. 365 Days	7 Days	MinMax Reset Cycle Period
8314	MinMaxRES.START	Min/Max meter		1 .. 365 Days	1 Days	MinMax Start Reset Cycle in
8315	MeterResolution	Energy		Standard Factor 10 Factor 100	Standard	Meter resolution

A.9 Information List

Indications for IEC 60 870-5-103 are always reported ON / OFF if they are subject to general interrogation for IEC 60 870-5-103. If not, they are reported only as ON.

New user-defined indications or such newly allocated to IEC 60 870-5-103 are set to ON / OFF and subjected to general interrogation if the information type is not a spontaneous event („.._Ev“). Further information with regard to the indications is set out 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 the column „Marked in Oscill. Record“ the following applies:

UPPER CASE NOTATION “M”: definitely set, not allocatable

lower case notation “m”: preset, allocatable

*: not preset, allocatable

<blank>: neither preset nor allocatable

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
-	>Back Light on (>Light on)	Device, General	SP	On Off	*		*	LED	BI		BO					
-	Reset LED (Reset LED)	Device, General	IntSP	on	*		*	LED			BO		160	19	1	No
-	Stop data transmission (DataS-top)	Device, General	IntSP	On Off	*		*	LED			BO		160	20	1	Yes
-	Test mode (Test mode)	Device, General	IntSP	On Off	*		*	LED			BO		160	21	1	Yes
-	Feeder GROUNDED (Feeder gnd)	Device, General	IntSP	*	*		*	LED			BO					
-	Breaker OPENED (Brk OPENED)	Device, General	IntSP	*	*		*	LED			BO					
-	Hardware Test Mode (HWTest-Mod)	Device, General	IntSP	On Off	*		*	LED			BO					
-	Clock Synchronization (Synch-Clock)	Device, General	IntSP_Ev	*	*		*									
-	Fault Recording Start (FltRecSta)	Osc. Fault Rec.	IntSP	On Off	*		m	LED			BO					
-	Setting Group A is active (P-GrpA act)	Change Group	IntSP	On Off	*		*	LED			BO		160	23	1	Yes
-	Setting Group B is active (P-GrpB act)	Change Group	IntSP	On Off	*		*	LED			BO		160	24	1	Yes
-	Setting Group C is active (P-GrpC act)	Change Group	IntSP	On Off	*		*	LED			BO		160	25	1	Yes
-	Setting Group D is active (P-GrpD act)	Change Group	IntSP	On Off	*		*	LED			BO		160	26	1	Yes
-	Controlmode REMOTE (ModeR-EMOTE)	Cntrl Authority	IntSP	On Off	*			LED			BO					

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
-	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
-	52 Breaker (52Breaker)	Control Device	CF_D12	On Off				LED			BO		240	160	20	
-	52 Breaker (52Breaker)	Control Device	DP	On Off					BI			CB	240	160	1	Yes
-	Disconnect Switch (Disc.Swit.)	Control Device	CF_D2	On Off				LED			BO		240	161	20	
-	Disconnect Switch (Disc.Swit.)	Control Device	DP	On Off					BI			CB	240	161	1	Yes
-	Ground Switch (GndSwit.)	Control Device	CF_D2	On Off				LED			BO		240	164	20	
-	Ground Switch (GndSwit.)	Control Device	DP	On Off					BI			CB	240	164	1	Yes
-	>CB ready Spring is charged (>CB ready)	Process Data	SP	*	*		*	LED	BI		BO	CB				
-	>Door closed (>DoorClose)	Process Data	SP	*	*		*	LED	BI		BO	CB				
-	>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
-	>No Voltage (Fuse blown) (>No Volt.)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	160	38	1	Yes
-	>Error Motor Voltage (>Err Mot V)	Process Data	SP	On Off	*		*	LED	BI		BO	CB	240	181	1	Yes
-	>Error Control Voltage (>ErrCntr-lV)	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 Minimum and Maximum counter (ResMinMax)	Min/Max meter	IntSP_Ev	ON												
-	Reset meter (Meter res)	Energy	IntSP_Ev	ON					BI							
-	Error Systeminterface (SysIn-tErr.)	Protocol	IntSP	On Off	*	*		LED			BO					
-	Threshold Value 1 (ThreshVal1)	Thresh.-Switch	IntSP	On Off				LED		FC TN	BO	CB				
1	No Function configured (Not con-figured)	Device, General	SP	*	*											
2	Function Not Available (Non Exis-tent)	Device, General	SP	*	*											
3	>Synchronize Internal Real Time Clock (>Time Synch)	Device, General	SP_Ev	*	*			LED	BI		BO		135	48	1	Yes
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Osc. Fault Rec.	SP	*	*		m	LED	BI		BO		135	49	1	Yes
5	>Reset LED (>Reset LED)	Device, General	SP	*	*		*	LED	BI		BO		135	50	1	Yes
7	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	SP	*	*		*	LED	BI		BO		135	51	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
8	>Setting Group Select Bit 1 (>Set Group Bit1)	Change Group	SP	*	*		*	LED	BI		BO		135	52	1	Yes
009.0100	Failure EN100 Module (Failure Module)	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					
15	>Test mode (>Test mode)	Device, General	SP	*	*		*	LED	BI		BO		135	53	1	Yes
16	>Stop data transmission (>DataStop)	Device, General	SP	*	*		*	LED	BI		BO		135	54	1	Yes
51	Device is Operational and Protecting (Device OK)	Device, General	OUT	On Off	*		*	LED			BO		135	81	1	Yes
52	At Least 1 Protection Funct. is Active (ProtActive)	Device, General	IntSP	On Off	*		*	LED			BO		160	18	1	Yes
55	Reset Device (Reset Device)	Device, General	OUT	on	*		*						160	4	1	No
56	Initial Start of Device (Initial Start)	Device, General	OUT	on	*		*	LED			BO		160	5	1	No
67	Resume (Resume)	Device, General	OUT	on	*		*	LED			BO					
68	Clock Synchronization Error (Clock SyncError)	Device, General	OUT	On Off	*		*	LED			BO					
69	Daylight Saving Time (DayLightSavTime)	Device, General	OUT	On Off	*		*	LED			BO					
70	Setting calculation is running (Settings Calc.)	Device, General	OUT	On Off	*		*	LED			BO		160	22	1	Yes
71	Settings Check (Settings Check)	Device, General	OUT	*	*		*	LED			BO					
72	Level-2 change (Level-2 change)	Device, General	OUT	On Off	*		*	LED			BO					
73	Local setting change (Local change)	Device, General	OUT	*	*		*									
110	Event lost (Event Lost)	Device, General	OUT_Ev	on	*			LED			BO		135	130	1	No
113	Flag Lost (Flag Lost)	Device, General	OUT	on	*		m	LED			BO		135	136	1	Yes
125	Chatter ON (Chatter ON)	Device, General	OUT	On Off	*		*	LED			BO		135	145	1	Yes
126	Protection ON/OFF (via system port) (ProtON/OFF)	P.System Data 2	IntSP	On Off	*		*	LED			BO					
140	Error with a summary alarm (Error Sum Alarm)	Device, General	OUT	On Off	*		*	LED			BO		160	47	1	Yes
160	Alarm Summary Event (Alarm Sum Event)	Device, General	OUT	On Off	*		*	LED			BO		160	46	1	Yes
161	Failure: General Current Supervision (Fail I Superv.)	Measurem.Superv	OUT	On Off	*		*	LED			BO		160	32	1	Yes
162	Failure: Current Summation (Failure Σ I)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	182	1	Yes
163	Failure: Current Balance (Fail I balance)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	183	1	Yes
167	Failure: Voltage Balance (Fail V balance)	Measurem.Superv	OUT	On Off	*		*	LED			BO		135	186	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		160	35	1	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
175	Failure: Phase Sequence Current (Fail Ph. Seq. I)	Measurem.Supervision	OUT	On Off	*		*	LED			BO		135	191	1	Yes
176	Failure: Phase Sequence Voltage (Fail Ph. Seq. V)	Measurem.Supervision	OUT	On Off	*		*	LED			BO		135	192	1	Yes
177	Failure: Battery empty (Fail Battery)	Device, General	OUT	On Off	*		*	LED			BO					
178	I/O-Board Error (I/O-Board error)	Device, General	OUT	On Off	*		*	LED			BO					
181	Error: A/D converter (Error A/D-conv.)	Device, General	OUT	On Off	*		*	LED			BO					
191	Error: Offset (Error Offset)	Device, General	OUT	On Off	*		*	LED			BO					
193	Alarm: NO calibration data available (Alarm NO calibr)	Device, General	OUT	On Off	*		*	LED			BO					
194	Error: Neutral CT different from MLFB (Error neutralCT)	Device, General	OUT	On Off	*											
197	Measurement Supervision is switched OFF (MeasSup OFF)	Measurem.Supervision	OUT	On Off	*		*	LED			BO		135	197	1	Yes
203	Waveform data deleted (Wave. deleted)	Osc. Fault Rec.	OUT_Ev	on	*			LED			BO		135	203	1	No
234.2100	27, 59 blocked via operation (27, 59 blk)	27/59 O/U Volt.	IntSP	On Off	*		*	LED			BO					
235.2110	>BLOCK Function $00 (>BLOCK $00)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2111	>Function $00 instantaneous TRIP (>$00 instant.)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2112	>Function $00 Direct TRIP (>$00 Dir.TRIP)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2113	>Function $00 BLOCK TRIP Time Delay (>$00 BLK.TDly)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2114	>Function $00 BLOCK TRIP (>$00 BLK.TRIP)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2115	>Function $00 BLOCK TRIP Phase A (>$00 BL.TripA)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2116	>Function $00 BLOCK TRIP Phase B (>$00 BL.TripB)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2117	>Function $00 BLOCK TRIP Phase C (>$00 BL.TripC)	Flx	SP	On Off	On Off	*	*	LED	BI	FC TN	BO					
235.2118	Function $00 is BLOCKED ($00 BLOCKED)	Flx	OUT	On Off	On Off	*	*	LED			BO					
235.2119	Function $00 is switched OFF ($00 OFF)	Flx	OUT	On Off	*	*	*	LED			BO					
235.2120	Function $00 is ACTIVE ($00 ACTIVE)	Flx	OUT	On Off	*	*	*	LED			BO					
235.2121	Function $00 picked up ($00 picked up)	Flx	OUT	On Off	On Off	*	*	LED			BO					
235.2122	Function $00 Pickup Phase A ($00 pickup A)	Flx	OUT	On Off	On Off	*	*	LED			BO					
235.2123	Function $00 Pickup Phase B ($00 pickup B)	Flx	OUT	On Off	On Off	*	*	LED			BO					
235.2124	Function $00 Pickup Phase C ($00 pickup C)	Flx	OUT	On Off	On Off	*	*	LED			BO					
235.2125	Function $00 TRIP Delay Time Out ($00 Time Out)	Flx	OUT	On Off	On Off	*	*	LED			BO					
235.2126	Function $00 TRIP ($00 TRIP)	Flx	OUT	On Off	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
235.2128	Function $00 has invalid settings ($00 inval.set)	Flx	OUT	On Off	On Off	*	*	LED			BO					
236.2127	BLOCK Flexible Function (BLK. Flex.Fct.)	Device, General	IntSP	On Off	*	*	*	LED			BO					
272	Set Point Operating Hours (SP. Op Hours>)	SetPoint(Stat)	OUT	On Off	*		*	LED			BO		135	229	1	Yes
301	Power System fault (Pow.Sys.Flt.)	Device, General	OUT	On Off	On Off								135	231	2	Yes
302	Fault Event (Fault Event)	Device, General	OUT	*	on								135	232	2	Yes
303	sensitive Ground fault (sens Gnd flt)	Device, General	OUT			On Off										
320	Warn: Limit of Memory Data exceeded (Warn Mem. Data)	Device, General	OUT	On Off	*		*	LED			BO					
321	Warn: Limit of Memory Parameter exceeded (Warn Mem. Para.)	Device, General	OUT	On Off	*		*	LED			BO					
322	Warn: Limit of Memory Operation exceeded (Warn Mem. Oper.)	Device, General	OUT	On Off	*		*	LED			BO					
323	Warn: Limit of Memory New exceeded (Warn Mem. New)	Device, General	OUT	On Off	*		*	LED			BO					
356	>Manual close signal (>Manual Close)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	6	1	Yes
395	>I MIN/MAX Buffer Reset (>I MinMax Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
396	>I1 MIN/MAX Buffer Reset (>I1 MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
397	>V MIN/MAX Buffer Reset (>V MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
398	>Vphph MIN/MAX Buffer Reset (>VphphMiMaRes)	Min/Max meter	SP	on	*		*	LED	BI		BO					
399	>V1 MIN/MAX Buffer Reset (>V1 MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
400	>P MIN/MAX Buffer Reset (>P MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
401	>S MIN/MAX Buffer Reset (>S MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
402	>Q MIN/MAX Buffer Reset (>Q MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
403	>Idmd MIN/MAX Buffer Reset (>Idmd MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
404	>Pdmd MIN/MAX Buffer Reset (>Pdmd MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
405	>Qdmd MIN/MAX Buffer Reset (>Qdmd MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
406	>Sdmd MIN/MAX Buffer Reset (>Sdmd MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
407	>Frq. MIN/MAX Buffer Reset (>Frq MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
408	>Power Factor MIN/MAX Buffer Reset (>PF MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
409	>BLOCK Op Counter (>BLOCK Op Count)	Statistics	SP	On Off			*	LED	BI		BO					
412	>Theta MIN/MAX Buffer Reset (>Θ MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
501	Relay PICKUP (Relay PICKUP)	P.System Data 2	OUT		ON		m	LED			BO		150	151	2	Yes
502	Relay Drop Out (Relay Drop Out)	Device, General	SP	*	*											

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
510	General CLOSE of relay (Relay CLOSE)	Device, General	SP	*	*											
511	Relay GENERAL TRIP command (Relay TRIP)	P.System Data 2	OUT		ON		m	LED			BO		150	161	2	Yes
533	Primary fault current Ia (Ia =)	P.System Data 2	VI		On Off								150	177	4	No
534	Primary fault current Ib (Ib =)	P.System Data 2	VI		On Off								150	178	4	No
535	Primary fault current Ic (Ic =)	P.System Data 2	VI		On Off								150	179	4	No
545	Time from Pickup to drop out (PU Time)	Device, General	VI													
546	Time from Pickup to TRIP (TRIP Time)	Device, General	VI													
561	Manual close signal detected (Man.Clos.Detect)	P.System Data 2	OUT	On Off	*		*	LED			BO					
916	Increment of active energy (WpΔ=)	Energy	-													
917	Increment of reactive energy (WqΔ=)	Energy	-													
1020	Counter of operating hours (Op.Hours=)	Statistics	VI													
1021	Accumulation of interrupted current Ph A (Σ Ia =)	Statistics	VI													
1022	Accumulation of interrupted current Ph B (Σ Ib =)	Statistics	VI													
1023	Accumulation of interrupted current Ph C (Σ Ic =)	Statistics	VI													
1106	>Start Fault Locator (>Start Flt. Loc)	Fault Locator	SP	on	*		*	LED	BI		BO		151	6	1	Yes
1114	Flt Locator: primary RESIS-TANCE (Rpri =)	Fault Locator	VI		On Off								151	14	4	No
1115	Flt Locator: primary REAC-TANCE (Xpri =)	Fault Locator	VI		On Off								151	15	4	No
1117	Flt Locator: secondary RESIS-TANCE (Rsec =)	Fault Locator	VI		On Off								151	17	4	No
1118	Flt Locator: secondary REAC-TANCE (Xsec =)	Fault Locator	VI		On Off								151	18	4	No
1119	Flt Locator: Distance to fault (dist =)	Fault Locator	VI		On Off								151	19	4	No
1120	Flt Locator: Distance [%] to fault (d[%] =)	Fault Locator	VI		On Off								151	20	4	No
1122	Flt Locator: Distance to fault (dist =)	Fault Locator	VI		On Off								151	22	4	No
1123	Fault Locator Loop AG (FL Loop AG)	Fault Locator	OUT	*	on		*	LED			BO					
1124	Fault Locator Loop BG (FL Loop BG)	Fault Locator	OUT	*	on		*	LED			BO					
1125	Fault Locator Loop CG (FL Loop CG)	Fault Locator	OUT	*	on		*	LED			BO					
1126	Fault Locator Loop AB (FL Loop AB)	Fault Locator	OUT	*	on		*	LED			BO					
1127	Fault Locator Loop BC (FL Loop BC)	Fault Locator	OUT	*	on		*	LED			BO					
1128	Fault Locator Loop CA (FL Loop CA)	Fault Locator	OUT	*	on		*	LED			BO					

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
1132	Fault location invalid (Flt.Loc.invalid)	Fault Locator	OUT	*	on		*	LED			BO					
1403	>BLOCK 50BF (>BLOCK 50BF)	50BF BkrFailure	SP	On Off	*		*	LED	BI		BO		166	103	1	Yes
1431	>50BF initiated externally (>50BF ext SRC)	50BF BkrFailure	SP	On Off	*		*	LED	BI		BO		166	104	1	Yes
1451	50BF is switched OFF (50BF OFF)	50BF BkrFailure	OUT	On Off	*		*	LED			BO		166	151	1	Yes
1452	50BF is BLOCKED (50BF BLOCK)	50BF BkrFailure	OUT	On Off	On Off		*	LED			BO		166	152	1	Yes
1453	50BF is ACTIVE (50BF ACTIVE)	50BF BkrFailure	OUT	On Off	*		*	LED			BO		166	153	1	Yes
1456	50BF (internal) PICKUP (50BF int Pickup)	50BF BkrFailure	OUT	*	On Off		*	LED			BO		166	156	2	Yes
1457	50BF (external) PICKUP (50BF ext Pickup)	50BF BkrFailure	OUT	*	On Off		*	LED			BO		166	157	2	Yes
1471	50BF TRIP (50BF TRIP)	50BF BkrFailure	OUT	*	on		m	LED			BO		160	85	2	No
1480	50BF (internal) TRIP (50BF int TRIP)	50BF BkrFailure	OUT	*	on		*	LED			BO		166	180	2	Yes
1481	50BF (external) TRIP (50BF ext TRIP)	50BF BkrFailure	OUT	*	on		*	LED			BO		166	181	2	Yes
1704	>BLOCK 50/51 (>BLK 50/51)	50/51 Overcur.	SP	*	*		*	LED	BI		BO					
1714	>BLOCK 50N/51N (>BLK 50N/51N)	50/51 Overcur.	SP	*	*		*	LED	BI		BO					
1718	>BLOCK 50-3 (>BLOCK 50-3)	50/51 Overcur.	SP	*	*		*	LED	BI		BO		60	144	1	Yes
1719	>BLOCK 50N-3 (>BLOCK 50N-3)	50/51 Overcur.	SP	*	*		*	LED	BI		BO		60	145	1	Yes
1721	>BLOCK 50-2 (>BLOCK 50-2)	50/51 Overcur.	SP	*	*		*	LED	BI		BO		60	1	1	Yes
1722	>BLOCK 50-1 (>BLOCK 50-1)	50/51 Overcur.	SP	*	*		*	LED	BI		BO		60	2	1	Yes
1724	>BLOCK 50N-2 (>BLOCK 50N-2)	50/51 Overcur.	SP	*	*		*	LED	BI		BO		60	4	1	Yes
1725	>BLOCK 50N-1 (>BLOCK 50N-1)	50/51 Overcur.	SP	*	*		*	LED	BI		BO		60	5	1	Yes
1751	50/51 O/C switched OFF (50/51 PH OFF)	50/51 Overcur.	OUT	On Off	*		*	LED			BO		60	21	1	Yes
1752	50/51 O/C is BLOCKED (50/51 PH BLK)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	22	1	Yes
1753	50/51 O/C is ACTIVE (50/51 PH ACT)	50/51 Overcur.	OUT	On Off	*		*	LED			BO		60	23	1	Yes
1756	50N/51N is OFF (50N/51N OFF)	50/51 Overcur.	OUT	On Off	*		*	LED			BO		60	26	1	Yes
1757	50N/51N is BLOCKED (50N/51N BLK)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	27	1	Yes
1758	50N/51N is ACTIVE (50N/51N ACT)	50/51 Overcur.	OUT	On Off	*		*	LED			BO		60	28	1	Yes
1761	50(N)/51(N) O/C PICKUP (50(N)/51(N) PU)	50/51 Overcur.	OUT	*	On Off		m	LED			BO		160	84	2	Yes
1762	50/51 Phase A picked up (50/51 Ph A PU)	50/51 Overcur.	OUT	*	On Off		m	LED			BO		160	64	2	Yes
1763	50/51 Phase B picked up (50/51 Ph B PU)	50/51 Overcur.	OUT	*	On Off		m	LED			BO		160	65	2	Yes
1764	50/51 Phase C picked up (50/51 Ph C PU)	50/51 Overcur.	OUT	*	On Off		m	LED			BO		160	66	2	Yes
1765	50N/51N picked up (50N/51NPickedup)	50/51 Overcur.	OUT	*	On Off		m	LED			BO		160	67	2	Yes
1767	50-3 picked up (50-3 picked up)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	146	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
1768	50N-3 picked up (50N-3 picked up)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	147	2	Yes
1769	50-3 TRIP (50-3 TRIP)	50/51 Overcur.	OUT	*	on		*	LED			BO		60	148	2	Yes
1770	50N-3 TRIP (50N-3 TRIP)	50/51 Overcur.	OUT	*	on		*	LED			BO		60	149	2	Yes
1787	50-3 TimeOut (50-3 TimeOut)	50/51 Overcur.	OUT	*	*		*	LED			BO		60	167	2	Yes
1788	50N-3 TimeOut (50N-3 TimeOut)	50/51 Overcur.	OUT	*	*		*	LED			BO		60	168	2	Yes
1791	50(N)/51(N) TRIP (50(N)/51(N)TRIP)	50/51 Overcur.	OUT	*	on		m	LED			BO		160	68	2	No
1800	50-2 picked up (50-2 picked up)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	75	2	Yes
1804	50-2 Time Out (50-2 TimeOut)	50/51 Overcur.	OUT	*	*		*	LED			BO		60	49	2	Yes
1805	50-2 TRIP (50-2 TRIP)	50/51 Overcur.	OUT	*	on		m	LED			BO		160	91	2	No
1810	50-1 picked up (50-1 picked up)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	76	2	Yes
1814	50-1 Time Out (50-1 TimeOut)	50/51 Overcur.	OUT	*	*		*	LED			BO		60	53	2	Yes
1815	50-1 TRIP (50-1 TRIP)	50/51 Overcur.	OUT	*	on		m	LED			BO		160	90	2	No
1831	50N-2 picked up (50N-2 picked up)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	59	2	Yes
1832	50N-2 Time Out (50N-2 TimeOut)	50/51 Overcur.	OUT	*	*		*	LED			BO		60	60	2	Yes
1833	50N-2 TRIP (50N-2 TRIP)	50/51 Overcur.	OUT	*	on		m	LED			BO		160	93	2	No
1834	50N-1 picked up (50N-1 picked up)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	62	2	Yes
1835	50N-1 Time Out (50N-1 TimeOut)	50/51 Overcur.	OUT	*	*		*	LED			BO		60	63	2	Yes
1836	50N-1 TRIP (50N-1 TRIP)	50/51 Overcur.	OUT	*	on		m	LED			BO		160	92	2	No
1840	Phase A inrush detection (PhA InrushDet)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	101	2	Yes
1841	Phase B inrush detection (PhB InrushDet)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	102	2	Yes
1842	Phase C inrush detection (PhC InrushDet)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	103	2	Yes
1843	Cross blk: PhX blocked PhY (INRUSH X-BLK)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	104	2	Yes
1851	50-1 BLOCKED (50-1 BLOCKED)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	105	1	Yes
1852	50-2 BLOCKED (50-2 BLOCKED)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	106	1	Yes
1853	50N-1 BLOCKED (50N-1 BLOCKED)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	107	1	Yes
1854	50N-2 BLOCKED (50N-2 BLOCKED)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	108	1	Yes
2150	Invalid external voltage (Ext.V. in-valid)	Device, General	OUT	On Off				LED			BO					
2151	Valid external voltage (Ext.Volt. valid)	Device, General	OUT	On Off				LED			BO					
2152	Invalid external battery connect-ed (Battery invalid)	Device, General	OUT	On Off				LED			BO					
2153	External battery charging (Bat. charging)	Device, General	OUT	On Off				LED			BO					
2154	External battery is fully charged (Battery charged)	Device, General	OUT	On Off				LED			BO					
2155	External battery load is good (Bat.Load good)	Device, General	OUT	On Off				LED			BO					
2156	External battery load is low (Bat.Load low)	Device, General	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
2157	External battery load is insufficient (Battery empty)	Device, General	OUT	On Off			*	LED			BO					
2158	External battery is under test (Battery testing)	Device, General	OUT	On Off				LED			BO					
2159	External battery bad or defect (Battery bad)	Device, General	OUT	On Off				LED			BO					
2160	Temperature out of range (Temp > Range)	Device, General	OUT	On Off			*	LED			BO					
2163	External battery in recovery mode (Battery recover)	Device, General	OUT	On Off				LED			BO					
2164	Hardware charger defect (HW Err Charger)	Device, General	OUT	On Off			*	LED			BO					
2165	LIN detection defect (LIN defect)	Device, General	OUT	On Off				LED			BO					
2166	Charging not possible (No charging)	Device, General	OUT	On Off				LED			BO					
2167	Charging current too high (High current)	Device, General	OUT	On Off				LED			BO					
2168	Float charge mode defect (Float Chg.Err)	Device, General	OUT	On Off				LED			BO					
2169	Error during external battery test (Bat. Test Error)	Device, General	OUT	On Off				LED			BO					
2170	Temperature measurement error (Temp Meas.Err)	Device, General	OUT	On Off				LED			BO					
2172	GPS Module Error (GPS ModuleError)	Device, General	OUT	On Off			*	LED			BO					
2186	Error occurred on IO board (Error IO board)	Device, General	OUT	On Off	*		*	LED			BO					
2187	>BLOCK 27 under voltage prot. Vx (>BLOCK 27 Vx)	27/59 Vx	SP	On Off	*		*	LED	BI		BO					
2188	27 under volt. Vx switched OFF (27 Vx OFF)	27/59 Vx	OUT	On Off	*		*	LED			BO					
2189	27 under volt. Vx is BLOCKED (27 Vx BLOCKED)	27/59 Vx	OUT	On Off	On Off		*	LED			BO					
2190	27 under volt. Vx is ACTIVE (27 Vx ACTIVE)	27/59 Vx	OUT	On Off	*		*	LED			BO					
2191	27-1 under volt. Vx PICKUP (27-1 Vx PU)	27/59 Vx	OUT	*	On Off		*	LED			BO					
2192	27-1 under volt. Vx TRIP (27-1 Vx TRIP)	27/59 Vx	OUT	*	on		m	LED			BO					
2193	27-2 under volt. Vx PICKUP (27-2 Vx PU)	27/59 Vx	OUT	*	On Off		*	LED			BO					
2194	27-2 under volt. Vx TRIP (27-2 Vx TRIP)	27/59 Vx	OUT	*	on		m	LED			BO					
2195	>BLOCK 59 over voltage prot. Vx (>BLOCK 59 Vx)	27/59 Vx	SP	On Off	*		*	LED	BI		BO					
2196	59 over volt prot. Vx switched OFF (59 Vx OFF)	27/59 Vx	OUT	On Off	*		*	LED			BO					
2197	59 over voltage Vx is BLOCKED (59 Vx BLOCKED)	27/59 Vx	OUT	On Off	On Off		*	LED			BO					
2198	59 over voltage Vx is ACTIVE (59 Vx ACTIVE)	27/59 Vx	OUT	On Off	*		*	LED			BO					
2199	59-1 over voltage Vx PICKUP (59-1 Vx PU)	27/59 Vx	OUT	*	On Off		*	LED			BO					
2200	59-1 over voltage Vx TRIP (59-1 Vx TRIP)	27/59 Vx	OUT	*	on		m	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
2201	59-2 over voltage Vx PICKUP (59-2 Vx PU)	27/59 Vx	OUT	*	On Off		*	LED			BO					
2202	59-2 over voltage Vx TRIP (59-2 Vx TRIP)	27/59 Vx	OUT	*	on		m	LED			BO					
2203	27-1 Phase A Undervoltage pickup (27-1 PhA pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2204	27-1 Phase B Undervoltage pickup (27-1 PhB pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2205	27-1 Phase C Undervoltage pickup (27-1 PhC pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2206	27-1 Phase A PICKUP w/curr. Supervision (27-1 PhA PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2207	27-1 Phase B PICKUP w/curr. Supervision (27-1 PhB PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2208	27-1 Phase C PICKUP w/curr. Supervision (27-1 PhC PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2209	27-2 Phase A Undervoltage pickup (27-2 PhA pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2210	27-2 Phase B Undervoltage pickup (27-2 PhB pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2211	27-2 Phase C Undervoltage pickup (27-2 PhC pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2212	27-2 Phase A PICKUP w/curr. Supervision (27-2 PhA PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2213	27-2 Phase B PICKUP w/curr. Supervision (27-2 PhB PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2214	27-2 Phase C PICKUP w/curr. Supervision (27-2 PhC PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2215	27-1 Phase A Undervoltage TRIP (27-1 PhA TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO					
2216	27-1 Phase B Undervoltage TRIP (27-1 PhB TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO					
2217	27-1 Phase C Undervoltage TRIP (27-1 PhC TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO					
2218	27-2 Phase A Undervoltage TRIP (27-2 PhA TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO					
2219	27-2 Phase B Undervoltage TRIP (27-2 PhB TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO					
2220	27-2 Phase C Undervoltage TRIP (27-2 PhC TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO					
2221	59-1 Phase A picked up (59-1 PhA pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2222	59-1 Phase B picked up (59-1 PhB pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2223	59-1 Phase C picked up (59-1 PhC pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2224	59-1 Phase A TRIP (59-1 Ph A TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO					
2225	59-1 Phase B TRIP (59-1 Ph B TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO					
2226	59-1 Phase C TRIP (59-1 Ph C TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO					
2227	59-2 Phase A picked up (59-2 PhA pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2228	59-2 Phase B picked up (59-2 PhB pickup)	27/59 O/U Volt.	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
2229	59-2 Phase C picked up (59-2 PhC pickup)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
2230	59-2 Phase A TRIP (59-2 Ph A TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO					
2231	59-2 Phase B TRIP (59-2 Ph B TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO					
2232	59-2 Phase C TRIP (59-2 Ph C TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO					
2234	Manual Battery Test (MANUAL BAT TST)	Device, General	IntSP	On Off			*	LED	BI	FC TN	BO					
2240	Several indications routed (Multi. routing)	Device, General	OUT													
2604	>BLOCK 67/67-TOC (>BLK 67/67-TOC)	67 Direct. O/C	SP	*	*		*	LED	BI		BO					
2614	>BLOCK 67N/67N-TOC (>BLK 67N/67NTOC)	67 Direct. O/C	SP	*	*		*	LED	BI		BO					
2615	>BLOCK 67-2 (>BLOCK 67-2)	67 Direct. O/C	SP	*	*		*	LED	BI		BO		63	73	1	Yes
2616	>BLOCK 67N-2 (>BLOCK 67N-2)	67 Direct. O/C	SP	*	*		*	LED	BI		BO		63	74	1	Yes
2621	>BLOCK 67-1 (>BLOCK 67-1)	67 Direct. O/C	SP	*	*		*	LED	BI		BO		63	1	1	Yes
2623	>BLOCK 67N-1 (>BLOCK 67N-1)	67 Direct. O/C	SP	*	*		*	LED	BI		BO		63	3	1	Yes
2628	Phase A forward (Phase A forward)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	81	1	Yes
2629	Phase B forward (Phase B forward)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	82	1	Yes
2630	Phase C forward (Phase C forward)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	83	1	Yes
2632	Phase A reverse (Phase A reverse)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	84	1	Yes
2633	Phase B reverse (Phase B reverse)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	85	1	Yes
2634	Phase C reverse (Phase C reverse)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	86	1	Yes
2635	Ground forward (Ground forward)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	87	1	Yes
2636	Ground reverse (Ground reverse)	67 Direct. O/C	OUT	on	*		*	LED			BO		63	88	1	Yes
2637	67-1 is BLOCKED (67-1 BLOCKED)	67 Direct. O/C	OUT	On Off	On Off		*	LED			BO		63	91	1	Yes
2642	67-2 picked up (67-2 picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	67	2	Yes
2646	67N-2 picked up (67N-2 picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	62	2	Yes
2647	67-2 Time Out (67-2 Time Out)	67 Direct. O/C	OUT	*	*		*	LED			BO		63	71	2	Yes
2648	67N-2 Time Out (67N-2 Time Out)	67 Direct. O/C	OUT	*	*		*	LED			BO		63	63	2	Yes
2649	67-2 TRIP (67-2 TRIP)	67 Direct. O/C	OUT	*	on		m	LED			BO		63	72	2	Yes
2651	67/67-TOC switched OFF (67/67-TOC OFF)	67 Direct. O/C	OUT	On Off	*		*	LED			BO		63	10	1	Yes
2652	67/67-TOC is BLOCKED (67 BLOCKED)	67 Direct. O/C	OUT	On Off	On Off		*	LED			BO		63	11	1	Yes
2653	67/67-TOC is ACTIVE (67 ACTIVE)	67 Direct. O/C	OUT	On Off	*		*	LED			BO		63	12	1	Yes
2655	67-2 is BLOCKED (67-2 BLOCKED)	67 Direct. O/C	OUT	On Off	On Off		*	LED			BO		63	92	1	Yes
2656	67N/67N-TOC switched OFF (67N OFF)	67 Direct. O/C	OUT	On Off	*		*	LED			BO		63	13	1	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
2657	67N/67N-TOC is BLOCKED (67N BLOCKED)	67 Direct. O/C	OUT	On Off	On Off		*	LED			BO		63	14	1	Yes
2658	67N/67N-TOC is ACTIVE (67N ACTIVE)	67 Direct. O/C	OUT	On Off	*		*	LED			BO		63	15	1	Yes
2659	67N-1 is BLOCKED (67N-1 BLOCKED)	67 Direct. O/C	OUT	On Off	On Off		*	LED			BO		63	93	1	Yes
2660	67-1 picked up (67-1 picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	20	2	Yes
2664	67-1 Time Out (67-1 Time Out)	67 Direct. O/C	OUT	*	*		*	LED			BO		63	24	2	Yes
2665	67-1 TRIP (67-1 TRIP)	67 Direct. O/C	OUT	*	on		m	LED			BO		63	25	2	Yes
2668	67N-2 is BLOCKED (67N-2 BLOCKED)	67 Direct. O/C	OUT	On Off	On Off		*	LED			BO		63	94	1	Yes
2679	67N-2 TRIP (67N-2 TRIP)	67 Direct. O/C	OUT	*	on		m	LED			BO		63	64	2	Yes
2681	67N-1 picked up (67N-1 picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	41	2	Yes
2682	67N-1 Time Out (67N-1 Time Out)	67 Direct. O/C	OUT	*	*		*	LED			BO		63	42	2	Yes
2683	67N-1 TRIP (67N-1 TRIP)	67 Direct. O/C	OUT	*	on		m	LED			BO		63	43	2	Yes
2691	67/67N picked up (67/67N pickedup)	67 Direct. O/C	OUT	*	On Off		m	LED			BO		63	50	2	Yes
2692	67/67-TOC Phase A picked up (67 A picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	51	2	Yes
2693	67/67-TOC Phase B picked up (67 B picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	52	2	Yes
2694	67/67-TOC Phase C picked up (67 C picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	53	2	Yes
2695	67N/67N-TOC picked up (67N picked up)	67 Direct. O/C	OUT	*	On Off		*	LED			BO		63	54	2	Yes
2696	67/67N TRIP (67/67N TRIP)	67 Direct. O/C	OUT	*	on		m	LED			BO		63	55	2	Yes
2720	>Enable 50/67-(N)-2 (override 79 blk) (>Enable ANSI#-2)	P.System Data 2	SP	On Off	*		*	LED	BI		BO		40	20	1	Yes
4601	>52-a contact (OPEN, if bkr is open) (>52-a)	P.System Data 2	SP	On Off	*		*	LED	BI		BO					
4602	>52-b contact (OPEN, if bkr is closed) (>52-b)	P.System Data 2	SP	On Off	*		*	LED	BI		BO					
5143	>BLOCK 46 (>BLOCK 46)	46 Negative Seq	SP	*	*		*	LED	BI		BO		70	126	1	Yes
5145	>Reverse Phase Rotation (>Reverse Rot.)	P.System Data 1	SP	On Off	*		*	LED	BI		BO					
5147	Phase rotation ABC (Rotation ABC)	P.System Data 1	OUT	On Off	*		*	LED			BO		70	128	1	Yes
5148	Phase rotation ACB (Rotation ACB)	P.System Data 1	OUT	On Off	*		*	LED			BO		70	129	1	Yes
5151	46 switched OFF (46 OFF)	46 Negative Seq	OUT	On Off	*		*	LED			BO		70	131	1	Yes
5152	46 is BLOCKED (46 BLOCKED)	46 Negative Seq	OUT	On Off	On Off		*	LED			BO		70	132	1	Yes
5153	46 is ACTIVE (46 ACTIVE)	46 Negative Seq	OUT	On Off	*		*	LED			BO		70	133	1	Yes
5159	46-2 picked up (46-2 picked up)	46 Negative Seq	OUT	*	On Off		*	LED			BO		70	138	2	Yes
5165	46-1 picked up (46-1 picked up)	46 Negative Seq	OUT	*	On Off		*	LED			BO		70	150	2	Yes
5166	46-TOC picked up (46-TOC pickedup)	46 Negative Seq	OUT	*	On Off		*	LED			BO		70	141	2	Yes
5170	46 TRIP (46 TRIP)	46 Negative Seq	OUT	*	on		m	LED			BO		70	149	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
5171	46 Disk emulation picked up (46 Dsk pickedup)	46 Negative Seq	OUT	*	*		*	LED			BO					
5203	>BLOCK 81O/U (>BLOCK 81O/U)	81 O/U Freq.	SP	On Off	*		*	LED	BI		BO		70	176	1	Yes
5206	>BLOCK 81-1 (>BLOCK 81-1)	81 O/U Freq.	SP	On Off	*		*	LED	BI		BO		70	177	1	Yes
5207	>BLOCK 81-2 (>BLOCK 81-2)	81 O/U Freq.	SP	On Off	*		*	LED	BI		BO		70	178	1	Yes
5208	>BLOCK 81-3 (>BLOCK 81-3)	81 O/U Freq.	SP	On Off	*		*	LED	BI		BO		70	179	1	Yes
5209	>BLOCK 81-4 (>BLOCK 81-4)	81 O/U Freq.	SP	On Off	*		*	LED	BI		BO		70	180	1	Yes
5211	81 OFF (81 OFF)	81 O/U Freq.	OUT	On Off	*		*	LED			BO		70	181	1	Yes
5212	81 BLOCKED (81 BLOCKED)	81 O/U Freq.	OUT	On Off	On Off		*	LED			BO		70	182	1	Yes
5213	81 ACTIVE (81 ACTIVE)	81 O/U Freq.	OUT	On Off	*		*	LED			BO		70	183	1	Yes
5214	81 Under Voltage Block (81 Under V Blk)	81 O/U Freq.	OUT	On Off	On Off		*	LED			BO		70	184	1	Yes
5232	81-1 picked up (81-1 picked up)	81 O/U Freq.	OUT	*	On Off		*	LED			BO		70	230	2	Yes
5233	81-2 picked up (81-2 picked up)	81 O/U Freq.	OUT	*	On Off		*	LED			BO		70	231	2	Yes
5234	81-3 picked up (81-3 picked up)	81 O/U Freq.	OUT	*	On Off		*	LED			BO		70	232	2	Yes
5235	81-4 picked up (81-4 picked up)	81 O/U Freq.	OUT	*	On Off		*	LED			BO		70	233	2	Yes
5236	81-1 TRIP (81-1 TRIP)	81 O/U Freq.	OUT	*	on		m	LED			BO		70	234	2	Yes
5237	81-2 TRIP (81-2 TRIP)	81 O/U Freq.	OUT	*	on		m	LED			BO		70	235	2	Yes
5238	81-3 TRIP (81-3 TRIP)	81 O/U Freq.	OUT	*	on		m	LED			BO		70	236	2	Yes
5239	81-4 TRIP (81-4 TRIP)	81 O/U Freq.	OUT	*	on		m	LED			BO		70	237	2	Yes
6503	>BLOCK 27 undervoltage protection (>BLOCK 27)	27/59 O/U Volt.	SP	*	*		*	LED	BI		BO		74	3	1	Yes
6505	>27-Switch current supervision ON (>27 I SUPRVSN)	27/59 O/U Volt.	SP	On Off	*		*	LED	BI		BO		74	5	1	Yes
6506	>BLOCK 27-1 Undervoltage protection (>BLOCK 27-1)	27/59 O/U Volt.	SP	On Off	*		*	LED	BI		BO		74	6	1	Yes
6508	>BLOCK 27-2 Undervoltage protection (>BLOCK 27-2)	27/59 O/U Volt.	SP	On Off	*		*	LED	BI		BO		74	8	1	Yes
6509	>Failure: Feeder VT (>FAIL:FEEDER VT)	Measurem.Superv	SP	On Off	*		*	LED	BI		BO		74	9	1	Yes
6510	>Failure: Busbar VT (>FAIL: BUS VT)	Measurem.Superv	SP	On Off	*		*	LED	BI		BO		74	10	1	Yes
6513	>BLOCK 59 overvoltage protection (>BLOCK 59)	27/59 O/U Volt.	SP	*	*		*	LED	BI		BO		74	13	1	Yes
6530	27 Undervoltage protection switched OFF (27 OFF)	27/59 O/U Volt.	OUT	On Off	*		*	LED			BO		74	30	1	Yes
6531	27 Undervoltage protection is BLOCKED (27 BLOCKED)	27/59 O/U Volt.	OUT	On Off	On Off		*	LED			BO		74	31	1	Yes
6532	27 Undervoltage protection is ACTIVE (27 ACTIVE)	27/59 O/U Volt.	OUT	On Off	*		*	LED			BO		74	32	1	Yes
6533	27-1 Undervoltage picked up (27-1 picked up)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO		74	33	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
6534	27-1 Undervoltage PICKUP w/curr. superv (27-1 PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO		74	34	2	Yes
6537	27-2 Undervoltage picked up (27-2 picked up)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO		74	37	2	Yes
6538	27-2 Undervoltage PICKUP w/curr. superv (27-2 PU CS)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO		74	38	2	Yes
6539	27-1 Undervoltage TRIP (27-1 TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO		74	39	2	Yes
6540	27-2 Undervoltage TRIP (27-2 TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO		74	40	2	Yes
6565	59-Overvoltage protection switched OFF (59 OFF)	27/59 O/U Volt.	OUT	On Off	*		*	LED			BO		74	65	1	Yes
6566	59-Overvoltage protection is BLOCKED (59 BLOCKED)	27/59 O/U Volt.	OUT	On Off	On Off		*	LED			BO		74	66	1	Yes
6567	59-Overvoltage protection is ACTIVE (59 ACTIVE)	27/59 O/U Volt.	OUT	On Off	*		*	LED			BO		74	67	1	Yes
6568	59-1 Overvoltage V> picked up (59-1 picked up)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO		74	68	2	Yes
6570	59-1 Overvoltage V> TRIP (59-1 TRIP)	27/59 O/U Volt.	OUT	*	on		m	LED			BO		74	70	2	Yes
6571	59-2 Overvoltage V>> picked up (59-2 picked up)	27/59 O/U Volt.	OUT	*	On Off		*	LED			BO					
6573	59-2 Overvoltage V>> TRIP (59-2 TRIP)	27/59 O/U Volt.	OUT	*	on		*	LED			BO					
7551	50-1 InRush picked up (50-1 InRushPU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	80	2	Yes
7552	50N-1 InRush picked up (50N-1 InRushPU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	81	2	Yes
7556	InRush OFF (InRush OFF)	50/51 Overcur.	OUT	On Off	*		*	LED			BO		60	92	1	Yes
7557	InRush BLOCKED (InRush BLK)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	93	1	Yes
7558	InRush Ground detected (InRush Gnd Det)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	94	2	Yes
7559	67-1 InRush picked up (67-1 InRushPU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	84	2	Yes
7560	67N-1 InRush picked up (67N-1 InRushPU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	85	2	Yes
7563	>BLOCK InRush (>BLOCK InRush)	50/51 Overcur.	SP	*	*		*	LED	BI		BO					
7564	Ground InRush picked up (Gnd InRush PU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	88	2	Yes
7565	Phase A InRush picked up (Ia InRush PU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	89	2	Yes
7566	Phase B InRush picked up (Ib InRush PU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	90	2	Yes
7567	Phase C InRush picked up (Ic InRush PU)	50/51 Overcur.	OUT	*	On Off		*	LED			BO		60	91	2	Yes
10034	50-3 BLOCKED (50-3 BLOCKED)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	169	1	Yes
10035	50N-3 BLOCKED (50N-3 BLOCKED)	50/51 Overcur.	OUT	On Off	On Off		*	LED			BO		60	170	1	Yes
17566	Disturbance CFC Source (Dist.CFC Src)	Device, General	VI	*	*											
30053	Fault recording is running (Fault rec. run.)	Osc. Fault Rec.	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
31000	Q0 operationcounter= (Q0 OpCnt=)	Control Device	VI	*												
31001	Q1 operationcounter= (Q1 OpCnt=)	Control Device	VI	*												
31008	Q8 operationcounter= (Q8 OpCnt=)	Control Device	VI	*												

A.10 Group Alarms

No.	Description	Function No.	Description
140	Error Sum Alarm	177 178 2186 191 193	Fail Battery I/O-Board error Error IO board Error Offset Alarm NO calibr
160	Alarm Sum Event	162 163 167 175 176	Failure Σ I Fail I balance Fail V balance Fail Ph. Seq. I Fail Ph. Seq. V
161	Fail I Superv.	162 163	Failure Σ I Fail I balance
171	Fail Ph. Seq.	175 176	Fail Ph. Seq. I Fail Ph. Seq. V
501	Relay PICKUP	5159 5165 5166 1761 2691 - - -	46-2 picked up 46-1 picked up 46-TOC pickedup 50(N)/51(N) PU 67/67N pickedup - - -
511	Relay TRIP	5170 - 1791 2696 - - -	46 TRIP - 50(N)/51(N)TRIP 67/67N TRIP - - -

A.11 Measured Values

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
-	Number of TRIPs= (#of TRIPs=)	Statistics	-	-	-	-	-	CFC		
-	Operating hours greater than (OpHour>)	SetPoint(Stat)	-	-	-	-	-	CFC		
601	Ia (Ia =)	Measurement	134	157	No	9	1	CFC		
602	Ib (Ib =)	Measurement	160	145	Yes	3	1	CFC		
			134	157	No	9	2			
603	Ic (Ic =)	Measurement	134	157	No	9	3	CFC		
604	In (In =)	Measurement	134	157	No	9	4	CFC		
605	I1 (positive sequence) (I1 =)	Measurement	-	-	-	-	-	CFC		
606	I2 (negative sequence) (I2 =)	Measurement	-	-	-	-	-	CFC		
621	Va (Va =)	Measurement	134	157	No	9	6	CFC		
622	Vb (Vb =)	Measurement	134	157	No	9	7	CFC		
623	Vc (Vc =)	Measurement	134	157	No	9	8	CFC		
624	Va-b (Va-b=)	Measurement	160	145	Yes	3	2	CFC		
			134	157	No	9	9			
625	Vb-c (Vb-c=)	Measurement	134	157	No	9	10	CFC		
626	Vc-a (Vc-a=)	Measurement	134	157	No	9	11	CFC		
627	VN (VN =)	Measurement	134	118	No	9	1	CFC		
629	V1 (positive sequence) (V1 =)	Measurement	-	-	-	-	-	CFC		
630	V2 (negative sequence) (V2 =)	Measurement	-	-	-	-	-	CFC		
641	P (active power) (P =)	Measurement	134	157	No	9	12	CFC		
642	Q (reactive power) (Q =)	Measurement	134	157	No	9	13	CFC		
644	Frequency (Freq=)	Measurement	134	157	No	9	5	CFC		
645	S (apparent power) (S =)	Measurement	-	-	-	-	-	CFC		
680	Angle Va-Ia (Phi A =)	Measurement	-	-	-	-	-	CFC		
681	Angle Vb-Ib (Phi B =)	Measurement	-	-	-	-	-	CFC		
682	Angle Vc-Ic (Phi C =)	Measurement	-	-	-	-	-	CFC		
831	3Io (zero sequence) (3Io =)	Measurement	-	-	-	-	-	CFC		
832	Vo (zero sequence) (Vo =)	Measurement	134	118	No	9	2	CFC		
833	I1 (positive sequence) Demand (I1 dmd=)	Demand meter	-	-	-	-	-	CFC		
834	Active Power Demand (P dmd =)	Demand meter	-	-	-	-	-	CFC		
835	Reactive Power Demand (Q dmd =)	Demand meter	-	-	-	-	-	CFC		
836	Apparent Power Demand (S dmd =)	Demand meter	-	-	-	-	-	CFC		
837	I A Demand Minimum (IAdmdMin)	Min/Max meter	-	-	-	-	-	CFC		
838	I A Demand Maximum (IAdmdMax)	Min/Max meter	-	-	-	-	-	CFC		
839	I B Demand Minimum (IBdmdMin)	Min/Max meter	-	-	-	-	-	CFC		
840	I B Demand Maximum (IBdmdMax)	Min/Max meter	-	-	-	-	-	CFC		
841	I C Demand Minimum (ICdmdMin)	Min/Max meter	-	-	-	-	-	CFC		
842	I C Demand Maximum (ICdmdMax)	Min/Max meter	-	-	-	-	-	CFC		
843	I1 (positive sequence) Demand Minimum (I1dmdMin)	Min/Max meter	-	-	-	-	-	CFC		
844	I1 (positive sequence) Demand Maximum (I1dmdMax)	Min/Max meter	-	-	-	-	-	CFC		
845	Active Power Demand Minimum (PdMin=)	Min/Max meter	-	-	-	-	-	CFC		
846	Active Power Demand Maximum (PdMax=)	Min/Max meter	-	-	-	-	-	CFC		
847	Reactive Power Minimum (QdMin=)	Min/Max meter	-	-	-	-	-	CFC		

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
848	Reactive Power Maximum (QdMax=)	Min/Max meter	-	-	-	-	-	CFC		
849	Apparent Power Minimum (SdMin=)	Min/Max meter	-	-	-	-	-	CFC		
850	Apparent Power Maximum (SdMax=)	Min/Max meter	-	-	-	-	-	CFC		
851	Ia Min (Ia Min=)	Min/Max meter	-	-	-	-	-	CFC		
852	Ia Max (Ia Max=)	Min/Max meter	-	-	-	-	-	CFC		
853	Ib Min (Ib Min=)	Min/Max meter	-	-	-	-	-	CFC		
854	Ib Max (Ib Max=)	Min/Max meter	-	-	-	-	-	CFC		
855	Ic Min (Ic Min=)	Min/Max meter	-	-	-	-	-	CFC		
856	Ic Max (Ic Max=)	Min/Max meter	-	-	-	-	-	CFC		
857	I1 (positive sequence) Minimum (I1 Min=)	Min/Max meter	-	-	-	-	-	CFC		
858	I1 (positive sequence) Maximum (I1 Max=)	Min/Max meter	-	-	-	-	-	CFC		
859	Van Min (VanMin=)	Min/Max meter	-	-	-	-	-	CFC		
860	Van Max (VanMax=)	Min/Max meter	-	-	-	-	-	CFC		
861	Vbn Min (VbnMin=)	Min/Max meter	-	-	-	-	-	CFC		
862	Vbn Max (VbnMax=)	Min/Max meter	-	-	-	-	-	CFC		
863	Vcn Min (VcnMin=)	Min/Max meter	-	-	-	-	-	CFC		
864	Vcn Max (VcnMax=)	Min/Max meter	-	-	-	-	-	CFC		
865	Vab Min (VabMin=)	Min/Max meter	-	-	-	-	-	CFC		
867	Vab Max (VabMax=)	Min/Max meter	-	-	-	-	-	CFC		
868	Vbc Min (VbcMin=)	Min/Max meter	-	-	-	-	-	CFC		
869	Vbc Max (VbcMax=)	Min/Max meter	-	-	-	-	-	CFC		
870	Vca Min (VcaMin=)	Min/Max meter	-	-	-	-	-	CFC		
871	Vca Max (VcaMax=)	Min/Max meter	-	-	-	-	-	CFC		
872	V neutral Min (Vn Min =)	Min/Max meter	-	-	-	-	-	CFC		
873	V neutral Max (Vn Max =)	Min/Max meter	-	-	-	-	-	CFC		
874	V1 (positive sequence) Voltage Minimum (V1 Min =)	Min/Max meter	-	-	-	-	-	CFC		
875	V1 (positive sequence) Voltage Maximum (V1 Max =)	Min/Max meter	-	-	-	-	-	CFC		
876	Active Power Minimum (Pmin=)	Min/Max meter	-	-	-	-	-	CFC		
877	Active Power Maximum (Pmax=)	Min/Max meter	-	-	-	-	-	CFC		
878	Reactive Power Minimum (Qmin=)	Min/Max meter	-	-	-	-	-	CFC		
879	Reactive Power Maximum (Qmax=)	Min/Max meter	-	-	-	-	-	CFC		
880	Apparent Power Minimum (Smin=)	Min/Max meter	-	-	-	-	-	CFC		
881	Apparent Power Maximum (Smax=)	Min/Max meter	-	-	-	-	-	CFC		
882	Frequency Minimum (fmin=)	Min/Max meter	-	-	-	-	-	CFC		
883	Frequency Maximum (fmax=)	Min/Max meter	-	-	-	-	-	CFC		
884	Power Factor Maximum (PF Max=)	Min/Max meter	-	-	-	-	-	CFC		
885	Power Factor Minimum (PF Min=)	Min/Max meter	-	-	-	-	-	CFC		
888	Pulsed Energy Wp (active) (Wp(puls))	Energy	133	55	No	205	-	CFC		
889	Pulsed Energy Wq (reactive) (Wq(puls))	Energy	133	56	No	205	-	CFC		
901	Power Factor (PF =)	Measurement	134	157	No	9	14	CFC		
924	Wp Forward (WpForward)	Energy	133	51	No	205	-	CFC		
925	Wq Forward (WqForward)	Energy	133	52	No	205	-	CFC		
928	Wp Reverse (WpReverse)	Energy	133	53	No	205	-	CFC		
929	Wq Reverse (WqReverse)	Energy	133	54	No	205	-	CFC		
963	I A demand (Ia dmd=)	Demand meter	-	-	-	-	-	CFC		
964	I B demand (Ib dmd=)	Demand meter	-	-	-	-	-	CFC		
965	I C demand (Ic dmd=)	Demand meter	-	-	-	-	-	CFC		

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
2161	External battery voltage (Vbat =)	Measurement	-	-	-	-	-	CFC		
2162	System temperature (SysTemp =)	Measurement	-	-	-	-	-	CFC		
2171	External battery current (Ibat =)	Measurement	-	-	-	-	-	CFC		
2233	Vx = (Vx =)	Measurement	-	-	-	-	-	CFC		
30701	Pa (active power, phase A) (Pa =)	Measurement	-	-	-	-	-	CFC		
30702	Pb (active power, phase B) (Pb =)	Measurement	-	-	-	-	-	CFC		
30703	Pc (active power, phase C) (Pc =)	Measurement	-	-	-	-	-	CFC		
30704	Qa (reactive power, phase A) (Qa =)	Measurement	-	-	-	-	-	CFC		
30705	Qb (reactive power, phase B) (Qb =)	Measurement	-	-	-	-	-	CFC		
30706	Qc (reactive power, phase C) (Qc =)	Measurement	-	-	-	-	-	CFC		
30707	Power Factor, phase A (PFa =)	Measurement	-	-	-	-	-	CFC		
30708	Power Factor, phase B (PFb =)	Measurement	-	-	-	-	-	CFC		
30709	Power Factor, phase C (PFc =)	Measurement	-	-	-	-	-	CFC		

■

Literature

/1/ SIPROTEC 4 System Description; E50417-H1176-C151-A1

/2/ SIPROTEC DIGSI, Start UP; E50417-G1176-C152-A2

/3/ DIGSI CFC, Manual; E50417-H1176-C098-A5

/4/ SIPROTEC SIGRA 4, Manual; E50417-H1176-C070-A1

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 graphics 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

DIGSI V4.6 and higher allows up to 32 compatible SIPROTEC 4 devices to communicate with each other in an inter-relay communication network (IRC). The combination matrix defines which devices exchange which information.

Communication branch

A communications branch corresponds to the configuration of 1 to n users which 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 image which is displayed on devices with a large (graphic) display after pressing the control key is called 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 diagram 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-Technischen-Bundesanstalt PTB" in Braunschweig. The atomic clock unit of the PTB transmits this time via the long-wave time-signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 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.

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, → 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, → Fleeting indication, → 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 → ground.

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) in accordance with IEC 61850 are data packages that are transmitted cyclically and event-controlled via the Ethernet communication system. They serve for direct information exchange among the relays. This mechanism facilitates cross-communication between bay devices.

GPS

Global Positioning System. Satellites with atomic clocks on board orbit the earth twice a day in different parts 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 running time of a satellite and thus correct the transmitted GPS universal time.

Ground

The conductive ground whose electric potential can be set equal to zero in any point. In the area of ground electrodes the ground can have a potential deviating from zero. The term "Ground reference plane" is often used for this state.

Grounding

Grounding means that a conductive part is to connect via a grounding system to → ground.

Grounding

Grounding is the total of all means and measured used for grounding.

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 memorized in an HV field description file. Within the HV project description file, each field is allocated such an HV field description file by a reference to the file name.

HV project description

All data are exported once the configuration and parameterization of PCUs and sub-modules using ModPara has been completed. This data is split up into several files. One file contains details about the fundamental project structure. This also includes, for example, information detailing which fields exist in this project. This file is called a HV project description file.

ID

Internal double-point indication → Double-point indication

ID_S

Internal double point indication intermediate position 00 → Double-point indication

IEC

International Electrotechnical Commission

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

Worldwide communication standard for communication in substations. This standard allows devices from different manufacturers to interoperate on the station bus. Data transfer is accomplished through an Ethernet network.

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 among 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 fleeting → Fleeting indication, → Single-point indication

ISO 9001

The ISO 9000 ff range of standards defines measures used to ensure the quality of a product from the development to the manufacturing.

LFO filter

(Low Frequency Oscillation) Filter for low-frequency oscillation

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 acronym of "MaschinenLesbare FabrikateBezeichnung" (machine-readable product designation). It is equivalent to the 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 saved 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 link with the SIPROTEC 4 device is not necessary. You work with data which are stored in files.

OI_F

Output indication fleeting → Transient information

On-line

When working in online mode, there is a physical link to a SIPROTEC 4 device which can be implemented in various ways. This link 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 featuring a process bus interface can communicate directly with the 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 by a number of objects which are integrated in a hierarchical structure. Physically, a project consists of a series of folders and files containing project data.

Protection devices

All devices with a protective function and no control display.

Reorganizing

Frequent addition and deletion of objects creates memory areas that can no longer be used. By cleaning up projects, you can release these memory areas. However, a clean up also reassigns the VD addresses. As a consequence, all SIPROTEC 4 devices need 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 fleeting → Transient information, → Single-point indication

SICAM PAS (Power Automation System)

Substation control system: The range of possible configurations spans from integrated standalone systems (SICAM PAS and M&C with SICAM PAS CC on one computer) to separate hardware for SICAM PAS and SICAM PAS CC to distributed systems with multiple SICAM Station Units. The software is a modular system with basic and optional packages. SICAM PAS is a purely distributed system: the process interface is implemented by the use of bay units / remote terminal units.

SICAM Station Unit

The SICAM Station Unit with its special hardware (no fan, no rotating parts) and its Windows XP Embedded operating system is the basis for SICAM PAS.

SICAM WinCC

The SICAM WinCC operator control and monitoring system displays the condition of your network graphically, visualizes alarms and indications, archives the network data, allows to intervene 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 source object. However, all variants derived from the source object have the same VD address as the source object. For this reason, they always correspond to the same real SIPROTEC 4 device as the source 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 station, the national code, the area code and the user-specific phone number.

Users

DIGSI V4.6 and higher allows up to 32 compatible SIPROTEC 4 devices to communicate with each other in an inter-relay communication network. The individual participating devices are called users.

VD

A VD (Virtual Device) includes all communication objects and their properties and states that are used by a communication user through services. A VD can be a physical device, a module of a device or a software module.

VD address

The VD address is assigned automatically by DIGSI Manager. It exists only once in the entire project and thus serves to identify unambiguously a real SIPROTEC 4 device. The VD address assigned by DIGSI Manager must be transferred to the SIPROTEC 4 device in order to allow communication with DIGSI Device Editor.

VFD

A VFD (Virtual Field Device) includes all communication objects and their properties and states that are used by a communication user through services.

VI

Value Indication

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