SIPROTEC

Numerical Overhead Contact Line Protection for AC Traction Power Supply 7ST6

V4.0

Manual

E50417-G1176-C251-A2

Disclaimer of liability

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

The information in this manual is checked periodically, and necessary corrections will be included in future editions. We appreciate any suggested improvements.

We reserve the right to make technical improvements without notice.

4.00.03

7ST6 Manual
E50417-G1176-C251-A2

Preface

Purpose of this Manual

This manual describes the functions, operation, mounting, and placing into service of device 7ST6. In particular, one will find:

- Information on how to configure the device scope and a description of the device functions and setting options;
- Instructions for mounting and commissioning;
- Compilation of the technical specifications;
- Summary of the most significant data for the experienced user in the Appendix.

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

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.

Validity of the Manual

This manual is valid for: SIPROTEC® 4 Numerical Overhead Contact Line Protection for AC Traction Power Supply 7ST6 ; Firmware version V4.0.

Indication of Conformity

CE	This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23 EEC). This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 50081 and EN 61000-6-2 for EMC directive, and with the standard EN 60255-6 for the low-voltage directive. The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

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.

Instructions and Warnings

The warnings and notes contained in this manual serve for your own safety and for an appropriate lifetime of the device. Please observe them!
The following indicators and standard definitions are used:

DANGER!

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

Warning

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

Caution

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

Note:

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

WARNING!

Hazardous voltages are present in this electrical equipment during operation.

Failure to observe these precautions can result in death, personal injury, or serious material damage.

Only qualified personnel shall work on and in the vicinity of this equipment. The personnel must be thoroughly familiar with all warnings and maintenance procedures of this manual as well as the safety regulations.

Successful and safe operation of the device is dependent on proper transportation, storage, mounting and assembly and the observance of the warnings and instructions of the unit manual.

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

Definition

QUALIFIED PERSONNEL

Prerequisites to proper and safe operation of this product are proper transport, proper storage, setup, installation, operation, and maintenance of the product, as well as careful operation and servicing of the device within the scope of the warnings and instructions of this manual. Qualifications are:

- Training and Instruction to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
- Training and instruction (or other qualification) for switching, earthing, and designating devices and systems.
- Training in rendering first aid.

Typographic and Graphical Conventions

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

`Parameter names`

Designators of configuration or function parameters which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI®), are marked in bold letters of a monospace type style. This also applies to header bars for selection 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 Conditions`

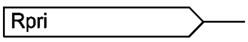
Possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI®), are additionally written in italics. This also applies to header bars for selection menus.

`“Annunciations”`

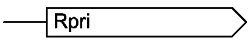
Designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotation marks.

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

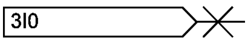
The following symbols are used in drawings:



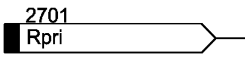
Device-internal logical input signal



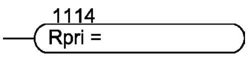
Device-internal (logical) output signal



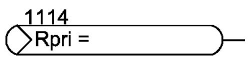
Internal input signal of an analog quantity



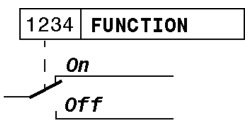
External binary input signal with number (binary input, input indication)



External binary output signal with number (device indication)

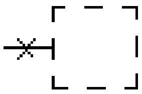


External binary output signal with number (device indication) used as input signal

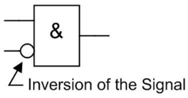


Example of a parameter switch designated **FUNCTION** with the address 1234 and the possible settings ON and OFF

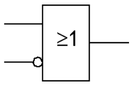
Besides these, graphical symbols are used according to IEC 60617-12 and IEC 60617-13 or symbols derived from these standards. Some of the most frequently used are listed below:



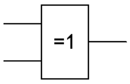
Input signal of an analog quantity



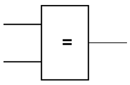
AND gate



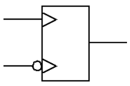
OR gate



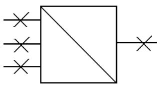
Exclusive–OR gate (antivalence): output is active, if only **one** of the inputs is active



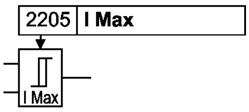
Equivalence: output is active, if **both** inputs are active or inactive at the same time



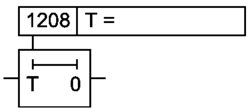
Dynamic inputs (edge–triggered) above with positive, below with negative edge



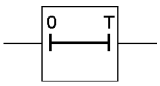
Formation of one analog output signal from a number of analog input signals



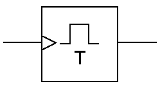
Limit stage with setting address and parameter designator (name)



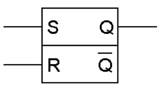
Timer (pickup delay T, example adjustable) with setting address and parameter designator (name)



Timer (dropout delay T, example non-adjustable)



Dynamic triggered pulse timer T (monoflop)



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

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Contents

Introduction 1

The SIPROTEC® 4 7ST6 is introduced in this chapter. The device is presented in its application, characteristics, and scope of functions.

1.1 Overall Operation

The SIPROTEC® 4 7ST6, Numerical Overhead Contact Line Protection for AC Traction Power Supply, is equipped with a powerful 32-bit microprocessor. All tasks are processed numerically, from acquisition of measured values up to commands to the circuit breakers. Figure 1-1 shows the basic structure of the 7ST63.

There are two different device versions, 7ST61 and 7ST63, which differ mainly by the size of their housing and the number of available inputs and outputs.

7ST61 housing size 1/2 * 19“ with 4-line display, 12 BI and 20 or 25 BO

7ST63 housing size 1/1 * 19“ with graphic display, control keys, 38 BI and 34 BO

Analog Inputs

The measuring inputs (MI) convert the currents and voltages coming from the transformers and adapt them to the level appropriate for the internal processing of the device. Depending on the version, the device is equipped with up to 3 current and voltage inputs.

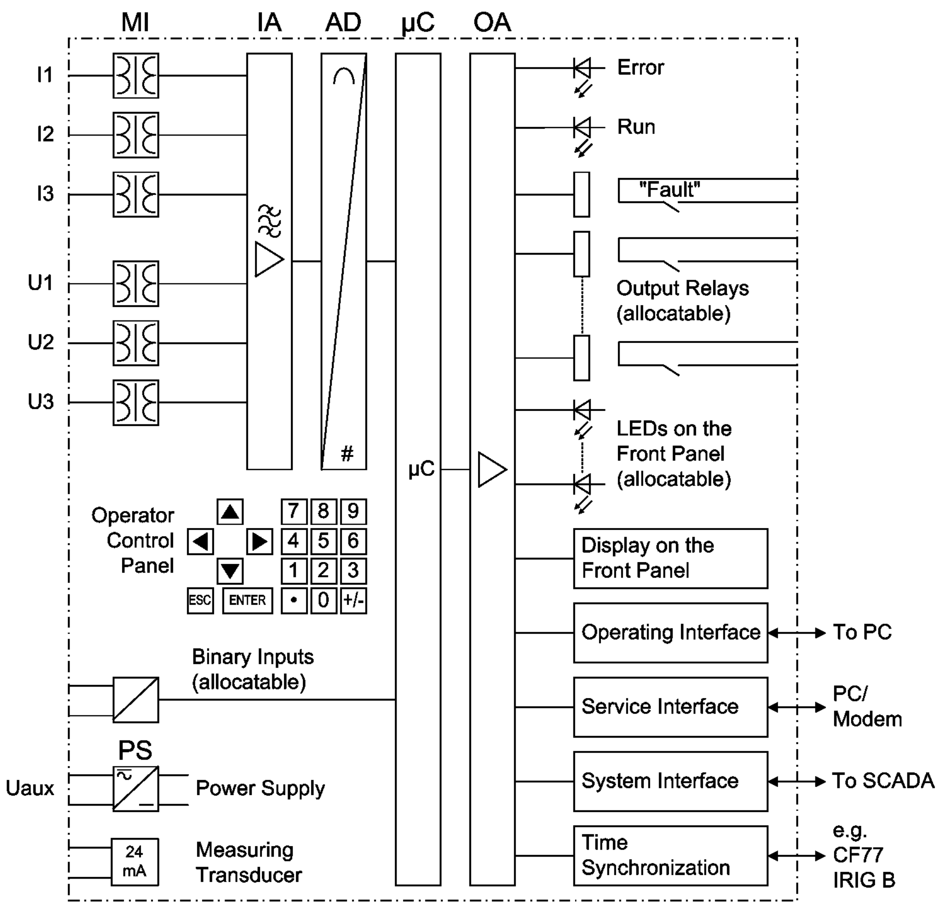

Figure 1-1 Hardware structure of the numerical overhead contact line protection 7ST63

The analog values are transferred to the IA input amplifier group.

The IA input amplifier group allows high impedance connection for analog input values and contains filters optimized with regard to bandwidth and processing speed for measured value processing.

In the analog/digital converter unit, the analog input values are sampled, digitized and supplied to the microcomputer system.

Microcomputer System

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

- Filtering and conditioning of the measured values
- Continuous monitoring of the measured values
- Monitoring of the pickup conditions for the individual protective functions
- Scanning of limit values and time sequences
- Control of signals for logic functions
- Deciding on trip and close commands
- Storage of indications, fault data and fault values for fault analysis purposes
- Management of the operating system and its functions, e.g. data memory, real-time clock, communication, interfaces, etc.

The information is provided via output amplifier OA.

Binary Inputs and Outputs

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

Front Elements

Optical indicators (LEDs) and a front LC display provide information on the function of the device and indicate events, states and measured values.

Integrated control and numeric keys in conjunction with the LCD facilitate local interaction with the local device. All information of the device can be accessed using the integrated control and numeric keys. The information includes protective and control settings, operating and fault indications, measured values and settings (see also Chapter 2 and SIPROTEC® 4 System Description, Order No. E50417-H1176-C151).

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

Serial Interfaces

Via the serial interface in the front panel the communication with a personal computer using the operating program DIGSI® is possible. This ensures convenient operation of all device functions.

The service interface can also be used for communication with a personal computer using DIGSI®. This interface is particularly well suited in case of hard wiring between the devices and the PC or in case of an operation via modem.

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

An additional interface is designed for time synchronization of the internal clock by means of external synchronization sources.

Further communication protocols can be implemented via additional interface modules.

Power Supply

These described functional units are supplied by a power supply PS with the necessary power in the different voltage levels. Brief supply voltage dips which may occur on short circuits in the auxiliary voltage supply of the power system are usually bridged by a capacitor (see also Technical Data, Chapter 4).

1.2 Application Scope

The SIPROTEC® 4 7ST6, Numerical Overhead Contact Line Protection for AC Traction Power Supply, is a selective and fast protection device for overhead contact lines with single- and multi-ended infeeds.

The device incorporates the functions which are normally required for the protection of an overhead contact line section and is therefore capable of universal application.

Protective Elements

The basic function of the device is the recognition of the distance to the fault with distance protection measurement. It is supplemented by a range of other protection functions:

When switching to a faulted line section, an undelayed trip signal can be output.

In the event of a failure of the measured voltages due to a fault in the secondary circuits (e.g. trip of the voltage transformer mcb or a fuse) the device can automatically revert to an emergency operation with an integrated time overcurrent protection (emergency time overcurrent protection), until the measured voltage again becomes available. There is an additional 3-stage definite/inverse time overcurrent protection operating in parallel to, and independent of, the distance protection. This time overcurrent protection has three current-independent stages and one current-dependent stage. For inverse time overcurrent protection, several curves of different standards are provided. The stages can be combined in any way. Moreover, a high-speed overcurrent protection function with a tripping time of less than 2 ms is integrated.

Most short-circuit functions work in conjunction with an integrated automatic reclose function which is designed for 8 reclosing attempts. Before reclosure, the validity of the reclosure can be checked by voltage and/or synchronism check by the device (this can be ordered as an option).

Beside the short-circuit protection functions described above, the device offers additional protection functions such as multiple-stage overvoltage and undervoltage protection, circuit breaker failure protection, and thermal overload protection, which protects the overhead contact line from excessive heating due to overloads. The fault locator supports fast location of the fault after a short-circuit. The inrush restraint feature is used for a clear distinction between operating and fault conditions during switching operations. The defrosting protection feature provides high-sensitivity detection of short-circuits during defrosting of the overhead contact line.

Control Functions

Depending on the ordered variant the device provides control functions which can be accomplished for activating and deactivating switchgear via the integrated operator panel, the system interface, binary inputs and a personal computer with the operating software 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 plausibility monitoring. The number of the primary equipment 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. switching error protection) 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 itself. Measurement quantities and resulting computed values can be displayed locally and communicated via the serial interfaces.

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

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

Communication

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

1.3 Characteristics

General Characteristics

- Powerful 32-bit microprocessor system
- Complete digital processing of measured values and control, from the sampling of the analog input values up to the closing and tripping commands to the circuit breakers
- Complete galvanic and reliable separation between internal processing circuits from the measurement, control, and power supply circuits by analog input transducers, binary inputs and outputs and the DC/DC or AC voltage converters
- Complete scope of functions which are normally required for the protection of a line feeder
- Simple device operation using the integrated operator panel or a connected personal computer with operator guidance
- Storage of fault indications as well as instantaneous values for fault recording

DistanceProtection

- Distance protection function with three zones (Z1, Z2, and Z3), high measuring accuracy and the ability to adapt to the given system conditions
- Impedance curve with “combined” or “polygonal” tripping characteristic can be selected
- for the direction characteristic settable to “forward“, “non-directional“, ”forward extended“, “reverse“;
- Combined tripping characteristic with separate setting of reach (absolute impedance value Z), angle and load limitation (resistance R);
- Adaptation to different switching states of the overhead contact line during operation is ensured by the changeover function of the impedance stages
- Instantaneous tripping when switching onto a fault;
- Inrush restraint possible for zone Z2 and higher;

Time Overcurrent Protection

- Full non-directional time overcurrent protection function (definite/inverse time) with three stages (very high set current stage I>>>, high set current stage I>>, overcurrent stage I>)
- Instantaneous tripping when switching onto a fault;
- Inrush restraint feature to prevent overfunctioning during the inrush phase

High Current Switch-onto-Fault Protection (optional)

- Very short tripping times (<2 ms) when the tripping threshold is exceeded
- Faults can be tripped as early as the first zero crossing of the current (in 16.7 Hz systems)

Emergency Time Overcurrent Protection

- Single-stage emergency time overcurrent protection (I> time overcurrent protection)
- Instantaneous tripping when switching onto a fault;
- Inrush restraint feature to prevent overfunctioning during the inrush phase
- Backup protection in case of measured voltage failure;

Voltage Protection (optional)

- Two-stage overvoltage and undervoltage detection
- Two overvoltage stages for the overhead contact line (U>>, U>)
- Two undervoltage stages for the overhead contact line (U<<, U<)

Thermal Overload Protection

- Determination of the overhead contact line temperature by creating a thermal profile of the object to be protected
- Adjustable thermal alarm level

Circuit Breaker Failure Protection (optional)

- 2 independent time stages
- Tripping by 2 independent, adjustable monitoring time stages
- Start by trip command of every internal protection function
- External start possible

Defrosting Protection

- Differential protection for defrosting current with configurable characteristic
- Back-up protection with two-stage definite-time overcurrent protection

Inrush Restraint (optional)

- Distinction between operating and fault condition by harmonics analysis
- Possibility of blocking selected protection functions

Automatic Reclosure Function (optional)

- Single or multiple reclosure (up to 8 reclosure attempts)
- With separate idle and operating times for the first 4 reclosure attempts
- Synchronism check before reclosing

Synchronism and Voltage Check (optional)

- Verification of the synchronous conditions before energisation;
- Fast measuring of voltage difference U_{Diff} of the phase angle difference φ_{Diff} and frequency difference f_{Diff}
- Alternatively, check of the de-energized state before energisation;
- Switching possible for asynchronous system conditions with prediction of the synchronization time
- Settable minimum and maximum voltage
- Verification of the synchronous conditions or de-energized state also possible before dispositive closing of the circuit breaker, with separate limit values;

Fault Locator (optional)

- Start by tripping command or dropout of the pickup, even with high-current switch-onto-fault protection
- Fault location output in Ω, kilometers or miles and % of line length;

Trip Load (optional)

- Detection and summation of interrupted currents
- Monitoring with It function (optional)
- Alarm output when limit is exceeded

Trip Circuit Supervision

- Integrated trip circuit supervision

User Defined Functions (optional)

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

Breaker Control

- Switchgear can be activated and de-activated manually via local control keys (7ST63), the programmable function keys, via the system interface (e.g. SITRAS ® SCS), or via the operating interface (using a personal computer and the DIGSI® software);
- Feedback on switching states via the circuit breaker auxiliary contacts (for commands with feedback)
- Plausibility monitoring of the circuit breaker positions and interlocking conditions for switching.

Monitoring Functions

- Availability of the device is greatly increased because of self-monitoring of the internal measurement circuits, power supply, hardware, and software
- Monitoring of overhead contact line voltage (Fuse Failure Monitoring);
- Monitoring of ambient temperature sensing
- Trip circuit supervision possible;
- Display of operating impedances and direction

Further Functions

- Battery buffered real time clock, which may be synchronized via a synchronization signal (e.g. DCF77, IRIG B via satellite receiver), binary input or system interface
- Continuous calculation and display of measured quantities on the front display
- Fault event memory (trip log) for the last 8 network faults (faults in the power system), with real time stamps
- Fault recording and data transfer for fault recording for a maximum time range of 15 s
- Statistics: Counter with the trip commands issued by the device, as well as recording of the current-time integrals, the fault current data and accumulation of the interrupted fault currents
- Communication with control center possible via serial interfaces (depending on the ordering variant), optionally via data line, modem or fibre optics;
- Commissioning aids such as connection and direction checks as well as circuit breaker test functions

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Functions

2

This chapter describes the numerous functions available on the SIPROTEC® 4 7ST6. It shows the setting possibilities for all the functions in maximum configuration. Instructions for deriving setting values and formulae, where required are provided.

Additionally it may be defined which functions are to be used.

2.1 General

A few seconds after the device is switched on, the initial display appears in the LCD. Depending on the device version either measured values (four-line display, device type 7ST61) or a single-phase switching diagram of the feeder status (graphic display, device type 7ST63) is displayed in the 7ST6.

Configuration of the device functions are made via the DIGSI® software from your PC. The procedure is described in detail in the SIPROTEC® 4 System Description, Order No. E50417-H1176-C151. Entry of password No. 7 (for setting modification) is required to modify configuration settings. Without the password, the settings may be read, but may not be modified and transmitted to the device.

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

2.1.1 Functional Scope

2.1.1.1 Configuration of the Functional Scope

The 7ST6 relay contains a series of protective and additional functions. The hardware and firmware provided is designed for this scope of functions. In addition the command functions can be matched to the system conditions. Individual functions can be activated or deactivated during the configuration procedure. The interaction of functions may also be modified.

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

Functions configured as ***Disabled*** are not processed by the 7ST6. There are no indications, and corresponding settings (functions, limit values) are not displayed during setting.

Note

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

2.1.1.2 Setting Notes

Configuration of Functional Scope

Configuration settings can be entered by using a PC and the software program DIGSI® and transferred via the operating interface of the device or via the service interface on the rear. Operation using DIGSI® is described in the SIPROTEC® 4 System Description, order no. E50417-H1176-C151.

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

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

Special Characteristics

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

If use of the setting group changeover function is desired, address 103 **Grp Chge OPTION** should be set to ***Enabled***. In this case, up to four different groups of settings may be changed quickly and easily during device operation (see also Subsection 2.1.4). Only one setting group may be selected and used if the setting is ***Disabled***.

The impedance characteristic valid for distance protection is selected under address 113 **DISTANCE CURVE**. You can choose between distance protection with combined tripping characteristic and distance protection with polygonal tripping characteristic (see Section 2.2).

The available protection and supplementary functions can be configured as ***Enabled*** or ***Disabled***.

When ordering devices, please note that the basic device version does not offer the full scope of functions. The table below shows which functions are provided in the basic device version, and which must be ordered separately if required:

Function	Provided in the Basic Version	Not Provided in the Basic Version
Distance Protection	X	
Time Overcurrent Protection	X	
Emergency Overcurrent Protection	X	
Thermal Overload Protection	X	
Ambient Temperature Sensing	X	
Trip Circuit Supervision	X	
Defrosting Protection	X	
Current-time Integral		X
High-Speed Overcurrent Protection		X
Inrush Restraint		X
Automatic Reclosure		X
Synchro-check		X
Circuit Breaker Failure Protection		X
Voltage Protection		X
Fault Locator		X

2.1.1.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Enabled	Setting Group Change Option
104	OSC. FAULT REC.	Disabled Enabled	Enabled	Oscillographic Fault Records
113	DISTANCE CURVE	Quadrilateral Combined	Combined	Distance Curve
122	InrushRestraint	Disabled Enabled	Enabled	2nd Harmonic Inrush Restraint
124	FCT HS O/C	Disabled Enabled	Enabled	Instantan. High-Speed O/C Protection
126	Back-Up O/C	Disabled Enabled	Enabled	Backup overcurrent
127	FCT Emerg. O/C	Disabled Enabled	Enabled	Emergency Overcurrent Protection
133	Auto Reclose	Disabled Enabled	Enabled	Auto-Reclose Function
135	Synchro-Check	Disabled Enabled	Enabled	Synchronism and Voltage Check
137	O/U VOLTAGE	Disabled Enabled	Enabled	Under / Overvoltage Protection
138	Fault Locator	Disabled Enabled	Enabled	Fault Locator
139	BREAKER FAILURE	Disabled Enabled	Enabled	Breaker Failure Protection
140	Trip Cir. Sup.	Disabled Enabled	Disabled	Trip Circuit Supervision
141	FCT It-Calc.	Disabled Start by Aux Start by TRIP	Start by TRIP	It Function (ampere-seconds)
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
143	Temp.Sens	Disabled -30 to +55 °C -55 to +55 °C	Disabled	Ambient Temperature Sensing
144	FCT DEFROSTING	Disabled Enabled	Disabled	Defrosting Protection Function

2.1.2 Device

The device requires some general information. This may be, for example, the type of indication to be issued in the event a power system fault occurs.

2.1.2.1 Trip Dependent Indications

The recording of indications masked to local LEDs, and the maintenance of spontaneous indications, can be made dependent on whether the device has issued a trip signal. This information is then not output if during a system disturbance one or more protection functions have picked up, but no tripping by the 7ST6 resulted because the fault was cleared by a different device (e.g. on another line). These indications are then limited to faults in the line to be protected.

The figure below illustrates the creation of the reset command for stored indications. When the relay drops out, stationary conditions (fault display Target on PU / Target on TRIP; Trip / No Trip) decide whether the new fault will be stored or reset.

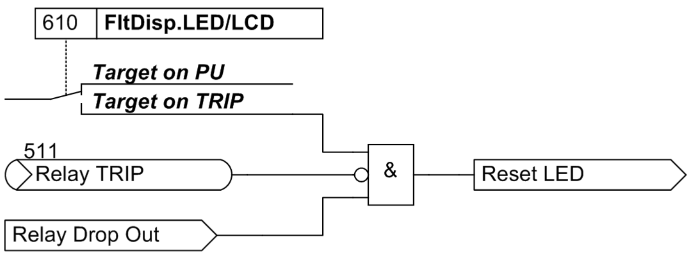


Figure 2-1 Creation of the reset command for the memory of LED and LCD displays

2.1.2.2 Spontaneous Indications on the Display

You can determine whether or not the most important data of a fault event is displayed automatically after the fault has occurred (see also “Fault indications” in Section 2.19.1 “Ancillary Functions”).

2.1.2.3 Setting Notes

Fault Indications

Pickup of a new protective function generally turns off any previously lit LEDs, so that only the latest fault is displayed at any time. It can be selected whether the stored LED displays and the spontaneous indications on the display appear upon renewed pickup, or only after a renewed trip signal is issued. In order to enter the desired type of display, select the submenu Device in the SETTINGS menu. At address 610 **FltDisp.LED/LCD** the two alternatives ***Target on PU*** and ***Target on TRIP*** (“No trip - no flag”) are offered.

For devices with graphical display use parameter 615 **Spont. FltDisp.** to specify whether or not a spontaneous indication will appear automatically on the display (***YES***) or not (***NO***). For devices with text display such indications will appear after a system fault by any means.

You can set at address 620 **T Backlight on** how long the display backlight will remain on after an entry on the integrated keypad.

2.1.2.4 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
610	FltDisp.LED/LCD	Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
615	Spont. FltDisp.	NO YES	NO	Spontaneous display of flt.annun-ciations
620	T Backlight on	1 .. 1000 min	60 min	Time Backlight on

2.1.2.5 Information List

No.	Information	Type of In-formation	Comments
-	Test mode	IntSP	Test mode
-	DataStop	IntSP	Stop data transmission
-	SynchClock	IntSP_Ev	Clock Synchronization
-	>Light on	SP	>Back Light on
-	HWTestMod	IntSP	Hardware Test Mode
-	Error FMS1	OUT	Error FMS FO 1
-	Error FMS2	OUT	Error FMS FO 2
-	Brk OPENED	IntSP	Breaker OPENED
-	FdrEARTHED	IntSP	Feeder EARTHED
1	Not configured	SP	No Function configured
2	Non Existent	SP	Function Not Available
3	>Time Synch	SP	>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
55	Reset Device	OUT	Reset Device
56	Initial Start	OUT	Initial Start of Device
60	Reset LED	OUT_Ev	Reset LED
67	Resume	OUT	Resume
68	Clock SyncError	OUT	Clock Synchronization Error
69	DayLightSavTime	OUT	Daylight Saving Time
70	Settings Calc.	OUT	Setting calculation is running
71	Settings Check	OUT	Settings Check
72	Level-2 change	OUT	Level-2 change
73	Local change	OUT	Local setting change
110	Event Lost	OUT_Ev	Event lost
113	Flag Lost	OUT	Flag Lost
125	Chatter ON	OUT	Chatter ON
140	Error Sum Alarm	OUT	Error with a summary alarm
144	Error 5V	OUT	Error 5V
158	Fail.TEMPSENS	OUT	Failure of outdoor temp. sensing
160	Alarm Sum Event	OUT	Alarm Summary Event
177	Fail Battery	OUT	Failure: Battery empty

No.	Information	Type of Information	Comments
181	Error A/D-conv.	OUT	Error: A/D converter
182	Alarm Clock	OUT	Alarm: Real Time Clock
183	Error Board 1	OUT	Error Board 1
184	Error Board 2	OUT	Error Board 2
185	Error Board 3	OUT	Error Board 3
186	Error Board 4	OUT	Error Board 4
187	Error Board 5	OUT	Error Board 5
188	Error Board 6	OUT	Error Board 6
189	Error Board 7	OUT	Error Board 7
190	Error Board 0	OUT	Error Board 0
192	-	OUT	-
193	Alarm adjustm.	OUT	Alarm: Analog input adjustment invalid

2.1.3 Power System Data 1

The device requires certain basic data regarding the protected equipment, so that the device will be compatible with its desired application. This comprises e.g. nominal system data, nominal data of transformers, polarity ratios and their physical connections, in certain cases circuit breaker properties, and similar. Furthermore, there are a number of settings associated with all functions rather than a specific protection, control or monitoring function. These data can normally only be changed from a PC running DIGSI® and are discussed in this subsection.

2.1.3.1 Setting Notes

General

In DIGSI® double-click on **Settings** to display the relevant selection. A dialog box with the tabs General, Transformer data, System data, Voltage transformers and Circuit breaker will open under **Power System Data 1**, in which you can configure the individual parameters. Thus, the following subsections are structured accordingly.

At address 245 **BI CONTROL** you specify the control of the binary inputs for the zone/catenary changeover (***Edge***/***Level***).

Transformer Data

In address 201 **CT Starpoint** the polarity of the current transformers must be stated. This setting determines the measuring direction of the device (forwards = line direction).

The measured value connections can be found in the Appendix under A.3.

At address 202 **CT PRIMARY** you set the primary rated CT current (overhead contact line current). The secondary rated current is set in address 203 **CT SECONDARY**.

At addresses 204 **Unom PRIMARY** and 205 **Unom SECONDARY**, information is entered regarding the primary and secondary current 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 incorrectly calculate primary data.

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

Transformer Data for Auto-transformer Systems

At address 206 **IF CT STARPOINT** the polarity of the current transformers (negative feeder current) must be stated. This setting determines the measuring direction of the device (forwards = line direction).

The measured value connections can be found in the Appendix under A.3.

At address 207 **IF CT PRIMARY** you set the primary rated CT current (negative feeder current).

At addresses 209 **UF PRIMARY** and 210 **UF SECONDARY**, information regarding the primary and secondary current ratings of the current transformers (negative feeder voltage) is entered.

Please heed the detailed description given in chapter 2.21!

In auto-transformer systems, the protection functions can evaluate either

- The summation current of the overhead contact line current and the negative feeder current, or
- The overhead contact line current

In the parameter **CURRENT I1, I2** (address 213) you specify which current will be fed to the protection functions for evaluation. If you want the summation current to be processed by the protection functions, set address 213 to ***Sum I1, I2***. The vectors of the overhead contact line current and the negative feeder current are added.

Note

If at address 213 the parameter **CURRENT I1, I2** is set to ***Sum I1, I2***, the setting of jumper X600 on the C-I/O 13 board must be changed for the summation! The default setting of this jumper on delivery is “without summation”!

Transformer Data for Defrosting

In address 211 **IX CT STARPOINT** the polarity of the current transformers (defrosting current) must be stated. This setting determines the measuring direction of the device (forwards = line direction).

At address 212 **IX CT PRIMARY** you set the primary rated CT current (defrosting current).

Transformer Data for Synchro-check

If in the Functional Scope of the device the synchro-check function = ***Enabled*** (address 135) has been configured, the following parameters must be set in the **P.System Data 1**:

At address 215 **Uline/Uref** you set the matching factor for the different transformers of the overhead contact line Vline and of the reference voltage Vref.

System Data

The permissible rated frequencies depend on the device variant: 16.7 Hz or 25 to 60 Hz. In the second variant, the rated frequency can be changed at address 230 **Rated Frequency**; options are 25 Hz, 50 Hz and 60 Hz.

The 7ST6 device supports several line sections with different reactance per unit length characteristics for the conversion of a fault impedance into a fault distance. The number of line sections with different reactance per unit length characteristics can be set in address 234 **No. SECTIONS**. The settings that you make here determine the setting parameters for the reactance per unit length characteristics that will be shown in the **P.System Data 2** in the setting sheet Power System.

Address 236 **Distance Unit** allows to determine the unit of length (***km*** or ***Miles***) for the fault location indications. This parameter is not relevant if no fault detection is available. Changing the length unit will not result in an automatic conversion between the systems. Such conversions must be entered at the appropriate addresses.

Circuit Breaker

At address 239 **T-CB close** the operating time of the connected circuit breaker is set for the CLOSE command. This operating time will be taken into account by the **Sync. Check** function when closing the circuit breaker.

At address 238 the operating time of the circuit breaker **T-CB open** is set for the TRIP command. This time is taken into account for tripping to determine the duration of the current-time integral.

In address 240 the minimum trip command duration **TMin TRIP CMD** is set. This setting applies to all protective functions that initiate tripping. It also determines the length of the trip pulse when a circuit breaker trip test is initiated via the device. Each trip command is extended by at least the time set here. This time must be chosen to ensure a reliable tripping of the breaker. This parameter can only be altered with DIGSI® under **Additional Settings**.

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

The 7ST6 allows a circuit breaker test during operation by means of a tripping and a closing command entered on the front panel or via DIGSI®. The duration of the trip command is set as explained above. Address 242 **T-CBtest-dead** determines the duration from the end of the trip command until the start of the close command for this test. It should not be less than 0.1 s.

At address 243 **TEST CB CIRCUIT** you can choose the trip circuits in which a circuit breaker test is to be performed. For an initial test, you should test both breaker circuits individually and one after the other in order to achieve a maximum of security.

2.1.3.2 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
201	CT Starpoint	towards Line towards Busbar	towards Line	CT Starpoint
202	CT PRIMARY	10 .. 5000 A	1000 A	CT Rated Primary Current
203	CT SECONDARY	1A 5A	1A	CT Rated Secondary Current
204	Unom PRIMARY	1.0 .. 150.0 kV	15.0 kV	Rated Primary Voltage
205	Unom SECONDARY	50.0 .. 130.0 V	100.0 V	Rated Secondary Voltage (Ph-Ph)
206	IF CT STARPOINT	towards Line towards Busbar	towards Line	IF CT Starpoint
207	IF CT PRIMARY	10 .. 5000 A	1000 A	CT Rated Primary Current IF
209	UF PRIMARY	1.0 .. 150.0 kV	15.0 kV	Rated Primary Voltage UF
210	UF SECONDARY	50.0 .. 130.0 V	100.0 V	Rated Secondary Voltage UF
211	IX CT STARPOINT	towards Line towards Busbar	towards Line	IX CT Starpoint
212	IX CT PRIMARY	10 .. 5000 A	1000 A	CT Rated Primary Current IX
213	CURRENT I1, I2	Separate I1, I2 Sum I1, I2	Separate I1, I2	Current Inputs I1, I2
215	Uline/Uref	0.50 .. 2.00	1.00	Matching Ratio Uline / Uref
230	Rated Frequency	50 Hz 60 Hz 25 Hz 16,7 Hz	50 Hz	Rated Frequency
234	No. SECTIONS	1 Section 2 Sections 3 Sections 4 Sections 5 Sections	1 Section	Number of Line Sections
236	Distance Unit	km Miles	km	Distance measurement unit
238	T-CB open	0.001 .. 0.200 sec	0.030 sec	CB Operating Time for Opening
239	T-CB close	0.01 .. 0.60 sec	0.06 sec	Closing (operating) time of CB
240A	TMin TRIP CMD	0.01 .. 32.00 sec	0.15 sec	Minimum TRIP Command Duration
241A	TMax CLOSE CMD	0.01 .. 32.00 sec	1.00 sec	Maximum Close Command Duration
242	T-CBtest-dead	0.10 .. 30.00 sec	0.10 sec	Dead Time for CB test-autoreclosure

Addr.	Parameter	Setting Options	Default Setting	Comments
243	TEST CB CIRCUIT	Main Trip Backup Trip Both	Main Trip	Trip Circuit Test
245	BI CONTROL	Edge Level	Edge	Control of BI for Changeover Functions

2.1.3.3 Information List

No.	Information	Type of In-formation	Comments
11	>Annunc. 1	SP	>User defined annunciation 1
12	>Annunc. 2	SP	>User defined annunciation 2
13	>Annunc. 3	SP	>User defined annunciation 3
14	>Annunc. 4	SP	>User defined annunciation 4

2.1.4 Change Group

2.1.4.1 Purpose of the Setting Groups

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

A setting group includes the setting values for all functions that have been selected as ***Enabled*** during configuration (see Section 2.1.1.2). In 7ST6 devices, four independent setting groups (A to D) are available. Whereas setting values and options may vary, the selected scope of functions is the same for all groups.

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

2.1.4.2 Setting Notes

General

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

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

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

2.1.4.3 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

2.1.4.4 Information List

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

2.1.5 Power System Data 2

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

2.1.5.1 Setting Notes

System Data

The parameters of Power System are only accessible if address 138 **Fault Locator** has been set to ***Enabled*** in the functional scope.

Depending on the settings under **P.System Data 1**, you set the reactance per unit length characteristics for up to 5 line sections in the **P.System Data 2** under Power System. These values are needed for conversion of the fault impedance into a fault distance.

The reactance per unit length characteristic X´ is entered as a secondary value. At address 1110 **X1 SEC** you set the secondary reactance per unit length characteristic for the 1st line section in Ω/km if the unit length set under System Data is ***km*** (address 236, see Subsection 2.1.3.1).

At address 1111 **d1** you set the corresponding line length of the 1st line section. The device needs these values for conversion of the fault impedance into a fault distance.

At address 1160 **X1 SEC** you set the secondary reactance per unit length characteristic for the 1st line section in Ω/mile if the unit length set under System Data is ***Miles*** (address 236, see Subsection 2.1.3.1).

At address 1161 **d1** you set the corresponding line length of the 1st line section. The device needs these values for conversion of the fault impedance into a fault distance.

Manual Close

At address 1150 **SI Time Man.Cl** you set the action time (seal-in time) for the manual close signal. The parameter **SI Time Man.Cl** can only be altered with DIGSI® under Additional Settings.

At address 1151 **SYN.MAN.CL** you specify whether a synchro-check (***with Sync-check***) will be performed in case of a manual closure or not (***w/o Sync-check***).

2.1.5.2 Settings

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

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1110	X1 SEC	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 1st Section
		5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1111	d1		1.00 .. 200.00 km; 0	20.00 km	Line Length 1st Section
1112	X2 SEC	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 2nd Section
		5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1113	d2		1.00 .. 200.00 km; 0	20.00 km	Line Length 2nd Section
1114	X3 SEC	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 3rd Section
		5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1115	d3		1.00 .. 200.00 km; 0	20.00 km	Line Length 3rd Section
1116	X4 SEC	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 4th Section
		5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1117	d4		1.00 .. 200.00 km; 0	20.00 km	Line Length 4th Section
1118	X5 SEC	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 5th Section
		5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1119	d5		1.00 .. 200.00 km; 0	20.00 km	Line Length 5th Section
1150A	SI Time Man.Cl		0.01 .. 30.00 sec	0.30 sec	Seal-in Time after MANUAL closures
1151	SYN.MAN.CL		with Sync-check w/o Sync-check NO	w/o Sync-check	Manual CLOSE COMMAND generation
1160	X1 SEC	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 1st Section
		5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1161	d1		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 1st Section
1162	X2 SEC	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 2nd Section
		5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1163	d2		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 2nd Section
1164	X3 SEC	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 3rd Section
		5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1165	d3		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 3rd Section

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1166	X4 SEC	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 4th Section
		5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1167	d4		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 4th Section
1168	X5 SEC	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 5th Section
		5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1169	d5		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 5th Section

2.1.5.3 Information List

No.	Information	Type of Information	Comments
52	ProtActive	IntSP	At Least 1 Protection Funct. is Active
126	ProtON/OFF	IntSP	Protection ON/OFF (via system port)
301	Pow.Sys.Flt.	VI	Power System fault
302	Fault Event	VI	Fault Event
356	>Manual Close	SP	>Manual close signal
357	>CloseCmd.Blo	SP	>Block all close commands from external
361	>FAIL:Feeder VT	SP	>Failure: Feeder VT (MCB tripped)
365	>Ctrl Select.	SP	>Select: Control by BI or SYS interface
378	>CB faulty	SP	>CB faulty
385	>Lockout SET	SP	>Lockout SET
386	>Lockout RESET	SP	>Lockout RESET
510	Relay CLOSE	OUT	General CLOSE of relay
511	Relay TRIP	OUT	Relay GENERAL TRIP command
530	LOCKOUT	IntSP	LOCKOUT is active
536	Final Trip	OUT	Final Trip
545	PU Time	VI	Time from Pickup to drop out
546	TRIP Time	VI	Time from Pickup to TRIP
561	Man.Clos.Detect	OUT	Manual close signal detected
562	Man.Close Cmd	OUT	CB close command for manual closing
563	CB Alarm Supp	OUT	CB alarm suppressed
1191	Pckup TstUnit	OUT	Pickup autom. testunit overh.cont.line
2640	forward dir.	OUT_Ev	Forward direction
2641	reverse dir.	OUT_Ev	Reverse direction
2730	>CB Ready	SP	>Circuit breaker READY for reclosing
4601	>Brk Aux NO	SP	>Breaker contact (OPEN, if bkr is open)
4602	>Brk Aux NC	SP	>Breaker contact(OPEN, if bkr is closed)
13951	>VT MCB UF	SP	>U feeder side VT MCB tripped
13952	>VT MCB Uref	SP	>U reference side VT MCB tripped
13990	Relay PU	OUT	Relay General pickup
13991	Protection PU	OUT	General protective PICKUP of device
13992	Protection TRIP	OUT	General protective TRIP of device

2.1.6 Oscillographic Fault Records

2.1.6.1 Functional Description

The 7ST6 numerical overhead contact line protection is equipped with a fault recording function.

The instantaneous values of the measurement quantities i (overhead contact line current) and u (overhead contact line voltage) are recorded in all variants of the 7ST6 device.

In devices with 3 measuring inputs (3xI, 3xU), the instantaneous value of the measurement quantity i_X (defrosting current) is recorded as well.

In protection devices with the maximum scope of functions, the following instantaneous values are additionally recorded:

i_{F-} Current of the negative feeder

u_{F-} Voltage of the negative feeder

u_{Ref} Busbar reference voltage

i1+i2 Summation current from I1 and I2

Furthermore, the following r.m.s. values of the defrosting protection are recorded:

id> Differential current

ir Restraint current

The 7ST6 works with an automatic frequency correction, i.e. the sampling interval is automatically adapted to frequency changes. The table below shows the sampling rates and sampling intervals for the individual rated frequencies:

Table 2-1 Sampling rates and sampling intervals of the available rated frequencies

Rated frequency [Hz]	Sampling rate	Sampling interval [ms]
16.7	48	1.25
25	32	1.25
50	16	1.25
60	16	1.04

For a fault, the data are stored for an adjustable period of time, but no more than 5 seconds per fault. A total of 8 records can be saved within 15 s. The fault record memory is automatically updated with every new fault, so no acknowledgment for previously recorded faults is required. The storage of fault values can be started by pickup of a protection function, as well as via binary input and via the serial interface.

The data can be retrieved via the serial interfaces by means of a personal computer and evaluated with the protection data processing program DIGSI® and the graphic analysis software SIGRA 4. The latter graphically represents the data recorded during the system fault and calculates additional information such as the impedance or r.m.s. values from the measured values. A selection may be made as to whether the currents and voltages are represented as primary or secondary values. Binary signal traces (marks) of particular events, e.g. “fault detection”, “tripping” are also represented.

If the device has a serial system interface, the fault recording data can be passed on to a central device via this interface. The data is evaluated by applicable programs in the central device. Currents and voltages are referred to their maximum values, scaled to their rated values and prepared for graphic representation. Binary signal traces (marks) of particular events, e.g. “fault detection”, “tripping” are also represented.

In the event of transfer to a central device, the request for data transfer can be executed automatically and can be selected to take place after each fault detection by the protection, or only after a trip.

2.1.6.2 Setting Notes

General

Other settings pertaining to fault recording (waveform capture) are specified in the submenu **Oscillographic Fault Records** of the **Settings** menu. Waveform capture makes a distinction between the trigger instant for an oscillographic record and the criterion to save the record (address 402 **WAVEFORMTRIGGER**). This setting is only possible via DIGSI® at **Additional Settings**. Normally the trigger is the pickup of a protective 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.

Recording of an oscillographic fault record starts with the pickup by a protective function and ends with the dropout of the last pickup of a protective function. Usually this is also the extent of a fault recording (address 403 **WAVEFORM DATA** = ***Fault event***). If automatic reclosure is implemented, the entire system disturbance — possibly with several reclose attempts — up to the ultimate fault clearance can be stored (address 403 **WAVEFORM DATA** = ***Pow.Sys.Flt.***). This facilitates the representation of the entire system fault history, but also consumes storage capacity during the auto-reclosure dead time(s). This setting is only possible via DIGSI® at **Additional Settings**.

The actual storage time begins at the pre-fault time **PRE. TRIG. TIME** (address 411) ahead of the reference instant, and ends at the post-fault time **POST REC. TIME** (address 412) after the storage criterion has reset. The maximum recording duration to each fault (**MAX. LENGTH**) is entered in address 410.

The fault recording can also be triggered via a binary input, via the keypad on the front of the device or with a PC via the operation or service interface. The storage is then dynamically triggered. The length of the fault recording is set in address 415 **BinIn CAPT.TIME** (maximum length however is **MAX. LENGTH**, address 410). Pre-fault and post-fault times will be included. If the binary input time is set for ∞, then the length of the record equals the time that the binary input is activated (static), or the **MAX. LENGTH** setting in address 410, whichever is shorter.

2.1.6.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
402A	WAVEFORMTRIGGE R	Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403A	WAVEFORM DATA	Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
410	MAX. LENGTH	0.30 .. 5.00 sec	1.00 sec	Max. length of a Waveform Capture Record
411	PRE. TRIG. TIME	0.05 .. 0.50 sec	0.10 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input

2.1.6.4 Information List

No.	Information	Type of Information	Comments
-	FltRecSta	IntSP	Fault Recording Start
4	>Trig.Wave.Cap.	SP	>Trigger Waveform Capture

2.2 Distance Protection

The type of characteristics used for the distance protection is specified in the Functional Scope under parameter 113 **DISTANCE CURVE**. Combined or polygonal tripping characteristics are available.

2.2.1 Enabling the Distance Protection

The distance protection requires several enable signals. These enable signals ensure that the distance protection works only with measurement signals that allow precise measurement of the impedance. The enabling of the distance protection is also influenced by a number of control signals which allow a dynamic enabling or blocking of this function. The figure below shows a cutout of the control logic that is responsible for enabling the function.

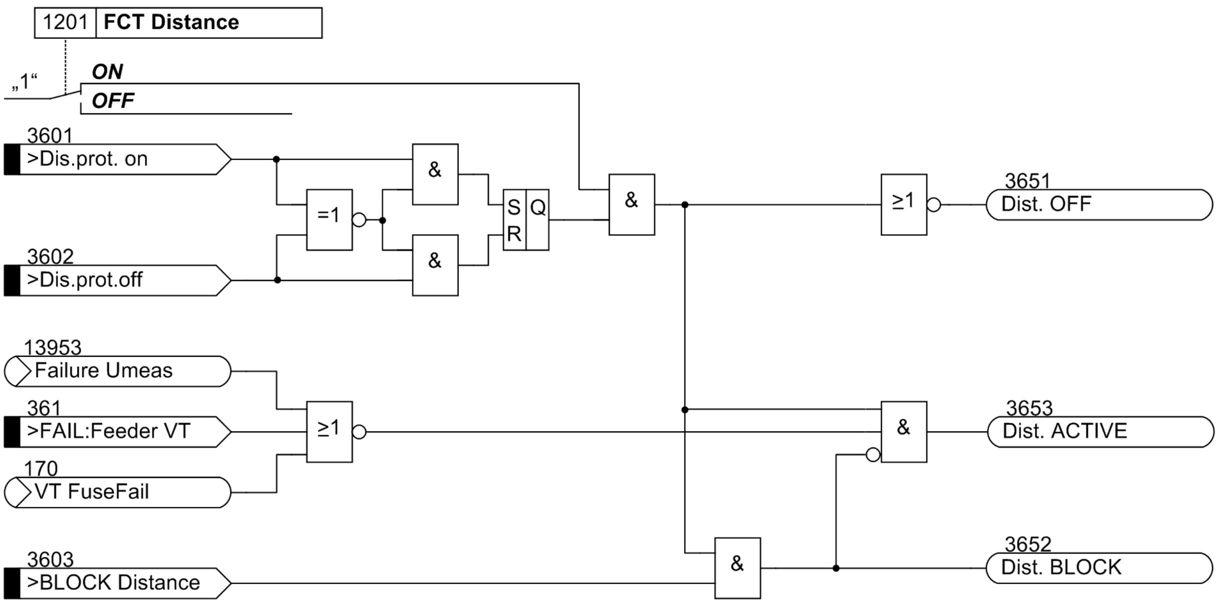


Figure 2-2 Control logic of the distance protection

The distance protection can be switched on or off by parameter settings, or via a binary input. Switching the function on or off via the binary inputs “>Dis.prot. on” (FNo. 3601) and “>Dis.prot.off” (FNo. 3602) is done with edge triggering. The distance protection can also be dynamically blocked via the binary input “>BLOCK Distance” (FNo. 3603).

The distance protection is equipped with an overcurrent pickup function. For precise impedance measurement, the current signal must have a minimum amplitude. This minimum amplitude can be set with parameter 1202 **Minimum Iph>**. For more information on this setting please refer to the setting notes.

The enabling of the distance protection incorporates the trip signal of the miniature circuit breaker of the voltage transformer circuit 361 “>FAIL:Feeder VT”; this prevents spurious tripping of the distance protection in case of a measuring voltage failure.

When the indication 3653 “`Dist. ACTIVE`” is active, all conditions for enabling the distance protection are fulfilled.

2.2.2 Distance Protection with Combined Tripping Characteristic

With this tripping characteristic, the curves are constituted by one circle segment and several straight lines.

The radius “Z” of the circle segment defines the reach of the associated tripping zone. The circle segment is limited by the directional straight lines “β” and “γ”.

In addition, an area “α + R” can be cut from the circle segment in order to adapt the tripping characteristic better to the load impedance.

This allows a better distinction between fault and load range, and an improved behaviour of the protection function is the presence of arc faults and close-up faults with transformer saturation.

For each single curve, the direction characteristic can be selected independently; options are “Forward”, “Forward extended”, “Reverse” and “Non-directional”.

The setting “Forward extended” has the same curve as the forward setting. In addition, the curve for close-up faults is extended to non-directional. This extension takes place if the secondary voltage has a value of less than 1 V, and the absolute value of the measured impedance is within the tripping zone.

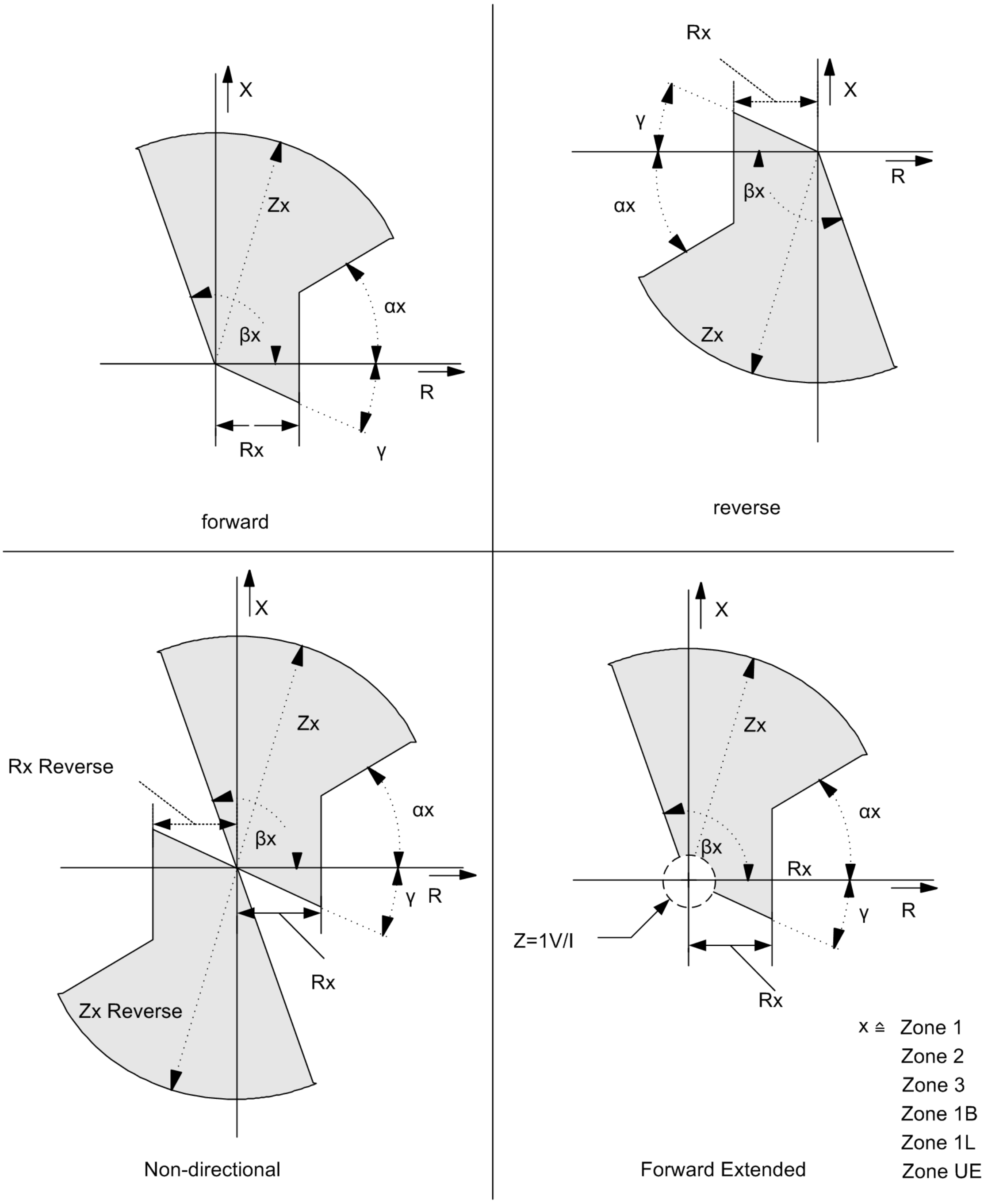


Figure 2-3 Tripping characteristic of the combined characteristic

2.2.3 Distance Protection with Polygonal Tripping Characteristic

With this tripping characteristic, the curves are constituted by several straight lines.

The straight line in parallel to the R axis defines the largest reactance present in the tripping area, and thus the range of the tripping zone.

The straight line in parallel to the X axis defines the limitation of the tripping area in R direction.

The tripping area is also limited by the directional straight lines. In addition, an area is cut from the polygon to exclude the load impedances area from the tripping area.

This allows a better distinction between fault and load range, and a better behaviour of the protection function is the presence of arc faults and close-up faults with transformer saturation.

For each single curve, the direction characteristic can be selected independently; options are Forward, Reverse and Non-directional.

An extra characteristic “Forward extended” is available for the detection of close-up faults. This characteristic differs from the “Forward” characteristic by the circle “Z”. The characteristic “Forward extended” is only active if the secondary voltage is <1 V and the absolute value of the measured impedance is within the associated tripping zone. The radius of the circle “Z” is dependent on the supply voltage and the impedance of the series-connected power system.

The figure below shows the tripping characteristic of the polygonal characteristic.

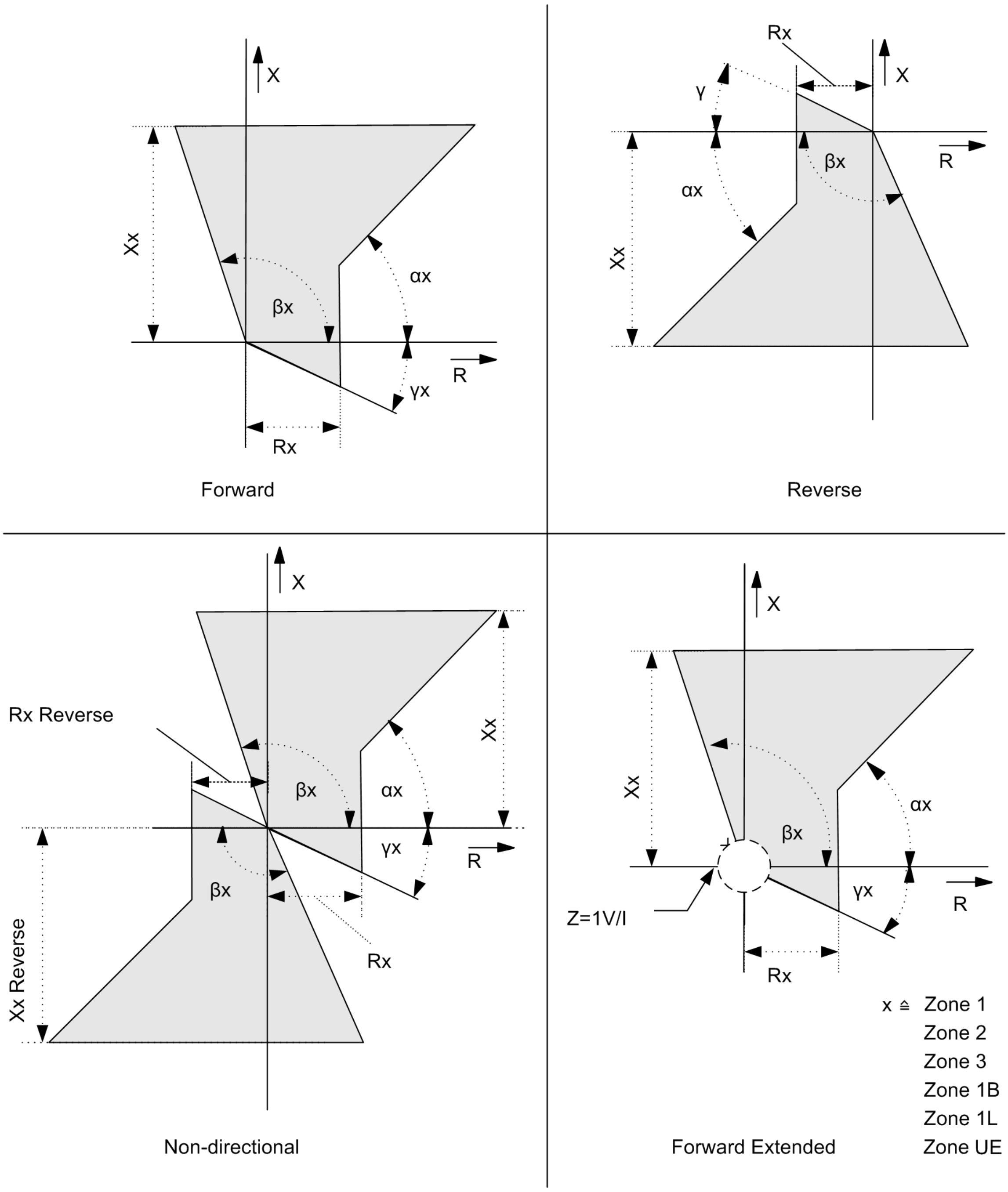


Figure 2-4 Tripping characteristic of the polygonal characteristic

2.2.4 Short-circuit Detection by Current and Voltage Angle Changes

In highly loaded, long overhead contact lines, when energizing with high loads or load currents at the end of long supply zones, the load impedances can be as high as the short-circuit impedances, so that an impedance comparison alone is no longer sufficient.

In order to distinguish between such operating states and short-circuits, the tripping characteristics Z2 and Z3 have two grading times which can be set independently.

The long grading time must be set to a value that is higher than the duration of a startup procedure.

The short grading time is the delay time of the tripping characteristic from the grading coordination chart.

In order to distinguish between short-circuits and energization, the 7ST6 devices are equipped with a short-circuit detection that uses the criteria "ΔI/Δt" and "ΔU/Δt". In case of an overload, the gradients of current (ΔI/Δt) and voltage (ΔU/Δt) are considerably smaller than in case of a short-circuit. For the definition of these threshold values, the load variations, which are a function of the distance between the feeding point and the vehicle, must be taken into account.

You can set parameter **Rel. T2K** at address 1210 for zone 2 and **Rel. T3K** at address 1220 for zone 3 to determine whether the criteria di/dt and du/dt are to be combined via "AND" or via "OR". Refer to Figure 2-6.

You can set the pickup sensitivity for di/dt against the present load current (energization current) to ensure the sensitivity for short-circuit detection with small current values and, simultaneously, prevent false tripping during energization with relatively large current values. For zone 2 this is parameter **di/dt Z2** at address 1343 for the initial value **Rest. di/dt Z2** at address 1211 for the slope in dependence on the load current or **di/dt Z3** at address 1363 and **Rest. di/dt Z3** at 1221 for zone 3. See following picture.

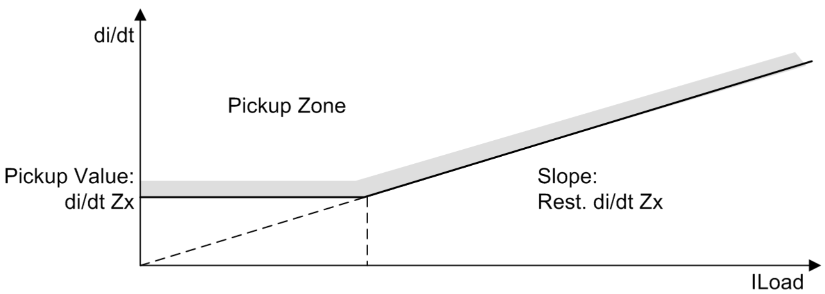


Figure 2-5 Tripping characteristic with restraint

If parameter **Rest. di/dt Z2** at address 1211 or **Rest. di/dt Z3** at address 1221 is set to 0, the settings for di/dt remain without restraint.

The figure below shows the short-circuit detection logic:

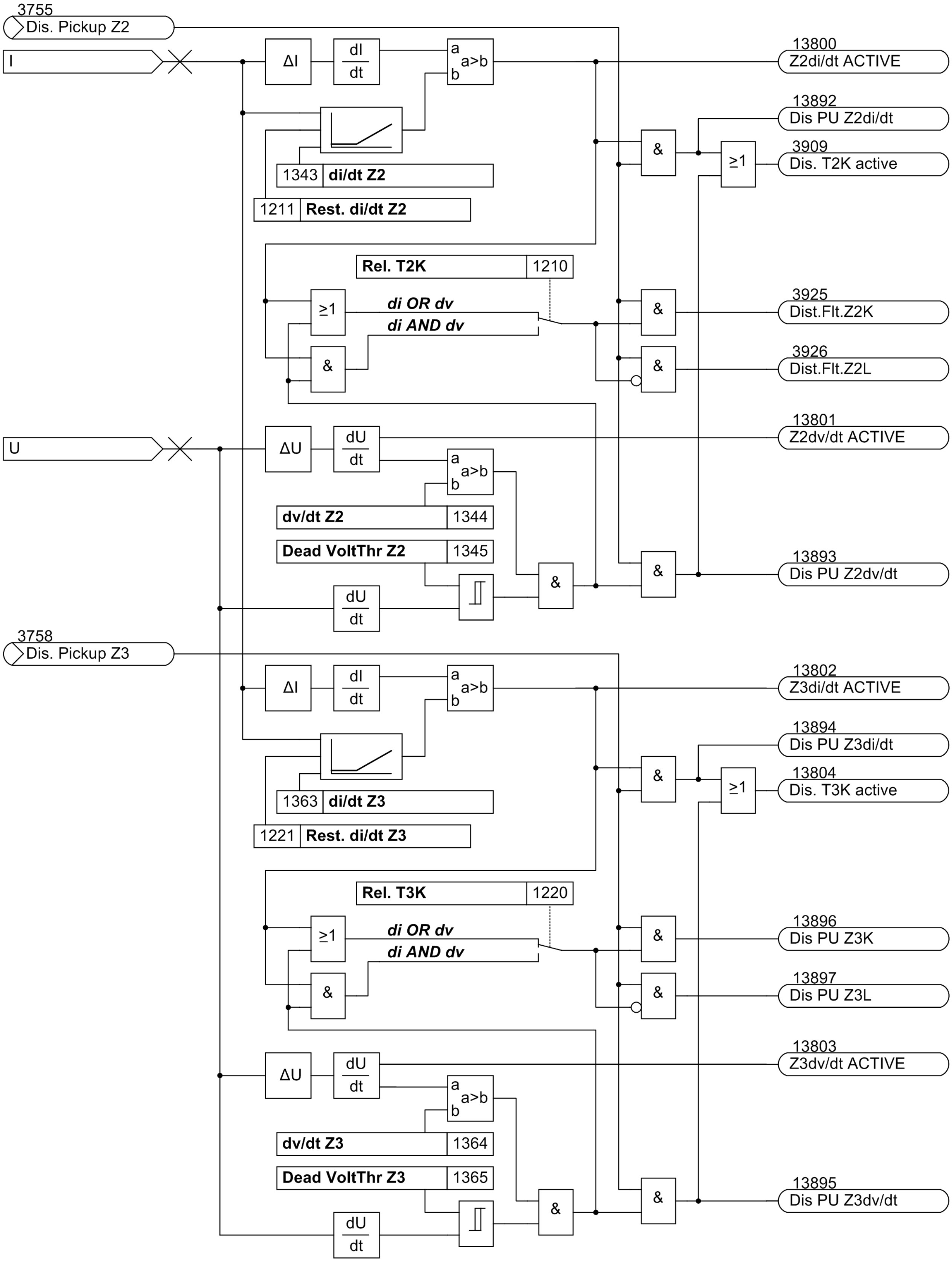


Figure 2-6 Logic of the short-circuit detection

The short-circuit detection logic provides the signals “`Dis. T2K active`” (FNo. 3909) and “`Dis. T3K active`” (FNo. 13804). These signals are used for switchover of the tripping times of the zones Z2 and Z3. If these signals are active, the tripping times **T2K** (FNo. 1346) or **T3K** (FNo. 1366) respectively of the associated zone are activated. Indications inform the user which criterion for short-circuit detection has picked up.

2.2.5 Tripping Logic of the Distance Protection

After enabling distance measurement, the system compares the measured impedance with the limit values of the set zones.

Tripping is carried out if the zone is enabled and the impedance is part of that zone when the corresponding time stage expires. The general criteria for enabling a zone are described in Subsection 2.2.1 “Enabling the Distance Protection”.

Zone Z1 is always enabled when the auto reclose function of the device is not active.

With the auto reclose function activated, either zone Z1, Z1B or Z1L is enabled, depending on the current cycle of the AR function.

The zones Z2 and Z3 have each two different tripping times. The indications “`Dis. T2K active`” (FNo. 3909) and “`Dis. T3K active`” (FNo. 13804) are used to control which of the two tripping times is effective for each stage. These signals are provided by the short-circuit detection function. In zones Z2 and Z3 only one of the two tripping times can be active at a time.

In zone Z2, the short tripping time **T2K** becomes effective, and the indication “`Dist.Flt.Z2K`” (FNo. 3925) is generated.

In the presence of an overload, the long tripping time **T2L** becomes effective in zone Z2, and the indication “`Dist.Flt.Z2L`” (FNo. 3926) is generated.

Similar tripping times and indications also exist for zone Z3.

In addition, the 7ST6 device has one zone that is activated when a circuit breaker is manually closed. The enable logic of the Overreach Zone is described separately in Subsection 2.2.7. “Tripping Characteristic for Manual Close”.

The zones Z1B and Z1L, which are only available in combination with the function **Auto Reclose**, are also described separately in Subsection 2.2.6. “Tripping Characteristic for Manual Reclose”.

The figure below shows the logic for generating the pickup and trip signals of the independent zones.

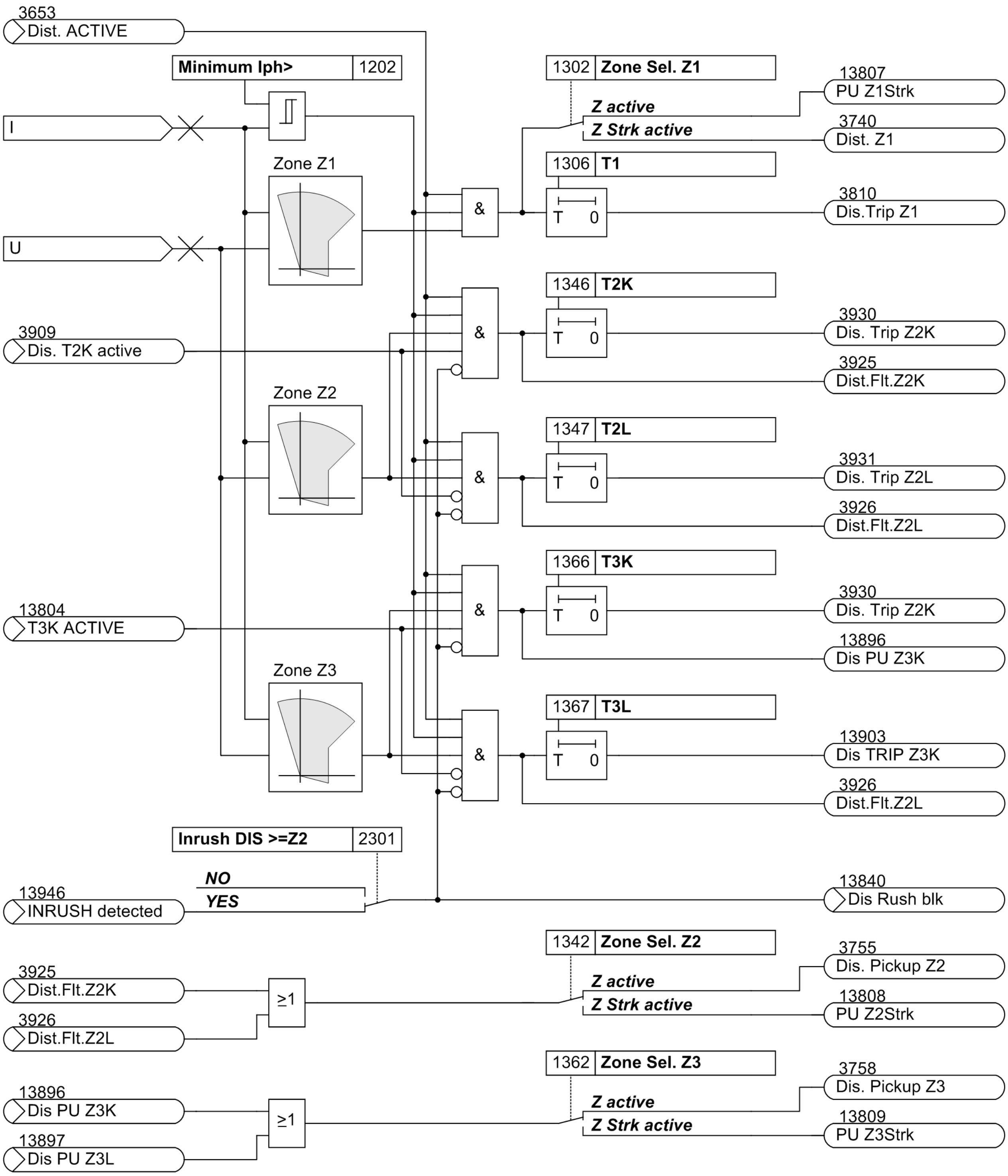


Figure 2-7 Tripping logic of independent zones

The logic for providing the direction signals and the general pickup and trip are shown separately in the figure below.

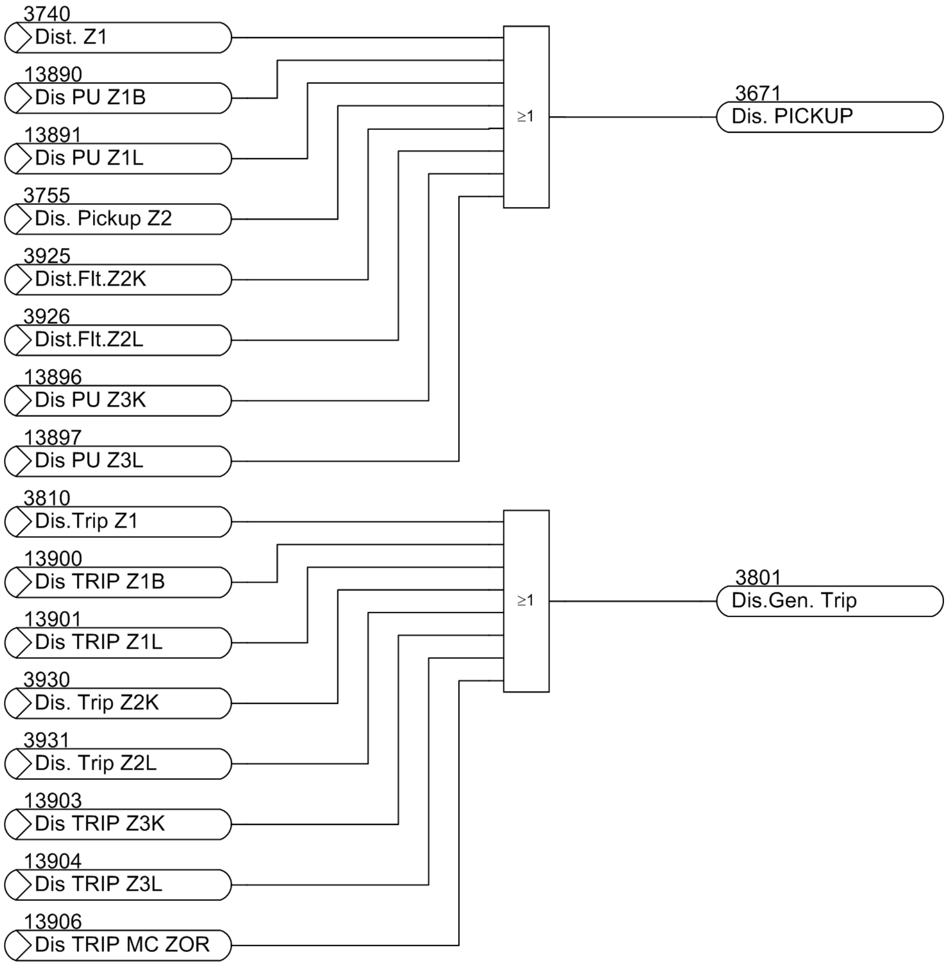


Figure 2-8 Overreach logic of the distance protection

2.2.6 Tripping Characteristic for Manual Reclose

The distance protection zones described in this subsection are only available if the function **`Auto Reclose`** is available in the device.

The controlled zone Z1B is usually applied as an overreaching zone. The logic is shown in Figure 2-9. It may be activated via various internal and external functions. The binary inputs for external activation of Z1B of the distance protection are “`>BLK 1.AR-cycle`” and “`>BLOCK AR`”. The former can, for example, be from an external teleprotection device, and only affects Z1B of the distance protection. The latter affects both overreaching stages. The **`Auto Reclose`** can also be controlled by an external protection device. The control signals for this arrive at the binary inputs “`>AR Start`” and “`>Trip for AR`”.

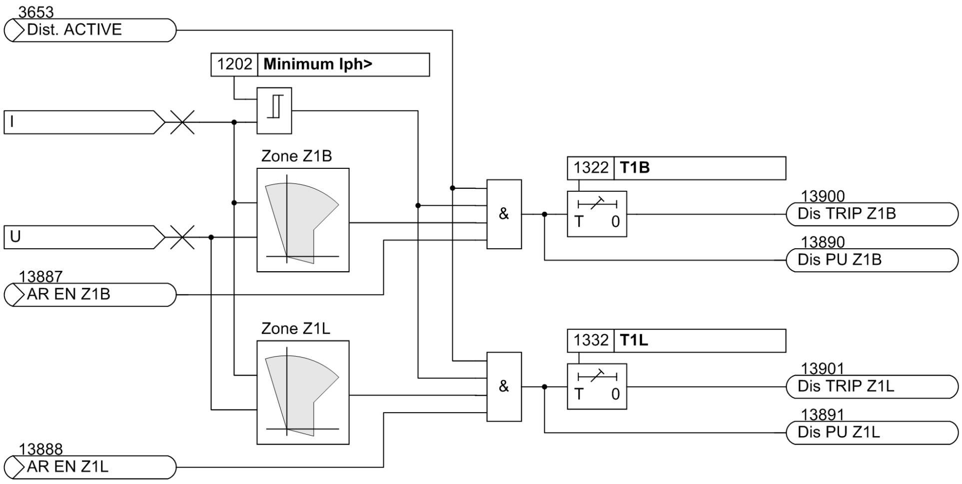


Figure 2-9 Tripping logic of dependent zones

In the initial state, with the **Distance prot.** switched on and the **Auto Reclose** operative, Zone Z1B-exten. is enabled.

With the function **Auto Reclose** switched off or not operative, Zone Z1 is enabled.

Before the 2nd reclosure cycle, the enable for zone Z1B is reset after the dead time has expired, and the enable for Zone Z1L is set with start of the blocking time and the CLOSE command. The pickup starts all action times which are enabled for initiation.

When the 1st action time has expired but the 2nd action time is still running, the zone enabling switches from Zone Z1B-exten. to Zone Z1L. An exception to this is the last reclosure cycle. If all reclosure attempts were unsuccessful, Zone Z1 is enabled prior to the last configured reclosure cycle.

2.2.7 Tripping Characteristic for Manual Close

Direction Determination on Closing

If you switch a deenergized line that is faulty line to a live busbar, the direction of faults close to the location of the voltage transformer is difficult to determine, because the measuring voltage required for correct direction determination is missing. If the voltage transformer is installed towards the line, no stored voltage is available.

With such local faults, the distance protection always assumes a fault in FORWARD direction. This allows instantaneous tripping, regardless of the set characteristic. The criterion for a non-directional trip in zone 1 on switching to a short-circuit is the fault voltage. With a secondary voltage of less than 1 V a non-directional trip command is issued.

Processing of the Manual Close Signal

To make undelayed tripping possible on switching of a faulted line, the control-discrepancy switch can use a binary input to issue the manual close command to the overhead contact line protection system. To do so, the external signal `“>Manual Close”` must be configured to a binary input. The figure below shows the logic diagram for this.

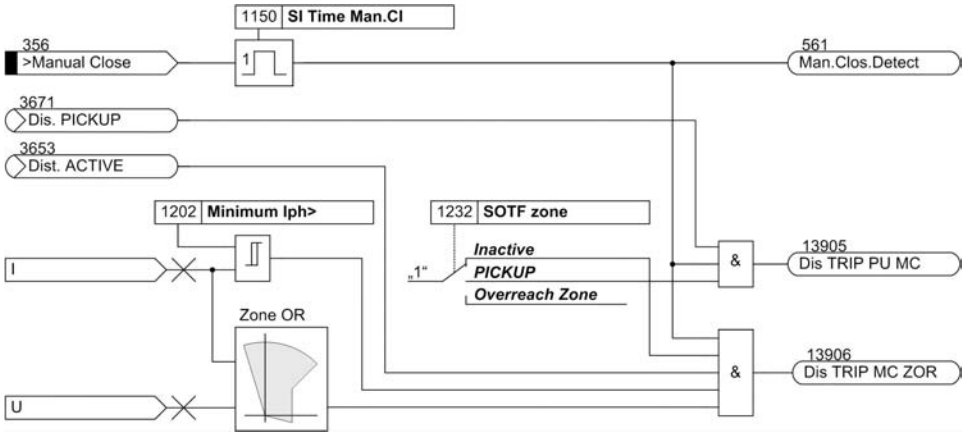


Figure 2-10 Tripping logic of the manual close zone

The parameter 1232 **SOTF zone** can be used to determine whether the instantaneous tripping after manual closing is valid for the Overreach Zone provided for this purpose, or for the general pickup of the distance protection. The function can also be disabled with this parameter. The Overreach Zone has its own characteristic curve parameters. The binary signal “>Manual Close” activates this mechanism by its rising edge for a duration that can be set with the parameter 1150 **SI Time Man.Cl**. The manual close function is thus independent of the duration of the signal present at the binary input.

2.2.8 Zone Changeover (only for 16.7 Hz)

To adapt the protection to different switching states of the overhead contact line during operation, the device is equipped with a changeover function of the impedance stages for Zone Z1, Zone Z2 and Zone Z3 via binary inputs, a control system or the operator control panel.

Depending on the selected type of characteristic curve, this function switches the parameters for the reach of these zones to an alternative value.

With combined characteristics, the Z Stroke or Z Stroke Reverse parameters are then used for these stages instead of the Z parameters. Likewise, the X Stroke or X Stroke Reverse parameters instead of the X parameters are used for polygonal characteristics.

The active control source for this changeover is selected with the parameter 1205 **CHANGE ZONE**; setting options are ***Binary Input***, ***Protocol***, ***Setting*** or ***Blocked***.

The control sources ***Binary Input*** and ***Protocol*** can continue to be operated, even if they are not activated. However, the status Zx or Zx Stroke set in this way will not take effect until the associated control source is selected again (see Figure 2-11).

For zone changeover by ***Protocol*** the commands 13811 through 13813 "Distance Zone Zx Stroke ON" are provided.

With ***Binary Input*** the changeover of Z1, Z2 and Z3 is performed via the binary input indications FNo. 3900 and 3901, 3902 and 3903, or 3906 and 3907, ">Dist. Zone Zx stroke is active" and ">Dist.: Zone Zx is active".

The binary inputs also allow to switch the setting **CHANGE ZONE** to ***Protocol*** when the binary input 365 "`>Ctrl Select.`"= ">Select: Control by BI or SYS interface" is activated.

With the setting ***Setting*** the changeover is performed with the parameters 1302 **Zone Sel. Z1**, 1342 **Zone Sel. Z2** and 1362 **Zone Sel. Z3**. These parameters are masked out if a different control source is selected.

The figure below shows the logic of the zone changeover, with zone Z1 as an example.

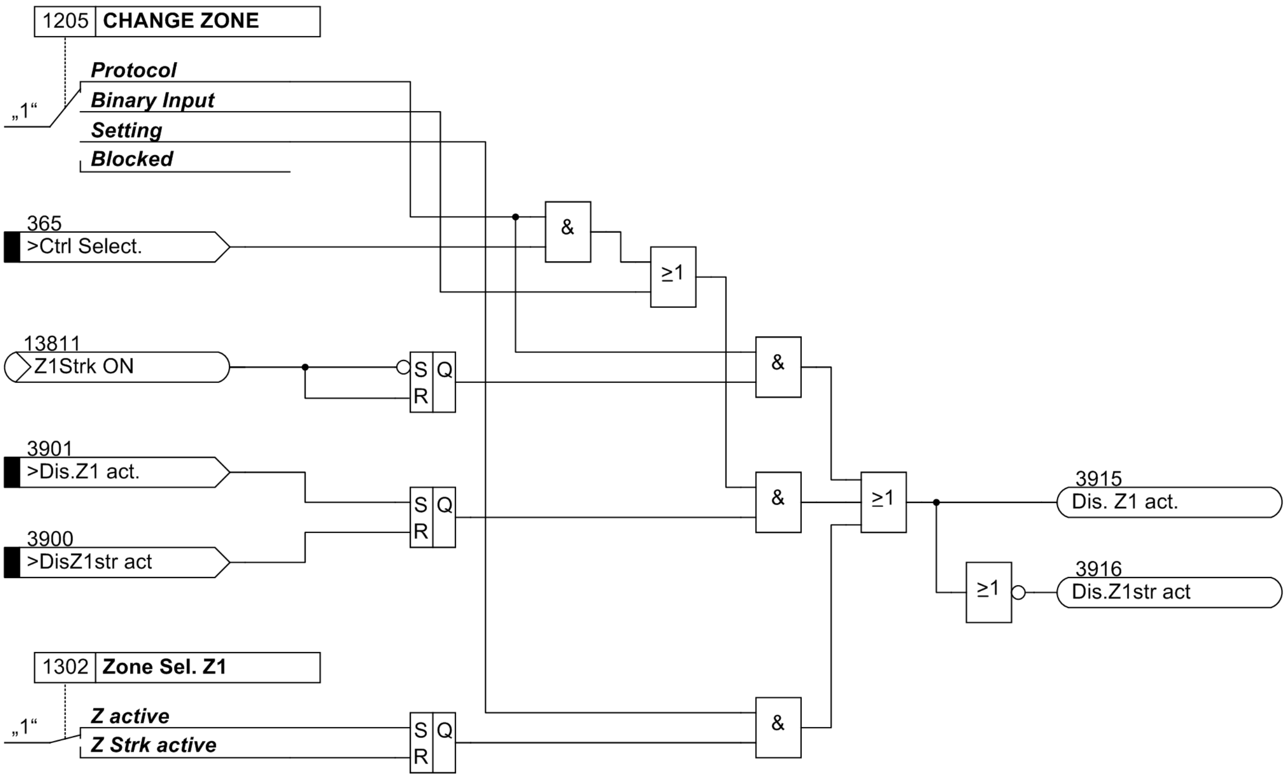


Figure 2-11 Logic of change to zone, example zone Z1

2.2.9 Setting Notes

At address 1201 **FCT Distance** the distance protection function can be switched ***ON*** or ***OFF***. At address 113 **DISTANCE CURVE** the characteristic types ***Quadrilateral*** and ***Combined*** can be selected (see Subsection 2.1.1.2). This setting is valid for all characteristics of the distance protection.

Minimum Current

The minimum phase current is set in address 1202 **Minimum Iph>**. The minimum current for fault detection **Minimum Iph>** is set a little (approx. 10 %) below the minimum short-circuit current that may occur.

Load Area

For the description of the parameters of the load range in this section, general designations will be used. Table 2-2 shows the assignment of these designations to the concrete parameters of a zone.

On long, highly loadable lines there is a risk of the load impedance rising as high as the tripping area of the distance protection. In order to avoid spurious pickup of the distance protection during the transfer of high powers, the load range can be set so as to exclude such spurious capture due to overloads. This load range has been taken into account for the description of the tripping characteristics (see margin headings “Combined Characteristics” and “Polygonal Characteristics”). The R value is set somewhat (approx. 10 %) below the minimum expected load impedance. The minimum load impedance results when the maximum load current and minimum operating voltage exist.

Example:

15 kV overhead contact line with the data:

Maximum transmitted power S_{Max} = 10 MVA

I_{LMax} = 784 A

Minimum operating voltage $U_{Min} = 0.85\ U_N$

Current transformers 1000 A / 1 A

Voltage transformers 15 kV/0.1 kV

The resulting minimum load impedance is therefore:

$$R_{Lprim} = \frac{U_{min}}{I_{Lmax}} = \frac{0.85 \cdot 15\ \text{kV}}{784\ \text{A}} \cdot 16.26\Omega$$

This value can be entered as a primary value when parameterizing with a PC and DIGSI®. Conversion to secondary quantities is:

$$R_{Lsec} = \frac{N_{CT}}{N_{VT}} \cdot R_{Lprim} = \frac{1000\text{A} / 1\text{A}}{15\text{kV} / 0.1\text{kV}} \cdot 16.25\Omega = 108.3\Omega$$

When applying a security margin of 10 % the following is set:

Primary: $R_L = 14.63\ \Omega$ or

Secondary: $R_L = 97.53\ \Omega$.

The spread angle of the load range “α” must be greater (approx. 10°) than the maximum arising load angle (corresponding to the minimum power factor $\cos\varphi_{Min}$).

Calculation example:

Minimum power factor:

$\cos\varphi_{Min} = 0.63$

$\varphi_{max} = 51°$

Setting value $\alpha = \varphi_{max} + 5° = 56°$.

Grading Coordination Chart

It is recommended to initially create a grading coordination chart for the entire galvanically interconnected system. This diagram should reflect the line lengths with their primary reactances X´ in Ω /km. For the reach of the distance zones, the reactance X is the deciding quantity.

The first zone Z1 is usually set to cover 85 % of the protected line without any trip time delay (i.e. T1 = 0.00 s). The protection clears faults in this range without additional time delay, i.e. the tripping time is the relay basic operating time.

The tripping time of the higher zones is sequentially increased by one time grading margin. The grading margin must take into account the circuit breaker operating time including the spread of this time, the resetting time of the protection equipment as well as the spread of the protection delay timers. Typical values are 0.2 s to 0.4 s. The reach is selected to cover up to approximately 80 % of the zone with the same set time delay on the shortest neighbouring feeder.

When using a personal computer and DIGSI® to apply the settings, these can be optionally entered as primary or secondary values. In the case of parameterization with secondary quantities, the values derived from the grading coordination chart must be converted to the secondary side of the current and voltage transformers. In general:

$$Z_{secondary} = \frac{\text{Current transformer ratio}}{\text{Voltage transformer ratio}} \cdot Z_{primary}$$

Accordingly, the reach for any distance zone can be specified as follows:

$$X_{sec} = \frac{N_{CT}}{N_{VT}} \cdot X_{prim}$$

where:

N_{CT} = Current transformer ratio

N_{VT} = Transformation ratio of voltage transformer

Calculation example:

15 kV overhead contact line with the data:

s (length) = 35 km

R1/s = 0.19 Ω /km

X1/s = 0.42 Ω /km

Current transformers 1000 A / 1 A

Voltage transformers 15 kV/0.1 kV

The following line data is calculated:

R_L = 0.19 Ω /km · 35 km = 6.65 Ω

X_L = 0.42 Ω /km · 35 km = 14.70 Ω

For the first zone, a setting of 85 % of the line length should be applied, which results in primary:

$X1_{Prim}$ = 0.85 · X_L = 0.85 · 14.70 Ω = 12.49 Ω

or secondary:

$$X1_{Sec} = \frac{N_{CT}}{N_{VT}} \cdot X1_{prim} = \frac{1000\text{A} / 1\text{A}}{15\text{kV} / 0.1\text{kV}} \cdot 12.49\Omega = 83.26\Omega$$

Determination of Direction

An impedance vector is also used to determine the direction of the short-circuit. Usually similar to the distance calculation, Z_L is used. However, depending on the "quality" of the measured values, different computation techniques are used. Immediately after fault inception, the short circuit voltage is disturbed by transients. The voltage memorized prior to fault inception is therefore used in this situation. If there is neither a current measured voltage nor a memorized voltage available which is sufficient for measuring the direction, the relay selects the **forward** direction. In practice this can only occur when the circuit breaker closes onto a de-energized line, and there is a fault on this line (e.g. closing onto an earthed line).

Figure 2-12 shows the theoretical steady-state characteristic. In practice, the position of the directional characteristic when using the memorized voltage is dependent on both the source impedance and the load transferred across the line prior to fault inception. If the direction is determined from the current voltage, the position of the directional characteristic with double infeed and a high fault resistance is also dependent on both the source impedance and the load transferred across the line prior to fault inception. Accordingly the directional characteristic includes a safety margin with respect to the limits of the first quadrant in the R–X diagram. This safety margin is defined by the parameters **Beta** (β) and **Gamma** (γ). Normally the default settings of these parameters need not be changed. For highly loaded overhead contact lines, the use of network calculation software is recommended to determine the setting values.

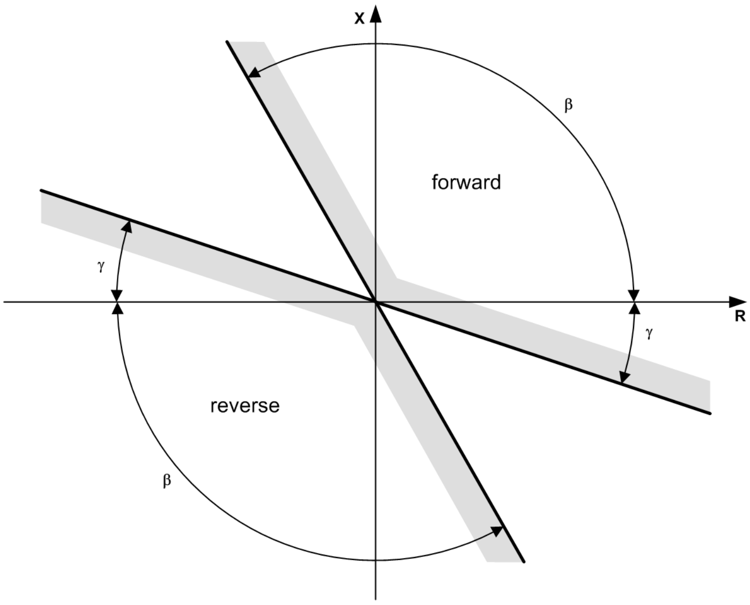


Figure 2-12 Directional characteristic

Combined Characteristics

If the distance protection is to have impedance curves with combined characteristic, set address 113 **DISTANCE CURVE**=***Combined***.

For the description of the characteristic parameters in this section, general designations will be used. Table 2-2 shows the assignment of these designations to the actual parameters of a zone.

The reach of the characteristic is set with the parameter **Z**. Here you set the absolute value of the balance point impedance, without taking into account an arc resistance for the zone. For more information on setting the reach, please refer to margin heading “Grading Coordination Chart”.

The load range is set with the parameters for the minimum load impedance $\mathbf{R_L}$ and the spread angle of the load range **Alpha** (α). For more information on setting the load range parameters, please refer to margin heading “Load Range”.

The safety margins of the directional characteristic are set in the parameters **Beta** (β) and **Gamma** (γ) (see margin heading “Determination of Direction”).

Note

For all three distance zones to function correctly, the following conditions must imperatively be met for each characteristic:

$\gamma < \alpha$

$R < Z \cos\alpha$

$R \leq Z \cos \gamma$

$\beta - \gamma \leq 180°$

Polygonal Characteristics

If the distance protection is to have impedance characteristics with polygonal characteristic, set address 113 **DISTANCE CURVE**=***Quadrilateral***.

For the description of the characteristic parameters in this section, general designations will be used. Table 2-2 shows the assignment of these designations to the actual parameters of a zone.

The reach of the characteristic is set with the parameter **X**. Here you set the balance point reactance for the zone. For more information on setting the reach, please refer to margin heading “Grading Coordination Chart”.

The load range is set with the parameters for the minimum load impedance $\mathbf{R_L}$ and the spread angle of the load range **Alpha** (α). For more information on setting the load range parameters, please refer to margin heading “Load Range”.

The safety margins of the directional characteristic are set in the parameters **Beta** (β) and **Gamma** (γ). (see margin heading “Determination of Direction”).

Note

For all three distance zones to function correctly, the following conditions must imperatively be met for each characteristic:

$\alpha > 10°$ (if this is disregarded, spurious tripping may occur!)

$\gamma < \alpha$

$R < 6 \cdot X$

$\beta - \gamma \leq 180°$

Independent Zones

The table below shows the assignment of the general characteristic parameters to the concrete setting values for the independent zones:

Table 2-2 Assignment of setting parameters for the independent zones of the distance protection

DIGSI® setting sheet	Parameter	Setting parameters	
		Z active	**Z Strk active**
Zone Z1	Z, X	Z1 (Addr.1310) X1 (Addr.1309) Z1 Reverse (Addr.1316) X1 Reverse (Addr.1315)	Z1 Strk (Addr.1318) X1 Strk (Addr.1317) Z1 Strk Reverse (Addr.1320) X1 Strk Reverse (Addr.1319)
	R_L	R1 (Addr.1308) R1 Reverse (Addr.1314)	
	Mode	Op. Mode Z1 (Addr.1301)	
	Alpha	ALPHA Z1 (Addr.1311)	
	Beta	BETA Z1 (Addr.1312)	
	Gamma	GAMMA Z1 (Addr.1313)	
Zone Z2	Z, X	Z2 (Addr.1350) X2 (Addr.1349) Z2 Reverse (Addr.1356) X2 Reverse (Addr.1355)	Z2 Strk (Addr.1358) X2 Strk (Addr.1357) Z2 Strk Reverse (Addr.1360) X2 Strk Reverse (Addr.1359)
	R_L	R2 (Addr.1348) R2 Reverse (Addr.1354)	
	Mode	Op. Mode Z2 (Addr.1341)	
	Alpha	ALPHA Z2 (Addr.1351)	
	Beta	BETA Z2 (Addr.1352)	
	Gamma	GAMMA Z2 (Addr.1353)	
Zone Z3	Z, X	Z3 (Addr. 1370) X3 (Addr.1369) Z3 Reverse (Addr.1376) X3 Reverse (Addr.1375)	Z3 Strk (Addr.1378) Z3 Strk (Addr.1378) Z3 Strk Reverse (address 1380) X3 Strk Reverse (Addr.1379)
	R_L	R3 (Addr.1368) R3 Reverse (Addr.1374)	
	Mode	Op. Mode Z3 (Addr.1361)	
	Alpha	ALPHA Z3 (Addr.1371)	
	Beta	BETA Z3 (Addr.1372)	
	Gamma	GAMMA Z3 (Addr.1373)	

In each zone, different values for reach and minimum load impedance can be set in forward and reverse direction.

The setting parameters marked with “reverse” (e.g. **Z1 Reverse**) are only visible if you have set “**non-directional**” for the distance stage of the corresponding zone.

Dependent Zones

These parameters are only available in combination with the auto reclose function, i.e. if you have set address 133 **Auto Reclose** to ***Enabled*** during the configuration of the functional scope.

For tripping within the first AR cycle, zone Z1B instead of zone Z1 is used. For the second and the following cycles, zone Z1L is used. Zone Z1 is activated if the AR function is blocked, or in the last cycle of the AR.

The impedance characteristics for the AR zones Z1B and Z1L must have the same characteristic type (combined, polygonal) and the same angle parameters (α, β, γ) as zone Z1. Therefore, these parameters cannot be set for the AR zones. They are normally set to at least 120 % of the line length. The delay times are set in accordance with the type of application, usually to zero or a very small delay.

Furthermore, these zones do not have alternative parameters for the reach and the minimum load impedance (see Table 2-3).

Overreach Zone, Manual Close

If the circuit breaker is manually closed onto a short circuit, the distance protection can issue an instantaneous trip command.

The parameter **SOTF zone** (address 1232) can be used to determine the zone(s) for which instantaneous tripping following manual closing applies. With the setting **SOTF zone**= ***PICKUP***, tripping occurs with the zones described above. When the protection trips on closing onto a fault, the indication “Dis TRIP PU MC” is output. With the setting **SOTF zone**=***Overreach Zone*** the ZOR zone is temporarily enabled.

The overreach zone ZOR is a zone which can be activated for a settable time **SI Time Man.Cl** in case of a manual closure. This setting of the parameter **SI Time Man.Cl** (address1150) is only possible with DIGSI® under **Additional Settings** (see Subsection 2.1.5.1). This zone is provided for protection of the entire line by instantaneous tripping. It has therefore the same settings as zone Z1B.

The following parameters can be set for the dependent zones:

Table 2-3 Assignment of setting parameters for the dependent zones of the distance protection

Dependent Zone	Parameter	Setting Parameter Forwards	Setting Parameter Reverse
Zone Z1B-exten.	Z	Z1B (Addr.1325) X1B (Addr.1324)	Z1B Reverse (Addr.1328) X1B Reverse (Addr.1327)
	R_L	R1B (Addr.1323)	R1B Reverse (Addr.1326)
	Mode	Op. Mode Z1B (Addr.1321)	
Zone Z1L	D	Z1L (Addr.1335) X1L (Addr.1334)	Z1L Reverse (Addr. 1338) X1L Reverse (Addr. 1337)
	R_L	R1L (Addr.1333)	R1L Reverse (Addr.1336)
	Mode	Op. Mode Z1L (Addr.1331)	
Overreach Zone	D	ZOR (Addr.1384) XOR (Addr.1383)	ZOR Reverse (Addr.1390) XOR Reverse (Addr.1389)
	R_L	ROR (Addr.1382)	ROR Reverse (Addr.1388)
	Mode	Op. Mode ZOR (Addr.1381)	

The setting parameters marked with “reverse” (e.g. Z1B reverse) are only visible if you have set “**non-directional**” for the distance stage of the corresponding zone.

Inrush Blocking

If the protection zone of the device includes power transformers, tripping may be caused by the inrush effect when switching in transmission lines operating at weak load or no load.

With such a constellation, you should activate the blocking of the distance protection by inrush detection. To do so, set under address 2301 **Inrush DIS >=Z2**=***YES***. This blocks the zones Z2 and Z3 in case of detection of an inrush.

Startup Stages

In highly loaded, long overhead contact lines, the operating currents may be as high as or even higher than the possible short-circuit currents.

As a result the operating impedances in the backup zones Z2 and Z3 may temporarily be located within the tripping polygon. The startup stage has the task of distinguishing between operational events such as startup procedures, and short-circuits.

The zones Z2 and Z3 have each two different grading margins. The grading margins **T2K** (address 1346) and **T3K** (address 1366) are activated on detection of a short-circuit. These grading margins must be set according to the grading coordination chart.

The grading margins **T2L** (address 1347) and **T3L** (address 1367) are activated in case of an overload. These margins must be set according to the overload carrying capacity of the overhead contact line.

The distinction between an overload and a short-circuit relies on the fact that in case of an overload the difference between the phasors of the currently measured current and of the current measured two cycles ago is much less than in case of a short-circuit. This current difference is defined by the parameters **di/dt Z2** (address 1343) and **di/dt Z3** (address 1363) referred to the rated current.

Set this current rise rate to approx. 10% more than the maximum value occurring in operation. If you do not want to use this criterion for a particular stage, set "∞".

In addition to the current rise rate criterion, voltage dips are used to distinguish between overloads and short-circuits. The criterion is the difference between the voltage phasors of the currently measured voltage and the voltage measured two cycles ago.

For the parameters **du/dt Z2** (address 1344) and **du/dt Z3** (address 1364) a value referred to the rated voltage must be specified. As soon as one of the set thresholds is exceeded, a short-circuit is detected. Set this voltage dip rate to approx. 10% more than the maximum value occurring in operation.

The criterion for the voltage dip rate is only activated when the minimum voltages set in the parameters **Dead VoltThr Z2** (address 1345) and **Dead VoltThr Z3** (address 1365) are undershot. Set here the maximum possible voltage dip for each stage in operation, with a safety margin of approx. 10%.

<u>Calculation example:</u>

15 kV infeed with the following impedance from the infeed point to the location of the voltage transformer: Z = (2 + j 7)Ω

Maximum startup current primary: I_{Bmax} = 550 A

Minimum infeed voltage: Umin = 15 kV · 0.9

Voltage transformer: 15 kV / 0.1 kV

From the above values, the following minimum voltage in operation results:

$$U_{bmin} = U_{min} - (Z \cdot I_{bmax}) = 13.5\text{ kV} - (\text{abs}(2 + j7)\Omega \cdot 550\text{A}) = 9.5\text{kV}$$

Setting value secondary: USec=15kV/0.1kV· 9.5kV= 63.3V

By setting the du/dt or di/dt parameters to 0, the grading margin **T2K** or **T3K** is released; at the same time the timers **T2L** and **T3L** are blocked. This blocking is signalled by the indication "`Dis. T2K active`" or "`Dis. T3K active`".

By setting the du/dt or di/dt parameters to infinite, the corresponding parts of the short-circuit detection are disabled.

By setting the di/dt and du/dt parameter to "∞ ", the stage T2L (T3L) is always activated. With another setting than "∞ " the indications "Z2(Z3)di/dt active" or "Z2(Z3)du/dt active" are output.

Note

The setting of "∞" is equally possible in DIGSI via "oo" or directly at the device via "**..**".

2.2.10 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1201	FCT Distance		ON OFF	ON	Distance protection is
1202	Minimum Iph>	1A	0.1 .. 2.0 A	0.1 A	Phase Current threshold for dist. meas.
		5A	0.5 .. 10.0 A	0.5 A	
1205	CHANGE ZONE		Binary Input Protocol Setting Blocked	Protocol	Change to Zone
1210	Rel. T2K		di OR du di AND du	di OR du	Release of TK of Zone Z2
1211	Rest. di/dt Z2		0.0 .. 0.5 ; ∞	0.0	Restraint Factor of di/dt-Stage Z2
1220	Rel. T3K		di OR du di AND du	di OR du	Release of TK of Zone Z2
1221	Rest. di/dt Z3		0.0 .. 0.5 ; ∞	0.0	Restraint Factor of di/dt-Stage Z3
1232	SOTF zone		PICKUP Overreach Zone Inactive	Inactive	Instantaneous trip after SwitchOnToFault
1240	1st Recl. Z1B		NO YES	YES	Enable Zone Z1B for 1st Reclosure Cycle
1301	Op. Mode Z1		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z1
1302	Zone Sel. Z1		Z active Z Strk active	Z active	Zone Selection Zone Z1
1306	T1		0.00 .. 30.00 sec; ∞	0.00 sec	Delay Time Zone Z1
1308	R1	1A	0.20 .. 250.00 Ω	5.00 Ω	Resistance R Zone Z1
		5A	0.04 .. 50.00 Ω	1.00 Ω	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1309	X1	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1310	Z1	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1311	ALPHA Z1		-70 .. 45 °	20 °	Angle Limitation Alpha Zone Z1 Right
1312	BETA Z1		70 .. 145 °; 0	135 °	Angle Limitation Beta Zone Z1 Left
1313	GAMMA Z1		-70 .. 40 °	-20 °	Angle Limitation Gamma Zone Z1 Bottom
1314	R1 Reverse	1A	0.20 .. 250.00 Ω	5.00 Ω	Resistance R Zone Z1 Reverse
		5A	0.04 .. 50.00 Ω	1.00 Ω	
1315	X1 Reverse	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1 Reverse
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1316	Z1 Reverse	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1 Reverse
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1317	X1 Strk	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1 Stroke
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1318	Z1 Strk	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1 Stroke
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1319	X1 Strk Reverse	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1 Stroke Reverse
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1320	Z1 Strk Reverse	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1 Stroke Reverse
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1321	Op. Mode Z1B		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z1B
1322	T1B		0.00 .. 30.00 sec; ∞	0.00 sec	Delay Time Zone Z1B
1323	R1B	1A	0.20 .. 250.00 Ω	6.00 Ω	Resistance R Zone Z1B
		5A	0.04 .. 50.00 Ω	1.20 Ω	
1324	X1B	1A	0.20 .. 250.00 Ω	12.00 Ω	Reactance X Zone Z1B
		5A	0.04 .. 50.00 Ω	2.40 Ω	
1325	Z1B	1A	0.20 .. 250.00 Ω	12.00 Ω	Impedance Z Zone Z1B
		5A	0.04 .. 50.00 Ω	2.40 Ω	
1326	R1B Reverse	1A	0.20 .. 250.00 Ω	6.00 Ω	Resistance R Zone Z1B Reverse
		5A	0.04 .. 50.00 Ω	1.20 Ω	
1327	X1B Reverse	1A	0.20 .. 250.00 Ω	12.00 Ω	Reactance X Zone Z1B Reverse
		5A	0.04 .. 50.00 Ω	2.40 Ω	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1328	Z1B Reverse	1A	0.20 .. 250.00 Ω	12.00 Ω	Impedance Z Zone Z1B Reverse
		5A	0.04 .. 50.00 Ω	2.40 Ω	
1331	Op. Mode Z1L		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z1L
1332	T1L		0.00 .. 60.00 sec; ∞	0.40 sec	Delay Time Zone Z1L
1333	R1L	1A	0.20 .. 250.00 Ω	9.00 Ω	Resistance R Zone Z1L
		5A	0.04 .. 50.00 Ω	1.80 Ω	
1334	X1L	1A	0.20 .. 250.00 Ω	18.00 Ω	Reactance X Zone Z1L
		5A	0.04 .. 50.00 Ω	3.60 Ω	
1335	Z1L	1A	0.20 .. 250.00 Ω	18.00 Ω	Impedance Z Zone Z1L
		5A	0.04 .. 50.00 Ω	3.60 Ω	
1336	R1L Reverse	1A	0.20 .. 250.00 Ω	9.00 Ω	Resistance R Zone Z1L Reverse
		5A	0.04 .. 50.00 Ω	1.80 Ω	
1337	X1L Reverse	1A	0.20 .. 250.00 Ω	18.00 Ω	Reactance X Zone Z1L Reverse
		5A	0.04 .. 50.00 Ω	3.60 Ω	
1338	Z1L Reverse	1A	0.20 .. 250.00 Ω	18.00 Ω	Impedance Z Zone Z1L Reverse
		5A	0.04 .. 50.00 Ω	3.60 Ω	
1341	Op. Mode Z2		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z2
1342	Zone Sel. Z2		Z active Z Strk active	Z active	Zone Selection Zone Z2
1343	di/dt Z2	1A	0.0 .. 1.0 A; ∞	0.5 A	Pickup Value of di/dt Function Zone Z2
		5A	0.0 .. 5.0 A; ∞	2.5 A	
1344	du/dt Z2		0 .. 100 V; ∞	20 V	Pickup Value of du/dt Function Zone Z2
1345	Dead VoltThr Z2		50 .. 100 V; ∞	80 V	Dead Voltage Threshold for Zone Z2
1346	T2K		0.00 .. 30.00 sec; ∞	0.80 sec	Delay Time TK Zone Z2
1347	T2L		0.00 .. 60.00 sec; ∞	4.00 sec	Delay Time TL Zone Z2
1348	R2	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Zone Z2
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1349	X2	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1350	Z2	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2
		5A	0.04 .. 50.00 Ω	4.00 Ω	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1351	ALPHA Z2		-70 .. 45 °	20 °	Angle Limitation Alpha Zone Z2 Right
1352	BETA Z2		70 .. 145 °; 0	135 °	Angle Limitation Beta Zone Z2 Left
1353	GAMMA Z2		-70 .. 40 °	-20 °	Angle Limitation Gamma Zone Z2 Bottom
1354	R2 Reverse	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Zone Z2 Reverse
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1355	X2 Reverse	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2 Reverse
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1356	Z2 Reverse	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2 Reverse
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1357	X2 Strk	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2 Stroke
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1358	Z2 Strk	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2 Stroke
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1359	X2 Strk Reverse	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2 Stroke Reverse
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1360	Z2 Strk Reverse	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2 Stroke Reverse
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1361	Op. Mode Z3		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z3
1362	Zone Sel. Z3		Z active Z Strk active	Z active	Zone Selection Zone Z3
1363	di/dt Z3	1A	0.0 .. 1.0 A; ∞	0.5 A	Pickup Value of di/dt Function Zone Z3
		5A	0.0 .. 5.0 A; ∞	2.5 A	
1364	du/dt Z3		0 .. 100 V; ∞	20 V	Pickup Value of du/dt Function Zone Z3
1365	Dead VoltThr Z3		50 .. 100 V; ∞	80 V	Dead Voltage Threshold Zone Z3
1366	T3K		0.00 .. 30.00 sec; ∞	1.20 sec	Delay Time TK Zone Z3
1367	T3L		0.00 .. 60.00 sec; ∞	8.00 sec	Delay Time TL Zone Z3
1368	R3	1A	0.20 .. 250.00 Ω	15.00 Ω	Resistance R Zone Z3
		5A	0.04 .. 50.00 Ω	3.00 Ω	
1369	X3	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3
		5A	0.04 .. 50.00 Ω	6.00 Ω	
1370	Z3	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3
		5A	0.04 .. 50.00 Ω	6.00 Ω	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1371	ALPHA Z3		-70 .. 45 °	20 °	Angle Limitation Alpha Zone Z3 Right
1372	BETA Z3		70 .. 145 °; 0	135 °	Angle Limitation Beta Zone Z3 Left
1373	GAMMA Z3		-70 .. 40 °	-20 °	Angle Limitation Gamma Zone Z3 Bottom
1374	R3 Reverse	1A	0.20 .. 250.00 Ω	15.00 Ω	Resistance R Zone Z3 Reverse
		5A	0.04 .. 50.00 Ω	3.00 Ω	
1375	X3 Reverse	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3 Reverse
		5A	0.04 .. 50.00 Ω	6.00 Ω	
1376	Z3 Reverse	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3 Reverse
		5A	0.04 .. 50.00 Ω	6.00 Ω	
1377	X3 Strk	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3 Stroke
		5A	0.04 .. 50.00 Ω	6.00 Ω	
1378	Z3 Strk	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3 Stroke
		5A	0.04 .. 50.00 Ω	6.00 Ω	
1379	X3 Strk Reverse	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3 Stroke Reverse
		5A	0.04 .. 50.00 Ω	6.00 Ω	
1380	Z3 Strk Reverse	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3 Stroke Reverse
		5A	0.04 .. 50.00 Ω	6.00 Ω	
1381	Op. Mode ZOR		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Over-reach Zone
1382	ROR	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Overreach Zone
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1383	XOR	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Overreach Zone
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1384	ZOR	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Overreach Zone
		5A	0.04 .. 50.00 Ω	4.00 Ω	
1385	ALPHA ZOR		-70 .. 45 °	20 °	Angle Limit. Alpha Over-reach Zone Right
1386	BETA ZOR		70 .. 145 °; 0	135 °	Angle Limit. Beta Over-reach Zone Left
1387	GAMMA ZOR		-70 .. 40 °	-20 °	Angle Limit. Gamma Over-reach Zone Bottom
1388	ROR Reverse	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Overreach Zone Reverse
		5A	0.04 .. 50.00 Ω	2.00 Ω	
1389	XOR Reverse	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Overreach Zone Reverse
		5A	0.04 .. 50.00 Ω	4.00 Ω	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1390	ZOR Reverse	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Overreach Zone Reverse
		5A	0.04 .. 50.00 Ω	4.00 Ω	
2301	Inrush DIS >=Z2		NO YES	NO	Distance Zones >=Z2 Blocked by Inrush

2.2.11 Information List

No.	Information	Type of Information	Comments
1190	forward dir.	OUT	Forward direction
3601	>Dis.prot. on	SP	>Distance protection is switched on
3602	>Dis.prot.off	SP	>Distance protection is switched off
3603	>BLOCK Distance	SP	>BLOCK Distance protection
3651	Dist. OFF	OUT	Distance is switched off
3652	Dist. BLOCK	OUT	Distance is BLOCKED
3653	Dist. ACTIVE	OUT	Distance is ACTIVE
3671	Dis. PICKUP	OUT	Distance PICKED UP
3740	Dist. Z1	OUT	Dist.: Fault detection Zone Z1
3755	Dis. Pickup Z2	OUT	Distance Pickup Z2
3758	Dis. Pickup Z3	OUT	Distance Pickup Z3
3771	Dis.Time Out T1	OUT	DistanceTime Out T1
3780	Dis.TimeOut T1B	OUT	DistanceTime Out T1B
3783	Dist. T1L	OUT	Dist.: Time T1L (Zone Z1L) expired
3801	Dis.Gen. Trip	OUT	Distance protection: General trip
3810	Dis.Trip Z1	OUT	Dist.: Trip in Zone Z1
3900	>DisZ1str act	SP	>Dist.: Zone Z1 stroke is active
3901	>Dis.Z1 act.	SP	>Dist.: Zone Z1 is active
3902	>DisZ2str act	SP	>Dist.: Zone Z2 stroke is active
3903	>Dis. Z2 act.	SP	>Dist.: Zone Z2 is active
3906	>Dis Z3str act	SP	>Dist.: Zone Z3 stroke active
3907	>Dis Z3 act	SP	>Dist.: Zone Z3 active
3909	Dis. T2K active	OUT	Dist.: Delay Time T2K is active
3915	Dis. Z1 act.	OUT	Dist.: Zone Z1 is active
3916	Dis.Z1str act	IntSP	Dist.: Zone Z1 stroke is active
3917	Dis.Z2 act.	OUT	Dist.: Zone Z2 is active
3918	Dis.Z2str act	IntSP	Dist.: Zone Z2 stroke is active
3925	Dist.Flt.Z2K	OUT	Dist.: Flt. detect. Z2 (short circuit)
3926	Dist.Flt.Z2L	OUT	Dist.: Fault detection Z2 (overload)
3927	Dist.Flt.VE	OUT	Dist.: Flt. detect. VE (short circuit)
3930	Dis. Trip Z2K	OUT	Dist.: Trip in zone Z2 (short circuit)
3931	Dis. Trip Z2L	OUT	Dist.: Trip in zone Z2 (overload)
3935	Dist. T2K	OUT	Dist.: Time T2K (Zone Z2) expired
3936	Dist. T2L	OUT	Dist.: Time T2L (Zone Z2) expired
3991	Dis. Z3 act	OUT	Dist.: Zone Z3 is active
3992	Dis. Z3str act	IntSP	Dist.: Zone Z3 stroke is active

No.	Information	Type of Information	Comments
13800	Z2di/dt ACTIVE	OUT	di/dt function is active in Zone Z2
13801	Z2du/dt ACTIVE	OUT	du/dt function is active in Zone Z2
13802	Z3di/dt ACTIVE	OUT	di/dt function is active in Zone Z3
13803	Z3du/dt ACTIVE	OUT	du/dt function is active in Zone Z3
13804	Dis. T3K active	OUT	Dist.: Delay Time T3K is active
13805	Time Out T3K	OUT	Time Out T3K
13806	Time Out T3L	OUT	Time Out T3L
13807	PU Z1Strk	OUT	Picked up in Zone Z1Strk
13808	PU Z2Strk	OUT	Picked up in Zone Z2Strk
13809	PU Z3Strk	OUT	Picked up in Zone Z3Strk
13810	ON/offBI	IntSP	ON/OFF via BI
13811	Z1StrkON/OFFser	IntSP	Zone Z1Stroke ON/OFF via Serial Inteface
13812	Z2StrkON/OFFser	IntSP	Distance Zone Z2Stroke ON
13813	Z3StrkON/OFFser	IntSP	Distance Zone Z3Stroke ON
13840	Dis Rush blk	OUT	Distance Protection: Inrush blocked
13890	Dis PU Z1B	OUT	Distance Prot. Picked up in Zone Z1B
13891	Dis PU Z1L	OUT	Distance Prot. Picked up in Zone Z1L
13892	Dis PU Z2di/dt	OUT	Picked up di/dt function in Zone Z2
13893	Dis PU Z2du/dt	OUT	Picked up du/dt function in Zone Z2
13894	Dis PU Z3di/dt	OUT	Picked up di/dt function in Zone Z3
13895	Dis PU Z3du/dt	OUT	Picked up du/dt function in Zone Z3
13896	Dis PU Z3K	OUT	Picked up in Zone Z3 (short circuit)
13897	Dis PU Z3L	OUT	Picked up in Zone Z3 (overload)
13900	Dis TRIP Z1B	OUT	Distance Protection TRIP in Zone Z1B
13901	Dis TRIP Z1L	OUT	Distance Protection TRIP in Zone Z1L
13903	Dis TRIP Z3K	OUT	Dist. Prot. TRIP Zone Z3 (short circuit)
13904	Dis TRIP Z3L	OUT	Dist. Prot. TRIP Zone Z3 (overload)
13905	Dis TRIP PU MC	OUT	Dist. Prot. TRIP after PU by Man. Close
13906	Dis TRIP MC ZOR	OUT	TRIP Overreach Zone after Man. Close
13911	Z1StrkON/OFF BI	IntSP	Zone Z1Stroke ON/OFF about Binary Input
13912	Z2StrkON/OFF BI	IntSP	Zone Z2Stroke ON/OFF about Binary Input
13913	Z3StrkON/OFF BI	IntSP	Zone Z3Stroke ON/OFF about Binary Input

2.3 Overcurrent Protection

The 7ST6 device has an integrated time overcurrent protection function. This function can be used as a backup overcurrent protection which works independently of the other protection and monitoring functions, including distance protection. The back-up time overcurrent protection could for instance be used as the only short-circuit protection if the voltage transformers are not yet available when the feeder is initially commissioned.

2.3.1 Functional Description

General

The time overcurrent protection has three stages for each phase current:

- Two overcurrent stages with a definite time characteristic (O/C with DT),
- One overcurrent stage with definite-time or inverse-time characteristic (selectable)

These three stages are independent of each other and are freely combinable. Instantaneous tripping can be set in all stages when the protected line is switched onto a fault. If some stages are not needed, those not needed can be deactivated by setting the pickup value to ∞.

The time overcurrent protection can be switched on or off by parameter settings, or via binary inputs. The figure below shows the control logic:

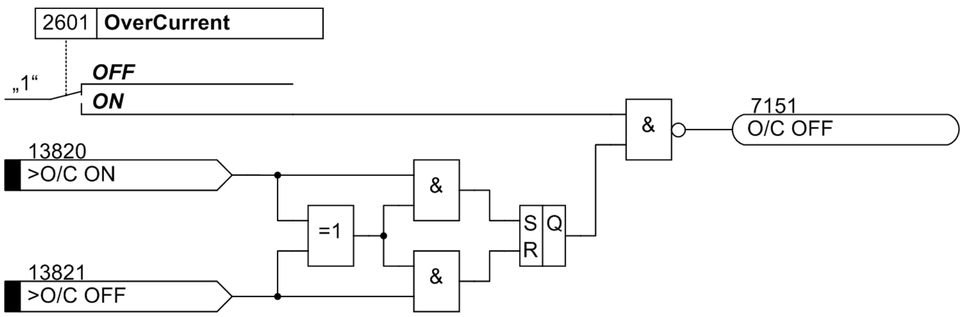


Figure 2-13 Control logic of the overcurrent protection

Definite Time Very High Set Current Stage I>>>

The current of the overhead contact line (or in auto-transformer systems optionally the summated overhead contact line current and the negative feeder current; can be set at address 213) are numerically filtered and compared with the setting **I>>>**. Currents above the associated pickup value are detected and signalled. After expiry of the associated time delay **T I>>>** a trip command is issued. The dropout value is approximately 5 % less than the pickup value, but at least 1.8 % of the rated current, below the pickup value.

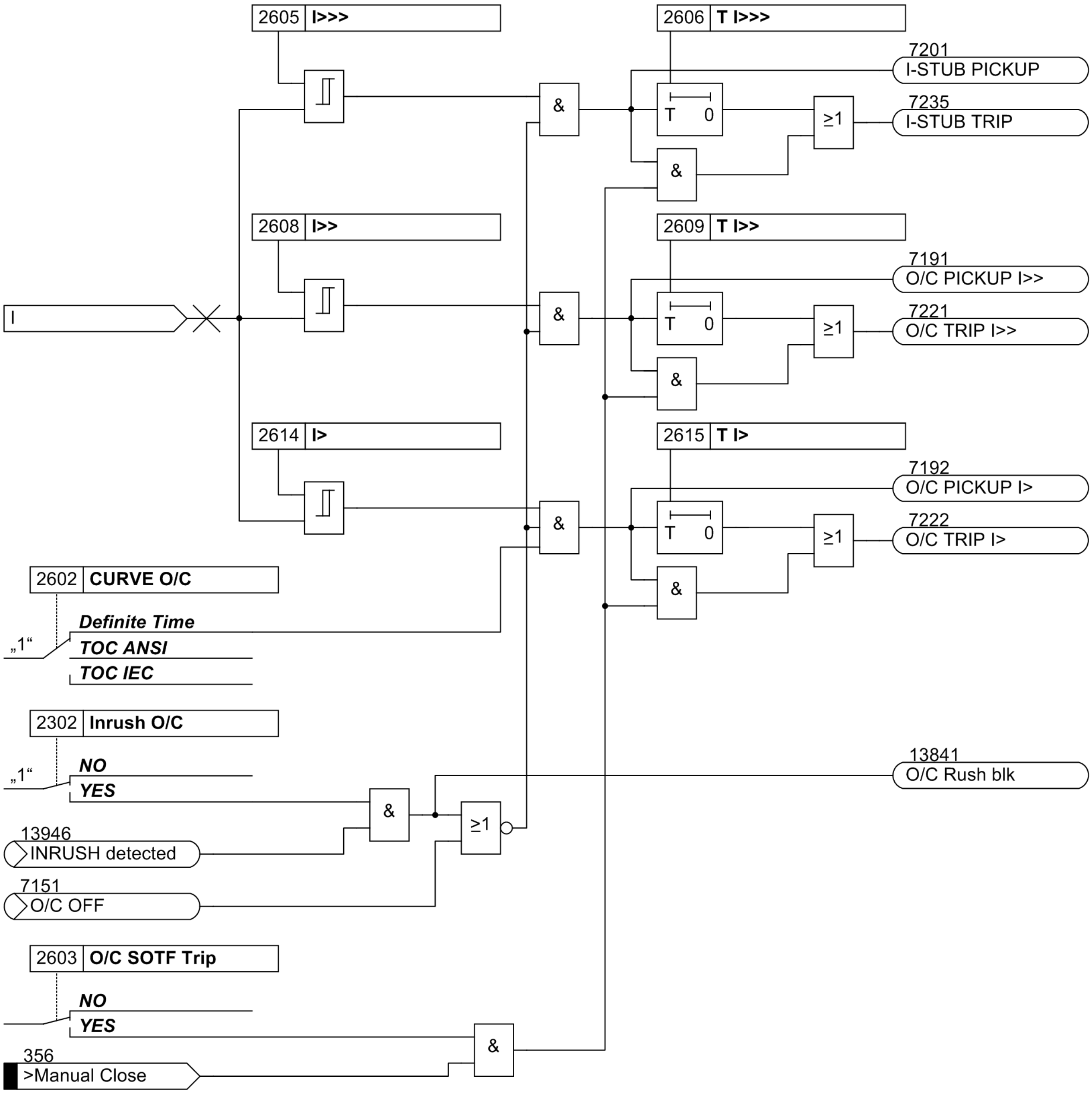


Figure 2-14 Pick-up and tripping logic of the definite time overcurrent stages

Figure 2-14 shows the logic diagram of the definite-time overcurrent stages.

The function block “Switch onto fault” is common to all stages. The parameter **O/C SOTF Trip** (address 2603) specifies whether instantaneous tripping of this stage via the binary input “>Manual Close” (FNo. 356) is possible (***YES***) or not possible (***NO***).

Furthermore, all stages can be blocked by the inrush restraint function. This blocking can be switched on (***YES***) or off (***NO***) in the parameter **Inrush O/C**. A blocking signal generates the indication “O/C Rush blk”.

Definite Time High-set Current Stage I>>

The logic of the high-set current stage I>> is the same as that of the I>>> stage. The two stages differ only in their parameters for the current threshold and the delay time. The parameter **I>>** is used for the current threshold, and the parameter **T I>>** for the delay time. In all other respects Figure 2-14 applies.

Definite Time Over-current Stage I>

This stage is available if the parameter **CURVE O/C** is set to ***Definite Time***. By default this stage is available. The logic of the time overcurrent stage I> is the same as that of the I>> stage. The parameter **I>** is used for the current threshold, and the parameter **T I>** for the delay time. In all other respects Figure 2-14 applies.

Inverse-Time Over-current Stage Ip

The inverse-time overcurrent stage is available if the parameter **CURVE O/C** is set to ***TOC ANSI*** or ***TOC IEC***. This parameter is also used to make a preselection of the characteristics available in the inverse-time overcurrent stage. This stage differs from the definite-time overcurrent stage I> by its current-dependent delay time characteristic. The delay time of the stage is the delay time associated with the applied current in the selected characteristic. Selectable characteristics are shown in the Technical Data in Section 4.3. The pickup current is set in the parameter **IP**. The delay time of the characteristic is calculated with the multiplier set in the parameter **T IP** or **D IP**.

Like all other stages, the inverse-time overcurrent stage has a logic for switching onto fault and can be blocked by the inrush restraint feature. A blocking signal generates the indication “O/C Rush blk”.

The following figure shows the logic diagram. In the configuration notes (Subsection 2.3.2) the different setting addresses are elaborated upon.

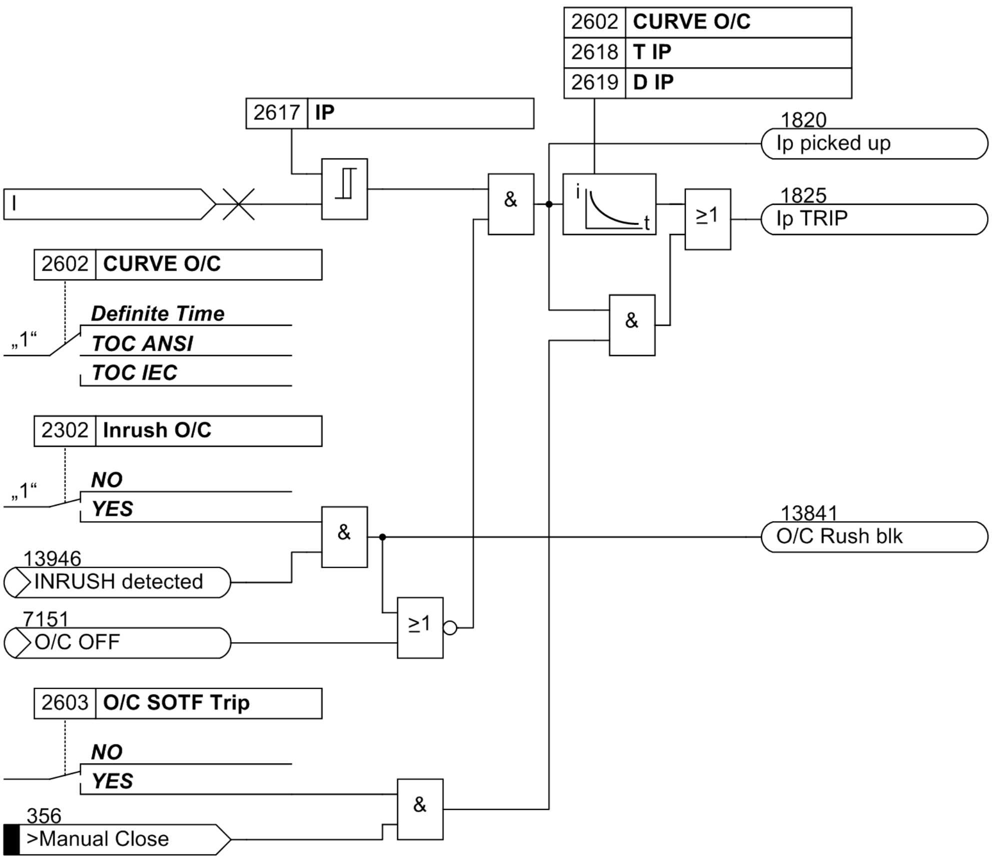


Figure 2-15 Pick-up and tripping logic of the inverse time overcurrent stages

Switching onto a Fault

The internal line energization detection can be used to achieve quick tripping of the circuit breaker in case of an earth fault. The time overcurrent protection then issues an instantaneous trip command.

Pickup Logic and Tripping Logic

The pickup signals of the individual stages are **OR**-combined and cause the indication "O/C PICKUP" to be output when one stage picks up.

Likewise, the trip signals of the individual stages are **OR**-combined. Tripping of one stage causes the indication "O/C TRIP" to be output.

2.3.2 Setting Notes

General

The time overcurrent protection is only effective and accessible if address 126 **Back-Up O/C** has been set to ***Enabled*** during the configuration of the functional scope. If the function is not required, ***Disabled*** is to be set.

In order to be effective, the time overcurrent protection function must also be switched ***ON*** in address 2601 **OverCurrent**. The time overcurrent protection operates independently of the other protection functions, i.e. as a backup time overcurrent protection. In address 2601 the time overcurrent protection can also be switched ***OFF***.

The **I>>>** stage (address 2605), the **I>>** stage (address 2608) and the **I>** stage (address 2614) together create a three-stage characteristic.

The very high-set current stage (**I>>>** stage) and the high-set current stage (**I>>** stage) operate always as a definite-time overcurrent protection.

The overcurrent stage (**I>** stage) may operate either as a definite-time overcurrent protection (address 2602 **CURVE O/C**=***Definite Time***) or as an time overcurrent protection with current-dependent characteristic (address 2602 **CURVE O/C**=***TOC IEC***).

If some stages are not needed, those not needed can be deactivated by setting the pickup value to ∞. If you set one assigned time stage to ∞, the delay time cannot expire. As a result, the trip indications are suppressed but not the pickup indications.

In case of switching onto a fault, the protection should trip instantaneously. To do so, set in address 2603 **O/C SOTF Trip**=***YES***. If the pickup threshold is exceeded when switching onto a fault, the delay time set for the function is bypassed, and the time overcurrent protection issues an instantaneous trip command.

The time overcurrent protection is blocked by the inrush restraint function if address 2302 **Inrush O/C** is set to ***YES***.

Definite Time Very High-set Current Stage I>>>

With the parameter **I>>>** (address 2605) the pickup threshold of the very high set current stage is specified.

When using a personal computer and DIGSI® to apply the settings, these can be optionally entered as primary or secondary values. If secondary quantities are used, all currents must be converted to the secondary side of the current transformers.

The delay time of the very high set current stage **T I>>>** is set in address 2606.

The delay set is in addition to the pickup time which does not include the operating time (measuring time).

The dropout to pickup ratio of the stage is 0.95.

High-set Current Stage I>>

With the parameter **I>>** (address 2608) the pickup threshold of the high-set current stage is specified.

When using a personal computer and DIGSI® to apply the settings, these can be optionally entered as primary or secondary values. If secondary quantities are used, all currents must be converted to the secondary side of the current transformers.

The delay time of the very high set current stage **T I>>** is set in address 2609.

The delay set is in addition to the pickup time which does not include the operating time (measuring time).

The dropout to pickup ratio of the stage is 0.95.

Overcurrent Stage I> in Definite-time Overcurrent Protection

If the overcurrent stage is to be operated as a definite-time overcurrent protection, address 2602 **CURVE O/C** must be set to ***Definite Time***.

For the setting of the current pickup value, **I>** (address 2614), the maximum operating current is most decisive. Pickup due to overload should never occur, since the device in this operating mode operates as fault protection with correspondingly short tripping times and not as overload protection. Therefore, the pickup value is set to about 20 % above the maximum expected overload.

When using a personal computer and DIGSI® to apply the settings, these can be optionally entered as primary or secondary values. If secondary quantities are used, all currents must be converted to the secondary side of the current transformers.

The time delay **T I>** (address 2615) results from the time grading schedule designed for the network. If implemented as emergency overcurrent protection, shorter tripping times are advisable (one grading time step above the fast tripping stage), as this function is only activated in the case of the loss of the local measured voltage.

The delay set is in addition to the pickup time which does not include the operating time (measuring time).

The dropout to pickup ratio of the stage is 0.95.

Overcurrent Stage IP in Inverse-time Overcurrent Protection with IEC Characteristics

If the overcurrent stage is to be operated as an inverse-time stage with IEC characteristics, address 2602 **CURVE O/C** must be set to ***TOC IEC***.

With IEC characteristics, the following characteristics are available in address 2611 **IEC Curve**:

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

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

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

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

For the setting of the pickup value **IP** (address 2617), the following must be observed: Pickup only occurs at a current which is approximately 10 % above the set value. The dropout threshold is the setting value.

The time multiplier **T IP** (address 2618) derives from the time grading schedule set for the network.

Overcurrent Stages IP in Inverse-time Overcurrent Protection with ANSI Characteristics

If the overcurrent stage is to be operated as an inverse-time stage with ANSI characteristics, address 2602 **CURVE O/C** must be set to ***TOC ANSI***.

With ANSI characteristics, the following characteristics are available in address 2612 **ANSI Curve**:

Inverse,

Short Inverse,

Long Inverse,

Moderately Inv.,

Very Inverse,

Extremely Inv. and

Definite Inv..

For the setting of the pickup value **IP** (address 2617), the following must be observed: Pickup only occurs at a current which is approximately 10 % above the set value. The dropout threshold is the setting value.

The time multiplier **D IP** (address 2619) derives from the time grading schedule set for the network.

2.3.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2302	Inrush O/C		NO YES	NO	O/C Blocked by Inrush
2601	OverCurrent		ON OFF	OFF	Overcurrent Protection Function
2602	CURVE O/C		Definite Time TOC ANSI TOC IEC	Definite Time	Characteristic Curve for O/C
2603	O/C SOTF Trip		YES NO	NO	Instantan. Trip after Switch-onto-Fault
2605	I>>>	1A	0.10 .. 25.00 A; ∞	4.00 A	Pickup Current I>>> Very-HighSetStage
		5A	0.50 .. 125.00 A; ∞	20.00 A	
2606	T I>>>		0.00 .. 30.00 sec; ∞	0.10 sec	Delay Time T I>>> Very High Set Stage
2608	I>>	1A	0.10 .. 25.00 A; ∞	2.00 A	I>> Pickup
		5A	0.50 .. 125.00 A; ∞	10.00 A	
2609	T I>>		0.00 .. 30.00 sec; ∞	0.30 sec	T I>> Time Delay
2611	IEC Curve		Normal Inverse Very Inverse Extremely Inv. LongTimeInverse	Normal Inverse	IEC Curve

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2612	ANSI Curve		Inverse Short Inverse Long Inverse Moderately Inv. Very Inverse Extremely Inv. Definite Inv.	Inverse	ANSI Curve
2614	I>	1A	0.10 .. 25.00 A; ∞	1.50 A	I> Pickup
		5A	0.50 .. 125.00 A; ∞	7.50 A	
2615	T I>		0.00 .. 30.00 sec; ∞	0.50 sec	T I> Time Delay
2617	IP	1A	0.10 .. 4.00 A; ∞	1.00 A	Pickup Current IP for IEC
		5A	0.50 .. 20.00 A; ∞	5.00 A	
2618	T IP		0.05 .. 3.00 sec; ∞	0.50 sec	Time Dial T IP for IEC
2619	D IP		0.50 .. 15.00 ; ∞	5.00	Time Dial D IP for ANSI

2.3.4 Information List

No.	Information	Type of Information	Comments
1820	Ip picked up	OUT	Ip picked up
1825	Ip TRIP	OUT	Ip TRIP
7151	O/C OFF	OUT	Overcurrent is switched OFF
7161	O/C PICKUP	OUT	Overcurrent PICKED UP
7191	O/C PICKUP I>>	OUT	Overcurrent Pickup I>>
7192	O/C PICKUP I>	OUT	Overcurrent Pickup I>
7201	I-STUB PICKUP	OUT	O/C I-STUB Pickup
7211	O/C TRIP	OUT	Overcurrent General TRIP command
7221	O/C TRIP I>>	OUT	Overcurrent TRIP I>>
7222	O/C TRIP I>	OUT	Overcurrent TRIP I>
7235	I-STUB TRIP	OUT	O/C I-STUB TRIP
13820	>O/C ON	SP	>Switch on Overcurrent Protection
13821	>O/C OFF	SP	>Switch off Overcurrent Protection
13822	O/C ON/OFF BI	IntSP	Overcurrent Protection ON/OFF via BI
13841	O/C Rush blk	OUT	Overcurrent Protection: Inrush blocked

2.4 High-Speed Overcurrent Protection

This function is optional, i.e. not included in all device variants.

In railway networks, close-in faults can lead to very high short-circuit currents. The high-speed overcurrent protection issues in very short time the trip command to the circuit breaker. This is advantageous especially with low power system frequencies (long cycles) since it allows to quench the arc as quickly as possible.

2.4.1 Functional Description

General

The high-speed overcurrent protection works independently of other functions.

The high-speed overcurrent protection can be switched on or off by parameter settings, or via binary inputs. The figure below shows the control logic:

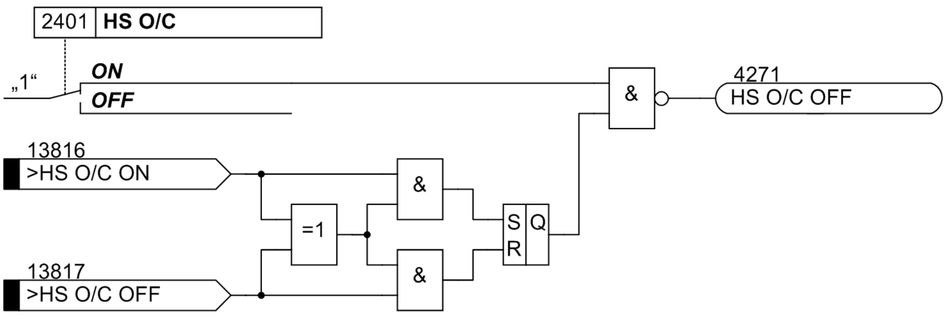


Figure 2-16 Control logic of the instantaneous high-speed overcurrent protection function

The instantaneous value of the overhead contact line current, or the sum of the overhead contact line current and the current of the negative feeder (2.1.3.1), is compared with the setting **I HS O/C** (address 2404).

When the settable delay time **T HS O/C** has expired, a trip command is issued.

The high-speed overcurrent protection has a fixed dropout delay which prevents that the stage that has picked up drops out at the instant of the current zero crossing before the set delay time has elapsed.

The figure below shows the pickup/trip logic of the high-speed overcurrent function.

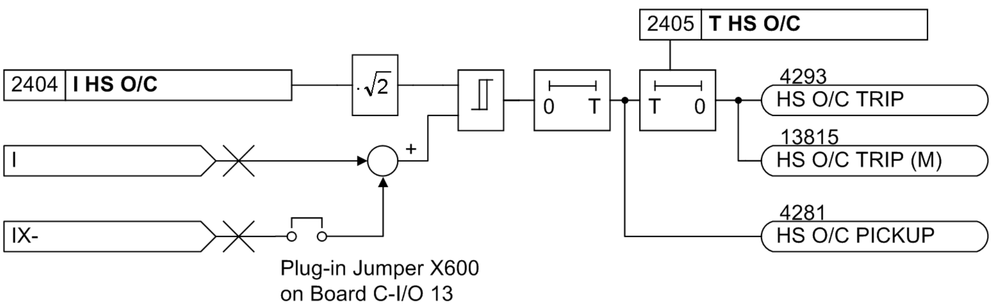


Figure 2-17 Tripping logic of the high–speed overcurrent protection function

2.4.2 Setting Notes

General

The high-speed overcurrent protection is only effective and accessible if address 124 **FCT HS O/C** has been set to ***Enabled*** during the configuration of the functional scope.

In order to be effective, the high-speed overcurrent protection function must also be switched ***ON*** in address 2401 = **HS O/C**. The high-speed overcurrent protection function works independently of other protection functions; it is an ancillary function of the distance protection. In address 2401 the function can also be switched ***OFF***.

The high-speed overcurrent protection function cooperates normally with the high-speed relay outputs BO1 and BO2. Therefore, the trip command from the high-speed overcurrent protection function ("HS O/C TRIP") is permanently masked to these relay outputs. In address 2408 **HS O/C TRIP** you set whether a trip command will be output only to BO1 (***single-channel***) or to BO1 and BO2 (***dual-channel***).

I HS O/C

The high-speed overcurrent protection function works with instantaneous values. In auto-transformer systems, the user can select whether the overhead contact line current or the summated current of the overhead contact line current and the negative feeder current will be evaluated.

Note

If at address 213 the parameter **CURRENT I1, I2** is set to ***Sum I1, I2***, the setting of jumper X600 on the C-I/O 13 board must be changed for the summation! On delivery, this jumper setting is for "without summation"!

The threshold **I HS O/C** (address 2404) is set as an RMS value. The setting value is converted internally to the peak current value, and used for threshold comparison. Depending on the phase angle of the voltage on fault inception, the short-circuit current can be superimposed by a decaying DC component. The peak value of the short-circuit current can be increased at most by the inrush current factor ψ in comparison to a short-circuit current without offset. In order to prevent that the high-speed overcurrent protection function picks up in the presence of offset currents with an r.m.s. value below the set threshold, the setting value **I HS O/C** (address 2404) **must** be multiplied with the inrush current factor ψ. The value thus calculated is the setting value. In Figure 2-18, the ratio of the inrush short-circuit current is shown as a function of the R/X ratio for the making angle $\psi = 0°$. If the R/X ratio is not known, the most unfavourable case is assumed, i.e. the RMS value of the expected short-circuit current is multiplied with 2.

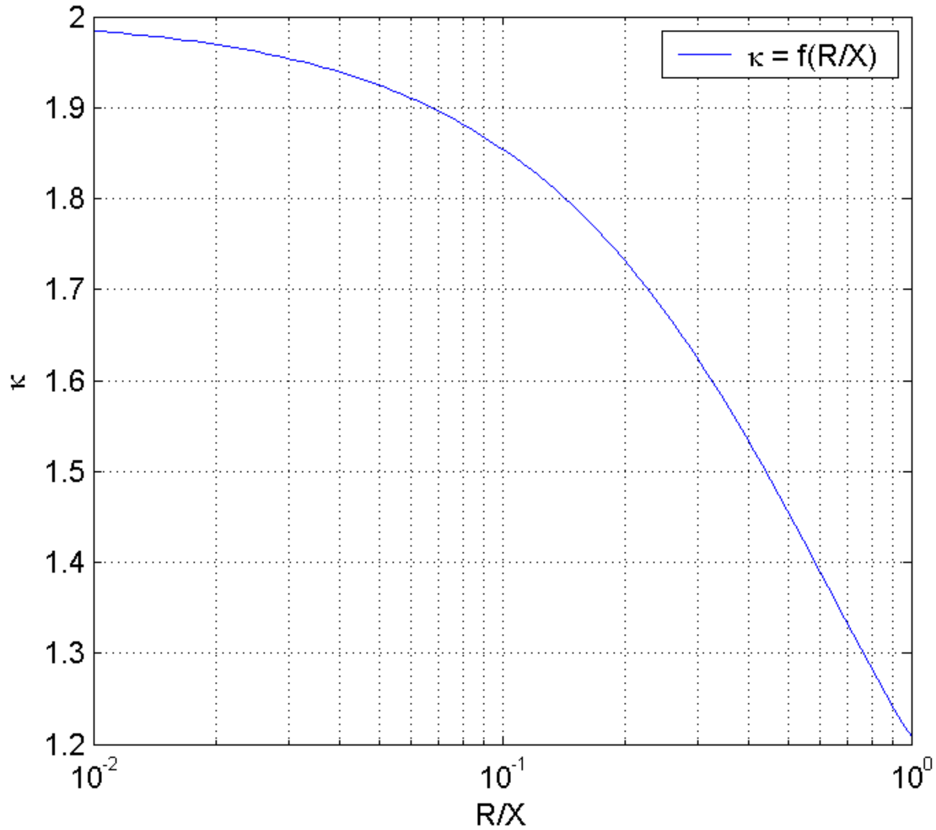


Figure 2-18 Inrush current factor as a function of the R/X ratio

If the stage is not needed, it can be deactivated by setting the pickup value to ∞.

T HS O/C

In address 2405 you set the delay time **T HS O/C** for enabling the trip condition when the pickup threshold of the high-speed overcurrent protection function is exceeded.

The delay time **T HS O/C** takes into account the measuring time and the operating time of the binary outputs, and thus characterizes the actual time between exceeding the threshold and issuing the binary output signal to BO1 and BO2. For very fast trip command times, this stage is undelayed, i.e. set to 0.000 s. If the stage is set to ∞ , it continues to issue pickup indications, but the output of trip indications and thus of trip commands is suppressed.

2.4.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2401	HS O/C		ON OFF	ON	High-Speed Overcurrent Protection
2404	I HS O/C	1A	1.0 .. 25.0 A; ∞	10.0 A	High-Speed O/C Pickup Current
		5A	5 .. 125 A; ∞	50 A	
2405	T HS O/C		0.006 .. 0.100 sec; 0; ∞	0.000 sec	High-Speed O/C Delay Time
2408	HS O/C TRIP		single-channel dual-channel	dual-channel	HS O/C TRIP Allocation

2.4.4 Information List

No.	Information	Type of Information	Comments
4271	HS O/C OFF	OUT	HS O/C is switched OFF
4281	HS O/C PICKUP	OUT	HS O/C PICKED UP
4293	HS O/C TRIP	OUT	HS O/C TRIPPED
13815	HS O/C TRIP (M)	OUT	HS O/C TRIPPED (M)
13816	>HS O/C ON	SP	>Switch on HS O/C Protection
13817	>HS O/C OFF	SP	>Switch off HS O/C Protection
13818	HSo/c ON/OFF BI	IntSP	HS O/C ON/OFF about Binary Input
13819	HS O/C Failure	OUT	HS O/C uC-Failure

2.5 Emergency Overcurrent Protection

2.5.1 General

Whereas the distance protection can only function correctly if the measured voltage signals are available to the device, the emergency overcurrent protection only requires the currents.

The emergency overcurrent protection function is activated automatically, and only if the distance protection is ineffective (emergency operation). Emergency operation supersedes in this case the distance protection as a short-circuit protection.

The emergency overcurrent protection is effective if one of the following conditions is fulfilled (see Figure 2-19):

- Tripping of the voltage transfomer m.c.bs.
- Pickup of the internal measuring voltage monitoring, e.g. by a short-circuit or an interruption of the voltage transformer secondary circuit (see also Section 2.16.3“Fuse Failure Monitor”, in Section 2.16), or
- Distance protection is switched off or ineffective.

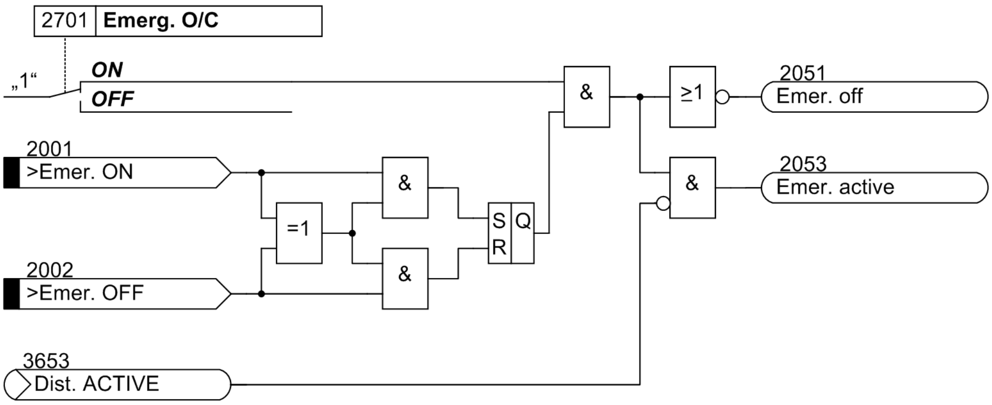


Figure 2-19 Control logic of the emergency overcurrent protection

2.5.2 Functional Description

Emergency Overcurrent Protection

The emergency overcurrent protection has a time overcurrent stage with current-independent trip time. Undelayed tripping can be set when the protected line is switched onto a fault. If the stage is not needed, it can be disabled (in address 2702).

The current of the overhead contact line, or in auto-transformer systems optionally the summated overhead contact line current and the negative feeder current, are numerically filtered and compared with the setting **I Emerg. O/C**.

Currents above the associated pickup value are detected and signalled. After expiry of the associated time delay **T Emerg. O/C** a trip command is issued.

The dropout value is approximately 5 % less than the pickup value, but at least 1.8 % of the rated current, below the pickup value.

The figure below shows the logic diagram of the emergency overcurrent protection function.

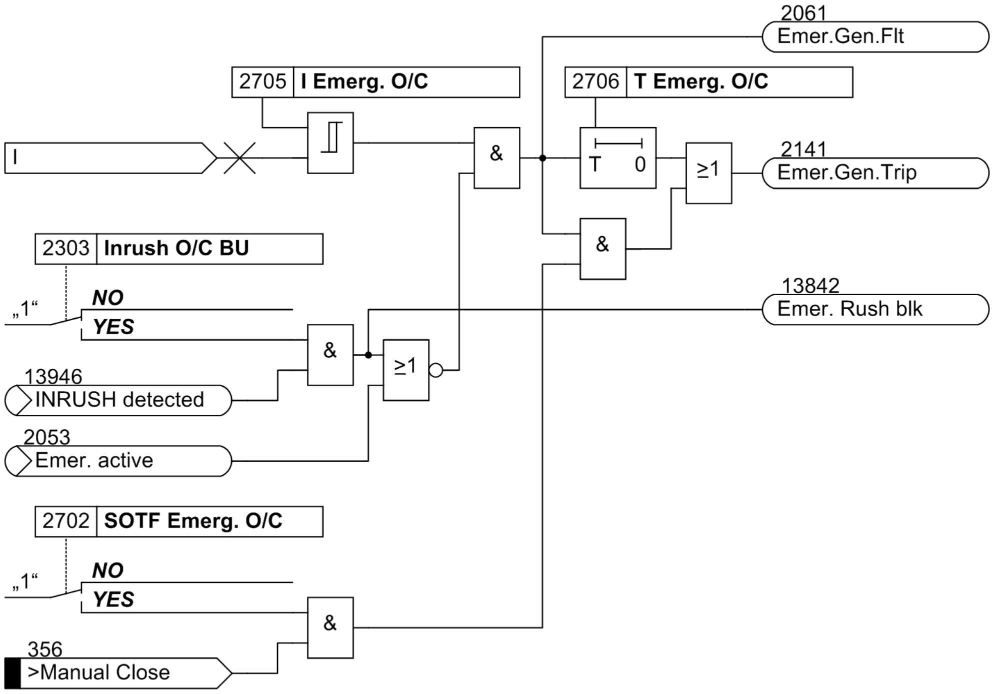


Figure 2-20 Pick-up and tripping logic of the backup O/C protection

2.5.3 Setting Notes

General

The emergency overcurrent protection is only effective and accessible if address 127 **FCT Emerg. O/C** has been set to ***Enabled*** during the configuration of the functional scope. If the function is not required, **FCT Emerg. O/C** = ***Disabled*** is to be set.

In order to be effective, the emergency overcurrent protection function must also be switched ***ON*** in address 2701 **Emerg. O/C**. The emergency overcurrent protection operates independently of other protection functions. It is automatically activated when the distance protection is not operative. In address 2701 the time overcurrent protection can also be switched ***OFF***.

In case of switching onto a fault, the protection should trip instantaneously. To do so, set in address 2702 **SOTF Emerg. O/C**=***YES***. If the pickup threshold is exceeded when switching onto a fault, the delay time set for the function is bypassed, and the emergency overcurrent protection issues an instantaneous trip command.

The emergency time overcurrent protection can be blocked by the inrush restraint feature if **Inrush O/C BU**=***YES*** is set in address 2303. The default setting for this parameter is **Inrush O/C BU**=***NO***.

When the inrush restraint is activated, at least one power system cycle must elapse after fault inception before the pickup signal of the emergency overcurrent protection can be generated.

I Emerg. O/C

In address 2705 you specify the pickup threshold **I Emerg. O/C** of the emergency overcurrent protection.

When using a personal computer and DIGSI® to apply the settings, these can be optionally entered as primary or secondary values. If secondary quantities are used, all currents must be converted to the secondary side of the current transformers.

The dropout to pickup ratio of the stage is 0.95.

T Emerg. O/C

In address 2706 you set the delay time **T Emerg. O/C** of the emergency overcurrent protection.

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

2.5.4 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2303	Inrush O/C BU		NO YES	NO	Emerg. O/C Blocked by Inrush
2701	Emerg. O/C		ON OFF	ON	Emergency Overcurrent Function
2702	SOTF Emerg. O/C		NO YES	NO	Instantan. trip after Switch-onto-Fault
2705	I Emerg. O/C	1A	0.10 .. 25.00 A; ∞	2.00 A	Emergency O/C Pickup Current
		5A	0.50 .. 125.00 A; ∞	10.00 A	
2706	T Emerg. O/C		0.00 .. 30.00 sec; ∞	0.30 sec	Emergency O/C Delay Time

2.5.5 Information List

No.	Information	Type of Information	Comments
2001	>Emer. ON	SP	>Switch ON emerg. overcurrent prot.
2002	>Emer. OFF	SP	>Switch OFF emerg. overcurrent prot.
2051	Emer. off	OUT	Emergency O/C protect. is switched off
2053	Emer. active	OUT	Emergency O/C protection is active
2061	Emer.Gen.Flt	OUT	Emerg. O/C prot.: General fault detect.
2141	Emer.Gen.Trip	OUT	Emerg. O/C protection: General Trip
13842	Emer. Rush blk	OUT	Emerg. O/C Protection: Inrush blocked
13994	Emer. ON/OFF BI	IntSP	Emerg.O/C Prot.: ON/OFF via Binary Input

2.6 Overvoltage and Undervoltage Protection

This function is optional, i.e. not included in all device variants.

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

Both the overvoltage and the undervoltage protection in the 7ST6 use the overhead contact line voltage U. The voltage protection functions can be combined as desired, and can be separately switched on and off. Each voltage protection function is two-stage, i.e. it is provided with two threshold settings each with the appropriate times delay.

Abnormally high voltages often occur e.g. on long overhead contact lines under low load conditions, especially in auto-transformer systems with several auto-transformers along the line, in islanded systems when generator voltage regulation fails, or after full load shutdown of a generator with the generator disconnected from the system. The undervoltage protection can be applied, for example, for disconnection or load shedding tasks in a system. Furthermore, this protection scheme can detect menacing stability problems. With induction machines undervoltages have an effect on the stability and permissible torque thresholds.

2.6.1 Overvoltage Protection

The figure below shows the logic diagram of the overvoltage protection.

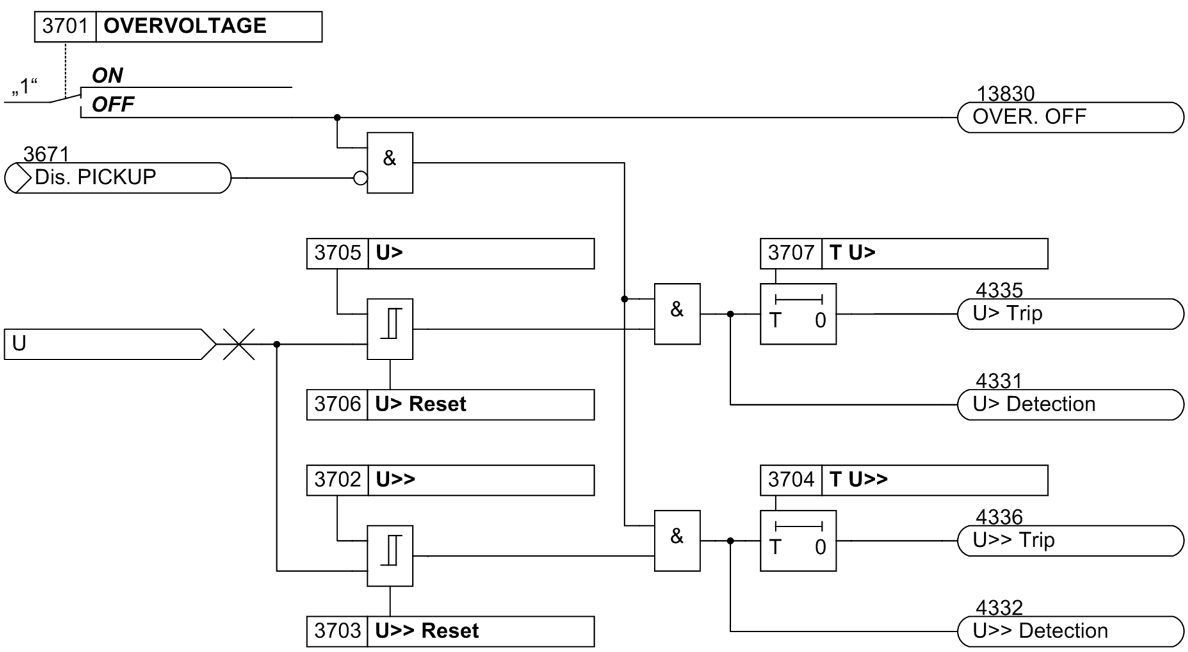


Figure 2-21 Control and pick-up/tripping logic of the overvoltage protection

With the parameter 3701 **OVERVOLTAGE** the overvoltage protection can be switched ***ON*** or ***OFF***. The indication “OVER. OFF” is output when the function is switched on/off. The overvoltage protection is blocked as soon as the signal “Dis. PICKUP” is activated.

Both stages of the overvoltage protection have a separately settable grading margin for the TRIP command of their respective stage.

2.6.2 Undervoltage Protection

The figure below shows the logic diagram of the undervoltage protection.

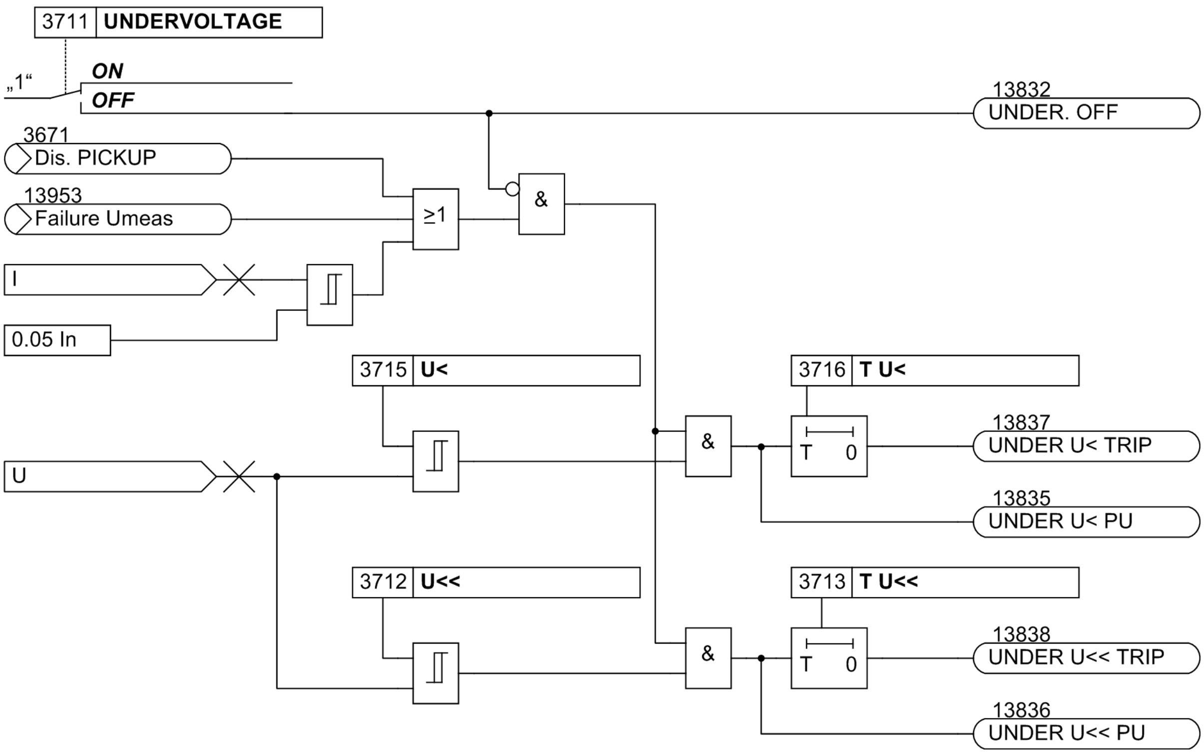


Figure 2-22 Control and pick-up/tripping logic of the undervoltage protection

With the parameter 3711 **UNDERVOLTAGE** the undervoltage protection can be switched ***ON*** or ***OFF***. The indication “UNDER. OFF” is output when the function is switched on/off.

The undervoltage protection is blocked when at least one of the signals “Dis. PICKUP” or “Failure Umeas” is active. The signal “Failure Umeas” prevents the undervoltage protection from picking up when the measuring voltage fails. The undervoltage protection is also blocked when the current drops below a set threshold of 0.05 I_n .

2.6.3 Setting Notes

The voltage protection can only operate if the parameter **O/U VOLTAGE** (address 137) has been set to ***Enabled*** during the configuration of the functional scope.

Note

For overvoltage protection it is particularly important to observe the setting hints: The overvoltage level must never be set to less than an undervoltage level. This would put the device immediately into a state of permanent pickup which cannot be reset by any measured value operation. As a result, the device would remain out of service!

Overvoltage

The zero sequence voltage stages can be switched ***ON*** or ***OFF*** in address 3701 **OVERVOLTAGE**. The settings of the voltage threshold and the timer values depend on the type of application.

To detect steady-state overvoltages on long lines carrying no load, set the **U>** stage (address 3705) to at least 5 % above the maximum stationary phase-earth voltage expected during operation. Additionally, a high dropout to pickup ratio is required (address 3706 **U> Reset** = 0.95 = presetting). The delay time **T U>** (address 3707) should be a few seconds so that overvoltages with short duration may not result in tripping.

The **U>>** stage (address 3702) is provided for high overvoltages with short duration. Here an appropriately high pickup value is set, e.g. 1.5 times the rated voltage. 0.1 s to 0.2 s are sufficient for the time delay **T U>>** (address 3704).

Undervoltage

The zero sequence voltage stages can be switched ***ON*** or ***OFF*** in address 3711 **UNDERVOLTAGE**. This undervoltage protection function has two stages.

The **U<** stage (address 3715) operates with the longer set time **T U<** (address 3716) for minor undervoltages. It must not be set to more than the undervoltage permissible in operation.

For greater voltage dips, the **U<<** stage (address 3712) with the delay **T U<<** (address 3713) takes effect.

The settings of the voltages and times depend on the application; therefore, general setting recommendations are not possible. For load shedding, for example, the values are often determined by a priority grading coordination chart.

In case of stability problems, the permissible undervoltages and their duration must be observed. With induction machines undervoltages have an effect on the permissible torque thresholds.

If the voltage transformers are located on the line side, the measuring voltages will be missing when the line is disconnected. In order to ensure that the undervoltage stages do not pick up or remain picked up in such cases, the undervoltage protection is blocked when the current drops below a preset threshold of 0.05 I_n. As soon as a significant current level ($I > 0.05\ I_n$) is measured on the line, the line is assumed to be energized, and the blocking of the undervoltage protection is reset.

2.6.4 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
3701	OVERVOLTAGE	ON OFF	ON	Overvoltage Protection
3702	U>>	20 .. 170 V; ∞	150 V	Pickup Overvoltage U>>
3703	U>> Reset	0.50 .. 0.95	0.95	Reset Ratio U>>
3704	T U>>	0.00 .. 60.00 sec; ∞	1.00 sec	Delay Time Overvoltage U>>
3705	U>	20 .. 170 V; ∞	120 V	Pickup Overvoltage U>
3706	U> Reset	0.50 .. 0.95	0.95	Reset Ratio U>
3707	T U>	0.00 .. 60.00 sec; ∞	2.00 sec	Delay Time Overvoltage U>
3711	UNDERVOLTAGE	ON OFF	ON	Undervoltage Protection
3712	U<<	20 .. 120 V; 0	30 V	Pickup Undervoltage U<< (pos. seq.)
3713	T U<<	0.00 .. 60.00 sec; ∞	1.00 sec	Delay Time Undervoltage U<<
3715	U<	20 .. 120 V; 0	70 V	Pickup Undervoltage U< (pos. seq.)
3716	T U<	0.00 .. 60.00 sec; ∞	2.00 sec	Delay Time Undervoltage U<

2.6.5 Information List

No.	Information	Type of In-formation	Comments
4331	U> Detection	OUT	Overvoltage detection : Stage U>
4332	U>> Detection	OUT	Overvoltage detection : Stage U>>
4335	U> Trip	OUT	Overvoltage trip : Stage U>
4336	U>> Trip	OUT	Overvoltage trip : Stage U>>
13830	OVER. OFF	OUT	Overvoltage Protection is switched off
13832	UNDER. OFF	OUT	Undervoltage Protection is switched off
13834	OVER/UNDER PU	OUT	Over/Undervoltage Protection picked up
13835	UNDER U< PU	OUT	Undervolt. U< picked up
13836	UNDER U<< PU	OUT	Undervolt. U<< picked up
13837	UNDER U< TRIP	OUT	Undervolt. U< TRIP command
13838	UNDER U<< TRIP	OUT	Undervolt. U<< TRIP command
13839	OVER/UNDER TRIP	OUT	Over/Undervoltage Prot. TRIP comm.

2.7 Thermal Overload Protection

The thermal overload protection prevents damage to the overhead contact line caused by thermal overloading. It is based on the principle of creating a thermal model of the overhead contact line on the basis of the current load and the ambient temperature. Where no ambient temperature sensing is provided, a fixed value can be used instead of an ambient temperature measurement.

2.7.1 Thermal Overload Protection

General

The thermal overload protection can be switched on or off by parameter settings, or via binary inputs. The figure below shows the control logic:

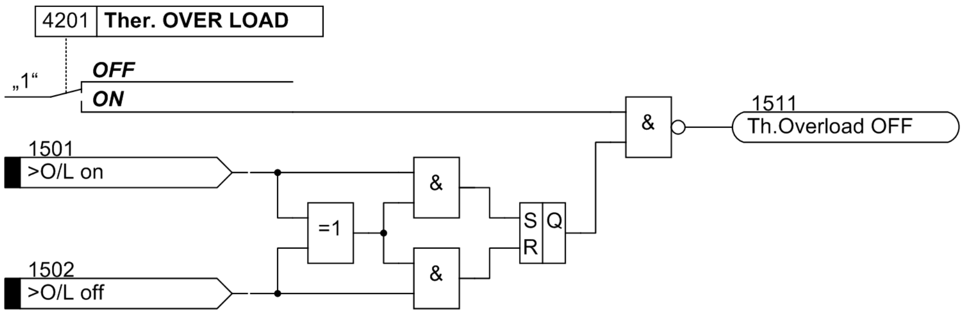


Figure 2-23 Control logic of the overload protection

When overload protection is disabled, the thermal replica will also be reset.

The device calculates the overtemperature in accordance with a single-body thermal model, based on the following differential equation:

$$\frac{dTemp}{dt} = \frac{1}{\tau} \cdot \left[T\ Rise \left(\frac{I}{IT\ Rise \cdot Cat.} \right)^2 - TEMP \right]$$

with

TEMP	– Current overtemperature (referred to the ambient temperature)
τ	– Thermal time constant of the contact line
TRise	– Final overtemperature at current ITRise
ITRise	– Current leading to the final temperature TRise
CHANGE TO CAT	– Parameter for catenary changeover; used for modifying the characteristic where there is more than one contact line
I	– Present r.m.s. current

The solution of this equation is in steady-state operation an e-function whose asymptote represents the final temperature **T Rise**. The overtemperature is proportional to the square of the contact line current. When the overtemperature reaches the first settable temperature threshold **TEMP ALARM**, which is below the overtemperature = tripping overtemperature, a warning alarm is given in order to allow a preventive load reduction. When the second temperature threshold, i.e. the final overtemperature or tripping temperature, is reached, the protected object is disconnected from the network. Reclosing is prevented until the temperature has dropped again below **TEMP CLOSE**. The figure below shows the pickup and trip logic of the overload protection.

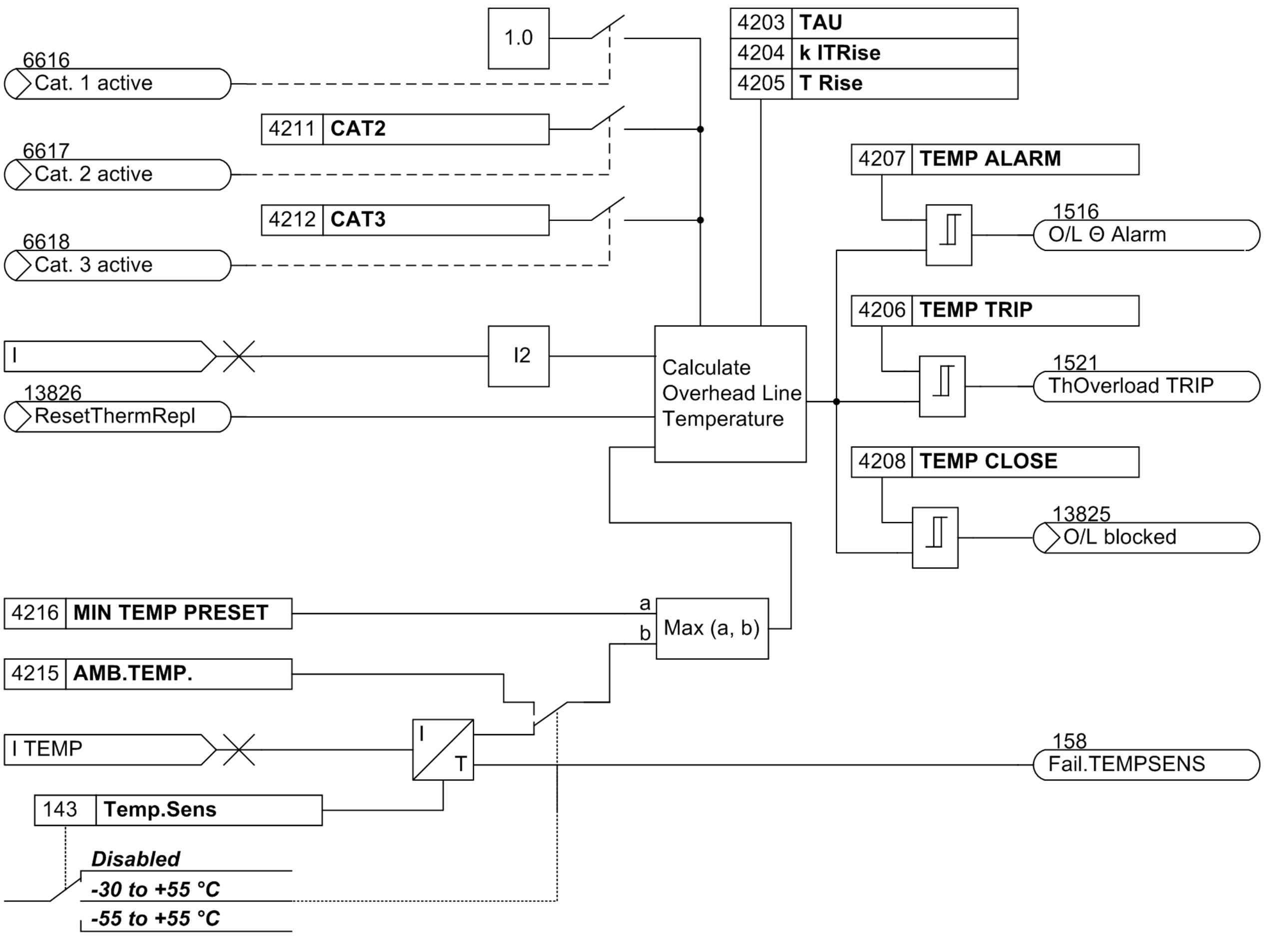


Figure 2-24 Pick-up and tripping logic of the overload protection

2.7.2 Ambient Temperature Sensing

Figure 2-25 shows a schematic representation of the ambient temperature sensing.

The ambient temperature is taken only once per substation with a separate device (7SW40) that has its own, galvanically separated power supply and its own housing. A Pt100 temperature sensor is used for this purpose. This device delivers at its output a load-independent current (4-20 mA TD input) which can be looped through up to 20 connected 7ST6 devices via an isolating amplifier. The ambient temperature sensing feature is available for the temperature ranges between -30°C and +55°C and between -55° and +55°C.

A failure of the ambient temperature sensing, e.g. because of a wire break of the Pt100 sensor, a defective device or a voltage failure, is detected by the main protection equipment by comparison with defined current values in the current loop.

After each update of the ambient temperature sensing, the device checks whether the current is in the permissible operating range. If this is not the case, a malfunction of the ambient temperature sensing is assumed, and the last valid ambient temperature is kept. In addition, the indication "Fail.TEMPSENS" (FNo. 158) is output.

If the ambient temperature sensing is already disturbed on power-up of the protection relay, the ambient temperature set at address 4215 **AMB.TEMP.** is used for the calculation, and the indication "Fail.TEMPSENS" (FNo. 158) is output, too.

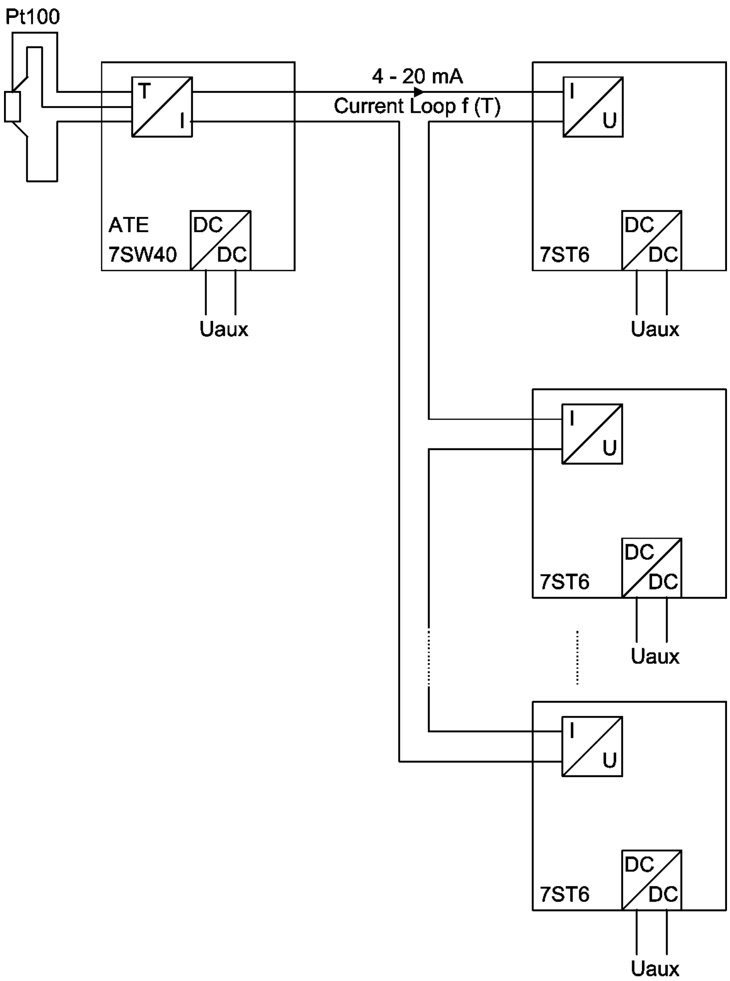


Figure 2-25 Ambient temperature sensing

The parameter **MIN TEMP PRESET** (address 4216) is provided for line sections where the temperature is higher than at the location of the ambient temperature sensing (e.g. tunnels in winter: ambient temperature = -15°C, tunnel temperature = 8°C). In such a case, a lower threshold must be set for the used ambient temperature (e.g. **MIN TEMP PRESET**= 3°C).

2.7.3 Catenary Changeover

Where the continuous current carrying capacity of the catenary assembly depends on the switching state, the current carrying capacity of up to 3 different switching states can be processed.

The thermal model can be matched to the current switching state by parameter settings, by the control system or through the system interface.

The active control source for this changeover is selected with the parameter 4202 **CAT CHANGEOVER**; setting options are ***Binary Input***, ***Protocol***, ***Setting*** or ***Blocked***.

The control sources ***Binary Input*** and ***Protocol*** can continue to be operated, even if they are not activated. However, the catenary factor - CAT1, CAT2 or CAT3 - set in this way will not take effect until the associated control source is selected again (see logic diagram 2-26).

For a changeover via ***Protocol***, the commands 13827 to 13829 “O/C Cat1/2/3ON” are provided.

With the setting ***Binary Input***, changeover between the catenaries CAT1, CAT2 and CAT3 is performed using the binary input indications “>Cat.1 active” (FNo. 6605), “>Cat.2 active” (FNo. 6604) and “>Cat.3 active” (FNo. 6603). The binary inputs can also be used for changeover with the setting ***Protocol***, if the binary input “>Ctrl Select.” (FNo. 365) “>Select: Control by BI or SYS interface” is activated.

With the setting ***Setting*** the changeover is performed with the parameter 4210 **CHANGE TO CAT**. This parameter is masked out when another control source is selected. If **CHANGE TO CAT** = ***CAT1 active***, the catenary factor “1” (for 1 catenary) is assumed. With **CHANGE TO CAT** = ***CAT2 active*** or **CHANGE TO CAT** = ***CAT3 active***, the factor set in parameter 4211 **CAT2** or 4212 **CAT3** applies.

The figure below shows the control logic of the catenary changeover:

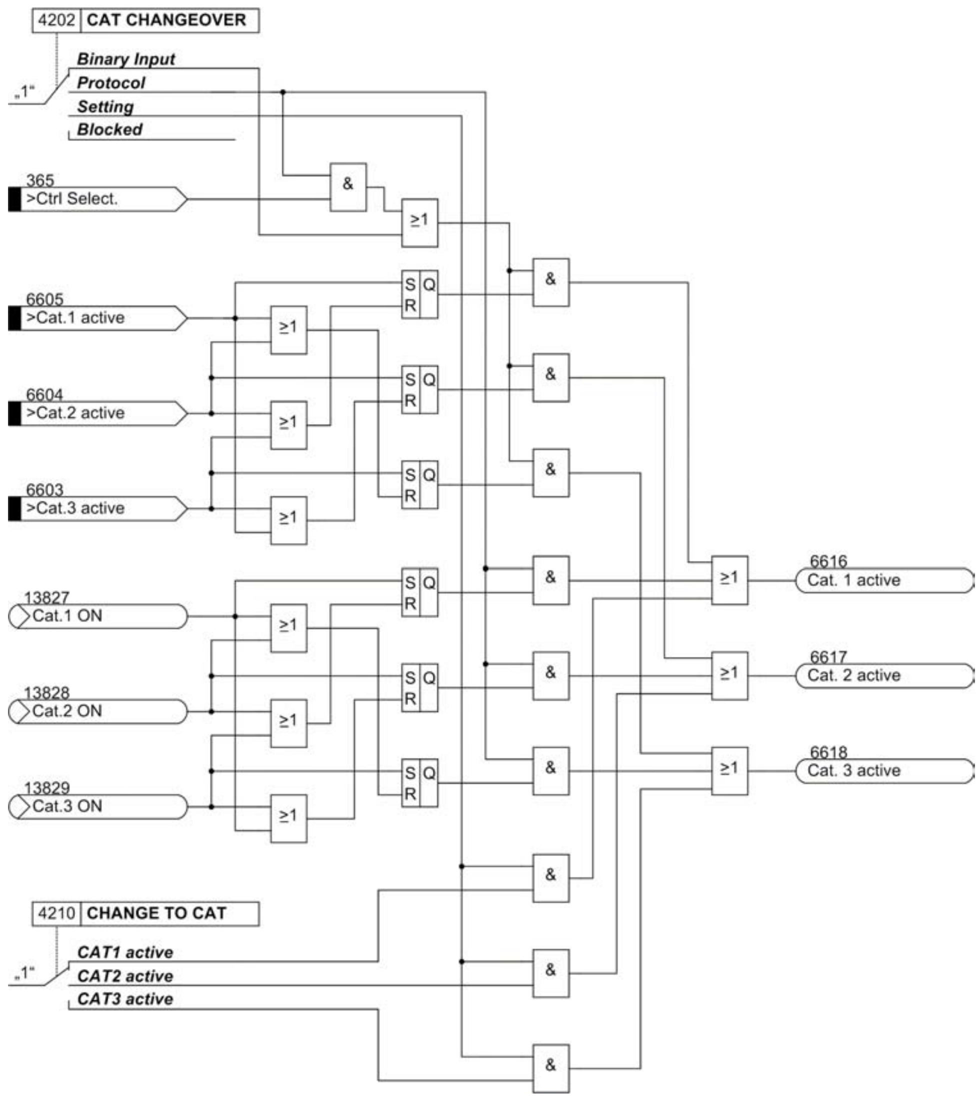


Figure 2-26 Control logic of the catenary changeover

2.7.4 Setting Notes

General

A prerequisite for the application of the thermal overload function is that during the configuration of the functional scope in address 142 **Therm.Overload** = ***Enabled*** was set. The function can be turned ***ON*** or ***OFF*** in address 4201 **Ther. OVER LOAD**.

When overload protection is disabled, the thermal replica will also be reset.

Time Constant τ

The thermal time constant τ is set at address 4203 **TAU**. This is also provided by the manufacturer. Please note that the time constant must be set in minutes. Quite often other values for determining the time constant are stated which can be converted into the time constant as follows:

1-s current

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

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

Example:

Regular overhead contact line Re250 with

Permissible 1-s current 10.5 kA

Permissible continuous catenary current 750 A

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

Setting value **TAU** = **3.3 min**

Limit Current Factor k ITRise

The limit current factor is set in address 4204 **k ITRise**. It is determined by the relation between the permissible thermal continuous current and this rated current:

$$\text{k IT Rise} = \frac{\text{IT Rise}}{\text{IN}}$$

The permissible continuous current is at the same time the current at which the e-function of the overtemperature has its asymptote. Manufacturers of electrical machines usually state the permissible continuous current. If no data are available, k ITRise is set to 1.2 times the rated current of the protected object. For conducting lines, the permissible continuous current depends on the cross section, the insulation material, the design and the way they are laid, and can be derived from the relevant tables. Please note that the overload capability of electrical equipment relates to its primary current. This has to be considered if the primary current differs from the rated current of the current transformers.

Example:

Regular overhead contact line Re250

Permissible continuous catenary current ITRise = 750 A

Current transformers 1000 A / 1 A

$$\text{k ITRise} = \frac{750\ \text{A}}{1000\ \text{A}} = 0.75$$

Setting value **k ITRise** = 0.7

Temperature Limits

In address 4207 **TEMP ALARM** the temperature threshold for the thermal alarm stage is set. When the set temperature threshold is exceeded, an alarm is output that can be used for automatic functions or for logging.

The tripping temperature is set in address 4206 **TEMP TRIP**. When the temperature reaches the tripping threshold, the protected device is disconnected from the network.

Note

The tripping temperature **TEMP TRIP** (address 4206) must always be set higher than the thermal alarm stage **TEMP ALARM** (address 4207)!

In address 4208 **TEMP CLOSE** the closing temperature is set. If the contact line was tripped by the thermal overload protection, the line is reclosed as soon as the temperature drops below the value **TEMP CLOSE** set here, provided that the thermal automatic reclosure function is activated (address 3450 **AUTO-TH-AR** = ***ON***, see Section 2.12).

Catenary Changeover

In address 4202 **CAT CHANGEOVER** you select the control source for catenary changeover. Catenary changeover is possible via binary input, via protocol or via parameters.

If **CAT CHANGEOVER** = ***Blocked*** is set, CAT = 1 is valid for 1 catenary.

Ambient Temperature Sensing

If ambient temperature sensing is not configured, or disturbed when the protection is switched on, a fixed value is specified in address 4215 **AMB.TEMP.** instead of the measured ambient temperature (see Section 2.1.1.2). The set **AMB.TEMP.** is then used for calculating the overhead contact line temperature.

In address 4216 **MIN TEMP PRESET** a lower limit is set for the ambient temperature used for calculating the overhead contact line temperature. If you set **MIN TEMP PRESET**=-55 °C, the parameter is ineffective.

With the internal input indication (tag) "ResetThermRepl" (FNo. 13826) the temperature model can be reset. A reset of the temperature model is equivalent to setting the contact line temperature to ambient temperature.

2.7.5 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4201	Ther. OVER LOAD	OFF ON	OFF	Thermal overload protection
4202	CAT CHANGEOVER	Binary Input Protocol Setting Blocked	Binary Input	Catenary Changeover
4203	TAU	2.0 .. 30.0 min	5.0 min	Thermal Time Constant
4204	k ITRise	0.10 .. 4.00	1.20	Max. Permissible Current Factor ITRise
4205	T Rise	0 .. 100 K; < > 0	50 K	Final Temperature at ITRise
4206	TEMP TRIP	50 .. 100 °C	50 °C	Tripping Temperature
4207	TEMP ALARM	40 .. 100 °C	40 °C	Alarm Temperature
4208	TEMP CLOSE	25 .. 100 °C	40 °C	Closing Temperature
4210	CHANGE TO CAT	CAT1 active CAT2 active CAT3 active	CAT1 active	Change to Catenary

Addr.	Parameter	Setting Options	Default Setting	Comments
4211	CAT2	1.0 .. 3.0	1.0	Factor for 2 Catenaries
4212	CAT3	1.0 .. 3.0	1.0	Factor for 3 Catenaries
4215	AMB.TEMP.	-55 .. 40 °C	15 °C	Ambient Temperature Value
4216	MIN TEMP PRESET	-55 .. 40 °C	-55 °C	Minimum Setting Ambient Temperature

2.7.6 Information List

No.	Information	Type of Information	Comments
1501	>O/L on	SP	>Switch on thermal overload protection
1502	>O/L off	SP	>Switch off thermal overload protection
1511	Th.Overload OFF	OUT	Thermal Overload Protection OFF
1516	O/L Θ Alarm	OUT	Overload Alarm! Near Thermal Trip
1521	ThOverload TRIP	OUT	Thermal Overload TRIP
6603	>Cat.3 active	SP	>Third catenary is active
6604	>Cat.2 active	SP	>Second catenary is active
6605	>Cat.1 active	SP	>First catenary is active
6616	Cat. 1 active	IntSP	First catenary is active
6617	Cat. 2 active	IntSP	Second catenary is active
6618	Cat. 3 active	IntSP	Third catenary is active
13824	O/L ON/OFF BI	IntSP	Overload Protection ON/OFF via BI
13825	O/L blocked	OUT	O/L Inrush blocking
13826	ResetThermRepl	IntSP	Reset thermal replica
13827	Cat1 ON/OFF TEL	IntSP	O/L Catenary 1 ON/OFF via Telegram
13828	Cat2 ON/OFF TEL	IntSP	O/L Catenary 2 ON/OFF via Telegram
13829	Cat3 ON/OFF TEL	IntSP	O/L Catenary 3 ON/OFF via Telegram
13980	Cat.1 ON/OFF BI	IntSP	Catenary 1 ON/OFF about Binary Input
13981	Cat.2 ON/OFF BI	IntSP	Catenary 2 ON/OFF about Binary Input
13982	Cat.3 ON/OFF BI	IntSP	Catenary 3 ON/OFF about Binary Input

2.8 Circuit Breaker Failure Protection

This function is optional, i.e. not included in all device variants.

The circuit breaker failure protection provides rapid back-up fault clearance, in the event that the circuit breaker fails to respond to a trip command from a protective function of the local circuit breaker.

2.8.1 Functional Description

General

Whenever a protection function issues a trip command to the circuit breaker, this is repeated to the breaker failure protection (Figure 2-27). The breaker failure protection consists of two stages. Two time stages **tBF1** (address 3904) and **tBF2** (address 3905) are started in it. The timers run as long as a trip command is present and current continues to flow through the breaker poles.

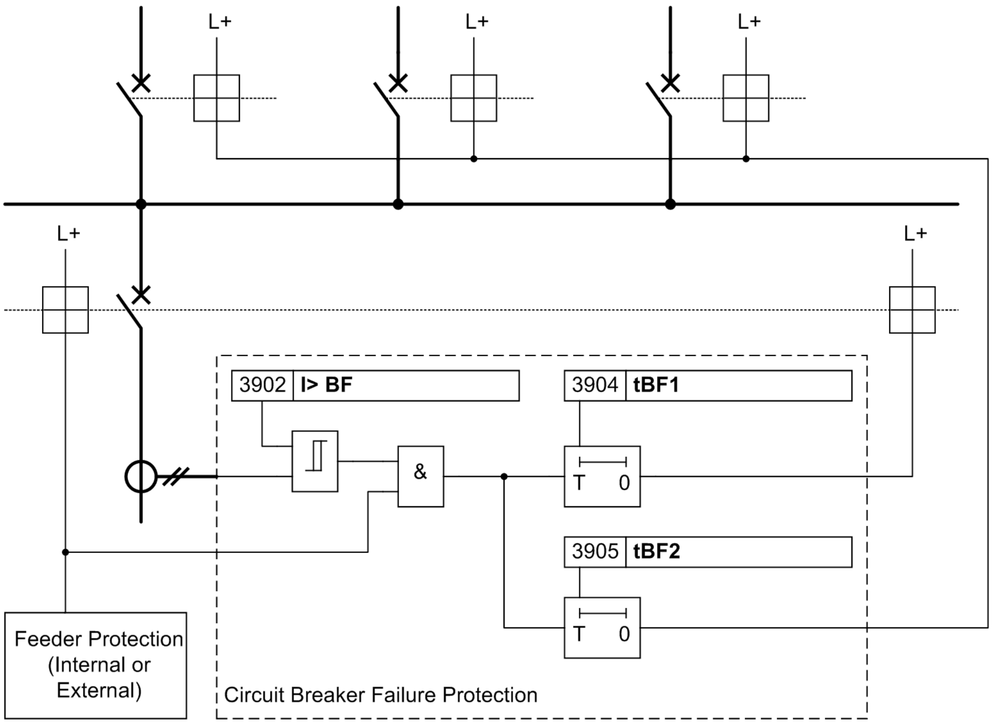


Figure 2-27 Simplified function diagram of circuit breaker failure protection with current flow monitoring

Normally, the breaker will open and interrupt the fault current. The current monitoring stage quickly resets (typically 1/2 cycle of the power system frequency) and stops the timers **tBF1** (address 3904) and **tBF2** (address 3905).

If the trip command is not carried out (breaker failure case), current continues to flow. When the delay time for the backup trip element **tBF1** (address 3904) has elapsed, a TRIP command for the backup trip element is generated. If this TRIP command, also, fails to interrupt the short-circuit current, the breaker failure protection issues a further TRIP command to the higher-level circuit breakers after the delay time **tBF2** (address 3905) has elapsed.

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

Current Flow Monitoring

The current detected by the device is filtered by numerical filters so that only the fundamental wave is evaluated.

Special features recognize the instant of current interruption. With sinusoidal currents, the current interruption is recognized after approx. half a cycle of the power system frequency. With aperiodic DC current components in the fault current and/or in the current transformer secondary circuit after interruption (e.g. current transformers with linearized core), or saturation of the current transformers caused by the DC component in the fault current, it can take one AC cycle before the interruption of the primary current is reliably detected.

The current is monitored and compared with the set threshold.

Initiation

If the breaker failure protection is intended to be initiated by further external protection devices, it is recommended, for security reasons, to connect two starting criteria to the device. Therefore, the trip command of the external protection should not be directly connected to the binary input "`>BrkFail extSRC`" (FNo. 1431). For such an application, create a CFC chart, combine in this chart the general device pickup and the trip command of the external protection by an AND gate and wire the output of that gate to the signal "`>BrkFail extSRC`" (FNo. 1431).

Nevertheless, it is possible to initiate the breaker failure protection in single-channel mode should a separate release criterion not be available.

When the trip signal appears from any internal or external feeder protection and the current flow criterion (according to Figure 2-27) is present, the breaker failure protection is initiated and the corresponding delay times are started.

The figure below shows the control logic of the circuit breaker failure protection.

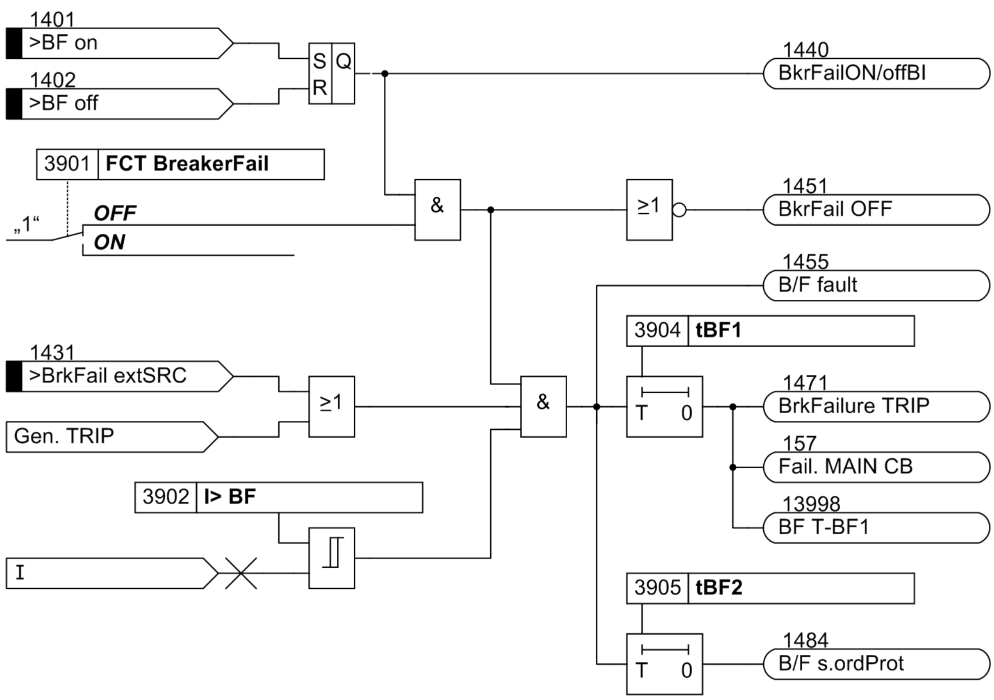


Figure 2-28 Pick-up and tripping logic of the breaker failure protection

The initiation cannot be blocked by a binary input.

Delay Times

When the initiate conditions are fulfilled, the associated timers **tBF1** (address 3904) and **tBF2** (address 3905) are started. The circuit breaker pole(s) must open before the associated time has elapsed. The device detects that the circuit breaker has opened when the current drops below the dropout threshold **I> BF** (address 3902).

With two-stage breaker failure protection, the trip command of the overhead contact line protection is usually repeated, after a first time stage, to the feeder circuit breaker, often via a second trip coil or set of trip coils, if the breaker has not responded to the original trip command. The signal 1471 “BrkFailure TRIP” is provided for this trip command repetition. A second time stage monitors the response to this repeated trip command and trips the breakers of the relevant bus-bar section with the signal 1484 “B/F s.ordProt”, if the fault has not yet been cleared after this second time.

2.8.2 Setting Notes

General

The breaker failure protection can only operate if it was configured ***Enabled*** during configuration of the functional scope (address 139 **BREAKER FAILURE**).

Circuit Breaker Failure Protection

The breaker failure protection is switched ***ON*** or ***OFF*** at address 3901 **FCT BreakerFail**.

The current threshold **I> BF** (address 3902) should be selected such that the protection will operate with the smallest expected short-circuit current. A setting of 10% below the minimum fault current for which breaker failure protection must operate is recommended. On the other hand, the value should not be set lower than necessary.

Single-stage Breaker Failure Protection

With single-stage operation, the adjacent circuit breakers (i.e. the breakers of the busbar zone and, if applicable, the breaker at the remote end) are tripped after a delay time **tBF2** (address 3905) following initiation, should the fault not have been cleared within this time.

The timer **tBF1** (address 3904) is set to ∞ in this case, as it is not needed.

You can also use the first stage as the only one. In that case you have to set the time **tBF1** (address 3904). Set **tBF2** (address 3905) to ∞ or equal to **tBF1** (address 3904). Be sure that the correct trip commands are assigned to the desired trip relay(s).

The delay times are determined from the maximum operating time of the feeder circuit breaker, the reset time of the current detectors of the breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. The time sequence is illustrated in Figure 2-29. For sinusoidal currents, the dropout time can be assumed to be less than 3/4 the cycle duration at rated frequency. If current transformer saturation is anticipated, the time should be set to 1.5 ms.

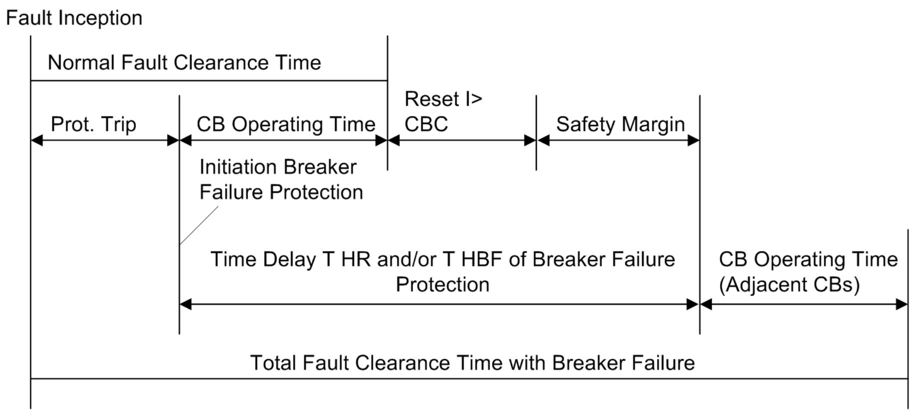


Figure 2-29 Time sequence example for single-stage breaker failure protection

Two-stage Breaker Failure Protection

With two-stage operation, the trip command is repeated after a time delay **tBF1** (address 3904) to the local feeder breaker, normally to a different set of trip coils of this breaker.

If the circuit breaker does not respond to the repeated trip command, the protection trips after a second delay time **tBF2** (address 3905) the adjacent circuit breakers, i.e. those of the busbar or the affected busbar section and, if necessary, also the circuit breaker at the remote end, if the fault is not yet eliminated.

The delay times of the two stages can be set separately

- For trip repetition to the local feeder circuit breaker after a trip of the feeder protection **tBF1** (address 3904),
- For trip of the adjacent circuit breakers (busbar zone) **tBF2** (address 3905).

The delay times are determined from the maximum operating time of the feeder circuit breaker, the reset time of the current detectors of the breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. The time sequence is illustrated in Figure 2-30. For sinusoidal currents, the dropout time can be assumed to be less than 3/4 the cycle duration at rated frequency. If current transformer saturation is anticipated, the time should be set to 1.5 ms.

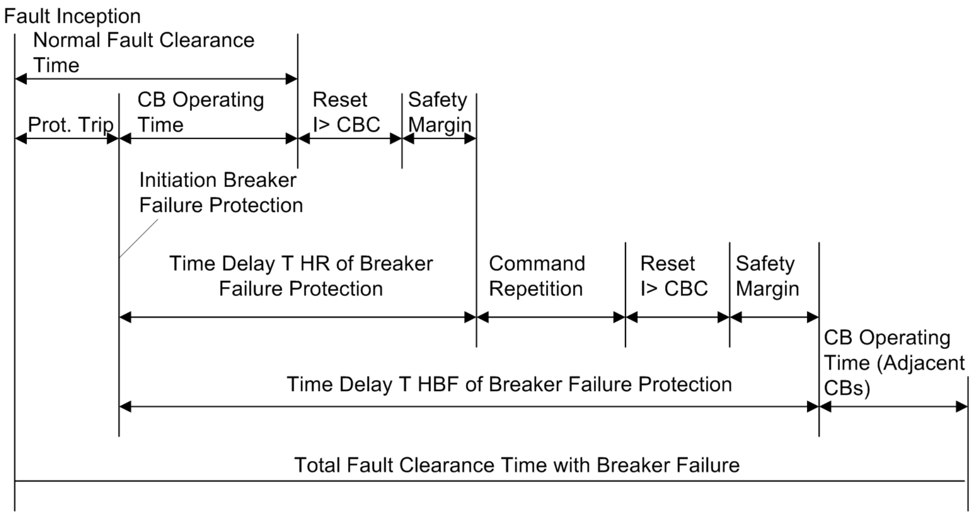


Figure 2-30 Time sequence example for two-stage breaker failure protection

2.8.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
3901	FCT BreakerFail		ON OFF	OFF	Breaker Failure Protection is
3902	I> BF	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold I>
		5A	0.25 .. 100.00 A	0.50 A	
3904	tBF1		0.10 .. 10.00 sec; ∞	0.50 sec	Delay Time Backup Trip Element
3905	tBF2		0.10 .. 10.00 sec; ∞	0.75 sec	Delay Time Higher-Level Protection

2.8.4 Information List

No.	Information	Type of Information	Comments
157	Fail. MAIN CB	OUT	Failure of main circuit breaker
1401	>BF on	SP	>BF: Switch on breaker fail protection
1402	>BF off	SP	>BF: Switch off breaker fail protection
1431	>BrkFail extSRC	SP	>Breaker failure initiated externally
1440	BkrFailON/offBI	IntSP	Breaker failure prot. ON/OFF via BI
1451	BkrFail OFF	OUT	Breaker failure is switched OFF
1455	B/F fault	OUT	Breaker failure : fault detection
1471	BrkFailure TRIP	OUT	Breaker failure TRIP
1484	B/F s.ordProt	OUT	B/F: pick up superordinat.prot.relais
13998	BF T-BF1	OUT	Delay time for back up trip expired

2.9 Trip Supervision

The trip supervision function checks whether the circuit breaker has tripped correctly in case of an external trip or a trip command by an additional current flow monitoring.

2.9.1 Functional Description

After the circuit breaker has tripped, the device checks that no current flows, or only a current below a certain threshold, once the settable supervision time has elapsed.

To start this supervision, the TRIP command is detected at the circuit breaker. This command must be configured to the signal “>Ext. CB Trip” (FNo.1438).

The maximum duration of the supervision can be set with the parameter **T I> CB MAX** at address 2922.

If the current flow has not been interrupted 100 ms after a TRIP command has been detected, the indication “CB Fault” (FNo. 1491) is output.

This indication is reset before the set supervision has elapsed if the device detects that the current flow has been interrupted, or if the signal “>Ext. CB Trip” (FNo.1438) indicates that the external TRIP signal has been reset.

The interruption of the current flow is monitored by a current threshold.

When this threshold, which is set with the parameter **I> CB** (address: 2921), is undershot, the current flow is considered to be interrupted.

The measuring function works with an intelligent method for fast detection of a current interruption. If the current signal contains decaying aperiodic components caused by the current transformers, these components are identified as such, and the current interruption is detected.

The figure below shows the logic diagram of the circuit breaker trip supervision.

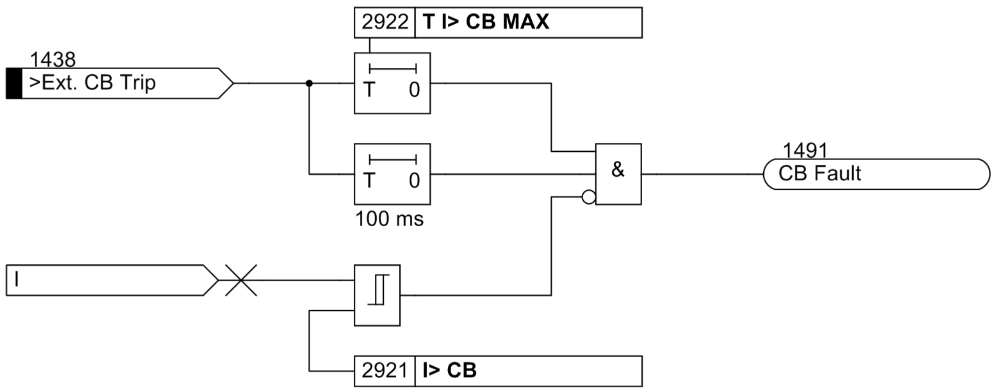


Figure 2-31 Circuit breaker trip supervision

2.9.2 Setting Notes

General

The circuit breaker trip supervision is one of the basic functions of the 7ST6 device. This function cannot be disabled by a configuration parameter.

To activate the function, the indication “`>Ext. CB Trip`” (FNo. 1438) must be configured to a binary input, and this binary input must be connected with the TRIP command of the circuit breaker to be monitored.

Current Interruption

The interruption of the current flow is monitored by a current threshold **`I> CB`** (address `2921`). Set this current threshold to a value that is lower than the pickup values of all overcurrent functions.

Supervision Duration

The maximum duration of the trip supervision is set with parameter **`T I> CB MAX`** in address `2922`. The supervision duration begins on activation of the signal “`>Ext. CB Trip`” (FNo.1438).

After the set supervision time **`T I> CB MAX`** has elapsed, a signal generated by the trip supervision “`CB Fault`” (FNo.1491) is reset.

2.9.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
2921	I> CB	1A	0.05 .. 0.50 A	0.10 A	Pickup Current Trip Supervision
		5A	0.25 .. 2.50 A	0.50 A	
2922	T I> CB MAX		1 .. 200 sec	30 sec	Maximum Duration of Trip Supervision

2.9.4 Information List

No.	Information	Type of Information	Comments
1438	>Ext. CB Trip	SP	>External CB Trip
1491	CB Fault	OUT	Circuit Breaker Fault

2.10 Defrosting Protection

In some models of the 7ST6 device, the basic variant is equipped with the defrosting protection (3xI, 3xU).

In order to remove icing from overhead contact line systems, unused lines are series-connected (by the operator) and heated with a low current, if necessary with an interposed resistor.

For sensitive detection of short-circuits during the defrosting, the current flowing into the line and back are measured in the protection device and processed by a differential protection function. The differential protection protects 100% of the measuring range.

The characteristic curve of the differential protection can be parameterized. As a backup protection of the differential protection, a two-stage definite-time overcurrent protection is provided that monitors the defrosting current.

2.10.1 Functional Description

General

Note

During defrosting, the overhead contact line is in a special switching state. All other protection functions remain active when the defrosting protection is switched on. The defrosting current can cause spurious tripping by one or more protection functions (e.g. by the overvoltage protection or a back-up stage of the distance protection). In such cases, these protection functions must be deactivated prior to activating the defrosting protection, or to switching on the defrosting current. Use for this purpose e.g. the settings group change option via a binary input or via the system interface.

In defrosting mode, the overhead contact line must be put into a special switching state. An example of such a switching state is shown in Figure 2-32. The breakers Q0 (overhead contact line 1), Q11 and Q9 are closed, breaker Q0 (overhead contact line 2) is open.

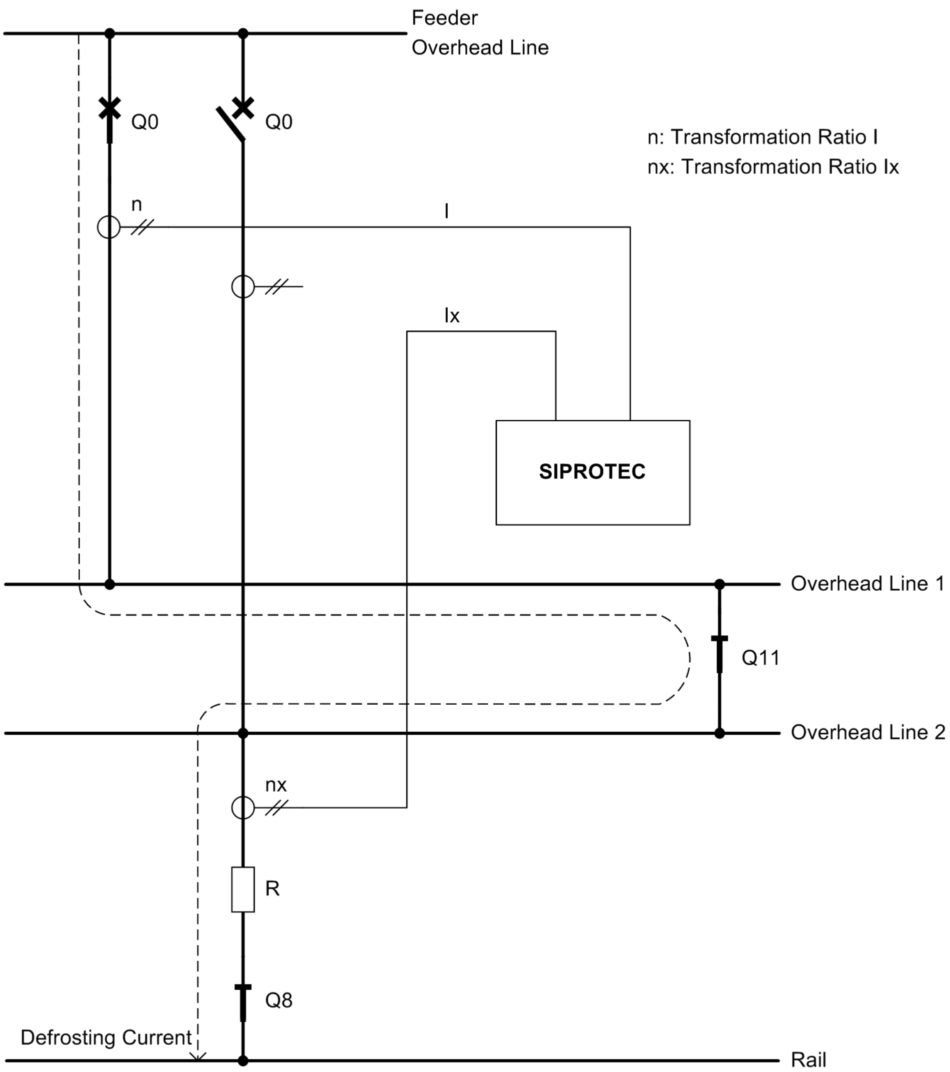


Figure 2-32 Simplified operation scheme of the defrosting protection operating on the differential current principle

In addition to the current transformer in the infeed of the overhead contact line **I** , which is shared with the other protection functions, another current transformer is needed for the defrosting current flowing back. This transformer is connected to the $\mathbf{I_x}$ input.

Note

In auto-transformer systems, the negative feeder current IF- is measured as well. If the negative feeder has its own current transformer, this current need not be considered, as the current IF- is very low in the special defrosting switching state.

Protection Principle

The defrosting protection operates on the differential protection principle. This principle says that the phases and amplitudes of both measured currents are the same in fault-free condition. The condition i(t) + ix(t) = 0 is always fulfilled in fault-free condition of the line.

Since different CTs may be used for detection of the currents i(t) and ix(t), such differences must be taken into account for the calculations. The measured current ix(t) is adapted to the conditions of i(t) as follows:

$$i_x'(t) = ix(t) \cdot \frac{n_x}{n}$$

where:

$$n = \frac{I_{prim}}{I_{sec}}$$

and

$$n_x = \frac{I_{xprim}}{I_{xsec}}$$

Due to measuring errors, the condition i(t) + ix(t) = 0 is not wholly fulfilled in fault-free condition. Therefore, a value greater than zero must be used as tripping threshold. With a high load current, the differential current is higher than with a low load current. Therefore, a load-dependent tripping threshold is required. The restraint current is then calculated as follows:

$$I_R = |\underline{I}| + |\underline{I}_X|$$

The restraint current is a measure of the current load. The pickup threshold is interpreted as a function of the restraint current.

From the measured currents, the differential current is determined with the following formula:

$$I_{Diff} = |\underline{I} - \underline{I}_X|$$

Characteristic

The pickup criterion is the location of the current operating point in the Id/Is level. A pickup situation exists if the fault is located above the characteristic shown in Figure 2-33.

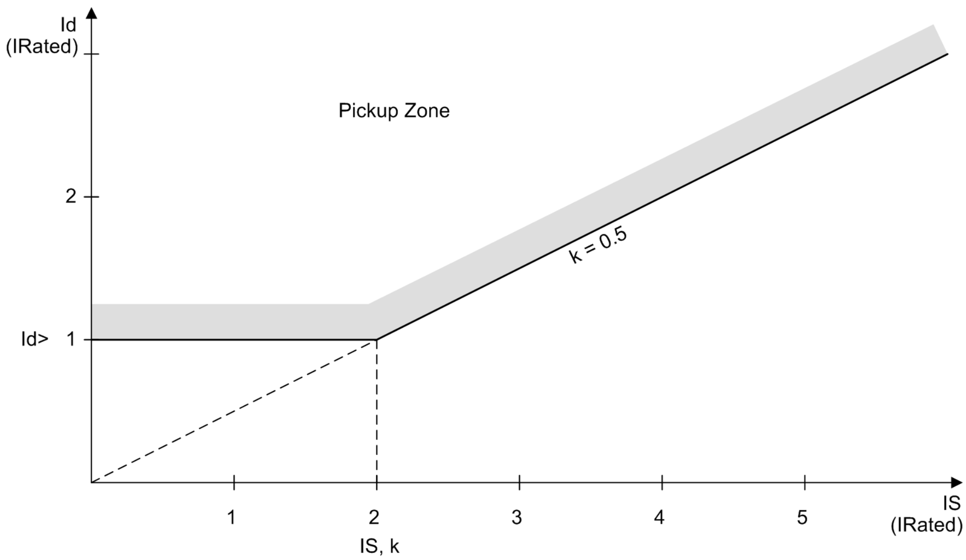


Figure 2-33 Characteristic curve of the differential protection for defrosting

The characteristic can be configured with the following parameters:

Id>	Pickup value of the differential current
k	Characteristic slope

The knee-point of the characteristic is determined by the parameters k and Id>. The value for Id> results from shunt currents which are independent of the defrosting current, and which can occur in fault-free condition. Such currents can be caused by capacitive leakage currents, or by the magnetizing currents of power transformers located upstream of the protected zone. The slope k to be set results from possible amplitude or angle errors of the current transformers used.

Switching On/Off and Blocking

The defrosting protection can be switched on/off via parameters, binary input or the protocol of the system interface.

Also, the defrosting protection can be dynamically blocked via binary input or via protocol. The figure below shows the control logic:

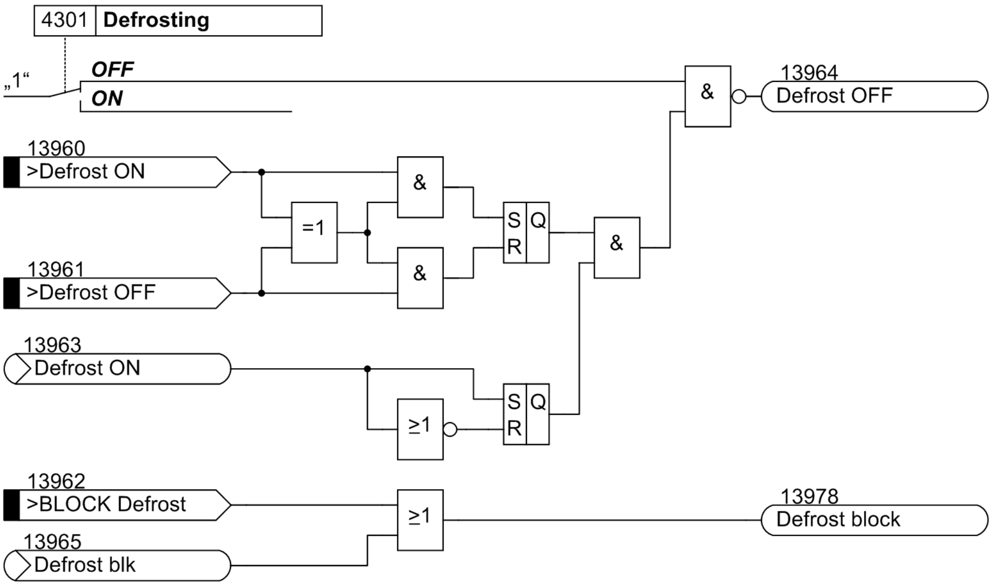


Figure 2-34 Control logic of the defrosting protection

Pickup and TRIP Command

A fault detected on the basis of the differential protection characteristic is signalled as a pickup if the defrosting protection is switched on. The pickup is signalled with the indication “`Defrost PICKUP`”, and the TRIP command “`Defrost TRIP`” is output after the delay time **`T ID>`** if the pickup condition is still present and the defrosting protection is not blocked. The delay time allows to bridge transient compensation states which occur on switching in the defrosting current, and which might for a short time cause a pickup of the defrosting current.

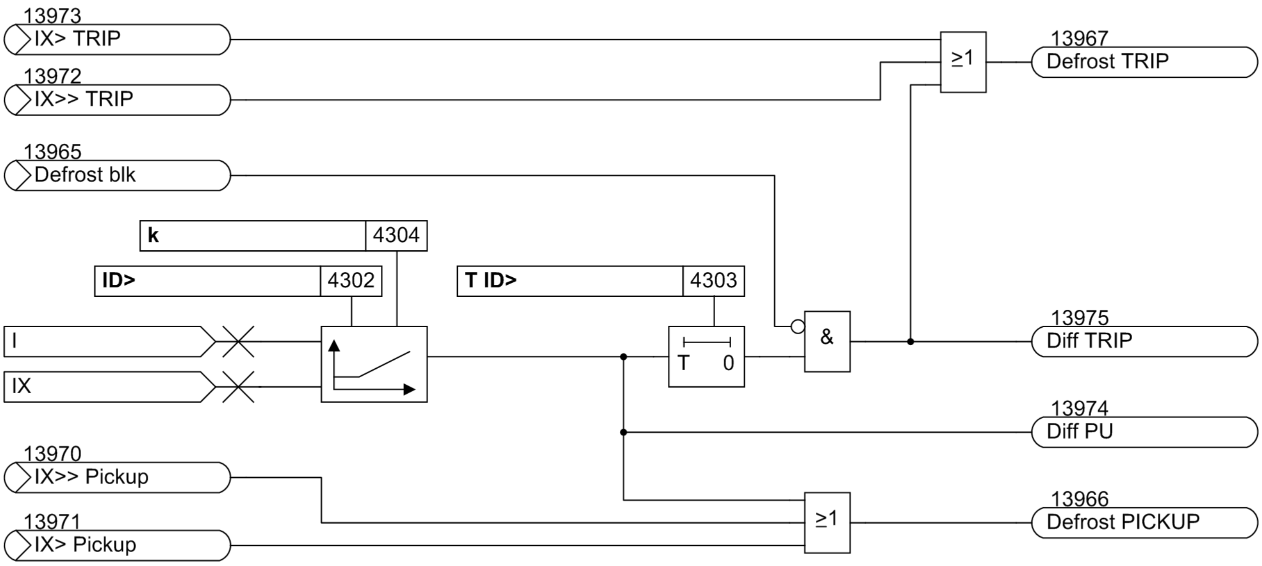


Figure 2-35 Pick-up and tripping logic of the defrosting protection

Definite-time Backup Time Over-current Protection

The defrosting protection is provided with a two-stage definite-time overcurrent protection as backup protection. This backup protection is switched on and off together with the differential protection. The stages operate with the fundamental wave component of the defrosting current I. The stages generate separate indications for pickup and tripping. The figure below shows the logic diagram of the back-up protection.

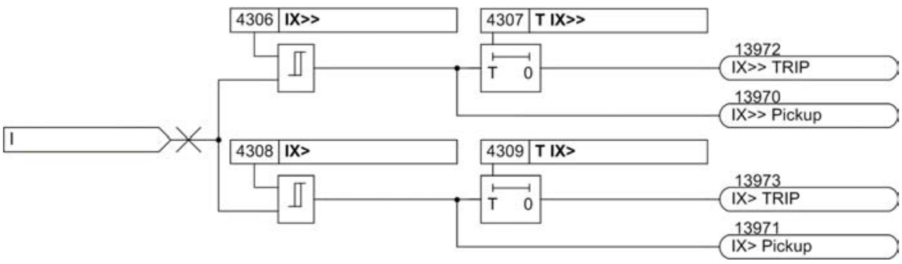


Figure 2-36 Pick-up and tripping logic of the backup O/C protection of the defrosting protection

Operational Measured Values

In some models (3xI, 3xU) the defrosting current Ix is always displayed as an operational measured value. It can be shown as a primary, secondary or percent value.

If the defrosting protection is configured, the differential current “`Id =`” (FNo. 13968) calculated by the differential protection, and the restraint current “`Ir =`” (FNo. 13969) can be displayed as percent values.

Fault Recording

In some models (3xI, 3xU) the defrosting current Ix is always recorded by the fault recording function.

If the defrosting protection is configured, the current Ix and the internally calculated currents “`Id =`” (differential current) and “`Ir =`” (restraint current) are also recorded by the fault recording function.

2.10.2 Setting Notes

Preconditions

When setting the general power system data (Power System Data 1, refer to Section 2.1.3.1) a number of parameters regarding the measured quantities and the operating mode of the defrosting protection function must be applied.

This concerns the following parameters:

201 **CT Starpoint**	Current direction of the current transformer
202 **CT PRIMARY**	CT rated primary current
211 **IX CT STARPOINT**	Current direction of the current transformer
212 **IX CT PRIMARY**	CT rated primary current
203 **CT SECONDARY**	CT rated secondary current

General

The defrosting operation can only operate if address 144 **FCT DEFROSTING** has been set to ***Enabled*** and the parameter **Defrosting** is set to ***ON*** (address 4301).

The measured values of the differential current "Id =" and the restraint current "Ir =" are only available or will only be calculated if the defrosting parameter **Defrosting** (address 4301) has been set to ***ON***.

The defrosting protection can be switched on or off via the binary inputs ">Defrost ON" (FNo. 13960) and ">Defrost OFF" (FNo. 13961), or via the system interface. For control via the system interface, the internal single-point indication "Defrost ON" (FNo. 13963) is used.

Blocking

There are various possibilities for blocking the defrosting protection. If the protection is blocked, only the TRIP indication "Diff TRIP" (Fno. 13975) will be blocked. All other indications are output as before.

The defrosting protection can be blocked locally from the operator panel, using the binary input or system interface.

For blocking via the system interface or the operator panel, the internal single-point indication "Defrost block" (FNo. 13978) is used. For blocking via a binary input, the signal ">BLOCK Defrost" (FNo. 13962) must be configured to the appropriate binary input.

If defrosting has been blocked from more than one source, the blocking must be reset from all sources to become ineffective again. When the defrosting protection is blocked, the indication "Defrost blk" (FNo. 13965) is output.

Differential Protection

For the differential protection, you must set as pickup current the differential current Id, which is permanently present in normal service. The pickup current 4302 **ID>** is set somewhat higher (approx. 20 %) than the maximum differential current Id that is to be expected in normal service.

Note

For the setting of the pickup current, the setting of the differential protection delay must be taken into account. If the delay of the TRIP signal for the differential protection is set in such a way that transient states occurring on switching on the defrosting current have not yet entirely decayed, the pickup current must be set to approx. 10 % more than the maximum transient current that is possible at this moment.

The slope 4304 **k** to be set results from possible amplitude or angle errors of the current transformers used.

The trip delay time following a pickup 4303 **T ID>** is set in such a way that transient states on switching on the defrosting current have completely decayed after that time. Typical values for these decay times are about 200 ms. This time constant is reduced by resistances in the current path.

Backup Protection

The backup protection of the defrosting protection function has two definite-time overcurrent stages. The high-current stage is set to approx. 10 % more than the transient current that is to be expected when switching on the defrosting current. This current is set at address 4306 **IX>>**. The delay of the stage is set at address 4307 **T IX>>** without delay, or with a short delay of approx. 100 ms.

The pickup value of the overcurrent stage is set at address 4308 **IX>** to approx. 10 % more than the expected continuous defrosting current. The delay of the overcurrent stage is set to approx. 100 ms more than the decay times of the transient states that occur when switching on the defrosting current.

2.10.3 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
4301	Defrosting		ON OFF	OFF	Defrosting Protection
4302	ID>		0.10 .. 2.00 I/In	0.40 I/In	Pickup Current ID> Defrosting Protection
4303	T ID>		0.00 .. 30.00 sec; ∞	0.10 sec	Delay Time ID> for Defrosting Protection
4304	k		0.00 .. 0.80	0.50	Charact. Slope of Defrosting Protection
4306	IX>>	1A	0.10 .. 25.00 A; ∞	2.00 A	Pickup Current High-Set Stage IX>>
		5A	0.50 .. 125.00 A; ∞	10.00 A	
4307	T IX>>		0.00 .. 30.00 sec; ∞	0.30 sec	Delay Time IX>>
4308	IX>	1A	0.10 .. 25.00 A; ∞	1.50 A	Pickup Overcurrent Stage IX>
		5A	0.50 .. 125.00 A; ∞	7.50 A	
4309	T IX>		0.00 .. 30.00 sec; ∞	0.50 sec	Delay Time IX>

2.10.4 Information List

No.	Information	Type of Information	Comments
13960	>Defrost ON	SP	>Switch on Defrosting Protection
13961	>Defrost OFF	SP	>Switch off Defrosting Protection
13962	>BLOCK Defrost	SP	>BLOCK Defrosting Protection
13963	Defrost ON	IntSP	Defrosting Protection is switched ON
13964	Defrost OFF	OUT	Defrosting Protection is switched OFF
13965	Defrost blk	OUT	Defrosting Protection is blocked
13966	Defrost PICKUP	OUT	Defrosting Protection PICKED UP
13967	Defrost TRIP	OUT	Defrosting Protection TRIP
13970	IX>> Pickup	OUT	Defrosting current IX>> Pickup
13971	IX> Pickup	OUT	Defrosting current IX> Pickup
13972	IX>> TRIP	OUT	Defrosting current IX>> TRIP command
13973	IX> TRIP	OUT	Defrosting current IX> TRIP command
13974	Diff PU	OUT	Differential Protection picked up
13975	Diff TRIP	OUT	Differential Protection TRIP
13976	DEF ON/OFF BI	IntSP	Defrosting Protection on/off about BI
13978	Defrost block	IntSP	Block Defrosting Protection

2.11 Inrush Restraint

This function is optional, i.e. not included in all device variants.

When switching in equipment, especially transformers operating at weak load or no load, high inrush currents may briefly occur which can cause unwanted pickup of protection functions. The inrush restraint feature allows to recognize such startup conditions. The functions provides signals that block the protection functions, in order to prevent overfunctioning when switching in transformers.

2.11.1 Functional Description

When switching in transformers, high inrush currents occur, which may amount to a multiple of the rated transformer current, depending on the making angle.

Although the fundamental current is evaluated by filtering of the measured current, overfunctioning during energization of the transformer may result if very short delay times are set. In the inrush current there is a substantial portion of fundamental current depending on the type and size of the transformer that is being energized.

The inrush restraint function generates an indication “INRUSH detected” for as long as the inrush currents persists. This indication informs you that the inrush restraint feature has detected an inrush current.

With the parameters **Inrush DIS >=Z2**, **Inrush O/C** and **Inrush O/C BU** the blocking of the respective protection functions can be switched on and off. The figure below shows the logic diagram for the inrush restraint.

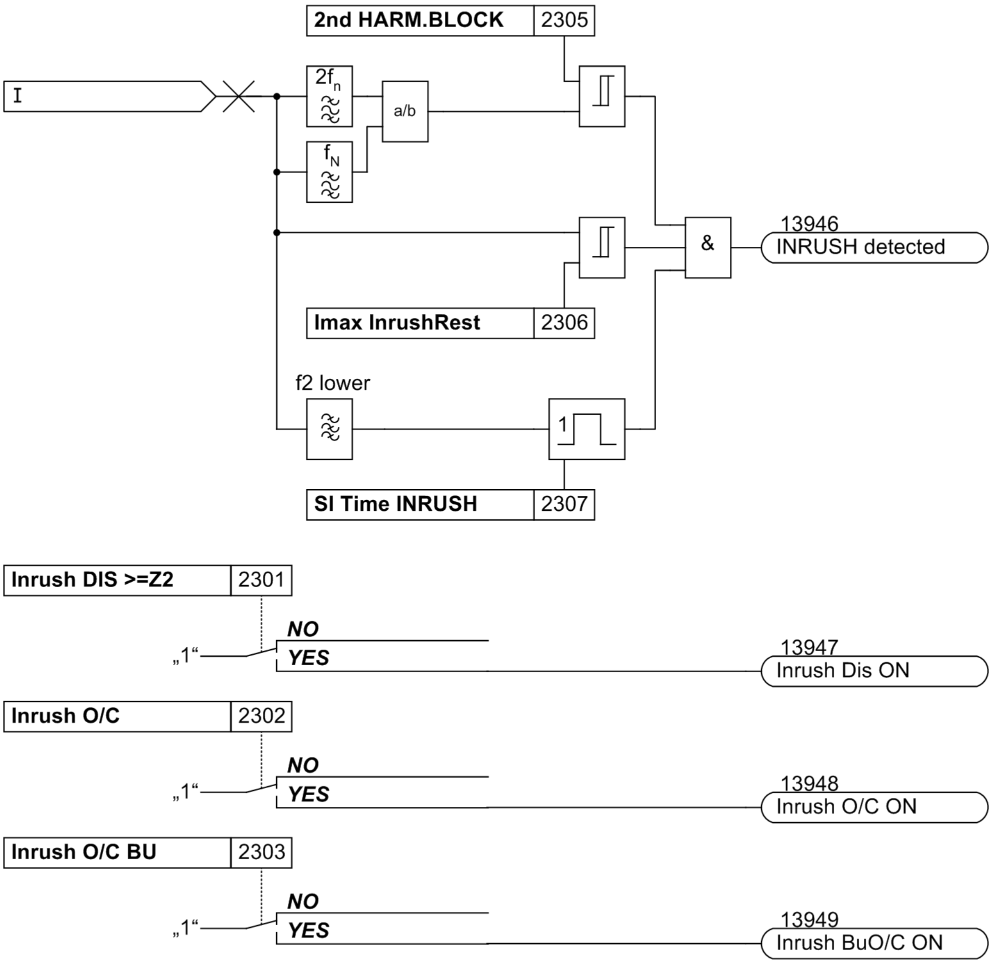


Figure 2-37 Logic diagram of the inrush restraint

Inrush current contains a relatively large second harmonic component (twice the nominal frequency) which is nearly absent during a fault current. Numerical filters that carry out a Fourier analysis of the current are used for the frequency analysis.

As soon as the harmonics content exceeds the value set in **2nd HARM.BLOCK**, an inrush current is detected.

With the parameter **Imax InrushRest** a maximum current amplitude for using this criterion can be specified. Above this current amplitude, the detection of inrush currents on the basis of the second harmonics is blocked. This blocking prevents that the inrush detection feature responds in case of transformer saturation since transformer saturation, also, causes a large proportion of second harmonics in the current signal.

2.11.2 Setting Notes

The inrush restraint is only necessary if the device is to be used on transformer feeders or on overhead contact lines in an auto-transformer system. Even in those applications, the inrush restraint is only needed for protection functions which the inrush current might cause to trip.

Such protection functions are the time overcurrent protection and the distance protection.

With the parameters **Inrush DIS >=Z2** (address 2301), **Inrush O/C** (address 2302) and **Inrush O/C BU** (address 2303), the inrush restraint can be set for each protection function separately to ***YES*** (effective) or ***NO*** (inrush restraint ineffective). If the inrush restraint has been disabled for all functions, the following parameters are of no consequence.

For the recognition of the inrush current, the portion of second harmonic current content referred to the fundamental current component can be set in address 2305 **2nd HARM.BLOCK**. Above this threshold the inrush blocking is effective. The preset value (15 %) should be sufficient in most cases. Lower values imply higher sensitivity of the inrush blocking (smaller portion of second harmonic current results in blocking).

In applications on transformer feeders or overhead contact lines that are terminated on transformers it may be assumed that, if very large currents occur, a short circuit has occurred in front of the transformer. In the event of such large currents, the inrush restraint is inhibited. This threshold value which is set in the address 2306 **Imax InrushRest**, should be larger than the maximum expected inrush current (RMS value).

In the parameter 2307 **SI Time INRUSH** the action time of the inrush detection can be specified. When this time has elapsed, the blocking of protection functions by the inrush restraint feature is reset, regardless of the second harmonics content of the current.

The indication "INRUSH detected" signals that an inrush has been detected. This indication can also be used to block external protection devices during the inrush phase if these external devices do not have an inrush restraint feature of their own.

2.11.3 Settings

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

<table>
<tr><th>Addr.</th><th>Parameter</th><th>C</th><th>Setting Options</th><th>Default Setting</th><th>Comments</th></tr>
<tr><td>2301</td><td>Inrush DIS >=Z2</td><td></td><td>NO
YES</td><td>NO</td><td>Distance Zones >=Z2 Blocked by Inrush</td></tr>
<tr><td>2302</td><td>Inrush O/C</td><td></td><td>NO
YES</td><td>NO</td><td>O/C Blocked by Inrush</td></tr>
<tr><td>2303</td><td>Inrush O/C BU</td><td></td><td>NO
YES</td><td>NO</td><td>Emerg. O/C Blocked by Inrush</td></tr>
<tr><td>2305</td><td>2nd HARM.BLOCK</td><td></td><td>10 .. 45 %</td><td>15 %</td><td>2nd Harmonics Content of Inrush Blocking</td></tr>
<tr><td rowspan="2">2306</td><td rowspan="2">Imax InrushRest</td><td>1A</td><td>0.5 .. 25.0 A</td><td>7.5 A</td><td rowspan="2">Max.Current, overriding inrush restraint</td></tr>
<tr><td>5A</td><td>2.5 .. 125.0 A</td><td>37.5 A</td></tr>
<tr><td>2307</td><td>SI Time INRUSH</td><td></td><td>0 .. 10000 ms; ∞</td><td>∞ ms</td><td>Seal-In Time of Inrush Detection</td></tr>
</table>

2.11.4 Information List

No.	Information	Type of Information	Comments
13946	INRUSH detected	OUT	Inrush detection picked up
13947	Inrush Dis ON	OUT	Inrush detection for Dis. is switched ON
13948	Inrush O/C ON	OUT	Inrush detection O/C is switched ON
13949	Inrush BuO/C ON	OUT	Inrush detection Emerg. O/C ON

2.12 Automatic Reclosure Function

This function is optional, i.e. not included in all device variants.

Experience shows that about 85% of the arc faults on overhead contact lines are extinguished automatically after being tripped by the protection. This means that the line can be connected again. Reclosure is performed by an automatic reclose function (AR).

The number and length of the reclosure cycles can be set as required by power system conditions. The actual reclosure happens after the dead time has expired. If the fault still exists after automatic reclosure (arc has not disappeared, there is a metallic fault), then the auto reclose function will attempt another reclosure after the repeated TRIP command by one of the protection functions. The number of reclosure attempts can be set. Ideally, the auto reclose function ends with a successful reconnection of the line. If the fault is still present after the configured maximum number of reclosure attempts, the line is definitely disconnected from the power system. The auto reclose function goes into the blocked state and signals that the last TRIP command was final.

The auto reclose function can also be started by the thermal overload protection. This protection prevents thermal overload of the overhead contact line and trips as soon as a threshold temperature is reached. After cooling off, the line can be reconnected by means of the auto reclose function.

It is also possible to control the integrated auto reclose function by an external protection device (e.g. a backup protection). The use of two 7ST6 with auto-reclosure or the use of one 7ST6 with auto-reclosure and a second protection with its own auto-reclosure are equally possible.

2.12.1 Functional Description

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

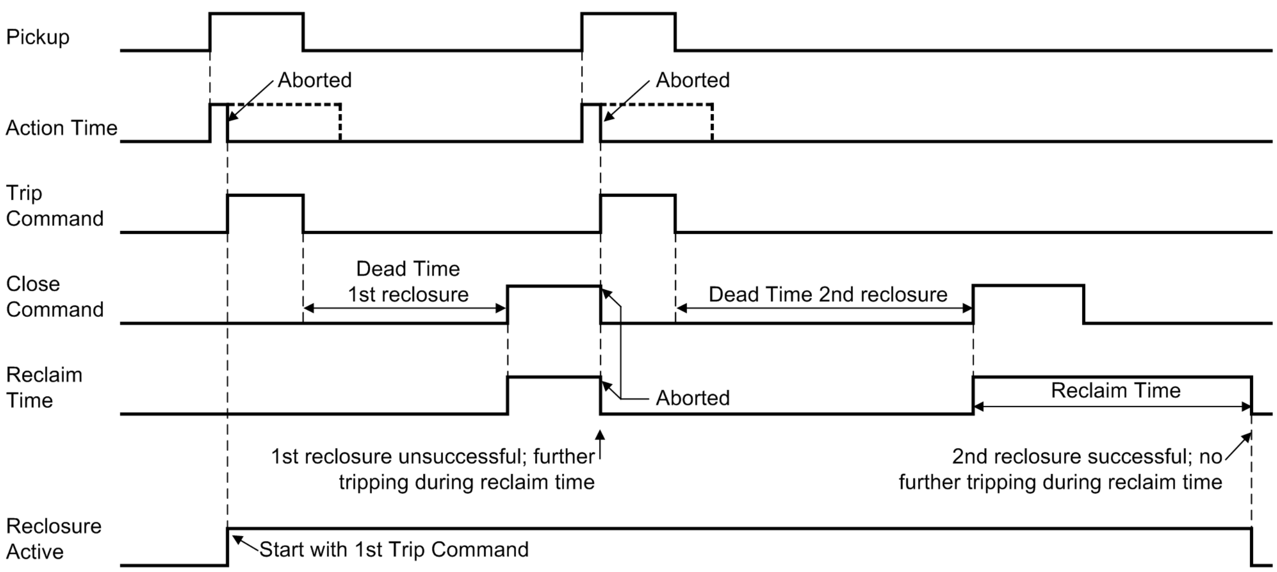


Figure 2-38 Timing diagram of a double-shot reclosure with action time (2nd reclosure successful)

The integrated auto reclose function allows up to 8 reclosure attempts. The first two interrupt cycles may operate with different parameters for action and dead times. The parameters of the second cycle also apply for the third cycle and onwards.

Selectivity before Reclosure

In order for the automatic reclosure to be successful, all faults on the entire overhead line must be cleared at all line ends simultaneously — as fast as possible. In the distance protection, for example, the overreach zone Z1B may be released before the first reclosure. This implies that faults up to the zone reach limit of Z1B are tripped without delay for the first cycle. A limited unselectivity in favour of fast simultaneous tripping is accepted here because a reclosure will be performed in any case. The normal stages of the distance protection (Z1, Z2, etc.) and the normal grading of the other short-circuit functions are independent of the automatic reclosure function. Figure 2-39 applies for one reclosure cycle.

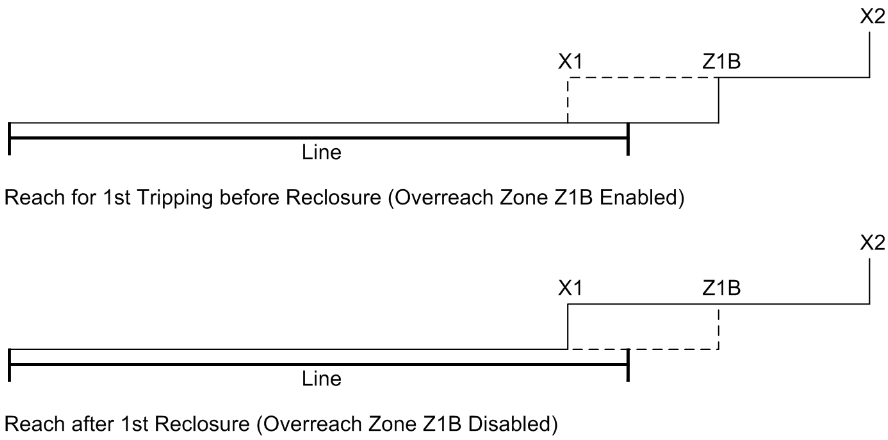


Figure 2-39 Reach control before first reclosure, using distance protection

The internal auto reclose function determines whether the overreach zone (Z1B for distance protection) will be decisive for fast tripping. If no reclosure is expected (e.g. circuit-breaker not ready) the normal grading of the distance protection (i.e. fast tripping only for faults in zone Z1) must apply to retain selectivity.

If restart in a higher stage is permitted, the auto reclose function can also be used for the back-up zones. The zone Z1L can in that case be used as an overreaching stage for zone Z2.

If the auto reclose function is only to be used for the overhead contact line that is directly allocated to the 7ST6 device, the reach of zone Z1L can be set in the same way as the reach of zone Z1B.

Zone Release for the Distance Protection

In the initial state, with the distance protection switched on and the auto reclose function operative, zone Z1B is released. If the distance protection is switched off or the auto reclose function is not operative, zone Z1 is released.

Before the 2nd reclosure cycle, the enable for zone Z1B is reset after the dead time has expired, and the enable for zone Z1L is set with start of the blocking time and the CLOSE command.

The pickup starts all action times which are enabled for initiation. When the 1st action time has expired but the 2nd action time is still running, the zone enabling switches from Z1B to Z1L.

An exception to this is the last reclosure cycle. If all reclosure attempts were fruitless, zone Z1 is enabled prior to the last configured reclosure cycle.

Initiation

Initiation of the auto reclose function means storing the first trip signal during a network fault that was generated by a protection function which operates with the auto reclose function. In case of multiple reclosure, initiation therefore only takes place once with the first trip command. The detection of the actual circuit breaker position is necessary for the correct functionality of the auto reclose function.

The initiation is important when the first trip command has not appeared before expiry of an action time (see margin heading “Action Times, Operating Mode”).

The auto reclose function can be set in such a way that it is only started if the circuit breaker is ready for at least one TRIP-CLOSE-TRIP cycle when the first trip command is issued (see also margin heading “Interrogation of Circuit Breaker Ready State“).

For the distance protection and the high current switch-onto-fault function, the user can configure by parameter settings whether they will cooperate with the auto reclose function or not, i.e. if they will be able to start the automatic reclosure or not. Starting of the auto reclose function by the thermal overload protection can also be switched on and off by parameter settings.

The same applies to the trip commands coupled in externally via binary input and/or the trip commands generated by the teleprotection via permissive or intertrip signals.

Action Times

It is often desirable to neutralize the ready–for–reclosure–state if the short-circuit condition was sustained for a certain time, e.g. because it is assumed that the arc has burned in to such an extent that there is no longer any chance of automatic arc extinction during the reclose dead time. For reasons of selectivity also (see above), frequently faults with delayed trip should not lead to reclosure.

For the auto reclose function of the 7ST6, one action time can be set for the 1st cycle and one for the 2nd to 8th cycle.

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

The user can set separately for the 1st reclosure cycle and the 2nd to 8th cycle whether they are allowed to be the first cycle. Following the first general pickup, only the action times of those cycles that are set such that they may start off the recloser are considered since the other cycles are not allowed to be the first cycle under any circumstances. Using the action times and the start permission you can control which cycles can be run under different command time conditions.

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

- 1st reclosure: T Action = 0.2 s
- From the 2nd reclosure: T Action = 1 s

Since reclosure is ready before the fault occurs, the first trip of a time overcurrent protection following a fault is fast, i.e. before the end of any action time. The auto reclose function is started as a result. After unsuccessful reclosure the 2nd cycle would then become active; but the time overcurrent protection will not trip in this example until after 0.6 s according to its grading time. The 3rd cycle with its parameters is therefore now executed. If the trip command appeared more than 1.2 s after the 1st reclosure, there would be no further reclosure.

Example 2: 3 cycles are set. Initiation of the auto-reclosure is only allowed for the first. The action times are set as in example 1. The first protection trip takes place 0.5 s after pickup. Since the action time for the 1st cycle has already expired at this time, this cannot start the auto reclose function. However, the 2nd and 3rd cycles cannot take place because they are not set to initiate. There is therefore no reclosure, because no initiating at all can take place.

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

Reclosure Block

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

The first or the other cycles of the auto reclose function can also be blocked separately via a binary input. In this case the cycle or cycles concerned will be declared as invalid, and skipped in the sequence of permissible cycles. If blocking takes place while the cycle concerned is already running, this leads to aborting of the reclosure, i.e. no reclosure takes place even if other valid cycles have been parameterized.

Internal blocking states restricted to certain time periods are processed during the course of reclosure cycles:

The reclaim time **TIME RESTRAINT** begins with every automatic reclosure command. If the reclosure is successful, all the functions of the automatic reclosure return to the idle state at the end of the reclaim time; a fault after expiry of the reclaim time is treated as a new fault in the power system. If one of the protection functions causes another trip during that period, the next reclosure cycle will be started if repeated reclosure has been set. If no more reclosure attempts are permitted, the last reclosure is regarded as unsuccessful in case of another trip during the blocking time. The automatic reclosure is locked out dynamically.

The dynamic blocking locks the reclosure for the duration of the dynamic blocking time (0.5 s). This occurs for example after a final tripping or other events which block the auto reclose function after it has been started. Restarting is blocked for this time. When this time has expired, the automatic reclosure returns to its idle position and is ready to process a new fault in the network.

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

Interrogation of Circuit Breaker Ready

A precondition for automatic reclosure following clearance of a short-circuit is that the circuit breaker is ready for at least one TRIP-CLOSE-TRIP-cycle when the automatic reclosure circuit is started (i.e. at the time of the first trip command). The readiness of the circuit breaker is monitored by the device using a binary input “>CB Ready” (FNo. 2730). If no such signal is available, the circuit breaker interrogation can be suppressed (presetting) as automatic reclosure would otherwise not be possible at all.

This interrogation usually suffices for a single reclosure scheme. Since, for example, the air pressure or the spring tension for the circuit breaker mechanism drops after the trip, no further interrogation should take place.

The time needed by the circuit breaker to regain the ready state can be monitored by the 7ST6. This monitoring time **`CB TIME OUT`** starts as soon as the CB indicates the not ready state. The dead time may be extended if no readiness is signalled at the end of it. However, if the circuit breaker does not indicate its ready status for a longer period than the monitoring time, reclosure is locked out dynamically (see also above under margin heading “Blocking of Auto-reclosure”).

Processing the Circuit Breaker Auxiliary Contacts

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

This requires that at least one of the auxiliary contacts is connected to the appropriate binary inputs “`>Brk Aux NC`” (FNo. 4602) and “`>Brk Aux NO`” (FNo. 4601). If both auxiliary contacts are connected, a plausibility check of the switching states is possible. The device checks the position of the circuit breaker continuously. As long as the auxiliary contacts indicate that the CB is not closed, the automatic reclosure function cannot be started. This guarantees that a close command can only be issued if the CB previously tripped (out of the closed state). The valid dead time begins when the trip command disappears or signals taken from the CB auxiliary contacts indicate that the CB has opened.

Sequence of a Reclose Cycle

The sequence described below applies for single-shot reclosure. In 7ST6 multiple reclosure (up to 8 shots) is also possible (see below).

If the auto reclose function is ready, the fault protection trips for all faults inside the stage selected for reclosure. The auto reclose function is then started. When the trip command resets or the circuit-breaker opens (auxiliary contact criterion) an (adjustable) dead time starts. At the end of this dead time the circuit breaker receives a close command. At the same time the (adjustable) reclaim time is started.

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

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

After unsuccessful reclosure (final tripping) the automatic reclosure is blocked dynamically (see also above under margin heading “Blocking of Auto-reclosure”).

Multi-shot Reclosing

If a fault still exists after a reclosure attempt, further reclosure attempts can be made. Up to 8 reclosure attempts are possible with the automatic reclosure function integrated in the7ST6.

The first two reclosure cycles are independent of each other. Each has separate action and dead times, and can be blocked separately via binary inputs. The parameters and intervention possibilities of the second cycle also apply to the third cycle and onwards.

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

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

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

If none of the cycles is successful, the short-circuit protection initiates a final trip after the last permissible reclosure, following a protection stage active without auto-reclosure. The auto reclose function is blocked dynamically (see also above under margin heading “Blocking of Auto-reclosure”).

Interaction with the Synchro-check

An activated external or internal synchro-check function may lead to an undesired extension of the dead time.

To prevent the automatic reclosure system from assuming an undefined state, the extension of the dead time is monitored. The extension time **T-DEAD EXT.** is started when the regular dead time has expired. When it has expired, the auto reclose function is blocked dynamically during 500 ms.

The auto reclose function resumes normal state when the blocking time has expired and new blocking conditions do not apply.

Controlling the Internal Automatic Reclosure by an External Protection Device

If the 7ST6 is equipped with the internal auto reclose function, this can also be controlled by an external protection device. This is useful for example for line ends with redundant protection or back-up protection when the second protection is used for the same line end and is to work with the automatic reclosure function integrated in the 7ST6.

Specific binary inputs and outputs must be considered in this case. It must be decided whether the internal auto-reclosure is to be controlled by the pickup or by the trip command of the external protection.

The following inputs and outputs are recommended to be used for the auto reclose function:

The auto reclose function is started via the binary inputs:

2711 “>AR Start” General pickup,

2746 “>Trip for AR” Trip command for automatic reclosure.

Automatic reclosure is controlled by the trip command. The external general pickup signal is only needed for starting the action times.

If the external protection device has dependent tripping zones, additional binary inputs for zone control are required.

Figure 2-40 shows as a connection example the interconnection between the internal automatic reclosure of 7ST6 and an external protection device.

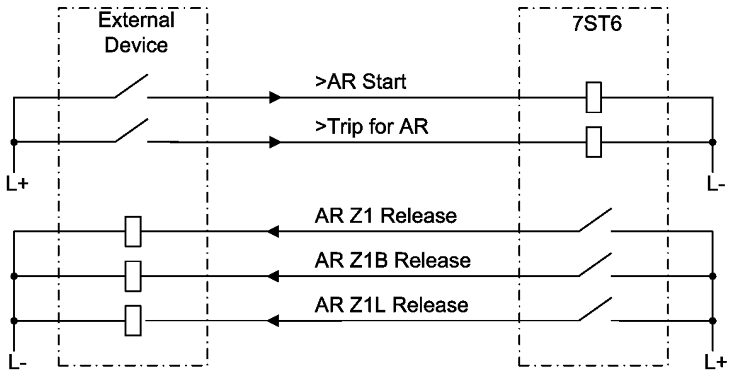


Figure 2-40 Connection of an external protection device to the internal automatic reclosure function

Thermal Auto-reclose Function

The thermal auto reclose function behaves largely in the same way as the general auto reclose function, but is in part controlled by its own parameters and outputs its own indications.

It differs from the general auto reclose function in the following points:

- The thermal auto reclose function cooperates only with the device-internal thermal overload protection. In the integrated thermal overload protection, pickup and TRIP coincide; therefore there are no action times.
- The thermal overload protection does not have multiple stages. Therefore no distinction is made between the 1st reclosure cycle and the subsequent cycles. As a result, the thermal auto reclose function has no cycle-specific parameters.
- There is no settable dead time. The dead time is dynamic, and results from the temperature curve. The reclosure temperature is set in the thermal overload protection.
- Separate parameters exist for switching the thermal auto reclose function on and off. Likewise, there are separate indications for the status of the thermal auto reclose function.

For circuit breaker supervision, interaction with a synchro-check, the manual-close feature and the dynamic blocking time, the parameters of the general auto reclose function are used.

2.12.2 Setting Notes

General

If no reclosure is required on the feeder to which the 7ST6 overhead contact line protection is applied, e.g. for transformers, the auto reclose function must be removed during configuration of the device (address 133, see Section 2.1.1.2). The auto reclose function is then totally disabled, i.e. the automatic reclosure is not processed in the 7ST6. No signals regarding the auto reclose function are generated, and the binary inputs for the auto reclose function are ignored. All parameters for setting the auto reclose function are inaccessible and of no significance.

Up to 8 reclosure attempts are allowed with the integrated auto reclose function in the 7ST6. The number of reclosure attempts is specified in address 3402 **No.Recl.**. Whereas the settings in the addresses 3401 to 3434 are common to all reclosure cycles, the individual settings for the first cycle are made from address 3430 onwards. For the second and all higher cycles, the parameters from address 3440 are valid.

The auto reclose function can be turned ***ON*** or ***OFF*** in address 3401 **AUTO RECLOSE**.

A prerequisite for automatic reclosure taking place after a trip due to a short-circuit is that the circuit breaker is ready for at least one TRIP-CLOSE-TRIP cycle at the time the automatic reclosure circuit is started, i.e. at the time of the first trip command. The readiness of the circuit breaker is signalled to the device through the binary input “>CB Ready” (FNo. 2730). If no such signal is available, leave the setting in address 3415 **CB? 1.TRIP** = ***NO*** (default setting) because no automatic reclosure would be possible at all otherwise. If circuit breaker interrogation is possible, set 3415 **CB? 1.TRIP** = ***YES***.

The circuit breaker ready state can also be interrogated by the 7ST6 prior to every reclosure. The monitoring time **CB TIME OUT** is set in address 3417. The monitoring time **CB TIME OUT** is the same for all reclosure cycles. It starts as soon as the CB indicates the "not ready" state. The time is set slightly longer than the recovery time of the circuit breaker after a TRIP-CLOSE-TRIP cycle. If the circuit breaker is not ready again by the time this timer expires, no reclosure takes place, the automatic reclosure function is blocked dynamically.

Waiting for the circuit breaker to be ready can lead to an increase of the dead times. Interrogation of a synchronization check (if used) can also delay reclosure. To avoid uncontrolled prolongation it is possible to set a maximum prolongation of the dead time in this case in address 3421 **T-DEAD EXT.**. This prolongation is unlimited if the setting ∞ is applied. This parameter can only be altered with DIGSI® under “ Displaying Additional Settings”. Remember that longer dead times are only permissible after three-pole tripping when no stability problems arise or when a synchro-check takes place before reclosure.

The blocking time **TIME RESTRAINT** (address 3420) defines the time that must elapse, after a successful reclosing attempt, before the auto reclose function is reset. Re-tripping of a protection function within this time initiates the next reclose cycle in the event of multiple reclosure; if no further reclosure is permitted, the last reclosure is treated as unsuccessful. The reclaim time must therefore be longer than the longest response time of a protective function which can start the automatic reclosure circuit.

A few seconds are generally sufficient. In areas with frequent thunderstorms or storms, a shorter reclaim time may be necessary to avoid feeder lockout due to sequential lightning strikes or flashovers.

A longer reclaim time should be chosen where circuit breaker supervision is not possible (see above) during multiple reclosures, e.g. because of missing auxiliary contacts and information on the circuit breaker ready status. In this case, the reclaim time should be longer than the time required for the circuit breaker mechanism to be ready.

The blocking duration following Manual-Close detection **T-BLOCK MC** (address 3423) must guarantee the circuit breaker to open and close reliably (0.5 s to 1 s). If a fault is detected by a protection function within this time after closing of the circuit breaker was detected, no reclosure takes place and a final trip command is issued. If this is not desired, address 3423 is set to 0.

Address 3416 **T-Start MONITOR** monitors the reaction of the circuit breaker after a trip command. If the CB has not opened during this time (from the beginning of the trip command), the automatic reclosure is blocked dynamically. The criterion for circuit breaker opening is the position of the circuit breaker auxiliary contact or the disappearance of the trip command. If a circuit breaker failure protection (internal or external) is used on the feeder, this time should be shorter than the delay time of the circuit breaker failure protection so that no reclosure takes place if the circuit breaker fails.

Configuration of Auto-Reclosure

This configuration concerns the interaction between the protection and supplementary functions of the device and the auto reclose function. Here you can select which functions of the device are to start the auto reclose function, and which not (see Table 2-4).

Table 2-4 Settings for configuring the auto reclose function

Address	Parameter
3405	AR w/ DIST., i.e. with distance protection
3406	AR w/ HS O/C, i.e. with high-speed overcurrent protection
3407	AR w/ DTT, i.e. with externally coupled trip command

For the functions which are to start the auto-reclosure function, the corresponding address is set to ***YES***, for the others to ***NO***. The other functions, e.g. overvoltage protection, circuit breaker failure protection, overcurrent protection, defrosting protection cannot start the automatic reclosure because reclosure is of little use here.

The thermal overload protection is a special case in this context. It is provided with a separate auto reclose function, the thermal auto reclosure. This auto reclose function can be switched ***ON*** or ***OFF*** with the parameter 3450 **AUTO-TH-AR**.

1st Reclosure Cycle

In address 3430 **1.AR: START** you set whether this cycle is permitted to start the auto reclose function (= ***YES***) or not.

The action time **1.AR: T-ACTION** (address 3431) is the interval from the pickup of a protection function within which the trip command must appear in order to start the automatic reclosure. If the command does not appear until after the action time has expired, there is no reclosure.

The dead time after tripping **1st Recl: Tdead** (address 3432) should be long enough for the short-circuit arc to be extinguished and the surrounding air to be deionized so that the reclosure promises to be successful. The longer the line, the longer is this time due to the charging of the conductor capacitances. The stability of the power system must also be kept in mind. Since the de-energized line cannot transfer synchronizing energy, only short dead times are allowed. Usual values are 0.3 s to 0.6 s.

If the device is equipped with a synchronism check (see Section 2.13), a longer time may be tolerated under certain circumstances. Longer times are also permitted for lines on which only vehicles with converters are used.

If there is a risk of stability problems in the network during a reclosure cycle, set address 3434 **SYN-CHECK** to ***YES***. In this case a check is made before every reclosure following tripping whether the voltages of the feeder and the reference are sufficiently synchronized. This is applicable on condition that either the internal synchronism and voltage check function is available or that an external device is available for synchronism check. Where no stability problems are to be expected during the auto-reclosure dead time, set address 3434 to ***NO***.

2nd to 8th Reclosure Cycle

In address 3440 **2nd Recl:START** you set whether the 2nd to 8th cycle are permitted to start the auto reclose function (= ***YES***) or not.

If more than two cycles are set in address 3402, those following the second cycle use the settings of the second cycle.

The table below shows a summary of the parameters of the 2nd cycle.

Table 2-5 Auto reclose function – 2nd to 8th cycle

Address	Parameter	Description
3440	2nd Recl:START	Start of auto reclose permitted for 2nd to 8th cycle
3441	2-8 Recl:T SI	Action time for 2nd to 8th reclosure cycle
3442	2-8 Recl:Tdead	Dead time for 2nd to 8th reclosure cycle

CB Ready Interrogation at 1st Trip

If the setting of address 3415 **CB? 1.TRIP**=***YES*** specifies that the readiness of the circuit breaker in normal state is to be continuously monitored via the binary input 2730 “>CB Ready”, the auto reclosure function is statically blocked if the binary input signal drops out. The blocking is reset as soon as the binary input signal returns. Circuit breaker ready signals that drop out during a power system fault are checked by monitoring times.

Circuit Breaker Open and TRIP

If the auto reclose function detects that the circuit breaker is open but that there is no TRIP command from any internal or external protection function, the auto reclose function is statically blocked. This state can occur, for instance, if the circuit breaker was not actuated by the protection but by the control. A prerequisite for detection of an open circuit breaker is in this case that the breaker auxiliary contacts are connected to the auto reclose function. The blocking is reset when the circuit breaker is closed.

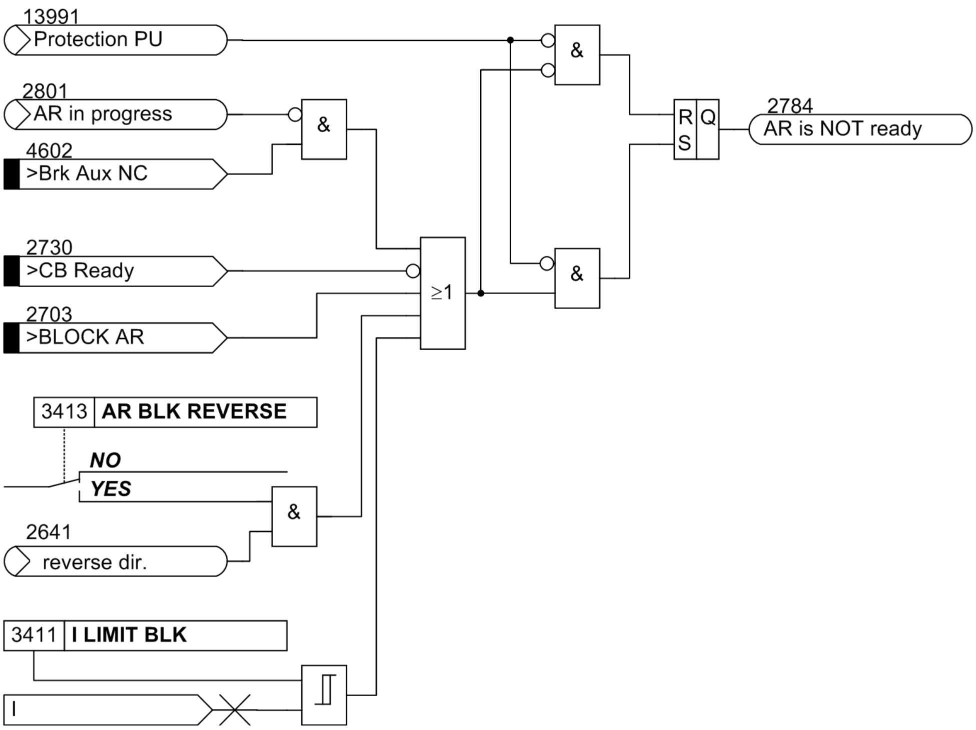


Figure 2-41 Static blocking

If a TRIP command occurs while the auto reclose function is statically blocked, the function passes to the dynamic blocking state.

Possible Causes of Dynamic Blocking

The table below summarizes the possible causes of dynamic blocking:

Table 2-6 Possible causes of dynamic blocking

Causes of dynamic blocking	Resulting indication(s)
Binary input 2703 “>BLOCK AR” active	2703 “>BLOCK AR”
TRIP out of action time	2829 “AR Tact expired”
Start signal monitoring time expired	2809 “AR T-Start Exp”
Dead time extension time expired	2810 “AR TdeadMax Exp”
Circuit breaker ready monitoring window expired	2788 “AR T-CBreadyExp”
Reclaim time expired without CB CLOSE	2785 “AR DynBlock”
Fault in reverse direction	13882 “AR BLK DIR”
Thermal overload pickup with auto reclosure running	2805 “Th-AR in prog”
Current has reached the limit value 3411 “AR DynBlock”	13883 “AR BLK I MAX”
Manual close command	13885 “AR BLK MC”
No more cycles possible	2863 “AR Lockout”
TRIP command from circuit breaker failure protection	13884 “AR BLK BF”
TRIP during static blocking	No indication

TRIP out of Action Time

The interval between the appearance of a pickup signal and the appearance of a TRIP command can be monitored by the action time in addresses 3431 **1.AR: T-ACTION** and 3441 **2-8 Recl:T SI**. The action time starts with the appearance of the pickup signal. If the action time expires without a TRIP command arriving, each TRIP command in the time between the expiry of the action time and the reset of the pickup leads to a dynamic blocking of the auto reclose function. The "blocked" signal starts the dynamic blocking time. The auto reclose function resumes normal state when the blocking time has expired and new blocking conditions do not apply.

Start Signal Monitoring Time Expired

The interval between the appearance of the TRIP command and the opening of the circuit breaker is monitored by means of the start signal monitoring time set in address 3416 **T-Start MONITOR**. If the time expires before the circuit breaker has opened, the auto reclose function is dynamically blocked and the dynamic blocking time launched. The auto reclose function resumes normal state when the blocking time has expired and new blocking conditions do not apply.

Dead Time Extension Expired

The monitoring of the circuit breaker ready signal and the synchro-check may cause undesired extension of the dead time. To prevent the automatic reclosure system from assuming an undefined state, the extension of the dead time is monitored. The extension time (address 3421 **T-DEAD EXT.**) is launched when the regular dead time has expired. When it has expired, the automatic reclosure function is blocked dynamically and the dynamic blocking time launched. The auto reclose function resumes its normal state when the blocking time has expired and new blocking conditions do not apply.

Circuit Breaker Ready Monitoring Time Expired / Reclaim Time Expired without CB CLOSE

If the setting of address 3415 **CB? 1.TRIP** specifies that the circuit breaker readiness is to be monitored during the dead time, the timer for the circuit breaker ready monitoring (3417 **CB TIME OUT**) is launched within the pause when the binary input indication2730 “>CB Ready” disappears. If it expires without the binary input signal returning, the auto reclose function is dynamically blocked, and the blocking time of 500 ms is launched. The auto reclose function resumes its normal state when the blocking time has expired and new blocking conditions do not apply. If the reclaim time, plus, where applicable, the CLOSE command time, expires without the circuit breaker being closed, the auto reclose function is also dynamically blocked.

Blocking by Pickup in Reverse Direction

In the case of a pickup by any of the internal protection functions, the general auto reclose function can be dynamically blocked in dependence on parameter 3413 **AR BLK REVERSE**) if the distance protection detects a fault in reverse direction. The auto reclose function resumes normal state when the blocking time has expired and new blocking conditions do not apply.

Current Limit Reached

When the fault current reaches a settable limit **I LIMIT BLK** (address 3411), a started automatic reclosure is dynamically blocked. The auto reclose function resumes its normal state when the blocking time of 500 ms has expired and new blocking conditions do not apply.

Blocking of the Thermal Auto Reclose Function by Pickup of another Protection Function

If the automatic reclosure function is active (actuated by the thermal overload function) and trips another protection function, the auto reclose function is dynamically blocked. The blocking is reset as soon as the dynamic blocking has expired.

No More Cycles Possible

The maximum number of reclosure attempts specified in the settings is reached. If now a TRIP command is given within the reclaim time, the auto reclose function is dynamically blocked during 500 ms. The auto reclose function resumes its normal state when the blocking time has expired and new blocking conditions do not apply.

Manual Close

The parameter **T-BLOCK MC** (address 3423) specifies whether the auto reclose function responds to a manual CLOSE command.

If **T-BLOCK MC** is set to 0, the auto reclose function does not respond on detecting a manual CLOSE command. If the parameter **T-BLOCK MC** is set to ≠ 0, the auto reclosure function is dynamically blocked on detecting a manual CLOSE command. This is also true if the auto reclose function has not yet been started, or if it is already statically blocked.

On appearance of the manual CLOSE signal, the manual CLOSE blocking time defined in the parameter **T-BLOCK MC** (address 3423) and the dynamic blocking time of 500 ms are launched. Both times overlap. If the dynamic blocking time is longer than the manual CLOSE blocking time, the device checks on expiry of the dynamic blocking time whether the blocking can be reset.

If no more blocking conditions apply, the auto reclose function resumes its normal state. If the manual CLOSE blocking time is still running when the dynamic blocking time has expired, the blocking is maintained, and the dynamic blocking time relaunched.

TRIP by Breaker Failure Protection

If the breaker failure protection issues a TRIP command, the auto reclose function is dynamically blocked, even if the set maximum number of cycles is not yet reached. The indication “AR DynBlock” (FNo. 2785) is output. Here the start signal monitoring time must be matched to the breaker failure protection. The auto reclose function resumes normal state when the dynamic blocking time has expired.

Interaction with an External Protection Device

The auto reclose functions provides binary input and output signals for interaction with an external protection device.

In the functional description of the auto reclose function, a connection example of the auto reclose function to an external protection device is shown under margin heading “Controlling the Internal Automatic Reclosure by an External Protection Device”.

Thermal Auto-reclose Function

The thermal auto reclose function is not an autonomous function. It is configured together with the general auto reclose function but can be separately switched ***ON*** or ***OFF*** with the parameter **AUTO-TH-AR** (address 3450). In address 3451 **No. of TH-AR**, the number of reclosure attempts is specified for the thermal auto reclose function.

The thermal auto reclose function behaves largely in the same way as the general auto reclose function, but is in part controlled by its own parameters and outputs its own indications (see margin heading “Thermal Auto Reclose Function” in the functional description).

In contrast to the general auto reclose function, there is no settable dead time. The dead time is dynamic, and results from the temperature curve. A maximum permissible dead time can be defined with the parameter **Tdead TH MAX** (address 3456). After this monitoring time has expired, the thermal auto reclose function is blocked, and an indication is output with “AR TH TO Tdead” after the dead time has expired. This means that the maximum dead time must be set longer than the expected time necessary for the line to cool off. The reclosure temperature is set in the thermal overload protection (see also Subsection 2.7.4).

Separate binary inputs exist for switching the thermal auto reclose function on and off and for blocking it. Likewise, there are separate indications for the status of the thermal auto reclose function. For circuit breaker supervision, interaction with a synchro-check, the manual-close feature and the dynamic blocking time, the parameters of the general auto reclose function are used.

Notes on the Information List

The most important information about automatic reclosure is briefly explained insofar as it was not mentioned in the following lists or described in detail in the preceding text.

“>BLK 1.AR-cycle” (FNo. 2742) and “>AR BLK >1st” (FNo. 13874)

The associated reclosure cycles are blocked. If the blocking state already exists when the automatic reclosure function is initiated, the blocked cycle is not executed and may be skipped. The same is true if the auto reclose function is started outside the blocked cycle. If the block signal of a cycle appears while this cycle is being executed (busy) the automatic reclosure function is blocked dynamically; no further automatic reclosures cycles are then executed.

“AR EN Z1B” (FNo. 13887), “AR EN Z1L” (FNo. 13888) and “AR EN Z1” (FNo. 13886)

If the signal “AR EN Z1B” is active, the automatic reclosure function is ready for the first reclosure cycle. An active signal “AR EN Z1L” indicates that the auto reclose function is ready for a second or higher cycle. On the other hand, the signal “AR EN Z1” indicates that the auto reclose function is in its last cycle, or blocked. For example, external protection functions can use these signals to release accelerated or overreaching trip stages prior to the corresponding reclose cycle.

“AR is NOT ready” (FNo. 2784)

The automatic reclosure is not ready for reclosure at the moment. In addition to the reasons mentioned above for static blocking, there are also obstructions during the course of the reclose cycles such as "action time run out" or "last reclaim time running". This information is particularly helpful during testing because no protection test cycle with reclosure may be initiated during this state.

“>BLOCK AR” (FNo. 2703)

A blocking via the BI (2703:“>BLOCK AR”) may cause both a static and a dynamic blocking. An activation of the BI with the auto reclose function in normal state will cause a static blocking. The blocking is terminated immediately when the binary input has been cleared, and the automatic reclosure function resumes its normal state.

If the auto reclose function is already running when the blocking arrives, the dynamic blocking takes effect. In this case, the blocking time defined by the parameter **T BLK DYN** (address 3422) is started when the binary input is set. After the time has expired, the function checks whether the BI is still active. If it is, the auto reclose function passes from dynamic to static blocking. If the binary input is no longer active when the time has expired and if no new blocking conditions apply, the automatic reclosure system resumes normal state.

“AR no starter” (FNo. 2823)

In the configuration parameters **AR w/ DIST.** (address 3405), **AR w/ HS O/C** (address 3406), **AR w/ DTT** (address 3407) and the parameter **AUTO-TH-AR** (address 3450) no source has been defined for starting the auto reclose function. The automatic reclosure is therefore statically blocked. With the parameter 3430: **1.AR: START** and 3440: **2nd Recl:START**, no start of one of the possible cycles is enabled. The automatic reclosure is therefore statically blocked. This state can only be changed by modification of the settings.

“AR in progress” (FNo. 2801)

This information appears following starting of the auto reclose function, i.e. with the first trip command that can start the auto reclose function. If this reclosure was successful (or any in the case of more than one), this information resets with the expiry of the last reclaim time. If no reclosure was successful or if reclosure was blocked, it ends with the last – the final – trip command.

“AR Sync.Request” (FNo. 2865)

Measuring request to an external synchronism check device. The information appears at the end of a dead time subsequent to tripping if a synchronism request is present. Reclosure only takes place when the synchronism check device has provided the release signal “>Sync.release” (FNo.2731).

“>Sync.release” (FNo. 2731)

Release of reclosure by an external synchronism check device if this was requested by the output information “AR Sync.Request” (FNo. 2865).

2.12.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
3401	AUTO RECLOSE	OFF ON	ON	Auto-Reclose Function
3402	No.Recl.	1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles	1 AR-cycle	Maximum Number of Reclosure Attempts
3405	AR w/ DIST.	YES NO	YES	AR with Distance Protection
3406	AR w/ HS O/C	YES NO	YES	AR with HS O/C Protection
3407	AR w/ DTT	YES NO	YES	AR with direct transfer trip
3411	I LIMIT BLK	1 .. 25 A; 0; ∞	10 A	Current Limit for AR Blocking
3412	No.Recl. HS O/C	1 AR-cycle All AR Cycles	1 AR-cycle	No. of Reclosure Attempts HS O/C Tripped
3413	AR BLK REVERSE	YES NO	NO	AR Blocking at Faults Reverse Direction
3415	CB? 1.TRIP	YES NO	NO	CB ready interrogation at 1st trip
3416	T-Start MONITOR	0.01 .. 300.00 sec	0.50 sec	AR start-signal monitoring time
3417	CB TIME OUT	0.01 .. 300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3420	TIME RESTRAINT	0.50 .. 300.00 sec	3.00 sec	Auto Reclosing reset time
3421A	T-DEAD EXT.	0.50 .. 300.00 sec; ∞	∞ sec	Maximum dead time extension
3423	T-BLOCK MC	0.50 .. 300.00 sec; 0	1.00 sec	AR blocking duration after manual close
3430	1.AR: START	YES NO	YES	Start of AR allowed in this cycle
3431	1.AR: T-ACTION	0.01 .. 300.00 sec; ∞	0.20 sec	Action Time
3432	1st Recl: Tdead	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead Time for 1st Reclosure Cycle
3434	SYN-CHECK	YES NO	NO	Synchro-Check after Dead Time
3440	2nd Recl:START	YES NO	NO	Start 2nd Reclosure Cycle Permitted
3441	2-8 Recl:T SI	0.01 .. 300.00 sec; ∞	0.20 sec	Seal-In Time for 2nd-8th Reclosure Cycle

Addr.	Parameter	Setting Options	Default Setting	Comments
3442	2-8 Recl:Tdead	0.01 .. 1800.00 sec; ∞	0.50 sec	Dead Time for 2nd to 8th Reclosure Cycle
3450	AUTO-TH-AR	ON OFF	ON	Automatic Reclosure after Thermal Trip
3451	No. of TH-AR	1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles	1 AR-cycle	Max. Number Automatic Reclosure Attempts
3455	TInhibit TH	0.50 .. 300.00 sec	3.00 sec	Inhibit Time after Reclosure
3456	Tdead TH MAX	1 .. 60 min; ∞	30 min	Maximum Duration of Dead Time

2.12.4 Information List

No.	Information	Type of Information	Comments
2701	>AR ON	SP	>Auto reclose ON
2702	>AR OFF	SP	>Auto reclose OFF
2703	>BLOCK AR	SP	>BLOCK Auto reclose
2710	>Th-AR block	SP	>Th-AR: Block thermal AR-function
2711	>AR Start	SP	>External start of internal Auto reclose
2718	>Th-AR ON	SP	>Th-AR: Switch on thermal-AR function
2719	>Th-AR OFF	SP	>Th-AR: Switch off thermal-AR function
2731	>Sync.release	SP	>AR: Synchronism from ext. sync.-check
2742	>BLK 1.AR-cycle	SP	>AR: Block 1st AR-cycle
2746	>Trip for AR	SP	>AR: External Trip for AR start
2781	Auto recl. OFF	OUT	Auto recloser is switched OFF
2782	Auto recl. ON	IntSP	Auto recloser is switched ON
2783	AR is blocked	OUT	AR: Auto-reclose is blocked
2784	AR is NOT ready	OUT	Auto recloser is NOT ready
2785	AR DynBlock	OUT	Auto-reclose is dynamically BLOCKED
2787	CB not ready	OUT	AR: Circuit breaker not ready
2788	AR T-CBreadyExp	OUT	AR: CB ready monitoring window expired
2793	Th-AR not rdy	OUT	Th-AR: Thermal AR not ready
2794	Th-AR off	OUT	Th-AR: Thermal AR is switched off
2795	Th-AR on	IntSP	Th-AR: Thermal AR is switched on
2796	AR on/off BI	IntSP	AR: Auto-reclose ON/OFF via BI
2801	AR in progress	OUT	Auto-reclose in progress
2805	Th-AR in prog	OUT	Th-AR: Thermal AR in progress
2808	AR BLK: CB open	OUT	AR: CB open with no trip
2809	AR T-Start Exp	OUT	AR: Start-signal monitoring time expired
2810	AR TdeadMax Exp	OUT	AR: Maximum dead time expired
2819	ThAR Tdead ru	OUT	Th-AR: dead time is running

No.	Information	Type of Information	Comments
2823	AR no starter	OUT	AR: no starter configured
2829	AR Tact expired	OUT	AR: action time expired before trip
2844	AR 1stCyc. run.	OUT	AR 1st cycle running
2851	AR Close	OUT	Auto-reclose Close command
2855	Th-AR ClosCmd	OUT	Th-AR: Close command from thermal AR
2861	AR T-Recl. run.	OUT	AR: Reclaim time is running
2862	AR Successful	OUT	Auto reclose cycle successful
2863	AR Lockout	OUT	Auto reclose Lockout
2865	AR Sync.Request	OUT	AR: Synchro-check request
2866	Th-AR T-Recl.	OUT	Th-AR: Therm.AR reclaim time is running
2867	Th-AR success	OUT	Th-AR: Thermal AR cycle successful
2868	Th-AR def.Trp	OUT	Th-AR: Thermal AR definite trip
13872	AR TH ON/OFFtel	IntSP	AR thermal trip:ON/OFF via Telegram
13873	AR TH ON/OFF BI	IntSP	AR thermal trip:ON/OFF via Binary Input
13874	>AR BLK >1st	SP	>AR: BLOCK 2nd-nth cycle
13875	AR TH TO Tdead	OUT	AR thermal trip:Time Out Dead time
13876	AR TH dyn Blk	OUT	AR thermal trip:dynam. blocked
13877	AR Dead Time	OUT	AR Dead time is running
13878	AR >1st cycle	OUT	AR 2nd cycle or higher is running
13879	AR Close 1st	OUT	AR CLOSE command 1st cycle
13880	AR Close >1st	OUT	AR CLOSE command 2nd cycle or higher
13881	AR ON/OFF TEL	IntSP	AR ON/OFF via Telegram
13882	AR BLK DIR	OUT	AR blocked by failure direction
13883	AR BLK I MAX	OUT	AR blocked by max. current
13884	AR BLK BF	OUT	AR blocked by BF
13885	AR BLK MC	OUT	AR blocked by manual closing
13886	AR EN Z1	OUT	AR enable Zone Z1
13887	AR EN Z1B	OUT	AR enable Zone Z1B
13888	AR EN Z1L	OUT	AR enable Zone Z1L
13889	AR TH T Reclaim	OUT	AR after thermal trip cannot start
13993	TH Recl.SyncReq	OUT	AR: Recl. after thermal trip: Meas. Req.
13995	AR Taction 1st	OUT	AR: Taction 1st cycle is running
13996	AR Taction >1st	OUT	AR: Taction 2nd cycle or higher running

2.13 Synchronism and Voltage Check

This function is optional, i.e. not included in all device variants.

The synchronism and voltage check function ensures, when switching a line onto a busbar, that the stability of the network is not endangered. The voltage of the feeder to be energized is compared to the voltage of the busbar (reference voltage) to check conformances in terms of magnitude, phase angle and frequency within certain tolerances. Optionally deenergization of the feeder can be checked before it is connected to an energized busbar (or vice versa).

The synchro check can either be conducted only for automatic reclosure, only for manual closing (this includes also closing via control command) or in both cases. Different close permission (release) criteria can also be programmed for automatic and manual closing.

Synchro check is also possible without external matching transformers if a power transformer is located between the measuring points.

Closing is released for synchronous or asynchronous system conditions. In the latter case the device determines the time for issuing the close command such that the voltages are identical the instant the breaker poles make contact.

2.13.1 Functional Description

General

For comparing the two voltages, the synchro check uses the overhead line voltage ULine and an additional reference voltage URef.

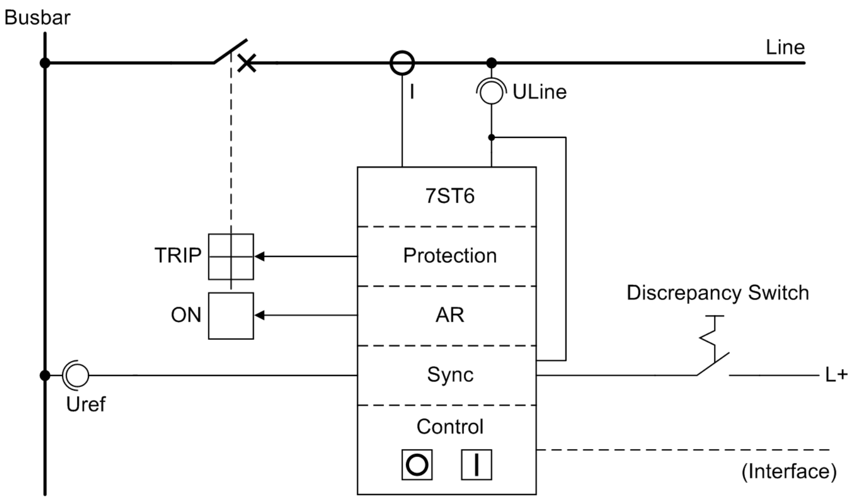


Figure 2-42 Connection example of the synchro-check, interaction with the protection function and the automatic reclosure function

The synchro-check function in the 7ST6 usually operates together with the integrated automatic reclose, manual close, and the control functions of the relay. It is also possible to employ an external automatic reclosing system. In such a case signal exchange between the devices is accomplished via binary inputs and outputs.

When closing via the integrated control function, the configured interlocking conditions may have to be verified before checking the conditions for synchronism. After the synchronism check grants the release, the interlocking conditions are not checked a second time.

Furthermore, closing is possible with synchronous or asynchronous system conditions or both. Synchronous closing means that the closing command is issued as soon as the critical values (voltage magnitude difference **Max. Volt. Diff**, angle difference **Max. Angle Diff**, and frequency difference **Max. Freq. Diff**) lie within the set tolerances. For closing with asynchronous system conditions, the device calculates the correct timing of the closing command from the angle difference **Max. Angle Diff** and the frequency difference **Max. Freq. Diff** such that the voltages on the busbar and the feeder circuit have exactly the same phase relationship at the instant that the circuit breaker primary contacts close. For this purpose the device must be informed on the operating time of the circuit breaker for closing. Different frequency limit thresholds apply to switching under synchronism and asynchronous conditions: If closing shall be permitted exclusively under synchronous system conditions, the frequency difference limit for this condition can be set. If closing is permitted under synchronous as well as under asynchronous system conditions, a frequency difference below 0.01Hz is treated as a synchronous condition, a higher frequency difference value can then be set for closing under asynchronous system conditions.

The synchro check function only operates when it is requested to do so. Various possibilities exist to this end:

- Measuring request from the external automatic reclosure device. If the internal automatic reclosing function is set accordingly (one or more reclosing attempts set to synchronism check, see also Section 2.12.2), the measuring request is accomplished internally. The release conditions for automatic reclosing apply.
- Measuring request from an internal automatic reclosure device. The measuring request must be injected via the binary input “>Sync. Start AR” (FNo 2906). The release conditions for automatic reclosing apply.
- Measuring request from the internal manual CLOSE detection. The manual CLOSE detection of the central function control (Section 2.18.1) issues a measuring request provided this was configured in the power system data 2 (Section 2.1.5, address 1151 **SYN.MAN.CL**). This requires the device to be informed of the manual closing via binary input “>Manual Close” (FNo 356). The release conditions for manual closing apply.
- Request to execute a check synchronism measurement from an external closing command. Binary input “>Sync. Start MC” FNo. 2905 fulfills this purpose. Unlike the “>Manual Close” (see previous paragraph), this merely affects the measuring request to the synchro check function, but not other integrated manual CLOSE function such as instantaneous tripping when switching onto a fault (e.g. overreaching zone for distance protection or accelerated tripping of a time overcurrent stage). The release conditions for manual closing apply.
- Measuring request from the integrated control function via control keys or via the serial interface using DIGSI ® on a PC or from a control centre. The release conditions for manual closing apply.

The synchro-check function gives permission for passage “Sync. release” (FNo. 2951) of the closing command to the required function. Furthermore a separate closing command is available as output indication “Sync.CloseCmd” (FNo. 2961).

The check of the release conditions is limited by an adjustable synchronous monitoring time **T-SYN. DURATION**. The configured conditions must be fulfilled within this time. If they are not, the synchronism will not be checked. A new synchronism check sequence requires a new request.

The device issues indications if, after a request to check synchronism, the conditions for release are not fulfilled, i.e. if the absolute voltage difference **Max. Volt. Diff**, the absolute frequency difference **Max. Freq. Diff**, or the absolute phase angle difference **Max. Angle Diff** lie outside the permissible limit values. A precondition for these indications is that voltages within the operating range of the relay are available. When a closing command is handled by the integrated control function and the conditions for synchronism are not fulfilled, the command is cancelled, i.e. the control function outputs “CO–” (refer also to Section 2.19.1).

Operating Modes

The closing check procedure can be selected from the following operating modes:

SYNC-CHECK =	Release at synchronism, that is, when the critical values **Max. Volt. Diff**, **Max. Freq. Diff** and **Max. Angle Diff** lie within the set limits. This parameter is only displayed if you have checked the “Advanced Settings” checkbox in DIGSI.
Uref>Uline< =	Release for energized busbar (URef>) and de-energized line (ULine<).
Uref<Uline> =	Release for de-energized busbar (URef<) and energized line (ULine>).
Uref<Uline< =	Release for de-energized busbar (URef<) and de-energized line (ULine<).
OVERRIDE =	Release without any check.

Each of these conditions can be enabled or disabled individually; combinations are also possible, e.g. release if **Uref>Uline<** or **Uref<Uline>** are fulfilled. Combination of **OVERRIDE** with other parameters is, of course, not reasonable.

The release conditions can be configured individually either for automatic reclosing or for manual closing or for closing via control commands. You can, for example, allow manual closing and control closing for synchronism or for de-energized feeder whereas before an automatic reclosing operation, checking only de-energized conditions at one feeder terminal and afterwards only synchronism at the other.

De-energized Switching

For release of the closing command to energize a voltage free line from a live busbar, the following conditions are checked:

- Is the feeder voltage ULine below the set value **Dead Volt. Thr.**?
- Is the reference voltage URef above the setting value **Live Volt. Thr.** but below the maximum voltage **Umax**?
- Is the frequency fRef within the permitted operating range $f_N \pm 3$ Hz?

After successful check the closing command is released.

Corresponding conditions apply when switching a live line onto a dead busbar or a dead line onto a dead busbar.

Switching under Synchronous System Conditions

Before granting a release for closing under synchronous conditions, the following conditions are checked:

- Is the reference voltage URef above the setting value **Live Volt. Thr.** but below the maximum voltage **Umax**?
- Is the feeder voltage ULine above the setting value **Live Volt. Thr.** but below the maximum voltage **Umax**?

- Is the magnitude of the voltage difference |ULine – URef| within the permissible limit **Max. Volt. Diff**?
- Are the two frequencies fRef and fLine within the permitted operating range f_N ± 3 Hz?
- Is the frequency difference |fLine – fRef| within the permissible limit **Max. Freq. Diff**?
- Is the angle difference |φLine – φref| within the permissible limit **Max. Angle Diff**?

To check whether these conditions are observed for a certain minimum time, you can set this minimum time as **T SYNC-STAB**. Checking the synchronism conditions can also be confined to a maximum monitoring time **T-SYN. DURATION**. This implies that the conditions must be fulfilled within the time **T-SYN. DURATION** for the duration of **T SYNC-STAB**. If this is the case, the closing release is released.

Switching under Asynchronous System Conditions

Before granting a release for closing under asynchronous conditions, the following conditions are checked:

- Is the reference voltage URef above the setting value **Live Volt. Thr.** but below the maximum voltage **Umax**?
- Is the feeder voltage ULine above the setting value **Live Volt. Thr.** but below the maximum voltage **Umax**?
- Is the magnitude of the voltage difference |ULine – URef| within the permissible limit **Max. Volt. Diff**?
- Are the two frequencies fRef and fLine within the permitted operating range f ± 3 Hz?
- Is the frequency difference |fLine – fRef| within the permissible limit **Max. Freq. Diff**?

When the check has been terminated successfully, the device determines the next synchronizing time from the angle difference and the frequency difference. The close command is issued at synchronization time minus the operating time of the circuit breaker.

2.13.2 Setting Notes

Preconditions

When setting the general power system data (refer to section 2.1.3.1) a number of parameters regarding the measured quantities and the operating mode of the synchronism check function must be applied.

This concerns the following parameters:

204 **Unom PRIMARY**	Primary rated voltage of the voltage transformers in kV;
205 **Unom SECONDARY**	Secondary rated voltage of the voltage transformers in V;
215 **Uline/Uref**	Matching factor for different transformers of overhead contact line voltage ULine and reference voltage URef;
230 **Rated Frequency**	The operating range of the synchronism check refers to the nominal frequency of the power system (f_N ± 3 Hz);

and, if closing at asynchronous system conditions is allowed,

239 **T-CB close** the closing time of the circuit breaker.

WARNING!

Closing under Asynchronous System Conditions

Closing under asynchronous system conditions requires the closing time of the circuit breaker to be set correctly in the Power system data 1 (address 239).

Otherwise, faulty synchronization may occur.

General

The synchro-check can only operate if it has been set to ***Enabled*** during the configuration of the device scope (address 135 **Synchro-Check**).

The measured values of the synchro check (636 “Udif=”, 637 “Uline=”, 638 “Uref=”, 647 “fdif=”, 649 “fline=”, 646 “fref=” and 648 “φ-diff=”) are only available if the synchro-check has been set to ***Enabled***.

Different interrogation conditions can be parameterized for automatic reclosure on the one hand and for manual closure on the other hand. Each closing command is considered a manual reclosure if it was initiated via the integrated control function or via a serial interface.

The general limit values for closure are set in addresses 3501 to 3508. For the automatic reclosure function, the addresses 3510 to 3519 are also relevant, and for manual closure or control closure the addresses 3530 to 3539. Moreover, address 3509 is relevant for reclosure via the integrated control function.

The complete synchronism check function is switched ***ON*** or ***OFF*** in address 3501 **FCT Synchronism**. If switched off, the synchro-check does not verify the synchronization conditions and release is not granted.

Address 3502 **Dead Volt. Thr.** indicates the voltage threshold below which the feeder or the busbar can safely be considered switched off (for checking a de-energized feeder or busbar). The setting is applied in Volts secondary. This value can be entered as a primary value when parameterizing with a PC and DIGSI®.

Address 3503 **Live Volt. Thr.** shows the voltage above it is safe to assume that the feeder or the busbar is carrying load. It must be set below the anticipated operational undervoltage. The setting is applied in Volts secondary. This value can be entered as a primary value when parameterizing with a PC and DIGSI®.

The maximum permissible voltage for the operating range of the synchronism check function is set in address 3504 **Umax**. The setting is applied in Volts secondary. This value can be entered as a primary value when parameterizing with a PC and DIGSI®.

The check of the release conditions through the synchronism check function can be limited to a configurable synchronous monitoring time **T-SYN. DURATION** (address 3507). The configured conditions must be fulfilled within this time. Below that, value reclosure will not be released. If this time is set to ∞, the conditions will be checked until they are fulfilled or the measuring request is deactivated.

If the conditions for synchronous operation must be checked to be maintained for a certain duration, this minimum duration **T SYNC-STAB** can be set in address 3508.

Synchronism Conditions for Automatic Reclosure

Addresses 3510 to 3519 are relevant to the check conditions before automatic reclosure of the circuit breaker. When setting the parameters for the internal automatic reclosing function (Section 2.12.2) it was decided whether the synchronism check should be carried out.

Address 3510 **Op.mode with AR** determines whether closing under asynchronous system conditions is allowed for automatic reclosure. Set this parameter to ***with T-CB close*** to allow asynchronous closing; the relay will then consider the circuit breaker closing time before determining the correct instant for the close command. Remember that closing under asynchronous system conditions is allowed only if the circuit breaker closing time is set correctly (see above under “Preconditions”)! If you wish to permit automatic reclosure only under synchronous system conditions, set this address to ***w/o T-CB close***.

The permissible magnitude difference of the voltages is set in address 3511 **Max. Volt. Diff**. The setting is applied in Volts secondary. This value can be entered as a primary value when parameterizing with a PC and DIGSI®.

The permissible frequency difference between the voltages is set in address 3512 **Max. Freq. Diff**, the permissible phase angle difference in address 3513 **Max. Angle Diff**.

The further release conditions for automatic reclosing are set in addresses 3515 to 3519:

The following addresses mean:

3515 **SYNC-CHECK**	The busbar (URef) and the feeder (ULine) must both be live (**Live Volt. Thr.**, address 3503); the conditions for synchronism are checked, i.e. **Max. Volt. Diff** (address 3511), **Max. Freq. Diff** (address 3512) and **Max. Angle Diff** (address 3513). This parameter can only be altered with DIGSI® under **Additional Settings**.
3516 **Uref>Uline<**	The busbar (URef) must be live (**Live Volt. Thr.**, address 3503), the feeder (ULine) must be dead (**Dead Volt. Thr.**, address 3502);
3517 **Uref<Uline>**	The busbar (URef) must be dead (**Dead Volt. Thr.**, address 3502), the feeder (ULine) must be live (**Live Volt. Thr.**, address 3503);
3518 **Uref<Uline<**	The busbar (URef) and the feeder (ULine) must both be dead (**Dead Volt. Thr.**, address 3502);
3519 **OVERRIDE**	Automatic reclosure is released without any check.

The five possible release conditions are independent of each other and can be combined.

Synchronism Conditions for Manual Closure and Control Command

Addresses 3530 to 3539 are relevant to the check conditions before manual reclosure and closing via control command of the circuit breaker. When setting the general protection data (Power System Data 2, Section 2.1.5.1) it was decided in address 1151 whether synchronism and voltage check should be carried out before manual closing. With the following setting in address **SYN.MAN.CL** = ***w/o Sync-check***, no checks are performed before manual closing.

For commands through the integrated control (local, DIGSI, serial interface), address 3509 **SyncSD** determines whether synchro checks will be performed or not. This address also tells the device to which switching device of the control the synchronizing request refers. You can select from the switching devices which are available for the integrated control. Choose the circuit breaker to be operated via the synchronism check. This is usually the circuit breaker which is operated in case of manual closing or automatic reclosure. If you set **SyncSD** = ***none*** here, a CLOSE command via the integrated control will be carried out without synchronism check.

Address 3530 **Op.mode with MC** determines whether closing under asynchronous system conditions is allowed for manual closing or reclosure via control command. Set this parameter to ***with T-CB close*** to allow asynchronous closing; the relay will then consider the circuit breaker closing time before determining the correct instant for the close command. Remember that closing under asynchronous system conditions is allowed only if the circuit breaker closing time is set correctly (see above under "Preconditions")! If you wish to permit manual closure or closing via control command only under synchronous system conditions, set this address to ***w/o T-CB close***.

The permissible magnitude difference of the voltages is set in address 3531 **MC maxVolt.Diff**. The setting is applied in Volts secondary. This value can be entered as a primary value when parameterizing with a PC and DIGSI®.

The permissible frequency difference between the voltages is set in address 3532 **MC maxFreq.Diff**, the permissible phase angle difference in address 3533 **MC maxAngleDiff**.

The further release conditions for manual reclosing or reclosure via control command are set in addresses 3535 to 3539.

The following addresses mean:

3535 **MC SYNCHR**	the busbar (URef) and the feeder (ULine) must both be live (**Live Volt. Thr.**, address 3503); the conditions for synchronism are checked, i.e. **MC maxVolt.Diff** (address 3531), **MC maxFreq.Diff** (address 3532) and **MC maxAngleDiff** (address 3533). This parameter can only be altered with DIGSI® under **Additional Settings**.
3536 **MC Uref>Uline<**	The busbar (URef) must be live (**Live Volt. Thr.**, address 3503), the feeder (ULine) must be dead (**Dead Volt. Thr.**, address 3502);
3537 **MC Uref<Uline>**	The busbar (URef) must be dead (**Dead Volt. Thr.**, address 3502), the feeder (ULine) must be live (**Live Volt. Thr.**, address 3503);
3538 **MC Uref<Uline<**	The busbar (UBus) and the feeder (ULine) must both be dead (**Dead Volt. Thr.**, address 3502);
3539 **MC O/RIDE**	Manual closing or closing via control command is released without any check.

The five possible release conditions are independent of each other and can be combined.

Note

The closing functions of the device issue individual output indications for the corresponding close command. Be sure that the output indications are assigned to the correct output relays.

FNo. 2851 “`AR Close`” for CLOSE via command of the automatic reclosure,

FNo. 562 “`Man.Close Cmd`” for manual CLOSE via binary input,

FNo. 2961 “`Sync.CloseCmd`” for CLOSE via synchronism check (not required if synchronism check releases the other CLOSE commands),

FNo. 13864 “`CB-TEST CLOSE M`” for CLOSE by circuit breaker test,

additionally CLOSE command via control, e.g. “`Breaker`”.

FNo. 510 “`Relay CLOSE`” general CLOSE command for all CLOSE commands described above.

Notes on the Information List

The most important information of the device is briefly explained in so far as it cannot be interpreted in the following information lists or described in detail in the foregoing text.

“`>Sync. Start MC`” (FNo. 2905)

Binary input which enables direct tripping of the synchronism check with setting parameters for manual close. This tripping with setting parameter for manual close has always precedence if binary inputs “`>Sync. Start MC`” (FNo. 2905) and “`>Sync. Start AR`” (FNo. 2906, see below) are activated at the same time.

“`>Sync. Start AR`” (FNo. 2906)

Measuring request from an internal automatic reclosure device. After this request, the conditions for automatic reclosure are checked.

“`Sync. req.CNTRL`” (FNo. 2936)

Measuring request form the control; evaluated on event-triggered basis and output only when the control issues a measuring request.

“`Sync. release`” (FNo. 2951)

Release signal to an external automatic reclosure device.

2.13.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
3501	FCT Synchronism	ON OFF	ON	Synchronism and Voltage Check function
3502	Dead Volt. Thr.	1 .. 60 V	5 V	Voltage Threshold Dead Line / Reference
3503	Live Volt. Thr.	20 .. 125 V	90 V	Voltage Threshold Live Line / Reference
3504	Umax	20 .. 140 V	110 V	Maximum permissible voltage
3507	T-SYN. DURATION	0.01 .. 600.00 sec; ∞	1.00 sec	Maximum duration of synchronism-check
3508	T SYNC-STAB	0.00 .. 30.00 sec	0.00 sec	Synchronous condition stability timer
3509	SyncSD	(Setting options depend on configuration)	None	synchronizable switching device
3510	Op.mode with AR	with T-CB close w/o T-CB close	w/o T-CB close	Operating mode with AR
3511	Max. Volt. Diff	1.0 .. 50.0 V	2.0 V	Maximum voltage difference
3512	Max. Freq. Diff	0.01 .. 2.00 Hz	0.10 Hz	Maximum frequency difference
3513	Max. Angle Diff	1 .. 80 °	10 °	Maximum angle difference
3515A	SYNC-CHECK	YES NO	YES	Live Ref. / Live Line and Sync
3516	Uref>Uline<	YES NO	NO	Live Ref. / Dead Line Check
3517	Uref<Uline>	YES NO	NO	Dead Ref. / Live Line Check
3518	Uref<Uline<	YES NO	NO	Dead Ref. / Dead Line Check
3519	OVERRIDE	YES NO	NO	Override of any check before AR
3530	Op.mode with MC	with T-CB close w/o T-CB close	w/o T-CB close	Operating mode with Man.Cl
3531	MC maxVolt.Diff	1.0 .. 50.0 V	2.0 V	Maximum voltage difference
3532	MC maxFreq.Diff	0.01 .. 2.00 Hz	0.10 Hz	Maximum frequency difference
3533	MC maxAngleDiff	1 .. 80 °	10 °	Maximum angle difference
3535A	MC SYNCHR	YES NO	YES	Live Ref. / Live Line and Sync before MC
3536	MC Uref>Uline<	YES NO	NO	Live Ref. / Dead Line Check before MC
3537	MC Uref<Uline>	YES NO	NO	Dead Ref. / Live Line Check before MC

Addr.	Parameter	Setting Options	Default Setting	Comments
3538	MC Uref<Uline<	YES NO	NO	Dead Ref. / Dead Line Check before MC
3539	MC O/RIDE	YES NO	NO	Override of any check before Man.Cl

2.13.4 Information List

No.	Information	Type of In-formation	Comments
2901	>Sync. on	SP	>Switch on synchro-check function
2902	>Sync. off	SP	>Switch off synchro-check function
2903	>BLOCK Sync.	SP	>BLOCK synchro-check function
2905	>Sync. Start MC	SP	>Start synchro-check for Manual Close
2906	>Sync. Start AR	SP	>Start synchro-check for AR
2907	>Sync. synch	SP	>Sync-Prog. Live bus / live line / Sync
2911	>Sync. o/ride	SP	>Sync-Prog. Override (bypass)
2930	Sync. on/off BI	IntSP	Synchro-check ON/OFF via BI
2931	Sync. OFF	OUT	Synchro-check is switched OFF
2932	Sync. BLOCK	OUT	Synchro-check is BLOCKED
2934	Sync. faulty	OUT	Synchro-check function faulty
2935	Sync.Tsup.Exp	OUT	Synchro-check supervision time expired
2936	Sync. req.CNTRL	OUT	Synchro-check request by control
2941	Sync. running	OUT	Synchronization is running
2942	Sync.Override	OUT	Synchro-check override/bypass
2943	Synchronism	OUT	Synchronism detected
2944	SYN Uref<Uline>	OUT	Sync. Dead ref. / Live line detected
2945	SYN Uref>Uline<	OUT	Sync. Live ref. / Dead line detected
2946	SYN Uref<Uline<	OUT	Sync. Dead ref. / Dead line detected
2947	Sync. Udiff>	OUT	Sync. Voltage diff. greater than limit
2948	Sync. fdiff>	OUT	Sync. Freq. diff. greater than limit
2949	Sync. φ-diff>	OUT	Sync. Angle diff. greater than limit
2951	Sync. release	OUT	Synchronism release (to ext. AR)
2961	Sync.CloseCmd	OUT	Close command from synchro-check
2970	Sync. fref>>	OUT	Sync. Reference frequency > (fn+3Hz)
2971	Sync. fref<<	OUT	Sync. Reference frequency < (fn-3Hz)
2972	Sync. f-line>>	OUT	Sync. Line frequency > (fn + 3Hz)
2973	Sync. f-line<<	OUT	Sync. Line frequency < (fn - 3Hz)
2974	Sync. Uref>>	OUT	Sync. Reference voltage > Umax
2975	Sync. Uref<<	OUT	Sync. Reference voltage < U>
2976	Sync. U-line>>	OUT	Sync. Line voltage > Umax (P.3504)
2977	Sync. U-line<<	OUT	Sync. Line voltage < U> (P.3503)

2.14 Fault Locator

This function is optional, i.e. not included in all device variants.

The measurement of the distance to a fault is an supplement to the protection functions. Availability of the line for power transmission within the system can be increased when the fault is located and cleared faster.

2.14.1 Functional Description

Initiation Conditions

The fault locator in the overhead contact line protection 7ST6 is a function which is independent of the distance measurement. It has a separate measured signal memory and dedicated algorithms for determination of the loop reactance and the fault location.

The short-circuit protection merely has to provide a start command to allow the selection of the best suited time interval for the storage of the measured signals.

The fault locator can be triggered either by the trip command of the short-circuit protection, or by each fault detection. In the latter case, a fault location calculation is also possible if a different protection device clears the fault.

For a fault outside the protected overhead contact line, the fault location information is not always correct, as the measured values can be distorted by, e.g. intermediate infeeds or by loads along the line.

Determination of the Fault Location

The measured value pairs of fault currents and fault voltages are the basis for calculating the impedance.

Filtering of the measured values and the number of impedance calculations are automatically adapted to the number of measured value pairs provided in the available data window. If a sufficient data window with appropriate measured value pairs could not be determined, the alarm “`Flt.Loc.invalid`” (FNo.1132) is issued.

The evaluation of the measured quantities takes place after the fault has been cleared.

At least three result pairs of R and X are calculated from the stored and filtered measured quantities in accordance with the line equations. The calculated average for X is the fault reactance which is proportional to the distance to fault.

For the fault locator up to 5 line sections with different reactance per unit length characteristics can be defined. Calculation of the fault location is thus possible even with inhomogeneous line sections. The figure below illustrates how the distance to fault is computed from the fault reactance determined by the fault location calculation.

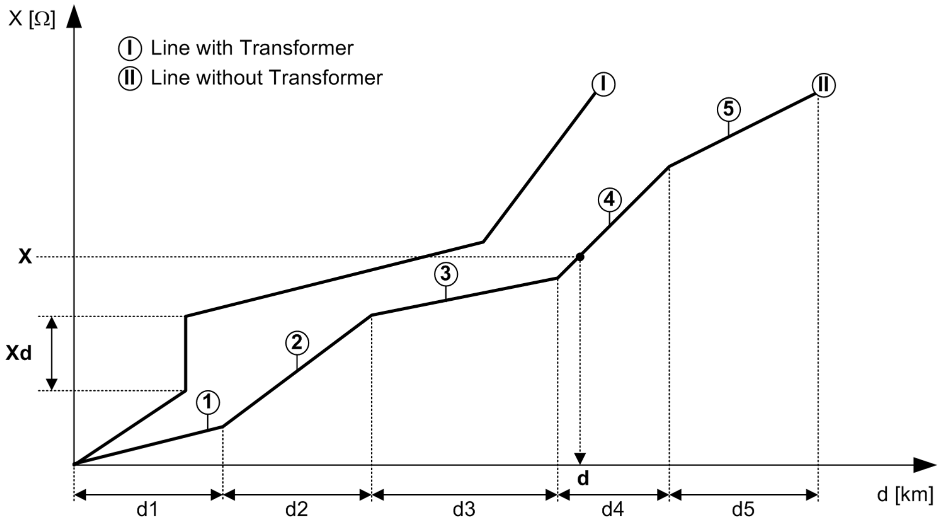


Figure 2-43 Determination of the distance to fault from the calculated fault reactance

As a result, the fault location works correctly even if there are line sections with different reactance per unit length characteristics, or transformers, between the protection device and the fault.

Note

The precision of the fault locator specified in the Technical Data applies to faults with a sufficiently long measuring window for calculating the fault location. In case of an instantaneous trip, the precision of the fault location is necessarily reduced due to the short fault clearance time and the high harmonics content in the measured current and voltage signals.

Output of the Fault Location

The fault locator issues the following results:

- Reactance X in Ω primary and Ω secondary,
- Resistance R in Ω primary and Ω secondary,
- Distance to fault d in kilometres or miles, calculated on the basis of the reactance per unit length characteristics parameterized for the line sections,
- Distance to fault d in % of the line length.

2.14.2 Setting Notes

General

The fault locator is only effective and available if address 138 **Fault Locator** was set to ***Enabled*** during configuration. If the function is not required, ***Disabled*** is to be set.

Start Condition

If the fault location calculation is to be started by the trip command of the protection, set address 3802 **START** = ***TRIP***.

If the fault location calculation is to be started on each fault detection by the device, set address 3802 **START** = ***Reclosing*** / ***Trip***. In this case the fault location is also calculated if, for example, a different protection device cleared the fault. For a fault outside the protected line, the fault location information is not always correct, as the measured values can be distorted by e.g. intermediate infeeds.

2.14.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
3802	START	TRIP Reclosing/Trip	TRIP	Start fault locator with

2.14.4 Information List

No.	Information	Type of Information	Comments
1106	>Start Flt. Loc	SP	>Start Fault Locator
1110	FltLoc block	OUT	Fault locator is blocked
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
1121	Fault section	VI	Fault in section
1122	dist =	VI	Flt Locator: Distance to fault
1129	FltLoc imposs	OUT_Ev	No calculation of distance possible
1130	Flt dist >	OUT_Ev	Distance to fault out of range
1132	Flt.Loc.invalid	OUT_Ev	Fault location invalid

2.15 It Function (current-time integral)

This function is optional, i.e. not included in all device variants.

The summation of the fault current-time integrals is a simple and reliable indicator of the degree of contact wear in a circuit breaker. This function thus allows a more efficient planning of the circuit breaker maintenance provided for in the plant maintenance and repair schedule. In addition to the fault current at the moment of the TRIP command, this function can determine the circuit breaker load from opening the main contacts to quenching the arc.

2.15.1 Functional Description

General

The circuit breaker load is proportional to the current-time integral over the time between the opening of the main breaker contacts $\mathbf{t_{Start}}$ and the quenching of the arc in the arcing chamber $\mathbf{t_{End}}$. This allows to determine a measure of the breaker load with the following formula:

$$I_t = \int_{t_{Start}}^{t_{End}} |i|\,dt$$

The starting time $\mathbf{t_{Start}}$, i.e. the opening of the contacts, can be determined either by the status of the CB auxiliary contacts or, if that status is not available, by the TRIP command from the device. For an accurate determination of the circuit breaker load, the instants $\mathbf{t_{Start}}$ and $\mathbf{t_{End}}$ must be determined as precisely as possible. The following two sections describe two alternative methods for determining the starting time $\mathbf{t_{Start}}$.

The plausibility of the times $\mathbf{t_{Start}}$ and $\mathbf{t_{End}}$ is monitored. When $\mathbf{t_{Start}}$is found to be greater than $\mathbf{t_{End}}$, there will be no It measurement, and the indication “`It set error`” (FNo. 13855) is output.

The starting time $\mathbf{t_{Start}}$ can be marked by the signal “`Start It Meas`” (FNo. 13848) in the fault record.

Using the Circuit Breaker Auxiliary Contacts

Here the starting time $\mathbf{t_{Start}}$ is determined from the moment of opening a circuit breaker auxiliary contact. For sufficient precision, it is absolutely necessary to use an NC contact of the circuit breaker auxiliary contact, i.e. the closed contact is equivalent to the OPEN position.

In the 7ST6 device the indication “`>Brk Aux NC`” (FNo 4602) is used for this purpose. The device does not detect the opening of the circuit breaker auxiliary contact until a delay time $\mathbf{t_{BI}}$ of approx. 5 ms has elapsed.

Note

The indication “`>Brk Aux NC`” must be allocated to a fast binary input. The binary inputs BI1 through BI12 must be used for this!

The circuit breaker main contact may open before or after the circuit breaker auxiliary contact. The time difference between the switching of these two contacts can be set with the parameter **`DELTA AuxCont`** (address 4103). A positive value is set for this time difference if the auxiliary contact opens or closes later than the main contact.

The figure below illustrates how the time limit for determination of the current integral is specified. The values used in it are:

tBI	Instant at which the device detects through a binary input BI that the auxiliary contact Aux is closed.
Δ tBI	Delay time of the binary input.
tAux	Time difference between the main and the auxiliary contact of the circuit breaker (end of movement of the main contact).
tCBTRIP	Circuit breaker operating time on tripping.

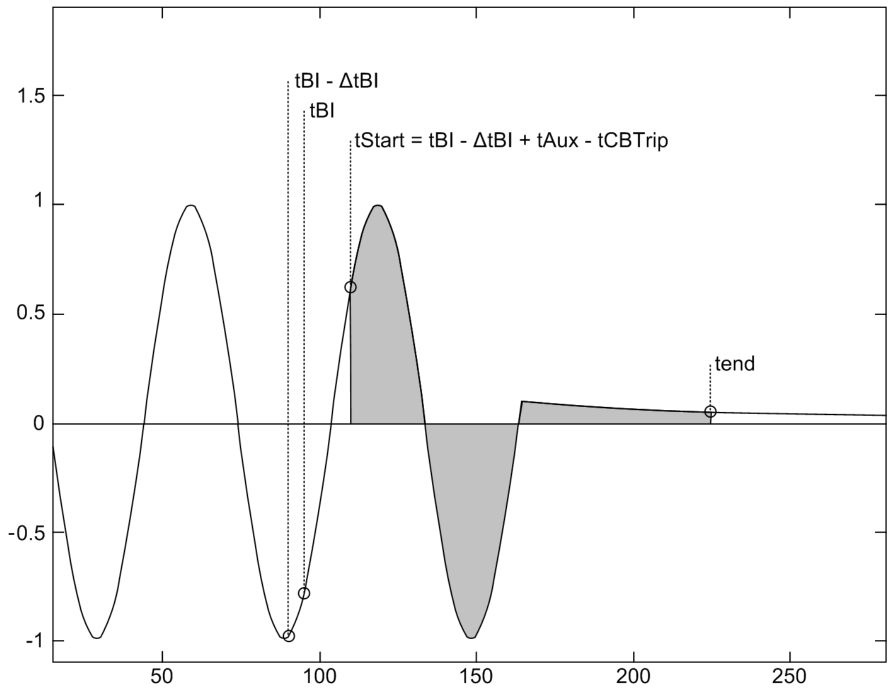


Figure 2-44 Typical course of a trip, including the beginning and end of the integration interval to determine the trip load

Following a TRIP command, the binary inputs for the circuit breaker auxiliary contacts are monitored for a maximum of 150 ms. If the binary input is activated during that interval, the current-time integral measurement is started. Then the last zero crossing of the current is determined.

Using the TRIP Command

In this case, the starting time of the current-time integral determination is computed with the following formula:

$$t_{Start} = t_{TRIP} + TS + T00$$

where:

t_{TRIP}	Instant at which the TRIP command is issued by one of the protection functions in the device,
TS	Output delay time (semiconductor switch) approx. 2 ms to 3 ms,
T00	CB response time (time between the TRIP command and the contact movement, can be set in address 4102).

Calculation of t_{End}

The current-time integral measurement ends with the quenching in a current zero crossing.

This current zero crossing is the last one if no new zero crossing occurs during the following cycle T (power system frequency). tEnd is the time of the last current zero crossing plus one cycle T.

Current-Time Integral Measurement

When the function is configured in address 141 **FCT It-Calc.**, one of the above methods for determining the time $\mathbf{t_{Start}}$ is selected.

The entire measuring time range starts with $\mathbf{t_{Start}}$ and is limited to the duration **tTest** = 2T + parameter T CBTRIP.

If the current is not interrupted within the test time, e.g. because of a breaker failure, there is no calculation, and the indication "It Overflow" (FNo. 13849) is generated. The sums of **I dt** (indication "Σ It="; FNo. 13851) and $\mathbf{I^2}$ **dt** (indication "Σ I2t="; FNo. 13852) are not changed in that case.

If the current is successfully interrupted, the values of the current-time integrals of the current **I dt** and of the squared current $\mathbf{I^2}$ **dt** are generated for the current trip. The accumulated sums of these values for all trips since the device startup or since the last reset are output in the indications "Σ It=" and "Σ I2t=". The accumulators can be individually set and cleared.

The cumulated fault current is also output in the indication "Σ I=" (FNo. 13927).

The values of the last individual trip are output in the indications "Last It=" (current-time integral over absolute value, FNo. 13853) and "Last I2t=" (current-time integral squared current, FNo. 13854).

If the limit of the current-time integral set in parameter **It ALARM** (address 4104) is exceeded by the last trip, the indication "It Alarm" (FNo. 13847) is output.

Neither does the use of auto-transformer systems affect the measured value acquisition as described above.

2.15.2 Setting Notes

General

The determination of the circuit breaker trip load can only operate if you have set address 141 **FCT It-Calc.** to ***Start by Aux*** or ***Start by TRIP*** during the configuration of the functional scope. Also, the **It FUNCTION** can be switched ***ON*** and ***OFF*** in address 4101.

When setting the parameter (address 141) that configures the functions, you select at the same time the method for determining the starting time $\mathbf{t_{Start}}$ of the **FCT It-Calc.**. If the circuit breaker auxiliary contacts are connected with the device, select the method ***Start by Aux***.

The **FCT It-Calc.** can be switched on and off with the binary inputs ">It ON" (FNo. 13845) and ">It OFF" (FNo. 13846). When the function is switched on, the indication "It ACTIVE" (FNo. 13850) is generated.

Time Difference CB Main and Auxiliary Contact

This setting is only needed if you have selected the method ***Start by Aux*** when configuring the **FCT It-Calc.**.

The moment of opening of the circuit breaker main contact can only be determined indirectly by acquisition of the circuit breaker auxiliary contacts. In the 7ST6 device the indication ">Brk Aux NC" (FNo. 4602) is used for this purpose. The circuit breaker main contact may open before or after the circuit breaker auxiliary contact. The time difference between the switching of these two contacts is set with the parameter **DELTA AuxCont** (address 4103). A positive value is set for this time difference if the auxiliary contact opens or closes later than the main contact.

CB Response Time

This setting is only needed if you have selected the method ***Start by TRIP*** when configuring the **FCT It-Calc.**.

The moment of opening of the circuit breaker main contact can only be determined indirectly by means of a preset time difference between the TRIP command and the opening of the circuit breaker main contacts. This time difference is set in address 4102 **T00**.

Circuit Breaker Alarm

The current value **I dt**, which is accumulated over all trips, is a measure for the circuit breaker load and can be used for planning the circuit breaker maintenance.

The limit for this measure of the circuit breaker load is set in address 4104 **It ALARM**. When the threshold is reached, the alarm “It Alarm” (FNo. 13847) is output.

2.15.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4101	It FUNCTION	ON OFF	ON	It Function
4102	T00	0.001 .. 0.100 sec; 0	0.005 sec	CB Response Time
4103	DELTA AuxCont	-0.050 .. 0.050 sec	0.000 sec	Time Diff. CB Main and Auxiliary Contact
4104	It ALARM	1.0 .. 1000.0 ; ∞	500.0	Alarm Stage of It Detection in I/In*s

2.15.4 Information List

No.	Information	Type of Information	Comments
13845	>It ON	SP	>Switch on It function
13846	>It OFF	SP	>Switch off It function
13847	It Alarm	OUT	CB It Alarm Stage
13848	Start It Meas	OUT_Ev	Start time for It measurement
13849	It Overflow	OUT	Overflow It measurement
13850	It ACTIVE	OUT	It function is ACTIVE
13855	It set error	OUT	It measurement CB settings not plausible
13856	It ON/offBI	IntSP	It function: ON/OFF via BI

2.16 Monitoring Function

The device 7ST6 incorporates comprehensive monitoring functions which cover both hardware and software; the measured values are continuously checked for plausibility, so that the current and voltage transformer circuits are also included in the monitoring system to a large extent. Furthermore it is possible to implement a trip circuit supervision function by means of the available binary inputs.

2.16.1 Hardware Monitoring

The device is monitored from the measuring inputs up to the command relays. Monitoring features and the processor check the hardware for malfunctions and impermissible states.

Auxiliary and Reference Voltages

The processor voltage of 5 V is monitored by the hardware, and if the voltage decreases below the minimum value, the processor is no longer operative. In that case, the device is not operational. When the cross-polarized voltage returns, the processor system is restarted.

If the supply voltage is removed or switched off, the device is taken out of service, and an indication is immediately generated by a normally closed contact. Brief voltage interruptions of up to 50 ms do not disturb the operational readiness of the device.

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

Battery

The buffer battery, which ensures the operation of the internal clock and the storage of counters and indications if the auxiliary voltage fails, is periodically checked for charge status. On its undershooting a minimum admissible voltage, the indication “Fail Battery” (FNo. 177) is issued.

If the device is not supplied with auxiliary voltage for more than 1 or 2 days, the internal clock is switched off automatically, i.e. the time is not registered any more. The data in the event and fault buffers, however, remain stored.

Memory Components

All working memories (RAMs) are checked during start-up. If an error occurs, the start-up is aborted, the Error LED and LED 1 light up, and the other LEDs start flashing simultaneously. During operation, the memory is checked using its checksum.

For the program memory (EPROM), the cross-checksum is cyclically generated and compared to a stored reference program cross-checksum.

A checksum for the parameter memory (FLASH-EPROM) is cyclically generated and compared with the checksum which is computed after each change of the stored parameters.

If a fault occurs the processor system is restarted.

Sampling Frequency

The sampling frequency and the synchronism between the ADCs is continuously monitored. If any deviations cannot be removed by renewed synchronization, then the processor system is restarted.

2.16.2 Software Monitoring

Watchdog

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

A further software watchdog ensures that any error in the processing of the programs will be recognized. 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. If the fault is still present after three restart attempts within 30 s, the protection system will take itself out of service, and the red LED “ERROR” lights up. The Device OK relay drops off and signals the malfunction by its life contact.

Ambient Temperature Sensing

If ambient temperature sensing by an external device has been configured, the functioning of the ambient temperature sensing is monitored. In case of malfunctions (ambient temperature sensing missing or defective, broken connection wire to the device or to the temperature sensor), the indication `“Fail.TEMPSENS”` (FNo. 158) is generated.

2.16.3 Fuse Failure Monitor

In the event of measured voltage failure due to a short circuit or a broken conductor in the voltage transformer secondary circuit, certain measuring loops may mistakenly see a voltage of zero, which due to the load current may result in an unwanted pickup or even trip.

If fuses are used instead of a secondary miniature circuit breaker (VT mcb) with connected auxiliary contacts, then the fuse failure monitoring can detect problems in the voltage transformer secondary circuit. Of course the miniature circuit breaker and the fuse failure monitor can be used at the same time.

A fuse failure is characterized by missing voltages but flowing current. Figure 2-45 shows the logic diagram of the fuse failure monitor.

If a substantial voltage drop is detected in the measurement quantities without a current flow being registered simultaneously, this indicates a fault in the secondary circuit of the voltage transformer.

The voltage drop is detected when the voltage drops below 0.05 UN while an operating current between 0.06 IN and 1.2 IN is flowing. Currents above 1.2 IN are considered not as normal operating currents but as short-circuit currents.

As soon as a fuse failure is detected, the distance protection and the undervoltage function are blocked. The emergency overcurrent-time protection is activated, provided that it has been configured accordingly (see Section 2.5).

If with the setting **MEASURE. SUPERV**=***With FFM*** a non-stationary current is detected within approximately 10 s after recognition of this criterion, the protection assumes a short-circuit and removes the blocking by the fuse failure monitor for the duration of the fault. If on the other hand the voltage failure criterion is present for longer than approx. 10 s, the blocking is permanently activated (latching of the voltage criterion after 10 s). Only 10 s after the voltage criterion has been removed by correction of the secondary circuit failure, will the blocking automatically reset, thereby releasing the blocked protection functions again.

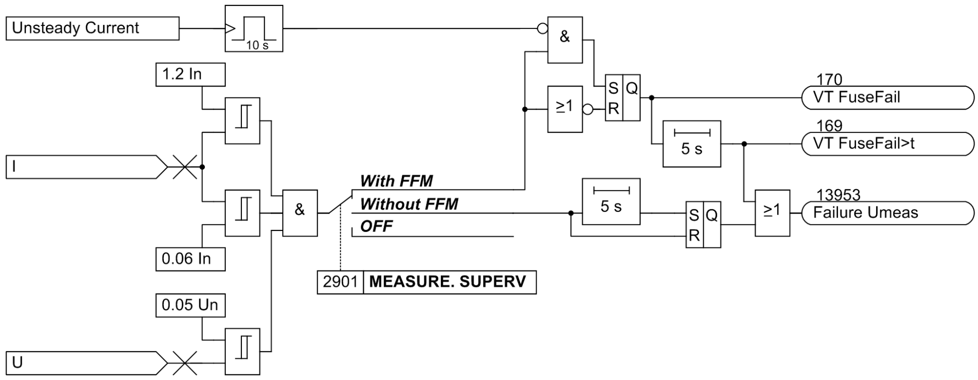


Figure 2-45 Logic diagram of the fuse failure monitor

2.16.4 Setting Notes

Fuse Failure Monitor

With the parameter **MEASURE. SUPERV** (address 2901) fuse failure monitoring can be either switched off or operated in one of the two possible operating modes. If the parameter is set to ***Without FFM***, a fuse failure (failure of the measuring voltage) is always detected when the voltage has dropped below 0.05 UN while at the same time an operating current is flowing. You should choose this setting if it ensured that the short-circuit currents occurring at the device will be at least 1.2 IN. With the setting ***Without FFM***, a fuse failure is detected with a delay of 5 s.

If this is not the case, select the setting ***With FFM***. With this setting, the device also checks whether a non-steady process is detected in the current path at the same time as the voltage dip. In this case a fuse failure will not be detected until 10 s after the voltage dip, provided that the currents are in the operating current range. If the currents reach a steady state before this, the fuse failure is detected earlier.

2.16.5 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
2901	MEASURE. SUPERV	With FFM Without FFM OFF	With FFM	Measurement Supervision

2.16.6 Information List

No.	Information	Type of Information	Comments
169	VT FuseFail>t	OUT	VT Fuse Failure (alarm >t)
170	VT FuseFail	OUT	VT Fuse Failure (alarm instantaneous)
196	Fuse Fail M.OFF	OUT	Fuse Fail Monitor is switched OFF
197	MeasSup OFF	OUT	Measurement Supervision is switched OFF
2054	Emer. mode	OUT	Emergency mode
13953	Failure Umeas	OUT	Measured value failure: Umeas failed

2.17 Trip Circuit Supervision

2.17.1 Functional Description

Trip Circuit Supervision

The overhead contact line protection 7ST6 is equipped with an integrated trip circuit supervision. Depending on the number of available binary inputs (not connected to a common potential), monitoring with one or two binary inputs can be selected. If the allocation of the required binary inputs does not match the selected monitoring mode, a corresponding alarm is issued (“TripC1 ProgFAIL”). When using two binary inputs, malfunctions in the trip circuit can be detected under all circuit breaker conditions. When only one binary input is used, malfunctions in the circuit breaker itself cannot be detected.

Supervision with Two Binary Inputs

When using two binary inputs, these are connected according to Figure 2-46, parallel to the associated trip contact on one side, and parallel to the circuit breaker auxiliary contacts on the other.

A precondition for the use of the trip circuit supervision is that the control voltage for the circuit breaker is higher than the total of the minimum voltages drops at the two binary inputs ($U_{Ctrl} > 2\ U_{BImin}$). Since at least 19 V are needed for each binary input, the monitor can only be used with a system control voltage of over 38 V.

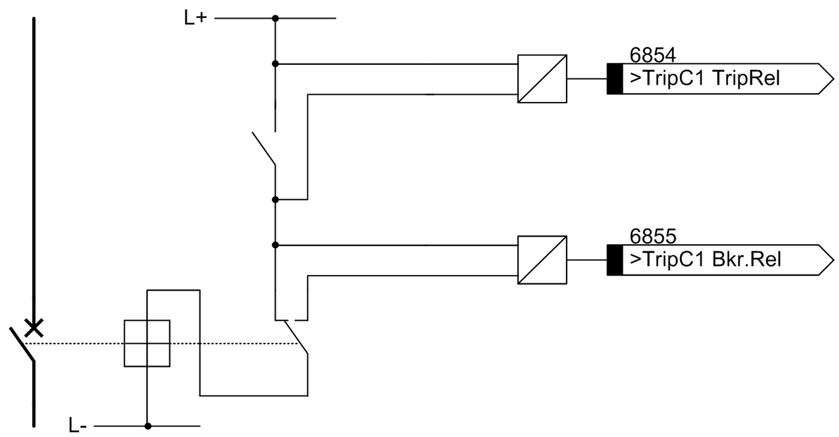


Figure 2-46 Principle of trip circuit monitoring with two binary inputs

Monitoring with two binary inputs not only detects interruptions in the trip circuit and loss of control voltage, it also monitors the response of the circuit breaker using the position of the circuit breaker auxiliary contacts.

Depending on the conditions of the trip contact and the circuit breaker, the binary inputs are activated (logical condition “H” in the following table), or short-circuited (logical condition “L”).

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

A continuous state of this condition is only possible when the trip circuit has been interrupted, a short-circuit exists in the trip circuit, a loss of battery voltage occurs, or malfunctions occur with the circuit breaker mechanism. Therefore, it is used as monitoring criterion.

Table 2-7 Condition table for binary inputs, depending on RTC and CB position

No.	Trip Contact	Circuit Breaker	Aux 1	Aux 2	BI 1	BI 2
1	Open	CLOSE	Closed	Open	H	L
2	Open	TRIP	Open	Closed	H	H
3	Closed	CLOSE	Closed	Open	L	L
4	Closed	TRIP	Open	Closed	L	H

The conditions of the two binary inputs are checked periodically. A query takes place about every 500 ms. If three consecutive conditional checks detect an abnormality, an alarm is output (see Figure 2-47). The repeated measurements determine the delay of the fault indication and avoid that an alarm is output during short transition periods. After the fault in the trip circuit is removed, the alarm is reset automatically after the same time (approx. 1.5 s).

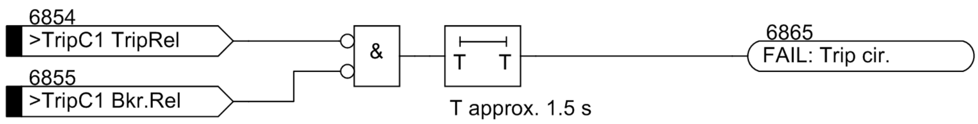


Figure 2-47 Logic diagram of the trip circuit supervision with two binary inputs

Supervision with One Binary Input

The binary input is connected in parallel to the respective command relay contact of the protection device according to Figure 2-48. The circuit breaker auxiliary contact is bridged with a high-ohm substitute resistor R.

The control voltage for the circuit breaker should be at least twice as high as the minimum voltage drop at the binary input (U_{Ctrl} > 2 U_{BImin}). Since at least 19 V are needed for the binary input, the monitor can be used with a system control voltage of over 38 V.

A calculation example for the resistance shunt R is shown in the configuration notes in Section “Mounting and Connections”, margin heading “Trip Circuit Supervision”.

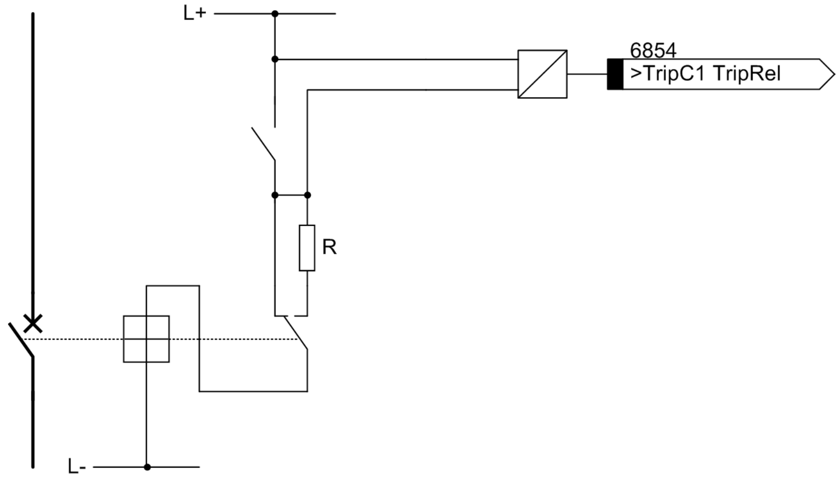


Figure 2-48 Principle of trip circuit monitoring with one binary input

In normal operation, the binary input is energized when the trip relay contact is open and the trip circuit is healthy (logic state “H”), as the monitoring circuit is closed via the auxiliary contact (if the circuit breaker is closed) or via the substitute resistor R. Only as long as the trip contact is closed, the binary input is short circuited and thereby deactivated (logical condition “L”).

If the binary input is permanently deactivated during operation, an interruption in the trip circuit or a failure of the (trip) control voltage can be assumed.

Because the trip circuit supervision does not operate during system faults, a closed tripping contact does not lead to a fault indication. If however other trip relay contacts from different devices are connected in parallel in the trip circuit, the fault indication must be delayed by **Alarm Delay** (see also Figure 2-49). After the fault in the trip circuit is removed, the indication is reset automatically after approx. 1.5 s.

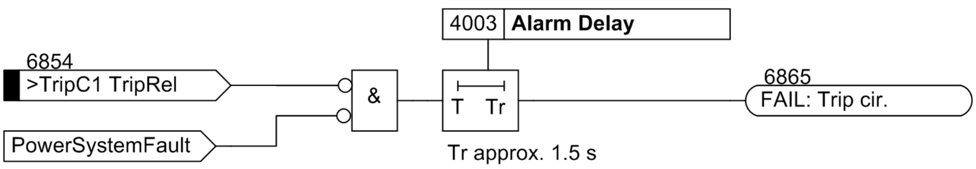


Figure 2-49 Logic diagram of trip circuit monitoring with one binary input

2.17.2 Setting Notes

General

This function is only effective and available if address 140 **Trip Cir. Sup.** has been set to ***Enabled*** during configuration.

If you do not want to use the trip circuit supervision, set ***Disabled***.

The trip circuit supervision can be switched ***ON*** or ***OFF*** in address 4001 **FCT TripSuperv.**.

The number of binary inputs that shall be used in each of the monitored circuits is set in address 4002 **No. of BI**. If the allocation of the required binary inputs does not match the selected monitoring mode, a corresponding indication is issued (“TripC1 ProgFAIL”).

Monitoring with One Binary Input

The alarm for monitoring with two binary inputs is always delayed by approx. 1 s to 2 s, whereas the delay time of the alarm for monitoring with one binary input can be set in address 4003 **Alarm Delay**. 1 s to 2 s are sufficient if only the 7ST6 device is connected to the trip circuits as the trip circuit supervision does not operate during a system fault.

If, however, trip contacts from other devices are connected in parallel in the trip circuit, the alarm must be delayed such that the longest trip command duration can be reliably bridged.

2.17.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4001	FCT TripSuperv.	ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	1 .. 2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	1 .. 30 sec	2 sec	Delay Time for alarm

2.17.4 Information List

No.	Information	Type of Information	Comments
6854	>TripC1 TripRel	SP	>Trip circuit superv. 1: Trip Relay
6855	>TripC1 Bkr.Rel	SP	>Trip circuit superv. 1: Breaker Relay
6861	TripC OFF	OUT	Trip circuit supervision OFF
6865	FAIL: Trip cir.	OUT	Failure Trip Circuit
6866	TripC1 ProgFAIL	OUT	TripC1 blocked: Binary Input is not set

2.18 Protection Function Control

The function logic coordinates the sequence of both the protective and ancillary functions, processes the functional decisions, and data received from the system.

In particular, this includes:

- Pick-up logic
- Tripping logic
- Fault display on the LEDs/LCD
- Statistics

2.18.1 General

2.18.1.1 Line Energization Recognition

During energization of the protected object, several measures may be required or desirable. Following a manual closure onto a short-circuit, immediate trip of the circuit breaker is usually required. In the distance protection for example, this is implemented by a special tripping logic for manual reclosure that can be selected with the parameter **SOTF zone** (address 1232). For example, the zone Overreach Zone can be activated for a short period. In addition at least one stage of each short-circuit protection function can be selected to trip without time delay following manual closure as described in the corresponding sections. Also see Subsection 2.1.5.1 at margin heading “Circuit Breaker Status”.

The manual closing command must be indicated to the device via a binary input. In order to be independent of the duration that the switch is closed, the command is set to a defined length in the device (adjustable with the address 1150 **SI Time Man.Cl**). Figure 2-50 shows the logic diagram.

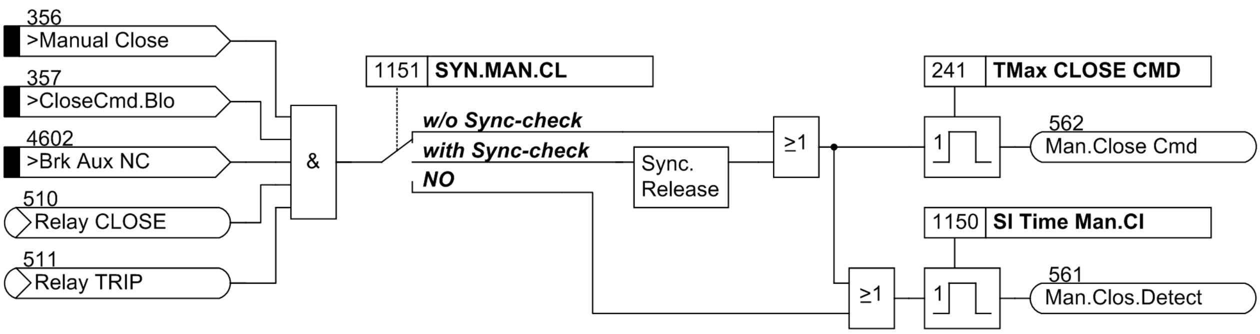


Figure 2-50 Logic diagram of the manual closing procedure

If the device has an integrated automatic reclosure, the integrated manual closure logic of the 7ST6 automatically distinguishes between an external control command via the binary input and an automatic reclosure by the internal automatic reclosure so that the binary input “>Manual Close” can be connected directly to the control circuit of the trip coil of the circuit breaker (Figure 2-51). Each reclosure that is not initiated by the internal automatic reclosure function is interpreted as a manual reclosure, even it has been initiated by a control command from the device.

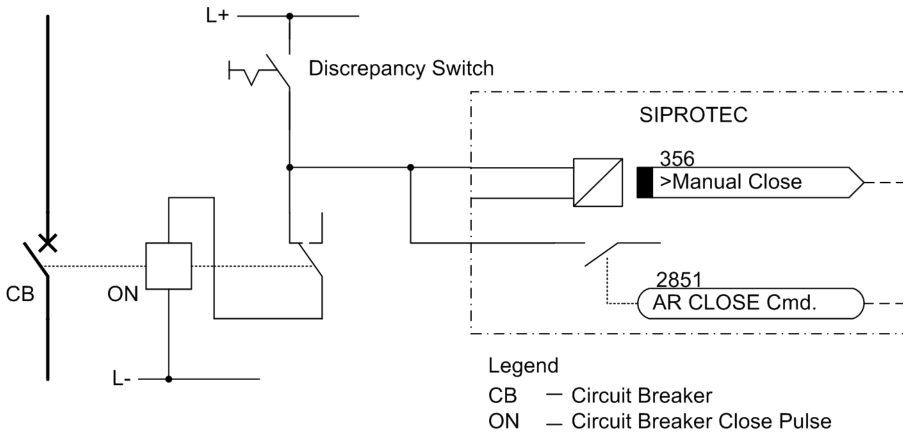


Figure 2-51 Manual closure with internal automatic reclosure

If, however, external close commands which should not activate the manual close function are possible, e.g. external reclosure device, the binary input “`>Manual Close`” must be triggered by a separate contact at the control discrepancy switch (Figure 2-52).

If in that latter case a manual close command can also be given by means of an internal control command from the device, such a command must be combined with the manual CLOSE function via a CFC chart. To do so, use the priority class for switchgear interlocking and the block CMD_INF to derive a logic signal from the switchgear control command. The “`>Manual Close`” must not be configured to a binary input in this case. Define this signal as a CFC output signal and add a new indication to the DIGSI matrix. Use this new binary signal for detection of the manual close signal, and link it in the CFC chart with an OR gate to the output signal of the CMD_INF block. Now you connect the output signal of this OR gate with the signal “`>Manual Close`” on the right-hand margin of the CFC chart.

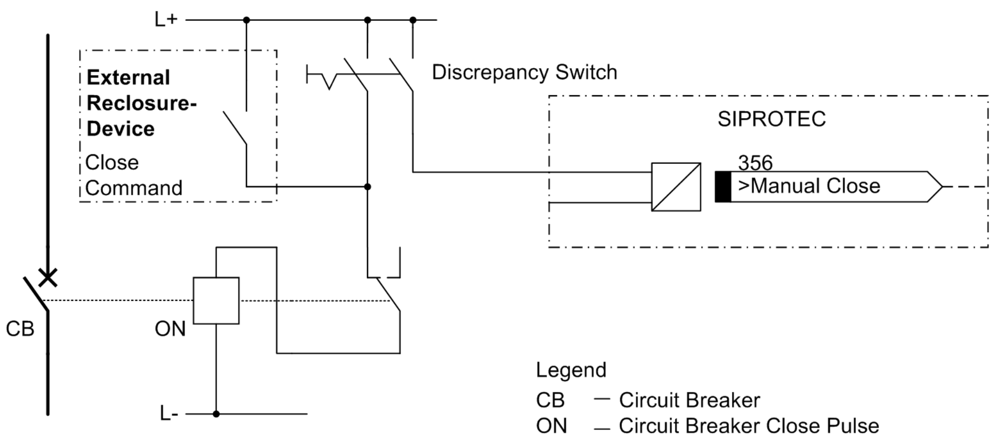


Figure 2-52 Manual closing with external automatic reclosure device

Depending on the configuration of the distance protection, an undelayed trip command can be generated after energization for each pickup or for pickup in Overreach Zone. The line energization recognition function is also used by the stages of the overcurrent protection.

Blocking of Under-voltage Protection

In configurations with voltage transformers on the line-side and single-side infeed, no voltage is measured after tripping of the line. If activated, the undervoltage protection would in such a case cause a spurious trip. In this condition it would no longer be possible to energize the line, since the presence of a TRIP command from the undervoltage protection would prevent energization.

To identify such situations, 7ST6 devices are provided with a residual current detection which blocks the undervoltage protection if the currents drop below a specified threshold of 0.05 I_n. As soon as a significant current level ($I>0.05\ I_n$) is measured on the line, the line is assumed to be energized, and the blocking is reset.

2.18.1.2 Detection of the Circuit Breaker Position

For Protection Purposes

Several protection and ancillary functions require information on the status of the circuit breaker for proper functioning. This is, for example, of assistance for

- The automatic reclosure (refer to Section 2.12),
- The It (refer to Section 2.15)

The device is provided with the signals for detection of the circuit breaker auxiliary contacts. The above functions assumes the circuit breaker auxiliary contacts to be wired if these signals have been configured to binary inputs. Therefore, signals for non-wired feedback information must not be configured to a binary input.

For Trip Circuit Supervision and Switch Objects

For these functions separate binary inputs with information on the circuit breaker position are available.

2.18.1.3 Pickup Logic for the Entire Device

Pickup Indications

The fault detection logic combines the fault detection (pick-up) signals of all protection functions. The group alarms “`Relay PU`” and“`Protection PU`” are available respectively for a general device pickup and a general pickup of the protection functions.

The above indications can be allocated to LEDs or output relays. They can also be used for local display, and for transfer of the indications to a personal computer or a control centre.

General Device Pickup

The pickup signals are combined with OR and lead to a general pickup of the protection device. It is signaled with the alarm “`Protection PU`”. If no protection function of the device has picked up any longer, “`Protection PU`” disappears (indication: “OFF”).

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 trip log: From general device pickup to general device dropout, all fault indications are entered in the trip log.
- Initialization of oscillographic records: The storage and maintenance of fault values can also be made dependent on the occurrence of a trip command.
- Generation of spontaneous indications: Certain fault indications can be displayed as so-called spontaneous indications (see “Spontaneous Indications” below). This indication can also be made dependent on the general device trip.
- Start action time of automatic reclosure (if available and used).

External functions may be controlled by this indication via an output contact. Examples are:

- Automatic reclose devices.
- Channel boost in conjunction with signal transmission by PLC.
- Further additional devices or similar.

Spontaneous Indications

Spontaneous indications are fault indications which appear in the display automatically following a general fault detection or trip command of the device. In the case of 7ST6 they are the following:

“Relay PICKUP”:	Protective function that picked up;
“S/E/F TRIP”:	Protective function that tripped;
“PU Time”:	Operating time from the general pickup to the dropout of the device, in ms;
“TRIP Time”:	Operating time from general pickup to the first trip command of the device, the time is given in ms;
“Xpri =”:	X (primary) (Xpri=);

2.18.1.4 Tripping Logic of the Entire Device

TRIP Command

Just like for pickup, a group alarm exists for the device TRIP command.

The alarm “Relay TRIP” is an OR combination of

- All trip signals of the individual protection functions
- The TRIP commands output by the control, and
- The TRIP commands output by the CB test function.

General Trip

All trip signals for the protective functions are connected by OR and generate the indication “Protection TRIP”. This can be allocated to LED or output relay.

Terminating the Trip Signal

A trip command once transmitted is stored (see Figure 2-53). 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 only be terminated when the last protection function dropped out, i.e. functions no longer pick up, AND the minimum trip signal duration expired.

A further condition for terminating the trip command is that the circuit breaker is recognized to be open. The function control of the device checks this by evaluating the current flow. It assumes that a current of 0.05 In will certainly be undershot with the circuit breaker open. The figure below shows the logic diagram for this.

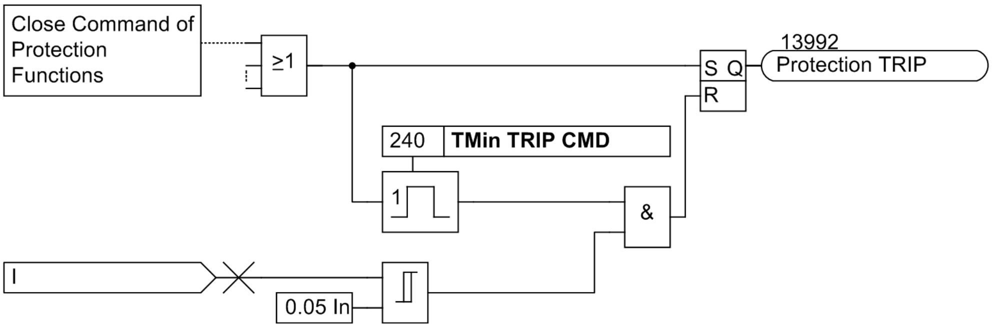


Figure 2-53 Storage and termination of the trip command

Reclosure Interlocking

When tripping the circuit breaker by a protection function the manual reclosure must often be blocked until the cause for the protection function operation is found. 7ST6 enables this via the integrated reclosure interlocking.

The interlocking state (“LOCKOUT”) is implemented by an RS flipflop which is protected against auxiliary voltage failure (see Figure 2-54). The RS flipflop is set via binary input “>Lockout SET” (FNo. 385). With the output alarm “LOCKOUT” (FNo. 530), if interconnected correspondingly, a reclosure of the circuitbreaker, e.g. for automatic reclosure, manual close signal, synchronization, closing via control, can be blocked. Only once the cause for the protection operation is known, should the interlocking be reset by a manual reset via binary input “>Lockout RESET” (FNo. 386).

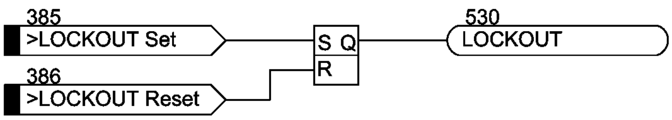


Figure 2-54 Reclosure interlocking

Conditions which cause reclosure interlocking and control commands which have to be interlocked can be set individually. The two inputs and the output can be wired via the correspondingly allocated binary inputs and outputs or be linked via user-defined logic functions (CFC).

If, for example, each trip by the protection function has to cause a reclosure lock-out, then combine the tripping command “Protection TRIP” (FNo. 13992) with the binary input “>Lockout SET”. If, however, automatic reclosure is applied, only the final trip of the protection function should activate reclosing lock-out. Combine in this case the output alarm “Final Trip” (FNo. 536) with the interlocking input “>Lockout SET”, so that the interlocking function is not established when an automatic reclosure is still expected to come. Please bear in mind that the alarm “Final Trip” (FNo. 536) is only present for 500 ms.

With the output alarm “LOCKOUT” (FNo. 530) it is possible in the most simple case to allocate to the output, which trips the circuit-breaker, without creating further links. Then the tripping command is maintained until the interlock is reset via the binary reset input. Naturally it has to be ensured in advance that the close coil at the circuit breaker — as is usually done — is blocked as long as a tripping command is maintained.

The output alarm "LOCKOUT" can also be applied to interlock certain closing commands (externally or via CFC), e.g. by combining the output alarm with the binary input ">CloseCmd.Blo" (FNo. 357) or by connecting the inverted alarm with the bay interlocking of the branch.

The reset input ">Lockout RESET" (FNo. 386) resets the interlocking state. This input is initiated by an external device which is protected against unauthorized or unintentional operation. The interlocking state can also be controlled by internal sources using CFC, e.g. a function key, operation of the device or using DIGSI® on a PC.

For each case please make sure that the corresponding logical combinations, security measures, etc. are taken into account for the routing of the binary inputs and outputs and are also considered for the setting of user-defined logic functions, if necessary. See also SIPROTEC® 4 System Description, Order No. E50417-H1176-C151.

Breaker Tripping Alarm Suppression

Since every trip command issued by a protection function on feeders without automatic reclosure is definite, it is desirable, when using automatic reclosure, to prevent the operation detector of the circuit-breaker (transient contact on the breaker) from sending an alarm if the trip of the breaker is not final (Figure 2-55).

For this purpose, the signal from the circuit-breaker is routed via a correspondingly allocated output contact of the 7ST6 (output alarm "CB Alarm Supp", FNo. 563). In the idle state and when the device is turned off, this contact is closed. Therefore an output contact with a normally open contact (NO contact) has to be allocated. Which contact is to be allocated is dependent on the device version. Refer to the general views in the Appendix.

Prior to the command, with the internal automatic reclosure in the ready state, the contact opens so that no signal from the circuit-breaker is forwarded. This is only the case if the device is equipped with internal automatic reclosure and if the latter was taken into consideration when configuring the protection functions (address 133 **Auto Reclose**).

This contact is also opened when closing the breaker via the binary input ">Manual Close" (FNo. 356), so that no breaker alarm can pass there either.

Further optional closing commands which are not sent via the device cannot be taken into consideration. Closing commands for control can be linked to the alarm suppression via the user-defined logic functions (CFC).

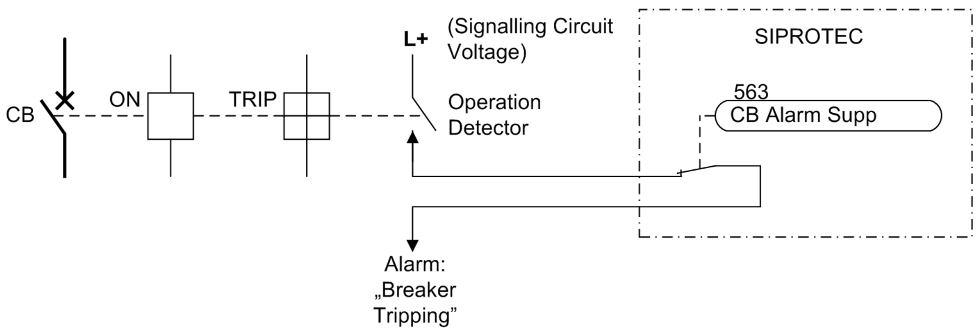


Figure 2-55 Breaker tripping alarm suppression

If the device issues a final trip command, the contact remains closed. This is the case, during the reclaim time of the automatic reclosure cycle, when the automatic reclosure is blocked or switched off or, due to other reasons is not ready for automatic reclosure, e.g. tripping only occurred after the action time expired.

Figure 2-56 shows time diagrams for manual trip and close as well as for short-circuit tripping with a single, failed automatic reclosure cycle.

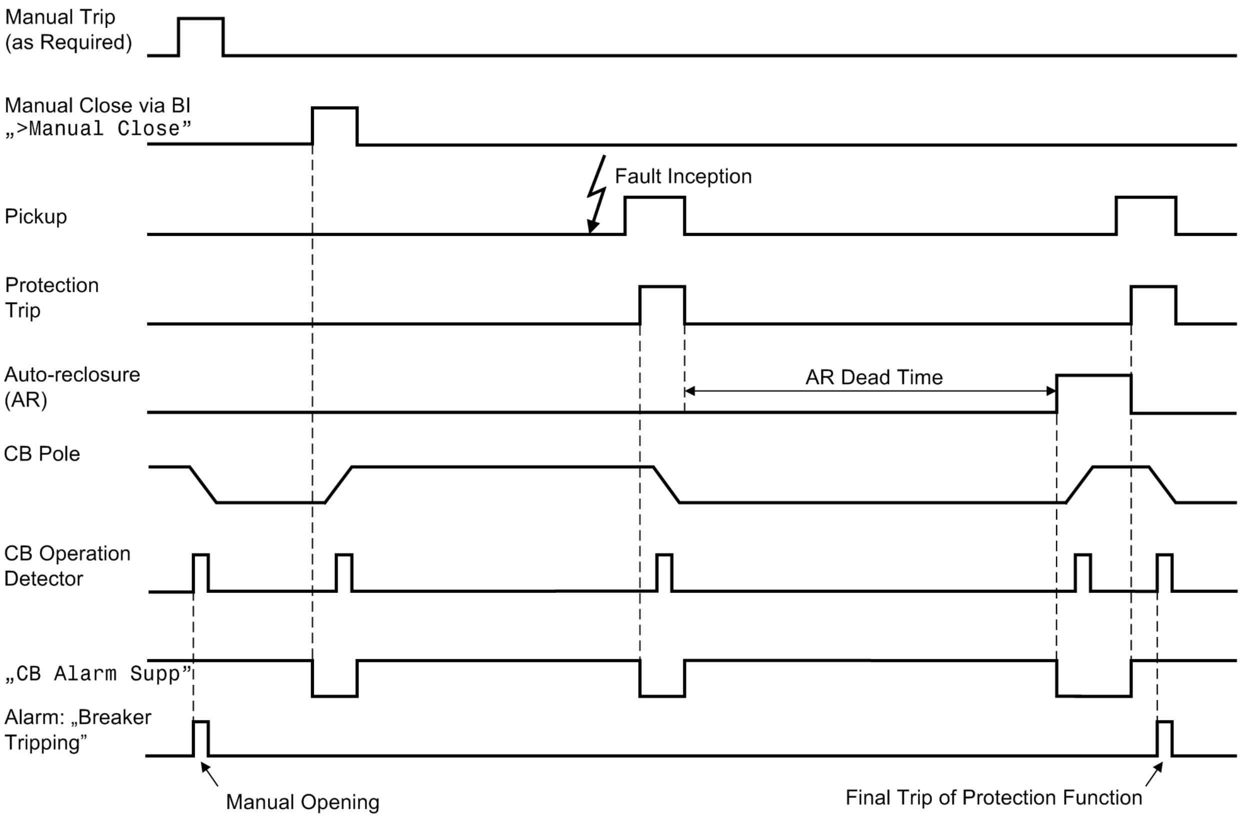


Figure 2-56 Breaker tripping alarm suppression — sequence examples

Trip-Dependent Indications

The recording of indications masked to local LEDs, and the maintenance of spontaneous indications, can be made dependent on whether the device has issued a trip signal. This information is then not output if during a system disturbance one or more protection functions have picked up, but no tripping by the 7ST6 resulted because the fault was cleared by a different device, e.g. on another line. These indications are then limited to faults in the line to be protected.

Statistics

The number of trips initiated by the device 7ST6 are counted.

Following each trip command the device registers the value of each current phase that was switched off. This information is then provided in the trip log and summated in a register. The squared interrupted current values are also summated. The maximum interrupted current is stored as well. Moreover, the device has a separately configurable It function to determine the circuit breaker trip load.

If the device is equipped with the integrated automatic reclosure, the automatic close commands are also counted, separately for the first reclosure cycle and other reclosure cycles.

The counter and memory levels are secured against loss of auxiliary voltage. They can be set to zero or to any other initial value. For more details, refer to the SIPROTEC® 4 System Description, Order No. E50417-H1100-C151.

2.18.1.5 Pickup of the Automatic Test Unit for the Overhead Contact Line (only for 16.7 Hz)

For the pickup of the automatic test unit for the overhead contact line, the indication “Pckup TstUnit” (FNo. 1191) is available in the 7ST6.

This indication is output on one of the following events:

- “Dis.Gen. Trip” (FNo. 3801)
- “O/C TRIP” (FNo. 7211)
- “HS O/C TRIP” (FNo. 4293)
- “Emer.Gen.Trip” (FNo. 2141)
- “CB-TEST TRIP M” (FNo. 13862)
- “CB-TEST TRIP B” (FNo. 13863)

The indication is reset as soon as none of the above TRIP signals is present any more (see logic diagram below).

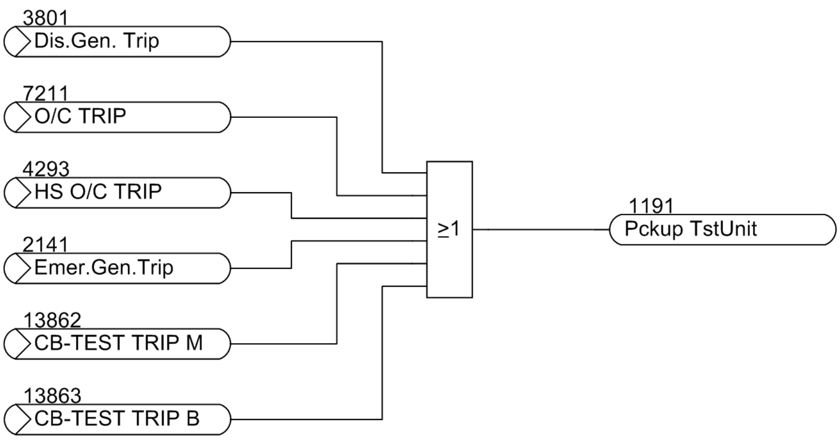


Figure 2-57 Start of the automatic overhead contact line check by TRIP commands

In addition, the indication “Pckup TstUnit” (FNo. 1191) is output if, following a TRIP command by the overload protection, “ThOverload TRIP” (FNo. 1521), the closing temperature is undershot, i.e. the inrush blocking “O/L blocked” (FNo. 13825) is reset.

The indication “Pckup TstUnit” stays activated for at least 200 ms and is reset after this time, provided that no TRIP command by one of the following functions is present:

- Distance protection
- Instantaneous high current switch-onto-fault protection
- Time overcurrent protection
- Emergency overcurrent protection
- Overload protection
- CB test

The figure below shows the logic diagram for this:

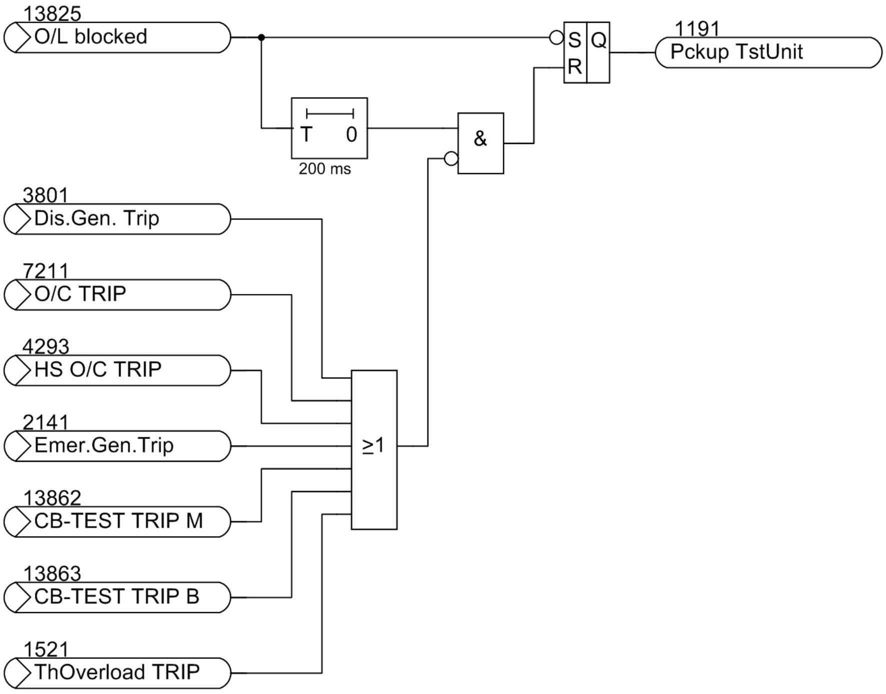


Figure 2-58 Start of the automatic overhead contact line check following TRIP commands by the overload protection

2.18.1.6 Setting Notes

Command Duration

The setting of the minimum trip signal duration **TMin TRIP CMD** (address 240) was already discussed in Subsection 2.1.3. This duration is valid for all protection functions which can issue a trip command.

2.18.2 Testing

The numerical overhead contact line protection 7ST6 allows an easy check of the trip circuits and the circuit breakers.

2.18.2.1 Functional Description

The test programs as shown in Table 2-8 are available.

The output alarms mentioned must be allocated to the relevant command relays that are used for controlling the circuit breaker coils.

The test is started using the operator panel on the front of the device or using the PC with DIGSI®. The procedure is described in detail in the SIPROTEC® 4 System Description, Order No. E50417-H1176-C151. Figure 2-59 shows the chronological sequence of one TRIP–CLOSE test cycle. The set times are those stated in Subsection 2.1.3.1 for “Trip command Duration” and “Circuit Breaker Test”.

Where the circuit breaker auxiliary contacts indicate the status of the circuit breaker or of its poles to the device via binary inputs, the test cycle can only be initiated if the circuit breaker is closed.

The alarms of the device show the respective state of the test sequence.

Table 2-8 Circuit breaker test programs

Serial No.	Test programs	Output indications (FNo)
1	TRIP test CB main trip element	“CB-TEST TRIP M” (13862)
2	TRIP test CB standby trip element	“CB-TEST TRIP B” (13863)
3	TRIP/CLOSE cycle CB main trip element	“CB-TEST CLOSE M” (13864)
4	TRIP/CLOSE cycle CB standby trip element	“CB-TEST CLOSE M” (13865)

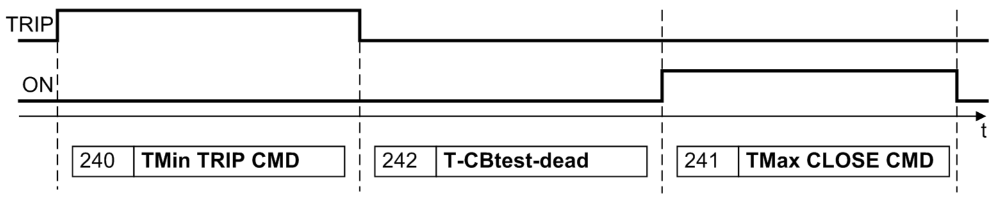


Figure 2-59 TRIP-CLOSE test cycle

2.18.2.2 Setting Notes

The set times are those stated in Subsection 2.1.3.1 under margin heading “Manual Close”.

2.18.2.3 Information List

No.	Information	Type of Information	Comments
-	CB-T T M	-	CB-Test:TRIP command main trip element
-	CB-T T B	-	CB-Test:TRIP command backup trip element
-	CB-T T/C M	-	CB-Test: trip/close main trip element
-	CB-T T/C B	-	CB-Test: trip/close backup trip element
7345	CB-TEST running	OUT	CB-TEST is in progress
7346	CB-TSTstop FLT.	OUT_Ev	CB-TEST canceled due to Power Sys. Fault
7347	CB-TSTstop OPEN	OUT_Ev	CB-TEST canceled due to CB already OPEN
7348	CB-TSTstop NOTr	OUT_Ev	CB-TEST canceled due to CB was NOT READY
7349	CB-TSTstop CLOS	OUT_Ev	CB-TEST canceled due to CB stayed CLOSED
7350	CB-TST .OK.	OUT_Ev	CB-TEST was succesful
13860	>CB-TEST	SP	>CB-Test: Start TRIP cycle
13861	>CB-TEST AR	SP	>CB-Test: Start TRIP-CLOSE cycle
13862	CB-TEST TRIP M	OUT	CB-Test: TRIP command main trip element
13863	CB-TEST TRIP B	OUT	CB-Test: TRIP command backup trip elem.
13864	CB-TEST CLOSE M	OUT	CB-Test: CLOSE command main trip element
13865	CB-TEST CLOSE M	OUT	CB-Test: CLOSE command backup trip elem.

2.19 Ancillary Functions

Chapter Ancillary Functions describes the general device functions.

2.19.1 Message Processing

After the occurrence of a system fault, data regarding the response of the protective relay and the measured quantities should be saved for future analysis. For this reason indications are processed in three ways.

2.19.1.1 Functional Description

LED Display and Binary Outputs (Output Relays)

Important events and statuses are displayed using front panel LEDs. The device furthermore has output relays for remote indication. Most indications and displays can be configured differently from the delivery default settings (for information on the delivery default setting see Appendix). The procedure is described in detail in the SIPROTEC® 4 System Description (Order No. E50417-H1176-C151).

The output relays and the LEDs may be operated in a latched or unlatched mode (each may be individually set).

The latched conditions are protected against loss of the auxiliary voltage. They are reset

- On site by pressing the LED key on the relay,
- Remotely using a binary input configured for that purpose,
- Using one of the serial interfaces,
- Automatically at the beginning of a new pickup.

Condition indications should not be latched. Also, they cannot be reset until the condition to be reported has been cancelled. This applies to e.g. indications from monitoring functions, or the like.

A green LED displays operational readiness of the relay (“RUN”), and cannot be reset. It extinguishes if the self-check feature of the microprocessor recognizes an abnormal occurrence, 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 processor blocks the relay.

DIGSI® enables you to control selectively each output relay and LED of the device and, in doing so, check the correct connection to the system. In a dialog box you can, for instance, cause each output relay to pick up, and thus test the wiring between the 7ST6 and the station, without having to create the indications masked to it.

Fast Binary Outputs (Output Relays)

The device 7ST6 has the fast binary outputs (output relays) BO1 and BO2. These binary outputs have extra short switching times. When used for TRIP commands, these binary outputs allow to achieve very short trip times.

These fast trip times are possible by a parallel connection of relays and semiconductor switches. The semiconductor switch has the task of switching the output on and off. The relay contact carries the continuous current and opens shortly before the semiconductor switch drops out. This helps to avoid erosion of the relay contacts, and thus to prolong the service life of these binary outputs. This procedure leads to a defined contact opening delay of 8 ms.

In all other respects, the properties of the fast binary outputs are the same as the general properties of the binary outputs described above.

Information on the Integrated Display (LCD) or to a Personal Computer

Events and conditions can be read out on the display on the front cover of the relay. Using the front PC interface or the rear service interface, for instance, a personal computer can be connected, to which the information can be sent.

In the quiescent state, i.e. as long as no system fault is present, the LCD can display selectable operational information (overview of the operational measured values) (default display). In the event of a system fault, information regarding the fault, the so-called spontaneous indications, are displayed instead. After the fault indications have been acknowledged, the quiescent data are shown again. Acknowledgement can be performed by pressing the LED buttons on the front panel (see above).

The device in addition has several event buffers for operational indications, fault indications, switching statistics, etc., which are saved against loss of auxiliary supply by means of a battery buffer. These indications can be displayed on the LCD at any time by selection using the keypad or transferred to a personal computer via the serial service or PC interface. The retrieval of indications during operation is extensively described in the SIPROTEC® 4 System Description, Order No. E50417-H1176-C151).

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.

With a PC and the DIGSI® protection data processing software it is also possible to retrieve and display the events with the convenience of visualization on a monitor and a menu-guided dialog. The data may either be printed or stored for evaluation at a later time and place.

The protection device stores the indications of the last eight system faults; in the event of a ninth fault, the oldest is erased.

A system fault starts with the recognition of the fault by the fault detection of any protection function and ends with the reset of the fault detection of the last protection function or after the expiry of the auto-reclose reclaim time, so that several unsuccessful auto-reclose cycles are also stored cohesively. Accordingly a system fault may contain several individual fault events (from fault detection up to reset of fault detection).

Information to a Control Centre

If the device has a serial system interface, stored information may additionally be transferred via this interface to a centralized control and storage device. Transmission is possible using different transmission protocols.

You may test whether the indications are transmitted correctly with DIGSI®.

Also the information transmitted to the control centre can be influenced during operation or tests. The IEC 60870-5-103 protocol allows to identify all indications and measured values transferred to the central control system with an added indication “test mode” while the device is being tested on site (test mode). This identification prevents the indications from being incorrectly interpreted as resulting from an actual power system disturbance or event. Alternatively, you may disable the transmission of indications to the system interface during tests (“Transmission block”).

To influence information at the system interface during test mode (“Test mode” and “Transmission block”) a CFC logic is required. Default settings already include this logic (see Appendix).

The SIPROTEC® 4 System Description describes in detail how to activate and deactivate test mode and blocked data transmission.

Classification of Indications

Indications are classified as follows:

- Operational indications: indications generated while the device is operating: They include information about the status of device functions, measurement data, system data, and similar information.
- Fault indications: indications from the last 8 network faults that were processed by the device.
- Indications of the Statistic: they include a counter for the switching actions of the circuit breakers initiated by the device, maybe reclose commands as well as values of interrupted currents and accumulated fault currents.

A complete list of all indication 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). It also indicates where each indication can be sent to. If functions are not present in the specific version of the device, or if they are set to disable, then the associated indications cannot appear.

Operational Indications (Buffer: Event Log)

Operational indications contain information that the device generates during operation and on operational conditions.

Up to 200 operational indications are recorded in chronological order in the device. Newly generated indications are added to those already there. When the maximum capacity of the memory is exhausted, the oldest indication is lost.

Operational indications come in automatically and can be read out from the device display or a personal computer. Faults in the power system are indicated with “Network Fault” and the consecutive fault number. The fault indications contain detailed information on the behaviour of the power system fault.

Fault Indications (Buffer: Trip Log)

Following a system fault, it is possible, for example, to retrieve important information regarding its progress, such as pickup and trip. The start of the fault is time stamped with the absolute time of the internal system clock. The progress of the 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.

A system fault starts with the recognition of the fault by the fault detection, i.e. first pickup of any protection function, and ends with the reset of the fault detection, i.e. dropout of the last protection function. Where fault causes several protective functions to pick up, the fault is considered to include all that occurred between pickup of the first protective function and dropout of the last protective function.

Spontaneous Indications

After a fault, the most important data of the fault are displayed automatically without any further operating actions in the sequence displayed below after a general device pickup:

```
Dis TRIP      Z1
T-Pickup=    180 ms
T-TRIP=       60 ms
Xpri =        10 Ω
```

Protective Function that Tripped, e.g. Distance Protection Zone 1;
Operating Time from General Pickup to Dropout;
Operating Time from General Pickup to the First Trip Command;
Flt Locator: primary REACTANCE (Xpri =);

Figure 2-60 Spontaneous indications for devices with a small display

Retrievable Indications

The indications of the last eight faults can be retrieved and output. In total 600 indications can be recorded. Oldest indications are erased for newest fault indications when the buffer is full.

Spontaneous Indications

Spontaneous indications contain information on new incoming indication. Each new incoming indication appears immediately, i.e. the user does not have to wait for an update or initiate one. This can be a useful help during operation, testing and commissioning.

Spontaneous indications can be read out via DIGSI®. You will find more details in the SIPROTEC® 4 System Description (Order No. E50417-H1176-C151).

General Interrogation

The present condition of a SIPROTEC® 4 device can be examined with DIGSI® by viewing the contents of the General Interrogation. All indications requiring general interrogation are displayed with their present value.

2.19.2 Measurement

2.19.2.1 Functional Description

Display of Measured Values

For local retrieval, or for data transmission via system interface, measured values and resulting computed values are continuously available. The operational measured values can be read out as secondary, primary or percent values. The measured values can only be correctly displayed if the transformer ratings are entered completely and correctly.

Calculation of Measured Values

In auto-transformer systems, the active and reactive power is calculated from the currents and voltages of the overhead contact line and the negative feeder. The operating impedance and the load angle are calculated using the overhead contact line voltage and the summation current.

Depending on the ordering code, connection type to the device and the configured protection function, only some of the listed operational measured values in Table 2-9 may be available.

Table 2-9 Operational measured values of the local device

Measured values		Primary	Secondary	% referred to
I	Operating current	A	A	Rated operational current
U	Operational voltage	kV	V	Rated operational voltage
IF	Negative feeder current (in auto-transformer systems)	A	A	Rated operational current

CL	Feeder voltage (in auto-transformer systems)	kV	V	Rated operational voltage
IX	Defrosting current	A	A	Rated operational current
f	Frequency	Hz	Hz	Rated system frequency
P, Q	Active and reactive power	kW, kVAr	—	$U_N \cdot I_N$ Operational ratings
Uref	Reference voltage	kV	V	Operational rated voltage
φ dif	Differential angle between operational voltage and reference voltage	°	°	—
Z	Operational impedance	Ω	Ω	—
R	Operational resistance	Ω	Ω	—
X	Operational reactance	Ω	Ω	—
φ	Load angle	°	°	—
Zsec	Calculated fault impedance (fault location)	—	Ω	—
Tline	Catenary temperature	°C	—	—
Tamb	Ambient temperature	°C	—	—

2.19.2.2 Information List

No.	Information	Type of Information	Comments
636	Udif=	MV	U - Difference (line - reference)
637	Uline=	MV	U - Line
638	Uref=	MV	U - Reference
641	P =	MV	P (active power)
642	Q =	MV	Q (reactive power)
644	Freq=	MV	Frequency
646	fref=	MV	f - Reference
647	fdif=	MV	f - Difference (line-reference)
648	φ-diff=	MV	Angle (difference line-bus)
649	fline=	MV	f - Line
668	I =	MV	Operational measurement: I =
678	U =	MV	Operational measurement: U =
950	Tmp.cat=	MV	Operat. meas. temp. of catenary
951	Tmp.amb=	MV	Operat. meas. ambient temperature
3941	Zsec=	VI	Fault impedance, Ohm sec.
13915	R =	MV	Resistive component of total resistance
13916	X =	MV	Reactive component of total resistance
13917	Z =	MV	Operating impedance
13918	φ =	MV	Phase angle PHI in [degrees]
13920	UF- =	MV	Voltage UF- is
13921	IF- =	MV	Current IF- is
13922	Uref=	MV	Reference voltage
13923	IX =	MV	Defrosting current IX is
13924	ΣI1,I2=	MV	Summated current I1 + I2 is
13968	Id =	MV	Differential current in [%] is
13969	Ir =	MV	Restraint current in [%] is

2.19.3 Statistics

The number of trips initiated by 7ST6, the accumulated interrupted currents resulting from trips initiated by protection functions and the number of close commands initiated by the auto-reclosure function are counted.

2.19.3.1 Functional Description

Counters and Memories

The counters and memories of the statistics are saved by the device. Therefore the information will not get lost in case the auxiliary voltage supply fails. The counters, however, can be reset back to zero or to any value within the setting range.

Switching statistics can be viewed on the LCD of the device, or on a PC running DIGSI® and connected to the operating or service interface.

A password is not required to read counter and stored values but is required to change or delete them. You will find more details in the SIPROTEC® 4 System Description (Order No. E50417-H1176-C151).

Number of Trips

The number of trips initiated by the device 7ST6 are counted.

Number of Automatic Reclosing Commands

If the device is equipped with the integrated automatic reclosure, the automatic close commands are also counted separately for the first reclosure cycle and other reclosure cycles.

Interrupted Currents

Following each trip command the device registers the value of each current phase that was switched off. This information is then provided in the trip log and summated in a register. The maximum interrupted current that was switched off is stored as well. The specified measured values are primary values.

For the last trip, the value of the current-time integral and the squared current-time integral I^2t are output and separately summated.

2.19.3.2 Setting Notes

Readout/Setting/Resetting

The SIPROTEC® 4 System Description describes how to read out the statistical counters using the device front panel or DIGSI®. Setting or resetting of these statistical counters takes place under the menu item **Annunciation** -> **STATISTIC** by overwriting the counter values displayed.

2.19.3.3 Information List

No.	Information	Type of Information	Comments
1000	# TRIPs=	VI	Number of breaker TRIP commands
1008	Σ(I/In)^2=	VI	Sum of fault currents (I/In)^2
13851	Σ It=	VI	Summation of measured It values
13852	Σ I2t=	VI	Summation of measured I2t values
13853	Last It=	VI	Last It value measured
13854	Last I2t=	VI	Last I2t value measured
13870	AR 1st cycle=	VI	AR Number reclosure attempts 1st cycle
13871	AR >1st cycle=	VI	AR Number reclosure attempts >1st cycle
13925	MAX I=	VI	Max. fault current
13926	Last I=	VI	Last current interrupted by CB
13927	Σ I=	VI	Summation interrupted primary currents

2.20 Command Processing

A control command process is integrated in the SIPROTEC ® 7ST6 to coordinate the operation of circuit breakers and other equipment in the power system.

Control commands can originate from four command sources:

- Local operation using the keypad on the local user interface of the device
- Operation using DIGSI®
- Remote operation via network control center or substation controller (e.g. SICAM®),
- Automatic functions (e.g., using a 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 binary inputs and outputs present. High security against inadvertent device operations can be ensured if interlocking checks are enabled. A standard set of optional interlocking checks is provided for each command issued to circuit breakers/switchgear.

2.20.1 Control Authorization

2.20.1.1 Command Types

Commands to the Process

These are all commands that are directly output to the switchgear to change their process state:

- Commands for the operation of circuit breakers (asynchronous; or synchronized by applying the synchronism check and closing control function) as well as commands for the control of isolators and earth switches.

Device-internal Commands

These commands do not directly operate command outputs. They serve for initiating internal functions, for communicating the detection of status changes to the device or for acknowledging them.

- Manual override commands for “manual update” of information on process-dependent objects such as indications 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 “set” the information values of internal objects, such as switching authority (remote vs. local), parameter set changeover, data transmission block to the SCADA interface, and measured value set-points.
- Acknowledgment and resetting commands for setting and resetting internal buffers or data states.
- Information status commands to set/delete the additional “Information Status” item of a process object, such as
  – Acquisition blocking,
  – Output blocking.

2.20.1.2 Sequence in the Command Path

Security mechanisms in the command path ensure that a switch command can be carried out only if the test of previously established criteria has been successfully completed. Additionally, user-defined interlocking conditions can be configured separately for each device. The actual execution of the command is also monitored after its release. The entire sequence of a command is described briefly in the following.

Checking a Command

Please observe the following:

- Command entry, e.g. using the keypad on the local user interface of the device
  - Check password → access rights;
  - Check switching mode (interlocking activated/deactivated) → selection of deactivated interlocking status.
- User configurable interlocking checks:
  - Switching authority;
  - Device position check (set vs. actual comparison);
  - Zone controlled / bay interlocking (logic using CFC);
  - System interlocking (centrally via SICAM);
  - Double operation (interlocking against parallel switching operation);
  - Protection blocking (blocking of switching operations by protective functions);
  - Check (synchronism check before a close command).
- Fixed commands:
  - Internal process time (software watch dog which checks the time for processing the control action between initiation of the control and final close of the relay contact);
  - Configuration in process (if setting modification is in process, commands are rejected or delayed);
  - Equipment not present at output (if controllable equipment is not assigned to a binary output, then the command is rejected);
  - Output block (if an output block has been programmed for the circuit breaker, and is active at the moment the command is processed, then the command is rejected);
  - Component hardware malfunction;
  - Command in progress (only one command can be processed at a time for each circuit breaker or switch);
  - 1–of–n check (for multiple allocations such as common contact relays it is checked if a command procedure was already initiated for the output relays concerned).

Command Execution Monitoring

The following is monitored:

- Interruption of a command because of a cancel command,
- Running time monitor (feedback monitoring time).

2.20.1.3 Switchgear Interlocking

Interlocking can be executed by the user-defined logic (CFC). System interlocking checks in a SICAM®/SIPROTEC® system are usually categorized as follows:

- System interlocking checked by a central control system (for interbay interlocking),
- Zone controlled / bay interlocking checked in the bay device (for the feeder).

System interlocking is based on the process replica of the master device Zone controlled / bay interlocking relies on the object database (feedback information) of the bay unit (here the SIPROTEC® 4 relay) as was determined during configuration (see SIPROTEC® 4 System Description).

The extent of the interlocking checks is determined by the configuration and interlocking logic of the relay.

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 (test mode) can be selected:

- For local commands by reprogramming the settings with password check,
- For automatic commands, via command processing by CFC and Deactivated Interlocking Recognition,
- For local / remote commands, using an additional interlocking disable command via PROFIBUS.

Interlocked/Non-interlocked Switching

The configurable command checks in the SIPROTEC® 4 devices are also called “standard interlocking”. These checks can be activated using DIGSI® (interlocked switching/tagging) or deactivated (non-interlocked).

De-interlocked or non-interlocked switching means that the configured interlock conditions are not tested.

Interlocked switching means that all configured interlocking conditions are checked within the command processing. If a condition could not be fulfilled, the command will be rejected by an indication with a minus added to it, e.g. “CO–”, followed by an operation response information. The command is rejected if a synchronism check is carried out before closing and the conditions for synchronism are not fulfilled. Table 2-10 shows some types of commands and indications. For the device the indications designated with *) are displayed in the event logs, for DIGSI® they appear in spontaneous indications.

Table 2-10 Command types and corresponding indications

Type of Command	Control	Cause	Indication
Control issued	Switching	CO	CO+/–
Manual tagging (positive / negative)	Manual tagging	MT	MT+/–
Information state command, Input blocking	Input blocking	ST	ST+/– *)
Information state command, Output blocking	Output blocking	ST	ST+/– *)
Cancel command	Cancel	CA	CA+/–

The plus sign indicated in the indication is a confirmation of the command execution: The command output has a positive result, as expected. A minus sign means a negative, i.e. an unexpected result; the command was rejected. Figure 2-61 shows an example in the operational indications command and feedback of a positively run switching action of the circuit breaker.

The check of interlocking can be programmed separately for all switching devices and tags that were set with a tagging command. Other internal commands such as overriding or abort are not tested, i.e. are executed independently of the interlockings.

```
EVENT LOG
---------------------
19.06.01 11:52:05,625
Q0          CO+ Close

19.06.01 11:52:06,134
Q0          FB+ Close
```

Figure 2-61 Example of an operational indication for switching circuit breaker 52

Standard Interlocking

The standard interlocking includes the checks for each switchgear which were set during the configuration of inputs and outputs, see SIPROTEC® 4 System Description.

An overview for processing the interlocking conditions in the relay is shown in Figure 2-62.

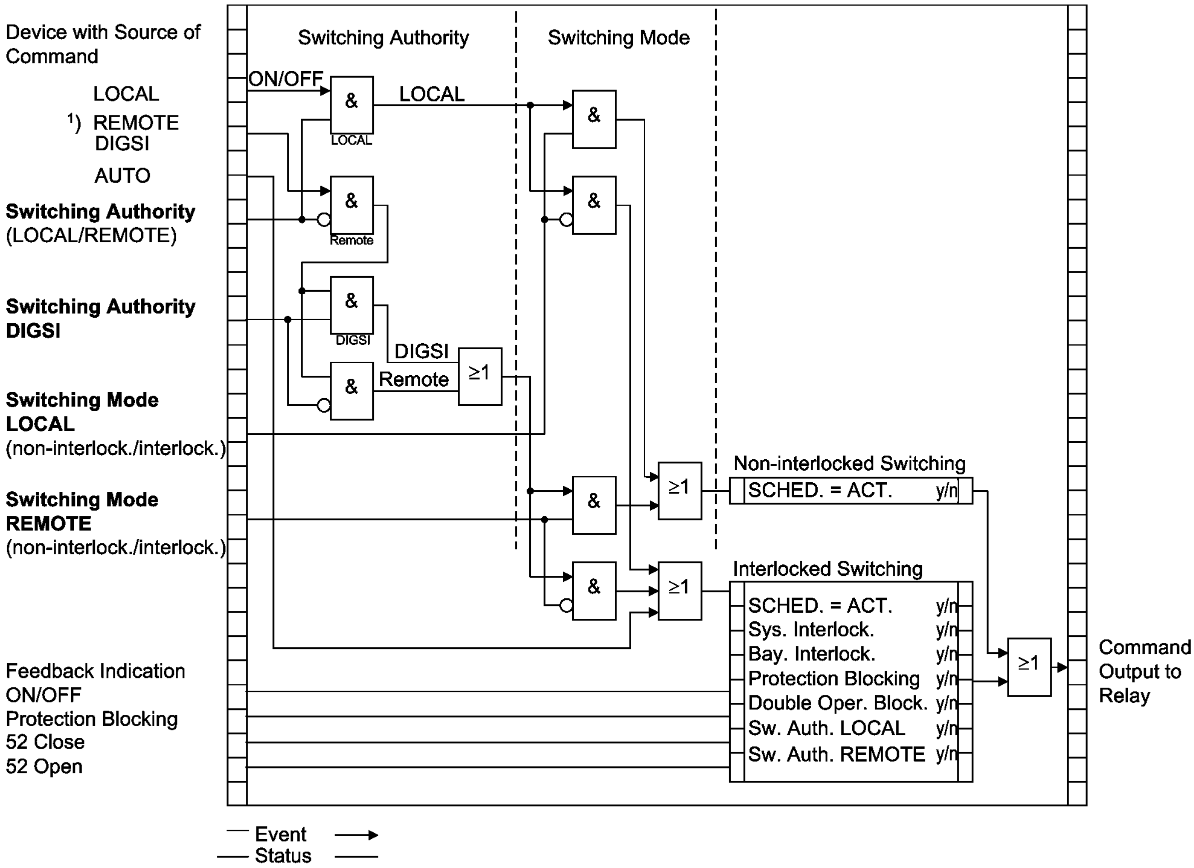


Figure 2-62 Standard interlockings

1) Source of Command REMOTE includes LOCAL.

LOCAL Command using substation controller

REMOTE Command via telecontrol station to power system management and from power system management to the device

The display shows the configured interlocking reasons. The are marked by letters explained in Table 2-11.

Table 2-11 Interlocking Commands

Interlocking Commands	Command	Display
Switching Authority	L	L
System Interlocking	S	S
Bay Interlocking	Z	Z
SET = ACTUAL (switch direction check)	P	P
Protection Blockage	B	B

Figure 2-63 shows all interlocking conditions (which usually appear in the display of the device) for three switchgear items with the relevant abbreviations explained in Table 2-11. All parametrized interlocking conditions are shown.

```
Interlocking      01/03
-----------------------
Q0 Close/Open S - Z P B
Q1 Close/Open S - Z P B

Q8 Close/Open S - Z P B
```

Figure 2-63 Example of configured interlocking conditions

Control Logic via CFC

For the bay interlocking, an enabling logic can be structured using the CFC. Via specific release conditions the information “released” or “bay interlocked” are available, e.g. object “52 Close” and “52 Open” with the data values: ON / OFF).

2.20.1.4 Information List

No.	Information	Type of Information	Comments
-	Cntrl Auth	DP	Control Authority
-	ModeLOCAL	DP	Controlmode LOCAL
-	ModeREMOTE	IntSP	Controlmode REMOTE
-	CntrlDIGSI	LV	Control DIGSI

2.20.2 Control Device

2.20.2.1 Information List

No.	Information	Type of Information	Comments
-	Breaker	CF_D12	Breaker
-	Breaker	DP	Breaker
-	Disc.Swit.	CF_D2	Disconnect Switch
-	Disc.Swit.	DP	Disconnect Switch
-	EarthSwit	CF_D2	Earth Switch
-	EarthSwit	DP	Earth Switch
-	52 Open	IntSP	Interlocking: 52 Open
-	52 Close	IntSP	Interlocking: 52 Close
-	Disc.Open	IntSP	Interlocking: Disconnect switch Open
-	Disc.Close	IntSP	Interlocking: Disconnect switch Close
-	E Sw Open	IntSP	Interlocking: Earth switch Open
-	E Sw Cl.	IntSP	Interlocking: Earth switch Close
-	Fan ON/OFF	CF_D2	Fan ON/OFF
-	Fan ON/OFF	DP	Fan ON/OFF
-	UnlockDT	IntSP	Unlock data transmission via BI

2.20.3 Process Data

During the processing of commands, independently of the further allocation and processing of indications, command and process feedbacks are sent to the indication processing. These indications contain information on the cause. With the corresponding allocation (configuration) these indications are entered in the event log, thus serving as a report.

A listing of possible operational indications and their meaning, as well as the command types needed for tripping and closing the switchgear or for raising and lowering of transformer taps and detailed information are described in the SIPROTEC® 4 System Description.

2.20.3.1 Method of Operation

Acknowledgement of Commands to the Device Front

All indications with the source of command LOCAL are transformed into a corresponding response and shown in the display of the device.

Acknowledgement of Commands to Local/Remote/DIGSI

The acknowledgement of indications which relate to commands with the origin “Command Issued = Local/ Remote/DIGSI” are sent back to the initiating point independent of the routing (configuration on the serial digital interface).

The acknowledgement of commands is therefore not executed by a response indication as it is done with the local command but by ordinary command and feedback information recording.

Feedback Monitoring

Command processing time monitors all commands with feedback. Parallel to the command, a monitoring time period (command runtime monitoring) is started which checks whether the switchgear has achieved the desired final state within this period. The monitoring time is stopped as soon as the feedback information arrives. If no feedback information arrives, a response “Time Limit Expired” appears and the process is terminated.

Commands and their feedbacks are also recorded as operational indications. Normally the execution of a command is terminated as soon as the feedback information (**FB+**) of the relevant switchgear arrives or, in case of commands without process feedback information, the command output resets.

In the feedback, the plus sign means that a command has been positively completed. The command was as expected, in other words positive. The "minus" is a negative confirmation and means that the command was not executed as expected.

Command Output / Switching Relays

The command types needed for tripping and closing of the switchgear or for raising and lowering of transformer taps have been defined during the configuration, see also SIPROTEC® 4 System Description.

2.20.4 Protocol

2.20.4.1 Functional Description

The following protocols are available for communication with the control system via the system interface:

- IEC 60870-5-103
- PROFIBUS FMS
- PROFIBUS DP
- Modbus
- DNP 3.0

Note

A description of the profiles and the mapping files are included on the DIGSI® CD.

2.20.4.2 Information List

No.	Information	Type of Information	Comments
-	SysIntErr.	IntSP	Error Systeminterface

2.21 Use in auto-transformer systems

This function is optional, i.e. not included in all device variants.

The system 2x15 kV (or 2x25 kV) is used increasingly in a.c. power traction networks to enhance the transmission properties. Additional auto-transformers and a return line - negative feeder - of 15 kV (or 25 kV) potential are characteristic of this type of infeed. For this reason, two-pole switching devices are necessary in the overhead contact line system.

2.21.1 Functional Description

General

Since auto-transformer systems require current inputs for summation, they can only be implemented in devices that feature 3 analog inputs each. It can be specified in parameter **CURRENT I1, I2** whether the protective function operates only with the overhead line current or with the summation current of overhead line and negative feeder. In the latter case, the two currents are detected via separate transformers, vectorially added and in the further process treated as a measured quantity. Please consider also the polarity of the current transformer (current of the negative feeder) at **IF CT STARPOINT** for determination of direction. The measured value connections can be found in the Appendix at A.3. These settings apply to all functions, not including some exceptions.

The following functions are treated differently:

- No use of the summation currents for the functions

  Overload protection, It measurement and defrost protection.
- In case of the high-speed overcurrent protection, the selection is additionally made via jumper X600 on the module C-I/O 13.
- The current-dependent statistic values are always calculated from the overhead line current.

All three currents (overhead line current, negative feeder current and the resulting summation current) are generally available for detection and display of the operational measured values and fault recording.

2.21.2 Setting Notes

General

In DIGSI® double-click on **Settings** to display the relevant selection. A dialog box with the tabs General, Transformer data, System data, Voltage transformers and Circuit breaker will open under **Power System Data 1**, in which you can configure the individual parameters. Thus, the following subsections are structured accordingly.

Transformer Data for Auto-transformer Systems

At address 206 **IF CT STARPOINT** the polarity of the current transformers (negative feeder current) must be stated. This setting determines the measuring direction of the device (forwards = line direction).

The measured value connections can be found in the Appendix under A.3.

At address 207 **IF CT PRIMARY** you set the primary rated CT current (negative feeder current).

At addresses 209 **UF PRIMARY** and 210 **UF SECONDARY**, information regarding the primary and secondary current ratings of the current transformers (negative feeder voltage) is entered.

In auto-transformer systems, the protection functions can evaluate either

- The summation current of the overhead contact line current and the negative feeder current, or
- The overhead contact line current

In the parameter **CURRENT I1, I2** (address 213) you specify which current will be fed to the protection functions for evaluation. If you want the summation current to be processed by the protection functions, set address 213 to ***Sum I1, I2***. The vectors of the overhead contact line current and the negative feeder current are added.

Note

If at address 213 the parameter **CURRENT I1, I2** is set to ***Sum I1, I2***, the setting of jumper X600 on the C-I/O 13 board must be changed for the summation! The default setting of this jumper on delivery is “without summation”!

■

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 the management of power systems and with the relevant safety rules and guidelines. Under certain circumstances particular power system adaptations of the hardware are necessary. 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 erection of the device.

Failure to observe these precautions can result in death, personal injury or substantial property damage.

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

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 mounting and connections the following conditions must be met:

The rated device data has been checked as recommended in the SIPROTEC® 4 System Description. The compliance of these data has been verified with the Power System Data.

Connection Variants

Outline diagrams are shown in Appendix A.2. Connection examples for the current and voltage transformer circuits are given in the Appendix A.3. It must be checked that the setting configuration of the **P.System Data 1**, Section 2.1.3.1, corresponds with the connections to the device.

Currents

Appendix A.3 shows examples for the possibilities of the current transformer connections in dependence on network conditions.

Voltages

Connection examples for current and voltage transformer circuits are provided in Appendix A.3.

Binary Inputs and Outputs

The connections to the system depend on the possible allocation of the binary inputs and outputs, i.e. how they are assigned to the system. The preset allocation can be found in the tables in Section A.4 of the Appendix. Check also whether the labelling corresponds to the allocated indication functions.

Changing Setting Groups

If binary inputs are used to change 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.
- To control two setting groups, only one binary input is required, namely "`>Set Group Bit0`", since binary input "`>Set Group Bit1`", which is not allocated, then is classified as "not controlled".
- The status of the signals controlling the binary inputs to activate a particular setting group must remain constant as long as that particular group is to remain active.

The following table shows the 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 controlled

Yes = controlled

Table 3-1 Changing setting groups using binary inputs

Binary Input		Active Group
>Set Group Bit0	**>Set Group Bit1**	
No	No	Group A
Yes	No	Group B
No	Yes	Group C
Yes	Yes	Group D

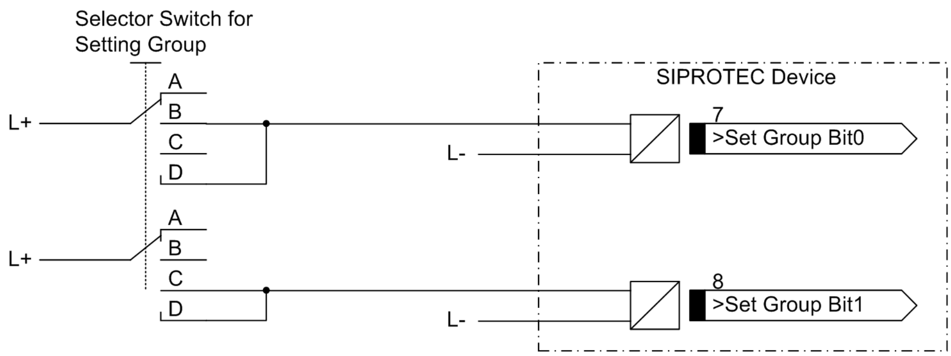


Figure 3-1 Connection diagram (example) for setting group switching with binary inputs

Trip Circuit Supervision

It must be noted that two binary inputs or one binary input and one substitute resistor R must be connected in series. The pick-up threshold of the binary inputs must therefore be substantially below half the rated control DC voltage.

If two binary inputs are used for the trip circuit supervision, these binary inputs must be volt-free i.e. not be commoned with each other or with another binary input.

If one binary input is used, a substitute resistor R must be employed (refer to Figure 3-2). The resistor R is inserted into the circuit of the second circuit breaker auxiliary contact (Aux2), to facilitate the detection of a malfunction also when the first circuit breaker auxiliary contact (Aux1) is open and the trip contact has dropped out. The value of this resistor must be such that in the circuit breaker open condition (therefore Aux1 is open and Aux2 is closed) the circuit breaker trip coil (TC) is no longer picked up and binary input (BI1) is still picked up if the command relay contact is open.

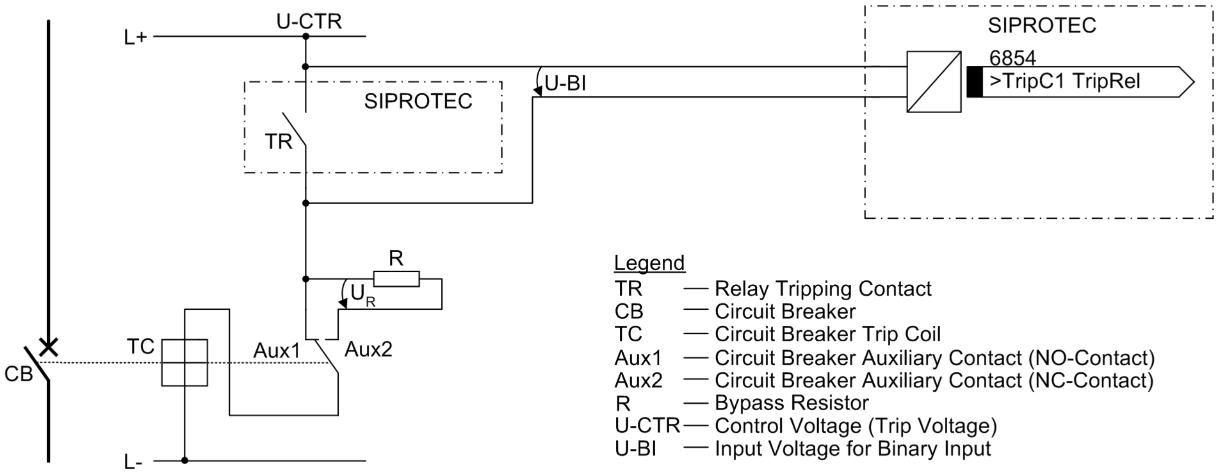


Figure 3-2 Trip circuit supervision with one binary input – example for trip circuit

This results in an upper limit for the resistance dimension, R_{max}, and a lower limit R_{min}, from which the optimal value of the arithmetic mean R should be selected:

$$R = \frac{R_{max} + R_{min}}{2}$$

In order that the minimum voltage for controlling the binary input is ensured, R_{max} is derived as:

$$R_{max} = \left(\frac{U_{CTR} - U_{BI\ min}}{I_{BI\ (High)}}\right) - R_{TC}$$

So the circuit breaker trip coil does not remain energized in the above case, R_{min} is derived as:

$$R_{min} = R_{TC} \cdot \left(\frac{U_{CTR} - U_{TC\ (LOW)}}{U_{TC\ (LOW)}}\right)$$

$I_{BI\ (HIGH)}$	Constant current with activated BI (= 1.8 mA)
$U_{BI\ min}$	Minimum control voltage for BI (= 19 V for delivery setting for nominal voltages of 24/48/60 V; 88 V for delivery setting for nominal voltages of 110/125/220/250 V, 176 V for delivery setting for nominal voltages of 220/250 V)
U_{CTR}	Control voltage for trip circuit
R_{TC}	DC resistance of circuit breaker trip coil
$U_{TC\ (LOW)}$	Maximum voltage on the circuit breaker trip coil that does not lead to tripping

If the calculation yields that $R_{max} < R_{min}$, then the calculation must be repeated using the next lowest switching threshold $U_{BI\ min}$, and this threshold must be implemented in the relay using plug-in jumpers (see Section “Hardware Modifications”).

For power consumption of the resistance:

$$P_R = I^2 \cdot R = \left(\frac{U_{CTR}}{R + R_{TC}}\right)^2 \cdot R$$

Example:

$I_{BI\ (HIGH)}$	1.8 mA (SIPROTEC® 4 7ST6)
$U_{BI\ min}$	19 V for delivery setting for nominal voltages of 24/48/60 V (from the 7ST6); 88 V for delivery setting for nominal voltages of 110/125/220/250 V (for device 7ST6) 176 V for delivery setting for nominal voltages of 220/250 V (for device 7ST6)
U_{CTR}	110 V (system / trip circuit)
R_{TC}	500 Ω (system / trip circuit)
$U_{TC\ (LOW)}$	2 V (system / trip circuit)

$$R_{max} = \left(\frac{110\ V - 19\ V}{1.8\ mA}\right) - 500\ \Omega = 50.1\ k\Omega$$

$$R_{min} = 500\ \Omega \cdot \left(\frac{110\ V - 2\ V}{2\ V}\right) = 27\ k\Omega$$

$$R = \frac{R_{max} + R_{min}}{2} = 38.6\ k\Omega$$

The closest standard value of 39 kΩ is selected; the power is:

$$P_R = \left(\frac{110\ V}{39\ k\Omega + 0.5\ k\Omega}\right)^2 \cdot 39\ k\Omega \geq 0.3\ W$$

3.1.2 Hardware Modifications

3.1.2.1 General

A subsequent adaptation of the hardware to the power system conditions can, for example, become necessary with regard to the control voltage for binary inputs or the termination of bus-capable interfaces. Follow the procedure described in this section, whenever hardware modifications are done.

Auxiliary Voltage

There are different ranges of input voltage for the auxiliary voltage. The versions for 60/110/125 VDC and 110/125/220/250 VDC are interchangeable by altering jumper settings. The assignment of these jumpers to the nominal voltage ranges and their spatial arrangement on the PCB are described further below at “Processor Board C-CPU-2”. Location and ratings of the miniature fuse and the buffer battery are also shown. On delivery of the device, all jumpers are correctly arranged according to the indications on the rating plate and do not need to be changed.

Life Contact

The life contact of the device is a changeover contact from which either the NC contact or the NO contact can be connected to the device terminals via a plug-in jumper (X40). Assignments of the jumpers to the contact type and the spatial layout of the jumpers are described in Section at margin heading “Processor Board C-CPU-2”.

Rated Currents

The rated currents can be 1 or 5 A depending on the variant ordered.

Control Voltage for Binary Inputs

When the device is delivered from the factory the binary inputs are set to operate with a voltage that corresponds to the rated DC voltage of the power supply. In case of deviating nominal values of the power system control voltage, it may become necessary to change the switching threshold of the binary inputs.

To change the switching threshold of a binary input, one jumper must be changed for each input. The assignments of the jumpers to the binary inputs and the spatial layout of the jumpers is described in the following sections under “Processor Board C-CPU-2”, Board C-I/O-7, “Board(s) C-I/O-12 and C-I/O-13” and “Board B-I/O-2”.

Note

If binary inputs are used for trip circuit monitoring, note that two binary inputs (or a binary input and a substitute resistor) are connected in series. The switching threshold must be significantly less than half the rated control voltage.

Contact Mode for Binary Outputs

Depending on the version, some output relays can be set to have normally closed or normally open contacts. To do so a jumper location must be changed. For which relays on which boards this is valid can be found in the following sections under “Switching Elements on Printed Circuit Boards”.

Termination of Serial Interfaces

If the device is equipped with a serial RS 485 interface or PROFIBUS, they must be terminated with resistors at the last device on the bus to ensure reliable data transmission. For this purpose terminating resistors are provided on the PCB of the C-CPU-2 processor boards and on the RS 485 or PROFIBUS interface module which can be connected via jumpers. The spatial arrangement of the jumpers on the PCB of the processor module C-CPU-2 is described in the following sections under “Processor Board C-CPU-2” and on the interface modules under “RS485 Interface” and “PROFIBUS Interface”. Both jumpers must be plugged in the same way.

On delivery of the device, the terminating resistors are switched ON.

Spare Parts

Spare parts can be the battery for storage of data in the battery-buffered RAM in case of a power failure, and the internal power supply miniature fuse. Their spatial arrangement is shown in the figure of the processor board. The ratings of the fuse are printed on the board next to the fuse itself. When exchanging the fuse, please observe the hints given in the SIPROTEC® 4 System Description in the chapter “Maintenance” and “Corrective Action / Repairs”.

3.1.2.2 Disassembly

Work on the Printed Circuit Boards

Note

It is assumed for the following steps that the device is not in operation.

Caution!

Caution when changing jumper settings that affect nominal values of the device:

As a consequence, the order number (MLFB) and the ratings on the nameplate no longer match the actual device properties.

Where such changes are necessary in exceptional changes, they MUST be marked clearly and visibly on the device. Self adhesive stickers are available that can be used as replacement nameplates.

To perform work on the PCB´s, such as checking or rearranging switching elements or exchanging modules, proceed as follows:

- Prepare area of work: Prepare a surface appropriate to electrostatic sensitive devices (ESD). In addition to this, the following tools are required:
  - Screwdriver with a 5 to 6 mm wide tip,
  - Philips screwdriver size 1,
  - 5 mm socket or nut driver.
- Unfasten the screw-posts of the D-subminiature connectors on the back panel at location “A” and “C”.
- If the device has, in addition to the communication interfaces at locations “A” and “C”, interfaces at locations “B” and “D”, the screws located diagonally to the interfaces must be removed.
- Remove the caps on the front cover of the device and withdraw the then accessible screws.
- Remove the front cover and tilt it to the side. With device versions with a detached operator panel it is possible to remove the front cover of the device right after having unscrewed all screws.

Work on the Plug Connectors

Caution!

Mind electrostatic discharges:

Non–observance can result in minor personal injury or material damage.

When handling plug connectors, eliminate electrostatic discharges by first touching an earthed metal surface.

Do not plug in or pull off interface terminals under voltage!

The assembly of the boards for the housing size $^1/_2$ is shown in Figure 3-3 and for the housing size $^1/_1$ in Figure 3-4.

- Disconnect the plug connector of the ribbon cable between the front cover and the processor board C-CPU-2 at the front cover side. To do this, spread the latches on the upper and lower end of the plug connector to release the plug connector of the ribbon cable. This action does not apply to the device version with detached operator panel. However, on the central processor unit C–CPU-2 (No. 1) the 7-pole plug connector X16 behind the D-subminiature connector and the plug connector of the ribbon cable (connected to the 68-pole plug connector on the rear side) must be removed.
- Disconnect the ribbon cables between the processor board C-CPU-2 (No. 1) and the input/output boards I/O (No. 2 to No. 6, depending on the ordered variant).
- Remove the modules and place them on a surface suitable for electrostatically sensitive modules (ESD).
- Check the jumpers according to Figures 3-5 to 3-10, 3-13, 3-14 and the following information. Change or remove the jumpers if necessary.

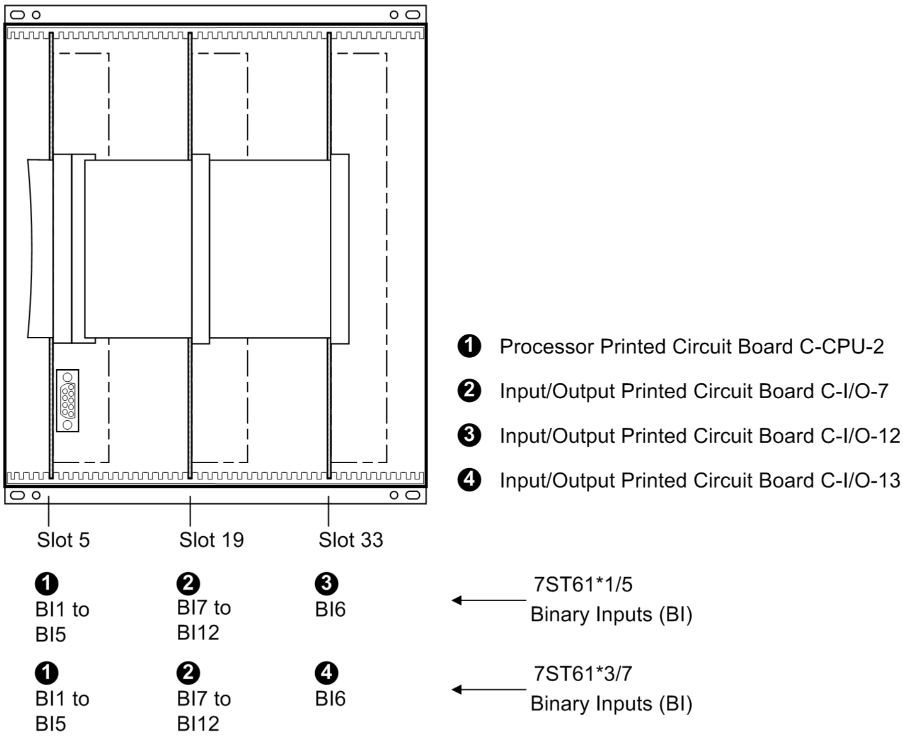


Figure 3-3 Front view with housing size $^1/_2$ after removal of the front cover (simplified and scaled down)

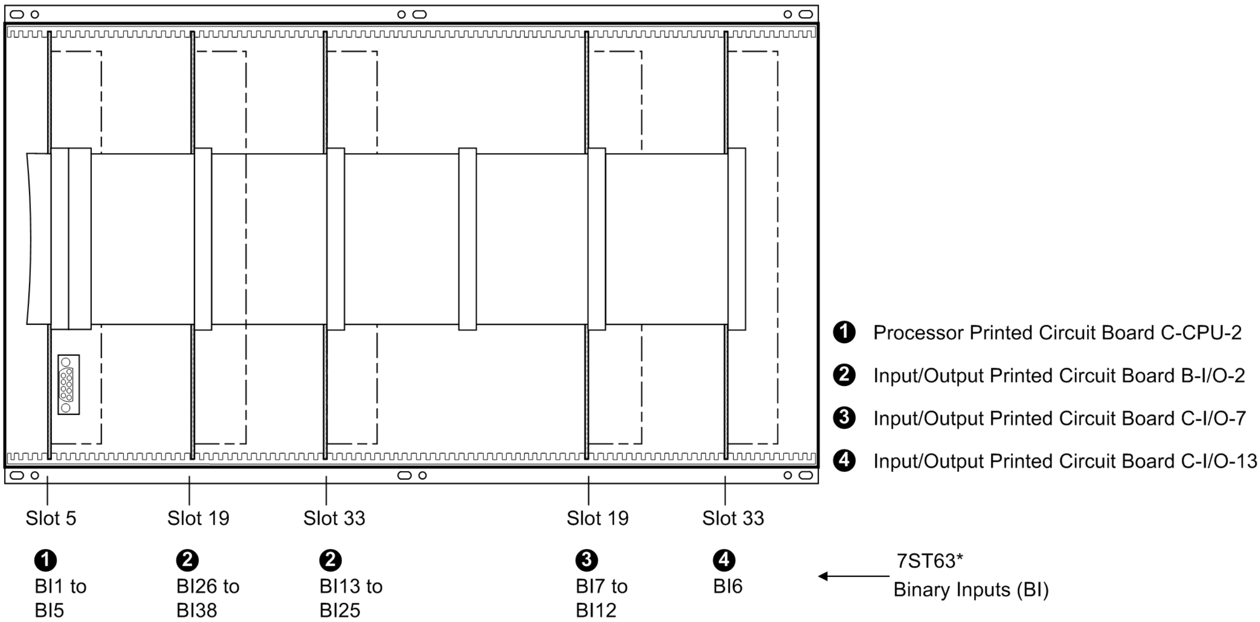


Figure 3-4 Front view with housing size $^1/_1$ after removal of the front cover (simplified and scaled down)

3.1.2.3 Switching Elements on Printed Circuit Boards

Processor Board C-CPU-2

The PCB layout of the processor board C–CPU-2 is illustrated in the following figure. The set rated voltage of the integrated power supply is checked according to Table 3-2, the quiescent state of the life contact according to Table 3-3, the selected pickup voltages of the binary inputs BI1 to BI5 according to Table 3-4 and the integrated RS232 / RS485 interface according to Table 3-5 to 3-7. The location and ratings of the miniature fuse (F1) and the buffer battery (G1) are shown in the following figure.

Before checking the integrated RS232/RS485 interface, it may be necessary to remove the interface modules mounted on top of it.

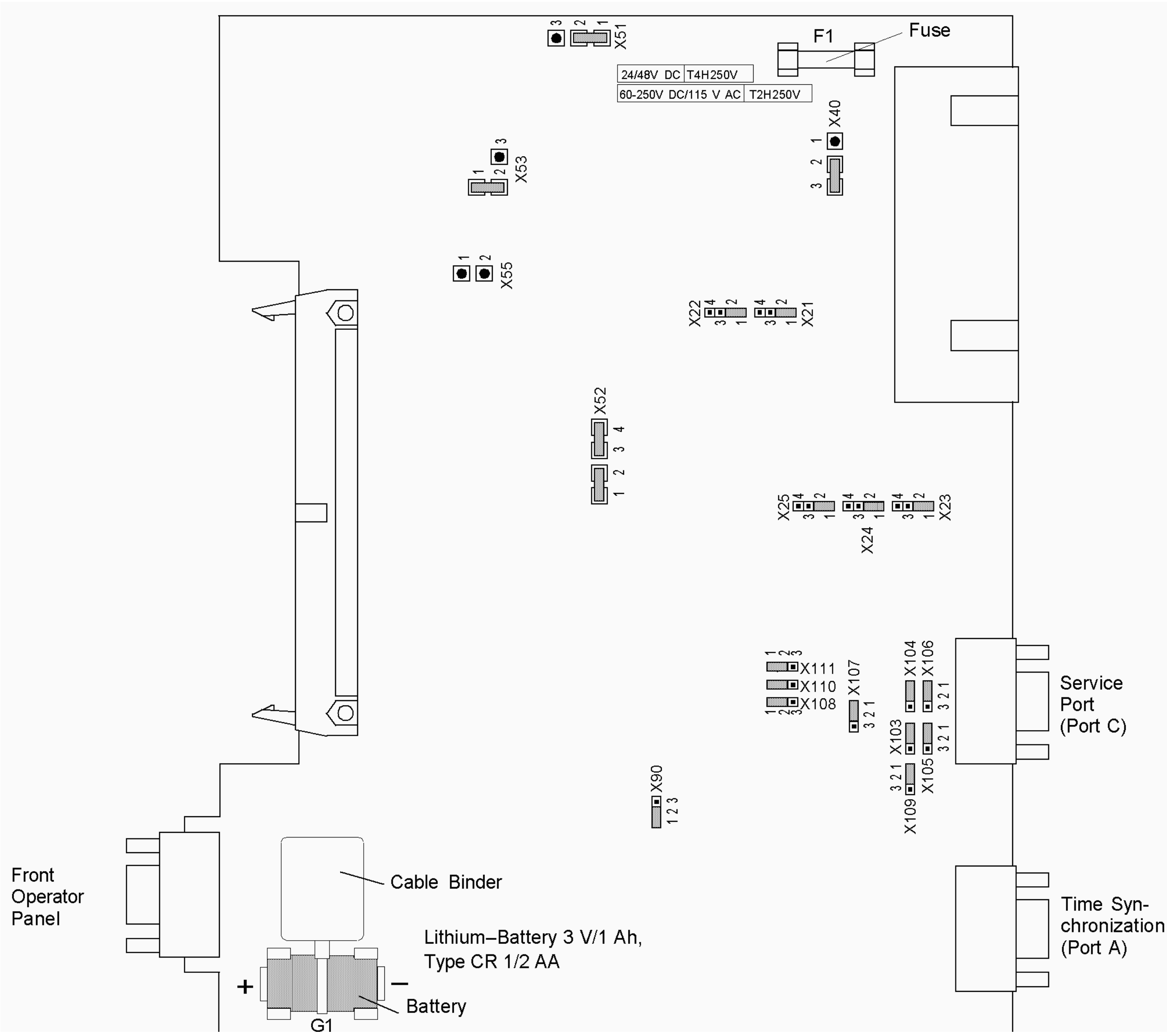


Figure 3-5 Processor board C–CPU with jumper settings required for the board configuration

Table 3-2 Jumper setting of the rated voltage of the integrated **Power Supply** on the C-CPU-2 processor board

Jumper	Rated Voltage		
	24 to 48 VDC	**60 to 125 VDC**	**110 to 250 VDC**
X51	Not used	1-2	2-3
X52	Not used	1-2 and 3-4	2-3
X53	Not used	1-2	2-3
X55	Not used	Not used	1-2
	Cannot be changed	Interchangeable	

Table 3-3 Jumper position of the quiescent state of the **Life Contact** on the C-CPU-2 processor board

Jumper	Quiescent State Open	Quiescent State Closed	Factory Setting
X40	1-2	2-3	2-3

Table 3-4 Jumper settings of the **Pickup Voltages** of the binary inputs BI1 to BI5 (DC voltage) on the C-CPU-2 processor board

Binary Inputs	Jumper	10 V Threshold 1)	44 V Threshold 2)	88 V Threshold 3)
BI1	X21	1-2	2-3	3-4
BI2	X22	1-2	2-3	3-4
BI3	X23	1-2	2-3	3-4
BI4	X24	1-2	2-3	3-4
BI5	X25	1-2	2-3	3-4

1) Factory settings for devices with rated power supply voltages 24 VDC to 125 VDC
2) Factory settings for devices with rated power supply voltages 110 VDC to 250 VDC
3) Factory settings for devices with rated power supply voltages 220 VDC to 250 VDC

By repositioning jumpers the interface RS485 can be modified into a RS232 interface and vice versa.

Jumpers X105 to X110 must be set to the same position.

Table 3-5 Jumper settings of the integrated **RS232/RS485 Interface** on the C-CPU-2 processor board

Jumper	RS232	RS485
X103 and X104	1-2	1-2
X105 to X110	1-2	2-3

The jumpers are preset at the factory according to the configuration ordered.

With interface RS232 jumper X111 is needed to activate CTS which enables the communication with the modem.

Table 3-6 Jumper setting for **CTS** on the C-CPU-2 board

Jumper	/CTS from Interface RS232	/CTS Controlled by /RTS
X111	1-2	2-3

Jumper setting 2-3: The connection to the modem is usually established with a star coupler or fibre-optic converter. Therefore the modem control signals according to RS232 standard DIN 66020 are not available. Modem signals are not required since communication to SIPROTEC® 4 devices is always carried out in the half duplex mode. Please use the connection cable with order number 7XV5100-4.

Jumper setting 1-2: This setting makes the modem signals available, i. e. for a direct RS232 connection between the SIPROTEC® 4 device and the modem this setting can be selected optionally. We recommend to use a standard RS232 modem connection cable (converter 9-pin to 25-pin).

Note

For a direct connection to DIGSI® with the RS232 interface, jumper X111 must be plugged in position 2-3.

If there are no external matching resistors in the system, the last devices on a RS485 bus must be configured using jumpers X103 and X104.

Table 3-7 Jumper settings of the **Terminating Resistors** of the RS485 interface on the C-CPU-2 processor board

Jumper	Terminating Resistor Switched ON	Terminating Resistor Switched OFF	Factory Setting
X103	2-3	1-2	1-2
X104	2-3	1-2	1-2

Note: Both jumpers must always be plugged in the same way!

Jumper X90 has currently no function. The factory setting is 1-2.

Terminating resistors can also be implemented outside the device (e.g. on the terminal block). In this case, the matching resistors located on the RS485 or PROFIBUS interface module or directly on the PCB of the C-CPU-2 board must be disabled.

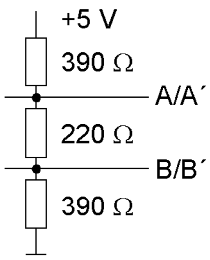


Figure 3-6 Termination of the RS485 interface (external)

C-I/O-7 Input/Output Board(s)

The P.C.B layout for the C-I/O-7 input/output board is shown in Figure 3-7.

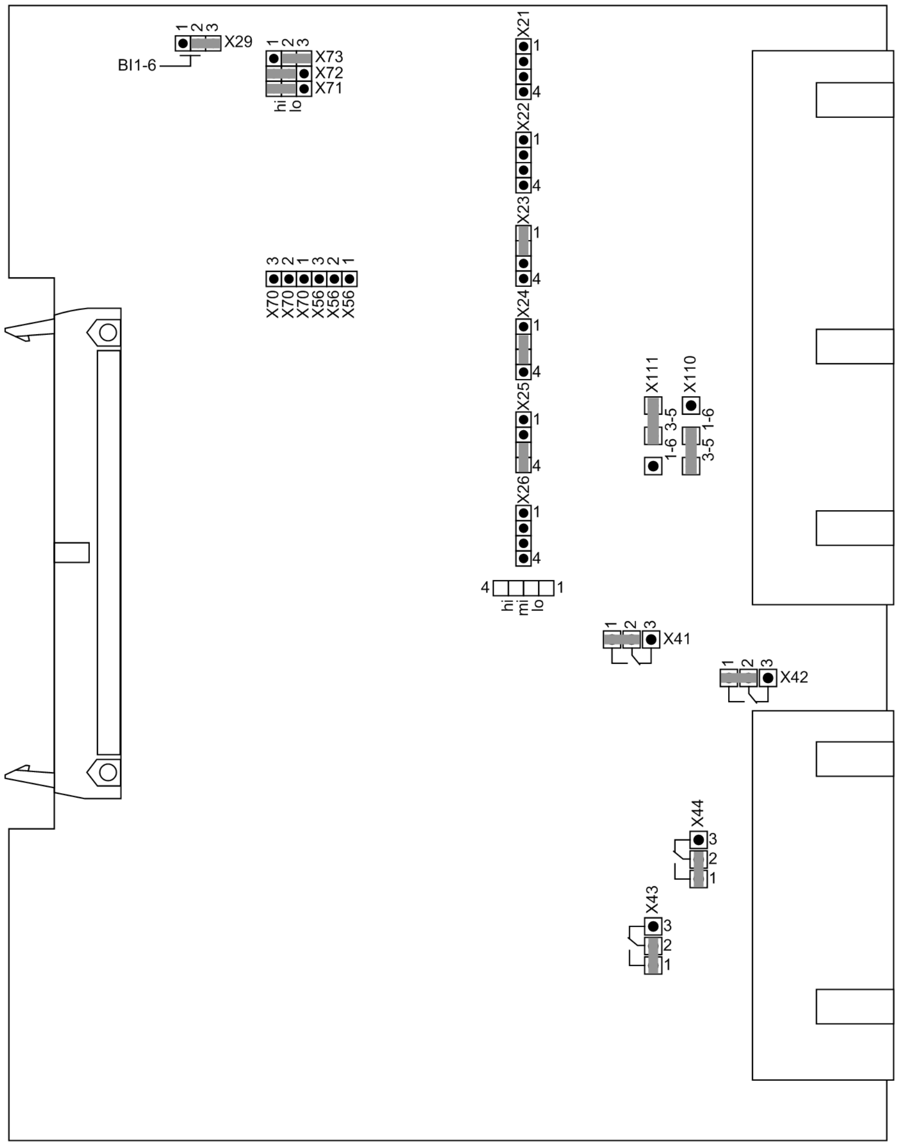


Figure 3-7 Input/output board C–I/O-7 with representation of the jumper settings required for the board configuration

Depending on the device version the contacts of some binary outputs can be changed from from normally open to normally closed (see Appendix, under section A.2).

- In versions 7ST6 1 * 1/5 (housing size **$^1/_2$** with 26 binary outputs) this is valid for the binary outputs BO14, BO15, BO25 and BO26 (Figure 3-3, slot 19).
- In versions 7ST6 1 * 3/7 (housing size **$^1/_2$** with 21 binary outputs) this is valid for the binary outputs BO9, BO10, BO20 and BO21 (Figure 3-3, slot 19).
- In versions 7ST6 3 (housing size **$^1/_1$** with 35 binary outputs) this is valid for the binary outputs BO9, BO10, BO20 and BO21 (Figure 3-4, slot 19).

The Tables 3-8 and 3-9 show the position of the jumpers for the contact mode.

Table 3-8 Jumper setting for the **Contact Mode** of the relays for BO14, BO15, BO25 and BO26 or BO9, BO10, BO20 and BO21 on the input/output board C-I/O-7 with housing size $^1/_2$

Device 7ST61*	Printed Circuit Board	For	Jumper	Open in Quiescent State (NO)	Closed in Quiescent State (NC)	Factory Setting
1/5	Slot 19	BO14	X41	1-2	2-3	1-2
	Slot 19	BO15	X42	1-2	2-3	1-2
	Slot 19	BO25	X43	1-2	2-3	1-2
	Slot 19	BO26	X44	1-2	2-3	1-2
3/7	Slot 19	BO9	X41	1-2	2-3	1-2
	Slot 19	BO10	X42	1-2	2-3	1-2
	Slot 19	BO20	X43	1-2	2-3	1-2
	Slot 19	BO21	X44	1-2	2-3	1-2

Table 3-9 Jumper setting for the **Contact Mode** of the relays for BO9, BO10, BO20 and BO21 on the input/output board C-I/O-7 with housing size $^1/_1$

Device 7ST63*	Printed Circuit Board	For	Jumper	Open in Quiescent State (NO)	Closed in Quiescent State (NC)	Factory Setting
	Slot 19 right side	BO9	X41	1-2	2-3	1-2
	Slot 19 right side	BO10	X42	1-2	2-3	1-2
	Slot 19 right side	BO20	X43	1-2	2-3	1-2
	Slot 19 right side	BO21	X44	1-2	2-3	1-2

Depending on the version there are 5 or 6 inputs available on this board. 6 binary inputs (BI7–BI12), connected to common potential, or 5 binary inputs divided into 1 x 2 binary inputs (BI7–BI8), connected to common potential and 1 x 3 binary inputs (BI9–BI11), connected to common potential. Please note that the relationship between jumpers X110, X111 and X29 must always be correct.

Table 3-10 Number of inputs

Jumper	5 Inputs 1 x 2 and 1 x 3 Binary Inputs, Connected to Common Potential	6 Inputs 1 x 6 Binary Inputs, Connected to Common Potential	Factory Setting
X110	1–2	2–3	2–3
X111	2–3	1–2	1–2
X29	2–3	1–2	1–2

Checking the control voltages of the binary inputs:

BI7 to BI12 (with housing size $^1/_2$ slot 19, and with housing size $^1/_1$ slot 19 right side) according to Table 3-11.

Table 3-11 Jumper settings of **Pickup Voltages** of the binary inputs BI7 to BI12 on the input/output board C-I/O-7

Binary Inputs	**Jumper**	**10 V Threshold** 1)	**44 V Threshold** 2)	**88 V Threshold** 3)
BI7	X21	L	M	H
BI8	X22	L	M	H
BI9	X23	L	M	H
BI10	X24	L	M	H
BI1	X25	L	M	H
BI12	X26	L	M	H

1) Factory settings for devices with rated power supply voltages 24 VDC to 125 VDC
2) Factory settings for devices with rated power supply voltages 110 VDC to 220 VDC
3) Use only with pickup voltages 220 to 250 VDC

Jumpers X71, X72 and X73 on the input/output board C-I/O-7 are used to set the bus address and must not be changed. The following two tables list the jumper presettings.

The mounting locations are shown in Figures 3-3 to 3-4.

Table 3-12 Jumper settings of the **PCB Address** of the input/output board C-I/O-7 or C-I/O-10 with housing size $^{1}/_{2}$ slot 19, and with housing size $^{1}/_{1}$ slot 19 right side)

Jumper	**Mounting Location 19**
A0 X71	1-2 (H)
A1 X72	1-2 (H)
A2 X73	2-3 (L)

Board C-I/O-12 The PCB layout for the C-I/O-12 input/output board is shown in Figure 3-8.

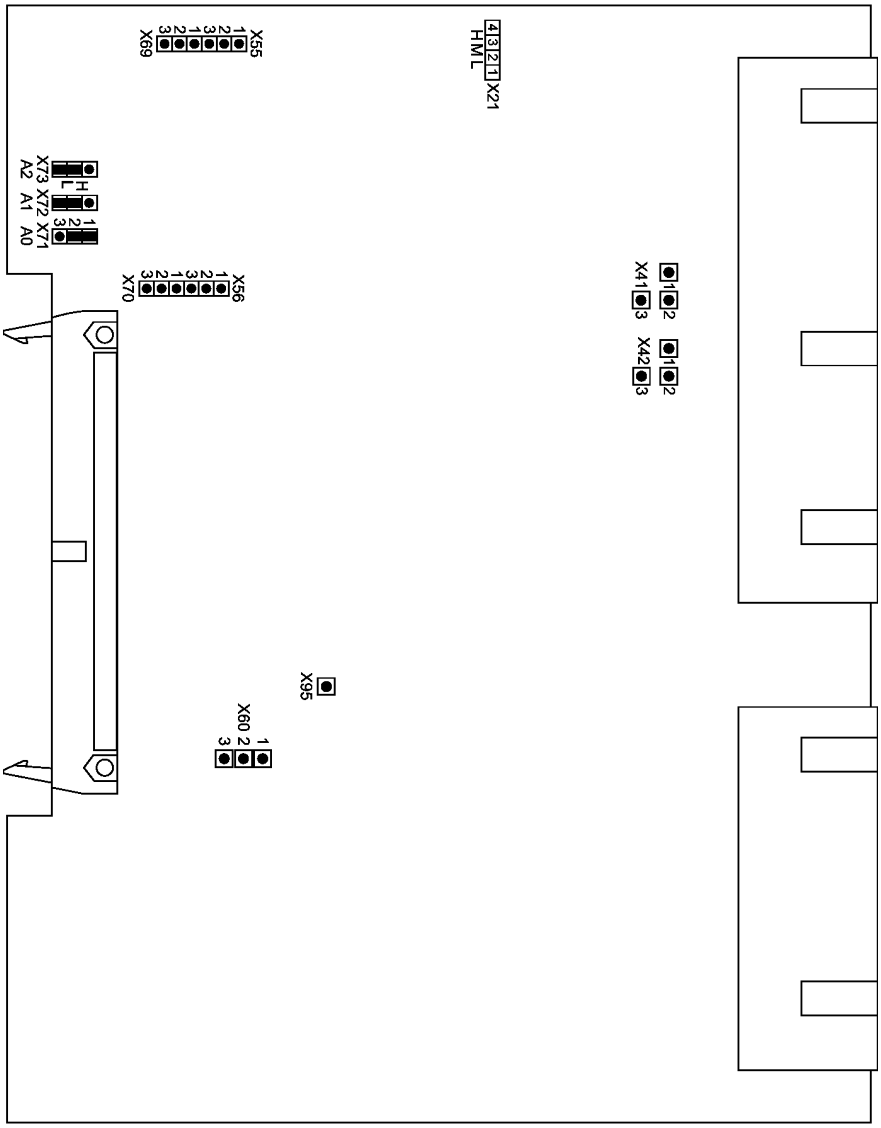


Figure 3-8 C-I/O-12 input/output board with representation of jumper settings required for checking configuration settings

Table 3-13 Jumper setting for the **Contact Mode** of the relays for BO4 and BO5 on the input/output board C-I/O-12 with housing size $^1/_2$

Device 7ST61*1/5	Printed Circuit Board	For	Jumper	Open in Quiescent State (NO)	Closed in Quiescent State (NC)	Factory Setting
	Slot 33	BO4	X41	1-2	2-3	1-2
	Slot 33	BO5	X42	1-2	2-3	1-2

Table 3-14 Jumper settings of **Pickup Voltages** of the binary input BI6 on the input/output board C-I/O-12

Binary Input	Jumper	10 V Threshold 1)	44 V Threshold 2)	88 V Threshold 3)
BI6	X21	L	M	H

1) Factory settings for devices with rated power supply voltages 24 VDC to 125 VDC
2) Factory settings for devices with rated power supply voltages 110 VDC to 250 VDC
3) Use only with pickup voltages 220 to 250 VDC

Jumpers X71, X72 and X73 on the input/output board C-I/O-12 are used to set the bus address and must not be changed. The following table lists the jumper presettings.

Mounting location:

with housing size $^1/_2$: in Figure 3-3, slot 33

Table 3-15 Jumper settings of **Board Address** of the input/output board C-I/O-12

Jumper	Factory Setting
A0 X71	1-2 (H)
A1 X72	2-3 (L)
A2 X73	2-3 (L)

C-I/O-13 Input/Output Board

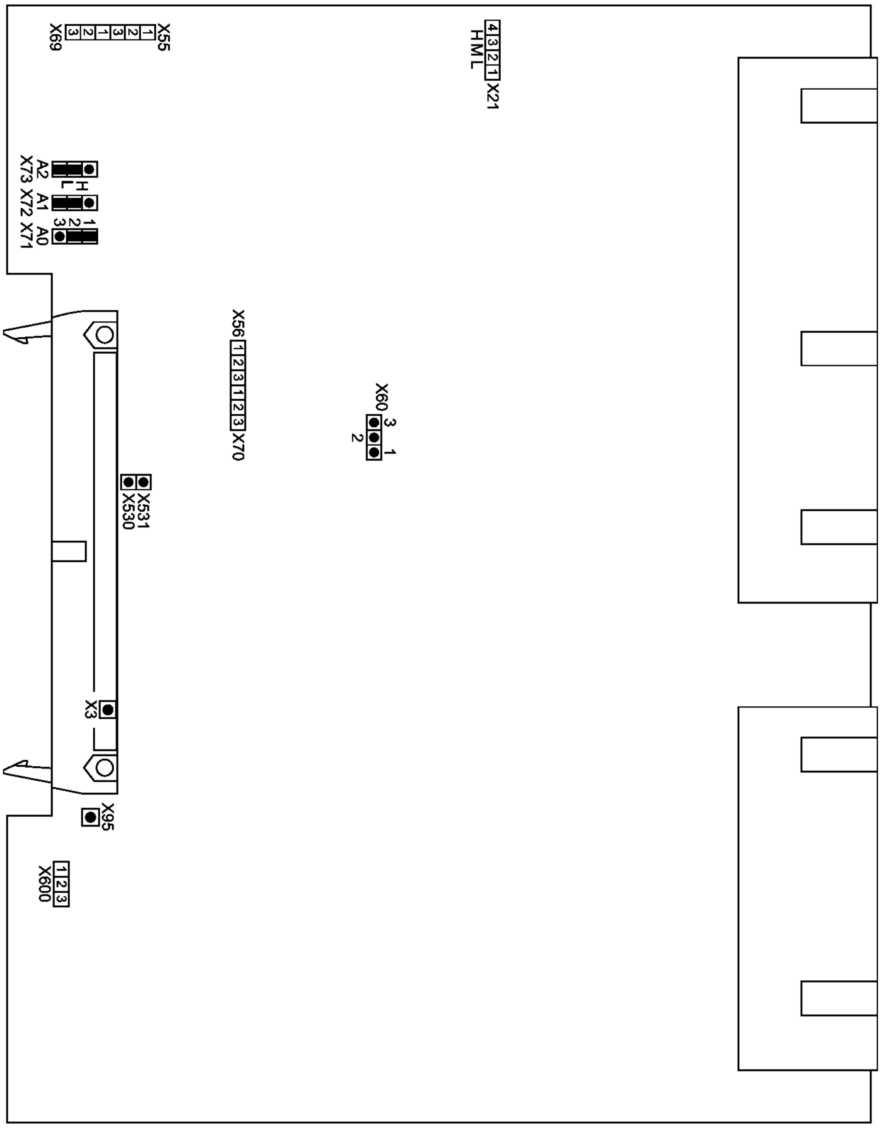


Figure 3-9 C-I/O-13 input/output board with representation of jumper settings required for checking configuration settings

Table 3-16 Jumper settings of **Pickup Voltages** of the binary input BI6 on the input/output board C-I/O-13

Binary Input	Jumper	10 V Threshold 1)	44 V Threshold 2)	88 V Threshold 3)
BI6	X21	L	M	H

1) Factory settings for devices with rated power supply voltages 24 VDC to 125 VDC
2) Factory settings for devices with rated power supply voltages 110 VDC to 250 VDC
3) Use only with pickup voltages 220 to 250 VDC

Jumpers X71, X72 and X73 on the input/output board C-I/O-13 are used to set the bus address and must not be changed. The following table lists the jumper presettings.

Mounting location:

with housing size $^{1}/_{2}$: in Figure 3-3, slot 33

with housing size $^{1}/_{1}$: in Figure 3-4, slot 33 right side;

Table 3-17 Jumper settings of **Bus Address** of the input/output board C-I/O-13

Jumper	Factory Setting
A0 X71	1-2 (H)
A1 X72	2-3 (L)
A2 X73	2-3 (L)

Table 3-18 Jumper setting for current summation I1+I2 with high-set stage

Jumper X600	Function
1–2	Only I1
2–3	I1+I2

Input/Output Board B-I/O-2

The PCB layout for the B-I/O-2 input/output board is shown in Figure 3-10.

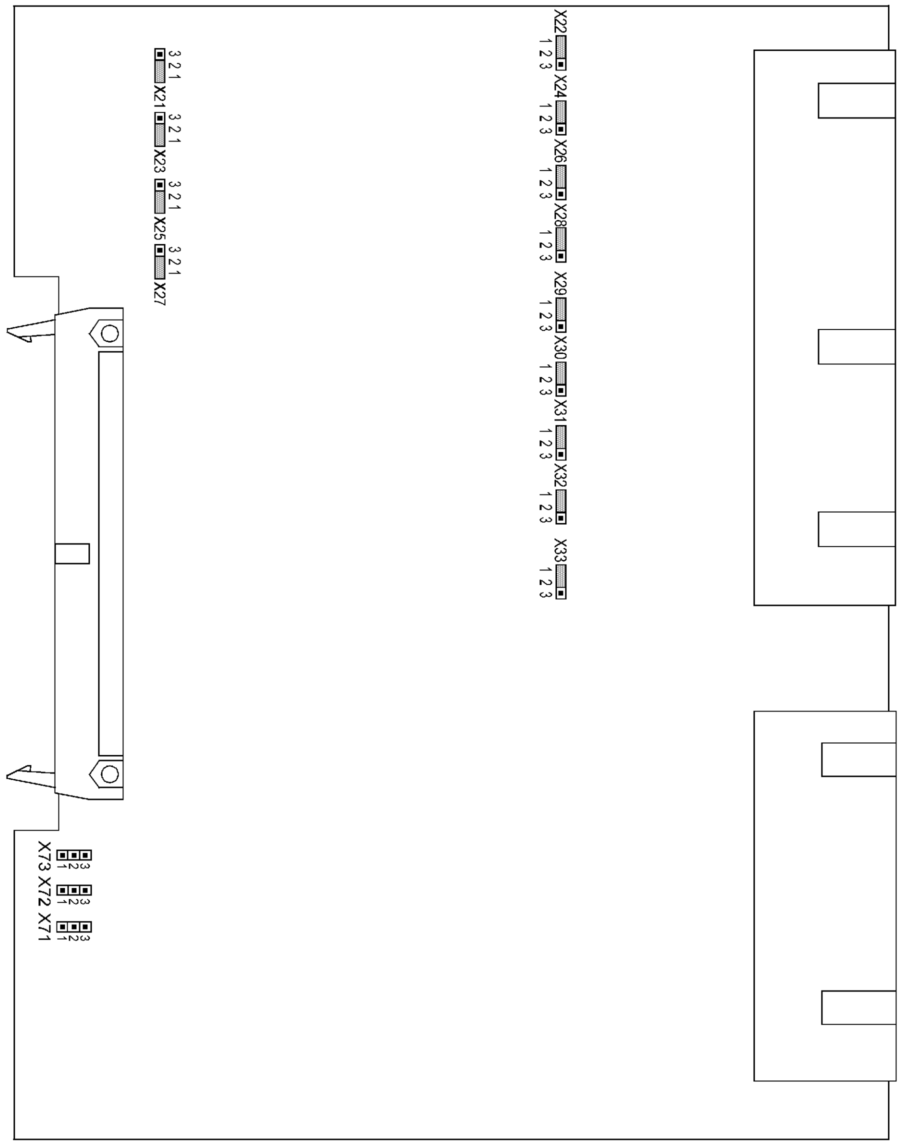


Figure 3-10 Input/output board B-I/O-2 with jumper settings required for the board configuration (representation of the jumpers X71, X72 and X73 for housing size $^1/_1$)

Checking the control voltages of the binary inputs:

BI13 to BI38 (with housing size $^1/_1$) according to Table3-19.

Table 3-19 Jumper settings for the **Pickup Voltages** of the binary inputs BI13 to BI38 on the B–I/O-2 board for model 7ST63*

Binary Inputs		**Jumper**	**10 V Threshold** [1)]	**44 V Threshold** [2)]
Slot 33 left side	**Slot 19 left side**			
BI13	BI26	X21	1-2	2-3
BI14	BI27	X22	1-2	2-3
BI15	BI28	X23	1-2	2-3
BI16	BI29	X24	1-2	2-3
BI17	BI30	X25	1-2	2-3
BI18	BI31	X26	1-2	2-3
BI1	BI32	X27	1-2	2-3
BI20	BI33	X28	1-2	2-3
BI21	BI34	X29	1-2	2-3
BI22	BI35	X30	1-2	2-3
BI23	BI36	X31	1-2	2-3
BI24	BI37	X32	1-2	2-3
BI25	BI38	X33	1-2	2-3

[1)] Factory settings for devices with rated power supply voltages 24 VDC to 125 VDC
[2)] Factory settings for devices with rated power supply voltages 110 VDC to 220 VDC

Jumpers X71, X72 and X73 on the input/output board B-I/O-2 are for the setting **Bus Address**. The jumpers must not be changed. The following two tables list the jumper presettings.

The mounting locations are shown in Figures 3-3 to 3-4.

Table 3-20 Jumper settings of the **Board Address** of the input/output board B-I/O-2 for housing size $^1/_1$

Jumper	**Mounting Location**	
	Slot 33 left side	**Slot 19 left side**
X71	1-2 (H)	1-2 (H)
X72	2-3 (L)	1-2 (H)
X73	1-2 (H)	1-2 (H)

3.1.2.4 Interface Modules

Exchanging Interface Modules

The interface boards are located on the C–CPU-2 board (in Figures 3-3 and 3-4).

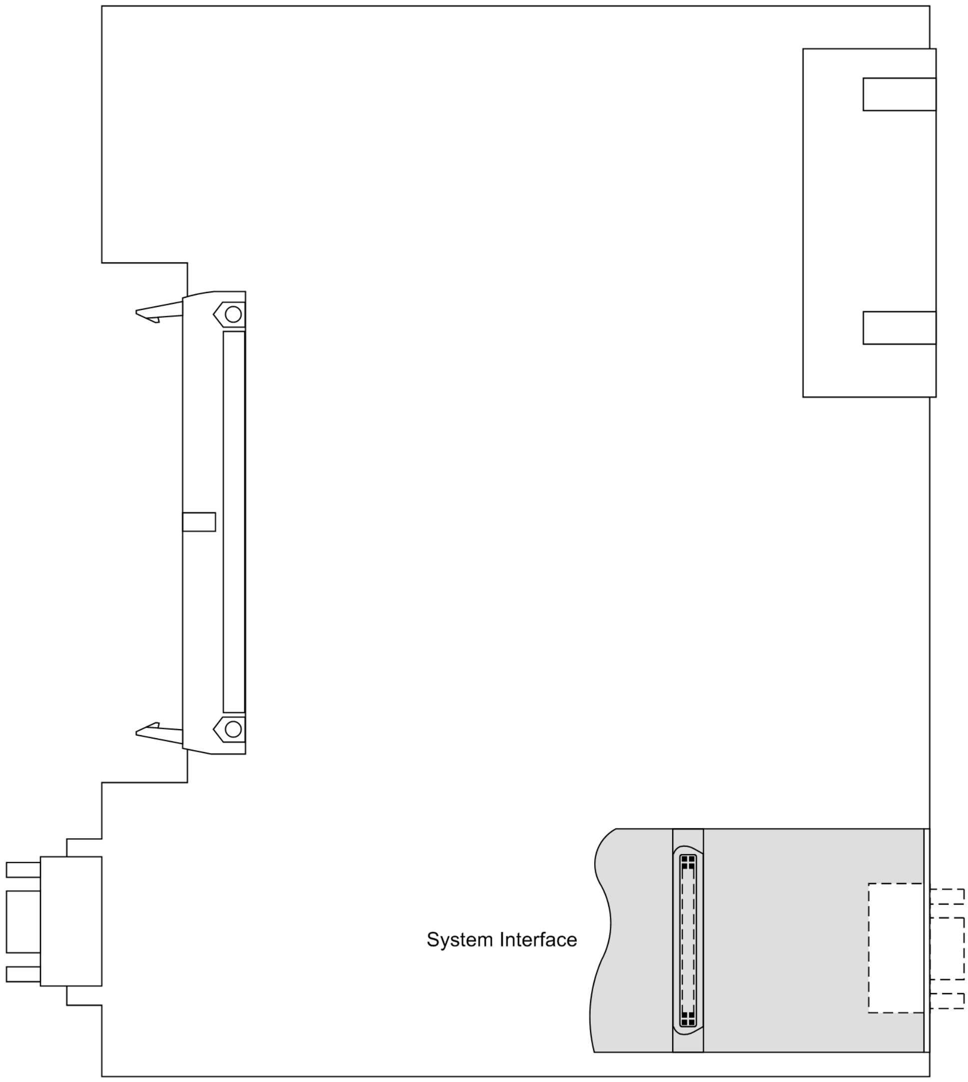


Figure 3-11 C-CPU-2 board with interface module

Please note the following:

- The interface modules can only be replaced in devices for panel flush mounting and cubicle mounting.
- Use only interface modules that can be ordered ex-factory via the ordering code (see also Appendix, Section A.1).
- You may have to ensure the termination of the interfaces featuring bus capability according to the margin heading “RS485 Interface”.

Table 3-21 Exchangeable Interface Modules

Interface	Mounting Location / Port	Exchange Module
System interface	O	Only interface modules that can be ordered in our facilities via the order key (see also Appendix, Section A.1).

The order numbers of the exchange modules can be found in the Appendix in Section A.1, Accessories.

RS232 Interface

Interface RS232 can be modified to interface RS485 and vice versa (see Figures 3-12 and 3-13).

Figure 3-11 shows the PCB of the C-CPU-2 with the layout of the boards.

The following figure shows the location of the jumpers of interface RS232 on the interface module.

The fibre optics module is controlled via an RS232 interface module at the associated CPU interface slot. For this application type the jumpers X12 and X13 on the RS232 module are plugged in position 2-3.

Jumper	Terminating Resistors Disconnected
X3	1-2 *)
X4	1-2 *)

*) Default Setting

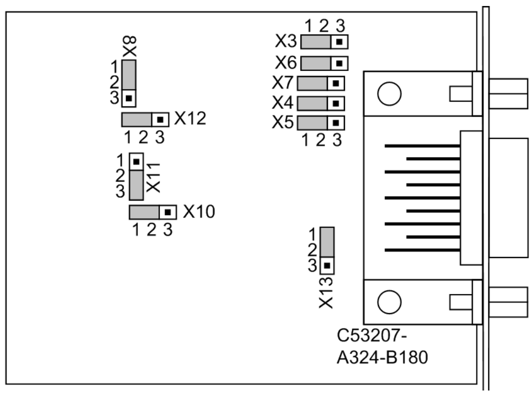


Figure 3-12 Location of the jumpers for configuration of RS232

Terminating resistors are not required for RS232. They are disconnected.

With jumper X11 the flow control which is important for modem communication is enabled.

Table 3-22 Jumper setting for **CTS (Flow Control)** on the interface board

Jumper	/CTS from Interface RS232	/CTS Controlled by /RTS
X11	1-2	2-3 [1)]

[1)] Factory Setting

Jumper setting 2-3: The connection to the modem is usually established with a star coupler or fibre-optic converter. Therefore the modem control signals according to RS232 standard DIN 66020 are not available. Modem signals are not required since communication to SIPROTEC® 4 devices is always carried out in the half duplex mode. Please use the connection cable with order number 7XV5100-4.

Jumper setting 1-2: This setting makes the modem signals available, i. e. for a direct RS232 connection between the SIPROTEC® 0.4 device and the modem this setting can be selected optionally. We recommend to use a standard RS232 modem connection cable (converter 9-pin to 25-pin).

Note

For a direct connection to DIGSI® with interface RS232 jumper X11 must be plugged in position 2-3.

RS485 Interface

The following figure shows the location of the jumpers of interface RS485 on the interface module.

Interface RS485 can be modified to interface RS232 and vice versa, according to Figure 3-12.

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	2-3	1-2 *)
X4	2-3	1-2 *)

*) Default Setting

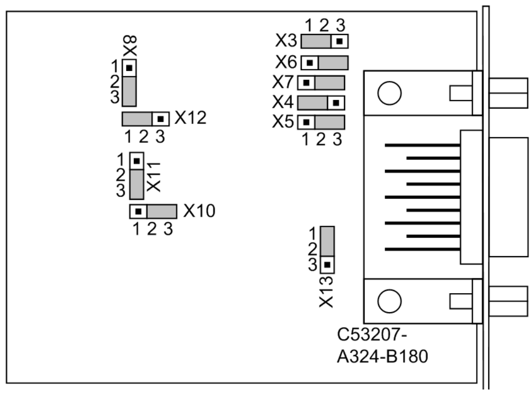


Figure 3-13 Position of matching resistors and the plug-in jumpers for configuration of the RS485 interface

PROFIBUS Interface

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	1-2	2-3 *)
X4	1-2	2-3 *)

*) Default Setting

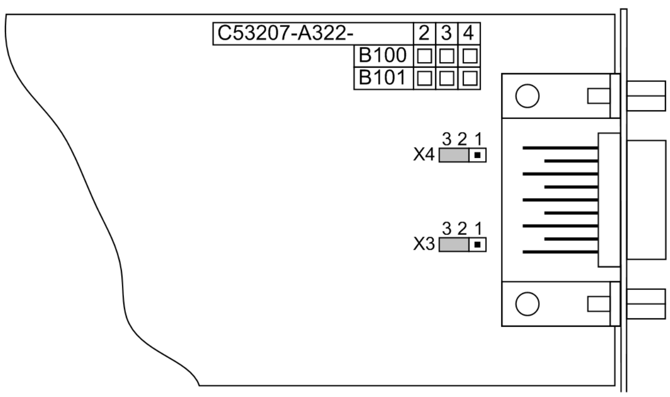


Figure 3-14 Position of the plug-in jumpers for the configuration of the terminating resistors at the interfaces PROFIBUS (FMS and DP), DNP3.0 and Modbus

Termination

For bus-capable interfaces a termination is necessary at the bus for each last device, i.e. terminating resistors must be connected. With the 7ST6 device, this concerns the variants with RS485 or PROFIBUS interfaces.

The terminating resistors are located on the RS485 or PROFIBUS interface module, which is on the board C-CPU-2 (No.1 in Figure 3-3 to 3-4), or directly on the PCB of the processor board C-CPU-2 (see margin heading “Processor Board C-CPU-2”, Table 3-7).

Figure 3-11 shows the C-CPU-2 P.C.B. with the layout of the boards.

The board with configuration as RS485 interface is shown in Figure 3-13, the module for the PROFIBUS interface in Figure 3-14.

For the configuration of the terminating resistors both jumpers have to be plugged in the same way.

On delivery the jumpers are set so that the terminating resistors are disconnected.

The terminating resistors can also be connected externally (e.g. to the connection module), see the following figure. In this case, the terminating resistors located on the RS485 or PROFIBUS interface module or directly on the PCB of the processor board C-CPU-2 must be de-energized.

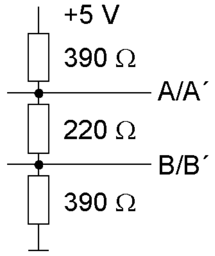


Figure 3-15 Termination of the RS485 interface (external)

3.1.2.5 Reassembly

The reassembly of the device is carried out in the following steps:

- Insert the boards carefully in the housing. The mounting locations of the boards are shown in Figures 3-3 to 3-4.
- First plug in the plug connectors of the ribbon cable onto the input/output boards I/O and then onto the processor board C-CPU-2. Avoid to bend connection pins! Do not apply force!
- Connect the plug connectors of the ribbon cable between the C-CPU-2 board and the front panel to the front panel plug connector. These activities are not necessary if the device has a detached operator panel. Instead of this, the connector of the ribbon cable connected to the 68-pin connector on the device rear panel must be plugged on the connector of the processor board C-CPU-2. The 7-pole X16 connector belonging to the ribbon cable must be plugged behind the D-subminiature female connector. The plugging position is not relevant in this context as the connection is protected against polarity reversal.
- Press the connector latches together.
- Attach the front cover and fix it again to the housing by means of the screws.
- Plug on the caps.
- Re-fasten the interfaces on the rear of the device housing.

3.1.3 Mounting

3.1.3.1 Panel Flush Mounting

Depending on the version, the device housing can be $^1/_2$ or $^1/_1$. For the $^1/_2$ housing size (Figure 3-16) there are four covers and four holes. For the $^1/_1$ housing size (Figure 3-17) there are six covers and six holes.

- Remove the 4 covers at the corners of the front cover, for size $^1/_1$ the two covers located centrally at the top and bottom also have to be removed. Thus the 4 respectively 6 elongated holes in the mounting flange are revealed and can be accessed.
- Insert the device into the panel cut-out and fasten it with four or six screws. Dimension drawings see Section 4.17.
- Mount the four or six covers.
- Connect the low-resistance operational and protective earth on the rear plate of the device, using at least one M4 screw for the device earthing. The cable-cross section used must correspond to the largest connected cable cross-section, at least being 2.5 mm^2.
- Establish connections via the plug-in or screw connections on the rear panel of the housing according to circuit diagram.

  For screw connections with forked lugs or direct connection, before inserting wires the screws must be tightened so that the screw heads are flush with the outer edge of the connection block.

  A ring lug must be centred in the connection chamber in such a way that the screw thread fits in the hole of the lug.

  Specifications regarding maximum cross sections, tightening torques, bending radii and tension relief as specified in the SIPROTEC® 4 System Description (Order No. E50417-H1176-C151) must be observed. You will find hints in the short description included in the device.

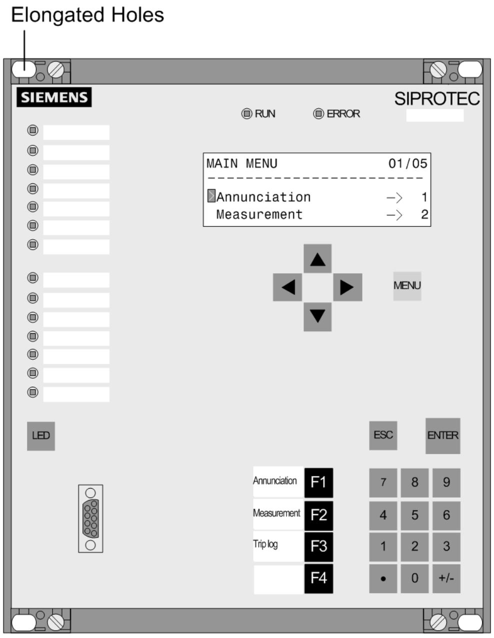


Figure 3-16 Example of panel flush mounting of a device (housing size $^1/_2$)

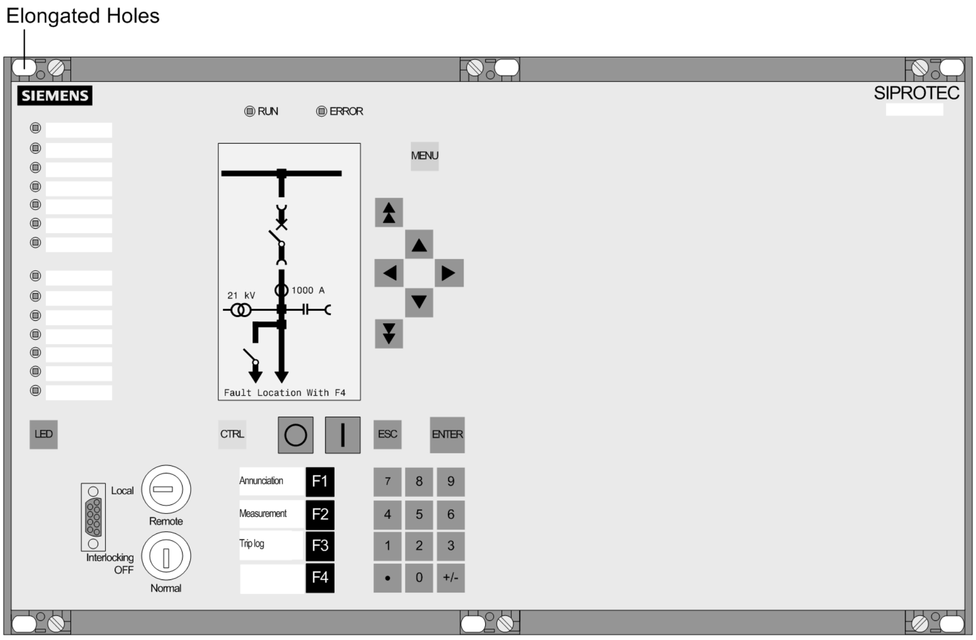


Figure 3-17 Example of panel flush mounting of a device (housing size $^1/_1$)

3.1.3.2 Rack and Cubicle Mounting

2 mounting brackets are required for incorporating a device in a rack or cubicle. The order number is given in the Appendix, Subsection A.1.

For the $^1/_2$ housing size (Figure 3-18), there are four covers and four holes. For the $^1/_1$ housing size (Figure 3-19) there are six covers and six holes.

- First the two mounting brackets in the rack or cubicle are screwed loosely by means of 4 screws each.
- Remove the 4 covers at the corners of the front cover, for size $^1/_1$ the two covers located centrally at the top and bottom also have to be removed. Thus the 4 respectively 6 elongated holes in the mounting flange are revealed and can be accessed.
- Fasten the device to the mounting brackets with four or six screws.
- Mount the four or six covers.
- Next, tighten the 8 screws of the mounting brackets in the frame or cabinet.
- Connect the low-resistance operational and protective earth on the rear plate of the device, using at least one M4 screw for the device earthing. The cable cross-section used must correspond to the largest connected cable cross-section, at least being 2.5 mm^2 (AWG 14).
- Establish connections via the plug-in or screw connections on the rear panel of the housing according to circuit diagram.

  For screw connections with forked lugs or direct connection, before inserting wires the screws must be tightened so that the screw heads are flush with the outer edge of the connection block.

  A ring lug must be centred in the connection chamber in such a way that the screw thread fits in the hole of the lug.

  Specifications regarding maximum cross sections, tightening torques, bending radii and tension relief as specified in the SIPROTEC® 4 System Description (Order No. E50417-H1176-C151) must be observed. You will find hints in the short description included in the device.

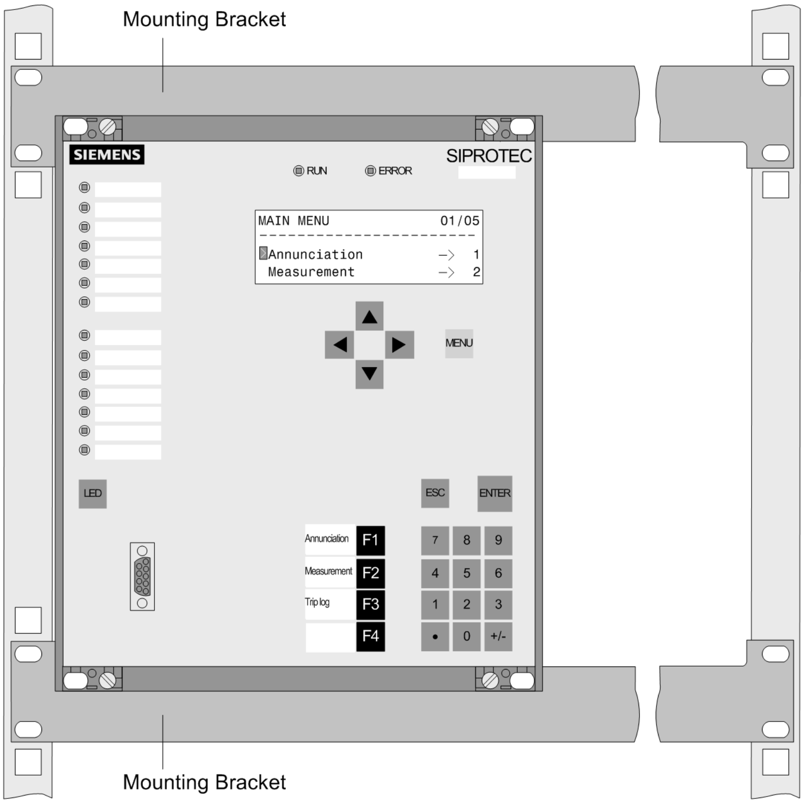


Figure 3-18 Example of rack or cubicle mounting of a device (housing size $^1/_2$)

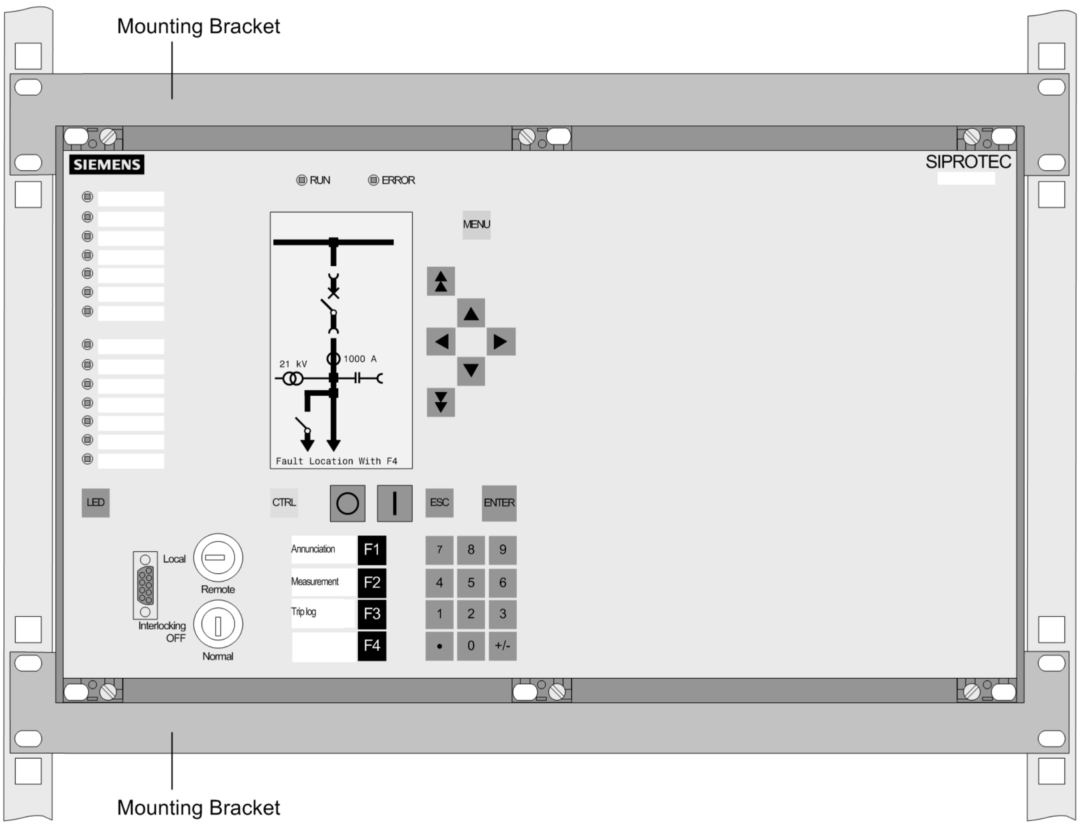


Figure 3-19 Example of rack or cubicle mounting of a device (housing size $^1/_1$)

3.2 Checking Connections

3.2.1 Checking Data Connections of Serial Interfaces

The following tables illustrate the pin assignment of the various serial device interfaces and of the time synchronization interface. The position of the connections can be seen in the following figure.

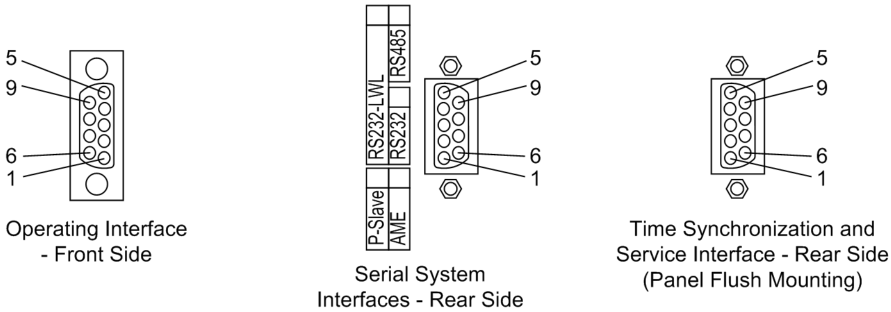


Figure 3-20 9-pin subminiature female connectors

Operator Interface

When the recommended communication cable is used, correct connection between the SIPROTEC® 4 device and the PC is automatically ensured. See the Appendix for an ordering description of the cable.

Service Interface

Check the data connection if the service interface (Port C) is used for communication with the device via fix wiring or a modem. If the service port is used as input for one or two RTD-boxes, verify the interconnection according to one of the connection examples given in the Appendix A.3.

System Interface

For versions equipped with a serial interface to a control centre, the user must check the data connection. The visual check of the assignment of the transmission and reception channels is of particular importance in the context. With RS232 and fibre optic interfaces, each connection is dedicated to one transmission direction. For this reason, the data output of the first device must be connected with the data input of the second device and vice-versa.

With data cables, the connections are designated according to DIN 66 020 and ISO 2110:

- TxD = Data Output
- RxD = Data Input
- $\overline{\text{RTS}}$ = Request to Send
- $\overline{\text{CTS}}$ = Clear to Send
- GND = Signal/Chassis Ground

The cable shield is to be earthed at **both** ends. In case of an extreme electromagnetic environment, a separate, individually shielded pair of wires can be incorporated for improving the interference immunity of the GND.

Termination

The RS485 interface is capable of half-duplex operation with signals A/A' and B/B' with the common reference potential C/C' (GND). It is necessary to check that the terminating resistors are connected to the bus only at the last unit, and not at other devices on the bus. The jumpers for the terminating resistors are on the interface module RS485 (see Figure 3-12) or on the PROFIBUS RS485 (see Figure 3-14), or in the 7ST6 directly on the C–CPU–2 (see Figure 3-5 and Table 3-7). Terminating resistors can also be implemented outside the device (e.g. in the plug connectors) as shown in Figure 3-6. In this case, the terminating resistors located on the module must be disabled.

If the bus is extended, make sure again that only terminating resistors at the last device to the bus are energized. The remaining terminating resistors at the bus may not be energized.

Time Synchronization Interface

It is optionally possible to process 5 V-, 12 V- or 24 V- time synchronization signals, provided that they are carried to the inputs named in the following table.

Table 3-23 D-subminiature connector assignment of the time synchronization interface

Pin No.	Description	Signal Meaning
1	P24_TSIG	Input 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return Line
4	– [1)]	– [1)]
5	SHIELD	Shield Potential
6	–	–
7	P12_TSIG	Input 12 V
8	P_TSYNC [1)]	Input 24 V [1)]
9	SHIELD	Shield potential

[1)] Assigned, but cannot be used

Fibre-Optic Cables

WARNING!

Warning of laser rays!

Non-observance of the following measure can result in death, personal injury or substantial property damage.

Do not look directly into the fibre-optic elements!

The transmission via fibre optics is particularly insensitive to electromagnetic interference and thus ensures galvanic isolation of the connection. Transmit and receive connections are represented by symbols.

The normal setting of the character idle state for the fibre optic cable interface is "Light off". If the character idle state is to be changed, use the operating program DIGSI®, as described in the SIPROTEC® 4 System Description.

3.2.2 Checking System Connections

WARNING!

Warning of hazardous voltages

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Only qualified people who are familiar with and observe the safety procedures and precautionary measures shall perform the inspection steps.

Caution!

Be careful when operating the device connected to a battery charger without a battery

Non-observance of the following measure can lead to unusually high voltages and consequently, the destruction of the device.

Do not operate the device on a battery charger without a connected battery. (For limit values see also Technical Data, Section 4.1).

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, the device should be in the final operating environment for at least 2 hours to equalize the temperature, to minimize humidity and avoid condensation. Connections are checked with the device at its final location. The system must first be switched off and earthed.

Proceed as follows in order to check the system connections:

- The protective circuit breakers of the auxiliary power supply and of the measuring voltage must be switched OFF.
- Check the continuity of all current and voltage transformer connections against the system and connection diagrams:
  - Is the earthing of the current transformers correct?
  - Do the current transformer connections have the same polarity?
  - Is the phase assignment of the current transformers correct?
  - Is the earthing of the voltage transformers correct?
  - Do the voltage transformer connections have the same, correct polarity?
  - Is the phase assignment of the voltage transformers correct?
- Check the functions of all test switches that may be installed for the purposes of secondary testing and isolation of the device. Of particular importance are test switches in current transformer circuits. Be sure these switches short-circuit the current transformers when they are in the test mode (open).

- The short-circuit feature of the current circuits of the device is to be checked. This may be performed with an ohmmeter or other test equipment for checking continuity. Make sure that terminal continuity is not wrongly simulated in reverse direction via current transformers or their short circuit links.
  - Remove the screws of the front cover.
  - Remove the ribbon cable connected to the I/O board with the measured current inputs (on the front side it is the right printed circuit board). Furthermore, remove the printed circuit board so that there is no more contact anymore with the plug-in terminal of the housing.
  - Check continuity on the connection side, for each current connection pair.
  - Insert the board again firmly; press the ribbon cable with care. Avoid to bend connection pins! Do not apply force!
  - At the terminals of the device, again check continuity for each pair of terminals that receives current from the CTs.
  - Reinstall the front cover and tighten it with screws.
- Connect an ammeter in the supply circuit of the power supply. A range of about 2.5 A to 5 A for the meter is appropriate.
- Switch on mcb 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.
- Switch off mcb for the auxiliary power supply.
- Remove ammeter; re-establish normal auxiliary voltage connection.
- Switch on mcb for the auxiliary power supply.
- Switch on voltage transformer protective circuit breaker.
- Switch off mcb for the voltage transformers and the auxiliary power supply.
- Check the trip and close circuits to the power system circuit breakers.
- Check control lines from and to the other devices.
- Check signalling lines.
- Switch on m.c.b.

3.3 Commissioning

WARNING!

Warning of hazardous voltages when operating electrical devices

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.

The device is to be earthed to the substation earth before any other connections are made.

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 removing voltage from the power supply, wait a minimum of 10 seconds before re-energizing the power supply. This wait allows the initial conditions to be firmly established before the device is re-energized.

The limit values given in Technical Data must not be exceeded, neither during testing nor during commissioning.

When testing the device with secondary test equipment, make sure that no other measured values are connected and that the TRIP command lines and possibly the CLOSE command lines to the circuit breakers are interrupted, unless otherwise specified.

DANGER!

Hazardous voltages during interruptions in secondary circuits of current transformers

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Short-circuit the current transformer secondary circuits before current connections to the device are opened.

For the commissioning switching operations have to be carried out. A prerequisite for the prescribed tests is that these switching operations can be executed without danger. They are accordingly not meant for operational checks.

WARNING!

Warning of dangers evolving from improper primary tests

Non-observance of the following measure can result in death, personal injury or substantial property damage.

Primary tests may only be carried out by qualified persons who are familiar with commissioning protection systems, with managing power systems and the relevant safety rules and guidelines (switching, earthing etc.).

3.3.1 Test Mode 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.5).

If **Test mode** is activated, then a message sent by a SIPROTEC®4 device to the main system has an additional test bit. This bit allows the indication to be recognized as resulting from testing and not an actual fault or power system event. In addition to this, the user can determine by activating the **transmission block** that no indications at all are transferred via the system interface during a test operation.

The SIPROTEC® 4 System Description describes in detail how to activate and deactivate test mode and blocked data transmission (Order No. E50417-H1176-C151). Note that when DIGSI® is being used, the program must be in the **Online** operating mode for the test features to be used.

3.3.2 Checking Time Synchronization

If external time synchronization sources are used, the data of the time source (antenna system, time generator) are checked (see Chapter 4 under “Time Synchronization”). A correct function (IRIG B, DCF77) is recognized in such a way that 3 minutes after the startup of the device the clock status is displayed as “synchronized”, accompanied by the indication “Alarm Clock OFF”.

Table 3-24 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 Summer time

3.3.3 Testing System Interfaces

Prefacing Remarks

If the device features a system interface and uses it to communicate with the control centre, the DIGSI® device operation can be used to test if indications are transmitted correctly. This test option should however definitely not be used while the device is in service on a “live” system.

DANGER!

The sending or receiving of indications via the system interface by means of the test function is a real information exchange between the SIPROTEC device and the control centre. Connected operating equipment such as circuit breakers or disconnectors can be switched in this way!

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during real operation performing transmission and reception of indications via the system interface.

Note

After termination of the hardware test, the device will reboot. 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 on **Generate Indications** shown in the list view. The dialog box **Generate Indications** opens (refer to the following figure).

Structure of the Dialog Box

The **Indication** column shows the display texts of all indications configured in the matrix to the system interface. The **SETPOINT** column serves to specify a value for the indications to be tested. Depending on the indication type, several input fields are offered (e.g. ***ON***/ ***OFF***). By double-clicking onto one of the fields the required value can be selected from the list.

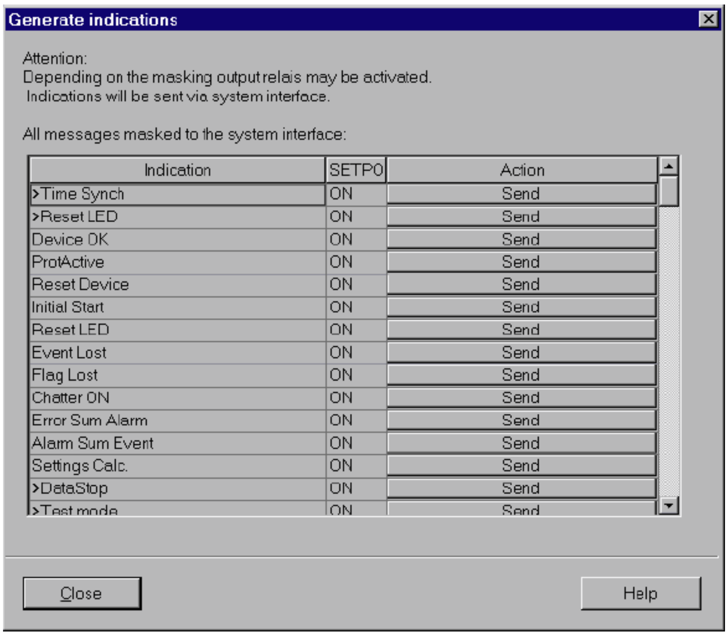


Figure 3-21 System interface test with dialog box: Generate Indications — example

Changing the Operating State

On clicking one of the buttons in the column **Action** you will be prompted for the password No. 6 (for hardware test menus). After you have entered the password correctly you can send the indications individually. To do so, click on the button **Send** on the corresponding line. The corresponding indication is sent 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 Indication Direction

For all information that is transmitted to the substation control system, test in **Status Scheduled** the desired options in the list which appears:

- Make sure that each checking process is carried out carefully without causing any danger (see above and refer to DANGER!).
- Click on Send in the function to be tested and check whether the transmitted information reaches the substation control system and shows the desired reaction. Data which are normally linked via binary inputs (first character “>”) are likewise indicated to the substation control system with this procedure. The function of the binary inputs itself is tested separately.

Exiting the Procedure

To end the system interface test, click **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 issued by the substation control system. Check whether the reaction is correct.

3.3.4 Checking the 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 e.g. to check the correct connection to the system during commissioning. This test option should however definitely not be used while the device is in service on a “live” system.

DANGER!

The sending or receiving of indications via the system interface by means of the test function is a real information exchange between the SIPROTEC device and the control centre. Connected operating equipment such as circuit breakers or disconnectors can be switched in this way!

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during real operation performing transmission and reception of indications via the system interface.

Note

After termination of the hardware test, the device will reboot. All annunciation buffers are erased. If required, these buffers should be extracted with DIGSI® prior to the test.

The hardware 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 in the list view on **Device Inputs / Outputs**. The dialog box of the same name opens (see the following figure).

Structure of the Dialog Box

The dialog box is divided into three groups: **BI** for binary inputs, **BO** for output relays, and **LED** for light-emitting diodes. On the left of each group is an accordingly labelled panel. By double-clicking a button, information regarding the associated group can be shown or hidden.

In the column **Actual** the present (physical) state of the hardware component is displayed. The display is made in symbols. The actual states of the binary inputs and outputs are displayed by the symbol of opened and closed switch contacts, those of the LEDs by a symbol of a lit or extinguished LED.

The opposite state of each element is displayed in the column **Scheduled**. The display is made in plain text.

The right-most column shows the commands or indications that are configured (masked) to the hardware components.

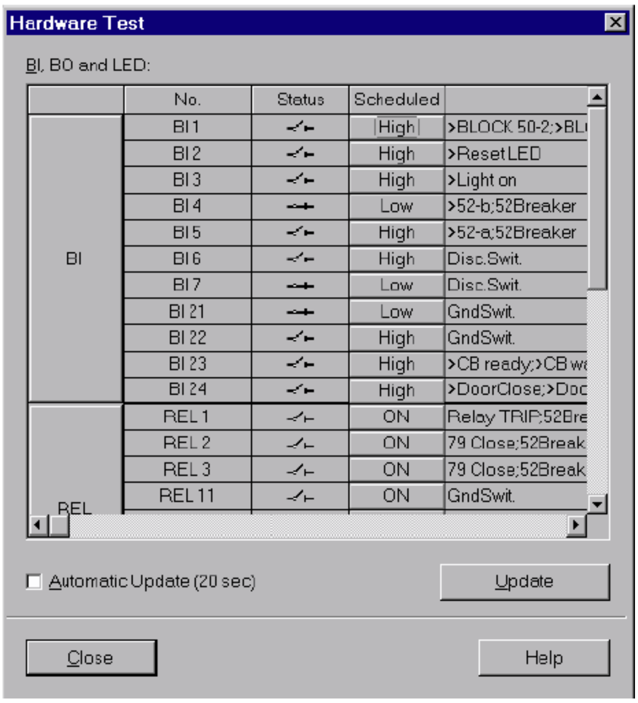


Figure 3-22 Test of the binary inputs and outputs – example

Changing the Operating State

To change the operating state of a hardware component, click on the associated button in the **Scheduled** column.

Before executing the first change of the operating state the password No. 6 is demanded (provided that it has been activated). After entry of the correct password a change of state will be executed. Further state changes remain possible while the dialog box is open.

Test of the Output Relays

Each individual output relay can be energized allowing a check of the wiring between the output relays of the protection device and the system, without having to generate the indication that is assigned to the relay. As soon as the first change of state for any one of the output relays is initiated, all output relays are separated from the internal device functions, and can only be operated by the hardware test function. This means that, e.g. a TRIP command coming from a protection function or a control command from the operator panel to an output relay cannot be executed.

Proceed as follows in order to check the output relay:

- 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** column in the dialog box.
- The test sequence must be terminated (refer to margin heading “Exiting the Procedure”), to avoid the initiation of inadvertent switching operations by further tests.

Test of the Binary Inputs

To test the wiring between the system and the binary inputs of the protection device, the condition in the system which initiates the binary input must be generated and the response of the device checked.

To do so, open the dialog box **Hardware Test** again to view the physical position of the binary input. The password is not yet required.

Proceed as follows in order to check the binary inputs:

- Each state in the system which causes a binary input to pick up must be generated.
- Check the reaction in the **Actual** column of the dialog box. To do this, the dialog box must be updated. The options may be found below under the margin heading "Updating the Display".
- Terminate the test sequence (see below under the margin heading "Exiting the Procedure").

If, however, the effect of a binary input must be checked without carrying out any switching in the system, it is possible to trigger individual binary inputs with the hardware test function. As soon as the first state change of any binary input is triggered and the password No. 6 has been entered, all binary inputs are separated from the system and can only be activated via the hardware test function.

Test of the LEDs

The LEDs may be tested in a similar manner to the other input/output components. As soon as the first state change of any LED has been triggered, all LEDs are separated from the internal device functionality and can only be controlled via the hardware test function. This means e.g .that no LED is illuminated anymore by a protection function or by pressing the LED reset button.

Updating the Display

When the dialog box **Hardware Test** is opened, the present conditions of the hardware components at that moment are read in and displayed.

An update occurs:

- 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 (20sec)** field is marked.

Exiting the Procedure

To end the hardware test, click on **Close**. The dialog box closes. The device becomes unavailable for a brief start-up period immediately after this. Then all hardware components are returned to the operating conditions determined by the system settings.

3.3.5 Tests for Circuit 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 can be tested under practical conditions.

Because of the manifold application facilities and various configuration possibilities of the system it is not possible to give a detailed description of the necessary test steps. It is important to observe local conditions and protection and system drawings.

Before starting the circuit breaker tests it is recommended to isolate at both ends the feeder which is to be tested, 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, it is recommended primarily to interrupt the tripping commands to the adjacent (busbar) breakers, e.g. by interrupting the corresponding pickup voltage supply.

Before the breaker is closed again for normal operation, the trip command of the feeder protection routed to the circuit breaker must be disconnected so that the trip command can only be initiated by the breaker failure protection.

Although the following 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.

Busbar Tripping

The most important thing is the check of the correct distribution of the trip commands to the adjacent circuit breakers in case of breaker failure.

The adjacent circuit breakers are those of all feeders which must be tripped in order to ensure interruption of the fault current should the local breaker fail. These are therefore the circuit breakers of all feeders which feed the busbar or busbar section to which the feeder with the fault is connected.

A general detailed test guide cannot be specified, because the layout of the surrounding circuit breakers largely depends on the system topology.

In particular with multiple busbars the trip distribution logic for the surrounding circuit breakers must be checked. Here 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 of the Checks

All temporary measures taken for testing must be undone, e.g. especially switching states, interrupted trip commands, changes to setting values or individually switched off protection functions.

3.3.6 Current and Voltage Test

Load Current ≥ [10% I N]

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 should pick up in the device. 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 (see Section 2.1.3.1).

Indications from the symmetry monitoring could occur because there are actually asymmetrical conditions in the network. If these asymmetrical conditions are normal service conditions, the corresponding monitoring functions should be made less sensitive (see Section 2.16).

Current and Voltage Values

Currents and voltages can be viewed in the display field on the front of the device or the operator interface using a PC. They can be compared to the actual measured values, 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.

Voltage Transformer Miniature Circuit Breaker (VT mcb)

Open the miniature circuit breaker of the feeder voltage transformers. The measured voltages in the operational measured values appear with a value close to zero (small measured voltages are of no consequence).

Check in the spontaneous indications that the VT mcb trip was entered (indication `“>FAIL:Feeder VT”` “ON” in the spontaneous indications). It has to be assured beforehand that the position of the VT mcb is connected to the device via a binary input.

Close the VT mcb again: The above indication appears in the spontaneous indications as “OFF”, i.e. `“>FAIL:Feeder VT”` “OFF”.

If one of the indications does not appear, the connection and allocation of these signals must be checked.

If the “ON” state and the “OFF” state are swapped, the contact type (H–active or L–active) must be checked and remedied.

If a busbar voltage is used (for voltage or synchronism check) and the assigned VT mcb is connected to the device, the following function must also be checked:

If the VT mcb is open the indication “ON” appears, if it is closed the indication “OFF” is displayed.

Switch off the protected power line.

3.3.7 Direction Check with Load Current

Load Current ≥ [10% I N]

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 $0.1 \cdot I_N$. 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 a 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, where the forward direction (measuring direction) extends from the busbar towards the line (see the following figure).

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.

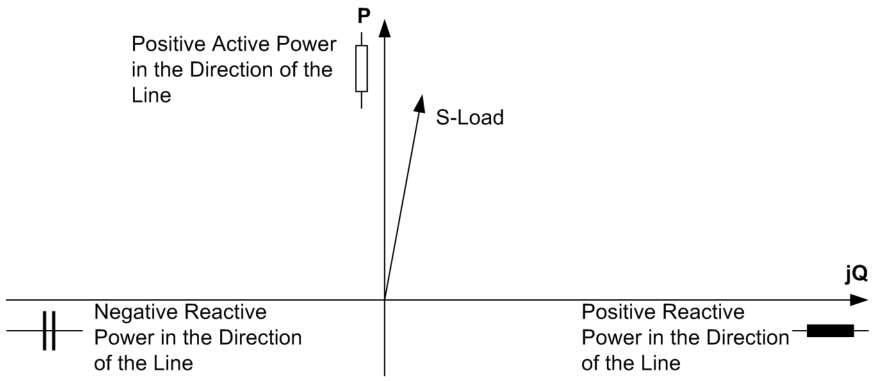


Figure 3-23 Apparent Load Power

The power measurement provides an initial indication as to whether the measured values have the correct polarity. If both the active power as well as the reactive power have the wrong sign, the polarity in address 201 **CT Starpoint** must be checked and rectified.

However, power metering itself is not able to detect all connection errors. Therefore, the impedance of the phase loop is read out as well. This impedance can also be found as primary and secondary quantity in the operational measured values.

In addition, the following applies for the impedance when the load is in the first quadrant:

R, **X** both positive, when power flows into the line,

R, **X** both negative, when power flows towards the busbar.

In this case the normal situation is assumed, where the forward direction (measuring direction) extends from the busbar towards the line. In the case of capacitive load, the X-component may have the opposite sign.

Finally, switch off the protected power line.

3.3.8 Measuring the Operating Time of the Circuit Breaker

Only for Synchronism Check

If the device is equipped with the function for synchronism and voltage check and it is applied, it is necessary - under asynchronous system conditions - that the operating time of the circuit breaker is measured and set correctly when closing. If the synchronism check function is not used or only for closing under synchronous system conditions, this subsection is irrelevant.

For measuring the operating time a setup as shown in Figure 3-24 is recommended. The timer is set to a range of 1 s and a graduation of 1 ms.

The circuit breaker is connected manually. At the same time the timer is started. After closing the poles of the circuit breaker, the voltage U_{Line} appears and the timer is stopped. The time displayed by the timer is the real circuit breaker closing time.

If the timer is not stopped due to an unfavourable closing moment, the attempt will be repeated.

It is particularly favourable to calculate the mean value from several (3 to 5) successful switching attempts.

Set the calculated time in address 239 as **T-CB close** (under **P.System Data 1**). Select the next lower settable value.

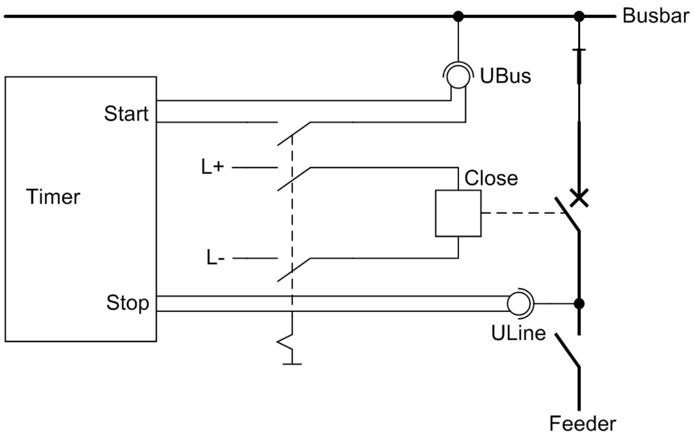


Figure 3-24 Measurement of the circuit breaker closing time

3.3.9 Testing User-Defined Functions

The device has a vast capability for allowing functions to be defined by the user, especially with the CFC logic. Any special function or logic added to the device must be checked.

Naturally, general test procedures cannot be given. Configuration of these functions and the set value conditions must be actually known beforehand and tested. Possible interlocking conditions of switching devices (circuit breakers, disconnectors, earth switch) are of particular importance. They must be considered and tested.

3.3.10 Trip and Close Test with the Circuit Breaker

The circuit breaker and tripping circuits can be conveniently tested by the device 7ST6.

The procedure to do so is described in detail in the SIPROTEC® System Description.

If the check does not produce the expected results, the cause may be established from the text in the display of the device or the PC. If necessary, the connections of the circuit breaker auxiliary contacts must be checked.

3.3.11 Switching Test of the Configured Operating Equipment

Switching via Command Input

If the configured operating devices were not switched sufficiently in the hardware test already described, all configured switching devices must be switched on and off from the device via the integrated control element. The feedback information of the circuit breaker position injected using binary inputs is read out at the device and compared with the actual breaker position. For devices with graphic display this is easy to do with the control display.

The switching procedure is described in the SIPROTEC® 4 System Description (Order No. E50417-H1176-C151). The switching authority must be set in correspondence with the source of commands used. With the switching mode, you can choose between locked and unlocked switching. In this case, you must be aware that unlocked switching is a safety risk.

Control from a Remote Control Centre

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 Oscillographic Recordings for Test

In order to be able to test the stability of the protection also during switch-on procedures, closing tests can also be carried out at the end. Oscillographic records obtain the maximum information about the behaviour of the protection.

Requirement

Along with the capability of storing fault recordings via pickup of the protection function, the 7ST6 also has the capability of initiating a measured value recording using the operator control program DIGSI® using the serial interface and via binary inputs. 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.

Those that are externally triggered (that is, without a protective element pickup) are processed by the device as a normal oscillographic record. For each oscillographic record a fault record is created which is given its individual number to ensure that assignment can be made properly. However, these recordings are not displayed in the fault indication buffer, as they are not fault events.

Start Triggering Oscillographic Recording

To trigger test measurement recording with DIGSI®, click on **Test** in the left part of the window. Double-click in the list view the entry **Test Wave Form** (see Figure 3-25).

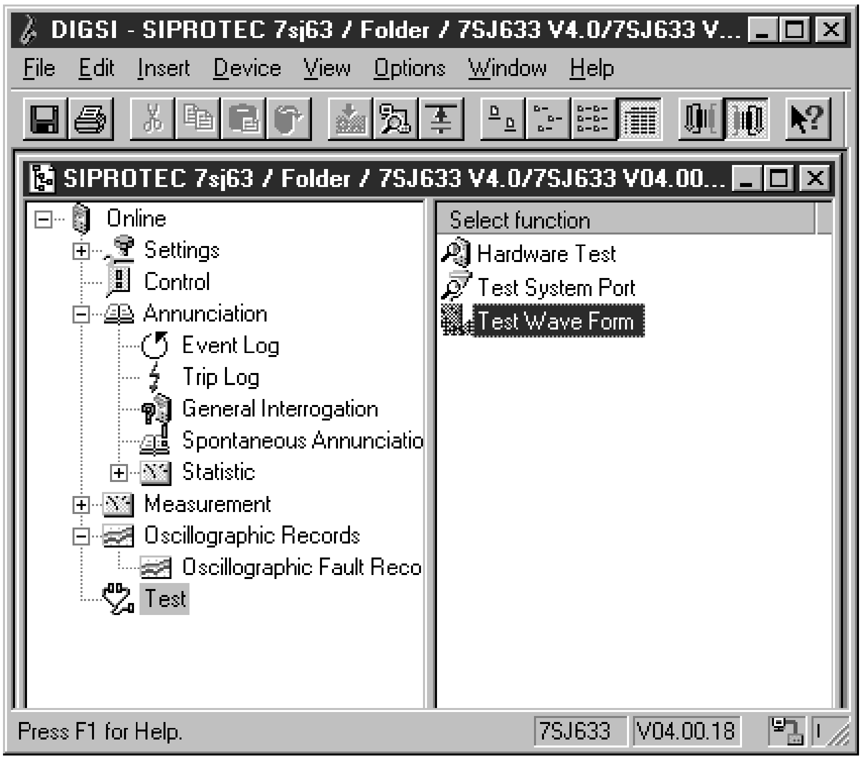


Figure 3-25 Triggering oscillographic recording with DIGSI® – example

Oscillographic recording is immediately started. During recording, an indication is given in the left part of the status bar. Bar segments also inform you of the progress of the operation.

The SIGRA or the Comtrade Viewer program is required to view and analyse the oscillographic data.

3.4 Final Preparation of the Device

The used terminal screws must be tightened, including those that are not used. All the plug connectors are correctly inserted.

Caution!

Don´t use force! The tightening torques must not be exceeded as the threads and terminal chambers may otherwise be damaged!

The setting values should be checked again, if they were modified during the tests. Check if protection, control and auxiliary functions to be found with the configuration parameters are set correctly (Section 2.1.1, Functional Scope). All desired elements and functions must be set ***ON***. Ensure that a copy of the setting values is stored on the PC.

The user should check the device-internal clock and set/synchronize it if necessary, provided that it is not synchronized automatically. Further details on this subject are described in /1/.

The indication buffers are deleted under **Main Menu** → **Annunciation** → ***Set/Reset***, so that in the future they only contain information on actual events and states. The numbers in the switching statistics should be reset to the values that were existing prior to the testing.

The counters of the operational measured values (e.g. operation counter, if available) are reset under **Main Menu** → **Measurement** → ***Reset***.

Press the ESC key, several times if necessary, to return to the default display. The default display appears in the display, e.g. the display of operational measured value.

Clear the LEDs on the front panel by pressing the LED key, so that they only show real events and states. In this context, saved output relays are reset, too. Pressing the LED key also serves as a test for the LEDs on the front panel because they should all light when the button is pressed. If the LEDs display states relevant by that moment, these LEDs, of course, stay lit.

The green “RUN” LED must light up, whereas the red “ERROR” must not light up.

Close the protective switches. If test switches are available, then these must be in the operating position.

The device is now ready for operation.

■

Technical Data 4

This chapter provides the technical data of the device SIPROTEC® 4 7ST6 and its individual functions, including the limiting values that under no circumstances may be exceeded. The electrical and functional data for the maximum functional extent are followed by the mechanical specifications with dimension diagrams.

4.1 General

4.1.1 Analog Inputs and Outputs

Rated system frequency (depending on ordered version, or settable)	f_N	16.7 25, 50 or 60 Hz	

Current Inputs

Rated current	I_N	1 A or 5 A
Measuring range		100 I_N
Error limits		1% of I_N for $I \leq I_N$ 1% of I for $I > I_N$
Thermal loading (rms values)		100 I_N for 1 s 20 I_N for 10 s 4 I_N continuous
Dynamic loading (pulse current)		250·I_N for one half-cycle
Power consumption per phase		Approx. 0.05 VA at I_N = 1 A Approx. 0.3 VA at I_N = 5 A

Voltage Inputs

Rated voltage	U_N	80 V to 125 V (adjustable)
Measuring range		200 V
Error limits		1% of U_N for $U \leq U_N$ 1% of U for $U > U_N$
Voltage overload capacity		220 V continuous
Power consumption per phase		Approx. 0.1 VA

Measuring Transducer Inputs

Rated DC current	I_N	20 mA
Measuring range DC		–24 to +24 mA
Error limits		1% of I_N for $I \leq I_N$ 1% of I for $I > I_N$
Input resistance		Approx. 11 Ω
Overload capability		± 100 mA continuous

4.1.2 Ancillary Voltage

DC Voltage

Voltage supply via integrated converter			
Rated auxiliary voltage U_{Aux} DC	24/48 VDC	60/110/125 VDC	110/125/220/250 V DC
Admissible voltage ranges	19 to 58 VDC	48 to 150 VDC	88 to 300 VDC
Admissible AC ripple voltage, peak to peak	≤15 % of the auxiliary voltage		
Power input			
- Quiescent		Approx. 5 W	
- Energized	7ST6 1*	Approx. 8 W	
	7ST6 3*	Approx. 15 W	
Plus approx. 1.5 W per interface module			
Bridging time for power supply failure/short circuit	≥ 50 ms at U_{Aux} = 48 V and U_{Aux} ≥ 110 V		
	for 7ST61 50 ms at U_{Aux} = 24 V and U_{Aux} = 60 V for 7ST63 ≥ 25 ms at U_{Aux} = 24 V and ≥ 30 ms at U_{Aux} = 60 V		

4.1.3 Binary Inputs and Outputs

Binary Inputs

Variant	Quantity	
7ST61*	12 (configurable)	
7ST63*	38 (configurable)	
Rated voltage range	24 VDC to 250 VDC, in 3 ranges, bipolar	
Switching thresholds	Adjustable with jumpers	
- For rated voltages	24/48/60/110/125 VDC	U high ≥ 19 VDC U low ≤ 10 VDC
- For rated voltages	110/125/220/250 VDC	U high ≥ 88 VDC U low ≤ 44 VDC
- For rated voltages	220/250 VDC	U high ≥ 176 VDC U low ≤ 88 VDC
Current consumption, energized	Approx. 1.8 mA Independent of the control voltage	
Maximum admissible voltage	300 VDC	
Interference suppression with capacitive coupling	With an interference pulse of 200 V and a coupling capacity of 220 nF, repeat time > 60 ms	

Output Relays

Signalling/trip relays (see also terminal assignments in Appendix A)				
Number and information		According to the order variant (configurable)		
Order variant		NO contact (normal)	NO/NC contact (selectable)	Fast digital output BO1 and BO2
7ST61*3/7		16	4	2
7ST61*1/5		21	4	2
7ST63*		30	4	2
Switching capability	ON	1000 W or VA		
	OFF	30 VA 40 W resistive 25 W at L/R ≤ 50 ms		1000 W or VA
Switching voltage	AC	250 V		200 V
	DC	250 V		300 V
Continuous current per contact		5 A		
Continuous total current on common paths		5 A		—
Max. DC inrush current with a closing time of 0.5 s for the NO contact (this does not apply for the NC contact)		30 A		
Closing time approx.		8 ms		1 ms
Tripping time approx.		2 ms		11 ms
Bounce time approx.		2 ms		—

4.1.4 Communication Interfaces

Operator Interface

Connection	Front side, non-isolated, RS232, 9 pin DSUB port for connecting a personal computer
Operation	With DIGSI®
Transmission speed	Min. 4800 Baud; max. 115200 Baud; factory setting: 38400 Baud; Parity: 8E1
Channel distance	15 m (50 ft.)

Service / Modem Interface (optional)

	RS232/RS485/FO Acc. to ordered variant	Isolated interface for data transfer
	Operation	With DIGSI®
RS232/RS485		RS232/RS485 according to ordered variant
	Connection for flush-mounted housing	Rear panel, mounting location “C”, 9-pin D-subminiature female connector
	Test voltage	500 V; 50 Hz
	Transmission speed	Min. 4800 Baud; max. 115200 Baud Factory setting 38400 Baud
RS232		
	Channel distance	15 m (50 ft.)
RS485		
	Channel distance	1,000 m (3,300 ft.)

System Interface (optional)

RS232/RS485/FO Profibus RS485/Profibus FO according to the ordered variant	Isolated interface for data transfer to a control centre	
RS232		
	Connection for panel flush-mounted housing	Rear panel, mounting location “B” 9-pin D-subminiature female connector
	Connection for panel surface-mounted housing	9-pin D-subminiature female connector in console housing on the bottom
	Test voltage	500 V; 50 Hz
	Transmission speed	Min. 4800 Baud; max. 38400 Baud Factory setting 19200 Baud
	Channel distance	Max. 15 m (50 ft.)
RS485		
	Connection for panel flush-mounted housing	Rear panel, mounting location “B” 9-pin D-subminiature female connector
	Connection for panel surface-mounted housing	9-pin D-subminiature female connector in console housing on the bottom
	Test voltage	500 V; 50 Hz
	Transmission speed	Min. 4800 Baud, max. 38400 Baud Factory setting 19200 Baud
	Channel distance	Max. 1 km (3,300 ft.)
MODBUS RS485		
	Connection for panel flush-mounted housing	Rear panel, mounting location "B", 9-pin D-subminiature female connector
	For panel surface-mounted housing	In console housing on bottom
	Test voltage	500 V; 50 Hz
	Transmission speed	Up to 19200 Baud
	Channel distance	Max. 1,000 m (3,300 ft.)

Fibre optic cable (FO)		
	FO connector type	ST connector
	Connection for panel flush-mounted housing	Rear panel, mounting location “B”
	Connection for panel surface-mounted housing	In console housing on bottom
	Optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825-1/-2	Using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
	Channel distance	Max. 1.5 km (5,000 ft.)
	Character idle state	Selectable: factory setting “Light off”
Profibus RS 485 (FMS and DP)		
	Connection for panel flush-mounted housing	Rear panel, mounting location “B” 9-pin D-subminiature female connector
	Connection for panel surface-mounted housing	9-pin D-subminiature female connector in console housing on the bottom
	Test voltage	500 V; 50 Hz
	Transmission speed	Up to 12 MBaud
	Channel distance	1,000 m (3,300 ft.) at ≤ 93.75 kBd 500 m (1,150 ft.) at ≤ 187.5 kBd 200 m (660 ft.) at ≤ 1.5 MBaud 100 m (330 ft.) at ≤ 12 MBaud
Profibus FO (FMS and DP)		
	FO connector type	ST-connector single ring / double ring according to the order for FMS; for DP only double ring available
	Connection for panel flush-mounted housing	Rear panel, mounting location “B”
	Connection for panel surface-mounted housing	Please use version with Profibus RS485 in the console housing at the housing bottom as well as separate electrical/optical converter
	Transmission speed	Conversion by means of external OLM [1)] up to 1.5 MBaud ≥ 500 kBaud for normal version ≤ 57600 Baud with detached operator panel
	Recommended speed:	> 500 kBd
	Optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825-1/-2	Using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
	Transmission distance between two modules with redundant optical ring topology and optical fibre 62.5/125 m	2 m (6.6 ft.) with plastic fibre 500 kB/s max. 1.6 km (5,250 ft.) 1500 kB/s 530 m (1,738 ft.)
	Character idle state (status for "No character")	Light OFF
	Max. number of modules in optical rings with 500 kB/s or 1500 kB/s	41

MODBUS FO		
	FO connector type	ST connector transmitter/receiver
	Connection for panel flush-mounted housing	Rear panel, mounting location "B"
	For panel surface-mounted housing	In console housing on bottom
	Transmission speed	Up to 19,200 Baud
	Optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825–1/–2	Using glass fibre 50/125 μm or using glass fibre 62.5/125 μm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 μm
	Channel distance	Max. 1.5 km (5,000 ft.)
DNP3.0 RS485		
	Connection for panel flush-mounted housing	Rear panel, mounting location “B”, 9-pin D-subminiature female connector
	Connection for panel surface-mounted housing	In console housing
	Test voltage	500 V; 50 Hz
	Transmission speed	Up to 19200 Baud
	Channel distance	Max. 1 km (3,300 ft.)
DNP3.0 Optical fibre		
	FO connector type	ST–connector receiver/transmitter
	Connection for panel flush-mounted housing	Rear panel, mounting location “B”
	Connection for panel surface-mounted housing	In console housing
	Transmission speed	Up to 19200 Baud
	Optical wavelength	λ = 820 nm
	Laser Class 1 according to EN60825-1/-2	Using glass fibre 50/125 μm or Using glass fibre 62.5/125 μm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 μm
	Channel distance	Max. 1.5 km (5,000 ft.)

Time Synchronization Interface

Time synchronization	DCF 77/IRIG B-Signal (telegram format IRIG-B000)
Connection for panel flush-mounted housing	Rear panel, mounting location “A”; 9-pin D-subminiature female connector
Connection for panel surface-mounted housing	At two-tier terminals on housing bottom
Nominal signal voltages	Selectable 5 V, 12 V or 24 V

Signal Levels and Burdens:			
	Nominal Signal Input Voltage		
	5 V	**12 V**	**24 V**
U_{IHigh}	6.0 V	15.8 V	31 V
U_{ILow}	1.0 V at I_{ILow} = 0.25 mA	1.4 V at I_{ILow} = 0.25 mA	1.9 V at I_{ILow} = 0.25 mA
I_{IHigh}	4.5 mA to 9.4 mA	4.5 mA to 9.3 mA	4.5 mA to 8.7 mA
R_I	890 Ω at U_I = 4 V	1930 Ω at U_I = 8.7 V	3780 Ω at U_I = 17 V
	640 Ω at U_I = 6 V	1700 Ω at U_I = 15.8 V	3,560 Ω at U_I = 31 V

Operating Modes for Time Tracking

1	Internal	Internal synchronization using RTC (default)
2	IEC 60870–5–103	Rear panel, mounting location “A”; 9-pin D-subminiature female connector
3	Time signal IRIG B	At two-tier terminals on housing bottom
4	Time signal DCF77	Selectable 5 V, 12 V or 24 V
5	Time signal Sync. Box	External synchronization using SIMEAS Sync. Box
6	Pulse via binary input	External synchronization with pulse via binary input
7	Field bus	External synchronization using field bus

4.1.5 Electrical Tests

Specifications

Standards:	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 DIN 435 Part 303 For more standards see also individual functions

Insulation Test

Standards:	IEC 60255-5, IEC 60870-2-1 and EN 50124–1
High voltage test (routine test): all circuits except power supply, binary inputs, high speed outputs, communication interface and time synchronization interfaces	2.5 kV (rms), 50 Hz
High voltage test (routine test): auxiliary voltage, binary inputs and high speed outputs	3.5 kVDC
High voltage test (routine test): only isolated communication and time synchronization interfaces	500 V (rms), 50 Hz
Impulse voltage test (type test): all circuits except communication and time synchronization interfaces, Class III	5 kV (peak), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses in intervals of 5 s

EMC Tests for Interference Immunity (type tests)

Standards:	IEC 60255-6 and -22 (product standards) EN 61000-6-2 (generic standard) DIN VDE 0435-110 EN 50121-5
High Frequency Test IEC 60255-22-1, Class III and VDE 0435 Part 303, Class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic Discharge IEC 60255-22-2, Class IV and IEC 61000-4-2, Class IV	8 kV contact discharge; 15 kV air discharge, both polarities; 150 pF; R_i = 330 Ω
Irradiation with HF field, single frequencies IEC 60255-22-3, Class III and IEC 61000-4-3, Class III	Class III: 10 V/m 80/160/450/900 MHz 80% AM 1 kHz: Closing time > 10s
Irradiation with HF field, frequency sweep IEC 61000-4-3, Class III	10 V/m; 80 MHz to 1000 MHz; 10 V/m; 800 MHz to 960 MHz; 20 V/m; 1,4 GHz to 2.4 GHz 80 % AM; 1 kHz
Fast Transient Disturbance Variables / Burst IEC 60255-22-4 and IEC 61000-4-4, Class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities: R_i = 50 Ω; test duration 1 min

High Energy Surge Voltages (SURGE), IEC 61000-4-5 Installation Class 3		Impulse: 1.2/50 μs
	Auxiliary voltage	Common mode: 2 kV; 12 Ω; 9 μF Diff. mode: 1 kV; 2 Ω; 18 μF
	Measuring Inputs, Binary Inputs and Relay Outputs	Common mode: 2 kV; 42 Ω; 0.5 μF Diff. mode: 1 kV; 42 Ω; 0.5 μF
Line conducted HF, amplitude modulated IEC 61000-4-6, Class III		10 V: 150 kHz to 80 MHz: 80 % AM: 1 kHz
Power System Frequency Magnetic Field IEC 61000-4-8, Class X IEC 60255-6		1000 A/m; continuous; 1800 A/m Impulse 8/20 μs; 16.7 Hz, 50 Hz and 60 Hz
Oscillatory Surge Withstand Capability ANSI/IEEE C37.90.1		2.5 to 3 kV (peak value); 1 to 1.5 MHz; damped oscillation; 50 surges per s; Test Duration 2 s; R_i = 150 Ω to 200 Ω
Fast transient surge withstand cap. ANSI/IEEE C37.90.1		4 kV to 5 kV: 10/150 ns: 50 pulses per s; both polarities: duration 2 s: R_i = 80 Ω
Radiated Electromagnetic Interference ANSI/IEEE C37.90.2		35 V/m; 25 MHz to 1000 MHz
Damped oscillations IEC 60694, IEC 61000-4-12		2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, R_i = 200 Ω

EMC Tests For Noise Emission (type test)

Standard:	EN 50081-* (generic standard)
Radio noise voltage to lines, only power supply voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio noise field strength IEC-CISPR 22	30 MHz to 1000 MHz limit class B

4.1.6 Mechanical stress tests

Vibration and Shock Stress During Steady State Operation

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	Sinusoidal 10 Hz to 60 Hz: ±0.075 mm amplitude; 60 Hz to 150 Hz: 1g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal 5 g acceleration, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-3, Class 1 IEC 60068-3-3	Sinusoidal 1 Hz to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 Hz to 8 Hz: ±1.5 mm amplitude (vertical vector) 8 Hz to 35 Hz: 1 g acceleration (horizontal axis) 8 Hz to 35 Hz: 0.5 g acceleration (vertical vector) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

Vibration and Shock Stress During Transport

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz:± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 g acceleration 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 each in both directions of the 3 axes
Continuous shock IEC 60255-21-2, Class 1 IEC 60068-2-29	Semi-sinusoidal 10 g acceleration, duration 16 ms, 1000 shocks each in both directions of the 3 axes

4.1.7 Climatic Stress Tests

Climatic tests

Standards:	IEC 60255-6
Type tested (acc. IEC 60086-2-1 and -2, Test Bd, for 16 h)	–23 °F to +85 °C (-25 °C bis +40 °C)
Limiting temporary (transient) operating temperature (tested for 96 h)	–4 °F to +158 °F or –20 °C to +70 °C (legibility of display may be restricted from +131 °F or +55 °C)
Recommended for permanent operation (according to IEC 60255-6)	–23 °F to +55 °C (–5 °C bis +40 °C)
Limit Temperatures for Storage	–23 °F to +55 °C (-25 °C bis +40 °C)
Limit Temperatures during Transport	–23 °F to +70 °C (-25 °C bis +40 °C)
STORE AND TRANSPORT OF THE DEVICE WITH FACTORY PACKAGING!	
Limit temperatures for normal operation (i.e. output relays not energized)	–23 °F to +70 °C (-20 °C bis +40 °C)
Limit temperatures under maximum load (max. cont. admissible input and output values)	-5 °C to +55 °C

Humidity

Permissible humidity	Annual average ≤ 75 % relative humidity; On 56 days of the year up to 93% relative humidity. Condensation must be avoided in operation!
Siemens recommends that all devices be installed so that they are not exposed to direct sunlight nor subject to large fluctuations in temperature that may cause condensation to occur.	

4.1.8 Service Conditions

The protection device is designed for installation in normal relay rooms and plants, so that electromagnetic compatibility (EMC) is ensured if installation is done properly.

In addition, the following are recommended:

- All contactors and relays that operate in the same cubicle, cabinet, or relay panel as the numerical protective device should, as a rule, be equipped with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables should be shielded with a conductive shield earthed at both ends. For substations with lower operating voltages, no special measures are normally required.
- Do not withdraw or insert individual modules while the protective device is energized. In withdrawn condition, some components are electrostatically endangered; during handling the ESD standards (for **E**lectrostatic **S**ensitive **D**evices) must be observed. The modules and device are not endangered when inserted into the housing.

4.1.9 Design

Housing	7XP20
Dimensions	See dimensional drawings, Section 4.17

Device	Housing	Size	Weight (mass)
7ST6 1	In flush mounting housing	$^1/_2$	6 kg (13.2 lb.)
7ST6 3	In flush mounting housing	$^1/_1$	10 kg (22 lb.)

Protection class acc. to IEC 60529		
For surface mounting housing equipment		IP 51
In flush-mounted case		
	Front	IP 51
	Rear	IP 50
For personal protection		IP 2x with cover
UL-certification conditions		“For use on a Flat Surface of a Type 1 Enclosure”

4.2 Distance Protection

Distance Measurement

Characteristic		Polygonal or combined	
Setting ranges			
I_{Ph}> = min. current, phases	for I_N = 1 A	0.10 A to 2.00 A	0.1 to 2.0 * I_N
	for I_N = 5 A	0.50 A to 10.00 A	
R1, X1, Z1, R1 Reverse, X1 Reverse, Z1 Reverse, R1, X1, Z1, R2, X2, Z2, R2 Reverse, X2 Reverse, Z2 Reverse, R3, X3, Z3, R3 Reverse, X3 Reverse, Z3 Reverse, R1B, X1B, Z1B, R1B Reverse, X1B Reverse, Z1B Reverse, R1L, X1L, Z1L, R1L Reverse, X1L Reverse, Z1L Reverse, ROR, XOR ZOR, ROR Reverse, XOR Reverse, ZOR Reverse, X1 Stroke, Z1 Stroke, X2 Stroke, Z2 Stroke, X3 Stroke, Z3 Stroke,	For I_N = 1 A	0.2 Ω to 250 Ω	
	For I_N = 5 A	0.04 Ω to 50 Ω	
ALPHA Z1, ALPHA Z2, ALPHA Z3 Angle limitation zone Z1, Z2, Z3 right		–70° to 45°	Increments 1°
BETA Z1, BETA Z2, BETA Z3 Angle limitation zone Z1, Z2, Z3 left		70° to 145°	Increments 1°
GAMMA Z1, GAMMA Z2, GAMMA Z3 Angle limitation zone Z1, Z2, Z3 left under axis R		–70° to 40°	Increments 1°

Pickup Values for Zone Z2 and Z3

Z2 DI/DT di/dt function	0; 0.1..1.0 I/IN; ∞	Increments 0.1 I/IN
Z2 DU/DT du/dt function	0; 0.1..1.0 U/UN; ∞	Increments 0.1 U/UN
Z2 U< U< function	0.5; 0.1..1.0 U/UN; ∞	Increments 0.1 U/UN
Z3 DI/DT di/dt function for zone Z2	0; 0.1..1.0 I/IN; ∞	Increments 0.1 I/IN
Z3 DU/DT du/dt function for zone Z2	0; 0.1..1.0 U/UN; ∞	Increments 0.1 U/UN
Z3 U< U< function for zone Z2	0.5; 0.1..1.0 U/UN; ∞	Increments 0.1 U/UN
Measuring tolerances for sinusoidal measured values	$\left\lvert\frac{\Delta X}{X}\right\rvert \le 5\ \%$ for $30° \le \varphi_{sc} \le 90°$ $\left\lvert\frac{\Delta R}{R}\right\rvert \le 5\ \%$ for $0° \le \varphi_{sc} \le 60°$	

Times

Shortest trip time	40 ms at 16.7 Hz 35 ms at 25 Hz 25 ms at 50/60 Hz	
Dropout time	80 ms at 16.7 Hz 60 ms at 25 Hz 30 ms at 50/60 Hz	
SI Time Man.Cl Operating time for manual close signal	0.01 s to 30.00 s	Increments 0.01 s
Stage timers: T1, T2, T2K, T2L, T3K, T3L, T1b, T1L Can be set separately for each timer	0.00 s to 30.00 s; ∞	Increments 0.01 s
Time expiry tolerances	1 % of setting value or 10 ms	
The set times are pure delay times		

4.3 Time Overcurrent Protection

Very High Set Current Stage, High Set Current Stage and Definite-time Overcurrent Stage

Pickup value I [1)]	0.10 A to 25.00 A; ∞	Increments 0.01 A
Delay time T I	0.00 s to 30.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio	Approx. 0.95 for $I/I_N \geq 0.5$	
Pickup time	Approx. 1 cycle + 10 ms	
Dropout time	Approx. 1–2 cycles	

[1)] The currents are specified in secondary values for I_N = 1 A. With I_N = 5 A, currents must be multiplied by 5.

Inverse-time Overcurrent Stage (IEC)

Pickup value IP	0.10 A to 4.00 A; ∞	Increments 0.01 A
Delay time T IP	0.05 s to 3.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio	Approx. 0.91 for $I/I_N \geq 0.5$	
Pickup time	Approx. 1 cycle + 10 ms	
Dropout time	Approx. 1–2 cycles	

Inverse-time Overcurrent Stage (ANSI)

Pickup value IP	0.10 A to 4.00 A; ∞	Increments 0.01 A
Delay time D IP	0.50 s to 15.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio	Approx. 0.91 for $I/I_N \geq 0.5$	
Pickup time	Approx. 1 cycle + 10 ms	
Dropout time	Approx. 1–2 cycles	

High-Speed Overcurrent Protection

Pickup value I HS O/C	1.0 A to 25.0 A; ∞	Increments 0.01 A
Delay time HS O/C	0 ms; 6 ms to 100 ms; ∞	Increments 1 ms
Dropout to pickup ratio	Approx. 0.95	
Pickup time	≤ 2ms	
Dropout time	Approx. 1–2 cycles	

Tolerances

DT		
Currents		5 % of setting value for $I_{Act} \geq I_N$
Times		1 % of setting value, at least 10 ms
	With high-speed overcurrent protection	1 % of setting value, at least 3 ms

IDMT	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of set value or 10 mA for I_N = 1 A or 50 mA for I_N 5 A
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value +2 % current tolerance, or 30 ms

Characteristics and Graphics

NORMAL INVERSE (Type A)

$$t_{Reset} = \frac{9.7}{(I/I_p)^2 - 1} \cdot T_p \quad [s]$$

VERY INVERSE (Type B)

$$t_{Reset} = \frac{43.2}{(I/I_p)^2 - 1} \cdot T_p \quad [s]$$

EXTREMELY INV. (Type C)

$$t_{Reset} = \frac{58.2}{(I/I_p)^2 - 1} \cdot T_p \quad [s]$$

LONG INVERSE (Type B)

$$t_{Reset} = \frac{80}{(I/I_p)^2 - 1} \cdot T_p \quad [s]$$

For all Characteristics

t_{RESET} = Reset time
T_p = Setting value of the time multiplier
I = Fault Current
I_p = Setting value of the pickup current

Trip Time Characteristics IEC

INVERSE

$$t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966 \right) \cdot D \quad [s]$$

SHORT INVERSE

$$t = \left(\frac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393 \right) \cdot D \quad [s]$$

LONG INVERSE

$$t = \left(\frac{5.6143}{(I/I_p) - 1} + 2.18592 \right) \cdot D \quad [s]$$

MODERATELY INV.

$$t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228 \right) \cdot D \quad [s]$$

VERY INVERSE

$$t = \left(\frac{3.922}{(I/I_p)^{2} - 1} + 0.0982 \right) \cdot D \quad [s]$$

EXTREMELY INVERSE

$$t = \left(\frac{5.64}{(I/I_p)^{2} - 1} + 0.02434 \right) \cdot D \quad [s]$$

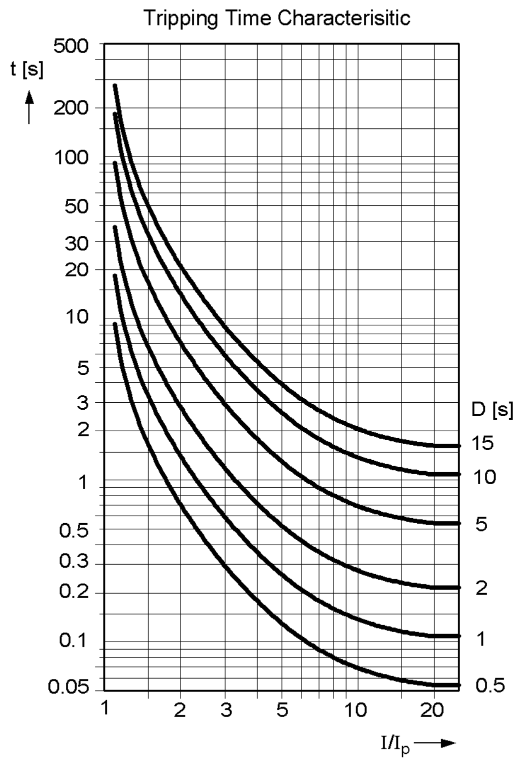
DEFINITE INVERSE

$$t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359 \right) \cdot D \quad [s]$$

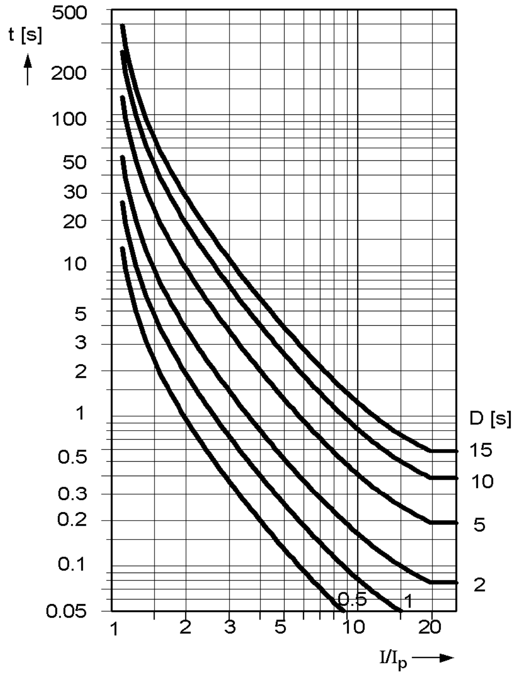
For all Characteristics

t = Trip time in seconds
D = Setting value of the time multiplier
I = Fault Current
I_p = Setting value of the pickup current

Trip Time Characteristics ANSI

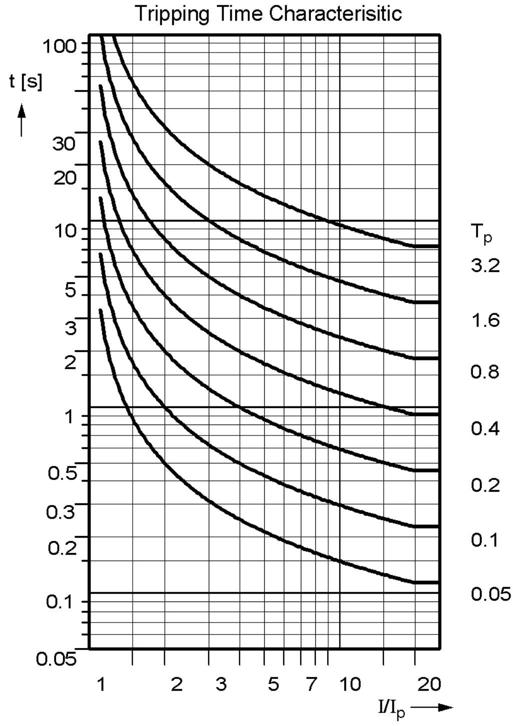


VERY INVERSE $t = \left(\frac{3.922}{(I/I_p)^2 - 1} + 0.0982\right) \cdot D$ [s]



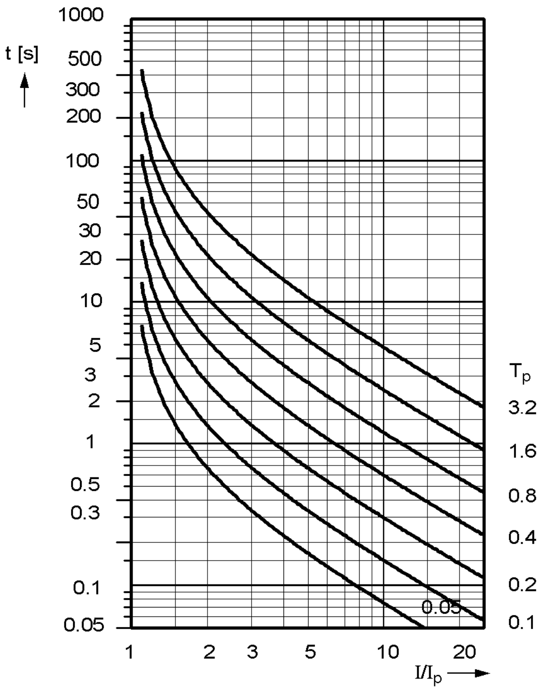
EXTREMELY INVERSE $t = \left(\frac{5.64}{(I/I_p)^2 - 1} + 0.02434\right) \cdot D$ [s]

Figure 4-1 Trip Time Characteristics of the Inverse-time Overcurrent Protection, acc. to ANSI/IEEE



Normal inverse:
(Type A)

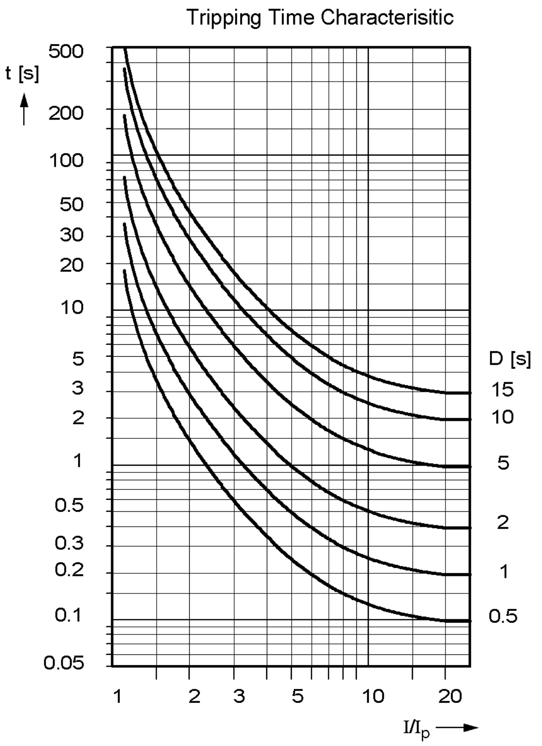
$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p \quad [s]$$



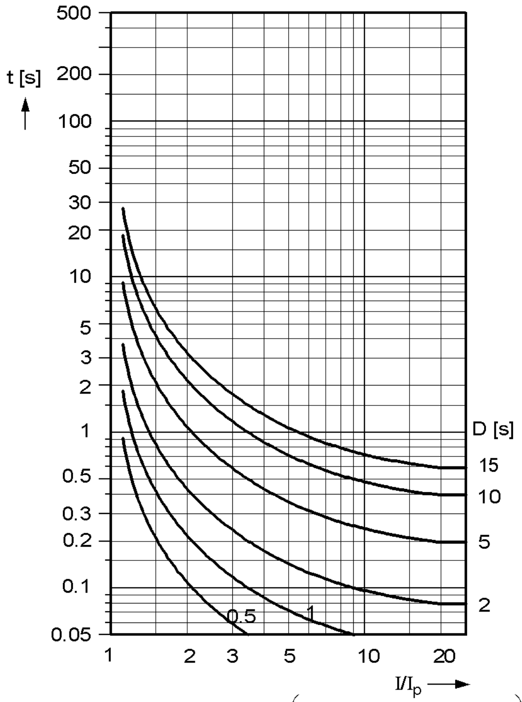
Very inverse:
(Type B)

$$t = \frac{13.5}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$

Figure 4-2 Trip Characteristics of the Inverse-time Overcurrent Protection, as per IEC



INVERSE $t = \left(\dfrac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966 \right) \cdot D$ [s]



SHORT INVERSE $t = \left(\dfrac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393 \right) \cdot D$ [s]

Figure 4-3 Trip Time Characteristics of the Inverse-time Overcurrent Protection, acc. to ANSI/IEEE

4.4 Voltage Protection (optional)

Overvoltage Protection U>> Stage

Pickup value U>>	20.0 V to 170.0 V; ∞	Increments 1 V
Delay time $T_{U>>}$	0.00 s to 60.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio $U_{>>Dropout}$	0.50 to 0.95	Increments 0.01
Pickup time	Approx. 1–2 cycles	
Dropout time	Approx. 1–2 cycles	

Overvoltage Protection U> Stage

Pickup value U>	20.0 V to 170.0 V; ∞	Increments 1 V
Delay time $T_{U>}$	0.00 s to 60.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio $U_{>>Dropout}$	0.50 to 0.95	Increments 0.01
Pickup time	Approx. 1–2 cycles	
Dropout time	Approx. 1–2 cycles	

Overvoltage Protection U<< Stage

Pickup value U<<	20.0 V to 120.0 V or 0	Increments 1 V
Delay time $T_{U<<}$	0.00 s to 60.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio	Approx. 1.05	
Pickup time	Approx. 1–2 cycles	
Dropout time	Approx. 1–2 cycles	

Overvoltage Protection U< Stage

Pickup value U<	20.0 V to 120.0 V or 0	Increments 1 V
Delay time $T_{U<}$	0.00 s to 60.00 s; ∞	Increments 0.01 s
Dropout to pickup ratio	Approx. 1.05	
Pickup time	Approx. 1–2 cycles	
Dropout time	Approx. 1–2 cycles	

Tolerances

Voltages	3 % of setting value or 1 V	
Times	1 % of setting value or 10 ms	

4.5 Thermal Overload Protection

Setting Ranges

Factor k ITRise = ITRise / I_N (continuous limit current)	0.10 to 4.00	Increments 0.01
Time constant TAU	2.0 min to 30.0 min	Increments 0.1 min (6 s)
Final temperature rise TRise (for continuous limit current)	0 to 100 K	Increments 1 K
Trip temperature TEMP TRIP	50 to 100 °C	Increments 1 °C
Alarm temperature TEMP ALARM	40 to 100 °C	Increments 1 °C
Close temperature TEMP CLOSE	25 to 100 °C	Increments 1 °C
Factor for 2 catenaries CAT2	1.0 to 3.0	Increments 0.1
Factor for 3 catenaries CAT3	1.0 to 3.0	Increments 0.1
Fixed ambient temperature value TEMP.SENS VALUE	-55 to 40 °C	Increments 1 °C

Dropout to Pickup Ratio

ULS TRIP	Drops out with internal signal „Current=0“	No dropout to pickup ratio
ULS ALARM		1K (dropout threshold = pickup value –1K)
ULS BLOCK	TEMP TRIP/TEMP CLOSE	Depends on the settings of TEMP TRIP and TEMP CLOSE

Tolerances

Currents	2 % of measured value (for currents above I_N), or 2 % of rated current (for currents < I_N)
Times	3 % or 1 s
Ambient temperature	+/-1 K

4.6 Circuit Breaker Failure Protection (optional)

Circuit Breaker Monitoring

Current flow monitoring	For I_N = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	For I_N = 5 A	0.25 A to 100.00 A	
Dropout to pickup ratio		Approx. 0.95	
Tolerance	For I_N = 1 A	5 % of the set value or 0.01 A	
	For I_N = 5 A	5 % of the set value or 0.05 A	
Pickup time		Approx. 1/4 cycle with measured values present	
Dropout time		<= 3/4 cycle with sinusoidal measured values <= 1 1/4 cycles max.	
Delay times		0.10 s to 10.00 s; ∞	Increments 0.01 s
Tolerance		1 % of setting value or 10 ms	

4.7 Defrosting Protection (depending on device version)

Defrosting Protection

Characteristic ID> [1)]	0.10 to 2.00 I/IN (referred to I) k: 0.00 to 0.80	Increments 0.01 I/IN Increments 0.01
Delay time T ID>	0.00 to 30.00 s; ∞	Increments 0.01
Dropout to pickup ratio	Approx. 0.88 for $I/I_N \geq 0.5$	
Pickup time	Approx. 1 cycle + 10 ms	
Dropout time	Approx. 1–2 cycles	

1) The currents are specified in secondary values for I_N = 1 A. With I_N = 5 A, currents must be multiplied by 5.

Definite Time Overcurrent Stages

Pickup value IX>>, IX>	0.10 A to 25.00 A; ∞	Increments 0.01 A
Delay time T IX>>, T IX>	0.05 s to 30.00 s or ∞	Increments 0.01 s
Dropout to pickup ratio	Approx. 0.95 for $I/I_N \geq 0.5$	
Pickup time	Approx. 1 cycle + 10 ms	
Dropout time	Approx. 1–2 cycles	

Tolerances

Currents	2 % of measured value (for currents above I_N), or 2 % of rated current	
Times	3 % or 10 ms	

4.8 Inrush Restraint (optional)

Pickup

2nd harmonics content	10 to 45 %
IMax for deactivation	0.5 to 25 A

4.9 Automatic Reclosure Function (optional)

General AR Function

Number of reclosures	Max. 8, the first 2 with individual parameters optionally 1 with SOTF-O/C	
Polarization	1-pole	
Control	With TRIP Command	
Action times	0.01 s to 300.00 s 2 separate parameters for cycle 1 and 2-8	
Dead times prior to reclosure	0.01 s to 1800.00 s 2 separate parameters for cycle 1 and 2-8	
Dead time extension - monitoring time	0.50 to 300.0 s; ∞	
Reclaim time after reclosure	0.50 to 300.0 s	
Blocking time after dynamic blocking	0.50 to 300.0 s	
Blocking time after manual closing	0.50 to 300.0 s	
Start signal monitoring time	0.01 to 300.0 s	
Circuit-breaker monitoring time	0.01 to 300.0 s	
I_{Limit}	1 to 25 A	Increments 1 A
Dynamic blocking in reverse direction	Yes/No	

AR Function for Thermal Overload Protection

Number of reclosures	Max. 8
Polarization	1-pole
Control	With PU=TRIP command
Operating Time	PU=TRIP
Dead time extension monitoring time	See "General AR Function"
Dead time duration monitoring time	1 to 60 min
Reclaim time after reclosure	0.50 to 300.0 s
Blocking time after dynamic blocking	See "General AR Function"
Blocking time after manual closing	See "General AR Function"
Start signal monitoring time	See "General AR Function"
Circuit-breaker monitoring time	See "General AR Function"
I_{Limit}	See "General AR Function"

4.10 Synchronism and Voltage Check (optional or depending on device version)

Operating Modes

Operating modes with automatic reclosure	Synchro check
	Dead line / live bus
	Dead bus / live line
	Dead bus and dead line
	Bypassing
	Or combination of the above
Synchronization	Closing the circuit breaker under asynchronous power conditions possible (with circuit breaker operating time)
Operating modes for manual closure	As for automatic reclosure, independently selectable

Voltages

Maximum operating voltage	20 V to 140 V	Increments 1 V
U< for dead status	1 V to 60 V	Increments 1 V
U> for live status	20 V to 125 V	Increments 1 V
Tolerances	2 % of pickup value or 1 V	
Dropout to pickup ratio	Approx. 0.9 (U>) or 1.1 (U<)	

∆U Measurement

Voltage difference	1 V to 50 V (phase-to-phase)	Increments 0.1 V
Tolerance	1 V	
Dropout to pickup ratio	Approx. 1.05	

Synchronous/Asynchronous Power Conditions

∆φ measurement	1° to 80°	Increments 1°
Tolerance	1°	
∆f measurement	0.01 Hz to 2.00 Hz	Increments 0.01 Hz
Tolerance	15 mHz	
Enable delay	0.00 s to 30.00 s	Increments 0.01 s

Times

Minimum measuring time	Approx. 80 ms	
Maximum measuring time	0.01 s to 600.00 s; ∞	Increments 0.01 s
Tolerance of all timers	1 % of setting value or 10 ms	

4.11 Fault Locator (optional)

General

Start	With trip command or dropout	
Reactance (secondary)	0.05 to 50.00 Ω/km	In km or miles
Line length	1.0 to 200.0 km	
Reactance (secondary)	0.08 to 80.00 Ω/mile	
Line length	0.6 to 124.0 miles	
Output of the fault distance	In Ω primary and Ω secondary, In km or miles of line length In % of the line length	
Tolerance	<3% if distance protection or time overcurrent protection trip <6% if the high current switch on to fault protection trips	

4.12 It Function (optional)

General

Operating mode	Start with G-Trip or start with CB auxiliary contact
Alarm stage	1.0 I/In*s to 1000 I/In*s; ∞
Statistics	Summated It Summated I^2t Last It Last I^2t

4.13 Trip Supervision

Monitoring

CB pickup threshold	0.05 to 0.5 A

4.14 Trip Circuit Supervision

Trip Circuit Supervision

Operating mode	With 1 binary input or with 2 binary inputs	
Alarm delay	1 s to 30 s	Increments 1 s

4.15 User Defined Functions (CFC) (optional)

Function Modules and Possible Assignments to Task Levels

Function Module	Explanation	Task Level			
		MW_BEARB	PLC1_BEARB	PLAN_BEARB	S_BEARB
ABSVALUE	Magnitude calculation	X	-	-	-
ADD	addition	X	X	X	X
AND	AND - Gate	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_CHAIN	Switching sequence	-	X	X	-
CMD_INF	Command information	-	-	-	X
CONNECT	Connection	-	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
DIV	division	X	X	X	X
DM_DECODE	Decode double point	X	X	X	X
DYN_OR	dynamic or	X	X	X	X
LIVE_ZERO	Live-zero, non linear Curve	X	-	-	-
LONG_TIMER	Timer (max.1193h)	X	X	X	X
LOOP	Feedback loop	X	X	X	X
LOWER_SETPOINT	Lower limit	X	-	-	-
MUL	multiplication	X	X	X	X
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
RS_FF	RS- Flipflop	-	X	X	X
SQUARE_ROOT	root extractor	X	X	X	X
SR_FF	SR- Flipflop	-	X	X	X
SUB	substraction	X	X	X	X
TIMER	Timer	-	X	X	-
UPPER_SETPOINT	Upper limit	X	-	-	-
X_OR	XOR - Gate	X	X	X	X
ZERO_POINT	Zero supression	X	-	-	-

General Limits

Description	Limit	Comment
Maximum number of all CFC charts considering all task levels	32	When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR LED lights up. Reduce the number of CFC charts until they are below the limit again.
Maximum number of all CFC charts considering one task level	16	Only error indication (evolving fault in processing procedure)
Maximum number of all CFC inputs considering all charts	400	When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR LED lights up. Reduce the number of CFC inputs until they are below the limit again.
Maximum number of inputs of one chart for each task level (number of unequal information items of the left border per task level)	400	Only error indication; here the number of elements of the left border per task level is counted. Since the same information is indicated at the border several times, only unequal information is to be counted.
Maximum number of reset-resistant flipflops D_FF_MEMO	50	No error indication (evolving error in processing procedure)

Device-Specific Limits

<table>
<tr><th>Description</th><th>Limit</th><th>Comment</th></tr>
<tr><td>Maximum number of synchronous changes of chart inputs per task level</td><td>50</td><td rowspan="2">When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.</td></tr>
<tr><td>Maximum number of chart outputs per task level</td><td>150</td></tr>
</table>

Additional Limits

<table>
<tr><th colspan="5">Additional Limits [1)] for the Following 4 CFC Blocks:</th></tr>
<tr><th>Task Level</th><th colspan="4">Maximum Number of Modules in the Task Levels</th></tr>
<tr><td></td><td>LONG_TIMER</td><td>TIMER</td><td>CMD_CHAIN</td><td>D_FF_MEMO</td></tr>
<tr><td>MW_BEARB</td><td rowspan="4">18</td><td></td><td></td><td rowspan="4">50</td></tr>
<tr><td>PLC1_BEARB</td><td rowspan="2">9</td><td rowspan="2">20</td></tr>
<tr><td>PLAN_BEARB</td></tr>
<tr><td>S_BEARB</td><td></td><td></td></tr>
</table>

1) When the limit is exceeded, an error indication is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

Maximum Number of TICKS in the Task Levels

Task Level	Limit in TICKS [1)]
MW_BEARB (Measured value processing)	10 000
PLC1_BEARB (Slow PLC processing)	1 900

Task Level	Limit in TICKS [1]
PLC_BEARB (Fast PLC processing)	200
SFS_BEARB (Switchgear interlocking)	10 000

[1] When the sum of TICKS of all blocks exceeds the limits before-mentioned, an error indication is output by CFC.

Processing Times in TICKS Required by the Individual Elements

Individual Element		Number of TICKS
Block, basic requirement		5
Each input more than 3 inputs for generic modules		1
Combination with input signal border		6
Combination with output signal border		7
Additionally for each chart		1
Operating sequence module	CMD_CHAIN	34
Flip-flop	D_FF_MEMO	6
Loop module	LOOP	8
Decoder	DM_DECODE	8
Dynamic OR	DYN_OR	6
Addition	ADD	26
Subtraction	SUB	26
Multiplication	MUL	26
Division	DIV	54
Square root	SQUARE_ROOT	83

4.16 Auxiliary Functions

Measured Values

Operational measured values for currents	I, IX, IF in A primary and secondary, and in % I_N
Tolerance	1 % of I_N for $I \leq I_N$ and 1 % of I for $I > I_N$
Operational measured values for voltages	U, UF, URef in kV primary, in V secondary or in % U_N
Tolerance	1 % of U_N for $U \leq U_N$ and 1 % of U for $U > U_N$
Operational measured values of impedances	R in Ω primary and secondary
Operational measured values for power	P in KW or MW Q in KVA or Mvar
Tolerance	2 % each
Operating measured value for power factor	cos φ
Tolerance	0.02
Operational measured values for frequency	f in Hz and % f_N
Area	90 % to 110 % of f_N
Tolerance	20 mHz
Thermal measured values	T_{Line} in °C $T_{Ambient}$ in °C
Operational measured values of synchro check	U_{Line}; U_{Sync} in kV primary f_{Line}; f_{Sync} in Hz

Operational Event Log Buffer

Capacity	200 records

Fault Logging

Capacity	8 faults with a total of max. 600 records

Fault Recording

Number of stored fault records	Max. 8
Storage time	Max. 5 s for each fault Approx. 15 s in total
Sampling rate at f_N = 16.7 Hz	1.25 ms
Sampling rate at f_N = 25 Hz	1.25 ms
Sampling rate at f_N = 50 Hz	1.25 ms
Sampling rate at f_N = 60 Hz	1.05 ms

Statistics

Number of trip events caused by device	n
Number of reclosure events caused by device	Separately for 1st AR cycle and for all further cycles
Total of interrupted currents	Summated It Summated I^2t Last It Last I^2t
Maximum interrupted current	in A; kA
Availability of transmission	Availability in %/min and %/h
Delay time of transmission	Resolution 0.01 ms

Real Time Clock and Buffer Battery

Resolution for operational indications	1 ms
Resolution for fault indications	1 ms
Battery	Type: 3 V/1 Ah, Type CR 1/2 AA Self-discharging time approx. 10 years

4.17 Dimensions

4.17.1 Housing for Panel Flush Mounting or Cubicle Mounting (Size $^1/_2$)

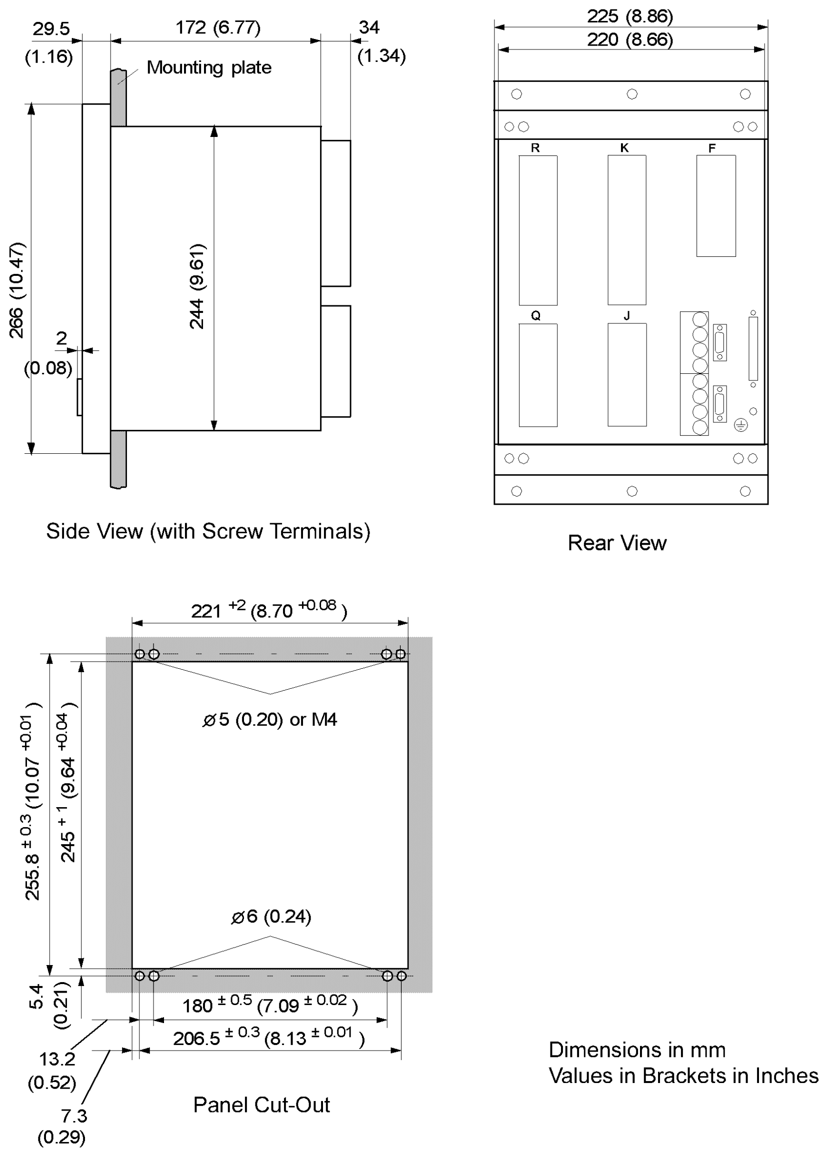
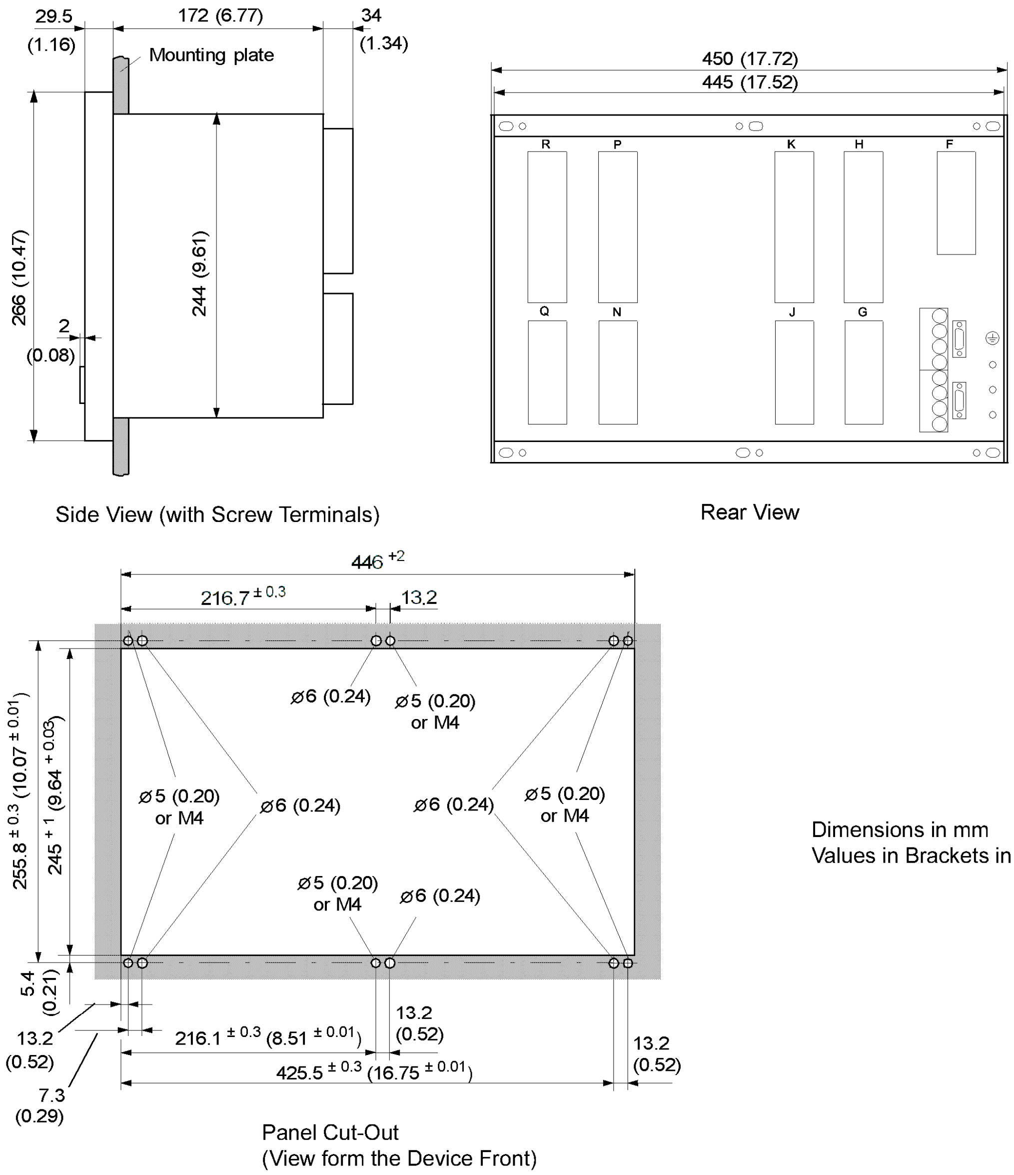


Figure 4-4 Dimensional drawing of a 7ST6 for panel flush or cubicle mounting (housing size $^1/_2$)

4.17.2 Housing for Panel Flush Mounting or Cubicle Mounting (Size $^1/_1$)



Dimensions in mm
Values in Brackets in Inches

Figure 4-5 Dimensional drawing of a 7ST6 for panel flush or cubicle mounting (housing size $^1/_1$)

■

Appendix A

This appendix is primarily a reference for the experienced user. This section provides ordering information for the models of this device. Connection diagrams for indicating the terminal connections of the models of this device are included. Following the general diagrams are diagrams that show the proper connections of the devices to primary equipment in many typical power system configurations. Tables with all settings and all information available in this device equipped with all options are provided. Default settings are also given.

A.1 Ordering Information and Accessories

A.1.1 Ordering Information

A.1.2 Accessories

Voltage Transformer Miniature Circuit Breaker (VT mcb)

Nominal Values	Order Number
Thermal 1.6 A; magnetic 6 A	3RV1611-1AG14

Interface Modules

Exchange Modules for Interfaces	Order Number
RS232	C53207-A351-D641-1
RS485	C73207-A351-D642-1
FO 820 nm	C73207-A351-D643-1
Profibus FMS RS 485	C53207-A351-D603-1
Profibus FMS double ring	C53207-A351-D606-1
Profibus DP RS485	C53207-A351-D611-1
Profibus DP double ring	C53207-A351-D613-1
Modbus RS485	C53207-A351-D621-1
Modbus opt. 820 nm	C53207-A351-D623-1
DNP 3.0 RS 485	C53207-A351-D631-1
DNP 3.0 820 nm	C53207-A351-D633-1
FO5 with ST-connector; 820 nm; multimode optical fibre - maximum length: 1.5 km	C53207-A351-D651-1
FO6 with ST-connector; 820 nm; multimode optical fibre - maximum length: 3 km (1.9 miles)	C53207-A351-D652-1
FO7 with ST-connector; 1300 nm; monomode optical fibre - maximum length: 10 km (6.25 miles)	C53207-A351-D653-1
FO8 with FC-connector; 1300 nm; monomode optical fibre - maximum length: 35 km (22 miles)	C53207-A351-D654-1

Terminal Block Covering Caps

Terminal block covering cap for block type	Order Number
18-pole voltage terminal, 12-pole current terminal	C73334-A1-C31-1
12-pole voltage terminal, 8-pole current terminal	C73334-A1-C32-1

Short-Circuit Links

Covering cap for terminal type	Order Number
Jumper-KIT: 3 jumpers for current terminal, 6 jumpers for voltage terminal	C73334-A1-C40-1

Socket Housing

Socket housing	Order Number
2-pole	C73334-A1-C35-1
3-pole	C73334-A1-C36-1

Mounting Bracket for 19"-Racks

Name	Order Number
Mounting bracket	C73165-A63-C200-3

Battery

Lithium battery 3 V/1 Ah, type CR 1/2 AA	Order Number
VARTA	6127 101 501

Interface Cable

An interface cable and the DIGSI® software is necessary for communication between the SIPROTEC® 4 device and a PC or laptop: The PC or laptop must run MS-WINDOWS 95/98, MS-WINDOWS ME, MS-WINDOWS NT 4, MS-WINDOWS 2000 or MS-WINDOWS XP.	Order Number
Interface cable between PC and SIPROTEC, Cable with 9-pin male/female connectors	7XV5100-4

DIGSI® Operating Software

Software for setting and operating SIPROTEC® 4 devices	Order Number of DIGSI® Protection Operation and Configuration Software
DIGSI®, basic version with licenses for 10 PCs	7XS5400-0AA00
DIGSI®, complete version with all option packages	7XS5402-0AA0

Graphical Analysis Program SIGRA

Software for graphical visualization, analysis, and evaluation of fault data. Option package of the complete Version of DIGSI®	Order Number
Graphical analysis program SIGRA®; Full version with license for 10 computers	7XS5410-0AA0

Display Editor

Software for creating basic and power system control pictures. Option package of the complete version of DIGSI®	Order Number
Display Editor 4; Full version with license for 10 PCs	7XS5420-0AA0

Graphic Tools

Graphical software to aid in the setting of characteristic curves and provide zone diagrams for overcurrent and distance protective devices. Option package of the complete version of DIGSI®.	Order Number
Graphic Tools 4; Full version with license for 10 PCs	7XS5430-0AA0

DIGSI REMOTE 4

Software for remotely operating protective devices via a modem (and possibly a star connector) using DIGSI®. Option package of the complete version of DIGSI®	Order Number
DIGSI REMOTE 4; Full version with license for 10 PCs; Language: English, German, French, Spanish	7XS5440-1AA0

SIMATIC CFC 4

Graphical software for setting interlocking (latching) control conditions and creating additional functions. Option package of the complete version of DIGSI®	Order Number
SIMATIC CFC 4; Full version with license for 10 PCs	7XS5450-0AA0

A.2 Terminal Assignments

A.2.1 Housing for Panel Flush and Cubicle Mounting

7ST61*1/5

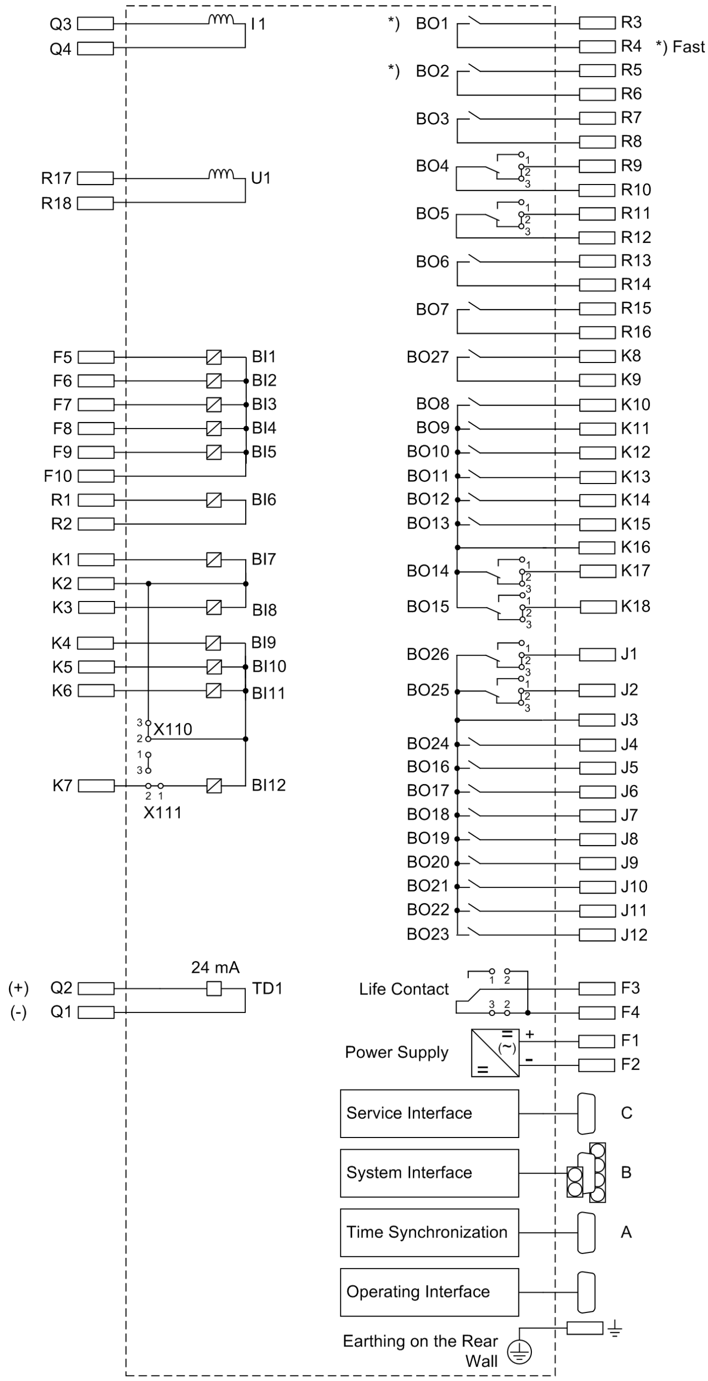


Figure A-1 Connection diagram for 7ST61*1/5 (panel flush mounted or cubicle mounted)

7ST61*3/7

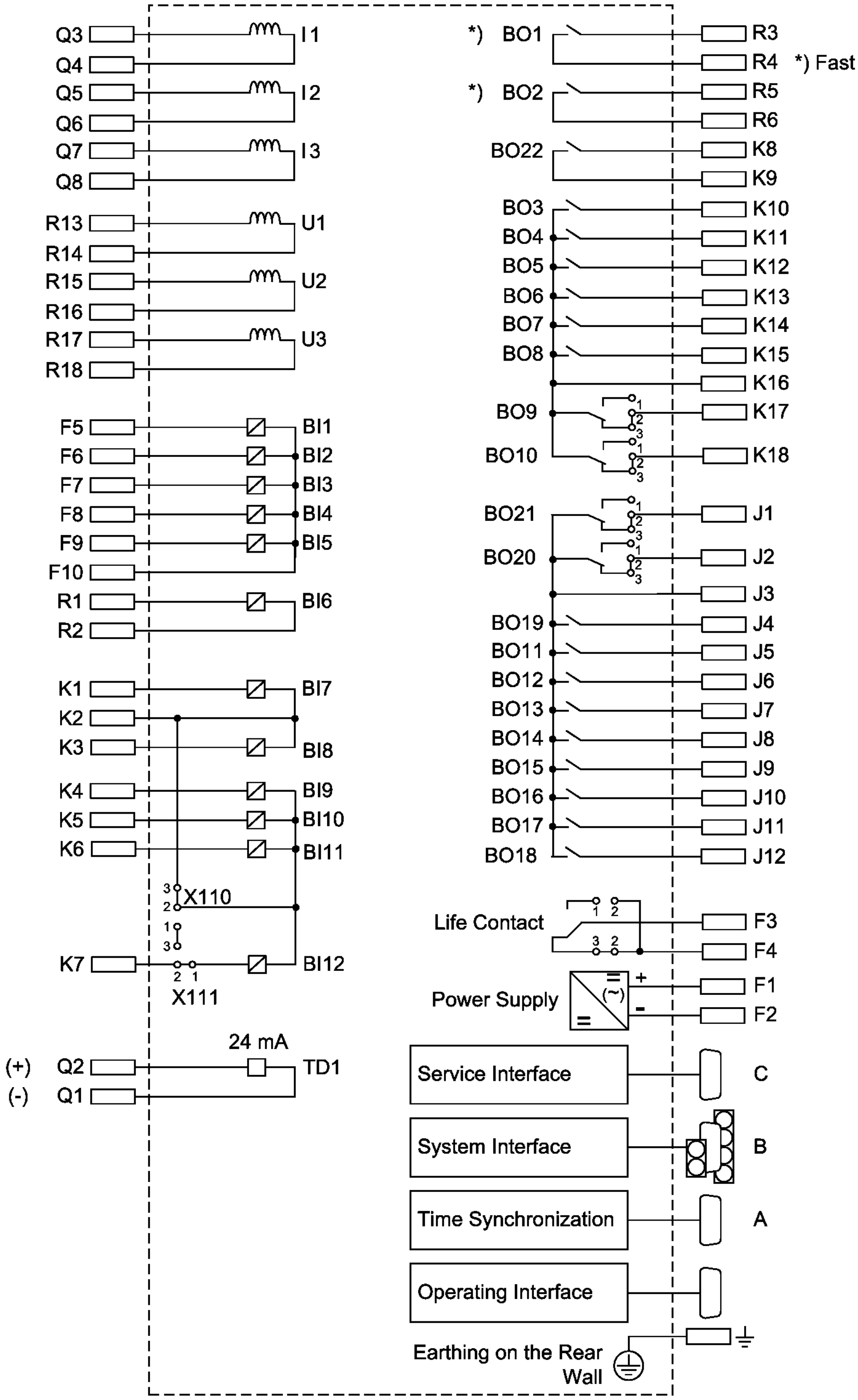


Figure A-2 Connection diagram for 7ST61*3/7 (panel flush mounted or cubicle mounted)

7ST63* Part 1

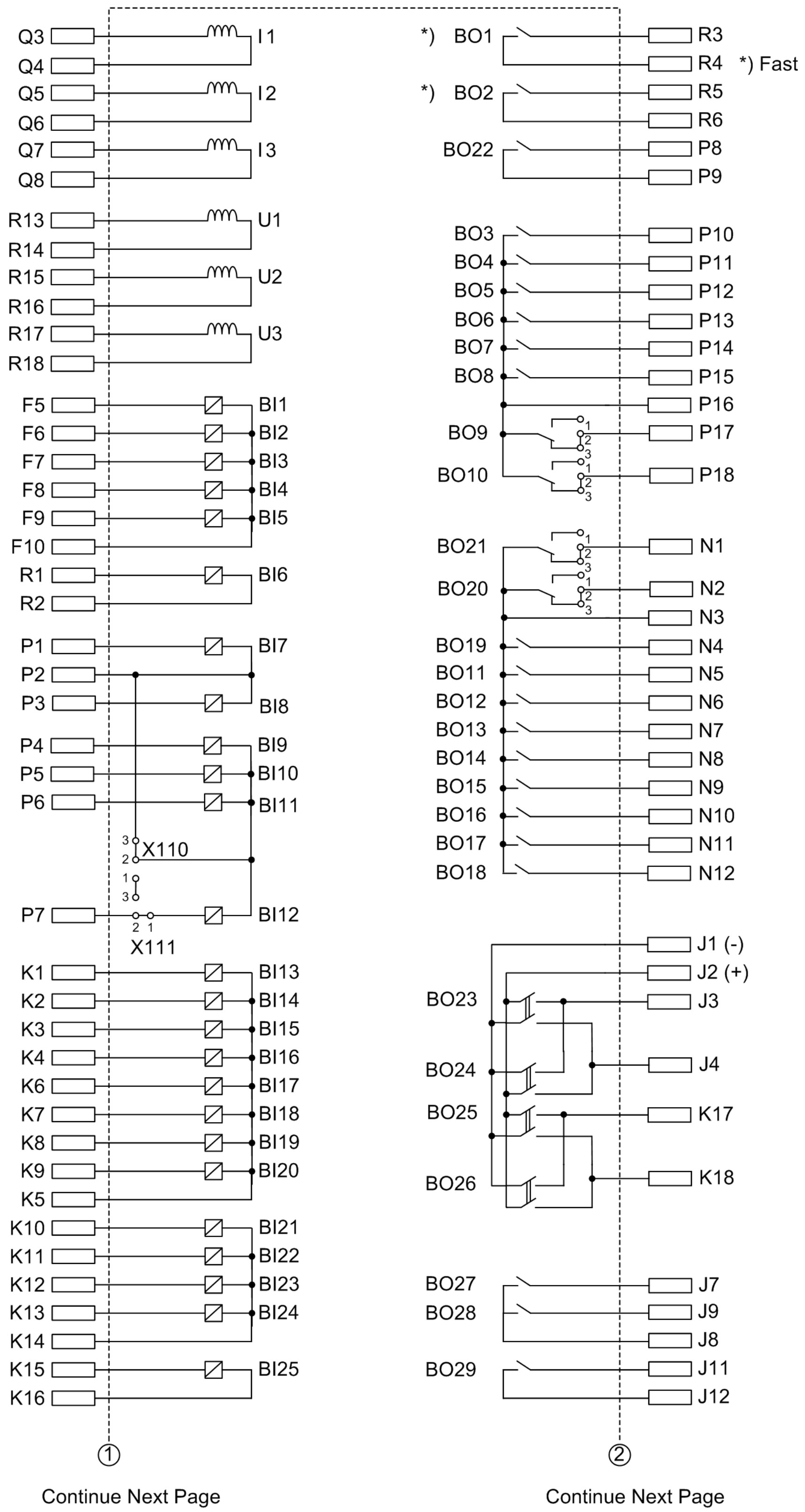


Figure A-3 Connection diagram for 7ST63 part 1 (panel flush mounted or cubicle mounted)

7ST63* Part 2

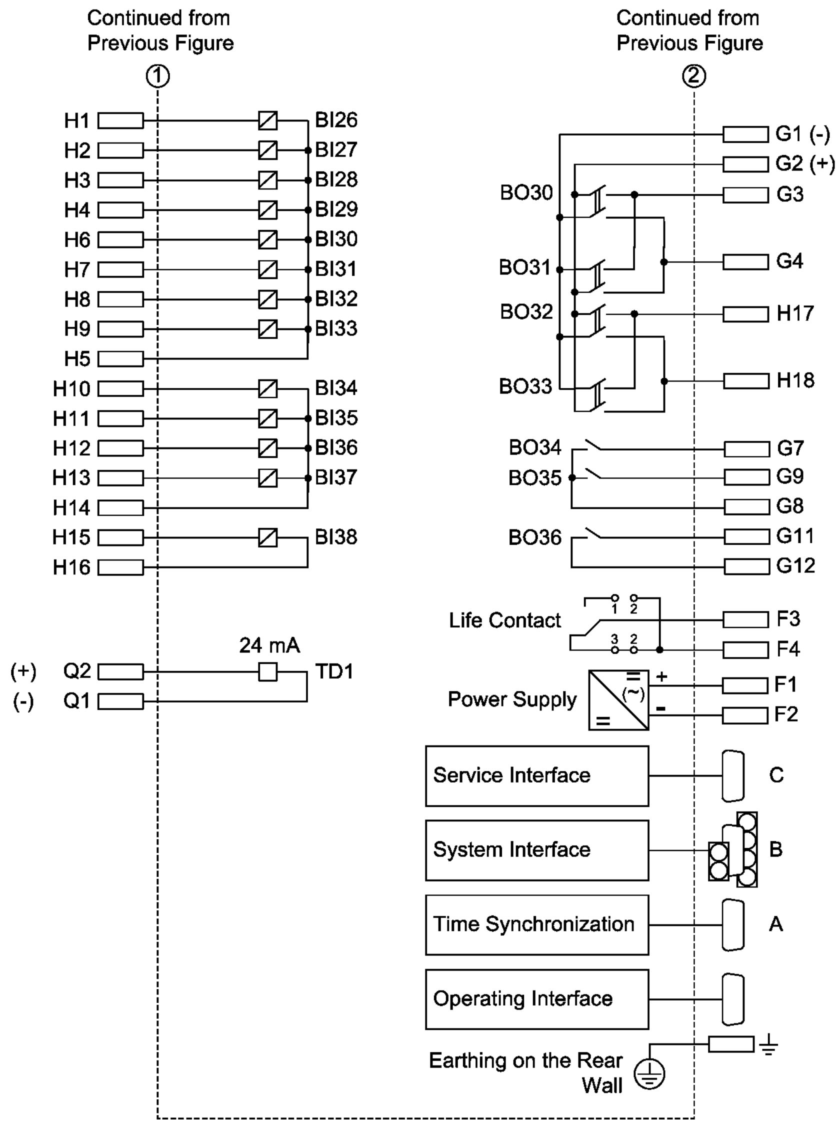


Figure A-4 Connection diagram for 7ST63 part 2 (panel flush mounted or cubicle mounted)

A.3 Connection Examples

A.3.1 Connection of Measured Values

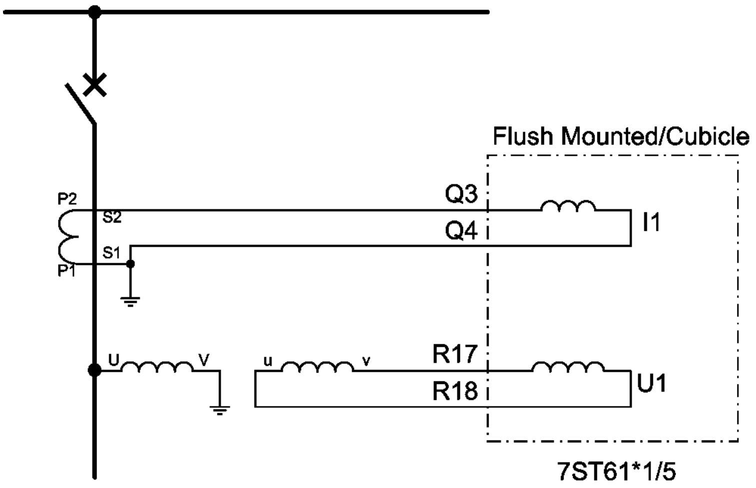


Figure A-5 Measured value connection in 7ST61*1/5 (single-phase)

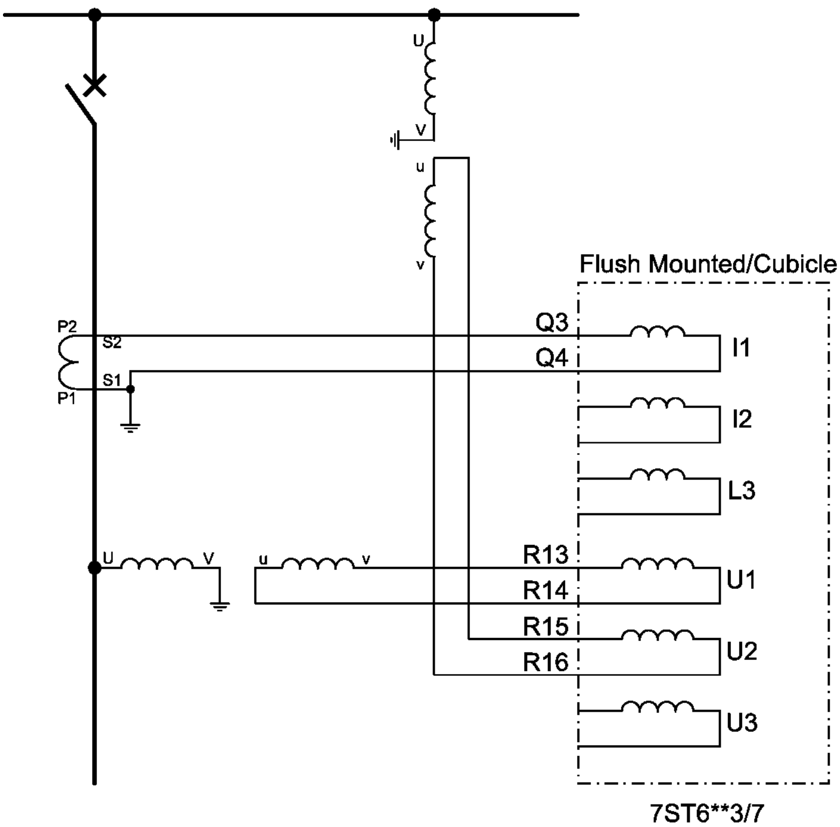


Figure A-6 Measured value connection in 7ST6**3/7 (single-phase)

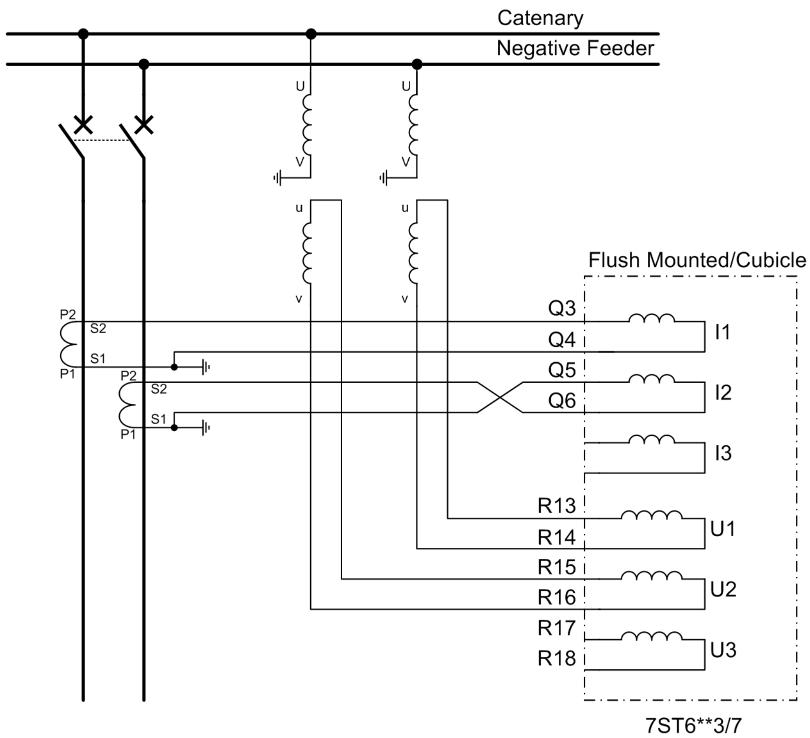


Figure A-7 Measured value connection in 7ST6**3/7 for auto-transformer systems

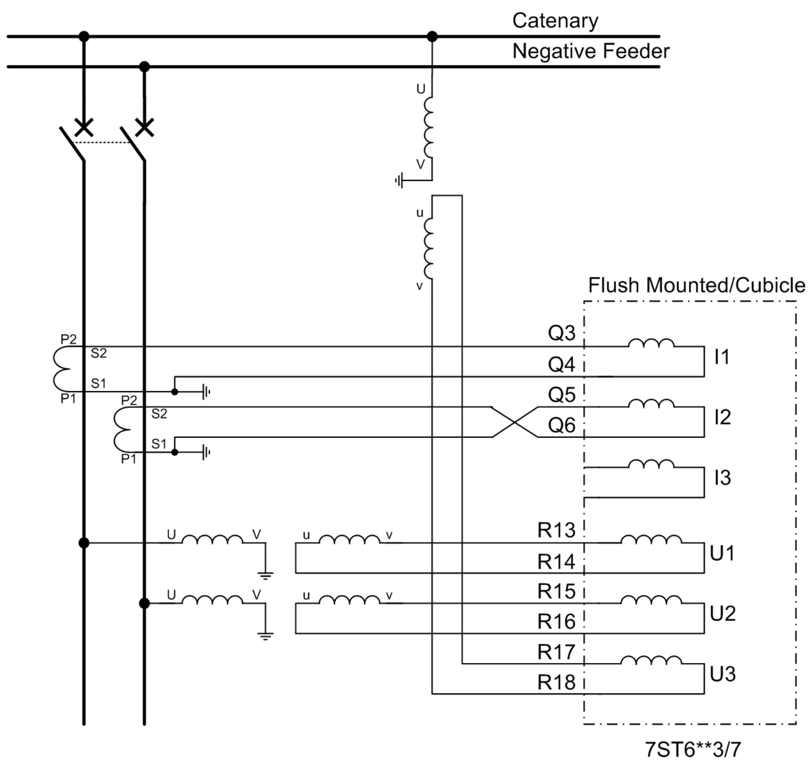


Figure A-8 Measured value connection in 7ST6**3/7 for auto-transformer systems with synchro-check

A.4 Default Settings

When the device leaves the factory, a large number of LED indications, binary inputs and outputs as well as function keys are already preset. They are summarised in the following table.

A.4.1 LEDs

Table A-1 LED indication presettings

LEDs	Short Text	Function No.	Description
LED1	HS O/C TRIP	4293	HS O/C TRIPPED
LED2	Dis.Trip Z1	3810	Dist.: Trip in Zone Z1
LED3	Dis. Trip Z2K	3930	Dist.: Trip in zone Z2 (short circuit)
LED4	Dis. Trip Z2L	3931	Dist.: Trip in zone Z2 (overload)
LED5	Dis TRIP Z3K	13903	Dist. Prot. TRIP Zone Z3 (short circuit)
LED6	Dis TRIP Z3L	13904	Dist. Prot. TRIP Zone Z3 (overload)
LED7	Emer.Gen.Trip	2141	Emerg. O/C protection: General Trip
LED8	O/C TRIP	7211	Overcurrent General TRIP command
LED9	ThOverload TRIP	1521	Thermal Overload TRIP
LED10	BrkFailure TRIP	1471	Breaker failure TRIP
LED11	Defrost TRIP	13967	Defrosting Protection TRIP
LED12	HS O/C PICKUP Dis. PICKUP Emer.Gen.Flt O/C PICKUP O/L Θ Alarm	4281 3671 2061 7161 1516	HS O/C PICKED UP Distance PICKED UP Emerg. O/C prot.: General fault detect. Overcurrent PICKED UP Overload Alarm! Near Thermal Trip
LED13	AR in progress Th-AR in prog	2801 2805	Auto-reclose in progress Th-AR: Thermal AR in progress
LED14	>FAIL:Feeder VT >VT MCB UF >VT MCB Uref	361 13951 13952	>Failure: Feeder VT (MCB tripped) >U feeder side VT MCB tripped >U reference side VT MCB tripped

A.4.2 Binary Input

Table A-2 Binary input presettings for all devices and ordering variants

Binary Input	Short Text	Function No.	Description
BI1	>FAIL:Feeder VT	361	>Failure: Feeder VT (MCB tripped)
BI2	>VT MCB UF	13951	>U feeder side VT MCB tripped
BI3	>Reset LED	5	>Reset LED
BI4	>Dis.Z1 act.	3901	>Dist.: Zone Z1 is active
BI5	>DisZ1str act	3900	>Dist.: Zone Z1 stroke is active
BI6	>Dis. Z2 act.	3903	>Dist.: Zone Z2 is active
BI7	>DisZ2str act	3902	>Dist.: Zone Z2 stroke is active
BI8	>Dis Z3 act	3907	>Dist.: Zone Z3 active
BI9	>Dis Z3str act	3906	>Dist.: Zone Z3 stroke active
BI10	>Cat.1 active	6605	>First catenary is active
BI11	>Cat.2 active	6604	>Second catenary is active
BI12	>Cat.3 active	6603	>Third catenary is active

Table A-3   Further binary input presettings for 7ST63*

Binary Input	Short Text	Function No.	Description
BI13	>Ctrl Select.	365	>Select: Control by BI or SYS interface
BI15	>Time Synch	3	>Synchronize Internal Real Time Clock
BI17	>Set Group Bit0	7	>Setting Group Select Bit 0
BI18	>Set Group Bit1	8	>Setting Group Select Bit 1
BI20	>CB-TEST	13860	>CB-Test: Start TRIP cycle
BI21	>CB-TEST AR	13861	>CB-Test: Start TRIP-CLOSE cycle
BI22	>Brk Aux NO	4601	>Breaker contact (OPEN, if bkr is open)
BI23	>Brk Aux NC	4602	>Breaker contact(OPEN, if bkr is closed)
BI24	>CB Ready	2730	>Circuit breaker READY for reclosing
BI26	>AR ON	2701	>Auto reclose ON
BI27	>AR OFF	2702	>Auto reclose OFF
BI28	>Sync. on	2901	>Switch on synchro-check function
BI29	>Sync. off	2902	>Switch off synchro-check function

A.4.3 Binary Output

Table A-4   Output relay presettings for all devices and ordering variants

Binary Output	Short Text	Function No.	Description
BO1	Protection TRIP	13992	General protective TRIP of device
BO2	With a 2-channel TRIP command control of the high-speed overcurrent protection function the BO2 is assigned like BO1. Usually it BO2 is not assigned.	-	-
BO3	BrkFailure TRIP CB-TEST TRIP M	1471 13862	Breaker failure TRIP CB-Test: TRIP command main trip element
BO4	AR in progress Th-AR in prog	2801 2805	Auto-reclose in progress Th-AR: Thermal AR in progress
BO5	Emer.Gen.Trip	2141	Emerg. O/C protection: General Trip
BO6	O/C TRIP	7211	Overcurrent General TRIP command
BO7	ThOverload TRIP	1521	Thermal Overload TRIP
BO8	Defrost TRIP	13967	Defrosting Protection TRIP

Table A-5   Further output relay presettings for 7ST61* 1/5 and 7ST61* 3/7

Binary Output	Short Text	Function No.	Description
BO9	Dis.Gen. Trip	3801	Distance protection: General trip
BO10	Dis. Z1 act.	3915	Dist.: Zone Z1 is active
BO11	Dis.Z1str act	3916	Dist.: Zone Z1 stroke is active
BO12	Dis.Z2 act.	3917	Dist.: Zone Z2 is active
BO13	Dis.Z2str act	3918	Dist.: Zone Z2 stroke is active
BO14	Dis. Z3 act	3991	Dist.: Zone Z3 is active
BO15	Dis. Z3str act	3992	Dist.: Zone Z3 stroke is active
BO16	Cat. 1 active	6616	First catenary is active

Binary Output	Short Text	Function No.	Description
BO17	Cat. 2 active	6617	Second catenary is active
BO18	Cat. 3 active	6618	Third catenary is active
BO19	Relay CLOSE	510	General CLOSE of relay
BO20	O/L Θ Alarm	1516	Overload Alarm! Near Thermal Trip
BO21	Fail.TEMPSENS	158	Failure of outdoor temp. sensing
BO22	B/F s.ordProt	1484	B/F: pick up superordinat.prot.relais

Table A-6 Further output relay presettings for 7ST61* 1/5

Binary Output	Short Text	Function No.	Description
BO28	Device OK	51	Device is Operational and Protecting

Table A-7 Further output relay presettings for 7ST61* 3/7

Binary Output	Short Text	Function No.	Description
BO23	Device OK	51	Device is Operational and Protecting

Table A-8 Further output relay presettings for 7ST63*

Binary Output	Short Text	Function No.	Description
BO9	Dis.Trip Z1	3810	Dist.: Trip in Zone Z1
BO10	Dis. Trip Z2K	3930	Dist.: Trip in zone Z2 (short circuit)
BO11	Dis. Trip Z2L	3931	Dist.: Trip in zone Z2 (overload)
BO12	Dis TRIP Z3K	13903	Dist. Prot. TRIP Zone Z3 (short circuit)
BO13	Dis TRIP Z3L	13904	Dist. Prot. TRIP Zone Z3 (overload)
BO15	B/F s.ordProt	1484	B/F: pick up superordinat.prot.relais
BO17	Dis. Z1 act.	3915	Dist.: Zone Z1 is active
BO18	Dis.Z1str act	3916	Dist.: Zone Z1 stroke is active
BO19	Dis.Z2 act.	3917	Dist.: Zone Z2 is active
BO20	Dis.Z2str act	3918	Dist.: Zone Z2 stroke is active
BO21	Dis. Z3 act	3991	Dist.: Zone Z3 is active
BO22	Dis. Z3str act	3992	Dist.: Zone Z3 stroke is active
BO24	Cat. 1 active	6616	First catenary is active
BO25	Cat. 2 active	6617	Second catenary is active
BO26	Cat. 3 active	6618	Third catenary is active
BO27	Relay TRIP	511	Relay GENERAL TRIP command
BO28	Relay CLOSE	510	General CLOSE of relay
BO29	O/L Θ Alarm	1516	Overload Alarm! Near Thermal Trip
BO30	Fail.TEMPSENS	158	Failure of outdoor temp. sensing
BO32	CB-TEST TRIP M CB-TEST TRIP B	13862 13863	CB-Test: TRIP command main trip element CB-Test: TRIP command backup trip elem.
BO33	CB-TEST CLOSE M CB-TEST CLOSE M	13864 13865	CB-Test: CLOSE command main trip element CB-Test: CLOSE command backup trip elem.
BO37	Device OK	51	Device is Operational and Protecting

A.4.4 Function Keys

Table A-9 Applies to all devices and ordered variants

Function Keys	Short Text	Function No.	Description
F1	Display of Operational Indications	-	-
F2	Operating Measured Values, Primary	-	-
F3	An overview of the last eight network faults	-	-
F4	Not assigned	-	-

A.4.5 Default Display

4-line Display

Table A-10 This selection is available as start page which may be configured.

Page 1	I: 5000 A U: 150.0 kV φ: 00 °
Page 2	P: 0000.00 kW Q: 0000.00 kVAR f: 00.00 Hz:
Page 3	Z: R: 00.00 Ω X: 00.00 Ω

Graphic Display

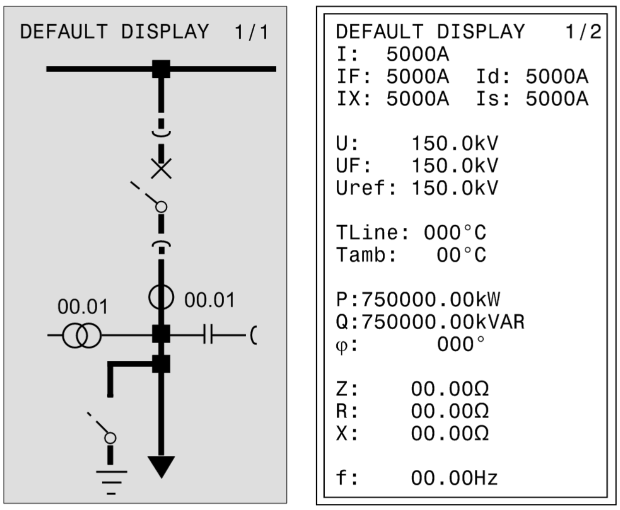


Figure A-9 Default displays of a graphical display

Spontaneous Displays

Spontaneous displays are fault indications which appear in the display automatically following a general fault detection or trip command of the device. In the case of 7ST6 they are the following:

"S/E/F TRIP":	Protective function that tripped;
"PU Time":	Operating time from the general pickup to the dropout of the device, in ms;
"TRIP Time":	Operating time from general pickup to the first trip command of the device, in ms;
"Xpri =":	X (primary) (Xpri=);

A.4.6 Pre-defined CFC Charts

Some CFC charts are already supplied with the SIPROTEC® device. Depending on the variant the following charts may be implemented:

Device and System Logic

Some of the event-controlled logical allocations are created with blocks of the slow logic (**PLC1_BEARB** = slow PLC processing). This way, the binary input "Data Stop" is modified from a single point indication (SP) into an internal single point indication (IntSP) by means of a negator block.

With double point indication "EarthSwit." = CLOSE an indication saying "fdrEARTHED" ON and with "EarthSwit." = OPEN or INT the indication "fdrEARTHED" OFF is generated.

From the output indication "definite TRIP" the internal indication "Brk OPENED" is generated. As indication "definite TRIP" is only queued for 500 ms, indication "Device Brk OPENED" is also reset after this time.

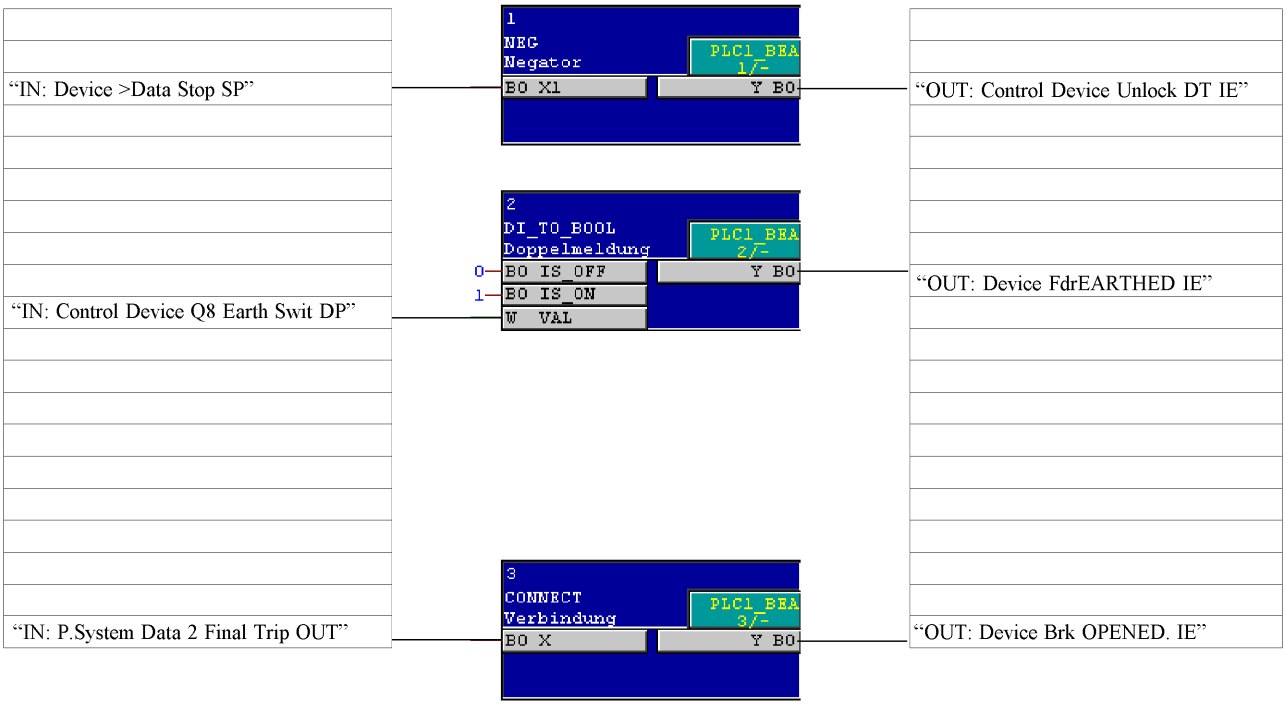


Figure A-10 Allocation of input and output with blocks of level System Logic

Interlocking

With blocks of level Interlocking (SFS_BEARB = interlocking), standard interlocking for three switchgears (circuit breaker, disconnector and earth switch) is pre-defined. Due to the large functional scope of the logic you will find this level on two worksheets.

The circuit breaker can only be closed if

- the circuit breaker is set to OPEN or CLOSE and
- the disconnector is set to OPEN or CLOSE and
- the earth switch is set to OPEN or CLOSE and
- the disconnector and the earth switch are not set to CLOSE at the same time and
- the input indication “CB wait” is set to OPEN and
- the input indication “Door open” is set to OPEN.

The disconnector can only be closed if:

- the circuit breaker is set to OPEN and
- the earth switch is set to OPEN and
- the disconnector is set to OPEN or CLOSE and
- the input indication “Door open” is set to OPEN.

The disconnector can only be opened if:

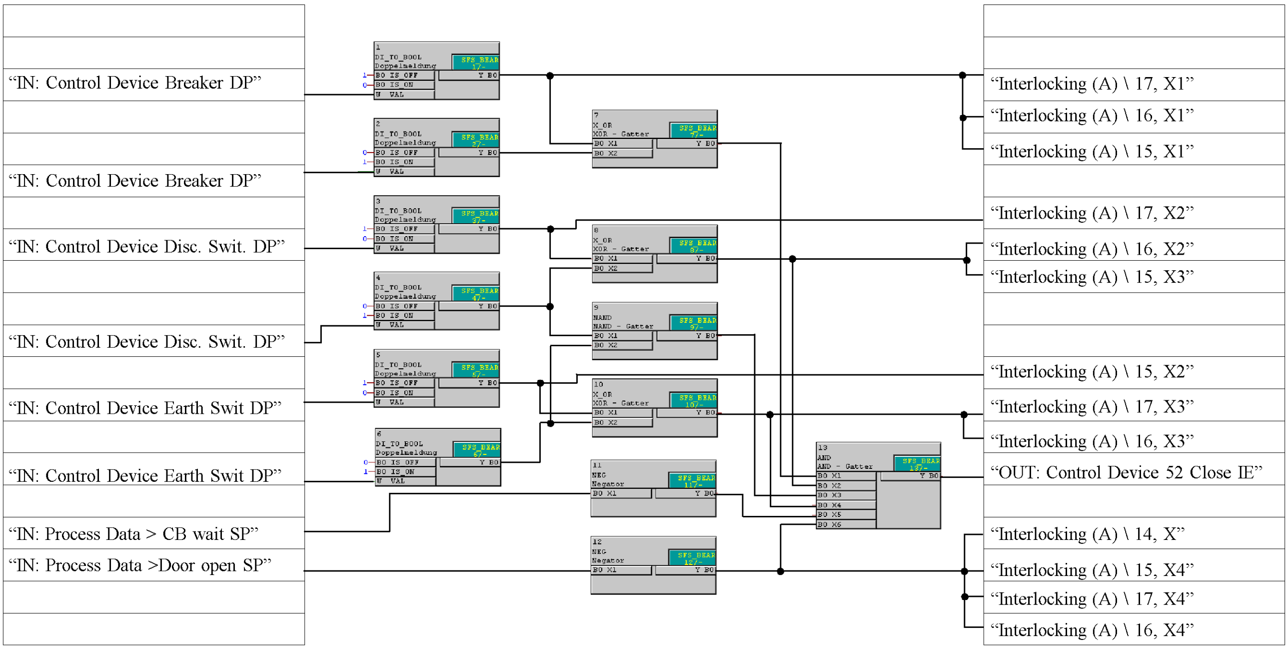
- the circuit breaker is set to OPEN and
- the disconnector is set to OPEN or CLOSE and
- the earth switch is set to OPEN or CLOSE and
- the input indication“Door open” is set to OPEN.

The earth switch can only be closed if:

- the circuit breaker is set to OPEN and
- the disconnector is set to OPEN and
- the earth switch is set to OPEN or CLOSE and
- the input indication “Door open” is set to OPEN.

If the above requirements are not fulfilled, the actions of the switch commands will be blocked with error messages by DIGSI®.

Worksheet 1



Worksheet 2 (continuation of Worksheet 1)

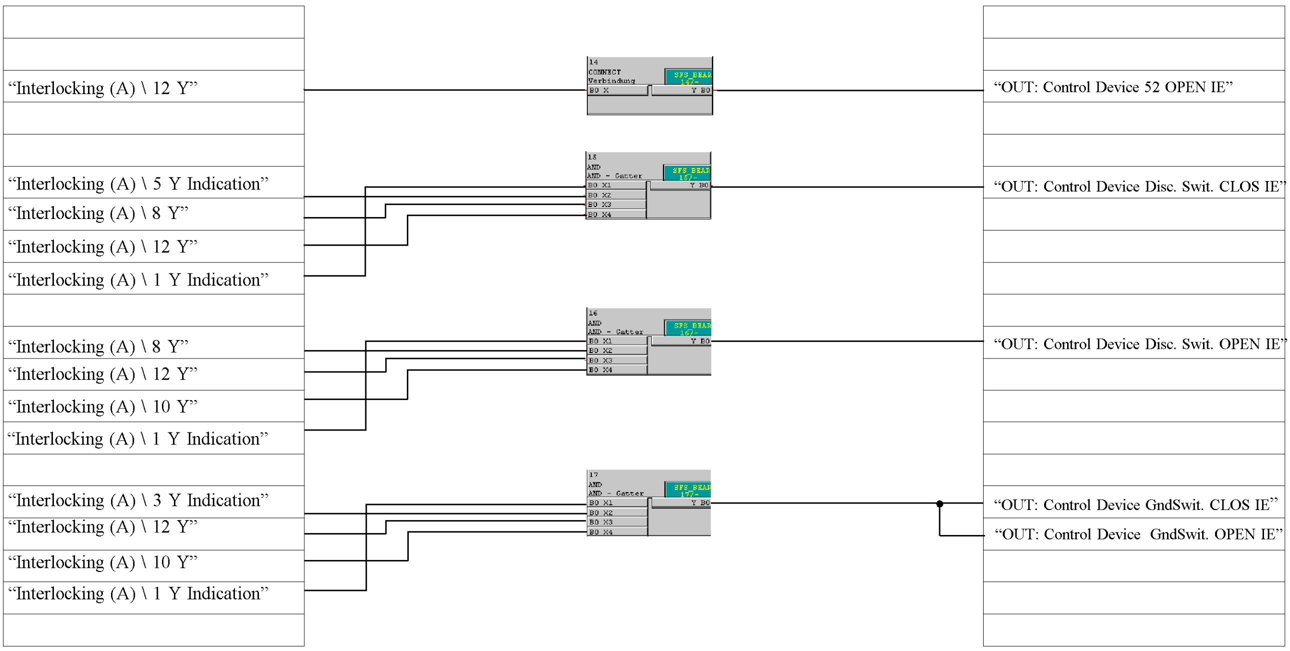


Figure A-11 Standard interlocking for circuit breaker (Breaker), disconnector (Disc. Swit.) and earth switch (GndSwit.)

A.5 Protocol-dependent Functions

Protocol → Function ↓	IEC 60870-5-103	PROFIBUS FMS	PROFIBUS DP	DNP3.0	Additional Service Interface (optional)
Operational Measured Values	Yes	Yes	Yes	Yes	Yes
Metered Values	Yes	Yes	Yes	Yes	Yes
Fault Recording	Yes	Yes	No. Only via additional service interface	No. Only via additional service interface	Yes
Remote Protection setting	No. Only via additional service interface	Yes	No. Only via additional service interface	No. Only via additional service interface	Yes
User-defined annunciations and switching objects	Yes	Yes	Predefined “User-defined Annunciations” in CFC	Predefined “User-defined Annunciations” in CFC	Yes
Time Synchronization	Via protocol; DCF77/IRIG B; Interface; Binary Input	Via protocol; DCF77/IRIG B; Interface; Binary Input	Via DCF77/IRIG B; Interface; Binary input	Via protocol; DCF77/IRIG B; Interface; Binary Input	-
Messages with Time Stamp	Yes	Yes	No	Yes	Yes
Commissioning Tools					
Measured Value Indication Blocking	Yes	Yes	No	No	Yes
Creating test messages	Yes	Yes	No	No	Yes
Physical Mode	Asynchronous	Asynchronous	Asynchronous	Asynchronous	-
Transmission Mode	Cyclically/Event	Cyclically/Event	Cyclically	Cyclically/Event	-
Baud Rate	4800 to 38400	Up to 1.5 MBaud	Up to 1.5 MBaud	2400 to 19200	2400 to 115200
Type	RS 232 RS 485 fibre optic cable	RS485 fibre optic cable Double ring	RS485 fibre optic cable Double ring	RS485 fibre optic cable	RS232/RS485

A.6 Functional Scope

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Enabled	Setting Group Change Option
104	OSC. FAULT REC.	Disabled Enabled	Enabled	Oscillographic Fault Records
113	DISTANCE CURVE	Quadrilateral Combined	Combined	Distance Curve
122	InrushRestraint	Disabled Enabled	Enabled	2nd Harmonic Inrush Restraint
124	FCT HS O/C	Disabled Enabled	Enabled	Instantan. High-Speed O/C Pro-tection
126	Back-Up O/C	Disabled Enabled	Enabled	Backup overcurrent
127	FCT Emerg. O/C	Disabled Enabled	Enabled	Emergency Overcurrent Protec-tion
133	Auto Reclose	Disabled Enabled	Enabled	Auto-Reclose Function
135	Synchro-Check	Disabled Enabled	Enabled	Synchronism and Voltage Check
137	O/U VOLTAGE	Disabled Enabled	Enabled	Under / Overvoltage Protection
138	Fault Locator	Disabled Enabled	Enabled	Fault Locator
139	BREAKER FAILURE	Disabled Enabled	Enabled	Breaker Failure Protection
140	Trip Cir. Sup.	Disabled Enabled	Disabled	Trip Circuit Supervision
141	FCT It-Calc.	Disabled Start by Aux Start by TRIP	Start by TRIP	It Function (ampere-seconds)
142	Therm.Overload	Disabled Enabled	Disabled	Thermal Overload Protection
143	Temp.Sens	Disabled -30 to +55 °C -55 to +55 °C	Disabled	Ambient Temperature Sensing
144	FCT DEFROSTING	Disabled Enabled	Disabled	Defrosting Protection Function

A.7 Settings

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

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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
201	CT Starpoint	P.System Data 1		towards Line towards Busbar	towards Line	CT Starpoint
202	CT PRIMARY	P.System Data 1		10 .. 5000 A	1000 A	CT Rated Primary Current
203	CT SECONDARY	P.System Data 1		1A 5A	1A	CT Rated Secondary Current
204	Unom PRIMARY	P.System Data 1		1.0 .. 150.0 kV	15.0 kV	Rated Primary Voltage
205	Unom SECONDARY	P.System Data 1		50.0 .. 130.0 V	100.0 V	Rated Secondary Voltage (Ph-Ph)
206	IF CT STARPOINT	P.System Data 1		towards Line towards Busbar	towards Line	IF CT Starpoint
207	IF CT PRIMARY	P.System Data 1		10 .. 5000 A	1000 A	CT Rated Primary Current IF
209	UF PRIMARY	P.System Data 1		1.0 .. 150.0 kV	15.0 kV	Rated Primary Voltage UF
210	UF SECONDARY	P.System Data 1		50.0 .. 130.0 V	100.0 V	Rated Secondary Voltage UF
211	IX CT STARPOINT	P.System Data 1		towards Line towards Busbar	towards Line	IX CT Starpoint
212	IX CT PRIMARY	P.System Data 1		10 .. 5000 A	1000 A	CT Rated Primary Current IX
213	CURRENT I1, I2	P.System Data 1		Separate I1, I2 Sum I1, I2	Separate I1, I2	Current Inputs I1, I2
215	Uline/Uref	P.System Data 1		0.50 .. 2.00	1.00	Matching Ratio Uline / Uref
230	Rated Frequency	P.System Data 1		50 Hz 60 Hz 25 Hz 16,7 Hz	50 Hz	Rated Frequency
234	No. SECTIONS	P.System Data 1		1 Section 2 Sections 3 Sections 4 Sections 5 Sections	1 Section	Number of Line Sections
236	Distance Unit	P.System Data 1		km Miles	km	Distance measurement unit
238	T-CB open	P.System Data 1		0.001 .. 0.200 sec	0.030 sec	CB Operating Time for Opening
239	T-CB close	P.System Data 1		0.01 .. 0.60 sec	0.06 sec	Closing (operating) time of CB
240A	TMin TRIP CMD	P.System Data 1		0.01 .. 32.00 sec	0.15 sec	Minimum TRIP Command Duration
241A	TMax CLOSE CMD	P.System Data 1		0.01 .. 32.00 sec	1.00 sec	Maximum Close Command Duration
242	T-CBtest-dead	P.System Data 1		0.10 .. 30.00 sec	0.10 sec	Dead Time for CB test-autoreclosure
243	TEST CB CIRCUIT	P.System Data 1		Main Trip Backup Trip Both	Main Trip	Trip Circuit Test
245	BI CONTROL	P.System Data 1		Edge Level	Edge	Control of BI for Changeover Functions
302	CHANGE	Change Group		Group A Group B Group C Group D Binary Input Protocol	Group A	Change to Another Setting Group
402A	WAVEFORMTRIGGER	Osc. Fault Rec.		Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403A	WAVEFORM DATA	Osc. Fault Rec.		Fault event Pow.Sys.Flt.	Fault event	Scope of Waveform Data
410	MAX. LENGTH	Osc. Fault Rec.		0.30 .. 5.00 sec	1.00 sec	Max. length of a Waveform Capture Record

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
411	PRE. TRIG. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.10 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	Osc. Fault Rec.		0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input
610	FltDisp.LED/LCD	Device		Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
615	Spont. FltDisp.	Device		NO YES	NO	Spontaneous display of flt.an-nunciations
620	T Backlight on	Device		1 .. 1000 min	60 min	Time Backlight on
1110	X1 SEC	P.System Data 2	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 1st Section
			5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1111	d1	P.System Data 2		1.00 .. 200.00 km; 0	20.00 km	Line Length 1st Section
1112	X2 SEC	P.System Data 2	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 2nd Section
			5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1113	d2	P.System Data 2		1.00 .. 200.00 km; 0	20.00 km	Line Length 2nd Section
1114	X3 SEC	P.System Data 2	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 3rd Section
			5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1115	d3	P.System Data 2		1.00 .. 200.00 km; 0	20.00 km	Line Length 3rd Section
1116	X4 SEC	P.System Data 2	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 4th Section
			5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1117	d4	P.System Data 2		1.00 .. 200.00 km; 0	20.00 km	Line Length 4th Section
1118	X5 SEC	P.System Data 2	1A	0.05 .. 50.00 Ω/km	0.20 Ω/km	Reactance per Unit Length 5th Section
			5A	0.01 .. 10.00 Ω/km	0.04 Ω/km	
1119	d5	P.System Data 2		1.00 .. 200.00 km; 0	20.00 km	Line Length 5th Section
1150A	SI Time Man.Cl	P.System Data 2		0.01 .. 30.00 sec	0.30 sec	Seal-in Time after MANUAL clo-sures
1151	SYN.MAN.CL	P.System Data 2		with Sync-check w/o Sync-check NO	w/o Sync-check	Manual CLOSE COMMAND generation
1160	X1 SEC	P.System Data 2	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 1st Section
			5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1161	d1	P.System Data 2		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 1st Section
1162	X2 SEC	P.System Data 2	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 2nd Section
			5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1163	d2	P.System Data 2		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 2nd Section
1164	X3 SEC	P.System Data 2	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 3rd Section
			5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1165	d3	P.System Data 2		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 3rd Section
1166	X4 SEC	P.System Data 2	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 4th Section
			5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1167	d4	P.System Data 2		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 4th Section
1168	X5 SEC	P.System Data 2	1A	0.05 .. 80.00 Ω/mi	0.30 Ω/mi	Reactance per Unit Length 5th Section
			5A	0.01 .. 16.00 Ω/mi	0.06 Ω/mi	
1169	d5	P.System Data 2		0.60 .. 124.00 Miles; 0	12.50 Miles	Line Length 5th Section
1201	FCT Distance	Distance prot.		ON OFF	ON	Distance protection is
1202	Minimum Iph>	Distance prot.	1A	0.1 .. 2.0 A	0.1 A	Phase Current threshold for dist. meas.
			5A	0.5 .. 10.0 A	0.5 A	
1205	CHANGE ZONE	Distance prot.		Binary Input Protocol Setting Blocked	Protocol	Change to Zone
1210	Rel. T2K	Distance prot.		di OR du di AND du	di OR du	Release of TK of Zone Z2
1211	Rest. di/dt Z2	Distance prot.		0.0 .. 0.5 ; ∞	0.0	Restraint Factor of di/dt-Stage Z2
1220	Rel. T3K	Distance prot.		di OR du di AND du	di OR du	Release of TK of Zone Z2
1221	Rest. di/dt Z3	Distance prot.		0.0 .. 0.5 ; ∞	0.0	Restraint Factor of di/dt-Stage Z3

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1232	SOTF zone	Distance prot.		PICKUP Overreach Zone Inactive	Inactive	Instantaneous trip after Switch-OnToFault
1240	1st Recl. Z1B	Distance prot.		NO YES	YES	Enable Zone Z1B for 1st Reclo-sure Cycle
1301	Op. Mode Z1	Distance prot.		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z1
1302	Zone Sel. Z1	Distance prot.		Z active Z Strk active	Z active	Zone Selection Zone Z1
1306	T1	Distance prot. Distance prot.		0.00 .. 30.00 sec; ∞	0.00 sec	Delay Time Zone Z1
1308	R1	Distance prot.	1A	0.20 .. 250.00 Ω	5.00 Ω	Resistance R Zone Z1
			5A	0.04 .. 50.00 Ω	1.00 Ω	
1309	X1	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1310	Z1	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1311	ALPHA Z1	Distance prot.		-70 .. 45 °	20 °	Angle Limitation Alpha Zone Z1 Right
1312	BETA Z1	Distance prot.		70 .. 145 °; 0	135 °	Angle Limitation Beta Zone Z1 Left
1313	GAMMA Z1	Distance prot.		-70 .. 40 °	-20 °	Angle Limitation Gamma Zone Z1 Bottom
1314	R1 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	5.00 Ω	Resistance R Zone Z1 Reverse
			5A	0.04 .. 50.00 Ω	1.00 Ω	
1315	X1 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1 Reverse
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1316	Z1 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1 Reverse
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1317	X1 Strk	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1 Stroke
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1318	Z1 Strk	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1 Stroke
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1319	X1 Strk Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Reactance X Zone Z1 Stroke Reverse
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1320	Z1 Strk Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Impedance Z Zone Z1 Stroke Reverse
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1321	Op. Mode Z1B	Distance prot.		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z1B
1322	T1B	Distance prot. Distance prot.		0.00 .. 30.00 sec; ∞	0.00 sec	Delay Time Zone Z1B
1323	R1B	Distance prot.	1A	0.20 .. 250.00 Ω	6.00 Ω	Resistance R Zone Z1B
			5A	0.04 .. 50.00 Ω	1.20 Ω	
1324	X1B	Distance prot.	1A	0.20 .. 250.00 Ω	12.00 Ω	Reactance X Zone Z1B
			5A	0.04 .. 50.00 Ω	2.40 Ω	
1325	Z1B	Distance prot.	1A	0.20 .. 250.00 Ω	12.00 Ω	Impedance Z Zone Z1B
			5A	0.04 .. 50.00 Ω	2.40 Ω	
1326	R1B Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	6.00 Ω	Resistance R Zone Z1B Reverse
			5A	0.04 .. 50.00 Ω	1.20 Ω	
1327	X1B Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	12.00 Ω	Reactance X Zone Z1B Reverse
			5A	0.04 .. 50.00 Ω	2.40 Ω	
1328	Z1B Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	12.00 Ω	Impedance Z Zone Z1B Reverse
			5A	0.04 .. 50.00 Ω	2.40 Ω	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1331	Op. Mode Z1L	Distance prot.		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z1L
1332	T1L	Distance prot. Distance prot.		0.00 .. 60.00 sec; ∞	0.40 sec	Delay Time Zone Z1L
1333	R1L	Distance prot.	1A	0.20 .. 250.00 Ω	9.00 Ω	Resistance R Zone Z1L
			5A	0.04 .. 50.00 Ω	1.80 Ω	
1334	X1L	Distance prot.	1A	0.20 .. 250.00 Ω	18.00 Ω	Reactance X Zone Z1L
			5A	0.04 .. 50.00 Ω	3.60 Ω	
1335	Z1L	Distance prot.	1A	0.20 .. 250.00 Ω	18.00 Ω	Impedance Z Zone Z1L
			5A	0.04 .. 50.00 Ω	3.60 Ω	
1336	R1L Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	9.00 Ω	Resistance R Zone Z1L Reverse
			5A	0.04 .. 50.00 Ω	1.80 Ω	
1337	X1L Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	18.00 Ω	Reactance X Zone Z1L Reverse
			5A	0.04 .. 50.00 Ω	3.60 Ω	
1338	Z1L Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	18.00 Ω	Impedance Z Zone Z1L Reverse
			5A	0.04 .. 50.00 Ω	3.60 Ω	
1341	Op. Mode Z2	Distance prot.		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z2
1342	Zone Sel. Z2	Distance prot.		Z active Z Strk active	Z active	Zone Selection Zone Z2
1343	di/dt Z2	Distance prot.	1A	0.0 .. 1.0 A; ∞	0.5 A	Pickup Value of di/dt Function Zone Z2
			5A	0.0 .. 5.0 A; ∞	2.5 A	
1344	du/dt Z2	Distance prot.		0 .. 100 V; ∞	20 V	Pickup Value of du/dt Function Zone Z2
1345	Dead VoltThr Z2	Distance prot.		50 .. 100 V; ∞	80 V	Dead Voltage Threshold for Zone Z2
1346	T2K	Distance prot. Distance prot.		0.00 .. 30.00 sec; ∞	0.80 sec	Delay Time TK Zone Z2
1347	T2L	Distance prot. Distance prot.		0.00 .. 60.00 sec; ∞	4.00 sec	Delay Time TL Zone Z2
1348	R2	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Zone Z2
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1349	X2	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1350	Z2	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1351	ALPHA Z2	Distance prot.		-70 .. 45 °	20 °	Angle Limitation Alpha Zone Z2 Right
1352	BETA Z2	Distance prot.		70 .. 145 °; 0	135 °	Angle Limitation Beta Zone Z2 Left
1353	GAMMA Z2	Distance prot.		-70 .. 40 °	-20 °	Angle Limitation Gamma Zone Z2 Bottom
1354	R2 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Zone Z2 Reverse
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1355	X2 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2 Reverse
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1356	Z2 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2 Reverse
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1357	X2 Strk	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2 Stroke
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1358	Z2 Strk	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2 Stroke
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1359	X2 Strk Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Zone Z2 Stroke Reverse
			5A	0.04 .. 50.00 Ω	4.00 Ω	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1360	Z2 Strk Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Zone Z2 Stroke Reverse
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1361	Op. Mode Z3	Distance prot.		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Distance Zone Z3
1362	Zone Sel. Z3	Distance prot.		Z active Z Strk active	Z active	Zone Selection Zone Z3
1363	di/dt Z3	Distance prot.	1A	0.0 .. 1.0 A; ∞	0.5 A	Pickup Value of di/dt Function Zone Z3
			5A	0.0 .. 5.0 A; ∞	2.5 A	
1364	du/dt Z3	Distance prot.		0 .. 100 V; ∞	20 V	Pickup Value of du/dt Function Zone Z3
1365	Dead VoltThr Z3	Distance prot.		50 .. 100 V; ∞	80 V	Dead Voltage Threshold Zone Z3
1366	T3K	Distance prot. Distance prot.		0.00 .. 30.00 sec; ∞	1.20 sec	Delay Time TK Zone Z3
1367	T3L	Distance prot. Distance prot.		0.00 .. 60.00 sec; ∞	8.00 sec	Delay Time TL Zone Z3
1368	R3	Distance prot.	1A	0.20 .. 250.00 Ω	15.00 Ω	Resistance R Zone Z3
			5A	0.04 .. 50.00 Ω	3.00 Ω	
1369	X3	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1370	Z3	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1371	ALPHA Z3	Distance prot.		-70 .. 45 °	20 °	Angle Limitation Alpha Zone Z3 Right
1372	BETA Z3	Distance prot.		70 .. 145 °; 0	135 °	Angle Limitation Beta Zone Z3 Left
1373	GAMMA Z3	Distance prot.		-70 .. 40 °	-20 °	Angle Limitation Gamma Zone Z3 Bottom
1374	R3 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	15.00 Ω	Resistance R Zone Z3 Reverse
			5A	0.04 .. 50.00 Ω	3.00 Ω	
1375	X3 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3 Reverse
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1376	Z3 Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3 Reverse
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1377	X3 Strk	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3 Stroke
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1378	Z3 Strk	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3 Stroke
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1379	X3 Strk Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Reactance X Zone Z3 Stroke Reverse
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1380	Z3 Strk Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	30.00 Ω	Impedance Z Zone Z3 Stroke Reverse
			5A	0.04 .. 50.00 Ω	6.00 Ω	
1381	Op. Mode ZOR	Distance prot.		Forward Forward ext. Reverse Non-Directional Inactive	Forward	Operating Mode Overreach Zone
1382	ROR	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Overreach Zone
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1383	XOR	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Overreach Zone
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1384	ZOR	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Overreach Zone
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1385	ALPHA ZOR	Distance prot.		-70 .. 45 °	20 °	Angle Limit. Alpha Overreach Zone Right
1386	BETA ZOR	Distance prot.		70 .. 145 °; 0	135 °	Angle Limit. Beta Overreach Zone Left

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1387	GAMMA ZOR	Distance prot.		-70 .. 40 °	-20 °	Angle Limit. Gamma Overreach Zone Bottom
1388	ROR Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	10.00 Ω	Resistance R Overreach Zone Reverse
			5A	0.04 .. 50.00 Ω	2.00 Ω	
1389	XOR Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Reactance X Overreach Zone Reverse
			5A	0.04 .. 50.00 Ω	4.00 Ω	
1390	ZOR Reverse	Distance prot.	1A	0.20 .. 250.00 Ω	20.00 Ω	Impedance Z Overreach Zone Reverse
			5A	0.04 .. 50.00 Ω	4.00 Ω	
2301	Inrush DIS >=Z2	Distance prot. InrushRestraint		NO YES	NO	Distance Zones >=Z2 Blocked by Inrush
2302	Inrush O/C	InrushRestraint Overcurrent		NO YES	NO	O/C Blocked by Inrush
2303	Inrush O/C BU	InrushRestraint Emerg. O/C		NO YES	NO	Emerg. O/C Blocked by Inrush
2305	2nd HARM.BLOCK	InrushRestraint		10 .. 45 %	15 %	2nd Harmonics Content of Inrush Blocking
2306	Imax InrushRest	InrushRestraint	1A	0.5 .. 25.0 A	7.5 A	Max.Current, overriding inrush restraint
			5A	2.5 .. 125.0 A	37.5 A	
2307	SI Time INRUSH	InrushRestraint		0 .. 10000 ms; ∞	∞ ms	Seal-In Time of Inrush Detection
2401	HS O/C	HS O/C		ON OFF	ON	High-Speed Overcurrent Protection
2404	I HS O/C	HS O/C	1A	1.0 .. 25.0 A; ∞	10.0 A	High-Speed O/C Pickup Current
			5A	5 .. 125 A; ∞	50 A	
2405	T HS O/C	HS O/C		0.006 .. 0.100 sec; 0; ∞	0.000 sec	High-Speed O/C Delay Time
2408	HS O/C TRIP	HS O/C		single-channel dual-channel	dual-channel	HS O/C TRIP Allocation
2601	OverCurrent	Overcurrent		ON OFF	OFF	Overcurrent Protection Function
2602	CURVE O/C	Overcurrent		Definite Time TOC ANSI TOC IEC	Definite Time	Characteristic Curve for O/C
2603	O/C SOTF Trip	Overcurrent		YES NO	NO	Instantan. Trip after Switch-onto-Fault
2605	I>>>	Overcurrent	1A	0.10 .. 25.00 A; ∞	4.00 A	Pickup Current I>>> VeryHigh-SetStage
			5A	0.50 .. 125.00 A; ∞	20.00 A	
2606	T I>>>	Overcurrent		0.00 .. 30.00 sec; ∞	0.10 sec	Delay Time T I>>> Very High Set Stage
2608	I>>	Overcurrent	1A	0.10 .. 25.00 A; ∞	2.00 A	I>> Pickup
			5A	0.50 .. 125.00 A; ∞	10.00 A	
2609	T I>>	Overcurrent		0.00 .. 30.00 sec; ∞	0.30 sec	T I>> Time Delay
2611	IEC Curve	Overcurrent		Normal Inverse Very Inverse Extremely Inv. LongTimeInverse	Normal Inverse	IEC Curve
2612	ANSI Curve	Overcurrent		Inverse Short Inverse Long Inverse Moderately Inv. Very Inverse Extremely Inv. Definite Inv.	Inverse	ANSI Curve
2614	I>	Overcurrent	1A	0.10 .. 25.00 A; ∞	1.50 A	I> Pickup
			5A	0.50 .. 125.00 A; ∞	7.50 A	
2615	T I>	Overcurrent		0.00 .. 30.00 sec; ∞	0.50 sec	T I> Time Delay
2617	IP	Overcurrent	1A	0.10 .. 4.00 A; ∞	1.00 A	Pickup Current IP for IEC
			5A	0.50 .. 20.00 A; ∞	5.00 A	
2618	T IP	Overcurrent		0.05 .. 3.00 sec; ∞	0.50 sec	Time Dial T IP for IEC
2619	D IP	Overcurrent		0.50 .. 15.00 ; ∞	5.00	Time Dial D IP for ANSI
2701	Emerg. O/C	Emerg. O/C		ON OFF	ON	Emergency Overcurrent Function
2702	SOTF Emerg. O/C	Emerg. O/C		NO YES	NO	Instantan. trip after Switch-onto-Fault

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2705	I Emerg. O/C	Emerg. O/C	1A	0.10 .. 25.00 A; ∞	2.00 A	Emergency O/C Pickup Current
			5A	0.50 .. 125.00 A; ∞	10.00 A	
2706	T Emerg. O/C	Emerg. O/C		0.00 .. 30.00 sec; ∞	0.30 sec	Emergency O/C Delay Time
2901	MEASURE. SUPERV	Monitoring		With FFM Without FFM OFF	With FFM	Measurement Supervision
2921	I> CB	Trip Superv	1A	0.05 .. 0.50 A	0.10 A	Pickup Current Trip Supervision
			5A	0.25 .. 2.50 A	0.50 A	
2922	T I> CB MAX	Trip Superv		1 .. 200 sec	30 sec	Maximum Duration of Trip Supervision
3401	AUTO RECLOSE	Auto Reclose		OFF ON	ON	Auto-Reclose Function
3402	No.Recl.	Auto Reclose		1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles	1 AR-cycle	Maximum Number of Reclosure Attempts
3405	AR w/ DIST.	Auto Reclose		YES NO	YES	AR with Distance Protection
3406	AR w/ HS O/C	Auto Reclose		YES NO	YES	AR with HS O/C Protection
3407	AR w/ DTT	Auto Reclose		YES NO	YES	AR with direct transfer trip
3411	I LIMIT BLK	Auto Reclose		1 .. 25 A; 0; ∞	10 A	Current Limit for AR Blocking
3412	No.Recl. HS O/C	Auto Reclose		1 AR-cycle All AR Cycles	1 AR-cycle	No. of Reclosure Attempts HS O/C Tripped
3413	AR BLK REVERSE	Auto Reclose		YES NO	NO	AR Blocking at Faults Reverse Direction
3415	CB? 1.TRIP	Auto Reclose		YES NO	NO	CB ready interrogation at 1st trip
3416	T-Start MONITOR	Auto Reclose		0.01 .. 300.00 sec	0.50 sec	AR start-signal monitoring time
3417	CB TIME OUT	Auto Reclose		0.01 .. 300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3420	TIME RESTRAINT	Auto Reclose		0.50 .. 300.00 sec	3.00 sec	Auto Reclosing reset time
3421A	T-DEAD EXT.	Auto Reclose		0.50 .. 300.00 sec; ∞	∞ sec	Maximum dead time extension
3423	T-BLOCK MC	Auto Reclose		0.50 .. 300.00 sec; 0	1.00 sec	AR blocking duration after manual close
3430	1.AR: START	Auto Reclose		YES NO	YES	Start of AR allowed in this cycle
3431	1.AR: T-ACTION	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Action Time
3432	1st Recl: Tdead	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead Time for 1st Reclosure Cycle
3434	SYN-CHECK	Auto Reclose		YES NO	NO	Synchro-Check after Dead Time
3440	2nd Recl:START	Auto Reclose		YES NO	NO	Start 2nd Reclosure Cycle Permitted
3441	2-8 Recl:T SI	Auto Reclose		0.01 .. 300.00 sec; ∞	0.20 sec	Seal-In Time for 2nd-8th Reclosure Cycle
3442	2-8 Recl:Tdead	Auto Reclose		0.01 .. 1800.00 sec; ∞	0.50 sec	Dead Time for 2nd to 8th Reclosure Cycle
3450	AUTO-TH-AR	Auto Reclose		ON OFF	ON	Automatic Reclosure after Thermal Trip
3451	No. of TH-AR	Auto Reclose		1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles	1 AR-cycle	Max. Number Automatic Reclosure Attempts
3455	TInhibit TH	Auto Reclose		0.50 .. 300.00 sec	3.00 sec	Inhibit Time after Reclosure
3456	Tdead TH MAX	Auto Reclose		1 .. 60 min; ∞	30 min	Maximum Duration of Dead Time

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3501	FCT Synchronism	Sync. Check		ON OFF	ON	Synchronism and Voltage Check function
3502	Dead Volt. Thr.	Sync. Check		1 .. 60 V	5 V	Voltage Threshold Dead Line / Reference
3503	Live Volt. Thr.	Sync. Check		20 .. 125 V	90 V	Voltage Threshold Live Line / Reference
3504	Umax	Sync. Check		20 .. 140 V	110 V	Maximum permissible voltage
3507	T-SYN. DURATION	Sync. Check		0.01 .. 600.00 sec; ∞	1.00 sec	Maximum duration of synchro-nism-check
3508	T SYNC-STAB	Sync. Check		0.00 .. 30.00 sec	0.00 sec	Synchronous condition stability timer
3509	SyncSD	Sync. Check		(Setting options depend on configuration)	None	synchronizable switching device
3510	Op.mode with AR	Sync. Check		with T-CB close w/o T-CB close	w/o T-CB close	Operating mode with AR
3511	Max. Volt. Diff	Sync. Check		1.0 .. 50.0 V	2.0 V	Maximum voltage difference
3512	Max. Freq. Diff	Sync. Check		0.01 .. 2.00 Hz	0.10 Hz	Maximum frequency difference
3513	Max. Angle Diff	Sync. Check		1 .. 80 °	10 °	Maximum angle difference
3515A	SYNC-CHECK	Sync. Check		YES NO	YES	Live Ref. / Live Line and Sync
3516	Uref>Uline<	Sync. Check		YES NO	NO	Live Ref. / Dead Line Check
3517	Uref<Uline>	Sync. Check		YES NO	NO	Dead Ref. / Live Line Check
3518	Uref<Uline<	Sync. Check		YES NO	NO	Dead Ref. / Dead Line Check
3519	OVERRIDE	Sync. Check		YES NO	NO	Override of any check before AR
3530	Op.mode with MC	Sync. Check		with T-CB close w/o T-CB close	w/o T-CB close	Operating mode with Man.Cl
3531	MC maxVolt.Diff	Sync. Check		1.0 .. 50.0 V	2.0 V	Maximum voltage difference
3532	MC maxFreq.Diff	Sync. Check		0.01 .. 2.00 Hz	0.10 Hz	Maximum frequency difference
3533	MC maxAngleDiff	Sync. Check		1 .. 80 °	10 °	Maximum angle difference
3535A	MC SYNCHR	Sync. Check		YES NO	YES	Live Ref. / Live Line and Sync before MC
3536	MC Uref>Uline<	Sync. Check		YES NO	NO	Live Ref. / Dead Line Check before MC
3537	MC Uref<Uline>	Sync. Check		YES NO	NO	Dead Ref. / Live Line Check before MC
3538	MC Uref<Uline<	Sync. Check		YES NO	NO	Dead Ref. / Dead Line Check before MC
3539	MC O/RIDE	Sync. Check		YES NO	NO	Override of any check before Man.Cl
3701	OVERVOLTAGE	Over/Under Volt		ON OFF	ON	Overvoltage Protection
3702	U>>	Over/Under Volt		20 .. 170 V; ∞	150 V	Pickup Overvoltage U>>
3703	U>> Reset	Over/Under Volt		0.50 .. 0.95	0.95	Reset Ratio U>>
3704	T U>>	Over/Under Volt		0.00 .. 60.00 sec; ∞	1.00 sec	Delay Time Overvoltage U>>
3705	U>	Over/Under Volt		20 .. 170 V; ∞	120 V	Pickup Overvoltage U>
3706	U> Reset	Over/Under Volt		0.50 .. 0.95	0.95	Reset Ratio U>
3707	T U>	Over/Under Volt		0.00 .. 60.00 sec; ∞	2.00 sec	Delay Time Overvoltage U>
3711	UNDERVOLTAGE	Over/Under Volt		ON OFF	ON	Undervoltage Protection
3712	U<<	Over/Under Volt		20 .. 120 V; 0	30 V	Pickup Undervoltage U<< (pos. seq.)
3713	T U<<	Over/Under Volt		0.00 .. 60.00 sec; ∞	1.00 sec	Delay Time Undervoltage U<<
3715	U<	Over/Under Volt		20 .. 120 V; 0	70 V	Pickup Undervoltage U< (pos. seq.)
3716	T U<	Over/Under Volt		0.00 .. 60.00 sec; ∞	2.00 sec	Delay Time Undervoltage U<
3802	START	Fault Locator		TRIP Reclosing/Trip	TRIP	Start fault locator with

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3901	FCT BreakerFail	Breaker Failure		ON OFF	OFF	Breaker Failure Protection is
3902	I> BF	Breaker Failure	1A	0.05 .. 20.00 A	0.10 A	Pick-up threshold I>
			5A	0.25 .. 100.00 A	0.50 A	
3904	tBF1	Breaker Failure		0.10 .. 10.00 sec; ∞	0.50 sec	Delay Time Backup Trip Element
3905	tBF2	Breaker Failure		0.10 .. 10.00 sec; ∞	0.75 sec	Delay Time Higher-Level Protec-tion
4001	FCT TripSuperv.	TripCirc.Superv		ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	TripCirc.Superv		1 .. 2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	TripCirc.Superv		1 .. 30 sec	2 sec	Delay Time for alarm
4101	It FUNCTION	It Function		ON OFF	ON	It Function
4102	T00	It Function		0.001 .. 0.100 sec; 0	0.005 sec	CB Response Time
4103	DELTA AuxCont	It Function		-0.050 .. 0.050 sec	0.000 sec	Time Diff. CB Main and Auxiliary Contact
4104	It ALARM	It Function		1.0 .. 1000.0 ; ∞	500.0	Alarm Stage of It Detection in I/In*s
4201	Ther. OVER LOAD	Therm. Overload		OFF ON	OFF	Thermal overload protection
4202	CAT CHANGEOVER	Therm. Overload		Binary Input Protocol Setting Blocked	Binary Input	Catenary Changeover
4203	TAU	Therm. Overload		2.0 .. 30.0 min	5.0 min	Thermal Time Constant
4204	k ITRise	Therm. Overload		0.10 .. 4.00	1.20	Max. Permissible Current Factor ITRise
4205	T Rise	Therm. Overload		0 .. 100 K; < > 0	50 K	Final Temperature at ITRise
4206	TEMP TRIP	Therm. Overload		50 .. 100 °C	50 °C	Tripping Temperature
4207	TEMP ALARM	Therm. Overload		40 .. 100 °C	40 °C	Alarm Temperature
4208	TEMP CLOSE	Therm. Overload		25 .. 100 °C	40 °C	Closing Temperature
4210	CHANGE TO CAT	Therm. Overload		CAT1 active CAT2 active CAT3 active	CAT1 active	Change to Catenary
4211	CAT2	Therm. Overload		1.0 .. 3.0	1.0	Factor for 2 Catenaries
4212	CAT3	Therm. Overload		1.0 .. 3.0	1.0	Factor for 3 Catenaries
4215	AMB.TEMP.	Therm. Overload		-55 .. 40 °C	15 °C	Ambient Temperature Value
4216	MIN TEMP PRESET	Therm. Overload		-55 .. 40 °C	-55 °C	Minimum Setting Ambient Tem-perature
4301	Defrosting	Defrosting		ON OFF	OFF	Defrosting Protection
4302	ID>	Defrosting		0.10 .. 2.00 I/In	0.40 I/In	Pickup Current ID> Defrosting Protection
4303	T ID>	Defrosting		0.00 .. 30.00 sec; ∞	0.10 sec	Delay Time ID> for Defrosting Protection
4304	k	Defrosting		0.00 .. 0.80	0.50	Charact. Slope of Defrosting Pro-tection
4306	IX>>	Defrosting	1A	0.10 .. 25.00 A; ∞	2.00 A	Pickup Current High-Set Stage IX>>
			5A	0.50 .. 125.00 A; ∞	10.00 A	
4307	T IX>>	Defrosting		0.00 .. 30.00 sec; ∞	0.30 sec	Delay Time IX>>
4308	IX>	Defrosting	1A	0.10 .. 25.00 A; ∞	1.50 A	Pickup Overcurrent Stage IX>
			5A	0.50 .. 125.00 A; ∞	7.50 A	
4309	T IX>	Defrosting		0.00 .. 30.00 sec; ∞	0.50 sec	Delay Time IX>

A.8 Information List

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
-	Test mode (Test mode)	Device	IntSP	ON OFF	*		*	LED			BO		128	21	1	Yes
-	Stop data transmission (DataStop)	Device	IntSP	ON OFF	*		*	LED			BO		128	20	1	Yes
-	Clock Synchronization (SynchClock)	Device	IntSP_Ev	*	*		*	LED			BO					
-	>Back Light on (>Light on)	Device	SP	ON OFF	*				BI							
-	Hardware Test Mode (HWTestMod)	Device	IntSP	ON OFF	*		*	LED			BO					
-	Error FMS FO 1 (Error FMS1)	Device	OUT	ON OFF	*		*	LED			BO					
-	Error FMS FO 2 (Error FMS2)	Device	OUT	ON OFF	*		*	LED			BO					
-	Breaker OPENED (Brk OPENED)	Device	IntSP	*	*		*	LED			BO					
-	Feeder EARTHED (FdrEARTHED)	Device	IntSP	*	*		*	LED			BO					
-	Group A (Group A)	Change Group	IntSP	ON OFF	*		*	LED			BO		128	23	1	Yes
-	Group B (Group B)	Change Group	IntSP	ON OFF	*		*	LED			BO		128	24	1	Yes
-	Group C (Group C)	Change Group	IntSP	ON OFF	*		*	LED			BO		128	25	1	Yes
-	Group D (Group D)	Change Group	IntSP	ON OFF	*		*	LED			BO		128	26	1	Yes
-	Fault Recording Start (FltRecSta)	Osc. Fault Rec.	IntSP	ON OFF	*		m	LED			BO					
-	CB-Test:TRIP command main trip element (CB-T T M)	Testing	-	*	*		*	LED			BO					
-	CB-Test:TRIP command backup trip element (CB-T T B)	Testing	-	*	*		*	LED			BO					
-	CB-Test: trip/close main trip element (CB-T T/C M)	Testing	-	*	*		*	LED			BO					
-	CB-Test: trip/close backup trip element (CB-T T/C B)	Testing	-	*	*		*	LED			BO					
-	Control Authority (Cntrl Auth)	Cntrl Authority	DP	ON OFF	*			LED					101	85	1	Yes
-	Controlmode LOCAL (ModeLOCAL)	Cntrl Authority	DP	ON OFF	*			LED					101	86	1	Yes
-	Controlmode REMOTE (ModeREMOTE)	Cntrl Authority	IntSP	ON OFF	*			LED								
-	Breaker (Breaker)	Control Device	CF_D12	on off	*						BO		240	160	20	
-	Breaker (Breaker)	Control Device	DP	on off	*				BI				240	160	1	Yes
-	Disconnect Switch (Disc.Swit.)	Control Device	CF_D2	on off	*						BO		240	161	20	
-	Disconnect Switch (Disc.Swit.)	Control Device	DP	on off	*				BI			CB	240	161	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
-	Earth Switch (EarthSwit)	Control Device	CF_D 2	on off	*						BO		240	164	20	
-	Earth Switch (EarthSwit)	Control Device	DP	on off	*				BI			CB	240	164	1	Yes
-	Interlocking: 52 Open (52 Open)	Control Device	IntSP	*	*		*									
-	Interlocking: 52 Close (52 Close)	Control Device	IntSP	*	*		*									
-	Interlocking: Disconnect switch Open (Disc.Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Disconnect switch Close (Disc.Close)	Control Device	IntSP	*	*		*									
-	Interlocking: Earth switch Open (E Sw Open)	Control Device	IntSP	*	*		*									
-	Interlocking: Earth switch Close (E Sw Cl.)	Control Device	IntSP	*	*		*									
-	Fan ON/OFF (Fan ON/OFF)	Control Device	CF_D 2	on off	*						BO		240	175	20	
-	Fan ON/OFF (Fan ON/OFF)	Control Device	DP	on off	*				BI			CB	240	175	1	Yes
-	Unlock data transmission via BI (UnlockDT)	Control Device	IntSP	*	*		*									
-	Error Systeminterface (SysIn-tErr.)	-	IntSP	on off	*		*	LED			BO					
1	No Function configured (Not con-figured)	Device	SP													
2	Function Not Available (Non Exis-tent)	Device	SP													
3	>Synchronize Internal Real Time Clock (>Time Synch)	Device	SP	*	*		*	LED	BI		BO					
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Osc. Fault Rec.	SP	ON	*		m	LED	BI		BO					
5	>Reset LED (>Reset LED)	Device	SP	*	*		*	LED	BI		BO					
7	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	SP	*	*		*	LED	BI		BO					
8	>Setting Group Select Bit 1 (>Set Group Bit1)	Change Group	SP	*	*		*	LED	BI		BO					
11	>User defined annunciation 1 (>Annunc. 1)	P.System Data 1	SP	*	*		*	LED	BI		BO		128	27	1	Yes
12	>User defined annunciation 2 (>Annunc. 2)	P.System Data 1	SP	*	*		*	LED	BI		BO		128	28	1	Yes
13	>User defined annunciation 3 (>Annunc. 3)	P.System Data 1	SP	*	*		*	LED	BI		BO		128	29	1	Yes
14	>User defined annunciation 4 (>Annunc. 4)	P.System Data 1	SP	*	*		*	LED	BI		BO		128	30	1	Yes
15	>Test mode (>Test mode)	Device	SP	ON OFF	*		*	LED	BI		BO		135	53	1	Yes
16	>Stop data transmission (>DataStop)	Device	SP	*	*		*	LED	BI		BO		135	54	1	Yes
51	Device is Operational and Pro-tecting (Device OK)	Device	OUT	ON OFF	*		*	LED			BO		138	32	1	Yes
52	At Least 1 Protection Funct. is Active (ProtActive)	P.System Data 2	IntSP	ON OFF	*		*	LED			BO		128	18	1	Yes
55	Reset Device (Reset Device)	Device	OUT	*	*		*	LED			BO		128	4	1	No
56	Initial Start of Device (Initial Start)	Device	OUT	ON	*		*	LED			BO		128	5	1	No
60	Reset LED (Reset LED)	Device	OUT_ Ev	ON	*		*	LED			BO		128	19	1	No

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
67	Resume (Resume)	Device	OUT	ON	*		*	LED			BO		135	97	1	No
68	Clock Synchronization Error (Clock SyncError)	Device	OUT	ON OFF	*		*	LED			BO					
69	Daylight Saving Time (DayLight-SavTime)	Device	OUT	ON OFF	*		*	LED			BO					
70	Setting calculation is running (Settings Calc.)	Device	OUT	ON OFF	*		*	LED			BO		128	22	1	Yes
71	Settings Check (Settings Check)	Device	OUT	*	*		*	LED			BO					
72	Level-2 change (Level-2 change)	Device	OUT	ON OFF	*		*	LED			BO					
73	Local setting change (Local change)	Device	OUT	*	*											
110	Event lost (Event Lost)	Device	OUT_ Ev	ON	*		*	LED			BO		135	130	1	No
113	Flag Lost (Flag Lost)	Device	OUT	ON	*		m	LED			BO		135	136	1	Yes
125	Chatter ON (Chatter ON)	Device	OUT	ON OFF	*		*	LED			BO		135	145	1	Yes
126	Protection ON/OFF (via system port) (ProtON/OFF)	P.System Data 2	IntSP	ON OFF	*		*	LED			BO					
140	Error with a summary alarm (Error Sum Alarm)	Device	OUT	ON OFF	*		*	LED			BO		128	47	1	Yes
144	Error 5V (Error 5V)	Device	OUT	ON OFF	*		*	LED			BO		135	164	1	Yes
157	Failure of main circuit breaker (Fail. MAIN CB)	Breaker Failure	OUT	on off	*		*	LED			BO		138	73	1	Yes
158	Failure of outdoor temp. sensing (Fail.TEMPSENS)	Device	OUT	on off	*		*	LED			BO		138	234	1	Yes
160	Alarm Summary Event (Alarm Sum Event)	Device	OUT	*	*		*	LED			BO		128	46	1	Yes
169	VT Fuse Failure (alarm >t) (VT FuseFail>t)	Monitoring	OUT	on off	*		*	LED			BO		135	188	1	Yes
170	VT Fuse Failure (alarm instanta-neous) (VT FuseFail)	Monitoring	OUT	on off	*		*	LED			BO					
177	Failure: Battery empty (Fail Bat-tery)	Device	OUT	ON OFF	*		*	LED			BO		135	193	1	Yes
181	Error: A/D converter (Error A/D-conv.)	Device	OUT	ON OFF	*		*	LED			BO		128	33	1	Yes
182	Alarm: Real Time Clock (Alarm Clock)	Device	OUT	ON OFF	*		*	LED			BO		135	194	1	Yes
183	Error Board 1 (Error Board 1)	Device	OUT	ON OFF	*		*	LED			BO		135	171	1	Yes
184	Error Board 2 (Error Board 2)	Device	OUT	ON OFF	*		*	LED			BO		135	172	1	Yes
185	Error Board 3 (Error Board 3)	Device	OUT	ON OFF	*		*	LED			BO		135	173	1	Yes
186	Error Board 4 (Error Board 4)	Device	OUT	ON OFF	*		*	LED			BO		135	174	1	Yes
187	Error Board 5 (Error Board 5)	Device	OUT	ON OFF	*		*	LED			BO		135	175	1	Yes
188	Error Board 6 (Error Board 6)	Device	OUT	ON OFF	*		*	LED			BO		135	176	1	Yes
189	Error Board 7 (Error Board 7)	Device	OUT	ON OFF	*		*	LED			BO		135	177	1	Yes
190	Error Board 0 (Error Board 0)	Device	OUT	ON OFF	*		*	LED			BO		135	210	1	Yes

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
192	- (-)	Device	OUT	ON OFF	*		*	LED			BO		135	169	1	Yes
193	Alarm: Analog input adjustment invalid (Alarm adjustm.)	Device	OUT	ON OFF	*		*	LED			BO		135	181	1	Yes
196	Fuse Fail Monitor is switched OFF (Fuse Fail M.OFF)	Monitoring	OUT	on off	*		*	LED			BO		135	196	1	Yes
197	Measurement Supervision is switched OFF (MeasSup OFF)	Monitoring	OUT	on off	*		*	LED			BO		135	197	1	Yes
301	Power System fault (Pow.Sys.Flt.)	P.System Data 2	VI	ON OFF	ON		*						138	43	2	Yes
302	Fault Event (Fault Event)	P.System Data 2	VI	*	ON		*						138	42	2	Yes
356	>Manual close signal (>Manual Close)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	6	1	Yes
357	>Block all close commands from external (>CloseCmd.Blo)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		150	7	1	Yes
361	>Failure: Feeder VT (MCB tripped) (>FAIL:Feeder VT)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		128	38	1	Yes
365	>Select: Control by BI or SYS interface (>Ctrl Select.)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO					
378	>CB faulty (>CB faulty)	P.System Data 2	SP	*	*		*	LED	BI		BO					
385	>Lockout SET (>Lockout SET)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		150	35	1	Yes
386	>Lockout RESET (>Lockout RESET)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		150	36	1	Yes
510	General CLOSE of relay (Relay CLOSE)	P.System Data 2	OUT	*	*		*	LED			BO					
511	Relay GENERAL TRIP command (Relay TRIP)	P.System Data 2	OUT	*			m	LED			BO					
530	LOCKOUT is active (LOCKOUT)	P.System Data 2	IntSP	ON OFF	ON OFF		*	LED			BO		150	170	1	Yes
536	Final Trip (Final Trip)	P.System Data 2	OUT	ON	ON		*	LED			BO		150	180	2	No
545	Time from Pickup to drop out (PU Time)	P.System Data 2	VI													
546	Time from Pickup to TRIP (TRIP Time)	P.System Data 2	VI													
561	Manual close signal detected (Man.Clos.Detect)	P.System Data 2	OUT	ON	*		*	LED			BO		150	211	1	No
562	CB close command for manual closing (Man.Close Cmd)	P.System Data 2	OUT	*	*		*	LED			BO		150	212	1	No
563	CB alarm suppressed (CB Alarm Supp)	P.System Data 2	OUT	*	*			LED			BO					
1000	Number of breaker TRIP commands (# TRIPs=)	Statistics	VI	*	*											
1008	Sum of fault currents (I/In)^2 (Σ(I/In)^2=)	Statistics	VI	*	*											
1106	>Start Fault Locator (>Start Flt. Loc)	Fault Locator	SP	on off	on off		*	LED	BI		BO					
1110	Fault locator is blocked (FltLoc block)	Fault Locator	OUT	on off	*		*	LED			BO		138	11	1	Yes
1114	Flt Locator: primary RESISTANCE (Rpri =)	Fault Locator	VI	*	on off								138	1	4	No
1115	Flt Locator: primary REACTANCE (Xpri =)	Fault Locator	VI	*	on off								128	73	4	No
1117	Flt Locator: secondary RESISTANCE (Rsec =)	Fault Locator	VI	*	on off								138	2	4	No

No.	Description	Function	Type of Information	Log Buffers: Event Log ON/OFF	Log Buffers: Trip (Fault) Log ON/OFF	Log Buffers: Ground Fault Log ON/OFF	Log Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Relay	Configurable in Matrix: Chatter Suppression	IEC 60870-5-103: Type	IEC 60870-5-103: Information Number	IEC 60870-5-103: Data Unit	IEC 60870-5-103: General Interrogation
1118	Flt Locator: secondary REACTANCE (Xsec =)	Fault Locator	VI	*	on off								138	8	4	No
1119	Flt Locator: Distance to fault (dist =)	Fault Locator	VI	*	on off								138	3	4	No
1120	Flt Locator: Distance [%] to fault (d[%] =)	Fault Locator	VI	*	on off								138	4	4	No
1121	Fault in section (Fault section)	Fault Locator	VI	*	on off								138	5	4	No
1122	Flt Locator: Distance to fault (dist =)	Fault Locator	VI	*	on off								138	10	4	No
1129	No calculation of distance possible (FltLoc imposs)	Fault Locator	OUT_Ev	on	*		*	LED			BO		138	6	1	No
1130	Distance to fault out of range (Flt dist >)	Fault Locator	OUT_Ev	on	*		*	LED			BO		138	7	1	No
1132	Fault location invalid (Flt.Loc.invalid)	Fault Locator	OUT_Ev	*	on		*	LED			BO					
1190	Forward direction (forward dir.)	Distance prot.	OUT	on off	*		*	LED			BO		138	40	1	Yes
1191	Pickup autom. testunit overh.cont.line (Pckup TstUnit)	P.System Data 2	OUT		on		*	LED			BO		138	38	2	Yes
1401	>BF: Switch on breaker fail protection (>BF on)	Breaker Failure	SP	on off	*		*	LED	BI		BO					
1402	>BF: Switch off breaker fail protection (>BF off)	Breaker Failure	SP	on off	*		*	LED	BI		BO					
1431	>Breaker failure initiated externally (>BrkFail extSRC)	Breaker Failure	SP	on off	*		*	LED	BI		BO					
1438	>External CB Trip (>Ext. CB Trip)	Trip Superv	SP	on off	*		*	LED	BI		BO					
1440	Breaker failure prot. ON/OFF via BI (BkrFailON/offBI)	Breaker Failure	IntSP	*	*		*	LED			BO					
1451	Breaker failure is switched OFF (BkrFail OFF)	Breaker Failure	OUT	on off	*		*	LED			BO		138	64	1	Yes
1455	Breaker failure : fault detection (B/F fault)	Breaker Failure	OUT	*	on off		*	LED			BO		138	75	2	Yes
1471	Breaker failure TRIP (BrkFailure TRIP)	Breaker Failure	OUT	*	on		*	LED			BO		138	76	2	No
1484	B/F: pick up superordinat.prot.relais (B/F s.ordProt)	Breaker Failure	OUT	*	on		*	LED			BO		138	72	2	No
1491	Circuit Breaker Fault (CB Fault)	Trip Superv	OUT	on off	on off		*	LED			BO		138	74	1	Yes
1501	>Switch on thermal overload protection (>O/L on)	Therm. Overload	SP	on off	*		*	LED	BI		BO		167	1	1	Yes
1502	>Switch off thermal overload protection (>O/L off)	Therm. Overload	SP	on off	*		*	LED	BI		BO		167	2	1	Yes
1511	Thermal Overload Protection OFF (Th.Overload OFF)	Therm. Overload	OUT	on off	*		*	LED			BO		138	224	1	Yes
1516	Overload Alarm! Near Thermal Trip (O/L Θ Alarm)	Therm. Overload	OUT	on off	*		*	LED			BO		138	230	1	Yes
1521	Thermal Overload TRIP (ThOverload TRIP)	Therm. Overload	OUT	*	on		m	LED			BO		138	231	2	No
1820	Ip picked up (Ip picked up)	Overcurrent	OUT	*	on off		*	LED			BO		138	212	2	Yes
1825	Ip TRIP (Ip TRIP)	Overcurrent	OUT	*	on		*	LED			BO		138	216	2	No
2001	>Switch ON emerg. overcurrent prot. (>Emer. ON)	Emerg. O/C	SP	on off	*		*	LED	BI		BO		61	1	1	Yes
2002	>Switch OFF emerg. overcurrent prot. (>Emer. OFF)	Emerg. O/C	SP	on off	*		*	LED	BI		BO		61	2	1	Yes

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
2051	Emergency O/C protect. is switched off (Emer. off)	Emerg. O/C	OUT	on off	*		*	LED			BO		61	51	1	Yes
2053	Emergency O/C protection is active (Emer. active)	Emerg. O/C	OUT	on off	*		*	LED			BO					
2054	Emergency mode (Emer. mode)	Monitoring	OUT	on off	*		*	LED			BO		128	37	1	Yes
2061	Emerg. O/C prot.: General fault detect. (Emer.Gen.Flt)	Emerg. O/C	OUT	*	on off		m	LED			BO		61	61	2	Yes
2141	Emerg. O/C protection: General Trip (Emer.Gen.Trip)	Emerg. O/C	OUT	*	on		m	LED			BO		138	53	2	No
2640	Forward direction (forward dir.)	P.System Data 2	OUT_Ev	*	on		*	LED			BO		128	74	2	No
2641	Reverse direction (reverse dir.)	P.System Data 2	OUT_Ev	*	on		*	LED			BO		128	75	2	No
2701	>Auto reclose ON (>AR ON)	Auto Reclose	SP	on off	*		*	LED	BI		BO		40	1	1	Yes
2702	>Auto reclose OFF (>AR OFF)	Auto Reclose	SP	on off	*		*	LED	BI		BO		40	2	1	Yes
2703	>BLOCK Auto reclose (>BLOCK AR)	Auto Reclose	SP	on off	on off		*	LED	BI		BO		40	3	1	Yes
2710	>Th-AR: Block thermal AR-function (>Th-AR block)	Auto Reclose	SP	on off	on off		*	LED	BI		BO		40	5	1	Yes
2711	>External start of internal Auto reclose (>AR Start)	Auto Reclose	SP	*	on off		*	LED	BI		BO		40	11	2	Yes
2718	>Th-AR: Switch on thermal-AR function (>Th-AR ON)	Auto Reclose	SP	on off	*		*	LED	BI		BO		40	18	1	Yes
2719	>Th-AR: Switch off thermal-AR function (>Th-AR OFF)	Auto Reclose	SP	on off	*		*	LED	BI		BO		40	19	1	Yes
2730	>Circuit breaker READY for reclosing (>CB Ready)	P.System Data 2	SP	*	*		*	LED	BI		BO		40	30	1	Yes
2731	>AR: Synchronism from ext. sync.-check (>Sync.release)	Auto Reclose	SP	*	*		*	LED	BI		BO		40	31	2	Yes
2742	>AR: Block 1st AR-cycle (>BLK 1.AR-cycle)	Auto Reclose	SP	on off	on off		*	LED	BI		BO		40	37	1	Yes
2746	>AR: External Trip for AR start (>Trip for AR)	Auto Reclose	SP	*	on off		*	LED	BI		BO		40	41	2	Yes
2781	Auto recloser is switched OFF (Auto recl. OFF)	Auto Reclose	OUT	on off	*		*	LED			BO		40	81	1	Yes
2782	Auto recloser is switched ON (Auto recl. ON)	Auto Reclose	IntSP	*	*		*	LED			BO		128	16	1	Yes
2783	AR: Auto-reclose is blocked (AR is blocked)	Auto Reclose	OUT	on off	*		*	LED			BO		128	130	1	Yes
2784	Auto recloser is NOT ready (AR is NOT ready)	Auto Reclose	OUT	on off	*		*	LED			BO					
2785	Auto-reclose is dynamically BLOCKED (AR DynBlock)	Auto Reclose	OUT	*	on		*	LED			BO		40	85	2	Yes
2787	AR: Circuit breaker not ready (CB not ready)	Auto Reclose	OUT	*	*		*	LED			BO		40	87	1	Yes
2788	AR: CB ready monitoring window expired (AR T-CBreadyExp)	Auto Reclose	OUT	*	on		*	LED			BO		40	88	2	No
2793	Th-AR: Thermal AR not ready (Th-AR not rdy)	Auto Reclose	OUT	on off	*		*	LED			BO		40	136	1	Yes
2794	Th-AR: Thermal AR is switched off (Th-AR off)	Auto Reclose	OUT	on off	*		*	LED			BO		40	94	1	Yes
2795	Th-AR: Thermal AR is switched on (Th-AR on)	Auto Reclose	IntSP	*	*		*	LED			BO		40	17	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
2796	AR: Auto-reclose ON/OFF via BI (AR on/off BI)	Auto Reclose	IntSP	*	*		*	LED			BO					
2801	Auto-reclose in progress (AR in progress)	Auto Reclose	OUT	*	on		*	LED			BO		40	101	2	Yes
2805	Th-AR: Thermal AR in progress (Th-AR in prog)	Auto Reclose	OUT	*	on		*	LED			BO		40	104	2	Yes
2808	AR: CB open with no trip (AR BLK: CB open)	Auto Reclose	OUT	*	*		*	LED			BO		40	55	1	Yes
2809	AR: Start-signal monitoring time expired (AR T-Start Exp)	Auto Reclose	OUT	*	on		*	LED			BO		40	174	2	No
2810	AR: Maximum dead time expired (AR TdeadMax Exp)	Auto Reclose	OUT	*	on		*	LED			BO		40	175	2	No
2819	Th-AR: dead time is running (ThAR Tdead ru)	Auto Reclose	OUT	*	on		*	LED			BO		40	138	2	Yes
2823	AR: no starter configured (AR no starter)	Auto Reclose	OUT	on off	*		*	LED			BO					
2829	AR: action time expired before trip (AR Tact expired)	Auto Reclose	OUT	*	on		*	LED			BO					
2844	AR 1st cycle running (AR 1stCyc. run.)	Auto Reclose	OUT	*	on		*	LED			BO		40	155	2	Yes
2851	Auto-reclose Close command (AR Close)	Auto Reclose	OUT	*	on		m	LED			BO		40	128	2	No
2855	Th-AR: Close command from thermal AR (Th-AR ClosCmd)	Auto Reclose	OUT	*	on		m	LED			BO		40	139	2	No
2861	AR: Reclaim time is running (AR T-Recl. run.)	Auto Reclose	OUT	*	*		*	LED			BO		40	161	1	Yes
2862	Auto reclose cycle successful (AR Successful)	Auto Reclose	OUT	*	*		*	LED			BO		40	162	1	Yes
2863	Auto reclose Lockout (AR Lock-out)	Auto Reclose	OUT	*	*		*	LED			BO		40	163	1	Yes
2865	AR: Synchro-check request (AR Sync.Request)	Auto Reclose	OUT	*	*		*	LED			BO		40	165	2	Yes
2866	Th-AR: Therm.AR reclaim time is running (Th-AR T-Recl.)	Auto Reclose	OUT	*	*		*	LED			BO					
2867	Th-AR: Thermal AR cycle successful (Th-AR success)	Auto Reclose	OUT	*	*		*	LED			BO		40	168	1	Yes
2868	Th-AR: Thermal AR definite trip (Th-AR def.Trp)	Auto Reclose	OUT	*	*		*	LED			BO		40	166	1	Yes
2901	>Switch on synchro-check function (>Sync. on)	Sync. Check	SP	on off	*		*	LED	BI		BO					
2902	>Switch off synchro-check function (>Sync. off)	Sync. Check	SP	on off	*		*	LED	BI		BO					
2903	>BLOCK synchro-check function (>BLOCK Sync.)	Sync. Check	SP	*	*		*	LED	BI		BO					
2905	>Start synchro-check for Manual Close (>Sync. Start MC)	Sync. Check	SP	on off	*		*	LED	BI		BO					
2906	>Start synchro-check for AR (>Sync. Start AR)	Sync. Check	SP	on off	*		*	LED	BI		BO					
2907	>Sync-Prog. Live bus / live line / Sync (>Sync. synch)	Sync. Check	SP	*	*		*	LED	BI		BO					
2911	>Sync-Prog. Override (bypass) (>Sync. o/ride)	Sync. Check	SP	*	*		*	LED	BI		BO					
2930	Synchro-check ON/OFF via BI (Sync. on/off BI)	Sync. Check	IntSP	on off	*		*	LED			BO					
2931	Synchro-check is switched OFF (Sync. OFF)	Sync. Check	OUT	on off	*		*	LED			BO		41	31	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
2932	Synchro-check is BLOCKED (Sync. BLOCK)	Sync. Check	OUT	on off	on off		*	LED			BO		41	32	1	Yes
2934	Synchro-check function faulty (Sync. faulty)	Sync. Check	OUT	on off	*		*	LED			BO		41	34	1	Yes
2935	Synchro-check supervision time expired (Sync.Tsup.Exp)	Sync. Check	OUT	on	on		*	LED			BO		41	35	1	No
2936	Synchro-check request by control (Sync. req.CNTRL)	Sync. Check	OUT	on	on		*	LED			BO		41	36	1	No
2941	Synchronization is running (Sync. running)	Sync. Check	OUT	on off	on		*	LED			BO		41	41	1	Yes
2942	Synchro-check override/bypass (Sync.Override)	Sync. Check	OUT	on off	on		*	LED			BO		41	42	1	Yes
2943	Synchronism detected (Synchro-nism)	Sync. Check	OUT	on off	*		*	LED			BO		41	43	1	Yes
2944	Sync. Dead ref. / Live line detect-ed (SYN Uref<Uline>)	Sync. Check	OUT	on off	*		*	LED			BO		41	44	1	Yes
2945	Sync. Live ref. / Dead line detect-ed (SYN Uref>Uline<)	Sync. Check	OUT	on off	*		*	LED			BO		41	45	1	Yes
2946	Sync. Dead ref. / Dead line de-tected (SYN Uref<Uline<)	Sync. Check	OUT	on off	*		*	LED			BO		41	46	1	Yes
2947	Sync. Voltage diff. greater than limit (Sync. Udiff>)	Sync. Check	OUT	on off	on off		*	LED			BO		41	47	1	Yes
2948	Sync. Freq. diff. greater than limit (Sync. fdiff>)	Sync. Check	OUT	on off	on off		*	LED			BO		41	48	1	Yes
2949	Sync. Angle diff. greater than limit (Sync. φ-diff>)	Sync. Check	OUT	on off	on off		*	LED			BO		41	49	1	Yes
2951	Synchronism release (to ext. AR) (Sync. release)	Sync. Check	OUT	*	*		*	LED			BO		41	51	1	Yes
2961	Close command from synchro-check (Sync.CloseCmd)	Sync. Check	OUT	*	*		*	LED			BO		41	61	1	Yes
2970	Sync. Reference frequency > (fn+3Hz) (Sync. fref>>)	Sync. Check	OUT	on off	on off		*	LED			BO					
2971	Sync. Reference frequency < (fn-3Hz) (Sync. fref<<)	Sync. Check	OUT	on off	on off		*	LED			BO					
2972	Sync. Line frequency > (fn + 3Hz) (Sync. f-line>>)	Sync. Check	OUT	on off	on off		*	LED			BO					
2973	Sync. Line frequency < (fn - 3Hz) (Sync. f-line<<)	Sync. Check	OUT	on off	on off		*	LED			BO					
2974	Sync. Reference voltage > Umax (Sync. Uref>>)	Sync. Check	OUT	on off	on off		*	LED			BO					
2975	Sync. Reference voltage < U> (Sync. Uref<<)	Sync. Check	OUT	on off	on off		*	LED			BO					
2976	Sync. Line voltage > Umax (P.3504) (Sync. U-line>>)	Sync. Check	OUT	on off	on off		*	LED			BO					
2977	Sync. Line voltage < U> (P.3503) (Sync. U-line<<)	Sync. Check	OUT	on off	on off		*	LED			BO					
3601	>Distance protection is switched on (>Dis.prot. on)	Distance prot.	SP	on off	*		*	LED	BI		BO					
3602	>Distance protection is switched off (>Dis.prot.off)	Distance prot.	SP	on off	*		*	LED	BI		BO					
3603	>BLOCK Distance protection (>BLOCK Distance)	Distance prot.	SP	on off	*		*	LED	BI		BO					
3651	Distance is switched off (Dist. OFF)	Distance prot.	OUT	on off	*		*	LED			BO		138	96	1	Yes
3652	Distance is BLOCKED (Dist. BLOCK)	Distance prot.	OUT	on off	on off		*	LED			BO		28	52	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
3653	Distance is ACTIVE (Dist. ACTIVE)	Distance prot.	OUT	on off	*		*	LED			BO		28	53	1	Yes
3671	Distance PICKED UP (Dis. PICKUP)	Distance prot.	OUT	*	on off		m	LED			BO		28	71	2	Yes
3740	Dist.: Fault detection Zone Z1 (Dist. Z1)	Distance prot.	OUT	*	on		*	LED			BO		138	116	2	Yes
3755	Distance Pickup Z2 (Dis. Pickup Z2)	Distance prot.	OUT	*	on		*	LED			BO		138	117	2	Yes
3758	Distance Pickup Z3 (Dis. Pickup Z3)	Distance prot.	OUT	*	on		*	LED			BO		138	118	2	Yes
3771	DistanceTime Out T1 (Dis.Time Out T1)	Distance prot.	OUT	*	on		*	LED			BO		138	176	2	No
3780	DistanceTime Out T1B (Dis.Tim-eOut T1B)	Distance prot.	OUT	*	on		*	LED			BO					
3783	Dist.: Time T1L (Zone Z1L) expired (Dist. T1L)	Distance prot.	OUT	*	on		*	LED			BO					
3801	Distance protection: General trip (Dis.Gen. Trip)	Distance prot.	OUT	*	on		m	LED			BO		138	192	2	No
3810	Dist.: Trip in Zone Z1 (Dis.Trip Z1)	Distance prot.	OUT	*	*		*	LED			BO		128	78	2	No
3900	>Dist.: Zone Z1 stroke is active (>DisZ1str act)	Distance prot.	SP	*	*		*	LED	BI		BO		28	22	1	Yes
3901	>Dist.: Zone Z1 is active (>Dis.Z1 act.)	Distance prot.	SP	*	*		*	LED	BI		BO		28	21	1	Yes
3902	>Dist.: Zone Z2 stroke is active (>DisZ2str act)	Distance prot.	SP	*	*		*	LED	BI		BO		28	24	1	Yes
3903	>Dist.: Zone Z2 is active (>Dis. Z2 act.)	Distance prot.	SP	*	*		*	LED	BI		BO		28	23	1	Yes
3906	>Dist.: Zone Z3 stroke active (>Dis Z3str act)	Distance prot.	SP	*	*		*	LED	BI		BO		28	26	1	Yes
3907	>Dist.: Zone Z3 active (>Dis Z3 act)	Distance prot.	SP	*	*		*	LED	BI		BO		28	25	1	Yes
3909	Dist.: Delay Time T2K is active (Dis. T2K active)	Distance prot.	OUT	on off	*		*	LED			BO					
3915	Dist.: Zone Z1 is active (Dis. Z1 act.)	Distance prot.	OUT	on off	*		*	LED			BO		138	80	1	Yes
3916	Dist.: Zone Z1 stroke is active (Dis.Z1str act)	Distance prot.	IntSP	on off	*		*	LED			BO		138	85	1	Yes
3917	Dist.: Zone Z2 is active (Dis.Z2 act.)	Distance prot.	OUT	on off	*		*	LED			BO		138	81	1	Yes
3918	Dist.: Zone Z2 stroke is active (Dis.Z2str act)	Distance prot.	IntSP	on off	*		*	LED			BO		138	86	1	Yes
3925	Dist.: Flt. detect. Z2 (short circuit) (Dist.Flt.Z2K)	Distance prot.	OUT	*	on		*	LED			BO		138	128	2	Yes
3926	Dist.: Fault detection Z2 (over-load) (Dist.Flt.Z2L)	Distance prot.	OUT	*	on		*	LED			BO		138	132	2	Yes
3927	Dist.: Flt. detect. VE (short circuit) (Dist.Flt.VE)	Distance prot.	OUT	*	on		*	LED			BO		28	115	2	Yes
3930	Dist.: Trip in zone Z2 (short cir-cuit) (Dis. Trip Z2K)	Distance prot.	OUT	*	*		*	LED			BO		138	194	2	No
3931	Dist.: Trip in zone Z2 (overload) (Dis. Trip Z2L)	Distance prot.	OUT	*	*		*	LED			BO		138	198	2	No
3935	Dist.: Time T2K (Zone Z2) expired (Dist. T2K)	Distance prot.	OUT	*	on		*	LED			BO		138	177	2	No
3936	Dist.: Time T2L (Zone Z2) expired (Dist. T2L)	Distance prot.	OUT	*	on		*	LED			BO		138	181	2	No

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log ON/OFF	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
3941	Fault impedance, Ohm sec. (Zsec=)	Measurement	VI		ON OFF								138	9	4	No
3991	Dist.: Zone Z3 is active (Dis. Z3 act)	Distance prot.	OUT	on off	*		*	LED			BO		138	82	1	Yes
3992	Dist.: Zone Z3 stroke is active (Dis. Z3str act)	Distance prot.	IntSP	on off	*		*	LED			BO		138	87	1	Yes
4271	HS O/C is switched OFF (HS O/C OFF)	HS O/C	OUT	on off	*		*	LED			BO		25	71	1	Yes
4281	HS O/C PICKED UP (HS O/C PICKUP)	HS O/C	OUT	*	on off		m	LED			BO		138	218	2	Yes
4293	HS O/C TRIPPED (HS O/C TRIP)	HS O/C	OUT	*	on		m	LED					138	220	2	No
4331	Overvoltage detection : Stage U> (U> Detection)	Over/Under Volt	OUT	*	on off		*	LED			BO		50	31	2	Yes
4332	Overvoltage detection : Stage U>> (U>> Detection)	Over/Under Volt	OUT	*	on off		*	LED			BO		50	32	2	Yes
4335	Overvoltage trip : Stage U> (U> Trip)	Over/Under Volt	OUT	*	on		*	LED			BO		50	35	2	Yes
4336	Overvoltage trip : Stage U>> (U>> Trip)	Over/Under Volt	OUT	*	on		*	LED			BO		50	36	2	Yes
4601	>Breaker contact (OPEN, if bkr is open) (>Brk Aux NO)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	60	1	Yes
4602	>Breaker contact(OPEN, if bkr is closed) (>Brk Aux NC)	P.System Data 2	SP	*	*		*	LED	BI		BO		150	61	1	Yes
6603	>Third catenary is active (>Cat.3 active)	Therm. Overload	SP	*	*		*	LED	BI		BO					
6604	>Second catenary is active (>Cat.2 active)	Therm. Overload	SP	*	*		*	LED	BI		BO					
6605	>First catenary is active (>Cat.1 active)	Therm. Overload	SP	*	*		*	LED	BI		BO					
6616	First catenary is active (Cat. 1 active)	Therm. Overload	IntSP	on off	*		*	LED			BO		138	225	1	Yes
6617	Second catenary is active (Cat. 2 active)	Therm. Overload	IntSP	on off	*		*	LED			BO		138	226	1	Yes
6618	Third catenary is active (Cat. 3 active)	Therm. Overload	IntSP	on off	*		*	LED			BO		138	227	1	Yes
6854	>Trip circuit superv. 1: Trip Relay (>TripC1 TripRel)	TripCirc.Superv	SP	on off	*		*	LED	BI		BO					
6855	>Trip circuit superv. 1: Breaker Relay (>TripC1 Bkr.Rel)	TripCirc.Superv	SP	on off	*		*	LED	BI		BO					
6861	Trip circuit supervision OFF (TripC OFF)	TripCirc.Superv	OUT	on off	*		*	LED			BO					
6865	Failure Trip Circuit (FAIL: Trip cir.)	TripCirc.Superv	OUT	on off	*		*	LED			BO		128	36	1	Yes
6866	TripC1 blocked: Binary Input is not set (TripC1 ProgFAIL)	TripCirc.Superv	OUT	on off	*		*	LED			BO					
7151	Overcurrent is switched OFF (O/C OFF)	Overcurrent	OUT	on off	*		*	LED			BO		138	208	1	Yes
7161	Overcurrent PICKED UP (O/C PICKUP)	Overcurrent	OUT	*	*		*	LED			BO		64	61	2	Yes
7191	Overcurrent Pickup I>> (O/C PICKUP I>>)	Overcurrent	OUT	*	on off		*	LED			BO		138	210	2	Yes
7192	Overcurrent Pickup I> (O/C PICKUP I>)	Overcurrent	OUT	*	on off		*	LED			BO		138	209	2	Yes
7201	O/C I-STUB Pickup (I-STUB PICKUP)	Overcurrent	OUT	*	on off		*	LED			BO		138	211	2	Yes

No.	Description	Function	Type of In-for-mation	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
7211	Overcurrent General TRIP command (O/C TRIP)	Overcurrent	OUT	*	*		*	LED			BO		64	111	2	No
7221	Overcurrent TRIP I>> (O/C TRIP I>>)	Overcurrent	OUT	*	on		*	LED			BO		138	214	2	No
7222	Overcurrent TRIP I> (O/C TRIP I>)	Overcurrent	OUT	*	on		*	LED			BO		138	213	2	No
7235	O/C I-STUB TRIP (I-STUB TRIP)	Overcurrent	OUT	*	on		*	LED			BO		138	215	2	No
7345	CB-TEST is in progress (CB-TEST running)	Testing	OUT	on off	*		*	LED			BO		153	45	1	Yes
7346	CB-TEST canceled due to Power Sys. Fault (CB-TSTstop FLT.)	Testing	OUT_Ev	on	*		*	LED			BO					
7347	CB-TEST canceled due to CB already OPEN (CB-TSTstop OPEN)	Testing	OUT_Ev	on	*		*	LED			BO					
7348	CB-TEST canceled due to CB was NOT READY (CB-TSTstop NOTr)	Testing	OUT_Ev	on	*		*	LED			BO					
7349	CB-TEST canceled due to CB stayed CLOSED (CB-TSTstop CLOS)	Testing	OUT_Ev	on	*		*	LED			BO					
7350	CB-TEST was succesful (CB-TST .OK.)	Testing	OUT_Ev	on	*		*	LED			BO					
13800	di/dt function is active in Zone Z2 (Z2di/dt ACTIVE)	Distance prot.	OUT	on off	*		*	LED			BO					
13801	du/dt function is active in Zone Z2 (Z2du/dt ACTIVE)	Distance prot.	OUT	on off	*		*	LED			BO					
13802	di/dt function is active in Zone Z3 (Z3di/dt ACTIVE)	Distance prot.	OUT	on off	*		*	LED			BO					
13803	du/dt function is active in Zone Z3 (Z3du/dt ACTIVE)	Distance prot.	OUT	on off	*		*	LED			BO					
13804	Dist.: Delay Time T3K is active (Dis. T3K active)	Distance prot.	OUT	on off	*		*	LED			BO					
13805	Time Out T3K (Time Out T3K)	Distance prot.	OUT	*	on		*	LED			BO		138	178	2	No
13806	Time Out T3L (Time Out T3L)	Distance prot.	OUT	*	on		*	LED			BO		138	182	2	No
13807	Picked up in Zone Z1Strk (PU Z1Strk)	Distance prot.	OUT	*	on		*	LED			BO		138	121	2	Yes
13808	Picked up in Zone Z2Strk (PU Z2Strk)	Distance prot.	OUT	*	on		*	LED			BO		138	122	2	Yes
13809	Picked up in Zone Z3Strk (PU Z3Strk)	Distance prot.	OUT	*	on		*	LED			BO		138	123	2	Yes
13810	ON/OFF via BI (ON/offBI)	Distance prot.	IntSP	*	*		*	LED			BO					
13811	Zone Z1Stroke ON/OFF via Serial Inteface (Z1StrkON/OFFs-er)	Distance prot.	IntSP	*	*		*	LED			BO					
13812	Distance Zone Z2Stroke ON (Z2StrkON/OFFser)	Distance prot.	IntSP	*	*		*	LED			BO					
13813	Distance Zone Z3Stroke ON (Z3StrkON/OFFser)	Distance prot.	IntSP	*	*		*	LED			BO					
13815	HS O/C TRIPPED (M) (HS O/C TRIP (M))	HS O/C	OUT	*	*		*	LED			BO					
13816	>Switch on HS O/C Protection (>HS O/C ON)	HS O/C	SP	on off	*		*	LED	BI		BO					
13817	>Switch off HS O/C Protection (>HS O/C OFF)	HS O/C	SP	on off	*		*	LED	BI		BO					
13818	HS O/C ON/OFF about Binary Input (HSo/c ON/OFF BI)	HS O/C	IntSP	*	*		*	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
13819	HS O/C uC-Failure (HS O/C Failure)	HS O/C	OUT	on off	*		*	LED			BO		138	221	1	Yes
13820	>Switch on Overcurrent Protection (>O/C ON)	Overcurrent	SP	on off	*		*	LED	BI		BO		64	1	1	Yes
13821	>Switch off Overcurrent Protection (>O/C OFF)	Overcurrent	SP	on off	*		*	LED	BI		BO		64	2	1	Yes
13822	Overcurrent Protection ON/OFF via BI (O/C ON/OFF BI)	Overcurrent	IntSP	*	*		*	LED			BO					
13824	Overload Protection ON/OFF via BI (O/L ON/OFF BI)	Therm. Overload	IntSP	*	*		*	LED			BO					
13825	O/L Inrush blocking (O/L blocked)	Therm. Overload	OUT	on off	*		*	LED			BO		138	232	1	Yes
13826	Reset thermal replica (ResetThermRepl)	Therm. Overload	IntSP	on	*		*	LED			BO		138	239	1	No
13827	O/L Catenary 1 ON/OFF via Telegram (Cat1 ON/OFF TEL)	Therm. Overload	IntSP	*	*		*	LED			BO					
13828	O/L Catenary 2 ON/OFF via Telegram (Cat2 ON/OFF TEL)	Therm. Overload	IntSP	*	*		*	LED			BO					
13829	O/L Catenary 3 ON/OFF via Telegram (Cat3 ON/OFF TEL)	Therm. Overload	IntSP	*	*		*	LED			BO					
13830	Overvoltage Protection is switched off (OVER. OFF)	Over/Under Volt	OUT	on off	*		*	LED			BO		73	2	1	Yes
13832	Undervoltage Protection is switched off (UNDER. OFF)	Over/Under Volt	OUT	on off	*		*	LED			BO		73	4	1	Yes
13834	Over/Undervoltage Protection picked up (OVER/UNDER PU)	Over/Under Volt	OUT	*	*		m	LED			BO		73	32	2	Yes
13835	Undervolt. U< picked up (UNDER U< PU)	Over/Under Volt	OUT	*	on off		*	LED			BO		73	33	2	Yes
13836	Undervolt. U<< picked up (UNDER U<< PU)	Over/Under Volt	OUT	*	on off		*	LED			BO		73	34	2	Yes
13837	Undervolt. U< TRIP command (UNDER U< TRIP)	Over/Under Volt	OUT	*	on		*	LED			BO		73	36	2	Yes
13838	Undervolt. U<< TRIP command (UNDER U<< TRIP)	Over/Under Volt	OUT	*	on		*	LED			BO		73	37	2	Yes
13839	Over/Undervoltage Prot. TRIP comm. (OVER/UNDER TRIP)	Over/Under Volt	OUT	*	*		m	LED			BO		73	35	2	No
13840	Distance Protection: Inrush blocked (Dis Rush blk)	Distance prot.	OUT	on off	on off		*	LED			BO		28	60	1	Yes
13841	Overcurrent Protection: Inrush blocked (O/C Rush blk)	Overcurrent	OUT	on off	on off		*	LED			BO		64	3	1	Yes
13842	Emerg. O/C Protection: Inrush blocked (Emer. Rush blk)	Emerg. O/C	OUT	on off	on off		*	LED			BO		61	8	1	Yes
13845	>Switch on It function (>It ON)	It Function	SP	on off	*		*	LED	BI		BO					
13846	>Switch off It function (>It OFF)	It Function	SP	on off	*		*	LED	BI		BO					
13847	CB It Alarm Stage (It Alarm)	It Function	OUT	*	*		*	LED			BO		138	17	1	Yes
13848	Start time for It measurement (Start It Meas)	It Function	OUT_Ev	*	on											
13849	Overflow It measurement (It Overflow)	It Function	OUT	*	*		*	LED			BO		138	18	1	No
13850	It function is ACTIVE (It ACTIVE)	It Function	OUT	*	*		*	LED			BO		138	19	1	Yes
13851	Summation of measured It values (Σ It=)	Statistics	VI	*	*											
13852	Summation of measured I2t values (Σ I2t=)	Statistics	VI	*	*											

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
13853	Last It value measured (Last It=)	Statistics	VI	*	*											
13854	Last I2t value measured (Last I2t=)	Statistics	VI	*	*											
13855	It measurement CB settings not plausible (It set error)	It Function	OUT	*	*		*	LED			BO					
13856	It function: ON/OFF via BI (It ON/offBI)	It Function	IntSP	*	*		*	LED			BO					
13860	>CB-Test: Start TRIP cycle (>CB-TEST)	Testing	SP	*	*		*	LED	BI		BO					
13861	>CB-Test: Start TRIP-CLOSE cycle (>CB-TEST AR)	Testing	SP	*	*		*	LED	BI		BO					
13862	CB-Test: TRIP command main trip element (CB-TEST TRIP M)	Testing	OUT	on off	*		*	LED			BO		138	34	1	Yes
13863	CB-Test: TRIP command backup trip elem. (CB-TEST TRIP B)	Testing	OUT	on off	*		*	LED			BO		138	35	1	Yes
13864	CB-Test: CLOSE command main trip element (CB-TEST CLOSE M)	Testing	OUT	on off	*		*	LED			BO		153	30	1	Yes
13865	CB-Test: CLOSE command backup trip elem. (CB-TEST CLOSE M)	Testing	OUT	on off	*		*	LED			BO		153	31	1	Yes
13870	AR Number reclosure attempts 1st cycle (AR 1st cycle=)	Statistics	VI	*	*											
13871	AR Number reclosure attempts >1st cycle (AR >1st cycle=)	Statistics	VI	*	*											
13872	AR thermal trip:ON/OFF via Telegram (AR TH ON/OFFtel)	Auto Reclose	IntSP	*	*		*	LED			BO					
13873	AR thermal trip:ON/OFF via Binary Input (AR TH ON/OFF BI)	Auto Reclose	IntSP	*	*		*	LED			BO					
13874	>AR: BLOCK 2nd-nth cycle (>AR BLK >1st)	Auto Reclose	SP	on off	on off		*	LED	BI		BO		40	48	1	Yes
13875	AR thermal trip:Time Out Dead time (AR TH TO Tdead)	Auto Reclose	OUT	on off	*		*	LED			BO					
13876	AR thermal trip:dynam. blocked (AR TH dyn Blk)	Auto Reclose	OUT	*	*		m	LED			BO		40	97	1	Yes
13877	AR Dead time is running (AR Dead Time)	Auto Reclose	OUT	*	on		*	LED			BO		40	72	2	Yes
13878	AR 2nd cycle or higher is running (AR >1st cycle)	Auto Reclose	OUT	*	on		*	LED			BO		40	66	2	Yes
13879	AR CLOSE command 1st cycle (AR Close 1st)	Auto Reclose	OUT	*	*		*	LED			BO		128	128	1	No
13880	AR CLOSE command 2nd cycle or higher (AR Close >1st)	Auto Reclose	OUT	*	*		*	LED			BO		128	129	1	No
13881	AR ON/OFF via Telegram (AR ON/OFF TEL)	Auto Reclose	IntSP	on off	*		*	LED			BO					
13882	AR blocked by failure direction (AR BLK DIR)	Auto Reclose	OUT	*	on		*	LED			BO		40	58	2	Yes
13883	AR blocked by max. current (AR BLK I MAX)	Auto Reclose	OUT	*	*		*	LED			BO		40	57	2	Yes
13884	AR blocked by BF (AR BLK BF)	Auto Reclose	OUT	*	*		*	LED			BO		40	56	2	Yes
13885	AR blocked by manual closing (AR BLK MC)	Auto Reclose	OUT	*	*		*	LED			BO		40	54	1	Yes
13886	AR enable Zone Z1 (AR EN Z1)	Auto Reclose	OUT	*	*		*	LED			BO		40	61	1	Yes
13887	AR enable Zone Z1B (AR EN Z1B)	Auto Reclose	OUT	*	*		*	LED			BO		40	62	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
13888	AR enable Zone Z1L (AR EN Z1L)	Auto Reclose	OUT	*	*		*	LED			BO		40	63	1	Yes
13889	AR after thermal trip cannot start (AR TH T Reclaim)	Auto Reclose	OUT	on off	*		*	LED			BO		40	95	1	Yes
13890	Distance Prot. Picked up in Zone Z1B (Dis PU Z1B)	Distance prot.	OUT	*	on		*	LED			BO					
13891	Distance Prot. Picked up in Zone Z1L (Dis PU Z1L)	Distance prot.	OUT	*	on		*	LED			BO					
13892	Picked up di/dt function in Zone Z2 (Dis PU Z2di/dt)	Distance prot.	OUT	*	on		*	LED			BO		138	160	2	Yes
13893	Picked up du/dt function in Zone Z2 (Dis PU Z2du/dt)	Distance prot.	OUT	*	on		*	LED			BO		138	164	2	Yes
13894	Picked up di/dt function in Zone Z3 (Dis PU Z3di/dt)	Distance prot.	OUT	*	on		*	LED			BO		138	161	2	Yes
13895	Picked up du/dt function in Zone Z3 (Dis PU Z3du/dt)	Distance prot.	OUT	*	on		*	LED			BO		138	165	2	Yes
13896	Picked up in Zone Z3 (short circuit) (Dis PU Z3K)	Distance prot.	OUT	*	on		*	LED			BO		138	129	2	Yes
13897	Picked up in Zone Z3 (overload) (Dis PU Z3L)	Distance prot.	OUT	*	on		*	LED			BO		138	133	2	Yes
13900	Distance Protection TRIP in Zone Z1B (Dis TRIP Z1B)	Distance prot.	OUT	*	*		*	LED			BO		28	118	2	No
13901	Distance Protection TRIP in Zone Z1L (Dis TRIP Z1L)	Distance prot.	OUT	*	*		*	LED			BO		28	119	2	No
13903	Dist. Prot. TRIP Zone Z3 (short circuit) (Dis TRIP Z3K)	Distance prot.	OUT	*	*		*	LED			BO		138	195	2	No
13904	Dist. Prot. TRIP Zone Z3 (overload) (Dis TRIP Z3L)	Distance prot.	OUT	*	*		*	LED			BO		138	199	2	No
13905	Dist. Prot. TRIP after PU by Man. Close (Dis TRIP PU MC)	Distance prot.	OUT	*	on		*	LED			BO		28	116	2	No
13906	TRIP Overreach Zone after Man. Close (Dis TRIP MC ZOR)	Distance prot.	OUT	*	on		*	LED			BO		28	117	2	No
13911	Zone Z1Stroke ON/OFF about Binary Input (Z1StrkON/OFF BI)	Distance prot.	IntSP	*	*		*	LED			BO					
13912	Zone Z2Stroke ON/OFF about Binary Input (Z2StrkON/OFF BI)	Distance prot.	IntSP	*	*		*	LED			BO					
13913	Zone Z3Stroke ON/OFF about Binary Input (Z3StrkON/OFF BI)	Distance prot.	IntSP	*	*		*	LED			BO					
13925	Max. fault current (MAX I=)	Statistics	VI	*	*											
13926	Last current interrupted by CB (Last I=)	Statistics	VI	*	*								138	16	4	No
13927	Summation interrupted primary currents (Σ I=)	Statistics	VI	*	*											
13946	Inrush detection picked up (INRUSH detected)	InrushRestraint	OUT	on off	on off		*	LED			BO					
13947	Inrush detection for Dis. is switched ON (Inrush Dis ON)	InrushRestraint	OUT	on off	*		*	LED			BO					
13948	Inrush detection O/C is switched ON (Inrush O/C ON)	InrushRestraint	OUT	on off	*		*	LED			BO					
13949	Inrush detection Emerg. O/C ON (Inrush BuO/C ON)	InrushRestraint	OUT	on off	*		*	LED			BO					
13951	>U feeder side VT MCB tripped (>VT MCB UF)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO					
13952	>U reference side VT MCB tripped (>VT MCB Uref)	P.System Data 2	SP	ON OFF	*		*	LED	BI		BO		150	11	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
13953	Measured value failure: Umeas failed (Failure Umeas)	Monitoring	OUT	*	on off		*	LED			BO					
13960	>Switch on Defrosting Protection (>Defrost ON)	Defrosting	SP	on off	*		*	LED	BI		BO		93	201	1	Yes
13961	>Switch off Defrosting Protection (>Defrost OFF)	Defrosting	SP	on off	*		*	LED	BI		BO		93	202	1	Yes
13962	>BLOCK Defrosting Protection (>BLOCK Defrost)	Defrosting	SP	*	*		*	LED	BI		BO		93	203	1	Yes
13963	Defrosting Protection is switched ON (Defrost ON)	Defrosting	IntSP	*	*		*	LED			BO		93	205	1	Yes
13964	Defrosting Protection is switched OFF (Defrost OFF)	Defrosting	OUT	on off	*		*	LED			BO		93	206	1	Yes
13965	Defrosting Protection is blocked (Defrost blk)	Defrosting	OUT	on off	on off		*	LED			BO		93	209	1	Yes
13966	Defrosting Protection PICKED UP (Defrost PICKUP)	Defrosting	OUT	*	*		m	LED			BO		93	211	2	Yes
13967	Defrosting Protection TRIP (Defrost TRIP)	Defrosting	OUT	*	*		m	LED			BO		93	212	2	No
13970	Defrosting current IX>> Pickup (IX>> Pickup)	Defrosting	OUT	*	on off		*	LED			BO					
13971	Defrosting current IX> Pickup (IX> Pickup)	Defrosting	OUT	*	on off		*	LED			BO					
13972	Defrosting current IX>> TRIP command (IX>> TRIP)	Defrosting	OUT	*	on		*	LED			BO					
13973	Defrosting current IX> TRIP command (IX> TRIP)	Defrosting	OUT	*	on		*	LED			BO					
13974	Differential Protection picked up (Diff PU)	Defrosting	OUT	*	on off		*	LED			BO		93	215	2	Yes
13975	Differential Protection TRIP (Diff TRIP)	Defrosting	OUT	*	on		*	LED			BO		93	216	2	No
13976	Defrosting Protection on/off about BI (DEF ON/OFF BI)	Defrosting	IntSP	*	*		*	LED			BO					
13978	Block Defrosting Protection (Defrost block)	Defrosting	IntSP	*	*		*	LED			BO		93	208	1	Yes
13980	Catenary 1 ON/OFF about Binary Input (Cat.1 ON/OFF BI)	Therm. Overload	IntSP	*	*		*	LED			BO					
13981	Catenary 2 ON/OFF about Binary Input (Cat.2 ON/OFF BI)	Therm. Overload	IntSP	*	*		*	LED			BO					
13982	Catenary 3 ON/OFF about Binary Input (Cat.3 ON/OFF BI)	Therm. Overload	IntSP	*	*		*	LED			BO					
13990	Relay General pickup (Relay PU)	P.System Data 2	OUT		*		m	LED			BO					
13991	General protective PICKUP of device (Protection PU)	P.System Data 2	OUT		on off		m	LED			BO		128	84	2	Yes
13992	General protective TRIP of device (Protection TRIP)	P.System Data 2	OUT		on		m	LED			BO		128	68	2	No
13993	AR: Recl. after thermal trip: Meas. Req. (TH Recl.SyncReq)	Auto Reclose	OUT	*	*		*	LED			BO		40	96	2	Yes
13994	Emerg.O/C Prot.: ON/OFF via Binary Input (Emer. ON/OFF BI)	Emerg. O/C	IntSP	*	*		*	LED			BO					
13995	AR: Taction 1st cycle is running (AR Taction 1st)	Auto Reclose	OUT	*	on off		*	LED			BO					
13996	AR: Taction 2nd cycle or higher running (AR Taction >1st)	Auto Reclose	OUT	*	on off		*	LED			BO					
13998	Delay time for back up trip expired (BF T-BF1)	Breaker Failure	OUT	on off	*		*	LED			BO		138	71	1	Yes

A.9 Group Alarms

No.	Description	Function No.	Description
140	Error Sum Alarm	144	Error 5V
		13953	Failure Umeas
		192	
		181	Error A/D-conv.
160	Alarm Sum Event	169	VT FuseFail>t
		170	VT FuseFail
		361	>FAIL:Feeder VT
		13951	>VT MCB UF
		177	Fail Battery
		193	Alarm adjustm.
		190	Error Board 0
		183	Error Board 1
		184	Error Board 2
		185	Error Board 3
		186	Error Board 4
		187	Error Board 5
		188	Error Board 6
		189	Error Board 7

A.10 Measured Values

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
-	Control DIGSI (CntrlDIGSI)	Cntrl Authority	-	-	-	-	-	CFC	CD	DD
636	U - Difference (line - reference) (Udif=)	Measurement	-	-	-	-	-	CFC	CD	DD
637	U - Line (Uline=)	Measurement	-	-	-	-	-	CFC	CD	DD
638	U - Reference (Uref=)	Measurement	-	-	-	-	-	CFC	CD	DD
641	P (active power) (P =)	Measurement	128	148	Yes	9	7	CFC	CD	DD
			134	120	No	9	7			
			138	241	No	9	6			
642	Q (reactive power) (Q =)	Measurement	128	148	Yes	9	8	CFC	CD	DD
			134	120	No	9	8			
			138	241	No	9	7			
644	Frequency (Freq=)	Measurement	128	148	Yes	9	9	CFC	CD	DD
			134	120	No	9	9			
			138	241	No	9	8			
646	f - Reference (fref=)	Measurement	-	-	-	-	-	CFC	CD	DD
647	f - Difference (line-reference) (fdif=)	Measurement	-	-	-	-	-	CFC	CD	DD
648	Angle (difference line-bus) (φ-diff=)	Measurement	-	-	-	-	-	CFC	CD	DD
649	f - Line (fline=)	Measurement	-	-	-	-	-	CFC	CD	DD
668	Operational measurement: I = (I =)	Measurement	128	148	Yes	9	1	CFC	CD	DD
			134	120	No	9	1			
			138	240	No	3	1			
			138	241	No	9	1			
678	Operational measurement: U = (U =)	Measurement	128	148	Yes	9	4	CFC	CD	DD
			134	120	No	9	4			
			138	240	No	3	2			
			138	241	No	9	4			
950	Operat. meas. temp. of catenary (Tmp.cat=)	Measurement	134	120	No	9	12	CFC	CD	DD
			138	241	No	9	2			
951	Operat. meas. ambient temperature (Tmp.amb=)	Measurement	-	-	-	-	-	CFC	CD	DD
13915	Resistive component of total resistance (R =)	Measurement	-	-	-	-	-	CFC	CD	DD
13916	Reactive component of total resistance (X =)	Measurement	-	-	-	-	-	CFC	CD	DD
13917	Operating impedance (Z =)	Measurement	134	120	No	9	10	CFC	CD	DD
			138	241	No	9	5			
13918	Phase angle PHI in [degrees] (φ =)	Measurement	134	120	No	9	11	CFC	CD	DD
			138	241	No	9	3			
13920	Voltage UF- is (UF- =)	Measurement	128	148	Yes	9	5	CFC	CD	DD
			134	120	No	9	5			
13921	Current IF- is (IF- =)	Measurement	128	148	Yes	9	2	CFC	CD	DD
			134	120	No	9	2			
13922	Reference voltage (Uref=)	Measurement	128	148	Yes	9	6	CFC	CD	DD
			134	120	No	9	6			
13923	Defrosting current IX is (IX =)	Measurement	128	148	Yes	9	3	CFC	CD	DD
			134	120	No	9	3			
13924	Summated current I1 + I2 is (ΣI1,I2=)	Measurement	-	-	-	-	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
13968	Differential current in [%] is (Id =)	Measurement	-	-	-	-	-	CFC	CD	DD
13969	Restraint current in [%] is (Ir =)	Measurement	-	-	-	-	-	CFC	CD	DD

■

Literature

/1/ SIPROTEC 4 System Description; E50417-H1176-C151-A4

/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-A3

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	Up to 16 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination (IRC combination). Which device exchanges which information is defined with the help of the combination matrix.
Communication branch	A communications branch corresponds to the configuration of 1 to n users 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 display which is displayed on devices with a large (graphic) display after you have pressed the control key is called the control display. It contains the switchgear that can be controlled in the feeder with status display. It is used to perform switching operations. Defining this display is part of the configuration.

Data pane → The right-hand area of the project window displays the contents of the area selected in the → navigation window, for example indications, measured values, etc. of the information lists or the function selection for the device configuration.

DCF77 The extremely precise official time is determined in Germany by the "Physikalisch-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.

Earth The conductive earth whose electric potential can be set equal to zero at every point. In the area of earth electrodes the earth can have a potential deviating from zero. The term "Earth reference plane" is often used for this state.

Earth (verb) This term means that a conductive part is connected via an earthing system to the → earth.

Earthing Earthing is the total of all means and measures used for earthing.

Electromagnetic compatibility Electromagnetic compatibility (EMC) is the ability of an electrical apparatus to function fault-free in a specified environment without influencing the environment unduly.

EMC → Electromagnetic compatibility

ESD protection ESD protection is the total of all the means and measures used to protect electrostatic sensitive devices.

ExBPxx External bit pattern indication via an ETHERNET connection, device-specific → Bit pattern indication

ExC External command without feedback via an ETHERNET connection, device-specific

ExCF External command with feedback via an ETHERNET connection, device-specific

ExDP External double point indication via an ETHERNET connection, device-specific → Double-point indication

ExDP_I External double point indication via an ETHERNET connection, intermediate position 00, device-specific → Double-point indication

ExMV External metered value via an ETHERNET connection, device-specific

ExSI External single point indication via an ETHERNET connection, device-specific → Single point indication

ExSI_F External single point indication via an ETHERNET connection, device-specific → Transient information, → Single point indication

Field devices Generic term for all devices assigned to the field level: Protection devices, combination devices, bay controllers.

Floating → Without electrical connection to the → Earth.

FMS communication branch Within an FMS communication branch the users communicate on the basis of the PROFIBUS FMS protocol via a PROFIBUS FMS network.

Folder This object type is used to create the hierarchical structure of a project.

General interrogation (GI) During the system start-up the state of all the process inputs, of the status and of the fault image is sampled. This information is used to update the system-end process image. The current process state can also be sampled after a data loss by means of a GI.

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.

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 a HV field description file. Within the HV project description file, each field is allocated such a HV field description file by a reference to the file name.

HV project description All the data is exported once the configuration and parameterisation of PCUs and submodules using ModPara has been completed. This data is split up into several files. One file contains details about the fundamental project structure. This also includes, for example, information detailing which fields exist in this project. This file is called a HV project description file.

ID Internal double point indication → Double-point indication

ID_S Internal double point indication intermediate position 00, → Double-point indication

IEC International Electrotechnical Commission

IEC address Within an IEC bus a unique IEC address has to be assigned to each SIPROTEC 4 device. A total of 254 IEC addresses are available for each IEC bus.

IEC communication branch Within an IEC communication branch the users communicate on the basis of the IEC60-870-5-103 protocol via an IEC bus.

Initialization string An initialization string comprises a range of modem-specific commands. These are transmitted to the modem within the framework of modem initialization. The commands can, for example, force specific settings for the modem.

Inter relay communication → IRC combination

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 Single-point indication fleeting → Transient information, → 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 stage to the manufacturing stage.

Link address The link address gives the address of a V3/V2 device.

List view The right pane of the project window displays the names and icons of objects which represent the contents of a container selected in the tree view. Because they are displayed in the form of a list, this area is called the list view.

LV Limit value

LVU Limit value, user-defined

Master Masters may send data to other users and request data from other users. DIGSI operates as a master.

Metered value Metered values are a processing function with which the total number of discrete similar events (counting pulses) is determined for a period, usually as an integrated value. In power supply companies the electrical work is usually recorded as a metered value (energy purchase/supply, energy transportation).

MLFB number MLFB is the abbreviation for "MaschinenLesbare FabrikateBezeichnung" (machine-readable product designation). This is the equivalent of an order number. The type and version of a SIPROTEC 4 device are coded in the order number.

Modem connection This object type contains information on both partners of a modem connection, the local modem and the remote modem.

Modem profile A modem profile consists of the name of the profile, a modem driver and may also comprise several initialization commands and a user address. You can create several modem profiles for one physical modem. To do so you need to link various initialization commands or user addresses to a modem driver and its properties and save them under different names.

Modems Modem profiles for a modem connection are 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 Off-line 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 On-line 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 with a process bus interface allow direct communication with SICAM HV modules. The process bus interface is equipped with an Ethernet module.

PROFIBUS PROcess FIeld BUS, the German process and field bus standard, as specified in the standard EN 50170, Volume 2, PROFIBUS. It defines the functional, electrical, and mechanical properties for a bit-serial field bus.

PROFIBUS address Within a PROFIBUS network a unique PROFIBUS address has to be assigned to each SIPROTEC 4 device. A total of 254 PROFIBUS addresses are available for each PROFIBUS network.

Project Content-wise, a project is the image of a real power supply system. Graphically, a project is represented 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 gives rise to memory areas that can no longer be used. By cleaning up projects, you can release these memory areas again. However, a clean up also reassigns the VD addresses. The consequence of that is that all SIPROTEC 4 devices have to be reinitialised.

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 SAS Modularly structured station control system, based on the substation controller → SICAM SC and the SICAM WinCC operator control and monitoring system.

SICAM SC Substation Controller. Modularly structured substation control system, based on the SIMATIC M7 automation system.

SICAM WinCC The SICAM WinCC operator control and monitoring system displays the state of your network graphically, visualizes alarms, interrupts and indications, archives the network data, offers the possibility of intervening manually in the process and manages the system rights of the individual employee.

Single command Single commands are process outputs which indicate 2 process states (for example, ON/OFF) at one output.

Single point indication Single indications are items of process information which indicate 2 process states (for example, ON/OFF) at one output.

SIPROTEC The registered trademark SIPROTEC is used for devices implemented on system base V4.

SIPROTEC 4 device This object type represents a real SIPROTEC 4 device with all the setting values and process data it contains.

SIPROTEC 4 variant This object type represents a variant of an object of type SIPROTEC 4 device. The device data of this variant may well differ from the device data of the 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 Up to 16 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination. The individual participating devices are called users.

VD A VD (Virtual Device) includes all communication objects and their properties and states that are used by a communication user through services. A VD can be a physical device, a module of a device or a software module.

VD address The VD address is assigned automatically by DIGSI Manager. It exists only once in the entire project and thus serves to identify unambiguously a real SIPROTEC 4 device. The VD address assigned by DIGSI Manager must be transferred to the SIPROTEC 4 device in order to allow communication with DIGSI Device Editor.

VFD A VFD (Virtual Field Device) includes all communication objects and their properties and states that are used by a communication user through services.

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