

Numerical Distance Protection for EHV Systems

7SA513 V3.2/V3.3

Instruction Manual

Order No. C53000–G1176–C103–6



Figure 1 Illustration of the numerical distance protection relay 7SA513 (in surface mounting case)

SIEMENS



Conformity

This product is in conformity 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 application within specified voltage limits (Low-voltage directive 73/23 EEC).

Conformity is proved by tests that had been performed according to article 10 of the Council Directive in accordance with the generic standards EN 50081–2 and EN 50082–2 (for EMC directive) and the standards EN 60255–6 (for low-voltage directive) by Siemens AG.

The device is designed and manufactured for application in industrial environment.

The device is designed in accordance with the international standards of IEC 60255 and the German standards DIN 57 435 part 303 (corresponding to VDE 0435 part 303).

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NOTE:

This instruction manual does not purport to cover all details in equipment, nor to provide for every possible contingency to be met in connection with installation, operation or maintenance.

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

The contents of this instruction manual shall not become part nor modify any prior or existing agreement, commitment or relationship. The sales contract contains the entire obligations of Siemens. The warranty contained in the contract between the parties is the sole warranty of Siemens. Any statements contained herein do not create new warranties nor modify the existing warranty.

1 Introduction

1.1 Application

Numerical distance protection relay 7SA513 provides fast, reliable and selective clearance of all kinds of ground and phase faults in single and/or multiple fed overhead lines and cables in radial, ring or any type of meshed networks. The system star-point may be isolated, compensated (arc suppressed by Petersen coil), solidly earthed or low resistance earthed. The measuring algorithms and the scope of functions are optimized for use on long-distance transmission lines; thus, it is particularly applicable for very high voltage and extremely high voltage systems. Principally, however, it can be used for any system voltage.

The unit contains all the vital functions for the protection of a EHV line feeder circuit and is thus universally applicable. It can also be used as a time-graded back-up protection for differential protection systems of all kinds for lines, transformers, generators, motors and busbars.

Its fundamental function is determination of the distance of the short circuit by impedance measurement. This can be supplemented by teleprotection interfaces with various operating modes (for 100 % rapid clearance). Additionally, a highly sensitive earth fault protection is available (for high-resistance earth faults, order option) which can operate as directional or non-directional earth current protection with or without directional comparison, or as inverse time zero sequence voltage protection. A weak-in-feed trip feature allows – in conjunction with teleprotection schemes – rapid interruption of both line ends even when a fault is fed from one line end only or when one line end carries only a small fault current. When the line is switched on a dead fault, instantaneous trip command can be given independent on the fault location on the line.

When the measured voltage fails, caused e.g. by trip of the voltage transformer secondary miniature circuit breaker or by a single open conductor or fuse, the relay can switch automatically over to emergency overcurrent time protection mode until the voltage has been reverted. Additionally, an independent back-up protection can operate either as definite time or as inverse time overcurrent protection for phase and earth faults.

The short-circuit protection functions can operate with an integrated automatic reclosure function (order option) which allows single-pole, three-pole, or single/three-pole auto-reclosure as well as multi-shot auto-reclosure on overhead lines. Before reclosing after three-pole trip, it is possible to check synchronism of the partial networks or e.g. to check that the line is dead (order option). Operation with an external auto-reclose and/or check-synchronism device is also possible as well as operation with two protective relays and one or two separate auto-reclose relays.

Besides the mentioned short-circuit protection functions, further protection functions can be incorporated: overvoltage protection, circuit breaker failure protection, out-of-step protection which latter is equally used for power swing blocking of the distance protection. For speedy location of the damaged area after a fault, a fault locator is available which can compensate for the influences of a parallel line and load current.

Throughout a fault in the network the magnitudes of the instantaneous values are stored for a period of max. 5 seconds and are available for subsequent fault analysis.

Continuous monitoring of the measured values permits rapid annunciation of any fault in the measuring transformer circuits. Continuous plausibility monitoring of the internal measured value processing circuits and monitoring of the auxiliary voltages to ensure that they remain within tolerance are obviously inherent features.

Serial interfaces allow comprehensive communication with other digital control and storage devices. For data transmission a standardized protocol in accordance with IEC 60870–5–103 and VDEW/ZVEI is used, as well as a protocol according DIN 19244 (selectable). The device can therefore be incorporated in Localized Substation Automation networks (LSA). This system interface is suited to communication via a modem link.

1.2 Features

- Multi-processor system with powerful microprocessors;
- continuous processing of all measured values by 32 bit signal processor system;
- administration, control and logical processing by a separate microprocessor system;
- complete digital measured value processing and control from data acquisition and digitizing of the measured values up to the trip and close decisions for the circuit breakers;
- complete galvanic and reliable separation of the internal processing circuits from the measurement, control and supply circuits of the system, with screened analog input transducers, binary input and output modules and d.c./d.c. converter;
- complete scope of functions required for the protection of a extremely high voltage feeder circuit;
- distance protection with phase angle dependent and voltage controlled ($U/I/\varphi$) fault detectors or phase angle dependent impedance fault detectors (selectable); additional overcurrent fault detection stage;
- polygonal tripping characteristic with independent setting of reach along the X-axis (distance reach) and the R-axis (resistance tolerance), with separate R-setting for earth faults;
- directional determination using sound phase polarization and voltage memory, giving unlimited directional sensitivity;
- compensation for the influence of a parallel line in case of earth faults;
- compensation for the influence of load current in case of double side infeed on resistive faults;
- suitable for lines with series capacitors;
- different measurement methods with adaptive algorithms as to the type of faults and measured values;
- comprehensive supplementary functions (refer also to Section 1.3);
- continuous calculation of operational measured values and indication on the front display;
- simple setting and operation using the integrated operation panel or a connected personal computer with menu-guided software;
- storage of fault data, storage of instantaneous values during a fault for fault recording;
- communication with central control and storage devices via serial interfaces is possible by use of optical fibre;
- continuous monitoring of the measured values and the hardware and software of the relay.

1.3 Implemented functions

7SA513 contains the following functions:

Distance protection

- short-circuit protection for all types of fault in power transmission systems with earthed, isolated or arc compensated neutral;
- optionally phase angle dependent and voltage controlled ($U/I/\varphi$) fault detection or impedance fault detection with angle dependent, polygonally shaped characteristic;
- reliable distinction between load condition and fault even on long, heavily loaded lines;
- high fault sensitivity combined with exceptional stability against load encroachment and power swings;
- six measurement systems for each of the distance zones, directional discrimination and fault detection;
- five distance zones can be set each to operate either in the forward direction or in the reverse direction or non-directional and two of which can be used as graded overreach zones;
- seven time stages;
- optimum matching to the line conditions by polygonal tripping characteristic with independent setting of reach along the R- and X-axis, separate R-setting for phase and earth faults;
- directional determination using sound phase polarization and voltage memory, thus suitable for use with capacitive voltage transformers and giving unlimited directional sensitivity;
- directional determination not affected by voltage reversal in case of series compensated lines using digital voltage memory with adaptive memory depth;
- filter algorithms with automatic adaptation to the quality of measured quantities;

- insensitive against current transformer saturation;
- parallel line and load compensation;
- shortest tripping time approx. 12 ms;
- phase segregated trip for use with single-pole auto-reclosure.

Power swing supplement

- power swing detection by symmetrical dZ/dt measurement;
- power swing detection with power swing frequency up to 7 Hz;
- selectable reaction programs for power swings;
- effective even during single-pole auto-reclosure cycle;
- avoids unwanted trip occurrences during power swings in the system;
- can be used for out-of-step tripping either.

Universal teleprotection interface

- Programmable for different schemes of:
 - permissive underreach transfer tripping (PUTT);
 - permissive overreach transfer tripping (POTT) in release or blocking mode using a special overreaching zone or directional comparison;
 - pilot wire scheme with local d.c. link or for very short lines;
- one overreach transfer mode and one underreach transfer mode can be used at the same time, independently of each other and via independent carrier channels.

Weak infeed trip

- operates in conjunction with permissive transfer modes;
- provides rapid trip at both line ends in case of one line end with weak infeed or no infeed;
- with phase dedicated undervoltage detection.

Dead-fault protection

- provides high speed operation at either line end when switching manually onto a bolted fault;
- with integrated switch-on detection.

Emergency overcurrent function

- for "emergency operation" if voltage transformer m.c.b. trips or
- for "emergency operation" in case of voltage transformer secondary fuse failure;
- operates as definite time or inverse time overcurrent protection with selectable characteristics;
- separate high current stage with definite time characteristic or instantaneous trip;
- separate earth current stages with separately selectable characteristic.

Highly sensitive earth fault protection (optional)

- directional definite time or inverse time overcurrent protection for high-resistive earth faults in networks with earthed starpoint;
- optionally with zero sequence voltage dependent tripping time characteristic;
- directional determination using zero sequence components of currents and voltages;
- optionally with directional comparison via communication link (e.g. PLC);

- with two-stage earth current pick-up;
- back-up function in case of voltage failure using definite time or inverse time earth current protection;
- integrated phase selector allows for single-pole auto-reclosure.

Automatic reclose function (optional)

- single-pole, three-pole or single- and three-pole;
- single or multi-shot (e.g. RAR and DAR, three-pole DAR from second shot on);
- with separately allocated action times and dead times for single-pole, three-pole RAR (rapid AR for first shot) and three-pole DAR (delayed AR for further shots).

Synchronism and voltage check (optional)

- synchro-check before auto-reclosure after three-pole trip;
- high-speed measurement of voltage amplitude difference ΔU , phase angle difference $\Delta \varphi$ and frequency difference Δf ;
- settable alternatively for dead-line check and/or dead-bus check;
- asynchronous switching possible with pre-determination of the instant of synchronism;
- settable minimum voltage;
- synchro-check, dead-line check and/or dead-bus check also possible before manual closing of the circuit breaker, with separate limits of ΔU , $\Delta \varphi$ and Δf ;
- measured voltages can be connected either phase-to-phase or phase-to-earth.

Back-up protection

- separate overcurrent time protection for local back-up, independent of the voltages;
- operates as definite time or inverse time overcurrent protection with selectable characteristic;
- with independent high-set overcurrent stage;
- separate earth current stages with separately selectable characteristic.

Overvoltage protection

- two-stage overvoltage processing;
- processing of all three voltages;
- $U >$ stage processes the positive sequence component of the voltages after numerical filtering;
- adjustable compounding for $U >$ stage;
- high-set $U >>$ stage can operate optionally with phase-to-phase voltages or with phase-to-earth voltages, combined with *AND* or *OR*;
- separate delay times with open circuit breaker or closed circuit breaker;
- adjustable stabilization time during switching operations on the circuit breaker;
- trip signal transmission to the remote line end possible.

Distance-to-fault location

- can be started by internal trip command or by external command or at drop-off of fault detection;
- calculation of the fault distance;
- output of fault distance in ohms, kilometers and % line length;
- optionally with parallel line mutual compensation.

Circuit breaker failure protection

- independent current stages for current monitoring of each circuit breaker pole;
- independent delay timers for each circuit breaker pole;
- initiation by each of the internal protection functions;
- short reset time, negligible overshoot time.

The standard functions also include:

- two logical functions with time stages which can be defined by the user in order to combine, delay or process external signals;
- continuous self-monitoring right from the DC circuits, through the current and voltage transformer inputs to the tripping relays, thus achieving maximum availability and a more corrective than preventive maintenance strategy;
- measurement and test routines under normal load conditions:
measurement of load currents and operating voltages,
measurement of power and frequency,
output of measured impedances, directional and phase sequence check;
- annunciation storage for the last three network faults, with real time clock;
- data storage and transmission for fault records giving
rapid fault analysis,
detailed fault records;
- counting of tripping and closing commands as well as recording of fault data and accumulative addition of the interrupted fault currents;
- commissioning aids such as directional verification and circuit breaker live test.

2 Design

2.1 Arrangements

All protection functions including dc/dc converter are accommodated on plug-in modules of Double Europa Format. These modules are installed in a housing 7XP20. Two different types of housings can be delivered:

- **7SA513★–★B★** in housing 7XP20 for **panel surface mounting**

The housing has full sheet-metal covers, as well as a removable front cover with transparent plastic window.

Plastic guide rails are built in for the support of plug-in modules. Next to the guide rail at the bottom on the left-hand side of each module, a contact area which is electrically connected to the housing is installed to mate with the earthing spring of the module. Connection to earth is made before the plugs make contact. Earthing screws have been provided on the left hand side of the housing. Additionally, terminal 51 is connected to the case.

All external signals are connected to 200 screwed terminals which are arranged over cut-outs on the top and bottom covers. The terminals are numbered consecutively from left to right at the bottom and top.

The heavy duty current plug connectors provide automatic shorting of the c.t. circuits whenever the modules are withdrawn. This does not release from the care to be taken when c.t. secondary circuits are concerned.

For the interface to a central control and storage unit, an additional coupling facility has been provided. For the interface for optical fibre connection, two F–SMA connectors have been provided.

The degree of protection for the housing is IP51, for the terminals IP21. For dimensions please refer to Figures 2.2 and 2.3.

- **7SA513★–★C★** in housing 7XP20 for **panel flush mounting** or **7SA513★–★E★** for **cubicle installation**

The housing has full sheet-metal covers as well as a removable front cover with transparent plastic window for panel mounting.

Plastic guide rails are built in for the support of plug-in modules. Next to the guide rail at the bottom on the left-hand side of each module, a contact area which is electrically connected to the housing is installed to mate with the earthing spring of the module. Connection to earth is made before the plugs make contact. Earthing screws have been provided on the rear wall of the housing.

All external signals are connected to connector modules which are mounted on the rear cover over cut-outs. For each electrical connection, one screwed terminal and one parallel snap-in terminal are provided. For field wiring, the use of the screwed terminals is recommended; snap-in connection requires special tools.

The heavy duty current plug connectors provide automatic shorting of the c.t. circuits whenever the modules are withdrawn. This does not release from the care to be taken when c.t. secondary circuits are concerned.

For the interface for optical fibre connection, a module with 2 F–SMA connectors is provided.

The plug modules are labelled according to their mounting position by means of a grid system (e.g. **1A2**). The individual connections within a module are numbered consecutively from left to right (when viewed from the rear), (e.g. **1A2**); refer Figure 2.1.

Degree of protection for the housing is IP51 (for cubicle installation IP 30), for the terminals IP21. For dimensions please refer to Figures 2.4 and 2.5.

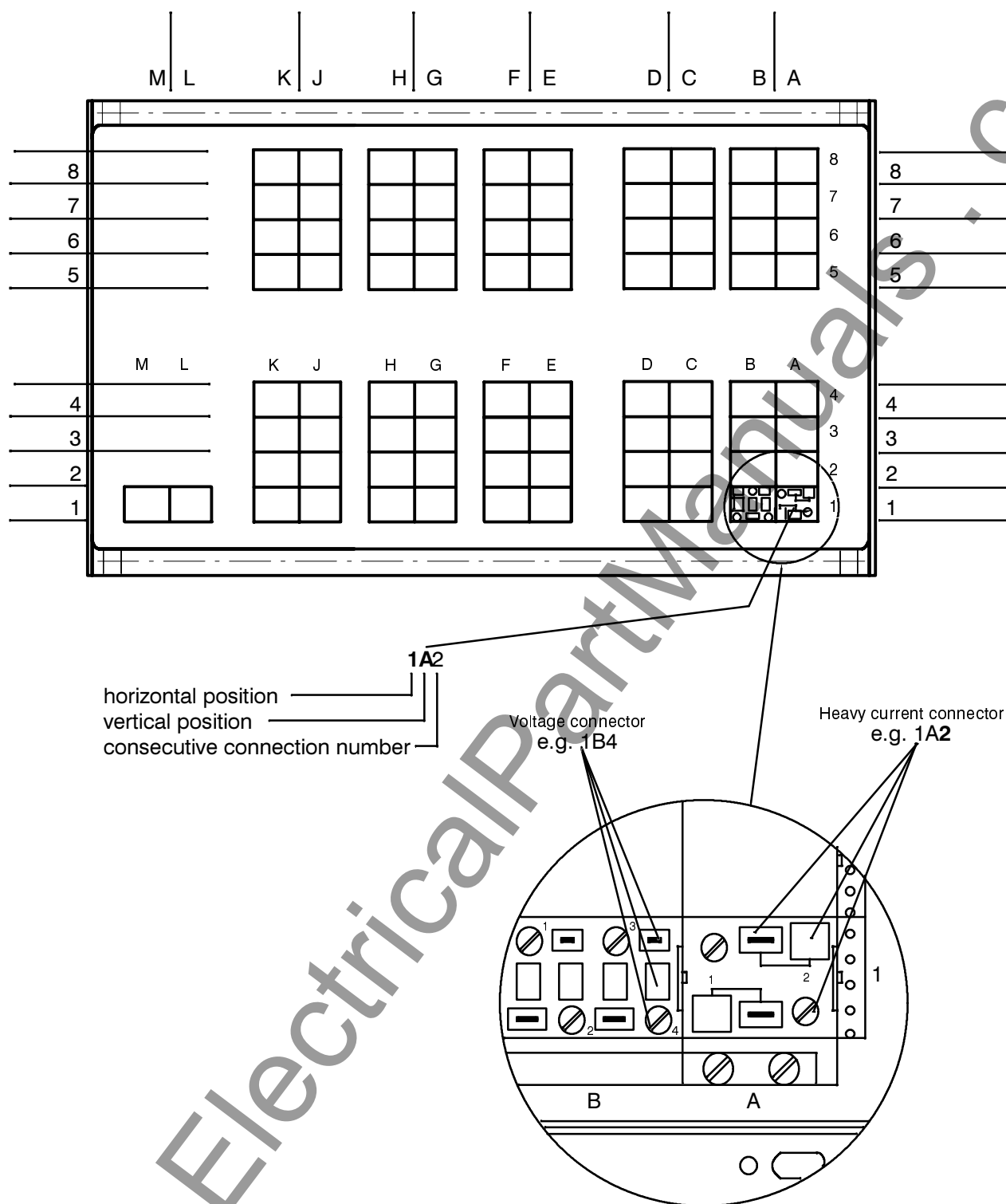
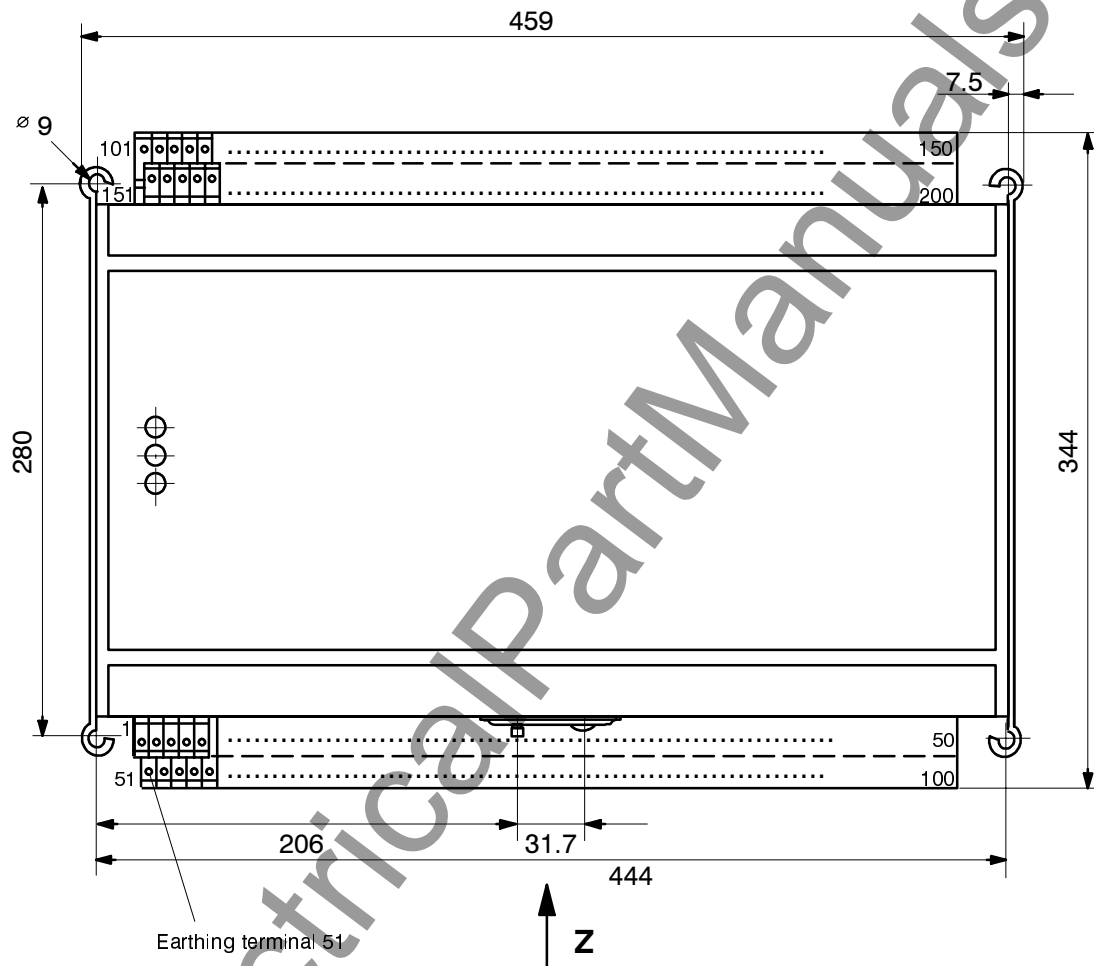


Figure 2.1 Connection plugs (rear view) – housing for flush mounting – example

2.2 Dimensions

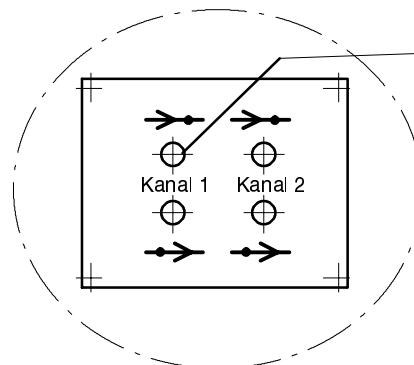
Figures 2.2 to 2.5 show the dimensions of the various types of housings available.

7SA513 Housing for panel surface mounting 7XP20



Max. 100 terminals for cross-section max. 5 mm² (AWG10)

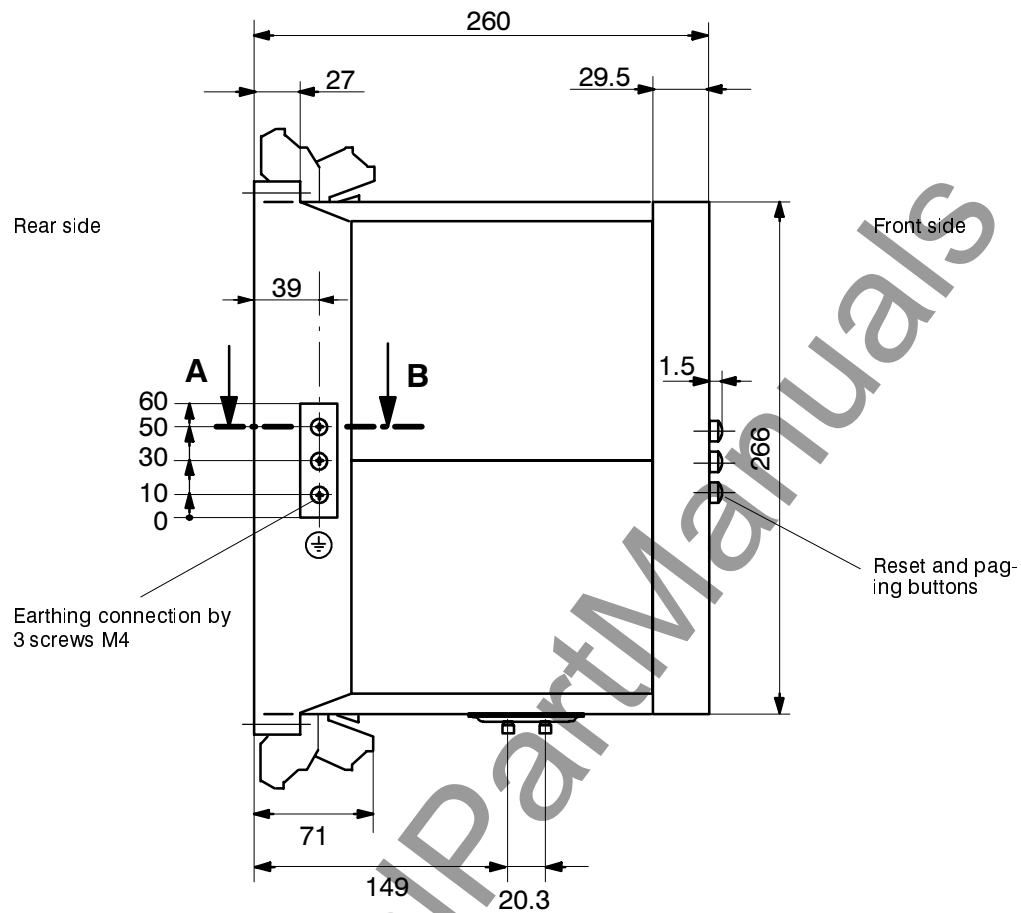
Max. torque value 1.7 Nm or 15 in-lb



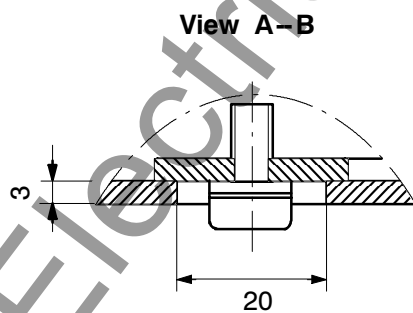
Optical fibre connectors:
integrated F-SMA connector,
with ceramic post;
e.g for glass fibre 62.5/125 μm

Dimensions in mm

Figure 2.2 Dimensions for housing 7XP20 for panel surface mounting, front view



Max. 100 terminals for cross-section max. 5 mm² (AWG10)
 Max. torque value 1.7 Nm or 15 in-lb



Dimensions in mm

Figure 2.3 Dimensions for housing 7XP20 for panel surface mounting, side view

7SA513 Housing for **panel flush mounting** or **cubicle installation** 7XP20

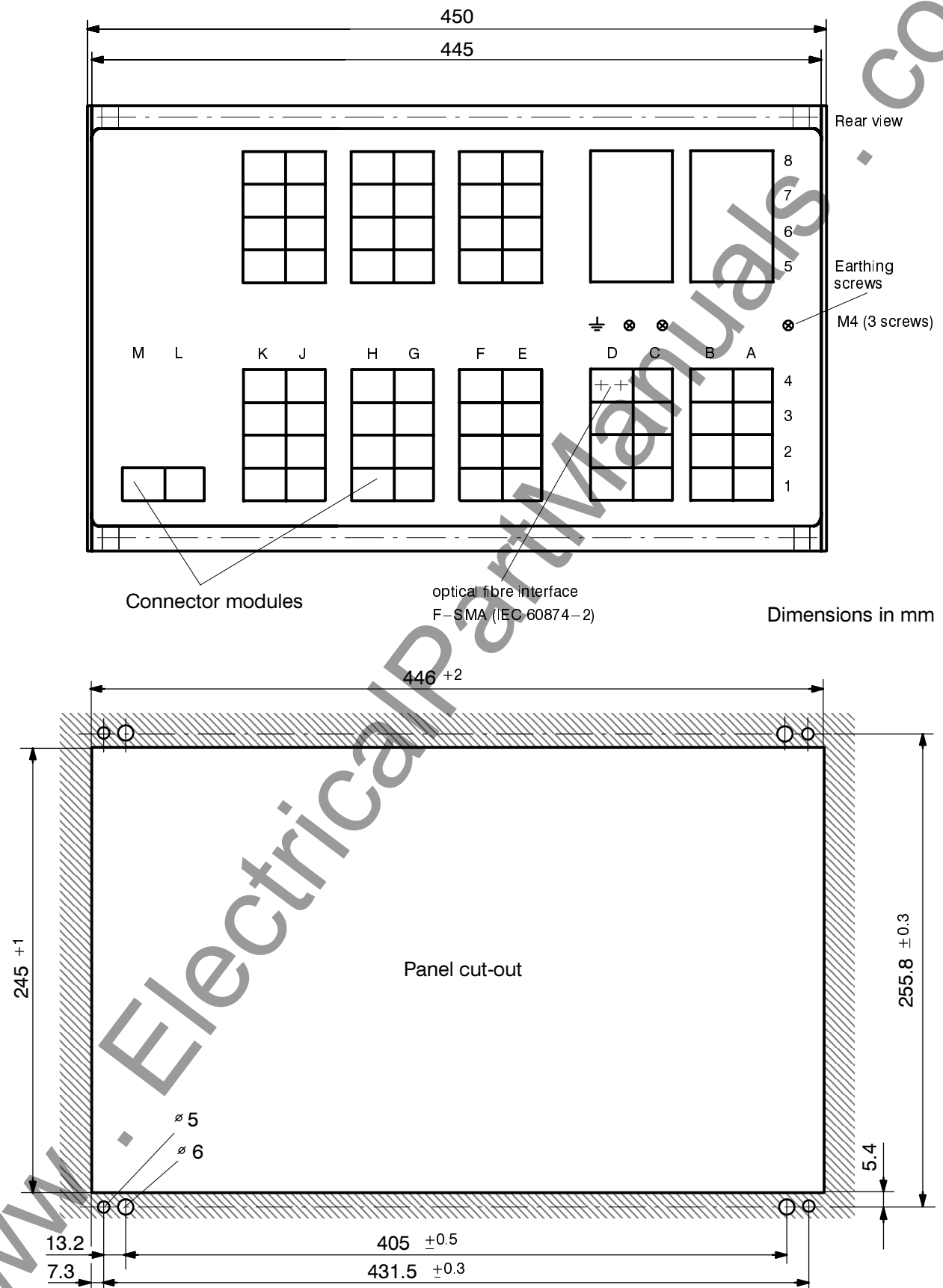
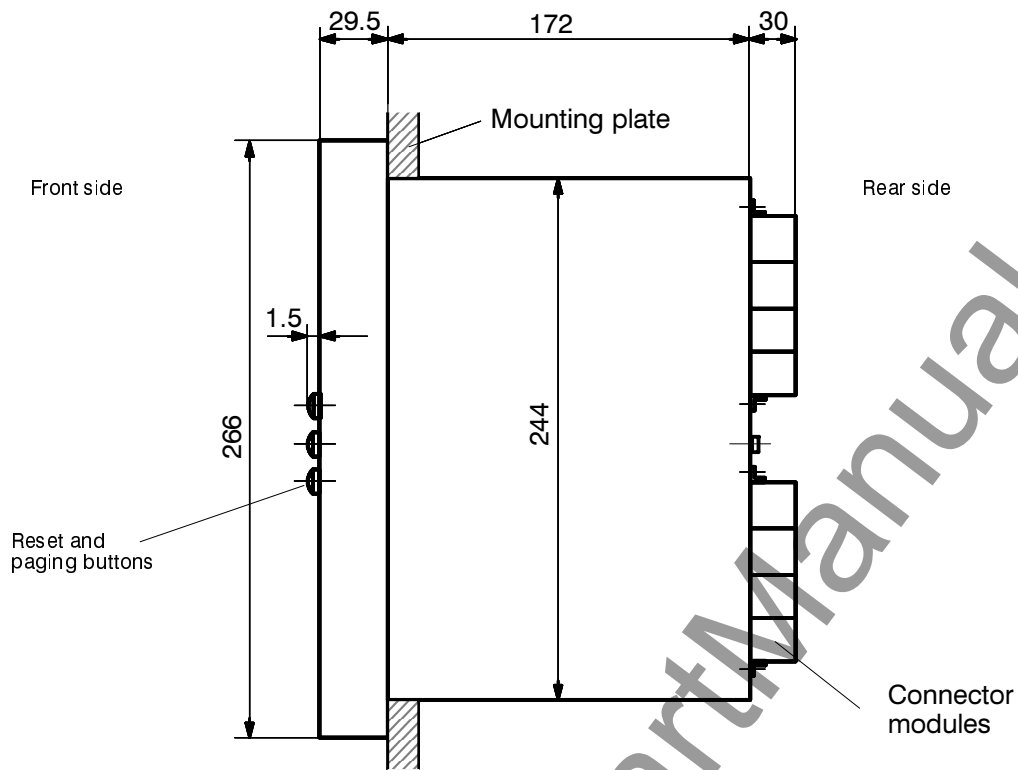


Figure 2.4 Dimensions for housing 7XP20 for panel flush mounting or cubicle installation, rear view

**Heavy current connectors:**Screwed terminal for max. 4 mm².Twin spring crimp connector in parallel for max. 2.5 mm²

max torque value 1.2 Nm or 10.6 in-lb

Further connectors:Screwed terminal for max. 1.5 mm².Twin spring crimp connector in parallel for max. 1.5 mm²

max torque value 0.8 Nm or 7.1 in-lb

Optical fibre connectors:

integrated F-SMA connector,

with ceramic post;

e.g for glass fibre 62.5/125 μm

Dimensions in mm

Figure 2.5 Dimensions for housing 7XP20 for panel flush mounting or cubicle installation, side view

2.3 Ordering data

Numerical Distance Protection Relay

for VHV and EHV Systems

7 S A 5 1 3

Rated current; rated frequency

1 A; 50/60 Hz	1
5 A; 50/60 Hz	5

Auxiliary voltage

48/60 V dc	2
110/125 V dc	4
220/250 V dc	5

Construction

in housing 7XP20 for panel surface mounting	B
in housing 7XP20 for panel flush mounting	C
in housing 7XP20 for cubicle installation (without glass front)	E

Input/output modules

2 input/output modules with a total of 16 binary inputs, 18 signal relays, 4 command (trip) relays	0
3 input/output modules with a total of 24 binary inputs, 27 signal relays, 6 command (trip) relays	1
2 input/output modules with a total of 16 binary inputs, 12 signal relays, 2 fast dry reed relays, 4 command (trip) relays	2
3 input/output modules with a total of 24 binary inputs, 18 signal relays, 3 fast dry reed relays, 6 command (trip) relays	3

(next page)

Numerical Distance protection relay**for VHV and EHV Systems**

7. 8. 9. 10. 11. 12. 13. 14. 15. 16.
7 S A 5 1 3 – **A 2** – **0 C**

Supplements A

without auto-reclosure,	without synchronism and voltage check	E
with auto-reclosure,	without synchronism and voltage check	G
with auto-reclosure,	with synchronism and voltage check	H

Supplements B

without highly sensitive earth fault protection for earthed systems	0
with highly sensitive earth fault protection for earthed systems	1

3 Technical data

3.1 General data

3.1.1 Inputs/outputs

Measuring circuits

Rated current I_N	1 A or 5 A
Rated voltage U_N	80 V to 125 V (selectable)
Rated frequency f_N	50 Hz/60 Hz (selectable)
Power consumption	current path at $I_N = 1$ A current path at $I_N = 5$ A
	approx 0.1 VA per phase and earth current approx 0.5 VA per phase and earth current
Power consumption	voltage path at 100 V
	approx 0.5 VA per phase
Overload capability – thermal (rms)	current path, phases and earth
	100 $\times I_N$ for ≤ 1 s 20 $\times I_N$ for ≤ 10 s 4 $\times I_N$ continuous
– dynamic (pulse current)	250 $\times I_N$ one half cycle
Overload capability – thermal (rms)	voltage path
	140 V continuous

Auxiliary voltage

Power supply via integrated dc/dc converter

Rated auxiliary voltage U _H	48/60 Vdc	110/125 Vdc	220/250 Vdc
Permissible variations	38 to 69 Vdc	88 to 144 Vdc	176 to 288 Vdc
Superimposed ac voltage, peak-to-peak	≤ 12 % at rated voltage ≤ 6 % at limits of admissible voltage		
Power consumption	quiescent	approx 15 W	
	energized, fully equipped	approx 45 W	
	energized, min. equipped	approx 35 W	
Bridging time during failure/short-circuit of auxiliary voltage	≥ 50 ms at U _{dc} ≥ 110 Vdc		

Heavy duty (trip) contacts

Command (trip) relays, number	4 to 6 (dependent on model)
Contacts per relays	2 NO
Switching capacity	1000W/VA
MAKE	30 W/VA
BREAK	
Switching voltage	250 V
Permissible current	5 A continuous
	30 A for 0.5 s

Signal contacts

Signal relays, number	12 to 27 (dependent on model)
Contact per relays	1 CO or 1 NO
Switching capacity	20 W/VA
MAKE/BREAK	
Switching voltage	250 V
Permissible current	1 A

Fast dry reed contacts

Number	0 to 3 (dependent on model)
Contact per relay	1 CO or 1 NO
Switching capacity	10 W/VA ohmic
MAKE/BREAK	
Switching voltage	220 V
Permissible current	0.3 A
Permissible switching capacitance	5 nF

Binary inputs

Number	16 to 24 (dependent on model)
Operating voltage	24 to 250 Vdc
Max. control voltage	288 Vdc
Current consumption, energized	approx 2.5 mA, independent of operating voltage

Serial interfaces

Operator terminal interface	non-isolated
– Connection	at the front, 25-pole subminiature connector acc. ISO 2110 for connection of a personal computer or similar
– Transmission speed	as delivered 9600 Baud min 1200 Baud, max 19200 Baud
Floating interface for data transfer to a control centre	for optical fibre connection
– Standards	protocol according to IEC 60870–5–103 and VDEW/ZVEI, or to DIN 19244
– Transmission speed	as delivered 9600 Baud min 1200 Baud, max 19200 Baud
– Transmission security	Hamming distance $d = 4$
– Connection optical fibre	integrated F–SMA connector for direct optical fibre connection, with ceramic post, e.g. glass fibre 62.5/125 μm for flush mounted housing: at the rear for surface mounted housing: on the bottom cover
Optical wave length	820 nm
Permissible line attenuation	max 8 dB
Transmission distance	max 1.5 km
Normal signal position	reconnectable; factory setting: "light off"

3.1.2 Electrical tests

Insulation tests

Standards:	IEC 60255–5
– High voltage test (routine test) except d.c. voltage supply input	2 kV (rms); 50 Hz
– High voltage test (routine test) only d.c. voltage supply input	2.8 kV dc
– Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 μ s; 0.5 J; 3 positive and 3 negative shots at intervals of 5 s

EMC tests; immunity (type tests)

Standards:	IEC 60255–6, IEC 60255–22 (product standards) EN 50082–2 (generic standard) VDE 0435 /part 303
– High frequency IEC 60255–22–1, class III	2.5 kV (peak); 1 MHz; $\tau = 15 \mu$ s; 400 shots/s; duration 2 s
– Electrostatic discharge IEC 60255–22–2 class III and IEC 61000–4–2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$
– Radio-frequency electromagnetic field, non-modulated; IEC 60255–22–3 (report) class III	10 V/m; 27 MHz to 500 MHz
– Radio-frequency electromagnetic field, amplitude modulated; IEC 61000–4–3, class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz
– Radio-frequency electromagnetic field, pulse modulated; IEC 61000–4–3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
– Fast transients IEC 60255–22–4 and IEC 61000–4–4, class III	2 kV; 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; duration 1 min
– Conducted disturbances induced by radio-frequency fields, amplitude modulated IEC 61000–4–6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
– Power frequency magnetic field IEC 61000–4–8, class IV IEC 60255–6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz

EMC tests; emission (type tests)

Standard:	EN 50081 –★ (generic standard)
– Conducted interference voltage, aux. voltage CISPR 22, EN 55022, class B	150 kHz to 30 MHz
– Interference field strength CISPR 11, EN 55011, class A	30 MHz to 1000 MHz

3.1.3 Mechanical stress tests

Vibration and shock during operation

Standards:	IEC 60255–21 and IEC 60068–2
– Vibration IEC 60255–21–1, class 1 IEC 60068–2–6	sinusoidal 10 Hz to 60 Hz: ± 0.035 mm amplitude; 60 Hz to 150 Hz: 0.5 g acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
– Shock IEC 60255–21–2, class 1	half sine acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
– Seismic vibration IEC 60255–21–3, class 1 IEC 60068–3–3	sinusoidal 1 Hz to 8 Hz: ± 3.5 mm amplitude (hor. axis) 1 Hz to 8 Hz: ± 1.5 mm amplitude (vert. axis) 8 Hz to 35 Hz: 1 g acceleration (hor. axis) 8 Hz to 35 Hz: 0.5 g acceleration (vert. axis) sweep rate 1 octave/min 1 cycle in 3 orthogonal axes

Vibration and shock during transport

Standards:	IEC 60255–21 and IEC 60068–2
– Vibration 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	half sine acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
– Continuous shock IEC 60255–21–2, class 1 IEC 60068–2–29	half sine acceleration 10 g, duration 16 ms, 1000 shocks each direction of 3 orthogonal axes

3.1.4 Climatic stress tests

– recommended temperature during service	–5 °C to +55 °C	(> 55 °C decreased
– permissible temperature during service	–20 °C to +70 °C	display contrast)
permissible temperature during storage	–25 °C to +55 °C	
permissible temperature during transport	–25 °C to +70 °C	
Storage and transport with standard works packaging!		

– Permissible humidity

mean value per year ≤ 75 % relative humidity;
on 30 days per year 95 % relative humidity;
condensation not permissible!

We recommend that all units are installed such that they are not subjected to direct sunlight, nor to large temperature fluctuations which may give rise to condensation.

3.1.5 Service conditions

The relay is designed for use in industrial environment, for installation in standard relay rooms and compartments so that with proper installation **electro-magnetic compatibility (EMC)** is ensured. The following should also be heeded:

- All contactors and relays which operate in the same cubicle or on the same relay panel as the digital protection equipment should, as a rule, be fitted with suitable spike quenching elements.
- All external connection leads in sub-stations from 100 kV upwards should be screened with a screen capable of carrying power currents and earthed at both sides. No special measures are

normally necessary for sub-stations of lower voltages.

- It is not permissible to withdraw or insert individual modules under voltage. In the withdrawn condition, some components are electrostatically endangered; during handling the standards for electrostatically endangered components must be observed. The modules are not endangered when plugged in.

WARNING! The relay is not designed for use in residential, commercial or light-industrial environment as defined in EN 50081.

3.1.6 Design

Housing	7XP20; refer to Section 2.1
Dimensions	refer to Section 2.2
Weight (mass)	
– in housing for surface mounting, fully equipped	approx 23 kg
– in housing for surface mounting, min. equipped	approx 21 kg
– in housing for flush mounting, fully equipped	approx 17 kg
– in housing for flush mounting, min. equipped	approx 15 kg
Degree of protection acc. to EN 60529	
– Housing	IP 51 *)
– Terminals	IP 21

*) IP30 for cubicle installation; the degree of protection required for the point of installation must be ensured by the cubicle.

3.2 Distance protection

Earth impedance matching

R_E/R_L	–7.00 to +7.00 (steps 0.01)
X_E/X_L	–7.00 to +7.00 (steps 0.01)

Mutual impedance matching

for parallel line compensation

R_M/R_L	–7.00 to +7.00 (steps 0.01)
X_M/X_L	–7.00 to +7.00 (steps 0.01)

Matching factors for earth impedance and mutual impedance are valid also for fault location (Section 3.14).

Phase preferences

for double earth faults
in solidly earthed systemsall concerned fault loops or
all concerned phase-to-earth loops or
all concerned phase-to-phase loops or
leading phase to earth blocked or
lagging phase to earth blockedfor double earth faults
in isolated or
arc compensated systemsall concerned fault loops or
L3 (L1) or L1 (L3) acyclic or
L2 (L1) or L1 (L2) acyclic or
L3 (L2) or L2 (L3) acyclic or
L3 (L1) or L1 (L3) cyclicDisplacement voltage pick-up $U_e > (= \sqrt{3} \cdot U_0)$
in isolated or arc compensated systems

10 V to 100 V (steps 1 V)

Fault detection

Earth fault detection

Residual (earth) current	$I_E >$	$0.10 \cdot I_N$ to $1.00 \cdot I_N$ (steps $0.01 \cdot I_N$)
Residual (earth) current	$I_E >>$	$0.10 \cdot I_N$ to $4.00 \cdot I_N$ (steps $0.01 \cdot I_N$)
Displacement voltage pick-up	$U_e > (= \sqrt{3} \cdot U_0)$	
in solidly earthed systems		2 V to 100 V (steps 1 V); ∞
Drop-off ratios		approx. 0.95 (for $I \geq I_N$)
Measuring tolerances according VDE 0435 part 303		$\pm 5\%$

Voltage and phase angle controlled current fault detection (under-impedance fault detection)

Characteristic three-stage with settable inclination
Voltage control by U_{ph-e} or U_{ph-ph} (selectable)

Setting ranges:

– minimum operating phase current	$I_{ph} >$	$0.10 \cdot I_N$ to $1.00 \cdot I_N$ (steps $0.01 \cdot I_N$)
– minimum current in short-circuit angle	$I_{\varphi} >$	$0.10 \cdot I_N$ to $2.00 \cdot I_N$ (steps $0.01 \cdot I_N$)
– overcurrent pick-up	$I_{ph} >>$	$0.25 \cdot I_N$ to $4.00 \cdot I_N$ (steps $0.01 \cdot I_N$)
– undervoltage pick-up	$U_{ph-e} <$	20 V to 70 V (steps 1 V)
(separate for $I_{ph} >$ and $I_{ph} >>$ and $I_{\varphi} >$)	$U_{ph-ph} <$	40 V to 130 V (steps 1 V)
– lower limit angle	$\varphi >$	30° to 60° (steps 1°)
– upper limit angle	$\varphi <$	90° to 120° (steps 1°)

Drop-off ratios:

– $I_{ph} >$, $I_{ph} >>$, $I_{\varphi} >$	approx. 0.95
– $U_{ph-e} <$, $U_{ph-ph} <$	approx. 1.05

Measuring tolerances with sinusoidal quantities

– magnitudes (U, I)	$\pm 5\%$
– angles φ	$\pm 3^\circ$

Impedance fault detection (fix-impedance)

Characteristic

polygonal, phase angle dependent R-sections

Setting values (based on $I_N = 1 \text{ A}^*$): $I_{ph>} =$ minimum operating phase current0.10 · I_N to 4.00 · I_N (steps 0.01 · I_N) $I_{ph>>} =$ overcurrent stage1.00 · I_N to 20.00 · I_N (steps 0.01 · I_N); ∞ $X_{+A} =$ forwards reach (for all faults)0.10 Ω to 250.00 Ω (steps 0.01 Ω) $X_{-A} =$ reverse reach (for all faults)0.10 Ω to 250.00 Ω (steps 0.01 Ω) $R_{A2} =$ resistance tolerance(phase-phase, $\varphi_{SC} > \varphi_A$)0.10 Ω to 250.00 Ω (steps 0.01 Ω) $R_{A1} =$ resistance tolerance(phase-phase, $\varphi_{SC} < \varphi_A$)0.10 Ω to 250.00 Ω (steps 0.01 Ω) $\varphi_A =$ limit angle between R_{A1} and R_{A2}

30.0° to 80.0° (steps 0.1°)

 $R_{A2E} =$ resistance tolerance(phase-earth, $\varphi_{SC} > \varphi_{AE}$)0.10 Ω to 250.00 Ω (steps 0.01 Ω) $R_{A1E} =$ resistance tolerance(phase-earth, $\varphi_{SC} < \varphi_{AE}$)0.10 Ω to 250.00 Ω (steps 0.01 Ω) $\varphi_{AE} =$ limit angle between R_{A1E} and R_{A2E}

30.0° to 80.0° (steps 0.1°)

Drop-off ratios:

– for R, X

approx. 1.06

Measuring tolerances with sinusoidal quantities

– impedances

 $\left| \frac{\Delta X}{X} \right| \leq 5\% \text{ for } 30^\circ \leq \varphi_{SC} \leq 90^\circ$ $\left| \frac{\Delta R}{R} \right| \leq 5\% \text{ for } 0^\circ \leq \varphi_{SC} \leq 60^\circ$

– currents

 $\pm 5\%$ – angles φ $\pm 3^\circ$ *) Secondary values are referred to $I_N = 1 \text{ A}$; for $I_N = 5 \text{ A}$ the values are to be divided by 5.**Distance measurement**

Characteristic

polygonal, 3 independent + 2 controlled stages;
all stages can be set to operate in forward or
reverse direction or non-directionalSetting values (based on $I_N = 1 \text{ A}^*$): $X =$ forwards reach (for all faults)0.05 Ω to 130.00 Ω (steps 0.01 Ω) $R =$ resistance tolerance (phase-phase)0.05 Ω to 65.00 Ω (steps 0.01 Ω) $R_E =$ resistance tolerance (phase-earth)0.05 Ω to 130.00 Ω (steps 0.01 Ω)

Measuring tolerances with sinusoidal quantities

– impedances

 $\left| \frac{\Delta X}{X} \right| \leq 5\% \text{ for } 30^\circ \leq \varphi_{SC} \leq 90^\circ$ $\left| \frac{\Delta R}{R} \right| \leq 5\% \text{ for } 0^\circ \leq \varphi_{SC} \leq 60^\circ$

– current

 $\pm 5\%$

Measured value correction

for parallel line mutual coupling,
for load influence during single-phase faults*) Secondary values are referred to $I_N = 1 \text{ A}$; for $I_N = 5 \text{ A}$ the values are to be divided by 5.

Directional determination

For all types of faults

with quadrature voltages and
voltage memory with adaptive memory depth
dynamically unlimited

Sensitivity

Times

Shortest tripping time

approx. 12 ms

Resetting time

approx. 30 ms

Time stages:

Setting ranges

for all stages

0.00 s to 32.00 s (steps 0.01 s)
or ∞ (i.e. stage ineffective)

Time expiry tolerances

 ≤ 1 % of set value or 10 ms

The set times are pure delay times.

Overcurrent emergency protection

with measured voltage failure,

e.g. VT secondary mcb trip or detected fuse failure

refer to Section 3.8

3.3 Power swing supplement (with impedance fault detection)

Power swing detection

rate of change of the impedance vector
and scanning of the vector course

max. detectable power swing frequency

approx. 7 Hz

Programs

block first distance zone only,
block first and second zone,
block all zones but first zone,
block all distance zones,
out-of-step tripping

3.4 Teleprotection interface

Teleprotection modes (selectable)

– Permissive underreach transfer trip	fault detection acceleration zone acceleration (special zone Z1B)
Transmit signal prolongation	0.01 s to 32.00 s (steps 0.01 s)
Transmit signal delay	0.00 s to 32.00 s (steps 0.01 s)
Received signal prolongation	0.00 s to 32.00 s (steps 0.01 s)
– Permissive overreach transfer trip	release overreaching zone Z1B release fault detection zone directional unblocking zone Z1B unblocking fault detection zone directional blocking zone Z1B
Transmit signal prolongation	0.01 s to 32.00 s (steps 0.01 s)
Transmit signal delay	0.00 s to 32.00 s (steps 0.01 s)
Echo delay time	0.01 s to 32.00 s (steps 0.01 s); ∞
Echo pulse duration	0.02 s to 32.00 s (steps 0.01 s)
Echo block duration	0.01 s to 32.00 s (steps 0.01 s)
Transient blocking time	0.01 s to 32.00 s (steps 0.01 s)
Waiting time for transient blocking	0.01 s to 32.00 s (steps 0.01 s); ∞
– Overreaching transfer via pilot wires	NC link with DC control cable
– Reverse interlocking	with NO or NC interlock loop

3.5 User definable logic functions

Number	2
logical inputs via binary input logical outputs for binary outputs	Start and Stop time expired
operating time	approx. 30 ms
Delay	0.00 s to 32.00 s (steps 0.01 s)
time tolerance	1 % of set value or 10 ms

3.6 High current switch-onto-fault protection

Pick-up

High-current pick-up	$I_{sc} > I_N$	1.00 to 25.00	(steps 0.01)
Drop-off ratio		approx. 0.95	
Pick-up tolerance acc. VDE 0435 part 303		$\leq 5\%$ of set value	

Switch-on detection

Minimum current for dead line	$I_{RES} < I_N$	0.05 to 1.00	(steps 0.01)
Minimum voltage for dead line	$U_{RES} <$	2 V to 70 V	(steps 1 V)
Drop-off ratio		approx. 0.95	
Pick-up tolerance acc. VDE 0435 part 303		$\leq 5\%$ of set value	

Times

Shortest trip time	approx. 10 ms
Time tolerance	$\leq 1\%$ of set value or 10 ms

The set times are pure delay times.

3.7 Weak infeed trip (in conjunction with teleprotection)

Operation mode	phase dedicated undervoltage detection after reception of carrier signal from remote end; additional echo feature for overreaching transfer in release modes

Undervoltage detection

Setting range (phase-earth)	2 V to 70 V (steps 1 V)

Times

Shortest trip time	after signal reception after voltage collapse	approx. 22 ms approx. 75 ms
Release delay		0.01 s to 32.00 s (steps 0.01 s)
Release prolongation		0.01 s to 32.00 s (steps 0.01 s)

3.8 Emergency overcurrent time protection

Emergency operation		with measured voltage failure, e.g. VT secondary m.c.b. trip or detected fuse failure	
operation modes		optionally definite time overcurrent protection or inverse time overcurrent protection; with definite time or instantaneous high current stage; separate phase and earth current stages	
Characteristics			
for definite time overcurrent protection – shortest trip time		approx. 30 ms	
for inverse time overcurrent protection – trip time characteristics		normal inverse, very inverse, extremely inverse (type A, B, C) acc. IEC 60255–3 or BS 142; refer to Figure 3.1	
Pick-up/Delays			
high-current stage	$I_{>>}/I_N$	0.10 to 9.99 ¹⁾ 0.10 to 15.00 ²⁾	(steps 0.01) (steps 0.01)
delay time	$T_{I_{>>}}$	0.00 s to 32.00 s or ∞ (stage ineffective)	(steps 0.01 s)
phase overcurrent stage for definite time	$I_{>}/I_N$	0.10 to 4.00 ¹⁾ 0.10 to 15.00 ²⁾	(steps 0.01) (steps 0.01)
delay time	$T_{I_{>}}$	0.00 s to 32.00 s or ∞ (stage ineffective)	(steps 0.01 s);
earth overcurrent stage for definite time	$I_{E>}/I_N$	0.10 to 4.00	(steps 0.01)
delay time	$T_{I_{E>}}$	0.00 s to 32.00 s or ∞ (stage ineffective)	(steps 0.01 s)
phase overcurrent stages for inverse time	I_p/I_N	0.10 to 4.00	(steps 0.01)
time multiplier	T_p	0.05 to 32.00 or ∞ (stage ineffective)	(steps 0.01);
earth overcurrent stage for inverse time	I_{Ep}/I_N	0.10 to 4.00	(steps 0.01)
time multiplier	T_{Ep}	0.05 to 32.00 or ∞ (stage ineffective)	(steps 0.01)
drop-off ratios:			
– for $I \geq I_N$		approx. 0.95	
– for $I \geq 0.25 \times I_N$		approx. 0.90	
measurement tolerances acc. VDE 0435 part 303			
– for definite time stages, $I_{>>}$, $I_{E>>}$, $I_{>}$, $I_{E>}$		$\pm 5\%$ of set value $\pm 0.02 I_N$	
– for inverse time stages I_p , I_{Ep}		pick-up at $1.05 < I/I_p < 1.15$	
time tolerances			
– for definite time stages		1 % of set value or 10 ms	
– for inverse time stages		$\leq 5\% \pm 15$ ms for $2 \leq I/I_{(E)p} \leq 20$ $1 \leq T_{(E)p}/s \leq 20$	

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or later

The set times are pure delay times in definite time mode.

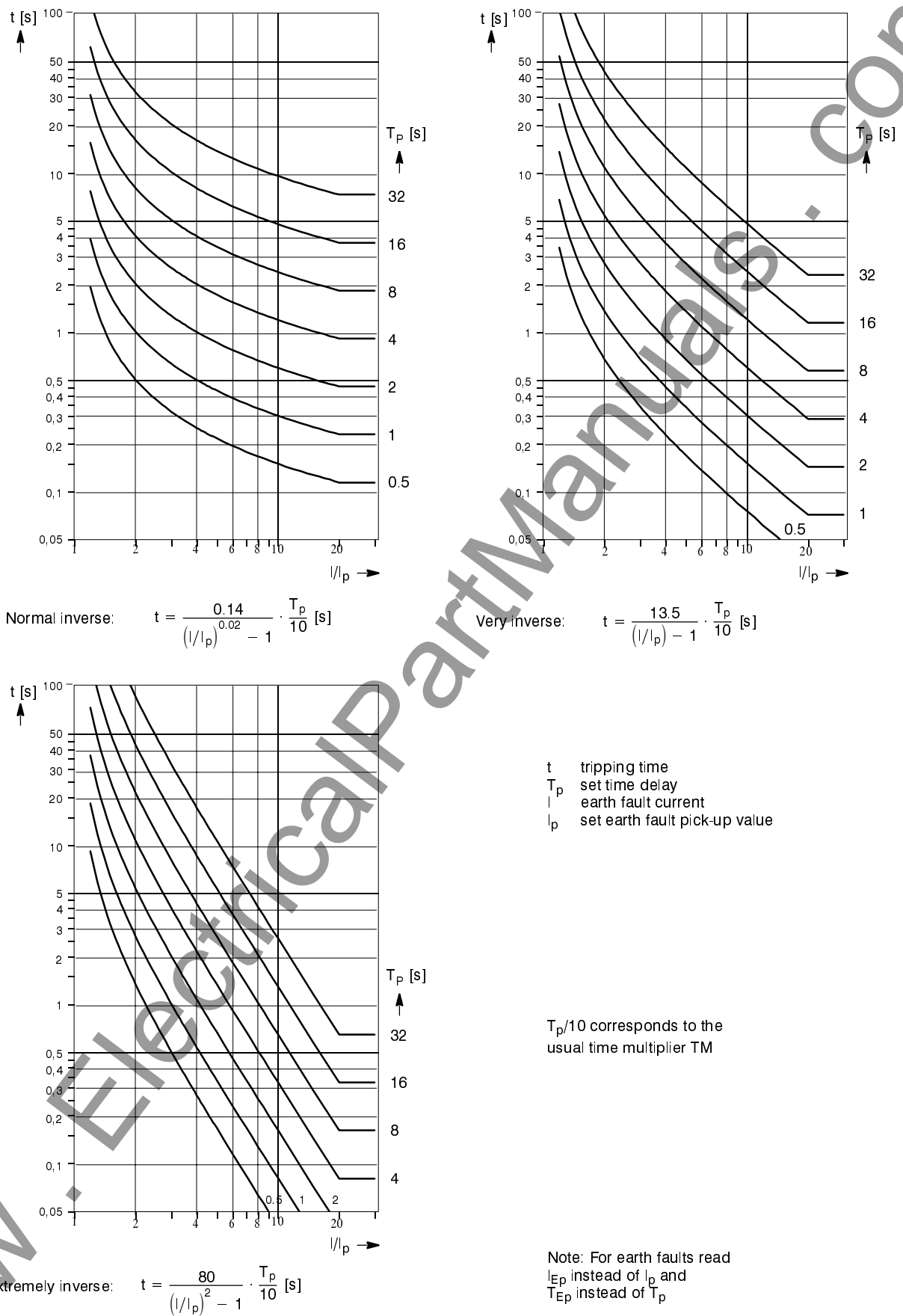


Figure 3.1 Tripping time characteristics of inverse time overcurrent protection

3.9 High-resistance earth fault protection (optional)

Characteristics

for **definite** time overcurrent protection

– shortest trip time

approx. 30 ms

for **inverse** time overcurrent protection

– trip time characteristics

normal inverse, very inverse, extremely inverse
(type A, B, C) acc. IEC 60255–3;
refer to Figure 3.2

for inverse time zero sequence voltage protection

– trip time characteristics

dependent of zero sequence voltage;
refer to Figure 3.3

Pick-up/Delays

earth current pick-up	$I_E > I_N$ or I_{Ep}/I_N	0.05 to 4.00 (steps 0.01)
delay times or } time multiplier }	T-DIRECTIONAL } T-NON-DIRECT }	0.00 s to 32.00 s (steps 0.01 s) } or ∞ (stage ineffective) }
zero sequence voltage	$U_{0\text{ inv min}}$	0.1 V to 5.0 V (steps 0.1 V)
drop-off ratios:		
– for $I \geq I_N$ and $U \geq 1\text{ V}$		approx. 0.95
– for $I \geq 0.25 \times I_N$		approx. 0.90
measurement tolerances acc. VDE 0435 part 303		
– for definite time stages $I_E >$, U_0		$\pm 5\%$ of set value $\pm 0.02 I_N$
– for inverse time stages I_{Ep}		pick-up at $1.05 < I/I_{Ep} < 1.15$
time tolerances		
– for definite time stages		1 % of set value or 10 ms
– for inverse time stages		$\leq 5\% \pm 15\text{ ms}$ for $2 \leq I/I_{Ep} \leq 20$ $1 \leq T_{Ip}/s \leq 20$

The set times are pure delay times in definite time mode.

Directional determination

Measuring principle

with $I_E (= 3 \cdot I_0)$ and $U_E (= \sqrt{3} \cdot U_0)$
or I_E and I_Y (transformer star-point current)

Forwards angle

Measuring tolerances at U_N and I_N
with sinusoidal quantities

approx. -14° to $+166^\circ$
 $\leq 5^\circ$

Directional comparison

release mode

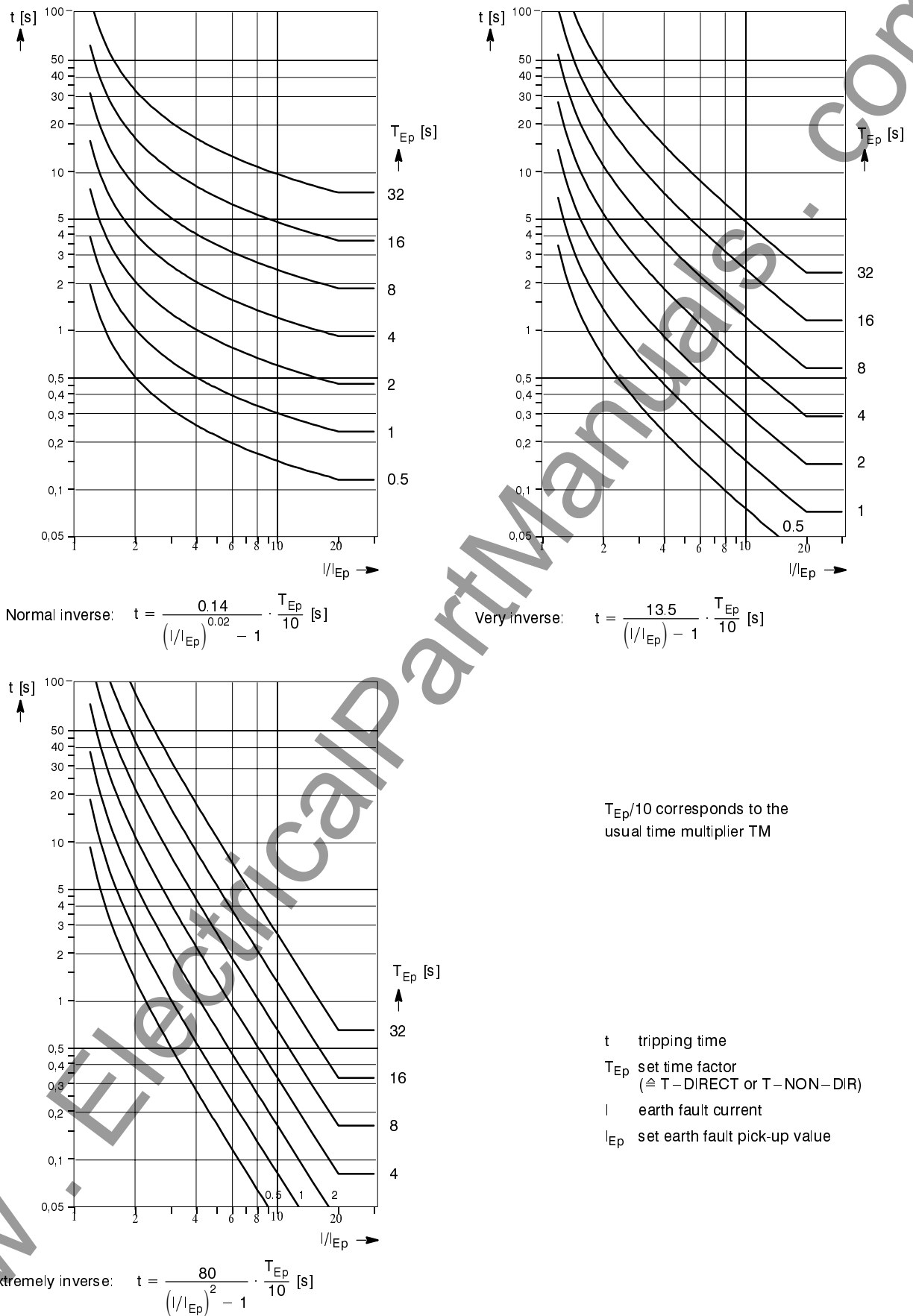


Figure 3.2 Tripping time characteristics of inverse time earth fault protection

Directional comparison/fault detection

Earth current pick-up $I_E > I_N$ (for trip)	0.05 to 4.00 (steps 0.01)
Lower pick-up value (for measurement release)	$0.75 \cdot I_E > I_N$
Displacement voltage $U_E >$	1.0 V to 10.0 V (steps 0.1 V)

Drop-off ratio	approx. 0.95
Measuring tolerance according VDE 0435 part 303	$\leq 5\%$ of set value $\pm 0.02 I_N$

Times

Shortest tripping time	approx. 30 ms
Re-orientation time after change of direction	approx. 30 ms
Trip and send delay time	0.00 s to 32.00 s (steps 0.01 s); ∞
Back-up time T directional	0.00 s to 32.00 s (steps 0.01 s); ∞
Back-up time T non-directional	0.00 s to 32.00 s (steps 0.01 s); ∞
Echo delay time	0.01 s to 32.00 s (steps 0.01 s); ∞
Echo pulse duration	0.02 s to 32.00 s (steps 0.01 s)
Echo block duration	0.01 s to 32.00 s (steps 0.01 s)
Transient blocking time	0.01 s to 32.00 s (steps 0.01 s)
Waiting time for transient blocking	0.01 s to 32.00 s (steps 0.01 s); ∞

Time expiry tolerances	$\leq 1\%$ or 10 ms

The set times are pure delay times.

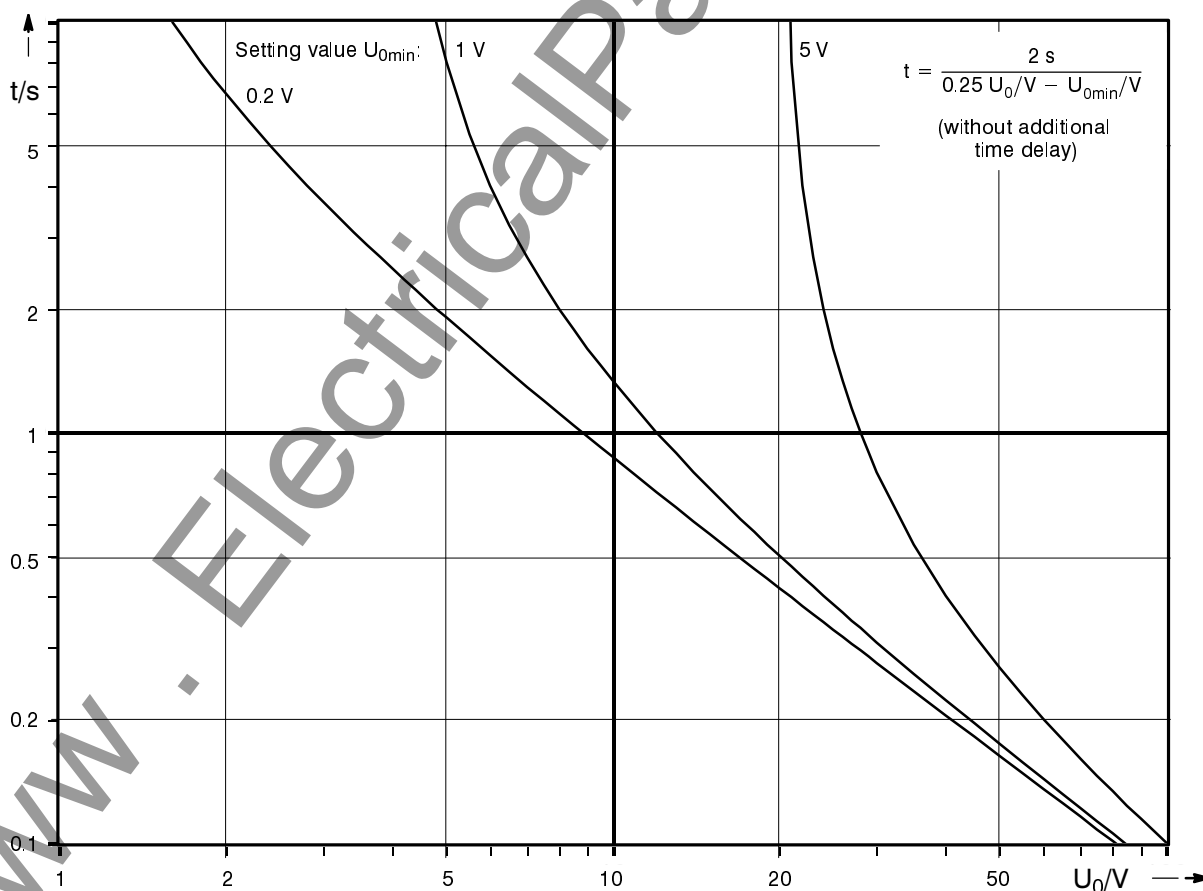


Figure 3.3 Trip time characteristic of zero sequence voltage time protection

3.10 Auto-reclosure (optional)

Max. number of possible shots	1 RAR (first shot) up to 9 DAR (further shots)
Auto-reclose modes	single-pole or three-pole or single/three-pole (1st shot RAR); further shots three-pole (DAR)
Action times	0.01 s to 320.00 s (steps 0.01 s)
RAR dead time single-pole	0.01 s to 320.00 s (steps 0.01 s)
RAR dead time three-pole	0.01 s to 320.00 s (steps 0.01 s)
DAR dead times	0.01 s to 1800.00 s (steps 0.01 s)
Discrimination time for evolving faults	0.01 s to 320.00 s (steps 0.01 s)
Reclaim time	0.50 s to 320.00 s (steps 0.01 s)
Lock-out time	0.50 s to 320.00 s (steps 0.01 s); ∞
Reclaim time after manual close	0.50 s to 320.00 s (steps 0.01 s)
Duration of RECLOSE command	0.01 s to 32.00 s (steps 0.01 s)

3.11 Synchronism and voltage check (optional)

Operation modes

Check programs for auto-reclose	synchro-check dead-line live-bus check dead-bus live-line check dead-bus dead-line check or combinations
Check programs for manual close	same as for auto-reclose, independent setting

Voltages

U< for dead-line or dead-bus check	1 V to 60 V (steps 1 V)
U> for live-line or live-bus check	20 V to 125 V (steps 1 V)
drop-off ratio	approx. 0.9

ΔU measurement

setting range	1 V to 50 V (steps 1 V)
measuring tolerance	2 V

$\Delta \varphi$ measurement

setting range	1° to 60° (steps 1°)
measuring tolerance	2°

Δf measurement

setting range for asynchronous switching	0.03 Hz to 1.00 Hz (steps 0.01 Hz)
setting range for synchronous switching	0.03 Hz to 0.10 Hz (steps 0.01 Hz); ∞
measuring tolerance	20 mHz

min operating voltage	20 V

Times

minimum measuring time	approx. 80 ms
release delay time	0.00 s to 32.00 s (steps 0.01 s)
active time	0.01 s to 32.00 s (steps 0.01 s)

3.12 Back-up overcurrent time protection

Operation modes

optionally definite time overcurrent protection or inverse time overcurrent protection; with definite time or instantaneous high current stage

Characteristics

for **definite** time overcurrent protection
– shortest trip time

approx. 30 ms

for **inverse** time overcurrent protection
– trip time characteristics

normal inverse, very inverse, extremely inverse (type A, B, C) acc. IEC 60255–3 or BS 142; refer to Figure 3.1 (Section 3.8)

Pick-up/Delays

high-current stage	$I > I_N$	0.10 to 9.99 ¹⁾ (steps 0.01) 0.10 to 15.00 ²⁾ (steps 0.01)
delay time	$T_{I>}$	0.00 s to 32.00 s (steps 0.01 s) or ∞ (stage ineffective)
phase overcurrent stages for definite time	$I > I_N$	0.10 to 4.00 ¹⁾ (steps 0.01) 0.10 to 15.00 ²⁾ (steps 0.01)
delay time	$T_{I>}$	0.00 s to 32.00 s (steps 0.01 s); or ∞ (stage ineffective)
earth overcurrent stage for definite time	$I_E > I_N$	0.10 to 4.00 (steps 0.01)
delay time	$T_{I_E>}$	0.00 s to 32.00 s (steps 0.01 s) or ∞ (stage ineffective)
phase overcurrent stages for inverse time	I_p / I_N	0.10 to 4.00 (steps 0.01)
time multiplier	T_p	0.05 to 32.00 (steps 0.01); or ∞ (stage ineffective)
earth overcurrent stage for inverse time	I_{Ep} / I_N	0.10 to 4.00 (steps 0.01)
time multiplier	$T_{I_{Ep}}$	0.05 to 32.00 (steps 0.01) or ∞ (stage ineffective)
drop-off ratios:		
– for $I \geq I_N$		approx. 0.95
– for $I \geq 0.25 \times I_N$		approx. 0.90
measurement tolerances acc. VDE 0435 part 303		
– for definite time stages, $I > I_N$, $I_E > I_N$, $I > I_N$, $I_E > I_N$		$\pm 5\%$ of set value $\pm 0.02 I_N$
– for inverse time stages I_p , I_{Ep}		pick-up at $1.05 < I/I_p < 1.15$
time tolerances		
– for definite time stages		1 % of set value or 10 ms
– for inverse time stages		$\leq 5\% \pm 15$ ms for $2 \leq I/I_{(E)p} \leq 20$ $1 \leq T_{(E)p}/s \leq 20$

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or later

The set times are pure delay times in definite time mode.

3.13 Overvoltage protection

U>> stage

measurement	phase–phase or phase–earth (selectable)
setting range U>>	1.00 U_N to 1.90 U_N (steps 0.01 U_N)
delay time with c.b. closed	0.00 s to 32.00 s (steps 0.01 s); ∞
delay time with c.b. open	0.00 s to 32.00 s (steps 0.01 s); ∞
operating time	approx. 50 ms
drop-off time	approx. 50 ms
tripping	local, remote, or local and remote
drop-off ratio, adjustable	0.50 to 0.99 (steps 0.01)
tolerances	
– pick-up U>>	5 % of set value
– times	1 % of set value or 10 ms

The set times are pure delay times.

U> stage

measurement	positive sequence component of measured voltages
setting range U>	1.00 U_N to 1.90 U_N (steps 0.01 U_N)
delay time	0.00 s to 32.00 s (steps 0.01 s); ∞
operating time	approx. 50 ms
drop-off time	approx. 50 ms
compounding	selectable with or without
tripping	local, remote, or local and remote
drop-off ratio, adjustable	0.50 to 0.99 (steps 0.01)
tolerances	
– pick-up U>>	3 % of set value
– times	1 % of set value or 10 ms

The set times are pure delay times.

Remote tripping

trip transfer to the remote line end	
minimum transmission pulse duration	0.05 s to 0.50 s (steps 0.01 s)
tolerance	1 % of set value or 10 ms

3.14 Fault location

Output of fault distance	in Ω primary and secondary in km line length ¹⁾ in percent line length ¹⁾
Start-to-measure command	by trip signal or by drop-off of fault detection or by external command via binary input
Setting reactance per unit line length (secondary*)	0.010 Ω /km to 5.000 Ω /km (steps 0.001 Ω /km)
Parallel line mutual compensation	setting of matching refer to to Section 3.2
Measuring tolerances according VDE 0435 part 303 with sinusoidal quantities	≤ 2.5 % of line length for $30^\circ \leq \varphi_{sc} \leq 90^\circ$ and $U_{sc}/U_N \geq 0.1$

*) Secondary values are referred to $I_N = 1$ A; for $I_N = 5$ A the values are to be divided by 5.

¹⁾ Output of fault distance in km or miles or percents only for homogeneous lines! When setting referred reactance in Ω /mile, the output can be read in miles.

3.15 Circuit breaker failure protection

Current detection	
setting range	0.04 I_N to 4.00 I_N (steps 0.01 I_N)
drop-off ratio	approx. 0.95
tolerance	5 % of set value
Times	
pick-up time	approx. 30 ms
drop-off time with sinusoidal measured quantities	≤ 10 ms
drop-off time maximum	≤ 20 ms
delay time	0.05 s to 1.00 s ¹⁾ (steps 0.01 ms) or ∞ 0.00 s to 1.00 s ²⁾ (steps 0.01 ms) or ∞
delay time tolerance	1 % of set value or 10 ms

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or later

The set times are pure delay times.

3.16 Ancillary functions

Output of measured values

Operational values of currents

- range
- tolerance

I_{L1}, I_{L2}, I_{L3}
in A primary and in % I_N
0 % to 240 % I_N
2 % of I_N for $I \leq I_N$
2 % of meas. value for $I > I_N$

Operational values of voltages

- range
- tolerance

$U_{L1-E}, U_{L2-E}, U_{L3-E}$
in kV primary and in % $U_N/\sqrt{3}$
0 % to 120 % $U_N/\sqrt{3}$
2 % of U_N

Operational values of voltages

- range
- tolerance

$U_{L1-L2}, U_{L2-L3}, U_{L3-L1}$
in kV primary and in % U_N
0 % to 120 % U_N
2 % of U_N

Operational values of powers

- range
- tolerance

P_a, P_r (active and reactive power)
in MW or MVar primary and
in % $S_N (= \sqrt{3} \cdot U_N \cdot I_N)$
0 % to 120 % S_N
5 % of S_N

Operational value of frequency

- range
- tolerance

f
in % f_N
96 % to 104 % f_N
0.5 % of f_N

Measured values plausibility checks

- Sum of currents
- Sum of voltages

phases and earth
phases and earth,
phase-to-phase,
phase-to-phase against phase-to-earth

Steady-state measured value supervision

Current unbalance

$I_{\max}/I_{\min} > \text{symmetry factor}$
as long as $I > I_{\text{limit}}$

Voltage unbalance
(phase-to-phase and phase-to-earth)

$U_{\max}/U_{\min} > \text{symmetry factor}$
as long as $U > U_{\text{limit}}$

Voltage failure (three-phase)

$|U|$ (phase-to-phase) < limit value
as long as $I_{\max} > \text{limit value}$

Voltage failure (single-phase, in earthed system)

$U_E >$ and $I_E <$

Phase sequence

clockwise phase rotation

Annunciations via binary inputs

- 4 user definable annunciations

Fault event data storage

Storage of annunciations of the eight last system faults, three of which can be read out locally

Circuit breaker operation log

Number of stored trip events caused by 7SA513	up to 9 decimal digits; pole segregated
Number of stored reclose events caused by 7SA513	up to 9 decimal digits; for each kind of auto-reclosure
Total of interrupted currents caused by 7SA513	up to 7 decimal digits plus 1 after decimal point pole segregated

Real time clock

Resolution for operational annunciations	1 min
Resolution for fault event annunciations	1 ms
Max time deviation	0.01 %
Buffer battery	Lithium battery 3 V/1 Ah, Type CR 1/2 AA Self-discharge time > 5 years

Data storage for fault recording

	max. 8 fault events
Storage period (fault detection or trip command = 0 ms),	max. 5 s per fault event (at 50 Hz), max. 10 s total (at 50 Hz), selectable pre-trigger and post-fault time
Sampling rate	1 instantaneous value per ms at 50 Hz 1 instantaneous value per 0.83 ms at 60 Hz

Commissioning aids

Phase sequence and directional check

Circuit breaker test	
– with auto-reclosure	single-pole or three-pole
– without auto-reclosure	three-pole

Storage of a test record

4 Method of operation

4.1 Operation of complete unit

The numerical distance protection relay 7SA513 is equipped with powerful and proven microprocessors. These provide fully digital processing of all functions from data acquisition of measured values to the trip signals for the circuit breakers.

Figure 4.1 shows the base structure of the unit.

The transducers of the measured value input section MI transform the currents and voltages from the measurement transformers of the switch-gear and match them to the internal processing level of the unit. The relay provides 5 measured current inputs and 7 measured voltage inputs. Three current inputs are intended for input of the phase currents of the

protected line. A choice can be made whether the remaining 2 current inputs are used for the earth current (residual current) of the protected line, for the earth current of a parallel line (for parallel line compensation), or for the star point current of an earthed infeed transformer (for directional earth fault protection). One voltage input is available for each of the line-to-earth and the line-to-line voltages. An additional voltage input can be used for either measurement of the displacement voltage (from an open-delta winding of the v.t.s) or the bus-bar voltage if the check synchronism function is to be used. The transformed measured values are transferred to the data acquisition module DA.

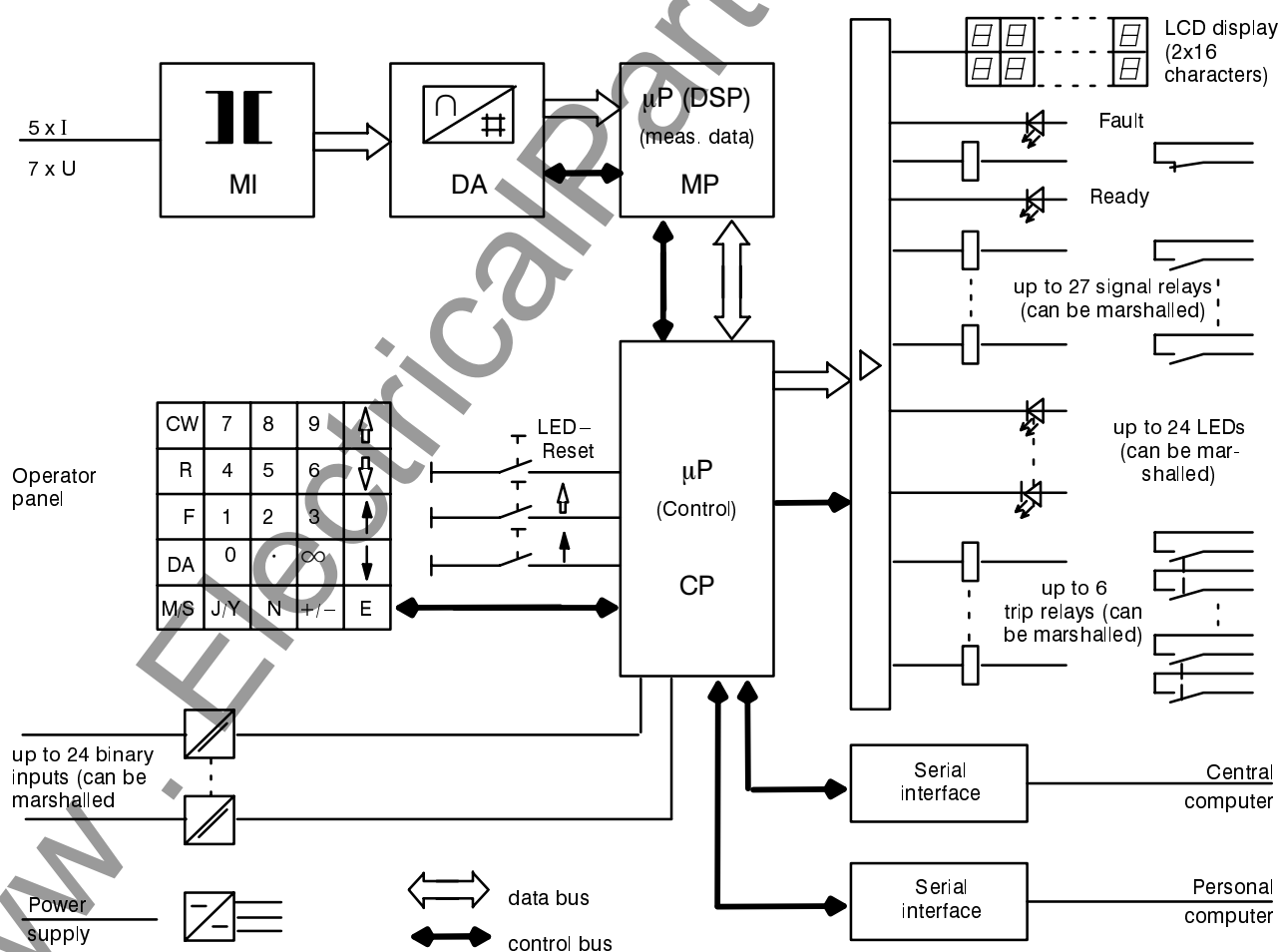


Figure 4.1 Hardware-structure of EHV distance protection relay 7SA513

Filters are provided for the suppression of interference. The filters have been optimized with regard to bandwidth and processing speed to suit the measured value processing.

The data acquisition module DA contains two input amplifiers for each of the twelve analog channels, multiplexers, sample and hold elements, analog-to-digital converters and memory circuits for the data transfer to the digital signal processor (measured data processing).

The digitized measured data are processed in the measured data processing module MP. This module contains a 32 bit digital signal processor system DSP. The signal processor carries out all measurement operations – e.g.

- filtering and formation of the measured quantities,
- continuous monitoring of the measured currents and voltages,
- continuous monitoring of the fault detection conditions of all protection functions,
- calculation of the loop impedances of all six line loops.

The central processing system CP controls the logical sequence of all protection, control and annunciation functions; it also administers the transmission of data between the modules as well as the interfaces to external devices, i.e. for operating or a central substation computer.

Additionally, the central processing system administers the integrated real-time clock and the storage devices for annunciations and messages.

Binary inputs and outputs to and from the processor system are channelled via the input/output ele-

ments. From these the processor system receives information from the switch-gear (e.g. remote resetting) or from other equipment (e.g. blocking signals). Outputs include, in particular, trip commands to the circuit breakers, signals for remote signalling of important events and conditions.

Optical indicators (LEDs) and an alphanumerical display on the front show important events, conditions, and measured values

An integrated membrane keyboard in connection with a built-in alphanumerical LCD display enables communication with the unit. All operational data such as setting values, plant data, etc. are entered into the protection from this panel (refer to Section 6.3). Using this panel the parameters can be recalled and the relevant data for the evaluation of a fault can be read out after a fault has occurred (refer to Section 6.4). The dialog with the relay can be carried out alternatively via the serial interface in the front plate by means of a personal computer.

Via a further serial interface, fault data can be transmitted to a central evaluation unit. During healthy operation, measured values can also be transmitted, e.g. the measured currents and voltages at the point of installation. This second interface is equipped with means for optical fibre links.

A power supply unit provides the auxiliary supply on the various voltage levels to the described functional units. +24 V is used for the relay outputs. The analog inputs require ± 15 V whereas the processors and their immediate peripherals are supplied with +5 V. Transient failures in the supply voltage, up to 50 ms, which may occur during short-circuits in the dc supply system of the plant are bridged by a dc voltage storage element (rated auxiliary voltage ≥ 110 Vdc).

4.2 Distance protection

Distance protection is the main short-circuit protection of the relay. It is characterized by high measuring accuracy and flexible adaptation possibilities for the given network characteristics. It can be extended by a range of supplementary functions.

The essential functions of the distance protection are:

- six fault detection system, one for each of the possible line loops, and an earth fault processing module,
- measurement circuits and logic for elimination of fault-free impedances,
- six distance measuring system, one for each of the possible line loops, with parallel line and load current compensation,
- six directional determination system, one for each of the six line loops, with quadrature polarized and stored voltages, effective also for series compensated lines,
- timers for delayed back-up distance stages,
- a tripping logic for the combination of the measurement results and for the decision of the tripped circuit breaker poles.

4.2.1 Fault detection

Fault detection has the duty to detect a faulty condition in the network and to initiate all the necessary procedures for selective clearance of the fault:

- start the delay times,
- determination of the faulted line loops,
- release of tripping command,
- initiation of auxiliary functions,
- indication/output of the faulty conductor(s).

The line protection relay 7SA513 provides a variety of fault detection functions from which the optimum can be chosen for the system under consideration. With these options comprehensive facilities are possible to match to the network conditions and the user's philosophy.

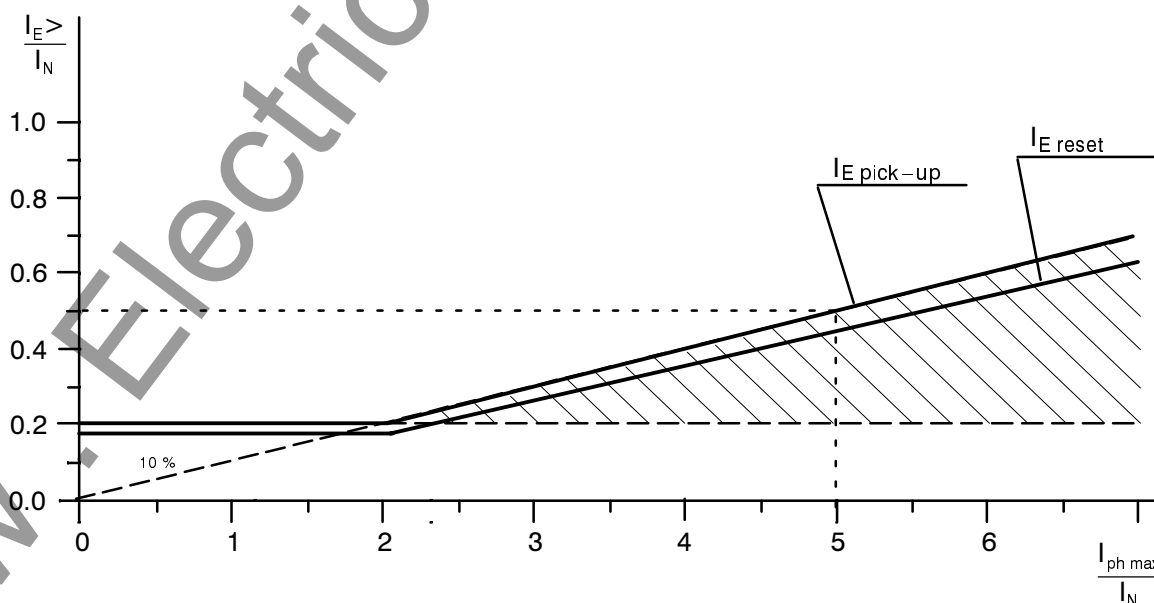


Figure 4.2 Earth current detector – pick-up/reset characteristic – example $I_E > I_N$ set at 0.2

4.2.1.1 Earth fault detection and processing

An important element for fault detection is the detection of an earth fault since the validity of the line loop impedances and the shape of the fault detection characteristic essentially depend on whether it is an earth fault or not. The model 7SA513 is equipped with stabilized measurement of the earth current, a comparison facility of the zero sequence current and the negative sequence current as well as a detection of the displacement voltage. Measures have also been provided to suppress fault detection in the case of single-phase earth faults in isolated or compensated systems.

The earth current detector monitors the fundamental wave (derived from numerical filters) of the total of the phase currents ($I_E = -3 \cdot I_0$) in comparison with the set threshold value (parameter 1602 $I_{E>}$). It is stabilized against faulty pick-up caused by asymmetric operating currents or distorted currents in the secondary circuit of the current transformers resulting from different current transformer saturation with earth-free short-circuits: the actual pick-up value is automatically increased as the phase currents increase (Figure 4.2: Example for setting 0.2; the horizontal branch is shifted according different settings). The drop-off value is approximately 95 % of the pick-up value.

Strong stabilization of the earth current detector may occur on long, heavy loaded lines, caused by high load currents (cf. Figure 4.2). In order to ensure earth fault detection even under those conditions, comparison is made between the earth current and the negative sequence current. If the earth current is at least 0.3 times the negative sequence current ($I_0 > 0.1 \cdot I_2$), then earth fault is detected even if stabilization would avoid pick-up of the earth current stage (shaded area in Figure 4.2).

The displacement voltage detector monitors the fundamental wave (derived from numerical filters) of the

displacement voltage ($U_E = \sqrt{3} \cdot U_0$) in comparison with the set threshold value (parameter 1701 $U_{E>}$). The drop-off value is 95 % of the pick-up value.

The two criteria supplement each other since the displacement voltage increases with higher ratio of zero sequence impedance/positive sequence impedance whereas the earth current increases with lower ratio of zero sequence impedance/positive sequence impedance. Earth fault detection is stabilized during a single-pole auto-reclose cycle in order to prevent from wrong measurement with the faulty zero sequence components in this case.

In systems with earthed star-point (effectively or low-resistance earthed), the voltage and current criteria can be combined by logical AND or logical OR (Figure 4.3) before an earth fault is detected (parameter 1707 E/F DETECT). Detection of an earth fault *on its own* does not lead to general fault detection signal of the distance protection but only controls the other fault detection modules. It is not annunciated *on its own* either.

In non-earthed systems (isolated starpoint or with arc compensation by means of Petersen coil), the displacement voltage monitor is not used for earth fault detection. A single-phase earth fault is also initially assumed in these systems in the event of a single-phase fault detection and the detection is suppressed to prevent faulty pick-up by the oscillation transients on the occurrence of a simple earth fault. Pick-up is enabled again following an adjustable delay time $T_{le\ 1PHASE}$ (address 1801); this is necessary so that the distance protection is still able to recognize a cross country double earth fault with one fault point on a spur feeder. If, however, an earth fault is already present in the system, this is detected by the displacement voltage monitor (Address 1802 $U_{E>}$); the delay is then not effective: an earth fault which now occurs in another phase can only be a double-phase earth fault.

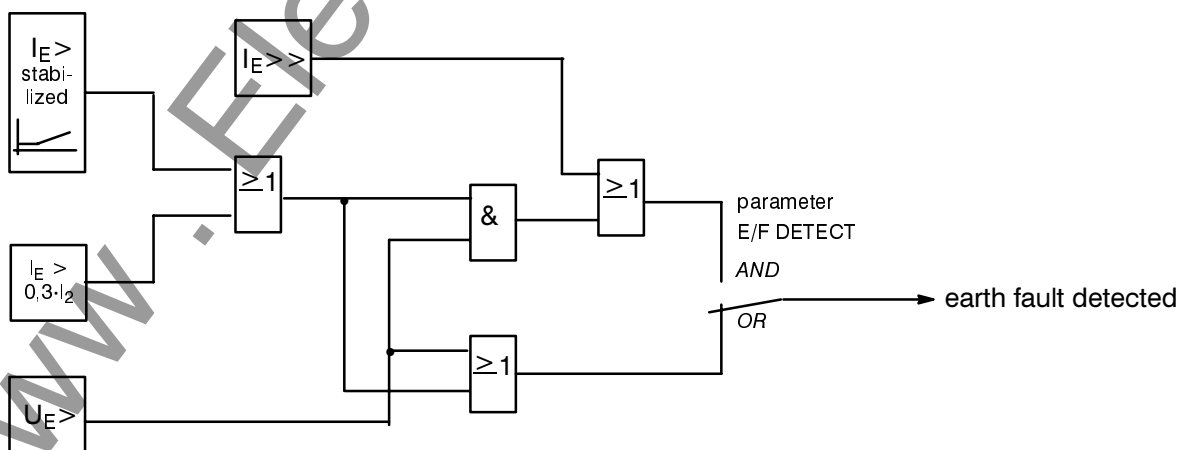


Figure 4.3 Earth fault processing

4.2.1.2 Impedance fault detection (fix-impedance)

Impedance fault detection is a loop-dedicated fault detection procedure.

For phase-to-phase fault detection, a prerequisite for measurement of a loop impedance is that the assigned phase currents as well as the difference current decisive for the loop have exceeded an adjustable minimum value $I_{ph} >$.

For phase-to-earth fault detection, a prerequisite for measurement of the phase–earth loop is that the assigned phase current has exceeded an adjustable minimum value $I_{ph} >$ and that the earth fault processing has detected an earth fault according to Section 4.2.1.1.

Pick-up caused by single-phase earth faults in systems with a non-earthed starpoint is effectively suppressed by the measures described in Section 4.2.1.1.

The impedances are calculated separately for R and X in cyclic time intervals and compared with the set values for all of the six line loops for which the current conditions are fulfilled. A measured value step change monitor is used to synchronize the measurement window on occurrence of a fault. Calculation procedure is the same as that described for distance measurement in Section 4.2.3.

An example of the fault detection characteristic in the complex R/X plane is shown in Figure 4.4. The bold dots identify the setting parameters which determine the geometry of the fault detection polygon. The X intersections $X+A$ and $X-A$ are decisive for the fault reach in the forward (line) direction and in the reverse (bus-bar) direction. The R intersections can be set differently for phase–phase loops (RA1) and phase–earth loops (RA1E). It is thus possible e.g. to permit a larger fault resistance tolerance for earth faults (bold dotted line in Figure 4.4). The polygon extended in R–direction is only valid when an earth fault has been detected according to Section 4.2.1.1.

In order to guarantee unequivocal criteria for discrimination between load operation and a short-circuit – especially in the case of long, high-loaded lines – the characteristics can be set dependent on the phase angle: the R section RA2 then applies to phase angles above a settable value φ_A , the R section RA1 below φ_A .

Phase angle dependence can separately be achieved for earth fault with RA2E and φ_{AE} but for reasons of simplification this is not illustrated in Figure 4.4.

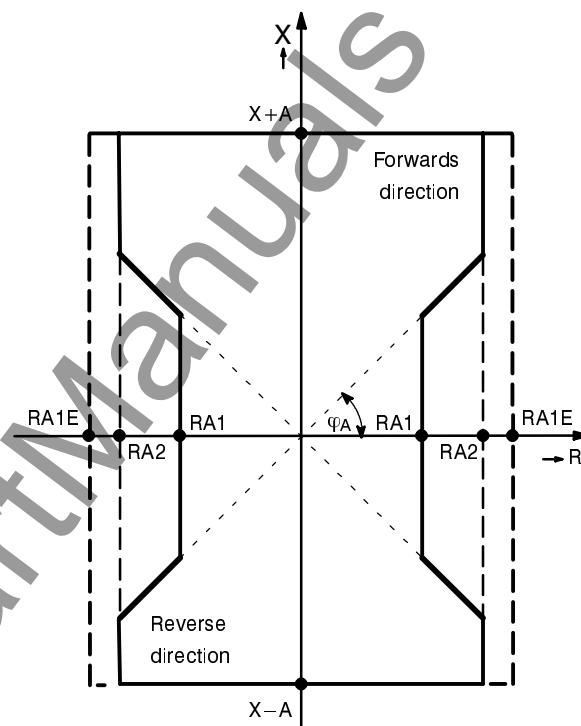


Figure 4.4 Impedance fault detection characteristics – example

To avoid intermittent pick-up signals near the border lines of the characteristic, a hysteresis of 6 % is provided.

Pick-up results for the measurement loop in which the impedance vector lies within the fault detection polygon. If detection occurs in more than one loop a particular loop verification becomes effective. This operates in two steps:

At first, a line simulation is calculated from the loop impedance and its part impedances (line or earth alone). If a plausible simulation can be found then the corresponding loop is marked as "unconditionally valid".

If the impedances of more than one loop are found within the fault detection polygon, the smallest is equally marked as valid. Additionally, the relay regards as valid all those loops whose impedance is not greater than 150 % of that smallest impedance. Loops with higher impedances are eliminated, but those which are marked as "unconditionally valid" remain valid even when they are greater than 150 % of the smallest loop impedance.

By this method, on one hand, the loops with "apparent fault impedances" are eliminated, but, on the other hand, unsymmetrical multi-phase faults and multiple faults are correctly detected.

When multiple phase faults occur, further influences on the measured loops are possible. The selection of valid short-circuit loops varies considerably, dependent upon whether the system starpoint is

earthed, isolated or compensated (Petersen coil). Accordingly, the treatment of the system star-point has to be known before the device is put into operation (see Section 6.3.3.1).

The impedance fault detection is supplemented by an overcurrent stage $I_{ph} >$. In this manner double faults with high current are also correctly detected even if a fault loop has been eliminated by the procedure described above. Overcurrent fault detection can be set ineffective during setting of the fault detector parameters.

The loop informations are converted into phase information for indication of the faulty phase(s). An earth fault is also annunciated if detected according to 4.2.1.1.

4.2.1.3 Voltage and phase angle controlled fault detection (under-impedance fault detection)

The voltage and phase angle controlled fault detection is a phase- and loop-dedicated fault detection procedure. The exceeding of phase currents is decisive, where the pick-up value depends on the magnitude of the loop voltages and the phase angle between currents and voltages.

For phase-to-phase angle measurement, a prerequisite is that assigned phase currents as well as the difference current decisive for the loop have exceeded an adjustable minimum value $I_{ph} >$. The angle is determined from the phase-to-phase voltage and the assigned current difference.

For phase-to-earth angle measurement, a prerequisite is that the assigned phase current has exceeded an adjustable minimum value $I_{ph} >$ and that the earth fault processing has detected an earth fault according to Section 4.2.1.1, or that a setting parameter prescribes exclusively phase-to-earth measurement. The angle is determined from the phase-to-earth voltage and the assigned phase current.

Pick-up caused by single-phase earth faults in systems with a non-earthed starpoint is effectively suppressed by the measures described in Section 4.2.1.1.

The basic characteristic can be gathered from the current/voltage characteristic shown in Figure 4.5. The exceeding of a minimum current $I_{ph} >$ is the first prerequisite for each phase pick-up. Above this current, voltage-controlled overcurrent detection is ef-

fective which is, additionally, dependent of the phase angle between currents and voltages. The slope is for phase angles in the load area, i.e. below a selectable angle $\varphi >$, defined by the parameters $U(I >)$ and $U(I > >)$. A high-set overcurrent stage $I_{ph} > >$ is superimposed in the case of short-circuits of high current. Above the critical angle $\varphi >$, i.e. with

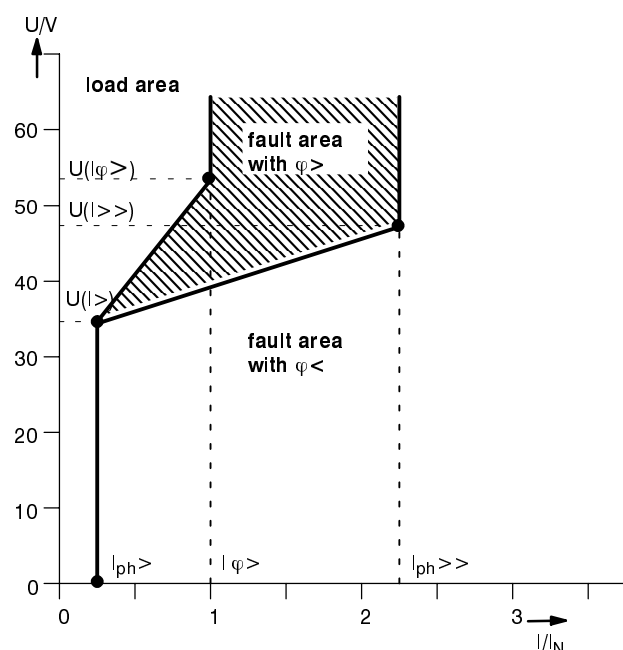


Figure 4.5 Voltage and angle controlled fault detectors, $U/I/\varphi$ characteristic

high phase angles (fault area), the characteristic between $U(I >)$ and $U(I_{\varphi} >)$ is decisive, which is cut by the overcurrent stage $I_{\varphi} >$. The bold dots in Figure 4.5 identify the setting parameters which determine the geometry of the current/voltage characteristic.

Fault detection of a phase is reset when 95 % of the respective current is fallen below or 105 % of the respective voltage is exceeded. Phase angle measurement has a hysteresis of approximately 5° .

Parameters are used to define whether the voltages U_{Ph-E} or the voltages U_{Ph-Ph} are decisive, or whether this depends on the earth fault detection as described in Section 4.2.1.1. This enables highly flexible adaptation to the system conditions. Optimum control largely depends on whether the system starpoint is not earthed (isolated or compensated), earthed with a low impedance (resistance

earthed) or solidly earthed. The position of the starpoint earthing is also significant in the latter case. Information on the setting is contained in Section 6.3.4.4.

Control with U_{Ph-E} is characterized by a high sensitivity to earth short-circuits and is therefore particularly advantageous in systems with an earthed starpoint. It is automatically adapted to the existing load conditions, i.e. it becomes more current-sensitive during low-load operation, the pick-up threshold is higher in the case of high load currents. This is particularly valid in systems with a low-impedance earthed starpoint, i.e. with earth fault limiting aids (so-called resistance earthing). In case only one fault detection system picks up, a choice can be made whether this results in a phase-to-phase fault detection or in a phase-to-earth fault detection (refer to Table 4.1).

Fault detection module	Measured current	Measured voltage	Earth fault detection	Parameter 1PH FAULTS	Resultant line loop	Annunciation
L1 L2 L3	L1 L2 L3	L1-E L2-E L3-E	no no no	PHASE-PHASE	L3-L1 L1-L2 L2-L3	L1, L3 L1, L2 L2, L3
L1 L2 L3	L1 L2 L3	L1-E L2-E L3-E	no no no	PHASE-EARTH ¹⁾	L1-E L2-E L3-E	L1 L2 L3
L1 L2 L3	L1 L2 L3	L1-E L2-E L3-E	yes yes yes	irrelevant	L1-E L2-E L3-E	L1, E L2, E L3, E

¹⁾ only for earthed system starpoint

Table 4.1 Line loops and phase annunciations with single-phase voltage controlled fault detection, program: phase-earth voltages

The sensitivity is particularly high in the case of phase-phase faults when controlling with U_{Ph-Ph} . This control is advantageous with extended compensated systems because its principle excludes pick-up by single earth faults. It is automatically adapted to the existing load conditions in the case of two-phase and three-phase faults; i.e. it becomes

more current-sensitive during low-load operation, the pick-up threshold is higher in the case of high load currents. When exclusively the phase-to-phase loops are used for underimpedance fault detection, the measured line loop is independent of the earth fault detection, and this method is therefore not suitable for earthed systems (refer to Table 4.2).

Fault detection module	Measured current	Measured voltage	Earth fault detection	Parameter 1PH FAULTS	Resultant line loop	Annunciation
L1 L2 L3	L1 L2 L3	L1-L2 L2-L3 L3-L1	irrelevant	irrelevant	L1-L2 L2-L3 L3-L1	L1, L2 L2, L3 L1, L3

Table 4.2 Line loops and phase annunciations with single-phase voltage controlled fault detection, program: phase-phase voltages

If the possibility of making the voltage loops dependent on the earth fault detection is used, the high sensitivity then also applies to phase–earth faults as well as to phase–phase faults. This possibility is, in principle, independent of the treatment of the system starpoint; it assumes, however, that the earth fault criteria according to Section 4.2.1.1 have been

satisfied safely for all earth faults (refer to Table 4.3).

The loop informations are converted into phase information for indication of the faulty phase(s). An earth fault is also annunciated if detected according to 4.2.1.1.

Fault detection module	Measured current	Measured voltage	Earth fault detection	Parameter 1PH FAULTS	Resultant line loop	Annunciation
L1 L2 L3	L1 L2 L3	L1–L2 L2–L3 L3–L1	no no no	irrelevant	L1–L2 L2–L3 L3–L1	L1, L2 L2, L3 L1, L3
L1 L2 L3	L1 L2 L3	L1–E L2–E L3–E	yes yes yes	irrelevant	L1–E L2–E L3–E	L1, E L2, E L3, E

Table 4.3 Line loops and phase annunciations with single-phase voltage controlled fault detection, program: phase–earth voltages with earth fault, phase–phase voltages without earth fault

4.2.2 Verification of the faulted loops

The impedances of the six possible conductor loops L1–E, L2–E, L3–E, L1–L2, L2–L3, L3–L1 are continuously calculated.

For calculation of a phase–phase loop, for example, for a two phase short-circuit L1–L2 (Figure 4.6) the following identity applies:

$$I_{L1} \cdot Z_L - I_{L2} \cdot Z_L = U_{L1-E} - U_{L2-E}$$

where U, I are (complex) measured values and $Z = R + jX$ is the (complex) line impedance.

The line impedance is thus

$$Z_L = \frac{U_{L1-E} - U_{L2-E}}{I_{L1} - I_{L2}}$$

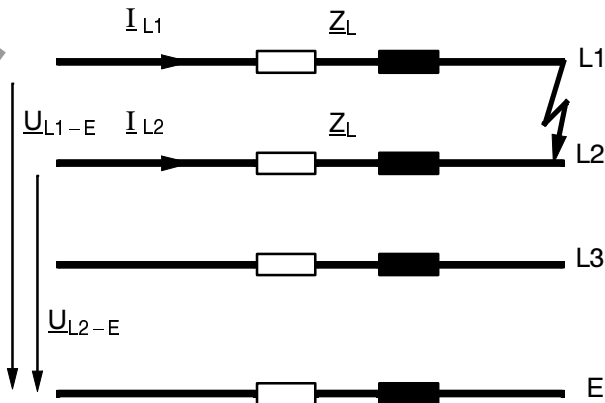


Figure 4.6 Phase–phase short circuit loop

For the calculation of a phase–earth loop, for example, for a short circuit L3–E (Figure 4.7) it must be observed that the impedance of the earth return path is not normally equal with the impedance of the phase. In the loop equation

$$I_{L3} \cdot Z_L - I_E \cdot Z_E = U_{L3-E}$$

Z_E is replaced by $\frac{Z_E}{Z_L} \cdot Z_L$ which gives us

$$I_{L3} \cdot Z_L - I_E \cdot Z_L \cdot \frac{Z_E}{Z_L} = U_{L3-E}$$

from which one obtains the line impedance

$$Z_L = \frac{U_{L3-E}}{I_{L3} - \frac{Z_E}{Z_L} \cdot I_E}$$

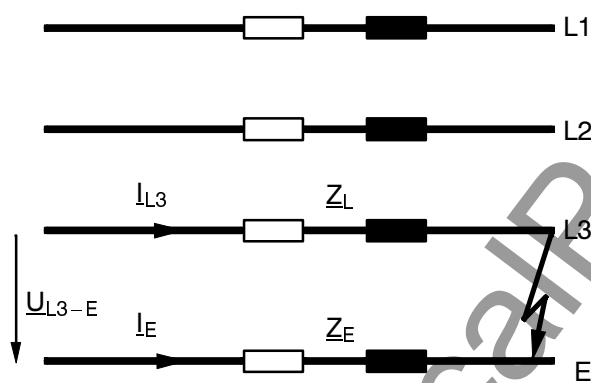


Figure 4.7 Phase–earth short-circuit loop

whereby the factor Z_E/Z_L is dependent only upon the line constants and not upon the distance to fault.

When multiple phase faults occur, further influences on the measured loops are possible. The selection of valid short-circuit loops varies considerably, dependent upon whether the system starpoint is earthed, isolated or compensated (Petersen coil). Accordingly, the treatment of the system star-point has to be known before the device is put into operation (see Section 6.3.3.1).

4.2.2.1 Measurement loops in earthed systems

In networks with earthed starpoint, each contact of a phase with earth is a short circuit which must be interrupted immediately by the nearest protective device. Fault detection occurs in the faulted loop(s).

With double earth faults, pick-up normally occurs in two phase–earth loops. If both faults are in the same direction, a phase–phase loop will often pick up, too. Normally, all loops which have been found as valid will operate (parameter PHPHE FLTTS = ALL). Alternatively, it is possible to set the relay such that only the phase–phase loop (parameter PHPHE FLTTS = PHASE–PHASE ONLY) or only the phase–earth loops (parameter PHPHE FLTTS = PHASE–EARTH ONLY) are evaluated. Furthermore, evaluation of one phase–earth loop can be blocked (PHPHE FLTTS = BLOCK LAGGING PH or BLOCK LEADING PH).

In case of three-phase faults, generally, the phase–phase fault detection systems will pick up. Thus, the three phase–phase loops will be evaluated. If phase–earth fault detection occurs (with earth fault detection), the phase–earth loops are evaluated, too.

Table 4.4 shows the measurement quantities which will be used for distance measurement in these cases.

Note: In systems with earthed star point the relay must be connected to three star connected voltage transformers U_{L1-N} , U_{L2-N} , U_{L3-N} with earthed primary star point and to three current transformers I_{L1} , I_{L2} , I_{L3} . The star point lead for the current transformers shall be connected to one of the the I_E current paths of the relay. If both I_E current paths of the relay are fed from other current sources (e.g. from the star point lead of the current transformer set of a parallel line for parallel line compensation and from the star point current transformer of an earthed feeder transformer for directional earth fault protection), the relay calculates the earth fault current from the sum of the three phase currents. If the voltage transformers have residual voltage windings, these should be connected in open delta to the voltage input provided for the purpose: this allows the relay to give complete monitoring of the voltage transformers' secondary circuits.

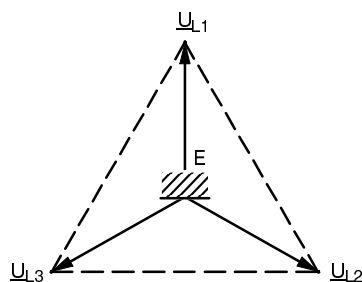
Fault detection phase loop(s)	Evaluated loop(s)	Selected setting parameter
L1-E L2-E L3-E	L1-E L2-E L3-E	irrelevant
L1-L2 L2-L3 L3-L1	L1-L2 L2-L3 L3-L1	irrelevant
L1-E, L2-E L2-E, L3-E L1-E, L3-E	L1-L2 L2-L3 L3-L1	PHPHE FLT = <i>PHASE-PHASE ONLY</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E	L1-E L2-E L3-E	PHPHE FLT = <i>BLOCK LAGGING PH</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E	L2-E L3-E L1-E	PHPHE FLT = <i>BLOCK LEADING PH</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E	L1-E, L2-E L2-E, L3-E L3-E, L1-E	PHPHE FLT = <i>PHASE-EARTH ONLY</i> or <i>ALL</i>
L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2	L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2	irrelevant
L1-E, L2-E, L1-L2 L2-E, L3-E, L2-L3 L1-E, L3-E, L3-L1	L1-L2 L2-L3 L3-L1	PHPHE FLT = <i>PHASE-PHASE ONLY</i>
L1-E, L2-E, L1-L2 L2-E, L3-E, L2-L3 L1-E, L3-E, L3-L1	L1-E, L1-L2 L2-E, L2-L3 L3-E, L3-L1	PHPHE FLT = <i>BLOCK LAGGING PH</i>
L1-E, L2-E, L1-L2 L2-E, L3-E, L2-L3 L1-E, L3-E, L3-L1	L2-E, L1-L2 L3-E, L2-L3 L1-E, L3-L1	PHPHE FLT = <i>BLOCK LEADING PH</i>
L1-E, L2-E, L1-L2 L2-E, L3-E, L2-L3 L1-E, L3-E, L3-L1	L1-E, L2-E L2-E, L3-E L3-E, L1-E	PHPHE FLT = <i>PHASE-EARTH ONLY</i>
L1-E, L2-E, L1-L2 L2-E, L3-E, L2-L3 L1-E, L3-E, L3-L1	L1-E, L2-E, L1-L2 L2-E, L3-E, L2-L3 L3-E, L1-E, L3-L1	PHPHE FLT = <i>ALL</i>
L1-E, L2-E, L3-E	L1-E, L2-E, L3-E	irrelevant
L1-L2, L2-L3, L3-L1	L1-L2, L2-L3, L3-L1	
L1-E, L2-E, L3-E, } L1-L2, L2-L3, L3-L1 }	L1-E, L2-E, L3-E, L1-L2, L2-L3, L3-L1	

Table 4.4 Evaluated conductor loops in **earthed** systems

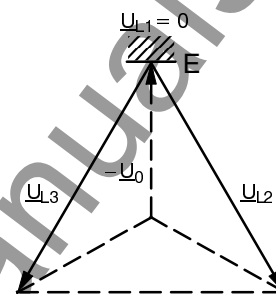
4.2.2.2 Measurement loops in non-earthed systems

In isolated or compensated networks, no currents resembling a short-circuit are present in the case of a single-phase earth fault. Only a displacement of the voltage triangle occurs (Figure 4.8). This condition does not represent any immediate danger for the operation of the network. In this case the distance protection must not respond since the phase-

to-earth voltage of the faulty phase is zero throughout the whole galvanically interconnected network. This would lead to a measured impedance equal zero, for the faulty phase–earth loop, at each measuring point. For this reason pick-up of one single phase-to-earth fault detector is avoided in 7SA513 relay.



a) sound network, without earth fault



b) earth fault in phase L1

Fig. 4.8 Earth fault in a non-earthed network

On the occurrence of an earth fault – above all in extensive, compensated networks – a significant ignition current can flow which could cause the earth current detector to pick up or, for the overcurrent element, in certain circumstances, even a phase current pick-up. 7SA513 has special features to prevent such faulty reaction (see Section 4.2.1.1).

In the case of a double earth fault in isolated or compensated networks, it is sufficient to eliminate one fault. The second fault remains in the network as a simple earth fault. Which one of the faults will be interrupted, is dependent upon the double earth fault priority which is set to be the same throughout the whole galvanically connected network. With 7SA511 the following double earth fault priorities can be selected:

acyclic L3 before L1 before L2,
abbreviated L3(L1) acyclic;
acyclic L1 before L3 before L2,
abbreviated L1(L3) acyclic;
acyclic L2 before L1 before L3,
abbreviated L2(L1) acyclic;
acyclic L1 before L2 before L3,
abbreviated L1(L2) acyclic;
acyclic L3 before L2 before L1,
abbreviated L3(L2) acyclic;
acyclic L2 before L3 before L1,
abbreviated L2(L3) acyclic;

cyclic L3 before L1 before L2 before L3,
abbreviated L3(L1) cyclic;
cyclic L1 before L3 before L2 before L1,
abbreviated L1(L3) cyclic.

One earth fault will be cleared in accordance with the selected preference; a second (cross-country) fault would remain on the network and can be detected by an earth fault detection relay.

In 7SA513 it is possible to clear both fault points of a double earth fault. In order to achieve this, the phase preference for double earth faults is set to *ALL*.

For unearthed networks, measuring quantities will be selected in accordance with Tables 4.5.

Note: Generally it is assumed that three current transformers I_{L1} , I_{L2} , I_{L3} and three star connected voltage transformers are provided. If only two current transformers and/or two voltage transformers (in V–connection) are available, reliable detection of double earth faults in non-earthed networks is not always possible. For the double earth fault preference, the preferred phases must always be equipped with the current transformers if only two current transformers are connected.

Fault detection phase loop(s)	Evaluated loop(s)	Selected setting parameter
L1-E L2-E L3-E	L1-E L2-E L3-E	irrelevant
L1-L2 L2-L3 L3-L1	L1-L2 L2-L3 L3-L1	irrelevant
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L1-E L3-E L3-E	PHASE PREF = <i>L3(L1) ACYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L1-E L3-E L1-E	PHASE PREF = <i>L1(L3) ACYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L2-E L2-E L1-E	PHASE PREF = <i>L2(L1) ACYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L1-E L2-E L1-E	PHASE PREF = <i>L1(L2) ACYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L2-E L3-E L3-E	PHASE PREF = <i>L3(L2) ACYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L2-E L2-E L3-E	PHASE PREF = <i>L2(L3) ACYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L1-E L2-E L3-E	PHASE PREF = <i>L3(L1) CYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L2-E L3-E L1-E	PHASE PREF = <i>L1(L3) CYCLIC</i>
L1-E, L2-E (L1-L2) L2-E, L3-E (L2-L3) L1-E, L3-E (L3-L1)	L1-E, L2-E L2-E, L3-E L3-E, L1-E	PHASE PREF = <i>ALL</i>
L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2	L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2	irrelevant
L1-E, L2-E, L3-E	L1-E, L2-E, L3-E	irrelevant
L1-L2, L2-L3, L3-L1	L1-L2, L2-L3, L3-L1	
L1-E, L2-E, L3-E, } L1-L2, L2-L3, L3-L1 }	L1-E, L2-E, L3-E, L1-L2, L2-L3, L3-L1	

Table 4.5 Evaluated conductor loops in **non-earthed** systems

4.2.3 Determination of the fault distance

4.2.3.1 Impedance calculation

The calculation is an integration of the line identity:

$$L \cdot \frac{di}{dt} + R \cdot i = u$$

with i , u , the instantaneous values at the instant t , and allows, with its ideal filter characteristics, determination of the R and $X (= \omega L)$ components for the short circuit loop, independent of the setting of the tripping characteristics.

Each equation is solved by two different calculation methods which complement each other with regard to accuracy and speed. Additionally, adaptive algorithms are used which automatically match to the measured value conditions after fault inception (measured value shape, fault type, fault distance, etc., refer also to Section 4.2.3.4).

For calculation of a phase-to-phase loop values conforming to Figure 4.6 given in 4.2.2, for u the instantaneous values of phase-to-phase voltage, and for i the difference of the phase currents, are used, e.g. (Figure 4.6)

$$L \cdot \left(\frac{di_{L1}}{dt} - \frac{di_{L2}}{dt} \right) + R \cdot (i_{L1} - i_{L2}) = u_{L1-E} - u_{L2-E}$$

For calculation of a phase-to-earth loop (according Figure 4.7)

$$L \cdot \left(\frac{di_{L3}}{dt} - \frac{X_E}{X_L} \cdot \frac{di_E}{dt} \right) + R \cdot \left(i_{L3} - \frac{R_E}{R_L} i_{L2} \right) = u_{L3-E}$$

R and L are the required impedance components.

The calculated reactance $X = \omega \cdot L$ is the line reactance X_L up to the point of fault. This determines the distance to fault. The resistance value on the other hand contains, in addition to the conductor resistance R_L , the fault resistance R_F (refer to Figures 4.9 and 4.10).

Note: The factors R_E/R_L and X_E/X_L are purely mathematical values and have no physical meaning. They can be relatively easily calculated from the line data – without using complex forms – from the formulae:

$$\frac{R_E}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right)$$

and

$$\frac{X_E}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right)$$

refer to Section 6.3.3.2.

The separate setting facilities for the factors allow the possible phase difference between earth and conductor impedance to be taken into account, in addition to the relationship Z_E/Z_L . This difference can be of significant value in cable networks.

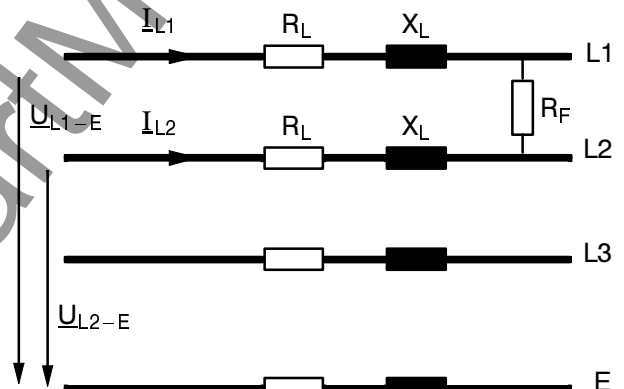


Figure 4.9 Phase-phase short circuit loop

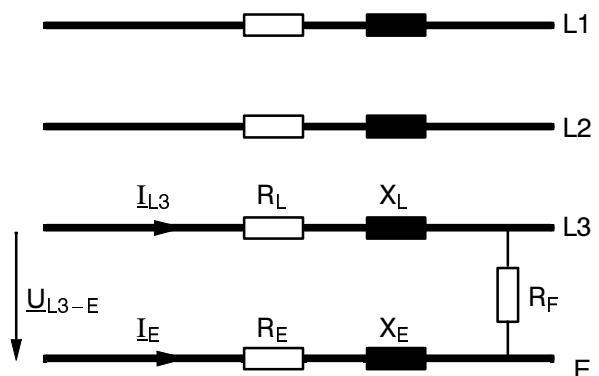


Figure 4.10 Phase-earth short circuit loop

4.2.3.2 Correction of measured values for parallel lines

When earth faults occur on double lines, the values used in the loop equation for calculation of the impedance are influenced by the earth impedance of **both** systems (Figure 4.11). If no correction is applied, this will lead to error in the calculated impedance value. A parallel line compensation can therefore be switched effective. This ensures that the earth current of the parallel line is taken into account in the line equation and thus compensates for the influence of the coupling. For this purpose, this earth current must be fed to the relay. The loop formula is then:

$$L \cdot \left(\frac{di_L}{dt} - \frac{X_E}{X_L} \cdot \frac{di_E}{dt} - \frac{X_M}{X_L} \cdot \frac{di_E'}{dt} \right) + R \cdot \left(i_L - \frac{R_E}{R_L} \cdot i_E - \frac{R_M}{R_L} \cdot i_E' \right) = U_{L-E}$$

where i_E' is the earth current in the parallel line and the ratios X_M/R_L and R_M/R_L are the line constants which result from the geometry of the double line and the characteristics of the earth path. These line constants are input to the relay – just as the other line data – when setting the relay.

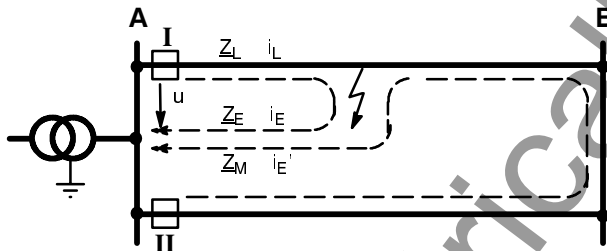


Figure 4.11 Earth fault on a double circuit line

Without parallel line compensation, the presence of the earth current of the parallel line leads, in most cases, to backwards movement of the balance point (underreach of distance measurement). In some cases – e.g. when the two lines terminate at different bus-bars and the earthed system star-point lies at one of the remote bars (at B in Figure 4.11) – overreach can result.

Parallel line compensation can be applied only to the line to be protected. Compensation cannot be carried out for the parallel line because this would cause very significant overreach. Compensation must not, therefore, be applied at location II in Figure 4.11.

For this reason, the relay incorporates an additional earth current balance, which carries out a transverse comparison of the earth currents in the two lines. Compensation is applied only to the line ends where the earth current of its associated line is not remarkably less than that of the parallel line. In the example in Figure 4.11, i_E is larger than i_E' . Compensation is therefore applied at location I, by including the factor $Z_M \cdot i_E$. Compensation is not applied at location II.

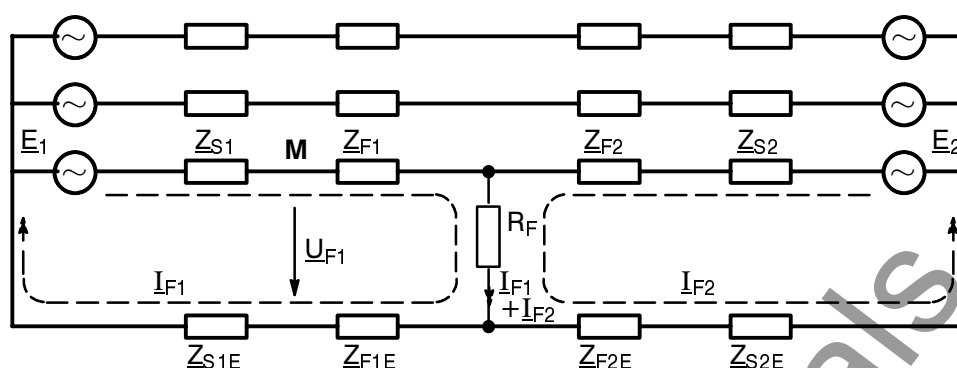
4.2.3.3 Correction of measured values for load current on double-end fed lines

When faults occur on loaded lines fed from both ends (Figure 4.12), the fault voltage U_{F1} is influenced not only by the source voltage E_1 but also by the source voltage E_2 , when both voltages are applied to the common earth resistance R_F . If not corrected, this will result in error in the calculated impedance, since the current component I_{F2} cannot be seen at the measuring point M. For long, heavily loaded lines, this will give a significant error (may be 50 % or more) in the X-component of the fault impedance (the determining factor for the distance calculation).

7SA513 provides a load compensation feature which corrects this measurement error. Correction for the R-component of the fault impedance is not possible; but the resultant error is not critical, since only the X-component is critical for distance measurement.

Load compensation is effective for single-phase faults. For single-phase earth faults, positive and zero phase sequence components of the symmetrical components are used in the compensation.

Load compensation can be switched on or off. Off-switching is useful, for example, during relay testing, in order to avoid influences caused by the test quantities.



Legend:

M	Measuring location	Z_{S1}, Z_{S2}	Source impedances
E_1, E_2	Source voltages (EMF)	Z_{S1E}, Z_{S2E}	Earth source impedances
U_{F1}	Fault voltage at the measuring location	Z_{F1}, Z_{F2}	Fault impedances
I_{F1}, I_{F2}	Part fault currents	Z_{F1E}, Z_{F2E}	Earth fault impedances
$I_{F1} + I_{F2}$	Total fault current	R_F	Common fault resistance

Figure 4.12 Fault currents and voltages on double-end fed lines

4.2.3.4 Calculation methods

To suppress higher frequency and non-periodic interference values, 80 measured values are taken per cycle for each required magnitude and reduced to 20 by averaging one from every four ("4-fold oversampling"). These 20 values per period are processed by three different methods, whereby each method employs two different algorithms, a differential and an integral in each case.

From the results, the possible measurement error is calculated. The reach values are automatically adjusted, so that a possible error is not allowed to lead to an overreach result.

A step-change detector synchronizes all calculations on commencement of fault. If a second fault occurs during evaluation of the first, calculation immediately restarts with the new measured quantities, so that evaluation always relates to the measured values of the actual current faults.

Firstly, the measured values for a half-period are processed by a simplified method. If this leads to plausible

results, a trip command is given immediately. This process is limited to simple faults – single-phase faults to earth, two-phase without earth contact and three-phase symmetrical short-circuits – since verification of the fault loop is not yet available at that moment (see Section 4.2.2). This allows an extremely short reaction time, as long as the quality of the measured values is adequate.

The second measurement method operates with measured values over three quarters of a period, with reduced reach. Here, too, a trip command can be given immediately, as soon as the results are considered to be plausible.

If measured values for a full period are available, these will be used. This procedure operates continuously after each quarter period, with the measured values of the previous period and remains valid under steady-state conditions as long as no new incidence of unstable measured values is detected by the step-change detector.

4.2.4 Directional determination

4.2.4.1 Directional characteristics

The direction of the flow of fault energy is determined in a similar way to distance measurement (Section 4.2.3). For the directional determination, however, sound phase and stored reference voltages are used.

The reference voltage for both a phase–earth loop and a phase–phase loop is always at right angles to the short circuit voltages (Figure 4.13). This is con-

sidered in the calculation of the directional vector. Table 4.6 shows the allocation of measured values for the calculation of distance and direction to the 6 possible fault loops.

The theoretical directional line is shown in Figure 4.14. In practice, the position of the directional characteristic is dependent upon the source impedance as well as the load current carried by the line immediately before fault inception.

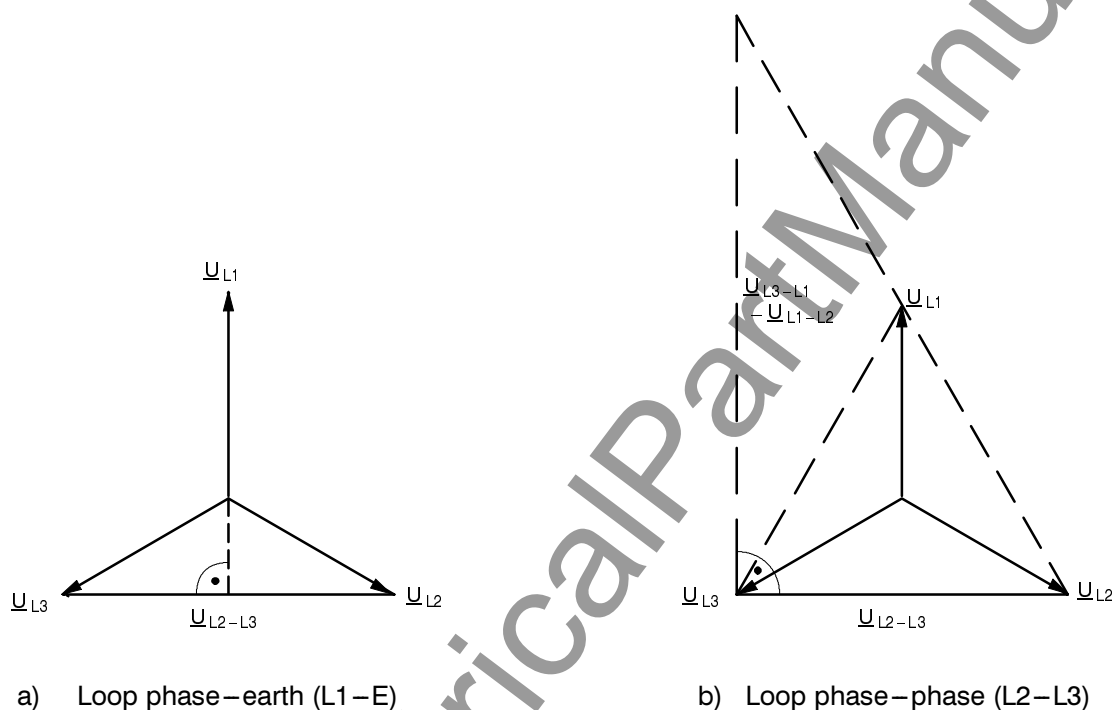


Figure 4.13 Reference voltages for directional determination

Measured loop	Measured current (distance)	Measured voltage (distance)	Measured current (direction)	Measured voltage (direction)
L1–E	$\underline{I}_{L1} - k_E \cdot \underline{I}_E$	$\underline{U}_{L1-E}$	$\underline{I}_{L1}$	$\underline{U}_{L2-L3}$
L2–E	$\underline{I}_{L2} - k_E \cdot \underline{I}_E$	$\underline{U}_{L2-E}$	$\underline{I}_{L2}$	$\underline{U}_{L3-L1}$
L3–E	$\underline{I}_{L3} - k_E \cdot \underline{I}_E$	$\underline{U}_{L3-E}$	$\underline{I}_{L3}$	$\underline{U}_{L1-L2}$
L1–L2	$\underline{I}_{L1} - \underline{I}_{L2}$	$\underline{U}_{L1-L2}$	$\underline{I}_{L1} - \underline{I}_{L2}$	$\underline{U}_{L2-L3} - \underline{U}_{L3-L1}$
L2–L3	$\underline{I}_{L2} - \underline{I}_{L3}$	$\underline{U}_{L2-L3}$	$\underline{I}_{L2} - \underline{I}_{L3}$	$\underline{U}_{L3-L1} - \underline{U}_{L1-L2}$
L3–L1	$\underline{I}_{L3} - \underline{I}_{L1}$	$\underline{U}_{L3-L1}$	$\underline{I}_{L3} - \underline{I}_{L1}$	$\underline{U}_{L1-L2} - \underline{U}_{L2-L3}$

Note: $k_E = \underline{Z}_E / \underline{Z}_L$

Table 4.6 Measured values for distance calculation and directional determination

Figure 4.15 shows the directional characteristic, taking into consideration the source impedance, without load current. Since the unfaulted voltage equals the generator voltage $\underline{E}$ and does not change after fault inception, the directional characteristic in the impedance diagram appears to be displaced by the source impedance $\underline{Z}_{S1} = \underline{E}_1 / \underline{I}_{SC1}$. If the location of the fault is F_1 (Figure 4.15a) the short circuit lies in the forward direction, the source impedance in the reverse direction. All fault locations right up to the relay location (c.t.s) are clearly recognized as "forwards" (Figure 4.15b). When the current flows in the opposite direction, the directional characteristic changes immediately (Figure 4.15c). Then the reversed current $\underline{I}_{SC2}$, which is determined by the source impedance $\underline{Z}_{S2} + \underline{Z}_L$, flows through the measuring point (current transformer).

4.2.4.2 Load influence on the directional characteristic

If load is carried by the line, then this results in a voltage drop at the source impedance (Figure 4.16a). Since, at the measuring point, the voltage $\underline{U}$ is mea-

sured, not generator voltage $\underline{E}$, the directional characteristic suffers a rotation by the load angle δ (Figures 4.16b and 4.16c). Therefore, the directional characteristic has a safety distance from the limits of the first quadrant in the R-X-diagram (Figure 4.14).

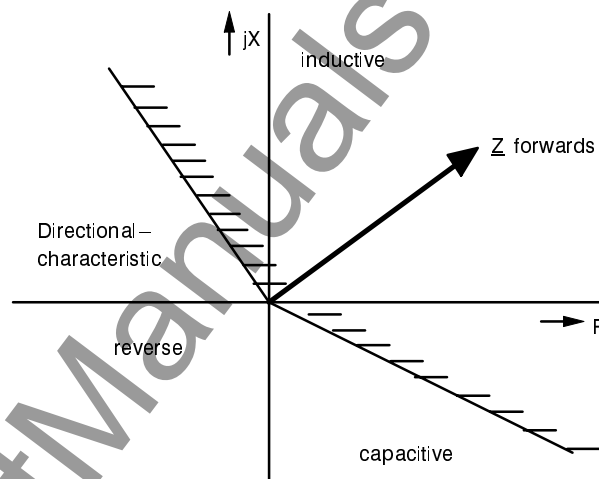


Figure 4.14 7SA513, directional characteristics

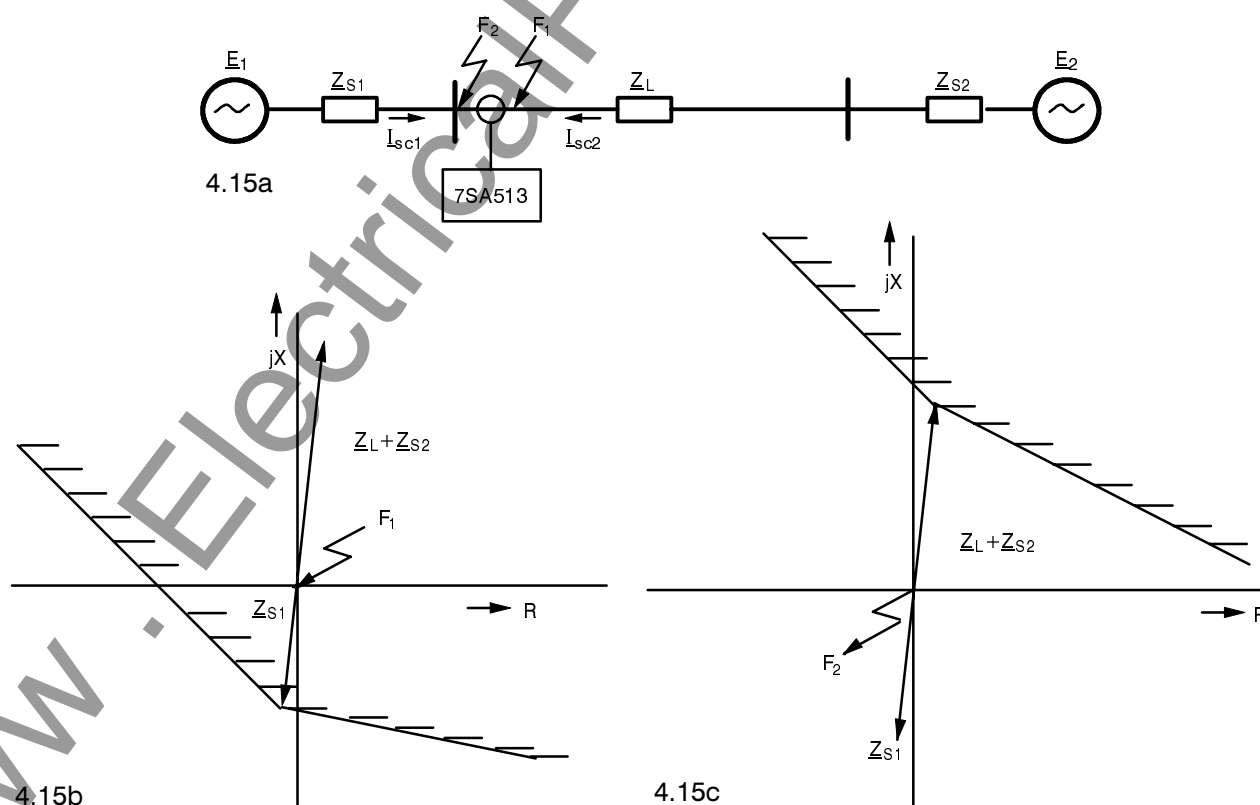
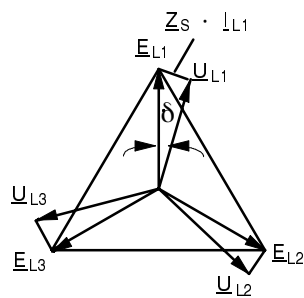
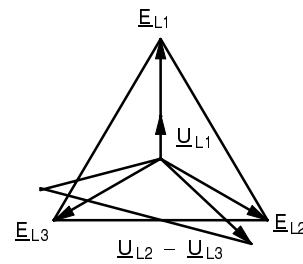


Figure 4.15 Directional characteristic with source impedance without load transport

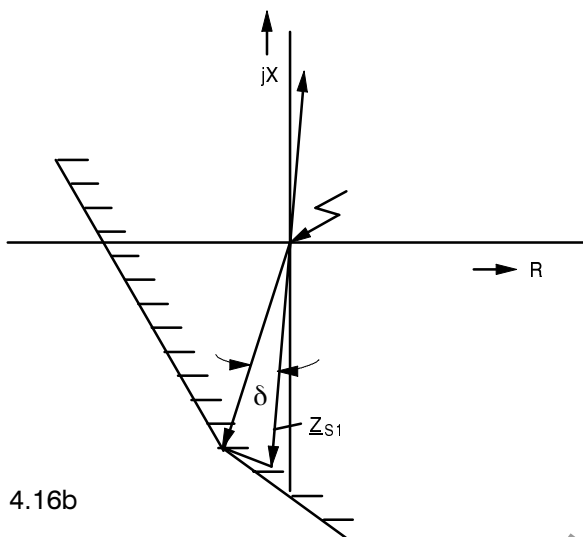


before fault inception

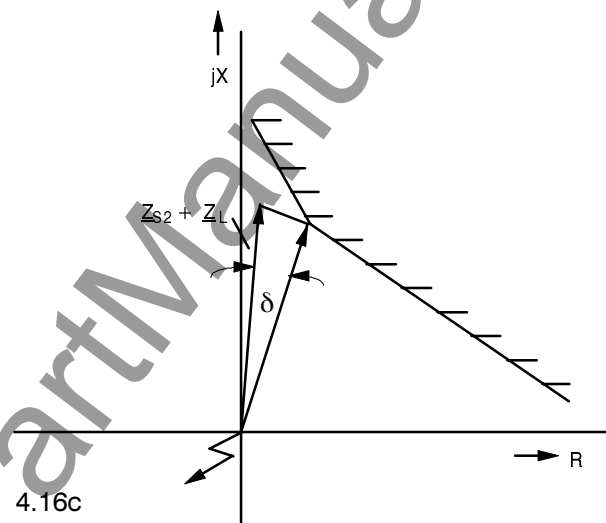


after fault inception

4.16a Voltage vector diagram for earth fault on loaded line



4.16b



4.16c

Figure 4.16 Directional characteristic with source impedance and load transport

4.2.4.3 Determination of direction on series compensated lines

The directional characteristics and their displacement by the source impedance are also valid for series compensated lines. For a short-circuit behind the local series capacitor, however, the short-circuit voltage reverses, as long as the spark-gap SG has not flashed over (Figure 4.17).

In that case, the wrong direction would be simulated to the distance protection. The use of stored voltages ensures that the directional response is correct, even in this case (see Figure 4.18).

Since the voltage which has been present before fault inception is used for determination of direction, the vertices of the directional characteristics are so displaced with relation to the source impedance and load conditions before fault inception that the capacitor reactance – which is always smaller than the

source reactance – does not give an apparent reversal of direction (Figure 4.18b).

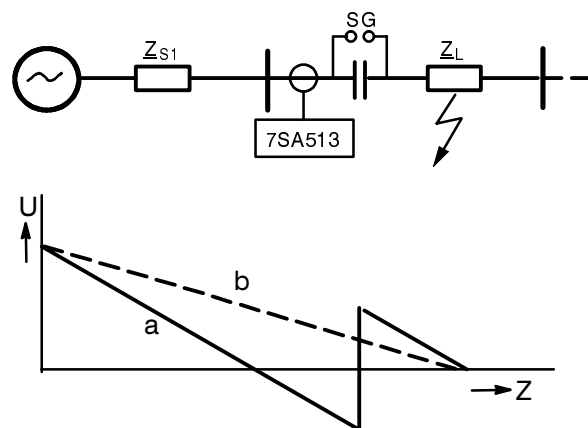


Figure 4.17 Voltage distribution for fault behind a series capacitor

- a) without } spark gap
b) with } flash-over

If the fault is in front – upstream – of the capacitor, that is, in the reverse direction as seen by the relay (current transformer location), then the vertices of the directional characteristics are displaced in the other direction (Figure 4.18c). Thus a correct evaluation of direction is also guaranteed in this case.

4.2.4.4 Calculation methods

Just as for impedance calculation (Section 4.2.3.4) a number of measurement processes are used for directional determination, from which the relay selects the optimum.

Measurement is also synchronized to fault inception in this case. The protection itself decides whether to use stored, unstored or a mixture of these voltages.

As a matter of principle, the actual quadrature voltages are used. When these are not sufficient – with multiple faults, especially three-phase faults – stored voltages are used. The memory time is variable. It starts with two a.c. periods, but it can auto-

matically extend up to 20 a.c. periods when there has been no earlier trip decision.

If a new fault occurs, directional determination immediately switches to the new measured value conditions. The actual quadrature voltage is used provided it is adequate in magnitude. Otherwise a mixture voltage is used.

When, during a fault, no more suitable voltage is present at all, the last valid directional decision is frozen until a sufficient voltage has returned or the protection has dropped off. But when all voltages had been absent already at the instant of fault inception, then the directional decision is defined as "forwards" (switching onto a dead fault).

Since the phase relationship of the stored voltages is frequency dependant, the frequency is measured and fed into the calculation.

For series compensator calculations always the memory voltage is used. After the maximum memory time has elapsed, the direction decision is maintained until drop-off of fault detection.

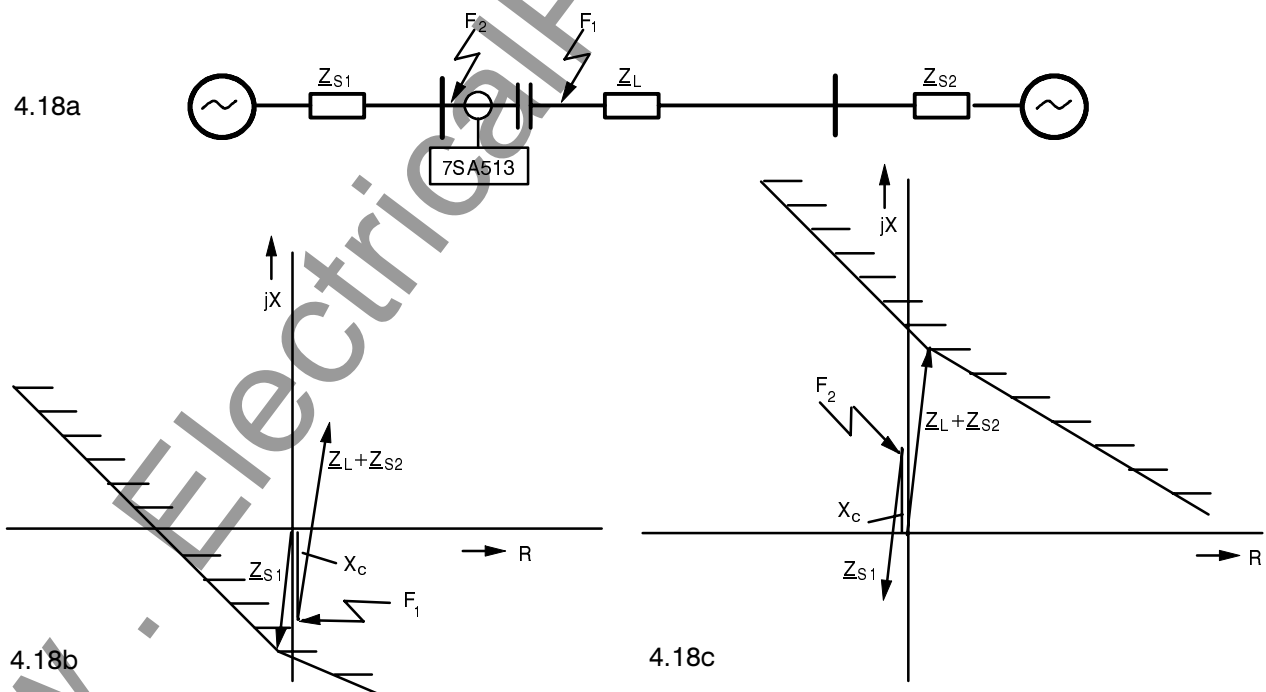


Figure 4.18 Directional characteristic at a series compensated line

4.2.5 Tripping characteristics

The tripping zones of the line protection relay 7SA513 have a polygonal characteristic. They consist of the directional lines in accordance with Section 4.2.4 and, in each case, a reactance and resistance limit. Reactance intersection X and resistance intersection R can be set separately and independently from each other. In addition, the R–intersections can be set separately for phase–phase faults and phase–earth faults (RE) so that a higher resistance margin can be obtained for earth faults, if required.

As shown in Figure 4.19 the relay possesses the following characteristics which can be set independently:

- 1st zone (instantaneous zone Z1), with the setting parameters:

X1 Reactance = reach,
 R1 Resistance phase–phase
 R1E Resistance phase–earth with earth fault detection,
 T1 T1 = 0 or delayed, if required, separate time settings for single-phase and multi-phase faults.

- 2nd zone (delayed back-up zone Z2) with the setting parameters:

X2 Reactance = reach,
 R2 Resistance phase–phase,
 R2E Resistance phase–earth with earth fault detection,
 T2 Delay (separate settings for single-phase and multi-phase faults).

- 3rd zone (delayed back-up zone Z3) with the setting parameters:

X3 Reactance = reach,
 R3 Resistance phase–phase,
 R3E Resistance phase–earth with earth fault detection,
 T3 Delay.

Besides these independent zones, two controlled zones are available which can be activated by logical conditions:

- Overreach zone Z1B for zone extension, e.g. for teleprotection, auto-reclosure or controlled via binary input, with the setting parameters:

X1B Reactance = reach,
 R1B Resistance phase–phase,
 R1BE Resistance phase–earth with earth fault detection,
 T1B T1B = 0 or delayed, if required, separate time settings for single-phase and multi-phase faults.
 A further special delay time TBLK DELAY allows very fine adjustment (1 ms steps) of this zone delay which can be used for time coordination when using blocking schemes.

- Overreach zone Z1L, activated e.g. by multi-shot AR (so-called DAR cycles) or via binary input, with the setting parameters:

X1L Reactance = reach,
 R1L Resistance phase–phase,
 R1LE Resistance phase–earth with earth fault detection,
 T1L T1L = 0 or delayed, if required.

All zones can be set to operate either in forward direction, or in reverse direction or non-directional.

Figure 4.19 shows the tripping characteristics. For an easier clarification, separate R–setting for earth faults is shown for 1st zone only. Zone Z1L is omitted for the same reason.

Additionally, a directional and a non-directional final stage are available. Characteristic and reach of these are determined by the selected fault detection option (refer to Section 4.2.1). For models with impedance fault detection (4.2.1.2), fault detection zone ZA is provided, as shown in Figure 4.4. The reaches of the other types of fault detection are dependent on the infeed characteristics (e.g. system impedance ratio), so that they have no fixed shape in the R–X–plane.

Fault detection resets approximately 30 ms after disappearance of the pick-up criteria. When a trip command has been issued, fault detection resets after disappearance of current flow, i.e. when the current has fallen below the minimum current threshold according to address 1140 I–RESID (refer to Section 6.3.3.4).

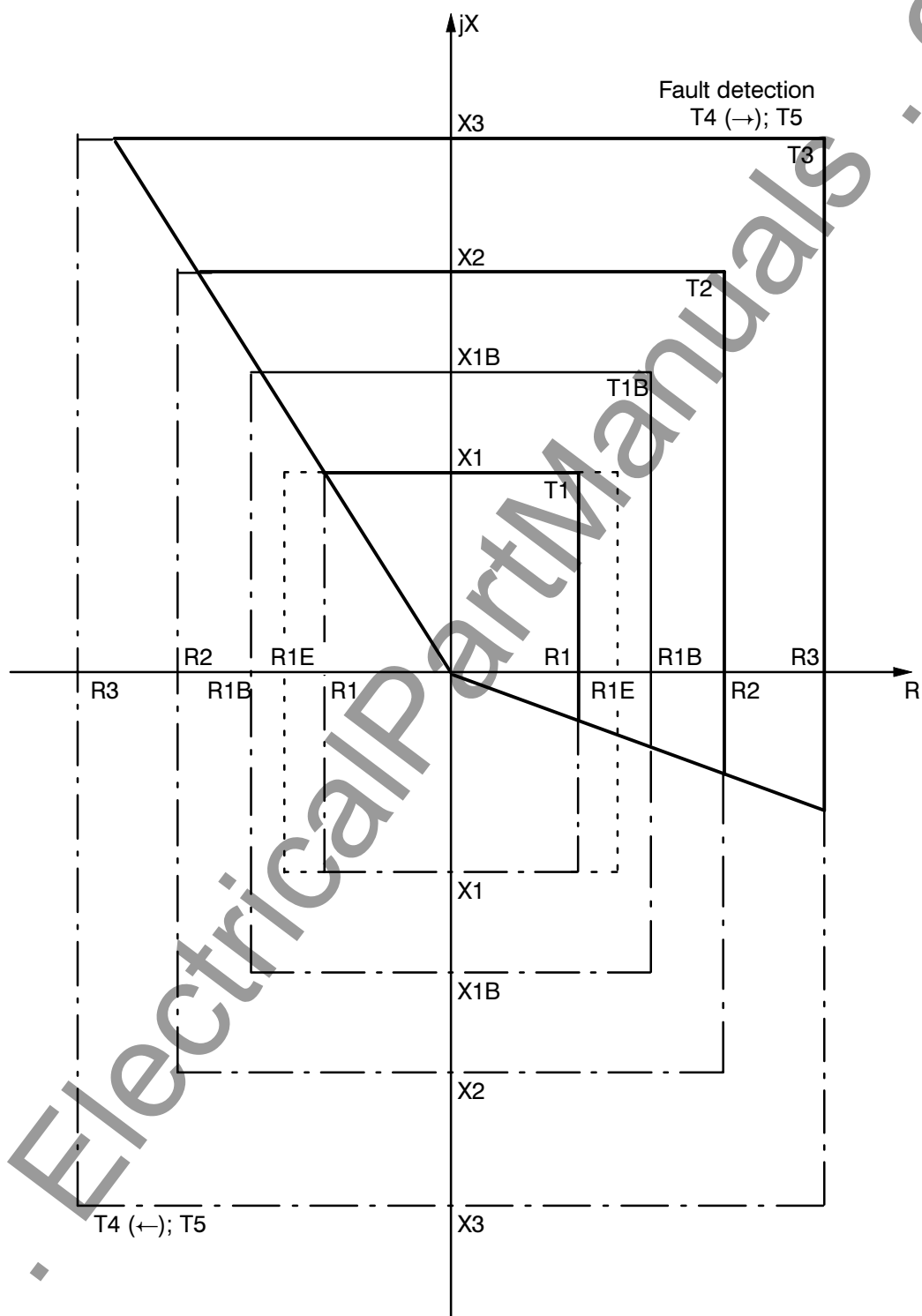


Figure 4.19 Tripping characteristics

4.2.6 Tripping logic

When the relay has detected a fault (see Section 4.2.1), the delay times are started. The impedances of the valid fault loops, according to Section 4.2.2, are compared with the threshold of the set zones. Tripping occurs when the impedance is within a zone whose corresponding time stage has expired and the fault direction complies with the direction as set for that zone. For zone Z1 (and Z1B) the delay time usually equals zero, i.e. tripping occurs as soon as it has been confirmed that the fault lies within the zone.

In stages Z1, Z1B, and if desired in stage Z2, single-phase faults can be tripped single-pole. This is always meaningful when the network practice requires single-pole auto-reclosure. Multi-phase faults will result in three-pole clearance. Possibility exists to trip a two-phase fault without earth connection single-pole. If the AR function is not ready to carry out an auto-reclosure cycle (see Section 4.10), three-pole clearances will always result. If single-pole auto-reclosure is not available, each clearance will equally be three-pole. If an external AR – relay is used, the tripping command can also be coupled, three-pole, via a binary input.

Moreover, external binary inputs can be used to release the overreach zones Z1B and/or Z1L.

Figure 4.20 illustrates the block diagram of the tripping logic for one measuring loop.

The integrated switch-onto-fault logic (Section 4.2.7) can be set to activate either zone Z1B (normally directional) or fault detection (non-directional and non-delayed). Figure 4.20 shows both possibilities.

For the issue of tripping commands to the circuit breaker, appropriately powerful tripping relays are provided, each with two closing contacts. The tripping relays are automatically reset, when the fault detector resets and the fault current has been switched off (reset of the adjustable minimum current monitor). Nevertheless, a minimum trip command duration can be set. The tripping circuit must be interrupted by an auxiliary contact on the circuit breaker.

4.2.7 Switch-onto-fault protection

If one switches a dead but short circuited line onto a live bus-bar it is essential, in general, that this line be immediately disconnected. Using distance protection alone, however, disconnection for faults close to either line end is not always possible: for a three-phase fault at the location of a relay an accurate measured voltage for correct directional determination will not necessarily be available; when the voltage transformers are connected on the line side, even stored voltage values are not available. If the fault is at the opposite line end, distance protection will operate only after a time delay.

For close-up faults the line protection will decide on "forwards" after connection of the line when the voltage signal is missing (refer also to Section 4.2.4.4). Thus, instantaneous trip by the first zone is possible.

To be sure of an immediate disconnection under any condition and especially when switching onto bolted fault, the manual close command from the discrepancy switch can be repeated, via a binary input to cause an immediate trip signal when a fault is detected (Figure 4.21). The fault is cleared either with pick-up of overreaching zone Z1B (directional), as illustrated in Figure 4.21, or pick-up of overreaching zone Z1B (non-directional²⁾, or pick-up of the fault detector (selectable) without delay.

The integrated switch-onto-fault logic of 7SA513 automatically distinguishes between an external control command and an automatic reclose command by means of the internal auto-reclose circuits, so that the binary input "manual close" can be connected directly to the control circuit of the closing coil of the circuit breaker. If, however, external closing commands are possible, which shall not operate the switch-onto-fault protection (e.g. external auto-reclose devices), the binary input "manual close" must be triggered by a separate auxiliary contact on the discrepancy switch.

The overreaching zone Z1B or the fault detection zone of the distance protection can equally be released during each closing operation of the circuit breaker, i.e. also during automatic reclosure. The integrated line energization recognition (refer to Section 4.17) can be used for this purpose.

²⁾ from firmware version V3.3 or higher

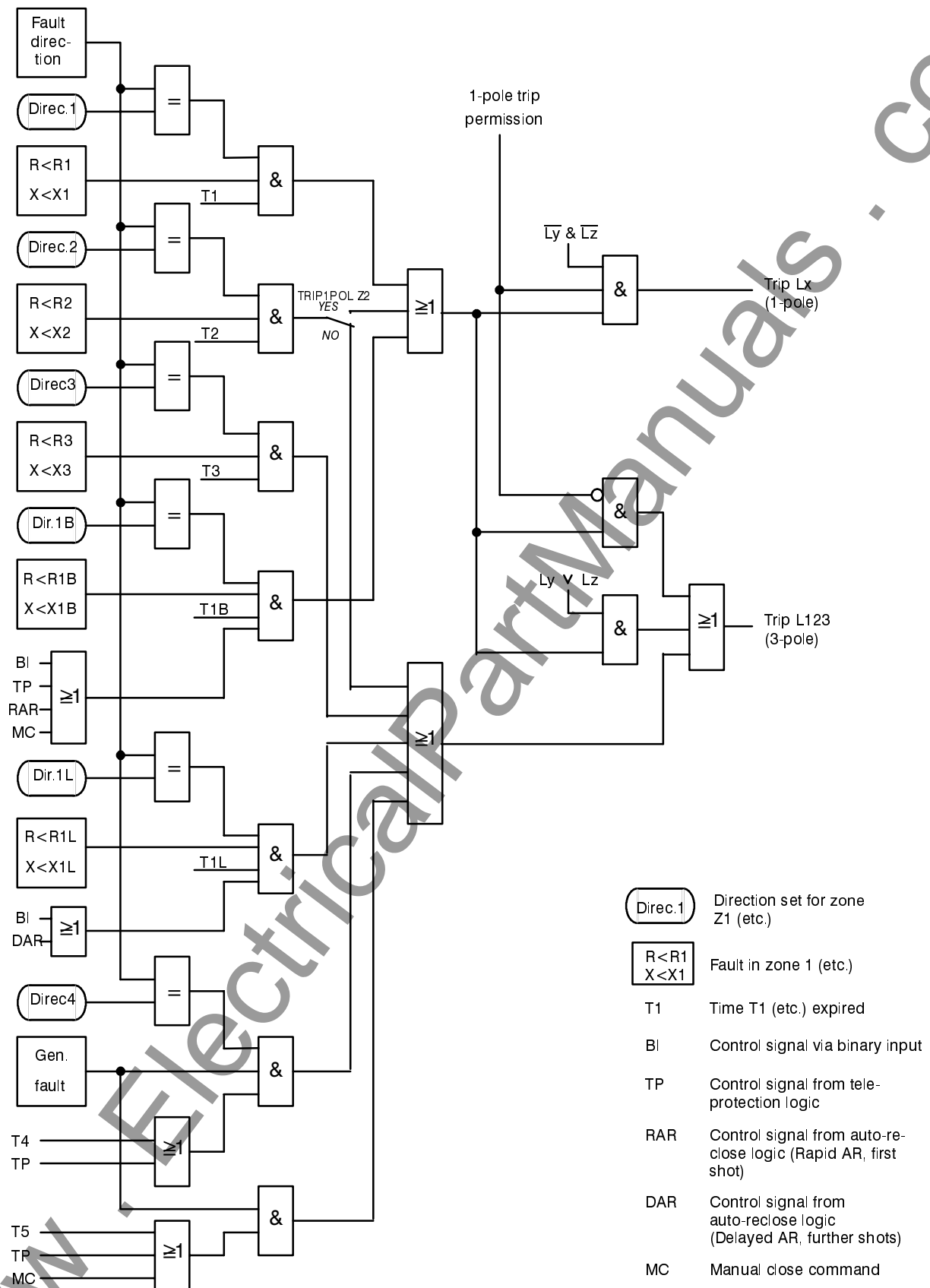


Figure 4.20 Schematic block diagram of the tripping logic of the distance protection for one phase

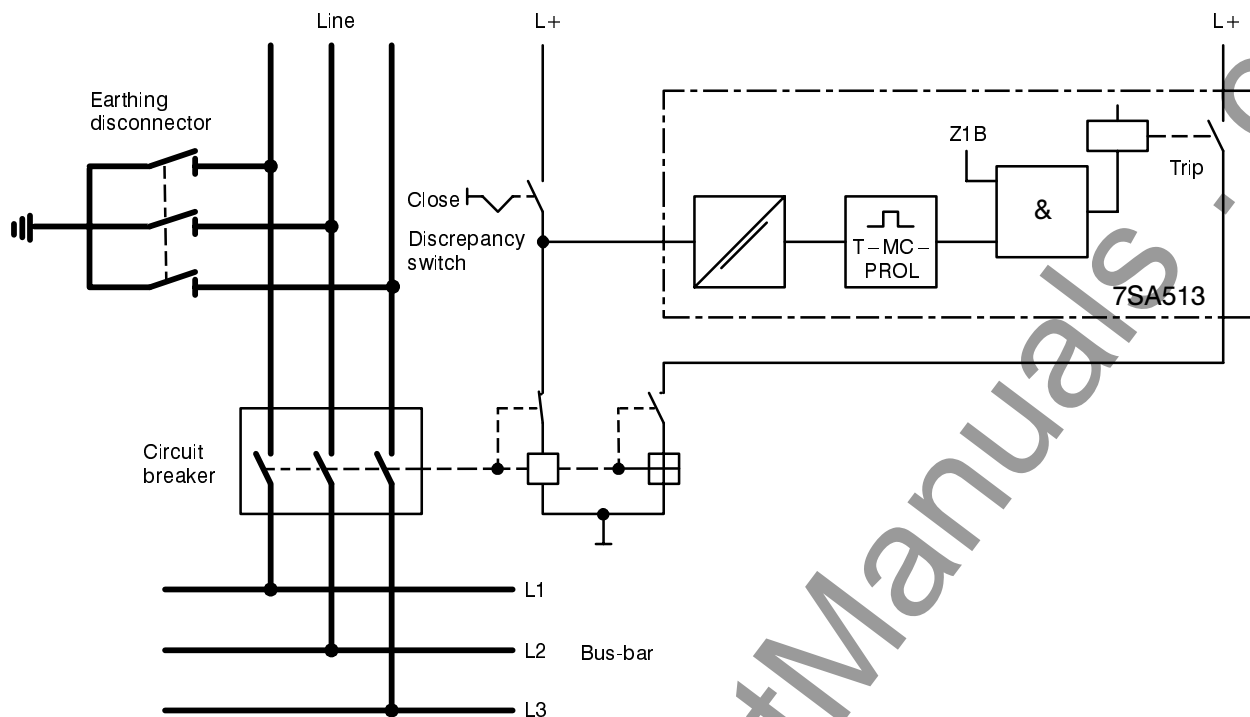


Figure 4.21 Functional diagram of the switch-onto-fault protection

4.2.8 Emergency operation

7SA513 provides an emergency overcurrent time protection. This feature may, for example, be useful when the measured voltages are absent since the overcurrent time protection needs no voltages.

The overcurrent function may come automatically into operation when the measured voltage is not available, e.g. during short-circuit or an interruption in the VT secondary circuits (emergency operation).

Under this condition, selectivity can only be achieved by time delay, just as for all other types of overcurrent protection scheme.

As soon as the device recognizes that the measured voltages have reappeared, the system switches back to distance protection.

Further information is given in Section 4.8 Emergency overcurrent time protection.

4.3 Power swing supplement (with impedance fault detection)

After dynamic occurrences, such as load fluctuations, short circuits, auto-reclosures or switching operations, the generators may have to adjust to the new load conditions in the network. The distance protection registers the high equalizing currents and – in particular in the electrical centre – reduced voltages during power swings (Figure 4.22). Small voltages with simultaneously high currents simulate apparently small impedances, which can lead to tripping. In extensive networks which carry high loads, even the stability of the energy transfer can be endangered by such power swings.

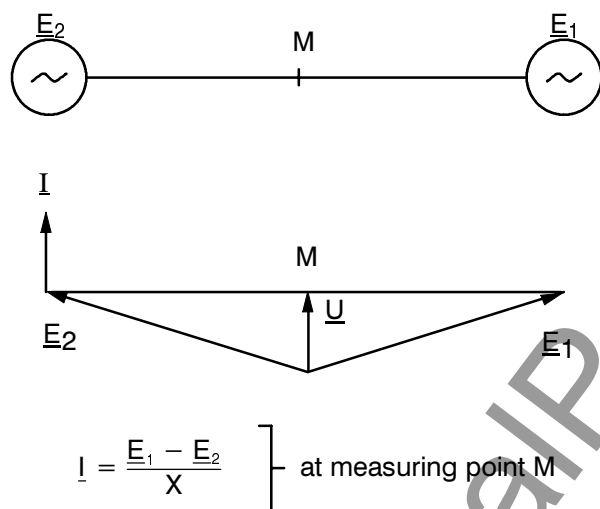


Figure 4.22 Power swing

In order to prevent uncontrolled tripping, the distance protection devices are provided with power swing blocking devices. In certain strategic locations within the network, out-of-step tripping devices are installed, so that the network can be split into part networks in the case of loss of synchronism due to strong (unstable) power swings.

The line protection relay 7SA513 is equipped with a powerful power swing supplementary function, which prevents tripping by the distance protection during power swings (power swing blocking), but also allows tripping at predetermined locations in the case of unstable power swings (out-of-step tripping). This power swing function operates only in conjunction with the polygonal impedance fault detection.

4.3.1 Detection of power swings

Power swings are three-phase symmetrical occurrences. The first prerequisite is therefore the absence of any earth fault and the symmetry of the measured impedances. As long as the earth fault detection has picked up (see Section 4.2.1.1), power swings are not detected. Power swings are equally not detected when $I_2/I_1 > 0.25$, (negative sequence current referred to positive sequence current). Asymmetrical short circuits (i.e. all one-phase and two-phase short circuits) can therefore not result in pick-up of the power swing blocking function. Even when a power swing has been recognized, the following asymmetrical short circuit currents lead to fast release of the power swing blocking function and render possible tripping by the distance protection.

In order to detect a power swing, the rate of change of the impedance vector is measured. The measurement commences when the impedance vector moves into the power swing polygon PPOL (see Figure 4.23). In the case of a three-phase short-circuit (1), the impedance vector immediately moves into the fault detection polygon APOL. However, in the case of a power swing, the apparent impedance vector first moves into the power swing polygon PPOL and later into the fault detection polygon APOL (2). It is also possible for the impedance vector to enter and leave the power swing polygon without moving into the fault detection polygon (3). If the impedance vector moves through the whole area represented by the power swing polygon, then parts of the network, seen from the protective device, have become asynchronous (4): the transfer of energy has become unstable.

When the rate of change of the impedance vector is smaller than 5Ω in 35 ms, power swing is recognized. Additionally, the course of the impedance vector is scanned. Power swing can be assumed as long as the vector passes steadily. The first method detects power swings with small slip frequencies whereas the latter allows to recognize power swings with higher frequencies up to approximately 7 Hz.

The power swing detection remains effective during a single-pole auto-reclose cycle. An auto-reclosure monitor detects the single-pole interruption and prevents from deactivation of the power swing detector. The plausibility of the distribution of voltages and currents is monitored. Only when this plausibility is not fulfilled, an evolving fault has occurred, and the distance protection is released.

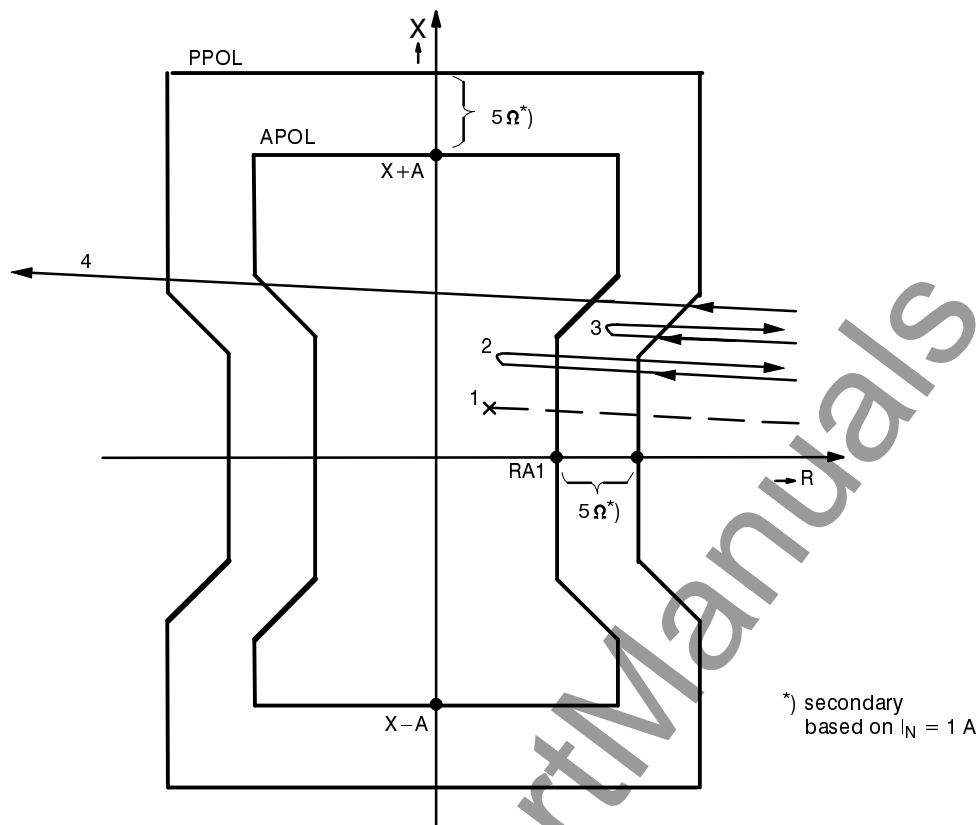


Figure 4.23 Pick-up characteristic for the detection of power swings

4.3.2 Power swing blocking

When the criteria for power swing detection have been met, then the following reactions are possible (settable) for power swing blocking:

- Blocking of the first stage only:
The first stage (Z1 and Z1B) cannot trip. Faults from the second stage onwards (T2 expired) are tripped after their delay time.
- Blocking of the first and second stage:
The first and second stage (Z1 and Z2) cannot trip.
- Blocking of all stages but the first:
Only the first stage (Z1 or Z1B) is available. Higher stages are not available.
- Blocking of all stages:
The distance protection is blocked with all of its stages.

The selected reaction remains effective until the measured impedance vector leaves the power swing polygon PPOL or when, due to earth fault pick-up or asymmetry, the power swing criteria are no longer met.

4.3.3 Out-of-step tripping

When the criteria for power swing detection are met, and when out-of-step tripping is selected, then the distance protection with all of its stages is blocked, in order to prevent tripping by the distance protection.

When the impedance vector leaves the power swing polygon, the vector is checked by its R-component. If the R-component still has the same sign as at the point of entry, then the power swing is in the process of stabilizing. Otherwise the vector has passed through the polygon (loss of synchronism, case (4) in Figure 4.23). The device issues a tripping command of adjustable duration. The out-of-step trip is announced.

4.4 Universal teleprotection interface for distance protection

Short circuits on the protected line which lie beyond the first distance zone can be selectively cleared by distance protection only after a delay time. For line lengths which are shorter than the shortest reasonable distance setting, short circuits can equally not be selectively cleared instantaneously.

Thus, to achieve instantaneous clearance of all faults for 100 % of line length, 7SA513 can exchange and process information from the opposite end station by the use of an incorporated teleprotection interface. For this purpose, the relay has transmitter output and receiver input.

Distinction is made between permissive underreach transfer trip modes (PUTT) and permissive overreach (comparison) transfer trip modes (POTT).

With 7SA513, an underreach transfer mode and an overreach transfer mode can be used, both at the same time, independently via different carrier links. The underreach transfer operates with the first zone Z1, the overreach transfer operates with the logically independent zone Z1B or with the fault detection zone.

For underreach transfer tripping, the relay is set with normal discrimination steps. If a tripping command is given in the first zone, this is transmitted to the other line end through a teleprotection system. There, the received signal will cause intertripping, so long as the relay at that end has picked up or has recognized a fault in its overreaching zone. 7SA513 permits:

- underreach transfer trip via fault detection zone (FD non-directional),
- underreach transfer trip via overreach zone Z1B acceleration (directional).

For the comparison (overreach) transfer modes the relay will already incorporate a fast overreach zone. This can, however, give a trip signal only when a fault is also detected at the other line end in an overreach zone. Either a release or a blocking signal can be transmitted.

Distinction is made between

Release modes:

- Permissive overreach transfer with overreach zone Z1B,
- Directional comparison transfer with fault detection,
- Zone Z1B comparison unblocking mode,
- Directional comparison unblocking mode (with fault detection).

Blocking mode:

- Blocking of the overreach zone Z1B.

Pilot wire modes:

- Zone Z1B overreach transfer trip via pilot,
- Reverse interlocking.

The comparison via pilot wire is particularly useful for short coupling lines. Here the information exchange between the line ends can be made via one pilot wire pair or control cores, using direct current. The reverse interlocking scheme works with d.c. control signals, too.

For the other teleprotection modes, a voice frequency channel is most frequently used (e.g. Siemens transmission device SWT 500 F6 with frequency shift modulation). The voice frequency is transmitted via telephone cable, power line carrier, or radio transmission.

If a fault occurs in the receiving device or in the transmission link, the receiver logic of the universal teleprotection interface can be blocked by the input of a binary signal without affecting the normal distance protection grading. Measurement range control (release of zone Z1B) can then be transferred to the auto-reclose function (see also Section 4.10.1) or the auto-reclose function can be blocked.

Since, in 7SA513, all zones operate independently, it is also possible to give rapid trip in Z1 without receipt of a release signal, or with a blocking signal present, in the comparison modes. If instantaneous trip is not desired, e.g. for extremely short lines for reasons of selectivity then zone Z1 must be delayed by time stage T1.

When emergency overcurrent protection is operating the universal teleprotection interface function is out of operation.

4.4.1 Permissive underreach transfer trip with fault detection

With a fault in zone Z1, an intertrip signal is transmitted to the opposite end of the line. This can be delayed by T_d . The signal received there will result in a trip, as long as the relevant protective device has picked up (fault detection FD). The duration of the transmit signal can be increased by T_s (programmable) in order to match with different pick-up times of the relays at the line ends. The duration of the receive signal can be increased by T_r .

Figure 4.24 shows a simplified block scheme of this function.

In this operating mode, the overreach zone Z1B is of no importance for the universal teleprotection interface, but it can be initiated by the auto-reclosure function (see Section 4.10.1).

4.4.2 Zone acceleration with Z1B

Just as for a permissive underreach transfer trip with fault detection, the tripping signal of distance zone Z1 will transmit an intertrip signal to the opposite line end (if desired, delayed by T_d). There, a trip command is given when the fault has been detected in zone Z1B in the set direction. The difference between permissive underreach trip with fault detection and zone Z1B acceleration is that at the receiving end the tripping area is defined by the extended zone Z1B directional. The duration of the transmit signal can be increased by T_s , the duration of the receive signal can be increased by T_r .

Figure 4.25 shows a simplified block scheme of this function.

If the transmission link is faulty, the overreach zone Z1B can be initiated by the auto-reclosure function (see Section 4.10.1).

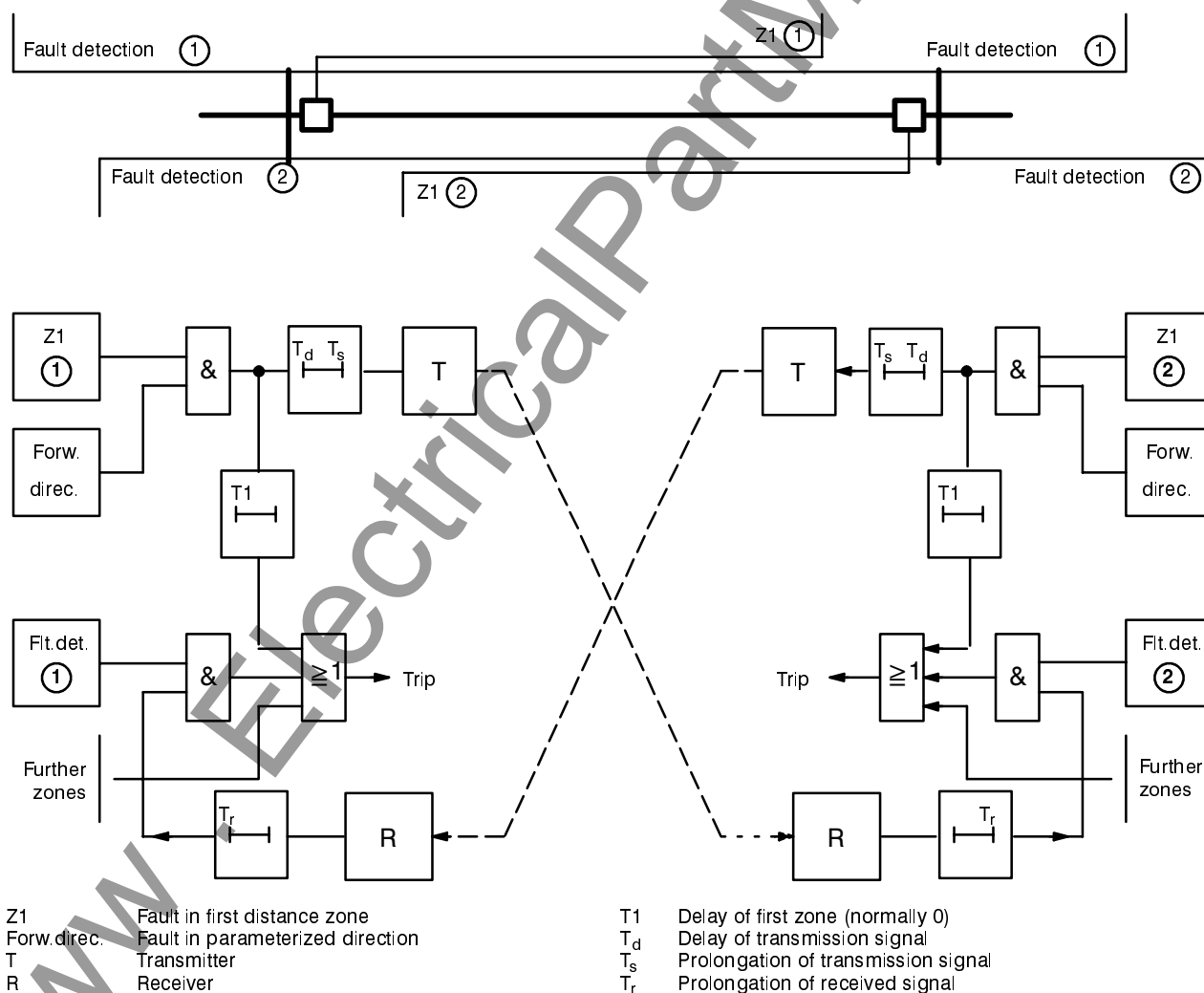


Figure 4.24 Permissive underreach transfer trip (FD acceleration) – block scheme

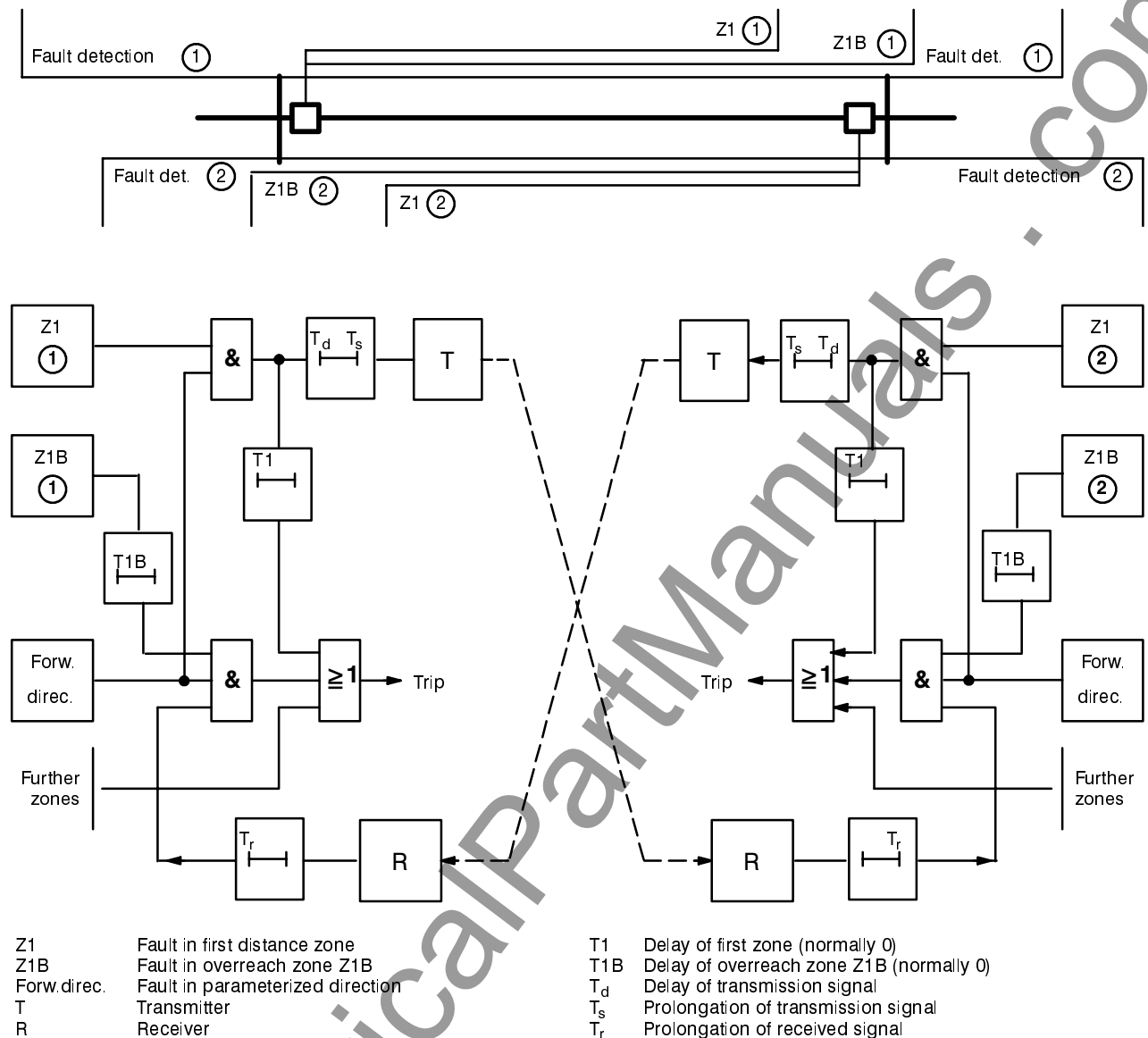


Figure 4.25 Zone acceleration Z1B – block scheme

4.4.3 Permissive overreach transfer trip with Z1B

The permissive overreach transfer trip function uses a permissive release principle. Zone Z1B is of significance as it is set to include the next station and beyond. This method of signal comparison can also be used for extremely short line lengths, when a setting to 85 % of the line length and therefore selective immediate disconnection is not possible. In the latter case, Zone Z1 has to be delayed by T1 because it will operate independent of receipt of a signal.

Figure 4.26 shows a simplified block scheme.

If the distance protection detects a fault within the overreach zone Z1B, a release signal is sent to the opposite line end (if desired, delayed by T_d). If a release signal is also received from the opposite end of the line, the tripping command is transmitted to the command relay. Prerequisite for immediate disconnection is therefore the detection of a fault within zone Z1B from both line ends in the parameterized direction.

The duration of the transmit signal can be increased by T_s (programmable), but this prolongation is effective only after the protection has issued a trip command. This ensures the remote line end to be released also in case the local line end is tripped very quickly by the independent first distance zone.

For the other zones (Z1, Z2, Z3), tripping occurs without release from the opposite line end, so that the distance protection works normally even without transmission.

If the teleprotection channel is monitored and a transmission fault is detected, the receiving end logic can be made ineffective by the input of a binary signal. Distance protection then operates with normal grading (rapid trip in Z1). Overreach zone Z1B

can then be initiated from the AR function (see Section 4.10.1).

False signals which may have been caused by transient oscillations after the interruption of external faults or by reversal of direction of flow after interruption of faults on parallel lines, are rendered harmless by a transient blocking function (refer Section 4.4.11).

For lines which are fed from one line end only, no release signal can be formed at the unfed line end, since no pick-up can occur there. In order to achieve even in this case immediate tripping over 100 % of the line length, an additional echo function is available (see Section 4.4.10).

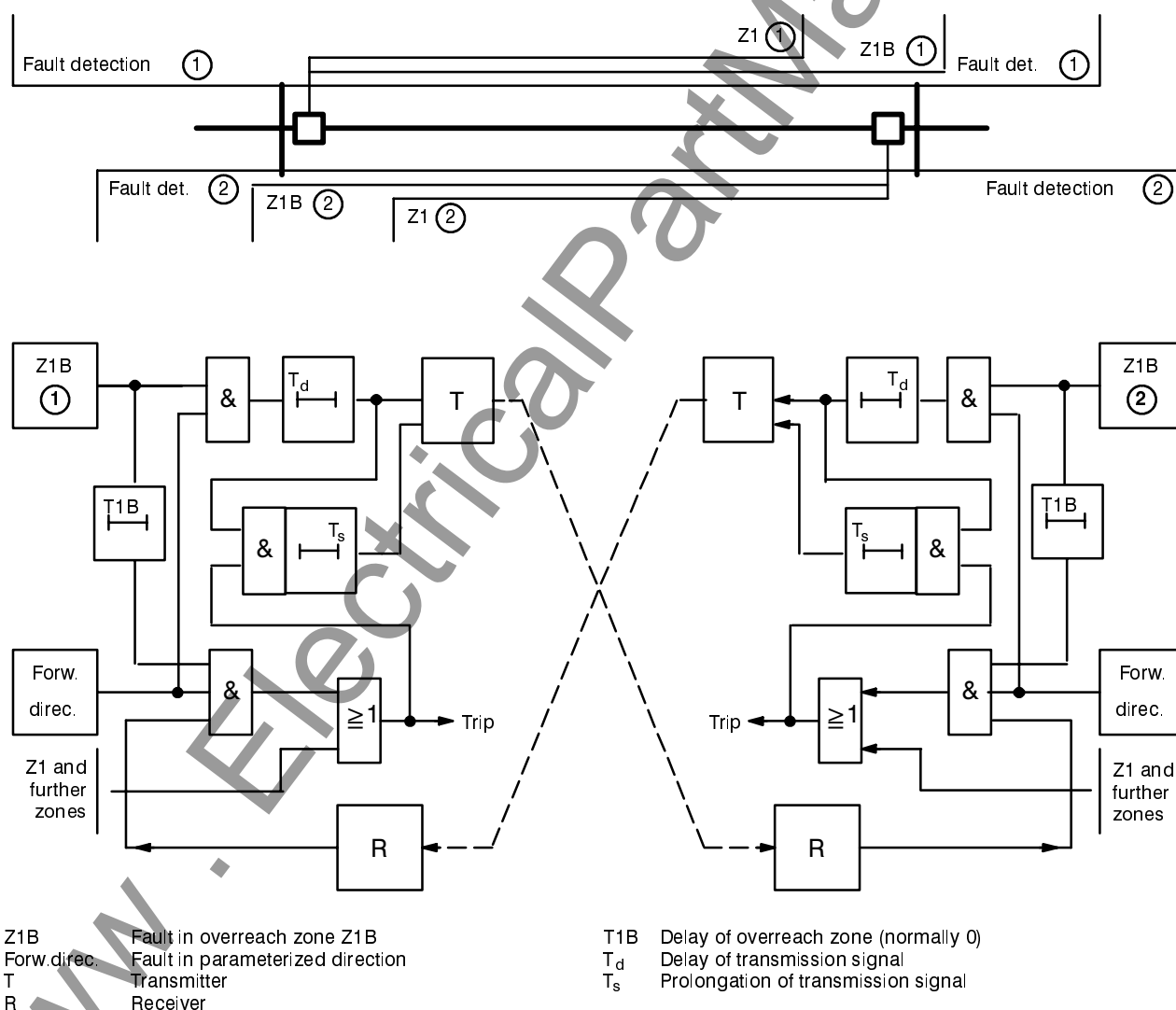


Figure 4.26 Permissive overreach transfer trip (release of Z1B) – block scheme

4.4.4 Directional comparison (fault detection zone release)

Directional comparison also performs a transfer release function.

Figure 4.27 shows a simplified block scheme.

If the relay detects a fault in the line direction it sends (after a settable time if desired) a release signal to the relay at the opposite line end and, when a corresponding confirmation signal is received, issues the tripping signal. The distance grading operates independently of the directional comparison.

The duration of the transmit signal can be increased by T_s (programmable), but this prolongation is effective only after the protection has issued a trip command. This ensures the remote line end to be released even in case the local line end is tripped very quickly by the independent first distance zone.

If the transmission channel is monitored and a fault is detected, this will only block the directional comparison function, via the input channel "Reception faulty".

False signals which may have been caused by transient oscillations after the interruption of external faults or by reversal of direction of flow after interruption of faults on parallel lines, are rendered harmless by a transient blocking function (refer Section 4.4.11).

For lines which are fed from one line end only, no release signal can be formed at the unfed line end, since no pick-up can occur there. In order to achieve even in this case immediate tripping over 100 % of the line length, an additional echo function is available (see Section 4.4.10).

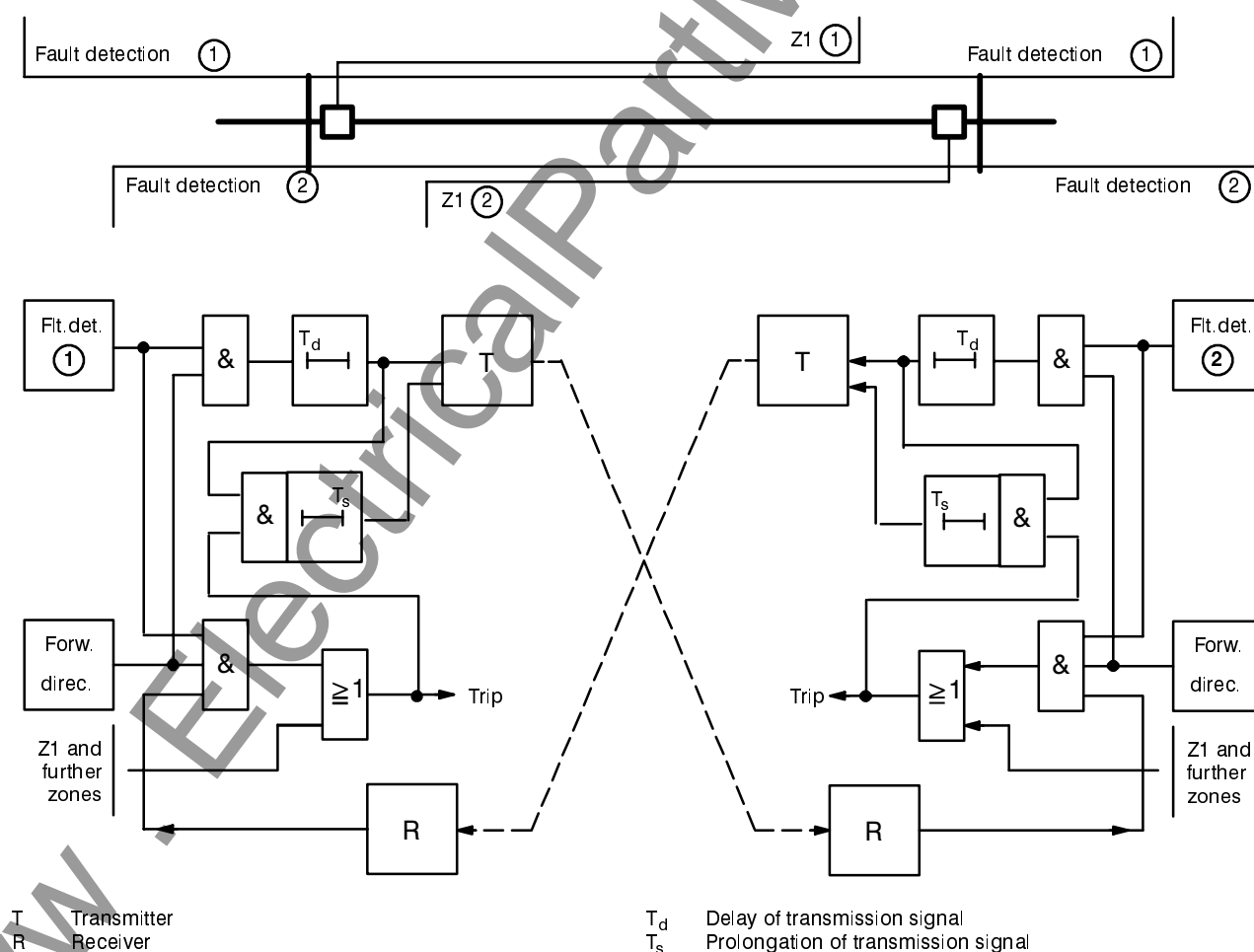


Figure 4.27 Directional comparison – block scheme

4.4.5 Unblocking mode with Z1B

The unblock mode is a releasing procedure. Zone Z1B is set to reach beyond the next station. The difference from permissive overreach transfer trip with Z1B (Section 4.4.3) is that a trip command is also possible when no release signal is received from the opposite end. It is therefore principally used for long lines, when the signal has to be transmitted over the protected line using a PLC system and the damping of the transmitted signal can be so large at the point of fault that its receipt from the other line end cannot be unconditionally guaranteed. For this particular case, a special unblocking logic comes into operation.

For signal transmission one requires two signal frequencies which are shifted over from the transmitter output in 7SA513. If the PLC system incorporates channel monitoring (e.g. Siemens voice frequency unit SWT 500 F6) then the monitoring frequency f_0 is switched to a working frequency. If the relay detects a fault within the overreach zone Z1B, it initiates transmission of the working frequency f_0 (unblocking frequency, can be delayed by T_d). Under normal conditions or with a fault outside the Z1B zone, or in the direction opposite to that set, the monitoring frequency f_0 is transmitted.

Figure 4.28 shows a simplified block scheme of this function.

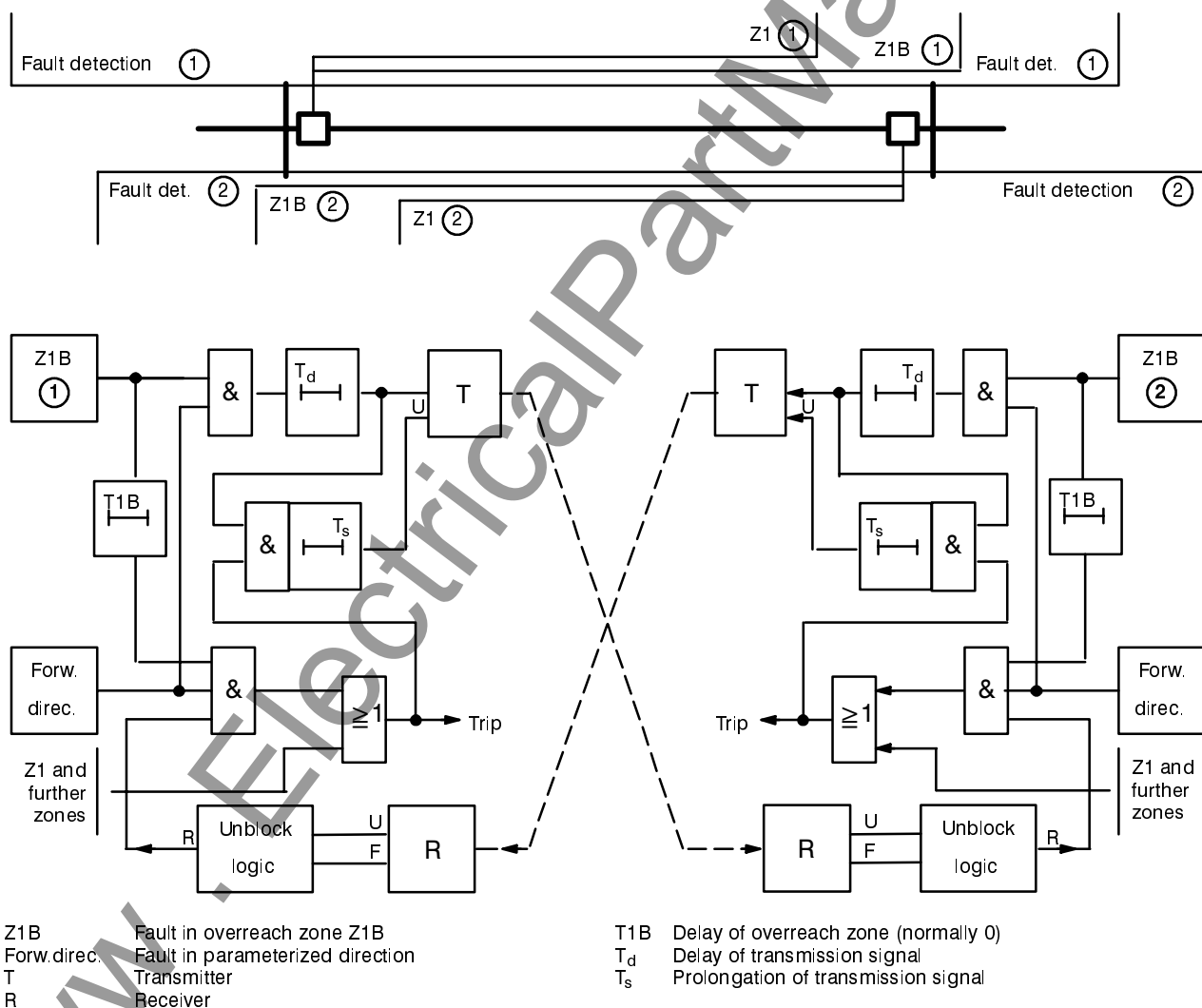


Figure 4.28 Unblocking mode with Z1B – block scheme

The duration of the transmit signal can be increased by T_s (programmable), but this prolongation is effective only after the protection has issued a trip command. This ensures the remote line end to be released even in case the local line end is tripped very quickly by the independent first distance zone.

If the transmission channel is distorted, the receiver unit will issue the fault signal F. Received signal and fault signal pass through an unblocking logic circuit which can be seen in Figure 4.29.

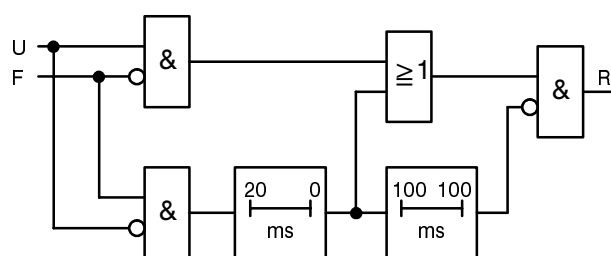


Figure 4.29 Unblocking Logic

If the unblocking signal U is faultlessly received, then the release signal R is formed (in Figure 4.29 upper signal route), that is, the tripping signal of zone Z1B is forwarded to the tripping relay (as with overreach transfer with Z1B). If fault signal F appears, no release is given.

If the signal to be transmitted does not reach the other line end, because a short circuit on the line causes excessive damping or reflection of the signal, the receiver recognizes a fault and issues fault signal F. In this case, after a safety delay time of 20 ms, release signal R is dispatched, but by the time stage 100/100 ms it is cancelled after a further 100 ms. When the fault signal disappears again, the quiescent condition is reestablished after a further 100 ms (reset delay of time stage 100/100 ms), that is, the

upper release route in Figure 4.29 is again available.

For all zones with the exception of Z1B, tripping is permitted without release, so that the relay operates independent of signal transmission. Overreach zone Z1B can then be initiated from the AR function (see Section 4.10.1).

If the transmission device has no channel supervision facility but only demodulates the two frequencies (unblocking frequency and blocking frequency), the fault signal F can be produced by a simple logic according to Figure 4.30. Instead of the AND gate, an exclusive-OR gate can be incorporated. Standing transmission faults will be recognized by 7SA513 after approximately 10 s and annunciated. During transmission failure, the overreach zone Z1B can then be initiated from the AR function (see Section 4.10.1).

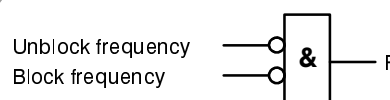


Figure 4.30 Producing the fault signal F

False signals which may have been caused by transient oscillations after the interruption of external faults or by reversal of direction of flow after interruption of faults on parallel lines, are rendered harmless by a transient blocking function (refer Section 4.4.11).

For lines which are fed from one line end only, no release signal can be formed at the unfed line end since no pick-up can occur there. In order to achieve even in this case immediate tripping over 100 % of the line length, an additional echo function is available (see Section 4.4.10).

4.4.6 Directional unblocking mode with fault detection

The unblocking mode is a release procedure. The difference from directional comparison procedures (Section 4.4.4.) is that a tripping signal is also possible when no release signal is received from the opposite end. It is therefore principally used for long lines when the signal must be transmitted over the protected line by a PLC system and the damping of the transmitted signal at the point of fault is so large that receipt from the other line end cannot be unconditionally guaranteed. In this case, a special unblocking logic comes into operation.

For signal transmission one requires two signal frequencies which are shifted over from the transmitter output in 7SA513. If the PLC system incorporates channel monitoring (e.g. Siemens voice frequency unit SWT 500 F6) then the monitoring frequency f_0 is switched to a working frequency. If the relay detects a fault in the line direction, it initiates transmission of the working frequency f_U (unblocking frequency, can be delayed by T_d). Under normal conditions or with a fault in the direction opposite to that set, the monitoring frequency f_0 is transmitted.

Figure 4.31 shows a simplified block scheme of this function.

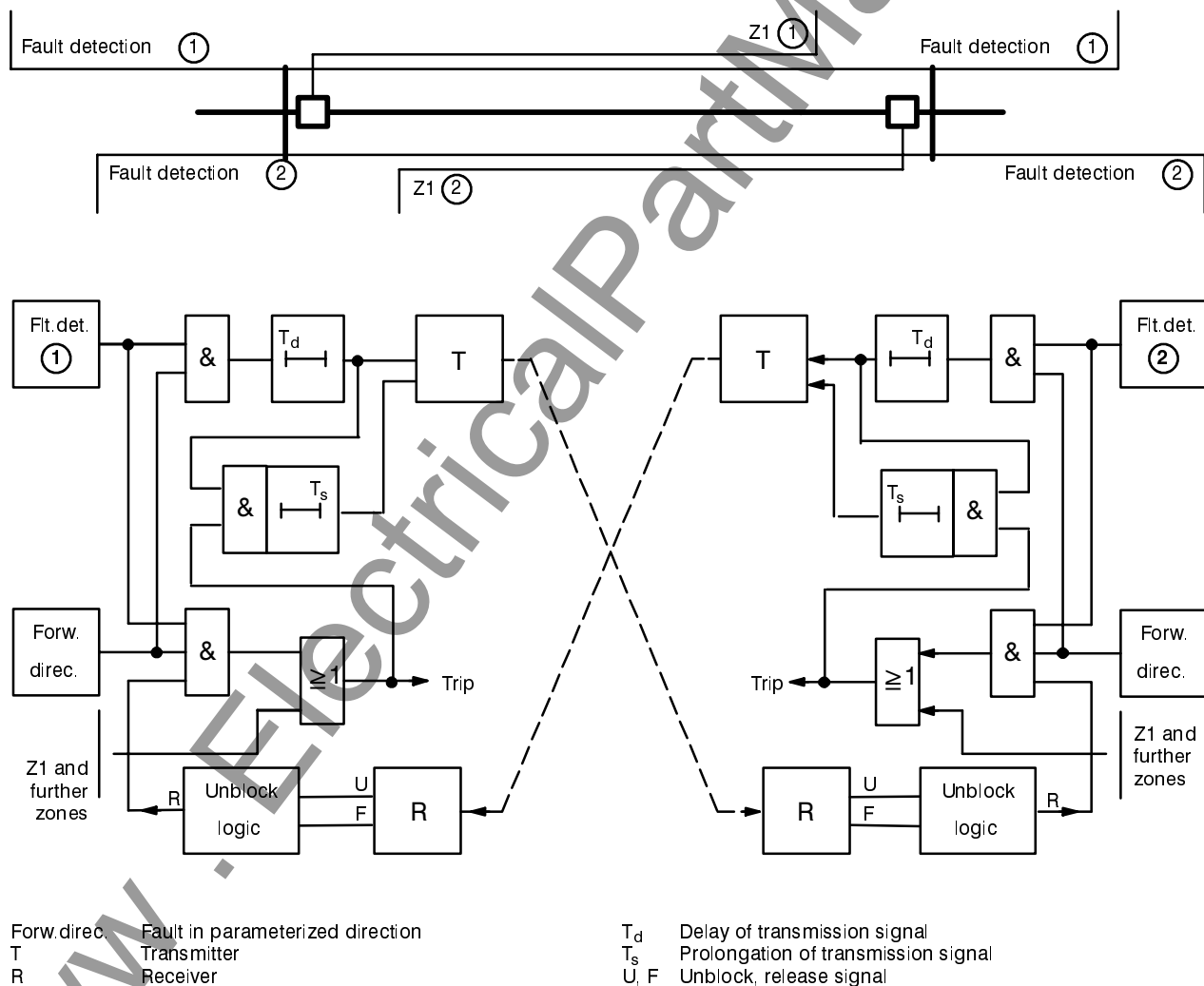


Figure 4.31 Directional comparison unblocking mode – block scheme

The duration of the transmit signal can be increased by T_s (programmable), but this prolongation is effective only after the protection has issued a trip command. This ensures the remote line end to be released even in case the local line end is tripped very quickly by the independent first distance zone.

If the transmission channel is distorted, the receiver unit will issue the fault signal F. Received signal and fault signal pass through an unblocking logic circuit which can be seen in Figure 4.32.

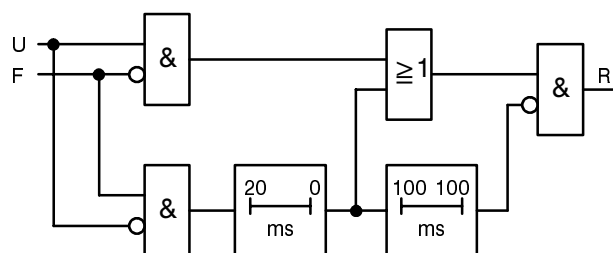


Figure 4.32 Unblocking Logic

If the unblocking signal U is faultlessly received, then the release signal R is formed (in Figure 4.32 upper signal route), that is, an undelayed tripping signal can be forwarded to the tripping relay for a detected fault in line direction (as with directional comparison). If fault signal F appears, no release is given.

If the signal to be transmitted does not reach the other line end, because a short circuit on the line causes excessive damping or reflection of the signal, the receiver recognizes a fault and issues fault signal F. In this case, after a safety delay time of 20 ms, release signal R is dispatched, but by the time stage 100/100 ms it is cancelled after a further 100 ms.

When the fault signal disappears again, the quiescent condition is reestablished after a further 100 ms (reset delay of time stage 100/100 ms), that is, the upper release route in Figure 4.32 is again available.

If the transmission device has no channel supervision facility but only demodulates the two frequencies (unblocking frequency and blocking frequency), the fault signal F can be produced by a simple logic in accordance with Figure 4.33. Instead of the AND gate, an exclusive OR gate can be incorporated. Standing transmission faults will be recognized by 7SA513 after approximately 10 s and announced.

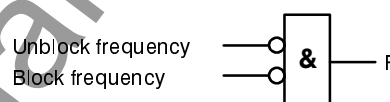


Figure 4.33 Producing the fault signal F

False signals which may have been caused by transient oscillations after the interruption of external faults or by reversal of direction of flow after interruption of faults on parallel lines, are rendered harmless by a transient blocking function (refer Section 4.4.11).

For lines which are fed from one line end only, no release signal can be formed at the unfed line end, since no pick-up can occur there. In order to achieve even in this case immediate tripping over 100 % of the line length, an additional echo function is available (see Section 4.4.10).

4.4.7 Blocking mode

In the blocking procedure, the transmission link is used to send a blocking signal from one line end to the other. The signal is transmitted with fault inception (step jump detector) and stopped as soon as

the relay detects a fault in the forward direction.

Figure 4.34 shows a simplified block scheme.

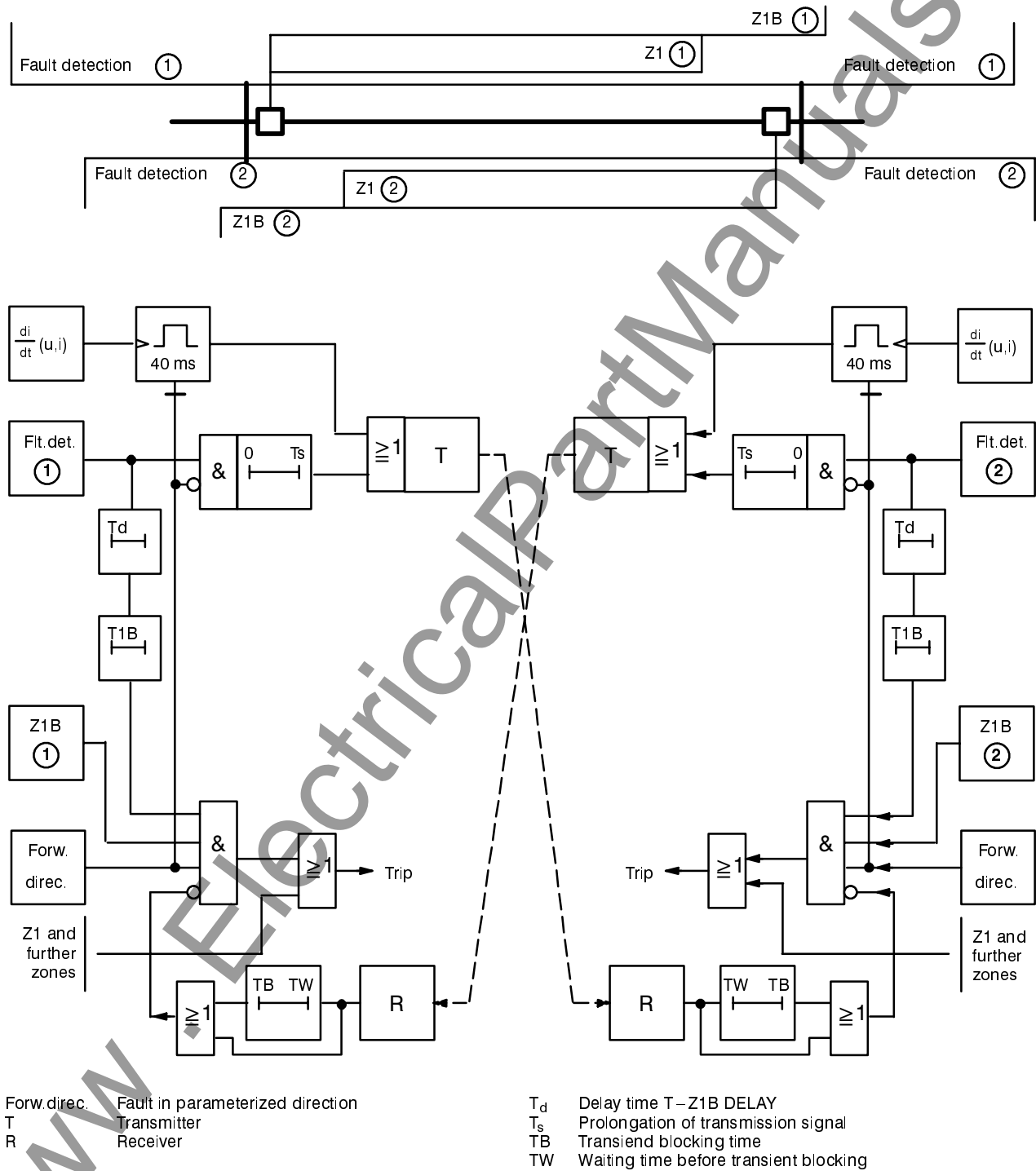


Figure 4.34 Blocking mode – block scheme

Faults in the overreach zone Z1B, which is set to approximately 120 % of the line length, lead to a trip signal as long as no blocking signal is received from the opposite line end. Because of possible differences in the pick-up times of the relays at each line end and because of the transmission time, zone Z1B must be somewhat delayed. The delay time T BLK DELAY (T_d in Figure 4.34) is particularly suitable because it can be set very exactly (steps 1 ms).

Equally, to avoid signal competition, a dispatched signal can be lengthened by the adjustable time T–SEND–PRL (T_s in Figure 4.34). Also the receive signal can be lengthened by the transient blocking time T–TRANSBLO (TB in Figure 4.34) provided it has been received for the waiting time (TW). When setting TW to ∞ , the prolongation of the received signal is suppressed. The transient blocking time again comes into operation to render harmless fault signals which may have been caused by transient oscillations after the interruption of external faults or by reversal of direction of flow after interruption of

faults on parallel line. (See transient blocking function, Section 4.4.11.).

If the teleprotection channel is monitored and a transmission fault is detected, the receiving end logic can be made ineffective by the input of a binary signal. Distance protection then operates with normal grading (rapid trip in Z1). Overreach zone Z1B can then be initiated from the AR function (see Section 4.10.1.).

An inherent characteristic of the blocking function is that rapid disconnection of single end fed faults is ensured even without special measures since no blocking signal can be formed at the non-feeding end. Thus, the procedure is particularly suitable when the signal must be transmitted via the protected line using a PLC system and the damping of the transmitted signal can be so large at the point of fault that its receipt from the other line end cannot be unconditionally guaranteed.

4.4.8 Overreaching zone comparison via pilot wires

In this mode the overreach zone Z1B takes on the function of the instantaneous stage at both ends of the protected line. Zone Z1B is set beyond the next station. The comparison function prevents non-selective tripping.

The information exchange between the two line ends is made via a pilot wire or control core loop, connected at each end via an auxiliary relay, and fed from the d.c. battery of one of the substations. For each line end an interposing relay 7PA5210–2A is therefore necessary (Figure 4.35). Connection diagrams are included in Appendix B.

Under healthy conditions the pilot wires carry direct current thus achieving pilot wire monitoring. Both auxiliary relays K2 are energized (in contrast to the illustration in Figure 4.35).

Distance protection pick-up at either line end will interrupt the wire loop via the send signal and associated auxiliary relay K1. Both K2 drop off and block tripping in Z1B via the receive signal. If the relay then detects the fault within the overreach zone Z1B, the send signal disappears again. If the loop at the opposite end station is also closed by the same procedure, relays K2 are energized again and, as a result,

the receive signals disappear and tripping is released at both line ends.

If a fault occurs beyond the protected line, the d.c. loop will be interrupted by fault detector pick-up of the devices at both ends. Since, however, at least one line end will not de-energize the send signal (fault not in zone Z1B in line direction), the loop remains open. The receive signals are maintained at both line ends and therefore no trip results. The remaining distance stages (incl. Z1) however operate independently, so that the back-up protection functions are not affected.

For lines shorter than the shortest distance setting one must nevertheless observe that the first distance zone shall be set to be either ineffective or the time T1 shall be set equal to the second distance zone.

With single end feed, instantaneous trip will equally be achieved for the total protected line length. Since no pick-up results at the non-feeding end, the loop is not interrupted there. When, at the other end the fault is detected within Z1B the loop is again closed and the trip signal released.

So that sufficient time is available to open and close the pilot wire loop between pick-up and trip signal from the relay, T1B must be slightly delayed. If the overreaching zone comparison via pilot wires is achieved with two different relay types at the two line ends (e.g. 7SA513 at one end and a conventional relay at the other), it must be ensured that possible fundamental differences in pick-up and tripping times of both relays do not lead to false release signals. This is also to be covered by the delay time T1B.

The normally closed d.c. pilot wire loop allows continuous monitoring of the pilot wires. Since, with each line fault, the loop is interrupted, the pilot wire interruption signal is delayed for 10 seconds. The comparison function is then blocked. The remaining stages of the distance protection continue to function normally. The input "Reception faulty" on 7SA513 is **not** used, because a pilot wire fault will be recognized within the relay itself.

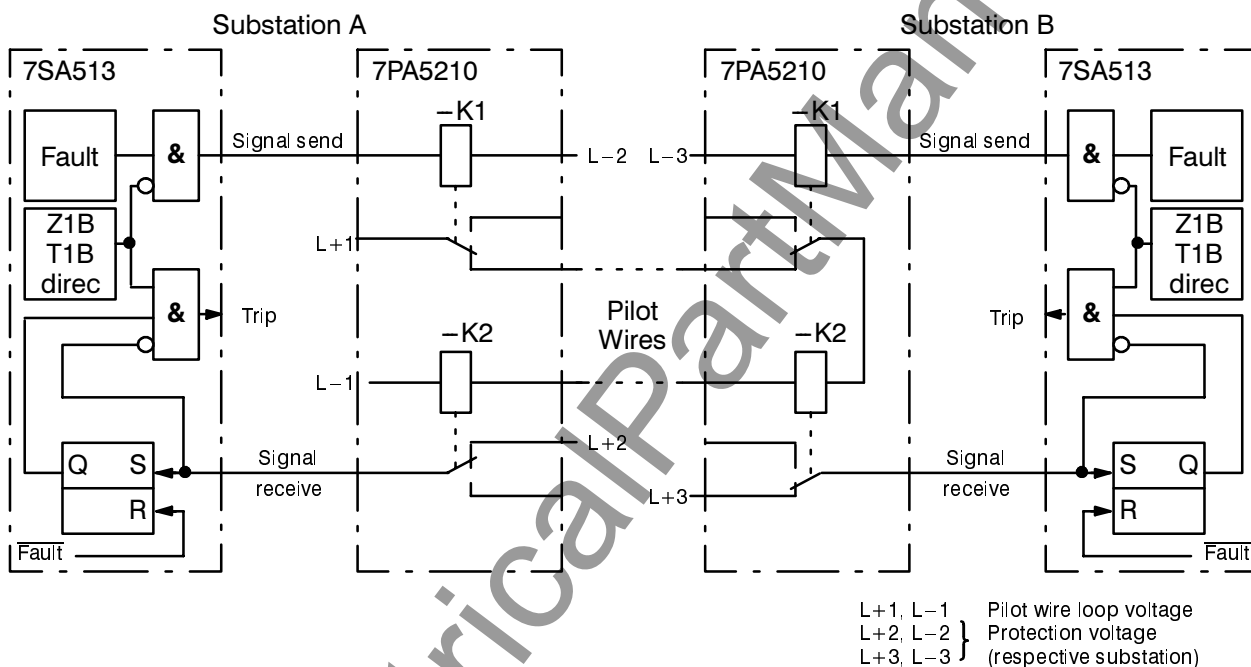


Figure 4.35 Overreaching zone comparison via pilot wires – schematic diagram

4.4.9 Reverse interlocking

If the protection system is installed as back-up protection in a single end feed transformer circuit, the distance relay can be used to provide high speed protection for the bus-bar, without endangering the selectivity for the outgoing lines.

Distance zones Z1 and Z2 then serve as back-up stages for faults on the outgoing lines, for example, at B, as illustrated in Figure 4.36. The distance zone settings should be based on the characteristics of the shortest line.

The overreaching zone Z1B, whose delay time T1B will be set higher than the pick-up time of any subordinate relay, will be blocked if a subordinate relay has picked up. As illustrated in Figure 4.36, the pick-up signal will be fed through the receiver input, to the protection system. However, in accordance with its

purpose and in the absence of such an input signal, this zone guarantees rapid disconnection of the bus-bar, in the case of:

- Fault in the outgoing transformer circuit, for example, in A
- Failure of a line protection relay.

Reverse interlocking is achieved by deliberate release or blocking of the overreaching zone Z1B. It can be used in a blocking mode (as shown in Figure 4.36) or in release mode by a normally closed circuit.

To avoid transient false signals after disconnection of external faults the blocking function is extended by a transient blocking time (TB in Figure 4.36) under reverse interlock conditions.

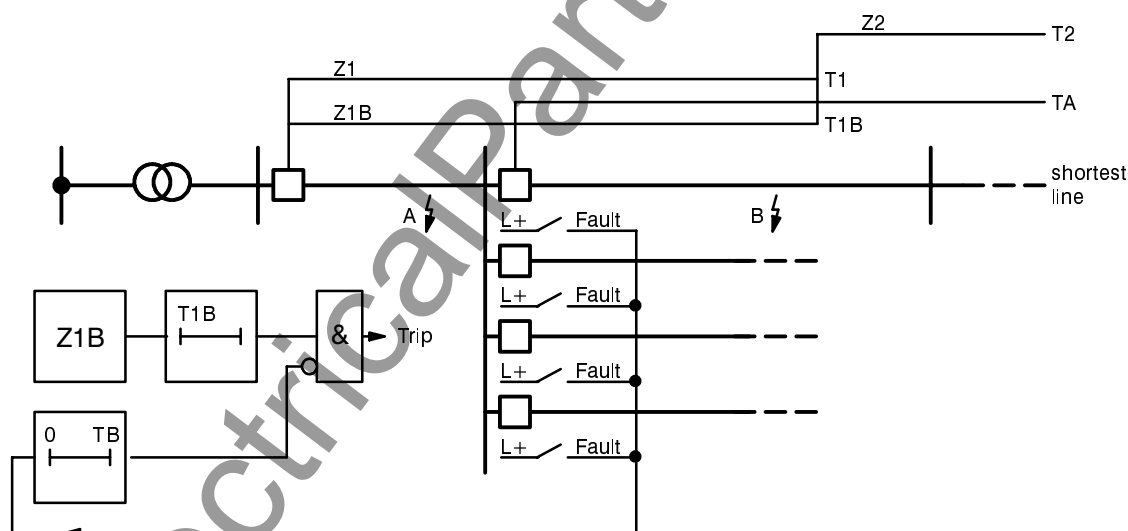


Figure 4.36 Reverse interlocking scheme, grading of distance zones (example)

4.4.10 Weak infed measures

In those cases, where at one line end there is no or only a weak infeed, the distance protection at that end cannot pick up and therefore cannot issue a trip command nor send any release signal. With overreach transfer schemes using a release signal not even the line terminal with strong infeed could trip instantaneously because of missing the release signal from the opposite line end, without any supplementary measures.

To ensure rapid fault clearance at both line ends, 7SA513 provides special measures for line end with weak or no infeed.

To allow rapid trip at the strong-infeed line end an echo intertrip function can be used at the weak-infeed line end, in conjunction with overreaching modes with release signal. This feature can be made effective or ineffective by a software ON/OFF switch. Figure 4.37 shows the logic diagram.

In the event of pick-up failure at the weak-infeed end, the echo function ensures that the received signal is sent back to the strong-infeed end as an "echo" and there permits release of the tripping command. The duration of the echo impulse is adjustable (T-ECHO-IMP).

The echo is delayed by an adjustable time $T-ECHO-DEL$. This delay is necessary so that the echo is not effective when the relay at one line end has a higher pick-up time or when it picks up somewhat later because of unfavourable short circuit current distribution. If, however, the circuit breaker at the weak-infeed line end is open, delay of the echo is not necessary. The echo delay time can then be bypassed, as long as the relay is informed of the status of the circuit breaker via a binary input.

To prevent the formation of an echo after disconnection of the line and reset of the fault detection element, no echo can be formed when fault detection has previously been present (RS – memory in Figure 4.37). For the same reason an adjustable time T-ECHO-BLO prevents formation of an echo after a tripping command.

With the blocking mode and for underreach transfer trip modes, the echo function is not effective. Equally it has no function in overreaching zone comparison via pilot wires or reverse interlocking schemes.

To achieve that the weak-infeed line end will also be interrupted, 7SA513 provides a weak-infeed trip function. This is a separate protection function with its separate trip signal. Therefore, it is described separately in Section 4.7.

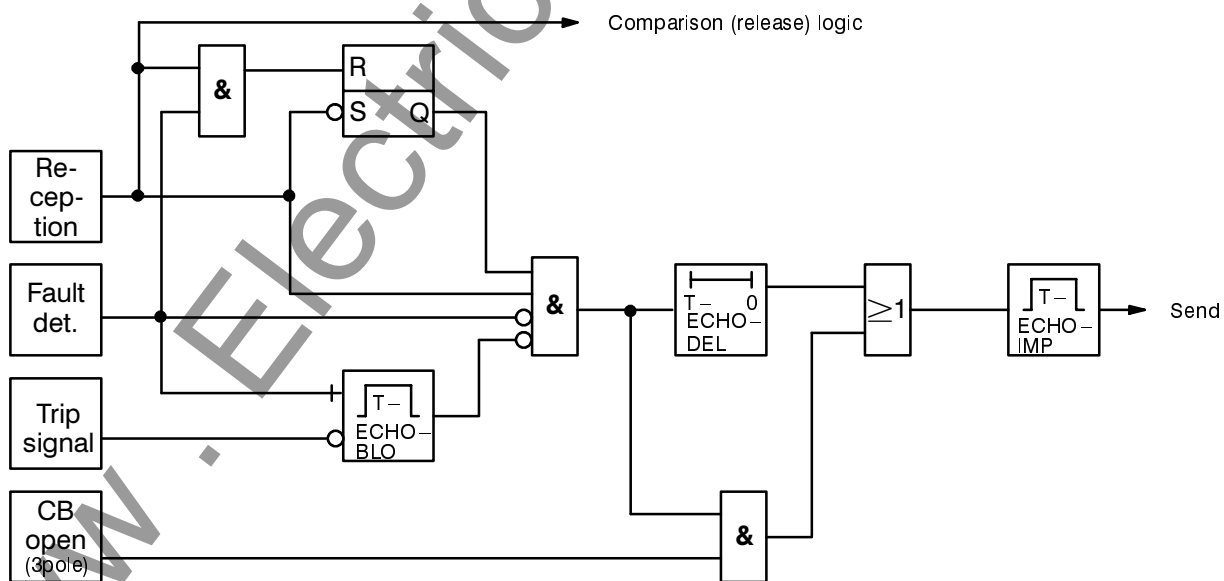


Figure 4.37 Block diagram of echo function (for release modes)

4.4.11 Transient blocking

In overreach transfer and comparison modes, transient blocking provides additional security against false signals which may have been caused by transient oscillation after the interruption of external faults or by reversal of direction of flow after interruption of faults on parallel lines.

The principle of transient blocking is that after the occurrence of an external fault, formation of a release signal is prevented for a specific (adjustable) time $T - \text{TRANSBLO}$. In the release modes this is accomplished by blocking the transmission and receiver circuits, in the blocking mode by lengthening of the blocking signal at the receiver end.

Figure 4.38 shows the principle of transient blocking for a release mode.

If, after fault detection, a fault is seen to be in the reverse direction (opposite to the set direction), the transmission circuit and the release of overreaching zone Z1B or directional trip will be blocked after a waiting time TWR. This blocking will be maintained

for the transient blocking time $T - \text{TRANSBLO}$ – identified in Figure 4.38 with TB – even after the blocking criterion has been removed.

Similarly, the release of overreaching zone Z1B or directional trip can be restricted when, after fault detection, no release signal is received from the opposite line end within the settable waiting time $T - \text{WAIT}$ – identified in Figure 4.38 with TW. This blocking will also be extended by the transient blocking time. Normally, this mode of transient blocking is reasonable only when the protection scheme at the remote line end has no transient blocking feature. Transient blocking is suppressed when the waiting time TW is set to infinity.

In the blocking mode, non-receipt of the release signal qualifies as receipt of a blocking signal. Here, transient blocking means prolongation of the blocking signal. The signal must have been received at least for the waiting time (TW). The transmission signal can be lengthened by the time $T - \text{SEND} - \text{PRL}$ (see also Section 4.4.7).

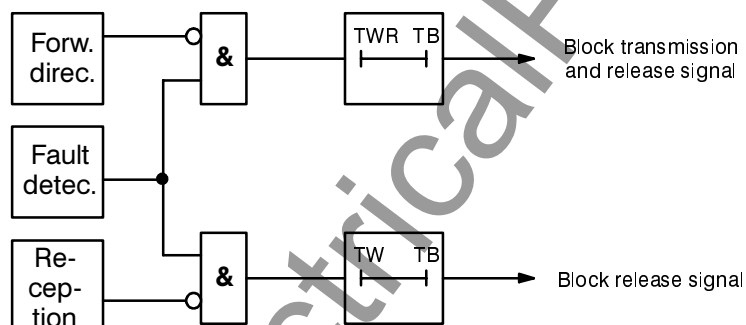


Figure 4.38 Transient blocking with release mode

4.5 User definable logic functions, trip commands, and annunciations

7SA513 contains two user definable logic modules. These comprise each a timer which can be started and blocked via a binary input (Figure 4.39). A pick-up time delay and a drop-off time delay can be set. The times can also be set to 0 or ∞ .

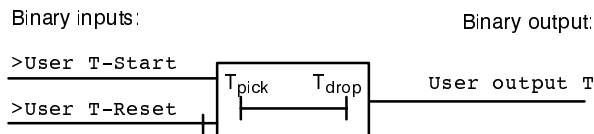


Figure 4.39 User definable logic, one module

The outputs are included in the annunciation processing of the device. They can be assigned to signal relays, LEDs or trip relays.

The following functions can be realized, for example:

- pick-up delay with T_{pick} ($T_{drop} = 0$),
- drop-off delay (pulse lengthening) with T_{drop} ($T_{pick} = 0$),
- pick-up delay and drop-off delay,
- bistable memory (flip-flop) (refer to Figure 4.40),

- flip-flop with delay.

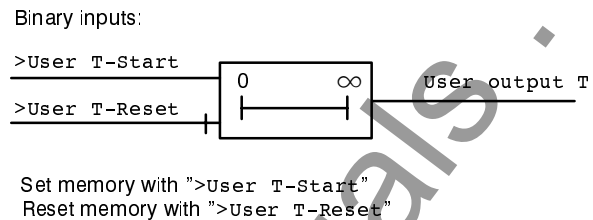


Figure 4.40 Flip-flop

Any desired trip signal from an external protection or supervision unit can be incorporated into the processing of 7SA513. The signal is coupled as "External signal" via a binary input. Like the internal protection and supervision signals, it can be annunciated as "External fault", and transmitted to the trip relays.

Additionally, four annunciations are available, which can be defined by the user himself. Signals and messages of other devices which have no interfaces (PC or LSA interface) can be included in the annunciation processing of the device. Like the internal annunciations, they can be allocated to signal relays, LEDs or trip relays, or transmitted to the front display, a PC or LSA.

4.6 High current switch-onto-fault protection

If a circuit is closed onto a high current "bolted" fault, this high-speed element shall give a trip command immediately and directly. This high current switch-onto-fault protection serves mainly as protection in the case of switching on to a closed earthing isolator but can be used also for any kind of switching on a dead fault – i.e. also during automatic reclosure; this possibility can be chosen during setting of the parameters of this protection function.

Energization of the line is transmitted to the protection function by the circuit breaker position processing which is described in detail in Section 4.17.

The high current element continuously monitors each line current and compares it with the set value. The currents are numerically filtered, so that only the fundamental frequency is evaluated. If the current exceeds the set value by more than two times, the relay automatically uses non-filtered values so that extremely short tripping time results.

This high current feature is practically uninfluenced by d.c. components, neither in the short-circuit cur-

rents nor in secondary currents which may arise after interruption of high currents.

The principle function is shown in Figure 4.41 for one phase. Release signal Rel L1 appears as long as the circuit breaker pole L1 is recognized to be open and is extended for a settable prolongation time T-RELEASE after the circuit breaker pole L1 has been closed. This phase segregated release signal is possible only when either the auxiliary contacts of each individual breaker pole are fed to the relay (refer to Section 4.17.1) or the integrated line energization recognition feature by use of the measured currents and voltages is effective (refer to Section 4.17.2).

The three-pole release signal Rel L123 appears after manual closing of the circuit breaker and is prolonged for a settable time T-MC-PROL.

Trip command always occurs three-pole. Phase segregated processing is only related to the pick-up signal by the combination of the high current criterion with the circuit breaker pole position.

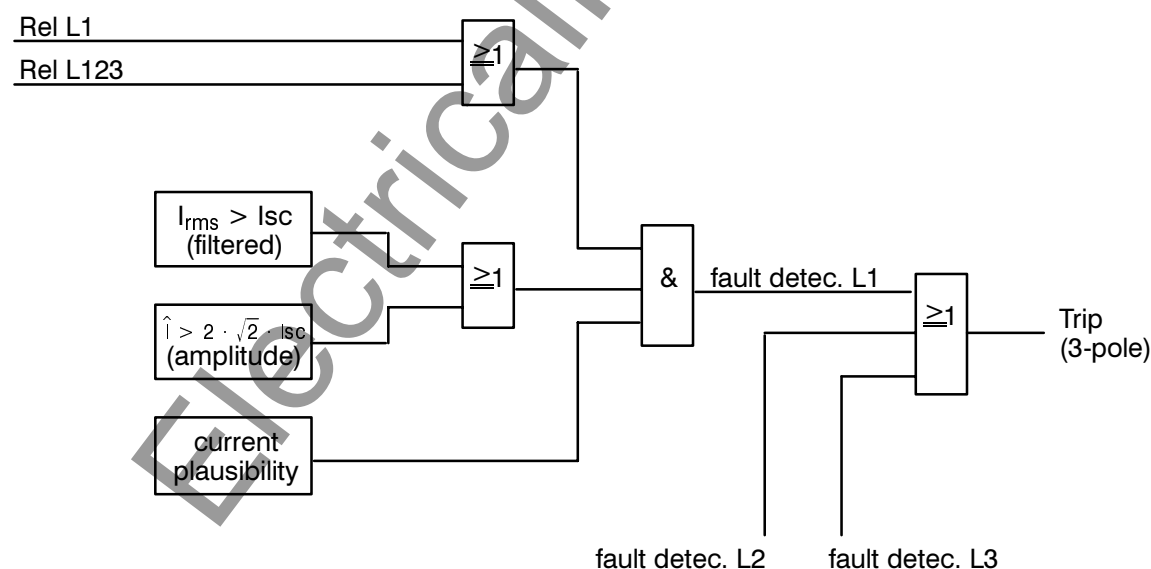


Figure 4.41 Switch-onto-fault protection – principle

4.7 Weak-infeed trip function

In those cases where there is no or only a weak infeed from one line end, the distance protection does not react.

To achieve rapid clearance at both line ends in those cases, the protection relay incorporates special features for lines with weak infeed. These features operate in conjunction with the signal transmission modules (see Section 4.4).

At the strongly feeding line end, the relay will always effect a rapid clearance for faults within zone Z1. With signal transmission and permissive release modes, the echo function (see Section 4.4.10) is operative for faults over 100 % of the line length and gives permission for tripping at the strongly fed line end.

But, tripping of the breaker at the weak-infeed end would also be desirable.

So that the line end with weak infeed will itself operate, 7SA513 incorporates a separate protection function with its separate trip signal capability.

For recognition of the weak-infeed condition, the same conditions apply as for the echo function. Figure 4.42 shows the principle.

When release signal is received from the other line end, even though the local protection has not picked up, this indicates a fault on the protected line.

To prevent the weak-infeed recognition after disconnection of the line and reset of the fault detection element, no weak-infeed condition is recognized when fault detection has previously been present (RS-memory in Figure 4.42).

Detection of the weak-infeed condition is delayed by a time $T-DELAY$. This delay is necessary to prevent permission to trip when the relay picks up somewhat later, due to an unfavourable short-circuit current distribution.

Under fault conditions it is to be expected that only a small voltage will appear at the line end with weak-infeed, because the small current can produce only a small voltage drop in the short-circuit loop. If there is no infeed, the loop voltage is even zero.

For this reason, weak-infeed tripping is made to be dependant upon the measured undervoltage. This undervoltage measurement allows even selection of the faulted phase and thus also allows single-pole auto-reclose at the line end with weak infeed.

When the weak-infeed condition is reliably recognized by the received signal, the signal is lengthened by a preset, adjustable time $T-PROLONG$, so that the under-voltage criterion can be safely established.

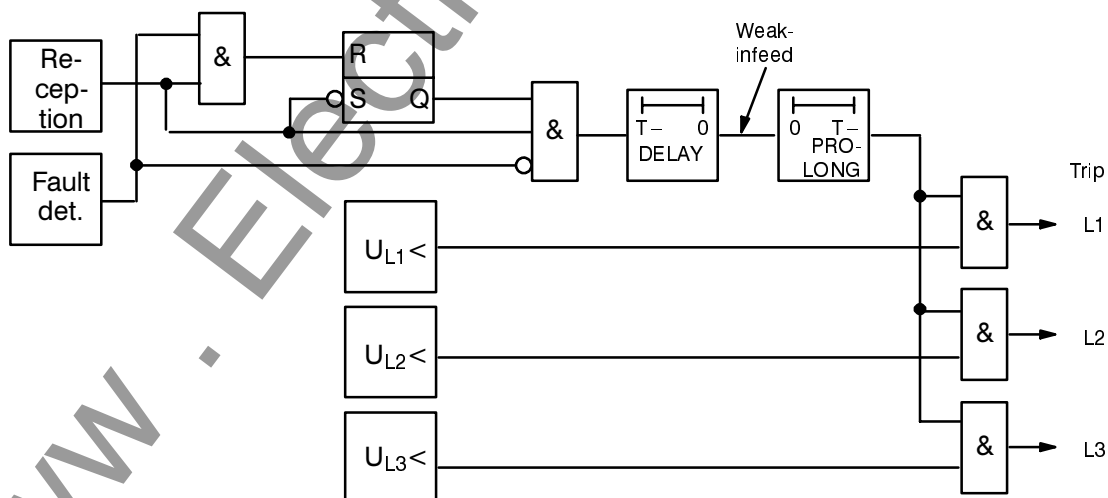


Figure 4.42 Weak-infeed trip function – block scheme

4.8 Emergency overcurrent time protection

7SA513 provides an emergency overcurrent time protection. Whereas distance protection can operate only as long as the line voltages are properly available, the overcurrent time protection needs the currents only.

The overcurrent function may come automatically into operation when the measured voltage is not available, e.g. during short-circuit or an interruption in the VT secondary circuits (emergency operation).

Overcurrent protection backs up the distance protection when failure of the measured voltages is detected by any one of the following conditions:

- operation of the fuse failure monitor or three-phase voltage failure supervision (refer to Section 4.18.4.3) or
- the signal "VT mcb tripped" is applied to a binary input.

If either of these factors occurs, distance protection is immediately blocked and emergency overcurrent protection may become operative (selectable).

Under this condition, selectivity can only be achieved by time delay, just as for all other types of overcurrent protection scheme.

As soon as the device recognizes that the measured voltages have reappeared, the system switches back to distance protection.

The emergency overcurrent time protection can be used as definite time or inverse time overcurrent protection. Three standardized inverse time characteristics according to IEC 60255–3 are available for inverse time mode. The trip time characteristics and the applied formulae are given in the Technical data, refer Figure 3.1, Section 3.8.

The selected overcurrent time characteristic can be superimposed by a high-set instantaneous or definite time delayed stage.

The characteristics can be individually set for phase currents and for earth currents. In total, the following stages are available:

- $I_{ph}>>$ high current limit value threshold for phase currents,
- $T_{I>>}$ associated delay time.
- $I_{ph}>$ definite time limit value threshold or I_p inverse time base value for phase currents,
- $T_{I>}$ associated delay time or T_p time multiplier.
- $I_E>>$ high current limit value threshold for earth currents,
- $T_{IE>>}$ associated delay time.
- $I_E>$ definite time limit value threshold or I_{Ep} inverse time base value for earth currents,
- $T_{IE>}$ associated delay time or T_{Ep} time multiplier.

All stages are independent from each other and can be set individually.

Under conditions of manual closing onto fault, the emergency overcurrent protection can also provide a rapid trip. A choice can be made whether the $I>>$ stages or the $I>/I_p$ stages are decisive for an undelayed trip, i.e. the associated time delay is bypassed for this condition.

The emergency protection can also be used in conjunction with auto-reclosure. In these cases the $I>>$ stages becomes valid before reclosure.

4.9 High-resistance earth fault protection (optional)

In earthed networks in which the earth path resistance can be extremely high (e.g. overhead lines without lightning protection conductor, or sandy soils) the impedance fault detection will often not pick up, since earth fault impedances can occur which appear to lie outside the pick-up characteristic of the distance relay.

Line protection 7SA513 can provide protective functions for such high resistance earth faults. The following features are then available:

- directional earth fault protection (definite time or inverse time earth overcurrent protection) with non-directional back-up stage,
- directional inverse time zero sequence voltage protection with non-directional back-up stage,
- directional comparison earth fault protection,
- instantaneous earth fault stage before auto-reclosure and/or switch-onto-fault stage,
- phase selection for single-pole auto-reclosure with all protection modes.

4.9.1 Directional determination

Directional determination is carried out using the earth current I_E ($= 3 \cdot I_0$) and a polarizing voltage U_P which is derived from the displacement voltage U_E ($= \sqrt{3} \cdot U_0$) (refer to Figure 4.43).

Alternatively, polarizing quantity can be a current I_P which is derived from the star-point current I_Y measured in the earthing conductor of an earthed feeder transformer (refer to Figure 4.44).

Additionally, the earth current I_E can be polarized by the displacement voltage as well as the star-point current. In this case, the polarizing quantity is the sum of the polarizing voltage U_P and a voltage proportional to the polarizing current I_P . Rated current in I_P corresponds to 20 V voltage in this proportion.

An advantage of polarization with the star-point current is that it is independent of any voltage transformer secondary voltage. Thus, it operates reliably also in case of secondary voltage failure. But it requires that the fault current is produced at least pre-

dominantly from this feeder transformer from which the star-point current is measured.

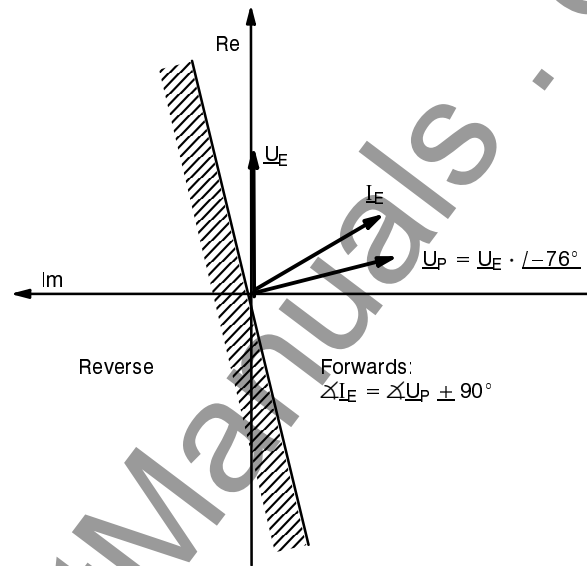


Figure 4.43 Directional characteristic with voltage polarization

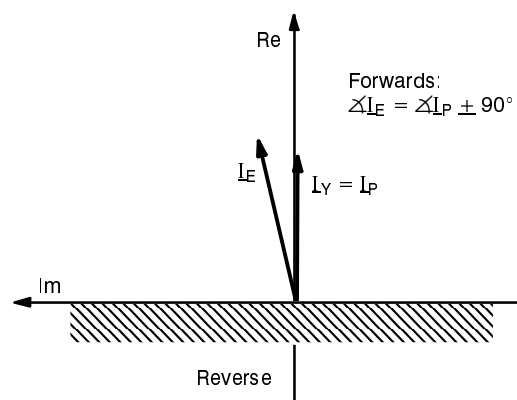


Figure 4.44 Directional characteristic with current polarization

After pick-up on $0.75 \cdot I_E$ the relay carries out directional determination. This requires a minimum displacement voltage, for which the $U_E >$ setting is used. If the displacement voltage is too small, a directional determination is possible only with star-point current polarization. Directional determination with U_E is suppressed when the indication "voltage transformer miniature circuit breaker tripped" is signalled to the relay via a binary input.

4.9.2 Directional earth current protection with non-directional back-up and emergency stage

The directional earth fault protection can be used as definite time or inverse time overcurrent protection.

The definite time earth current protection provides an adjustable pick-up stage $I_E >$ and an adjustable delay time (refer to Figure 4.45).

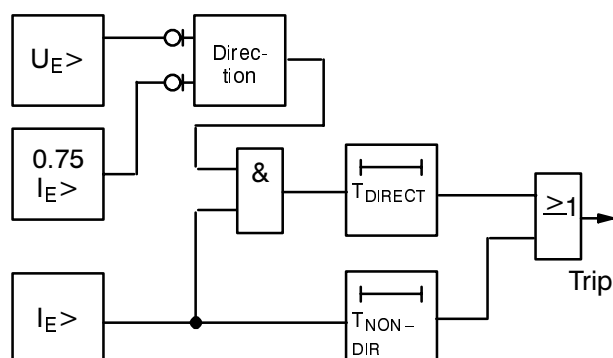


Figure 4.45 Directional definite time earth current protection with non-directional stage

For the inverse time earth current protection an overcurrent value and a time multiplier can be set (Figure 4.46). The available trip time characteristics are

- normal inverse (type A acc. IEC 60255–3),
- very inverse (type B acc. IEC 60255–3),
- extremely inverse (type C acc. IEC 60255–3).

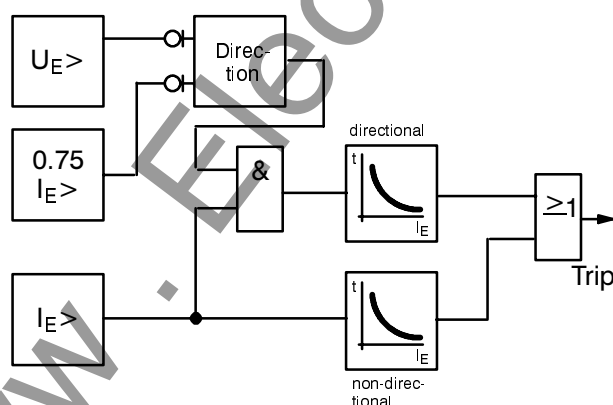


Figure 4.46 Directional inverse time earth current protection with non-directional stage

The trip time characteristics and the applied formulae are given in the Technical data (refer to Section 3.9, Figure 3.2).

Tripping time is dependent on the level of current. If this value changes during the fault, the tripping time will be determined strictly in accordance with the changing current value. This is achieved by an integrating process similar to that of conventional inverse time overcurrent protection relays. Thus the grading plan can easily be coordinated with inverse time overcurrent relays of conventional construction. In strongly meshed, all-round earthed networks, the largest fault currents flow at the ends of the faulty line section; the inverse characteristic has the effect that here the shortest response time occurs and the remaining relays reset.

The range of definition of the characteristics goes further than that of the IEC standards. They are defined from 20 % above the set value up to 20 times the set value. Beyond that point no further reduction of the tripping time occurs.

A further time stage $T_{\text{NON-DIR}}$ will cause tripping without directional measurement. It can be set as a non-directional back-up stage for the directional stage. If direction determination is not possible (e.g. the displacement voltage is too small), this stage remains effective and can also serve as an emergency function for the directional earth fault protection and the earth fault directional comparison protection.

The earth fault overcurrent time protection function can be blocked by the distance protection. Then, if a fault is recognized by the distance protection, the earth fault protection does not operate. This gives selective fault evaluation by the distance protection preference over tripping via the earth fault protection.

The earth fault protection function is blocked during a single-pole auto-reclose cycle in order to prevent from wrong measurement with the faulty zero sequence components in this case, which occur in voltage and current.

If 7SA513 operates with an external auto-reclose device or if single-pole tripping is possible from a different protection relay of the feeder, the earth fault protection must be blocked via a binary input during single-pole interruption.

4.9.3 Directional inverse time zero sequence voltage protection with non-directional stage

The zero sequence voltage time protection operates with an inverse time characteristic whose trip time is dependent on the magnitude of the zero sequence voltage. It can be used instead of the directional earth current protection according to Section 4.9.2.

The voltage time characteristic can be shifted by a constant voltage value ($U_{inv\ min}$, valid for $t \rightarrow \infty$) and a constant time value along the time axis (T-DIRECT).

The trip time characteristics and the applied formulae are given in the Technical data (refer to Section 3.9, Figure 3.3).

Figure 4.47 shows a block scheme.

Tripping time is dependent on the level of zero sequence voltage U_0 . In strongly meshed, all-round earthed networks, the zero sequence voltage increases in the vicinity of the fault location; the inverse time characteristic has the effect that here the shortest response time occurs and the remaining relays reset.

A further time stage T-NON-DIR will cause tripping without directional measurement and with a definite

time. It can be set as a non-directional back-up stage for the directional stage. Precondition of tripping by this stage is that the inverse time stage (but non-directional) has operated. If the zero sequence voltage is too small or the voltage transformer secondary m.c.b. has tripped, this stage cannot operate.

The zero sequence voltage time protection function can be blocked from the distance protection. Then, if a fault is recognized by the distance protection, the zero sequence voltage time protection does not operate. This gives selective fault evaluation by the distance protection preference over tripping via the zero sequence voltage time protection.

The zero sequence voltage time protection function can be blocked during a single-pole auto-reclose cycle in order to prevent from wrong measurement with the faulty zero sequence components in this case.

If 7SA513 operates with an external auto-reclose device or if single-pole tripping is possible from a different protection relay of the feeder, the zero sequence voltage time protection must be blocked via a binary input during single-pole interruption.

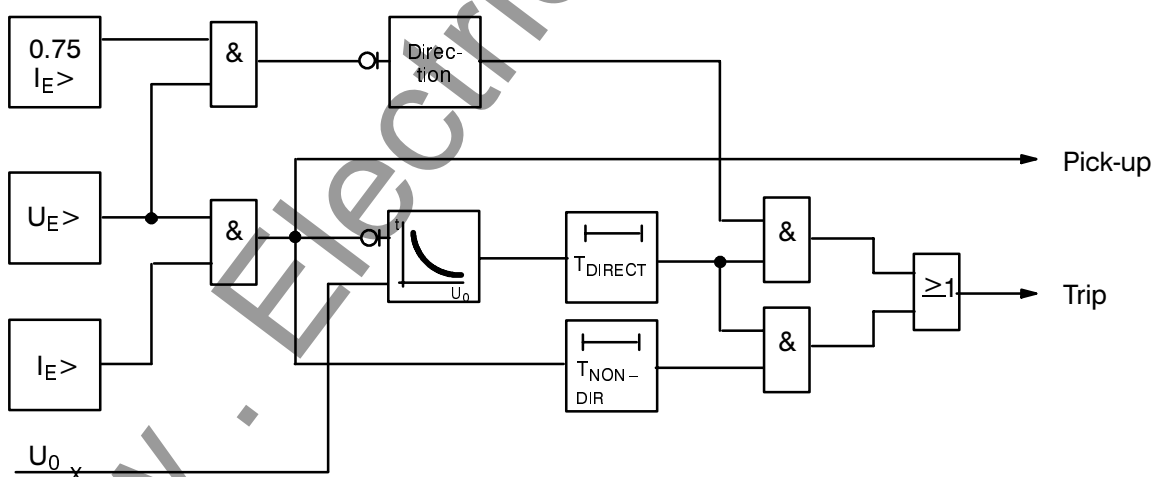


Figure 4.47 Directional inverse time zero sequence voltage time protection with non-directional back-up stage

4.9.4 Directional comparison earth fault protection

With the aid of the integrated comparison logic, the directional protection according to Section 4.9.2 or 4.9.3 can be extended to form a directional comparison protection. For this purpose a carrier channel is necessary for each direction, which transmits the signals of the directional earth fault protection, (e.g. via PLC) to the associated other line end. This can also be the same channel as for signal transmission with distance protection (Section 4.4) under the condition that a corresponding comparison procedure (Section 4.4.3 Permissive overreach transfer trip with Z1B or Section 4.4.4 Directional comparison) has been selected at the distance protection element!

After pick-up on $0.75 \cdot I_E >$ the relay carries out directional determination provided the displacement voltage $U_E (= \sqrt{3} \cdot U_0)$ or the star-point current I_y is of sufficient magnitude. With an earth fault in the line direction a release signal is sent to the opposite end; if a release signal is then received from that end, tripping results, as long as this relay has also detected an earth fault in the line direction and the set pick-up value $I_E >$ is exceeded (Figure 4.48). Transmission signal and tripping can both be made dependent on a delay time $T - \text{DELAY}$.

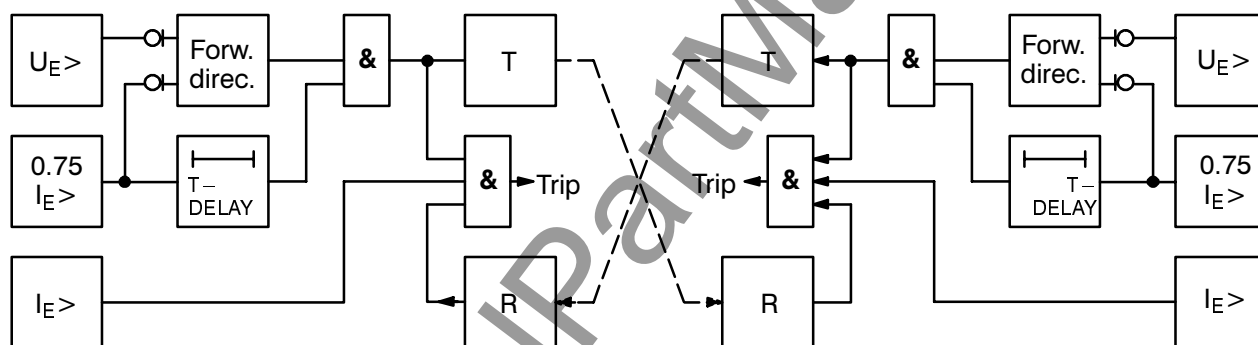


Figure 4.48 Earth fault directional comparison protection

Any faulty signals which could be caused by transient oscillations during the clearance of external faults or during change of direction after clearance of faults on parallel lines, are made harmless by means of a transient blocking function (Figure 4.49). The principle of this transient blocking is that after the occurrence of an external fault the formation of a release signal is prevented for a specific (adjustable) time $T - \text{TRANSBLO}$.

If after fault detection, it is determined that the fault is in the reverse direction (opposite to the set direction) the transmission circuit and release are suppressed after a waiting time TWR. This blocking will be maintained for the transient blocking time $T - \text{TRANSBLO}$ – in Figure 4.49 abbreviated to TB – even after the blocking criterion is removed.

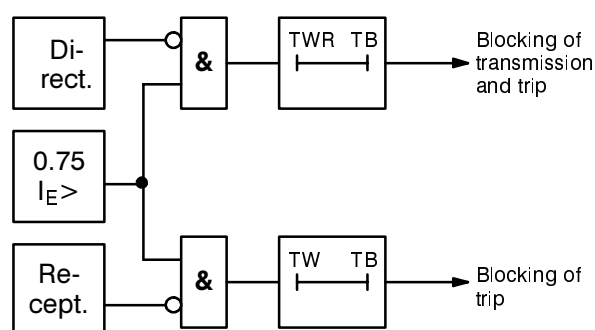


Figure 4.49 Transient blocking

Similarly, the release of directional trip can be restricted when, after fault detection, no release signal is received from the opposite line end within the settable waiting time $T-WAIT$ – identified in Figure 4.49 with TW . This blocking will also be extended by the transient blocking time. Normally, this mode of transient blocking is necessary only when the protection scheme at the remote line end has no transient blocking feature. Transient blocking is suppressed when the waiting time TW is set to infinity.

For lines with single end infeed or star point earthing at one line end only, no release can be formed from the residual-current-free line, since no fault detection signal occurs at that end. To achieve tripping by the directional comparison element even in this case, an echo function is additionally available (Figure 4.50). This has the effect that when the low value detection signal is not present at one line end ($0.75 \cdot I_E >$) the received signal will be sent back to the other line end as an "echo" and thus permits the release of a tripping command at that end. The duration of this echo impulse is adjustable ($T-ECHO-IMP$).

The echo is delayed by an adjustable time ($T-ECHO-DEL$). This delay is necessary so that

the echo will not be effective when the protection at one line end has a higher fault detection time or if it picks up somewhat later due to unfavourable earth current distribution. If, however, the circuit breaker at the non-earthed line end is open, the delay of the echo is not necessary. The echo delay time can then be by-passed if the relay is informed of the position of the circuit breaker, through a binary input.

To prevent the formation of an echo after clearance of the line and reset of the fault detection elements, an echo is not formed when a pick-up has already been present (RS memory in Figure 4.50). For the same reason, no echo is permitted for an adjustable time $T-ECHO-BLO$ after a tripping command has been issued.

Independent of the result of the directional comparison, the directional earth fault overcurrent protection according to Section 4.9.2 or the directional zero sequence voltage time protection according to Section 4.9.3 is effective with the time $T-DIRECT$, and the non-directional back-up stage of the corresponding protection function with the time $T-NON-DIR$. If one of these stages is not required, the corresponding time must be set to infinity.

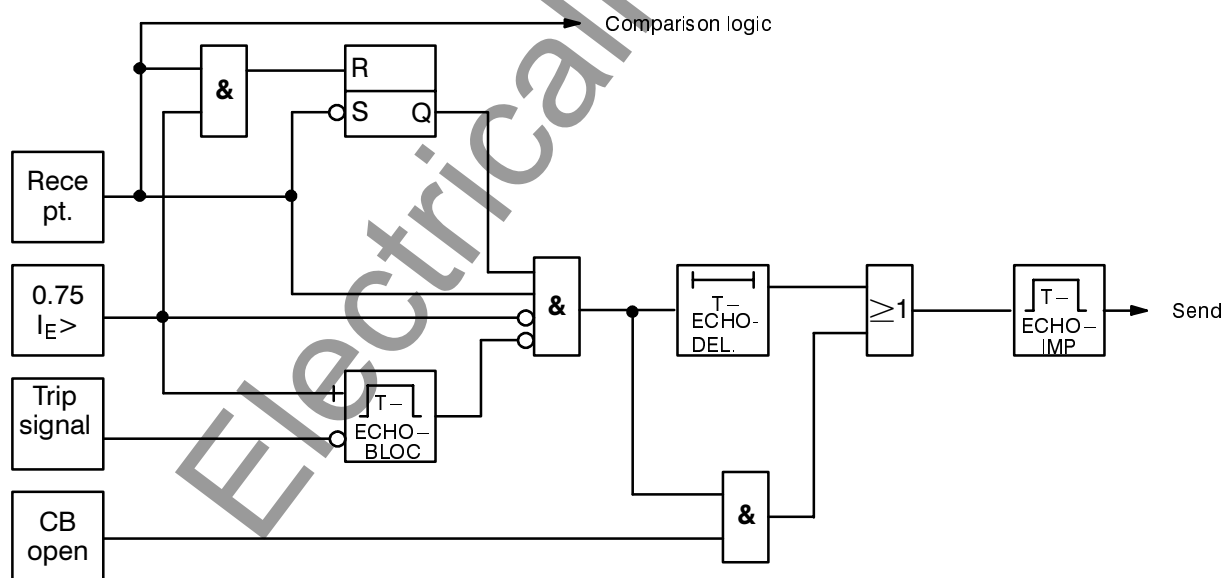


Figure 4.50 Block diagram of echo function for directional comparison

4.9.5 Rapid trip on switch-onto-earth-fault or before auto-reclosure

If one switches a dead but earth-faulted line onto a live bus-bar it is essential, in general, that this line be immediately disconnected. To be sure of an immediate disconnection under any condition and especially when switching onto bolted fault, the manual close command from the discrepancy switch can be repeated, via a binary input to cause an immediate trip signal when a fault is detected. The fault can be cleared either with fault detection of the earth fault protection or pick-up and additional direction discrimination (selectable). With earth current protection, fault detection means pick-up of the I_E stage;

with zero sequence voltage time protection, additionally the zero sequence voltage threshold must pick up because this function depends fundamentally on the zero sequence voltage.

If the earth fault protection operates with the integrated auto-reclose function or an external auto-reclose device, rapid fault clearance can be achieved by a separate time which may be set to 0. The normal time stages are independently effective as parameterized.

4.9.6 Selection of the earth-faulted phase

The earth fault protection functions operate with the zero sequence components of the currents and voltages. These components cannot indicate the faulted phase. In order to achieve single-pole tripping in spite of this, 7SA513 provides a phase selector for earth fault protection.

The phase selector examines the distribution of the measured voltages and currents

- in order to detect whether it is a single-phase fault or a multi-phase fault and
- in order to discriminate the faulted phase in case it is a single-phase fault.

As soon as a multi-phase fault is recognized, three-pole trip is initiated. Three-pole trip is initiated either when single-pole trip is not allowed (e.g. by setting parameter or by three-pole coupling signal from other internal or external functions, e.g. AR).

The phase selector processes the phase-to-earth voltages, the phase currents and the symmetrical components of the currents. If an essential voltage drop is recognized in one single phase or an essential overcurrent occurs in one single phase then a single-phase earth fault is present without doubt: the assigned circuit breaker pole is tripped immediately.

Three-pole trip command is issued as soon as the voltages or currents indicate a multi-phase fault.

When the type of fault is not clearly discriminated by the above criteria, the negative sequence and zero sequence components are filtered out from the currents by numerical filter algorithms. The phase displacement of these components is used to decide whether a single-phase fault or a multi-phase fault is present. For this, even the phase currents are evaluated but corrected by the load current influence: It is taken into account that the unfaulted phases can lead only either no significant currents or currents which are nearly equal in phase.

The phase selector has an active time of 40 ms. If the phase selector has not detected the faulted phase within the active time, three-pole trip is initiated. Immediate three-pole trip is initiated, of course, as soon as a multi-phase fault is recognized as described above.

During the dead time of a single-pole auto-reclose cycle the phase selector cannot operate correctly and shall not operate. During this time the entire earth fault protection is blocked, as described above in the appropriate sections (refer to Section 4.9.2 or 4.9.3).

4.10 Automatic reclosure (optional)

Experience has shown that approximately 85 % of short-circuits are caused by an arc, on overhead lines, and self-extinguish after interruption by the protective device. The line can therefore be re-energized. This is carried out by the automatic reclosure (AR) function. Figure 4.51 shows an example for the time sequence of a two-shot auto-reclosure with a RAR cycle followed by a DAR cycle.

If the circuit breaker poles can be tripped individually, then AR is often carried out single-pole for single-phase faults, and three-pole for multi-phase faults, in networks with earthed star-point. If the short circuit is still present after the auto-reclosure (arc not quenched or metallic short-circuit), then the protective relay finally disconnects the power. Multiple auto-reclosure attempts, often with a first rapid auto-reclosure (RAR) and subsequent delayed auto-reclose cycles (DAR) are possible in some networks.

The stringent loop verification of the distance protection (refer to Section 4.2.2) and the phase selection of the earth fault protection (refer to Section 4.9.6) allow reliably single-pole auto-reclosure. The 7SA513 also allows automatic single- and three-pole as well as single- and multi-shot reclosure.

7SA513 can also work in conjunction with an external auto-reclose system. In this case, the signal exchange between 7SA513 and the external AR-unit must be accomplished via the binary inputs and outputs (see Section 4.10.9).

Furthermore, it is also possible to allow the internal AR-function to be triggered from an external protection relay (e.g. back-up relay) (see Section 4.10.10). The use of two 7SA513 with internal AR-function is also possible as well as the use of one 7SA513 with AR-function and a second protection relay with separate AR-unit (example see Section 4.10.11).

The possible programs of the internal AR-function for the first AR-cycle (designated in the following with RAR – rapid auto-reclosure) are:

- RAR PROG. = *THREE-POLE*, i.e. all types of faults result in three-pole AR.
- RAR PROG. = *SINGLE-POLE*, i.e. single-phase faults result in single-pole AR, multi-phase faults in three-

pole final disconnection. Optionally single-pole AR is possible after two-phase faults without earth connection.

- RAR PROG. = *SINGLE/THREE-POLE*, i.e. single-phase faults (or two-phase without earth) result in single-pole AR, multi-phase faults in three-pole AR.

If more than one reclose attempt will be carried out, the second and any further auto-reclose cycle are designated in the following with DAR (delayed auto-reclosure) independent on the setting of the dead times of the cycles. It is possible to skip the RAR cycle so that only DAR cycles occur. DAR cycles are always three-pole. For the DAR-function, the following programs are selectable:

- DAR PROG. = *NO DAR*, i.e. no DAR occurs; unsuccessful RAR results in final trip.
- DAR PROG. = *DAR WITHOUT RAR*, i.e. DAR cycles can be carried out even without a preceding RAR cycle (e.g. RAR is by-passed because blocked).
- DAR PROG. = *DAR AFTER RAR*, i.e. the DAR cycles can only be initiated after an unsuccessful RAR.

The possibilities and functions of the internal AR-unit are described in the following sections. Prerequisite for initiation of the AR-function is always that the circuit breaker is ready for operation when pick-up occurs. This information has to be transmitted to the device via a binary input.

Furthermore, reclosure is blocked if the tripping command occurs after the action time, which can be set individually for RAR and DAR. Additionally, the auto-reclosure function is not ready when, at the moment of initiation, the circuit breaker is announced (via a binary input) to be open. This prevents from an accidental close command, should the auto-reclosure function receive an erroneous trip command – for any reason (e.g. via a binary input) – even though the breaker is open (and the line may be dead).

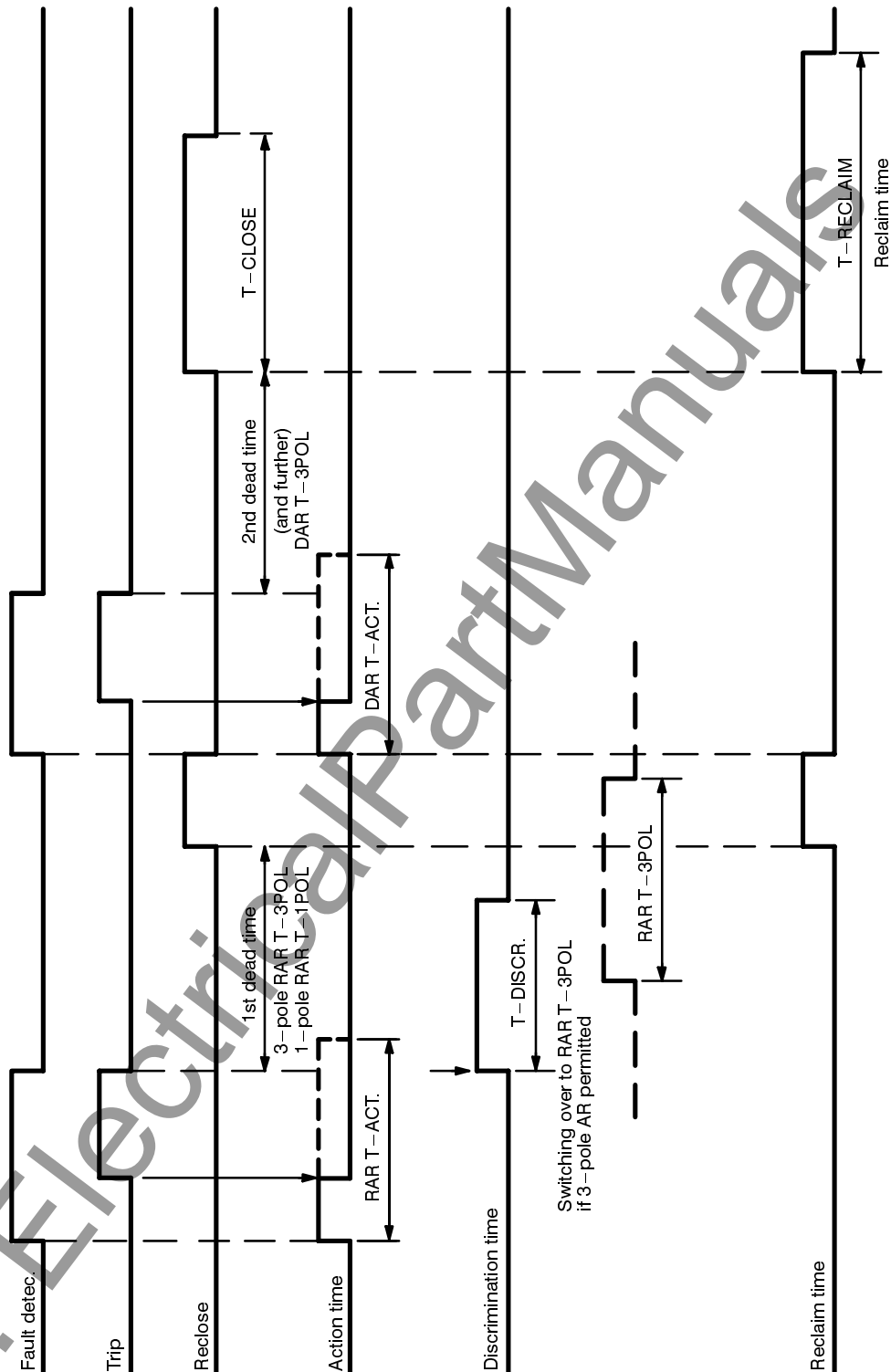


Figure 4.51 Diagram of an auto-reclosure sequence: RAR cycle followed by a DAR cycle

4.10.1 Selectivity during automatic reclosure

For the auto-reclosure sequence to be successful, faults on any part of the line must be cleared from both line ends within the same – shortest possible – time. Usually, therefore, an instantaneous stage of the short-circuit protection is set to operate before a reclosure by the AR–unit. Therefore, each short-circuit protection function of 7SA513 which can initiate the auto-reclose function provides a special RAR stage. Furthermore, one can decide for each short-circuit protection whether or not it shall initiate the auto-reclose function.

With distance protection the first AR–cycle (in the following called RAR) allows faults in the overreach zone Z1B to be cleared instantaneously; however, this can be changed when setting the relay. For possible further cycles (in the following called DAR), a separate zone Z1L with a separate time stage T1L becomes effective.

The normal distance zones Z1, Z2, Z3 and the directional and non-directional end stages of the distance protection are independent of the automatic reclose function. This must be considered when a fault shall be cleared after a time delay, for selectivity reasons, when no auto-reclose will occur. Thus, it is not reasonable to set a shorter time delay for normal distance zones than for the RAR overreach zone Z1B.

If the distance protection is operated with one of the carrier signal teleprotection systems described in Section 4.4, the overreach zone is controlled by the universal teleprotection interface, i.e. the interface determines if an undelayed trip (or with T1B) is permitted for faults in the overreach zone (i.e. to the limit of zone Z1B) and thus if tripping is simultaneous at both line ends. Whether the AR–function is ready for operation or not is irrelevant in this case, since the transmission system guarantees selectivity over 100 % of the line length **and** fast, simultaneous disconnection. Similar applies for directional comparison earth fault protection (refer to Section 4.9.4)

However, if the universal teleprotection is switched off or if the carrier device is faulty, then the AR–function determines which stage (Z1 or Z1B) is decisive for fast tripping. If no auto-reclosure is available (for example, circuit breaker not ready for operation), then the normal grading of the distance protection must be valid (i.e. instantaneous tripping only for faults within stage Z1) in order to maintain selectivity (Figure 4.52).

It is also possible to block the AR–function if the transmission system is not working.

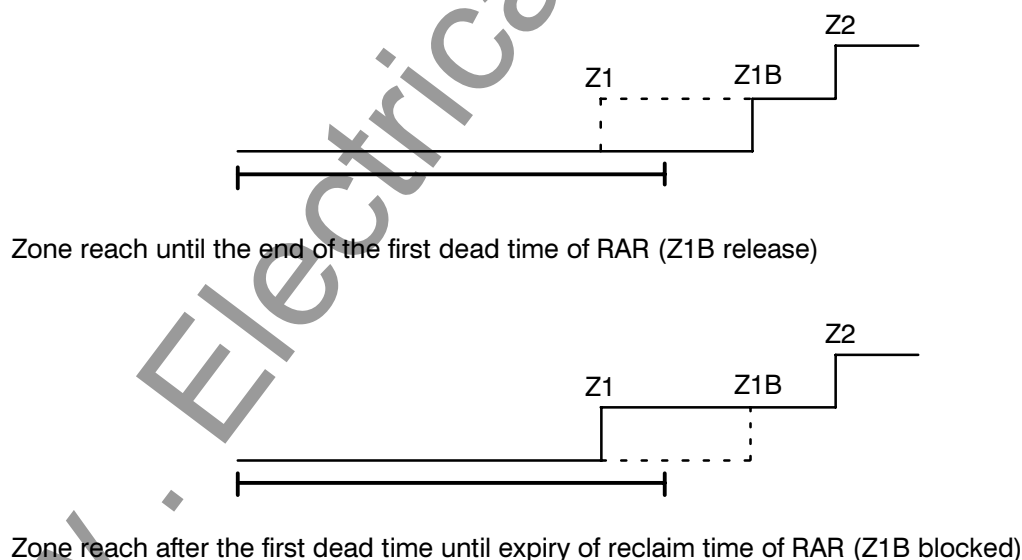


Figure 4.52 Zone reach control with the RAR–function with distance protection

7SA513 provides a selection procedure which can improve selectivity during single-pole auto-reclosure in those cases where no teleprotection mode is available or used ($3U_0$ processing, parameter 3423). A prerequisite is that the voltage transformers are installed at the line side (as seen from the circuit breaker).

When a single-phase short-circuit occurs near one end of the line, even the neighbouring lines are tripped, at first, because they recognize the fault in their overreaching zone Z1B (refer Figure 4.53). If the network is interconnected and the bus-bar B is fitted with at least one earthed transformer with a delta winding, the voltages will be symmetrized there. Thus, distinction can be made between the faulted line and the unfaulted lines after disconnection at the locations I, II, and III:

Since line B–C is interrupted at one end only, a reverse voltage appears from the non-interrupted line end B. Thus, the interrupted phase carries voltage again. Therefore, the zero sequence voltage measured at the relay location III is very small. If the relay at this location recognizes this, it can reclose immediately or with only a small dead time (which may cover the voltage measuring time). The healthy lines are in operation very soon by this procedure.

Line A–B has been interrupted single-pole at both ends. Thus, a significant zero sequence voltage is present, which identifies this line at both line ends as the faulty line. The normal dead time for single-pole auto-reclosure becomes valid.

Furthermore, 7SA513 presents the possibility to trip a persistent fault instantaneously over 100 % line length even after unsuccessful auto-reclosure: Since line A–B has been identified as the faulted line by the method previously described, the overreach zone can remain effective even after unsuccessful auto-reclosure so that a persistent fault can be cleared immediately even at line end I.

Additionally, different dead times can be set at both line ends so that one end – e.g. at the location I – is reclosed at first. If reclosure has been successful, then the healthy voltage is present also at the other line end II, so that the zero sequence voltage is very small: this line end can be reclosed with a slightly higher dead time. If the fault has remained (unsuccessful auto-reclosure), it can be instantaneously cleared at line end I; at line end II, a significant zero sequence voltage remains because one single pole of the circuit breaker is open: reclosure is blocked. The circuit breaker poles which are still closed can be tripped by the pole discrepancy protection or by 7SA513 itself. This method, by the way, saves the circuit breaker at location II because this CB need not switch onto the fault again.

The setting parameters for the auto-reclose functions at both line ends determine, at which line end the breaker is reclosed with normal dead time without zero sequence voltage check, and at which line end the zero sequence voltage is measured to decide whether reclosure takes place with a slightly higher dead time or not.

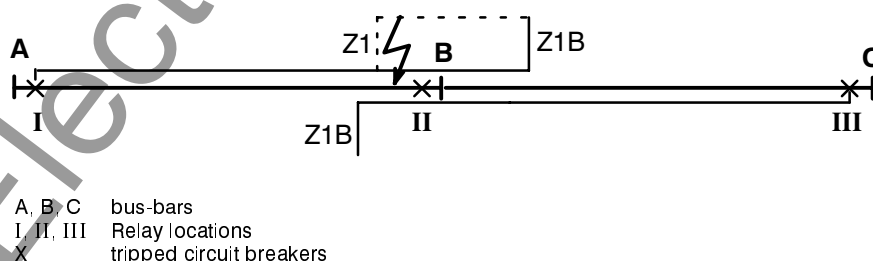
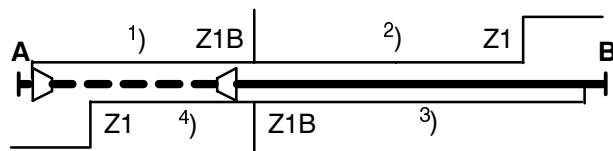


Figure 4.53 Example for the $3U_0$ procedure

If a line to be protected is composed of overhead line and cable sections, the controlled zones Z1B and Z1L can be used to distinguish between faults on the overhead section and cable faults, to a certain degree. Reclosure can be blocked for cable faults using setting parameters (refer to Section 6.3.4.1). If, for example, a cable section is followed by an overhead line section (refer to Figure 4.54), zone Z1B is set to cover the cable section, and reclosure is blocked for faults within Z1B but released for faults out of Z1B. Conversely, the other line end is set such that faults within zone Z1B, which nearly covers the overhead line section, are cleared with auto-reclosure whereas reclosure is blocked for fault out of zone Z1B. If further segregation is necessary (e.g. cable – overhead line – cable), distinction can be made by a further zone Z1L in similar way.



Substation A:

- 1) up to Z1B auto-reclosure blocked
- 2) out of Z1B auto-reclosure permitted

Substation B:

- 3) up to Z1B auto-reclosure permitted
- 4) out of Z1B auto-reclosure blocked

— overhead line section
 - - - cable section

Figure 4.54 Line with overhead and cable section

The weak-infeed trip function is slightly delayed for safety reasons. This delay is effective also when auto-reclose is expected. As this function operates only in conjunction with teleprotection, trip will be always selective.

The high current switch-onto-fault protection always operates instantaneously. By the option of the user, it can operate with auto-reclosure, without auto-reclosure, or auto-reclosure can be blocked when the high current protection has operated.

For overcurrent time protection (emergency mode and back-up protection), stage I>> operates as undelayed RAR stage. Before any reconnection, i.e. when the RAR-function is ready for operation, disconnection is effected with I>>. After an unsuccessful auto-reclosure attempt or when the AR-function is not ready for operation, stage I>> is blocked. In order to maintain selectivity, disconnection then is effected with I> or I_p after expiry of the delay time T_{I>} or according to the trip time characteristic. When the AR-function is blocked or switched off, I>> is also blocked. This can be changed in that the I>> stage is always effective, independent of the RAR.

The highly sensitive earth fault protection (if fitted) provides a separate RAR stage which can be briefly delayed or operate instantaneously. When delivered, this short-circuit protection is equally set to trip instantaneously when the RAR function is ready. This can be changed when setting the functional parameters.

The remaining protection functions – out-of-step tripping function, overvoltage protection, circuit breaker failure protection – always operate without auto-reclosure, therefore they have no AR stage.

The auto-reclose function provides an action time for each of RAR and DAR function which can separately set. The action times are started with any fault detection of a short-circuit protection which shall trigger the AR function. If the action time has elapsed before any trip signal is given, it is assumed that the fault is not on the protected line but on another line; auto-reclosure is not initiated.

All protection functions which can operate directional can block reclosure in case the fault lies in reverse direction. This applies also if a trip command is given for a reverse fault before the action time has elapsed.

4.10.2 Action times and reclaim times

It is often appropriate to prevent readiness for reclosure, when the fault has persisted for a specified time; for example, when it can be assumed that the arc has burnt itself in to such an extent, that there is no chance of natural quenching during the dead time.

Tripping after faults which are cleared in a delayed time should, for reasons of selectivity (refer to the foregoing section), also not result in an auto-reclosure.

The AR-functions of 7SA513 are provided with settable action times, separate for RAR and DAR, which are started by the fault detection signal. If, after expiry of the action time, no tripping signal has been given, reclosure is blocked.

The AR-functions of 7SA513 are provided with three settable reclaim times, which do not discriminate between RAR and DAR. Generally, the reclaim time is the time period during which no further reclosure attempt is permitted.

The reclaim time T-RECLAIM is started at every reclose command. If auto-reclosure has been successful, all functions reset to the quiescent condition after expiry of T-RECLAIM; any fault occurring after the expiry of the reclaim time is considered to be a new system fault. When a renewed trip command is given within this reclaim time, the next auto-reclose cycle is started if multi-shot AR is permitted; if no further AR cycle is permitted, a renewed trip command within the reclaim time is final: AR has been unsuccessful.

The lock-out time T-LOCK is the time period during which any further close command by the 7SA513 relay is locked after final disconnection. This applies for all closing attempts which are performed by the relay. If this time is set to ∞ , closing is locked out until the AR function is reset by energization of the binary input ">AR Reset". After the reset signal all functions reset to the quiescent condition.

A special reclaim time T-BLOCK MC is provided for manual closing. During this time reclosure is blocked after manual close; any trip command within this time will be a final trip.

4.10.3 Interrogation for readiness of the circuit breaker

Pre-condition for a reclose attempt after short-circuit interruption is that the circuit breaker is ready for at least one TRIP-CLOSE-TRIP cycle when the AR function is initiated (i.e. at the instant of trip command). The readiness information from the breaker has to be transmitted to the device via a binary input. In case that such readiness information is not available, interrogation can be suppressed since otherwise no auto-reclose would be possible at all.

When single-shot auto-reclosure is performed it is sufficient to interrogate the breaker readiness one single time before initiation of AR. As, for example, the air pressure for breaker operation will collapse during the trip execution, no further interrogation should be carried out.

When multi-shot auto-reclosure is used, it is advantageous to interrogate breaker readiness not only at the instant of the first trip command but also before every reclose attempt or before every other reclose attempt. If this facility is selected, reclosure is blocked as long as the circuit breaker is not ready for another TRIP-CLOSE sequence.

The recovery time of the circuit breaker can be supervised by the 7SA513 relay. This supervision time T-CB-SUPV will run as long as the circuit breaker does not inform about readiness. In this case, the dead time may be extended when the breaker is not ready after expiry of the set dead time. But if the breaker is not yet ready after expiry of the supervision time then reclosure is blocked. This blocking is canceled only after the lock-out time T-LOCK (refer to Section 4.10.2) has elapsed. If T-LOCK is set to ∞ , closing is locked out until the AR function is reset by energization of the binary input ">AR Reset". After the reset signal all functions reset to the quiescent condition.

4.10.4 Three-pole auto-reclosure

When the AR function is ready for operation, the short-circuit protection trips three-pole for all faults within the stage valid for RAR (e.g. the distance protection in zone Z1B). The AR-function is initiated provided tripping occurs within the action time (refer to Section 4.10.2). With fault clearance, the (settable) dead time RAR T-3POL commences for three-pole RAR. After this, the circuit breaker receives a closing command, the duration of which is settable. Simultaneously, the (settable) reclaim time T-RECLAIM (Section 4.10.2) is started.

If the fault is cleared (successful RAR), the reclaim time T-RECLAIM, Section 4.10.2) expires and all functions reset to the quiescent condition. The network fault is terminated.

If the fault has not been cleared (unsuccessful AR) then the short-circuit protection carries out a final disconnection in the stage that is valid without RAR; when the universal teleprotection interface is in operation with distance protection, then Z1B can remain effective for distance protection – see Section 4.4. Also, every fault during the reclaim time will result in final disconnection.

After unsuccessful AR (final disconnection) the lock-out time T-LOCK (Section 4.10.2) is started. For this time any close command from 7SA513 is locked.

The above sequence comes into effect with single-shot RAR. With 7SA513, multiple AR-attempts (up to 9 DAR-shots, refer to Section 4.10.8) are also possible. Additionally, it is possible to skip the RAR cycle by a signal via a binary input of the device. In this case only DAR is effective (refer to Section 4.10.8).

4.10.5 Single-pole auto-reclosure

When only single-pole auto-reclosure is carried out and the RAR function is ready for reclose, the short-circuit protection trips single-pole if a single-phase fault is detected in the stage valid for RAR. For distance protection e.g. zone Z1B is effective only for single-phase faults. The relay can also be set to trip single-pole in case of two-phase faults without earth connection.

After occurrences of multi-phase faults the short-circuit protection trips finally, three-pole after the time that is valid without RAR. For distance protection e.g. zone Z1 is decisive not Z1B (when the universal teleprotection is in operation, zone Z1B can remain effective – see Section 4.4). Every three-pole trip is a final trip. The lock-out time T-LOCK (Section 4.10.2) is started. For this time any close command from 7SA513 is locked.

After a single-pole trip, the AR-function is initiated provided tripping occurs within the action time (Section 4.10.2). With the clearance of the fault, the (settable) dead time RAR T-1POL for single-pole RAR commences. After this, the circuit breaker receives a closing command, the duration of which is settable. Simultaneously, the (settable) reclaim time T-RECLAIM (Section 4.10.2) is started. If auto-reclosure is blocked during the dead time after single-pole trip, then the breaker can be tripped three-pole immediately (selectable).

If the fault is cleared (successful RAR), the reclaim time T-RECLAIM, Section 4.10.2) expires and all functions reset to the quiescent condition. The network fault is terminated.

If the fault has not been cleared (unsuccessful AR) then the short-circuit protection carries out a final disconnection in the stage that is valid without RAR; when the universal teleprotection interface is in operation with distance protection (see Section 4.4) or when the U_0 processing feature is operative (see Section 4.10.1), then Z1B can remain effective for distance protection. Also, every fault during the reclaim time will result in final disconnection.

After unsuccessful AR (final disconnection) the lock-out time T-LOCK (Section 4.10.2) is started. For this time any close command from 7SA513 is locked.

In this mode, only single-shot auto-reclosure is possible.

4.10.6 Single- and three-pole auto-reclosure

When the AR function is ready for operation, the short-circuit protection trips single-pole for single-phase faults and three-pole for multi-phase faults. The relay can also be set to trip single-pole in case of two-phase faults without earth connection. The stage valid for RAR (e.g. the distance protection zone Z1B) is valid for all types of fault.

The AR-function is initiated provided tripping occurs within the action time (refer to Section 4.10.2). With fault clearance, the (settable) dead time RAR T-1POL commences for single-pole RAR, or the separately settable dead time RAR T-3POL for three-pole RAR. After this, the circuit breaker receives a closing command, the duration of which is settable. Simultaneously, the (settable) reclaim time T-RECLAIM (Section 4.10.2) is started.

If the fault is cleared (successful RAR), the reclaim time T-RECLAIM, Section 4.10.2) expires and all functions reset to the quiescent condition. The network fault is terminated.

If the fault has not been cleared (unsuccessful AR) then the short-circuit protection carries out a final disconnection in the stage that is valid without RAR; when the universal teleprotection interface is in operation with distance protection (see Section 4.4) or when the U_0 processing feature is operative (see Section 4.10.1), then Z1B can remain effective for distance protection. Also, every fault during the reclaim time will result in final disconnection.

After unsuccessful AR (final disconnection) the lock-out time T-LOCK (Section 4.10.2) is started. For this time any close command from 7SA513 is locked.

The above sequence comes into effect with single-shot RAR. With 7SA513, multiple AR-attempts (up to 9 DAR-shots, refer to Section 4.10.8) are also possible. Additionally, it is possible to skip the RAR cycle by a signal via a binary input of the device. In this case only DAR is effective (refer to Section 4.10.8).

4.10.7 Treatment of multiple and evolving faults for single-pole auto-reclosure

When single-pole or single- and three-pole auto-reclosures are carried out in the network, special attention has to be directed to multiple and evolving faults.

Multiple faults are here defined as faults which practically simultaneously (before clearance of the first detected fault) affect more than one line loop.

Evolving faults are those which, after clearance of the first-detected fault, occur during the dead time of an AR cycle.

Particular interest for the treatment by the auto-reclose function arises, when, in the first case, two single-phase earth faults occur on different lines, for example, on two parallel lines. In the example given in Figure 4.55, the protection relays on all four line ends recognize a fault L1-L2-E, i.e. a two-phase earth fault. Since each of the two lines has suffered a single-phase short-circuit, single-pole auto-reclosure on each of the lines would be desirable.

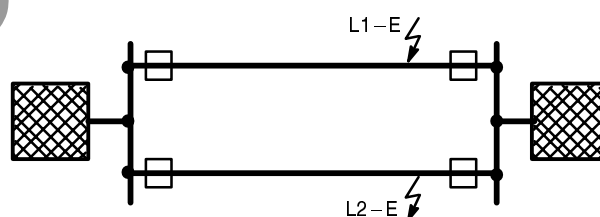


Figure 4.55 Multiple fault on a double line

In some case, however, it would be more favourable to disconnect the faults three-pole: for example, when the double line is located close to a large generator block (Figure 4.56). To the generator, the two single-phase short-circuits appear to be a double earth fault, with the corresponding dynamic stress on the turbine shaft.

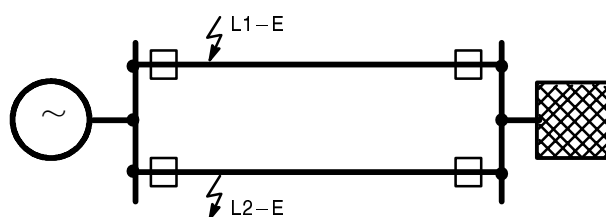


Figure 4.56 Multiple fault on a double line

7SA513 takes these two factors into account, in that the decision, whether the fault is single-phase (with single-pole AR) or multi-phase (with three-pole AR or final disconnection) can either be made by tripping command (favourable for the first case) or by fault detection (favourable for the second example).

Equally, 7SA513 allows several possibilities for the treatment of **evolving faults**, dependent upon the requirements of the network:

The criterion for recognition of evolving faults can be selected to be either *TRIP COMMAND* in another phase during the dead time or any further *FAULT DETECTION*.

The reaction of the AR-function to a recognized evolving fault can also be selected:

a) *NO* special reaction to evolving faults:

As soon as an evolving fault has been detected, the unit switches to the three-pole auto-reclosure cycle. Every trip will be three-pole. If three-pole auto-reclosure is permitted, then the dead time for three-pole auto-reclosure begins simultaneously with the interruption of the evolving fault. When the dead time has expired, the circuit breaker receives the command to close. The further sequence is the same as for single- and three-pole auto-reclosure.

The total dead time in this case consists of the dead time for the single-pole auto-reclosure, which has expired when the evolving fault is interrupted, plus the dead time for the three-pole auto-reclosure. This is useful because only the dead time for three-pole auto-reclosure is of importance for the stability of the network.

b) Blocking of reclosure, after evolving faults *ALWAYS*:

As soon as an evolving fault has been detected, reclosure is blocked. Every trip will be three-pole regardless whether three-pole AR is permitted or not.

c) Blocking, after evolving faults, after an adjustable discrimination time, $>T-DISCR$:

The discrimination time starts simultaneously with the dead time. It is used to discriminate from which point in time an evolving fault is identified as such. If the evolving fault occurs before the expiry of the discrimination time, the device is switched to a three-pole AR-cycle (if permitted), as under a). If however, the evolving fault occurs after the discrimination time has expired, reclosure is blocked, as under b).

4.10.8 Multi-shot auto-reclosure

The internal auto-reclose feature in 7SA513 will also permit multi-shot reclosure, up to 9 consecutive DAR-cycles. The second and each further cycle are always three-pole. An individual zone Z1L with delay time T1L is available for the distance protection. Also the action time and several dead times can be independently set for these DAR cycles.

Different numbers of DAR cycles can be set for single-phase faults and multi-phase fault; tripping command is, nevertheless, always three-pole. The set number of DAR cycles does not include the first RAR cycle.

Dead times can be individually set for the first three AR cycles; further cycles operate with the dead time of the third cycle. In this case, all AR cycles are decisive, i.e. also the RAR cycle. The RAR cycle operates with its dead time (RAR T-1POL for single- or RAR T-3POL for three-pole RAR), the first DAR is the second cycle with the dead time for the second cycle DAR T3POL2, etc.! If no RAR cycle has occurred (e.g. RAR blocked) then the first DAR cycle operates with the dead time for the first cycle DAR T3POL1, etc.

Each new pick-up restarts the action time DAR T-ACT. within which a tripping command must occur. After fault clearance, the dead time begins. At the end of this, the circuit breaker is given a new closing command. Simultaneously, the reclaim time T-RECLAIM (Section 4.10.2) is started.

As long as the permitted number of cycles has not been reached, the reclaim time is reset by each new pick-up and recommences with the next closing command.

If one of the cycles is successful, that is, after reclose the fault is no longer present, the reclaim time T-RECLAIM equally runs out and all functions return to the quiescent condition. The network fault is cleared.

If none of the AR-cycles has been successful then the short-circuit protection carries out a final disconnection after the last permissible cycle. The lock-out time T-LOCK (Section 4.10.2) is started. For this time any close command from 7SA513 is locked.

The subsequent cycles (DAR) can be blocked by a binary input independently of the function of the RAR cycle.

4.10.9 Connection of an external auto-reclose system

7SA513 can operate in conjunction with an external auto-reclose system. The internal AR–function cannot then be allowed to operate, it must be programmed to be ineffective (de-configured, see Section 5.4.2).

Signal exchange between 7SA513 and the external auto-reclose device must be made via the binary inputs and outputs of the relay. The following list may be regarded as a recommendation.

Binary inputs:

383 >RAR Release The external AR device releases the RAR stages of all short-circuit protection functions within 7SA513 which shall operate with AR (e.g. zone Z1B of the distance protection) via this binary input.

382 >Only 1pole The external AR device is programmed to reclose only in case of single-pole tripping. The RAR stages of the short-circuit protection functions of 7SA513 are released by binary input 383 only when a single-phase fault is detected; when a multi-phase fault is detected the RAR stages are not released.

381 >1p Trip Perm The external AR device permits single-pole tripping, i.e. is ready for reclosure after single-pole trip. This function is the logical inversion of three-pole coupling. If this binary input is not allocated then only three-pole tripping can occur.

384 >DAR Release The external AR device releases the DAR stage Z1L of the distance protection (only relevant when multi-shot auto-reclosure is used).

Binary outputs:

501 DeviceFltDet General fault detection of the device.

515 Dev. Trip 3p Three-pole trip command of the device.

512 Dev. Trip L1 Single-pole trip command L1 of the device.

515 Dev. Trip 3p Three-pole trip command of the device.

513 Dev. Trip L2 Single-pole trip command L2 of the device.

515 Dev. Trip 3p Three-pole trip command of the device.

514 Dev. Trip L3 Single-pole trip command L3 of the device.

In order to achieve a phase segregated trip signal, the single-pole trip command for each pole and the three-pole trip command must be combined to the phase trip signal.

Dependent of the features of the external auto-reclose device it is also possible to combine the three single-pole trip commands (FNo 512, 513, 514) to a signal "single-pole trip"; the three-pole trip command (FNo 515) gives the signal "three-pole trip".

For three-pole AR the general fault detection and tripping signals are, of course, sufficient.

Figure 4.57 shows a connection example for the interconnection between 7SA513 and an external AR–system using a program selector switch.

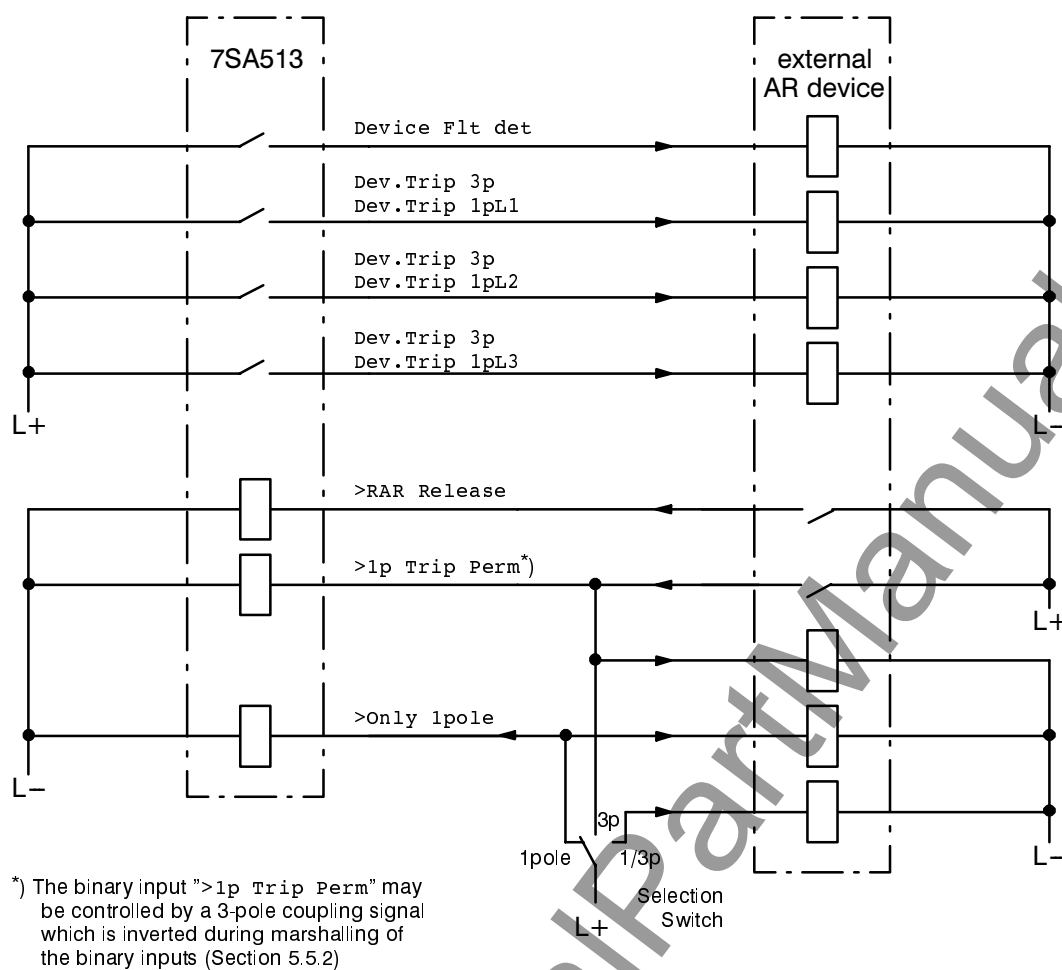


Figure 4.57 Example of connections with external AR-system

4.10.10 Control of the internal auto-reclose function by an external protective relay

If 7SA513 is fitted with an internal AR-function, this can be controlled from an external protective device. This is applicable, for example, for line ends with duplicated protection or additional back-up protection, when a second protective device is used for the same line end and shall operate with the AR-function incorporated in 7SA513.

Signal exchange between 7SA513 and the external auto-reclose device must be made via the binary inputs and outputs of the relay. The following list may be regarded as a recommendation.

The internal AR-function can be started via the binary inputs

2711 >Start AR	general start signal for AR,
2712 >Trip L1 AR	tripping command L1 for AR,
2713 >Trip L2 AR	tripping command L2 for AR,
2714 >Trip L3 AR	tripping command L3 for AR.

The general start signal is the criterion for the start of the action times. At the issue of the tripping command it is decided whether the dead time for single-pole AR or three-pole AR will be effected, or if, for three-pole tripping, reclosure will be blocked (dependent upon the set AR program). A possibility for three-pole coupling should be available externally.

It is also possible to use the single-pole and three-pole trip signals instead of the phase dedicated trip signals provided the external protection relay disposes of these outputs. That means, the following binary inputs of 7SA513 are used:

2711 >Start AR	general start signal for AR,
2715 >Trip 1p AR	tripping command single-pole for AR,
2716 >Trip 3p AR	tripping command three-pole for AR.

If *only* three-pole AR is to be carried out, it is sufficient to use the binary input ">Trip 3p AR" (FNo 2716) for the tripping signal.

To couple the external relay three-pole and to release its overreach zones, the following output functions are suitable:

2864 1p Trip Perm.	internal AR is ready for single-pole reclosure (logical inversion of three-pole coupling),
2817 RAR Zone Rel.	internal AR is ready for an RAR cycle, i.e. releases RAR zone for the external protection relay,
2837 DAR Zone Rel.	internal AR is ready for a DAR cycle, i.e. releases DAR zone for the external protection relay,
2815 RAR 1p Prog.	internal RAR programmed to single-pole reclosure only, i.e. will reclose only after single-pole trip.

Depending on the actual philosophy and the used functions of the auto-reclosure function, one or the other binary input or output may be omitted. For example, general start and general trip signal of the protection relay, and the "RAR Zone Rel." output, are sufficient when only three-pole auto-reclosure is used.

4.10.11 Two protection relays with two auto-reclose devices

If a feeder is equipped with duplicated protection and each protection relay should control its own auto-reclose device, certain exchange of information is necessary between the two combinations. This is shown, as an example, in Figure 4.58. Three-

pole coupling should be arranged with an external coupling unit which interacts directly with the circuit breaker trip circuits. This ensures three-pole tripping under all circumstances of multi-pole faults!

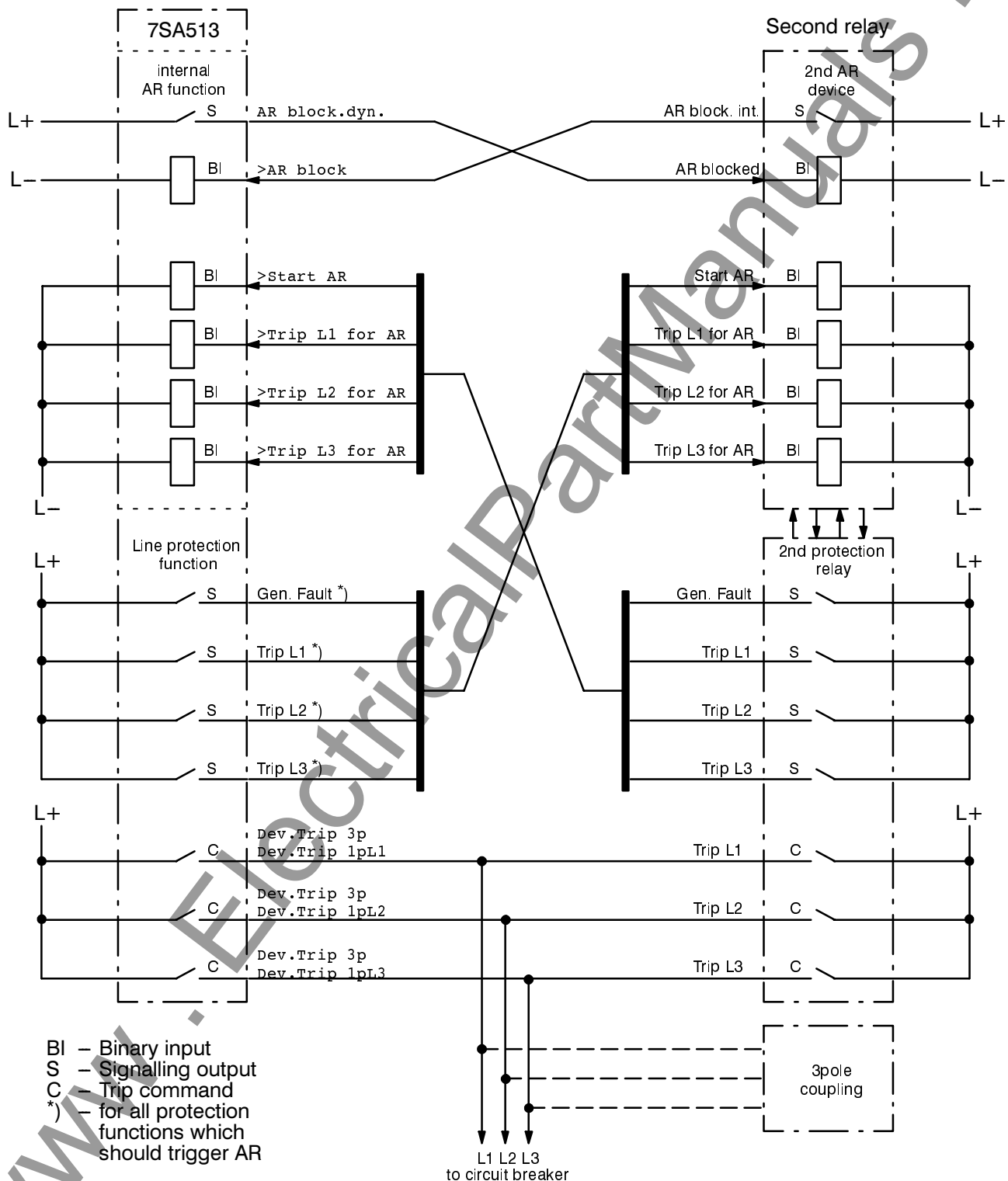


Figure 4.58 Connection example for 2 protection relays with 2 auto-reclosure devices

4.11 Synchronism and voltage check (optional)

The synchronism and voltage check function will ensure, when switching a line circuit onto a bus-bar, that the stability of the network will not be endangered. The function can be programmed to perform the synchro-check only for auto-reclose, only for manual close, or for both cases. Different permission criteria can also be programmed for automatic reclosure and for manual closure.

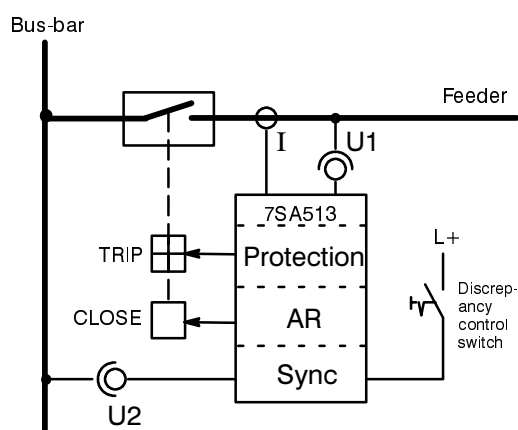


Figure 4.59 Synchronism and voltage check on closing

For comparison of the two voltages, the synchro-check element uses the feeder voltage U_1 and an additionally connected bus-bar voltage U_2 . The latter can be any convenient phase-earth or phase-phase voltage from the bus-bar voltage transformers.

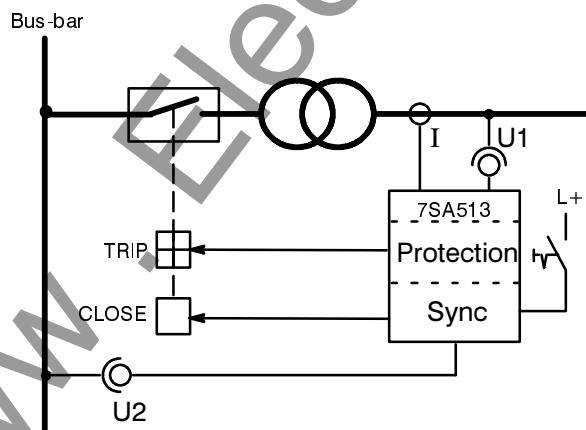


Figure 4.60 Synchronism and voltage check across transformer

When a power transformer lies between the feeder voltage transformer and the bus-bar voltage transformer (Figure 4.60), its vector group can be matched at the 7SA513 relay, so that no external matching transformers are necessary.

The synchro-check function in 7SA513 normally operates in conjunction with the integrated auto-reclose and manual close functions. It is however possible to operate with an external protection relay and/or with an external auto-reclose relay. In this case, the signal exchange between the devices must be performed through binary inputs and outputs.

Furthermore, synchronous or asynchronous switching is possible. Synchronous switching means that the closing command is given as soon as the critical values (voltage magnitude difference ΔU , angle difference $\Delta \varphi$ and frequency difference Δf) lie within the set tolerances. For asynchronous switching, the device calculates the correct timing of the closing command from the angle difference $\Delta \varphi$ and the frequency difference Δf such that the voltages at the bus-bar and the feeder circuit are exactly the same at the instant that the circuit breaker contacts touch. For that purpose the circuit breaker closing time must be programmed into the relay. For synchronous and asynchronous switching, different frequency difference limits can be programmed.

The synchro-check function operates only when it is requested to do so. This request can come from the internal auto-reclose function, from the manual closing command or from an external auto-reclose relay by binary input.

The synchro-check function gives permission for passage of the closing command.

Optionally, a closing command can be given by the synchro-check function. This can control the closing coil of the circuit breaker, or AR closing command and synchro-check closing command can be connected in series.

The permission time window is limited by an adjustable synchronous monitoring time. Within this period, the programmed conditions must have been met otherwise closing permission will not be given. A new synchro-check sequence requires a new request.

4.11.1 Operating modes

The closing check procedure can be selected from the following functions:

- SYNCHR. = Release at synchronism, that is, when the critical values ΔU , $\Delta \varphi$ and Δf lie within the set limits.
- $U1 > U2 <$ = Release for energized line ($U1 >$) and de-energized bus-bar ($U2 <$).
- $U1 < U2 >$ = Release for de-energized line ($U1 <$) and energized bus-bar ($U2 >$).
- $U1 < U2 <$ = Release for de-energized line ($U1 <$) and de-energized bus-bar ($U2 <$).
- OVERRIDE = Release without any check.

Each of these conditions can be switched to effective or not effective; combinations are also possible (e.g. release when $U1 > U2 <$ or $U1 < U2 >$ are satisfied). Combination of OVERRIDE with other parameters is, of course, not meaningful.

The release conditions can be set individually for automatic and for manual closing, e.g. one can permit manual closing at synchronism *or* dead line, whilst before an auto-reclose, at one line end *only* freedom from voltage and, at the other, *only* synchronism will be checked.

4.11.2 Dead-line or dead-bus switching

For release of the closing command to energize a volt-free line from the bus-bar, the following conditions are checked:

- Does the voltage $U1$ lie below the set value $U <$?
- Does the voltage $U2$ lie above the set value $U >$?

When the conditions are satisfied, the closing command is released. The duration of the command can be adjusted.

Corresponding conditions apply when switching a live line onto a dead bus-bar or a dead line onto a dead bus-bar.

4.11.3 Switching at synchronism

To release a closing command, the following conditions are checked:

- Does the voltage $U1$ lie above the set value $U >$?
- Does the voltage $U2$ lie above the set value $U >$?
- Is the voltage magnitude difference $||U1| - |U2||$ within the permissible tolerance ΔU ?
- Is the angle difference $|\varphi1 - \varphi2|$ within the permissible tolerance $\Delta \varphi$?
- Is the frequency difference $|f1 - f2|$ within the permissible tolerance Δf ?

When the conditions are satisfied, the closing command is released. The duration of the command can be adjusted.

4.11.4 Asynchronous switching

For release of a closing command, the following conditions are checked:

- Does the voltage $U1$ lie above the set value $U >$?
- Does the voltage $U2$ lie above the set value $U >$?
- Is the voltage magnitude difference $||U1| - |U2||$ within the permissible limit ΔU ?
- Is the frequency difference $|f1 - f2|$ within the permissible difference Δf , but larger than Δf_{sync} ?

When the conditions are satisfied, the device calculates the time to the next instant of synchronism, from the rate of change of angle and the frequency difference. The closing command is then released at the instant that the closing time of the breaker equals the difference between instant of command and the next instant of synchronism. The duration of the command is adjustable.

4.12 Back-up overcurrent time protection

The back-up overcurrent time protection of 7SA513 operates as voltage independent short-circuit protection. Its functions can be blocked or released by external switch-gear criteria via binary inputs. For example, the high current stage could be used for stub protection in 1½ circuit breaker arrangements, where it should be effective only when the line disconnector is open.

The back-up overcurrent time protection can also operate, e.g., as the only short-circuit protection when, during first commissioning, voltage transformer output is not yet available.

When the relay is used for line ends with series capacitors, the high-current stage could be used as fast short-circuit protection when a short-circuit occurs behind the capacitor and the protection spark-gap fails to flash over. Thus, the capacitor is prevented from impermissible stress.

Various matching possibilities exist for several applications as the protection has four stages, two for each of phase or earth faults which can be set independently.

The back-up overcurrent time protection can be used as definite time or inverse time overcurrent protection. Three standardized inverse time characteristics according to IEC 60255–3 are available for inverse time mode. The trip time characteristics and the applied formulae are given in the Technical data, refer to Figure 3.1, Section 3.8.

The selected overcurrent time characteristic can be superimposed by a high-set instantaneous or definite time delayed stage.

The characteristics can be individually set for phase currents and for earth currents. In total, the following stages are available:

- $I_{ph}>>$ High current limit value threshold for phase currents,
- $T_{I>>}$ associated delay time.
- $I_{ph}>$ Definite time limit value threshold or
 I_p inverse time base value for phase currents,
- $T_{I>}$ associated delay time or
 T_p time multiplier.
- $I_E>>$ High current limit value threshold for earth currents,
- $T_{IE>>}$ associated delay time.
- $I_E>$ Definite time limit value threshold or
 I_{Ep} inverse time base value for earth currents,
- $T_{IE>}$ associated delay time or
 T_{Ep} time multiplier.

All stages are independent from each other and can be set individually.

Under conditions of manual closing onto fault, the back-up overcurrent protection can also provide a rapid trip. A choice can be made whether the $I>>$ stages or the $I>/I_p$ stages are decisive for an undelayed trip, i.e. the associated time delay is bypassed for this condition.

The back-up protection can also be used in conjunction with auto-reclosure. In these cases the $I>>$ stages becomes valid before reclosure.

4.13 Overvoltage protection

Overvoltage protection serves mainly to detect standing overvoltages on weakly loaded long high voltage transmission lines. These voltage rises are caused by the capacitive charge on the line and are at their greatest on unloaded lines (Ferranti effect).

To avoid these overvoltages compensation reactors are often used to compensate for the line capacitance and to reduce the effect. If these shunt reactors are disconnected, for example, because of fault clearance, the insulation of the line can be seriously endangered; the line must be rapidly disconnected.

The overvoltage protection feature in 7SA513 has two stages, a (rapid) $U >>$ stage and a (delayed) $U >$ stage. The $U >$ stage has adjustable compounding facility. Each stage can be individually activated or de-activated.

4.13.1 $U >$ stage with adjustable compounding

For the $U >$ stage, the base frequency of the positive sequence component is filtered out of the measured voltages. If the set value is exceeded, a command, with adjustable delay, is generated. This stage detects steady-state overvoltages.

The adjustable compounding calculates, also from the positive sequence component, the voltage at the other line end. For this purpose the line data are fed into the relay when parameterizing (inductance, capacitance, phase angle, length). Compounding is not allowed at series compensated lines.

From the voltage and current flowing at the local line end, the voltage at the remote line end is calculated using a Π equivalent:

$$\underline{U}_{\text{end}} = \underline{U}_{\text{meas}} - \left(\underline{I}_{\text{meas}} - j\omega \frac{C_L}{2} \underline{U}_{\text{meas}} \right) \cdot (R_L + j\omega L_L)$$

where:

- $\underline{U}_{\text{meas}}$ voltage measured at local line end
- $\underline{I}_{\text{meas}}$ current measured at local line end
- C_L operational capacity of the line
- R_L ohmic line resistance
- L_L line inductance
- $\underline{U}_{\text{end}}$ calculated voltage at other line end

4.13.2 Rapid $U >>$ stage

For the $U >>$ stage, either the line-line voltages or the line-earth voltages are monitored (selectable). From each of the three measured values, the base frequency is filtered out numerically so that harmonics or transient voltage peaks are extensively suppressed.

For pick-up of this stage one can select whether only *one* of the three voltages or *all* three voltages must exceed the setting. The first case corresponds to an *OR*-coupling, the second to an *AND*-coupling of the three overvoltage measuring systems.

Delay times can be set individually for both open or closed circuit breaker. This allows, for example, a very short or even no delay time to be set for closed breaker where one can expect stable conditions; for open breaker, where one must expect heavy transient overvoltages during switching operation at the other line end, a correspondingly longer delay can be set. For this, the position of the circuit breaker must be fed to the relay via a binary input, which is processed according to Section 4.17.

When switching the local breaker, the $U >>$ -stage can be momentarily blocked so that it does not sense the heavy transient. For this, also the position of the circuit breaker is considered (for further details refer Section 4.17).

4.13.3 Tripping

Since the cause of the overvoltages cannot always be cleared by opening the breaker at the local line end, the tripping command can be transmitted to the remote end. The device can be so programmed for each of the overvoltage stages that the tripping command will be transmitted to the local, the remote, or both line ends. In the last two cases, an inter-tripping facility is required (e.g. power line carrier, radio wave, or optical fibre).

4.14 Distance-to-fault location

Distance-to-fault measurement before clearance of the fault is an important addition to the function of a line protection relay. Availability of the line for energy transmission in the network can be increased by rapid location of point of fault and repair of any resultant damage.

Distance-to-fault location in line protection relay 7SA513 is a function independent of distance protection. It possesses independent measured value stores and its own filter algorithms. The short-circuit protection provides only a start-to-measure command in order to determine the valid measurement loop and the most favourable time interval for measured value storage.

Normally, the fault location function is started by the tripping command from the short-circuit protection. Paired values of short circuit current and short circuit voltage, taken at intervals of $\frac{1}{20}$ of a cycle and stored in a circulating buffer, are frozen 15 ms later which, even with extremely fast circuit breakers, ensures that the measurements are not distorted by the tripping transients. Filtering of the measured values and quantity of the impedance calculations are automatically matched to the number of incoming value pairs from the time of fault inception to 15 ms after tripping command.

Fault location can also be initiated via a binary input. Thus, calculation is possible when a different protection device effects clearance of a short circuit. Nevertheless, distance protection must have picked up. Further, fault calculation can be started without receipt of any tripping command. In this case, the start-to-measure criterion is fault detection by the 7SA513 relay.

Evaluation of the measured values occurs after the fault has been cleared. From the stored and filtered values at least three resultant pairs for R and X are determined. If less than three resultant pairs are available, no fault location is given. From the resultant pairs, average value and standard deviation are calculated. After elimination of "exceptions", which are recognized by their excessive difference from the standard deviation, another average is again calculated. This average for X is taken as fault reactance and proportional to the fault distance.

As a result of the fault location calculation the following outputs are given:

- the short circuit loop, from which the fault reactance is determined,
- the reactance per phase in Ohms primary and secondary,
- the resistance per phase in Ohms primary and secondary,
- the fault distance in km line length proportional to the reactance, calculated on the basis of the set unit reactance of the line,
- the distance to fault in % of the line length, calculated on the basis of the set unit reactance and the set line length.

Note: Calculation of the distance in km and percent can only be applicable to homogeneous line lengths. But, if the line is made up of sections with differing reactance values, e.g. overhead line – cable combinations, the distance to fault can still be calculated manually from the reactance determined by the fault location, if the line characteristics are known.

With earth faults on parallel circuit lines the loop equation used for calculation of the impedance (see Section 4.2.3) is influenced by the coupling of the earth impedances of **both** conductor systems. If no special measures are taken this will lead to measurement errors in the result of the impedance calculation. The relay is therefore fitted with a parallel line compensation. This takes into account the earth current of the parallel line in the line equation and thus compensates for the influence of the coupling. The method is the same as described for distance measurement in Section 4.2.3.2. For this purpose, this earth current must be fed into the relay.

The parallel line compensation is valid only for faults on the protected line. For faults beyond the protected zone and faults on the parallel line, compensation is not possible.

4.15 Circuit breaker failure protection

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

Whenever a protection function issues a trip command to the breaker, a timer T-B/F, in the breaker failure protection module, is started. The timer runs as long as a tripping command is present and current continues to flow through the breaker poles (Figure 4.61).

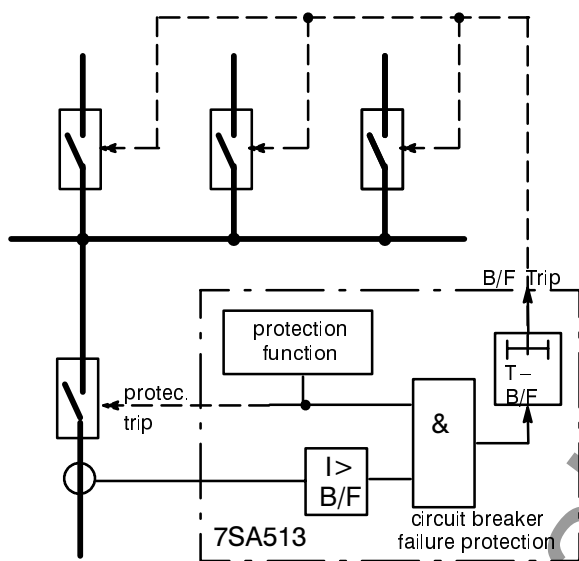


Figure 4.61 Simplified function scheme of circuit breaker failure protection

Normally, the breaker will open and interrupt the fault current. The current monitoring stage quickly resets (typical 10 ms) and stops the timer T-B/F.

If the tripping command is not carried out (breaker failure case), current continues to flow and the timer runs to its set value. The breaker failure protection feature then issues a command to trip the back-up breakers and interrupt the fault current.

The reset time of the feeder protection is unimportant because the breaker failure feature itself recognizes the interruption of the current.

4.15.1 Current flow monitoring and delay

The current monitoring feature reacts to the fundamental frequency of the current in the circuit. Each of the three phase currents are numerically filtered and compared with the set value.

A fourth threshold monitors the residual current. This does not have any direct influence on the function of the breaker failure feature but it allows a 2-out-of-4 comparison to be made. This means that the timer allocated to any phase cannot be started unless current is present in at least one of the other phases, or an earth (residual) current is detected.

When a phase-to-phase fault occurs, current flows in at least two poles of the breaker; with a single phase fault, a residual current is always present (residual sum of the phase currents) if only one pole carries current. Thus, on the one hand, detection of the fault current and start of the timer is guaranteed. On the other hand, the 2-out-of-4 logic provides high security against false operation.

The delay times are allocated to each phase. Thus the current in each breaker pole is monitored and, even during a single pole auto-reclose sequence, only the concerned pole will be monitored for reliable current interruption.

Particular features apply for recognition of the instant of interruption. With sinusoidal currents, current interruption is detected after approx. 5 ms. Even with aperiodic d.c. current components in the fault current and after interruption (e.g. with linear current transformers) the interruption is very quickly recognized. However, if the current transformers are saturated by the d.c. component in the fault current, it can take up to one a.c. cycle before the disappearance of the primary current is reliably detected.

4.15.2 Reaction to tripping commands when there is no fault current

For protection functions for which the tripping criteria are not dependant on current (e.g. overvoltage protection), current flow is not a reliable criterion for proper operation of the breaker.

In the such cases, the circuit breaker position can only be read from an auxiliary contact on the breaker. Therefore, instead of monitoring the current, the condition of the auxiliary contact is monitored. For that purpose, the output from the auxiliary contact must be fed to a binary input on the relay (refer also to Section 4.17).

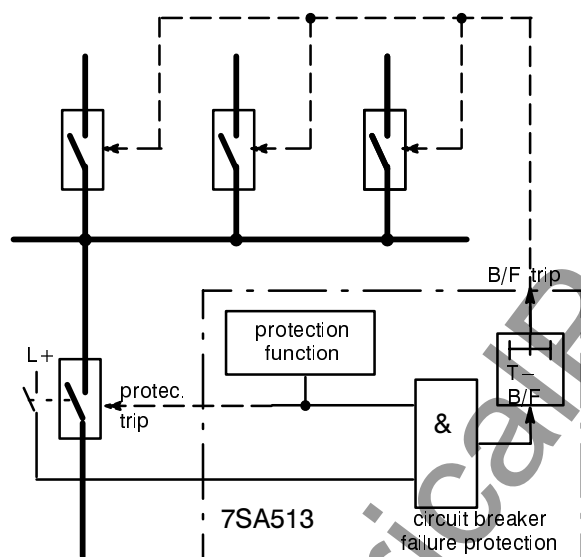


Figure 4.62 Simplified function scheme of circuit breaker failure protection controlled by circuit breaker auxiliary contact

If the auxiliary contact is not connected, failure of the breaker cannot be detected, and the breaker failure protection function will not operate in this case.

When the circuit breaker auxiliary contact is connected, it is used as an additional criterion even for tripping by a short-circuit protection function. If it is not connected, the breaker failure protection feature still operates correctly, with current flow monitoring as described 4.15.1.

4.16 Circuit breaker trip test

Feeder protection relay 7SA513 allows checking of the tripping circuits and the circuit breaker by a simple method. By means of the incorporated auto-reclose feature, a TRIP – CLOSE test sequence is possible. This sequence can also be initiated with an external auto-reclose device.

A precondition for any test sequence is that no protection function is energized. As long as an auxiliary contact on the breaker is connected to a binary input on the relay (cf. Section 4.17), the test sequence can only be started when the breaker is closed three-pole. This additional security should not be defeated.

Additionally, for a TRIP – CLOSE cycle, the conditions for an auto-reclose sequence must be fulfilled (circuit breaker ready, auto-reclose not blocked). This applies equally to initiation from an external device.

The test sequence can be started from the operator keyboard or via the operator interface.

For a straight forward trip test, the device issues a three-phase trip command.

With a TRIP – CLOSE test sequence, tripping can be three-pole or single pole. A three-pole test is possible only when the AR unit (internal or external) also allows three 3-pole reclose. Similarly, single-pole test is possible only when the AR unit (internal or external) also allows a single-pole auto-reclose. In the latter case, a test sequence TRIP L1 – CLOSE – TRIP L2 – CLOSE – TRIP L3 – CLOSE can be initiated.

The test sequence is monitored by the position of the breaker, as given by its auxiliary contacts (when connected). If the breaker does not respond to a command, the test sequence will be aborted and an appropriate message is displayed. The sequence can be followed on the indicator panel or a personal computer.

The test sequence can also be started by a binary input. Additionally, a pure trip test without auto-reclosure is possible via binary input even when the internal or an external auto-reclose unit is available and ready for operation.

4.17 Processing of the circuit breaker position

Some of the protection and supplementary functions require information about the position of the circuit breaker to operate optimally. This is valid for

- switch-onto-fault detection for distance protection (cf. Section 4.2.7),
- the echo function of the teleprotection functions with distance protection (cf. Section 4.4.10),
- switch-onto-fault detection for high current switch-onto-fault protection (cf. Section 4.6),
- the weak-infeed trip function (cf. Section 4.7),
- the echo function of the directional comparison earth fault protection (cf. Section 4.9.4),
- trip delay of the U>> stage of the overvoltage protection (cf. 4.13.2),
- tripping by the circuit breaker failure protection when used for low-current or no-current faults (cf. Section 4.15.2),
- supervision of the auto-reclosure function,
- the circuit breaker test facility (cf. Section 4.16).

Information about the position of each individual circuit breaker pole is useful (but not a precondition) for some of the functions.

4.17.1 Processing of the circuit breaker auxiliary contacts

The relay incorporates a circuit breaker position logic (Figure 4.63), which offers various possibilities, dependent of which auxiliary contacts are available from the circuit breaker and how they are connected to binary inputs of the relay.

If the circuit breaker is switched only three-pole its auxiliary contact is connected to a binary input module which is assigned to the input function ">CB Aux. 1p c1" (BI 355 in Figure 4.63). The remaining inputs in the figure are not used then.

If the circuit breaker poles can be switched individually but only the parallel connected auxiliary contacts are available, then the binary input for this connection must be assigned exclusively to the input function ">CB Aux. 1p c1" (BI 355 in Figure 4.63). The remaining inputs in the figure are not used then.

If the circuit breaker poles can be switched individually and each individual auxiliary contact is available then it is recommended to connect the auxiliary contact of each individual pole to an individual binary input. This connection allows maximum information to be processed in the relay. The assignment of the binary inputs is as follows:

- auxiliary contact of pole L1 assigned to input function ">CB Aux. L1" (BI 351 in Figure 4.63),
- auxiliary contact of pole L2 assigned to input function ">CB Aux. L2" (BI 352 in Figure 4.63),
- auxiliary contact of pole L3 assigned to input function ">CB Aux. L3" (BI 353 in Figure 4.63).

Binary inputs BI 354 and BI 355 are not used in this case.

If the circuit breaker poles can be switched individually but only two binary inputs can be used, one can connect the parallel connection of one set of auxiliary contacts to one binary input and the series connection to another. The inputs are assigned to the function ">CB Aux. 1p c1" (BI 355 in Figure 4.63) for the parallel connection and to ">CB Aux. 3p c1" (BI 354 in Figure 4.63) for the series connection.

Note that Figure 4.63 shows the total logic for all the connection possibilities. In the actual case a part of the inputs and logic is only used, as described above.

The 8 outputs of the circuit breaker position logic can be processed by the individual protection and supplementary functions. The output signals are blocked as long as the input signals are not plausible: e.g. a circuit breaker pole cannot be open and closed at the same time.

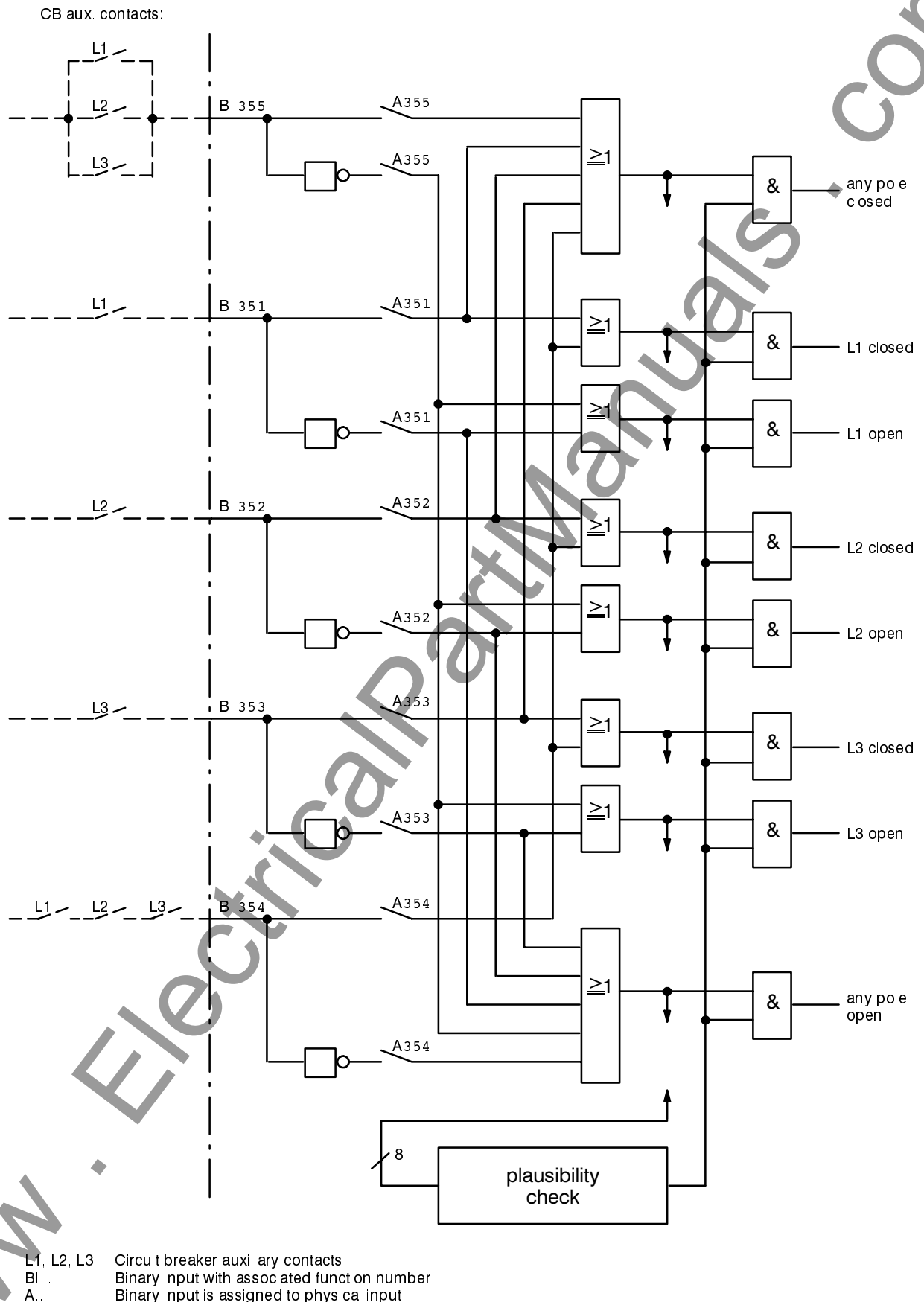


Figure 4.63 Circuit breaker position logic

4.17.2 Dead line and line energization recognition

Besides processing of the circuit breaker auxiliary contacts, 7SA513 provides dead line and line energization recognition features by use of the measured quantities.

Dead line recognition monitors disconnection of the line. As an interrupted line cannot carry currents, the first criterion is that a preset minimum current I_{RESID} is undershot, this is a first indication that the line has been de-energized. The currents are numerically filtered, so that only the fundamental frequency is evaluated. This undercurrent detection is practically not influenced by d.c. components and particularly does not react to the decay transients after disconnection of high currents (e.g. by current transformers with linear cores).

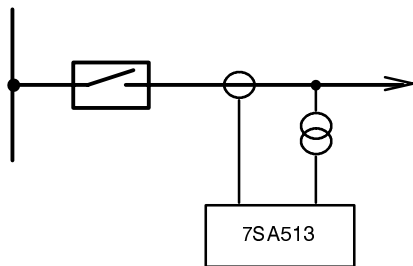


Figure 4.64 Location of measuring transformers

But also a current-free line can be connected to the bus-bar. That is why an additional voltage monitor is provided. For this to operate, the current and voltage transformers must be installed on the line side of the breaker. (Figure 4.64). The line is considered to be de-energized, when even the voltage is less than a preset value U_{RESID} . The fundamental wave is filtered out in this measuring element, too. Undervoltage is not registered as long as a secondary voltage failure has been detected (e.g. v.t. secondary m.c.b. has tripped).

In cases where the voltage transformers are not installed at the line side, voltage collapse is no criterion for a disconnected line. Using the setting parameter CB COND, it can be decided that the voltage monitor signal is replaced by the circuit breaker position signal according 4.17.1 (refer Figure 4.65): parameter CB COND is then set to CB AUX and $I <$.

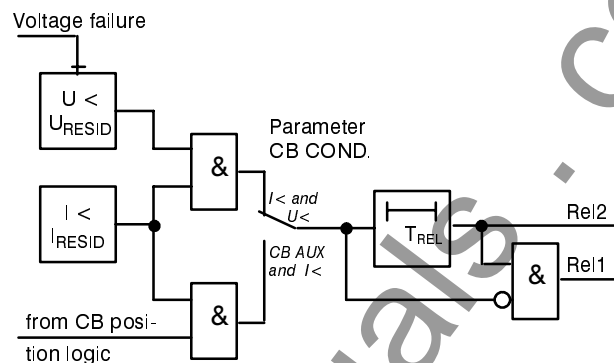


Figure 4.65 Dead line and line energization recognition

When the voltage reappears after the line has been recognized disconnected, the line must have been re-energized (possibly from the other end). Also, if only the current value is exceeded, after recognition of line de-energization, without reappearance of voltage (closing onto a close-up fault) the line is recognized to be switched on.

Dead line and line energization recognition is provided phase segregated. This allows switching detection for each individual circuit breaker pole. But, when using the circuit breaker position logic according to Section 4.17.1, reliable phase segregation is only possible if the circuit breaker auxiliary contacts are connected for each individual breaker pole (inputs BI 351, BI 352, and BI 353 in Figure 4.63).

The dead line and line energization logic (Figure 4.65) generates two output signals Rel1 and Rel2. The release signal Rel1 appears immediately after energization of the line for a selectable time T_{REL} (in Figure 4.65 abbreviated with T_{REL}). This output can be used to release the overreaching zone of the distance protection, for example (cf. Section 4.2.7); this signal is not phase segregated. The release signal Rel2 will even be present during the time where the line is de-energized. This phase segregated signals are intended for the high current switch-onto-fault protection (refer Section 4.6).

Note that the dead line and line energization recognition function does not discriminate between manual closing and automatic reclosure.

4.18 Ancillary functions

The ancillary functions of the line protection 7SA513 include:

- Processing of annunciations,
- Storage of short circuit data for fault recording,
- Operational measurements and testing routines,
- Monitoring functions.

4.18.1 Processing of annunciations

After a fault in the protected object, information concerning the response of the protective device and knowledge of the measured values are of importance for an exact analysis of the history of the fault. For this purpose the device provides annunciation processing which is effective in three directions.

4.18.1.1 Indicators and binary outputs (signal relays)

Important events and conditions are indicated by optical indicators (LED) on the front plate. The modules also contain signal relays for remote signalling. Most of the signals and indications can be marshalled, i.e. they can be allocated meanings other than the factory settings. In Section 5.5 the delivered condition and the marshalling facilities are described in detail.

The output signal relays are not latched and automatically reset as soon as the originating signal disappears. The LEDs can be arranged to latch or to be self-resetting.

The memories of the LEDs can be safe against supply voltage failure. They can be reset:

- locally, by operation of the reset button on the relay,
- remotely by energization of the remote reset input,
- remotely via one of the interfaces,
- automatically, on occurrence of a new general pick-up signal.

Some indicators and relays indicate conditions; it is not appropriate that these should be stored. Equally they cannot be reset until the originating criterion has been removed. This mainly concerns fault indications such as "auxiliary voltage fault", etc.

A green LED indicates readiness for operation. This LED cannot be reset and remains illuminated when the microprocessor is working correctly and the unit is not faulty. The LED extinguishes when the self-checking function of the microprocessor detects a fault or when the auxiliary voltage is absent.

With the auxiliary voltage present but with an existing internal fault in the unit, a red LED illuminates ("Blocked") and blocks the unit.

4.18.1.2 Information on the display panel or to a personal computer

Events and conditions can be read off in the display on the front plate of the device. Additionally, a personal computer, for example, can be connected via the operation interface, and all the informations can then be sent to it.

In the quiescent state, i.e. as long as no network faults are present, the display outputs selectable operating information (usually an operational measured value) in each of the two lines. In the event of a network fault, selectable information on the fault appears instead of the operating information, e.g. detected phase(s) and elapsed time from fault detection to trip command. The quiescent information is displayed again once these fault annunciations have been acknowledged. The acknowledgement is identical to resetting of the stored LED displays as in Section 4.18.1.1.

The device also has several event buffers, e.g. for operating messages, circuit breaker operation statistics etc. (refer to Section 6.4) which can be saved against supply voltage failure by a buffer battery. These messages, as well as all available operating values, can be transferred into the front display at any time using the keyboard or to the personal computer via the operating interface.

After a fault, for example, important information concerning its history, such as pick-up and tripping, can be called up on the display of the device. The fault inception is indicated with the absolute time of the operating system. The sequence of the events is tagged with the relative time referred to the moment at which the fault detector has picked up. Thus, the elapsed time until tripping is initiated and until the protection is reset can be read out. The resolution is 1 ms.

The events can also be read out with a personal computer by means of the appropriate program DIGSI®. This provides the comfort of a CRT screen and menu-guided operation. Additionally, the data can be documented on a printer or stored on a floppy disc for evaluation elsewhere.

The protection device stores the data of the last eight network faults; if a ninth fault occurs the oldest fault is overwritten in the fault memory. The annunciations of the last three faults can be read out on the local display.

A network fault begins with recognition of the fault by pick-up of any fault detector and ends with the last fault detector reset or expiry of the auto-reclose sequence so that non-successful auto-reclose attempts will also be stored as part of one network fault. Thus, one network fault can include different fault events (from pick-up until drop-off). This is particularly advantageous for allocation of time data.

4.18.1.3 Information to a central unit

In addition, all stored information can be transmitted via an optical fibre connector or the isolated second interface (system interface) to a control centre, for example, the SIEMENS Localized Substation Automation System LSA 678. Transmission uses a standardized transmission protocol according to IEC 60870-5-103 and VDEW/ZVEI, or (selectable) according to DIN 19244.

4.18.2 Data storage and transmission for fault recording

The instantaneous values of the measured values

$$i_{L1}, i_{L2}, i_{L3}, i_E, u_{L1-N}, u_{L2-N}, u_{L3-N}, u_{EN}$$

are sampled at 1 ms intervals (for 50 Hz) and stored in a circulating shift register. In case of a fault, the data are stored over a selectable time period, but max. over 5 seconds for one fault event. The maximum number of fault records is 8 fault events within a time period of 10 s. These data are then available for fault analysis. For each renewed fault event, the actual new fault data are stored without acknowledgement of the oldest data.

The data can be transferred to a connected personal computer via the operation interface at the front and evaluated by the protection data evaluation program DIGSI®. The currents and voltages are referred to their maximum values, normalized to their rated values and prepared for graphic visualization. In addition, signals can be marked as binary traces, e.g. "Pick-up" and "Trip".

Additionally, the fault record data can be transmitted to a control centre via the serial system interface. Evaluation of the data is made in the control centre, using appropriate software programs. The currents and voltages are referred to their maximum values, normalized to their rated values and prepared for graphic visualization. In addition, signals can be marked as binary traces, e.g. "Pick-up" and "Trip".

When the data are transferred to a central unit, read-out can proceed automatically, optionally after each pick-up of the relay or only after a trip. The following then applies:

- The relay signals the availability of fault record data,
- The data remain available for recall until they are overwritten by new data.
- A transmission in progress can be aborted by the central unit.

4.18.3 Operating measurements and conversion

For local recall or transmission of data, the true r.m.s. values of the phase currents and the voltages are always available as are active and reactive power, as well as the frequency calculated from an average of 100 ms, as long as at least one phase voltage is present.

The following is valid:

- I_{L1}, I_{L2}, I_{L3} Phase currents in amps primary and in % of rated current
- $U_{L1E}, U_{L2E}, U_{L3E}$ Voltages (phase–earth) in kilovolts primary and in % of rated voltage $U_N/\sqrt{3}$
- $U_{L12}, U_{L23}, U_{L31}$ Voltages (phase–phase) in kilovolts primary and in % of rated voltage U_N
- P_a Active power in megawatts primary and in % of $\sqrt{3} I_N U_N$
- P_r Reactive power in megvars primary and in % of $\sqrt{3} I_N U_N$
- f Frequency in % of rated frequency.

Even the direction of the energy flow (forwards = line direction) can be recalled upon request. These data are particularly useful when checking that the transformer connections are correct during commissioning (see Section 6.7.2).

4.18.4 Monitoring functions

The device incorporates comprehensive monitoring functions which cover both hardware and software; furthermore, the measured values are continuously checked for plausibility so that the current and voltage transformer circuits are also included in the monitoring system.

4.18.4.1 Hardware monitoring

The complete hardware is monitored for faults and inadmissible functions, from the measured value inputs to the output relays. In detail this is accomplished by monitoring:

- Auxiliary and reference voltages

The processor monitors the offset and reference voltage of the ADC (analog/digital converter). The protection is blocked as soon as impermissible deviations occur. Permanent faults are annunciated.

Failure or switch-off of the auxiliary voltage automatically puts the system out of operation; this status is indicated by a fail-safe contact. Transient dips in supply voltage of less than 50 ms will not disturb the function of the relay (rated auxiliary voltage ≥ 110 Vdc).

- Measured value acquisition

The complete chain, from the input transformers up to and including the analog/digital converters are monitored by the plausibility check of the measured values.

In the **current path**, there are five input converters; the digitized sum of the outputs of four of these must always be zero. A fault in the current path is recognized when

$$|i_{L1} + i_{L2} + i_{L3} + k_i \times i_E| >$$

$$\text{SUM.lthres} \times I_N + \text{SUM.Fact.l} \times I_{\max}$$

An adjustable factor k_i (parameter le/lph) can be set to correct the different ratios of phase and earth current transformers (e.g. summation transformer). If the residual earth current is derived from the current transformer starpoint, $k_i = 1$. SUM.lthres and SUM.Fact.l are setting parameters. The component $\text{SUM.Fact.l} \times I_{\max}$ takes into account permissible current proportional transformation errors in the input converters which may particularly occur under conditions of high short circuit currents (Figure 4.66).

Note: Current sum monitoring can operate properly only when the residual current of the protected line is fed to one of the additional inputs I4 or I5 of the relay.

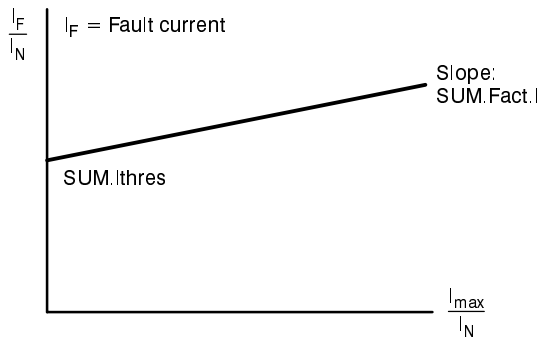


Figure 4.66 Current sum monitoring (current plausibility check)

In the **voltage path**, there are seven input converters: three connected to each phase–earth voltage, three connected to each phase–phase voltage, one further can be connected to the displacement voltage U_{EN} . A fault in the voltage circuits will be recognized when

$$|u_{L1} + u_{L2} + u_{L3} + k_U \cdot u_{EN}| > 25 \text{ V.}$$

Factor k_U (parameter U_{ph}/U_{delta}) can be set to correct different ratios of phase and open delta voltage transformer windings.

Note: Voltage sum (phase–earth) monitoring can operate properly only when an externally formed open delta voltage U_{EN} is connected to the residual voltage input of the relay.

Since the phase-to-phase voltages are separately formed and measured within the device, a similar monitoring procedure applies:

$$|u_{L1-L2} + u_{L2-L3} + u_{L3-L1}| > 20 \text{ V.}$$

Additionally, the phase–phase voltages are compared with the associated phase–earth voltages. A fault will be recognized when

$$|u_{L1-L2} - (u_{L1} - u_{L2})| > 20 \text{ V}$$

$$|u_{L2-L3} - (u_{L2} - u_{L3})| > 20 \text{ V}$$

$$|u_{L3-L1} - (u_{L3} - u_{L1})| > 20 \text{ V}$$

If any of these monitoring functions detects that the measured values are not plausible it will conclude that there is a fault in the analog measurement circuits. After approximately 1 second, an alarm will be given.

– Command output channels:

The command relays for tripping and closing are controlled by two command and one additional release channels. As long as no pick-up condition exists, the central processor makes a cyclic check of these command output channel for availability, by exciting each channels one after the other and checking for change in the output signal level. Change of the feed-back signal to low level indicates a fault in one of the control channels or in the relay coil. Such a condition leads automatically to alarm and blocking of the command output.

– Memory modules:

The memory modules are periodically checked for fault by:

- Writing a data bit pattern for the working memory (RAM) and reading it,
- Formation of the modulus for the program memory (EPROM) and comparison of it with a reference program modulus stored there,
- Formation of the modulus of the values stored in the parameter store (EEPROM) then comparing it with the newly determined modulus after each parameter assignment process.

4.18.4.2 Software monitoring

For continuous monitoring of the program sequences, a watchdog timer is provided which will reset the processor in the event of processor failure or if a program falls out of step. Further, internal plausibility checks ensure that any fault in processing of the programs, caused by interference, will be recognized. Such faults lead to reset and restart of the processor.

If such a fault is not eliminated by restarting, further restarts are initiated. If the fault is still present after three restart attempts within 30 s the protective system will switch itself out of service and indicate this condition by drop-off of the availability relay, thus indicating "equipment fault" and simultaneously the LED "Blocked" comes on.

4.18.4.3 Monitoring of external measuring transformer circuits

To detect interruptions or short circuits in the external measuring transformer circuits or faults in the connections (an important commissioning aid) the measured values are checked at cyclic intervals, as long as no pick-up condition exists:

– Current symmetry

In healthy operation it can be expected that the currents will be approximately symmetrical. The following applies:

$$\begin{aligned} &|I_{\min}| / |I_{\max}| < \text{SYM.Fact.I} \\ &\text{if} \\ &I_{\max} / I_N > \text{SYM.lthres} / I_N \end{aligned}$$

$I_{\max}$ is always the largest of the three phase currents and $I_{\min}$ always the smallest. The symmetry factor SYM.Fact.I represents the magnitude of asymmetry of the phase currents, and the threshold SYM.lthres is the lower limit of the processing area of this monitoring function (see Figure 4.67). Both parameters can be set (see Section 6.3.11).

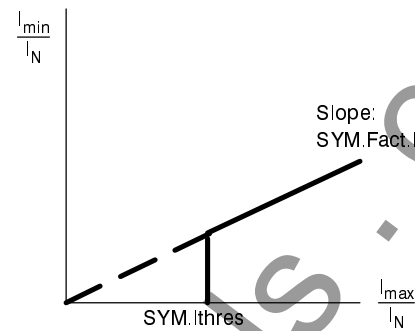


Figure 4.67 Current symmetry monitoring

– Voltage symmetry

In healthy operation it can be expected that the voltages will be approximately symmetrical. Therefore, the device checks the three phase-to-phase voltages for symmetry.

The following applies:

$$\begin{aligned} &|U_{\min}| / |U_{\max}| < \text{SYM.Fact.U} \\ &\text{if} \\ &|U_{\max}| > \text{SYM.Uthres} \end{aligned}$$

whereby $U_{\max}$ is the largest of the three voltages and $U_{\min}$ the smallest. The symmetry factor SYM.Fact.U represents the magnitude of the asymmetry of the sum of the voltages. The threshold SYM.Uthres is the lower limit of the processing area of this monitoring function (see Figure 4.68). Both parameters can be set (see Section 6.3.11).

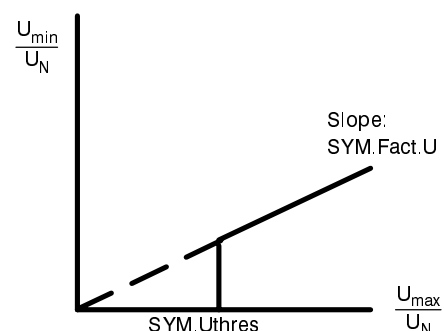


Figure 4.68 Voltage symmetry monitoring

– Measured voltage failure

Failure of the measurement voltage can be detected when a minimum current flows on the protected line but the current stages $I_{ph}>$ of the fault detectors have not yet picked up. Voltage failure is detected when

$$U_{ph-ph} < UMEAS U< \text{ and at the same time } I_{max} > UMEAS I>$$

whereby U_{ph-ph} represents any phase–phase voltage. $UMEAS U<$ and $UMEAS I>$ are setting parameters (see Section 6.3.10). This monitor does not operate once the minimum current threshold of any fault detector has been exceeded since this may indicate a system fault.

After this monitor has operated, distance protection is blocked and will not be released until the cause of the voltage failure has been removed. The distance protection function will then automatically be restored. Change-over to overcurrent emergency protection is possible.

– Fuse failure monitor

If any measured voltage is not present, due to short circuit or conductor breakage in the voltage transformer secondary system, it can appear that the voltage is zero for certain measured loops.

If no protective m.c.b. with appropriately set auxiliary contact is available in the VT secondary circuit, but instead, for example, fuses are fitted, the optional function "fuse failure monitor" can be made effective, in solidly earthed networks. Obviously, this function can also be used together with the above mentioned VT–protective m.c.b.

When a zero sequence voltage is indicated, without simultaneous recognition of an earth fault, this is indicative of a single phase fault in the secondary circuits of the voltage transformers. The distance function is then blocked and the relay can be switched to emergency overcurrent operation (see Section 4.8). Immediate blocking is performed provided at least one phase current is flowing.

If, within approximately 10 seconds of recognition of this criterion, an earth current occurs, distance protection automatically becomes operative again for the duration of the time of the earth fault. If the fuse failure criterion lasts longer than approximately 10 seconds the distance protection is blocked and will not be released until the cause of the voltage failure has been removed. The distance protection function will then automatically be restored.

Note: When, for example, on lines fed by un-earthed transformers, the earth current during earth fault is insignificantly small or absent, the fuse failure monitoring must **not** be activated! In non-earthed networks, this fuse failure monitoring facility is pointless and will be ignored by 7SA513!

– Phase rotation

Since correct functioning of measured value verification, phase preference and directional determination relies upon a clockwise sequence of the phase voltages, the direction of rotation is monitored:

$$U_{L1} \text{ before } U_{L2} \text{ before } U_{L3}$$

This check is carried out when the measured voltages as described in 4.18.4.1 are plausible and have a minimum value of at least

$$|U_{L1}|, |U_{L2}|, |U_{L3}| > 40 \text{ V}/\sqrt{3}$$

Counter-clockwise rotation will cause an alarm.

Table 4.7 gives a survey of all the functions of the measured value monitoring system.

Monitoring	Failure covered, reaction
1. Plausibility check of currents $ i_{L1} + i_{L2} + i_{L3} + I_{e/Iph} \times i_E > \text{SUM.Ithres} \times I_N + \text{SUM.Fact.I} \times I_{max}$	Relay failures in the signal acquisition circuits $i_{L1}, i_{L2}, i_{L3}, i_E$ delayed alarm "Failure ΣI "
2. Plausibility check of voltages phase–earth $ u_{L1} + u_{L2} + u_{L3} + U_{ph/Udelta} \times u_{EN} > 25 \text{ V}$	Relay failures in the signal acquisition circuits $u_{L1}, u_{L2}, u_{L3}, u_E$ delayed alarm "Failure $\Sigma Up-e$ "
3. Plausibility check of voltage phase–phase $ u_{L1-L2} + u_{L2-L3} + u_{L3-L1} > 20 \text{ V}$	Relay failures in the signal acquisition circuits $u_{L1-L2}, u_{L2-L3}, u_{L3-L1}$ delayed alarm "Failure $\Sigma Up-p$ "
4. Phase–phase voltages against voltage differences $ u_{L1-L2} - (u_{L1} - u_{L2}) > 20 \text{ V}$ $ u_{L2-L3} - (u_{L2} - u_{L3}) > 20 \text{ V}$ $ u_{L3-L1} - (u_{L3} - u_{L1}) > 20 \text{ V}$	Connection error in one of the voltage connections phase–phase and/or phase–earth delayed alarm "Failure $\Sigma Up-p$ "
5. Current unbalance $\frac{ I_{min} }{ I_{max} } < \text{SYM.Fact.I}$ and $ I_{max} > \text{SYM.Ithres}$	Single, or phase-to-phase short circuits or broken conductors in the c.t. circuits i_{L1}, i_{L2}, i_{L3} or Unbalanced load delayed alarm "Failure I_{symm} "
6. Voltage unbalance (phase–phase) $\frac{ U_{min} }{ U_{max} } < \text{SYM.Fact.U}$ and $ U_{max} > \text{SYM.Uthres}$	Short-circuit or interruption (1-phase, 2-phase) in v.t. secondary circuits or unbalanced voltage on the system delayed alarm "Failure U_{symm} "
7. Measured voltage failure $U_{ph-ph} < \text{UMEAS } U < \text{and } I_{max} > \text{UMEAS } I >$	Loss of measured voltages delayed alarm "Failure U_{meas} " and block of distance protection
8. Fuse failure monitor $ u_{L1} + u_{L2} + u_{L3} > \text{FFM } 3 \times U_o$ and $ i_{L1} + i_{L2} + i_{L3} < \text{FFM } I_e$	Fuse failure or conductor interruption (non-symmetric) in v.t. secondary circuit delayed alarm "Fuse-Failure" and immediate block of distance protection
9. Phase rotation u_{L1} before u_{L2} before u_{L3} , as long as $ U_{L1} , U_{L2} , U_{L3} > 40 \text{ V}/\sqrt{3}$	Swopped voltage connections or reverse rotation sequence delayed alarm "Fail.PhaseSeq"

Bolted figures are setting values.

Table 4.7 Summary of measuring circuit monitoring

5 Installation instructions



Warning

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

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

5.1 Unpacking and repacking

When dispatched from the factory, the equipment is packed in accordance with the guidelines laid down in IEC 60255–21, which specifies the impact resistance of packaging.

This packing shall be removed with care, without force and without the use of inappropriate tools. The equipment should be visually checked to ensure that there are no external traces of damage.

The transport packing can be re-used for further transport when applied in the same way. The storage packing of the individual relays is not suited to transport. If alternative packing is used, this must also provide the same degree of protection against mechanical shock, as laid down in IEC 60255–21–1 class 2 and IEC 60255–21–2 class 1.

Before initial energization with supply voltage, the relay shall be situated in the operating area for at least two hours in order to ensure temperature equalization and to avoid humidity influences and condensation.

5.2 Preparations

The operating conditions must accord with VDE 0100/5.73 and VDE 0105 part 1/7.83, or corresponding national standards for electrical power installations.



Caution!

The modules of digital relays contain CMOS circuits. These shall not be withdrawn or inserted under live conditions! The modules must be so handled that any possibility of damage due to static electrical charges is excluded. During any necessary handling of individual modules the recommendations relating to the handling of electrostatically endangered components (EEC) must be observed.

In installed conditions, the modules are in no danger.

5.2.1 Mounting and connections

5.2.1.1 Model 7SA513★–★B★★ for panel surface mounting

- Secure the unit with four screws to the panel. For dimensions refer to Figure 2.2 and 2.3.
- Connect the earthing terminal (Terminal 51) of the unit to the protective earth of the panel.
- Make a solid low-ohmic and low-inductance operational earth connection between the earthing surface at the side of the unit using at least one standard screw M4, and the earthing continuity system of the panel; recommended grounding strap DIN 72333 form A, e.g. Order-No. 15284 of Messrs Druseidt, Remscheid, Germany.
- Make connections via screwed terminals.

5.2.1.2 Model 7SA513★–★C★★ for panel flush mounting or 7SA513★–★E★★ for cubicle installation

- Lift up both labelling strips on the lid of the unit and remove cover to gain access to the four holes for the fixing screws.
- Insert the unit into the panel cut-out and secure it with the fixing screws. For dimensions refer to Figure 2.4 and 2.5.
- Connect the earthing screw on the rear of the unit to the protective earth of the panel or cubicle.
- Make a solid low-ohmic and low-inductance operational earth connection between the earthing surface at the rear of the unit using at least one standard screw M4, and the earthing continuity system of the panel or cubicle; recommended grounding strap DIN 72333 form A, e.g. Order-No. 15284 of Messrs Druseidt, Remscheid, Germany.
- Make connections via the screwed or snap-in terminals of the sockets of the housing. Observe labelling of the individual connector modules to ensure correct location; observe the max. permissible conductor cross-sections. The use of the screwed terminals is recommended; snap-in connection requires special tools and must not be used for field wiring unless proper strain relief and the permissible bending radius are observed.

5.2.2 Checking the rated data and modules

5.2.2.1 Rated data of the device

The rated data of the unit must be checked against the plant data. This applies in particular to the auxiliary voltage and the rated current of the current transformers.

5.2.2.2 Allocation of the modules

A reduced and simplified front view of the fully equipped device is shown in Figure 5.1 when the front door is opened. The modules are designated with numbers ❶ to ❷. These numbers are used for identification of the individual modules in the following sections.

When the relay is delivered, all identification means are adjusted by the factory. The remaining of this section 5.2.2.2 is relevant only when one of the input/output modules are to be replaced or if the allocation of the modules should be checked.

The input/output modules ❸ to ❹ are in principle identical but have to be definitely identified by the central processor. This is done by plug bridges at the upper edge of the individual left p.c.b. (when viewed from the front) of the module.

The position of the plug bridges and their allocation to the installation places of the modules are shown in Figure 5.2. If the bridges should be checked or changed, this is preferably carried out in conjunction with the rated d.c. voltage checks described in the following section.

5.2.2.3 Control d.c. voltage of binary inputs

When delivered from the factory, the binary inputs are designed to operate in the total control voltage range from 19 V to 288 V. If the rated control voltage for the binary inputs is 110 V or higher, it is advisable to fit a higher pick-up threshold to these inputs to increase stability against stray voltages in the d.c. circuits.

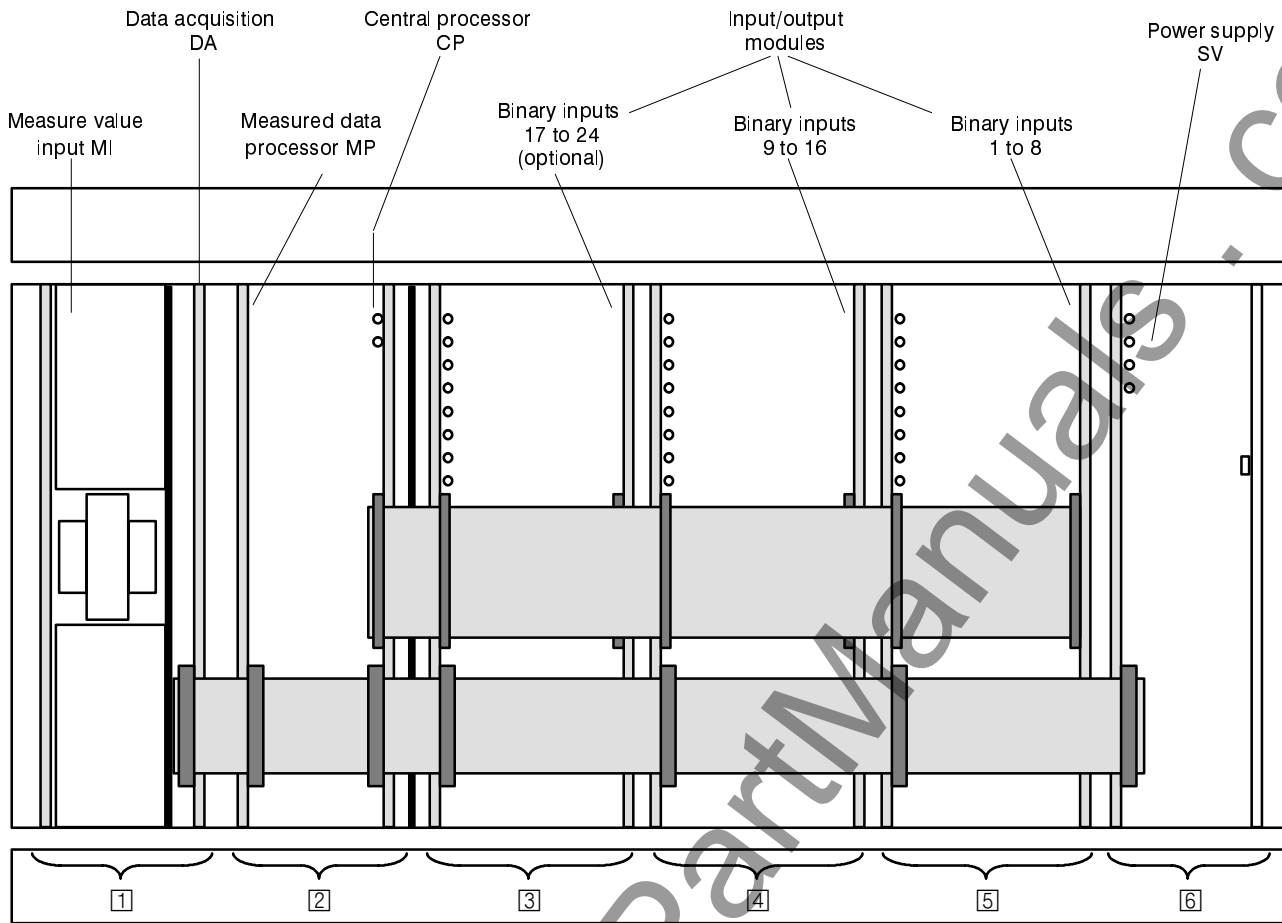


Figure 5.1 Front view 7SA513 after removal of the front door (simplified and reduced)

For rated control voltages of 110 Vdc or higher the pick-up threshold can be increased to approximately 80 V; for rated control voltages of 220 V or higher to approximately 160 V. In order to fit a higher pick-up threshold a solder bridge must be removed. Figure 5.3 shows the location of these solder bridges and their assignment. Table 5.1 shows the position of the bridges.

The procedure to change any bridge is as follows:

- Prepare area of work: provide conductive surface for the relay and modules.
- Open housing cover.



Caution!

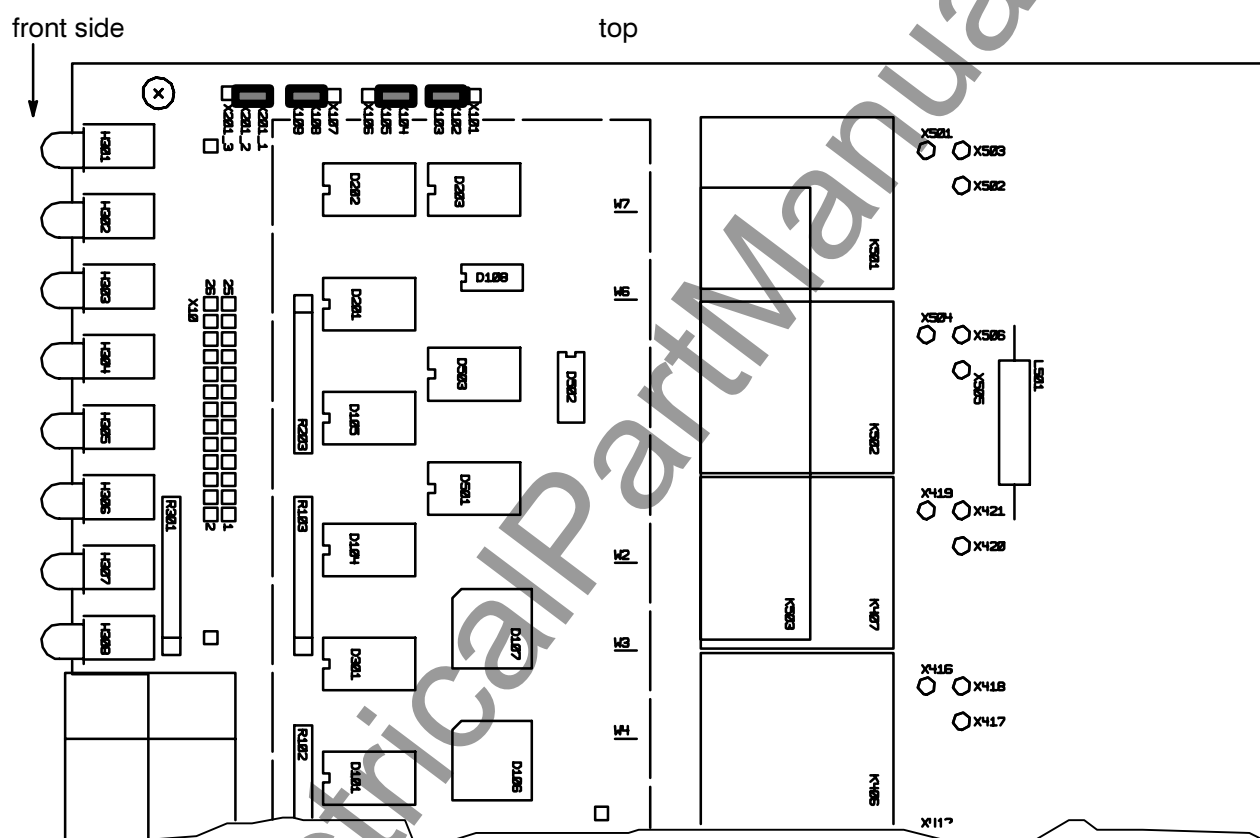
Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.

- Loosen the captive screws of the housing; they are placed in the upper and lower edge at the right hand side of the front door.
- Carefully loosen the ribbon cable that links the modules with each other so that the desired module can be drawn out. If necessary, loosen the cable from the adjacent modules, too.
- Pull out the module and place it on the conductive surface.
- Check the identification plugs according to Figure 5.2.
- Check the solder bridges for the intended voltage range and noise margin according to Figure 5.3 and Table 5.1, remove bridges where necessary.
- Insert module into the housing; ensure that the module is firmly pushed in.

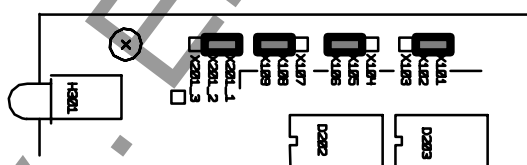
- Similarly check solder bridges on the remaining input/output modules (total of 2 or 3, depending on model).

The ribbon cables need not be re-connected now if the back-up battery is to be inserted (refer to Section 5.2.3) or if the interface to LSA shall be matched (refer to Section 5.2.4). Otherwise continue with the next steps:

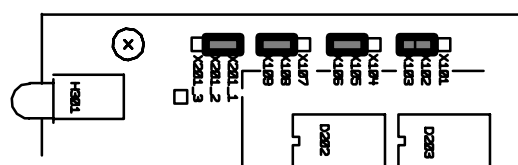
- Re-connect the ribbon cable to all concerned modules. Ensure that the connection pins do not bend! Do not use force!
- Close the front door of the device.
- Fix the door with the fixing screws.
- Close housing cover and tighten the screws.



Upper half of the p.c.b. with identification plugs for input/output module ③ (if fitted)



Identification plugs for input/output module ④



Identification plugs for input/output module ⑤

Figure 5.2 Location of the identification plugs on the input/output modules ③ to ⑤, component side of the left p.c.b. (when viewed from the front)

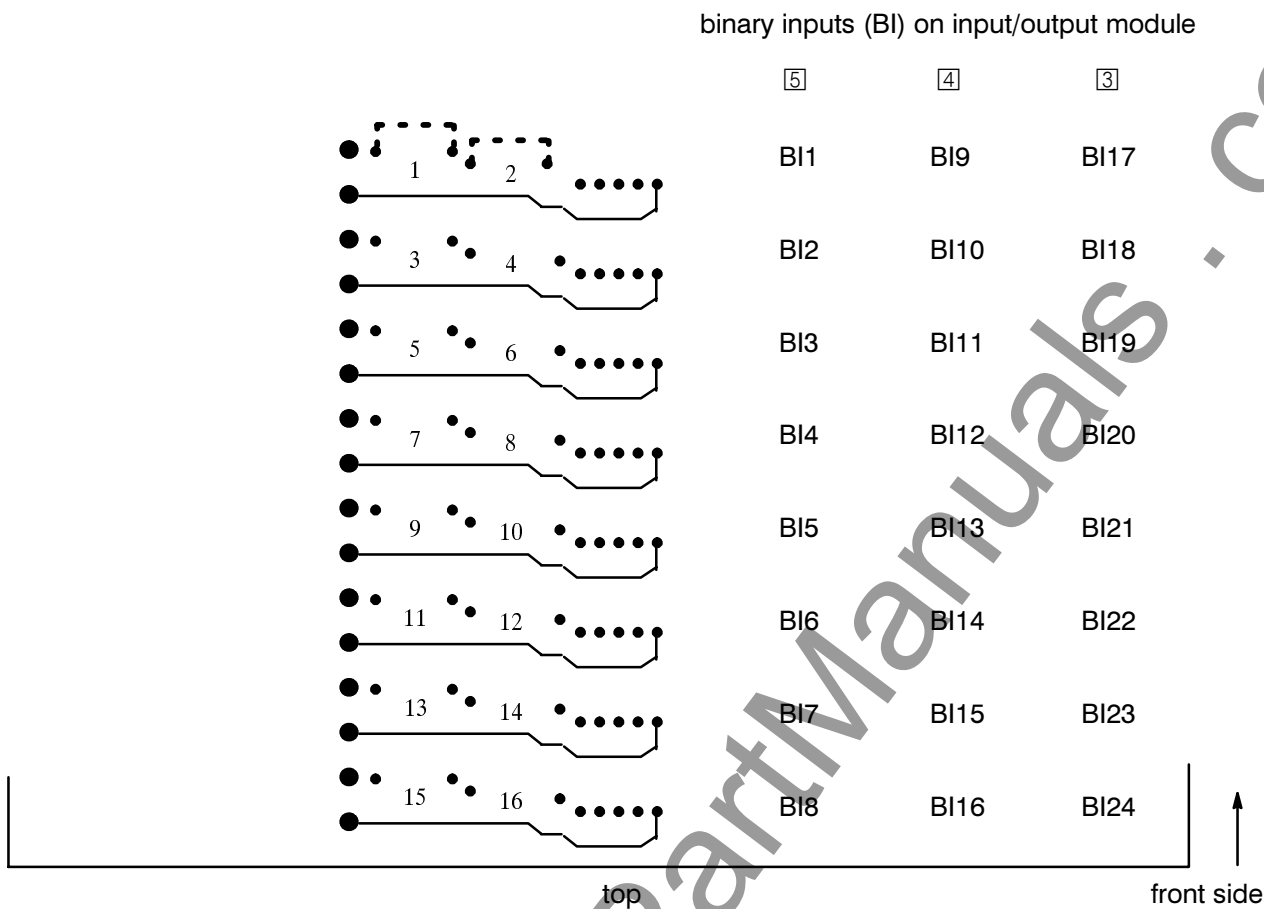


Figure 5.3 Checking for control voltages for binary inputs on the input/output modules 3 to 5; printed side of the right p.c.b. (when vied from the front)

Attention! The top of the p.c.b. is at the bottom side of the illustration!

Attention! The allocation of the binary inputs counts from right to left!

Rated d.c. control voltage	24 V/48 V/60 V	110 V/125 V	220 V/250 V
Bridge 1 etc.	inserted	inserted	removed
Bridge 2 etc.	inserted	removed	removed

Table 5.1 Position of the solder bridges for control voltages, example for binary input 1 on input/output module 5

5.2.3 Inserting the back-up battery

The device annunciations are stored in NV–RAMs. A back-up battery is installed so that these are retained even during a long failure of the d.c. supply voltage. The back-up battery is also required for the internal system clock with calendar to continue in the event of a power supply failure.

The battery is supplied separately with relays of production series up to /EE. It should be inserted before

the relay is installed. Section 7.2 explains in detail how to replace the back-up battery. Join this section accordingly when inserting the battery for the first time.

When the production series of the relay is /FF or later, the battery is installed at delivery so that no activities are necessary here.

5.2.4 Checking the data transmission link to LSA

For models with interface for a central data processing station (e.g. LSA) these connections must also be checked. It is important to visually check the allocation of the transmitter and receiver channels. Since each connection is used for one transmission direction, the transmit connection of the relay must be connected with the receive connection of the central unit and vice versa.

Transmission via optical fibre is particularly insensitive against disturbances and automatically provides galvanic isolation. Transmit and receive connectors are designated with the symbols $\bullet \rightarrow$ for transmit output and $\rightarrow \bullet$ for receive input.

The normal signal position for the data transmission is factory preset as "light off". This can be changed by means of a jumper plug on the central processor p.c.b. ② (refer to Figure 5.1). The plug is situated in the bottom area of the p.c.b. Figure 5.4 shows the location of this plug for models up to production series /EE, Figure 5.5 for models from production series /FF or later. The actual production series is stated on the name plate behind the complete order designation.

- Prepare area of work: provide conductive surface for the relay and modules.
- Open housing cover.
- Loosen the captive screws of the housing; they are placed in the upper and lower edge at the right hand side of the front door.



Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.

- Carefully loosen the ribbon cable that links the modules with each other so that the desired module can be drawn out. If necessary, loosen the cable from the adjacent modules, too.
- Loosen further ribbon cables which connect the processor module with the front plate:
 - to the operational interface,
 - to the LCD display,
 - to the membrane keyboard.
- Pull out the processor module ② (refer to Figure 5.1) and place it on the conductive surface.
- Check jumper positions according to the following table: Figure 5.4 is valid for relays up to production series /EE; Figure 5.5 is valid for relays from production series /FF or later.

Jumper position	Normal signal position
X50 – X55	"Light off"
X50 – X49	"Light on"

- Insert processor module into the housing; ensure that the module is firmly pushed in.
- Re-connect the ribbon cables from the front plate; take care for correct polarity:
from the operational interface,
from the LCD display,
from the membrane keyboard.
- Re-connect the ribbon cable to all concerned modules. Ensure that the connection pins do not bend! Do not use force!
- Close the front door of the device.
- Close housing cover and tighten the screws.
- Fix the door with the fixing screws.

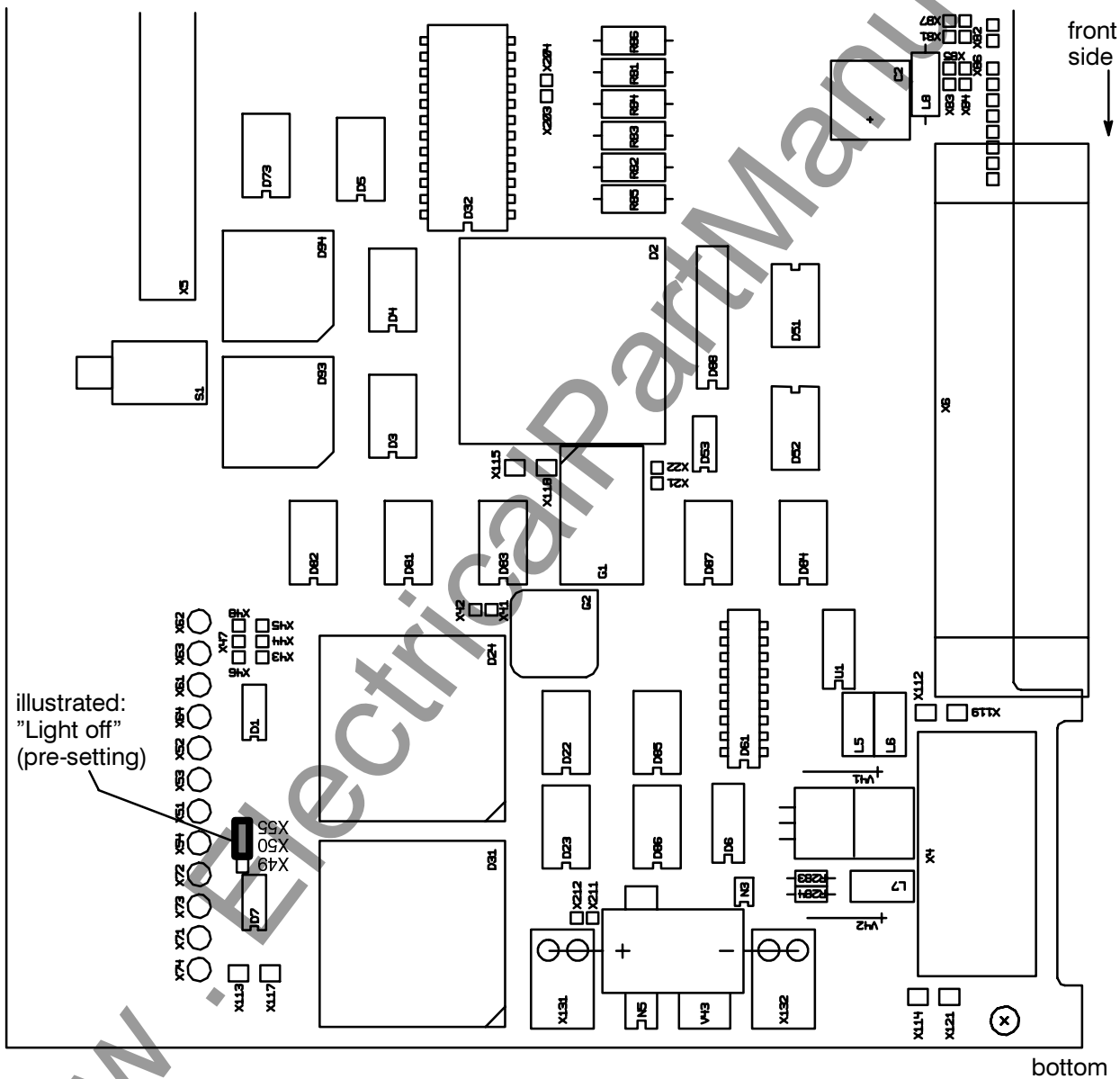


Figure 5.4 Position of the jumpers X49, X50, and X55 on the central processor board, valid for relays until production series /EE

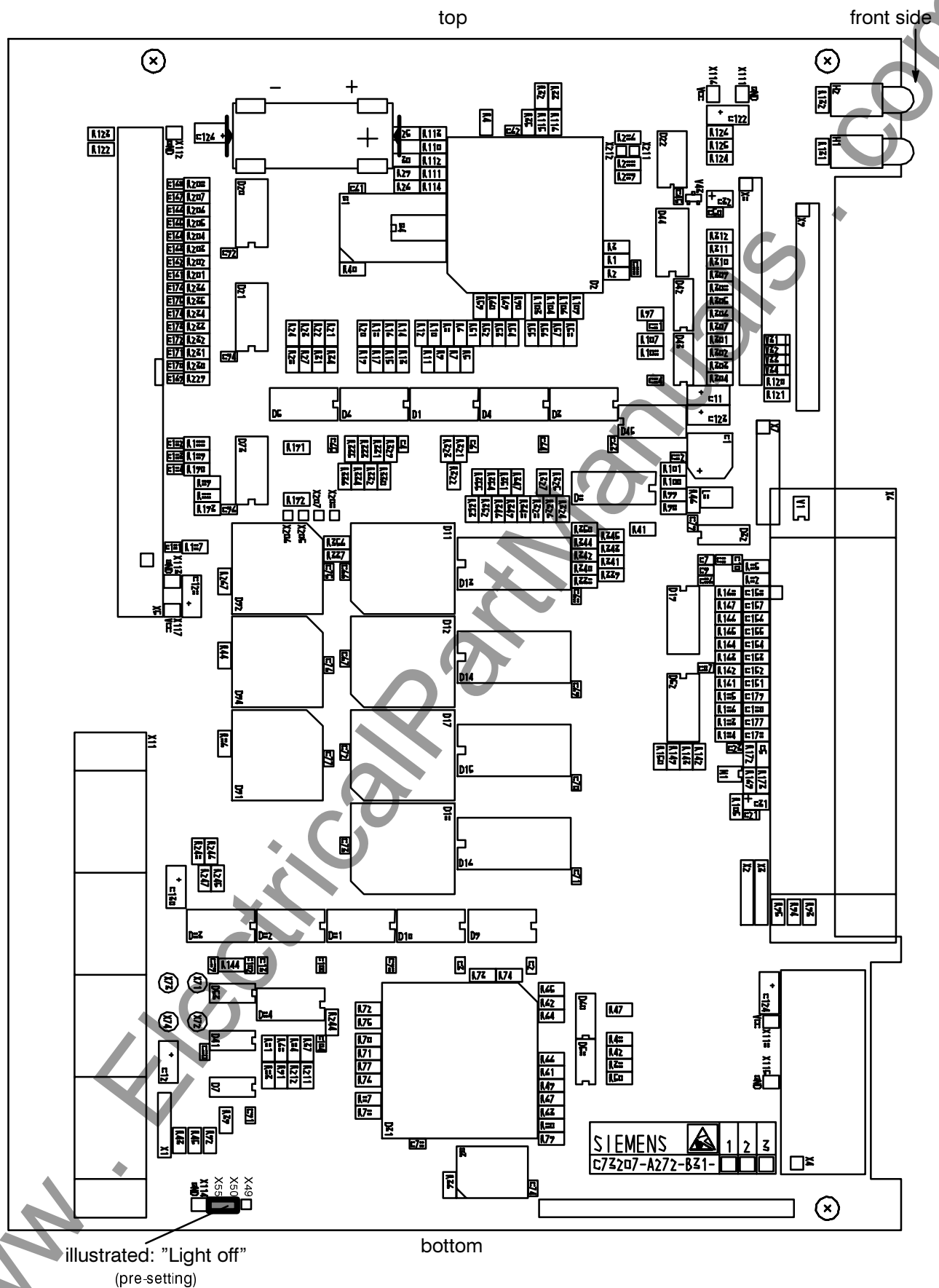


Figure 5.5 Position of the jumpers X49, X50, and X55 on the central processor board, valid for relays from production series /FF or later

5.2.5 Connections

General and connection diagrams are shown in Appendix A and B. The marshallings possibilities of the binary inputs and outputs are described in Section 5.5.

5.2.5.1 Connections for circuit breaker auxiliary contacts

Various protective and supplementary functions are able to process the position of the circuit breaker, as for example the echo feature of the carrier transmission functions, the high current instantaneous protection, the weak-infeed trip feature, or the overvoltage protection. The circuit breaker live trip function can supervise the reaction of the breaker during the test sequence.

Binary inputs are provided to be connected to the auxiliary contact(s) of the circuit breaker in order to inform the relay about the breaker position. Various possibilities exist (refer also to Section 4.17).

If the circuit breaker is switched only three-pole, its auxiliary contact is connected to a binary input module which is assigned to the input function ">CB Aux. 1p c1" (FNo 355). The input function must be activated when the breaker is in the closed position. Function numbers 351, 352, 353, and 354 are not used.

If the circuit breaker poles can be switched individually but only the parallel connected auxiliary contacts are available, then the binary input for this connection must be assigned exclusively to the input function ">CB Aux. 1p c1" (FNo 355). Function numbers 351, 352, 353, and 354 are not used.

If the circuit breaker poles can be switched individually and each individual auxiliary contact is available then it is recommended to connect the auxiliary contact of each individual pole to an individual binary input (example in Figure 5.6). The assignment of the binary inputs is as follows:

- auxiliary contact of pole L1 assigned to input function ">CB Aux. L1" (FNo 351),
- auxiliary contact of pole L2 assigned to input function ">CB Aux. L2" (FNo 352),
- auxiliary contact of pole L3 assigned to input function ">CB Aux. L3" (FNo 353).

Function numbers 354 and 355 are not used. This connection allows maximum information to be processed in the relay.

If the circuit breaker poles can be switched individually but only two binary inputs can be used, one can connect the parallel connection of one set of auxiliary contacts to a binary input and the series connection to another. The inputs are assigned to the function ">CB Aux. 1p c1" (FNo 355) for the parallel connection and to ">CB Aux. 3p c1" (FNo 354) for the series connection (Figure 5.7).

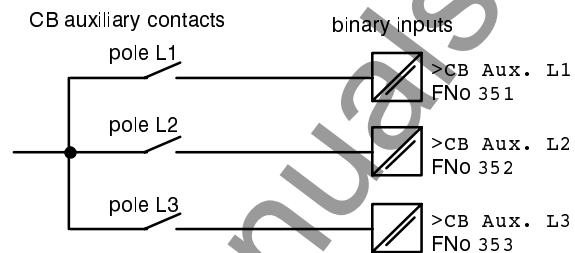


Figure 5.6 Connection example for CB auxiliary contacts

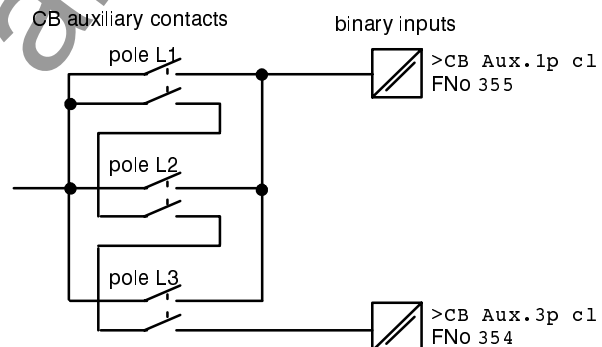


Figure 5.7 Connection example for CB auxiliary contacts

5.2.5.2 Connections for switch-over of parameter sets

If switch-over of different parameter sets is to be performed via binary inputs, the connection example of Figure 5.8 can be used. Further information on selectable parameter set is given in the Sections 6.3.1.2 and 6.5.5.3.

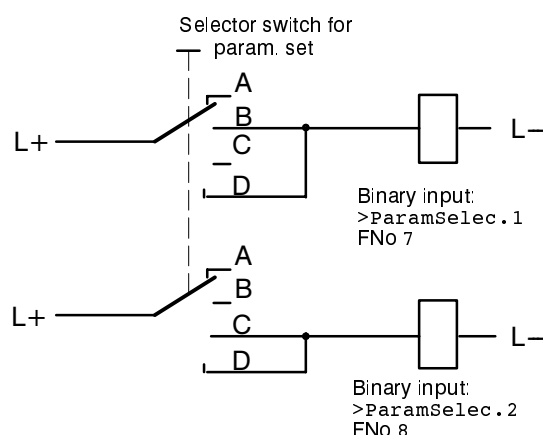


Figure 5.8 Connection scheme for parameter change-over via binary inputs

5.2.6 Checking the connections



Warning

Some of the following test steps are carried out in the presence of hazardous voltages. They shall be performed by qualified personnel only which is thoroughly familiar with all safety regulations and precautionary measures and pay due attention to these.

Non-observance can result in severe personal injury.

Before initial energization with supply voltage, the relay shall be situated in the operating area for at least two hours in order to ensure temperature equalization and to avoid humidity influences and condensation.

- Switch off the circuit breakers for the dc supply and the voltage transformer circuits!
- Check the continuity of all the current and voltage transformer circuits against the plant and connection diagrams:
 - Are the current transformers correctly earthed?
 - Are the polarities of the current transformer connections consistent?
 - Is the phase relationship of the current transformers correct?
 - Are the voltage transformers correctly earthed?
 - Are the polarities of the voltage transformer circuits correct?
 - Is the phase relationship of the voltage transformers correct?
- Is the polarity of the current input I4 correct (if used)?
- Is the polarity of the current input I5 correct (if used)?
- Is the polarity of the open delta winding on the voltage transformers and the connection correct (if used)?
- Is the polarity of the bus-bar voltage transformer(s) correct (if used)?
- If test switches have been fitted in the secondary circuits, check their function, particularly that in the "test" position the current transformer secondary circuits are automatically short-circuited.
- Ensure that the miniature slide switch on the front plate is in the "OFF" $\odot$ position. (refer Figure 6.1).
- Fit a dc ammeter in the auxiliary power circuit; range approx. 1.5 A to 3 A.
- Close the battery supply circuit breaker; check polarity and magnitude of voltage at the terminals of the unit or at the connector module.
- The measured current consumption should be insignificant. Transient movement of the ammeter pointer only indicates the charging current of the storage capacitors.
- Put the miniature slide switch of the front plate in the "ON" position $\odot$. The green LED "Service" on the front comes on as do the four LEDs of the power supply. The unit starts up and, on completion of the run-up period, the red LED "Blocked" gets off.
- Open the circuit breaker for the dc power supply.
- Remove dc ammeter; reconnect the auxiliary voltage leads.
- Close the voltage transformer m.c.b. (secondary circuit).
- Check the direction of phase rotation at the relay terminals (clockwise!).
- Open the m.c.b.'s for voltage transformer secondary circuits and dc power supply.
- Check through the tripping circuits to the circuit breakers.
- Check through the control wiring to and from other devices.
- Check the signal circuits.
- Close the protective m.c.b.'s.

5.3 Configuration of operation and memory functions

5.3.1 Operational preconditions and general

For most operational functions, the input of a code-word is necessary. This applies for all entries via the membrane keyboard or front interface which concern the operation on the relay, for example

- configuration parameters for operation language, configuration of the interfaces and the device functions,
- allocation or marshalling of annunciation signals, binary inputs, optical indications, and trip relays,

- setting of functional parameters (thresholds, functions),
- initiation of test procedures.

The codeword is not required for the read-out of annunciations, operating data or fault data, or for the read-out of setting parameters.

To indicate authorized operator use, press key **CW**, enter the six figure code **0 0 0 0 0 0** and confirm with **E**. Codeword entry can also be made retrospectively after paging or direct addressing to any setting address.

ENTER CODEWORD :
@ @ @ @ @ @
CW ACCEPTED
CODEWORD WRONG

The entered characters do not appear in the display, instead only a symbol @ appears. After confirmation of the correct input with **E** the display responds with **CW ACCEPTED**. Press the entry key **E** again.

If the codeword is not correct the display shows **CODEWORD WRONG**. Pressing the **CW** key allows another attempt at codeword entry.

Address blocks 70 to 79 are provided for configuration of the software operating system. These settings concern the operation of the relay, communication with external operating and processing devices via the serial interfaces, and the interaction of the device functions.

The simplest way of arriving at the beginning of this configuration blocks is to use key **DA**, followed by the address number **7 0 0 0** and ENTER, key **E**. The address 7000 appears, which forms the heading of the configuration blocks:

↑	7 0 0 0	OP .	SYSTEM
↓	CONFIGURATION		

Beginning of the block "Operating system configuration"

The double arrow key ↑ switches over to the first configuration block (see below). Use the key ↑ to find the next address. The display shows the four-digit address number, i.e. block and sequence number. The title of the requested parameter appears behind the bar (see below). The second line of the display shows the text applicable to the parameter. The present text can be rejected by the "No" – key **N**.

The next text choice then appears, as shown in the boxes below. The chosen alternative **must be confirmed with enter key E!**

The setting procedure can be ended at any time by the key combination **FE**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS?".

Confirm with the "Yes" – key **Y** that the new settings shall become valid now. If you press the "No" – key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

If one tries to leave the setting range for the configuration blocks (i.e. address blocks 60 to 79) with keys $\uparrow$ $\downarrow$, the display shows the question "END OF CODEWORD OPERATION ?". Press the "No" – key **N** to continue configuration. If you press the

"Yes" – key **J/Y** instead, another question appears: "SAVE NEW SETTINGS ?". Now you can confirm with **J/Y** or abort with **N**, as above.

When one exits the setting program, the altered parameters, which until then have been stored in buffer stores, are permanently secured in EEPROMs and protected against power outage. If configuration parameters have been changed the processor system will reset and re-start. During re-start the device is not operational.

5.3.2 Settings for the integrated operation – address block 71

Operating parameters can be set in address block 71. This block allows the operator language to be changed and the date format to be selected. Messages on the front display can be selected here for the quiescent state of the unit or after a fault event. To change any of these parameters, codeword entry is necessary.

When delivered from factory, the device is programmed to give function names and outputs in the German language, the date is shown in the European format. This can be changed under addresses 7101 and 7102. The operator languages available at present are shown in the boxes below.

$\uparrow$ $\downarrow$ 7 1 0 0 ■ I N T E G R A T E D
O P E R A T I O N

Beginning of the block "Integrated operation"

$\uparrow$ $\downarrow$ 7 1 0 1 ■ L A N G U A G E
D E U T S C H
E N G L I S H
F R A N C A I S
E S P A N O L

The available languages can be called up by repeatedly pressing the "No" – key **N**. Each language is spelled in the corresponding country's language. If you don't understand a language, you should find your own language.

The required language is chosen with the enter key **E**.

$\uparrow$ $\downarrow$ 7 1 0 2 ■ D A T E F O R M A T
D D . M M . Y Y Y Y
M M / D D / Y Y Y Y

The date in the display is preset to the European format Day.Month.Year. Switch-over to the American format Month/Day/Year is achieved by depressing the "No" – key **N**; then confirm with the entry key **E**.

DD two figures for the day
MM two figures for the month
YYYY four figures for the year (incl. century)

7 1 0 5 ■ O P E R . 1 s t L
I L 1 [%] =
I L 2 [%] =
I L 3 [%] =
etc.

Message to be displayed in the **1st** display line during operation. Any of the operational measured values according to Section 6.4.5 can be selected as messages in the quiescent state of the relay by repeatedly depressing the "No"-key **N**; The value selected by the entry key **E** under address 7105 will appear in the **first** line of the display.

7 1 0 6 ■ O P E R . 2 n d L
U L 1 2 [%] =
etc.

Message to be displayed in the **2nd** display line during operation. The value selected by the entry key **E** under address 7106 will appear in the **second** line of the display.

Fault event annunciations can be displayed after a fault on the front. These can be chosen under addresses 7107 and 7108. The possible messages can be selected by repeatedly pressing the "No"-key **N**. The desired message is confirmed with the enter key **E**. These spontaneous messages

are acknowledged during operation with the RESET key or via the remote reset input of the device or via the system interface (if fitted). After acknowledgement, the operational messages of the quiescent state will be displayed again as chosen under addresses 7105 and 7106.

7 1 0 7 ■ F A U L T 1 s t L
F a u l t T y p e
T r i p T y p e
P r o t . P i c k - u p
P r o t . T r i p
T - D r o p
T - T r i p
F a u l t l o c a t .

After a fault event, the **first** line of the display shows: type of fault (faulty phases),

type of trip command (tripped breaker pole or three-pole trip),

protection function which has picked up,

protection function, which has tripped,

the elapsed time from pick-up to drop-off,

the elapsed time from pick-up to trip command,

for the fault location, each of the fault locator messages according 6.4.3 can be selected.

7 1 0 8 ■ F A U L T 2 n d L
T - T r i p
etc.

After a fault event, the **second** line of the display shows:

the possibilities are the same as under address 7107.

7 1 1 0 ■ F A U L T I N D I C
W I T H F A U L T D E T E C
W I T H T R I P C O M M .

Stored LED indications and the fault event messages in the display can be displayed either with each fault detection or only after trip command is given. This mode can be changed by depressing the "No"-key **N** and confirmed with the enter-key **E**.

5.3.3 Configuration of the serial interfaces – address block 72

The device provides two serial interfaces: one PC interface in the front for operation by means of a personal computer and a further system interface for connection of a central control and storage unit, e.g. Siemens LSA 678. Communication via these interfaces requires some data prearrangements: identification of the relay, transmission format, transmission speed.

These data are entered to the relay in address block 72. Codeword input is necessary (refer to Section 5.3.1). The data must be coordinated with the connected devices.

All annunciations which can be processed by the LSA are stored within the device in a separate table. This is listed in Appendix C.

↑	7	2	0	0	■	P	C	/	S	Y	S	T	E	M
↓	I	N	T	E	R	F	A	C	E	S				

Beginning of the block "Interfaces for personal computer and central computer system"

↑	7	2	0	1	■	D	E	V	I	C	E	A	D	D	.
↓	1														

Identification number of the relay within the substation; valid for both the interfaces (operating and system interface). The number can be chosen at liberty, but must be used only once within the plant system

Smallest permissible number: **1**
Largest permissible number: **254**

↑	7	2	0	2	■	F	E	E	D	E	R	A	D	D	.
↓	1														

Number of the feeder within the substation; valid for both the interfaces (operating and system interface)

Smallest permissible number: **1**
Largest permissible number: **254**

↑	7	2	0	3	■	S	U	B	S	T	.	A	D	D	.
↓	1														

Identification number of the substation, in case more than one substation can be connected to a central device

Smallest permissible number: **1**
Largest permissible number: **254**

↑	7	2	0	8	■	F	U	N	C	T	.	T	Y	P	E
↓	1	2	8												

Function type in accordance with VDEW/ZVEI and IEC 60870–5–103; for distance protection no. 128.

This address is mainly for information, it should not be changed.

↑	7	2	0	9	■	D	E	V	I	C	E	T	Y	P	E
↓	2	2													

Device type for identification of the device in Siemens LSA 678 and program DIGSI®. For 7SA513 V3 no. 22. This address is only for information, it cannot be changed.

Addresses 7211 to 7216 are valid for the operating (PC) interface on the front of the relay.

Note: For operator panel 7XR5, the PC–interface format (address 7211) must be *ASCII*, the PC Baud-rate (address 7215) must be *1200 BAUD*, the PC parity (address 7216) must be *NO 2 STOP*.

The setting of the PC GAPS (address 7214 for the operating interface) or the SYS GAPS (address 7224 for the system interface) is relevant only when the relay is intended to communicate via a modem. The settings are the maximum time period which is tolerated by the relay when gaps occur during transmission of a telegram. Gaps may occur, when modems are used, by compression of data, error correction,

and differences of the Baud-rate. With good transmission quality, 1.0 s is adequate. The value should be increased when transmission quality is not so good. It must be noted that GAPS must be smaller than the setting of "reaction time protection relay" in the protection software DIGSI® V3. Recommended value:

$$\text{GAPS} \approx \frac{\text{"reaction time protection relay"}}{2}$$

Higher values for "reaction time protection relay" reduce the transmission speed in case of transmission errors. If the relay interface is connected directly to a personal computer, then GAPS may be set to 0.0 s.

7	2	1	1	■	P	C	I	N	T	E	R	F	.
D	I	G	S	I	V	3							
A S C I I													

Data format for the PC (operating) interface:
format for Siemens protection data processing program
DIGSI® Version V3

ASCII format

7	2	1	4	■	P	C	G	A	P	S			
0	.	0	s										

Maximum time period of data gaps within telegrams which may occur during data transmission via modem on the operating (PC) interface

Smallest setting value:

0.0 s

Largest setting value:

5.0 s

7	2	1	5	■	P	C	B	A	U	D	R	A	T	E
9	6	0	0	B	A	U	D							
1 9 2 0 0 B A U D														
1 2 0 0 B A U D														
2 4 0 0 B A U D														
4 8 0 0 B A U D														

The transmission Baud-rate for communication via the PC (operating) interface at the front can be adapted to the operator's communication interface, e.g. personal computer, if necessary. The available possibilities can be displayed by repeatedly depression of the "No" –key **N**. Confirm the desired Baud-rate with the entry key **E**.

7	2	1	6	■	P	C	P	A	R	I	T	Y	
D	I	G	S	I	V	3							
N O 2 S T O P													
N O 1 S T O P													

Parity and stop-bits for the PC (operating) interface:

format for Siemens protection data processing program
DIGSI® Version V3 with even parity and 1 stop-bit

transmission with *NO* parity and 2 *STOP*–bits

transmission with *NO* parity and 1 *STOP*–bit, e.g. modem

Addresses 7221 to 7235 are valid for the system (LSA) interface (if fitted).

7 2 2 1	■	S Y S	I N T E R F .
V D E W		C O M P A T I B L E	
V D E W E X T E N D E D			
D I G S I V 3			
L S A			

Format of annunciations and fault records for the system (LSA) interface:

only data in accordance with *VDEW/ZVEI* and IEC 60870-5-103

data in accordance with *VDEW/ZVEI* and IEC 60870-5-103, extended by Siemens specified data

format for Siemens protection data processing program *DIGSI*® Version V3

format of the former Siemens *LSA* version

7 2 2 2	■	S Y S	M E A S U R .
V D E W		C O M P A T I B L E	
V D E W E X T E N D E D			

Format of measured values for the system (LSA) interface:

only data in accordance with *VDEW/ZVEI* and IEC 60870-5-103

data in accordance with *VDEW/ZVEI* and IEC 60870-5-103, extended by Siemens specified data

7 2 2 4	■	S Y S	G A P S
0 . 0		s	

Maximum time period of data gaps within telegrams which may occur during data transmission via modem on the system (LSA) interface

Smallest setting value:

0.0 s

Largest setting value:

5.0 s

7 2 2 5	■	S Y S	B A U D R .
9 6 0 0		B A U D	
1 9 2 0 0 B A U D			
1 2 0 0 B A U D			
2 4 0 0 B A U D			
4 8 0 0 B A U D			

The transmission Baud-rate for communication via the system interface can be adapted to the system interface, e.g. *LSA*, if necessary. The available possibilities can be displayed by repeatedly depression of the "No"-key **N**. Confirm the desired Baud-rate with the entry key **E**.

7 2 2 6	■	S Y S	P A R I T Y
V D E W /		D I G S I V 3 /	L S A
N O 2 S T O P			
N O 1 S T O P			

Parity and stop-bits for the system (LSA) interface:

format for *VDEW*-protocol (acc. IEC 60870-5-103) or Siemens protection data processing program *DIGSI*® Version 3 and former *LSA*

transmission with *NO* parity and 2 *STOP*-bits

transmission with *NO* parity and 1 *STOP*-bit, e.g. modem

It is possible to switch the VDEW–protocol (acc. IEC 60870–5–103) over to the transmission protocol according to the operation software DIGSI® during operation. A precondition is that a transmission format is selected for the system interface which is compatible to the VDEW–protocol (acc. IEC 60870–5–103), i.e. address 7221 SYS INTERF is switched to *VDEW COMPATIBLE* or *VDEW EXTENDED*. If this facility is to be used, address 7227 SYS SWITCH must be set to YES. This configuration

address does only permit to switch over from VDEW–protocol (acc. IEC 60870–5–103) to DIGSI®–protocol and vice versa at the system interface. The actual switch-over is arranged by a special telegram which is sent by DIGSI® to the system interface when to PC–operator initiates the corresponding command. When address 7235 (see below) is equally set to YES, then remote parameterizing is possible via the system interface by means of DIGSI®–procedures.

7	2	2	7	■	S	Y	S	S	W	I	T	C	H
N	O												

Y	E	S

Switch-over between VDEW transmission protocol (acc. IEC 60870–5–103) and DIGSI®–protocol via the system interface

NO – is not permitted

YES – is permitted

Address 7235 is relevant only in case the system interface is connected with a hardware that operates with the protection data processing program DIGSI®. This address determines whether is shall be permitted to change parameters via this interface. One of the following preconditions must be fulfilled:

- either address 7221 SYS INTERF is set to *DIGSI V3*,
- or address 7221 SYS INTERF is set to *VDEW COMPATIBLE* or *VDEW EXTENDED* and, at the same time, address 7227 SYS SWITCH (see above) is set to YES.

7	2	3	5	■	S	Y	S	P	A	R	A	M	E	T
N	O													

Y	E	S

Remote parameterizing via the system interface

NO – is not permitted

YES – is permitted

5.3.4 Settings for fault recording – address block 74

The line protection relay is equipped with a fault data store (see Section 4.18.2). Distinction must be made between the reference instant and the storage criterion (address 7402). Normally, the general fault detection signal of the protection is the reference instant. The storage criterion can be the general fault detection, too (*STORAGE BY FD*), or the trip command (*STORAGE BY TRIP*). Alternatively, the trip command can be selected as reference instant (*START WITH TRIP*), in this case, the trip command is the storage criterion, too.

A fault event begins with the fault detection of any protection functions and ends with drop-off of the latest fault detection. The scope of a fault record is normally this fault event (address 7403). If auto-reclosure is carried out, the complete network fault sequence – with one or more reclosure attempts – can be recorded until final fault clearance. This shows the total time sequence of the fault but utilizes more memory space even during the dead time(s).

The actual recording time starts with the pre-trigger time T–PRE (address 7411) before the reference in-

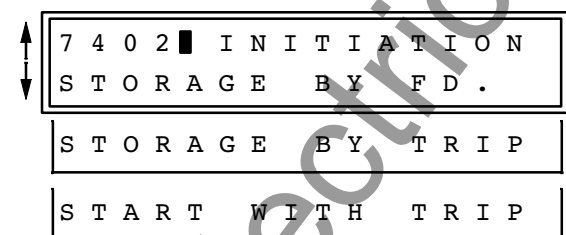
stant and ends with the post-fault time T–POST (address 7412) after the recording criterion has disappeared. The permissible recording time for each record is set under address 7410, the maximum is 5 s per record. Altogether 10 s are available for fault recording. In this time range up to 8 fault records can be stored.

Note: The set times are related on a system frequency of 50 Hz. They are to be matched, accordingly, for different frequencies.

Data storage can also be initiated via a binary input or by operator action from the membrane keyboard on the front of the relay or via the operating interface (see Section 6.7.8). The storage is triggered dynamically, in these cases. The length of the data storage is determined by the settings in addresses 7431 and 7432, but max. T–MAX, address 7410. Pre-trigger time and post-fault time are additive to the set values. If the storage time for start via binary input is set to ∞ , then the storage time ends after de-energization of the binary input (statically), but not after T–MAX (address 7410).

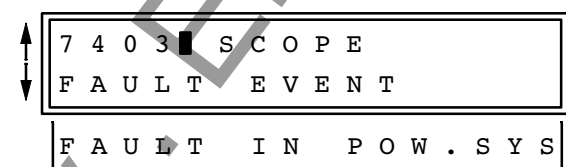


Beginning of block "Fault recordings"



Data storage is initiated:

- fault detection is reference instant
fault detection is storage criterion
- fault detection is reference instant
trip command is storage criterion
- trip command is reference instant
trip command is storage criterion



Scope of a fault record:

a fault record is stored for each *FAULT EVENT*, i.e. from pick-up until drop-off

a fault record comprises the total *NETWORK FAULT* including auto-reclosure attempts



Maximum time period of a fault record

Smallest setting value: 0.30 s

Largest setting value: 5.00 s

7	4	1	1	■	T - P R E
0	.	1	0		s

Pre-trigger time before the reference instant
 Smallest setting value: **0.05 s**
 Largest setting value: **0.50 s**

7	4	1	2	■	T - P O S T
0	.	1	0		s

Post-fault time after the storage criterion disappears
 Smallest setting value: **0.05 s**
 Largest setting value: **0.50 s**

7	4	3	1	■	T - B I N A R Y I N
0	.	5	0		s

Storage time when fault recording is initiated via a binary input, pre-trigger and post-fault times are additive
 Smallest setting value: **0.10 s**
 Largest setting value: **5.00 s**
 or ∞ , i.e. as long as the binary input is energized (but not longer than T-MAX)

7	4	3	2	■	T - K E Y B O A R D
0	.	5	0		s

Storage time when fault recording is initiated via the membrane keyboard, pre-trigger and post-fault times are additive
 Smallest setting value: **0.10 s**
 Largest setting value: **5.00 s**

Address 7490 is not relevant in case that the relay is connected to a control and storage processing system which operates with the protocol according to VDEW/ZVEI and IEC 60870-5-103. But, if the relay is connected to a former LSA system, the relay must be informed how long a transmitted fault record must be, so that the former LSA system receives the correct number of fault record values.

Only for communication with a former LSA system:

7	4	9	0	■	S Y S L E N G T H
6	6	0			V A L U E S F I X
< = 3 0 0 0 V A L . V A R					

Length of a fault record which is transmitted via the serial system interface:
 660 values fix or
 variable length with a maximum of 3000 values

5.4 Configuration of the protective functions

5.4.1 Introduction

The **device** 7SA513 is capable of providing a series of **protection** and additional functions. The scope of the hard- and firm-ware is matched to these functions. Furthermore, individual functions can be set (configured) to be effective or non-effective or the interaction of the functions can be modified by configuration parameters. Additionally, the relay can be adapted to the system frequency.

1st example for configuration of the scope of the device:

Assume a network comprising overhead lines and cable sections. For reasons of uniformity, all devices have been specified with auto-reclose facilities. Since auto-reclosure is only applicable for the overhead line sections, this function will be "de-configured" for the devices protecting the cable sections.

2nd example for the interaction of the functions:

The device includes distance protection and earth fault protection (for high resistance earth faults in earthed networks). The distance protection is required to operate with single-pole auto-reclose, the earth fault protection shall operate without auto-reclosure. The device will be "informed" of this condition during configuration.

The configuration parameters are input through the integrated operation keyboard at the front of the device or by means of a personal computer, connected to this front interface. The use of the integrated operating keyboard is described in detail in Section 6.2. Alteration of the programmed parameters requires the input of the codeword (see Section 5.3.1). Without codeword, the setting can be read out but not altered.

For the purpose of configuration, addresses 78** and 79** are provided. One can access the beginning of the configuration blocks either by direct dial

- press direct address key **DA**,
- type in address **7 8 0 0**,
- press execute key **E** ;

or by paging with the keys ↑ (forwards) or ↓ (backwards), until address 7800 appears.

Within the block 78 one can page forward with ↑ or back with ↓. Each paging action leads to a further address for the input of a configuration parameter. In the following sections, each address is shown in a box and explained. In the upper line of the display, behind the number and the bar, stands the associated device function. In the second line is the associated text (e.g. "EXIST"). If this text is appropriate the arrow keys ↑ or ↓ can be used to page the next address. If the text should be altered press the "No"–key **N**; an alternative text then appears (e.g. "NON-EXIST"). There may be other alternatives which can then be displayed by repeated depression of the "No"–key **N**. The required alternative **must be confirmed with the key E**!

Use of the double arrow key ↑↑ brings one to the next address block, in this case 79. There one finds further setting parameters which can equally be confirmed or altered.

The configuration procedure can be ended at any time by the key combination **F E**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS ?". Confirm with the "Yes"–key **J/Y** that the new settings shall become valid now. If you press the "No"–key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

If one tries to leave the setting range for the configuration blocks (i.e. address blocks 60 to 79) with keys ↑↑ ↓↓, the display shows the question "END OF CODEWORD OPERATION ?". Press the "No"–key **N** to continue configuration. If you press the "Yes"–key **J/Y** instead, another question appears: "SAVE NEW SETTINGS ?". Now you can confirm with **J/Y** or abort with **N**, as described above.

When one exits the setting program, the altered parameters, which until then have been stored in volatile memories, are then permanently secured in EEPROMs and protected against power outage. The processor system will reset and re-start. During re-start the device is not operational.

5.4.2 Programming the scope of functions – address block 78

The available protective and additional functions can be programmed as existing or not existing. For some functions it may also be possible to select between multiple alternatives.

Functions which are **configured** as *NON-EXIST* will not be processed in 7SA513: There will be no annunciations and the associated setting parameters (functions, limit values) will not be requested during setting (Section 6.3). In contrast, **switch-off** of a

function means that the function will be processed, that indication will appear (e.g. "... switched off") but that the function will have no effect on the result of the protective process (e.g. no tripping command).

The following boxes show the possibilities for the maximum scope of the device. In an actual case, functions which are not available will not appear in the display.

7 8 0 0 ■ S C O P E O F
F U N C T I O N S

Beginning of the block "scope of functions"

Distance protection:

7 8 1 2 ■ D I S T . P R O T .
E X I S T
N O N - E X I S T

Teleprotection permissive overreach transfer trip:

7 8 2 2 ■ P O T T
N O N - E X I S T
E X I S T

Fault detection mode for distance protection:

7 8 1 3 ■ D I S T . F . D E T .
I M P E D A N C E Z O N E
U / I / φ F A U L T D E T .

User definable logic functions:

7 8 2 3 ■ U S E R L O G I C
N O N - E X I S T
E X I S T

Power swing detection:

7 8 2 0 ■ P O W E R S W I N G
N O N - E X I S T
E X I S T

High-current switch-onto-fault protection:

7 8 2 4 ■ S W I T C H - O - F
N O N - E X I S T
E X I S T

Teleprotection permissive underreach transfer trip:

7 8 2 1 ■ P U T T
N O N - E X I S T
E X I S T

Weak-infeed trip facility:

7 8 2 5 ■ W E A K I N F E E D
N O N - E X I S T
E X I S T

Emergency overcurrent time protection:

7 8 2 6 ■ E M E R G . O / C
E X I S T
N O N - E X I S T

Back-up overcurrent time protection:

7 8 3 6 ■ B A C K - U P O / C
N O N - E X I S T
E X I S T

High resistance earth fault protection:

7 8 3 1 ■ E A R T H F A U L T
N O N - E X I S T
D I R E C . C O M P A R I S O N
D I R / N O N - D I R

Overvoltage protection:

7 8 3 7 ■ O V E R V O L T .
N O N - E X I S T
E X I S T

Fault location:

7 8 3 8 ■ F A U L T L O C A T
E X I S T
N O N - E X I S T

Internal auto-reclosure function:

7 8 3 4 ■ I N T E R N A L A R
N O N - E X I S T
E X I S T

Circuit breaker failure protection:

7 8 3 9 ■ B R E A K . F A I L
N O N - E X I S T
E X I S T

Internal synchronism and voltage check function:

7 8 3 5 ■ S Y N C H . C H E C K
N O N - E X I S T
E X I S T

Parameter set change-over:

7 8 8 5 ■ P A R A M . C / O
N O N - E X I S T
E X I S T

The rated system frequency must comply with the setting under address 7899. If the system frequency is not 50 Hz, address 7899 must be changed.

7 8 9 9 ■ F R E Q U E N C Y
f N 5 0 H z
f N 6 0 H z

Rated system frequency 50 Hz or 60 Hz

5.4.3 Setting the device configuration – address block 79

The configuration affects the interaction of the protective and additional functions, above all, for

7SA513, the interaction of the auto-reclosing system with the protection functions.

7 9 0 0 ■ D E V I C E C O N F I G U R A T I O N

Beginning of the block "Device configuration"

7 9 1 0 ■ C B T E S T B I T R I P - C L O S E 3 P O L E S E Q U . L 1 - L 2 - L 3 T H R E E - P O L E T R I P

Circuit breaker test via binary input is carried out
TRIP-CLOSE 3POLE, that is three-pole AR cycle,
or each pole one after the other with a
SEQU. L1-L2-L3 open and close (this is only applica-
ble when single-pole AR is used),
or
THREE-POLE TRIP will be initiated (without reclose)

7 9 1 2 ■ A R w / D I S T . Y E S N O

Auto-reclosing works together with distance protection
or not

7 9 2 1 ■ A R w / o T E L E Y E S N O

If signal transmission is distorted or switched off
YES – AR operates as set
NO – AR is blocked

7 9 2 4 ■ A R w / S - O - F Y E S N O B L O C K A R

With high-current switch-onto-fault protection
YES – AR works in accordance with the setting
NO – no AR will be carried out
BLOCK AR – either AR will be blocked

7 9 2 5 ■ A R w / W / I Y E S N O

With weak infeed trip
YES – AR works in accordance with the setting
NO – no AR will be carried out

7 9 2 6 ■ A R w / E M E R G
Y E S
N O

Emergency overcurrent time protection operation

YES – AR works in accordance with the setting but no auto-reclose when only I_E pick-up

NO – no AR will be carried out

7 9 3 1 ■ A R w / E / F
Y E S
N O

With earth fault protection (for earthed networks)

YES – AR works in accordance with the setting

NO – no AR will be carried out

7 9 3 6 ■ A R w / B A C K
Y E S
N O

Back-up overcurrent time protection operation

YES – AR works in accordance with the setting but no auto-reclose when only I_E pick-up

NO – no AR will be carried out

7 9 4 1 ■ A R w / E X T .
Y E S
N O

With tripping from an external command

YES – AR will be carried out as parameterized

NO – no AR will be carried out

5.5 Marshalling of binary inputs, binary outputs, and LED indicators

5.5.1 Introduction

The functions of the binary inputs and outputs represented in the general diagrams (Appendix A) relate to the factory settings. The assignment of the inputs and outputs of the internal functions can be rearranged and thus adapted to the on-site conditions.

Marshalling of the inputs, outputs and LEDs is performed by means of the integrated operator panel or via the operating interface in the front. The operation of the operator panel is described in detail in Section 6.2. Marshalling begins at the parameter address 6000.

The input of the codeword is required for marshalling (refer Section 5.3.1). Without codeword entry, parameters can be read out but not be changed. During codeword operation, i.e. from codeword entry until the termination of the marshalling procedure, the solid bar in the display flashes.

When the 7SA513 programs are running the specific logic functions will be allocated to the physical input and output modules or LEDs in accordance with the selection.

Example: Fault detection is registered from the distance protection in phase L1. This event is generated in 7SA513 as an "Annunciation" (logical function) and should be available at certain terminals of the unit as a N.O. contact. Since specific unit terminals are hard-wired to a specific (physical) signal relay, e.g. to the signal relay 1, the processor must be advised that the logical signal "Dist.Fault L1" should be transmitted to the signal relay 1. Thus, when marshalling is performed two statements of the operator are important: **Which** (logical) annunciation generated in the protection unit program should trigger **which** (physical) signal relay? Up to 20 logical annunciations can trigger one (physical) signal relay.

A similar situation applies to binary inputs. In this case external information (e.g. voltage transformer m.c.b. tripped) is connected to the unit via a (physical)

cal) input module and should initiate a (logical) function, namely blocking. The corresponding question to the operator is then: **Which** signal from a (physical) input relay should initiate **which** reaction in the device? One physical input signal can initiate up to 10 logical functions.

The trip relays can also be assigned different functions. Each trip relay can be controlled by each command function or combination of command functions.

The logical annunciation functions can be used in multiple manner. E.g. one annunciation function can trigger several signal relays, several trip relays, additionally be indicated by LEDs, and be controlled by a binary input unit. The restriction is, that the total of all physical input/output units (binary inputs plus signal relays plus LEDs plus trip relays) which are to be associated with one logical function must not exceed a number of 10. If this number is tried to be exceeded, the display will show a corresponding message.

The marshalling procedure is set up such that for each (physical) binary input, each output relay, and for each marshallable LED, the operator will be asked which (logical) function should be allocated.

The offered logical functions are tabulated for the binary inputs, outputs and LEDs in the following sections.

The beginning of the marshalling parameter blocks is reached by directly selecting the address 6000, i.e.

- press direct address key **DA**,
- enter address **6 0 0 0**,
- press enter key **E**

or by paging with keys ↑ (forwards) or ↓ (backwards) until address 6000 has been reached. The beginning of the marshalling blocks then appears:



Beginning of marshalling blocks

One can proceed through the marshalling blocks with the key $\uparrow$ or go back with the key $\downarrow$. Within a block, one goes forwards with $\uparrow$ or backwards with $\downarrow$. Each forward or backward step leads to display of the next input, output or LED position. In the display, behind the address and the solid bar, the physical input/output unit forms the heading.

The key combination **F** $\uparrow$, i.e. depressing the function key **F** followed by the arrow key $\uparrow$, switches over to the selection level for the logical functions to be allocated. During this change-over (i.e. from pressing the **F** key until pressing the $\uparrow$ key) the bar behind the address number is replaced by a "F". The display shows, in the upper line, the physical input/output unit, this time with a three digit index number. The second display line shows the logical function which is presently allocated.

On this selection level the allocated function can be changed by pressing the "No" – key **N**. By repeated use of the key **N** all marshallable functions can be paged through the display. Back-paging is possible with the backspace key **R**. When the required function appears press the execute key **E**. After this, further functions can be allocated to the same physical input or output module (with further index numbers) by using the key $\uparrow$. **Each selection must be confirmed by pressing the key E!** If a selection place shall not be assigned to a function, selection is made with the function "not allocated".

You can leave the selection level by pressing the key combination **F** $\uparrow$ (i.e. depressing the function key **F** followed by the arrow key $\uparrow$). The display shows again the four digit address number of the physical input/output module. Now you can page with key $\uparrow$ to the next input/output module or with $\downarrow$ to the previous to repeat selection procedure, as above.

The logical functions are also provided with function numbers which are equally listed in the tables. If the function number is known, this can be input directly on the selection level. Paging through the possible functions is then superfluous. With direct input of the function number, leading zeros need not be entered. After input of the function number, use **the enter key E**. Immediately the associated identification of the

function appears for checking purposes. This can be altered either by entering a different function number or by paging through the possible functions, forwards with the "No" – key **N** or backwards with the backspace key **R**. If the function has been changed, another confirmation is necessary with **the enter key E**.

In the following paragraphs, allocation possibilities for binary inputs, binary outputs and LED indicators are given. The arrows $\uparrow$ or $\downarrow$ at the left hand side of the display box indicate paging from block to block, within the block or on the selection level. The character F before the arrow indicates that the function key **F** must be pressed before pushing the arrow key $\uparrow$.

The function numbers and designations are listed completely in Appendix C.

The marshalling procedure can be ended at any time by the key combination **F E**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS?". Confirm with the "Yes" – key **J/Y** that the new allocations shall become valid now. If you press the "No" – key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

If one tries to leave the setting range for the configuration blocks (i.e. address blocks 60 to 79) with keys $\uparrow$ $\downarrow$, the display shows the question "END OF CODEWORD OPERATION ?". Press the "No" – key **N** to continue marshalling. If you press the "Yes" – key **J/Y** instead, another question appears: "SAVE NEW SETTINGS ?". Now you can confirm with **J/Y** or abort with **N**, as above.

When one exits the marshalling program, the altered parameters, which until then have been stored in volatile memory, are then permanently secured in EEPROMs and protected against power outage. The processor system will reset and re-start. During re-start the device is not operational.

5.5.2 Marshalling of the binary inputs – address block 61

The unit contains up to 24 binary inputs which are designated INPUT 1 to INPUT 24. They can be marshalled in address block 61. The address block is reached by paging in blocks or by direct addressing with **DA 6100 E**. The selection procedure is carried out as described in Section 5.5.1.

A choice can be made for each individual input function as to whether the desired function should become operative in the "normally open" mode or in the "normally closed" mode, whereby:

NO – "normally open" mode: the input acts as a NO contact, i.e. the control voltage at the input terminals activates the function;

NC – "normally closed" mode: the input acts as a NC contact, i.e. control voltage present at the terminals turns off the function, control voltage absent activates the function.

When paging through the display, each input function is displayed with the index "NO" or "NC" when proceeding with the "No"–key **N**.

Table 5.2 shows a complete list of all the binary input functions with their associated function number **FNo**. Input functions naturally have no effect if the corresponding protection function is not fitted in the

relay or has been programmed out ("de-configured", refer Section 5.4.2).

With direct input of the function number, leading zeros need not be used. To indicate the contact mode the function number can be extended by a decimal point followed by **0** or **1**, whereby

.0 means "normally open" mode, corresponds to "NO" as above.

.1 means "normally closed" mode, corresponds to "NC" as above.

If the extension with .0 or .1 is omitted the display first indicates the function designation in "normally open" mode **NO**. By pressing the "No"–key **N** the mode is changed to **NC**. After direct input other functions can be selected by paging through the functions forwards with the "No"–key **N** or backwards with the backspace key **R**. The changed function then must be re-confirmed by the entry key **E**.

Note: One logical function must not be marshalled to two or more binary inputs, because an OR–logic of the signals can not be guaranteed!

The following boxes show, as an example, the allocation for binary input 1. Table 5.3 shows all binary inputs as preset from the factory.

6 1 0 0 ■ MARSHALLING
B I N A R Y I N P U T S

Beginning of block "Marshalling binary inputs"

The first binary input is reached with the key **↑**:

6 1 0 1 ■ B I N A R Y
I N P U T 1

Allocations for binary input 1

Change over to the selection level with **F ↑**:

0 0 1 ■ I N P U T 1
> L E D r e s e t N O

Reset of stored LED indications, FNo 5;
"normally open" operation:
LEDs are reset when control voltage present

0 0 2 ■ I N P U T 1
n o t a l l o c a t e d

No further functions are initiated by binary input 1

Leave the selection level with key combination **F ↑**. You can go then to the next binary input with the arrow key **↑**.

6	1	0	1	■	B I N A R Y
I	N	P	U	T	1

Marshalling binary input 1

FNo	Abbreviation	Description
1	not allocated	Binary input is not allocated to any input function
3	>Time Synchro	Synchronize internal real time clock
4	>Start FltRec	Start fault recording from external command via binary input
5	>LED reset	Reset LED indicators
7	>ParamSelec.1	Parameter set selection 1 (in conjunction with FNo 8)
8	>ParamSelec.2	Parameter set selection 2 (in conjunction with FNo 7)
11	>Annunc. 1	User definable annunciation 1
12	>Annunc. 2	User definable annunciation 2
13	>Annunc. 3	User definable annunciation 3
14	>Annunc. 4	User definable annunciation 4
15	>Sys-Test	System interface messages/values are marked with "Test operation"
16	>Sys-MM-block	System interface messages and measured values are blocked
351	>CB Aux. L1	Circuit breaker auxiliary contact L1 (L1 is closed)
352	>CB Aux. L2	Circuit breaker auxiliary contact L2 (L2 is closed)
353	>CB Aux. L3	Circuit breaker auxiliary contact L3 (L3 is closed)
354	>CB Aux.3p cl	Circuit breaker auxiliary contact all poles closed (series connection)
355	>CB Aux.1p cl	Circuit breaker auxiliary contact any pole closed (parallel connec.)
356	>Manual Close	Circuit breaker is manually closed (from discrepancy switch)
357	>CloseCmd.Blo	Block all closing commands
361	>VT mcb Trip	Voltage transformer secondary m.c.b. (feeder) has tripped
362	>V2 mcb Trip	Voltage transformer secondary m.c.b. (bus-bar) has tripped
381	>1p Trip Perm	External AR ready for single-pole reclosure
382	>Only 1pole	External AR is programmed single-pole only
383	>RAR Release	Release RAR stages from external (e.g. external AR device)
384	>DAR Release	Release DAR stage from external (e.g. external AR device)
1106	>Start FltLoc	Start fault locator from external command via binary input
1156	>CB Test	Trigger circuit breaker test
1303	>E/F block	Block earth fault protection for earthed system
1311	>E/F comp. on	Switch on directional comparison earth fault protection
1312	>E/F comp.off	Switch off directional comparison earth fault protection
1316	>E/F Recept	Carrier reception signal for directional E/F comparison
1317	>E/F Rec.Fail	Carrier reception for directional earth fault comparison faulty
1401	>B/F on	Switch on circuit breaker failure protection
1402	>B/F off	Switch off circuit breaker failure protection
1403	>B/F block	Block circuit breaker failure protection
1432	>B/F release	Release of breaker failure protection from external (2nd channel)
1435	>B/F Start L1	Initiate breaker failure protection pole L1 from external source
1436	>B/F Start L2	Initiate breaker failure protection pole L2 from external source
1437	>B/F Start L3	Initiate breaker failure protection pole L3 from external source
1706	>I>> block	Block I>> stage of all overcurrent protection
1707	>I>/Ip block	Block I> stage (definite) or I _p stage (inverse) of overcurrent protection
1716	>IE>> block	Block I _E >> stage of all overcurrent protection
1717	>IE>/IEp bloc	Block I _E > stage (definite) or I _{Ep} stage (inverse) of overcurrent protec.
2003	>Emer. block	Block emergency overcurrent time protection
2303	>Backup block	Block Back-up overcurrent time protection

Table 5.2 Marshalling possibilities for binary inputs (continued next page)

FNo	Abbreviation	Description
2701	>AR on	Switch on internal auto-reclose function
2702	>AR off	Switch off internal auto-reclose function
2703	>AR block	Block internal auto-reclose function statically
2704	>AR reset	Reset internal auto-reclose function (incl. lock-out)
2706	>1p RAR block	Block single-pole RAR
2707	>3p RAR block	Block three-pole RAR
2708	>RAR block	Block complete RAR
2709	>DAR block	Block complete DAR
2711	>Start AR	Start signal from external protection for internal AR
2712	>Trip L1 AR	Trip signal L1 from external protection for internal AR
2713	>Trip L2 AR	Trip signal L2 from external protection for internal AR
2714	>Trip L3 AR	Trip signal L3 from external protection for internal AR
2715	>Trip 1p AR	Trip signal single-pole from external protection for internal AR
2716	>Trip 3p AR	Trip signal three-pole from external protection for internal AR
2721	>DAR aft. RAR	DAR is permitted only after unsuccessful RAR
2730	>CB ready	Circuit breaker ready for AR cycle
2731	>Sync.release	Reclose release from an external synchronism-check relay
2901	>Sync. on	Switch on internal synchronism and voltage check function
2902	>Sync. off	Switch off internal synchronism and voltage check function
2903	>Sync. block	Block internal synchronism and voltage check function
2906	>Sync. Start	Start-to-measure signal for internal synchronism and voltage check
2907	>Sync. synch	Synchro-check program: check synchronism
2908	>Sync. U1>U2<	Synchro-check program: live line, dead bus
2909	>Sync. U1<U2>	Synchro-check program: dead line, live bus
2910	>Sync. U1<U2<	Synchro-check program: dead line, dead bus
2911	>Sync. o/ride	Synchro-check program: override any check
3603	>Dist. block	Block distance protection
3611	>Extens. Z1B	Release distance overreaching zone Z1B from external
3612	>Extens. Z1L	Release distance overreaching zone Z1L from external
4011	>Dis.POTT on	Switch on permissive overreach transfer function
4012	>Dis.POTT off	Switch off permissive overreach transfer function
4014	>Dis.Recept.O	Reception signal for distance protection overreach transfer trip
4015	>Dis.RecFailO	Reception for overreach transfer trip faulty
4021	>Dis.PUTT on	Switch on permissive underreach transfer function
4022	>Dis.PUTT off	Switch off permissive underreach transfer function
4024	>Dis.Recept.U	Reception signal for distance protection underreach transfer trip
4025	>Dis.RecFailU	Reception for underreach transfer trip faulty
4203	>W/I block	Block weak-infeed trip function
4206	>W/I Rec	Reception for weak-infeed trip function
4253	>Sw-o-Flt.blo	Block high-current switch-onto-fault protection
4301	>U> Prot. on	Switch on overvoltage protection stage U>
4302	>U> Prot. off	Switch off overvoltage protection stage U>
4304	>U>>Prot. on	Switch on overvoltage protection stage U>>
4305	>U>>Prot. off	Switch off overvoltage protection stage U>>
4306	>U> Block	Block overvoltage protection stage U>
4307	>U>> Block	Block overvoltage protection stage U>>
4403	>Ext.Trip blk	Block trip signal from external protection function
4412	>Ext.Trip L1	Trip signal L1 from external protection function
4413	>Ext.Trip L2	Trip signal L2 from external protection function
4414	>Ext.Trip L3	Trip signal L3 from external protection function
4416	>Ext.Trp.woAR	Trip signal from external protection function without auto-reclosure
6206	>User T1Start	User definable logic function timer 1 start
6207	>User T1Reset	User definable logic function timer 1 reset
6208	>User T2Start	User definable logic function timer 2 start
6209	>User T2Reset	User definable logic function timer 2 reset

Table 5.2 Marshalling possibilities for binary inputs

The complete pre-settings are listed in Table 5.3.

Note: Dependent on the ordered model, not all binary inputs listed in Table 5.3 may be present.

Addr	1st display line	2nd display line	FNo	Remarks
6100	MARSHALLING	BINARY INPUTS		Heading of the address block
6101	BINARY INPUT 1	INPUT 1 >LED reset NO	5	Acknowledge and reset of stored LED and display indications, LED – test
6102	BINARY INPUT 2	INPUT 2 >VT mcb Trip NO	361	Voltage transformer secondary m.c.b. has tripped
6103	BINARY INPUT 3	INPUT 3 not allocated	1	no function allocated
6104	BINARY INPUT 4	INPUT 4 >Manual Close NO	356	Manual close command from discrepancy switch
6105	BINARY INPUT 5 INPUT 5 INPUT 5	INPUT 5 >Dis.Recept.O NO >Dis.Recept.U NO >W/I Rec NO	4014 4024 4206	from carrier device for teleprotection with distance protection and weak-infeed trip
6106	BINARY INPUT 6 INPUT 6 INPUT 6	INPUT 6 >Dis.RecFailO NO >Dis.RecFailU NO	4015 4025	
6107	BINARY INPUT 7	INPUT 7 >CB ready NO	2730	
6108	BINARY INPUT 8	INPUT 8 >AR block NO	2703	Binary inputs 7 to 11 are only effective when the internal auto-reclose function has been configured as <i>EXIST</i> (refer Section 5.4.2).
6109	BINARY INPUT 9	INPUT 9 >AR on NO	2701	
6110	BINARY INPUT 10	INPUT 10 >AR off NO	2702	
6111	BINARY INPUT 11	INPUT 11 E/F Recept NO	1316	from carrier device for directional earth fault protection
6112	BINARY INPUT 12	INPUT 12 E/F Rec.Fail NO	1317	

For binary inputs 13 to 24 (if fitted), no functions are preset by the factory.

Table 5.3 Preset binary inputs

5.5.3 Marshalling of the signal output relays – address block 62

The unit contains – dependent on model – up to 27 signal outputs (alarm relays). The signal relays are designated SIGNAL RELAY 1 to SIGNAL RELAY 27 and can be marshalled in address block 62. The block is reached by paging in blocks with $\uparrow \downarrow$ or by directly addressing **DA 6200 E**. The selection procedure is carried out as described in Section 5.5.1. Multiple annunciations are possible, i.e. one logical annunciation function can be given to several physical signal relays (see also Section 5.5.1).

Table 5.4 gives a listing of all annunciation functions with the associated function numbers **FNo**. Annunciation functions are naturally not effective when the corresponding protection function is not fitted in the relay or has been programmed out ("de-configured")

– refer Section 5.4.2).

Note as to Table 5.4: Annunciations which are indicated by a leading ">" sign, represent the direct confirmation of the binary inputs and are available as long as the corresponding binary input is energized.

Further information about annunciations see Section 6.4.

The following boxes show examples for marshalling. In the example for signal relay 1 the group annunciation for several annunciation functions on one signal relay is shown. Table 5.5 shows all signal relays as preset from the factory.

$\uparrow \downarrow$ 6 2 0 0 ■ M A R S H A L L I N G
S I G N A L R E L A Y S

Beginning of the block "Marshalling of the output signal relays"

The first signal relay is reached with the key $\uparrow$:

$\uparrow$ 6 2 0 1 ■ S I G N A L
R E L A Y 1

Allocations for signal relay 1

Change over to the selection level with **F** $\uparrow$:

$\uparrow \downarrow$ 0 0 1 ■ R E L A Y 1
D e v . F l t D e t L 1

Signal relay 1 has been preset for:
Fault detection of the device (general) phase L1;
FNo 503

$\uparrow \downarrow$ 0 0 2 ■ R E L A Y 1
n o t a l l o c a t e d

no further functions are preset for signal relay 1

Leave the selection level with key combination **F** $\uparrow$. You can go then to the next signal output relay with the arrow key $\uparrow$.

$\uparrow$ 6 2 0 1 ■ S I G N A L
R E L A Y 1

Allocations for signal relay 1,
Meaning: "Fault annunciations of phase L1"

FNo	Abbreviation	Description
1	not allocated	No annunciation allocated
3	>Time Synchro	Synchronize internal real time clock
4	>Start FltRec	Start fault recording by external command via binary input
5	>LED reset	Reset LED indicators
7	>ParamSelec.1	Parameter set selection 1 (in conjunction with FNo 8)
8	>ParamSelec.2	Parameter set selection 2 (in conjunction with FNo 7)
11	>Annunc. 1	User definable annunciation 1
12	>Annunc. 2	User definable annunciation 2
13	>Annunc. 3	User definable annunciation 3
14	>Annunc. 4	User definable annunciation 4
15	>Sys-Test	System interface messages/values are marked with "Test operation"
16	>Sys-MM-block	System interface messages and measured values are blocked
51	Dev.operative	Protection relay operative
52	Prot. operat.	At least one protection function active
60	LED reset	Stored annunciations are reset
95	Param.running	Parameters are being set
96	Param. Set A	Parameter Set A is activated
97	Param. Set B	Parameter Set B is activated
98	Param. Set C	Parameter Set C is activated
99	Param. Set D	Parameter Set D is activated
141	Failure 24V	Failure 24 V internal dc supply
143	Failure 15V	Failure 15 V internal dc supply
144	Failure 5V	Failure 5 V internal dc supply
145	Failure 0V	Failure 0 V A/D converter
161	I supervision	General failure detected by current supervision
162	Failure ΣI	Failure supervision ΣI (measured currents)
163	Failure Isymm	Failure supervision symmetry I
164	U supervision	General failure detected by voltage supervision
165	Failure ΣU -e	Failure supervision ΣU phase-earth
166	Failure ΣU -p	Failure supervision ΣU phase-phase
167	Failure Usymm	Failure supervision symmetry U
168	Failure Umeas	Failure measured voltage
169	Fuse-Failure	Fuse failure monitor operated
171	Fail.PhaseSeq	Failure supervision phase sequence
351	>CB Aux. L1	Circuit breaker auxiliary contact L1 (L1 is closed)
352	>CB Aux. L2	Circuit breaker auxiliary contact L2 (L2 is closed)
353	>CB Aux. L3	Circuit breaker auxiliary contact L3 (L3 is closed)
354	>CB Aux.3p cl	Circuit breaker auxiliary contact all poles closed (series connection)
355	>CB Aux.1p cl	Circuit breaker auxiliary contact any pole closed (parallel connec.)
356	>Manual Close	Circuit breaker is manually closed (from discrepancy switch)
357	>CloseCmd.Blo	Block closing command
361	>VT mcb Trip	Voltage transformer secondary m.c.b. (feeder) has tripped
362	>V2 mcb Trip	Voltage transformer secondary m.c.b. (bus-bar) has tripped
381	>1p Trip Perm	External AR ready for 1-pole reclosure
382	>Only 1pole	External AR is programmed 1-pole only
383	>RAR Release	Release RAR stages from external
384	>DAR Release	Release DAR stages from external
501	Device FltDet	General fault detection of the device
503	Dev.FltDet L1	Fault detection of the device phase L1
504	Dev.FltDet L2	Fault detection of the device phase L2
505	Dev.FltDet L3	Fault detection of the device phase L3
506	Dev.FltDet E	Fault detection of the device earth fault

Table 5.4 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
511	Device Trip	General trip of the device
512	Dev.Trip 1pL1	Trip by the device single-pole L1
513	Dev.Trip 1pL2	Trip by the device single-pole L2
514	Dev.Trip 1pL3	Trip by the device single-pole L3
515	Dev.Trip 3p	Trip by the device three-pole L1–L2–L3
516	Dev.Trip forw	Trip by the device on fault in forward (line) direction
517	Dev.Trip rev.	Trip by the device on fault in reverse (bus-bar) direction
561	Manual Close	Manual close indication of circuit breaker
562	Man.Close Cmd	Manual close command for the circuit breaker
563	CB Alarm Supp	Circuit breaker operation alarm suppressed
1106	>Start FltLoc	Start fault locator by external command via binary input
1132	FltLoc.inval. ²⁾	Fault location invalid; distance to fault not determined ²⁾
1156	>CB Test	Trigger circuit breaker test
1174	CB in Test	Circuit breaker test is in progress
1181	CB Test Trip	Trip by internal circuit breaker test function, general
1182	CB Test 1pL1	Trip by internal circuit breaker test function single-pole L1
1183	CB Test 1pL2	Trip by internal circuit breaker test function single-pole L2
1184	CB Test 1pL3	Trip by internal circuit breaker test function single-pole L3
1185	CB Test 3p	Trip by internal circuit breaker test function three-pole L123
1303	>E/F block	Block earth fault protection for earthed networks
1311	>E/F comp. on	Switch on earth fault protection
1312	>E/F comp.off	Switch off earth fault protection
1316	>E/F Recept	Reception signal for directional comparison earth fault protection
1317	>E/F Rec.Fail	Reception failure for directional comparison earth fault protection
1331	E/F Prot. off	Earth fault protection is switched off
1332	E/F blocked	Earth fault protection is blocked
1333	E/F active	Earth fault protection is active
1334	E/F Dir.block	Earth fault protection directional stage is blocked
1341	E/F Flt75%Ie>	Earth fault protection low value stage 75 % I _E picked up
1342	E/F Flt Ie<->	Earth fault protection non-directional stage I _E picked up
1343	E/F Flt Ie ->	Earth fault protection directional stage I _E picked up
1351	E/F T-Delay	Earth fault protection delay time expired
1352	E/F T->	Earth fault protection directional delay time expired
1353	E/F T<->	Earth fault protection non-directional delay time expired
1361	E/F Trip	Trip by earth fault protection (general)
1362	E/F Trip L1	Trip by earth fault protection single-pole L1
1363	E/F Trip L2	Trip by earth fault protection single-pole L2
1364	E/F Trip L3	Trip by earth fault protection single-pole L3
1365	E/F Trip 3p	Trip by earth fault protection three-pole
1381	E/F Dir off	Directional earth fault protection is switched off
1384	E/F Send	Carrier transmission signal for directional comparison E/F
1385	E/F Echo	Echo signal sent for directional comparison E/F
1386	E/F TransBloc	Transient blocking of earth fault protection after external fault
1401	>B/F on	Switch on circuit breaker failure protection
1402	>B/F off	Switch off circuit breaker failure protection
1403	>B/F block	Block circuit breaker failure protection
1432	>B/F release	Release of breaker failure protection from external (2nd channel)
1435	>B/F Start L1	Initiate breaker failure protection pole L1 from external source
1436	>B/F Start L2	Initiate breaker failure protection pole L2 from external source
1437	>B/F Start L3	Initiate breaker failure protection pole L3 from external source
1451	B/F off	Breaker failure protection is switched off
1452	B/F blocked	Breaker failure protection is blocked

²⁾ from firmware version V3.3 or higher

Table 5.4 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
1453	B/F active	Breaker failure protection is active
1461	B/F Start	Breaker failure protection is started
1471	B/F Trip	Trip by breaker failure protection
1472	B/F Trip L1	Trip by breaker failure protection due to failure L1
1473	B/F Trip L2	Trip by breaker failure protection due to failure L2
1474	B/F Trip L3	Trip by breaker failure protection due to failure L3
1476	B/F Trip 3pol	Trip by breaker failure protection due to failure three-pole
1478	B/F Trip wo I	Trip by breaker failure protection without fault current
1706	>I>> block	Block I>> stage of all overcurrent protection
1707	>I>/Ip block	Block I> stage (definite) or I _p stage (inverse) of overcurrent protection
1716	>IE>> block	Block I _E >> stage of all overcurrent protection
1717	>IE>/IEp bloc	Block I _E > stage (definite) or I _{Ep} stage (inverse) of overcurrent protec.
2003	>Emer. block	Block emergency overcurrent time protection
2051	Emer. off	Emergency overcurrent time protection is switched off
2052	Emer. block	Emergency overcurrent time protection is blocked
2053	Emer. active	Emergency overcurrent time protection is active
2055	Emer. E off	Emergency overcurrent time protection phase currents switched off
2056	Emer.Ph.off	Emergency overcurrent time protection earth current switched off
2061	Emer.Gen.Flt	General fault detection of emergency overcurrent protection
2062	Emer. Flt L1	Fault detection L1 of emergency overcurrent protection
2063	Emer. Flt L2	Fault detection L2 of emergency overcurrent protection
2064	Emer. Flt L3	Fault detection L3 of emergency overcurrent protection
2065	Emer. Flt E	Earth fault detection of emergency overcurrent protection
2091	Emer. I>>	Fault detection of I>> stage of emergency O/C protection
2092	Emer. I>/Ip	Fault detection of I> or I _p stage of emergency O/C protection
2095	Emer. IE>>	Fault detection of I _E >> stage of emergency O/C protection
2096	Emer. IE>/IEp	Fault detection of I _E > or I _{Ep} stage of emergency O/C protection
2121	Emer. TI>>	Emergency O/C protection time T _{I>>} expired
2122	Emer. TI>/Tp	Emergency O/C protection time T _{I>} or T _p expired
2125	Emer. TIE>>	Emergency O/C protection time T _{IE>>} expired
2126	Emer. TIE>TEp	Emergency O/C protection time T _{IE>} or T _{Ep} expired
2141	Emer.Gen.Trip	General trip by emergency overcurrent protection
2142	Emer.Trip1pL1	Trip single-pole L1 by emergency overcurrent protection
2143	Emer.Trip1pL2	Trip single-pole L2 by emergency overcurrent protection
2144	Emer.Trip1pL3	Trip single-pole L3 by emergency overcurrent protection
2145	Emer.Trip 3p	Trip three-pole by emergency overcurrent protection
2303	>Backup block	Block Back-up overcurrent time protection
2403	Backup active	Back-up overcurrent time protection is active
2405	Backup E off	Back-up overcurrent time protection earth currents is switched off
2406	Backup Ph off	Back-up overcurrent time protection phase currents is switched off
2411	Back Gen. Flt	General fault detection of back-up overcurrent protection
2412	Backup Flt L1	Fault detection L1 of back-up overcurrent protection
2413	Backup Flt L2	Fault detection L2 of back-up overcurrent protection
2414	Backup Flt L3	Fault detection L3 of back-up overcurrent protection
2415	Backup Flt E	Earth fault detection of back-up overcurrent protection
2421	Backup I>>	Fault detection by I>> stage of back-up O/C protection
2422	Backup I>/Ip	Fault detection by I> or I _p stage of back-up O/C protection
2425	Backup IE>>	Fault detection by I _E >> stage of back-up O/C protection
2426	Back IE>/IEp	Fault detection by I _E > or I _{Ep} stage of back-up O/C protection
2441	Backup TI>>	Back-up O/C protection time T _{I>>} expired
2442	Backup TI>/Tp	Back-up O/C protection time T _{I>} or T _p expired
2445	Back TIE>>	Back-up O/C protection time T _{IE>>} expired
2446	Back TIE>TEp	Back-up O/C protection time T _{IE>} or T _{Ep} expired
2451	Back Gen.Trip	General trip by back-up overcurrent protection

Table 5.4 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
2452	Back Trip L1	Trip single-pole L1 by back-up overcurrent protection
2453	Back Trip L2	Trip single-pole L2 by back-up overcurrent protection
2454	Back Trip L3	Trip single-pole L3 by back-up overcurrent protection
2455	Back Trip 3p	Trip three-pole by back-up overcurrent protection
2701	>AR on	Switch on internal auto-reclose function
2702	>AR off	Switch off internal auto-reclose function
2703	>AR block	Block internal auto-reclose function
2704	>AR reset	Reset internal auto-reclose function
2706	>1p RAR block	Block single-pole rapid auto-reclosure (RAR, 1st shot)
2707	>3p RAR block	Block three-pole rapid auto-reclosure (RAR, 1st shot)
2708	>RAR block	Block complete rapid auto-reclosure (RAR, 1st shot)
2709	>DAR block	Block complete delayed auto-reclosure (DAR, further shots)
2711	>Start AR	Start signal from external protection for AR
2712	>Trip L1 AR	Trip signal L1 from external protection for AR
2713	>Trip L2 AR	Trip signal L2 from external protection for AR
2714	>Trip L3 AR	Trip signal L3 from external protection for AR
2715	>Trip 1p AR	Trip signal single-pole from external protection for AR
2716	>Trip 3p AR	Trip signal three-pole from external protection for AR
2721	>DAR aft. RAR	DAR is permitted only after unsuccessful RAR
2730	>CB ready	Circuit breaker ready for AR cycle
2731	>Sync.release	Reclose release by an external synchronism check relay
2781	AR off	Internal auto-reclose function is switched off
2782	AR on	Internal auto-reclose function is switched on
2783	AR inoperativ	Internal auto-reclose function is not operative
2784	AR not ready	Internal auto-reclose function is not ready for reclose
2785	AR block.dyn.	Internal auto-reclose function is blocked dynamically
2787	CB not ready	Circuit breaker not ready for a trip/reclose cycle
2788	AR T-CB Exp.	Circuit breaker supervision time expired
2801	AR in prog.	Auto-reclose cycle is in progress
2811	RAR only	Internal AR function is programmed to perform only RAR cycle
2812	RAR T-act.run	Auto-reclose function action time for RAR is running
2813	RAR T-1p run.	Auto-reclose function single-pole dead time for RAR is running
2814	RAR T-3p run.	Auto-reclose function three-pole dead time for RAR is running
2815	RAR 1p Prog.	RAR function is programmed to perform only single-pole AR
2816	RAR 3p Prog.	RAR function is programmed to perform only three-pole AR
2817	RAR Zone Rel.	Internal AR function is ready to permit trip in RAR stage
2818	AR evolv.Flt.	Auto-reclose function evolving fault recognized during dead time
2831	DAR Only	Internal AR function is programmed to perform only DAR cycles
2832	DAR T-act.run	Auto-reclose function action time for DAR is running
2833	DAR T-3p1 run	Auto-reclose function dead time for first DAR is running
2834	DAR T-3p2 run	Auto-reclose function dead time for second DAR is running
2835	DAR T-3p3 run	Auto-reclose function dead time for further DAR is running
2837	DAR Zone Rel.	internal AR function is ready to permit trip in DAR stage
2851	AR Close Cmd.	Reclose command by internal auto-reclose function
2852	RAR 1p Close	Reclose command after 1-pole RAR
2853	RAR 3p Close	Reclose command after 3-pole RAR (rapid AR)
2854	DAR 3p Close	Reclose command after 3-pole DAR (delayed AR)
2861	AR T-Recl.run	Auto-reclose function reclaim time is running
2862	AR successful	Auto-reclosure was successful
2863	Definit.Trip	Definitive (final) trip signal
2864	1p Trip Perm.	Internal AR function is ready to permit single pole trip
2865	Sync.Meas.Reg	Internal AR function request for synchronism or voltage check
2871	AR Trip 3p	Internal AR function trips three-pole because blocked

Table 5.4 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
2901	>Sync. on	Switch on synchronism and voltage check function
2902	>Sync. off	Switch off synchronism and voltage check function
2903	>Sync. block	Block synchronism and voltage check function
2906	>Sync. Start	Start-to-measure signal for internal synchronism and voltage check
2907	>Sync. synch	Synchro-check program: check synchronism
2908	>Sync. U1>U2<	Synchro-check program: live line, dead bus
2909	>Sync. U1<U2>	Synchro-check program: dead line, live bus
2910	>Sync. U1<U2<	Synchro-check program: dead line, dead bus
2911	>Sync. o/ride	Synchro-check program: override any check
2931	Sync. off	Synchronism and voltage check function is switched off
2932	Sync. blocked	Synchronism and voltage check function is blocked
2934	Sync. faulty	Synchronism and voltage check function is disturbed
2935	Sync.Tsup.Exp	Circuit breaker supervision time expired
2941	Sync. running	Synchronism and voltage check is running
2942	Sync.Override	Synchronism and voltage check has stated: override
2943	Sync. Synchro	Synchronism and voltage check has stated: synchronism
2944	Sync. U1>U2<	Synchronism and voltage check has stated: live line, dead bus
2945	Sync. U1<U2>	Synchronism and voltage check has stated: dead line, live bus
2946	Sync. U1<U2<	Synchronism and voltage check has stated: dead line, dead bus
2947	Sync. Udiff>	Synchronism check ΔU exceeded
2948	Sync. fdiff>	Synchronism check Δf exceeded
2949	Sync. φ diff>	Synchronism check $\Delta \varphi$ exceeded
2951	Sync. release	Synchronism and voltage check: closing release
2961	Sync.CloseCmd	Synchronism and voltage check: closing command
3603	>Dist. block	Block distance protection
3611	>Extens. Z1B	Release distance overreaching zone Z1B from external
3612	>Extens. Z1L	Release distance overreaching zone Z1L from external
3651	Dist. off	Distance protection is switched off
3652	Dist. blocked	Distance protection is blocked
3653	Dist. active	Distance protection is active
3661	DisZ1B AR blk	Distance protection blocks reclosure after fault in zone Z1B
3662	DisZ1L AR blk	Distance protection blocks reclosure after fault in zone Z1L
3671	Dist.Gen.Flt.	Distance protection: General fault detection
3672	Dist.Fault L1	Distance protection: Fault detection L1
3673	Dist.Fault L2	Distance protection: Fault detection L2
3674	Dist.Fault L3	Distance protection: Fault detection L3
3675	Dist.Fault E	Distance protection: Earth fault detection
3695	Dist. φ L1	Distance protection: angle dependent stage L1 picked up
3696	Dist. φ L2	Distance protection: angle dependent stage L2 picked up
3697	Dist. φ L3	Distance protection: angle dependent stage L3 picked up
3701	Loop L1-E f	Distance protection: Fault in loop L1-E in forward direction
3702	Loop L2-E f	Distance protection: Fault in loop L2-E in forward direction
3703	Loop L3-E f	Distance protection: Fault in loop L3-E in forward direction
3704	Loop L1-2 f	Distance protection: Fault in loop L1-L2 in forward direction
3705	Loop L2-3 f	Distance protection: Fault in loop L2-L3 in forward direction
3706	Loop L3-1 f	Distance protection: Fault in loop L3-L1 in forward direction
3707	Loop L1-E r	Distance protection: Fault in loop L1-E in reverse direction
3708	Loop L2-E r	Distance protection: Fault in loop L2-E in reverse direction
3709	Loop L3-E r	Distance protection: Fault in loop L3-E in reverse direction
3710	Loop L1-2 r	Distance protection: Fault in loop L1-L2 in reverse direction
3711	Loop L2-3 r	Distance protection: Fault in loop L2-L3 in reverse direction
3712	Loop L3-1 r	Distance protection: Fault in loop L3-L1 in reverse direction

Table 5.4 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
3713	Loop L1-E <->	Distance protection: Fault in loop L1 – E in reverse direction
3714	Loop L2-E <->	Distance protection: Fault in loop L2 – E in reverse direction
3715	Loop L3-E <->	Distance protection: Fault in loop L3 – E in reverse direction
3716	Loop L1-2 <->	Distance protection: Fault in loop L1 – L2 in reverse direction
3717	Loop L2-3 <->	Distance protection: Fault in loop L2 – L3 in reverse direction
3718	Loop L3-1 <->	Distance protection: Fault in loop L3 – L1 in reverse direction
3719	Dist. For.Dir	Distance protection: Fault in forward direction
3720	Dist. Rev.Dir	Distance protection: Fault in reverse direction
3741	Dist.Z1 L1E	Distance protection: Fault L1 – E in zone Z1
3742	Dist.Z1 L2E	Distance protection: Fault L2 – E in zone Z1
3743	Dist.Z1 L3E	Distance protection: Fault L3 – E in zone Z1
3744	Dist.Z1 L12	Distance protection: Fault L1 – L2 in zone Z1
3745	Dist.Z1 L23	Distance protection: Fault L2 – L3 in zone Z1
3746	Dist.Z1 L31	Distance protection: Fault L3 – L1 in zone Z1
3747	Dist.Z1B L1E	Distance protection: Fault L1 – E in zone Z1B
3748	Dist.Z1B L2E	Distance protection: Fault L2 – E in zone Z1B
3749	Dist.Z1B L3E	Distance protection: Fault L3 – E in zone Z1B
3750	Dist.Z1B L12	Distance protection: Fault L1 – L2 in zone Z1B
3751	Dist.Z1B L23	Distance protection: Fault L2 – L3 in zone Z1B
3752	Dist.Z1B L31	Distance protection: Fault L3 – L1 in zone Z1B
3753	Dist. Z1L	Distance protection: Fault in zone Z1L
3755	Dist. Z2	Distance protection: Fault in zone Z2
3758	Dist. Z3	Distance protection: Fault in zone Z3
3771	Dist. T1	Distance protection: Time T1 (1st stage) expired
3774	Dist. T2	Distance protection: Time T2 (2nd stage) expired
3777	Dist. T3	Distance protection: Time T3 (3rd stage) expired
3778	Dist. T4	Distance protection: Time T4 (4th stage, directional) expired
3779	Dist. T5	Distance protection: Time T5 (final stage, non-directional) expired
3780	Dist. T1B	Distance protection: Time T1B (1st extended stage) expired
3783	Dist. T1L	Distance protection: Time T1L (2nd extended stage) expired
3801	Dis.Gen. Trip	Distance protection: General Trip command
3802	Dis.Trip 1pL1	Distance protection: Trip single-pole L1
3803	Dis.Trip 1pL2	Distance protection: Trip single-pole L2
3804	Dis.Trip 1pL3	Distance protection: Trip single-pole L3
3805	Dis.Trip 3p	Distance protection: Trip three-pole
3808	Dis.Trip back	Distance protection: Trip with a higher (back-up) stage
3811	Dis.TripZ1/1p	Distance protection: Trip in stage Z1/T1 single-pole
3812	Dis.TripZ1/3p	Distance protection: Trip in stage Z1/T1 three-pole
3813	Dis.TripZ1B1p	Distance protection: Trip in extended stage Z1B/T1B single-pole
3814	Dis.TripZ1B3p	Distance protection: Trip in extended stage Z1B/T1B three-pole
3815	Dis.Trip Z1L	Distance protection: Trip in extended stage Z1L/T1L
3816	Dis.TripZ2/1p	Distance protection: Trip in stage Z2/T2 single-pole
3817	Dis.TripZ2/3p	Distance protection: Trip in stage Z2/T2 three-pole
3818	Dis.TripZ3/T3	Distance protection: Trip in stage Z3/T3
3819	Dis.Trip FD->	Distance protection: Trip in directional stage (fault detection)
3820	Dis.Trip <->	Distance protection: Trip in non-directional stage (fault detection)
4011	>Dis.POTT on	Switch on permissive overreach transfer trip
4012	>Dis.POTT off	Switch off permissive overreach transfer trip
4014	>Dis.Recept.O	Reception signal for distance protection overreach transfer trip
4015	>Dis.RecFailO	Reception for overreach transfer trip faulty
4021	>Dis.PUTT on	Switch on permissive underreach transfer trip
4022	>Dis.PUTT off	Switch off permissive underreach transfer trip

Table 5.4 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
4024	>Dis.Recept.U	Reception signal for distance protection underreach transfer trip
4025	>Dis.RecFailU	Reception for underreach transfer trip faulty
4051	Dis.Tele.on	Teleprotection with distance protection is switched on
4054	Dis. Recept	Carrier signal for distance protection received
4055	Dis. RecFail	Carrier reception for distance protection faulty
4056	Dis. Send	Send signal from distance protection transmitted
4062	POTT Tele off	Permissive overreach transfer trip is switched off
4065	Dis.Rec.FailU	Reception for underreach transfer trip faulty
4066	Dis.POTT Send	Send signal of permissive overreach transfer transmitted
4067	Dis.POTT Echo	Echo signal of permissive overreach transfer transmitted
4068	Dis.TransBlo	Transient blocking is running
4069	Blk.Sig.Trans	Send signal only for blocking procedure
4070	Blk.Sig.Stop	Stop signal only for blocking procedure
4072	PUTT Tele off	Permissive underreach transfer trip is switched off
4075	Dis.Rec.FailU	Reception for underreach transfer trip faulty
4076	Dis.PUTT Send	Send signal of permissive underreach transfer transmitted
4164	Power Swing	Power swing detected
4165	P/S T-action	Power swing action time is running
4166	O/S Trip	Out-of-step trip command
4203	>W/I block	Block weak-infeed trip function
4206	>W/I Rec	Reception for weak-infeed trip function
4221	W/I off	Weak-infeed trip function is switched off
4222	W/I blocked	Weak-infeed trip function is blocked
4223	W/I active	Weak-infeed trip function is active
4231	W/I Gen. Flt	General fault detection of weak-infeed trip function
4232	W/I Flt. L1	Fault detection phase L1 of weak-infeed trip function
4233	W/I Flt. L2	Fault detection phase L2 of weak-infeed trip function
4234	W/I Flt. L3	Fault detection phase L3 of weak-infeed trip function
4241	W/I Gen. Trip	General trip signal of weak-infeed trip function
4242	W/I Trip L1	Trip single-pole L1 by weak-infeed trip function
4243	W/I Trip L2	Trip single-pole L2 by weak-infeed trip function
4244	W/I Trip L3	Trip single-pole L3 by weak-infeed trip function
4245	W/I Trip L123	Trip three-pole by weak-infeed trip function
4253	>Sw-o-Flt.Blo	Block high-current switch-onto-fault protection
4271	S-O-F off	High-current switch-onto-fault protection is switched off
4272	S-O-F block	High-current switch-onto-fault protection is blocked
4273	S-O-F active	High-current switch-onto-fault protection is active
4281	S-O-F Gen.Flt	General fault detection of high-current switch-onto-fault protection
4282	S-O-F Flt. L1	Fault detection phase L1 high-current switch-onto-fault protection
4283	S-O-F Flt. L2	Fault detection phase L2 high-current switch-onto-fault protection
4284	S-O-F Flt. L3	Fault detection phase L3 high-current switch-onto-fault protection
4295	S-O-F Trip 3p	Trip by high-current switch-onto-fault protection
4301	>U> Prot. on	Switch on overvoltage protection stage U>
4302	>U> Prot. off	Switch off overvoltage protection stage U>
4304	>U>>Prot. on	Switch on overvoltage protection stage U>>
4305	>U>>Prot. off	Switch off overvoltage protection stage U>>
4306	>U> Block	Block overvoltage protection stage U>
4307	>U>> Block	Block overvoltage protection stage U>>
4323	U>/U>> active	Overvoltage protection is active (U> or U>> stage)
4325	U> off	Overvoltage protection U> stage is switched off
4326	U> blocked	Overvoltage protection U> stage is blocked
4328	U>> off	Overvoltage protection U>> stage is switched off
4329	U>> blocked	Overvoltage protection U>> stage is blocked

Table 5.4 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
4331	U> Detection	Overvoltage detection by overvoltage protection U> stage
4332	U>> Detection	Overvoltage detection by overvoltage protection U>> stage
4335	U> Trip	Trip by overvoltage protection U> stage
4336	U>> Trip	Trip by overvoltage protection U>> stage
4339	U> Intertrip	Intertrip signal of overvoltage protection U> stage
4340	U>> Intertrip	Intertrip signal of overvoltage protection U>> stage
4403	>Ext.Trip blk	Block trip signal by external trip function
4412	>Ext.Trip L1	Trip signal L1 by external trip function
4413	>Ext.Trip L2	Trip signal L2 by external trip function
4414	>Ext.Trip L3	Trip signal L3 by external trip function
4416	>Ext.Trp.woAR	Trip signal by external trip function without auto-reclosure
4431	Ext.Gen. Trip	General trip by external trip function
4432	Ext.Trip 1pL1	Trip single-pole L1 by external trip function
4433	Ext.Trip 1pL2	Trip single-pole L2 by external trip function
4434	Ext.Trip 1pL3	Trip single-pole L3 by external trip function
4435	Ext.Trip 3p	Trip three-pole by external trip function
4436	Ext.Trip woAR	Trip three-pole by external trip function without auto-reclosure
6206	>User T1Start	User definable logic function timer 1 start
6207	>User T1Reset	User definable logic function timer 1 reset
6208	>User T2Start	User definable logic function timer 2 start
6209	>User T2Reset	User definable logic function timer 2 reset
6254	User output 1	Output signal of user definable logic function 1
6255	User output 2	Output signal of user definable logic function 2

Table 5.4 Marshalling possibilities for signal relays and LEDs

Addr	1st display line	2nd display line	FNo	Remarks
6200	MARSHALLING	SIGNAL RELAYS		Heading of the address block
6201	SIGNAL RELAY 1	RELAY 1 Dev.FltDet L1	503	Fault detection annunciations of all protection function in phase L1 or earth fault
6202	SIGNAL RELAY 2	RELAY 2 Dev.FltDet L1	504	
6203	SIGNAL RELAY 3	RELAY 3 Dev.FltDet L1	505	
6204	SIGNAL RELAY 4	RELAY 4 Dev.FltDet E	506	
6205	SIGNAL RELAY 5	RELAY 5 Dev.operative	51	The NC contact of this relay indicates "Device fault"
6209	SIGNAL RELAY 9 RELAY 9	RELAY 9 Dis.PUTT Send Dis.POTT Send	4076 4066	Transmission signals for carrier from tele-protection with distance protection

Table 5.5 Preset annunciations for signal relays (continued next page)

Addr	1st display line	2nd display line	FNo	Remarks
6210	SIGNAL RELAY 10	RELAY 10 Device Trip	511	General trip command given (by either protection function)
6211	SIGNAL RELAY 11	RELAY 11 Dist. Rev.Dir	3720	Fault in reverse direction (distance protection)
6212	SIGNAL RELAY 12 RELAY 12 RELAY 12 RELAY 12 RELAY 12 RELAY 12 RELAY 12 RELAY 12 RELAY 12	RELAY 12 >VT mcb Trip Failure ΣI Failure $\Sigma Up-e$ Failure $\Sigma Up-p$ Failure Isymm Failure Usymm Failure Umeas Fuse-Failure Fail.PhaseSeq	361 162 165 166 163 167 168 169 171	Group annunciation of all disturbances in measured quantities
6213	SIGNAL RELAY 13	RELAY 13 CB Alarm Supp	563	only when auto-reclose function is available and configured as <i>EXIST</i>
6214	SIGNAL RELAY 14	RELAY 14 AR inoperativ	2783	
6218	SIGNAL RELAY 18	RELAY 18 E/F Send	1384	Transmission signal for carrier from teleprotection with directional earth fault protection and overvoltage protection
6227	SIGNAL RELAY 27	RELAY 27 U> Intertrip	4339	
	RELAY 27	U>> Intertrip	4340	

For the signal relays not mention in the table, no functions are preset by the factory.

Table 5.5 Preset annunciations for signal relays

Note: Dependent on the ordered model, not all signal relays listed in Table 5.5 may be present.

5.5.4 Marshalling of the LED indicators – address block 63

The unit contains up to 24 LEDs for optical indications, which can be marshalled. They are designated LED 1 to LED 24. Marshalling is carried out in address block 63. The block is reached by paging in blocks with $\uparrow \downarrow$ or by directly addressing with **DA 6 2 0 0 E**. The selection procedure is carried out as described in Section 5.5.1. Multiple annunciations are possible, i.e. one logical annunciation function can be given to several LEDs (see also Section 5.5.1).

Apart from the logical function, each LED can be marshalled to operate either in the stored mode (m for memorized) or unstored mode (nm for "not memorized"). Each annunciation function is displayed with the index m or nm when proceeding with the **N**-key.

The marshallable annunciation functions are the same as those listed in Table 5.3. Annunciation functions are, of course, not effective when the corresponding protection function is not fitted in the relay or has been programmed out (de-configured).

With direct input of the function number it is not necessary to input the leading zeros. To indicate whether the stored or unstored mode shall be effective the function number can be extended by a decimal point followed by 0 or 1, whereby

- .0 unstored indication (not memorized) corresponds to "nm" as above,
- .1 stored indication (memorized) corresponds to "m" as above.

If the extension with .0 or .1 is omitted the display shows first the function designation in unstored mode with "nm". Press the "No"-key **N** to change to stored mode "m". After direct input other functions can be selected by paging through the functions forwards with the "No"-key **N** or backwards with the backspace key **B**. The changed function then must be re-confirmed by the enter-key **E**.

The assignment of the LEDs as preset by the factory is shown in the front of the unit (Figure 6.1). The following boxes show, as an example, the assignment for LED 1. Table 5.6 shows all LED indicators as they are preset from the factory.

$\uparrow \downarrow$ 6 3 0 0 ■ M A R S H A L L I N G
L E D I N D I C A T O R S

Beginning of the block "Marshalling of the LED indicators"

The first marshallable LED is reached with the key $\uparrow$:

$\uparrow \downarrow$ 6 3 0 1 ■ L E D 1

Allocations for LED 1,

Change over to the selection level with **F** $\uparrow$:

$\uparrow \downarrow$ 0 0 1 ■ L E D 1
D i s . G e n . T r i p m

LED 1 has been preset for:
General trip of distance protection, memorized;
FNo 3801

$\uparrow \downarrow$ 0 0 2 ■ L E D 1
n o t a l l o c a t e d

no further functions are preset for LED 1

After input of all annunciation functions for LED 1, change back to the marshalling level is carried out with **F** $\uparrow$:

$\uparrow \downarrow$ 6 3 0 1 ■ L E D 1

Allocations for LED 1

The complete presettings for LED indicators are listed in Table 5.6.

Addr	1st display line	2nd display line	FNo	Remarks
6300	MARSHALLING	LEDs		Heading of the address block
6301	LED 1 LED 1	Dis.Gen. Trip m	3801	Trip signal given from the various protection functions of the device
6302	LED 2 LED 2	O/S Trip m	4166	
6303	LED 3 LED 3	S-O-F Trip 3p m	4295	
6304	LED 4 LED 4	W/I Gen. Trip m	4241	
6305	LED 5 LED 5	Emer.Gen.Trip m	2141	
6306	LED 6 LED 6	E/F Trip m	1361	
6307	LED 7 LED 7	Back Gen.Trip m	2451	
6308	LED 8 LED 8 LED 8	U> Trip m U>> Trip m	4335 4336	
6309	LED 9 LED 9 LED 9 LED 9 LED 9 LED 9 LED 9 LED 9 LED 9 LED 9	>VT mcb Trip nm Failure Σ I nm Failure Σ Up-e nm Failure Σ Up-p nm Failure Isymm nm Failure Usymm nm Failure Umeas nm Fuse-Failure nm Fail.PhaseSeq nm	361 162 165 166 163 167 168 169 171	Group annunciation of all disturbances in measured quantities
6310	LED 10 LED 10	Dev.FltDet L1 m	503	Fault detection annunciations of the various protection functions related to each phase
6311	LED 11 LED 11	Dev.FltDet L2 m	504	
6312	LED 12 LED 12	Dev.FltDet L3 m	505	

Table 5.6 Preset LED indicators (continued next page)

Addr	1st display line	2nd display line	FNo	Remarks
6313	LED 13 LED 13	Dev.FltDet E m	506	Earthfault detection annunciations of either protection function
6314	LED 14 LED 14	AR not ready nm	2784	only when the internal auto-reclose function is fitted and configured as <i>EXIST</i>
6315	LED 15 LED 15	AR Close Cmd. m	2851	
6316	LED 16 LED 16	B/F Trip m	1471	Trip by circuit breaker failure protection
6317	LED 17 LED 17 LED 17	Dist. T1 m Emer. TI>> m	3771 2121	Indication of expiry of the distance protection stages or of the time stages of the emergency overcurrent time protection
6318	LED 18 LED 18	Dist. T2 m	3774	
6319	LED 19 LED 19	Dist. T3 m	3777	
6320	LED 20 LED 20	Dist. T4 m	3778	
6321	LED 21 LED 21 LED 21	Dist. T5 m Emer. TI>/Tp m	3779 2122	
6322	LED 22 LED 22 LED 22	Dev.Trip 1pL1 m Dev.Trip 3p m	512 515	Trip signal given by either protection function of the device, related to the breaker pole
6323	LED 23 LED 23 LED 23	Dev.Trip 1pL2 m Dev.Trip 3p m	513 515	
6324	LED 24 LED 24 LED 24	Dev.Trip 1pL3 m Dev.Trip 3p m	514 515	

Table 5.6 Preset LED indicators

Note: Dependent on the ordered model, not all LEDs listed in Table 5.6 may be present.

5.5.5 Marshalling of the command (trip) relays – address block 64

The unit contains up to 6 trip relays – dependent on model – which are designated TRIP RELAY 1 to TRIP RELAY 6. Each trip relay can be controlled by up to 10 logical commands. The trip relays can be marshalled in the address block 64. The block is reached by paging in blocks with $\uparrow \downarrow$ or by directly addressing with **DA**, input of the address number **6 4 0 0** and pressing the enter key **E**. The selection procedure is carried out as described in Section 5.5.1. Multiple commands are possible, i.e. one logical command function can be given to several trip relays (see also Section 5.5.1).

Most of the annunciation functions in accordance with Table 5.4, can be marshalled to output command relays. But those listed in Table 5.7 are particularly suitable for trip relay output. Regard the table as a recommended pre-selection. Command functions are naturally not effective when the corresponding protection function is not fitted in the relay or has

been programmed out (de-configured).

The following boxes show an example for marshalling of trip relay 2. Table 5.8 shows all trip relays as preset from the factory.

Important note: With single-pole auto-reclosure it is imperative that for each circuit breaker pole the corresponding phase segregated command, e.g. "Dis.Trip 1pL1" (FNo 3802) for pole L1, as also the three-pole command "Dis.Trip 3p" (FNo 3805) are marshalled to the correct tripping relay. This is taken care of in the presetting of the relay but must also be considered if the allocation of the trip relays is altered.

If further protection functions shall trip the same breaker, each trip relay must be triggered by the corresponding command function. Similar is valid for closing commands.

$\uparrow \downarrow$ 6 4 0 0 ■ M A R S H A L L I N G
T R I P R E L A Y S

Beginning of the block "Marshalling of the trip relays"

Page on with the key $\uparrow$ until the desired trip relay is reached, e.g. trip relay 2:

$\uparrow \downarrow$ 6 4 0 2 ■ T R I P
R E L A Y 2

Allocations for trip relay 2

Change over to the selection level with **F** $\uparrow$:

$\uparrow \downarrow$ 0 0 1 ■ T R I P R E L . 2
D e v . T r i p 3 p

Trip relay 2 has been preset for:
1st: General three-pole trip command of the device;
FNo 515

$\uparrow \downarrow$ 0 0 2 ■ T R I P R E L . 2
D i s . T r i p 1 p L 1

Trip relay 2 has been preset for:
2nd: Trip command of distance protection single-pole L1; FNo 3802

$\uparrow \downarrow$ 0 0 3 ■ T R I P R E L . 2
D i s . T r i p 3 p

Trip relay 2 has been preset for:
3rd: Trip command of distance protection three-pole; FNo 3805

0 0 4 ■ T R I P R E L . 2
S - O - F T r i p 3 p

Trip relay 2 has been preset for:
4th: Trip command of high-current switch-onto-fault protection three-pole; FNo 4295

0 0 5 ■ T R I P R E L . 2
D e v . T r i p 1 p L 1

Trip relay 2 has been preset for:
5th: Trip command of the device single-pole L1; FNo 512

0 0 6 ■ T R I P R E L . 2
n o t a l l o c a t e d

no further functions are preset for trip relay 2

Leave the selection level with key combination **F** ↑. You can go then to the next trip relay with the arrow key ↑. Trip relay 2 represents – as preset from the factory – an example for tripping of the circuit breaker pole L1. For this, all command functions which shall trip pole L1 are allocated.

6 4 0 2 ■ T R I P
R E L A Y 2

Allocations for trip relay 2

FNo	Abbreviation	Logical command function
1	not allocated	No function allocated
501	Device FltDet	General fault detection of the device
512	Dev.Trip 1pL1	Trip by the device single-pole L1
513	Dev.Trip 1pL2	Trip by the device single-pole L2
514	Dev.Trip 1pL3	Trip by the device single-pole L3
515	Dev.Trip 3p	Trip by the device three-pole L1 – L2 – L3
516	Dev.Trip forw	Trip by the device on fault in forward (line) direction
517	Dev.Trip rev.	Trip by the device on fault in reverse (bus-bar) direction
562	Man.Close Cmd	Manual close command for the circuit breaker
563	CB Alarm Supp	Suppression of circuit breaker operation alarm
1182	CB Test 1pL1	Trip by internal circuit breaker test function single-pole L1
1183	CB Test 1pL2	Trip by internal circuit breaker test function single-pole L2
1184	CB Test 1pL3	Trip by internal circuit breaker test function single-pole L3
1185	CB Test 3p	Trip by internal circuit breaker test function three-pole L123
1341	E/F Flt 75%I _E >	Earth fault protection low value stage 75 % I _E picked up
1342	E/F Flt I _E <->	Earth fault protection non-directional stage I _E picked up
1343	E/F Flt I _E ->	Earth fault protection directional stage I _E picked up
1351	E/F T-Delay	Earth fault protection delay time expired
1352	E/F T->	Earth fault protection directional delay time expired
1353	E/F T<->	Earth fault protection non-directional delay time expired
1362	E/F Trip L1	Trip by earth fault protection single-pole L1
1363	E/F Trip L2	Trip by earth fault protection single-pole L2
1364	E/F Trip L3	Trip by earth fault protection single-pole L3
1365	E/F Trip 3p	Trip by earth fault protection three-pole
1384	E/F Send	Carrier transmission signal of directional comparison E/F
1471	B/F Trip	Trip by breaker failure protection
1478	B/F Trip wo I	Trip by breaker failure protection without current flow

Table 5.7 Command functions (continued next page)

FNo	Abbreviation	Logical command function
2061	Emer.Gen.Flt	General fault detection of emergency overcurrent protection
2121	Emer. TI>>	Emergency O/C protection time $T_{I>>}$ expired
2122	Emer. TI>/Tp	Emergency O/C protection time $T_{I>}$ or T_p expired
2125	Emer. TIE>>	Emergency O/C protection time $T_{IE>>}$ expired
2126	Emer. TIE>TEp	Emergency O/C protection time $T_{IE>}$ or T_{Ep} expired
2142	Emer.Trip1pL1	Trip single-pole L1 by emergency overcurrent protection
2143	Emer.Trip1pL2	Trip single-pole L2 by emergency overcurrent protection
2144	Emer.Trip1pL3	Trip single-pole L3 by emergency overcurrent protection
2145	Emer.Trip 3p	Trip three-pole by emergency overcurrent protection
2411	Back Gen. Flt	General fault detection of back-up overcurrent protection
2441	Backup TI>>	Back-up O/C protection time $T_{I>>}$ expired
2442	Backup TI>/Tp	Back-up O/C protection time $T_{I>}$ or T_p expired
2445	Back TIE>>	Back-up O/C protection time $T_{IE>>}$ expired
2446	Back TIE>/TEp	Back-up O/C protection time $T_{IE>}$ or T_{Ep} expired
2452	Back Trip L1	Trip single-pole L1 by back-up overcurrent protection
2453	Back Trip L2	Trip single-pole L2 by back-up overcurrent protection
2454	Back Trip L3	Trip single-pole L3 by back-up overcurrent protection
2455	Back Trip 3p	Internal auto-reclose function is blocked dynamically
2785	AR block.dyn.	Trip three-pole by back-up overcurrent protection
2851	AR Close Cmd.	Reclose command by internal auto-reclose function
2852	RAR 1p Close	Reclose command after 1-pole RAR
2853	RAR 3p Close	Reclose command after 3-pole RAR (rapid AR)
2854	DAR 3p Close	Reclose command after 3-pole DAR (delayed AR)
2961	Sync.CloseCmd	Synchronism and voltage check: closing command
3671	Dist.Gen.Flt.	Distance protection: General fault detection
3802	Dis.Trip 1pL1	Distance protection: Trip single-pole L1
3803	Dis.Trip 1pL2	Distance protection: Trip single-pole L2
3804	Dis.Trip 1pL3	Distance protection: Trip single-pole L3
3805	Dis.Trip 3p	Distance protection: Trip three-pole
3808	Dis.Trip back	Distance protection: Trip with a higher (back-up) stage
4066	Dis.POTT Send	Send signal from permissive overreach transfer trip
4069	Blk.Sig.Trans	Send signal only for blocking procedure
4070	Blk.Sig.Stop	Stop signal only for blocking procedure
4076	Dis.PUTT Send	Send signal from permissive underreach transfer trip
4166	O/S Trip	Out-of-step trip command
4231	W/I Gen. Flt.	General fault detection of weak-infeed trip function
4242	W/I Trip L1	Trip single-pole L1 by weak-infeed trip function
4243	W/I Trip L2	Trip single-pole L2 by weak-infeed trip function
4244	W/I Trip L3	Trip single-pole L3 by weak-infeed trip function
4245	W/I Trip L123	Trip three-pole by weak-infeed trip function
4281	S-O-F Gen.Flt	General fault detection of high-current switch-onto-fault protection
4295	S-O-F Trip 3p	Trip by high-current switch-onto-aault protection
4331	U> Detection	Overvoltage detection by overvoltage protection U> stage
4332	U>> Detection	Overvoltage detection by overvoltage protection U>> stage
4335	U> Trip	Trip by overvoltage protection U> stage
4336	U>> Trip	Trip by overvoltage protection U>> stage
4339	U> Intertrip	Intertrip signal of overvoltage protection U> stage
4340	U>> Intertrip	Intertrip signal of overvoltage protection U>> stage
4432	Ext.Trip 1pL1	Trip single-pole L1 by external trip function
4433	Ext.Trip 1pL2	Trip single-pole L2 by external trip function
4434	Ext.Trip 1pL3	Trip single-pole L3 by external trip function
4435	Ext.Trip 3p	Trip three-pole by external trip function

Table 5.7 Command functions (continued next page)

FNo	Abbreviation	Logical command function
4436	Ext.Trip woAR	Trip three-pole by external trip function without AR
6254	User output 1	Output signal of user definable logic function 1
6255	User output 2	Output signal of user definable logic function 2

Table 5.7 Command functions

Addr	1st display line	2nd display line	FNo	Remarks
6400	MARSHALLING	TRIP RELAYS		Heading of the address block
6401	TRIP TRIP REL. 1	RELAY 1 AR Close Cmd.	2851	only effective, when internal auto-reclose function is available and configured as <i>EXIST</i>
6402	TRIP TRIP REL. 2 TRIP REL. 2 TRIP REL. 2 TRIP REL. 2 TRIP REL. 2	RELAY 2 Dev.Trip 3p Dis.Trip 1pL1 Dis.Trip 3p S-O-F Trip 3p Dev.Trip 1pL1	515 3802 3805 4295 512	trip commands for circuit breaker pole L1
6403	TRIP TRIP REL. 3 TRIP REL. 3 TRIP REL. 3 TRIP REL. 3 TRIP REL. 3	RELAY 3 Dev.Trip 3p Dis.Trip 1pL2 Dis.Trip 3p S-O-F Trip 3p Dev.Trip 1pL2	515 3803 3805 4295 513	trip commands for circuit breaker pole L2
6404	TRIP TRIP REL. 4 TRIP REL. 4 TRIP REL. 4 TRIP REL. 4 TRIP REL. 4	RELAY 4 Dev.Trip 3p Dis.Trip 1pL3 Dis.Trip 3p S-O-F Trip 3p Dev.Trip 1pL3	515 3804 3805 4295 514	trip commands for circuit breaker pole L3
6405	TRIP TRIP REL. 5	RELAY 5 Device FltDet	501	general fault detection of the device
6406	TRIP TRIP REL. 6	RELAY 6 not allocated	1	no presetting for trip relay 6

Table 5.8 Preset command functions for trip relays

Note: Dependent on the ordered model, not all trip relays listed in Table 5.8 may be present.

6 Operating instructions

6.1 Safety precautions



Warning

All safety precautions which apply for work in electrical installations are to be observed during tests and commissioning.



Caution!

Connection of the device to a battery charger without connected battery may cause impermissibly high voltages which damage the device. See also Section 3.1.1 under Technical data for limits.

6.2 Dialog with the relay

Setting, operation and interrogation of digital protection and automation systems can be carried out via the integrated membrane keyboard and display panel located on the front plate. All the necessary operating parameters can be entered and all the information can be read out from here. Operation is, additionally, possible via the interface socket by means of a personal computer or similar.

6.2.1 Membrane keyboard and display panel

The membrane keyboard and display panel is externally arranged similar to a pocket calculator. Figure 6.1 illustrates the front view.

A two-line, each 16 character, liquid crystal display presents the information. Each character comprises a 5 x 8 dot matrix. Numbers, letters and a series of special symbols can be displayed.

During dialog, the upper line gives a four figure number, followed by a bar. This number presents the **setting address**. The first two digits indicate the address **block**, then follows the two-digit **sequence number**. In models with parameter change-over facility, the identifier of the parameter set is shown before the setting address.

The keyboard comprises 28 keys with numbers, Yes/No and control buttons. The significance of the keys is explained in detail in the following.

Numerical keys for the input of numerals:

 to  Digits 0 to 9 for numerical input

 Decimal point

 Infinity symbol

 Change of sign (input of negative numbers)

Yes/No keys for text parameters:

 Yes key: operator affirms the displayed question

 No key: operator denies the displayed question or rejects a suggestion and requests for alternative

Keys for paging through the display:

 Paging forwards: the next address is displayed

 Paging backwards: the previous address is displayed

 Block paging forwards: the beginning of the next address block is displayed

 Block paging backwards: the beginning of previous address block is displayed

Confirmation key:

E	Enter or confirmation key: each numerical input or change via the Yes/No keys must be confirmed by the enter key; only then does the device accept the change. The enter key can also be used to acknowledge and clear a fault prompt in this display; a new input and repeated use of the enter key is then necessary.

Control and special keys:

CW	Codeword: prevents unauthorized access to setting programs (not necessary for call-up of annunciations or messages)
R	Backspace erasure of incorrect entries
F	Function key; explained when used
DA	Direct addressing: if the address number is known, this key allows direct call-up of the address
M/S	Messages/Signals: interrogation of annunciations of fault and operating data (refer Section 6.4)

The three keys $\uparrow$; $\uparrow$; RESET which are somewhat separated from the rest of the keys, can be accessed when the front cover is closed. The arrows have the same function as the keys with identical symbols in the main field and enable paging in forward direction. Thus all setting values and event data can be displayed with the front cover closed. Furthermore, stored LED indications on the front can be erased via the RESET key without opening the front cover. During reset operation all LEDs on the front will be illuminated thus performing a LED test. With this reset, additionally, the fault event indications in the display on the front panel of the device are acknowledged; the display shows then the operational values of the quiescent state. The display is switched over to operating mode as soon as one of the keys **DA**, **M/S**, **CW** or $\uparrow$ is pressed.

6.2.2 Operation with a personal computer

A personal computer allows, just as the operator panel, all the appropriate settings, initiation of test routines and read-out of data, but with the added comfort of screen-based visualization and a menu-guided procedure.

All data can be read in from, or copied onto, magnetic data carrier (floppy disc) (e.g. for settings and configuration). Additionally, all the data can be documented on a connected printer. It is also possible, by connecting a plotter, to print out the fault history traces.

For operation of the personal computer, the instruction manuals of this device are to be observed. The PC program DIGSI® is available for setting and processing of all digital protection data. Note that the operating interface in the front of the relay is not galvanically isolated and that only adequate connection cables are applied (e.g. 7XV5100–2). Further information about facilities on request.

6.2.3 Operational preconditions

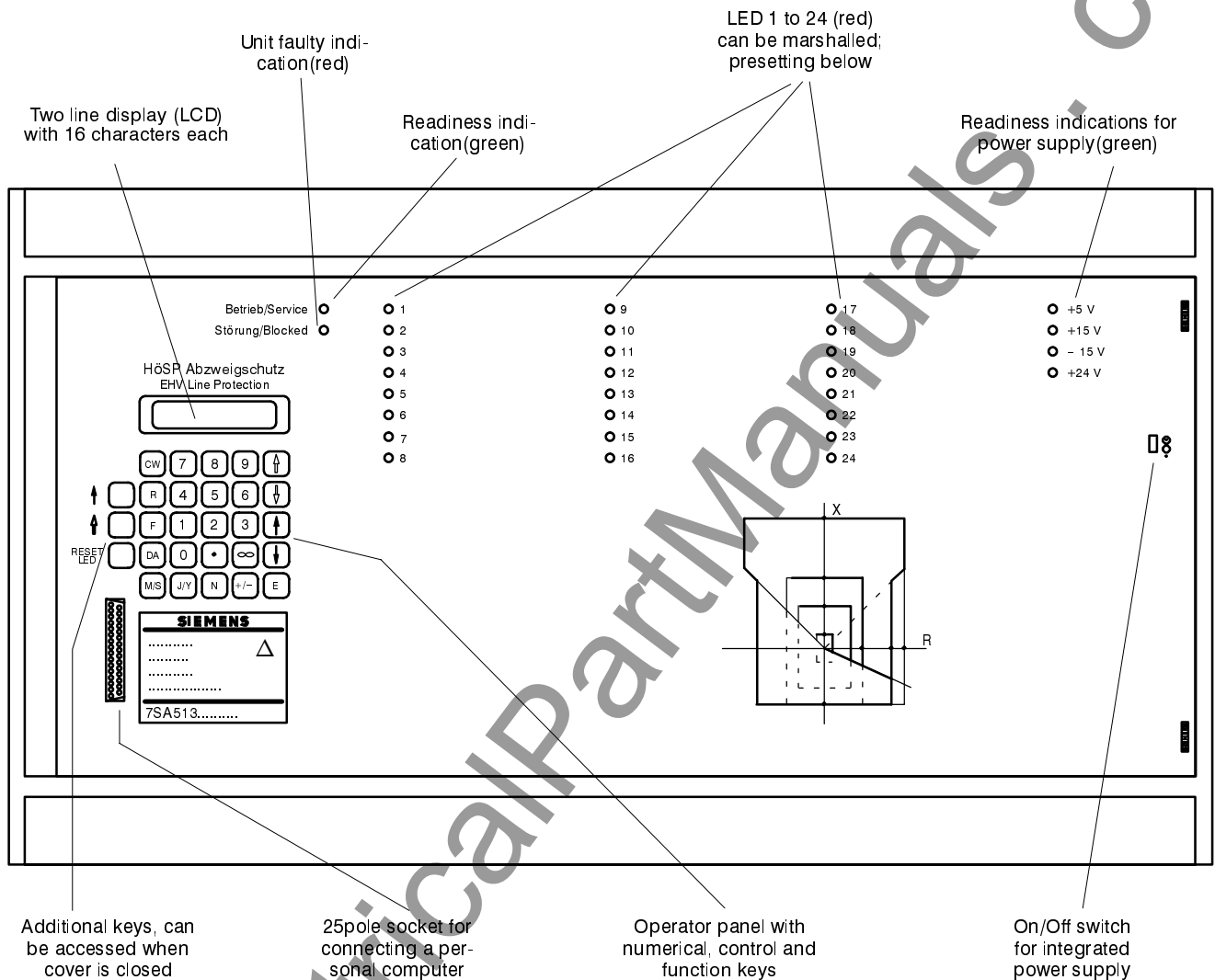
For most operational functions, the input of a codeword is necessary. This applies for all entries via the membrane keyboard or front interface which concern the operation on the relay, for example

- setting of functional parameters (thresholds, functions),
- allocation or marshalling of trip relays, signals, binary inputs, LED indicators,
- configuration parameters for operating language, device and interface configuration,
- initiation of test procedures.

The codeword is not required for the read-out of annunciations, operating data or fault data, or for the read-out of setting parameters.

The method of entry of the codeword is explained in detail in the installation instructions under Section 5.3.

6.2.4 Representation of the relay (front view)



Factory presetting LEDs:

1 Distance protection trip	9 Measured values faulty	17 T1/TI >> expired
2 Out-of-step trip	10 Fault L1	18 T2 expired
3 High current fault trip	11 Fault L2	19 T3 expired
4 Weak-infeed trip	12 Fault L3	20 T4 expired
5 Emergency O/C protection trip	13 Fault E	21 T5/TI > expired
6 Earth fault protection trip	14 AR not ready	22 Trip L1
7 Back-up O/C protection trip	15 Closing command	23 Trip L2
8 Overvoltage protection trip	16 Trip CB failure protection	24 Trip L3

Figure 6.1 Front view of 7SA513 with operating key board and display panel (maximum complement)

6.3 Setting the functional parameters

6.3.1 Introduction

6.3.1.1 Parameterizing procedure

For setting the functional parameters it is necessary to enter the codeword (see Section 5.3.1). Without codeword entry, parameters can be read out but not be changed.

If the codeword is accepted, parameterizing can begin. In the following sections each address is illustrated in a box and is explained. There are three forms of display:

– Addresses without request for operator input

The address is identified by the block number followed by 00 as sequence number (e.g. **1100** for block **11**). Displayed text forms the heading of this block. No input is expected. By using keys $\uparrow$ or $\downarrow$ the next or the previous block can be selected. By using the keys $\uparrow$ or $\downarrow$ the first or last address within the block can be selected and paged.

– Addresses which require numerical input

The display shows the four-digit address, i.e. block and sequence number (e.g. **1104** for block **11**, sequence number **4**). Behind the bar appears the meaning of the required parameter, in the second display line, the value of the parameter. When the relay is delivered a value has been preset. In the following sections, this value is shown. If this value is to be retained, no other input is necessary. One can page forwards or backwards within the block or to the next (or previous) block. If the value needs to be altered, it can be overwritten using the numerical keys and, if required, the decimal point and/or change sign (+/-) or, where appropriate, infinity sign ∞ . The permissible setting range is given in the following text, next to the associated box. Entered values beyond this range will be rejected. The setting steps correspond to the last decimal place as shown in the setting box. Inputs with more decimal places than permitted will be truncated down to the permissible number. **The value must be confirmed with the entry key E!** The display then confirms the accepted value. The changed parameters are only saved after termination of parameterizing (refer below).

– Addresses which require text input

The display shows the four-digit address, i.e. block and sequence number (e.g. **1101** for block **11**, sequence number **1**). Behind the bar appears the meaning of the required parameter, in the second display line, the applicable text. When the relay is delivered, a text has been preset. In the following sections, this text is shown. If it is to be retained, no other input is necessary. One can page forwards or backwards within the block or to the next (or previous) block. If the text needs to be altered, press the "No" key **N**. The next alternative text, also printed in the display boxes illustrated in the following sections, then appears. If the alternative text is not desired, the **N** key is pressed again, etc. The alternative which is chosen, **is confirmed with the entry key E**. The changed parameters are only saved after termination of parameterizing (refer below).

For each of the addresses, the possible parameters and text are given in the following sections. If the meaning of a parameter is not clear, it is usually best to leave it at the factory setting. The arrows $\uparrow$ $\downarrow$ or $\uparrow$ $\downarrow$ at the left hand side of the illustrated display boxes indicate the method of moving from block to block or within the block. Unused addresses are automatically passed over.

If the parameter address is known, then direct addressing is possible. This is achieved by depressing key **DA** followed by the four-digit address and subsequently pressing the enter key **E**. After direct addressing, paging by means of keys $\uparrow$ $\downarrow$ and keys $\uparrow$ $\downarrow$ is possible.

The setting procedure can be ended at any time by the key combination **FE**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS?". Confirm with the "Yes" – key **Y** that the new settings shall become valid now. If you press the "No" – key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

If one tries to leave the setting range for the function parameter blocks (i.e. address blocks 10 to 39) with keys $\uparrow \downarrow$, the display shows the question "END OF CODEWORD OPERATION ?". Press the "No" – key **N** to continue parameter setting. If you press the "Yes" – key **J/Y** instead, another question appears: "SAVE NEW SETTINGS ?". Now you can confirm with **J/Y** or abort with **N**, as above.

After completion of the parameterizing process, the changed parameters which so far have only been stored in volatile memory, are then permanently stored in EEPROMs. The display confirms "NEW SETTINGS SAVED". After pressing the key **M/S** followed by RESET LED, the indications of the quiescent state appear in the display.

6.3.1.2 Selectable parameter sets

Up to 4 different sets of parameters can be selected for the functional parameters, i.e. the addresses above 1000 and below 4000. These parameter sets can be switched over during operation, locally using the operator panel or via the operating interface using a personal computer, or also remotely using binary inputs.

If this facility is not used then it is sufficient to set the parameters for the preselected set. The rest of this section is of no importance. Otherwise, the parameter change-over facility must be configured as *EXIST* under address 7885 (refer Section 5.4.2). The first parameter set is identified as set A, the other sets are B, C and D. Each of these sets is adjusted one after the other.

If the switch-over facility is to be used, first set all parameters for the normal status of parameter set A. Then switch over to parameter set B:

- First complete the parameterizing procedure for set A as described in Section 6.3.1.1.
- Press key combination **F 2**, i.e. first the function key **F** and then the number key **2**. All following inputs then refer to parameter set B.

All parameter sets can be accessed in a similar manner:

- Key combination **F 1**:
access to parameter set **A**
- Key combination **F 2**:
access to parameter set **B**
- Key combination **F 3**:
access to parameter set **C**
- Key combination **F 4**:
access to parameter set **D**

Input of the codeword is again necessary for the setting of a new selected parameter set. Without input of the codeword, the settings can only be read but not modified.

Since only a few parameters will be different in most applications, it is possible to copy previously stored parameter sets into another parameter set.

It is additionally possible to select the original settings, i.e. the settings preset on delivery, for a modified and stored parameter set. This is done by copying the "ORIG.SET" to the desired parameter set.

It is finally still possible to define the active parameter set, i.e. the parameter set which is valid for the functions and threshold values of the unit. See Section 6.5.5 for more details.

The parameter sets are processed in address block 85. The most simple manner to come to this block is using direct addressing:

- press direct address key **DA**,
- enter address, e.g. **8 5 0 0**,
- press enter key **E**.

The heading of the block for processing the parameter sets then appears.

It is possible to scroll through the individual addresses using the $\uparrow$ key. The copying facilities are summarized in Table 6.1.



Beginning of the block "Parameter change-over"; processing of parameter sets

Addr.	Copy	
	from	to
8510	ORIG.SET	SET A
8511	ORIG.SET	SET B
8512	ORIG.SET	SET C
8513	ORIG.SET	SET D
8514	SET A	SET B
8515	SET A	SET C
8516	SET A	SET D
8517	SET B	SET A
8518	SET B	SET C
8519	SET B	SET D
8520	SET C	SET A
8521	SET C	SET B
8522	SET C	SET D
8523	SET D	SET A
8524	SET D	SET B
8525	SET D	SET C

Table 6.1 Copying parameter sets

Following copying, only such parameters need be changed which are to be different from the source parameter set.

Parameterizing must be terminated for each parameter set as described in Section 6.3.1.1.

6.3.1.3 Setting of date and time

The date and time can be set as long as the real time clock is available. Setting is carried out in block 81 which is reached by direct addressing **DA 8100 E** or by paging with ↑ and ↓. Input of the codeword is required to change the data.

Selection of the individual addresses is by further scrolling using ↑ ↓ as shown below. Each modification must be confirmed with the enter key **E**.

The date and time are entered with dots as separator signs since the keyboard does not have a colon or slash (for American date).

The clock is synchronized at the moment when the enter key **E** is pressed following input of the complete time. The difference time facility (address 8104) enables exact setting of the time since the difference can be calculated prior to the input, and the synchronization of the clock does not depend on the moment when the enter key **E** is pressed.

↑↓

8100 ■ S E T T I N G
R E A L T I M E C L O C K

Beginning of the block "Setting the real time clock"
Continue with ↑.

↑↓

26 . 06 . 1996
11 : 44 : 45

At first, the actual date and time are displayed.
Continue with ↑.

↑↓

8102 ■ D A T E

Enter the new date: 2 digits for day, 2 digits for month and 4 digits for year (including century); use the order as configured under address 7102 (Section 5.3.2), but always use a dot for separator:
DD.MM.YYYY or **MM.DD.YYYY**

↑↓

8103 ■ T I M E

Enter the new time: hours, minutes, seconds, each with 2 digits, separated by a dot:
HH.MM.SS

↑↓

8104 ■ D I F F . T I M E

Using the difference time, the clock is set forwards by the entered time, or backwards using the +/- key.
The format is the same as with the time setting above.

6.3.2 Initial displays – address blocks 0 and 10

When the relay is switched on, firstly the address 0 and the type identification of the relay appears. All Siemens relays have an MLFB (machine readable type number). When the device is operative and displays a quiescent message, any desired address can be reached e.g. by pressing the direct address key **DA** followed by the address number.

↑	0	■	7	S	A	5	1	3		V	3	.	*	*
↓	7	S	A	5	1	3	*	*	*	*	*	*	*	*

The relay introduces itself by giving its type number and the version of firmware with which it is equipped. The second display line shows the complete ordering designation.

After address 1000, the functional parameters begin. Further address possibilities are listed under "Annunciations" and "Tests".

↑	1	0	0	0	■					
↓	P	A	R	A	M	E	T	E	R	S

Commencement of functional parameter blocks

6.3.3 Power system data – address block 11

6.3.3.1 General data

The relay requests basic data of the power system and the switchgear.

↑	1	1	0	0	■											
↓	P	O	W	E	R	S	Y	S	T	E	M		D	A	T	A

Beginning of the block "Power system data"

↑	1	1	0	1	■	C	T		S	T	A	R	P	N	T	
↓	T	O	W	A	R	D	S		L	I	N	E				
	T	O	W	A	R	D	S		B	U	S	B	A	R		

Current transformer polarity:
LINE – c.t. star-point towards line
BUSBAR – c.t. star-point towards bus-bar
 This setting determines the measurement direction of the relay (forwards = line direction)

↑	1	1	0	2	■	S	Y	S	T	E	M	S	T	A	R
↓	S	O	L	I	D	L	Y		E	A	R	T	H	E	D
	C	O	M	P	E	N	S	A	T	E	D				
	I	S	O	L	A	T	E	D							

System star-point condition:
 Important for fault detection and earth fault and double earth fault conditioning

↑	1	1	0	3	■	U	n		P	R	I	M	A	R	Y
↓	4	0	0			k	V								

Voltage transformer primary voltage (line-to-line)
 Smallest setting value: **1 kV**
 Largest setting value: **1200 kV**

1	1	0	4	■	U n	S E C O N D .
1	0	0	V			

Voltage transformer secondary voltage (line-to-line)
 Smallest setting value: **80 V**
 Largest setting value: **125 V**

1	1	0	5	■	I n	P R I M A R Y
1	0	0	0	A		

Current transformer primary rated current (phases)
 Smallest setting value: **10 A**
 Largest setting value: **5000 A**

7SA513 provides a saturation indicator which reduces measurement errors due to current transformer saturation to a large extent. Its operation threshold can be set in address 1107 ISAT>. This is the current limit above which saturation may occur. When set to ∞ , the saturation indicator is ineffective. The following formula gives a thumb rule for determination of the setting value provided saturation is expected:

$$\text{Setting ISAT>} = \frac{n'}{1 + \omega \tau_N}$$

with $n' = \frac{P_N + P_i}{P' + P_i}$ = effective overcurrent factor

P_N = rated burden of the c.t.s

P_i = internal burden of the c.t.s

P' = actually connected burden (protection relay plus c.t. secondary wires)

$\omega = 2 \pi f$ = system frequency

τ_N = system d.c. time constant

With addresses 1109 to 1116, the device is instructed as to how the current and voltage transformer inputs of the device are connected to the instrument transformers of the switch-gear. The phase current transformers I_{L1} , I_{L2} , and I_{L3} must always be connected to the corresponding inputs according to the connection diagrams. The same applies for the voltage transformers U_{L1-N} , U_{L2-N} , U_{L3-N} . Additionally, one more voltage input and two more current inputs are provided.

The additional voltage input is designated in address 1109 with Ux CONNECT; it can be declared as *NOT CONNECTED*, or *Udelta TRANSFORM* or *U2 TRANSFORMER*.

If the voltage transformer set has e-n (open-delta) windings, and if these are connected to the device (refer Figure B.9 in Appendix B), then this has to be recorded in address 1109 with Ux CONNECT = *Udelta TRANSFORM*. Since the ratio of the voltage transformers is normally

$$\frac{U_{N_{prim}}}{\sqrt{3}} : \frac{U_{N_{sec}}}{\sqrt{3}} : \frac{U_{N_{sec}}}{3}$$

the factor U_{ph}/U_{delta} (secondary values, address 1110) shall be set as $3/\sqrt{3} = \sqrt{3} \approx 1.73$ when the delta windings are connected. If the ratio is different, e.g. when the displacement voltage is formed by intermediate transformers, the factor has to be selected accordingly. This information is important for the monitoring of measured values.

If the synchronism and voltage check function is to be used at the feeder, then the additional voltage input of the device must be connected to the bus-bar voltage. In this case, address 1109 must be set as Ux CONNECT = *U2 TRANSFORMER* (refer Figure B.11 in Appendix B). Under address 1116 the device must be informed which voltage of the bus-bar voltage transformers is used (phase-to-phase or phase-to-ground and which phase(s)). The device automatically selects the corresponding feeder voltage for synchronism check.

The additional measured current inputs are designated under addresses 1111 and 1114 as I4-CONNECT and I5-CONNECT. These inputs are relevant for the treatment of earth faults in earthed networks, for parallel line compensation (if used), and for the monitoring of measured values. For each of these two additional measured current inputs, three possibilities exist as shown in the following example for I4-CONNECT:

- Connection of the earth current from the star point of the feeder current transformers (standard circuit arrangement, see also Appendix B, Figure B.3):

Address 1111 is then set as

I4-CONNECT = *PROTECTED LINE*

Address 1112 is set as

$I_e/I_{ph} = 1.000$

but, if the earth current of the protected line is derived from a separate earth current transformer (e.g. summation current transformer, refer Figure B.4 in Appendix B) with a ratio which differs from that of the c.t.s of the phases, the relation of these ratios has to be set for I_e/I_{ph} , e.g.

current transformers phase current 1200 A/1 A
current transformer earth current 1000 A/1 A

results in $I_e/I_{ph} = 1000/1200 = 0.833$

- Connection of the earth current from the transformer star point of a parallel line (compensation for parallel lines, see also Appendix B, Figure B.5 for input I5 or Figure B.7):

Address 1111 is then set as
 $I4-CONNECT = PARALLEL LINE$

Address 1113 is set as $I_ePARAL/I_p = 1.000$
but, if the transformers of the parallel line have a ratio which differs from those of the protected line, the relation of these ratios has to be set for I_ePARAL/I_p , e.g.

current transformers protected line 1200 A/1 A
current transformers parallel line 1500 A/1 A

results in $I_ePARAL/I_p = 1500/1200 = 1.250$

- Connection of the earth current from a current transformer which is installed in the earthing connection of an earthed infeed power transformer; this connection is sometimes used for directional discrimination by a directional earth fault protection (refer Figure B.6 in Appendix B, for input I5).

Address 1111 is then set as
 $I4-CONNECT = STAR POINT$

Matching of the amplitude is not necessary in this case.

In similar manner, the connection of the $I5-CONNECT$ is set in address 1114. It is not meaningful, of course, to select the same connections for addresses 1111 and 1114.

The matching factors always refer to the origin of the current connected to the corresponding input (I_e/I_{ph} to the current of the protected line, I_ePARAL/I_p to the current of the parallel line, etc.) independent on which of the additional current inputs is selected for this function.

If one of the additional measured current inputs is not used, the related address (address 1111 for $I4-CONNECT$, address 1114 for $I5-CONNECT$) is set to *NOT CONNECTED*.

1 1 0 7 ■ I S A T >
∞ I / I_n

Current threshold for saturation indicator
Smallest setting value: **0.20** · I_N
Largest setting value: **50.00** · I_N
and ∞ (saturation indicator ineffective)

1 1 0 9 ■ U_x C O N N E C T
N O T C O N N E C T E D
U d e l t a T R A N S F O R M
U 2 T R A N S F O R M E R

The additional measured voltage input U_x of the device is
NOT CONNECTED or

connected to the e–n (open delta) windings of the voltage transformer set of the feeder or
connected to the a voltage transformer of the bus-bar (for synchronism and voltage check)

1 1 1 0 ■ U_{p h} / U d e l t a
1 . 7 3

Matching factor for residual voltage if connected (address 1109 $U_x CONNECT = U_{delta} TRANSFORM$):

$\frac{\text{rated secondary voltage of v.t. phase winding}}{\text{rated secondary voltage of open delta winding}}$

normally 1.73

Smallest setting value: **0.00**
largest setting value: **9.99**

1 1 1 1 ■ I 4 - C O N N E C T
P R O T E C T E D L I N E
P A R A L L E L L I N E
S T A R P O I N T
N O T C O N N E C T E D

The additional measured current input I4 of the device is connected to the c.t. starpoint of the *PROTECTED LINE* or connected to the c.t. starpoint of a *PARALLEL LINE* connected to the c.t. in the earthing connection of the *STAR POINT* of an earthed feeder transformer

NOT CONNECTED

1 1 1 2 ■ I e / I p h
1 . 0 0 0

Matching factor for residual current of the current transformer set of the protected line if this is connected to I4-CONNECT or I5-CONNECT:

1 for connection in c.t. starpoint;

$\frac{\text{earth c.t. ratio}}{\text{phase c.t. ratio}}$

for connection to separate earth current transformer

Smallest setting value: **0.100**
Largest setting value: **20.000**

1 1 1 3 ■ I e P A R A L / I p
1 . 0 0 0

Matching factor for residual current of the current transformer set of the parallel line if this is connected to the I4-CONNECT or the I5-CONNECT:

$\frac{\text{c.t. ratio of the parallel line}}{\text{c.t. ratio of the protected line}}$

Smallest setting value: **0.100**
Largest setting value: **20.000**

1 1 1 4 ■ I 5 - C O N N E C T
P A R A L L E L L I N E
P R O T E C T E D L I N E
S T A R P O I N T
N O T C O N N E C T E D

The additional measured current input I5 of the device is connected to the c.t. starpoint of a *PARALLEL LINE* or connected to the c.t. starpoint of the *PROTECTED LINE* or connected to the c.t. in the earthing connection of the *STAR POINT* of an earthed feeder transformer

NOT CONNECTED

1 1 1 6 ■ U 2 C O N N E C T
L 1 - L 2
L 2 - L 3
L 3 - L 1
L 1 - E
L 2 - E
L 3 - E

Phase allocation for the bus-bar voltage U2 if it is used for synchronism check

When synchronism or voltage is to be checked before closing of the circuit breaker, the bus-bar voltage connected to the U2 voltage input of the relay is compared with the voltage of the feeder voltage transformers as selected in this address

6.3.3.2 Line data, general

General line data are those line constants which are independent of reach of the distance zones and the grading plan. Matching of the earth impedance ratio is achieved by entering the resistance ratio R_E/R_L and the reactance ratio X_E/X_L . These are purely formally calculated and are not identical with real and imaginary parts of Z_E/Z_L . **No** complex calculation is necessary!

The setting parameters can be determined from the line data using the following formulae:

Resistance ratio

$$\frac{R_E}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right)$$

Reactance ratio

$$\frac{X_E}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right)$$

Whereby

- R_0 – Zero sequence line resistance
- X_0 – Zero sequence line reactance
- R_1 – Positive sequence line resistance
- X_1 – Positive sequence line reactance

It is unimportant whether total line values or values per unit length are used, since the ratios are independent of the line length.

Calculation Example

220 kV overhead line Alu/Steel 240/40 mm² with the line parameters

s (length) = 60 km

$R_1/s = 0.13 \Omega/\text{km}$
 $X_1/s = 0.39 \Omega/\text{km}$ } pos. seq. impedance

$R_0/s = 0.38 \Omega/\text{km}$
 $X_0/s = 1.15 \Omega/\text{km}$ } zero seq. impedance

Current transformers 1200 A/5 A
 Voltage transformers 220 kV/0.1 kV

For the earth impedance ratio we have:

$$\frac{R_E}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right) = \frac{1}{3} \cdot \left(\frac{0.38 \Omega/\text{km}}{0.13 \Omega/\text{km}} - 1 \right) = 0.64$$

$$\frac{X_E}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right) = \frac{1}{3} \cdot \left(\frac{1.15 \Omega/\text{km}}{0.39 \Omega/\text{km}} - 1 \right) = 0.65$$

With double lines there is mutual coupling between the two conductor systems. This is only relevant for 7SA513 when it is to operate with parallel line compensation.

The setting parameters can be determined by the following formulae:

Resistance ratio

$$\frac{R_M}{R_L} = \frac{1}{3} \cdot \frac{R_{0M}}{R_1}$$

Reactance ratio

$$\frac{X_M}{X_L} = \frac{1}{3} \cdot \frac{X_{0M}}{X_1}$$

Where

X_{0M} – mutual reactance (couple reactance) of the line system

X_1 – positive sequence reactance of the line

These data can be set either for the total parallel circuit line length or as length related values, since the quotients are independent of length.

1	1	1	7	RE / RL
1	.	0	0	

Matching of earth impedance, resistance ratio
 Smallest setting value: **-7.00**
 Largest setting value: **7.00**

1	1	1	8	■	X E / X L
1	.	0	0		

Matching of earth impedance, reactance ratio
 Smallest setting value: **-7.00**
 Largest setting value: **7.00**

Only for parallel circuit lines if parallel line compensation is used:

1	1	1	9	■	R M / R L
0	.	0	0		

Matching of mutual impedance, resistance ratio
 Smallest setting value: **-7.00**
 Largest setting value: **7.00**

1	1	2	0	■	X M / X L
0	.	0	0		

Matching of mutual impedance, reactance ratio
 Smallest setting value: **-7.00**
 Largest setting value: **7.00**

Some additional data are requested for various protection functions. These have to be entered to the relay under the addresses 1121 to 1132.

The line angle (address 1121) can be calculated from the line constants using the formula

$$\tan \varphi = \frac{X_L}{R_L}$$

It is unimportant whether total line values or values per unit length are used, since the ratios are independent of the line length.

The reactance per unit line length (address 1122) and the capacitance per unit line length (address 1123) are entered as secondary values. These can be derived from the primary values using the formulae

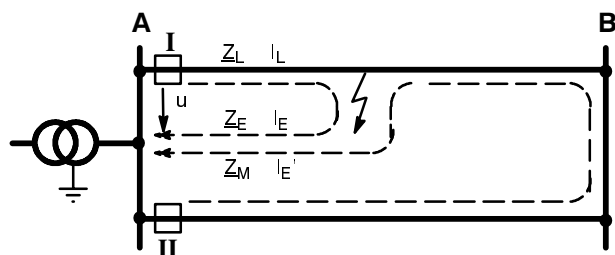
$$X_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X_{\text{prim}} \cdot \frac{I_N}{A}$$

$$C_{\text{sec}} = \frac{N_{\text{vt}}}{N_{\text{ct}}} \cdot C_{\text{prim}} \cdot \frac{1}{I_N/A}$$

where $\frac{N_{\text{ct}}}{N_{\text{vt}}}$ — c.t. ratio
 $\frac{N_{\text{vt}}}{N_{\text{ct}}}$ — v.t. ratio

Finally, the line length is entered under address 1124.

Address 1125 is of interest for measured value correction of distance calculation on double circuit lines. When mutual compensation is applied, theoretically no additional measurement error should occur for earth faults on the protected line. Setting value PARAL COMP is, therefore, relevant only for earth fault outside of the protected line. It determines the ratio $I_E/I_{E'}$ (Figure 6.2), above which compensation should be effective. In general, the preset value 85 % is recommended. A more sensitive (higher) setting will be no gain. A smaller setting is only reasonable for extremely unsymmetrical networks or for systems with very small coupling factor Z_M/Z_L (smaller than approximately 0.4).



Legend:

I Location of the relay to be set

I_E Earth current of the protected line

$I_{E'}$ Earth current of the parallel line

Setting value PARAL COMP corresponds to the ratio $I_E/I_{E'}$

Figure 6.2 Factor for parallel line compensation

1	1	2	1	LINE ANGLE
8	5	.	0	°

Line angle arc tan (X/R), for the line replica, for load compensation and overvoltage compounding

Smallest setting value: **30.0°**

Largest setting value: **89.0°**

1	1	2	2	X SEC
0	.	1	5	Ω / km

Line reactance per unit line length, secondary, for the line replica, for fault location, load compensation and overvoltage compounding

Smallest setting value: **0.010 Ω/km**

Largest setting value: **5.000 Ω/km**

1	1	2	3	C SEC
0	.	0	1	μF / km

Line capacitance per unit line length, for overvoltage compounding

Smallest setting value: **0.000 μF/km**

Largest setting value: **99.000 μF/km**

1	1	2	4	LINE LENGTH
1	0	0	.	0 km

Length of the total line, secondary, for fault location, load compensation and overvoltage compounding

Smallest setting value: **1.0 km**

Largest setting value: **1000.0 km**

Note: When the line length is entered in miles instead of kilometers, and the line constants are entered in ohms per mile and microfarads per mile, then the relay will operate properly.

1	1	2	5	PARAL COMP
8	5	.	%	

Compensation for parallel line mutual influence

Smallest setting value: **50 %**

Largest setting value: **95 %**

6.3.3.3 Additional plant data

Additional plant data are requested for some device functions.

Under addresses 1130 and 1131, the minimum trip command duration can be set. This is then valid for all protection functions of the device which can issue

a trip signal. Distinction can be made between the minimum trip command duration with current flow T-TRIP I> (address 1130) and the duration without current flow T-TRIP I< (address 1131). Address 1140 I-RESID (refer to Section 6.3.3.4) is decisive for the current flow criterion. The trip command duration is, nevertheless, internally limited to 5 s.

1	1	3	0	T - TRIP I >
0	.	0	0	s

Minimum duration of **trip** command with current flow

Smallest setting value: **0.00 s**

Largest setting value: **32.00 s**

1	1	3	1	T - TRIP I <
0	.	1	5	s

Minimum duration of **trip** command without current flow

Smallest setting value: **0.01 s**

Largest setting value: **32.00 s**

If the synchronism and voltage check function is used, note the following:

The feeder voltage is designated with U1; it is the reference voltage for all device functions which operate with measured voltages. The bus-bar voltage is designated U2. The mode of connection of U2 (i.e. which voltage, phase–phase or phase–earth) has been entered to the relay under address 1109 and 1116. If a power transformer is installed between the bus-bar and the location of the feeder voltage transformers then the phase displacement according to the power transformer connection group must be compensated. This can be done using the parameter address 1132.

The secondary rated voltages of the voltage transformers must be equal. Additionally, the primary rated voltages of the feeder voltage transformers on the one hand and the bus-bar voltage transformer(s) on the other hand must relate to the transformation ratio of the power transformer.

If no phase shifting transformer is installed between feeder and bus-bar, then address 1132 remains 0°; otherwise it must be changed. The voltage is defined from U1 to U2.

Example:

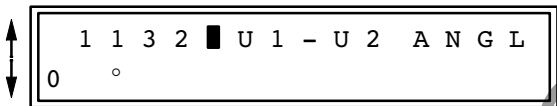
Bus-bar	400 kV primary 110 V secondary
Feeder	220 kV primary 110 V secondary

A power transformer should be installed between bus-bar voltage transformers and feeder voltage transformers:

Power transformer	400 kV/220 kV connection group Dy(n)5

The connection group of the power transformer is defined from the upper voltage side to the lower voltage side. The feeder voltage transformers, which are the reference voltages for the protection relay, are installed on the lower voltage side of the power transformer. Thus, the phase displacement according to the connection group numeral, i.e. $5 \times 30^\circ$, must be entered as negative value.

Setting will be	
address 1132	PHI U1–U2 = –150°



Phase displacement between U1 (feeder voltage) and U2 (bus-bar voltage), for synchronism check
 Smallest setting value: –179°
 Largest setting value: +180°

6.3.3.4 General device data

Under addresses 1133 to 1149, some additional general device data are entered to the protection relay, to match it to the switch gear conditions.

The closing time of the circuit breaker (address 1133) is necessary if the synchro-check function of the relay is used also for asynchronous switching. In this case, the protection calculates the ideal closing instant such that the two voltages (bus-bar and feeder) are in synchronism at the instant when the breaker poles contact each other.

Under address 1135, the maximum close command duration can be set. This time is then valid for all functions of the device which can close the circuit breaker. It must be long enough to ensure reliable

closure of the circuit breaker. The closing command will be interrupted at once on renewed trip command of any of the protection functions.

Under address 1136 it is stated whether three-pole tripping shall occur if a fault is detected in more than one phase or if the trip condition is fulfilled for more than one phase: The 3–Pole COUPLing can be set *WITH FAULT DETECTION* or *WITH TRIP COMMAND*.

Address 1137 determines whether the short-circuit protection functions will trip single-pole in case of an isolated two-phase fault (i.e. without earth), as long as single-pole tripping is allowed. This parameter can be changed if single-pole auto-reclosure should be performed with this fault type.

1 1 3 3 ■ T - C B C L O S E
0 . 0 6 s

Circuit breaker **closing** time (relevant only in case asynchronous switching is used in connection with synchro-check)

Smallest setting value:

0.01 s

Largest setting value:

0.50 s

1 1 3 5 ■ T - C L O S E
1 . 0 0 s

Maximum duration of **close** command

Smallest setting value:

0.01 s

Largest setting value:

32.00 s

1 1 3 6 ■ 3 - P . C O U P L
W I T H F A U L T D E T E C
W I T H T R I P C O M M .

Three-pole coupling

- each multi-phase FAULT DETECTION results in three-pole coupling of the trip command
- with more than one-phase TRIP decision, three-pole tripping occurs

1 1 3 7 ■ T R I P 2 p h F L T
T H R E E - P O L E
1 - P O L E L E A D I N G
1 - P O L E L A G G I N G

With two-phase faults without earth

- three-pole trip will always occur
- single-pole trip of the leading phase will occur provided single-pole trip is allowed
- single-pole trip of the lagging phase will occur provided single-pole trip is allowed

Some protection functions, as the distance protection and the fault locator, comprise an automatic compensation of the measurement error which would be caused by the load current, e.g. in case of a single-phase-to-earth fault with common fault resistance, on a double-end fed line. This LOAD COMPENSATION can be set to YES or NO under address 1138. Since the load compensation could influence test procedures with usual test kits it should be switched OFF in those cases. In practise, in meshed networks it can be set YES because it is only effective if a measurement error would occur without compensation.

Some of the protection and supplementary functions require information about the position of the circuit breaker to operate optimally. The relay incorporates a circuit breaker position logic, which processes the position of the circuit breaker auxiliary contacts and even provides dead line and line energization recognition features by use of the measured quantities (for details refer Section 4.17).

When the line is switched off, the residual current I-RESID set under address 1140 must not be exceeded.

ed. This setting can be very sensitive provided that no parasitical currents are expected during dead line (e.g. caused by induction). Otherwise a higher value must be chosen.

When the line is switched off, the residual voltage of the dead line U-RESID (address 1141) must not be exceeded. It is assumed that the voltage transformers are installed at the line side. Because of possible stray voltages (e.g. caused by electrical influence) the value should not be too small. On the other hand, it must be below the smallest phase-to-earth voltage which is expected under operational conditions.

The release time T-CL-PROL (address 1142) is decisive for how long time those protection stages are released which shall operate when the line is energized (e.g. the high current switch-onto-fault protection), after the internal switch-on detection has operated or the circuit breaker auxiliary contact has indicated that the circuit breaker has been closed. It must be longer than the circuit breaker closing time plus operating time of the high current switch-onto-fault protection plus circuit breaker opening time.

Address 1143 determines which criteria should be used by the integrated line energization feature. Using the setting parameter CB COND, it can be decided that line energization is recognized only by monitoring the measured quantities $I < \text{AND } U <$, or that the voltage monitor signal is replaced by the circuit breaker position signal: parameter CB COND is then set to *CB AUX AND I <*. In cases where the voltage transformers are not installed at the line side, the latter parameter setting must be chosen.

Whereas the release time T-CL-PROL (address 1142, see above) is operative after each closing of the line, the parameter T-M/C-PROL (address 1145) is operative only after manual closing of the breaker. This time is decisive for those protection stages which shall operate only during manual closing (e.g. overreach zone of the distance protection).

1 1 3 8 ■ L O A D C O M P . NO YES	Compensation of load influence with single-phase faults NO no compensation YES compensation effective
1 1 4 0 ■ I - R E S I D . 0 . 1 0 I / I_N	Residual current of the dead line Smallest setting value: 0.05 I_N Largest setting value: 1.00 I_N
1 1 4 1 ■ U - R E S I D . 3 0 V	Residual voltage (phase–earth) of the dead line Smallest setting value: 2 V Largest setting value: 70 V
1 1 4 2 ■ T - C L P R O L 0 . 0 5 s	Prolongation time after each closing of the line, for which the associated protection stage shall operate Smallest setting value: 0.01 s Largest setting value: 32.00 s
1 1 4 3 ■ C B C O N D . I < A N D U < C B A U X A N D I <	CB condition shall be recognized by the criteria undercurrent and undervoltage or CB auxiliary contacts and undercurrent
1 1 4 5 ■ T - M / C - P R O L 0 . 3 0 s	Prolongation time after manual closing, for which the associated protection stages shall operate Smallest setting value: 0.01 s Largest setting value: 32.00 s
1 1 4 9 ■ T - E X T . S T A B 0 . 0 1 s	Stabilization time (delay) for external trip command via binary input Smallest setting value: 0.00 s Largest setting value: 32.00 s

6.3.4 Settings for distance protection

Since the main function of 7SA513 is that of distance protection, it is assumed in the following that in setting the scope of the device (Section 5.4.2) the distance protection function has been set as *EXIST* (address, 7812). If the response *NON-EXIST* has been set for the distance protection (for example, because only other functions shall be used) this section is irrelevant.

6.3.4.1 General settings – address block 12

The distance protection of 7SA513 comprises 5 distance zones and 7 time stages arranged as follows:

Independent distance stages:

zone Z1	delay T1
zone Z2	delay T2
zone Z3	delay T3

Controlled (overreaching) stages:

zone Z1B	delay T1B
zone Z1L	delay T1L

Final stages:

fault detection, directional	delay T4
fault detection, non-directional	delay T5

For Z1, Z2 and Z1B, different delay times can be set for single-phase faults and multi-phase faults respectively.

Address block 12 contains the general settings for the distance protection function. These comprise the direction of the directional final stage (address 1202) and the delay times of the directional (address 1203) and the non-directional (address 1204) final stage.

NOTE:

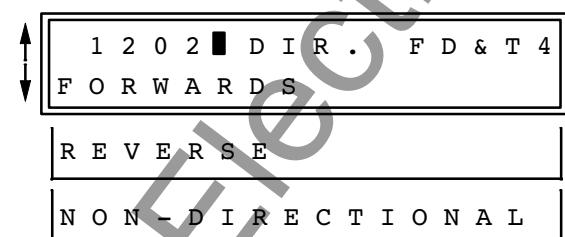
The direction which is set for the directional final stage (address 1202) is not valid for other directionally dependent functions of the fault detection functions, for example, for directional comparison when this is selected!



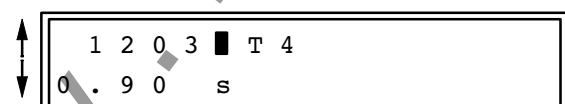
Beginning of the block
"Distance protection general settings"



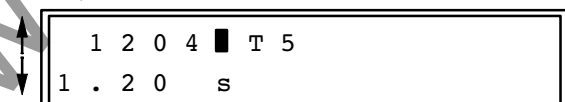
Distance protection is
ON switched on
or
OFF switched off



Direction for directional trip with fault detection, which can be set
FORWARDS (line direction) or
REVERSE (busbar direction) or
NON-DIRECTIONAL (either direction)



Delay for T4 (fault detection directional trip)
Smallest setting value: 0.00 s
Largest setting value: 32.00 s
and ∞ (no directional trip)



Delay for T5 (fault detection non-directional trip)
Smallest setting value: 0.00 s
Largest setting value: 32.00 s
and ∞ (no non-directional trip)

For manual closure onto the short circuit, the distance protection can be set for various values of reach (address 1205). For *Z1 EFFECTIVE*, no special measures are taken. Possible measures are switch to overreach zone (instantaneous directional) *Z1B DIRECTIONAL* or overreach zone (instantaneous non-directional, only with firmware version 3.3) *Z1B NON-DIRECT* or *FD EFFECTIVE*, i.e. fault detection instantaneous non-directional. Prerequisite is that the manual closing command is fed to the relay via a binary input from the discrepancy switch.

For manual closure onto the short circuit, the distance protection can be set for various values of reach (address 1205). For *Z1 EFFECTIVE*, no special measures are taken. Possible measures are switch to overreach zone (directional undelayed) *Z1B EFFECTIVE* or *FD EFFECTIVE*, i.e. fault detection non-directional undelayed. Prerequisite is that the manual closing command is fed to the relay via a binary input from the discrepancy switch.

If the line is series compensated (with series capacitors), address 1208 must be set to SER. COMP = YES. Otherwise wrong directional decision could be the result.

Under address 1209, the measured value correction on double circuit lines can be set effective or not.

If the distance protection operates together with the integrated or an externally connected auto-reclose device, address 1216 determines which distance zone is valid before auto-reclose. Normally, measurement for the RAR cycle takes place in the (extended) overreach zone *Z1B*. This can be changed by setting RAR → *Z1B* to NO. Overreaching zone *Z1B* is not released by the RAR function in this case. Zone *Z1* is effective continuously.

For DAR (further auto-reclose cycles), a separate distance zone *Z1L* is available. Release of this zone before a DAR cycle can be blocked by setting address 1218 DAR → *Z1L* to NO. The DAR cycles can also be blocked by a binary input. One can select the stage that should be effective during blocking of the DAR cycles (address 1217): Normally, *Z1* with *T1* is effective in this case, this can be changed to *Z1* with *T1B*.

The protection relay comprises an integrated switch-on detection which can process the position of the circuit breaker auxiliary contacts as well as the status of current flow and voltages of the line. This function does not discriminate between manual closure and automatic reclosure. For closure onto the short circuit, the distance protection can be set for various values of reach (address 1220). For the normal setting *Z1 EFFECTIVE*, no special measures are taken. Possible measures are switching to overreach zone (undelayed and directional unless set non-directional) *Z1B EFFECTIVE* or *FD EFFECTIVE*, i.e. fault detection non-directional undelayed. The latter may be useful when U_0 processing feature is carried out for single-pole AR. For details of U_0 processing refer to Section 4.10.1.

If a line to be protected is composed of overhead line and cable sections, the controlled zones *Z1B* and *Z1L* can be used to distinguish between faults on the the overhead section and cable faults, to a certain degree. Reclosure can be blocked for cable faults using addresses 1221 and 1222. If, for example, a cable section is followed by an overhead line section, zone *Z1B* is set to cover the cable section and address 1221 is set such that reclosure is blocked for faults *WITHIN Z1B*. If further segregation is necessary (e.g. cable – overhead line – cable), distinction can be made by address 1222 in similar way. In all other cases, both addresses remain in position NO.

↑	1 2 0 5	MAN . C L O S E
↓	Z 1 B	D I R E C T I O N A L
	Z 1 B	N O N - D I R E C T .
	F D	E F F E C T I V E
	Z 1	E F F E C T I V E

Distance measuring range which is valid when the circuit breaker is closed manually:

<i>Z1B DIRECTIONAL</i>	i.e. the overreach zone, directional as set in address 1414 ¹⁾
<i>Z1B NON-DIRECT</i>	i.e. the overreach zone, non-directional ²⁾
<i>FD EFFECTIVE</i>	i.e. fault detection zone, non-directional
<i>Z1 EFFECTIVE</i>	i.e. the normal first zone: no special measures

¹⁾ up to firmware version V3.2 designated *Z1B EFFECTIVE*
²⁾ possible from firmware version V3.3 or higher

1 2 0 8 ■ S E R . C O M P
N O
Y E S

Compensation of series capacitors

NO

YES

1 2 0 9 ■ P A R . C O M P
N O
Y E S

Compensation for parallel line mutual influence

NO

YES

1 2 1 6 ■ R A R - > Z 1 B
Y E S
N O

Overreach zone Z1B is released before the first AR-cycle ("RAR")

YES Overreaching zone Z1B with T1B

or

NO Z1B not released, normal first zone Z1 with T1 is effective

1 2 1 7 ■ D A R B L O C K
Z 1 ; T 1
Z 1 ; T 1 B

If DAR (2nd and further shots) is blocked,

Z1; T1 zone Z1 is valid with delay T1

Z1; T1B zone Z1 is valid with delay T1B

1 2 1 8 ■ D A R - > Z 1 L
Y E S
N O

Overreach zone Z1L is released before further AR-cycles ("DAR")

YES Overreaching zone Z1L with T1L

or

NO Z1L not released

1 2 2 0 ■ C L O S E Z O N E
Z 1 E F F E C T I V E
Z 1 B E F F E C T I V E
F D E F F E C T I V E

Distance measuring zone which is valid when the line is energized (manually or automatically):

Z1 i.e. the normal first zone:
no special measuresZ1B i.e. the overreach zone, directional
undelayedFD i.e. fault detection zone, non-directional
undelayed

1 2 2 1 ■ B L K . A R Z 1 B
N O
W I T H I N
O U T S I D E

Auto-reclosure is blocked for faults

NO normal setting

WITHIN zone Z1B

OUTSIDE of zone Z1B

1 2 2 2 ■ B L K . A R Z 1 L
N O
W I T H I N
O U T S I D E

Auto-reclosure ist blocked for faults

NO normal setting

WITHIN zone Z1L

OUTSIDE of zone Z1L

6.3.4.2 Setting of the distance stages – address blocks 13 and 14

The relevant parameters are set for each distance stage. The reactance X determines the reach of its associated zone. The resistance R forms the allowance for line and fault resistance. It can be set separately for phase–phase faults and for phase–earth faults to allow, for example, for earth faults with higher fault path resistance.

Measurement direction can be set individually for each zone. This allows free choice of forwards, reverse or non-directional stages, e.g. at transformers, generators or bus-bar couplers.

The delay times T1 and T2 can each be set individually and differently for single-phase faults and multi-phase faults. Thus one can, for example, make a setting for single-phase faults higher than that of an associated differential earth fault protection (T1 1PHASE greater than T1 >1PHASE) or, set a shorter reserve time for multi-phase faults close to a power station (T2 >1PHASE less than T2 1PHASE). The independent zones Z1, Z2, Z3 operate independently from one another and independently of the overreach zones Z1B, Z1L.

It is recommended that a comprehensive grading plan should be made for the complete electrically connected network. It should be made before this entry series is attempted. This plan should contain the line lengths with their primary reactances X in Ω /phase. These reactances X are the basis for zone reach determination.

For the first zone Z1, one normally selects no delay time (i.e. T1 = 0.00 s) for the first 85 % of the protected line length. Over this distance the relay will then disconnect faults within its inherent operating time.

For each of the following stages the delay time is increased by one grading time unit. This grading time unit must be adequate to cover the circuit breaker operating time inclusive tolerance, the reset time of the protection devices and the tolerance of the delay times. Normally 0.3 s to 0.4 s is used. Reach is selected so that it covers up to 80 % of the equal time stage of the relay for the shortest following line section.

The values determined from the grading plan must be converted for the secondary side of current and voltage transformers. In general:

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

The secondary values given to the relay must be related to a current of 1A. Thus the conversion formula for reach for any distance zone is:

$$X_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X_{\text{prim}} \cdot \frac{I_N}{A}$$

Where N_{ct} – c.t. ratio
 N_{vt} – v.t. ratio
 I_N/A – rated relay current in Ampere =
 secondary rated current of current transformers

Resistance setting R allows a margin for fault resistance, which appears as an in-phase resistance addition to the line impedance, at the point of fault. It comprises, for example, arc resistances, tower footing resistances or similar. The setting should take these fault resistances into account but not be set higher than absolutely necessary. An adequate difference from the operating impedance must be ensured, even under conditions of temporary overload. The resistance margin can be set separately for phase–phase faults and for phase–earth faults.

Calculation Example

220 kV overhead line Alu/Steel 240/40 mm² with the characteristics:

s (length) = 60 km

$R_1/s = 0.13 \Omega/\text{km}$

$X_1/s = 0.39 \Omega/\text{km}$

$R_0/s = 0.38 \Omega/\text{km}$

$X_0/s = 1.15 \Omega/\text{km}$

Current transformers 1200 A/5 A

Voltage transformers 220 kV/0.1 kV

Maximum overload:

$P_{\text{max}} = 520 \text{ MVA}$ corresponding to

$I_{\text{max}} = 1360 \text{ A}$

Figure 6.3 shows a sample network section with primary grading plan.

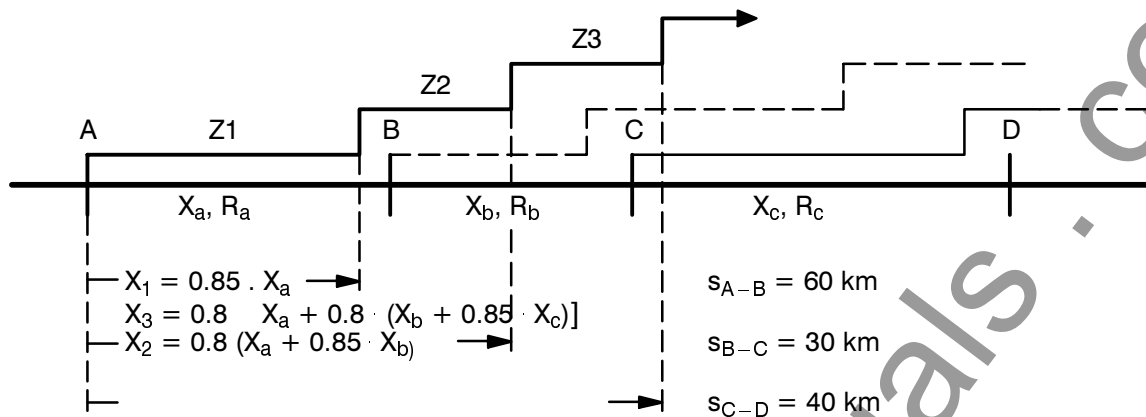


Figure 6.3 Grading plan related to calculation example

Which gives the line data:

$$X_a = 0.39 \, \Omega/\text{km} \cdot 60 \, \text{km} = 23.4 \, \Omega$$

$$R_a = 0.13 \, \Omega/\text{km} \cdot 60 \, \text{km} = 7.8 \, \Omega$$

$$X_b = 0.39 \, \Omega/\text{km} \cdot 30 \, \text{km} = 11.7 \, \Omega$$

$$R_b = 0.13 \, \Omega/\text{km} \cdot 30 \, \text{km} = 3.9 \, \Omega$$

$$X_c = 0.39 \, \Omega/\text{km} \cdot 40 \, \text{km} = 15.6 \, \Omega$$

$$R_c = 0.13 \, \Omega/\text{km} \cdot 40 \, \text{km} = 5.2 \, \Omega$$

Thus the following zone limits arise:

Zone 1 primary 85 % of line length

$$X_{1\text{prim}} = 0.85 \cdot X_a = 0.85 \cdot 23.4 \, \Omega = 19.89 \, \Omega$$

Zone 1 secondary

$$X_{1\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X_{1\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{1200/5}{220/0.1} \cdot 19.89 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 10.85 \, \Omega$$

Zone 2 primary 80 % up to Z1 of the next line b

$$X_{2\text{prim}} = 0.8 \cdot (X_a + 0.85 X_b)$$

$$= 0.8 \cdot (23.4 \, \Omega + 0.85 \cdot 11.7 \, \Omega)$$

$$= 26.68 \, \Omega$$

Zone 2 secondary

$$X_{2\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X_{2\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{1200/5}{220/0.1} \cdot 26.68 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 14.55 \, \Omega$$

Zone 3 primary 80 % up to Z2 of the next line b

$$X_{3\text{prim}} = 0.8 \cdot [X_a + 0.8 (X_b + 0.85 X_c)]$$

$$= 0.8 \cdot [23.4 \, \Omega + 0.8 (11.7 \, \Omega + 0.85 \cdot 15.6 \, \Omega)]$$

$$= 34.69 \, \Omega$$

Zone 3 secondary

$$X_{3\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X_{3\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{1200/5}{220/0.1} \cdot 34.69 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 18.92 \, \Omega$$

Resistance setting

For resistance setting in relation to overhead lines, consideration of the arc resistance is most important. In cable networks, an extensive arc is not possible; thus the effective resistance of the cable itself normally plays the more important role. With very short cable lengths, however, it must be ensured that the resistance of an arc at the terminals at the close-up cable end is covered by the resistance which is set for the first zone.

In this example, for phase-phase arcs, an arc voltage drop of max. 12 kV is assumed. With an assumed minimum short circuit current of 1000 A, this corresponds to 12 Ω primary. For the resistance setting of the first zone, this results in

$$R1_{\text{prim}} = R1_{\text{line}} + \frac{1}{2} \cdot R_{\text{arc}}$$

$$= 6.63 \, \Omega + \frac{1}{2} \cdot 12 \, \Omega = 12.63 \, \Omega$$

$$R1_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot R1_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{1200/5}{220/0.1} \cdot 12.63 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 6.9 \, \Omega$$

Only half of the arc resistance value was used, because it is additive to the *loop* impedance and only half should be added to the impedance *per phase*.

For earth faults, a separate resistance tolerance can be set. If an arc resistance of 9 Ω and a resistance of 25 Ω for the tower footing earth path are assumed,

this then leads to

$$R1E_{\text{prim}} = R1_{\text{line}} + R_{\text{arc}} + R_{\text{tower}}$$

$$= 6.63 \, \Omega + 9 \, \Omega + 25 \, \Omega$$

$$= 40.63 \, \Omega$$

$$R1E_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot R1E_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{1200/5}{220/0.1} \cdot 40.63 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 22.2 \, \Omega$$

This value gives an adequate clearance to the minimum load impedance. The power swing polygon can be ignored for the phase–earth faults, because the power swing detection works only with phase–phase measurement.

NOTE: The setting values R for each zone should, if possible, not exceed 6 times the set X–value.

Independent zones Z1, Z2 and Z3 – address block 13

1 3 0 0 ■ D I S T . P R O T .
I N D E P E N D . Z O N E S

Beginning of block
"Distance protection, independent zones Z1, Z2 and Z3"

First zone Z1

1 3 0 1 ■ R 1
1 . 2 5 Ω

Resistance for phase–phase

0.05 Ω

Smallest setting value:

65.00 Ω

Largest setting value:

1 3 0 2 ■ X 1
2 . 5 0 Ω

Reactance value (reach)

0.05 Ω

Smallest setting value:

200.00 Ω

Largest setting value:

1 3 0 3 ■ R 1 E
2 . 5 0 Ω

Resistance for phase–earth

0.05 Ω

Smallest setting value:

130.00 Ω

Largest setting value:

1 3 0 4	■	D I R E C .	Z 1
F O R W A R D S			
R E V E R S E			
N O N - D I R E C T I O N A L			

Direction for zone Z1: can be

FORWARDS (line direction) or

REVERSE (busbar direction)

NON-DIRECTIONAL (either direction)

1 3 0 5	■	T 1	1 P H A S E
0 . 0 0	s		

Delay for zone Z1, single-phase faults

Smallest setting value: **0.00 s**

Largest setting value: **32.00 s**
and ∞ (no trip in zone Z1 for single-phase faults)

1 3 0 6	■	T 1	> 1 P H A S E
0 . 0 0	s		

Delay for zone Z1, multi-phase faults

Smallest setting value: **0.00 s**

Largest setting value: **32.00 s**
and ∞ (no trip in zone Z1 for multi-phase faults)

Normally, addresses 1305 and 1306 are set to the same value.

Second zone Z2

1 3 1 1	■	R 2
2 . 5 0	Ω	

Resistance for phase-phase

Smallest setting value: **0.05 Ω**

Largest setting value: **65.00 Ω**

1 3 1 2	■	X 2
5 . 0 0	Ω	

Reactance value (reach)

Smallest setting value: **0.05 Ω**

Largest setting value: **200.00 Ω**

1 3 1 3	■	R 2 E
5 . 0 0	Ω	

Resistance for phase-earth

Smallest setting value: **0.05 Ω**

Largest setting value: **130.00 Ω**

1 3 1 4	■	D I R E C .	Z 2
F O R W A R D S			
R E V E R S E			
N O N - D I R E C T I O N A L			

Direction for zone Z2: can be

FORWARDS (line direction) or

REVERSE (busbar direction)

NON-DIRECTIONAL (either direction)

1 3 1 5	T 2	1 P H A S E
0 . 3 0	s	

Delay for zone Z2, single-phase faults
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip in zone Z2 for single-phase faults)

1 3 1 6	T 2	> 1 P H A S E
0 . 3 0	s	

Delay for zone Z2, multi-phase faults
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip in zone Z2 for multi-phase faults)

1 3 1 7	T R I P	1 P Z 2
N O		
Y E S		

Single-pole trip with single-phase fault even in zone Z2?
 NO or YES

Normally, addresses 1315 and 1316 are set to the same value.

Third zone Z3

1 3 2 1	R 3
5 . 0 0	Ω

Resistance for phase–phase
 Smallest setting value: **0.05 Ω**
 Largest setting value: **65.00 Ω**

1 3 2 2	X 3
1 0 . 0 0	Ω

Reactance value (reach)
 Smallest setting value: **0.05 Ω**
 Largest setting value: **200.00 Ω**

1 3 2 3	R 3 E
1 0 . 0 0	Ω

Resistance for phase–earth
 Smallest setting value: **0.05 Ω**
 Largest setting value: **130.00 Ω**

1 3 2 4	D I R E C . Z 3
F O R W A R D S	
R E V E R S E	
N O N - D I R E C T I O N A L	

Direction for zone Z3: can be
FORWARDS (line direction) or
REVERSE (busbar direction)
NON-DIRECTIONAL (either direction)

1 3 2 5	T 3
0 . 6 0	s

Delay for zone Z3
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip in zone Z3)

Controlled (overreach) zones Z1B and Z1L – address block 14

The two overreach zones Z1B and Z1L are controlled stages. They do not influence the normal zones Z1, Z2, Z3. There is, therefore, no switch-over, rather the overreach zones will be switched effective or non-effective by the appropriate criteria. If one of these stages is not required, set it to the same values as Z1.

Zone Z1B is effective in conjunction with rapid reclosing (first shot) and/or teleprotection modes. It can also be activated via a binary input circuit. It is generally set at at least 120 % of the line length. The zone Z1L is used for multiple reclosing, after the second shot (DAR = "delayed auto-reclosure"). It can also be activated via a binary input circuit. Each of these stages have their own delay time whereby, for

Z1B, one can again distinguish between single-phase (T1B 1PHASE) and multi-phase faults (T1B > 1PHASE).

Measurement direction can also be set individually for the overreach zones.

NOTE: The direction set for zone Z1B applies in general for this stage, independent of the cause which leads to activation of this zone.

An additional release delay is possible for zone Z1B which is used only in conjunction with blocking schemes. This allows a very fine adjustment of waiting time for blocking signal (cf. also Section 4.4.7).

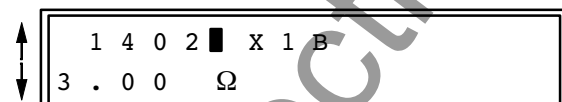


Beginning of block
"Distance protection, controlled zones
Z1B and Z1L"

Overreach zone Z1B (controlled by AR, teleprotection signals or binary input)



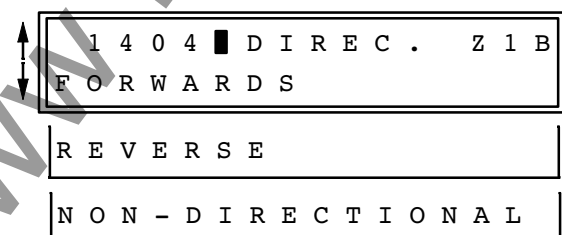
Resistance for phase–
phase
Smallest setting value: **0.05 Ω**
Largest setting value: **65.00 Ω**



Reactance value (reach)
Smallest setting value: **0.05 Ω**
Largest setting value: **200.00 Ω**



Resistance for phase–earth
Smallest setting value: **0.05 Ω**
Largest setting value: **130.00 Ω**



Direction for zone Z1B: can be
FORWARDS (line direction) or
REVERSE (busbar direction)
NON-DIRECTIONAL (either direction)

1 4 0 5	T 1 B	1 P H A S E
0 . 0 0	s	

Delay for zone Z1B, single-phase faults
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip in zone Z1B for single-phase faults)

1 4 0 6	T 1 B	> 1 P H A S
0 . 0 0	s	

Delay for zone Z1B, multi-phase faults
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip in zone Z1B for multi-phase faults)

1 4 0 7	T B L K	D E L A Y
0 . 0 1 0	s	

Additional release delay for zone Z1B (only for signal transmission in blocking mode, cf. Section 4.4.7)
 Smallest setting value: **0.000 s**
 Largest setting value: **1.000 s**

Normally, addresses 1405 and 1406 are set to the same value.

Overreach zone Z1L (controlled by DAR i.e. from second AR shot on, or via binary input)

1 4 1 1	R 1 L	
2 . 0 0	Ω	

Resistance for phase–phase
 Smallest setting value: **0.05 Ω**
 Largest setting value: **65.00 Ω**

1 4 1 2	X 1 L	
4 . 0 0	Ω	

Reactance value (reach)
 Smallest setting value: **0.05 Ω**
 Largest setting value: **200.00 Ω**

1 4 1 3	R 1 L E	
4 . 0 0	Ω	

Resistance for phase–earth
 Smallest setting value: **0.05 Ω**
 Largest setting value: **130.00 Ω**

1 4 1 4	D I R E C .	Z 1 L
F O R W A R D S		
R E V E R S E		
N O N - D I R E C T I O N A L		

Direction for zone Z1L: can be
FORWARDS (line direction) or
REVERSE (busbar direction)
NON-DIRECTIONAL (either direction)

1 4 1 5	T 1 L	
0 . 0 0	s	

Delay for zone Z1L
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip in zone Z1L)

6.3.4.3 Selection of the fault detection program and general fault detection settings – address blocks 15 and 16

The line protection relay has a variety of fault detection functions from which the optimum can be chosen for the system under consideration.

The possible fault detection methods are individually described in Section 4.2.1. Selection of the fault detection mode was made during configuration according Section 5.4.2 (address 7813). The following paragraphs show the parameters for all fault detection facilities. When paging through the display, only those addresses appear which are valid for the selected fault detection method(s).

When the voltage and phase angle dependent fault detection mode is used, selection can be made how the fault detection modules are controlled. Address 1501 determines, which loop voltages should be valid for measurement of the phase-to-phase loops (LL:) and which for the phase-to-earth loops (LE:).

In most cases, control with U_{Ph-E} for earth faults and U_{Ph-Ph} for earth-free faults is preferred in systems with **earthed** starpoint (address 1501 LE:Uphe/LL:Uphph). This ensures maximum sensitivity for all kinds of fault. A pre-requisite is, however, that the earth fault criteria are satisfied at the measuring point safely for all earth faults (refer Section 4.2.1.1). Otherwise, control with U_{Ph-E} for all kinds of fault is

reasonable (address 1501 LE:Uphe/LL:Uphe), which is less sensitive for earth-free short-circuits. In many cases this can be accepted because phase-to-phase faults are covered by the overcurrent fault detection stage I>>.

In order to prevent faulty pick-up of the earth fault detector by the oscillation transients on occurrence of a simple earth fault in **isolated** or **compensated** (Petersen–coil) networks, earth fault detection can be delayed by the parameter Tle 1PHASE (address 1801, refer Section 6.3.4.6). If the earth current could exceed the earth fault threshold even under steady-state conditions, Tle 1PHASE should be set to ∞ : pick-up on one single-phase fault is then no more possible even if a high earth current will flow. Double earth faults will, nevertheless, be detected correctly and cleared in accordance with the double fault preference program (Section 6.3.4.6).

Additionally, it is possible to make voltage control with phase-to-phase voltages only (address 1501 LE:Uphph/LL:Uphph). The measured line loop in this case is independent of the earth fault detection; this method excludes pick-up on earth faults absolutely, however, correct double earth fault preference is not possible.

1 5 0 0 ■ D I S T . P R O T .
F A U L T D E T E C . P R O G

Beginning of the block "Distance protection, fault detection program"

1 5 0 1 ■ P R O G . U / I / φ
L E : U p h e / L L : U p h p h

L E : U p h p h / L L : U p h p h

L E : U p h e / L L : U p h e

only with voltage controlled (U/I) fault detection:
measurement control

U_{Ph-E} with detected earth fault

U_{Ph-Ph} without detected earth fault

U_{Ph-Ph} with detected earth fault

U_{Ph-E} without detected earth fault

U_{Ph-E} with detected earth fault

U_{Ph-E} without detected earth fault

↑
↓

1	6	0	0	■	D	I	S	T	.	P	R	O	T	.
F	A	U	L	T	D	E	T	E	C	T	I	O	N	

Beginning of the block "Fault detection for distance protection"

The parameters of the earth current stages in addresses 1602 and 1603 are common for all modes of fault detection.

In solidly earthed networks, the pick-up value of the earth current $I_{E>}$ (Address 1602) is set below the minimum expected earth fault current value. In isolated or compensated networks, the setting value for

correct detection of double earth faults must be set below the minimum expected double earth fault current.

The high earth current stage $I_{E>>}$ (address 1603) will detect an earth fault even in the case that the parameter E/F DETECTION (address 1707, refer to Section 6.3.4.6) prescribes $U_{e>} \text{ AND } I_{e>}$.

↑
↓

1	6	0	2	■	I	e	>
0	.	5	0	I	/	I	n

Threshold value for earth current detection $I_{E>}$
 Smallest setting value: **0.10** · I_N
 Largest setting value: **1.00** · I_N

↑
↓

1	6	0	3	■	I	e	>>
1	.	0	0	I	/	I	n

Threshold value for high earth current $I_{E>>}$
 Smallest setting value: **0.10** · I_N
 Largest setting value: **4.00** · I_N

6.3.4.4 Settings for voltage and phase angle controlled fault detection ($U/I/\varphi$)

NOTE: This section applies only when the voltage and angle controlled fault detection method has been selected (Section 5.4.2). Otherwise it can be passed over.

The meaning of the parameters can be gathered from the current/voltage characteristic shown in Figure 6.4. $I_{ph>}$ (address 1611) is the minimum operating current, the prerequisite for each phase pick-up. It must be set below the minimum presumed short-circuit current.

The voltage dependent branches can be set either for phase-to-earth voltages in addresses 1612, 1613, and 1617, or for phase-to-phase voltages under addresses 1614, 1615, and 1618. The parameters $I_{\varphi>}$ (address 1616) and $U(I_{\varphi>})$ (address 1617 or 1618) determine the pick-up characteristic in the range of high phase angles (fault area $\varphi>$). The limit

angles themselves are set under addresses 1619 ($\varphi>$) and 1620 ($\varphi<$). The fault angle area lies between these limits.

The characteristic must be set such that it has a sufficient safety distance from the maximum operation current at minimum operation voltage, when the phase angle lies in the load angle area, i.e. below the value $\varphi>$. In the range of higher phase angles, it must be ensured, that pick-up must not occur due to charging currents of the line. When the line should carry reactive power, the maximum reactive current at minimum operational voltage must not cause pick-up, i.e. must not lie in the fault area $\varphi>$. In cases of doubt one should check the pick-up conditions against the $U/I/\varphi$ -characteristic. With comprehensive networks, short-circuit calculations may be useful.

The lower limit angle $\varphi >$ (address 1619) should lie between the phase angle during normal operation and the phase angle during short-circuit condition. It must be smaller than the line angle $\varphi_L = \arctan(X_L/R_L)$ (approx. 10° to 20°). Then it must be checked that this angle is not exceeded during normal load conditions. If not, e.g. because reactive power can be transmitted through the line, it must be ensured that the voltage dependent branch, determined by $I_{\varphi >}$ and $U(I_{\varphi >})$, will never pick up due to the reactive power.

The overcurrent stage $I_{ph >>}$ is superimposed on the voltage dependent branches of the characteristic; it is set in address 1610. The determining factor is the maximum possible operating current. Pick-up under conditions of permissible overload must be excluded! The threshold value $I_{ph >>}$ must therefore be set above the maximum anticipated (over-)load current (approx. 1.2 times). In case healthy phases could carry short-circuit current, $I_{ph >>}$ must be set above this current.

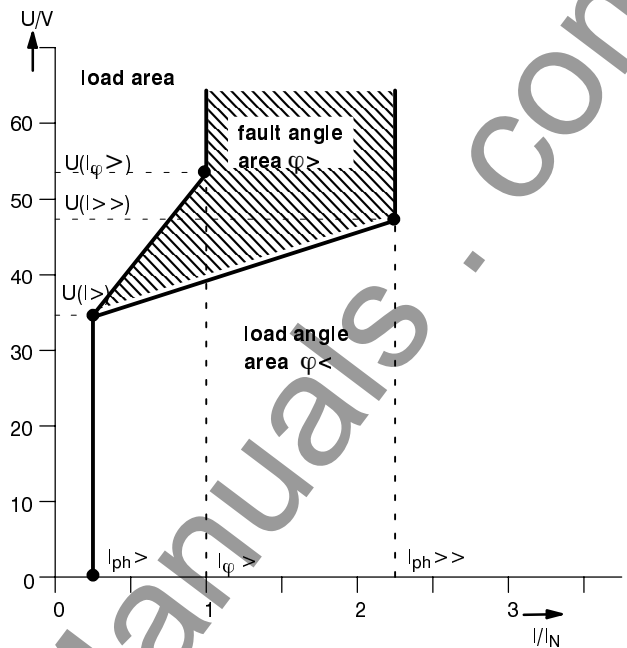


Figure 6.4 Voltage and angle controlled fault detectors, $U/I/\varphi$ characteristic

1 6 1 0	$I_{ph >>}$
1 . 8 0	I / I_N

Overcurrent detection threshold value $I_{ph >>}$
 Smallest setting value: **0.25** $\cdot I_N$
 Largest setting value: **4.00** $\cdot I_N$

1 6 1 1	$I_{ph >}$
0 . 2 0	I / I_N

Minimum operating current for fault detection $I_{ph >}$
 Smallest setting value: **0.10** $\cdot I_N$
 Largest setting value: **1.00** $\cdot I_N$

1 6 1 2	$U_{phe} (I >>)$
4 8	V

Undervoltage pick-up value at $I_{ph >>}$ (address 1610) (Figure 6.4); phase-to-earth voltage
 Smallest setting value: **20** V
 Largest setting value: **70** V

1 6 1 3	$U_{phe} (I >)$
4 8	V

Undervoltage pick-up value at $I_{ph >}$ (address 1611) (Figure 6.4); phase-to-earth voltage
 Smallest setting value: **20** V
 Largest setting value: **70** V

1 6 1 4	$U_{pph} (I >>)$
8 0	V

Undervoltage pick-up value at $I_{ph >>}$ (address 1610) (Figure 6.4); phase-to-phase voltage
 Smallest setting value: **40** V
 Largest setting value: **130** V

1 6 1 5	$U_{pph} (I >)$
8 0	V

Undervoltage pick-up value at $I_{ph >}$ (address 1611) (Figure 6.4); phase-to-phase voltage
 Smallest setting value: **40** V
 Largest setting value: **130** V

1 6 1 6 ■ I φ > 0 . 5 0 I / I_N	Current pick-up value in the range of high angles (refer also to address 1619 and 1620) Smallest setting value: 0.10 · I_N Largest setting value: 2.00 · I_N
1 6 1 7 ■ U p h e (I φ >) 4 8 V	Undervoltage pick-up value at Iφ > (address 1616) (Figure 6.4); phase-to-earth voltage Smallest setting value: 20 V Largest setting value: 70 V
1 6 1 8 ■ U p h p (I φ >) 8 0 V	Undervoltage pick-up value at Iφ > (address 1616) (Figure 6.4); phase-to-phase voltage Smallest setting value: 40 V Largest setting value: 130 V
1 6 1 9 ■ φ > 5 0 °	Lower angle limit for the fault angle area (Figure 6.4) Smallest setting value: 30° Largest setting value: 60°
1 6 2 0 ■ φ < 1 1 0 °	Upper angle limit for the fault angle area (Figure 6.4) Smallest setting value: 90° Largest setting value: 120°

6.3.4.5 Settings for impedance fault detection ZA

NOTE: This section applies only when the impedance detection method has been selected during configuration or the protection functions (Section 5.4.2). Otherwise it can be passed over.

The impedance fault detection for phase–earth is supplemented by an overcurrent stage I > >. This stage allows rapid fault detection in case of high-current faults (small fault impedance).

The meaning of the parameters can be gathered from the impedance characteristic shown in Figure 6.5. The bold dots identify the setting parameters which determine the geometry of the fault detection polygon. I_{ph} > (address 2621) is the minimum operating current, the prerequisite for each phase pick-up. It must be set below the minimum presumed short-circuit current.

Impedance detection should, with safety, be looked upon as the ultimate protection. Taking into account intermediate feeding for remote faults, a larger, rather

er than smaller threshold value should be chosen. If the line carries reactive power, the pick-up threshold must lie below the reactive power impedance, however.

Considering the calculation example in Section 6.3.4.2 we select approximately 2 times the value of the third zone. A calculation using primary values is superfluous in this consideration:

$$X + A_{\text{sec}} = \underline{\underline{38 \, \Omega}}$$

For the reverse direction do not forget, that with overreach teleprotection procedures, a reverse fault must definitely be recognized if it lies within the overreach zone of the relay at the other line end. Normal setting values are approximately half those of the reach in the forwards direction.

$$X - A_{\text{sec}} = \underline{\underline{19 \, \Omega}}$$

For the resistance setting there is a lower and an upper limit. The setting RA2 (address 1625) must still recognize arc faults within its tolerance range. Roughly, 2 or 3 times the value of the third zone applies here also.

At the upper end, the setting value RA should not exceed **6 times** the setting for X–A.

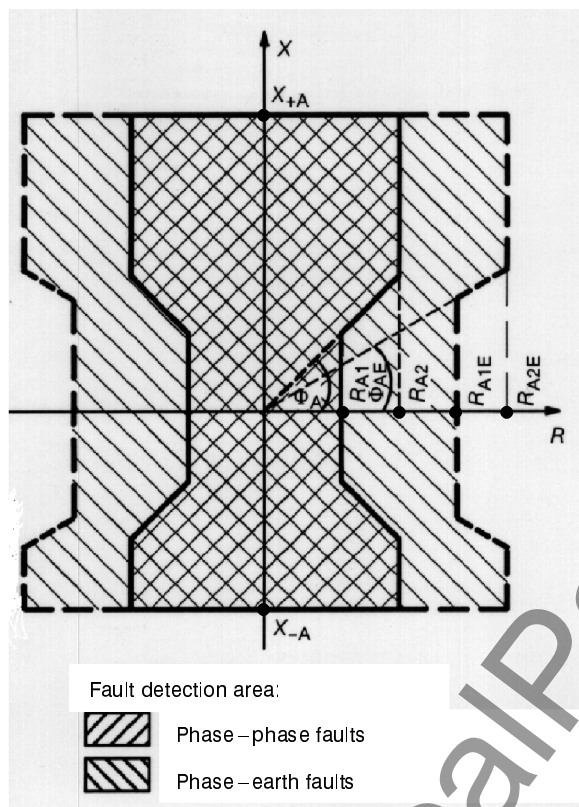


Figure 6.6 Impedance fault detection characteristic

For long overhead lines it must be considered that the setting in the resistive direction must have a sufficient safety margin from the minimum load impedance. The minimum load impedance occurs at maximum load current and minimum operating voltage. In this example, therefore

$$R_{Lprim} = \frac{U_{min}}{\sqrt{3} \cdot I_{Lmax}} = \frac{0.9 \cdot 220 \text{ kV}}{\sqrt{3} \cdot 1360 \text{ A}} = 84.06 \, \Omega$$

or secondary

$$R_{Lsec} = \frac{N_{ct}}{N_{vt}} \cdot R_{Lprim} \cdot \frac{I_N}{A} \\ = \frac{1200/5}{220/0.1} \cdot 84.06 \, \Omega \cdot \frac{5 \text{ A}}{A} = 45.85 \, \Omega$$

A safety margin of at least 20 % should be maintained with respect to this value.

$$R_{max} = 0.8 \cdot 45.85 \, \Omega = 36.6 \, \Omega$$

When the power swing blocking function is used, this value must not be exceeded by the power swing polygon either, so the pick-up value in the R–direction must be set considerably smaller, in order to obtain adequate measuring clearance between the power swing polygon and the fault detection polygon (refer to Section 6.3.5)

In order to guarantee unequivocal criteria for discrimination between load operation and a short-circuit, in the case of long, high-loaded lines – in other words if above preconditions cannot be fulfilled – the characteristic can be set dependent on the phase angle: the R intersection RA2 (address 1625) then applies to phase angles above the value ANGLE PHIA (address 1628), the R intersection RA1 (address 1624) to phase angles below ANGLE PHIA. The safety margin from the minimum load impedance is necessary only for RA1. The angle ANGLE PHIA must be set higher than the maximum phase angle during load transport. Fundamentally, it is most important the the fault detection characteristic never exceeds the load impedance during operation.

For earth faults, a separate resistance tolerance and a separate limit angle ANG. PHIAE can be set (address 1629). Load impedance can be ignored for the phase–earth faults unless the pick-up value of the earth current detection (address 1602) could be exceeded by zero sequence currents caused by asymmetries in currents. Power swing detection operates with a phase–phase loop.

The power swing detection uses phase-to-phase quantities. Thus, setting of the R–section for phase–earth measurement are irrelevant.

1	6	2	1	■	I	p	h	>
0	.	2	0		I	/	I	n

Minimum current for impedance fault detection

Smallest setting value: $0.10 \cdot I_N$

Largest setting value: $4.00 \cdot I_N$

1 6 2 2	X + A
1 2 . 0 0	Ω

Reactance value (reach) forwards
 Smallest setting value: **0.10 Ω**
 Largest setting value: **250.00 Ω**

1 6 2 3	X - A
2 . 5 0	Ω

Reactance value (reach) reverse
 Smallest setting value: **0.10 Ω**
 Largest setting value: **250.00 Ω**

1 6 2 4	R A 1
6 . 0 0	Ω

Resistance for phase–phase; phase angle below
 ANGLE PHIA (address 1628) (load area)
 Smallest setting value: **0.10 Ω**
 Largest setting value: **250.00 Ω**

1 6 2 5	R A 2
6 . 0 0	Ω

Resistance for phase–phase; phase angle above
 ANGLE PHIA (address 1628) (fault area)
 Smallest setting value: **0.10 Ω**
 Largest setting value: **250.00 Ω**

1 6 2 6	R A 1 E
1 2 . 0 0	Ω

Resistance for phase–earth; phase angle below ANG.
 PHIAE (address 1629)
 Smallest setting value: **0.10 Ω**
 Largest setting value: **250.00 Ω**

1 6 2 7	R A 2 E
1 2 . 0 0	Ω

Resistance for phase–earth; phase angle above ANG.
 PHIAE (address 1629)
 Smallest setting value: **0.10 Ω**
 Largest setting value: **250.00 Ω**

1 6 2 8	A N G L E P H I A
4 5 . 0	°

Limit angle for phase–phase measurement, below
 which resistance intersection RA1 (address 1624) is
 valid (load area), above which resistance intersection
 RA2 (address 1625) is valid (fault area)
 Smallest setting value: **30.0°**
 Largest setting value: **80.0°**

1 6 2 9	A N G . P H I A E
4 5 . 0	°

Limit angle for phase–earth measurement, below
 which resistance intersection RA1E (address 1626) is
 valid, above which resistance intersection RA2E (ad-
 dress 1627) is valid
 Smallest setting value: **30.0°**
 Largest setting value: **80.0°**

Note: Distinction between RA1 and RA2 can be made for use on long, heavy-loaded lines. In other cases both the parameters are to be set to the same value. Distinction between RA1E and RA2E is usually not necessary.

1 6 3 0	I p h >
∞	I / I n

Overcurrent detection threshold value $I_{ph} \gg$
 Smallest setting value: **1.00 · I_N**
 Largest setting value: **20.00 · I_N**
 and ∞ (I> stage ineffective)

6.3.4.6 Settings for verification of the faulted loops – address blocks 17 and 18

The selection of valid short-circuited loops varies considerably, dependent upon whether the system star-point is earthed, isolated or compensated (Peterson coil). Accordingly, the treatment of the system star-point has to be known before the device is put into operation (see Section 6.3.3.1; address 1102).

The parameter block 17 is important for networks with solidly earthed starpoint. With unearthed star-point it is irrelevant and can be passed over.

Parameter block 18 is for isolated and compensated networks. For networks with earthed star-points it is irrelevant and can be passed over.

In **earthed networks**, an earth fault can be detected by earth current or displacement voltage (address 1701). A choice can be made whether an earth fault is detected on pick-up of the earth current detector (address 1602) or on pick-up of the displacement voltage detector (address 1701) or only if both elements have picked up. Under address 1707 can be selected $E/F\ DETECT = U_{e>} OR I_{e>}$, if one of these elements shall have picked up, $E/F\ DETECT = U_{e>} AND I_{e>}$ if both elements shall have picked up before an earth fault is stated. If only the $I_{e>}$ criterion should be valid, $E/F\ DETECT$ is set to $U_{e>} OR I_{e>}$ and the threshold for $U_{e>}$ (address 1701 is set to ∞). If the value of the high earth current stage (address 1603, refer to Section 6.3.4.3) is exceeded, an earth fault is detected regardless of the setting of address 1707.

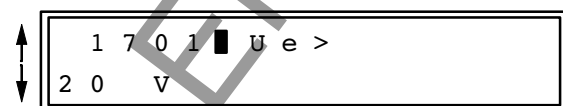
In 7SA513, all six conductor loops are continuously calculated. Thus, with multiple faults, each individual fault loop is evaluated. Nevertheless, it is possible to suppress certain loop, when multiple faults occur.

Loop verification for double phase-to-earth faults can be influenced in address 1703. Normally, *ALL* detected fault loops are evaluated. This can be changed to *PHASE – EARTH ONLY*, i.e. only the concerned phase-to-earth loops are valid. If high footing resistances are expected then *BLOCK LEADING PH* may be more favourable because the leading phase-earth loop tends to overreach. In some cases (fault resistance phase – phase larger than phase – earth) *BLOCK LAGGING PH* can be more favourable. *PHASE – PHASE ONLY* means that only the concerned phase – phase loop is evaluated; for two-phase earth faults this allows the highest accuracy but is unfavourable in case of cross-country earth faults.

Under address 1705, one can select whether, under conditions of a single-phase pick-up without earth fault detection, a conductor – earth loop is selected. The setting *1PH FAULTS = PHASE – EARTH* only makes sense in earthed networks when no current or only extremely low current can flow in the case of an earth fault. For impedance fault detection, this parameter is irrelevant because impedance fault detection always is related to a fault *loop*.



Beginning of block
"Verification of the fault loop in solidly earthed networks"



Displacement voltage ($U_e = \sqrt{3} \cdot U_0$) for earth fault detection in earthed systems.

Smallest setting value:

2 V

Largest setting value:

100 V

or ∞ (no earth fault detection based on displacement voltage measurement)

Note: Address 1110 Uph/Udelta has no influence on this pick-up value. If the displacement voltage is connected to the relay from the open delta winding of the voltage transformers, the pick-up value $U_{e>}$ is related to this voltage.

1 7 0 3	PHPHE	FLTS
BLOCK	LEADING	PH
BLOCK LAGGING PH		
ALL		
PHASE - PHASE ONLY		
PHASE - EARTH ONLY		

For double earth faults in earthed networks:
 the *LEADING PHase*–earth loop is *BLOCKed*,
 the *LAGGING PHase*–earth loop is *BLOCKed*,
ALL concerned loops are evaluated,
 the *PHASE–PHASE* loop is *ONLY* evaluated,
 the *PHASE–EARTH* loops are *ONLY* evaluated.

1 7 0 5	1PH	FAULTS
PHASE - EARTH		
PHASE - PHASE		

with fault detection in one single phase
PHASE–EARTH – fault loop phase-to-earth is selected, even without earth fault detection
PHASE–PHASE – fault loop phase-to-phase is selected

1 7 0 7	E / F	DETECT
Ue >	AND	Ie >
Ue >	OR	Ie >

The earth fault criteria $U_{e>}$ (address 1701) and $I_{e>}$ (address 1602) are
AND combined
OR combined

In **isolated or compensated networks** it must be ensured that the preference under conditions of double (cross-country) earth faults is the same throughout the whole electrically connected network (address 1803). As 7SA513 is able to process each of the fault loops separately, it is, additionally, possible to set the relay such that *ALL* concerned phase-to-earth loops are evaluated during a multiple earth fault (cross-country fault).

In order to prevent pick-up during the transient swings on inception of a single phase fault, I_E pick-up is delayed for single phase pick-up by setting Tie

1PHASE at 0.04 seconds (address 1801). In extended compensated networks this time should be increased. If it is set to ∞ no start of the distance protection takes place if only one phase picks up. If, however, a cross-country double earth fault occurs after detection of a simple earth fault, this is recognized by the relay and measured according to the selected double earth fault preference program. Single earth fault is recognized by the displacement voltage $U_{e>}$ (address 1802); delay Tie 1PHASE is not effective thereafter: a further earth fault after occurrence of a single earth fault can only be a double earth fault.

1 8 0 0	FAULT
NON - EARTHED NET	

Beginning of block
 "Determination of the fault loop in non-earthed (isolated or compensated) networks"

1 8 0 1	Tie	1PHASE
0.04	s	

Delay for I_E detection with single-phase pick-up in non-earthed systems
 Smallest setting value: **0.04 s**
 Largest setting value: **0.50 s**
 and ∞ (I_E pick-up totally suppressed)

1 8 0 2 ■ U e >
4 0 V

Displacement voltage ($U_e = \sqrt{3} \cdot U_0$) for earth fault detection in non-earthed systems. *Note:* Address 1110 has no influence on this pick-up value

Smallest setting value:

10 V

Largest setting value:

100 V

1 8 0 3 ■ P H A S E P R E F
L 3 (L 1) A C Y C L I C
L 1 (L 3) A C Y C L I C
L 2 (L 1) A C Y C L I C
L 1 (L 2) A C Y C L I C
L 3 (L 2) A C Y C L I C
L 2 (L 3) A C Y C L I C
L 3 (L 1) C Y C L I C
L 1 (L 3) C Y C L I C
A L L

Phase preference for double (cross-country) earth faults. For isolated or compensated networks the preference sequence **must** be the same throughout the whole electrically interconnected network unless **ALL** is selected

When **ALL** is selected, no phase is preferred, but all loops are evaluated in case of multiple earth fault

6.3.5 Settings for the power swing supplement – address block 20

The power swing supplement only operates if it is configured (address 7820 POWER-SWING = *EXIST*, refer Section 5.4.2) and if the impedance fault detection is selected.

Four possible programs can be selected for the power swing blocking function (address 2002). In addition, a tripping function in the case of unstable power swings (asynchronism) can be switched effective (address 2006).

↑

↓

2000

POWER SWING

Beginning of block
"Power swing detection"

↑

↓

2002

P / S P R O G R .

B L O C K A L L

B L O C K Z 1 O N L Y

B L O C K A L L B U T Z 1

B L O C K Z 1 - Z 2

Functional program of the power swing supplement:

- blocking of the first zone only
- blocking of the higher (delayed) zones only, Z1 is released
- blocking of the first and second zone

↑

↓

2006

P / S T R I P

N O

Y E S

Out-of-step tripping:
NO is not effective
YES is effective

6.3.6 Settings for teleprotection – address blocks 21 and 22

In 7SA513, one permissive underreaching transfer trip (PUTT) and one permissive overreaching transfer trip (POTT) scheme can be used simultaneously. They are logically independent from each other and can operate via different carrier links. A pre-requisite is that it is configured (address 7821 PUTT = *EXIST* and/or address 7821 POTT = *EXIST*, refer to Section 5.4.2).

If only one of the transfer schemes shall be used the other must be switched *OFF* in address 2101 or 2201.

The function of the various procedures is described in Section 4.4.

6.3.6.1 Underreach transfer schemes – address block 21

For the underreach transfer schemes, the transmission signal prolongation T-SEND-PRL (address 2103) shall ensure that the transmission signal safely reaches the opposite line end, even when the signal from the transmitting line end is interrupted quickly and/or when the transmission time is relatively long. Similar considerations can apply for the received signal prolongation T-REC-PROL (address 2104). Delay of the first zone Z1 does not delay the transmission signal but an own time delay T-SEND-DEL (address 2106) is available.

2100 ■ TELEPROTECT
PERM. UNDERREACH

Beginning of block
"Teleprotection, permissive underreach transfer schemes"

2101 ■ PUTT
ON
OFF

Permissive underreach transfer trip mode is

ON switched on

OFF switched off

2102 ■ PUTT MODE
Z1B ACCELERATION
FD ACCELERATION

Mode selection of permissive underreach transfer trip:

Zone acceleration Z1B with T1B

Trip with fault detection non-directional (instantaneous)

2103 ■ T-SEND-PRL
0.05 s

Prolongation of transmit signal with underreach modes

Smallest setting value:

0.01 s

Largest setting value:

32.00 s

2104 ■ T-REC-PROL
0.00 s

Prolongation of received signal with underreach modes

Smallest setting value:

0.00 s

Largest setting value:

32.00 s

2106 ■ T-SEND-DEL
0.00 s

Delay of transmission signal in permissive underreach modes (T1 is not decisive for transmission signal delay even if a delay is set)

Smallest setting value:

0.00 s

Largest setting value:

32.00 s

6.3.6.2 Overreach transfer schemes – address block 22

For the overreach transfer schemes it must be noted that the normal zones – particularly therefore also Z1 – operate independently.

For the blocking procedures *Z1B BLOCKING* and *REVERS INTERLOCK*, zone Z1B must be sufficiently delayed that the blocking signal is safely transmitted under conditions of external fault. This may be carried out by the time T1B (addresses 1405 and 1406). In *Z1B BLOCKING* procedure, the zone may be delayed by the time TBLK DELAY (address 1407) which allows a very fine time adjustment. For *PILOT WIRE COMParison* a delay of T1B is equally necessary when significant differences are present between the pick-up and drop-off times of the devices at two line ends. Additionally, a sufficient time period must remain between fault detection pick-up and trip signal in zone Z1B so that the closed wire loop can safely be interrupted (by fault detection) and re-closed (by trip in Z1B). If necessary, T1B must be delayed for this case, too.

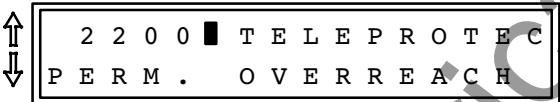
The transient blocking time T–TRANSBLO (address 2203) must be longer than the transmission time; in addition, the duration of heavy transient reactions at the inception and interruption of short circuits has to be taken into consideration.

The time T–WAIT (address 2204) is a waiting time for initiation of transient blocking: When the distance protection has detected a fault, the reception circuit (release) will be blocked if no reception signal has been received within this time; thereafter a reception signal can only be effective after the transient blocking time T–TRANSBLO (refer also to Section 4.4.11). If set to ∞, no blocking takes place for this case.

When, after pick-up, the distance protection has detected a fault in reverse direction within the waiting time TW REVERSE (address 2211), transient blocking is initiated either. The preset value is adequate in most cases.

Prolongation of the transmission signal T–SEND–PRL (address 2206) is only effective during the release procedure when the relay has already issued a tripping command. This also guarantees release of the other line end when the short circuit is rapidly cleared by the independent zone Z1.

If a delay T1B is set for the overreach zone Z1B, this does not lead to delay of the transmit signal but transmission can be delayed by the time T–SEND DEL (address 2212), for the release modes.



Beginning of block "Teleprotection, permissive overreach transfer schemes"



Permissive overreach transfer trip mode is

ON switched on

OFF switched off

2 2 0 2	P O T T M O D E
Z 1 B	R E L E A S E
F D	D I R E C R E L E A S E
Z 1 B	U N B L O C K
F D	U N B L O C K
Z 1 B	B L O C K I N G
P I L O T	W I R E C O M P .
R E V E R S	I N T E R L O C K

Mode selection of permissive overreach transfer trip:

- Z1B RELEASE** – permissive overreach with zone Z1B, release mode
- FD DIREC RELEASE** – directional comparison, release fault detection
- Z1B UNBLOCK** – Unblocking mode with zone Z1B
- FD UNBLOCK** – Unblocking mode with fault detection directional
- Z1B BLOCKING** – Blocking mode with zone Z1B
- PILOT WIRE COMP.** – Comparison Z1B via pilot wires
- REVERS INTERLOCK** – Reverse interlocking

2 2 0 3	T - T R A N S B L
0 0 . 0 5	s

Transient blocking time (after external fault)

- Smallest setting value: **0.01 s**
- Largest setting value: **32.00 s**

2 2 0 4	T - W A I T
∞	s

Waiting time before transient blocking with missing reception signal

- Smallest setting value: **0.01 s**
- Largest setting value: **32.00 s**
- or ∞, i.e. no transient blocking with missing reception

2 2 0 6	T - S E N D - P R L
0 . 0 5	s

Prolongation of the transmission signal; effective only with **Z1B BLOCKING** after detected reverse fault, or with the release modes after a trip signal has been issued

- Smallest setting value **0.01 s**
- Largest setting value **32.00 s**

2 2 1 0	P O T T D i r F D
F O R W A R D S	
R E V E R S E	
N O N - D I R E C T I O N A L	

Effective direction for directional POTT modes (**FD DIREC RELEASE** and **FD UNBLOCK**) (not relevant for the other POTT modes)

- FORWARDS** Normal application
- REVERSE** } for special application only
- NON-DIRECTIONAL**

2 2 1 1	T W R E V E R S E
0 . 0 4	s

Waiting time before transient blocking with detected reverse fault

- Smallest setting value: **0.01 s**
- Largest setting value: **32.00 s**

2 2 1 2	T - S E N D D E L
0 . 0 0	s

Delay of transmission signal in permissive overreach modes (T1B is not decisive for transmission signal delay even if a delay is set)

- Smallest setting value: **0.00 s**
- Largest setting value: **32.00 s**

For line ends with **weak** power **infeed** the echo function is reasonable when using overreach transfer schemes with release (permission) signals, so that the strong feeding line end can be released even when the weak infeed end does not pick up. For other transfer schemes the echo function is not effective; respective parameters are of no concern, then.

The echo delay time T–ECHO–DEL (address 2221) must be set to such a long duration that differing reaction times of the fault detectors of the protective relays at both line ends cannot result in a false echo signal in the case of external faults.

The echo impulse duration T–ECHO–IMP (address 2222) can be adjusted in accordance with the requirements of the network. It has to be long enough so that even with differing operating times of the protective devices at both line ends and of the transmission devices, recognition of the receive signal is guaranteed.

To avoid false echo signals after disconnection of the line, a blocking time for echo generation T–ECHO–BLO (address 2223) is set. This should include the echo delay time T–ECHO–DEL plus the echo impulse duration T–ECHO–IMP plus a safety margin of at least twice the transmission time.

2 2 2 0

E C H O

ON

OFF

The echo function for weak-infeed line ends is

ON switched on

OFF switched off

2 2 2 1

T - E C H O - D E L

0 . 0 4 s

Echo delay time
Smallest setting value: 0.01 s
Largest setting value: 32.00 s
and ∞ (no echo signal when circuit breaker is closed)

2 2 2 2

T - E C H O - I M P

0 . 0 5 s

Duration of echo impulse
Smallest setting value: 0.02 s
Largest setting value: 32.00 s

2 2 2 3

T - E C H O - B L O

0 . 1 5 s

Echo blocking time
Smallest setting value: 0.01 s
Largest setting value: 32.00 s

6.3.7 Settings for user definable logic functions – address block 23

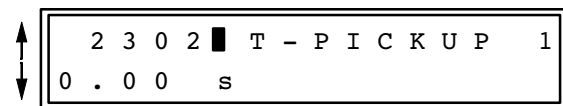
Two user definable logical functions are available. They can operate if they are configured as EXIST under address 7823 during configuration of the scope of functions (refer to Section 5.4.2). Each function can be triggered by binary inputs and marshalled to binary outputs (LEDs, signal relays, trip relays). For

pick-up and drop-off, delay times can be set in address block 23.

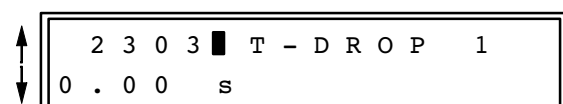
Note that the set times are pure delay times which do not include the inherent operating times of the binary inputs and outputs.



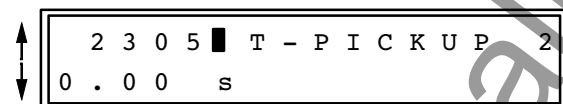
Beginning of block
"User definable logical functions"



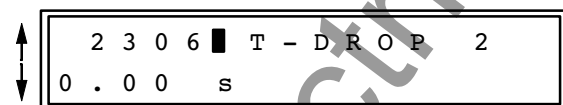
Pick-up time delay for the first user definable logical function
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ , i.e. no start



Drop-off time delay for the first user definable logical function
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ , i.e. drop-off only by reset signal



Pick-up time delay for the second user definable logical function
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ , i.e. no start



Drop-off time delay for the second user definable logical function
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ , i.e. drop-off only by reset signal

6.3.8 Settings for high current switch-onto-fault protection – address block 24

The high current switch-onto-fault protection can operate only when it has been configured 7824 SWITCH-ON = *EXIST* (refer Section 5.4.2).

The high current trip function has the task to disconnect the line instantaneously if it is switched onto a dead fault. For this, the relay must be informed about the closing instant. The integrated line energization recognition (refer Section 4.17) can process the position of the circuit breaker auxiliary contacts as well as the measured quantities. The related parameters have already been entered in Section 6.3.3.4.

The high current switch-onto-fault protection can operate optionally during each closing of the circuit breaker or only during manual closing (address 2402).

The short-circuit current threshold which should lead to pick-up of the high current protection is set as *I*_{sc} under address 2404. This value must be high enough that this protection does not pick-up at all during overload of the line or other high current situation – e.g. during an auto-reclose cycle on a parallel line. At least 2.5 times the rated current of the line is recommended.

2

4

0

0

■

S

W

I

T

C

H

O

N

T

O

-

F

A

U

L

T

P

R

O

T

.

Beginning of the blocks "High current switch-onto-fault protection"

2

4

0

1

■

S

W

I

T

C

H

-

O

-

F

O

N

O

F

F

Activation of the high current switch-onto-fault protection

ON switched on

OFF switched off

2

4

0

2

■

S

-

O

-

F

R

E

L

O

N

L

Y

M

/

C

A

L

W

A

Y

S

The high current switch-onto-fault protection shall be released

ONLY during Manual Closing or

ALWAYS, i.e. during each closing operation

2

4

0

4

■

I

s

c

2

.

5

0

I

/

I

n

Pick-up current of the high-current switch-onto-fault protection

Smallest setting: **1.00** *I*_N

Largest setting: **25.00** *I*_N

6.3.9 Settings for weak-infeed trip – address block 25

The weak-infeed trip function can operate only when it has been configured 7825 WEAK INFEED = *EXIST* (refer Section 5.4.2).

As the weak-infeed trip function can operate only in conjunction with a teleprotection scheme it is only meaningful if the distance protection works together with teleprotection (refer Section 6.3.6). The carrier reception signal is inherent part of the trip conditions of this function. Thus, the weak-infeed trip function **must not be used with a teleprotection blocking method**. It must be used only with permissive underreach transfer trip methods or permissive overreach transfer methods using a release signal. Otherwise it must be configured as *NON-EXIST* under address 7825. All parameters of address block 25 are then irrelevant.

The undervoltage pick-up value $U_{ph-e} <$ (address

2502) must be set below the minimum expected voltage phase-to-earth under operational conditions. The lowest value is determined by the maximum expected voltage drop between the point of installation of the relay and the fault location during a fault on the protected line if the distance protection may no more operate.

The stabilizing delay time $T-DELAY$ (address 2505) must be such that a longer reaction time of the distance protection cannot result in a false trip release. The setting value should be the same as for $T-ECHO-DELAY$ in address 2221 (refer Section 6.3.6.2) since the setting criteria are the same.

Similar consideration apply for the release signal prolongation time $T-PROLONG$ (address 2506). Ensure that the reception signal reliably leads to the weak-infeed trip.

↑	2 5 0 0	WEAK
↓	INFEED	PROT.

Beginning of the block "Weak-infeed trip function"

↑	2 5 0 1	WEAK INFEED
↓	ON	
	OFF	

Activation of the weak-infeed trip function

ON switched on

OFF switched off

↑	2 5 0 2	$U_{ph-e} <$
↓	2 5	V

Undervoltage pick-up $U_{ph-e} <$

Smallest setting value:

2 V

Largest setting value:

70 V

↑	2 5 0 5	T - DELAY
↓	0 . 0 4	s

Trip release delay after reception of the signal from the remote line end

Smallest setting value:

0.01 s

Largest setting value:

32.00 s

↑	2 5 0 6	T - PROLONG
↓	0 . 0 2	s

Prolongation of the trip release after the reception signal has disappeared

Smallest setting value:

0.01 s

Largest setting value:

32.00 s

6.3.10 Settings for emergency overcurrent time protection – address block 26

If the measured voltage fails, e.g. because the v.t. protection m.c.b. has tripped, the relay can still be operated as a definite time or inverse time overcurrent protection (emergency overcurrent function). A pre-condition is that the emergency protection has been configured under address 7826 as EMERG. O / C = *EXIST*.

The parameters of the emergency overcurrent time protection are set in block 26. Different stages are available for phase currents and earth current. Additionally, phase overcurrent and earth overcurrent time stages can be switched individually *ON* or *OFF* (addresses 2601 and 2631).

During emergency operation teleprotection communication is not possible for distance protection.

6.3.10.1 Phase fault overcurrent time protection

At first, the high-set overcurrent stage $I > >$ is set under addresses 2602 and 2603. This stage is always a definite time stage, independent on which characteristic is set for the overcurrent stage.

The emergency overcurrent stage can be used as definite time overcurrent protection or inverse time

overcurrent protection. This function mode can be selected in address 2611. For inverse time, a choice can be made between three tripping time characteristics defined in IEC 60255–3.

The pick-up value $I >$ (address 2612 for definite time) or I_p (address 2614 for inverse time) must be set above the maximum expected (over)load current (approximately 1.2 times).

Together with the high-current stage $I > >$, a two-stage overcurrent time protection is achieved. The corresponding delay times $T-I > >$ (address 2603) and $T-I >$ (address 2613 for definite time) or $T-I_p$ (address 2615 for inverse time) are set in such a way that they allow the highest possible degree of selectivity. In a ring network, for example, one can set up a deliberate break point, with rapid interruption, to allow for emergency cases (e.g. fault in the v.t. secondary circuit). The resultant radial networks can be protected in accordance with the conventional practice of grading of overcurrent time protection.

It must be noted that the set times for the $I > >$ and the definite time stages are pure delay time which do not include the inherent operation time of the protection functions.

If a stage is not required the related time is set at ∞ ; this does not avoid pick-up annunciations.



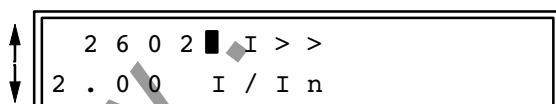
Beginning of block
"Emergency overcurrent time protection"



Emergency overcurrent time protection for phase currents is

ON switched on

OFF switched off



High-current pick-up threshold $I > >$ for phase currents

Smallest setting value: $0.10 \cdot I_N$
Largest setting value: $9.99 \cdot I_N^{1)}$
Largest setting value: $15.00 \cdot I_N^{2)}$

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

2	6	0	3	■	T - I > >
0	.	3	0	s	

Time delay for the high-current stage $I > >$ for phase currents

Smallest setting value: **0.00 s**

Largest setting value: **32.00 s**
and ∞ (no trip with $I > >$ phases)

2	6	1	1	■	C H A R A C T . P H
D	E	F	I	N	I T E T I M E
N	O	R	M	A	L I N V E R S E
V	E	R	Y	I	N V E R S E
E	X	T	R	E	M E L Y I N V E R S

Characteristic of the overcurrent stage for phase currents

DEFINITE TIME characteristic

NORMAL INVERSE time (type A acc. IEC 60255–3)

VERY INVERSE time (type B acc. IEC 60255–3)

EXTREMELY INVERSE time (type C acc. IEC 60255–3)

2	6	1	2	■	I >
1	.	0	0	I / I _N	

Only for definite time protection:

Pick-up threshold $I >$ for phase currents

Smallest setting value: **0.10** · I_N ¹⁾

Largest setting value: **4.00** · I_N ¹⁾

Largest setting value: **15.00** · I_N ²⁾

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

2	6	1	3	■	T - I >
0	.	5	0	s	

Delay time for $I >$ stage for phase currents

Smallest setting value: **0.00 s**

Largest setting value: **32.00 s**

and ∞ (no trip with $I >$ phases)

When setting the emergency function to **inverse time** overcurrent protection, it must be considered that, according to IEC 60255–3, the protection picks up only when at more than 1.05 (typically 1.07) times the set value is exceeded.

The time setting corresponds to 10 times the usual time multiplier TM, e.g.

$T_p = 10 \text{ s}$ means $TM = 1$,
thus for normal inverse

$t_{\text{trip}} = 10 \text{ s}$ tripping time at 2 times set value I_p

With the definite time characteristic the fundamental waves of the measured currents are evaluated for pick-up. When one of the **inverse time** characteristics is selected, a choice can be made whether the fundamental waves of the measured currents *WITHOUT HARMONICS* are formed for evaluation, or if the true r.m.s. values *WITH HARMONICS* are calculated. As the relay is used as short-circuit protection, the preset value is recommended. If the time grading is to be coordinated with conventional relays which operate with true r.m.s. values, then *WITH HARMONICS* may be advantageous.

2	6	1	4	■	I _p
0	.	2	0	I / I _N	

Only for inverse time protection:

Pick-up threshold I_p for phase currents

Smallest setting value: **0.10** · I_N

Largest setting value: **4.00** · I_N

2	6	1	5	■	T - I p
0	.	5	0	s	

Time multiplier for phase currents
 Smallest setting value: **0.05 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip with I_p phases)

2	6	1	6	■	M E A . F O R M . P								
W	I	T	H	O	U	T	H	A	R	M	O	N	.
W	I	T	H	H	A	R	M	O	N	I	C	S	

Only for inverse time protection:

The fundamental waves of the measured currents are evaluated by a Fourier filter

The true r.m.s. values of the measured currents are evaluated (only for inverse time characteristics)

Address 2621 determines which stage is effective if the circuit breaker is manually closed. A pre-requisite is, that the manual close command for the breaker is repeated via a binary input to the relay so that it is informed about manual closing of the breaker. *INEFFECTIVE* means that the stages operate according to the settings in addresses 2602 to 2615.

It is also possible to carry out auto-reclosure in the emergency overcurrent protection mode. This has to be entered into the device during configuration

under address 7926 (refer Section 5.4.3). In this case, the $I >$ stage is of interest because of its independent trip time: If reclosure is expected the protection will trip with the undelayed $I >$ stage, final disconnection is carried out via $I >$ or I_p with $T I >$ or T_p delayed. $I >$ and $I >$ should then be set to the same value.

Address 2623 determines whether the $I >$ stage is effective only in conjunction with auto-reclosure or whether it operates independently.

2	6	2	1	■	M / C L O S E P H								
I	>	>	U	N	D	E	L	A	Y	E	D		
I	>	/	I	p	U	N	D	E	L	A	Y	E	D
I	N	E	F	F	E	C	T	I	V	E			

Overcurrent stage which is effective during manual closing of the circuit breaker:

$I >$ i.e. $I >$ stage but without delay $T I >$

$I >/I_p$ i.e. $I >$ stage (definite time) or I_p stage (inverse time) but without delay

INEFFECTIVE, i.e. stages operate as parameterized

2	6	2	3	■	R A R Z O N E P			
I	>	>	W	I	T	H	A	R
I	>	>	A	L	W	A	Y	S

AR function (if configured) operates with the $I >$ stage:

$I >$ WITH AR i.e. $I >$ is released only if AR is ready

$I >$ ALWAYS i.e. $I >$ stage operates always, independent of the AR function

6.3.10.2 Earth fault overcurrent time protection

For earth faults, all parameters of the emergency overcurrent time protection can be set separately and independently. This allows separate time grading for earth faults with e.g. shorter times.

The setting possibilities are the same as for phase currents.

If an earth fault is detected by one phase current element as well as by the earth current element, trip command can be given single-pole according to the

faulty phase but with the (shorter) time for earth faults. This allows single-pole auto-reclosure also with the emergency overcurrent time protection.

If a separate overcurrent time protection for earth faults is not required, the earth current stages can be switched off independent on the phase current stages in address 2631

If part functions are not required, then the corresponding delay times can be set at ∞ . This does not avoid the pick-up annunciation.

2 6 3 1 ■ E M E R . O / C E
O N
O F F

Emergency overcurrent time protection for earth currents is

ON switched on

OFF switched off

2 6 3 2 ■ I E > >
0 . 5 0 I / I n

High-current pick-up threshold $I_{>>}$ for earth currents

Smallest setting value: **0.10** · I_N

Largest setting value: **4.00** · I_N

2 6 3 3 ■ T - I E > >
0 . 3 0 s

Time delay for the stage $I_{>>}$ for earth currents

Smallest setting value: **0.00** s

Largest setting value: **32.00** s
and ∞ (no trip with $I_{>>}$ earth)

2 6 4 1 ■ C H A R A C T . E
D E F I N I T E T I M E
N O R M A L I N V E R S E
V E R Y I N V E R S E
E X T R E M E L Y I N V E R S E

Characteristic of the overcurrent stage for earth currents

DEFINITE TIME characteristic

NORMAL INVERSE time (type A acc. IEC 60255–3)

VERY INVERSE time (type B acc. IEC 60255–3)

EXTREMELY INVERSE (type C time acc. IEC 60255–3)

2 6 4 2 ■ I E >
0 . 2 0 I / I n

Only for definite time protection:

Pick-up threshold $I_{E>}$ for earth currents

Smallest setting value: **0.10** · I_N

Largest setting value: **4.00** · I_N

2 6 4 3 ■ T - I E >
0 . 3 0 s

Delay time for $I_{E>}$ stage for earth currents

Smallest setting value: **0.00** s

Largest setting value: **32.00** s
and ∞ (no trip with $I_{E>}$ earth)

2 6 4 4 ■ I E p
0 . 3 0 I / I n

Only for inverse time protection:Pick-up threshold I_{Ep} for earth currentsSmallest setting value: **0.10** · I_N Largest setting value: **4.00** · I_N

2 6 4 5 ■ T - I E p
0 . 5 0 s

Time multiplier for earth currents

Smallest setting value: **0.05** sLargest setting value: **32.00** sand ∞ (no trip with I_{Ep} earth)

2 6 4 6 ■ M E A . F O R M . E
W I T H O U T H A R M O N .
W I T H H A R M O N I C S

Only for inverse time protection:

The fundamental wave of the measured current is evaluated by a Fourier filter

The true r.m.s. value of the measured current is evaluated (only for inverse time characteristics)

2 6 5 1 ■ M / C L O S E E
I E > > U N D E L A Y E D
I E > / I E p U N D E L A Y .
I N E F F E C T I V E

Overcurrent stage which is effective during manual closing of the circuit breaker:

 $I_{E>>}$ i.e. $I_{E>>}$ stage but without delay $I_{E>}/I_{Ep}$ i.e. $I_{E>}$ stage (definite time) or I_{Ep} stage (inverse time) but without delay**INEFFECTIVE**, i.e. stages operate as parameterized

2 6 5 3 ■ R A R Z O N E E
I E > > W I T H A R
I E > > A L W A Y S

AR function (if configured) operates with the $I_{E>>}$ stage: $I_{E>>}$ **WITH AR** i.e. $I_{E>>}$ is released only if AR is ready $I_{E>>}$ **ALWAYS** i.e. $I_{E>>}$ stage operates always, independent of the AR function**6.3.11 Settings for measured value monitoring – address block 29**

The different monitoring functions of the protective relay are described in Section 4.18.4. They partly monitor the relay itself, partly the steady-state measured values of the transformer circuits.

The sensitivity of the measured value monitoring can be changed in address block 29. The factory settings are sufficient in most cases. If particularly high operational asymmetries of the currents and/or volt-

ages are expected, or if, during operation, one or more monitoring functions react sporadically, then sensitivity should be reduced.

NOTE: Prerequisite for correct function of the measured value monitors is the proper setting of the general power system data (Section 6.3.3.1), especially the parameters concerning earth current, voltage connections and the matching factors.

↑ ↓ 2 9 0 0 ■ M E A S . V A L U E
S U P E R V I S I O N

Beginning of block
"Measured value supervision"

↑ ↓ 2 9 0 1 ■ S Y M . U t h r e s
5 0 V

Voltage threshold (phase-phase) above which the symmetry monitoring is effective (refer Figure 4.68)
Smallest setting value: **10 V**
Largest setting value: **100 V**

↑ ↓ 2 9 0 2 ■ S Y M . F a c t . U
0 . 7 5

Symmetry factor for the voltage symmetry = slope of the symmetry characteristic (refer Figure 4.68)
Smallest setting value: **0.58**
Largest setting value: **0.95**

↑ ↓ 2 9 0 3 ■ S Y M . I t h r e s
0 . 5 0 I / I_N

Current threshold above which the symmetry monitoring is effective (refer Figure 4.67)
Smallest setting value: **0.10 · I_N**
Largest setting value: **1.00 · I_N**

↑ ↓ 2 9 0 4 ■ S Y M . F a c t . I
0 . 5 0

Symmetry factor for the current symmetry = slope of the symmetry characteristic (see Figure 4.67)
Smallest setting value: **0.10**
Largest setting value: **0.95**

↑ ↓ 2 9 0 5 ■ S U M . I t h r e s
0 . 1 0 I / I_N

Current threshold above which the summation monitoring (refer Figure 4.66) reacts (absolute content, related to I_N only)
Smallest setting value: **0.05 · I_N**
Largest setting value: **2.00 · I_N**

↑ ↓ 2 9 0 6 ■ S U M . F a c t . I
0 . 1 0

Relative content (related to the maximum conductor current) for operation of the current summation monitoring (refer Figure 4.66)
Smallest setting value: **0.00**
Largest setting value: **0.95**

↑ ↓ 2 9 0 7 ■ U M E A S U <
6 0 V

Voltage threshold (phase-to-phase), below which the voltage failure monitor operates
Smallest setting value: **10 V**
Largest setting value: **125 V**

↑ ↓ 2 9 0 8 ■ U M E A S I >
0 . 0 6 I / I_N

Minimum current to detect a voltage failure
Smallest setting value: **0.06 · I_N**
Largest setting value: **1.00 · I_N**

The setting values of the fuse failure monitor (addresses 2911 and 2912) have to be chosen so that it picks up reliably in the case of single phase voltage failure (criterion $3 \times U_0$), but on the other hand does not pick up in the case of earth faults in an earthed network. I_E must therefore be set at a correspondingly sensitive level (below the smallest fault current in the case of earth faults). **The function "Fuse fail-**

ure monitor" must not be chosen for lines in earthed networks, in which earth faults with small or zero earth currents can occur, for example, when feeder transformers may not be earthed. In non-earthed networks, this fuse failure monitor is not meaningful and will be ignored by the 7SA513. The fuse failure monitor can be switched off under address 2910.

2910	FUSE - FAIL
ON	
OFF	

Fuse failure monitor is

ON switched on

OFF switched off

2911	FFM	3 * U ₀ >
30	V	

Displacement voltage $3 \cdot U_0$, above which fuse failure should be detected

Smallest setting value: **10 V**

Largest setting value: **100 V**

2912	FFM	I _e <
0.10	I / I _N	

Earth current, above which no fuse failure is assumed

Smallest setting value: **$0.10 \cdot I_N$**

Largest setting value: **$1.00 \cdot I_N$**

The following is valid for firmware version **V3.3** or higher:

If a miniature circuit breaker for voltage transformers (VT mcb) is installed in the secondary circuit of the voltage transformers, the status is sent, via binary input, to the device informing it about the position of the VT mcb. If a short-circuit in the secondary side initiates the tripping of the VT mcb, the distance

protection function has to be blocked immediately. Otherwise a trip by the distance protection due to the lack of measured voltage while load current is possible. The blocking must be faster than the first stage of the distance protection. This requires an extremely short reaction time for the VT mcb (≤ 4 ms for 50 Hz, ≤ 3 ms for 60 Hz nominal frequency). If this cannot be ensured, the reaction time of the mcb is to be set under address 2921 T VT-mcb.

2921	T VT - mcb
0	ms

Reaction time of the VT secondary mcb ²⁾

Smallest setting value: **0 ms**

Largest setting value: **30 ms**

²⁾ from firmware version V3.3 or higher

6.3.12 Settings for high-resistance earth fault protection – address blocks 31 and 32

NOTE: This section is valid only for models with earth fault protection (7SA513★-★★★-★★★1). Otherwise it can be passed over. Earth fault protection is effective only if configured as *EXIST* under address 7831 (refer to Section 5.4.2).

The following possibilities are available for the detection of high-resistance earth faults:

- directional earth fault overcurrent time protection, optionally definite time or inverse time delayed, with non-directional back-up stage,
- directional zero sequence voltage time protection with zero sequence voltage dependent tripping time and non-directional back-up stage,
- directional comparison earth fault protection with non-directional definite time or inverse time overcurrent back-up stage,
- instantaneous trip possible in case of auto-reclosure and manual switching onto a dead fault,

- phase selection allows single-pole auto-reclosure with all above operation modes.

During configuration of the protection functions (see Section 5.4.2, address 7831), the operation mode has been selected. Dependent on this selection only those parameters are available which relate to the selected mode.

6.3.12.1 Directional earth fault protection with non-directional emergency and back-up stage – address block 31

Selection of the overcurrent time characteristic of this function is made under address 3102. It may be definite time or one of three inverse time characteristics stated in IEC 60255–3: normal inverse or very inverse or extremely inverse. The formulae and characteristics are shown in the technical Data (refer to Figure 3.2, Section 3.9).

3 1 0 0 ■ E A R T H F A U L T
P R O T E C T I O N

Beginning of block
"Earth fault protection"

3 1 0 1 ■ E / F P R O T E C
O N
O F F

High-resistance earth fault protection (complete) is

ON switched on

OFF switched off

3 1 0 2 ■ E / F C H A R A C
D E F I N I T E T I M E
N O R M A L I N V E R S E
V E R Y I N V E R S E
E X T R E M E L Y I N V E R S
U 0 I N V E R S E

Characteristic of the earth fault protection, can be

DEFINITE TIME lag

NORMAL INVERSE time lag acc. IEC 60255–3 (type A)

VERY INVERSE time lag acc. IEC 60255–3 (type B)

EXTREMELY INVERSE time lag acc. IEC 60255–3 (type C)

Zero sequence voltage time protection with *INVERSE* time voltage characteristic

The pick-up value $I_{E>} / I_{Ep}$ (address 3103) should be set somewhat below the minimum expected earth fault current when the *DEFINITE TIME* mode or the *U0 INVERSE* mode is chosen. When using one of the *INVERSE* time modes it must be considered that, according to IEC 60255-3, the protection picks up only when approx 1.07 (> 1.05) times the set value is exceeded and the characteristics are defined only from 2 times the setting value onwards. In any event, 7SA513 already trips for currents above approximately 1.1 times the setting value in accordance with the formulae valid for the characteristics (Figure 3.2, Section 3.9).

The set value of the earth voltage $U_{e>}$ (address 3104) shall not be exceeded by operational asymmetry of the voltages. U_e means the voltage at the input to the device, with open delta VT; if this input is not used, the relay calculates

$$U_e = \sqrt{3} \cdot U_0 = (U_{L1} + U_{L2} + U_{L3}) / \sqrt{3}.$$

The directional dependent tripping time *T-DIRECT* (address 3106) is independent on directional comparison and received signal. The direction set under address 3107 is decisive for the directional stage. Normally, the line direction is set as *FORWARDS* direction.

With definite or inverse time overcurrent protection, the non-directional back-up stage *T-NON-DIR* (address 3108) also operates when no directional determination is possible because the measured voltage is too small, or if the voltage transformer protective m.c.b. has tripped out. It thus also performs the emergency function for earth fault protection as well as a back-up stage.

When setting the delay times it should be noted:

All set times for definite time stages are pure delay times which do not include the inherent operating times of the protection functions.

In the *inverse time* modes the time setting value corresponds to 10 times the usual time factor of the tripping time formula, e.g.

T-DIRECT = 10 s means $T_M = 1$, thus for normal inverse $t_{trip} = 10s$ tripping time at 2 times the set value

In *U0 INVERSE* mode the set times are additional to the delay according to the inverse time characteristic as shown in the Technical data (Section 3.9, Figure 3.3). The set times are additional definite delays.

3 1 0 3 ■ $I_{E>} / I_{Ep}$
0 . 2 0 I / I_N

Pick-up value for earth current detection
(0,75 x $I_{e>}$ for transmit signal)

Smallest setting value:

0.05 I/I_N

Largest setting value:

4.00 I/I_N

3 1 0 4 ■ $U_{e>}$
5 . 0 V

Minimum voltage for directional discrimination

Smallest setting value:

1.0 V

Largest setting value:

10.0 V

3 1 0 6 ■ *T-DIRECT* .
0 . 9 0 s

Delay time for directional trip

Smallest setting value:

0.00 s

Largest setting value:

32.00 s

and ∞ (no directional trip)

3 1 0 7 ■ *DIRECTION*
FORWARDS

Direction for directional stage;

can be set to trip

FORWARDS

in line direction

REVERSE

REVERSE

in busbar direction

NON-DIRECTIONAL

NON-DIRECTIONAL

in either direction

3 1 0 8	T - N O N - D I R .
1 . 2 0	s

Delay time for non-directional back-up stage
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no non-directional trip)

Directional discrimination is made by the measured quantity I_E . Polarizing quantity is the displacement voltage U_E . Alternatively or, additionally, measurement can be polarized by a current I_Y which can be derived from the star-point current of an earthed feeder transformer. This star-point current must be fed to one of the additional current inputs of the

relay; and the device must be informed about this connection under address 1111 or 1114 (see Section 6.3.3.1). Address 3111 determines whether directional determination is polarized *WITH U_E AND I_Y* or *ONLY WITH I_Y* . If I_Y is not connected and U_E should be the only polarizing quantity, leave setting in position *WITH U_E AND I_Y* .

3 1 1 1	D I R E C T I O N
W I T H	U_e A N D I_Y
O N L Y	W I T H I_Y

Measured quantity I_E is polarized
WITH U_E AND I_Y i.e. with displacement voltage and star-point current of a feeder transformer; I_Y is only valid if connected
ONLY WITH I_Y i.e. with the star-point current of a feeder transformer only; U_E is not valid even if connected

The tripping characteristic of the zero sequence voltage dependent inverse time protection can be shifted in U_0 -direction (U_{0min} in the trip time formula,

refer to Section 3.9, Figure 3.3). Address 3112 determines the voltage at which the tripping time reverts to infinity.

3 1 1 2	$U_0 >$ I N V .
0 . 2	V

Minimum voltage for U_0 , for $T \rightarrow \infty$
 Smallest setting value: **0.1 V**
 Largest setting value: **5.0 V**

Address 3113 determines whether instantaneous trip is effected when auto-reclosure (RAR) will be carried out. Normally, this parameter is left in *ON* position so that rapid fault clearance occurs when the RAR function is ready to reclose. Nevertheless, this RAR stage can be delayed (address 3115) should transient inrush currents be expected which could lead to premature trip. If the RAR function is not ready to reclose then delayed trip occurs according to the grading plan, i.e. according to the delay times

as set under addresses 3106 or 3108.

Address 3114 determines which stage is effective if the circuit breaker is manually closed. A pre-requisite is, that the manual close command for the breaker is repeated via a binary input to the relay so that it is informed about manual closing of the breaker. *INEFFECTIVE* means that the stages operate according to the settings in addresses 3106 or 3108.

3 1 1 3	R A R Z O N E
O N	
O F F	

Rapid fault clearance before RAR with the stage according to address 3115
ON RAR stage effective
OFF RAR stage not effective

3 1 1 4 ■ M A N . C L O S E

O F F

F / D U N D E L A Y E D

F / D D I R E C T I O N A L

Measures to be taken in case of manual close of the circuit breaker

OFF no special measures

Fault Detection (non-directional) UNDELAYED trip

Fault Detection DIRECTIONal trip after T DIR. RAR (address 3115)

3 1 1 5 ■ T D I R . R A R

0 . 0 0 s

Rapid fault clearance before RAR or after manual closing can be delayed

Smallest setting value: 0.00 s

Largest setting value: 32.00 s or ∞

The earth fault protection can be blocked when the distance protection has picked up in order to allow selective fault clearing by the distance protection when it has detected the fault (address 3117). The earth fault protection should be blocked during a single-pole auto-reclose cycle in order to prevent from measuring with the simulated zero sequence

voltage and current which occur during a single-pole open condition (address 3118).

Finally, it can be determined in address 3125 whether the earth fault protection is allowed to trip single-pole when the phase selector has detected a single-phase fault.

3 1 1 7 ■ D I S B L E / F

Y E S

N O

The earth fault protection is blocked in case of fault detection by the distance protection

YES or NO

3 1 1 8 ■ B L O E / F 1 p

Y E S

N O

The earth fault protection is blocked during single-pole auto-reclose cycle

YES or NO

3 1 2 5 ■ T R I P 1 P E / F

Y E S

N O

The earth fault protection is allowed to trip single-pole in case a single-phase fault is detected

YES or NO

6.3.12.2 Directional comparison earth fault protection – address block 32

If the earth fault directional protection is extended by directional comparison, the parameters are set in address block 32, in addition to those of address block 31 (Section 6.3.12.1).

The directional comparison can be switch *ON* and *OFF* under address 3201. The functions according to address block 31 (Section 6.3.12.1) operate independently. But, when the earth fault protection is switched off under address 3101 (Section 6.3.12.1) the directional comparison earth fault protection is ineffective, too.

Transmission signal and trip will be delayed by the delay time $T\text{-DELAY}$ (address 3202). This allows compensation for different reaction times of the devices at the two line ends.

The transient blocking time (address 3203) must be longer than the transmission time; in addition, the duration of heavy transient reactions at the inception and interruption of short circuits has to be taken into consideration.

The time $T\text{-WAIT}$ (address 3204) is a waiting time for initiation of transient blocking: When the earth fault protection has detected a fault, the reception circuit (release) will be blocked if no reception signal has been received within this time; thereafter a reception signal can only be effective after the transient blocking time $T\text{-TRANSBLO}$ (refer also to Section 4.9.4). If set to ∞ , no blocking takes place for this case.

When, after pick-up, the directional earth fault protection has detected a fault in reverse direction within the waiting time $TW\text{ REVERSE}$ (address 3206), transient blocking is initiated either. The preset value is adequate in most cases.

For lines with one **weak-infeed** or non-infeed end, or without sufficient earth current, the echo function is reasonable. So the strong feeding line end can be released even when the weak-infeed end does not pick up. The echo function can be set effective or not under address 3210.

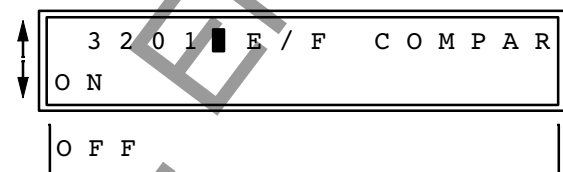
The echo delay time $T\text{-ECHO-DEL}$ (address 3211) must be set to such a long duration that differing reaction times of the fault detectors of the protective relays at both line ends cannot result in a false echo signal in the case of external faults.

The echo impulse duration $T\text{-ECHO-IMP}$ (address 3212) can be adjusted in accordance with the requirements of the transmission system. It has to be long enough so that even with differing operating times of the protective devices at both line ends and of the transmission devices, recognition of the receive signal is guaranteed.

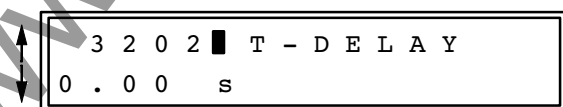
To avoid false echo signals after disconnection of the line, a blocking time for echo generation $T\text{-ECHO-BLO}$ (address 3213) is set. This should include the echo delay time $T\text{-ECHO-DEL}$ plus the echo impulse duration $T\text{-ECHO-IMP}$ plus twice the transmission time plus a safety margin.



Beginning of block
"Earth fault directional comparison"



Directional comparison for earth fault protection is
ON switched on
OFF switched off



Delay time for transmission and trip
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
or ∞ , i.e. no transmission, no trip

3 2 0 3

T - T R A N S B L O

0 . 0 5 s

Transient blocking time (after external fault)

Smallest setting value: **0.01 s**Largest setting value: **32.00 s**

3 2 0 4

T - W A I T

∞ s

Waiting time before transient blocking with missing reception signal

Smallest setting value: **0,01 s**Largest setting value: **32,00 s**or ∞ , i.e. no transient blocking with missing reception

3 2 0 6

T W R E V E R S E

0 . 0 4 s

Waiting time before transient blocking with detected reverse fault

Smallest setting value: **0.01 s**Largest setting value: **32.00 s**

3 2 1 0

E / F E C H O

ON

OFF

Echo function for directional comparison earth fault protection is

ON switched on

OFF switched off

3 2 1 1

T - E C H O - D E L

0 . 0 4 s

Echo delay time when circuit breaker closed

Smallest setting value: **0.01 s**Largest setting value: **32.00 s**and ∞ (no echo signal when circuit breaker is closed)

3 2 1 2

T - E C H O - I M P

0 . 0 5 s

Duration of echo impulse

Smallest setting value: **0.02 s**Largest setting value: **32.00 s**

3 2 1 3

T - E C H O - B L O

0 . 1 5 s

Echo blocking time

Smallest setting value: **0.01 s**Largest setting value: **32.00 s**

6.3.13 Settings for auto-reclosure – address block 34

NOTE: This section is valid only for models with integrated auto-reclose function (7SA513★–★★★★–★★G/H★). Otherwise it can be passed over. Auto-reclose function is effective only if configured as *EXIST* under address 7834 (refer to Section 5.4.2).

When no auto-reclosure is to be carried out on the feeder which is protected by the line protection relay (e.g. cables, transformers, motors, etc.), then the internal AR function must be configured as *NON-EXIST* in address 7834 (refer to Section 5.4.2). The AR function is then not effective at all, i.e. 7SA513 does not process the AR function. No corresponding announcements are given, binary inputs for auto-reclosure are ignored. All parameters in block 34 are irrelevant and unavailable. Tripping occurs three-pole with all kinds of fault.

If the relay is required to operate with an external AR device, the relevant binary inputs and outputs are to be used. Particularly, the corresponding control signals must be connected to 7SA513, e.g. release of RAR or DAR stages and single/three-pole tripping (if necessary); the fault detection and trip signal outputs of 7SA513 must be connected to the external AR device (refer to Section 4.10.9 for details). The internal AR function must be set as *NON-EXIST* (Section 5.4.2, address 7834), in this case unless it is not fitted.

With the internal AR function, generally distinction is made between the first AR-cycle, identified in the following with RAR (rapid auto-reclosure), and further AR-cycles with multi-shot auto-reclosure, identified in the following with DAR (delayed auto-reclosure). The above identifications are regardless whether the dead times are really "rapid" or "delayed". Setting address 3401 to 3419 are common for all types of auto-reclosure.

Most of the short-circuit protection functions of 7SA513 have several stages which operate independent on each other, e.g. for the distance protection stages, time delay and direction can be selected for each stage individually and independently. Therefore reclosure is normally blocked if a protection trips on a fault detected in reverse direction. Accordingly address 3402 is preset to AR BLO REV = YES.

When switching manually on a dead fault, it is normally desired that the short-circuit protection trips instantaneously, and the AR function is blocked. Thus,

address 3403 should remain in position MC BLOCK = YES.

The reclaim time T-RECLAIM (address 3405) is the time period after which the network fault is supposed to be terminated after a successful auto-reclose cycle. A renewed trip of any protection function within this time increments the AR counter (when multi-shot AR is used) so that the next AR cycle starts; if no further AR is allowed the last AR is treated as unsuccessful.

The lock-out time T-LOCK (address 3406) is the time period during which after an unsuccessful auto-reclosure further reclosures by 7SA513 are blocked. If the manual close command is led via the 7SA513 then this will be blocked also. This time must be longer than the renewed readiness for operation of the circuit breaker unless the CB is supervised in the relay (see below, address 3415). If this time is set to ∞, all breaker close commands via 7SA513 are locked. In this case switching can be unlocked only when the binary input ">AR Reset" (FNo 2704) is energized.

The set time for T-BLOCK MC (address 3407) must cover the time for safe closing and opening of the circuit breaker (0.5 s to 1 s). If any of the protection functions of 7SA513 detects a fault within this time, three-pole definitive trip command is issued and reclosure is blocked provided MC BLOCK (address 3403, see above) is switched to YES.

The duration of the closing command has already been set when setting the general parameters of the device (address 1135, Section 6.3.3.4).

A prerequisite for initiation of the AR function is that the circuit breaker is ready for at least one trip—close cycle when any short-circuit protection function trips. This information has to be given to the relay via the binary input ">CB ready" (FNo 2730). In case such information is not available from the CB circuit, interrogation of ">CB ready" can be suppressed by setting the parameter CB? 1 TRIP = NO (i.e. CB interrogation 1st trip, address 3412); otherwise reclosure would not be possible at all.

Additionally it is possible to interrogate readiness of the circuit breaker before each further reclose command or before every other reclose command. Setting is made in address 3413:

CB? CLOSE = *CB? NEVER*; interrogation is not made or only at the moment of the first trip command as parameterized under address 3412,

CB? CLOSE = *CB? WITH EACH AR*; interrogation is made before each reclose command,

CB? CLOSE = *CB? WITH 2nd AR*; interrogation is made before every other reclose command, i.e. before the 2nd, 4th, etc.; every trip–close cycle is valid regardless whether it is RAR or DAR.

In order to monitor the regeneration time of the circuit breaker a special circuit breaker supervision time $T-CB-SUPV$ can be set under address 3415. This time should be set slightly above the regeneration time of the breaker after a trip–close cycle. If the circuit breaker is not yet ready after this time, reclosure is suppressed.

Finally, address 3419 determines for which reclose cycles synchronism or voltages shall be checked by the synchro-check function. In the cases which are parameterized in this address, reclosure is blocked as long as the conditions as set for the synchro-check function (Section 6.3.14) are not fulfilled.

3 4 0 0 ■ A U T O -
R E C L O S E F U N C T I O N

Beginning of block
"Auto-reclosure functions"

3 4 0 1 ■ A R F U N C T
O N
O F F

Auto-reclose function is

ON switched on

OFF switched off

3 4 0 2 ■ A R B L O R E V
Y E S
N O

AR will be blocked when a fault in reverse direction is tripped (for all short-circuit protection functions which can operate directional)

normal setting: YES

3 4 0 3 ■ M C B L O C K
Y E S
N O

Blocking of reclosing after manual close of the circuit breaker

normal setting: YES

3 4 0 5 ■ T - R E C L A I M
3 . 0 0 s

Reclaim time after successful AR cycle

Smallest setting value: 0.50 s

Largest setting value: 320.00 s

3 4 0 6 ■ T - L O C K
3 . 0 0 s

Lock-out time after unsuccessful AR; any close command is blocked

Smallest setting value: 0.50 s

Largest setting value: 320.00 s

and ∞ (locked until ">AR Reset" via binary input)

3	4	0	7	T - B L O C K M C
1	.	0	0	s

Reclaim time after manual closing of circuit breaker
 Smallest setting value: **0.50 s**
 Largest setting value: **320.00 s**

3	4	1	2	C B ? 1 . T R I P
Y E S				
N O				

CB ready interrogation at the first trip command

YES – normal setting

NO – only if there is no possibility to interrogate CB readiness

3	4	1	3	C B ? C L O S E
C B ? N E V E R				
C B ? W I T H E A C H A R				
C B ? W I T H 2 n d A R				

CB ready interrogation before reclosing

NEVER – no CB ready interrogation before reclosing

WITH EACH AR – CB ready interrogation before each reclosing

WITH EACH 2nd AR – CB ready interrogation before 2nd, 4th, 6th, etc. reclosing (RAR or DAR)

3	4	1	5	T - C B - S U P V
3	.	0	0	s

CB supervision time within which CB must be ready

Smallest setting value: **0.01 s**

Largest setting value: **320.00 s**

3	4	1	9	S Y N - R E Q U E S T
B E F O R E 3 P O L E A R				
O N L Y B E F O R E D A R				
B E F O R E 2 n d D A R				
N E V E R				

Request for synchro-check (internal or external) is made

– before every reclose after three-pole tripping;

– only before reclose during DAR

– only before reclose during DAR from the 2nd DAR shot on

– no request for synchro-check

For RAR (first auto-reclose cycle), several programs are possible (address 3422): three-pole, single-pole, or single- and three-pole.

If the 3U₀ processing feature is used for identification of the faulty line, then address 3423 must be changed accordingly; otherwise it remains in position 3U₀ PROC = *INEFFECTIVE*. This feature is explained in detail in Section 4.10.1. It must be ensured that only one end of the line must be parameterized 3U₀ PROC = *1-POLE WITH U₀* (i.e. single-pole auto-reclosure with U₀ interrogation). The other end is set 3U₀ PROC = *1-POLE W/O U₀* (i.e. single-

pole auto-reclosure without U₀ interrogation). If only the immediate reclosure of the healthy lines should be used, both line ends can be set to 3U₀ PROC = *1-POLE W/O U₀*. Address 3427 (see below) must be observed for immediate reclosure of the unfaulted lines, too.

When setting the action time RAR T-ACT (address 3424), it must be ensured that this time is at least as long as the command time of the protective relay, including any possible signal transmission times, but smaller than the delay T₂ of the second distance zone (usually 0.2 s).

With single-pole auto-reclosure, the dead time RAR T-1POL (address 3426) must be long enough to ensure that the fault arc is extinguished and the air surrounding the arc is de-ionized, so that auto-reclosure can be successful. Because of the discharge and re-charge of the conductor capacitances, this time increases with the length of the line. Conventional values lie between 0.9 s and 1.5 s.

Address 3427 RAR T1POL2 is only relevant when the U_0 processing feature is used to discriminate the unfaulted lines during single-pole reclosure. In these cases, address 3427 determines the dead time which is valid after the line has been identified by the U_0 processing feature as the unfaulted line. It can, therefore, be very short, 0.1 s is sufficient. This immediate reclosure is independent on whether address 3423 has been set to 3U0 PROC = 1-POLE WITH U_0 or 3U0 PROC = 1-POLE W/O U_0 . Nevertheless, it must be observed that a slightly higher single-pole dead time (address 3426) must be set at the line end with U_0 interrogation (3U0 PROC = 1-POLE WITH U_0): it should be higher than the dead time of the line end without U_0 interrogation plus the circuit breaker closing time plus approximately 50 to 100 ms.

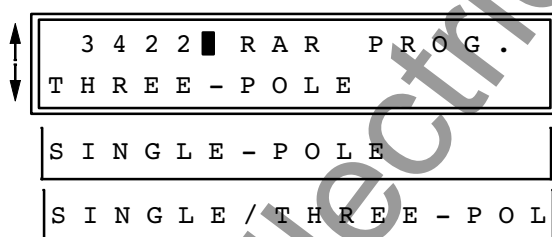
With three-pole auto-reclosure (address 3425), the stability of the network is the most important consideration. Since the disconnected line can no longer produce any synchronizing power, only a short dead time is permitted in most cases. Conventional values lie between 0.3 s and 0.6 s. If the device is equipped

with the synchro-check function, a longer time may often be tolerated.

The possibilities for the treatment of multiple and evolving faults have been described in detail in Section 4.10.7. The recognition of an evolving fault can be made dependent upon a tripping command or upon fault detection during the dead time (address 3428). The reaction to evolving faults is set in address 3429: blocking in the case of an evolving fault either occurs *ALWAYS* (i.e. with each evolving fault) or *NEVER* at all, or blocking occurs only after the fault is detected after the discrimination time $> T_{DISCRIM}$ which has to be set in address 3430. Blocking in these cases occurs even when three-pole auto-reclosure is permitted!

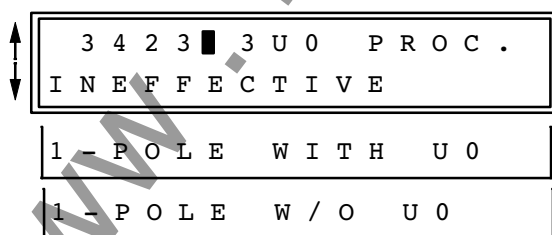
Also, for the treatment of evolving faults and for the discrimination time T-DISCRIM the stability of the network is of the utmost importance. In addition, the dynamic burden of the generators must be taken into account in the case of faults close to a power station. For the discrimination time T-DISCRIM (address 3430) it is only meaningful to choose a value which is smaller than the dead time for single-pole AR, RAR T-1POL (address 3426).

Finally, address 3431 determines whether the protection relay should issue a three-pole trip when, during the dead time of a single-pole auto-reclose cycle, reclosure is blocked (e.g. because of detection of an evolving fault).



Auto-reclose program for the first AR cycle (RAR)

- THREE-POLE** – for each type of fault three-pole auto-reclosure
- SINGLE-POLE** – single-pole AR; for multi-phase faults no reclosure takes place (AR blocked)
- SINGLE/THREE-POLE** – for single-phase faults single-pole AR; for multi-phase faults three-pole AR



Use of the $3U_0$ processing for discrimination of the faulted line:

- INEFFECTIVE** – $3U_0$ processing is ineffective
- 1-POLE WITH U_0** – $3U_0$ processing with U_0 interrogation
- 1-POLE W/O U_0** – $3U_0$ processing without U_0 interrogation

3 4 2 4 ■ R A R T - A C T .
0 . 2 0 s

Action time for RAR (first AR-shot) (if trip signal is given after this time, AR is blocked)

Smallest setting value: **0.01 s**

Largest setting value: **320.00 s**
and ∞

3 4 2 5 ■ R A R T - 3 P O L
0 . 5 0 s

Dead time for first three-pole (RAR) cycle

Smallest setting value: **0.01 s**

Largest setting value: **320.00 s**

3 4 2 6 ■ R A R T - 1 P O L
1 . 2 0 s

Dead time for first AR cycle (RAR) single-pole

Smallest setting value: **0.01 s**

Largest setting value: **320.00 s**

3 4 2 7 ■ R A R T 1 P O L 2
0 . 5 0 s

Dead time for first AR cycle (RAR) single-pole, when the line has been identified as unfaulted by the U₀ processing feature

Smallest setting value: **0.01 s**

Largest setting value: **320.00 s**

3 4 2 8 ■ E V . F . R E C O G
W I T H F A U L T D E T E C

Recognition of evolving faults (only with single-pole AR)

WITH FAULT DETECTION – each fault detection during single-pole dead time is recognized as an evolving fault

W I T H T R I P C O M M .

WITH TRIP COMMAND – faults during single-pole dead time are recognized as evolving faults only when the relay trips

3 4 2 9 ■ E V . F . B L O C K
A L W A Y S

Treatment of evolving faults (only with 1 pole AR)

– each evolving fault results in final three-pole trip; reclosure is blocked

N E V E R

– no blocking of reclosure in the case of evolving faults; a change from single-pole AR to three-pole AR occurs (when permitted)

> T - D I S C R .

– before expiry of T-DISCR a change to three-pole AR (when permitted) occurs, after expiry of T-DISCR reclosure is blocked

3 4 3 0 ■ T - D I S C R I M
0 . 1 0 s

Discrimination time for evolving faults (only with single-pole AR)

Smallest setting value: **0.01 s**

Largest setting value: **320.00 s**

3 4 3 1 ■ A R T R I P 3 P
Y E S

Three-pole trip is given when the AR function is blocked during a single-pole dead time cycle (only with single-pole AR)

YES or

NO

N O

For DAR (further auto-reclose cycles), several programs are possible (address 3442). DAR can be excluded (DAR PROG = *NO DAR*). DAR can be permitted also if no RAR has been preceded (DAR PROG = *DAR WITHOUT RAR*). DAR can be permitted only after an unsuccessful RAR (DAR PROG = *DAR AFTER RAR*). DAR is always three-pole.

Multiple auto-reclosure with longer three-pole dead times are only permitted in networks in which no stability problems are to be expected (for example, due to a high degree of meshing), or in radial networks, or if synchro-check is used (refer to Section 6.3.14).

The number of DARs can be set differently after single-pole RAR (address 3443) and after three-pole RAR (address 3444). Nevertheless, trip occurs always three-pole.

For DAR, a separate action time DAR T–ACT can be set (address 3445).

Different dead times can be set for the first, second and third trip–close cycle. The dead time for the first cycle (address 3446) is only valid if the DAR cycle is really the first cycle (i.e. RAR is suppressed). For the second (address 3447) and third (address 3448) cycle, a RAR counts only if it has occurred. Further cycles are treated like the third cycle.

3 4 4 2 ■ D A R P R O G .
N O D A R

Auto-reclose program for DAR cycles

NO DAR – no delayed AR

DAR WITHOUT RAR – DAR will be carried out also when no RAR has preceded

DAR AFTER RAR – DAR will be carried out only after an unsuccessful RAR cycle

D A R W I T H O U T R A R

D A R A F T E R R A R

3 4 4 3 ■ D A R N o . 1 P H
1

Number of permissible DAR cycles after single-pole RAR (the RAR is not included in this number)

Smallest setting value:

0

Largest setting value:

9

3 4 4 4 ■ D A R N o . 3 P H
1

Number of permissible DAR cycles after three-pole RAR (the RAR is not included in this number) or without preceding RAR

Smallest setting value:

0

Largest setting value:

9

3 4 4 5 ■ D A R T - A C T .
0 . 2 0 s

Action time for DAR (further AR–shots) (if trip signal is given after this time, AR is blocked)

Smallest setting value:

0.01 s

Largest setting value:

320.00 s

and ∞

3 4 4 6 ■ D A R T 3 P O L 1
0 . 8 0 s

Dead time for the first AR cycle if it is a DAR cycle

Smallest setting value:

0.01 s

Largest setting value:

1800.00 s

3 4 4 7 ■ D A R T 3 P O L 2
0 . 8 0 s

Dead time for the second AR cycle

Smallest setting value:

0.01 s

Largest setting value:

1800.00 s

3 4 4 8 ■ D A R T 3 P O L 3
0 . 8 0 s

Dead time for further AR cycles

Smallest setting value:

0.01 s

Largest setting value:

1800.00 s

6.3.14 Settings for synchronism and voltage check – address block 35

NOTE: This section is valid only for models with integrated synchro-check function (7SA513★–★★★★–★★H★) and when this function is configured as *EXIST* under address 7835 (refer to Section 5.4.2).

When setting the general power system data (Section 6.3.3) the relay has been informed which voltages are connected to the relay to which inputs. This concerns the parameters

1104 UN SECOND. rated secondary voltage of the feeder voltage transformers (phase-to-phase) in V; it must be equal to the rated secondary voltage of the bus-bar voltage transformers!

1109 Ux CONNECT connection of the additional voltage transformer input of the device; must be *U2 TRANSFORM!*

1116 U2 CONNECT type of voltage which is connected to the device from the bus-bar voltage transformers;

1132 U1–U2 ANGLE
phase angle displacement between the voltages of the bus-bar voltage transformers and the feeder voltage transformers;

and, if asynchronous switching shall be allowed,

1133 T–CB CLOSE the closing time of the circuit breaker.

Different interrogation conditions can be parameterized for automatic reclosure on one hand and for manual closure on the other hand.

The general functions and limit values for closure are set under addresses 3501 to 3507 and 3530. Additionally, addresses 3508 to 3519 are relevant for automatic reclosure, addresses 3521 to 3529 are relevant for manual closure.

The complete synchronism and voltage check function is switched *OFF* or *ON* under address 3501.



Warning

If synchronism check function is switched off (address 3501) each manual or automatic closure is carried out without synchronism check!

The voltage below which the line or bus-bar is regarded safely as dead, is set under address 3502 $U <$ (for dead line or dead bus check).

The voltage above which the line or bus-bar is regarded safely as live, is set under address 3503 $U >$ (for live line or live bus check). It must be set below the minimum operating voltage under normal conditions.

The permissible magnitude difference ΔU between the voltages is set under address 3505 $\Delta U <$.

Depending on the bus-bar voltage connection U2 CONNECT (address 1116) the line-to-line voltage or the line-to-earth voltage is to be set.

The permissible frequency difference Δf between the voltages is set under address 3506 $\Delta f <$.

The permissible phase angle difference $\Delta \varphi$ between the voltages is set under address 3507 $\Delta \varphi <$.



Beginning of the block "Synchronism and voltage check"

3 5 0 1 ■ S Y N C - C H E C K

ON

OFF

Synchro-check function (complete) is

ON switched on

Off switched off

3 5 0 2 ■ U <

5 V

Voltage magnitude below which the line or bus-bar can be regarded as dead (phase–phase or phase–earth) in V

Smallest setting value:

1 V

Largest setting value:

60 V

3 5 0 3 ■ U >

8 0 V

Voltage magnitude above which the line or bus-bar can be regarded as live (phase–phase or phase–earth) in V

Smallest setting value:

20 V

Largest setting value:

125 V

3 5 0 5 ■ D E L T A U <

5 V

Limit value ΔU for the permissible voltage difference in magnitude (phase–phase or phase–earth) in V

Smallest setting value:

1 V

Largest setting value:

50 V

3 5 0 6 ■ D E L T A f <

0 . 1 0 H z

Limit value Δf for the permissible frequency difference in Hz

Smallest setting value:

0.03 Hz

Largest setting value:

1.00 Hz

3 5 0 7 ■ D E L T A P H I <

1 0 °

Limit value $\Delta\varphi$ for the permissible phase angle difference in °

Smallest setting value:

1 °

Largest setting value:

60 °

The synchro-check function in 7SA513 can also give closing commands in asynchronous networks. In this case, closing command is given such that – under consideration of the circuit breaker closing time (address 1133) – the voltage phasors of the line and bus-bar voltages agree in phase at the instant when there is contact of the breaker poles.

Address 3508 DEL.f<SYNC defines the limit within which the frequency difference must lie when the

networks are regarded as synchronous. Above this frequency difference, asynchronous closing is carried out under consideration of the phase angle difference, frequency difference and the circuit breaker closing time. Below this frequency difference, the synchro-check conditions as set under addresses 3505, 3506, and 3507 are only relevant. The setting value of address 3508 must lie below that of address 3506. If set to ∞ , asynchronous switching is suppressed for automatic reclosure.

3 5 0 8 ■ D E L . f < S Y N C

∞ H z

Limit value $\Delta f <$ for synchronous auto-reclosure

Smallest setting value:

0.03 Hz

Largest setting value:

0.10 Hz

and ∞ (no asynchronous auto-reclosure)

The further release conditions for automatic reclosing are set under addresses 3515 to 3519:

3515 SYNCHR synchronism check: the conditions for synchronism ΔU , Δf , and $\Delta \varphi$ are checked before reclosure;

3516 U1>U2< dead-bus check: the feeder (U1) must be live (U>, refer to address 3503), the bus-bar (U2) must be dead (U<, refer to address 3502);

3517 U1<U2> dead-line check: the feeder (U1) must be dead (U<, refer

3518 U1<U2<

to address 3502), the bus-bar (U2) must be live (U>, refer to address 3503);

dead-line and dead-bus check: the feeder (U1) and the bus-bar (U2) must both be dead (U<, refer to address 3502);

3519 OVERRIDE

automatic reclosure is released without any check;

The five possible release conditions are independent from each other and can be combined.

3 5 1 5 ■ S Y N C H R .

Y E S

N O

Synchronism check before automatic reclosure

YES synchro-check is done before auto-reclosure

NO auto-reclosure without synchro-check

3 5 1 6 ■ U 1 > U 2 <

N O

Y E S

Dead-bus check before automatic reclosure

NO auto-reclosure is not permitted onto a dead bus

YES auto-reclosure is permitted onto a dead bus

3 5 1 7 ■ U 1 < U 2 >

N O

Y E S

Dead-line check before automatic reclosure

NO auto-reclosure is not permitted onto a dead line

YES auto-reclosure is permitted onto a dead line

3 5 1 8 ■ U 1 < U 2 <

N O

Y E S

Dead-line and dead-bus check before automatic reclosure

NO auto-reclosure is not permitted onto a dead line and dead bus

YES auto-reclosure is permitted onto a dead line and dead bus

3 5 1 9 ■ O V E R R I D E

N O

Y E S

Override of any check before automatic reclosure

NO

YES auto-reclosure is executed without any check

The further release conditions for manual closing are set under addresses 3521 to 3529: The synchronism an voltage check function for manual closing can be individually switched off or on under address 3521. When SYN.MAN.CL is switched OFF, no checks are carried out for manual closing.

A separate frequency difference limit can be set for asynchronous switching after manual close command. Address 3522 MC Df<SYN defines the limit within which the frequency difference must lie when the networks are regarded as synchronous. Above this frequency difference, asynchronous closing is carried out under consideration of the phase angle difference, frequency difference and the circuit breaker closing time. Below this frequency difference, the synchro-check conditions as set under addresses 3505, 3506, and 3507 are only relevant. The setting value of address 3522 must lie below that of address 3506. If set to ∞, asynchronous switching is suppressed for manual closure.

The further release conditions for manual closing are set under addresses 3525 to 3529:

- 3525 MC SYNCHR synchronism check: the conditions for synchronism ΔU, Δf, and Δφ are checked before manual closure;
- 3526 MC U1>U2< dead-bus check: the feeder (U1) must be live (U>, refer to address 3503), the bus-bar (U2) must be dead (U<, refer to address 3502);
- 3527 MC U1<U2> dead-line check: the feeder (U1) must be dead (U<, refer to address 3502), the bus-bar (U2) must be live (U>, refer to address 3503);
- 3528 MC U1<U2< dead-line and dead-bus check: the feeder (U1) and the bus-bar (U2) must both be dead (U<, refer to address 3502);
- 3529 MC O/RIDE manual closing is released without any check;

The five possible release conditions are independent from each other and can be combined.

3521 ■ SYN . M A N . C L

ON

OFF

Synchro-check before manual close command is
ON switched on
OFF switched off

3522 ■ M C D f < S Y N

∞ H z

Limit value Δf< for synchronous manual closure
Smallest setting value: 0.03 Hz
Largest setting value: 0.10 Hz
and ∞ (no asynchronous manual switching)

3525 ■ M C S Y N C H R

YES

NO

Synchronism check before manual closure
YES synchro-check is done before manual closure
NO manual closure without synchro-check

3526 ■ M C U 1 > U 2 <

NO

YES

Dead-bus check before manual closure
NO manual closure is not permitted onto a dead bus
YES manual closure is permitted onto a dead bus

3 5 2 7 ■ M C U 1 < U 2 >
N O
Y E S

Dead-line check before manual closure

NO manual closure is not permitted onto a dead line

YES manual closure is permitted onto a dead line

3 5 2 8 ■ M C U 1 < U 2 <
N O
Y E S

Dead-line and dead-bus check before manual closure

NO manual closure is not permitted onto a dead line and dead bus

YES manual closure is permitted onto a dead line and dead bus

3 5 2 9 ■ M C O / R I D E
N O
Y E S

Override of any check before manual closure

NO

YES manual closure is executed without any check

Finally, address 3530 determines the time period, beginning from the measuring request (i.e. from close command), within which the check conditions as parameterized must be fulfilled. This time is valid for automatic reclosure as well as for manual closure. When the conditions are not fulfilled within this time, closing is blocked. Only after a renewed mea-

suring request the time starts again and a new check is carried out.

If the conditions for synchronous operation should be checked to be maintained for a certain duration, this minimum duration can be set under address 3531.

3 5 3 0 ■ T - S Y N . S U P V
1 . 0 0 s

Supervision time period within which the check conditions must be fulfilled

Smallest setting value:

0.01 s

Largest setting value:

320.00 s

3 5 3 1 ■ T I N - S Y N C
0 . 0 0 s

Minimum time during which the synchronous conditions must be fulfilled

Smallest setting value:

0.01 s

Largest setting value:

32.00 s

6.3.15 Settings for back-up overcurrent time protection – address block 36

The back-up overcurrent time protection does not operate during emergency operation. A pre-condition for its function is that the back-up overcurrent time protection has been configured under address 7836 as BACKUP O/C = *EXIST*.

The parameters of the back-up overcurrent time protection are set in block 36. Different stages are available for phase currents and earth current. Additionally, phase overcurrent and earth overcurrent time stages can be switched individually *ON* or *OFF* (addresses 3601 and 3631).

Generally, it must be noted that the set times for the $I > >$ stages and the definite time stages are pure delay time which do not include the inherent operation time of the protection functions.

6.3.15.1 Phase fault overcurrent time protection

At first, the high-set overcurrent stage $I > >$ is set under addresses 3602 and 3603. This stage is always a definite time stage, independent on which characteristic is set for the overcurrent stage. It is often used for current grading before high impedances. It is set such that it picks up on short-circuits into this impedance.

The effect of inrush currents is reduced by numerical filters. Nevertheless, the inrush currents contain also increased fundamental wave component. Thus, it may be advisable to set a short delay time especially when relatively sensitive settings are chosen.

If a stage is not required the time is set at ∞ . This does not avoid pick-up annunciation.

3 6 0 0 ■ B A C K - U P
O V E R C U R R E N T P R O T

Beginning of the block "Back-up overcurrent time protection"

3 6 0 1 ■ B A C K O / C P
O N
O F F

Back-up overcurrent time protection for phase currents is

ON switched on

OFF switched off

3 6 0 2 ■ I > >
2 . 0 0 I / I n

High-current pick-up threshold $I > >$ for phase currents

Smallest setting value: **0.10** · I_N

Largest setting value: **9.99** · I_N ¹⁾

Largest setting value: **15.00** · I_N ²⁾

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

3 6 0 2 ■ I > >
2 . 0 0 I / I n

High-current pick-up threshold $I > >$ for phase currents

Smallest setting value: **0.10** · I_N

Largest setting value: **9.99** · I_N

3 6 0 3 ■ T - I > >
0 . 3 0 s

Time delay for the high-current stage $I > >$ for phase currents

Smallest setting value: **0.00** s

Largest setting value: **32.00** s

and ∞ (no trip with $I > >$ phases)

The back-up overcurrent time protection can be used as definite time overcurrent protection or inverse time overcurrent protection. This function

mode is selected under address 3611. For inverse time, a choice can be made between three tripping time characteristic defined in IEC 60255–3.

3 6 1 1	CHARACT . PH
DEFINITE	TIME
NORMAL INVERSE	
VERY INVERSE	
EXTREMELY INVERS	

Characteristic of the overcurrent stage for phase currents

DEFINITE TIME characteristic

NORMAL INVERSE time (type A acc. IEC 60255–3)

VERY INVERSE time (type B acc. IEC 60255–3)

EXTREMELY INVERSE time (type C acc. IEC 60255–3)

Addresses 3612 and 3613 are relevant only in case the **definite time** characteristic has been chosen under address 3611 (CHARAC.PH = *DEFINITE TIME*). The maximum load current determines the setting of the overcurrent stage I>. Pick-up on overload must be excluded since the unit operates in this mode as short circuit protection with adequate short tripping time and not as overload protection. Therefore, the overcurrent stage is set to 120 % for feeder lines, and 150 % for transformers or motors referred to

maximum (over)load current.

The time delay T–I> depends on the grading plan for the network. The set times are pure delay times which do not include the operating time.

If the overcurrent stage I> is not used then set the time TI> (address 3613) to ∞. This does not avoid pick-up annunciation.

3 6 1 2	I >
1 . 0 0	I / I _N

Only for definite time protection:

Pick-up threshold I> for phase currents

Smallest setting value: **0.10** · I_N¹⁾

Largest setting value: **4.00** · I_N¹⁾

Largest setting value: **15.00** · I_N²⁾

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

3 6 1 3	T – I >
0 . 5 0	s

Delay time for I> stage for phase currents

Smallest setting value: **0.00** s

Largest setting value: **32.00** s

and ∞ (no trip with I> phases)

Addresses 3614 to 3616 are relevant only in case the **inverse time** characteristic has been chosen under address 3611. When setting the protection to inverse time overcurrent protection, it must be considered that, according to IEC 60255–3, the protection picks up only when at more than 1.05 (typically 1.07) times the set value is exceeded.

The time setting corresponds to 10 times the usual time multiplier TM, e.g.

T_p = 10 s means TM = 1,
thus for normal inverse

t_{trip} = 10 s tripping time at 2 times set value I_p

With the definite time characteristic the fundamental waves of the measured currents are evaluated for pick-up. When one of the **inverse time** characteristic is selected, a choice can be made whether the fundamental waves of the measured currents **WITH-OUT HARMONICS** are evaluated by means of a numerical Fourier filter, or if the true r.m.s. values **WITH**

HARMONICS are calculated. As the relay is used as short-circuit protection, the preset value is recommended. If the time grading is to be coordinated with conventional relays which operate with true r.m.s. value, then **WITH HARMONICS** may be advantageous.

3 6 1 4 ■ I p
0 . 2 0 I / I n

Only for inverse time protection:

Pick-up threshold I_p for phase currents

Smallest setting value:

0.10 $\cdot I_N$

Largest setting value:

4.00 $\cdot I_N$

3 6 1 5 ■ T - I p
0 . 5 0 s

Time multiplier for phase currents

Smallest setting value:

0.05 s

Largest setting value:

32.00 s

and ∞ (no trip with I_p phases)

3 6 1 6 ■ M E A . F O R M . P
W I T H O U T H A R M O N .

Only for inverse time protection:

The fundamental waves of the measured currents is evaluated by a Fourier filter

W I T H H A R M O N I C S

The true r.m.s. values of the measured currents is evaluated (only for inverse time characteristics)

Address 3621 determines which stage is effective if the circuit breaker is manually closed. A pre-requisite is, that the manual close command for the breaker is repeated via a binary input to the relay and this input is assigned accordingly, so that it is informed about manual closing of the breaker. **INEFFECTIVE** means that the stages operate according to the settings in addresses 3602 to 3615.

It is also possible to carry out auto-reclosure in conjunction with the back-up overcurrent time protection.

In this case, the $I > >$ stage is of interest because of its independent trip time: If reclosure is expected the protection will trip with the undelayed $I > >$ stage, final disconnection is carried out via $I >$ or I_p with delay according to the set values for $T_{I >}$ or T_p . $I > >$ and $I >$ should then be set to the same value.

Address 3623 determines whether the $I > >$ stage is effective only in conjunction with auto-reclosure or whether it operates independently.

3 6 2 1 ■ M / C L O S E P H
I > > U N D E L A Y E D

Phase overcurrent stage which is effective during

manual closing of the circuit breaker:

$I > >$ i.e. $I > >$ stage but without delay $T_{I > >}$

I > / I p U N D E L A Y E D

$I > / I_p$ i.e. $I >$ stage (definite time) or I_p stage (inverse time) but without delay

I N E F F E C T I V E

INEFFECTIVE, i.e. stages operate as parameterized

3 6 2 3 ■ R A R Z O N E P
I > > W I T H A R

AR function (if configured) operates with the $I > >$ stage (phases):

$I > >$ **WITH AR** i.e. $I > >$ is released only if AR is ready

$I > >$ **ALWAYS** i.e. $I > >$ stage operates always, independent of the AR function

I > > A L W A Y S

6.3.15.2 Earth fault overcurrent time protection

For earth faults, all parameters can be set separately and independently. This allows separate time grading for earth faults with e.g. shorter times.

The setting possibilities are the same as for phase currents.

If an earth fault is detected by one phase current ele-

ment as well as by the earth current element, trip command can be given single-pole according to the faulty phase but with the (shorter) time for earth faults. This allows single-pole auto-reclosure even with the back-up overcurrent time protection.

If a separate overcurrent time protection for earth faults is not required, the earth current stages can be switched of independent of the phase current stages in address 3631

3 6 3 1 ■ B A C K O / C E
O N
O F F

Back-up overcurrent time protection for earth currents is

ON switched on

OFF switched off

3 6 3 2 ■ I E > >
0 . 5 0 I / I n

High-current pick-up threshold $I_{E>>}$ for earth currents

Smallest setting value: $0.10 \cdot I_N$

Largest setting value: $4.00 \cdot I_N$

3 6 3 3 ■ T - I E > >
0 . 3 0 s

Time delay for the stage $I_{E>>}$ for earth currents

Smallest setting value: 0.00 s

Largest setting value: 32.00 s
and ∞ (no trip with $I_{E>>}$ earth)

3 6 4 1 ■ C H A R A C T . E
D E F I N I T E T I M E
N O R M A L I N V E R S E
V E R Y I N V E R S E
E X T R E M E L Y I N V E R S E

Characteristic of the overcurrent stage for earth currents

DEFINITE TIME characteristic

NORMAL INVERSE time (type A acc. IEC 60255-3)

VERY INVERSE time (type B acc. IEC 60255-3)

EXTREMELY INVERSE time (type C acc. IEC 60255-3)

3 6 4 2 ■ I E >
0 . 2 0 I / I n

Only for definite time protection:

Pick-up threshold $I_{E>}$ for earth currents

Smallest setting value: $0.10 \cdot I_N$

Largest setting value: $4.00 \cdot I_N$

3 6 4 3 ■ T - I E >
0 . 3 0 s

Delay time for $I_{E>}$ stage for earth currents

Smallest setting value: 0.00 s

Largest setting value: 32.00 s
and ∞ (no trip with $I_{E>}$ earth)

3 6 4 4 ■ I E p
0 . 3 0 I / I n

Only for inverse time protection:Pick-up threshold I_p for earth currentsSmallest setting value: **0.10** · I_N Largest setting value: **4.00** · I_N

3 6 4 5 ■ T - I E p
0 . 5 0 s

Time multiplier for earth currents

Smallest setting value: **0.05** sLargest setting value: **32.00** s
and ∞ (no trip with I_{Ep} earth)

3 6 4 6 ■ M E A . F O R M . E
W I T H O U T H A R M O N .
W I T H H A R M O N I C S

Only for inverse time protection:

The fundamental waves of the measured current is evaluated by a Fourier filter

The true r.m.s. values of the measured current is evaluated (only for inverse time characteristics)

3 6 5 1 ■ M / C L O S E E
I E > > U N D E L A Y E D
I E > / I E p U N D E L A Y .
I N E F F E C T I V E

Earth overcurrent stage which is effective during manual closing of the circuit breaker:

 $I_{E>>}$ i.e. $I_{E>>}$ stage but without delay $I_{E>}/I_{Ep}$ i.e. $I_{E>}$ stage (definite time) or I_{Ep} stage (inverse time) but without delay**INEFFECTIVE**, i.e. stages operate as parameterized

3 6 5 3 ■ R A R Z O N E E
I E > > W I T H A R
I E > > A L W A Y S

AR function (if configured) operates with the $I_{E>>}$ stage (earth): $I_{E>>}$ **WITH AR** i.e. $I_{E>>}$ is released only if AR is ready $I_{E>>}$ **ALWAYS** i.e. $I_{E>>}$ stage operates always, independent of the AR function

6.3.16 Setting for overvoltage protection – address block 37

The overvoltage protection can operate only if configured as *EXIST* under address 7837 (refer to Section 5.4.2).

The overvoltage protection is of two-stage design. It contains a (rapid) $U >>$ stage and a (delayed) $U >$ stage. The latter is equipped with an adjustable compounding facility. Both stages can individually switched *OFF* or *ON*, under address 3701 for the $U >$ stage and under address 3711 for the $U >>$ stage.

6.3.16.1 $U >$ stage with adjustable compounding

The pick-up value $U >$ (address 3703) should be set to approximately 5 % above the maximum expected operational voltage. The value is related to the rated voltage transformer voltage as parameterized under address 1104 (refer to Section 6.3.3.1).

The drop-off value (address 3704) is set as a factor of the pick-up value. It should be as high as possible, but not so high that the overvoltage protection shows intermittent pick-up. The drop-off value must not be smaller than the maximum expected steady-state operational voltage.

The delay time (address 3705) should be some seconds to avoid trip caused by short overvoltages.

The compounding facility (address 3706) calculates the voltage at the remote line end from the local line voltage, the current, and the line data. A pre-condition is that the line data are parameterized correctly as explained in Section 6.3.3.2. The following addresses are concerned:

1121	LINE ANGLE	the line angle $\varphi_{\text{line}} = \arctan(X_{\text{line}}/R_{\text{line}})$;
1122	X SEC	the secondary reactance per unit line length in Ω/km ;
1123	C SEC	the secondary capacitance per unit line length in $\mu\text{F}/\text{km}$;
1124	LINELENGTH	the length of the line in km

The line data can equally be given in Ω/mile , $\mu\text{F}/\text{mile}$ but the line length must then also be given in miles!

If the compounding facility is switched *ON* (address 3706) then the voltage at the remote line end is decisive for pick-up of the $U >$ stage of the overvoltage protection. If the compounding facility is switched *OFF* then the voltage at the local line end is decisive for pick-up of the $U >$ stage of the overvoltage protection.

If series capacitors are installed at the local end of the protected line or in the course of the line then the compounding facility must be switched *OFF*.

If a shunt reactor is installed at the protected line end, then compounding is only possible provided the shunt reactor is located on the bus-bar side of the current transformers; otherwise the compounding facility must be switched *OFF*.

Address 3708 determines to which line end the trip command is issued. When set to *LOCAL TRIP*, the trip command is given to the local circuit breaker. When set to *TRIP SEND*, a transmission signal is given which can be transmitted to the remote end circuit breaker. When set to *LOCAL AND SEND*, both trip signals are given. Pre-condition is, of course, that the signals are allocated to the respective binary outputs (refer to Section 5.5). The minimum transmission pulse duration can be set under address 3721 (refer to Section 6.3.16.3).

3 7 0 0 ■ O V E R V O L T .
P R O T E C T I O N

Beginning of the block "Overvoltage protection"

3 7 0 1 ■ U > S T A G E
O N
O F F

Overvoltage protection stage U> is

ON switched on

OFF switched off

3 7 0 3 ■ U >
1 . 2 0 U / U_N

Pick-up value of the U> stage

Smallest setting value: **1.00** · U_N

Largest setting value: **1.90** · U_N

3 7 0 4 ■ U - R E S E T / U >
0 . 9 8

Drop-off to pick-up ratio of the U> stage

Smallest setting value: **0.50**

Largest setting value: **0.99**

3 7 0 5 ■ T - U >
2 . 0 0 s

Delay time of the U> stage

Smallest setting value: **0.00 s**

Largest setting value: **32.00 s**

and ∞ (no trip with U> stage)

3 7 0 6 ■ U > C O M P O U N D
O F F
O N

Switching the compounding facility effective

OFF compounding is switched off: the measured local voltage is decisive for U>

ON compounding is switched on: the calculated voltage of the remote line end is decisive for U>

3 7 0 8 ■ U > T R I P
L O C A L T R I P
T R I P S E N D
L O C A L A N D S E N D

Trip command of the U> stage

LOCAL TRIP is given (via marshalling) to the local circuit breaker

TRIP SEND is transmitted (via marshalling) to the remote line end

LOCAL AND SEND is available for local trip as well as for transmission to the remote end

6.3.16.2 Rapid U>> stage

Voltage measurement can be carried out either from the phase-to-phase voltages or from the phase-to-earth voltages (address 3712). The overvoltage detection of the three measuring elements can be combined with *AND* or with *OR* (address 3715).

The pick-up value U>> (address 3713) is normally set approximately 10 % above the voltage which may occur for short periods when the circuit breaker is closed. The setting is related to the rated secondary voltage as parameterized under address 1104 (refer to Section 6.3.3.1).

The drop-off value (address 3714) is set as a factor of the pick-up value. It should be high enough that the drop-off value lies at least 5 % above the voltage which may occur for short periods when the circuit breaker is closed.

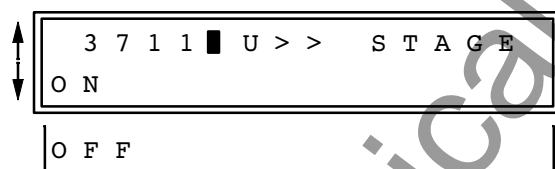
Two different delay times are available:

When the circuit breaker is closed, delay time TU>>CB ON is decisive (address 3716). Since in this case steady-state conditions can be presumed, delay can be very short (e.g. 50 ms).

When the circuit breaker is open, delay time TU>>CB OFF is decisive (address 3717). Since in this case heavy transient voltages may occur during switching operations at the remote line end, delay must be longer than the duration of these overvoltages (several 100 ms).

If the local circuit breaker is switched, high transient overvoltages may occur, too. For this reason, the U>> stage is blocked with every switching operation of the local breaker for the duration TBLOCK U>> (address 3718). This time also is dependent on the power system conditions, it should be several 100 ms. Precondition for correct function of this blocking is that the relay is informed about switching by connection of the auxiliary contact(s) of the circuit breaker to binary input.s

Address 3720 determines to which line end the trip command is issued. When set to *LOCAL TRIP*, the trip command is given to the local circuit breaker. When set to *TRIP SEND*, a transmission signal is given which can be transmitted to the remote end circuit breaker. When set to *LOCAL AND SEND*, both trip signals are given. Pre-condition is, of course, that the signals are allocated to the respective binary outputs (refer to Section 5.5). The minimum transmission pulse duration can be set under address 3721 (refer to Section 6.3.16.3).



Overvoltage protection stage U>> is

ON switched on

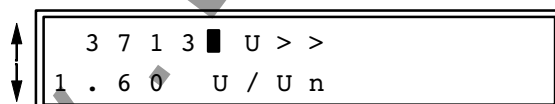
OFF switched off



Selection of the measured voltages of the overvoltage protection stage U>>

PHASE - EARTH or

PHASE - PHASE



Pick-up value of the U>> stage

Smallest setting value: $1.00 \cdot U_N$

Largest setting value: $1.90 \cdot U_N$



Drop-off to pick-up ratio of the U>> stage

Smallest setting value: **0.50**

Largest setting value: **0.99**

3 7 1 5 ■ U > > P H A S E S
A N D C O M B I N E D

O R C O M B I N E D

Logical combination of the overvoltage elements
AND or
OR

3 7 1 6 ■ T U > > C B O N

0 . 0 5 s

Delay time of the U>> stage when the circuit breaker is closed
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ (no trip with U>> when the circuit breaker is closed)

3 7 1 7 ■ T U > > C B O F F

0 . 2 0 s

Delay time of the U>> stage when the circuit breaker is open
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ (no trip with U>> when the circuit breaker is open)

3 7 1 8 ■ T B L O C K U > >

0 . 5 0 s

Time period during which the U>> stage is blocked when the circuit breaker is switched
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**

3 7 2 0 ■ U > > T R I P
L O C A L T R I P

T R I P S E N D

L O C A L A N D S E N D

Trip command of the U>> stage
LOCAL TRIP is given (via marshalling) to the local circuit breaker
TRIP SEND is transmitted (via marshalling) to the remote line end
LOCAL AND SEND is available for local trip as well as for transmission to the remote end

6.3.16.3 Intertrip to the remote line end

For transmission of the trip command of any of the overvoltage protection function (according to the

parameters address 3708 and 3720) to the remote line end, the minimum transmit signal duration can be set under address 3721. Thus, it can be matched to the carrier equipment.

3 7 2 1 ■ T - S E N D - I M P

0 . 2 5 s

Minimum duration of the send signal when a trip command is transmitted to the remote line end
Smallest setting value: **0.05 s**
Largest setting value: **0.50 s**

6.3.17 Settings for fault location – address block 38

Distance to fault will be calculated provided FAULT LOCAT. = *EXIST* has been set in address 7838 during configuration (see Section 5.4.2).

Normally fault location calculation is initiated at the instant when a tripping command is issued. It can, however, also be started on fault detection drop-off (address 3802) if, for example, another protection device clears the fault. Additionally, fault location can be initiated by an external command via a binary input (FNo 1106, refer to Section 5.5.2), provided the distance protection has picked up.

To calculate the distance in kilometers, the device requires the reactance value in Ω/km as a secondary value, referred to 1 A. Conversion from primary to secondary value is made by using the same formula as for the distance setting (Section 6.3.4.2). If one puts in the reactance value of the line in Ω/km for X_{prim} one obtains the required setting value X_{SEC} (address 1122).

For correct output of the distance to fault in % of line length, the total line length in km must also be input (address 1124). If the reactance X_{SEC} is entered in Ω/mile and the LINE LENGTH entered in miles, the result of fault calculation would be read in miles instead of kilometers.

Example:

For the example given in Section 6.3.4.2 we obtain:

$$X_{\text{prim}} = 0.39 \Omega/\text{km}$$

$$\begin{aligned} X_{\text{sec}} &= \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X_{\text{prim}} \cdot \frac{I_N}{A} \\ &= \frac{1200/5}{220/0.1} \cdot 0.39 \Omega/\text{km} \cdot \frac{5 \text{ A}}{A} = 0.213 \Omega/\text{km} \end{aligned}$$

$$\text{Length} = 60 \text{ km}$$

If, for example, a fault reactance of 2.29Ω primary is calculated, this example gives us the fault location data

$$\begin{aligned} X_{\text{pri}} &= 2.29 \Omega \\ d &= 5.86 \text{ km} \\ d &= 9.78 \% \end{aligned}$$

Parallel line compensation can only function correctly if

- the earth current of the parallel line is connected with the correct polarity to one of the additional current input and
- in the power system data (see Section 6.3.3.1) one of the additional current inputs is parameterized as *PARALLEL LINE* (address 1111 or 1114) and
- in the power system data (see Section 6.3.3.1) the rated current ratio I_{ePARAL}/I_p is set correct (address 1113) and
- in the power system data (see Section 6.3.3.2) the coupling impedances R_M/R_L and X_M/X_L (addresses 1119 and 1120) are correctly set and
- for the fault location the compensation is switched to effective, under address 3805.

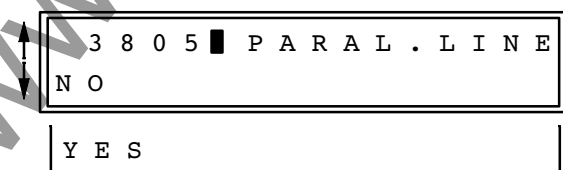


Beginning of block "Fault location"



Start-to-measure of fault location is initiated

- by *DROP-OFF* of the fault detector or by *TRIP* command
- only by *TRIP COMMAND*



This parameter determines whether parallel line compensation is effective (provided above prerequisites are fulfilled) or not

6.3.18 Settings for circuit breaker failure protection – address block 39

The circuit breaker failure protection can operate only if configured as *EXIST* under address 7839 (refer to Section 5.4.2).

The current threshold $I > B/F$ (address 3902) shall be selected such that the protection will operate at the smallest expected short-circuit current. To be sure of this, the value should be 10 % less then the minimum anticipated fault current. On the other hand, the value should not be set much lower than necessary.

The delay time $T - B/F$ (address 3903) is determined from the maximum tripping time of the circuit breaker, the reset time of the current detectors of the protection, plus a safety margin which allows for any tolerance of the delay timers. The sequence is illustrated in Figure 6.6.

For sinusoidal currents one can assume that the reset time is less than 10 ms (typically 5 ms) but if current transformer saturation is expected then 20 ms should be calculated.

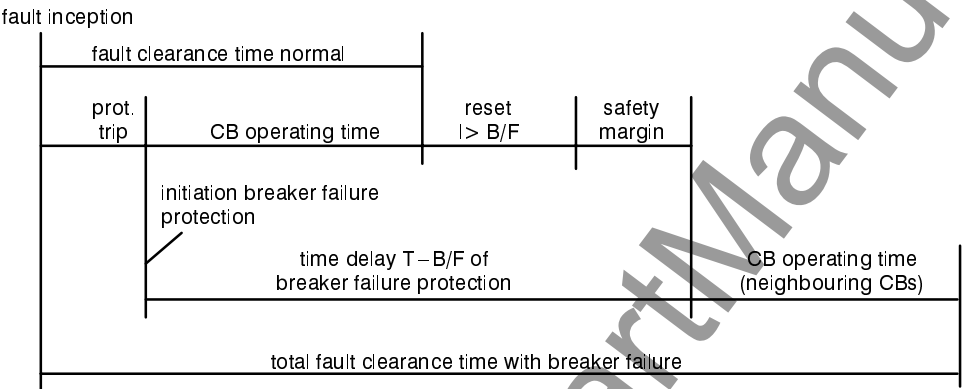


Figure 6.6 Time sequence for normal clearance of a fault, and with circuit breaker failure

3900 BREAKER FAILURE PROTECT.	Beginning of the block "Circuit breaker failure protection"
3901 B / F PROT. ON OFF	Circuit breaker failure protection is ON switched on OFF switched off
3902 I > B F 0.20 I / I_n	Pick-up value of the current detector of the breaker failure protection Smallest setting value: 0.04 I _N Largest setting value: 4.00 I _N
3903 T - B / F 0.20 s	Delay time of the breaker failure protection Smallest setting value: 0.05 s ¹⁾ Smallest setting value: 0.00 s ²⁾ Largest setting value: 1.00 s or ∞, i.e. no trip by breaker failure protection ¹⁾ up to firmware version V3.2 ²⁾ from fimware version V3.3 or higher

6.4 Annunciations

6.4.1 Introduction

After a network fault, annunciations and messages provide a survey of important fault data and the function of the relay, and serve for checking sequences of functional steps during testing and commissioning. Further, they provide information about the condition of measured data and the relay itself during normal operation.

To read out recorded annunciations, no codeword input is necessary.

The annunciations generated in the relay are presented in various ways:

- LED indications in the front plate of the relay (Figure 6.1),
- Binary outputs (output relays) via the connections of the relay,
- Indications in the display on the front plate or on the screen of a personal computer, via the operating interface,
- Transmission via the system interface to local or remote control facilities.

Most of these annunciations can be relatively freely allocated to the LEDs and binary outputs (see Section 5.5). Also, within specific limitations, group and multiple indications can be formed.

To call up annunciations on the operator panel, the following possibilities exist:

- Block paging with the keys ↑ forwards or ↓ backwards up to address 5000,
- Direct selection with address code, using key **DA**, address **5 0 0 0** and execute with key **E**,
- Press key **M/S** (M stands for "messages", S for "signals"); then the address 5000 appears auto-

matically as the beginning of the annunciation blocks.

For configuration of the transfer of annunciations via the serial interfaces, the necessary data are entered in address block 72 (see Section 5.3.3).

The annunciations are arranged as follows:

Block 51 Operational annunciations; these are messages which can appear during the operation of the relay: information about condition of relay functions, measurement data etc.

Block 52 Event annunciations for the last fault; pick-up, trip, AR, expired times, calculated distance, or similar. As defined, a network fault begins with pick-up of any fault detector. If auto-reclosure is carried out, the network fault ends after expiry of the last reclaim time; thus an AR-shot (or all shots) occupy only one fault data store. Within a network fault, several fault events can occur, from pick-up of any fault detection until drop-off.

Block 53 Event annunciations for the previous network fault, as block 52.

Block 54 Event annunciations for the last but two network fault, as block 52.

Block 56 Annunciations for CB operation statistics, that is counters for first AR (RAR), second or further AR (DAR) and tripping commands, together with accumulated short-circuit currents of each breaker pole.

Block 57 Indication of operational measured values (currents, voltages, powers, frequency).



Commencement of "annunciation blocks"

A comprehensive list of the possible annunciations and output functions with the associated function number FNo is given in Appendix C. It is also indicated to which device each annunciation can be routed.

6.4.2 Operational annunciations – address block 51

Operational and status annunciations contain information which the unit provides during operation and about the operation. They begin at address 5100. Important events and status changes are chronologically listed, starting with the most recent message. Time information is shown in hours and minutes. Up to 50 operational indications can be stored. If more occur, the oldest are erased in sequence.

Faults in the network are only indicated as "Syst. Flt" together with the sequence number of the fault. Detailed information about the history of the fault is contained in blocks "Fault annunciations", refer to Section 6.4.3.

The input of the codeword is not required.

After selection of the address 5100 (by direct selection with **DA 5100 E** and/or paging with ↑ or ↓ and further scrolling ↑ or ↓) the operational annunciations appear. The boxes below show all available operational annunciations. In each specific case, of course, only the associated annunciations appear in the display. The annunciations which are indicated by a leading ">" sign, represent the direct confirmation of the binary inputs.

Next to the boxes below, the abbreviated forms are explained. It is indicated whether an event is announced on occurrence (**C** = "Coming") or a status is announced "**Coming**" and "**Going**" (**C/G**). The first listed message is, as example, assigned with date and time in the first line; the second line shows the beginning of a condition with the character **C** to indicate that this condition occurred at the displayed time.

↑
↓
5 1 0 0 ■ O P E R A T I O N A L
A N N U N C I A T I O N S

Beginning of the block "Operational annunciations"

↑
↓
1 9 . 0 7 . 9 6 1 7 : 0 2
L E D r e s e t : C

1st line: Date and time of the event or status change

2nd line: Annunciation text, in the example **C**oming

If the real time clock is not available the date is replaced by ★★.★★.★★, the time is given as relative time from the last re-start of the processor system.

Direct response from binary inputs:

> S t a r t F l t R e c

Fault recording started via binary input (C)

> A n n u n c . 1

User defined annunciation No 1 received via binary input (C/G)

> A n n u n c . 2

User defined annunciation No 2 received via binary input (C/G)

> A n n u n c . 3

User defined annunciation No 3 received via binary input (C/G)

> A n n u n c . 4

User defined annunciation No 4 received via binary input (C/G)

> C l o s e C m d . B l o

Block all closing commands (C/G)

> V T m c b T r i p

Voltage transformer secondary m.c.b. (feeder v.t.) tripped (C/G)

> V 2 m c b T r i p

Voltage transformer secondary m.c.b. (bus-bar v.t.) tripped (C/G)

> 1 p T r i p P e r m	Single-pole tripping is permitted (from external AR device) (C/G)
> O n l y 1 p o l e	External AR device is programmed for single-pole reclosure only (C/G)
> R A R R e l e a s e	Release RAR stages from external AR device (C/G)
> D A R R e l e a s e	Release DAR stage from external AR device (C/G)
> S t a r t F l t L o c	Start fault locator via binary input (C/G)
> E / F R e c e p t	Carrier signal for directional comparison earth fault protection received (C)
> E / F R e c . F a i l	Carrier reception for directional comparison earth fault protection faulty (C/G)
> I > > b l o c k	Block I>> stage of emergency and back-up overcurrent protection from an external device (C/G)
> I > / I p b l o c k	Block I> (definite time) or Ip (inverse time) stage of emergency and back-up overcurrent protec. (C/G)
> I E > > b l o c k	Block I _E >> stage of emergency and back-up overcurrent protection from an external device (C/G)
> I E > / I E p b l o c k	Block I _E > (definite time) or I _{Ep} (inverse time) stage of emergency and back-up overcurrent prot. (C/G)
> B a c k u p b l o c k	Back-up overcurrent time protection blocked (C/G)
> A R b l o c k	Block auto-reclosure statically via binary input (C/G)
> A R r e s e t	Reset auto-reclosure function from external via binary input (C)
> 1 p R A R b l o c k	Block single-pole RAR via binary input (C/G)
> 3 p R A R b l o c k	Block three-pole RAR via binary input (C/G)
> R A R b l o c k	Block complete RAR via binary input (C/G)
> D A R b l o c k	Block complete DAR via binary input (C/G)
> S t a r t A R	Starting signal from external protection for internal AR (C)
> T r i p L 1 A R	Trip signal pole L1 from external protection for internal AR (C)
> T r i p L 2 A R	Trip signal pole L2 from external protection for internal AR (C)
> T r i p L 3 A R	Trip signal pole L3 from external protection for internal AR (C)
> T r i p 1 p A R	Single-pole trip signal from external protection for internal AR (C)
> T r i p 3 p A R	Three-pole trip signal from external protection for internal AR (C)
> D A R a f t . R A R	DAR permitted only after unsuccessful RAR (C/G)
> E x t e n s . Z 1 B	Switch distance reach to extended zone Z1B from external signal (C/G)

> E x t e n s . Z 1 L	Switch distance reach to extended zone Z1L from external signal (C/G)
> D i s . R e c e p t . O	Carrier signal for teleprotection with distance protection in overreaching mode received (C/G)
> D i s . R e c e p t . U	Carrier signal for teleprotection with distance protection in underreaching mode received (C)
> E x t . T r i p b l k	Block external trip function (C/G)
> E x t . T r i p L 1	Trigger external trip function for pole L1 (C)
> E x t . T r i p L 2	Trigger external trip function for pole L2 (C)
> E x t . T r i p L 3	Trigger external trip function for pole L3 (C)
> E x t . T r p . w o A R	Trigger external trip function three-pole without reclosure (C/G)
> U s e r T 1 S t a r t	Start user definable timer T1 (C/G)
> U s e r T 1 R e s e t	Reset user definable timer T1 (C)
> U s e r T 2 S t a r t	Start user definable timer T2 (C/G)
> U s e r T 2 R e s e t	Reset user definable timer T2 (C)
> B / F r e l e a s e	Release breaker failure protection from an external source (2nd channel) (C/G)
> B / F S t a r t L 1	Initiate breaker failure protection pole L1 from an external source (2nd channel) (C/G)
> B / F S t a r t L 2	Initiate breaker failure protection pole L2 from an external source (2nd channel) (C/G)
> B / F S t a r t L 3	Initiate breaker failure protection pole L3 from an external source (2nd channel) (C/G)

General operational annunciations of the protection device:

D e v . o p e r a t i v e	Device operative (C/G)
P r o t . o p e r a t .	At least one protection function is operative (C/G)
I n i t i a l s t a r t	Initial start of the processor system (C)
L E D r e s e t	Stored LED indications reset (C)
L o g M e t e r B l o c k	Messages and measured values via the system interface are blocked (C/G)
T e s t m o d e	Messages and measured value via the system interface are marked with "Test operation" (C/G)
P a r a m . r u n n i n g	Parameters are being set (C/G)

P a r a m . S e t A	Parameter set A is active (C/G)
P a r a m . S e t B	Parameter set B is active (C/G)
P a r a m . S e t C	Parameter set C is active (C/G)
P a r a m . S e t D	Parameter set D is active (C/G)
S y s t . F l t	Network system fault (C/G), detailed information in the fault annunciations
M a n u a l C l o s e	Manual close command registered (impulse) (C)
C B i n T e s t	Circuit breaker test is in progress (C/G)
F l t . R e c D a t D e l	Fault recording data deleted (C)
F l t . R e c . v i a B I	Fault recording triggered via binary input (C)
F l t . R e c . v i a K B	Fault recording triggered via the front keyboard (C)
F l t . R e c . v i a P C	Fault recording triggered via operating (PC) interface (C)

Operational annunciations of monitoring functions:

W r o n g S W - v e r s	Software version of the device is wrong (C)
W r o n g d e v . I D	Device identification number is wrong (C)
A n n u n c . l o s t	Annunciations lost (buffer overflow) (C)
A n n u . P C l o s t	Annunciations for operating (PC) interface lost (C)
O p e r . A n n . I n v a	Operational annunciations invalid (C/G)
F l t . A n n . I n v a l	Fault annunciations invalid (C/G)
S t a t . B u f f . I n v	Buffer for operation statistics invalid (C/G)
L E D B u f f . I n v a	Buffer for stored LEDs invalid (C/G)
V D E W - S t a t e I n v	VDEW state (protocol acc. IEC 60870–5–103) invalid (C/G)
C h s E r r o r	Check-sum error detected (C/G)
C h s . A E r r o r	Check-sum error detected for parameter set A: no operation possible with this set (C/G)

C h s . B E r r o r	Check-sum error detected for parameter set B: no operation possible with this set (C/G)
C h s . C E r r o r	Check-sum error detected for parameter set C: no operation possible with this set (C/G)
C h s . D E r r o r	Check-sum error detected for parameter set D: no operation possible with this set (C/G)
F a i l u r e 2 4 V	Failure in internal supply voltage 24 V (C/G)
F a i l u r e 1 5 V	Failure in internal supply voltage 15 V (C/G)
F a i l u r e 5 V	Failure in internal supply voltage 5 V (C/G)
F a i l u r e 0 V	Failure in offset voltage 0 V (C/G)
F a i l . T r i p R e l	Failure in internal trip relay circuit (C/G)
L S A d i s r u p t e d	LSA–link disrupted (system interface) (C/G)
F a i l u r e ΣI	Failure detected by current plausibility monitor ΣI (C/G)
F a i l u r e I s y m m	Failure detected by current symmetry monitor (C/G)
F a i l u r e ΣU_{ph-e}	Failure detected by voltage plausibility monitor ΣU_{ph-e} (C/G)
F a i l u r e ΣU_{ph-ph}	Failure detected by voltage plausibility monitor ΣU_{ph-ph} (C/G)
F a i l u r e U s y m m	Failure detected by voltage symmetry monitor (C/G)
F a i l u r e U m e a s	Loss of measured voltages (C/G)
F F M p i c k - u p	Fuse failure monitor picked up (undelayed annunciation) (C/G)
F u s e - F a i l u r e	Fuse failure monitor operated (delayed annunciation, approx. 10 s) (C/G)
F a i l . P h a s e S e q	Failure detected by phase sequence monitor (C/G)

Operational annunciations of distance protection:

D i s t . o f f	Distance protection is switched off (C/G)
D i s t . b l o c k e d	Distance protection is blocked (C/G)
> E x t e n s . Z 1 B	Release zone extension stage Z1B (C/G)
> E x t e n s . Z 1 L	Release zone extension stage Z1L (C/G)

Operational annunciations of power swing supplement:

P o w e r S w i n g	Power swing detected (C/G)
O / S T r i p	Out-of-step trip signal issued (C)

Operational annunciations of teleprotection with distance protection:

P O T T T e l e . o f f	Teleprotection function with distance protection in overreaching mode is switched off (C/G)
> D i s . R e c e p t . O	Carrier signal for teleprotection with distance protection in overreaching mode received (C)
D i s . R e c . F a i l O	Reception signal for teleprotection with distance protection in overreaching mode is faulty (C/G)
D i s . P O T T E c h o	Echo signal for teleprotection with distance protection transmitted (C)
P U T T T e l e o f f	Teleprotection function with distance protection in underreaching mode is switched off (C/G)
> D i s . R e c e p t . U	Carrier signal for teleprotection with distance protection in underreaching mode received (C)
D i s . R e c . F a i l U	Reception signal for teleprotection with distance protection in underreaching mode is faulty (C/G)

Operational annunciations of user definable logic functions and external trip function:

> U s e r T 1 S t a r t	Start user definable timer T1 (C/G)
> U s e r T 1 R e s e t	Reset user definable timer T1 (C)
U s e r o u t p u t 1	Output of user definable timer T1 (C/G)
> U s e r T 2 S t a r t	Start user definable timer T2 (C/G)
> U s e r T 2 R e s e t	Reset user definable timer T2 (C)
U s e r o u t p u t 2	Output of user definable timer T2 (C/G)
> E x t . T r i p b l k	Block external trip function (C/G)
> E x t . T r i p L 1	Trigger external trip function for pole L1 (C)
> E x t . T r i p L 2	Trigger external trip function for pole L2 (C)
> E x t . T r i p L 3	Trigger external trip function for pole L3 (C)
> E x t . T r p . w o A R	Trigger external trip function three-pole without reclosure (C/G)

Operational annunciations of high-current switch-onto-fault protection:

S - O - F o f f	High current switch-onto-fault protection is switched off (C/G)
S - O - F b l o c k	High current switch-onto-fault protection is blocked (C/G)

Operational annunciations of weak-infeed trip function:

W / I o f f	Weak-infeed trip function is switched off (C/G)
W / I b l o c k e d	Weak-infeed trip function is blocked (C/G)

Operational annunciations of emergency overcurrent time protection:

E m e r . P h . o f f	Emergency overcurrent time protection for phase currents is switched off (C/G)
E m e r . E o f f	Emergency overcurrent time protection for earth currents is switched off (C/G)
E m e r . b l o c k	Emergency overcurrent time protection is blocked (C/G)
E m e r . a c t i v e	Emergency overcurrent time protection is active (C/G)

Operational annunciations of high-resistance earth fault protection in earthed systems:

E / F P r o t . o f f	Earth fault protection is switched off (C/G)
E / F b l o c k e d	Earth fault protection is blocked (C/G)
E / F D i r o f f	Earth fault directional comparison is switched off (C/G)
> E / F R e c e p t	Carrier signal for directional comparison earth fault protection received (C)
> E / F R e c . F a i l	Carrier reception for directional comparison earth fault protection faulty (C/G)
E / F E c h o	Echo signal for directional comparison transmitted (C)

Operational annunciations of the internal auto-reclose function:

A R o f f	Auto-reclose function is switched off (C/G)
A R i n o p e r a t i v	Auto-reclose function inoperative, i.e, cannot be initiated (C/G)
> A R b l o c k	Block auto-reclosure statically via binary input (C/G)
> A R r e s e t	Reset auto-reclosure function from external via binary input (C)
> 1 p R A R b l o c k	Block single-pole RAR via binary input (C/G)
> 3 p R A R b l o c k	Block three-pole RAR via binary input (C/G)
> R A R b l o c k	Block complete RAR via binary input (C/G)
> D A R b l o c k	Block complete DAR via binary input (C/G)
> S t a r t A R	Starting signal from external protection for internal AR (C)
> T r i p L 1 A R	Trip signal pole L1 from external protection for internal AR (C)
> T r i p L 2 A R	Trip signal pole L2 from external protection for internal AR (C)
> T r i p L 3 A R	Trip signal pole L3 from external protection for internal AR (C)
> T r i p 1 p A R	Single-pole trip signal from external protection for internal AR (C)
> T r i p 3 p A R	Three-pole trip signal from external protection for internal AR (C)
> D A R a f t . R A R	DAR permitted only after unsuccessful RAR (C/G)
A R c l o s e C m d .	Reclose command from auto-reclose function issued (C)

Operational annunciations of the internal synchronism and voltage check function:

S y n c . o f f	Synchronism and voltage check function is switched off; closing is released (C/G)
S y n c . b l o c k e d	Synchronism and voltage check function is blocked (C/G)
S y n c . f a u l t y	Synchronism and voltage check function is disturbed (C/G)
S y n c . T s u p . E x p	Synchronism and voltage check function: supervision time expired (C)

S y n c . O v e r r i d e	Synchronism and voltage check function overridden (C/G)
S y n c . S y n c h r o	Synchronism detected (C/G)
S y n c . U 1 > U 2 <	Live line (U1>) and dead bus-bar (U2<) detected (C/G)
S y n c . U 1 < U 2 >	Dead line (U1<) and live bus-bar (U2>) detected (C/G)
S y n c . U 1 < U 2 <	Dead line (U1<) and dead bus-bar (U2<) detected (C/G)
S y n c . U d i f f >	Synchronism check ΔU exceeded (C/G)
S y n c . f d i f f >	Synchronism check Δf exceeded (C/G)
S y n c . φ d i f f >	Synchronism check $\Delta \varphi$ exceeded (C/G)

Operational annunciations of the back-up overcurrent time protection:

B a c k u p P h o f f	Back-up overcurrent time protection for phase currents is switched off (C/G)
B a c k u p E o f f	Back-up overcurrent time protection for earth current is switched off (C/G)
> B a c k u p b l o c k	Back-up overcurrent time protection blocked (C/G)

Operational annunciations of the overvoltage protection:

U > o f f	Overvoltage protection stage U> is switched off (C/G)
U > b l o c k e d	Overvoltage protection stage U> is blocked (C/G)
U > > o f f	Overvoltage protection stage U>> is switched off (C/G)
U > > b l o c k e d	Overvoltage protection stage U>> is blocked (C/G)

Operational annunciations of fault location:

> S t a r t F l t L o c	Start fault locator via binary input (C/G)

Operational annunciations of the circuit breaker failure protection:

B / F o f f	Circuit breaker failure protection is switched off (C/G)
B / F b l o c k e d	Circuit breaker failure protection is blocked (C/G)
> B / F r e l e a s e	Release breaker failure protection from an external source (2nd channel) (C/G)
> B / F S t a r t L 1	Initiate breaker failure protection pole L1 from an external source (2nd channel) (C/G)
> B / F S t a r t L 2	Initiate breaker failure protection pole L2 from an external source (2nd channel) (C/G)
> B / F S t a r t L 3	Initiate breaker failure protection pole L3 from an external source (2nd channel) (C/G)

Operational annunciations of the circuit breaker test function:

C B i n T e s t	Circuit breaker test in progress (C/G)
C B T e s t 1 p L 1	Trip single-pole L1 by internal circuit breaker test function (C)
C B T e s t 1 p L 2	Trip single-pole L2 by internal circuit breaker test function (C)
C B T e s t 1 p L 3	Trip single-pole L3 by internal circuit breaker test function (C)
C B T e s t 3 p	Trip three-pole by internal circuit breaker test function (C)

Further messages:

T a b l e o v e r f l o w	If more messages have been received the last valid message is <i>Table overflow</i> .
E n d o f t a b l e	If not all memory places are used the last message is <i>End of table</i> .

6.4.3 Fault annunciations – address blocks 52 to 54

The annunciations which occurred during the last three network faults can be read off on the front panel or via the operating interface. The indications are recorded in the sequence from the youngest to the oldest under addresses 5200, 5300 and 5400. When a further fault occurs, the data relating to the oldest are erased. Each fault data buffer can contain up to 80 annunciations.

Input of the codeword is not required.

To call up the **last** fault data, one goes to address 5200 either by direct address **DA 5200 E** or by paging with the keys $\uparrow$ or $\downarrow$. With the keys $\uparrow$ or $\downarrow$ one can page the individual annunciations forwards or backwards. Each annunciation is assigned with a sequence item number.

For these purposes, the term "system fault" means the period from short circuit inception up to final clearance. If auto-reclose occurs, then the "system fault" is finished on expiry of the last reclaim or lock-out time, that is, after successful or unsuccessful AR. Thus the total fault clearance procedure inclusive AR-cycles occupies only one fault annunciation store. Within one system fault, several fault events can have occurred, i.e. from pick-up of any protection function until drop-off of the last pick-up of a protection function.

In the following clarification, all the available fault annunciations are indicated. In the case of a specific fault, of course, only the associated annunciations appear in the display. At first, an example is given for a system fault, and explained.

5 2 0 0 ■ L A S T
F A U L T

Beginning of the block "Fault annunciations of the last system fault"

0 0 1 ■ 3 0 . 0 6 . 9 6
S y s t . F l t 2 2

under item 1, the date of the system fault is indicated, in the second line the consecutive number of the system fault

0 0 2 ■ 1 1 : 0 0 : 4 8 . 5 2 9
F a u l t : C

under item 2, the time of the beginning of the fault is given; time resolution is 1 ms

0 0 3 ■ 0 m s
D i s t . F l t . L 1 E : C

The following items indicate all fault annunciations which have occurred from fault detection until drop-off of the device, in chronological sequence. These annunciations are tagged with the relative time in milliseconds, starting with the fault detection.

0 0 4 ■ 6 m s
D i s . T r i p 3 p : C

0 0 5 ■ 1 1 5 m s
D e v . D r o p - o f f : C

0 0 6 ■ 1 1 5 m s
F L L o o p L 1 E

For fault location, the conductor loop is given, from which the fault location has been derived. Fault distance is displayed in Ohms primary, in Ohms secondary, in kilometers and in percentage line length, calculated from the parameters which have been set for line and transformer data (refer Section 6.3.3).

0 0 7 ■
d = 1 6 . 0 k m

If the per unit line reactance has been parameterized in Ω /mile instead of Ω /km (address 1122) then the fault distance is to be read in miles.

0 0 8 ■
d [%] = 6 1 3 %

etc.

General fault annunciations of the device:

S y s t . F l t	System fault with consecutive number
F a u l t	Beginning of fault
F l t . B u f f . O v e r	Fault annunciations lost (buffer overflow)
> R A R R e l e a s e	Release RAR stages from external AR device when occurred during a fault
> D A R R e l e a s e	Release DAR stage from external AR device when occurred during a fault
D e v . T r i p r e v .	Trip on fault in reverse (bus-bar) direction
I L 1 / I n =	Interrupted fault current of phase L1
I L 2 / I n =	Interrupted fault current of phase L2
I L 3 / I n =	Interrupted fault current of phase L3
D e v i c e T r i p	The general trip command of the device is annunciated Going , i.e. reset of the trip is indicated
D e v . D r o p - o f f	Drop-off of the device, general

Fault annunciations of distance protection:

D i s Z 1 B A R b l k	Auto-reclosure blocked by fault in zone Z1B
D i s Z 1 L A R b l k	Auto-reclosure blocked by fault in zone Z1L
D i s t . F l t . L 1	Fault detection distance protection, phase L1
D i s t . F l t . L 1 E	Fault detection distance protection, phase L1–E
D i s t . F l t . L 2	Fault detection distance protection, phase L2
D i s t . F l t . L 2 E	Fault detection distance protection, phase L2–E
D i s t . F l t . L 1 2	Fault detection distance protection, phases L1–L2
D i s t . F l t . L 1 2 E	Fault detection distance protection, phases L1–L2–E
D i s t . F l t . L 3	Fault detection distance protection, phase L3
D i s t . F l t . L 3 E	Fault detection distance protection, phase L3–E
D i s t . F l t . L 1 3	Fault detection distance protection, phases L1–L3

D i s t . F l t . L 1 3 E	Fault detection distance protection, phases L1–L3–E
D i s t . F l t . L 2 3	Fault detection distance protection, phases L2–L3
D i s t . F l t . L 2 3 E	Fault detection distance protection, phases L2–L3–E
D i s t . F l t . L 1 2 3	Fault detection distance protection, phases L1–L2–L3
D i s t . F l t . 1 2 3 E	Fault detection distance protection, phases L1–L2–L3–E
D i s t . φ L 1	Fault detection distance protection, phase angle dependent stage L1 picked up
D i s t . φ L 2	Fault detection distance protection, phase angle dependent stage L2 picked up
D i s t . φ L 3	Fault detection distance protection, phase angle dependent stage L3 picked up
L o o p L 1 – E f	In line loop L1–E, a fault in forward direction is detected
L o o p L 2 – E f	In line loop L2–E, a fault in forward direction is detected
L o o p L 3 – E f	In line loop L3–E a fault in forward direction is detected
L o o p L 1 – 2 f	In line loop L1–L2, a fault in forward direction is detected
L o o p L 2 – 3 f	In line loop L2–L3, a fault in forward direction is detected
L o o p L 3 – 1 f	In line loop L3–L1, a fault in forward direction is detected
L o o p L 1 – E r	In line loop L1–E, a fault in reverse direction is detected
L o o p L 2 – E r	In line loop L2–E, a fault in reverse direction is detected
L o o p L 3 – E r	In line loop L3–E, a fault in reverse direction is detected
L o o p L 1 – 2 r	In line loop L1–L2, a fault in reverse direction is detected
L o o p L 2 – 3 r	In line loop L2–L3, a fault in reverse direction is detected
L o o p L 3 – 1 r	In line loop L3–L1, a fault in reverse direction is detected
L o o p L 1 – E < - >	In line loop L1–E, non-directional stage picked up
L o o p L 2 – E < - >	In line loop L2–E, non-directional stage picked up
L o o p L 3 – E < - >	In line loop L3–E, non-directional stage picked up
L o o p L 1 – 2 < - >	In line loop L1–L2, non-directional stage picked up
L o o p L 2 – 3 < - >	In line loop L2–L3, non-directional stage picked up

L o o p L 3 - 1 < - >	In line loop L3–L1, non-directional stage picked up
D i s . T r i p Z 1 / 1 p	Trip in zone Z1 single-pole by distance protection
D i s . T r i p Z 1 / 3 p	Trip in zone Z1 three-pole by distance protection
D i s . T r i p Z 1 B 1 p	Trip in zone Z1B single-pole by distance protection
D i s . T r i p Z 1 B 3 p	Trip in zone Z1B three-pole by distance protection
D i s . T r i p Z 1 L	Trip in zone Z1L by distance protection
D i s . T r i p Z 2 / 1 p	Trip in zone Z2 single-pole by distance protection
D i s . T r i p Z 2 / 3 p	Trip in zone Z2 three-pole by distance protection
D i s . T r i p Z 3 / T 3	Trip in zone Z3 by distance protection
D i s . T r i p F D - >	Trip in fault detection zone directional by distance protection
D i s . T r i p < - >	Trip in fault detection zone non-directional by distance protection
D i s . T r i p 1 p L 1	Trip single-pole L1 by distance protection
D i s . T r i p 1 p L 2	Trip single-pole L2 by distance protection
D i s . T r i p 1 p L 3	Trip single-pole L3 by distance protection
D i s . T r i p 3 p	Trip three-pole by distance protection
D i s t . G e n . F l t .	The general fault detection of the distance protection is annunciated G oing, i.e. reset is indicated

Fault annunciation of power swing supplement:

P o w e r S w i n g	Power swing detected (when during fault)
O / S T r i p	Out-of-step trip signal issued

Fault annunciations of teleprotection with distance protection:

> D i s . R e c e p t . O	Carrier signal for teleprotection with distance protection in overreaching mode received
D i s . P O T T S e n d	Carrier send signal for teleprotection with distance protection in overreaching mode transmitted

D i s . T r a n s B l o	Transient blocking function of teleprotection with distance protection has operated
B l k . S i g . S t o p	Stop signal only for blocking procedure
> D i s . R e c e p t . U	Carrier signal for teleprotection with distance protection in underreaching mode received
D i s . P U T T S e n d	Carrier send signal for teleprotection with distance protection in underreaching mode transmitted

Fault annunciations of user definable logic functions and external trip function:

> U s e r T 1 S t a r t	Start user definable timer T1 during fault
> U s e r T 1 R e s e t	Reset user definable timer T1 during fault
U s e r o u t p u t 1	Output of user definable timer T1 during fault
> U s e r T 2 S t a r t	Start user definable timer T2 during fault
> U s e r T 2 R e s e t	Reset user definable timer T2 during fault
U s e r o u t p u t 2	Output of user definable timer T2 during fault
E x t . T r i p 1 p L 1	Trip by external trip function single-pole L1
E x t . T r i p 1 p L 2	Trip by external trip function single-pole L2
E x t . T r i p 1 p L 3	Trip by external trip function single-pole L3
E x t . T r i p 3 p	Trip by external trip function three-pole
E x t . T r i p w o A R	Trip by external trip function three-pole without reclosure

Fault annunciations of high-current switch-onto-fault protection:

S - O - F F l t . L 1	Fault detection phase L1 of high-current switch-onto-fault protection
S - O - F F l t . L 2	Fault detection phase L2 of high-current switch-onto-fault protection
S - O - F F l t . L 3	Fault detection phase L3 of high-current switch-onto-fault protection
S - O - F T r i p 3 p	Three-pole trip by high-current switch-onto-fault protection

Fault annunciations of weak-infeed trip facility:

W / I F l t . L 1	Fault detection phase L1 of weak-infeed trip function
W / I F l t . L 2	Fault detection phase L2 of weak-infeed trip function
W / I F l t . L 3	Fault detection phase L3 of weak-infeed trip function
W / I T r i p L 1	Single-pole weak-infeed trip pole L1
W / I T r i p L 2	Single-pole weak-infeed trip pole L2
W / I T r i p L 3	Single-pole weak-infeed trip pole L3
W / I T r i p L 1 2 3	Three-pole weak-infeed trip

Fault annunciations of emergency overcurrent time protection:

E m e r . F l t E	Earth fault detection of emergency overcurrent time protection
E m e r . F l t L 1	Fault detection emergency overcurrent time protection, phase L1
E m e r . F l t L 1 E	Fault detection emergency overcurrent time protection, phase L1 – earth
E m e r . F l t L 2	Fault detection emergency overcurrent time protection, phase L2
E m e r . F l t L 2 E	Fault detection emergency overcurrent time protection, phase L2 – earth
E m e r . F l t L 1 2	Fault detection emergency overcurrent time protection, phases L1 – L2
E m e r . F l t L 1 2 E	Fault detection emergency overcurrent time protection, phases L1 – L2 – earth
E m e r . F l t L 3	Fault detection emergency overcurrent time protection, phase L3
E m e r . F l t L 3 E	Fault detection emergency overcurrent time protection, phase L3 – earth
E m e r . F l t L 1 3	Fault detection emergency overcurrent time protection, phases L1 – L3
E m e r . F l t L 1 3 E	Fault detection emergency overcurrent time protection, phases L1 – L3 – earth
E m e r . F l t L 2 3	Fault detection emergency overcurrent time protection, phases L2 – L3
E m e r . F l t L 2 3 E	Fault detection emergency overcurrent time protection, phases L2 – L3 – earth
E m e r . F l t L 1 2 3	Fault detection emergency overcurrent time protection, phases L1 – L2 – L3
E m e r . F l t 1 2 3 E	Fault detection emergency overcurrent time protection, phases L1 – L2 – L3 – earth

E m e r . I > >	Fault detection emergency overcurrent protection on high phase current stage I>>
E m e r . I > / I p	Fault detection emergency overcurrent protection on phase overcurrent stage I> or I _p
E m e r . I E > >	Fault detection emergency overcurrent protection on high earth current stage I _E >>
E m e r . I E > / I E p	Fault detection emergency overcurrent protection on earth overcurrent stage I _E > or I _{Ep}
E m e r . T r i p 1 p L 1	Trip single-pole L1 by emergency overcurrent time protection
E m e r . T r i p 1 p L 2	Trip single-pole L2 by emergency overcurrent time protection
E m e r . T r i p 1 p L 3	Trip single-pole L3 from emergency overcurrent time protection
E m e r . T r i p 3 p	Trip three-pole by emergency overcurrent time protection
E m e r . G e n . F l t	The general fault detection of the emergency overcurrent time protection is annunciated Going , i.e. reset is indicated

Fault annunciations of high-resistance earth fault protection in earthed systems:

E / F b l o c k e d	Earth fault protection blocked (when during fault)
E / F F l t 7 5 % I e >	Fault detection earth fault protection 75 % I _E > stage (valid for directional determination and transmission)
E / F F l t I e - >	Fault detection earth fault protection directional
E / F F l t I e < - >	Fault detection earth fault protection non-directional
> E / F R e c e p t	Carrier signal for directional comparison earth fault protection received (C)
E / F S e n d	Directional comparison earth fault protection, carrier signal transmitted
E / F T r a n s B l o c	Transient blocking function of directional comparison earth fault protection has operated
E / F T r i p L 1	Earth fault protection trip single-pole L1
E / F T r i p L 2	Earth fault protection trip single-pole L2
E / F T r i p L 3	Earth fault protection trip single-pole L3
E / F T r i p 3 p	Earth fault protection trip three-pole

Fault annunciations of internal auto-reclose function:

A R i n p r o g .	Auto-reclose cycle in progress
R A R T - 1 p r u n .	Dead time of single-pole RAR is running
R A R T - 3 p r u n .	Dead time of three-pole RAR is running
D A R T - 3 p 1 r u n	Dead time of first three-pole DAR is running
D A R T - 3 p 2 r u n	Dead time of second three-pole DAR is running
D A R T - 3 p 3 r u n	Dead time of third or further three-pole DAR is running
A R b l o c k . d y n .	AR function dynamically blocked (by internal cause)
A R C l o s e C m d .	Reclose command from auto-reclose function issued
A R T r i p 3 p	Three-pole trip by internal auto-reclose function caused by blocking during single-pole AR cycle

Fault annunciation of internal synchronism and voltage check function:

S y n c . T s u p . E x p	Supervision time for synchronism and voltage check expired: no more closure release

Fault annunciations of back-up overcurrent time protection:

B a c k u p F l t L 1	Fault detection phase L1 of back-up overcurrent time protection
B a c k u p F l t L 2	Fault detection phase L2 of back-up overcurrent time protection
B a c k u p F l t L 3	Fault detection phase L3 of back-up overcurrent time protection
B a c k u p F l t E	Earth fault detection of back-up overcurrent time protection
B a c k u p I > >	Pick-up of high phase current stage I>> of back-up overcurrent time protection
B a c k u p I > / I p	Pick-up of phase overcurrent stage I> or I _p of back-up overcurrent time protection
B a c k u p I E > >	Pick-up of high earth current stage I _E >> of back-up overcurrent time protection
B a c k I E > / I E p	Pick-up of earth overcurrent stage I _E > or I _{Ep} of back-up overcurrent time protection
B a c k T r i p L 1	Trip single-pole L1 by back-up overcurrent time protection
B a c k T r i p L 2	Trip single-pole L2 by back-up overcurrent time protection

B a c k T r i p L 3	Trip single-pole L3 by back-up overcurrent time protection
B a c k T r i p 3 p	Trip three-pole by back-up overcurrent time protection
B a c k G e n . F l t	The general fault detection of the back-up overcurrent time protection is annunciated Going , i.e. reset is indicated

Fault annunciations of overvoltage protection:

U > D e t e c t i o n	Overvoltage detection U> stage
U > > D e t e c t i o n	Overvoltage detection U>> stage
U > T r i p	Trip by overvoltage protection U> stage
U > > T r i p	Trip by overvoltage protection U>> stage
U > I n t e r t r i p	Intertrip signal sent by overvoltage protection stage U>
U > > I n t e r t r i p	Intertrip signal sent by overvoltage protection stage U>>

Fault annunciations of fault location:

F a u l t L o c a t .	Fault location data, the line loop is indicated from which fault data have been calculated
R p r i = Ω	Calculated primary fault resistance in ohms, based on the parameterized rated values (addresses 1103 to 1105, refer to Section 6.3.3.1)
X p r i = Ω	Calculated primary fault reactance in ohms, based on the parameterized rated values (addresses 1103 to 1105, refer to Section 6.3.3.1)
R s e c = Ω	Calculated secondary fault resistance in ohms, based on 1 A
X s e c = Ω	Calculated secondary fault reactance in ohms, based on 1 A
d = k m	Calculated fault distance in kilometers, based on the parameterized rated values (addresses 1103 to 1105, refer to Section 6.3.3.1) and the line data as parameterized under addresses 1122 and 1124 (refer to Section 6.3.3.2)
d [%] = %	Calculated fault distance in % of line length, based on the parameterized rated values (addresses 1103 to 1105, refer to Section 6.3.3.1) and the line data as parameterized under addresses 1122 and 1124 (refer to Section 6.3.3.2)
F l t L o c . i n v a l .	Fault location invalid; distance to fault cannot be determined (from firmware version V3.3 or higher)

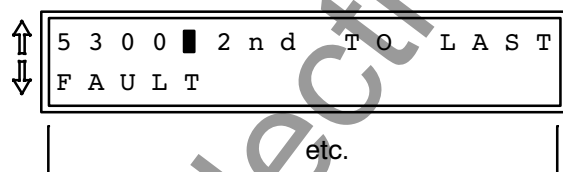
Fault annunciations of circuit breaker failure protection:

B / F S t a r t	Initiation of breaker failure protection
B / F T r i p L 1	Trip by breaker failure protection caused by failure in pole L1
B / F T r i p L 2	Trip by breaker failure protection caused by failure in pole L2
B / F T r i p L 3	Trip by breaker failure protection caused by failure in pole L3
B / F T r i p 3 p o l	Trip by breaker failure protection three-pole
B / F T r i p w o I	Trip by breaker failure protection without current detection, i.e. only by interrogation of CB auxiliary contact

Further messages:

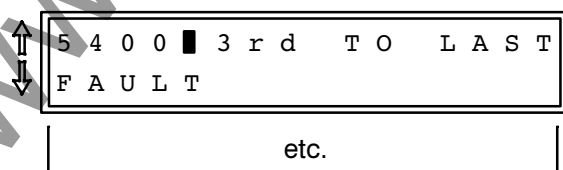
T a b l e e m p t y	means that no fault event has been recorded
T a b l e o v e r f l o w	means that other fault data have occurred, however, memory is full
T a b l e s u p e r c e d e d	a new fault event has occurred during read-out: page on with ↑ or ↓; the display shows the first annunciation in the actualized order
E n d o f t a b l e	If not all memory places are used the last message is End of table.

The data of the **second to last** system fault can be found under address 5300. The available annunciations are the same as for the last fault.



Beginning of the block "Fault annunciations of the second to last system fault"

The data of the **third to last** system fault can be found under address 5400. The available annunciations are the same as for the last fault.



Beginning of the block "Fault annunciations of the third to last system fault"

6.4.4 Circuit breaker operation statistics – address block 56

The number of trip commands initiated by the relay is counted separately for each of the breaker poles. Also, the number of auto-reclose attempts is counted, separately for single-pole RAR, three-pole RAR (first shot) and three-pole DAR (further shots). Additionally, the interrupted currents are stated for each individual pole and given under the fault annunciations (refer to Section 6.4.3) following each trip command. These currents are accumulated and stored. Counter status and stores are secured

against auxiliary voltage failure and can be read off in address block 56. The address can be reached by direct addressing **DA 5 6 0 0 E** or by paging with the keys $\uparrow$ or $\downarrow$ until address 5600 is reached. The counters can be called up using the key $\uparrow$ for forwards paging or $\downarrow$ for backwards paging.

Entry of the codeword is not required for read-off of counter states.

$\uparrow$
5 6 0 0 ■ C B O P E R A T .
 $\downarrow$
S T A T I S T I C S

Beginning of the block "Circuit breaker operation statistics"

$\uparrow$
5 6 0 1 ■ A R 1 p o l e =
 $\downarrow$
1 7

Number of auto-reclose attempts after single-pole trip, e.g. 17

Page on with key $\uparrow$ to get further counter states

$\uparrow$
5 6 0 2 ■ A R 3 p o l e =

Number of auto-reclose attempts after three-pole trip, 1st AR cycle (RAR)

$\uparrow$
5 6 0 3 ■ D A R 3 p o l e =

Number of auto-reclose attempts after three-pole trip, further AR cycles (DAR)

$\uparrow$
5 6 0 4 ■ T r i p N o L 1 =

Number of trip commands for circuit breaker pole L1

$\uparrow$
5 6 0 5 ■ T r i p N o L 2 =

Number of trip commands for circuit breaker pole L2

$\uparrow$
5 6 0 6 ■ T r i p N o L 3 =

Number of trip commands for circuit breaker pole L3

$\uparrow$
5 6 0 7 ■ $\Sigma I L 1 / I n =$

Accumulated interrupted currents for CB pole L1

$\uparrow$
5 6 0 8 ■ $\Sigma I L 2 / I n =$

Accumulated interrupted currents for CB pole L2

$\uparrow$
5 6 0 9 ■ $\Sigma I L 3 / I n =$

Accumulated interrupted currents for CB pole L3

The maximum values of the counters are:

- RAR 1pole, RAR 3pole, DAR 3pole
- Trip No L1, Trip No L2, Trip No L3
- $\Sigma I L 1 / I n$, $\Sigma I L 2 / I n$, $\Sigma I L 3 / I n$

9 digits

9 digits

7 digits plus 1 decimal digit

The counters can be reset to 0 in block 82 (see Section 6.5.2).

6.4.5 Read-out of operational measured values – address block 57

The steady state r.m.s. operating values can be read out at any time in address block 57. The address can be called up directly using **DA 5700 E** or by paging with $\uparrow$ or $\downarrow$. The individual measured values can be found by further paging with $\uparrow$ or $\downarrow$. Entry of the codeword is not necessary. The values will be updated in approximately 1 to 5 seconds intervals.

The data are displayed in absolute primary values and in percent of the rated device values. To ensure correct primary values, the rated data must be entered to the device under address block 11 as described in Section 6.3.3.1.

In the following example, some typical values have been inserted. In practice the actual values appear.

$\uparrow \downarrow$ 5 7 0 0 ■ O P E R A T I O N A L
M E A S U R E D V A L U E S

Beginning of the block "Operational measured values"

Use $\uparrow$ key to move to the next address with the next measured value.

$\uparrow \downarrow$ 5 7 0 1 ■ M E A S . V A L U E
I L 1 = 1 0 6 0 A

Page on with the $\uparrow$ key to read off the next address with the next measured value, or page back with $\downarrow$.

$\uparrow \downarrow$ 5 7 0 2 ■ M E A S . V A L U E
I L 2 = 1 0 8 5 A

One address is available for each measured value. The values can be reached also by direct addressing using key **DA** followed by the address number and execute with **E**.

$\uparrow \downarrow$ 5 7 0 3 ■ M E A S . V A L U E
I L 3 = 1 0 7 3 A

The primary values (addresses 5701 to 5711) are based on the primary rated values as parameterized under addresses 1103 (for U_N) and 1105 (for I_N) (refer Section 6.3.3.1).

$\uparrow \downarrow$ 5 7 0 4 ■ M E A S . V A L U E
U L 1 E = 2 3 7 . 9 k V

$\uparrow \downarrow$ 5 7 0 5 ■ M E A S . V A L U E
U L 2 E = 2 3 6 . 9 k V

$\uparrow \downarrow$ 5 7 0 6 ■ M E A S . V A L U E
U L 3 E = 2 3 8 . 3 k V

5 7 0 7 ■ M E A S . V A L U E
U L 1 2 = 4 1 0 . 2 k V

5 7 0 8 ■ M E A S . V A L U E
U L 2 3 = 4 1 1 . 6 k V

5 7 0 9 ■ M E A S . V A L U E
U L 3 1 = 4 1 4 . 5 k V

5 7 1 0 ■ M E A S . V A L U E
P a = 7 3 8 . 8 M W

5 7 1 1 ■ M E A S . V A L U E
P r = 1 9 8 . 0 M V A r

5 7 1 2 ■ M E A S . V A L U E
f [%] = 9 9 . 9 %

The percentage is referred to rated frequency 50 Hz or 60 Hz as parameterized under address 7899 (refer Section 5.4.2)

5 7 1 3 ■ M E A S . V A L U E
I L 1 [%] = 5 3 . 0 %

The percentage is referred to rated current

5 7 1 4 ■ M E A S . V A L U E
I L 2 [%] = 5 4 . 3 %

5 7 1 5 ■ M E A S . V A L U E
I L 3 [%] = 5 3 . 7 %

5 7 1 6 ■ M E A S . V A L U E
U L 1 E [%] = 1 0 3 . 0 %

The percentage is referred to rated voltage divided by $\sqrt{3}$

5 7 1 7 ■ M E A S . V A L U E
U L 2 E [%] = 1 0 2 . 6 %

5 7 1 8 ■ M E A S . V A L U E
U L 3 E [%] = 1 0 3 . 2 %

5 7 1 9 ■ M E A S . V A L U E
U L 1 2 [%] = 1 0 2 . 6 %

The percentage is referred to rated voltage

5 7 2 0 ■ M E A S . V A L U E
U L 2 3 [%] = 1 0 2 . 9 %

5 7 2 1 ■ M E A S . V A L U E
U L 3 1 [%] = 1 0 3 . 6 %

5 7 2 2 ■ M E A S . V A L U E
P a [%] = 5 3 . 3 %

The percentage is referred to rated apparent power
 $\sqrt{3} \cdot U_N \cdot I_N$

5 7 2 3 ■ M E A S . V A L U E
P r [%] = 1 4 . 3 %

6.5 Operational control facilities

During operation of the protection relay it may be desired to intervene in functions or annunciations manually or from system criteria. 7SA513 comprises facilities, e.g. to re-adjust the real time clock, to erase stored informations and event counters, to switch on or off partial functions under specific conditions, or to change over preselected sets of function parameters. The scope of operational control facilities depends on the ordered scope of functions of the device (refer to Section 2.3 Ordering data).

The functions can be controlled from the operating panel on the front of the device, via the operating and system interface as well as via binary inputs.

In order to control functions via binary inputs it is necessary that the binary inputs have been marshalled to the corresponding switching functions during installation of the device and that they have been connected (refer Section 5.5.2 Marshalling of the binary inputs).

The control facilities begin with address block 8000. This address is reached

- by block paging with the keys ↑ forwards or ↓ backwards up to address 8000, or
- by direct selection with address code, using key **DA**, address **8 0 0 0** and execute with key **E**.

↑	8 0 0 0 ■ D E V I C E
↓	C O N T R O L

Beginning of the block "Device control"

6.5.1 Adjusting and synchronizing the real time clock – address block 81

The date and time can be adjusted at any time during operation as long as the real time clock is operative. Setting is carried out in block 81 which is reached by direct addressing **DA 8 1 0 0 E** or by paging with ↑ and ↓. Input of the codeword is required to change the data.

Selection of the individual addresses is by further scrolling using ↑ ↓ as shown below. Each modification must be confirmed with the enter key **E**.

↑	8 1 0 0 ■ S E T T I N G
↓	R E A L T I M E C L O C K

Beginning of the block "Setting the real time clock". Continue with ↑.

↑	3 0 . 0 6 . 1 9 9 6
↓	1 3 : 4 3 : 2 6

At first, the actual date and time are displayed. Continue with ↑.

↑	8 1 0 2 ■ D A T E

Enter the new date: 2 digits for day, 2 digits for month and 4 digits for year (including century); use the order as configured under address 7102 (Section 5.3.2), but always use a dot for separator:
DD.MM.YYYY or **MM.DD.YYYY**

↑	8 1 0 3 ■ T I M E

Enter the new time: hours, minutes, seconds, each with 2 digits, separated by a dot:
HH.MM.SS

↑	8 1 0 4 ■ D I F F . T I M E

Using the difference time, the clock is set forwards by the entered time, or backwards using the +/- key. The format is the same as with the time setting above.

6.5.2 Erasing stored annunciations and counters – address block 82

The statistical indications (Section 6.4.4, address block 56) are stored in EEPROMs in the device. They are not therefore erased if the auxiliary power supply fails. Additionally, annunciations and the status of the LED memories are stored in NV-RAMs and thus saved provided the back-up battery is operational. These stores can be cleared in block 82. Block 82 is called up by paging with the keys $\uparrow$ or $\downarrow$ or directly by keying in the code **DA 8 2 0 0 E**. With the exception

of resetting the LED indications (address 8201), codeword entry is necessary to erase the stored items. Reset is separate for the different groups of counters, memories and annunciations. One reaches the individual items by paging $\uparrow \downarrow$. Erasure requires confirmation with the key **J/Y**. The display then confirms the erasure. If erasure is not required, press key **N** or simply page on.

$\uparrow \downarrow$ 8 2 0 0 ■
R E S E T

Beginning of block "Reset"

$\uparrow \downarrow$ 8 2 0 1 ■ R E S E T
L E D ?

Request whether the LED memories should be reset

$\uparrow \downarrow$ 8 2 0 2 ■ R E S E T
O P E R A T . A N N U N C . ?

Request whether the operational annunciation buffer store should be erased

$\uparrow \downarrow$ 8 2 0 3 ■ R E S E T
F A U L T A N N U N C . ?

Request whether the fault annunciation buffer and fault recording stores should be erased

$\uparrow \downarrow$ 8 2 0 4 ■ R E S E T
C O U N T E R S ?

Request whether the CB operation counters should be set to zero

$\uparrow \downarrow$ 8 2 0 5 ■ R E S E T
T O T A L I s c ?

Request whether the total of switched short-circuit currents should be set to zero

During erasure of the stores (which may take some time) the display shows TASK IN PROGRESS. After erasure the relay acknowledges erasure, e.g.

8 2 0 2 ■ R E S E T
E X E C U T E D

6.5.3 Off/On control of part functions of the device

During operation of the protection relay it may be desired to control the relay manually or from system criteria, temporarily to switch off partial functions of the relay or to switch them on only under specific conditions. Examples may be the switching off of the tele-protection function during maintenance or repair of the transmission medium or the switching on or off of the auto-reclose system when a transfer bus is being used, dependent upon whether a transformer or line branch is switched to the transfer.

7SA513 allows partial functions to be switched on or off via binary inputs or manual operation via the integrated operator panel or via the operating interface at the front using a personal computer.

For switching via binary inputs it is, of course, necessary that the binary inputs have been marshalled to the corresponding switching functions. Furthermore, it must be noted that a binary input is required for each function, switching off and switching on. The switching command is stored in the relay and protected against auxiliary voltage failure (the function of a bi-stable store). The command can be annunciated via an annunciation relay or LED display.

For switching via the integrated operator panel or the front interface, a code word is necessary. The control functions are found at the beginning of the parameter block of each protection or supplementary function. The switch condition shown in the display can be changed over using the "No"–key **N**. The opposite switch condition then appears in the display. Each change of condition must be confirmed with the **E**–key. The change-over is first recorded in the relay when codeword operation has been terminated. This is done by the key combination **F E**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS?". Confirm with the "Yes"–key **J/Y** that the new settings shall become valid now. The switched conditions are then permanently stored in EEPROMs and protected against auxiliary voltage failure; the display confirms "NEW SETTINGS SAVED". If you press the "No"–key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

A function is switched **ON** when the on-command has been given by both the binary input AND also from the operator panel or interface.

A function is switched **OFF** when the off–command is given by EITHER the binary input OR from the operator panel or the operating interface. Thus it is ensured that a partial function can only be switched on from that place where it was previously switched off.

Control inputs which are not marshalled to a binary input are regarded, from that location, as switched on, so that change of the condition is possible from the operator panel or the operating interface.

At the operator panel and the operating interface the factory setting is equally that all partial functions are switched on, so that switching via binary inputs is possible.

The completion of a switching command is, independent of its cause, output as an operational annunciation:

- "(function) off" **Comes** at the instant of switch-off,
- "(function) off" **Goes** at the instant that it is switched on.

These annunciations are listed in block 51 under OPERATIONAL ANNUNCIATIONS and can also be transmitted via the system (LSA) interface to a central computer. Also they can be marshalled as binary outputs; the signal relay then indicates the switched off condition.

For annunciations one must differentiate:

- Direct confirmation of a binary input is available as long as the corresponding binary input is energized. It can be output via a signal relay or LED. In the summary of all annunciations (Appendix C) and in the marshalling tables (Section 5.5), these annunciations are identified with a '>' symbol.
- The completion indication of the switched-off condition is signaled independently of the source of the command. It appears ("Comes") at the instant of switch-off and disappears ("Goes") at the instant of switching on.

The following survey shows the control functions and also indicates which confirmation indications are generated.

	Binary input confirmation	Completion indication ('comes' and 'goes')
1 2 0 1 ■ D I S T . P R O T . ON OFF	Distance protection (without emergency O/C prot.)	3651 Dist. off
2 1 0 1 ■ P U T T ON OFF	Permissive underreach transfer trip mode for distance protection	4021 >Dis.PUTT on 4022 >Dis.PUTT off 4072 PUTT Tele off
2 2 0 1 ■ P O T T ON OFF	Permissive overreach transfer trip mode for distance protection	4011 >Dis.POTT on 4012 >Dis.POTT off 4062 POTT Tele off
2 2 2 0 ■ E C H O ON OFF	Echo function for teleprotection with distance protection (is switched off also together with address 2201)	
2 4 0 1 ■ S W I T C H - O - F ON OFF	High current switch-onto-fault protection	4271 S-O-F off
2 5 0 1 ■ W E A K I N F . ON OFF	Weak-infeed trip function	4221 W/I off
2 6 0 1 ■ E M E R . O / C P ON OFF	Emergency overcurrent time protection for phase currents	2056 Emer.Ph off

2 6 3 1 ■ E M E R O / C E

O N

O F F

Emergency earth overcurrent time protection

2055 Emer. E off

2 9 1 0 ■ F U S E - F A I L

O N

O F F

Fuse failure monitor

3 1 0 1 ■ E / F P R O T E C

O N

O F F

High-resistance earth fault protection for earthed systems; directional stage with non-directional back-up stage (complete functions)

1331 E/F Prot. off

3 2 0 1 ■ E / F C O M P A R

O N

O F F

Directional comparison earth fault protection for earthed systems

1311 >E/F comp. on

1312 >E/F comp.off 1381 E/F Dir off

3 2 1 0 ■ E / F E C H O

O N

O F F

Echo function for directional comparison earth fault protection

(is switched off together with E/F COMPAR)

3 4 0 1 ■ A R F U N C T

O N

O F F

Internal auto-reclose function

2701 >AR on

2702 >AR off

2781 AR off

3 5 0 1 ■ S Y N C - C H E C K

O N

O F F

Internal synchronism and voltage check function

2901 >Sync. on

2902 >Sync. off

2931 Sync. off

Attention! When the internal synchronism and voltage check function is switched off, each closing command is released without any check!

3 5 2 1 ■ S Y N . M A N . C L
O N
O F F

Internal synchronism and voltage check during manual close

(is switched off together with address 3501)

3 6 0 1 ■ B A C K O / C P
O N
O F F

Back-up phase overcurrent time protection

2406 Backup Ph off

3 6 3 1 ■ B A C K O / C E
O N
O F F

Back-up earth overcurrent time protection

2405 Backup E off

3 7 0 1 ■ U > S T A G E
O N
O F F

Overvoltage protection U> stage

4301 >U> Prot. on

4302 >U> Prot. off 4325 U> off

3 7 1 1 ■ U > > S T A G E
O N
O F F

Overvoltage protection U>> stage

4304 >U>>Prot. on

4305 >U>>Prot. off 4328 U>> off

3 9 0 1 ■ B / F P R O T .
O N
O F F

Circuit breaker failure protection

1401 >B/F on

1402 >B/F off 1451 B/F off

6.5.4 Information to LSA during test operation – address block 83

When the relay is connected to a central storage device or localized substation automation system and the protocol according VDEW/ZVEI (IEC 60870–5–103) is used, then the informations which are transmitted to the central computing system can be influenced.

The standardized protocol allows all annunciations, messages, and measured values to be tagged with the origin "test operation", which occur while the relay is tested. Thus, these messages can be distinguished from those which occur during real operation. Additionally, it is possible to block all annunciations, messages and measured values to LSA during test operation.

This features can be accomplished via binary inputs or using the integrated operating keyboard or via the operating (PC) interface.

In order to accomplish switch-over via binary inputs, the respective inputs must have been assigned during marshalling (refer to Section 5.5.2). The following input functions are suitable:

FNo 15 >Sys-Test for tagging the messages and measured values with the origin "Test operation",

FNo 16 >Sys-MM-block for blocking all messages and measured values.

In order to carry out switch-over by the operator, entry of the codeword is necessary (refer to Section 5.3.1). For this purpose, address block 83 is available provided the VDEW/ZVEI protocol (acc. IEC 60870–5–103) has been chosen during configuration of the serial system interface (Section 5.3.3, address 7221 and/or 7222 VDEW COMPATIBLE or VDEW EXTENDED). The block is called up by paging with the keys ↑ or ↓ or directly by keying in the code **DA 8300 E**. Use key ↑ to scroll to address 8301. By pressing the "No"-key **N** the positions of this switch are changed. The desired position must be confirmed with the enter key **E**.

As with every settings of the device for which codeword input is necessary, codeword operation must be terminated. This is done by using the key combination **F E**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS?". Confirm with the "Yes"-key **J/Y** that the new settings shall become valid now. If you press the "No"-key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

8 3 0 0 ■ S Y S - V D E W
A N N U N C . - M E A S . V A L

Beginning of block "Annunciations and measured values for the system interface with VDEW/ZVEI compatible protocol (IEC 60870–5–103)"

8 3 0 1 ■ S Y S T E S T
O F F
O N

Only for VDEW/ZVEI compatible protocol (IEC 60870–5–103):

in **ON** position, the VDEW/ZVEI-compatible annunciations (IEC 60870–5–103) are assigned with the origin "test operation"

8 3 0 2 ■ S Y S B L O C K
O F F
O N

Only for VDEW/ZVEI compatible protocol (IEC 60870–5–103):

in **ON** position, no annunciations and measured values are transmitted to the system interface

Do not forget to switch the addresses back to OFF after having finished test operations!

6.5.5 Selection of parameter sets – address block 85

Up to 4 different sets of parameters can be selected for the functional parameters, i.e. the addresses above 1000 and below 4000. These parameter sets can be switched over during operation, locally using the operator panel or via the operating interface using a personal computer, or also remotely using binary inputs or the system interface.

The first parameter set is identified as set A, the other sets are B, C and D. Each of these sets has been set during parameterizing (Section 6.3.1.2) provided the switch-over facility is used.

6.5.5.1 Read-out of settings of a parameter set

In order to **look up** the settings of a parameter set **in the display** it is sufficient to go to any address of the function parameters (i.e. addresses above 1000 and below 4000), either by direct addressing using key **DA**, entering the four-figure address code and terminating with enter key **E**, or by paging through the display with $\uparrow$ or $\downarrow$. You can switch-over to look up a different parameter set, e.g.

- Press key combination **F 2**, i.e. first the function key **F** and then the number key **2**. All displayed parameters now refer to parameter set B.

The parameter set is indicated in the display by a leading character (A to D) before the address number indicating the parameter identification.

The corresponding procedure is used for the other parameter sets:

- Key combination **F 1**:
access to parameter set **A**
- Key combination **F 2**:
access to parameter set **B**
- Key combination **F 3**:
access to parameter set **C**
- Key combination **F 4**:
access to parameter set **D**

The relay operates always with the active parameter set even during read-out of the parameters of any desired parameter set. The change-over procedure described here is, therefore, only valid for **read-out** of parameters **in the display**.

6.5.5.2 Change-over of the active parameter set from the operating panel

For **change over to a different parameter set**, i.e. if a different set shall be activated, the address block 85 is to be used. For this, codeword entry is required.

The block for processing parameter sets is reached by pressing the direct address key **DA** followed by the address **8 5 0 0** and enter key **E** or by paging through the display with $\uparrow$ or $\downarrow$. The heading of the block will appear:



Beginning of the block "Parameter change-over":
processing of parameter sets

It is possible to scroll through the individual addresses using the $\uparrow$ key or to scroll backwards with $\downarrow$.

Address 8501 shows the actually active parameter set with which the relay operates.

In order to switch over to a different parameter set scroll on with $\uparrow$ to address 8503. Using the "No"–key **N** you can change to any desired parameter set; alternatively, you can decide that the parameter sets are to be switched over from binary inputs, or via the system interface. If the desired set or possibility appears in the display, press the enter key **E**.

As with every settings of the device for which codeword input is necessary, codeword operation must be terminated. This is done by using the key combination **F E**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS ?". Confirm with the "Yes"–key **J/Y** that the new settings shall become valid now. If you press the "No"–key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.



Address 8501 shows the actually active parameter set



Use the "No" – key **N** to page through the alternative possibilities. The desired possibility is selected by pressing the enter key **E**.

SET B

SET C

SET D

SET BY BIN.INPUT

SET BY LSA CONTR

If you select *SET BY BIN.INPUT*, then the parameter set can be changed over via binary inputs (see Section 6.5.5.3)

If you select *SET BY LSA CONTR*, then the parameter set can be changed over via the system interface

6.5.5.3 Change-over of the active parameter set via binary inputs

If change-over of parameter sets is intended to be carried out via binary inputs, the following is to be heeded:

- Locally (i.e. from the operator panel or from PC via the operating interface), **ACTIVATING** must be switched to *SET BY BIN.INPUT* (refer to Section 6.5.5.2).
- 2 logical binary inputs are available for control of the 4 parameter sets. These binary inputs are designated ">ParamSelec.1" and ">ParamSelec.2" (FNo 7 and 8).
- The logical binary inputs must be allocated to 2 physical input modules (refer Section 5.5.2) in order to allow control. An input is treated as not energized when it is not assigned to any physical input.
- The control input signals must be continuously present as long as the selected parameter set shall be active.

The active parameter sets are assigned to the logical binary inputs as shown in Table 6.2.

A simplified connection example is shown in Figure 6.7. Of course, the binary inputs must be declared in normally open ("NO") mode.

Binary input		causes active set
ParamSelec.1	ParamSelec.2	
no	no	Set A
yes	no	Set B
no	yes	Set C
yes	yes	Set D

no = input not energized
yes = input energized

Table 6.2 Parameter selection via binary input

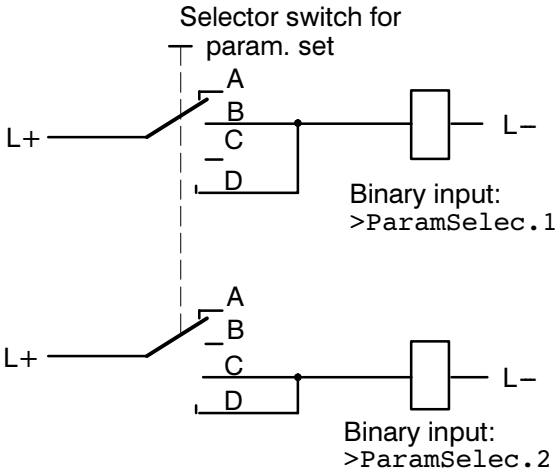


Figure 6.7 Connection scheme for parameter change-over via binary inputs

6.6 Testing and commissioning

6.6.1 General

Prerequisite for commissioning is the completion of the preparation procedures detailed in Chapter 5.



Warning

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

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

Particular attention must be drawn to the following:

- ▶ The earthing screw of the device must be connected solidly to the protective earth conductor before any other connection is made.
- ▶ Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- ▶ Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- ▶ The limit values given in the Technical data (Section 3.1) must not be exceeded at all, not even during testing and commissioning.

When testing the unit with a secondary injection test set, it must be ensured that no other measured values are connected and that the tripping leads to the circuit breaker trip coils have been interrupted.



DANGER!

Secondary connections of the current transformers must be short-circuited before the current leads to the relay are interrupted!

If a test switch is installed which automatically short-circuits the current transformer secondary leads, it is sufficient to set this switch to the "Test" position. The short-circuit switch must be checked beforehand (refer to Section 5.2.6).

It is recommended that the actual settings for the relay be used for the testing procedure. If these values are not (yet) available, test the relay with the factory settings. In the following description of the test sequence the preset settings are assumed unless otherwise noted; for different setting values formulae are given, where necessary.

For the functional test a three-phase symmetrical voltage source with individually adjustable voltage outputs, together with a three-phase symmetrical current source with individually adjustable currents, should be available. For checking the distance zones, AR, teleprotection and back-up overcurrent, a single-phase current source is sufficient, but this is not adequate for a correct functional check of the measured value monitoring systems, power swing detector, and phase selector. Phase displacement between test current I_P and test voltage U_P should preferably be continuously adjustable but at least settings of 90° and 0° shall be available.

If unsymmetrical currents and voltages occur during the tests it is likely that the asymmetry monitoring will frequently operate. This is of no concern because the condition of steady-state measured values is monitored and, under normal operating conditions, these are symmetrical; under short circuit conditions these monitoring systems are not effective. Additionally, unsymmetrical voltages may cause the fuse failure monitor to operate. This switches the distance protection out of service so that distance measurement is not possible! If this happens, this monitoring must either be made ineffective during the test (by switching it OFF under Address 2910) or it must be ensured that during all tests without earth current detection no residual voltage occurs.

NOTE! The accuracy which can be achieved during testing depends on the accuracy of the testing equipment. The accuracy values specified in the Technical data can only be reproduced under the reference conditions set down in IEC 60255 resp. VDE 0435/part 303 and with the use of precision measuring instruments. The tests are therefore to be looked upon purely as functional tests.

During all the tests it is important to ensure that the correct command (trip) contacts close, that the proper indications appear at the LEDs and the output relays for remote signalling. If the relay is con-

nected to a central memory device via the serial interface, correct communication between the relay and the master station must be checked.

After tests which cause LED indications to appear, these should be reset, at least once by each of the possible methods: the reset button on the front plate and via the remote reset relay (see connection diagrams, Appendix A). If the reset functions have been tested, resetting the stored indications is no more necessary as they are erased automatically with each new pick-up of the relay and replaced by the new annunciations.

6.6.2 Testing the voltage and phase angle controlled fault detection $U/I/\varphi$

Close voltage transformer m.c.b.

Testing can be performed with single-phase, two-phase or three-phase test current.

Set test voltage to 0 V.

Slowly increase test current of one phase and earth until the fault detector picks up:

- When the test current exceeds the setting value (address 1611, 0.2 times I_N when delivered), pick-up annunciation occurs for the associated phase(s):
"Dist.Flt.L1E" and LED 10 when delivered for phase L1; for a different phase accordingly (LED 11 for L2, LED 12 for L3).
Switch off test current.

The voltage dependent branches of the pick-up characteristic are shown in Figure 6.8. When delivered the slope of the voltage dependent branch is 0.

The fault detection is dependent of the phase angle, Therefore, test should be carried out with 0° and 90° phase angle between current and voltage.

If voltage control is carried out with U_{Ph-E} , set test voltage of the tested phase to approximately the rated phase-to-earth voltage; set test current of the same phase to twice the setting value $I_{ph>}$ (address 1611). The phase-to-earth voltage is decisive for pick-up.

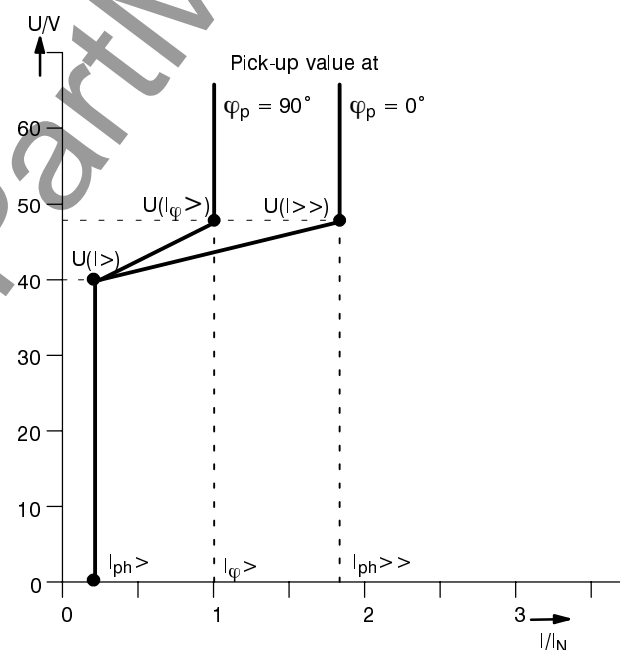


Figure 6.8 Voltage controlled fault detection, $U/I/\varphi$ characteristic

With phase displacement $\varphi_P = 0^\circ$ between test current and test voltage, slowly decrease voltage until the fault detector picks up:

- When the test voltage goes below the set value of address 1612/1613 (48 V at delivery) pick-up annunciation occurs for the associated phase: "Dist.Flt.L1E" and LED 10 at delivery for phase L1; for a different phase accordingly ("Dist.Flt.L2E" and LED 11 for L2, "Dist.Flt.L3E" and LED 12 for L3).
Readjust test voltage to rated voltage.

If voltage control is carried out with U_{Ph-Ph} , set test voltage of the tested loop to approximately the rated voltage; set test current of both the phases to twice the setting value $I_{ph>}$ (address 1611); phase displacement $\varphi_P = 0^\circ$ between test current and test voltage. The phase-to-phase voltage is decisive for pick-up.

Slowly decrease voltage until the fault detector picks up:

- When the test voltage gets smaller than the set value of address 1614/1615 (80 V at delivery) pick-up annunciation occurs for both the associated phases: "Dist.Flt.L12" and LED 10 and LED 11 at delivery for phase loop L1–L2; for a different loop accordingly "Dist.Flt.L23" and LED 11 and LED 12 for phase loop L2–L3, "Dist.Flt.L13" and LED 12 and LED 10 for phase loop L1–L3).

Readjust test voltage to rated voltage.

The procedure described above is valid for the pre-set values of $Uphe(I>)$ (address 1612), $Uphe(I>)$ (address 1613), $Uphph(I>)$ (address 1614) and $Uphph(I>)$ (address 1615). In this case the slope of the voltage dependent branch of the pick-up characteristic is 0, i.e. $Uphe(I>)> = Uphe(I>)$ and $Uphph(I>)> = Uphph(I>)$.

If the voltage dependent branch is inclined, the expected pick-up value of the voltage can be calculated according the following formula, provided the test current is 2 times the setting value of $I_{ph>}$:

$$\text{Pick-up value } U = U(I>) + [U(I>)> - U(I>)] \cdot \frac{I_{ph>}}{I_{ph>}> - I_{ph>}}$$

where:

$U(I>)$ is the setting value $Uphe(I>)$ (address 1613) with U_{ph-e} control but $Uphph(I>)$ (address 1615) with U_{ph-ph} control,

$U(I>)>$ is the setting value $Uphe(I>)>$ (address 1612) with U_{ph-e} control but $Uphph(I>)>$ (address 1614) with U_{ph-ph} control.

The overcurrent branches $I>>$ are tested with applied rated voltage.

Setting parameter $I_{ph>>}$ (address 1610) is decisive for the phase currents when they have equal phase with the voltages. For setting values up to $4 \times I_N$, the current can be increased gradually in any phase until the stage picks up.



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

When, for test current phase–earth, the set value for $I_{ph>>}$ (factory setting $1.8 \times I_N$) is exceeded the pick-up indication for $I_E>$ (LED13 at factory setting) and pick-up indication appears for the tested phase (LED 10 for L1 or LED 11 for L2 or LED 12 for L3 at factory setting). When testing phase–phase, pick-up indication appears for the associated phases.

Switch off test current. Set phase displacement to 90° (current lagging).

Setting parameter $I_{\varphi>}$ (address 1616) is decisive for the phase currents when the phase displacement against the voltages is 90° (current lagging). The current is increased in any convenient phase and earth until the stage picks up.

When, for test current phase–earth, the set value for $I_{\varphi>}$ (address 1616, factory setting $0.5 \times I_N$) is exceeded the pick-up indication for $I_E>$ (LED13 at factory setting) and pick-up indication appears for the tested phase (LED 10 for L1 or LED 11 for L2 or LED 12 for L3 at factory setting). When testing phase–phase, pick-up indication appears for the associated phases.

Switch off test current.

Final times are normally tested at $2 \times$ setting value. Dependent upon polarity of the voltage, directional final time T4 or non-directional final time T5 will apply (address 1203 or 1204; consider also address 1202 for directional trip). It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

Put voltage transformer m.c.b. in tripped position. Repeat time measurement for one phase. Now, the delay time for emergency back-up operation is applicable: $T-I>$ or $TIEp$ (address 2613 or 2615), $T-I>>$ (address 2603), $T-IE>$ or $TIEp$ (address 2643 or 2645). A prerequisite is that the function EM-ERG. O/C = EXIST (address 7826) in the scope of functions (Section 5.4.2) and this function is switched ON under address 2601 and/or 2631.

6.6.3 Testing the impedance fault detection ZA

Close voltage transformer mcb.

Always apply three-phase test voltage; ensure clockwise phase rotation!

Feed a test current $I_P = 2 \cdot I_N$ into the loop under test. If the test voltage would exceed rated voltage when the threshold is reached, reduce test current, but only so far that operation of minimum current detection $I_{ph>}$ (address 1621) is guaranteed. The test current must be kept constant during a test!

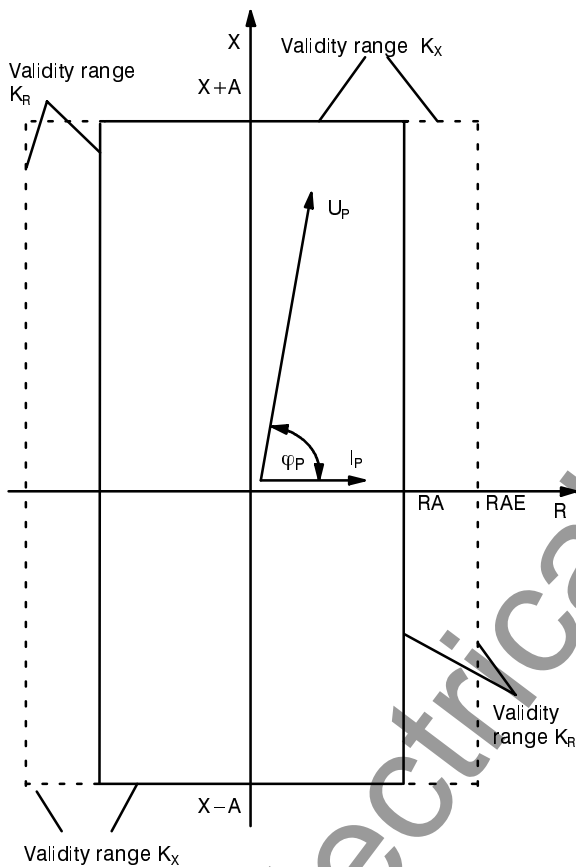


Figure 6.9 Impedance fault detection characteristic

Determine the threshold point by slow reduction of the voltage. Check indicators and outputs. Since the fault detection polygon is made up of straight lines (Figure 6.9) different formulae must be used for the threshold voltages dependent upon the intersections of these lines. The general formulae are:

– For the reactance intersections (X–reach)

$$U_P/V = K_X \cdot X_{\pm A} \cdot I_P/I_N$$

– For the resistance intersections (R–limitation)

$$U_P/V = K_R \cdot R_A \cdot I_P/I_N$$

where I_P – test current
 I_N – rated current of relay
 U_P – test voltage at threshold in volts
 $X_{\pm A}$ – setting value $X+A$ for X–axis positive or setting value $X-A$ for X–axis negative
 R_A – setting value RA or RAE , for $+R$ –axis is positive, for $-R$ –axis negative
 K_X – factor for X intersection according Table 6.4
 K_R – factor for R intersection according Table 6.4

For phase-to-earth testing, the test current is applied to one phase and the earth current path. When none of the additional measured current inputs is provided for the earth current, then the test current is applied to one phase only; the protection calculates the earth current from the phase currents in this case. Test voltage is the phase-to-earth voltage.

For testing phase-to-phase the current must flow through the tested phases in opposite directions. Test voltage is the phase-to-phase voltage. It is essential to ensure absolute symmetry of the two phase voltages, otherwise error will occur!

For three-phase testing, it is reasonable to measure one phase-to-earth voltage and the associated phase current.

with fault type	$\varphi_P = 0^\circ$	$\varphi_P = 90^\circ$	$\varphi_P = 180^\circ$	$\varphi_P = 270^\circ = -90^\circ$
3–phase	$U_P = 12 \text{ V}$	$U_P = 24 \text{ V}$	$U_P = 12 \text{ V}$	$U_P = 5 \text{ V}$
2–phase	$U_P = 24 \text{ V}$	$U_P = 48 \text{ V}$	$U_P = 24 \text{ V}$	$U_P = 10 \text{ V}$
1–phase	$U_P = 48 \text{ V}$	$U_P = 48 \text{ V}$	$U_P = 48 \text{ V}$	$U_P = 10 \text{ V}$

Table 6.3 Test voltages U_P with test current $I_P = 2 \cdot I_N$ and presetting

with fault type	K_X		K_R	
	$\varphi_P = 90^\circ/270^\circ$	general	$\varphi_P = 0^\circ/180^\circ$	general
3-phase	1	$\frac{1}{\sin \varphi_P}$	1	$\frac{1}{\cos \varphi_P}$
2-phase	2	$\frac{2}{\sin \varphi_P}$	2	$\frac{2}{\cos \varphi_P}$
1-phase	$1 + X_E/X_L$	$\frac{1 + X_E/X_L}{\sin \varphi_P}$	$1 + R_E/R_L$	$\frac{1 + X_E/X_L}{\cos \varphi_P}$

Table 6.4 Test factors K_X and K_R for individual settings

For the factory set values and $I_P/I_N = 2$ the resultant voltages will be as Table 6.3.

If different values have been set for RA1 (address 1624) and RA2 (address 1625) then RA1 is valid for phase angles between $-\text{PHI A}$ and $+\text{PHI A}$ (address 1628), and between the complement angles $180^\circ - \text{PHI A}$ and $180^\circ + \text{PHI A}$. For other phase angles, setting value RA2 is decisive.

If different values have been set for RA1E (address 1626) and RA2E (address 1627) then RA1E is valid for phase angles between $-\text{PHI AE}$ and $+\text{PHI AE}$ (address 1629), and between the complement angles $180^\circ - \text{PHI AE}$ and $180^\circ + \text{PHI AE}$. For other phase angles, setting value RA2E is decisive.

Table 6.4 gives the factors K_X and K_R for your own settings, for test angles $\varphi_P = 90^\circ$ and 0° , and the generally applicable formulae.

6.6.4 Testing the distance zones

Always apply three-phase test voltage; ensure clockwise phase rotation. Keep the voltage(s) in the untested phase(s) at approximately rated value.

Feed a test current $I_P = 2 \cdot I_N$ into the loop under test. If the test voltage would exceed rated voltage when the threshold is reached, reduce test current, but only so far that operation of the minimum current detection, $I_{ph} >$ is guaranteed (address address 1611 or 1621). The test current must be kept constant during a test!

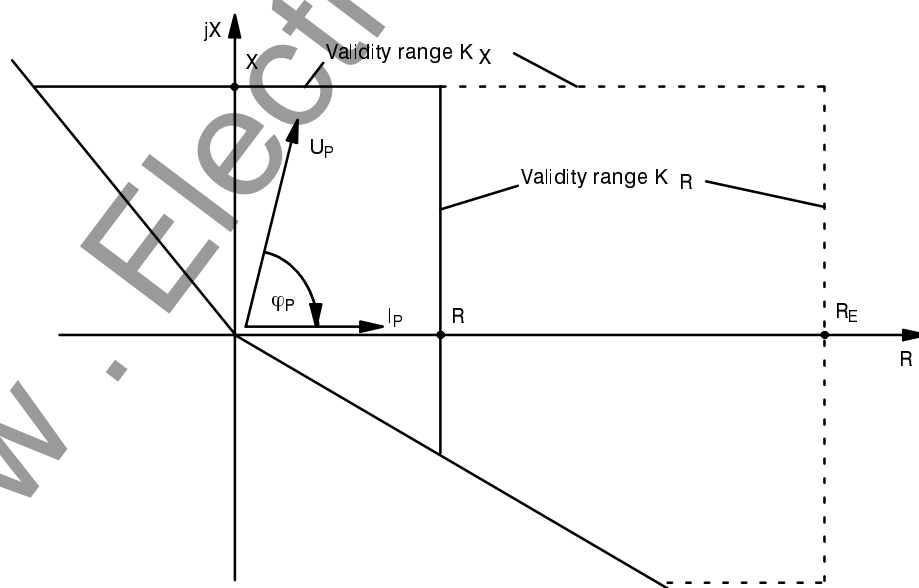


Figure 6.10 Distance zone characteristics

Determine the threshold point by slow reduction of the voltage. Check indicators and outputs. Since the tripping polygon is made up of straight lines (Figure 6.10), different formulae must be used for the threshold voltages dependent upon the intersection of these lines. The general formulae are:

- For the reactance intersections (X–reach)

$$U_P/V = K_X \cdot X_{Zone} \cdot I_P/I_N$$

- For the resistance intersections (R–limitation)

$$U_P/V = K_R \cdot R_{Zone} \cdot I_P/I_N$$

where I_P – test current

I_N – rated current of relay

U_P – test voltage at threshold in volts

X_{Zone} – setting value X of the distance zone to be checked

R_{Zone} – setting value R or RE of the distance zone to be checked

K_X – factor for X intersection according Table 6.4

K_R – factor for R intersection according Table 6.4

For phase-to-earth testing, the the test current is applied to one phase and the earth current path. Test voltage is the phase-to-earth voltage.

For testing phase-to-phase the test current must flow through the tested phases in opposite directions. Test voltage is the phase-to-phase voltage. It is essential to ensure absolute symmetry of the two phase voltages, otherwise error will occur!

For three-phase testing, it is reasonable to measure one phase-to-earth voltage and the associated phase current. For the factory set values and $I_P/I_N = 2$ the resultant voltages will be as Tables 6.5 to 6.9.

Table 6.4 gives the factors K_X and K_R for your own settings, for test angles $\varphi_P = 0^\circ$ and 90° , and the generally applicable formulae.

Zone Z3	$\varphi_P = 0^\circ$	$\varphi_P = 90^\circ$
3–phase	$U_P = 10 \text{ V}$	$U_P = 20 \text{ V}$
2–phase	$U_P = 20 \text{ V}$	$U_P = 40 \text{ V}$
1–phase	$U_P = 40 \text{ V}$	$U_P = 40 \text{ V}$

Table 6.5 Test voltages U_P for zone Z3 at $I_P = 2 \cdot I_N$ and pre-setting

Zone Z2	$\varphi_P = 0^\circ$	$\varphi_P = 90^\circ$
3–phase	$U_P = 5 \text{ V}$	$U_P = 10 \text{ V}$
2–phase	$U_P = 10 \text{ V}$	$U_P = 20 \text{ V}$
1–phase	$U_P = 20 \text{ V}$	$U_P = 20 \text{ V}$

Table 6.6 Test voltages U_P for zone Z2 at $I_P = 2 \cdot I_N$ and pre-setting

Zone Z1	$\varphi_P = 0^\circ$	$\varphi_P = 90^\circ$
3–phase	$U_P = 2.5 \text{ V}$	$U_P = 5 \text{ V}$
2–phase	$U_P = 5 \text{ V}$	$U_P = 10 \text{ V}$
1–phase	$U_P = 10 \text{ V}$	$U_P = 10 \text{ V}$

Table 6.7 Test voltages U_P for zone Z1 at $I_P = 2 \cdot I_N$ and pre-setting

Overreach zone Z1B can only be checked under steady-state conditions, when an input relay has been allocated to the input function ">Extens Z1B" and is energized (FNo 3611, not allocated at delivery).

Zone Z1B	$\varphi_P = 0^\circ$	$\varphi_P = 90^\circ$
3–phase	$U_P = 3 \text{ V}$	$U_P = 6 \text{ V}$
2–phase	$U_P = 6 \text{ V}$	$U_P = 12 \text{ V}$
1–phase	$U_P = 12 \text{ V}$	$U_P = 12 \text{ V}$

Table 6.8 Test voltages U_P for zone Z1B at $I_P = 2 \cdot I_N$ and pre-setting

Overreach zone Z1L can only be checked under steady-state conditions, when an input relay has been allocated to the input function ">Extens Z1L" and is energized (FNo 3612, not allocated at delivery).

Zone Z1L	$\varphi_P = 0^\circ$	$\varphi_P = 90^\circ$
3–phase	$U_P = 4 \text{ V}$	$U_P = 8 \text{ V}$
2–phase	$U_P = 8 \text{ V}$	$U_P = 16 \text{ V}$
1–phase	$U_P = 16 \text{ V}$	$U_P = 16 \text{ V}$

Table 6.9 Test voltages U_P for zone Z1L at $I_P = 2 \cdot I_N$ and pre-setting

6.6.5 Testing the grading times

For each time stage at least one additional dynamic test should be made to check the correct signalling of the time stages. For this purpose a short circuit approximately in the middle of two zones would be simulated.

When measuring the response times, do not forget that the programmed values are delay times. The inherent measurement and trip time of the relay is additional.

6.6.6 Testing the signal transmission functions

When programming the scope of the functions of the relay (Section 5.4.2.) it is decided whether the distance protection operates with permissive underreach transfer trip or permissive overreach transfer trip or both, or if no teleprotection will be used (address 7821). When using a teleprotection feature, transmission and receiver circuits must be checked. Since correct function of the overreaching zone is a prerequisite, the auto-reclose function – as far as available and configured *EXIST* (address 7834, refer also to Section 5.4.2) – should be switched off (address 3401). Communication between the devices and the carrier channel will be checked during commissioning with primary values (see Section 6.7.5).

6.6.6.1 Permissive underreach procedures

The permissive underreach function must be switched on (address 2101 PUTT = ON). Simulate a short circuit in zone Z1. For the duration of the command, respectively extended by transmission signal prolongation T-SEND-PRL (address 2103) the transmission signal appears.

With permissive underreach transfer trip in zone Z1B (address 2102 PUTT MODE = *Z1B ACCELERATION*) simulate a short circuit in Z1B, but beyond Z1. Tripping results immediately the received signal ">Dis.Recept.U" (FNo 4024) appears (respectively in T1B) or, without received signal, first in a delayed stage.

For the condition permissive underreach transfer trip by fault detection (address 2102 PUTT MODE = *FD ACCELERATION*) the relay must trip immediately upon receipt of the signal ">Dis.Recept.U" (FNo 4024), as long as it has already picked up.

6.6.6.2 Permissive overreach procedures

The permissive overreach function must be switched on (address 2201 POTT = ON). The transmission signal is checked by simulation of a short circuit in the applicable zone:

- With the release procedures POTT MODE = *Z1B RELEASE* or *Z1B UNBLOCK* (address 2202), a short circuit is simulated in Z1B;
- with POTT MODE = *FD DIREC RELEASE* or *FD UNBLOCK*, fault detection in the forward direction is simulated;
- with the blocking procedure POTT MODE = *Z1B BLOCKING* or *PILOT WIRE COMP*, a short circuit in the reverse direction is simulated.

In all these cases, the transmitting relay closes its working contact.

Similarly, to check the receiver circuit, a short circuit is simulated and simultaneously an external binary input ">Dis.Recept.O" (FNo 4014) is energized, as follows:

- with POTT MODE = *Z1B RELEASE* or *Z1B UNBLOCK* (address 2202), a short circuit in Z1B but beyond Z1: immediate trip results (respectively T1B);
- with POTT MODE = *FD DIREC RELEASE* or *FD UNBLOCK* within the fault detection zone, beyond Z1B: immediate trip results;
- with POTT MODE = *Z1B BLOCK* or *PILOT WIRE COMP* or *REVERSE INTERLOCK*, within Z1B but beyond Z1: tripping can only occur in a higher stage.

6.6.7 Testing the user definable logic functions

The operation of the user definable logic functions is widely dependent of the application. The input condition have to be produced in accordance with the intended function, and the output conditions must be checked.

When measuring the delay times, it must be noted that the set time (pick-up and/or drop-off) delays do not include the inherent time of the input and output modules; these are additional.

6.6.8 Testing the weak-infeed trip function

For testing the weak-infeed trip function, address 7825 WEAK INFEED must be switched to *EXIST* and in address 2501 WEAK INF = *ON*.

The weak-infeed trip function is activated by the binary input ">W/I Rec." (FNo 4206).

Apply three-phase symmetrical measured voltage; energize the binary input (FNo 4206): No trip will occur. De-energize input.

Switch off measured voltages; energize binary input: instantaneous trip will occur. De-energize input.

6.6.9 Testing the emergency overcurrent time protection

For testing the emergency overcurrent time protection the voltage transformer secondary protective m.c.b. must be switched to trip position. Address 7826 EMERG. O/C must be switched to *EXIST*.

6.6.9.1 Testing the high-set overcurrent stages $I_{>>}$, $I_{E>>}$

In order to test the phase current stages, this function must be switched on, i.e. address 2601 EMER.O/C P = *ON*, for earth current test, address 2631 EMER.O/C E = *ON*.

Testing can be performed with single-phase, two-phase or three-phase test current.



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

For testing the $I_{>>}$ stages, therefore, measurement shall be performed dynamically. It should be stated that the relay picks up at 1.1 times setting value and does not at 0.9 times setting value.

When the test current is injected via one phase and the earth path and the set value for $I_{E>>}$ (address 2632) is exceeded, the pick-up indication for $I_{E>>}$ appears; with increase above the pick-up value of the phase current stage (address 2602 $I_{>>}$), pick-up indication appears for the tested phase.

After expiry of the time delay (address 2633 T- $I_{E>>}$ for the earth current path, address 2603 T- $I_{>>}$ for the phase path), trip signal is given.

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

6.6.9.2 Testing the definite time overcurrent stages $I_{>}$, $I_{E>}$

For these tests the related functions must be switched on (as above), furthermore, the *DEFINITE TIME* mode must be selected in addresses 2611 and/or address 2641.

Testing can be performed with single-phase, two-phase or three-phase test current.

When the test current is injected via one phase and the earth path and the set value for $I_{E>}$ (address 2642) is exceeded, the pick-up indication for $I_{E>}$ appears; with further increase above the pick-up value of the phase current stage (address 2612 $I_{>}$), pick-up indication appears for the tested phase.

After expiry of the time delay (address 2643 T- $I_{E>}$ for the earth current path, address 2613 T- $I_{>}$ for the phase path), trip signal is given.

The reset value should lie at 95% of the pick-up value.

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

6.6.9.3 Testing the inverse time overcurrent time protection stages I_p , I_{Ep}

For these tests the related functions must be switched on (address 2601 and/or 2631), furthermore, one of the *INVERSE* time modes must be selected in addresses 2611 and/or address 2641.

Testing can be performed with single-phase, two-phase or three-phase test current.

For test current below $4 \times I_N$, slowly increase the test current over one phase and earth until the protection picks up.



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

When the test current is injected via one phase and the earth path and the set value for I_{Ep} (address 2644) is exceeded by approx. 1.1, the pick-up indication for I_{Ep} appears; with further increase above 1.1 times the set value of the phase current stage (address 2614 I_p), pick-up indication appears for the tested phase.

The time delay depends on which characteristic has been selected in addresses 2641 and/or 2611 and the set time multiplier in addresses 2645 and/or 2615. The expected time delays can be calculated from the formulae given in the technical data or read from the characteristic curves in Figure 3.1. Observe thermal capability in this case, too!

6.6.10 Testing the high-resistance earth fault protection for earthed systems (if fitted)

This protective function – if fitted – can be programmed as directional earth fault protection with or without directional comparison and with non-directional back-up stage (address 7831, see Section 5.4.2.).

Before testing the earth fault protection, the distance protection shall be switched off (address 1201 DIST. PROT = OFF), so that it will not pick up (pick-up of the distance protection may block the earth fault protection according address 3116!). The earth fault protection must be switched on (address 3101 E/F PROTEC = ON). At first, directional comparison is switched off (address 3201 E/F COMPAR = OFF).

The non-directional earth fault protection can operate as definite time overcurrent protection or inverse time overcurrent protection with three standardized characteristics (address 3102). At first, the non-directional stage is checked by slowly raising the earth current; if the earth current path of the relay is not connected to the star point of the current transformer set, then one phase current is raised.



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

When set as definite time overcurrent protection and the set value for $I_{E>}/I_{Ep}$ (address 3103) is exceeded the pick-up indication "E/F Flt $I_{E<->}$ " (FNo 1353) appears. After expiry of the time delay (address 3108 T-NON-DIR), trip signal is given.

When set as inverse time overcurrent protection and the set value for $I_{E>}$ (address 3103) is exceeded by approx. 1.1, the pick-up indication "E/F Flt $I_{E<->}$ " (FNo 1353) appears. The time delay depends on which characteristic has been selected in addresses 3102 and the set time multiplier in addresses 3108. The expected time delays can be calculated from the formulae given in the technical data or read from the characteristics in Figure 3.2. Observe overload capability of the measured current inputs during these tests, too!

It must be noted that the set times are pure delay times in definite time mode; operating times of the measurement functions are not included.

To test the directional stage a polarizing voltage or current is necessary. If address 1109 is set as U_x CONNECT = $U_{en TRANSF}$, the voltage from the residual voltage winding is applied to the measured value input or, a single-phase voltage will be applied to the phase into which the current is fed. It must be remembered that current and voltage in that same phase must be in phase opposition so that the relay trips in the "forwards" direction (annunciation "E/F T->", FNo 1352). The test procedure is the same as with the non-directional stage above.

When testing with a polarizing current, no voltage is applied to the relay. A phase-equal current is injected in the measured value input for the star-point current. If address 1111 I4 CONNECT is set to STAR POINT, then this input is used for the polarizing current; if address 1114 I5 CONNECT is set to STAR POINT, then this input is used for the polarizing current. The test procedure is the same as with the non-directional stage above.

If the zero sequence voltage time protection mode is used, the applied inverse time trip characteristic can be checked. The expected trip time can be calculated from the formula given in the technical data (Section 3.9) or read from the characteristic curves in Figure 3.3. If an additional delay is set (address 3106 or 3108), this is to be considered when calculating the expected trip time.

If directional comparison is also carried out the transmission circuit can be simultaneously checked: Directional comparison is switched on (address 3201 E/F COMPAR = ON).

The test is performed as with the directional definite time stage. After pick-up on a forward earth fault the transmitting relay for directional comparison "E/F Send" (FNo 1384) is energized.

To check the receiver circuit, a single-phase fault in the forwards direction is similarly simulated, simultaneously with external input of the binary signal ">E/F Recept" (FNo 1316) is applied.



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

Switch distance protection on (address 1201 DIST.PROT. = ON)!

6.6.11 Testing the internal auto-reclose functions (if fitted)

The internal AR function can be programmed to single-pole, three-pole or single/three-pole AR (address 3422), provided it is fitted and configured as INTERNAL AR = *EXIST* (Address 7810, refer to Section 5.4.2) and switched to AR FUNCT = *ON* (Address 3401).

To check the control of the overreach zone properly, the teleprotection function should be switched to PUTT = *OFF* (address 2101) and POTT = *OFF* (address 2201), and address 7921 must be set AR w/o TELE = *YES*.

The binary input "circuit breaker ready" must be simulated unless an open circuit contact has been programmed for this purpose (FNo 2730 ">CB ready", refer also to Section 5.5.2). If binary inputs are allocated to circuit breaker auxiliary contacts, the circuit breaker must be simulated to be closed. Otherwise reclosing may not occur.

Depending of the selected AR program (address 3422 RAR PROG), a single-phase and/or two-phase

short circuit should be simulated within Z1, and beyond Z1 but within Z1B, each time once with successful and once with unsuccessful AR. Check the proper reaction of the relay according to the set AR program.

Note that each new test can begin only after the reclaim time or lock-out time for the previous test has expired; otherwise an auto-reclose cannot result: LED "AR not ready" (FNo 2784, LED 14, as delivered) must not be illuminated.

If the circuit breaker is not ready a reclose attempt must not result; clearance of short circuits beyond Z1 is delayed by T2 or in a later stage. However, a normal AR cycle must occur when the signal "circuit breaker ready" first disappears after the inception of the fault.

If multi-shot auto-reclosure is used, test the function sequence in accordance to the set DAR program and the number of desired shots.

6.6.12 Testing the internal synchronism and voltage check functions (if fitted)

The integrated synchronism and voltage check function can operate with the integrated auto-reclose function or with an external auto-reclosure device. Additionally, synchronism or dead-line check can be performed before manual closing of the circuit breaker. A pre-requisite is, that it is fitted and configured as SYNCH.CHECK = *EXIST* (Address 7835, refer to Section 5.4.2) and switched to SYNC.CHECK = *ON* (Address 3501).

The measured voltage input Ux must be parameterized as connected to the bus-bar voltage U2 (i.e. address 1109 Ux CONNECT = *U2 TRANSFORMER*). It must be considered, which voltage of the bus-bar shall be used. Address 1116 must be matched (*L1-L2, L2-L3, L3-L1, L1-E, L2-E or L3-E*). The corresponding test voltage has to be connected to the Ux-input of the relay.

The start-to-measure signal can be given to the relay via the binary input ">Sync. Start" (FNo 2906). The device checks for close permission according to the check program which is set under the addresses 3515 to 3519. If the check result is positive, close command is released (Annunciation "Sync. Release", FNo 2951).

SYNCHR = YES If the voltage as parameterized under address 1116 is in phase with the Ux-voltage, close command is released; if the voltages are in phase opposition no release occurs.

U1>U2< = YES If the measured feeder voltage (U1) is present but the Ux-voltage (U2) switched off, close command is released.

U1<U2> = YES If the Ux-voltage (U2) is present but the measured feeder voltage (U1) switched off, close command is released.

U1<U2< = YES If the Ux-voltage (U2) and the measured feeder voltage (U1) are both switched off, close command is released.

OVERRIDE = YES Close command is released independent on whether voltages are present or not, or what is the phase relationship.

6.6.13 Testing the back-up overcurrent time protection

For testing the back-up overcurrent time protection address 7836 BACK-UP O/C must be switched to *EXIST*.

6.6.13.1 Testing the high-set overcurrent stages $I_{>>}$, $I_{E>>}$

In order to test the phase current stages, this function must be switched on, i.e. address 3601 BACK O/C P = *ON*, for earth current test, address 3631 BACK O/C E = *ON*.

Testing can be performed with single-phase, two-phase or three-phase test current. Apply rated voltages.



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

For testing the $I_{>>}$ stages, therefore, measurement shall be performed dynamically. It should be stated that the relay picks up at 1.1 times setting value and does not at 0.9 times setting value.

When the test current is injected via one phase and the earth path and the set value for $I_{E>>}$ (address 3632) is exceeded, the pick-up indication for $I_{E>>}$ appears; with increase above the pick-up value of the phase current stage (address 3602 $I_{>>}$), pick-up indication appears for the tested phase.

After expiry of the time delay (address 3633 T- $I_{E>>}$ for the earth current path, address 3603 T- $I_{>>}$ for the phase path), trip signal is given.

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

6.6.13.2 Testing the definite time overcurrent stages $I_{>}$, $I_{E>}$

For these tests the related functions must be switched on (as above), furthermore, the *DEFINITE TIME* mode must be selected in addresses 3611 and/or address 3641.

Testing can be performed with single-phase, two-phase or three-phase test current. Apply rated voltages.

When the test current is injected via one phase and the earth path and the set value for $I_{E>}$ (address 3642) is exceeded, the pick-up indication for $I_{E>}$ appears; with further increase above the pick-up value of the phase current stage (address 3612 $I_{>}$), pick-up indication appears for the tested phase.

After expiry of the time delay (address 3643 T- $I_{E>}$ for the earth current path, address 3613 T- $I_{>}$ for the phase path), trip signal is given.

The reset value should lie at 95 % of the pick-up value.

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

6.6.13.3 Testing the inverse time overcurrent stages I_p , I_{Ep}

For these tests the related functions must be switched on (address 3601 and/or 3631), furthermore, one of the *INVERSE* time modes must be selected in addresses 3611 and/or address 3641.

Testing can be performed with single-phase, two-phase or three-phase test current. Apply rated voltages.

For test current below $4 \times I_N$, slowly increase the test current over one phase and earth until the protection picks up.



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

When the test current is injected via one phase and the earth path and the set value for I_{Ep} (address 3644) is exceeded by approx. 1.1, the pick-up indication for I_{Ep} appears; with further increase above 1.1 times the set value of the phase current stage (address 3614 I_p), pick-up indication appears for the tested phase.

The time delay depends on which characteristic has been selected in addresses 3641 and/or 3611 and the set time multiplier in addresses 3645 and/or 3615. The expected time delays can be calculated from the formulae given in the technical data or read from the characteristic curves in Figure 3.1. Observe thermal capability in this case, too!

6.6.14 Testing the overvoltage protection

For testing the overvoltage protection address 7837 OVERVOLT must be switched to *EXIST*.

The set voltage thresholds are related to the rated voltage: 100 % phase–phase voltage means the voltage which is parameterized as *Un SECOND* under address 1104. 100 % phase–earth voltage means the rated voltage of address 1104 divided by $\sqrt{3}$.

6.6.14.1 Testing the U> stage

In order to test the U> stage, this function must be switched on, i.e. address 3701 U> STAGE = *ON*.

The positive sequence component of the voltages is used for the internal formation of the measured value. Measurements on the voltage protection functions should therefore be performed with three-phase symmetrical measurement values. If asymmetrical values are used, deviations must be expected.

Increase the three-phase symmetrical voltage until the U> stage picks up (address 3703 U>): Annunciation "U> Detection" (FNo 4331).



Caution!

Test voltages larger than 140 V may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability).

After expiry of the time delay (address 3705 T–U>) trip signal is given (annunciation "U> Trip", FNo 4335). Precondition is that local trip has been parameterized (address 3708 U> TRIP = *LOCAL TRIP* or *LOCAL AND SEND*).

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

If the trip signal is to be transferred to the remote line end, the transmission signal must appear, too (annunciation "U> Intertrip", FNo 4339). Precondition is that remote trip has been parameterized (address 3708 U> TRIP = *TRIP SEND* or *LOCAL AND SEND*). The minimum duration of the transmission signal has been set under address 3721 T–SEND–IMP.

The drop-off value corresponds to the reset factor as set under address 3704 U>RESET/U>.

6.6.14.2 Testing the U>> stage

In order to test the U>> stage, this function must be switched on, i.e. address 3711 U>> STAGE = *ON*.

The test voltages must be applied three-phase symmetrical if address 3715 has been set to *AND COMBINED*. If address 3711 has been set to *OR COMBINED*, a single-phase voltage is sufficient, but this must correspond to the setting of address 3712 U>> SELECT, i.e. *PHASE–EARTH* or *PHASE–PHASE*.

When the secondary test equipment is not able to produce voltages as high as necessary to test the pick-up value, then the U>> stage setting must be altered to a lower value (address 3713 U>>).



Caution!

Test voltages larger than 140 V may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability).

Therefore, switch the voltage(s) from 0 V to approximately 1.1 times the set value U>> (address 3713): Annunciation "U>> Detection" (FNo 4332) will appear.

After expiry of the time delay (address 3717 T–U>> CB OFF) trip signal is given (annunciation "U>> Trip", FNo 4336). Precondition is that local trip has been parameterized (address 3720 U>> TRIP = *LOCAL TRIP* or *LOCAL AND SEND*).

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

If the trip signal is to be transferred to the remote line end, the transmission signal must appear, too (annunciation "U>> Intertrip", FNo 4340). Precondition is that remote trip has been parameterized (address 3720 U>> TRIP = *TRIP SEND* or *LOCAL AND SEND*).

Attention! If setting values have been changed for testing, reset to correct values (addresses 3703 and 3713).

6.6.15 Testing the circuit breaker failure protection

For testing the circuit breaker failure protection address 7839 BREAK. FAIL must be switched to *EXIST*. Additionally, this function must be switched on, i.e. address 3901 must be set to B/F PROT = *ON*.

Initiation of the breaker failure protection is performed by the trip command of any desired protection function. It is advisable to use the back-up overcurrent time protection by simulation of a two-phase short-circuit: in this case an a.c. test current is sufficient. The remaining protection functions should be switched off, particularly the distance protection. Besides the breaker failure protection, the overcurrent time protection for phase currents is switched on, for this test procedure, i.e. address 3601 BACK O/C P = *ON*.

The current pick-up value of the breaker failure protection I–B/F (address 3902) must be set smaller than or equal to the pick-up value of the phase current stage of the overcurrent time protection (address 3612 for definite time overcurrent protection or 3614 for inverse time overcurrent protection).

Switch test current from 0 to twice the pick-up value of the overcurrent time protection (address 3612 I> for definite time overcurrent or 3614 I_p for inverse time overcurrent).



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

The overcurrent time protection will pick up and issue a trip command after the set time delay T–I> (address 3613 for definite time overcurrent) or according to the trip time characteristic and time multiplier T–I_p (address 3615 for inverse time overcurrent). This is the start signal for the breaker failure protection.

After expiry of the set time delay T–B/F (address 3903), trip signal is given by the breaker failure protection.

If the breaker failure protection is intended to be initiated (additionally) by an external protection relay, it is necessary to allocate the assigned input functions to binary input modules (FNos 1432 and 1435 to 1437, cf. Section 5.5.2). Check the external initiation as follows.

Produce an initiation signal for each phase:

- FNo 1435 "B/F Start L1" for phase L1,
- FNo 1436 "B/F Start L2" for phase L2,
- FNo 1437 "B/F Start L3" for phase L3.

If initiation should be common for all three phases, then combine the three input functions with one physical input module.

Ensure that the release signal

FNo 1432 "B/F release"

is applied together with the initiation signal(s), because the breaker failure protection will start only with this second channel for safety reasons.

Continue the test in analogy to the procedure above described for the internal initiation by the overcurrent time protection.

6.7 Commissioning using primary tests

All secondary testing sets and equipment must be removed. Reconnect current and voltage transformers. For testing with primary values the line must be energized.



Warning

Primary tests shall be performed only by qualified personnel which is trained in commissioning of protection systems and familiar with the operation of the protected object as well as the rules and regulations (switching, earthing, etc.)

6.7.1 Current, voltage and phase sequence checks

Connections to current and voltage transformers are checked with primary values. For this purpose a load current of at least 10 % of the rated current is necessary. If the measuring circuit connections are correct, none of the measured value monitoring systems in the relay will operate. If a fault indication appears, the possible causes can be found in the operational annunciations (address block 51).

For current sum or voltage sum errors, the matching factors (Section 6.3.3.1) should be checked.

If the symmetry monitoring appears, it is possible that asymmetry is in fact present on the line. If this is a normal operational condition, the corresponding monitoring function should be set at a less sensitive value (Section 6.3.11).

The phase rotation must be clockwise, otherwise the indication "Fail.PhaseSeq" will appear. Check and correct the phase relationships in the measuring circuits. If the network has counter-clock-

wise rotation, two phases must be interchanged. This phase exchange must be taken into account in the setting for double earth fault preference (in isolated or compensated networks, address 1803, Section 6.3.4.6) or for double earth fault treatment (in earthed networks, address 1703, Section 6.3.4.6) and, when appropriate, in the allocation of the individual phase pick-up indications (Section 5.5.2 to 5.5.5).

Currents and voltages can be read off on the display in the front or via the operating interface in block 57 and compared with the actual measured values.

Switch off voltage transformer secondary m.c.b. of the feeder voltage. Check that the voltages indicated in the operational measured values (address block 57) are near 0. Small voltage values can be tolerated.

Check that the relay has recognized the position of the m.c.b.: The message "VT mcb Trip C" must be given in the operational annunciations in address block 51.

In case the bus-bar voltage is connected to the relay in order to obtain synchronism check, also switch off the voltage transformer secondary m.c.b. of the bus-bar voltage. In the operational annunciation (address block 51) the message "U2 mcb Trip C" must occur.

Switch the m.c.b.s on. The above message(s) must occur in address block 5100 again, but with the 'Going' index, e.g. "VT mcb Trip G".

Should one of the messages not be given under the operational annunciation then check the connection of the voltage transformer secondary circuits, and check correct marshalling of the binary inputs from the auxiliary contacts of the m.c.b.s (refer to Section 5.5.2).

If the indices "c" for "Coming" and "G" for "Going" are interchanged, check and correct the contact mode of the binary inputs ("NO" or "NC" contact) in accordance with Section 5.5.2.

6.7.2 Direction check with load current

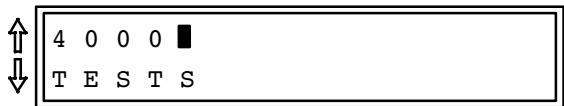
Correct connections of current and voltage transformers are checked using load current over the protected line. The line must be energized and must carry a load current of at least 10 % of the rated relay current; this shall be ohmic or ohmic-inductive. The direction of the load current must be known. In cases of doubt, interconnected or ring networks must be isolated.

Initiation of the test is made via operator keyboard or personal computer. Tests are listed from address

4000, the directional test in Address 4200.

The address is reached:

- directly with key **DA** followed by address number **4 2 0 0** and finally operation of the enter key **E** or
- by paging through the blocks with $\uparrow$ or $\downarrow$ until address 4200 is reached.



Beginning of block "Tests"



Block "Directional tests and impedance measurement"

When the address 4200 appears in the display, the directional test of the individual measurement loops is selected with the key $\uparrow$. For confirmation of the directional test, the "Yes" – key **J/Y** is used; this starts

the directional test. The selected measurement loop carries out a directional check and indicates the result on the display:



Make directional test L1 – E? Confirm with **J/Y**



Load flow forwards

or



load flow backwards

or



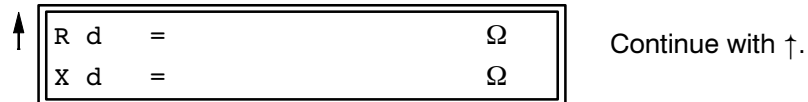
directional determination not possible
(e.g. current too small)

The load direction must be indicated correctly. The next address shows the active and reactive component of the load impedance. The load impedances

allow determination of the position of the load impedance vector in the R/X diagram (Figure 6.11).



After confirmation with the "Yes" – key **J/Y** the load impedance will be calculated and displayed:



The same applies for the other loops: addresses 4203 and 4204 for L2–E, addresses 4205 and 4206 for L3–E, addresses 4207 and 4208 for L1–L2, ad-

resses 4209 and 4210 for L2–L3, addresses 4211 and 4212 for L3–L1, e.g.



All six measurement loops must indicate the correct direction of the load flow. If all directions are wrong, the polarity of the measuring transformers and the programmed polarity (address 1101, Section 6.3.3.1) do not agree with each other. Check the polarity and program correctly. If the directions given in the display differ from each other, the individual phases in the current or voltage transformer connections are interchanged, or the phase relationship is not correct. Check the connections.

If the load is capacitive, caused for example by underexcited generators or charging currents, borderline cases can occur with respect to the directional characteristics which will lead to undefined or inconsistent directional information. By means of the load impedance calculation the position of the load impedance vector can be determined (see Figure 6.11).

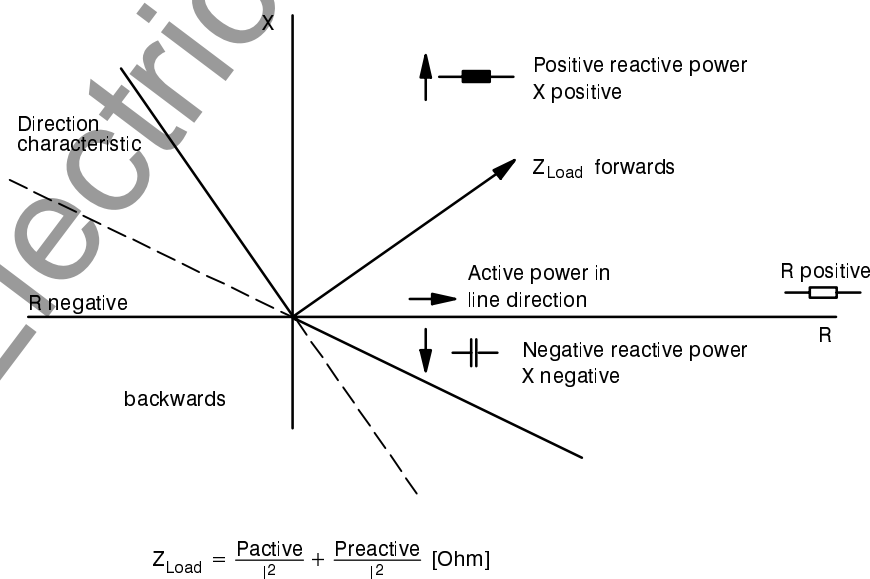


Figure 6.11 Load impedance vector

6.7.3 Direction check for directional earth fault protection (if fitted)

The primary current test allows determination of the correct polarity of transformer connections for the earth fault direction protection. If this function is set as EARTH FAULT = *NON EXIST* (address 7831), or if only the non-directional earth current option is used,

then this directional check becomes superfluous. The distance protection shall be switched off (address 1201 DIST. PROT. = *OFF*), so that it will not interfere with the earth fault protection.

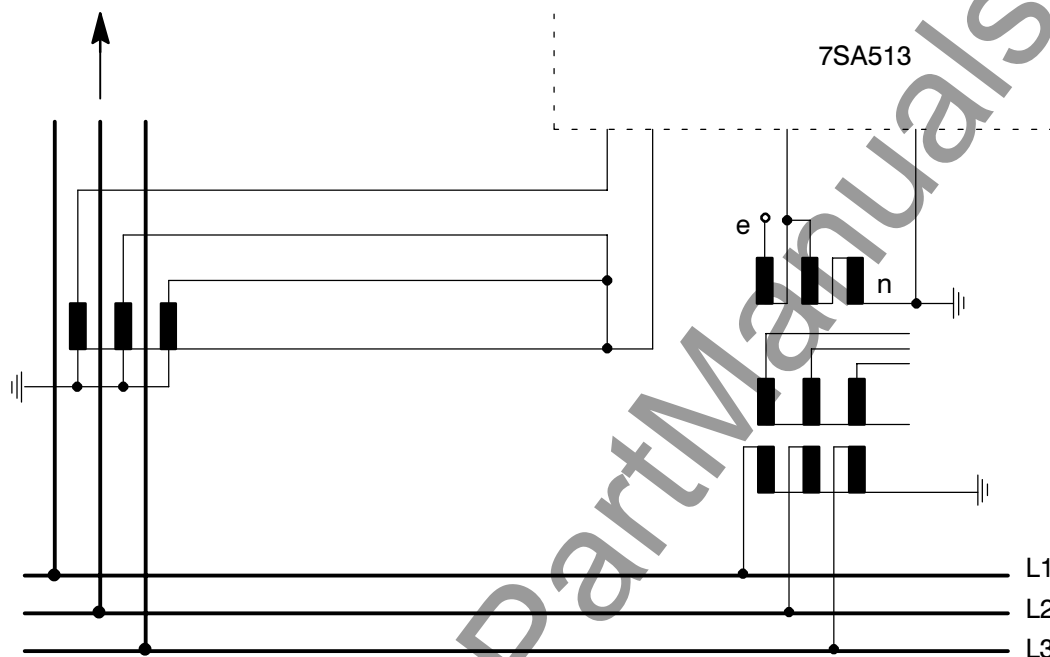


Figure 6.12 Earth fault direction test with Holmgreen connection

The trip circuits should be made inoperative as the relay will issue a trip command during this test. Furthermore, it must be noted, that during all such simulations which do not represent exactly the practical conditions, asymmetry of the measured values can cause the measured value monitors to operate. These annunciations should then be ignored.



DANGER!

All precautionary measures must be observed when working on the instrument transformers! Secondary connections of the current transformers must be short-circuited before any current leads to the relay are interrupted!

The displacement voltage will be derived by bypassing a voltage transformer phase (e.g. L1, see Figure 6.12). If earth detection windings of the voltage transformers are not available, the corresponding phase should be interrupted on the secondary side. In the current circuit, only the current from the cur-

rent transformer corresponding to the phase in which the voltage is missing, will be used. If the line is carrying active and inductive power in line direction, practically the same relationships apply for the relay as with an earth fault in the line direction.

Check the directional indication. In the fault event report on the display panel (address 5200, see also Section 6.4.3) at least the fault annunciation "E/F Flt Ie->" must be indicated and a trip signal. Should directional fault annunciation be missing, then a crossed connection is present in either the current or voltage transformer connections. If no pick-up annunciation occurs the current is probably too low or the phase relationship of the test circuit is not correct. If there is no indication whatsoever, it is possible that the threshold value of the displacement voltage (Address 3104 Ue>) has not been reached.

Finally, **properly reconnect all the transformer connections! Switch distance protection on** (address 1201 DIST.PROT. = *ON*)!

6.7.4 Checking for synchronism and voltage check (if fitted)

6.7.4.1 Preparations

This check should verify the correct polarity of the voltage transformer connections for the synchronism check function. The bus-bar voltage must be connected to the device. The measured voltage U_x must be parameterized correct in the power system data (address 1109 U_x CONNECT = U_2 TRANSFORMER, refer to Section 6.3.3.1).

The voltage which is connected from the bus-bar voltage transformers, must be correctly entered to the relay in address 1116 U_2 -CONNECT (refer to Section 6.3.3.1).

Address 1132 $U_1 - U_2$ ANGLE must be set to 0° if no power transformer is installed between the feeder voltage transformers and the bus-bar voltage transformers (see Section 6.3.3.3).

But, if a power transformer is installed between the feeder voltage transformers and the bus-bar voltage transformers, then this angle must be set in accordance with the phase shifting of the power transformer, seen from the feeder to the bus-bar!

The annunciations FNo 2947 "Sync. U_{diff} >" and FNo 2949 "Sync. φ_{diff} >" form an additional aid for connection check and can be assigned to signal relays or LEDs, or read out in the operational annunciations in address block 51, when the following checks are performed. They are particularly useful when a power transformer is installed between the feeder voltage transformers and the bus-bar voltage transformers, but they may help you generally when hunting a connection error.

The synchronism and voltage check function must be switched to ON under address 3501.

6.7.4.2 Realization

At first, switch off the protective m.c.b.s of both the voltage transformer secondary circuits. Open the main circuit breaker.

Set the synchro-check function to the override program, i.e. address 3519 OVERRIDE = YES. Start synchronism check by energizing the binary start-to-measure input (FNo 2906 ">Sync. Start". The synchro-check function must issue the release command (annunciation "Sync. release", FNo 2951). If not, check all relevant parameters according to the sections 5.4.2, 6.3.3, and 6.3.14.

Set address 3519 OVERRIDE to NO. Next, open the line isolator and close the circuit breaker as to Figure 6.13. Thus, both voltage transformer sets receive the same voltage.

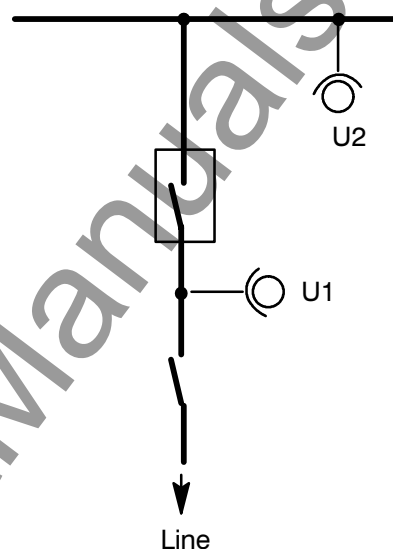


Figure 6.13 Measured voltages for synchronism check

Set the synchronism check function to the synchro-check program, i.e. address 3515 SYNCHR = YES. Start synchronism check by energizing the binary start-to-measure input (FNo 2906 ">Sync. Start". The synchro-check function must issue the release command (annunciation "Sync. release", FNo 2951). If not, check at first whether one of the above mentioned annunciations "Sync. U_{diff} >" or "Sync. φ_{diff} >" has appeared.

If "Sync. U_{diff} >" has appeared, possibly the secondary voltages of the feeder voltage transformers and the bus-bar voltage transformers do not agree, or the primary rated voltages of the voltage transformers on both sides of a power transformer do not agree with the power transformer transformation ratio (when a transformer is installed between the points of voltage measurement).

If "Sync. φ_{diff} >" has appeared, possibly the voltage connected from the bus-bar voltage transformers does not agree with the voltage as parameter-

ized under address 1116 U2–CONNECT (see Section 6.3.3.1). If measurement is carried out over a transformer, check address 1132, too; this parameter matches the connection group of the transformer (cf. Section 6.3.3.3). If these parameters are correct, check and correct the polarity of the voltage transformer connection from the bus-bar voltage.

- Check and correct the connections and parameters. Repeat the test.

Set the synchronism check function to the dead-bus check program, i.e. address 3516 U1>U2< = YES and 3515 SYNCHR = NO. Switch voltage transformer m.c.b. of the bus-bar voltage to tripped position. Start by energizing the binary start-to-measure input (FNo 2906 ">Sync. Start"). No release command occurs. Reclose voltage transformer m.c.b. of the bus-bar voltage.

Open circuit breaker. Set the synchronism check function to the dead-line check program, i.e. address 3517 U1<U2> = YES. Start by energizing the binary start-to-measure input (FNo 2906 ">Sync. Start"). The synchro-check function must issue the release command (annunciation "Sync. release", FNo 2951). If not, check again carefully all connections and parameters relating to the synchronism check function according to Section 6.3.3.1.

Switch voltage transformer m.c.b. of the feeder voltage to tripped position. Start by energizing the binary start-to-measure input (FNo 2906 ">Sync. Start"). No release command occurs.

Reclose voltage transformer m.c.b. of the feeder voltage.

Re-check addresses 3515 to 3519 (in case they were altered for the tests). If the allocation of annunciation to the binary inputs and outputs have been changed for these test, re-adjust and re-check them.

6.7.4.3 Measuring the closing time of the circuit breaker

If asynchronous switching is to be allowed the circuit breaker closing time is measured and set correctly in address 1133 (see also Section 6.3.3.4). A suitable arrangement is shown in Figure 6.14.

The time meter is set to the 1 s range or to a resolution of 1 ms.

Close the circuit breaker manually; the time meter is started at the same time. The voltage U1 appears when the poles of the circuit breakers are closed; the time meter is then stopped. The time indicated on the meter is the circuit breaker closing time.

The experiment must be repeated if the time meter does not stop because of an unfavourable closing instant.

It is best to calculate the mean value from several (3 to 5) successful switching attempts and to set this under address 1133 T–CB CLOSE.

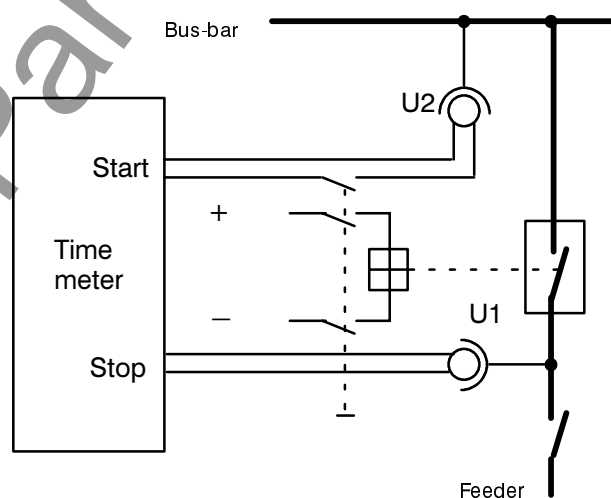


Figure 6.14 Measuring the circuit breaker closing time

6.7.5 Checking the carrier transmission system

All the equipment associated with transmission of signals should be commissioned in accordance with the appropriate documents.

6.7.5.1 Checking overreach zone comparison via pilot wires

This overreaching zone comparison operating mode differs fundamentally from the other teleprotection systems in its transmission method (d.c. current, fail-safe loop). The test procedure is described in the following. If a different teleprotection method is used, this sub-section can be passed over.

In the scope of devices under address 7822 must be set *POTT = EXIST* (refer to Section 5.4.2) and *POTT MODE* (address 2202) must be parameterized as *PILOT WIRE COMP* (refer to Section 6.3.6.2). Furthermore, *POTT* must be switched *ON* in address 2201.

The line protection devices at both line ends must be in operation. At first the auxiliary voltage for the fail-safe current loop around the pilot wires should not be switched on, the additional relays are de-energized.

Simulate a short circuit beyond Z1 but within the overreach zone Z1B. The relay will trip only in one of the higher zones (normally T2). Make this test from both line ends.

Now switch on the d.c. voltage for the fail-safe loop. The additional relays for teleprotection must be in operation. The loop now carries monitoring current, the additional relays at both line ends are energized.

Simulate a short circuit at one line end beyond the first zone but within the overreach zone Z1B. Tripping occurs instantaneously or after T1B (when a delay is set). Make this test also at both line ends.

Since the d.c. monitor is an essential part of the pilot wire system, this test has simultaneously proved that the pilot wires are functioning correctly. The tests described in this section under 6.7.5.2 to 6.7.5.4 become superfluous.

6.7.5.2 Checking reverse interlocking

The test procedure is described in the following. If a different teleprotection method is used, this subsection can be passed over.

In the scope of devices under address 7822 must be set *POTT = EXIST* (refer to Section 5.4.2) and *POTT MODE* (address 2202) must be parameterized as *REVERS INTERLOCK* (refer to Section 6.3.6.2). Furthermore, *POTT* must be switched *ON* in address 2201.

The protection relay on the incoming feeder and those on all outgoing circuits must be in operation. At first the auxiliary voltage for reverse interlocking should not be switched on.

Simulate a short circuit within zone Z1 and within the overreach zone Z1B. If the interlock circuit is carried out in NO mode (fault detection signals from the outgoing feeders are NO and parallel connected), then the relay trips in the (delayed) time T1B because of the absence of the receive signal. If the interlock circuit is carried out in NC mode (fault detection signals from the outgoing feeders are NC and series connected), then the relay trips after the (delayed) time T1.

Now switch on the d.c. voltage for the reverse interlocking. The test as described above is repeated. The relay will trip in the (delayed) time T1B, independent of the connection mode (NO or NC).

Simulate a trip on each protective device on all outgoing feeders. Simultaneously, a short circuit is simulated on the incoming feeder (as described before). Tripping now occurs after delay T1.

These tests have simultaneously proved that the pilot wires are functioning correctly. The tests described in this section under 6.7.5.3 and 6.7.5.4 become superfluous.

6.7.5.3 Checking carrier transmission with release signal

With permissive overreach transfer trip (POTT) using release signal transmission, POTT = *EXIST* in address 7822 (refer to Section 5.4.2) and POTT MODE = *Z1B RELEASE* or *FD DIREC RELEASE* or *Z1B UNBLOCK* or *FD UNBLOCK* (address 2202) must be set. Furthermore, POTT must be switched *ON* in address 2201.

With the release modes, it is simple to check the carrier system from one end of the line with the echo function. Simulate a short circuit in Z1B beyond Z1. Since the relay at the remote line end has not picked up on fault, the echo function will be effective at that end and a trip signal results. The precondition is that the echo function is switched on (address 2220) at both line ends. This test is to be performed from both line ends.

The effect of the echo delay time and the input of the circuit breaker position can be checked at this stage. With the following tests the echo function of the relay at the opposite line end is checked:

The circuit breakers at both line ends must be open. A short circuit is simulated as above. Because of the echo function of the relay at the opposite line end, signal is received and a trip signal occurs at once.

Close the circuit breaker at the opposite line end. Repeat above test once more. Received signal and trip command occur again but now with an additional delay caused by the echo delay time at the opposite line end (0.04 s as delivered, see address 2221).

If delayed and undelayed echo are interchanged the function mode (NO/NC operation) of the binary input for CB position should be wrong. Check and correct it at the opposite line end (refer to Section 5.5.2): When delivered from factory, the input for the CB auxiliary contact is INPUT 3, assigned to the function ">CB Aux1p c1 NO" (refer to Section 5.5.2). Change the function mode from NO to NC: ">CB Aux.1p c1 NC". With different allocation change the mode accordingly.

Open circuit breaker. Repeat these tests for the other line end.

6.7.5.4 Checking carrier transmission with blocking signal

With overreaching transfer mode (POTT) using blocking signal, POTT = *EXIST* in address 7822 (refer to Section 5.4.2) and POTT MODE = *Z1B BLOCKING* (address 2202) must be set. Furthermore, POTT must be switched *ON* in address 2201. An understanding between both line ends is necessary.

At the line end to be tested as sender, simulate a fault in reverse direction; at the other end, simulate a forward fault within zone Z1B but beyond the limit of Z1. Since the transmitter sends a blocking signal, the receiving protection must not trip, unless in a delayed zone, as long as blocking signal is transmitted. After switching off the reverse fault on the sending side the receiving side remains blocked for the send prolongation T-SEND-PRL (address 2206). The transient blocking time T-TRANSBLO (address 2203) of the receiving side may be additional when the waiting time T-WAIT (address 2204) has elapsed provided this time is not set to infinity.

Repeat test for the other transmission direction.

6.7.5.5 Checking carrier transmission with underreach transfer signal

With permissive underreach transfer trip (PUTT), the scope of devices is set PUTT = *EXIST* in address 7821. Furthermore, PUTT must be switched *ON* in address 2101. An understanding between both line ends is necessary.

At the line end to be tested as sender, simulate a fault within zone Z1.

At the receiving end, simulate a fault within zone Z1B but beyond Z1, when set PUTT MODE = *Z1B ACCELERATION* (address 2102). The protection trips at once (or T1B), without reception a delayed stage can only be effective.

At the receiving end, simulate any pick-up, when set PUTT MODE = *FD ACCELERATION* (address 2102). The protection trips instantaneous, without reception in a delayed stage.

Repeat tests for the other transmission direction.

6.7.5.6 Checking carrier transmission for directional comparison earth fault protection (if fitted)

If the directional comparison earth fault protection is set as *EARTH FAULT = DIREC.COMPARISON* in address 7831, carrier transmission must be checked. Switch off distance protection (address 1201 *DIST.PROT. = OFF*).

It is simple to check the carrier system from one end of the line with the echo function. Simulate an earth fault in line direction. Since the relay at the other line end has not picked up on fault, the echo function will be effective at that end and a trip signal results. The precondition is that the echo function is switched on (address 3210) at both line ends. This test is to be performed from both line ends.

The effect of the echo delay time and the input of the circuit breaker position can be checked unless it has already been done under 6.7.5.3. The opposite line end is checked:

The circuit breakers at both line ends must be open. An earth fault is simulated as above. Because of the echo function of the relay at the opposite line end, signal is received and a trip signal occurs at once.

Close the circuit breaker at the opposite line end. Repeat above test once more. received signal and trip command occur again but now with an additional delay caused by the echo delay time of the relay at the opposite line end (0.04 s as delivered, see Address 3211).

Open circuit breaker. Repeat these tests for the other line end.

Switch distance protection on (address 1201 *DIST.PROT. = ON*)!

6.7.5.7 Checking carrier transmission for overvoltage protection

The overvoltage protection must be configured as *OVERVOLT = EXIST* in address 7837 (refer to Section 5.4.2). At least the U> stage must be switched *ON* under address 3701. Furthermore, trip transfer must be parameterized (address 3708 U> *TRIP = TRIP SEND* or *LOCAL AND SEND*).

If only the U>> stage is to be used, the test should be carried out, nevertheless, with the U> stage, because, normally, the pick-up value of the U>> stage is too high.

The U> stage is made pick up. If this is not possible with operational means, then switch off the measured voltages and test with secondary injection.

Check that the transmission signal is sent and received at the remote line end, and that it causes the desired reaction.

Repeat this test for the other transmission direction, if transfer trip is desired for both directions.

When finished the tests, **ensure that the desired functions and pick-up values are re-parameterized** in case they have been altered during the tests (addresses 37xx).

6.7.6 Checking the coupling of external signals and commands

If the coupling of external functions for alarm and/or trip processing or the user definable annunciations or logic functions are used, these have to be checked.

For this, the source object of the coupled signal is operated and the effect is checked.

6.7.7 Tripping test including circuit breaker

Line protection 7SA513 allows simple checking of the tripping circuit and the circuit breaker. By means of the internal auto-reclose system, a TRIP–CLOSE test cycle is also possible. The test can be initiated either via a binary input.

puts indicate the circuit breaker position. If the auxiliary contacts are assigned to binary inputs they must be connected, too. If none is assigned to any binary input then the device will perform tripping test without interrogation of the circuit breaker position!

6.7.7.1 TRIP–CLOSE test cycle – address block 43

Prerequisite for the start of a trip–close test cycle is that the integrated auto-reclose function is fitted and programmed as *EXIST* (address 7834) and that it is switched *ON* (Address 3401).

A TRIP–CLOSE test cycle is also possible with an external auto-reclose system. Since in this case, however, 7SA513 only gives the tripping command, the procedure shall be followed as described in Section 6.7.2.2.

If the circuit breaker auxiliary contacts advise the relay, through binary inputs, of the circuit breaker position, the test cycle can only be started when the circuit breaker is closed. This additional security feature should not be omitted.

During marshalling of the binary inputs (refer to Section 5.5.2 relay it has been informed which binary in-



DANGER!

A successfully started test cycle will lead to closing of the circuit breaker!

Initiation of the test cycle can be given from the operator keyboard or via the front operator interface. A codeword input is necessary. The procedure is started with address 4300 which can be reached by direct addressing **DA 4 3 0 0 E** or by paging with ↓ or ↑. In the addresses of this block there is a number of possibilities available which are shown in the following boxes. Single-pole trip–close–tests will only be carried out by the relay when single-pole AR is also permitted. Three-pole trip–close cycle will only be carried out when three-pole AR is permitted.

Further prerequisites for the start of test are that no protective function fault detector has picked up and that the conditions for reclose (circuit breaker ready, AR not blocked) are fulfilled.

↑	4	3	0	0	■	C	B	T	E	S	T
↓	T	R	I	P	-	C	L	O	S	E	C
											E

Beginning of the block "Circuit breaker test, TRIP–CLOSE cycle"

↑	4	3	0	1	■	C	B	T	E	S	T
	L	1	W	I	T	H	A	R	?		
	C	B	C	L	O	S	E	D	?		

Carry out test cycle with pole L1 of circuit breaker?
Confirm with "J/Y"–key or abort with page-on key ↑

Confirm with "J/Y" key that circuit breaker is closed or abort with page-on ↑

After confirmation by the operator that the circuit breaker is closed, the test cycle proceeds. If the test is terminated successfully, this is annunciated in the display or on the PC screen. If, however, circuit breaker auxiliary contacts are assigned to binary inputs and connected, the relay rejects the test cycle

as long as an auxiliary contact indicates that the circuit breaker is not closed, even if the operator has confirmed that it is. Only when no circuit breaker auxiliary contact is assigned to any binary input, will the relay consider the operator's confirmation valid.

↑ 4 3 0 2 ■ C B T E S T
L 2 W I T H A R ?

C B C L O S E D ?

Carry out test cycle with pole L2 of circuit breaker?
Confirm with "J/Y" – key or abort with page-on key ↑

Confirm with "J/Y" key that circuit breaker is closed or abort with page-on key ↑

↑ 4 3 0 3 ■ C B T E S T
L 3 W I T H A R ?

C B C L O S E D ?

Carry out test cycle with pole L3 of circuit breaker?
Confirm with "J/Y" – key or abort with page-on key ↑

Confirm with "J/Y" – key that circuit breaker is closed or abort with page-on key ↑

↑ 4 3 0 4 ■ C B T E S T
L 1 2 3 W I T H A R ?

C B C L O S E D ?

Carry out three-pole test cycle of circuit breaker?
Confirm with "J/Y" – key or abort with page-on key ↑

Confirm with "J/Y" – key that circuit breaker is closed or abort with page-on key ↑

↑ 4 3 0 5 ■ C B T E S T
S E Q U . L 1 - L 2 - L 3 ?

C B C L O S E D ?

Carry out sequence of single-pole test cycles L1–L2–L3 of circuit breaker? Confirm with "J/Y" – key or abort with page-on key ↑

Confirm with "J/Y" – key that circuit breaker is closed or abort with page-on key ↑

6.7.7.2 Live tripping of the circuit breaker – address block 44

To check the tripping circuits, the circuit breaker can be tripped by 7SA513 independently of whether an auto-reclose will occur or not. However, this test can also be made with an external auto-reclose relay.

If the circuit breaker auxiliary contacts advise the relay, through binary inputs, of the circuit breaker position, the test can only be started when the circuit breaker is closed. This additional security feature should not be omitted when an external auto-reclose relay is present.

During marshalling of the binary inputs (refer to Section 5.5.2 relay it has been informed which binary inputs indicate the circuit breaker position. If auxiliary contacts are assigned to binary inputs they must be connected, too. If none is assigned to any binary input then the device will perform tripping test without interrogation of the circuit breaker position!



DANGER!

A successfully started test cycle may lead to closing of the circuit breaker if an external auto-reclosure relay is started!

Initiation of the test can be given from the operator keyboard or from the front operator interface. A codeword input is necessary. The procedure is started with address 4400 which can be reached by direct dialling **DA 4 4 0 0 E** or by paging with ↑ or ↓. In the addresses of this block there is a number of possibilities available which are shown in the following boxes.

In order to trip the circuit breaker single-pole, it is necessary to permit single-pole tripping through the binary input ">1p Trip Perm" (FNo 381), with external single-pole AR: otherwise the single-pole test will not be carried out.

To trip all three poles of the circuit breaker, an external signal ">Only 1pole" must not be present from an external auto-reclose relay (FNo 382).

In the absence of auto-reclose, only the three-pole trip (address 4404) has any meaning.

Prerequisite for starting the test is that no protection function of the relay be picked up.

↑ ↓
4 4 0 0 ■ C B T R I P
L I V E T R I P

Beginning of the block "Circuit breaker test; live trip"

↑
4 4 0 1 ■ C B T R I P
C B P O L E L 1 ?
C B C L O S E D ?

Trip circuit breaker pole L1? Confirm with "J/Y" – key or abort by paging on with ↑

Confirm with "J/Y" – key that circuit breaker is closed or abort by paging on with ↑

After confirmation by the operator that the circuit breaker is closed, the test cycle proceeds. If the test is terminated successfully, this is annunciated in the display or on the PC screen. If, however, circuit breaker auxiliary contacts are assigned to binary inputs and connected, the relay rejects the test cycle

as long as an auxiliary contact indicates that the circuit breaker is not closed, even if the operator has confirmed that it is. Only when no circuit breaker auxiliary contact is assigned to any binary input, will the relay consider the operator's confirmation valid.

↑
4 4 0 2 ■ C B T R I P
C B P O L E L 2 ?
C B C L O S E D ?

Trip circuit breaker pole L2? Confirm with "J/Y" – key or abort with page-on key ↑

Confirm with "J/Y" – key that circuit breaker is closed or abort with page-on key ↑

↑
4 4 0 3 ■ C B T R I P
C B P O L E L 3 ?
C B C L O S E D ?

Trip circuit breaker pole L3? Confirm with "J/Y" – key or abort with page-on key ↑

Confirm with "J/Y" – key that circuit breaker is closed or abort with page-on key ↑

↑
4 4 0 4 ■ C B T R I P
C B T H R E E - P O L E ?
C B C L O S E D ?

Trip circuit breaker three-pole? Confirm with "J/Y" – key or abort with page-on key ↑

Confirm with "J/Y" – key that circuit breaker is closed or abort with page-on Key ↑

6.7.8 Starting a test fault record – address block 49

A fault record storage can be started using the operating panel or via the operating interface. Starting a test fault record is also possible via a binary input provided this is accordingly allocated (FNo 4 ">Start FltRec").

The configuration parameters as set in address block 74 are decisive for this fault recording (refer to Section 5.3.4): address 7431 concerns triggering via binary input, address 7432 triggering via the operating keyboard or via the operating interface. The pre-trigger time was set under address 7411.

Scanning a test fault record is especially interesting for use on cables and long overhead lines where considerable inrush currents can be produced by charging of the line capacitances. The fault record is triggered via a binary input at the instant of the breaker closing command.

Manual starting of a fault record can be carried out in address block 49, which can be reached by paging with ↑ or ↓, or by direct dialling with **DA 4 9 0 0 E**. The start address is reached with ↑:

↑↓ 4 9 0 0 ■ T E S T
F A U L T R E C O R D I N G

Beginning of block "Test fault recording" page on with ↑ to address 4901

↑ 4 9 0 1 ■ F A U L T R E C .
S T A R T ?
S U C C E S S F U L

Start fault recording? Confirm with "J/Y" –key or abort with page-on key ↑

The relay acknowledges successful completion of the test recording

6.8 Putting the relay into operation

All setting values should be checked again, in case they were altered during the tests. Particularly check that all desired protection functions have been programmed in the configuration parameters (address blocks 78 and 79, refer to Section 5.4) and all desired protection functions have been switched ON.

The counters for circuit breaker operation statistics should be erased (address block 82, refer to Section 6.5.2).

Push the key **M/S** on the front. The display shows the beginning of the annunciation blocks. Thus, it is possible that the measured values for the quiescent state of the relay can be displayed (see below). These values have been chosen during configuration (refer to Section 5.3.2) under the addresses 7105 and 7106.

Stored indications on the front plate should be reset

by pressing the push-button "RESET LED" on the front so that from then on only real faults are indicated. From that moment the measured values of the quiescent state are displayed. During pushing the RESET button, the LEDs on the front will light up (except the "Blocked" – LED); thus, a LED test is performed at the same time.

The green LED must be on on the front; the red LED must not be on.

Close housing cover.

All terminal screws – even those not in use – must be tightened.

If a test switch is available, then this must be in the operating position.

The line protection relay is now ready for operation.

7 Maintenance and fault tracing

Siemens digital protection relays are designed to require no special maintenance. All measurement and signal processing circuits are fully solid state and therefore completely maintenance free. Input modules are even static, relays are hermetically sealed or provided with protective covers.

If the device is equipped with a back-up battery for saving of stored annunciations and the internal time clock, the battery should be replaced after at most 5 years of operation (refer to Section 7.2). This recommendation is valid independent on whether the battery has been discharged by occasional supply voltage failures or not.

As the protection is almost completely self-monitored, from the measuring inputs to the command output relays, hardware and software faults are automatically annunciated. This ensures the high availability of the relay and allows a more corrective rather than preventive maintenance strategy. Tests at short intervals become, therefore, superfluous.

With detected hardware faults the relay blocks itself; drop-off of the availability relay signals equipment fault. If there is a fault detected in the external measuring circuits, generally an alarm is given only.

Recognized software faults cause the processor to reset and restart. If such a fault is not eliminated by restarting, further restarts are initiated. If the fault is still present after three restart attempts the protective system will switch itself out of service and indicate this condition by the red LED "Blocked" on the front plate. Drop-off of the availability relay signals equipment fault.

The reaction to defects and indications given by the relay can be individually and in chronological sequence read off as operational annunciations under the address 5100, for defect diagnosis (refer to Section 6.4.2).

If the relay is connected to a local substation automation system (LSA), defect indications will also be transferred via the serial interface to the central control system.



Warning

Ensure that the connection modules are not damaged when removing or inserting the device modules! Hazardous voltages may occur when the heavy current plugs are damaged!

7.1 Routine checks

Routine checks of characteristics or pick-up values are not necessary as they form part of the continuously supervised firmware programs. The planned maintenance intervals for checking and maintenance of the plant can be used to perform operational testing of the protection equipment. This maintenance serves mainly for checking the interfaces of the unit, i.e. the coupling with the plant. The following procedure is recommended:

- Read-out of operational values (address block 57) and comparison with the actual values for checking the analog interfaces.



Warning

Hazardous voltages can be present on all circuits and components connected with the supply voltage or with the measuring and test quantities!



Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

- Circuit breaker trip circuits are tested by actual live tripping. Respective notes are given in Section 6.7.7.

7.2 Replacing the back-up battery

The device annunciations are stored in NV–RAMs. A back-up battery is inserted so that they are retained even with a longer failure of the d.c. supply voltage. The back-up battery is also required for the internal system clock with calendar to continue in the event of a power supply failure.

The back-up battery should be replaced at the latest after 10 years of operation. The way of displacement depends on the production series of the relay. This production series is found on the name plate behind the complete order designation.

Recommended battery:

Lithium battery 3 V/1 Ah, type CR 1/2 AA, e.g.

- VARTA Order No. 6127 501 501 for relays until production series /EE,
- VARTA Order No. 6127 101 501 for relays from production series /FF or later.

The battery is located either at the bottom edge (production series up to /EE) or at the upper edge (production series from /FF) of the central processor board of the processor module ② (see Figure 7.1). The processor module must be removed from the housing in order to replace the battery.

The procedure when replacing the battery is described below.

- Prepare area of work: provide conductive surface for the device and modules.
- Open housing cover.
- Read out device annunciations, i.e. all addresses which commence with 5 (5000 onwards). This is carried out most convenient using the front operating interface and a personal computer with the DIGSI® protection data processing program; the information is thus stored in the PC.

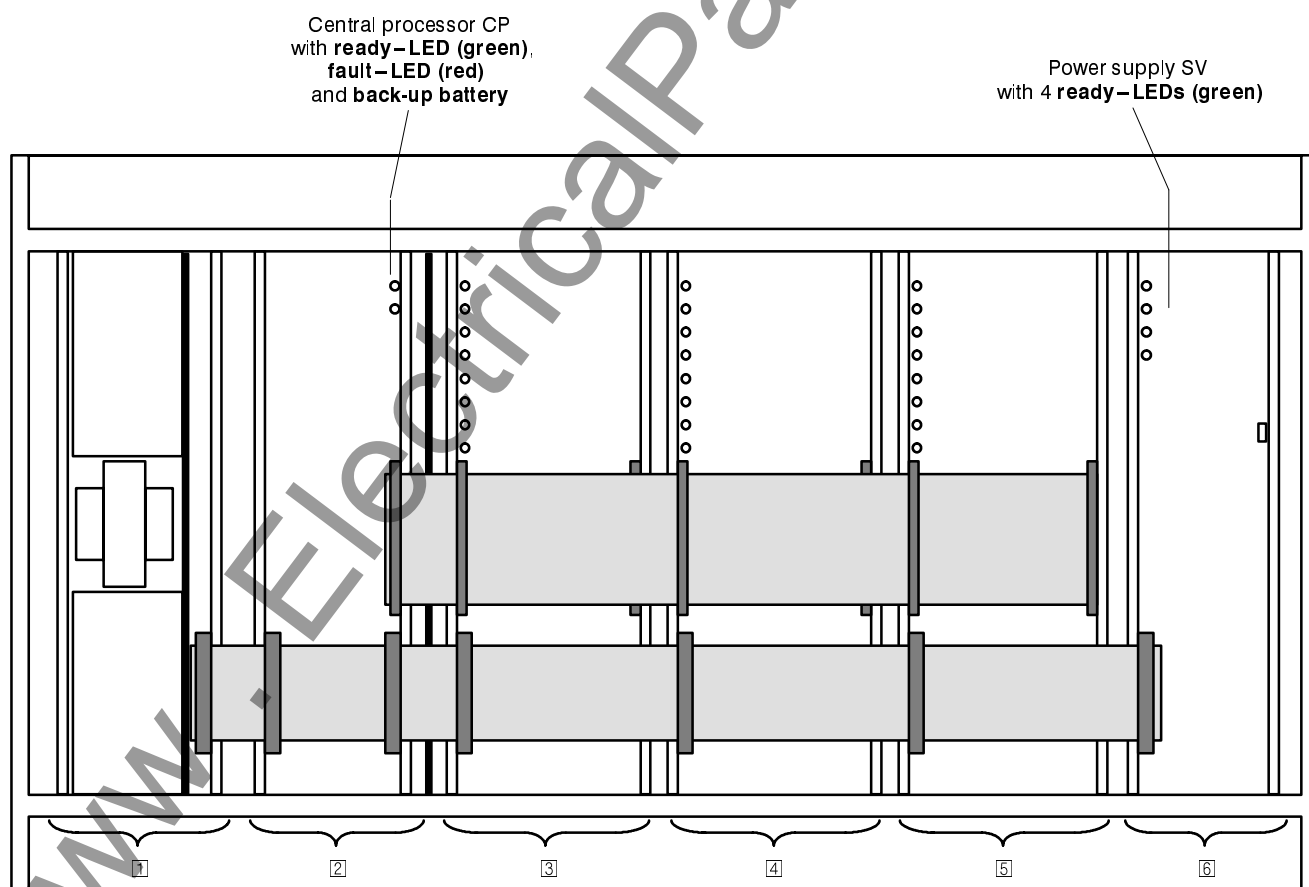


Figure 7.1 Front view 7SA513 after removal of the front door (simplified and reduced)

Note: All configuration data and settings of the device are stored in EEPROMs protected against switching off of the power supply. They are stored independent of the back-up battery. They are, therefore, neither lost when the battery is replaced nor when the device is operated without a battery.

- Loosen the captive screws of the housing; they are placed in the upper and lower edge at the right hand side of the front door.



Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.

- Carefully loosen the ribbon cable that links the modules with each other so that the processor module can be drawn out. If necessary, loosen the cable from the adjacent modules, too.
- Loosen further ribbon cables which connect the processor module with the front plate:
to the operational interface,
to the LCD display,
to the membrane keyboard.
- **Only for relay until production series /EE:** Prepare the battery as in Figure 7.2:



Caution!

Do not short-circuit battery! Do not reverse battery polarities! Do not charge battery!

Shorten the legs to 15 mm (6/10 inch) each and bend over at a length of 40 mm (16/10 inch).

Relays from production series /FF or later have no axial legs.

- Pull out processor module  (refer to Figure 7.1) and place onto the conductive surface.

- Unscrew used battery from the terminals or remove it from the holder; **do not place on the conductive surface!** Refer to Figure 7.3 for relay until production series /EE and to Figure 7.4 from production series /FF.



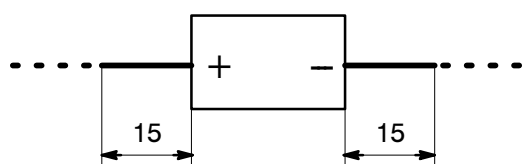
Warning

The discharged battery contains Lithium. It must only be disposed off in line with the applicable regulations!

Do not reverse polarities! Do not recharge! Do not throw into fire! Danger of explosion!

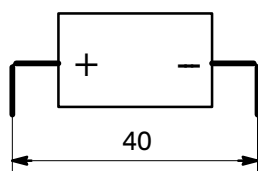
- Insert the prepared battery into the terminals or holder as in Figure 7.3 (until production series /EE) and tighten the screws or as in Figure 7.3 (from production series /FF).
- Insert processor module into the housing; ensure that the module is firmly pushed in.
- Re-connect the ribbon cables from the front plate; take care for correct polarity:
from the operational interface,
from the LCD display,
from the membrane keyboard.
- Re-connect the ribbon cable to all concerned modules. Ensure that the connection pins do not bend! Do not use force!
- Close the front door of the device.
- Fix the door with the fixing screws.
- Provided the internal system clock is not automatically synchronized via the LSA interface, it can now be set or synchronized as described in Section 6.5.1
- Close housing cover and tighten the screws.

Replacing the back-up battery has thus been completed.

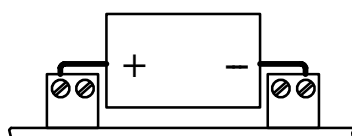


shorten the legs

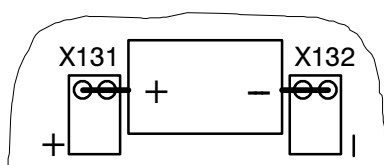
Dimensions in
mm



bend the legs

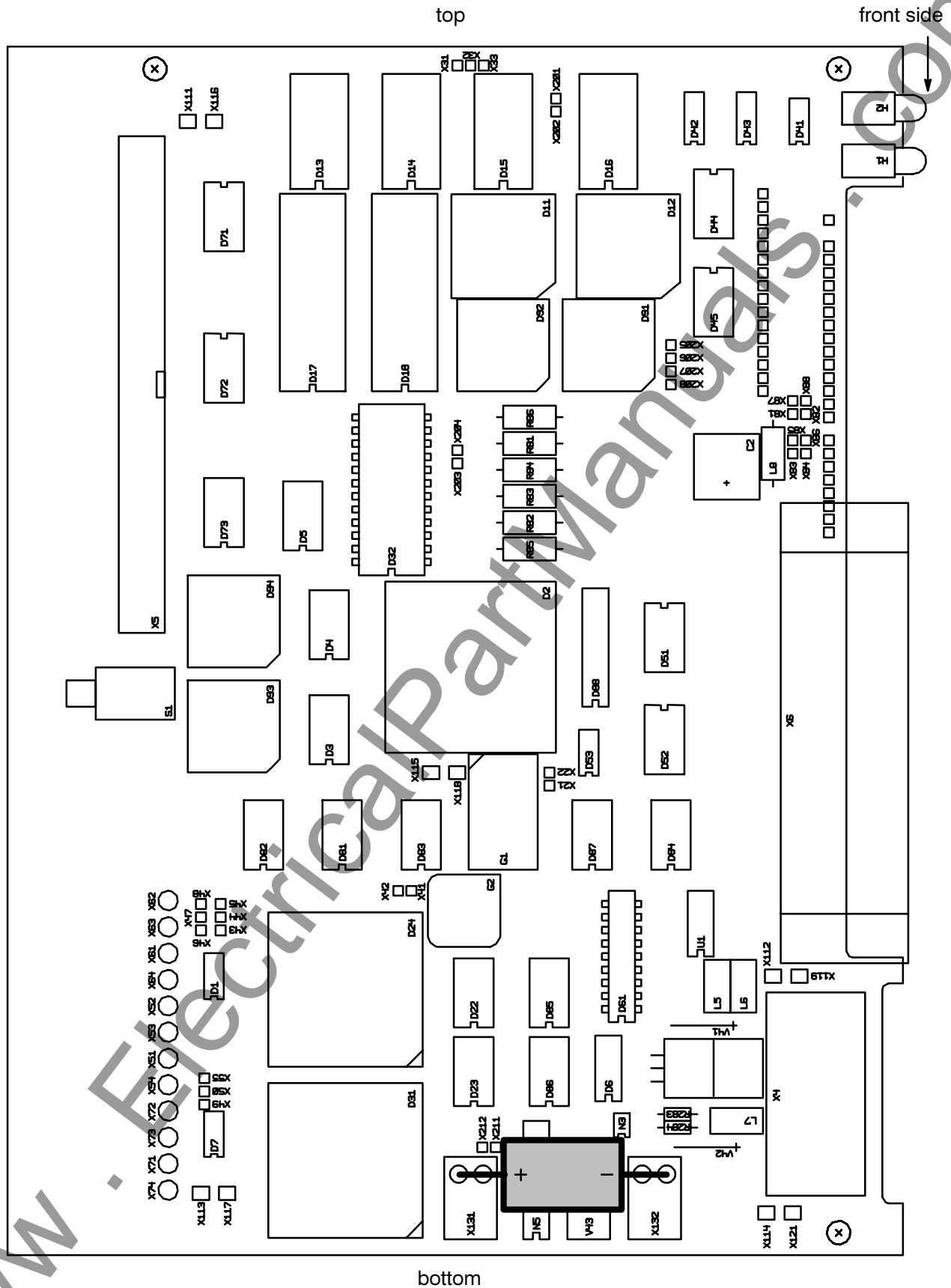


install-
ing



viewed from above

Figure 7.2 Inserting the back-up battery for
relay until production series /EE



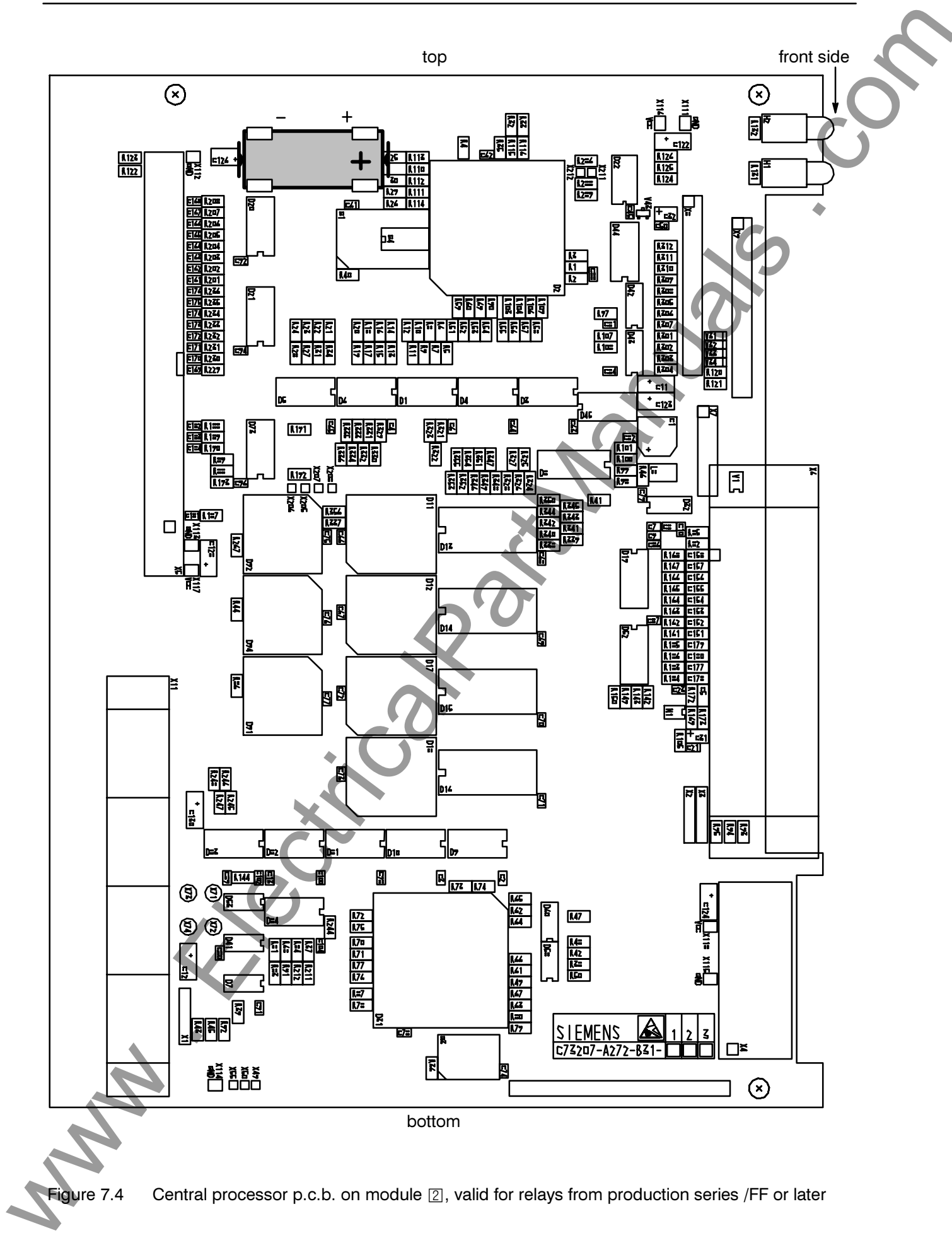


Figure 7.4 Central processor p.c.b. on module 2, valid for relays from production series /FF or later

7.3 Fault tracing

If the protective device indicates a defect, the following procedure is suggested:

If none of the LEDs on the front plate of the device is on, then check:

- Is the ON/OFF switch on the front plate in the ON position  ?
- Is the auxiliary voltage available with the correct polarity and of adequate magnitude, connected to the correct terminals (General diagrams in Appendix A)?

Should not all LEDs on the front of the power supply module  (Figure 7.1) be illuminated, one of the mini-fuses may have blown. The dark LED identifies which supply circuit could be affected. The device must be opened in order to check or replace one of the fuses. Refer to Section 7.3.1 for further details.

If all 4 readiness—LEDs on the front of the power supply module  (Figure 7.1) are illuminated, then check:

- Is the green readiness indicator on the processor module  (Figure 7.1) on and the red "Blocked" indicator off?

If the red fault indicator "Blocked" on the front is on and the green ready LED remains dark, the device has recognized an internal fault. Re-initialization of the protection system could be tried by switching the d.c. auxiliary voltage off and on again. This, however, results in loss of fault data and messages if the relay is not equipped with a buffer battery, and, if a parameterizing process has not yet been completed, the last parameters are not stored.

If obvious problems occur with binary inputs or outputs (signal or trip relays), the input/output module can be replaced. Refer to Section 7.3.2 for details.

If the defect cannot be corrected by operator procedures such as described above, it is recommended that the complete relay should be returned to the manufacturer.

7.3.1 Checking and replacing the mini-fuses

- **Switch off the primary supply voltage!**
- Select a replacement fuse 5×20 mm. Ensure that the rated value, time lag (medium slow) and code letters are correct. The rated data are given in Figures 7.5 and 7.6.
- Prepare area of work: provide conductive surface for the module.
- Open housing cover.
- Loosen the captive screws of the housing; they are placed in the upper and lower edge at the right hand side of the front door.



Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.

- Carefully loosen the ribbon cable that links the modules with each other so that the power supply module  (Figure 7.1) can be drawn out. If necessary, loosen the cable from the adjacent modules, too.



Warning

Hazardous voltages can be present in the power supply module even after disconnection of the supply voltage or after removal of the modules from the housing (storage capacitors)!

- Pull out power supply module  (refer to Figure 7.1) and place onto the conductive surface.
- Check the fuses. Figure 7.5 shows the left p.c.b. (viewed from the front side) with the output portion of the power supply module; Figure 7.6 the right p.c.b. (viewed from the front side) with the input portion. The fuses are located at the front edge or in the bottom area.

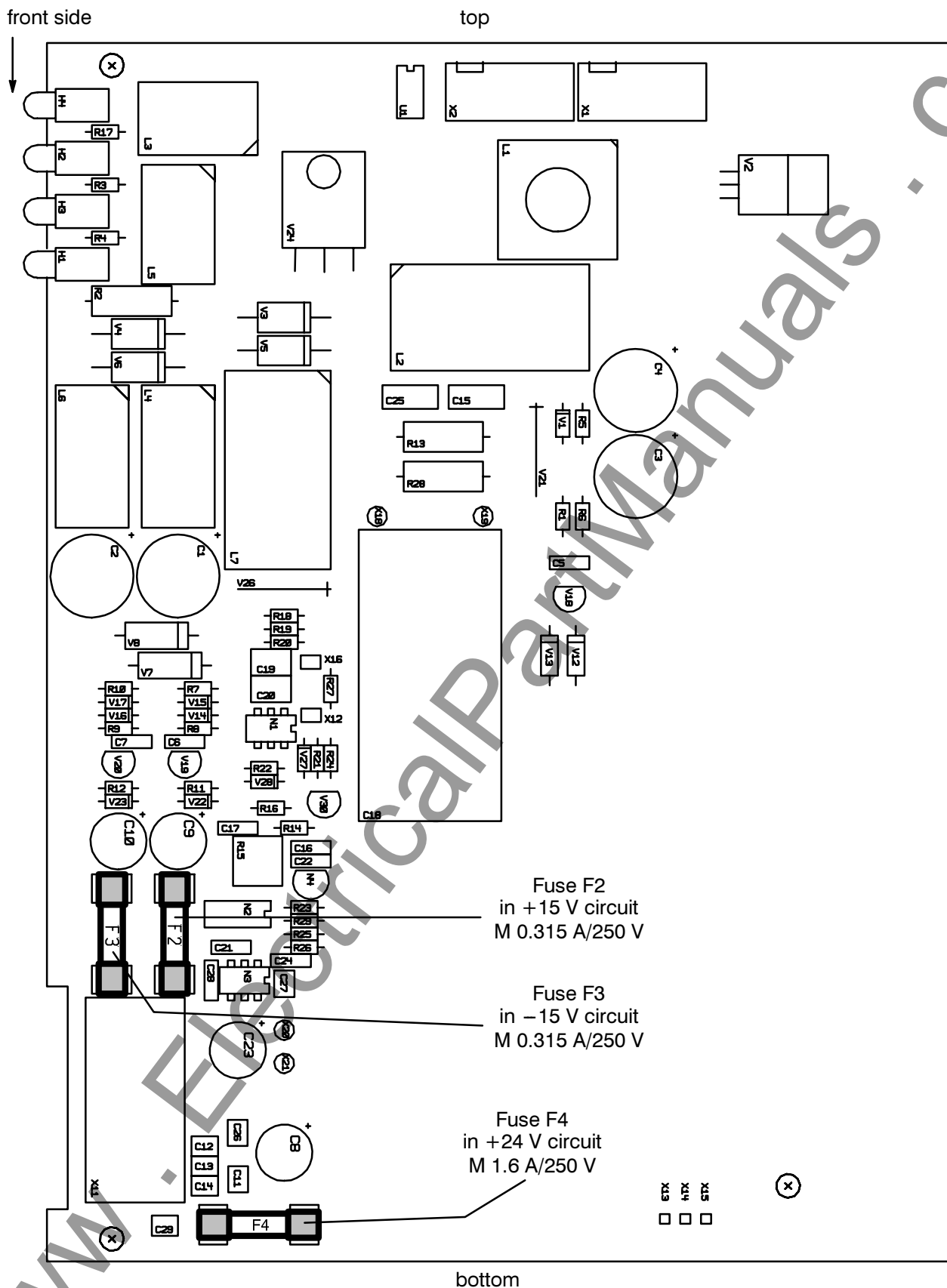


Figure 7.5 Mini-fuses on the output p.c.b. of the power supply module 6, component side of the left p.c.b. (when viewed from the front)

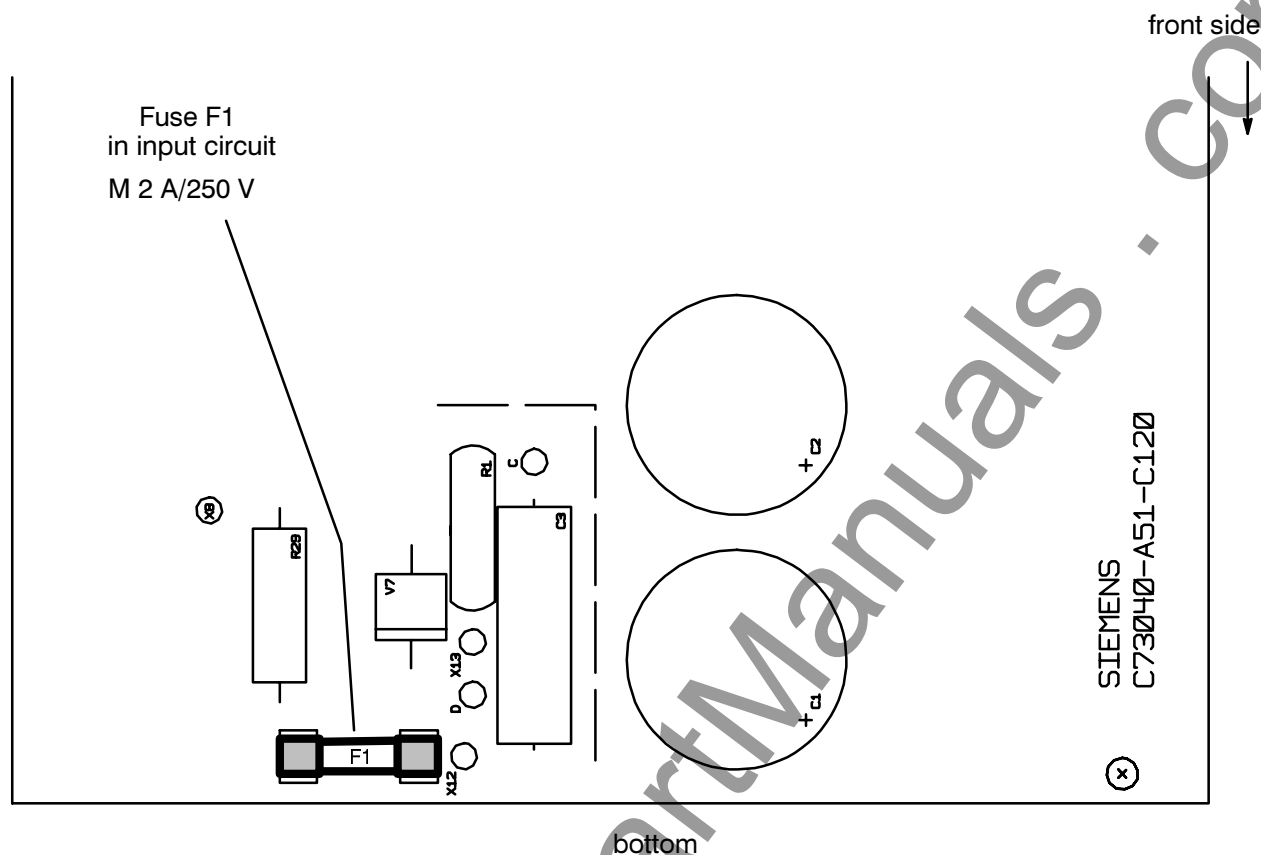


Figure 7.6 Mini-fuse on the input p.c.b. of the power supply module [6], component side of the right p.c.b. (when viewed from the front)

When all fuses are healthy the the device is re-installed (see below). If one or more fuses have blown, proceed as follows:

- Remove blown fuse from the holder.
- Fit new fuse into the holder (Figure 7.5 and/or 7.6).

Re-installation of the device:

- Insert power supply module into the housing; ensure that the module is firmly pushed in.

- Re-connect the ribbon cable to all concerned modules. Ensure that the connection pins do not bend! Do not use force!

- Close the front door of the device.
- Fix the door with the fixing screws.
- Close housing cover and tighten the screws.

Switch on the device again. If a power supply failure is still signalled, a fault or short-circuit is present in an internal power supply circuit. The device should be returned to the factory (see Chapter 8).

7.3.2 Replacing an input/output module

Should an obvious defect occur on one of the input/output modules – e.g because a protection function does not react to a binary input command or an output relay does not give contact – the corresponding module can be replaced by a spare module.

The input/output modules ③ to ⑤ are in principle identical but have to be definitely identified by the central processor. The replacement module must be matched.

Module identification is performed by plug bridges at the upper edge of the individual left p.c.b. (when viewed from the front) of each input/output module. The location of these bridges is shown in Figure 7.7.

Additionally, for rated control voltages of 110 V or higher the pick-up threshold of the binary inputs can be increased to approximately 80 V; for rated control voltages of 220 V or higher to approximately 160 V. This can be done by removing solder bridges.

The location of these bridges and their allocation to the binary inputs are shown in Figure 7.8. Table 7.1 shows the assignment of the bridges.

The procedure to change any bridge is as follows:

- Prepare area of work: provide conductive surface for the relay and modules.
- Open housing cover.



Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.

- Loosen the captive screws of the housing; they are placed in the upper and lower edge at the right hand side of the front door.
- Carefully loosen the ribbon cable that links the modules with each other so that the desired module can be drawn out. If necessary, loosen the cable from the adjacent modules, too.
- Pull out the defective module.
- Unpack the spare module and place it on the conductive surface.
- Fit the identification plugs according to Figure 7.7 into the correct position, dependent of the insertion place of the module.
- Remove the solder bridges for the intended voltage range and noise margin according to Figure 7.8 and Table 5.1, where necessary.
- Insert spare module into the housing; ensure that the module is firmly pushed in.
- If further input/output modules are to be replaced, do it in the same manner.
- Re-connect the ribbon cable to all concerned modules. Ensure that the connection pins do not bend! Do not use force!
- Close the front door of the device.
- Fix the door with the fixing screws.
- Close housing cover and tighten the screws.
- Switch on the d.c. power supply of the device and check the binary inputs and outputs.

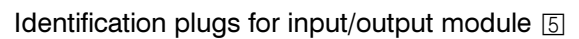
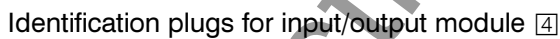


Figure 7.7 Location of the identification plugs on the input/output modules ③ to ⑤, component side of the left p.c.b. (when vied from the front)

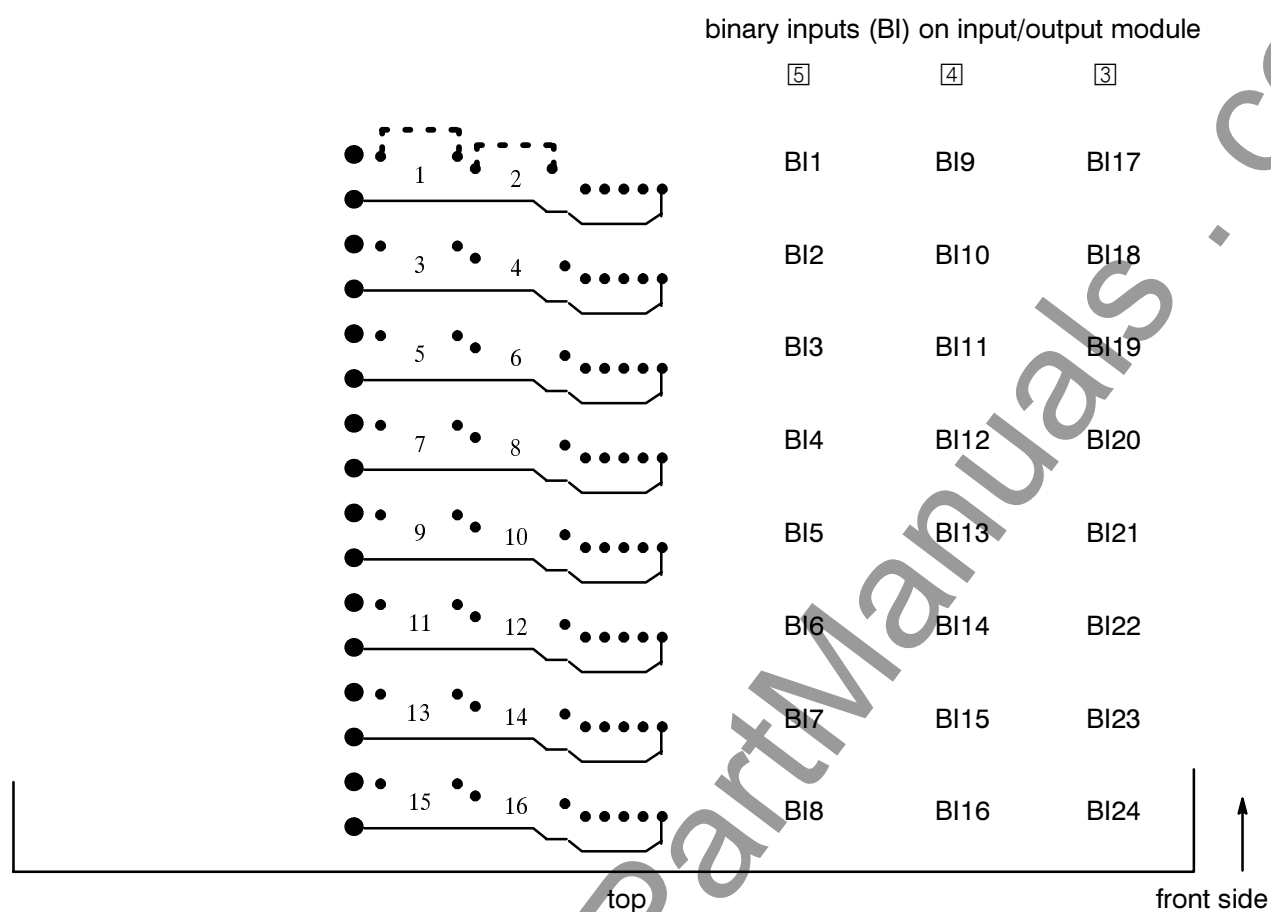


Figure 7.8 Checking for control voltages for binary inputs on the input/output modules 3 to 5; printed side of the right p.c.b. (when vied from the front)
Attention! The top of the p.c.b. is at the bottom side of the illustration!
Attention! The allocation of the binary inputs counts from right to left!

Rated d.c. control voltage	24 V/48 V/60 V	110 V/125 V	220 V/250 V
Bridge 1 etc.	inserted	inserted	removed
Bridge 2 etc.	inserted	removed	removed

Table 7.1 Position of the solder bridges for control voltages, example for binary input 1 on input/output module 5

8 Repairs

Repair of defective modules is not recommended at all because specially selected electronic components are used which must be handled in accordance with the procedures required for **Electrostatically Endangered Components (EEC)**. Furthermore, special manufacturing techniques are necessary for any work on the printed circuit boards in order to do not damage the bath-soldered multilayer boards, the sensitive components and the protective finish.

Therefore, if a defect cannot be corrected by operator procedures such as described in Chapter 7, it is recommended that the complete relay should be returned to the manufacturer. Use the original transport packaging for return. If alternative packing is used, this must provide the degree of protection against mechanical shock, as laid down in IEC 60255-21-1 class 2 and IEC 60255-21-2 class 1.

If it is unavoidable to replace individual modules, it is imperative that the standards related to the handling of **Electrostatically Endangered Components** are observed.



Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the module from the housing (storage capacitors)!



Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface. This applies equally for the replacement of removable components, such as EPROM or EEPROM chips. For transport and returning of individual modules electrostatic protective packing material must be used.

Components and modules are not endangered as long as they are installed within the relay.

Should it become necessary to exchange any device or module, the complete parameter assignment should be repeated. Respective notes are contained in Chapter 5 and 6.

9 Storage

Solid state protective relays shall be stored in dry and clean rooms. The limit temperature range for storage of the relays or associated spare parts is $-25\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$ (refer Section 3.1.4 under the Technical data), corresponding to $-12\text{ }^{\circ}\text{F}$ to $130\text{ }^{\circ}\text{F}$.

The relative humidity must be within limits such that neither condensation nor ice forms.

It is recommended to reduce the storage temperature to the range $+10\text{ }^{\circ}\text{C}$ to $+35\text{ }^{\circ}\text{C}$ ($50\text{ }^{\circ}\text{F}$ to $95\text{ }^{\circ}\text{F}$); this prevents from early ageing of the electrolytic capacitors which are contained in the power supply.

For very long storage periods, it is recommended that the relay should be connected to the auxiliary voltage source for one or two days every other year, in order to regenerate the electrolytic capacitors. The same is valid before the relay is finally installed. In extreme climatic conditions (tropics) pre-warming would thus be achieved and condensation avoided.

Before initial energization with supply voltage, the relay shall be situated in the operating area for at least two hours in order to ensure temperature equalization and to avoid humidity influences and condensation.

Appendix

- A General diagrams**
- B Connection diagrams**
- C Tables**

A General diagrams

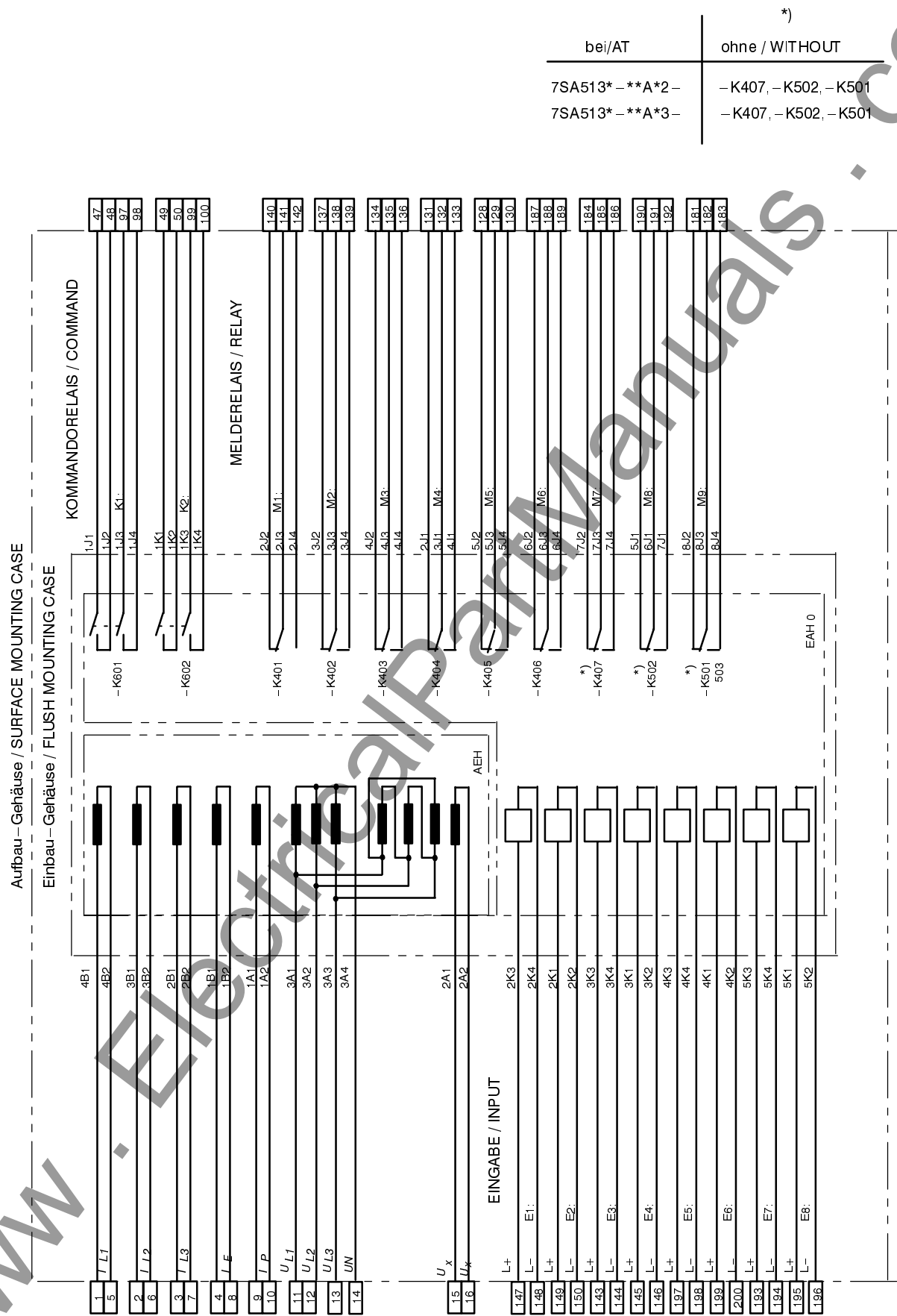
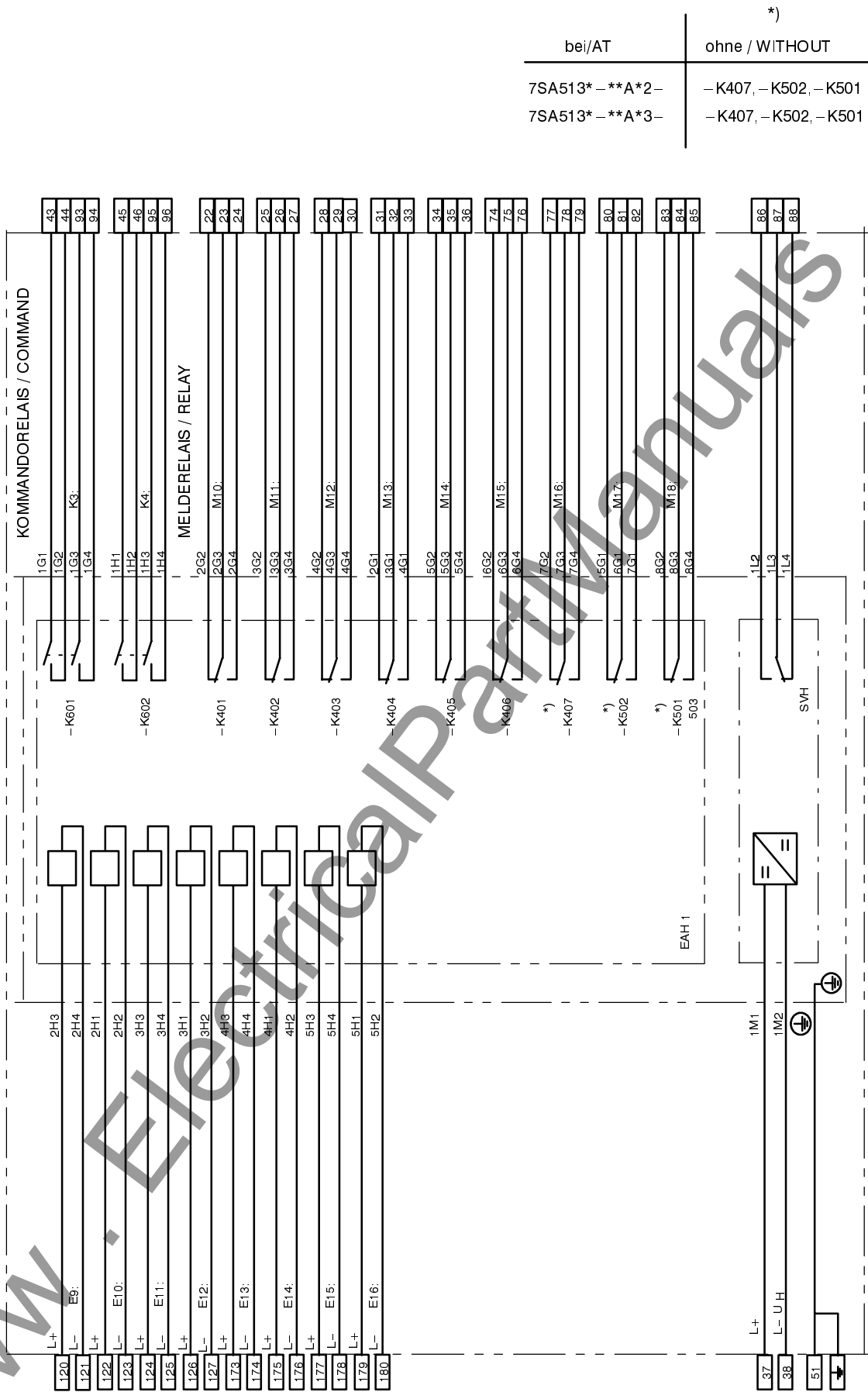


Figure A.1 General diagram 7SA513 (sheet 1 of 3)



bei/AT	ohne / WITHOUT
7SA513* - **A*2 -	- K407, - K502, - K501
7SA513* - **A*3 -	- K407, - K502, - K501

Figure A.2 General diagram 7SA513 (sheet 2 of 3)

bei / AT	ohne / WITHOUT
7SA513*–**A*0–	EAH2
7SA513*–**A*2–	EAH2
7SA513*–**A*3–	–K407, –K502, –K501

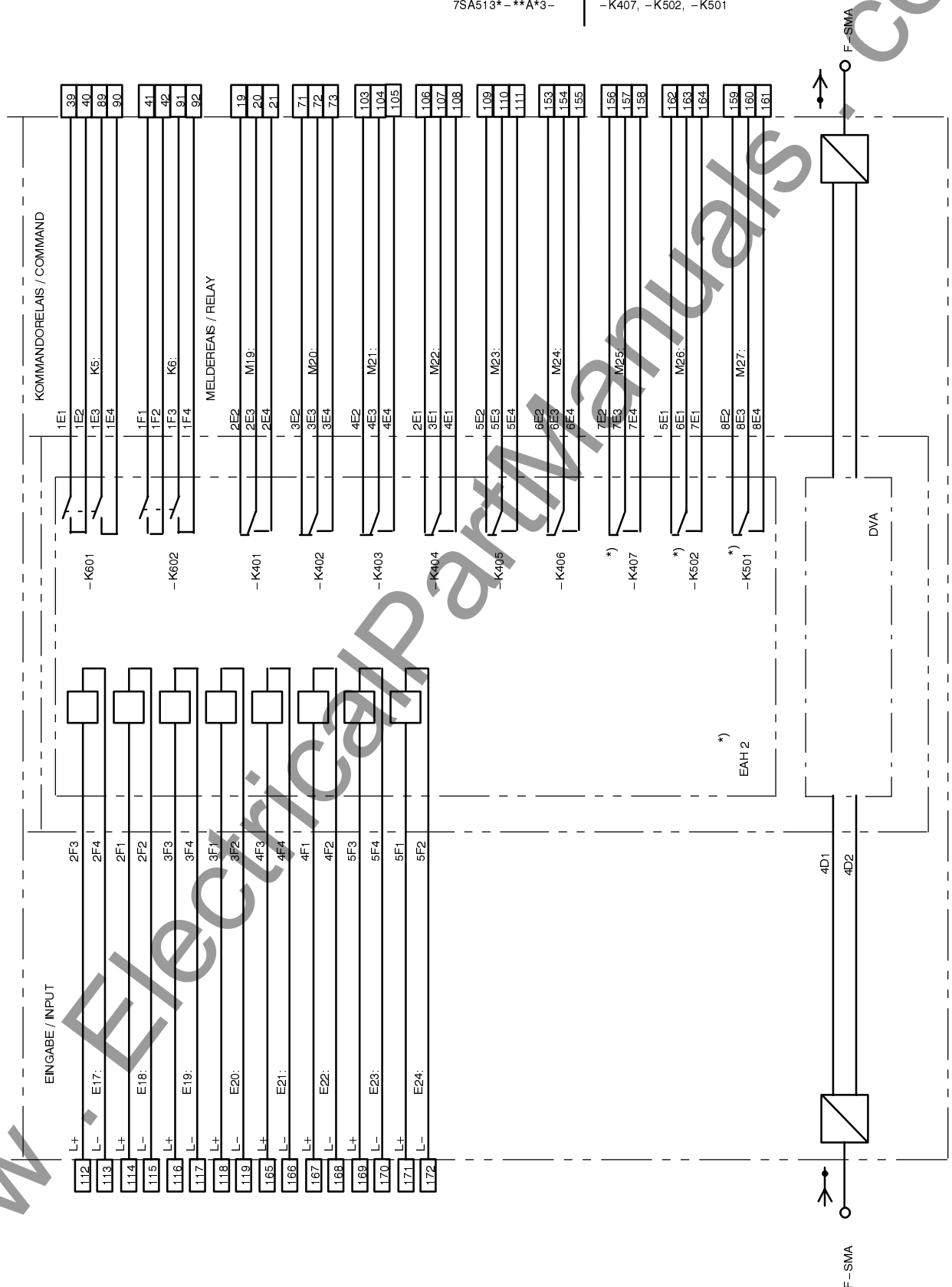


Figure A.3 General diagram 7SA513 (sheet 3 of 3)

B Connection diagrams

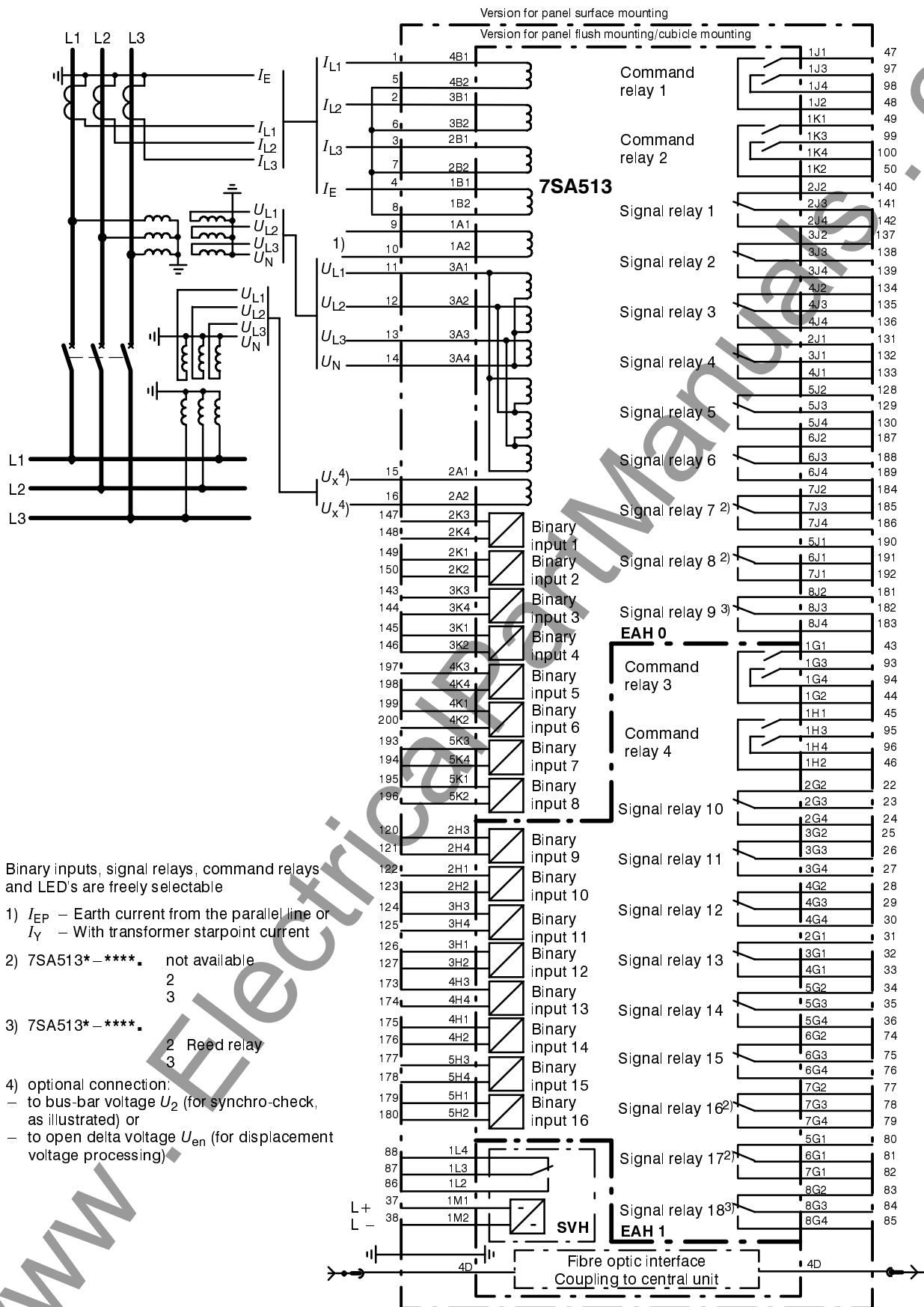


Figure B.1 Connection example 7SA513 (sheet 1 of 2)

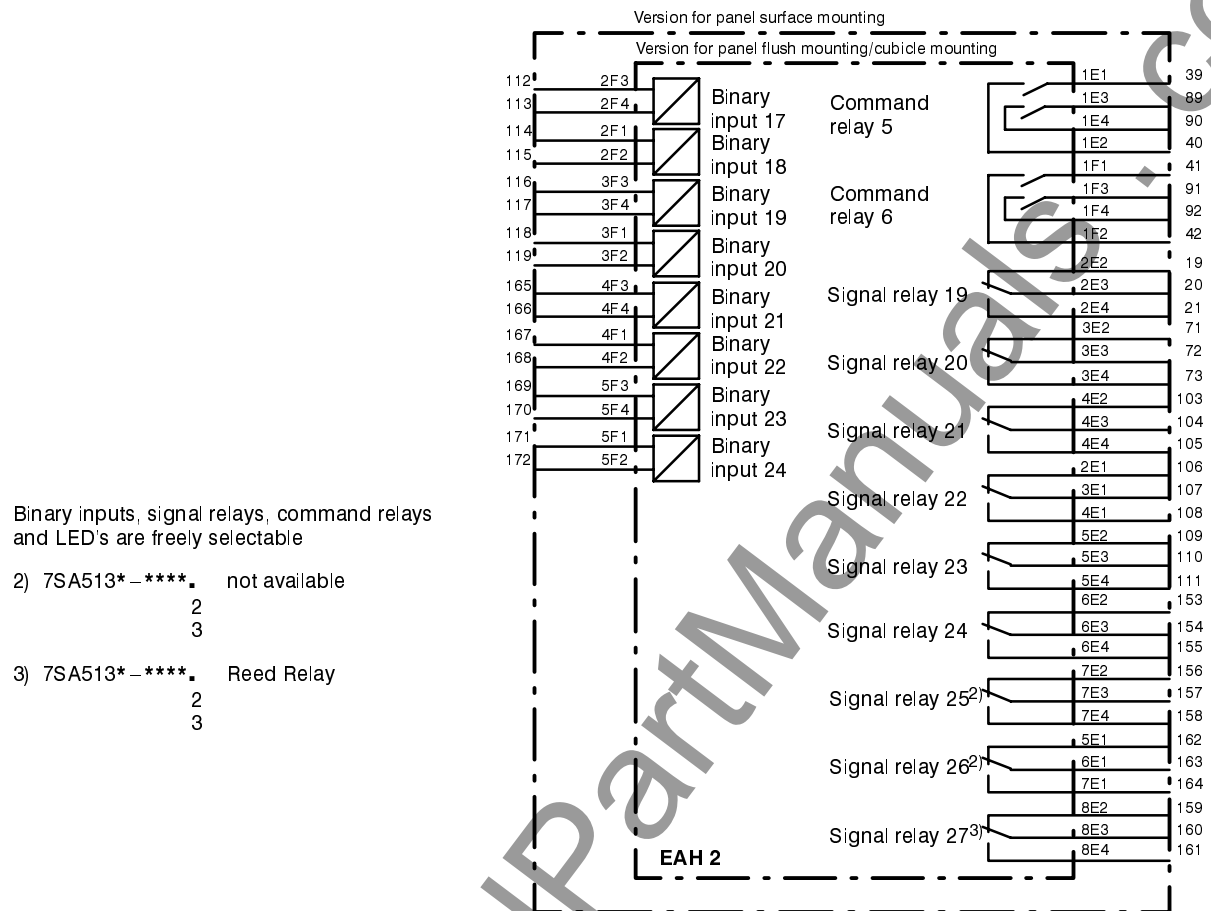


Figure B.2 Connection example 7SA513 (sheet 2 of 2); available only in models with 3 input/output modules

Figures B.3 to B.7 show examples for CT connections, figures B.8 to B.11 show examples for VT connections. Figures B.12 and B.13 show examples for connection of pilot wires for overreach transfer via pilot wires.

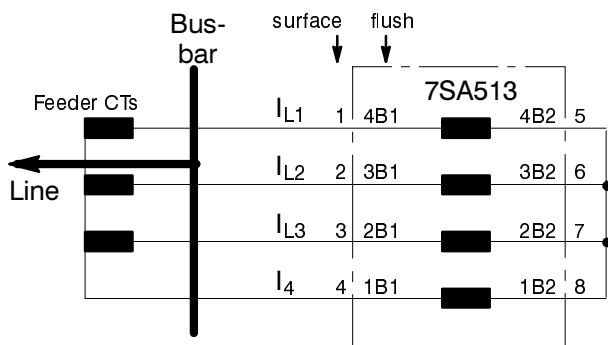


Figure B.3 CT circuits with 3 CTs

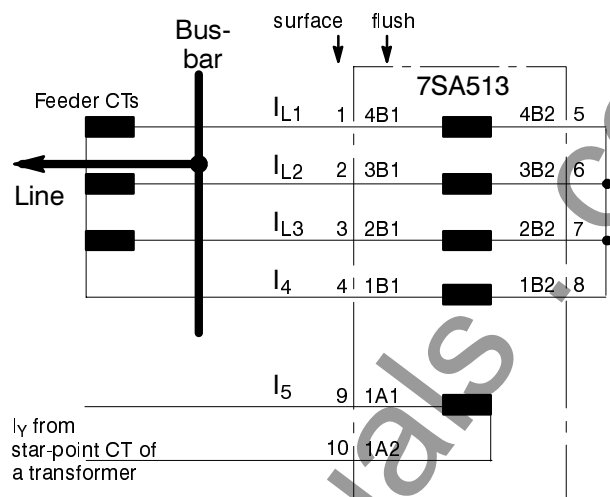
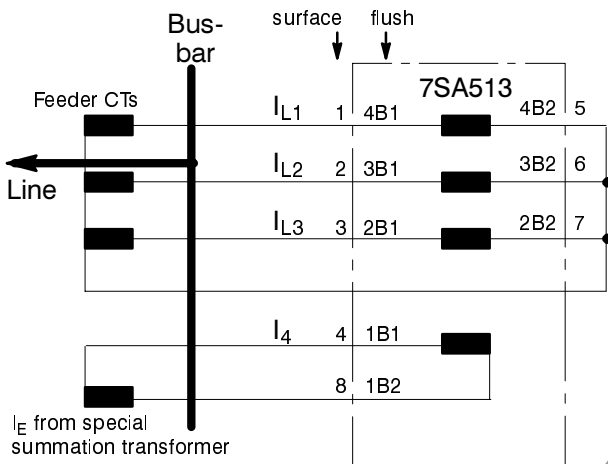


Figure B.6 CT circuits with 3 CTs and additional star-point CT of an earthed feeder transformer



Note: If the current polarity is changed under address 1101, this changes also the polarity of the current input I_4 !

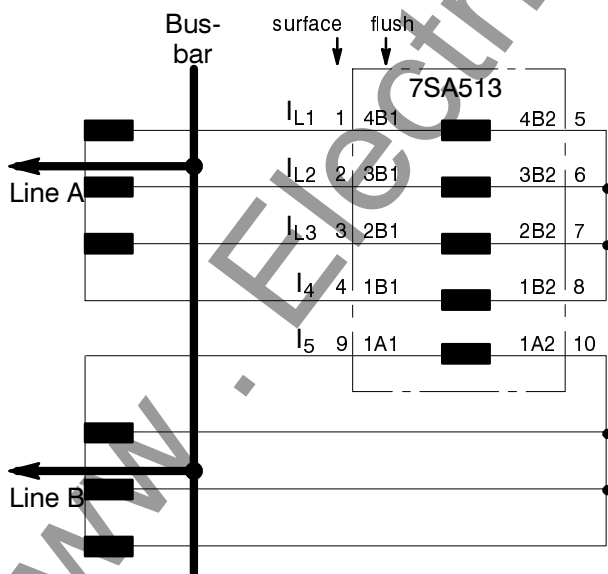
Figure B.4 CT circuits with 3 CTs and additional I_E summation CT

Figure B.5 CT circuits with 3 CTs and earth current of a parallel line B

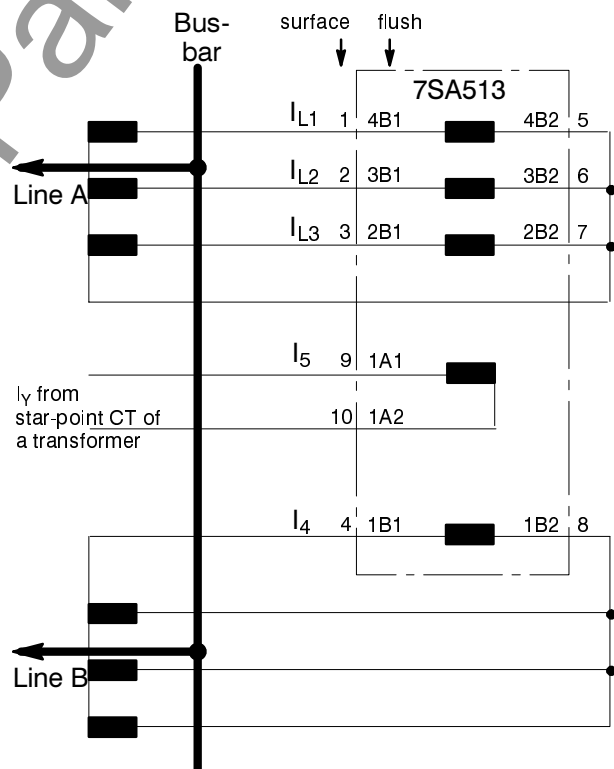


Figure B.7 CT circuits with 3 CTs, with additional star-point CT of an earthed feeder transformer, and with earth current connection of a parallel line

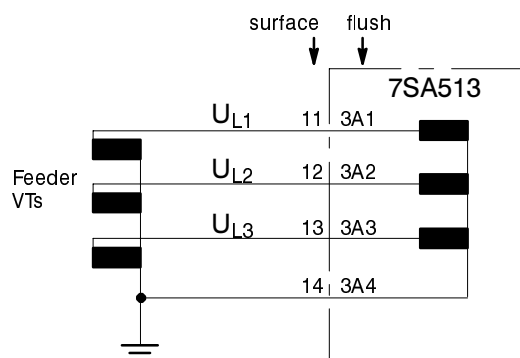


Figure B.8 VT circuits with 3 VTs

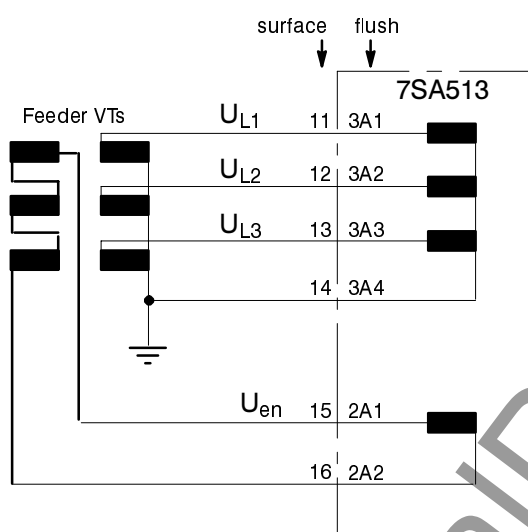


Figure B.9 VT circuits with 3 VTs with open delta windings (e–n)

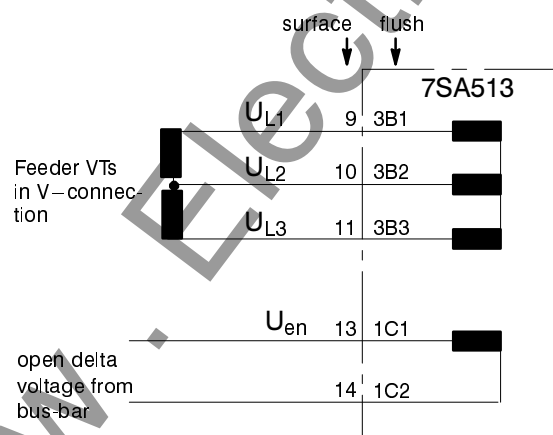


Figure B.10 VT circuits with 2 VTs and open delta voltage from a bus-bar voltage transformer set (not for earthed systems)

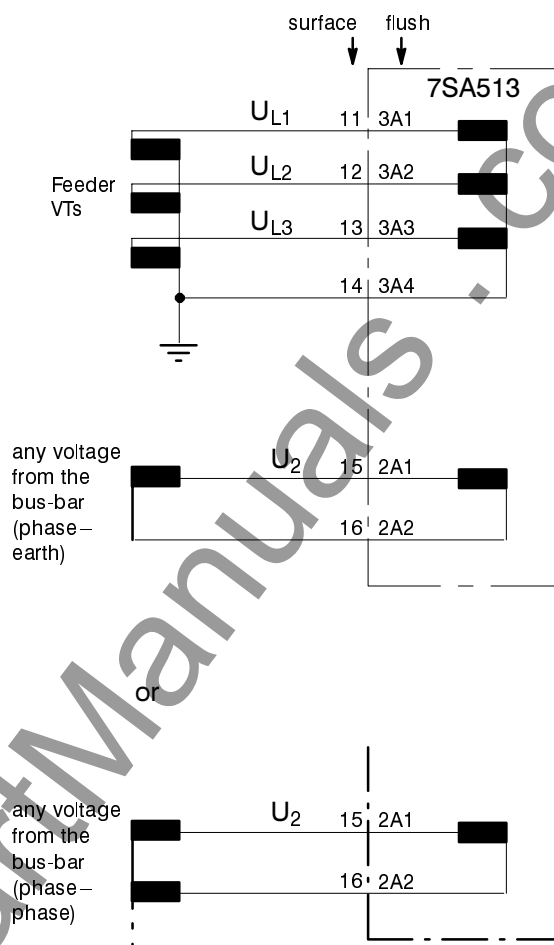


Figure B.11 VT circuits with 3 VTs and any desired voltage from the bus-bar VTs

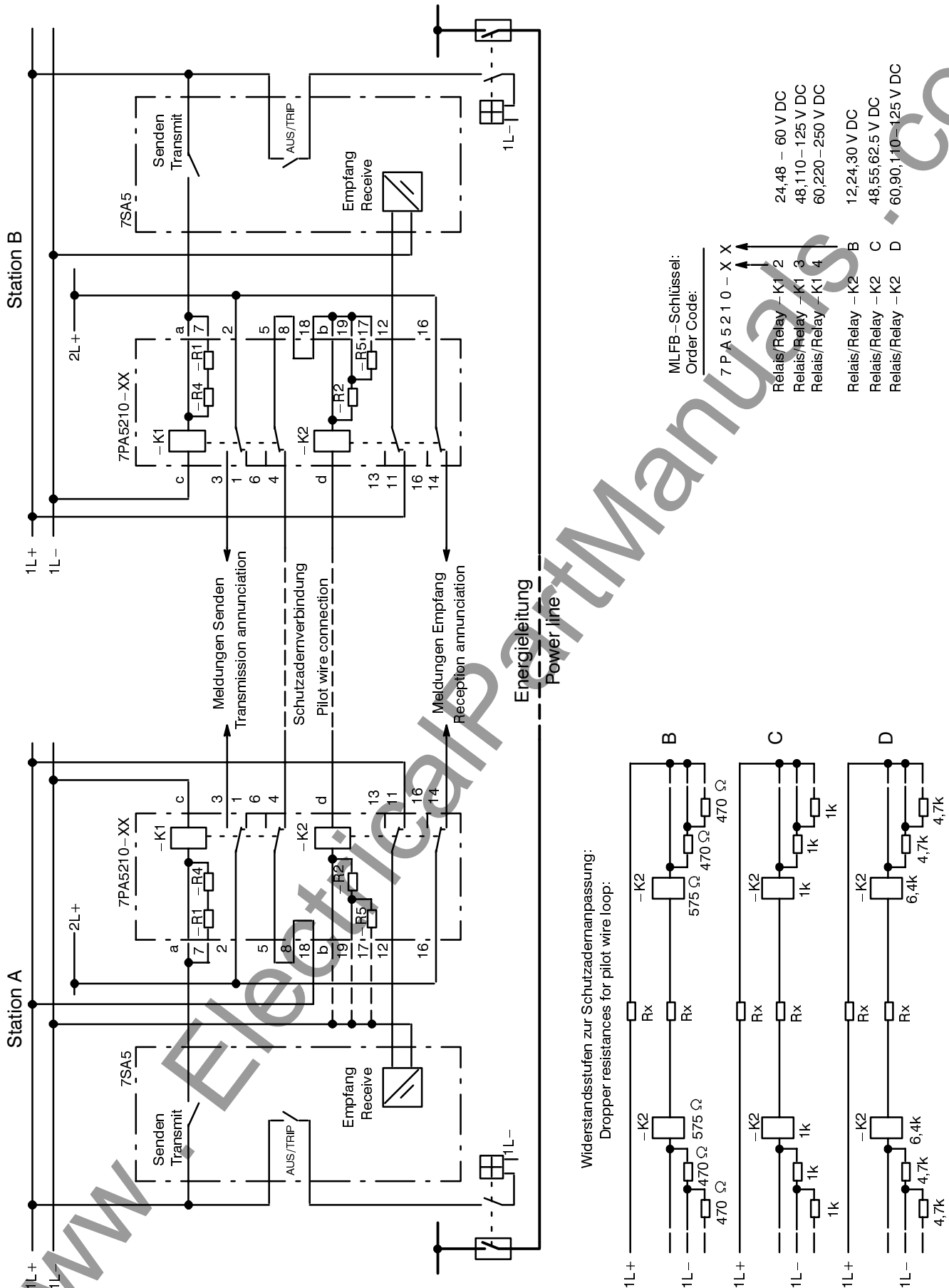


Figure B.12 Pilot wire connection scheme for overreach transfer via pilot wires, with 7SA5 at both line ends

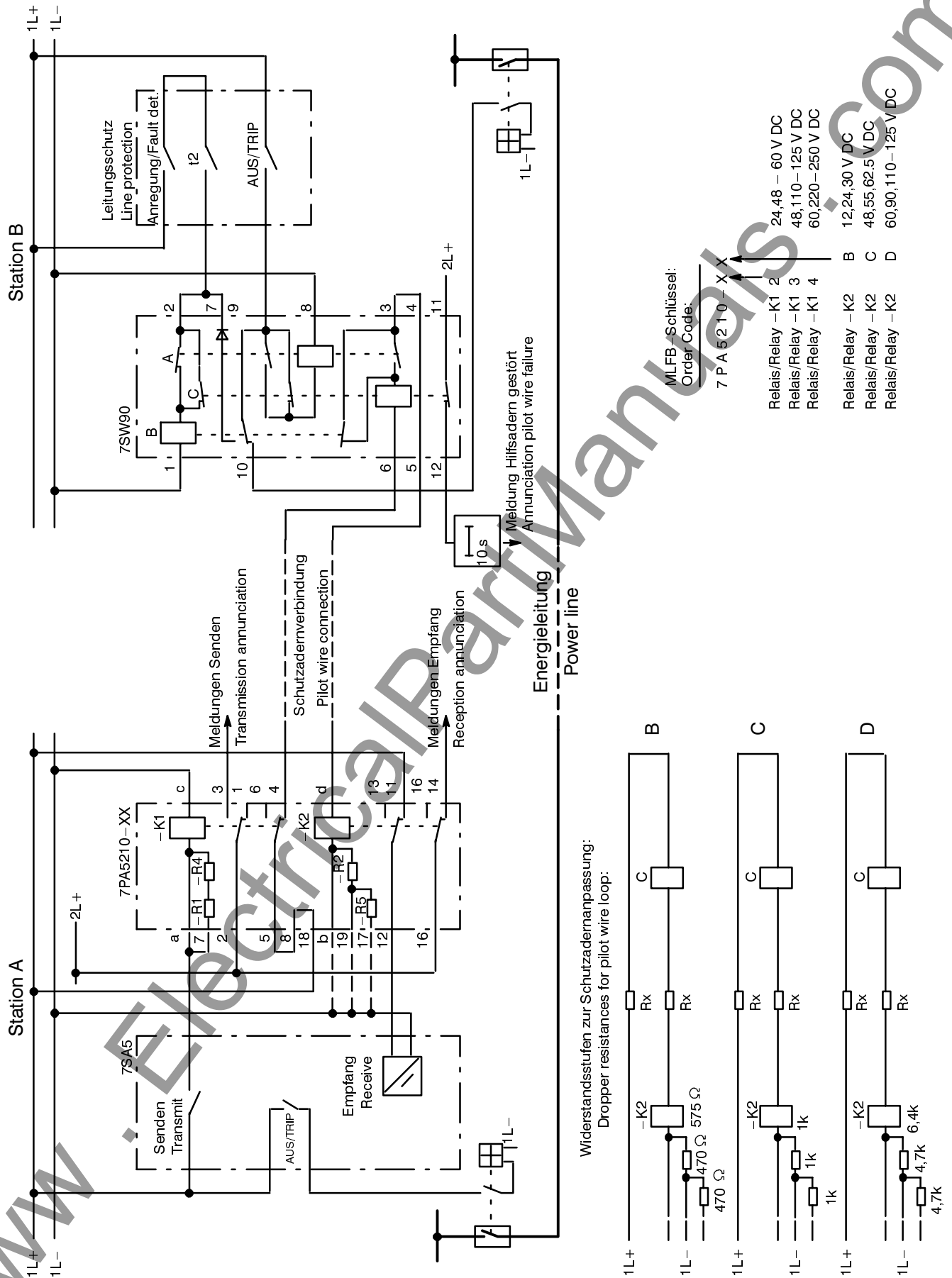


Figure B.13 Pilot wire connection scheme for overreach transfer via pilot wires, with 7SA5 at one line end and 7SW90 at the other line end

C Tables

Table C.1	Annunciations fo LSA	337
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NOTE: The following tables list all data which are available in the maximum complement of the device. Dependent on the ordered model, only those data may be present which are valid for the individual version.

NOTE: The actual tables are attached to the purchased relay.

Annunciations 7SA513 for LSA (DIN 19244 and according IEC 60870-5-103)

FNo. - Function number of annunciation
 Op/Ft - Operation/Fault annunciation
 C/CG: Coming/Coming and Going annunciation
 V : Annunciation with Value
 M : Measurand

LSA No.- Number of annunciation for former LSA (DIN 19244)

according to IEC 60870-5-103:

CA - Compatible Annunciation
 GI - Annunciation for General Interrogation
 BT - Binary Trace for fault recordings
 Typ - Function type (p: according to the configured "Function type")
 Inf - Information number

FNo.	Meaning	Ann.		LSA No.	IEC 60870-5-103				
		Op	Ft		CA	GI	BT	Typ	Inf
11	>User defined annunciation 1	CG		24	CA	GI	BT	p	27
12	>User defined annunciation 2	CG		25	CA	GI	BT	p	28
13	>User defined annunciation 3	CG		26	CA	GI	BT	p	29
14	>User defined annunciation 4	CG		27	CA	GI	BT	p	30
15	>Testing via system-interface							135	53
16	>Block. of monitoring dir. via sys.-int							135	54
51	Device operative / healthy	CG		1		GI		135	81
52	Any protection operative	CG			CA	GI		p	18
55	Re-start of processor system	C		8	CA			p	4
56	Initial start of processor system	C		14	CA			p	5
59	Real time response to LSA	C		6					
60	LED Reset	C		13	CA			p	19
61	Logging and measuring functions blocked	CG			CA	GI		p	20
62	Test mode	CG			CA	GI		p	21
63	PC operation via system interface	CG				GI		135	83
95	Parameters are being set	CG		11	CA	GI		p	22
96	Parameter set A is active	CG		40	CA	GI		p	23
97	Parameter set B is active	CG		41	CA	GI		p	24
98	Parameter set C is active	CG		42	CA	GI		p	25
99	Parameter set D is active	CG		43	CA	GI		p	26
110	Annunciations lost (buffer overflow)	C		9				135	130
112	Annunciations for LSA lost	C		10				135	131
113	Fault tag lost						BT	135	136
140	General internal failure of device	CG			CA	GI		p	47
141	Failure of internal 24 VDC power supply	CG		96		GI		135	161
143	Failure of internal 15 VDC power supply	CG		97		GI		135	163
144	Failure of internal 5 VDC power supply	CG		98		GI		135	164
145	Failure of internal 0 VDC power supply	CG		99		GI		135	165
154	Supervision trip circuit	CG		100	CA	GI		p	36
160	Common alarm	CG			CA	GI		p	46
161	Measured value supervision of currents	CG			CA	GI		p	32
162	Failure: Current summation supervision	CG		104		GI		135	182
163	Failure: Current symmetry supervision	CG		107		GI		135	183
164	Measured value supervision of voltages	CG			CA	GI		p	33
165	Failure: Voltage sum superv. (ph-e)	CG		105		GI		135	184
166	Failure: Voltage sum superv. (ph-ph)	CG		106		GI		135	185
167	Failure: Voltage symmetry supervision	CG		108		GI		135	186
168	Failure: Measuring voltages absent	CG		109		GI		135	187
169	Fuse failure monitor operated (>10s)	CG		110		GI		135	188
171	Failure: Phase sequence supervision	CG		111	CA	GI		p	35
204	Fault recording initiated via bin.input						BT	135	204

FNo.	Meaning	Ann.		LSA No.	IEC 60870-5-103				Inf
		Op	Ft		CA	GI	BT	Typ	
205	Fault recording initiated via keyboard						BT	135	205
206	Fault recording initiated via PC interf						BT	135	206
301	Fault in the power system		CG	2				135	231
302	Flt. event w. consecutive no.		C					135	232
361	>U Line side VT MCB tripped	CG		20	CA	GI		p	38
362	>U2 Busbar side VT MCB tripped	CG		19		GI		150	12
501	General fault detection of device		CG		CA	GI	BT	p	84
502	General drop-off of device		C	152				150	152
503	General device fault detection: Ph. L1		CG		CA	GI	BT	p	64
504	General device fault detection: Ph. L2		CG		CA	GI	BT	p	65
505	General device fault detection: Ph. L3		CG		CA	GI	BT	p	66
506	General device fault detection: Ph. N		CG		CA	GI	BT	p	67
507	General device trip: Phase L1		C		CA		BT	p	69
508	General device trip: Phase L2		C		CA		BT	p	70
509	General device trip: Phase L3		C		CA		BT	p	71
511	General trip of device		C		CA		BT	p	68
516	General trip for fault in forward dir.		CG	242				150	166
517	General trip for fault in reverse dir.		CG	243				150	167
521	Interrupted current: Phase L1(I/In)		V	250				150	171
522	Interrupted current: Phase L2(I/In)		V	251				150	172
523	Interrupted current: Phase L3(I/In)		V	252				150	173
561	Circuit breaker manually closed (pulse)	C		18				150	211
562	CB close command for manual closing	C		249				150	212
601	Current in phase IL1 [%] =	M			CA			134	128
602	Current in phase IL2 [%] =	M			CA			134	128
603	Current in phase IL3 [%] =	M			CA			134	128
621	UL1E [%]=	M			CA			134	128
622	UL2E [%]=	M			CA			134	128
623	UL3E [%]=	M			CA			134	128
624	UL12 [%] =	M						134	128
625	UL23 [%] =	M						134	128
626	UL31 [%] =	M						134	128
641	Active power Pa [%] =	M			CA			134	128
642	Reactive power Pr [%] =	M			CA			134	128
644	Frequency f [%] =	M			CA			134	128
1114	Fault resistance, Ohm prim.		V					151	14
1115	Fault reactance, Ohm prim.		V		CA			p	73
1117	Fault resistance, Ohm sec.		V	201				151	17
1118	Fault reactance, Ohm sec.		V	202				151	18
1119	Distance to fault in km		V	203				151	19
1120	Distance to fault in %		V	204				151	20
1174	Circuit breaker test in progress	CG		21		GI		151	74
1181	Circuit breaker test: General trip	C		125				151	81
1316	>Carrier reception for direct. E/F comp	CG		68		GI		166	16
1317	>Carrier reception for dir. E/F faulty	CG		67		GI		166	17
1331	Earth fault protection is switched off	CG		71		GI		166	31
1332	Earth fault protection is blocked	CG		64		GI		166	32
1333	Earth fault protection is active	CG				GI		166	33
1334	Earth fault prot. direct.stage blocked	CG				GI		166	34
1341	Earth fault detection 75% Ie picked up		CG	208			BT	166	41
1342	Earth fault detection non-direct. Ie		CG	209				166	42
1343	Earth fault detection directional Ie		CG	207				166	43
1361	Trip by earth fault protection		C	247				166	61
1362	Earth fault protection: Trip 1pole L1		C	210				166	62
1363	Earth fault protection: Trip 1pole L2		C	211				166	63
1364	Earth fault protection: Trip 1pole L3		C	212				166	64
1365	Earth fault protection: Trip 3pole		C	213				166	65

FNo.	Meaning	Ann.		LSA No.	IEC 60870-5-103				Typ	Inf
		Op	Ft		CA	GI	BT			
1381	Earth fault dir. comp. is switched off	CG				GI		166	81	
1384	Carrier transmission for dir. comp. E/F		C	245				166	84	
1385	Echo signal for directional comp. E/F		C	70				166	85	
1386	Transient block. of E/F protection		C	218				166	86	
1451	Breaker fail protection is switched off	CG		113		GI		166	151	
1452	Breaker failure protection is blocked	CG				GI		166	152	
1453	Breaker failure protection is active	CG				GI		166	153	
1461	Breaker failure protection is picked up		CG	220				166	161	
1471	Trip by breaker failure protection		C	221	CA			p	85	
2051	Emergency O/C protect. is switched off	CG				GI		61	51	
2052	Emergency O/C protection is blocked	CG				GI		61	52	
2053	Emergency O/C protection is active	CG		50	CA	GI		p	37	
2055	Emergency O/C for earth switched off	CG		52		GI		61	55	
2056	Emergency O/C for phases switched off	CG		51		GI		61	56	
2061	Emerg. O/C prot.: General fault detect.		CG	160			BT	61	61	
2062	Emerg. O/C prot.: Fault detection L1		CG	145				61	62	
2063	Emerg. O/C prot.: Fault detection L2		CG	146				61	63	
2064	Emerg. O/C prot.: Fault detection L3		CG	147				61	64	
2065	Emerg. O/C prot.: Earth fault detection		CG	148				61	65	
2071	Emerg. O/C earth fault detection only		C	175				61	71	
2072	Emerg. O/C fault detection L1 only		C	161				61	72	
2073	Emerg. O/C fault detection L1E		C	162				61	73	
2074	Emerg. O/C fault detection L2 only		C	163				61	74	
2075	Emerg. O/C fault detection L2E		C	164				61	75	
2076	Emerg. O/C fault detection L12		C	165				61	76	
2077	Emerg. O/C fault detection L12E		C	166				61	77	
2078	Emerg. O/C fault detection L3 only		C	167				61	78	
2079	Emerg. O/C fault detection L3E		C	168				61	79	
2080	Emerg. O/C fault detection L13		C	169				61	80	
2081	Emerg. O/C fault detection L13E		C	170				61	81	
2082	Emerg. O/C fault detection L23		C	171				61	82	
2083	Emerg. O/C fault detection L23E		C	172				61	83	
2084	Emerg. O/C fault detection L123		C	173				61	84	
2085	Emerg. O/C fault detection L123E		C	174				61	85	
2091	Emerg. O/C phase fault detection I>>		CG	176				61	91	
2092	Emerg. O/C phase fault detection I>/Ip		CG	177				61	92	
2095	Emerg. O/C earth fault detection IE>>		CG	178				61	95	
2096	Emerg. O/C earth fault det. IE>/IEp		CG	179				61	96	
2121	Emerg. O/C prot.: Time TI>> expired		C	153				61	121	
2122	Emerg. O/C prot.: Time TI>/Tp expired		C	157				61	122	
2125	Emerg. O/C prot.: Time TIE>> expired		C					61	125	
2126	Emerg. O/C prot.: Time TIE>/TEp expired		C					61	126	
2141	Emerg. O/C protection: General Trip		C	191	CA			p	72	
2142	Emerg. O/C protection: Trip 1pole L1		C	238				61	142	
2143	Emerg. O/C protection: Trip 1pole L2		C	239				61	143	
2144	Emerg. O/C protection: Trip 1pole L3		C	240				61	144	
2145	Emerg. O/C protection: Trip 3pole		C	241				61	145	
2403	Back-up overcurrent prot. is active	CG				GI		62	103	
2405	Back-up earth O/C is switched off	CG		54		GI		62	105	
2406	Back-up phase O/C is switched off	CG		53		GI		62	106	
2411	Back-up overcurrent: Gen. fault det.		CG	180			BT	62	111	
2412	Back-up overcurrent: Fault detection L1		CG	181				62	112	
2413	Back-up overcurrent: Fault detection L2		CG	182				62	113	
2414	Back-up overcurrent: Fault detection L3		CG	183				62	114	
2415	Back-up earth fault detection , E		CG	184				62	115	
2421	Back-up overcurrent: Fault det. I>>		CG	185				62	121	
2422	Back-up overcurrent: Fault det. I>/Ip		CG	186				62	122	

FNo.	Meaning	Ann.		LSA No.	IEC 60870-5-103				Typ	Inf
		Op	Ft		CA	GI	BT			
2425	Back-up earth fault det. highset IE>>		CG	187					62	125
2426	Back-up earth fault detection IE>/IEp		CG	188					62	126
2451	Back-up overcurrent: General trip		C	189					62	151
2452	Back-up overcurrent: Trip 1pole L1		C	214					62	152
2453	Back-up overcurrent: Trip 1pole L2		C	215					62	153
2454	Back-up overcurrent: Trip 1pole L3		C	216					62	154
2455	Back-up overcurrent: Trip 3pole		C	217					62	155
2704	>AR: Reset auto-reclose function	CG		15		GI			40	4
2709	>AR: Block delayed auto-reclose	CG		76		GI			40	9
2711	>AR: External start for internal AR	CG		28		GI			40	11
2712	>AR: Ext. Trip L1 for internal AR	CG		29		GI			40	12
2713	>AR: Ext. Trip L2 for internal AR	CG		30		GI			40	13
2714	>AR: Ext. Trip L3 for internal AR	CG		31		GI			40	14
2781	AR: Auto-reclose is switched off	CG		79		GI			40	81
2782	AR: Auto-reclose is switched on	CG			CA	GI			p	16
2783	AR: Auto-reclose is blocked	CG		72		GI			40	83
2784	AR: Auto-reclose is not ready	CG			CA	GI	BT		p	130
2785	AR: Auto-reclose is dynamically blocked	CG		234		GI			40	85
2787	AR: Circuit breaker not ready	CG		78		GI			40	87
2788	AR: CB supervision time expired	C		227					40	88
2801	AR: Auto-reclose in progress	CG	CG	228		GI			40	101
2813	AR: 1pole dead time for RAR is running	CG	CG	229		GI			40	113
2814	AR: 3pole dead time for RAR is running	CG	CG	230		GI			40	114
2818	AR: Evolving fault recognition	C		235					40	118
2833	AR: 3pole dead time 1 for DAR running	CG	CG	231		GI			40	133
2834	AR: 3pole dead time 2 for DAR running	CG	CG	232		GI			40	134
2835	AR: 3pole dead time 3 for DAR running	CG	CG	233		GI			40	135
2851	AR: Close command from auto-reclose	C		248	CA		BT		p	128
2852	AR: Close command after 1pole RAR cycle	C		253					40	152
2853	AR: Close command after 3pole RAR cycle	C		254					40	153
2854	AR: Close command after 3pole DAR cycle	C		255	CA				p	129
2862	AR: Auto-reclose cycle successful	C		236					40	162
2863	AR: Definitive trip		C	237					40	163
2871	AR: Trip during 1pole AR cycle		C						40	171
2931	Synchro-check function is switched off	CG		119		GI			41	31
2932	Synchro-check function is blocked	CG		122		GI			41	32
2934	Synchro-check function faulty	CG		121		GI			41	34
2935	Synchro-check supervision time expired	C							41	35
2941	Synchro-check function is running	CG		120		GI			41	41
2942	Synchro-check function override/bypass	C							41	42
2943	Synchronism (U1>,U2>) detected	C							41	43
2944	Live line,dead busbar(U1>,U2<) detected	C							41	44
2945	Dead line, live busbar(U1<,U2>) detected	C							41	45
2946	Dead line,dead busbar(U1<,U2<) detected	C							41	46
2947	Sync.: Voltage diff. greater than limit	C							41	47
2948	Sync.: Freq. diff. greater than limit	C							41	48
2949	Sync.: Angle diff. greater than limit	C							41	49
2951	Synchronism release (to ext. AR)	C		123					41	51
2961	Close command from synchro-check	C		124					41	61
3651	Distance protection is switched off	CG		55		GI			28	51
3652	Distance protection is blocked	CG		48		GI			28	52
3653	Distance protection is active	CG				GI			28	53
3671	Dist.: General fault detection		CG	144					28	71
3672	Dist.: Fault detection , phase L1		CG	145		GI	BT		28	72
3673	Dist.: Fault detection , phase L2		CG	146		GI	BT		28	73
3674	Dist.: Fault detection , phase L3		CG	147		GI	BT		28	74
3675	Dist.: Fault detection , earth fault		CG	148		GI	BT		28	75

FNo.	Meaning	Ann.		LSA No.	IEC 60870-5-103				Typ	Inf
		Op	Ft		CA	GI	BT			
3681	Dist.: Fault detection only phase L1		C	161					28	81
3682	Dist.: Fault detection phase L1,E		C	162					28	82
3683	Dist.: Fault detection only phase L2		C	163					28	83
3684	Dist.: Fault detection phase L2,E		C	164					28	84
3685	Dist.: Fault detection phase L1,2		C	165					28	85
3686	Dist.: Fault detection phase L1,2,E		C	166					28	86
3687	Dist.: Fault detection only phase L3		C	167					28	87
3688	Dist.: Fault detection phase L3,E		C	168					28	88
3689	Dist.: Fault detection phase L1,3		C	169					28	89
3690	Dist.: Fault detection phase L1,3,E		C	170					28	90
3691	Dist.: Fault detection phase L2,3		C	171					28	91
3692	Dist.: Fault detection phase L2,3,E		C	172					28	92
3693	Dist.: Fault detection phase L1,2,3		C	173					28	93
3694	Dist.: Fault detection phase L1,2,3,E		C	174					28	94
3719	Dist.: Fault det. in forward direction		C	149	CA		BT		p	74
3720	Dist.: Fault det. in reverse direction		C	150	CA		BT		p	75
3771	Dist.: Time T1 (Zone Z1) expired		C	153	CA				p	78
3774	Dist.: Time T2 (Zone Z2) expired		C	154	CA				p	79
3777	Dist.: Time T3 (Zone Z3) expired		C	155	CA				p	80
3778	Dist.: Time T4 (direct. zone) expired		C	156	CA				p	81
3779	Dist.: Time T5 (non-dir. zone) expired		C	157	CA				p	82
3780	Dist.: Time T1B (Zone Z1B) expired		C	158					28	180
3783	Dist.: Time T1L (Zone Z1L) expired		C	159					28	183
3801	Distance protection: General trip		C						28	201
3802	Dist.: Trip phase L1 1pole only		C	238					28	202
3803	Dist.: Trip phase L2 1pole only		C	239					28	203
3804	Dist.: Trip phase L3 1pole only		C	240					28	204
3805	Dist.: Trip 3pole		C	241					28	205
4014	>Dist.:Teleprot./carrier receive POTT	C		57					29	14
4024	>Dist.:Teleprot./carrier receive PUTT	C		58					29	24
4051	Dist. teleprotection is switched on	CG			CA	GI			p	17
4054	Dist. teleprotection: Carrier reception		C		CA				p	77
4055	Dist. teleprotection: Carrier faulty	CG			CA	GI			p	39
4056	Dist. teleprotection: Carrier send		C		CA				p	76
4062	POTT teleprot.:function is switched off	CG		63		GI			29	62
4065	POTT teleprot.: Carrier faulty	CG		60		GI			29	65
4066	POTT teleprotection: Carrier send		C	244					29	66
4067	POTT teleprotection: Carrier echo send		C	59					29	67
4068	POTT teleprotection: Transient block		C	198					29	68
4072	PUTT teleprot.:function is switched off	CG		62		GI			29	72
4075	PUTT teleprotection: Carrier faulty	CG		61		GI			29	75
4076	PUTT teleprotection: Carrier send		C	246					29	76
4164	Power swing detection	CG		80		GI			29	164
4166	Out-of-step trip 3pole		C	81					29	166
4221	Weak infeed function is switched off	CG		112		GI			25	21
4222	Weak infeed function is blocked	CG				GI			25	22
4223	Weak infeed function is active	CG				GI			25	23
4231	Weak infeed: General fault detection		CG	136					25	31
4241	Weak infeed: General trip		C	190					25	41
4242	Weak infeed: Trip phase L1 only		C	192					25	42
4243	Weak infeed: Trip phase L2 only		C	193					25	43
4244	Weak infeed: Trip phase L3 only		C	194					25	44
4245	Weak infeed: Trip 3pole		C	195					25	45
4271	Switch-onto-fault is switched off	CG		118		GI			25	71
4272	Switch-onto-fault is blocked	CG				GI			25	72
4273	Switch-onto-fault is active	CG				GI			25	73
4281	Switch-onto-fault: Gen. fault detect.		CG	222					25	81

FNo.	Meaning	Ann.		LSA No.	IEC 60870-5-103				
		Op	Ft		CA	GI	BT	Typ	Inf
4282	Switch-onto-fault: Fault detection L1		CG	223				25	82
4283	Switch-onto-fault: Fault detection L2		CG	224				25	83
4284	Switch-onto-fault: Fault detection L3		CG	225				25	84
4295	Switch-onto-fault: Trip 3pole		CG	226				25	95
4323	Overvoltage protection active	CG				GI		50	23
4325	Overvoltage stage U> is switched off	CG		114		GI		50	25
4328	Overvoltage highset U>> is switched off	CG		115		GI		50	28
4331	Overvoltage detection : Stage U>		CG	130				50	31
4332	Overvoltage detection : Stage U>>		CG	131				50	32
4335	Overvoltage trip : Stage U>		C	132				50	35
4336	Overvoltage trip : Stage U>>		C	133				50	36
4339	Overvoltage stage U> intertrip send		C	134				50	39
4340	Overvoltage highset U>> intertrip send		C	135				50	40
4431	Ext. trip via binary input: Trip		C	151				51	31
4432	Ext. trip via binary input: 1pole L1		C					51	32
4433	Ext. trip via binary input: 1pole L2		C					51	33
4434	Ext. trip via binary input: 1pole L3		C					51	34
4435	Ext. trip via binary input: 3pole		C					51	35
4436	Ext. trip via binary input: Without AR		C					51	36
6254	Output signal of user defined timer T1	CG				GI		214	54
6255	Output signal of user defined timer T2	CG				GI		214	55

Annunciations 7SA513 for PC, LC-display and binary inputs/outputs

FNo. - Function number of annunciation
 Op/Ft - Operation/Fault annunciation
 C/CG: Coming/Coming and Going annunciation
 M : Measurand
 E - Earth fault annunciation
 IOT - I: can be marshalled to binary input
 O: can be marshalled to binary output (LED, signal relay)
 T: can be marshalled to trip relay

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
3	>Time Synchro	>Time synchronization				IO
4	>Start FltRec	>Start fault recording	C			IO
5	>LED reset	>Reset LED indicators				IO
7	>ParamSelec.1	>Parameter set selection 1 (with No.8)				IO
8	>ParamSelec.2	>Parameter set selection 2 (with No.7)				IO
11	>Annunc. 1	>User defined annunciation 1	CG			IOT
12	>Annunc. 2	>User defined annunciation 2	CG			IOT
13	>Annunc. 3	>User defined annunciation 3	CG			IOT
14	>Annunc. 4	>User defined annunciation 4	CG			IOT
15	>Sys-Test	>Testing via system-interface				IO
16	>Sys-MM-block	>Block. of monitoring dir. via sys.-int				IO
51	Dev.operative	Device operative / healthy	CG			O
52	Prot. operat.	Any protection operative	CG			O
56	Initial start	Initial start of processor system	C			
60	LED reset	LED Reset	C			O
61	LogMeasBlock	Logging and measuring functions blocked	CG			
62	Test mode	Test mode	CG			
95	Param.running	Parameters are being set	CG			O
96	Param. Set A	Parameter set A is active	CG			O
97	Param. Set B	Parameter set B is active	CG			O
98	Param. Set C	Parameter set C is active	CG			O
99	Param. Set D	Parameter set D is active	CG			O
100	Wrong SW-vers	Wrong software-version	C			
101	Wrong dev. ID	Wrong device identification	C			
110	Annunc. lost	Annunciations lost (buffer overflow)	C			
111	Annu. PC lost	Annunciations for PC lost	C			
115	Flt.Buff.Over	Fault annunciation buffer overflow		C		
120	Oper.Ann.Inva	Operational annunciations invalid	CG			
121	Flt.Ann.Inval	Fault annunciations invalid	CG			
123	Stat.Buff.Inv	Statistic annunciation buffer invalid	CG			
124	LED Buff.Inva	LED annunciation buffer invalid	CG			
129	VDEW-StateInv	VDEW state invalid	CG			
135	Chs Error	Error in check sum	CG			
136	Chs.A Error	Error in check sum for parameter set A	CG			
137	Chs.B Error	Error in check sum for parameter set B	CG			
138	Chs.C Error	Error in check sum for parameter set C	CG			
139	Chs.D Error	Error in check sum for parameter set D	CG			
141	Failure 24V	Failure of internal 24 VDC power supply	CG			OT
143	Failure 15V	Failure of internal 15 VDC power supply	CG			OT
144	Failure 5V	Failure of internal 5 VDC power supply	CG			OT
145	Failure 0V	Failure of internal 0 VDC power supply	CG			OT
154	Fail. TripRel	Supervision trip circuit	CG			
159	LSA disrupted	LSA (system interface) disrupted	CG			
161	I supervision	Measured value supervision of currents				O
162	Failure ΣI	Failure: Current summation supervision	CG			OT
163	Failure Isymm	Failure: Current symmetry supervision	CG			OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
164	U supervision	Measured value supervision of voltages				O
165	Failure Σ Up-e	Failure: Voltage sum superv. (ph-e)	CG			OT
166	Failure Σ Up-p	Failure: Voltage sum superv. (ph-ph)	CG			OT
167	Failure Usymm	Failure: Voltage symmetry supervision	CG			OT
168	Failure Umeas	Failure: Measuring voltages absent	CG			OT
169	Fuse-Failure	Fuse failure monitor operated (>10s)	CG			OT
170	FFM pick-up	Fuse failure monitor pick-up	CG			
171	Fail.PhaseSeq	Failure: Phase sequence supervision	CG			OT
203	Flt.RecDatDel	Fault recording data deleted	C			
204	Flt.Rec.viaBI	Fault recording initiated via bin.input	C			
205	Flt.Rec.viaKB	Fault recording initiated via keyboard	C			
206	Flt.Rec.viaPC	Fault recording initiated via PC interf	C			
244	D Time=	Diff. time of clock synchronism	M			
301	Syst.Flt	Fault in the power system	CG	C		
302	Fault	Flt. event w. consecutive no.		C		
351	>CB Aux. L1	>Circuit breaker aux. contact: Phase L1				IOT
352	>CB Aux. L2	>Circuit breaker aux. contact: Phase L2				IOT
353	>CB Aux. L3	>Circuit breaker aux. contact: Phase L3				IOT
354	>CB Aux.3p cl	>CB aux. contact:3poles closed (series)				IOT
355	>CB Aux.1p cl	>CB aux. contact:1pole closed(parallel)				IOT
356	>Manual Close	>Manual close				IOT
357	>CloseCmd.Blo	>Block all close commands from external	CG			IOT
361	>VT mcb Trip	>U Line side VT MCB tripped	CG			IOT
362	>V2 mcb Trip	>U2 Busbar side VT MCB tripped	CG			IOT
381	>1p Trip Perm	>External auto-reclose ready for 1pole	CG			IOT
382	>Only 1pole	>External AR programmed for 1pole only	CG			IOT
383	>RAR Release	>Release overreach zones RAR	CG	CG		IOT
384	>DAR Release	>Release overreach zones DAR	CG	CG		IOT
501	Device FltDet	General fault detection of device				OT
502	Dev. Drop-off	General drop-off of device		C		
503	Dev.FltDet L1	General device fault detection: Ph. L1				OT
504	Dev.FltDet L2	General device fault detection: Ph. L2				OT
505	Dev.FltDet L3	General device fault detection: Ph. L3				OT
506	Dev.FltDet N	General device fault detection: Ph. N				OT
511	Device Trip	General trip of device		G		OT
512	Dev.Trip 1pL1	General 1pole trip of device: Phase L1				OT
513	Dev.Trip 1pL2	General 1pole trip of device: Phase L2				OT
514	Dev.Trip 1pL3	General 1pole trip of device: Phase L3				OT
515	Dev.Trip 3p	General 3pole trip of device				OT
516	Dev.Trip forw	General trip for fault in forward dir.				OT
517	Dev.Trip rev.	General trip for fault in reverse dir.		C		OT
521	IL1/In=	Interrupted current: Phase L1(I/In)		C		
522	IL2/In=	Interrupted current: Phase L2(I/In)		C		
523	IL3/In=	Interrupted current: Phase L3(I/In)		C		
545	T-Drop	Time from fault detection to drop-off				
546	T-Trip	Time from fault detection to trip				
561	Manual Close	Circuit breaker manually closed (pulse)	C			OT
562	Man.Close Cmd	CB close command for manual closing				OT
563	CB Alarm Supp	CB alarm suppressed				OT
601	IL1[%] =	Current in phase IL1 [%] =	M			
602	IL2[%] =	Current in phase IL2 [%] =	M			
603	IL3[%] =	Current in phase IL3 [%] =	M			
621	UL1E[%]=	UL1E [%]=	M			
622	UL2E[%]=	UL2E [%]=	M			
623	UL3E[%]=	UL3E [%]=	M			
624	UL12[%]=	UL12 [%] =	M			
625	UL23[%]=	UL23 [%] =	M			
626	UL31[%]=	UL31 [%] =	M			

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
641	Pa[%]=	Active power Pa [%] =	M			
642	Pr[%]=	Reactive power Pr [%] =	M			
644	f [%]=	Frequency f [%] =	M			
651	IL1 =	Current in phase IL1 =	M			
652	IL2 =	Current in phase IL2 =	M			
653	IL3 =	Current in phase IL3 =	M			
671	UL1E=	Voltage UL1E =	M			
672	UL2E=	Voltage UL2E =	M			
673	UL3E=	Voltage UL3E =	M			
674	UL12=	Voltage UL12 =	M			
675	UL23=	Voltage UL23 =	M			
676	UL31=	Voltage UL31 =	M			
691	Pa=	Active power Pa =	M			
692	Pr=	Reactive power Pr =	M			
1001	TripNo L1=	Number of trip commands: Phase L1	M			
1002	TripNo L2=	Number of trip commands: Phase L2	M			
1003	TripNo L3=	Number of trip commands: Phase L3	M			
1004	Σ IL1/In=	Summated current tripped IL1/In	M			
1005	Σ IL2/In=	Summated current tripped IL2/In	M			
1006	Σ IL3/In=	Summated current tripped IL3/In	M			
1011	AR 1pole=	No. of auto-reclose commands:1p RAR	M			
1012	AR 3pole=	No. of auto-reclose commands:3p RAR	M			
1013	DAR 3pol=	No. of auto-reclose commands:3p DAR	M			
1106	>Start FltLoc	>Start fault locator	CG			IOT
1114	Rpri=	Fault resistance, Ohm prim.		C		
1115	Xpri=	Fault reactance, Ohm prim.		C		
1117	Rsec=	Fault resistance, Ohm sec.		C		
1118	Xsec=	Fault reactance, Ohm sec.		C		
1119	d =	Distance to fault in km		C		
1120	d[%]=	Distance to fault in %		C		
1132	FltLoc.inval.	Fault location invalid		C		OT ²⁾
1156	>CB Test	>CB test start				IOT
1174	CB in Test	Circuit breaker test in progress	CG			OT
1181	CB Test Trip	Circuit breaker test: General trip				OT
1182	CB Test 1pL1	Circuit breaker test: Trip 1pole L1	C			OT
1183	CB Test 1pL2	Circuit breaker test: Trip 1pole L2	C			OT
1184	CB Test 1pL3	Circuit breaker test: Trip 1pole L3	C			OT
1185	CB Test 3p	Circuit breaker test: Trip 3pole	C			OT
1303	>E/F block	>Block E/F protection				IOT
1311	>E/F comp. on	>Switch on directional E/F comparison				IOT
1312	>E/F comp.off	>Switch off directional E/F comparison				IOT
1316	>E/F Recept	>Carrier reception for direct. E/F comp	C	C		IOT
1317	>E/F Rec.Fail	>Carrier reception for dir. E/F faulty	CG			IOT
1331	E/F Prot. off	Earth fault protection is switched off	CG			OT
1332	E/F blocked	Earth fault protection is blocked	CG	CG		OT
1333	E/F active	Earth fault protection is active				OT
1334	E/F Dir.block	Earth fault prot. direct.stage blocked				OT
1341	E/F Flt75%Ie>	Earth fault detection 75% Ie picked up		CG		OT
1342	E/F Flt Ie<->	Earth fault detection non-direct. Ie		C		OT
1343	E/F Flt Ie ->	Earth fault detection directional Ie		C		OT
1351	E/F T-Delay	Earth fault protection time expired				OT
1352	E/F T->	Earth fault prot. dir. time expired				OT
1353	E/F T<->	Earth fault prot. non-dir. time expired				OT
1361	E/F Trip	Trip by earth fault protection				OT
1362	E/F Trip L1	Earth fault protection: Trip 1pole L1		C		OT
1363	E/F Trip L2	Earth fault protection: Trip 1pole L2		C		OT
1364	E/F Trip L3	Earth fault protection: Trip 1pole L3		C		OT
1365	E/F Trip 3p	Earth fault protection: Trip 3pole		C		OT
1381	E/F Dir off	Earth fault dir. comp. is switched off	CG			OT

²⁾ from firmware version V3.3 or higher

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
1384	E/F Send	Carrier transmission for dir. comp. E/F		C		OT
1385	E/F Echo	Echo signal for directional comp. E/F	C			OT
1386	E/F TransBloc	Transient block. of E/F protection		C		OT
1401	>B/F on	>Switch on breaker fail protection				IOT
1402	>B/F off	>Switch off breaker fail protection				IOT
1403	>B/F block	>Block breaker fail protection				IOT
1432	>B/F release	>ext. release breaker failure protect.	CG			IOT
1435	>B/F Start L1	>Breaker fail: Start L1 from external	CG			IOT
1436	>B/F Start L2	>Breaker fail: Start L2 from external	CG			IOT
1437	>B/F Start L3	>Breaker fail: Start L3 from external	CG			IOT
1451	B/F off	Breaker fail protection is switched off	CG			OT
1452	B/F blocked	Breaker failure protection is blocked	CG			OT
1453	B/F active	Breaker failure protection is active				OT
1461	B/F Start	Breaker failure protection is picked up		CG		OT
1471	B/F Trip	Trip by breaker failure protection				OT
1472	B/F Trip L1	Breaker fail: Trip due to L1		C		OT
1473	B/F Trip L2	Breaker fail: Trip due to L2		C		OT
1474	B/F Trip L3	Breaker fail: Trip due to L3		C		OT
1476	B/F Trip 3pol	Breaker fail: 3pole trip		C		OT
1478	B/F Trip wo I	Breaker fail: No current trip		C		OT
1706	>I>> block	>Block I>> stage of O/C protection	CG			IOT
1707	>I>/Ip block	>Block overcurrent I>/Ip	CG			IOT
1716	>IE>> block	>Block IE>> stage of O/C protection	CG			IOT
1717	>IE>/IEp bloc	>Block earth overcurrent IE>/Ip	CG			IOT
2003	>Emer. block	>Block emergency overcurrent protection				IOT
2051	Emer. off	Emergency O/C protect. is switched off				OT
2052	Emer. block	Emergency O/C protection is blocked	CG			OT
2053	Emer. active	Emergency O/C protection is active	CG			OT
2055	Emer. E off	Emergency O/C for earth switched off	CG			OT
2056	Emer.Ph.off	Emergency O/C for phases switched off	CG			OT
2061	Emer.Gen.Flt	Emerg. O/C prot.: General fault detect.		G		OT
2062	Emer. Flt L1	Emerg. O/C prot.: Fault detection L1				OT
2063	Emer. Flt L2	Emerg. O/C prot.: Fault detection L2				OT
2064	Emer. Flt L3	Emerg. O/C prot.: Fault detection L3				OT
2065	Emer. Flt E	Emerg. O/C prot.: Earth fault detection				OT
2071	Emer. Flt E	Emerg. O/C earth fault detection only		C		
2072	Emer. Flt L1	Emerg. O/C fault detection L1 only		C		
2073	Emer. Flt L1E	Emerg. O/C fault detection L1E		C		
2074	Emer. Flt L2	Emerg. O/C fault detection L2 only		C		
2075	Emer. Flt L2E	Emerg. O/C fault detection L2E		C		
2076	Emer. Flt L12	Emerg. O/C fault detection L12		C		
2077	Emer.Flt L12E	Emerg. O/C fault detection L12E		C		
2078	Emer. Flt L3	Emerg. O/C fault detection L3 only		C		
2079	Emer. Flt L3E	Emerg. O/C fault detection L3E		C		
2080	Emer. Flt L13	Emerg. O/C fault detection L13		C		
2081	Emer.Flt L13E	Emerg. O/C fault detection L13E		C		
2082	Emer. Flt L23	Emerg. O/C fault detection L23		C		
2083	Emer.Flt L23E	Emerg. O/C fault detection L23E		C		
2084	Emer.Flt L123	Emerg. O/C fault detection L123		C		
2085	Emer.Flt L123E	Emerg. O/C fault detection L123E		C		
2091	Emer. I>>	Emerg. O/C phase fault detection I>>		C		OT
2092	Emer. I>/Ip	Emerg. O/C phase fault detection I>/Ip		C		OT
2095	Emer. IE>>	Emerg. O/C earth fault detection IE>>		C		OT
2096	Emer. IE>/IEp	Emerg. O/C earth fault det. IE>/IEp		C		OT
2121	Emer. TI>>	Emerg. O/C prot.: Time TI>> expired				OT
2122	Emer. TI>/Tp	Emerg. O/C prot.: Time TI>/Tp expired				OT
2125	Emer. TIE>>	Emerg. O/C prot.: Time TIE>> expired				OT
2126	Emer. TIE>TEp	Emerg. O/C prot.: Time TIE>/TEp expired				OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
2141	Emer.Gen.Trip	Emerg. O/C protection: General Trip				OT
2142	Emer.Trip1pL1	Emerg. O/C protection: Trip 1pole L1		C		OT
2143	Emer.Trip1pL2	Emerg. O/C protection: Trip 1pole L2		C		OT
2144	Emer.Trip1pL3	Emerg. O/C protection: Trip 1pole L3		C		OT
2145	Emer.Trip 3p	Emerg. O/C protection: Trip 3pole		C		OT
2303	>Backup block	>Block back-up overcurrent time prot.	CG			IOT
2403	Backup active	Back-up overcurrent prot. is active				OT
2405	Backup E off	Back-up earth O/C is switched off	CG			OT
2406	Backup Ph off	Back-up phase O/C is switched off	CG			OT
2411	Back Gen. Flt	Back-up overcurrent: Gen. fault det.		G		OT
2412	Backup Flt L1	Back-up overcurrent: Fault detection L1		C		OT
2413	Backup Flt L2	Back-up overcurrent: Fault detection L2		C		OT
2414	Backup Flt L3	Back-up overcurrent: Fault detection L3		C		OT
2415	Backup Flt E	Back-up earth fault detection , E		C		OT
2421	Backup I>>	Back-up overcurrent: Fault det. I>>		C		OT
2422	Backup I>/Ip	Back-up overcurrent: Fault det. I>/Ip		C		OT
2425	Backup IE>>	Back-up earth fault det. highset IE>>		C		OT
2426	Back IE>/IEp	Back-up earth fault detection IE>/IEp		C		OT
2441	Backup TI>>	Back-up overcurrent: Time TI>> expired				OT
2442	Backup TI>/Tp	Back-up overcurrent: Time TI>/Tp exp.				OT
2445	Back TIE>>	Back-up overcurrent: Time TIE>> exp.				OT
2446	Back TIE>/TEp	Back-up overcurrent: Time TIE>/TEp exp.				OT
2451	Back Gen.Trip	Back-up overcurrent: General trip				OT
2452	Back Trip L1	Back-up overcurrent: Trip 1pole L1		C		OT
2453	Back Trip L2	Back-up overcurrent: Trip 1pole L2		C		OT
2454	Back Trip L3	Back-up overcurrent: Trip 1pole L3		C		OT
2455	Back Trip 3p	Back-up overcurrent: Trip 3pole		C		OT
2701	>AR on	>AR: Switch on auto-reclose function				IOT
2702	>AR off	>AR: Switch off auto-reclose function				IOT
2703	>AR block	>AR: Block auto-reclose function	CG			IOT
2704	>AR reset	>AR: Reset auto-reclose function	C			IOT
2706	>1p RAR block	>AR: Block 1pole rapid auto-reclose	CG			IOT
2707	>3p RAR block	>AR: Block 3pole rapid auto-reclose	CG			IOT
2708	>RAR block	>AR: Block rapid auto-reclose	CG			IOT
2709	>DAR block	>AR: Block delayed auto-reclose	CG			IOT
2711	>Start AR	>AR: External start for internal AR	C			IOT
2712	>Trip L1 AR	>AR: Ext. Trip L1 for internal AR	C			IOT
2713	>Trip L2 AR	>AR: Ext. Trip L2 for internal AR	C			IOT
2714	>Trip L3 AR	>AR: Ext. Trip L3 for internal AR	C			IOT
2715	>Trip 1p AR	>AR: Ext. 1pole trip for internal AR	C			IOT
2716	>Trip 3p AR	>AR: Ext. 3pole trip for internal AR	C			IOT
2721	>DAR aft. RAR	>AR: Delayed AR only after rapid AR	CG			IOT
2730	>CB ready	>AR: Circuit breaker ready for reclose				IOT
2731	>Sync.release	>AR: Synchronism from ext. sync.-check				IOT
2781	AR off	AR: Auto-reclose is switched off	CG			OT
2782	AR on	AR: Auto-reclose is switched on				OT
2783	AR inoperativ	AR: Auto-reclose is blocked	CG			OT
2784	AR not ready	AR: Auto-reclose is not ready				OT
2785	AR block.dyn.	AR: Auto-reclose is dynamically blocked		C		OT
2787	CB not ready	AR: Circuit breaker not ready				OT
2788	AR T-CB Exp.	AR: CB supervision time expired				OT
2801	AR in prog.	AR: Auto-reclose in progress		C		OT
2811	RAR only	AR: Only rapid auto-reclosing allowed				OT
2812	RAR T-act.run	AR: Action time for RAR is running				OT
2813	RAR T-1p run.	AR: 1pole dead time for RAR is running		C		OT
2814	RAR T-3p run.	AR: 3pole dead time for RAR is running		C		OT
2815	RAR 1p Prog.	AR: 1pole rapid auto-reclose program				OT
2816	RAR 3p Prog.	AR: 3pole rapid auto-reclose program				OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
2817	RAR Zone Rel.	AR: Zone extension for rapid reclosing				OT
2818	AR evolv.Flt.	AR: Evolving fault recognition				OT
2831	DAR Only	AR: Only delayed auto-reclosing allowed				OT
2832	DAR T-act.run	AR: Action time for DAR is running				OT
2833	DAR T-3p1 run	AR: 3pole dead time 1 for DAR running		C		OT
2834	DAR T-3p2 run	AR: 3pole dead time 2 for DAR running		C		OT
2835	DAR T-3p3 run	AR: 3pole dead time 3 for DAR running		C		OT
2837	DAR Zone Rel.	AR: Zone extension for delayed reclose				OT
2851	AR Close Cmd.	AR: Close command from auto-reclose	C	C		OT
2852	RAR 1p Close	AR: Close command after 1pole RAR cycle				OT
2853	RAR 3p Close	AR: Close command after 3pole RAR cycle				OT
2854	DAR 3p Close	AR: Close command after 3pole DAR cycle				OT
2861	AR T-Recl.run	AR: Reclaim time is running				OT
2862	AR successful	AR: Auto-reclose cycle successful				OT
2863	Definit.Trip	AR: Definitive trip				OT
2864	1p Trip Perm.	AR: 1pole trip allowed by internal AR				OT
2865	Sync.Meas.Reg	AR: Sync-check request				OT
2871	AR Trip 3p	AR: Trip during 1pole AR cycle		C		OT
2901	>Sync. on	>Switch on synchro-check function				IOT
2902	>Sync. off	>Switch off synchro-check function				IOT
2903	>Sync. block	>Block synchro-check function				IOT
2906	>Sync. Start	>Initiate internal synchro-check				IOT
2907	>Sync. synch	>Sync.: Check synchronism				IOT
2908	>Sync. U1>U2<	>Sync. live line (U1>), dead bus (U2<)				IOT
2909	>Sync. U1<U2>	>Sync. dead line (U1<), live bus (U2>)				IOT
2910	>Sync. U1<U2<	>Sync. dead line (U1<), dead bus (U2<)				IOT
2911	>Sync. o/ride	>Synchro-check override (bypass)				IOT
2931	Sync. off	Synchro-check function is switched off	CG			OT
2932	Sync. blocked	Synchro-check function is blocked	CG			OT
2934	Sync. faulty	Synchro-check function faulty	CG			OT
2935	Sync.Tsup.Exp	Synchro-check supervision time expired	C	C		OT
2941	Sync. running	Synchro-check function is running				OT
2942	Sync.Override	Synchro-check function override/bypass	CG			OT
2943	Sync. Synchro	Synchronism (U1>,U2>) detected	CG			OT
2944	Sync. U1>U2<	Live line,dead busbar(U1>,U2<) detected	CG			OT
2945	Sync. U1<U2>	Dead line,live busbar(U1<,U2>) detected	CG			OT
2946	Sync. U1<U2<	Dead line,dead busbar(U1<,U2<) detected	CG			OT
2947	Sync. Udiff>	Sync.: Voltage diff. greater than limit	CG			OT
2948	Sync. fdiff>	Sync.: Freq. diff. greater than limit	CG			OT
2949	Sync. p.diff>	Sync.: Angle diff. greater than limit	CG			OT
2951	Sync. release	Synchronism release (to ext. AR)				OT
2961	Sync.CloseCmd	Close command from synchro-check				OT
3603	>Dist. block	>Block distance protection				IOT
3611	>Extens. Z1B	>Dist.: Zone 1B extension from external	CG			IOT
3612	>Extens. Z1L	>Dist.: Zone 1L extension from external	CG			IOT
3651	Dist. off	Distance protection is switched off	CG			OT
3652	Dist. blocked	Distance protection is blocked	CG			OT
3653	Dist. active	Distance protection is active				OT
3661	DisZ1B AR blk	Dist.: Block AR by fault detec. Z1B		C		OT
3662	DisZ1L AR blk	Dist.: Block AR by fault detec. Z1L		C		OT
3671	Dist.Gen.Flt.	Dist.: General fault detection			G	OT
3672	Dist.Fault L1	Dist.: Fault detection , phase L1				OT
3673	Dist.Fault L2	Dist.: Fault detection , phase L2				OT
3674	Dist.Fault L3	Dist.: Fault detection , phase L3				OT
3675	Dist.Fault E	Dist.: Fault detection , earth fault				OT
3681	Dist.Flt.L1	Dist.: Fault detection only phase L1		C		
3682	Dist.Flt.L1E	Dist.: Fault detection phase L1,E		C		
3683	Dist.Flt.L2	Dist.: Fault detection only phase L2		C		

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
3684	Dist.Flt.L2E	Dist.: Fault detection phase L2,E		C		
3685	Dist.Flt.L12	Dist.: Fault detection phase L1,2		C		
3686	Dist.Flt.L12E	Dist.: Fault detection phase L1,2,E		C		
3687	Dist.Flt.L3	Dist.: Fault detection only phase L3		C		
3688	Dist.Flt.L3E	Dist.: Fault detection phase L3,E		C		
3689	Dist.Flt.L13	Dist.: Fault detection phase L1,3		C		
3690	Dist.Flt.L13E	Dist.: Fault detection phase L1,3,E		C		
3691	Dist.Flt.L23	Dist.: Fault detection phase L2,3		C		
3692	Dist.Flt.L23E	Dist.: Fault detection phase L2,3,E		C		
3693	Dist.Flt.L123	Dist.: Fault detection phase L1,2,3		C		
3694	Dist.Flt.L23E	Dist.: Fault detection phase L1,2,3,E		C		
3695	Dist. phi L1	Dist.: Phi phase L1 active		CG		OT
3696	Dist. phi L2	Dist.: Phi phase L2 active		CG		OT
3697	Dist. phi L3	Dist.: Phi phase L3 active		CG		OT
3701	Loop L1-E f	Dist.: Loop L1E selected forward		CG		OT
3702	Loop L2-E f	Dist.: Loop L2E selected forward		CG		OT
3703	Loop L3-E f	Dist.: Loop L3E selected forward		CG		OT
3704	Loop L1-2 f	Dist.: Loop L12 selected forward		CG		OT
3705	Loop L2-3 f	Dist.: Loop L23 selected forward		CG		OT
3706	Loop L3-1 f	Dist.: Loop L31 selected forward		CG		OT
3707	Loop L1-E r	Dist.: Loop L1E selected reverse		CG		OT
3708	Loop L2-E r	Dist.: Loop L2E selected reverse		CG		OT
3709	Loop L3-E r	Dist.: Loop L3E selected reverse		CG		OT
3710	Loop L1-2 r	Dist.: Loop L12 selected reverse		CG		OT
3711	Loop L2-3 r	Dist.: Loop L23 selected reverse		CG		OT
3712	Loop L3-1 r	Dist.: Loop L31 selected reverse		CG		OT
3713	Loop L1-E <->	Dist.: Loop L1E selected non-direct.		CG		OT
3714	Loop L2-E <->	Dist.: Loop L2E selected non-direct.		CG		OT
3715	Loop L3-E <->	Dist.: Loop L3E selected non-direct.		CG		OT
3716	Loop L1-2 <->	Dist.: Loop L12 selected non-direct.		CG		OT
3717	Loop L2-3 <->	Dist.: Loop L23 selected non-direct.		CG		OT
3718	Loop L3-1 <->	Dist.: Loop L31 selected non-direct.		CG		OT
3719	Dist. For.Dir	Dist.: Fault det. in forward direction				OT
3720	Dist. Rev.Dir	Dist.: Fault det. in reverse direction				OT
3741	Dist.Z1 L1E	Dist.: Fault det. Zone Z1 Loop L1-E				OT
3742	Dist.Z1 L2E	Dist.: Fault det. Zone Z1 Loop L2-E				OT
3743	Dist.Z1 L3E	Dist.: Fault det. Zone Z1 Loop L3-E				OT
3744	Dist.Z1 L12	Dist.: Fault det. Zone Z1 Loop L1-2				OT
3745	Dist.Z1 L23	Dist.: Fault det. Zone Z1 Loop L2-3				OT
3746	Dist.Z1 L31	Dist.: Fault det. Zone Z1 Loop L3-1				OT
3747	Dist.Z1B L1E	Dist.: Fault det. Zone Z1B Loop L1E				OT
3748	Dist.Z1B L2E	Dist.: Fault det. Zone Z1B Loop L2E				OT
3749	Dist.Z1B L3E	Dist.: Fault det. Zone Z1B Loop L3E				OT
3750	Dist.Z1B L12	Dist.: Fault det. Zone Z1B Loop L12				OT
3751	Dist.Z1B L23	Dist.: Fault det. Zone Z1B Loop L23				OT
3752	Dist.Z1B L31	Dist.: Fault det. Zone Z1B Loop L31				OT
3753	Dist. Z1L	Dist.: Fault detection Zone Z1L				OT
3755	Dist. Z2	Dist.: Fault detection Zone Z2				OT
3758	Dist. Z3	Dist.: Fault detection Zone Z3				OT
3771	Dist. T1	Dist.: Time T1 (Zone Z1) expired				OT
3774	Dist. T2	Dist.: Time T2 (Zone Z2) expired				OT
3777	Dist. T3	Dist.: Time T3 (Zone Z3) expired				OT
3778	Dist. T4	Dist.: Time T4 (direct. zone) expired				OT
3779	Dist. T5	Dist.: Time T5 (non-dir. zone) expired				OT
3780	Dist. T1B	Dist.: Time T1B (Zone Z1B) expired				OT
3783	Dist. T1L	Dist.: Time T1L (Zone Z1L) expired				OT
3801	Dis.Gen. Trip	Distance protection: General trip				OT
3802	Dis.Trip 1pL1	Dist.: Trip phase L1 1pole only		C		OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
3803	Dis.Trip 1pL2	Dist.: Trip phase L2 1pole only		C		OT
3804	Dis.Trip 1pL3	Dist.: Trip phase L3 1pole only		C		OT
3805	Dis.Trip 3p	Dist.: Trip 3pole		C		OT
3808	Dis.Trip back	Dist.: Trip in back-up stage				OT
3811	Dis.TripZ1/1p	Dist.: Trip 1pole in zone Z1/T1		C		OT
3812	Dis.TripZ1/3p	Dist.: Trip 3pole in zone Z1/T1		C		OT
3813	Dis.TripZ1B1p	Dist.: Trip 1pole in zone Z1B/T1B		C		OT
3814	Dis.TripZ1B3p	Dist.: Trip 3pole in zone Z1B/T1B		C		OT
3815	Dis.Trip Z1L	Dist.: Trip for fault in zone Z1L/T1L		C		OT
3816	Dis.TripZ2/1p	Dist.: Trip 1pole in zone Z2/T2		C		OT
3817	Dis.TripZ2/3p	Dist.: Trip 3pole in zone Z2/T2		C		OT
3818	Dis.TripZ3/T3	Dist.: Trip for fault in zone Z3/T3		C		OT
3819	Dis.Trip FD->	Dist.: Trip by fault detection, direct		C		OT
3820	Dis.Trip <->	Dist.: Trip by fault detec., non-direct		C		OT
4011	>Dis.POTT on	>Dist.:Switch on teleprotection POTT				IOT
4012	>Dis.POTT off	>Dist.:Switch off teleprotection POTT				IOT
4014	>Dis.Recept.O	>Dist.:Teleprot./carrier receive POTT	C	C		IOT
4015	>Dis.RecFailO	>Dist.:Teleprot./carrier faulty POTT				IOT
4021	>Dis.PUTT on	>Dist.:Switch on teleprotection PUTT				IOT
4022	>Dis.PUTT off	>Dist.:Switch off teleprotection PUTT				IOT
4024	>Dis.Recept.U	>Dist.:Teleprot./carrier receive PUTT	C	C		IOT
4025	>Dis.RecFailU	>Dist.:Teleprot./carrier faulty PUTT				IOT
4051	Dis.Tele.on	Dist. teleprotection is switched on				OT
4054	Dis. Recept	Dist. teleprotection: Carrier reception				OT
4055	Dis. RecFail	Dist. teleprotection: Carrier faulty				OT
4056	Dis. Send	Dist. teleprotection: Carrier send				OT
4062	POTT Tele.off	POTT teleprot.:function is switched off	CG			OT
4065	Dis.Rec.FailO	POTT teleprot.: Carrier faulty	CG			OT
4066	Dis.POTT Send	POTT teleprotection: Carrier send		C		OT
4067	Dis.POTT Echo	POTT teleprotection: Carrier echo send	C			OT
4068	Dis.TransBlo	POTT teleprotection: Transient block		C		OT
4069	Blk.Sig.Trans	BLOCKING: Signal transmit				OT
4070	Blk.Sig.Stop	BLOCKING: Signal stop		C		OT
4072	PUTT Tele off	PUTT teleprot.:function is switched off	CG			OT
4075	Dis.Rec.FailU	PUTT teleprotection: Carrier faulty	CG			OT
4076	Dis.PUTT Send	PUTT teleprotection: Carrier send		C		OT
4164	Power Swing	Power swing detection	CG	C		OT
4165	P/S T-action	Power swing action time running				OT
4166	O/S Trip	Out-of-step trip 3pole	C	C		OT
4203	>W/I block	>Block weak infeed trip function				IOT
4206	>W/I Rec	>Weak infeed carrier receive				IOT
4221	W/I off	Weak infeed function is switched off	CG			OT
4222	W/I blocked	Weak infeed function is blocked	CG			OT
4223	W/I active	Weak infeed function is active				OT
4231	W/I Gen. Flt.	Weak infeed: General fault detection				OT
4232	W/I Flt. L1	Weak infeed: Fault detection phase L1		C		OT
4233	W/I Flt. L2	Weak infeed: Fault detection phase L2		C		OT
4234	W/I Flt. L3	Weak infeed: Fault detection phase L3		C		OT
4241	W/I Gen. Trip	Weak infeed: General trip				OT
4242	W/I Trip L1	Weak infeed: Trip phase L1 only		C		OT
4243	W/I Trip L2	Weak infeed: Trip phase L2 only		C		OT
4244	W/I Trip L3	Weak infeed: Trip phase L3 only		C		OT
4245	W/I Trip L123	Weak infeed: Trip 3pole		C		OT
4253	>Sw-o-Flt.Blo	>Block Switch-onto-fault function				IOT
4271	S-O-F off	Switch-onto-fault is switched off	CG			OT
4272	S-O-F block	Switch-onto-fault is blocked	CG			OT
4273	S-O-F active	Switch-onto-fault is active				OT
4281	S-O-F Gen.Flt	Switch-onto-fault: Gen. fault detect.				OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
4282	S-O-F Flt. L1	Switch-onto-fault: Fault detection L1		C		OT
4283	S-O-F Flt. L2	Switch-onto-fault: Fault detection L2		C		OT
4284	S-O-F Flt. L3	Switch-onto-fault: Fault detection L3		C		OT
4295	S-O-F Trip 3p	Switch-onto-fault: Trip 3pole		C		OT
4301	>U> Prot. on	>Switch on overvoltage protection U>				IOT
4302	>U> Prot. off	>Switch off overvoltage protection U>				IOT
4304	>U>>Prot. on	>Switch on highset protection U>>				IOT
4305	>U>>Prot. off	>Switch off highset protection U>>				IOT
4306	>U> Block	>Block overvoltage protection U>				IOT
4307	>U>> Block	>Block highset overvoltage protection U>>				IOT
4323	U>/U>> active	Overvoltage protection active				OT
4325	U> off	Overvoltage stage U> is switched off	CG			OT
4326	U> blocked	Overvoltage stage U> is blocked	CG			OT
4328	U>> off	Overvoltage highset U>> is switched off	CG			OT
4329	U>> blocked	Overvoltage highset U>> is blocked	CG			OT
4331	U> Detection	Overvoltage detection : Stage U>		CG		OT
4332	U>> Detection	Overvoltage detection : Stage U>>		CG		OT
4335	U> Trip	Overvoltage trip : Stage U>		C		OT
4336	U>> Trip	Overvoltage trip : Stage U>>		C		OT
4339	U> Intertrip	Overvoltage stage U> intertrip send		C		OT
4340	U>> Intertrip	Overvoltage highset U>> intertrip send		C		OT
4403	>Ext.Trip blk	>Block external trip function	CG			IOT
4412	>Ext.Trip L1	>External trip L1 via binary input	C			IOT
4413	>Ext.Trip L2	>External trip L2 via binary input	C			IOT
4414	>Ext.Trip L3	>External trip L3 via binary input	C			IOT
4416	>Ext.Trp.woAR	>External 3pole trip without AR	CG			IOT
4431	Ext.Gen. Trip	Ext. trip via binary input: Trip				OT
4432	Ext.Trip 1pL1	Ext. trip via binary input: 1pole L1		C		OT
4433	Ext.Trip 1pL2	Ext. trip via binary input: 1pole L2		C		OT
4434	Ext.Trip 1pL3	Ext. trip via binary input: 1pole L3		C		OT
4435	Ext.Trip 3p	Ext. trip via binary input: 3pole		C		OT
4436	Ext.Trip woAR	Ext. trip via binary input: Without AR		C		OT
6206	>User T1Start	>Start of user defined timer T1	CG	CG		IOT
6207	>User T1Reset	>Reset of user defined timer T1	C	C		IOT
6208	>User T2Start	>Start of user defined timer T2	CG	CG		IOT
6209	>User T2Reset	>Reset of user defined timer T2	C	C		IOT
6254	User output 1	Output signal of user defined timer T1	CG	C		OT
6255	User output 2	Output signal of user defined timer T2	CG	C		OT

Reference Table for Functional Parameters 7SA513

1000 PARAMETERS

1100 POWERSYSTEM DATA

1101	CT STARPNT		Current transformer polarity
	TOWARDS LINE	[]	Towards line
	TOWARDS BUSBAR	[]	Towards busbar
1102	SYSTEMSTAR		System star-point condition
	SOLIDLY EARTHED	[]	Solidly earthed
	COMPENSATED	[]	Compensated
	ISOLATED	[]	Isolated
1103	Un PRIMARY		Primary rated voltage
	min. 1		kV
	max. 1200	—	
1104	Un SECOND.		Secondary rated voltage
	min. 80		V
	max. 125	—	
1105	In PRIMARY		Primary rated current
	min. 10		A
	max. 5000	—	
1107	ISAT>		Min. current for CT-saturation
	min. 0.20		I/In
	max. 50.00/∞	—	
1109	Ux CONNECT		Ux voltage transformer connection
	NOT CONNECTED	[]	Not connected
	Udelta TRANSFORM	[]	Udelta transformer
	U2 TRANSFORMER	[]	U2 transformer
1110	Uph/Udelta		Matching factor Uph/Udelta (sec.earth voltage)
	min. 0.00		
	max. 9.99	—	
1111	I4-CONNECT		I4 current transformer connection
	PROTECTED LINE	[]	Protected line
	PARALLEL LINE	[]	Parallel line
	STAR POINT	[]	Star Point
	NOT CONNECTED	[]	Not connected
1112	Ie/Iph		Matching factor Ie/Iph (Ie protected line)
	min. 0.100		
	max. 20.000	—	
1113	IePARAL/Ip		Matching factor Ie/Iph (Ie parallel line)
	min. 0.100		
	max. 20.000	—	
1114	I5-CONNECT		I5 current transformer connection
	PARALLEL LINE	[]	Parallel line
	PROTECTED LINE	[]	Protected line
	STAR POINT	[]	Star Point
	NOT CONNECTED	[]	Not connected

1116	U2 CONNECT		Voltage transformer U2 input connection
	L1-L2	[]	L1-L2
	L2-L3	[]	L2-L3
	L3-L1	[]	L3-L1
	L1-E	[]	L1-E
	L2-E	[]	L2-E
	L3-E	[]	L3-E
1117	RE/RL		Residual compensating factor RE/RL
	min. -7.00	—	
	max. 7.00		
1118	XE/XL		Residual compensating factor XE/XL
	min. -7.00	—	
	max. 7.00		
1119	RM/RL		Mutual compensating factor RM/RL
	min. -7.00	—	
	max. 7.00		
1120	XM/XL		Mutual compensating factor XM/XL
	min. -7.00	—	
	max. 7.00		
1121	LINE ANGLE		Line angle
	min. 30.0	—	°
	max. 89.0		
1122	X SEC		Secondary reactance per unit line length Xsec
	min. 0.010	—	Ω/km
	max. 5.000		
1123	C SEC		Sec. capacitance per unit line length Csec
	min. 0.000	—	µF/km
	max. 99.000		
1124	LINELENGTH		Line length
	min. 1.0	—	km
	max. 1000.0		
1125	PARAL COMP		Earth current ratio parallel line comp.
	min. 50	—	%
	max. 95		
1130	T-TRIP I>		Trip command min.duration for I > I-RES
	min. 0.00	—	s
	max. 32.00		
1131	T-TRIP I<		Trip command min.duration for I < I-RES
	min. 0.01	—	s
	max. 32.00		
1132	U1-U2 ANGL		Phase angle between U1 and U2
	min. -179	—	°
	max. 180		
1133	T-CB CLOSE		Closing (operating) time of circuit breaker
	min. 0.01	—	s
	max. 0.50		

1135	T-CLOSE min. 0.01 max. 32.00	_____	Maximum close command duration s
1136	3-P. COUPL WITH FAULT DETEC [] WITH TRIP COMM. []		3 pole coupling With fault detection With trip command
1137	TRIP2phFLT THREE-POLE [] 1-POLE LEADING [] 1-POLE LAGGING []		Trip type with 2phase faults Three-pole 1-pole leading 1-pole lagging
1138	LOAD COMP. NO [] YES []		Load compensation no yes
1140	I-RESID. min. 0.05 max. 1.00	_____	Current threshold for open line detect. I-RES I/In
1141	U-RESID. min. 2 max. 70	_____	Voltage threshold for open line detect. U-RES V
1142	T-CL-PROL min. 0.01 max. 32.00	_____	CB close zone release extension s
1143	CB COND. I< AND U< [] CB AUX AND I< []		Checking of circuit breaker position I-RES.< and U-RES.< CB aux. and I-RES.<
1145	T-M/C-PROL min. 0.01 max. 32.00	_____	Prolongation time after manual closing s
1149	T-EXT.STAB min. 0.00 max. 32.00	_____	Stabilization time for external trip s
1200	DIST.PROT. GENERAL SETTINGS		
1201	DIST.PROT. ON [] OFF []		Distance protection function on off
1202	DIR. FD&T4 FORWARDS [] REVERSE [] NON-DIRECTIONAL []		Direction for fault detection directional trip Forwards Reverse Non-directional
1203	T4 min. 0.00 max. 32.00/∞	_____	Delay T4 fault detection directional trip s
1204	T5 min. 0.00 max. 32.00/∞	_____	Delay T5 fault detection non-directional trip s

1205	MAN. CLOSE		Distance zone effective with manual close
	Z1B EFFECTIVE	☐	Z1B directional effective ¹⁾
	Z1B DIRECTIONAL	☐	Z1B directional effective ²⁾
	Z1B NON-DIRECT.	☐	Z1B non-directional effective ²⁾
	FD EFFECTIVE	☐	Fault detection
	Z1 EFFECTIVE	☐	Z1 effective
1208	SER. COMP		Series compensated line
	NO	☐	no
	YES	☐	yes
1209	PAR. COMP		Compensation parallel line
	NO	☐	no
	YES	☐	yes
1216	RAR -> Z1B		Distance zone Z1B effective before 1st RAR
	YES	☐	yes
	NO	☐	no
1217	DAR BLOCK		Effective zone if DAR is blocked
	Z1; T1	☐	Z1; T1
	Z1; T1B	☐	Z1; T1B
1218	DAR -> Z1L		Distance zone Z1L effective before DAR
	YES	☐	yes
	NO	☐	no
1220	CLOSE ZONE		Distance zone effective for any closure
	Z1 EFFECTIVE	☐	Z1 effective
	Z1B EFFECTIVE	☐	Z1B effective
	FD EFFECTIVE	☐	Fault detection
1221	BLK.AR Z1B		Autoreclosure is blocked for Z1B faults
	NO	☐	no
	WITHIN	☐	Within
	OUTSIDE	☐	Outside
1222	BLK.AR Z1L		Autoreclosure is blocked for Z1L faults
	NO	☐	no
	WITHIN	☐	Within
	OUTSIDE	☐	Outside

1300 DIST.PROT. INDEPEND. ZONES

1301	R1		Zone 1: Resistance (phase-phase) R1
	min. 0.05		Ω
	max. 65.00	_____	
1302	X1		Zone 1: Reactance (reach) X1
	min. 0.05		Ω
	max. 200.00	_____	
1303	R1E		Zone 1: Resistance (phase-earth) R1E
	min. 0.05		Ω
	max. 130.00	_____	

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

1304	DIREC. Z1		Zone 1: Direction
	FORWARDS	☐	Forwards
	REVERSE	☐	Reverse
	NON-DIRECTIONAL	☐	Non-directional
1305	T1 1PHASE		Zone 1: Delay for single phase faults T1 1PH
	min. 0.00		s
	max. 32.00/∞	_____	
1306	T1 >1PHASE		Zone 1: Delay for multi-phase faults T1
	min. 0.00		s
	max. 32.00/∞	_____	
1311	R2		Zone 2: Resistance (phase-phase) R2
	min. 0.05		Ω
	max. 65.00	_____	
1312	X2		Zone 2: Reactance (reach) X2
	min. 0.05		Ω
	max. 200.00	_____	
1313	R2E		Zone 2: Resistance (phase-earth) R2E
	min. 0.05		Ω
	max. 130.00	_____	
1314	DIREC. Z2		Zone 2: Direction
	FORWARDS	☐	Forwards
	REVERSE	☐	Reverse
	NON-DIRECTIONAL	☐	Non-directional
1315	T2 1PHASE		Zone 2: Delay for single phase faults T2 1PH
	min. 0.00		s
	max. 32.00/∞	_____	
1316	T2 >1PHASE		Zone 2: Delay for multi-phase faults T2
	min. 0.00		s
	max. 32.00/∞	_____	
1317	TRIP 1P Z2		Single pole trip for faults in Z2
	NO	☐	no
	YES	☐	yes
1321	R3		Zone 3: Resistance (phase-phase) R3
	min. 0.05		Ω
	max. 65.00	_____	
1322	X3		Zone 3: Reactance (reach) X3
	min. 0.05		Ω
	max. 200.00	_____	
1323	R3E		Zone 3: Resistance (phase-earth) R3E
	min. 0.05		Ω
	max. 130.00	_____	
1324	DIREC. Z3		Zone 3: Direction
	FORWARDS	☐	Forwards
	REVERSE	☐	Reverse
	NON-DIRECTIONAL	☐	Non-directional
1325	T3		Zone 3: Delay for all faults T3
	min. 0.00		s
	max. 32.00/∞	_____	

1400 DIST.PROT. CONTROLLED ZONES

1401	R1B		Zone 1B: Resistance (phase-phase) R1B
	min. 0.05	Ω	
	max. 65.00	——	
1402	X1B		Zone 1B: Reactance (reach) X1B
	min. 0.05	Ω	
	max. 200.00	——	
1403	R1BE		Zone 1B: Resistance (phase-earth) R1BE
	min. 0.05	Ω	
	max. 130.00	——	
1404	DIREC. Z1B		Zone 1B: Direction
	FORWARDS	[]	Forwards
	REVERSE	[]	Reverse
	NON-DIRECTIONAL	[]	Non-directional
1405	T1B 1PHASE		Zone 1B: Delay for single phase faults T1B 1PH
	min. 0.00	s	
	max. 32.00/∞	——	
1406	T1B >1PHAS		Zone 1B: Delay for multi-phase faults T1B
	min. 0.00	s	
	max. 32.00/∞	——	
1407	TBLK DELAY		Coord.-Timer for blocking scheme
	min. 0.000	s	
	max. 1.000	——	
1411	R1L		Zone 1L: Resistance (phase-phase) R1L
	min. 0.05	Ω	
	max. 65.00	——	
1412	X1L		Zone 1L: Reactance (reach) X1L
	min. 0.05	Ω	
	max. 200.00	——	
1413	R1LE		Zone 1L: Resistance (phase-earth) R1LE
	min. 0.05	Ω	
	max. 130.00	——	
1414	DIREC. Z1L		Zone 1L: Direction
	FORWARDS	[]	Forwards
	REVERSE	[]	Reverse
	NON-DIRECTIONAL	[]	Non-directional
1415	T1L		Zone 1L: Delay for all faults T1L
	min. 0.00	s	
	max. 32.00/∞	——	

1500 DIST.PROT. FAULT DETEC.PROG

1501	PROG.U/I/phi		Fault detection program U/I/phi
	LE:Uphe/LL:Uphph	[]	LE:Uphe/LL:Uphph
	LE:Uphph/LL:Uphp	[]	LE:Uphph/LL:Uphp
	LE:Uphe/LL:Uphe	[]	LE:Uphe/LL:Uphe

1600 DIST.PROT. FAULT DETECTION

1602	Ie> min. 0.10 max. 1.00	Earth fault detection Ie> I/In
1603	Ie>> min. 0.10 max. 4.00	Earth flt. detect. (independent of 1707) Ie>> I/In
1610	Iph>> min. 0.25 max. 4.00	Overcurrent detection Iph>> I/In
1611	Iph> min. 0.10 max. 1.00	Minimum current for fault detection Iph> I/In
1612	Uphe(I>>) min. 20 max. 70	Undervoltage pick-up at I>> (phase-earth) V
1613	Uphe(I>) min. 20 max. 70	Undervoltage pick-up at I> (phase-earth) V
1614	Uphph(I>>) min. 40 max. 130	Undervoltage pick-up at I>> (phase-phase) V
1615	Uphph(I>) min. 40 max. 130	Undervoltage pick-up at I> (phase-phase) V
1616	Iphi> min. 0.10 max. 2.00	Overcurrent fault detection (phi) Iphi> I/In
1617	Uphe(Iphi>) min. 20 max. 70	Undervoltage pick-up at Iphi> (phase-earth) V
1618	Uphph(Iphi>) min. 40 max. 130	Undervoltage pick-up at Iphi> (phase-phase) V
1619	phi> min. 30 max. 60	U/I/phi-fault detection phi>
1620	phi< min. 90 max. 120	U/I/phi-fault detection phi<
1621	Iph> min. 0.10 max. 4.00	Minimum current for fault detection Iph> I/In
1622	X+A min. 0.10 max. 250.00	Fault detection forward reach X+A Ω

1623	X-A	Fault detection reverse reach X-A
	min. 0.10	Ω
	max. 250.00	—
1624	RA1	Fault det. resistance (ph-ph, $\phi < \phi_{I A}$) RA1
	min. 0.10	Ω
	max. 250.00	—
1625	RA2	Fault det. resistance (ph-ph, $\phi > \phi_{I A}$) RA2
	min. 0.10	Ω
	max. 250.00	—
1626	RA1E	Fault det. resistance (ph-e, $\phi < \phi_{I AE}$) RA1E
	min. 0.10	Ω
	max. 250.00	—
1627	RA2E	Fault det. resistance (ph-e, $\phi > \phi_{I AE}$) RA2E
	min. 0.10	Ω
	max. 250.00	—
1628	ANGLE PHIA	Fault det. ph-ph angle betw. RA1/RA2 $\phi_{I A}$
	min. 30.0	—
	max. 80.0	—
1629	ANG. PHIAE	Fault det. ph-e angle betw. RA1E/RA2E $\phi_{I AE}$
	min. 30.0	—
	max. 80.0	—
1630	Iph>>	Overcurrent fault detection Iph>>
	min. 1.00	I/In
	max. 20.00/ ∞	—
1700	FAULT IN EARTHED NETWORKS	
1701	Ue>	Displacement voltage for earth fault det. Ue>
	min. 2	V
	max. 100/ ∞	—
1703	PHPHE FLTS	Loop selection with Ph-Ph-E faults
	BLOCK LEADING PH []	Block leading phase
	BLOCK LAGGING PH []	Block lagging phase
	ALL []	All
	PHASE-PHASE ONLY []	Phase to phase only
	PHASE-EARTH ONLY []	Phase to earth only
1705	1PH FAULTS	Loop select. for single ph. w/o earth flt.det.
	PHASE-EARTH []	Phase-earth
	PHASE-PHASE []	Phase-phase
1707	E/F DETECT	Earth fault detection with
	Ue> AND Ie>	[] Ue> and Ie>
	Ue> OR Ie>	[] Ue> or Ie>
1800	FAULT NON-EARTHED NET	
1801	Tie 1PHASE	Delay time for single phase flt. det. Tie 1PH
	min. 0.04	s
	max. 0.50/ ∞	—

1802 Ue> Displacement voltage for earth fault det. Ue>
 min. 10 V
 max. 100

1803 PHASE PREF Phase preference for double earth faults
 L3(L1) ACYCLIC [] L3(L1) acyclic
 L1(L3) ACYCLIC [] L1(L3) acyclic
 L2(L1) ACYCLIC [] L2(L1) acyclic
 L1(L2) ACYCLIC [] L1(L2) acyclic
 L3(L2) ACYCLIC [] L3(L2) acyclic
 L2(L3) ACYCLIC [] L2(L3) acyclic
 L3(L1) CYCLIC [] L3(L1) cyclic
 L1(L3) CYCLIC [] L1(L3) cyclic
 ALL [] All

2000 POWER SWING

2002 P/S PROGR. Program of power swing (P/S) function
 BLOCK ALL [] Block all zones
 BLOCK Z1 ONLY [] Block Z1 only
 BLOCK ALL BUT Z1 [] Block all but Z1
 BLOCK Z1-Z2 [] Block Z1-Z2

2006 P/S Trip Power swing trip
 NO [] no
 YES [] yes

2100 TELEPROTEC PERM. UNDERREACH

2101 PUTT Permissive underreach transfer trip
 ON [] on
 OFF [] off

2102 PUTT MODE Permissive underreach transfer trip mode
 Z1B ACCELERATION [] Z1B acceleration
 FD ACCELERATION [] FD acceleration

2103 T-SEND-PRL Send signal prolongation for PUTT
 min. 0.01 s
 max. 32.00

2104 T-REC-PROL Receive signal prolongation for PUTT
 min. 0.00 s
 max. 32.00

2106 T-SEND-DEL Send signal delay for PUTT
 min. 0.00 s
 max. 32.00

2200 TELEPROTEC PERM. OVERREACH

2201 POTT Permissive overreach transfer trip
 ON [] on
 OFF [] off

2202	POTT MODE		Permissive overreach transfer trip mode
	Z1B RELEASE	[]	Z1B release
	FD DIREC RELEASE	[]	Direct. comparison
	Z1B UNBLOCK	[]	Unblocking with Z1B
	FD UNBLOCK	[]	Unblocking with FD
	Z1B BLOCKING	[]	Blocking with Z1B
	PILOT WIRE COMP.	[]	Comp. via pilot wire
	REVERS INTERLOCK	[]	Reverse interlocking
2203	T-TRANSBLO		Transient blocking time after external fault
	min. 0.01		s
	max. 32.00	—	
2204	T-WAIT		Waiting time for trans.block. (missing receipt)
	min. 0.01		s
	max. 32.00/∞	—	
2206	T-SEND-PRL		Send signal prolongation for POTT
	min. 0.01		s
	max. 32.00	—	
2210	POTT DirFD		Effect. direction for directional comparison
	FORWARDS	[]	Forwards
	REVERSE	[]	Reverse
	NON-DIRECTIONAL	[]	Non-directional
2211	TW REVERSE		Waiting time for trans.block. (reverse faults)
	min. 0.01		s
	max. 32.00/∞	—	
2212	T-SEND DEL		Send signal delay for POTT
	min. 0.00		s
	max. 32.00	—	
2220	ECHO		Echo function for weak infeed
	ON	[]	on
	OFF	[]	off
2221	T-ECHO-DEL		Echo delay time
	min. 0.01		s
	max. 32.00/∞	—	
2222	T-ECHO-IMP		Duration of echo impulse
	min. 0.02		s
	max. 32.00	—	
2223	T-ECHO-BLO		Echo blocking time
	min. 0.01		s
	max. 32.00	—	
2300	USER LOGIC FUNCTIONS		
2302	T-PICKUP 1		1st user logic function: Pick-up time
	min. 0.00		s
	max. 32.00/∞	—	
2303	T-DROP 1		1st user logic function: Drop-off time
	min. 0.00		s
	max. 32.00/∞	—	

2305	T-PICKUP 2 min. 0.00 max. 32.00/∞	_____	2nd user logic function: Pick-up time s
2306	T-DROP 2 min. 0.00 max. 32.00/∞	_____	2nd user logic function: Drop-off time s
2400	SWITCH ONTO-FAULT PROT.		
2401	SWITCH-O-F ON OFF	[] []	Switch-onto-fault function is on off
2402	S-O-F REL ONLY M/C ALWAYS	[] []	Release of switch-onto-fault-protection Only man. close With every CB close
2404	Isc min. 1.00 max. 25.00	_____	Current for fault recognition Isc I/In
2500	WEAK INFEEED PROT.		
2501	WEEK INF. ON OFF	[] []	Week infeed function is on off
2502	Uphe< min. 2 max. 70	_____	Undervoltage Uphe< V
2505	T-DELAY min. 0.01 max. 32.00	_____	Reception signal delay (for stabilization) s
2506	T-PROLONG. min. 0.01 max. 32.00	_____	Reception signal extension s
2600	EMERGENCY OVERCURRENT PROT		
2601	EMER.O/C P ON OFF	[] []	State of emergency overcurrent prot.: phase on off
2602	I>> min. 0.10 max. 9.99 max. 15.00	_____	Highset phase overcurrent threshold (DT) I>> I/In I/In ¹⁾ ²⁾
2603	T-I>> min. 0.00 max. 32.00/∞	_____	Delay time for I>> TI>> s

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

2611	CHARACT.PH		Emerg. phase overcurrent characteristic
	DEFINITE TIME	[]	Definite time
	NORMAL INVERSE	[]	Normal inverse
	VERY INVERSE	[]	Very inverse
	EXTREMELY INVERS	[]	Extremely inverse
2612	I>		Phase overcurrent threshold (DT) I>
	min. 0.10		I/In
	max. 4.00		I/In ¹⁾
	max. 15.00	—	²⁾
2613	T-I>		Delay time for I> TI>
	min. 0.00		s
	max. 32.00/∞	—	
2614	Ip		Phase o/c threshold (inverse time IDMT) Ip
	min. 0.10		I/In
	max. 4.00	—	
2615	T-IP		Time multiplier for Ip (inverse time IDMT) Tp
	min. 0.05		s
	max. 32.00/∞	—	
2616	MEA.FORM.P		Phase current measurement format
	WITHOUT HARMON.	[]	Without harmonics
	WITH HARMONICS	[]	With harmonics
2621	M/CLOSE PH		Phase overcurrent stage effect.: Manual close
	I>> UNDELAYED	[]	I>> undelayed
	I>/Ip UNDELAYED	[]	I>/Ip undelayed
	INEFFECTIVE	[]	Ineffective
2623	RAR ZONE P		Phase overcurrent stage effect.: Auto reclose
	I>> WITH AR	[]	I>> only with AR
	I>> ALWAYS	[]	I>> always
2631	EMER.O/C E		State of emergency overcurrent prot.: earth
	ON	[]	on
	OFF	[]	off
2632	IE>>		Highset earth overcurrent threshold (DT) IE>>
	min. 0.10		I/In
	max. 4.00	—	
2633	T-IE>>		Delay time for IE>> TIE>>
	min. 0.00		s
	max. 32.00/∞	—	
2641	CHARACT. E		Emergency earth overcurrent characteristic
	DEFINITE TIME	[]	Definite time
	NORMAL INVERSE	[]	Normal inverse
	VERY INVERSE	[]	Very inverse
	EXTREMELY INVERS	[]	Extremely inverse
2642	IE>		Earth overcurrent threshold (DT) IE>
	min. 0.10		I/In
	max. 4.00	—	
2643	T-IE>		Delay time for IE> TIE>
	min. 0.00		s
	max. 32.00/∞	—	

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

2644	IEp min. 0.10 max. 4.00	_____	Earth o/c threshold (inverse time IDMT) IEp I/In
2645	T-IEp min. 0.05 max. 32.00/∞	_____	Time multiplier for IEp (inv. time IDMT) TEs
2646	MEA.FORM.E WITHOUT HARMON. [] WITH HARMONICS []		Earth current measurement format Without harmonics With harmonics
2651	M/CLOSE E IE>> UNDELAYED [] IE>/IEp UNDELAY. [] INEFFECTIVE []		Earth overcurrent stage effect: Manual close IE>> undelayed IE>/IEp undelayed Ineffective
2653	RAR ZONE E IE>> WITH RAR [] IE>> ALWAYS []		Earth overcurrent stage effect: Auto reclose Ie>> with RAR Ie>> always
2680	CHARACTERISTIC 1		Characteristic curve 1
2681	CHARACTERISTIC 2		Characteristic curve 2

2900 MEAS.VALUE SUPERVISION

2901	SYM.Uthres min. 10 max. 100	_____	Symmetry threshold for voltage monitoring V
2902	SYM.Fact.U min. 0.58 max. 0.95	_____	Symmetry factor for voltage monitoring
2903	SYM.Ithres min. 0.10 max. 1.00	_____	Symmetry threshold for current monitoring I/In
2904	SYM.Fact.I min. 0.10 max. 0.95	_____	Symmetry factor for current monitoring
2905	SUM.Ithres min. 0.05 max. 2.00	_____	Summation threshold for current monitoring I/In
2906	SUM.Fact.I min. 0.00 max. 0.95	_____	Factor for current summation monitoring
2907	UMEAS U< min. 10 max. 125	_____	Threshold for voltage failure monitor V
2908	UMEAS I> min. 0.06 max. 1.00	_____	Minimum current for voltage failure monitor I/In

2910	FUSE-FAIL		Fuse failure monitoring (FFM)
	ON	☐	on
	OFF	☐	off
2911	FFM 3*Uo>		Displacement voltage level for FFM
	min. 10		V
	max. 100	—	
2912	FFM Ie<		Earth current for fuse failure monitoring
	min. 0.10		I/In
	max. 1.00	—	
2921	T VT-mcb		Response time of the VT mini-circuit breaker ²⁾
	min. 0		ms ²⁾
	max. 30	—	²⁾
3100	EARTHFAULT PROTECTION		
3101	E/F PROTEC		Earth fault protection is
	ON	☐	on
	OFF	☐	off
3102	E/F CHARAC		Earth overcurrent characteristic
	DEFINITE TIME	☐	Definite time
	NORMAL INVERSE	☐	Normal inverse
	VERY INVERSE	☐	Very inverse
	EXTREMELY INVERS	☐	Extremely inverse
	U0 INVERSE	☐	U0 inverse charact.
3103	IE>/IEp		Earth overcurrent threshold IE>, IEp
	min. 0.05		I/In
	max. 4.00	—	
3104	Ue>		Minimum voltage for direct. measurement Ue>
	min. 1.0		V
	max. 10.0	—	
3106	T-DIREC.		Delay time for directional trip T-DIREC
	min. 0.00		s
	max. 32.00/∞	—	
3107	DIRECTION		Direction
	FORWARDS	☐	Forwards
	REVERSE	☐	Reverse
	NON-DIRECTIONAL	☐	Non-directional
3108	T-NON-DIR.		Delay time for non-direct. trip T-NON-DIR
	min. 0.00		s
	max. 32.00/∞	—	
3111	DIRECTION		Directional decision
	WITH Ue AND IY	☐	With Ue and IY
	ONLY WITH IY	☐	Only with IY
3112	Ue> INV		Ue inverse time characteristic Ue> INV
	min. 0.1		V
	max. 5.0	—	
3113	RAR ZONE		Rapid trip (w/3115) w/ rapid auto reclose(RAR)
	ON	☐	on
	OFF	☐	off

²⁾ from firmware version V3.3 or higher

3114	MAN.CLOSE		Mode of operation with manual close (M/C)
	OFF	[]	off
	F/D UNDELAYED	[]	F/D undelayed
	F/D DIRECTIONAL	[]	F/D directional
3115	T-DIR. RAR		Delay for RAR (3113) and MC w/ F/D dir (3114)
	min. 0.00		s
	max. 32.00/∞	—	
3117	DIS BL E/F		Dist.prot.pick-up: Earth fault prot. BLOCKED
	YES	[]	yes
	NO	[]	no
3118	E/F BLO/1p		AR 1p. dead-time: Earth fault prot. BLOCKED
	YES	[]	yes
	NO	[]	no
3125	TRIP1P E/F		Trip single-pole with earth flt.prot. ENABLED
	YES	[]	yes
	NO	[]	no

3200 EARTHFAULT DIREC.COMPARISON

3201	E/F COMPAR		Earth fault directional comparison is
	ON	[]	on
	OFF	[]	off
3202	T-DELAY		Delay-time for transmission and trip
	min. 0,00		s
	max. 32.00/∞	—	
3203	T-TRANSBLO		Transient blocking time after external fault
	min. 0.01		s
	max. 32.00	—	
3204	T-WAIT		Waiting time for trans.block. (missing receipt)
	min. 0.01		s
	max. 32.00/∞	—	
3206	TW REVERSE		Waiting time for trans.block. (reverse faults)
	min. 0.01		s
	max. 32.00/∞	—	
3210	E/F ECHO		Echo function for weak infeed
	ON	[]	on
	OFF	[]	off
3211	T-ECHO-DEL		Echo delay time
	min. 0.01		s
	max. 32.00/∞	—	
3212	T-ECHO-IMP		Duration of echo impulse
	min. 0.02		s
	max. 32.00	—	
3213	T-ECHO-BLO		Echo blocking time
	min. 0.01		s
	max. 32.00	—	

3400 AUTORECLOSE FUNCTION

3401	AR FUNCT		Auto-reclose function
	ON	☐	on
	OFF	☐	off
3402	AR BLO REV		Auto-reclose block with reverse faults
	YES	☐	yes
	NO	☐	no
3403	MC BLOCK		Auto-reclose block with manual close
	YES	☐	yes
	NO	☐	no
3405	T-RECLAIM		Reclaim time after successful AR
	min. 0.50		s
	max. 320.00	—	
3406	T-LOCK		Lock-out time after unsuccessful AR
	min. 0.50		s
	max. 320.00/∞	—	
3407	T-BLOCK MC		Blocking duration with manual close
	min. 0.50		s
	max. 320.00	—	
3412	CB? 1.TRIP		CB ready interrogation at 1st trip command
	YES	☐	yes
	NO	☐	no
3413	CB? CLOSE		CB ready interrogation before reclosing
	CB? NEVER	☐	CB? never
	CB? WITH EACH AR	☐	CB? with each AR
	CB? WITH 2nd AR	☐	CB? with 2nd AR
3415	T-CB-SUPV		Circuit breaker supervision time
	min. 0.01		s
	max. 320.00	—	
3419	SYN-REQUEST		AR request for synchro-check
	BEFORE 3POLE AR	☐	Before 3pole AR
	ONLY BEFORE DAR	☐	Only before DAR
	BEFORE 2nd DAR	☐	Before second DAR
	NEVER	☐	Never
3422	RAR PROG.		Rapid auto-reclose program
	THREE-POLE	☐	Three-pole
	SINGLE-POLE	☐	Single-pole
	SINGLE/THREE-POL	☐	Single/three-pole
3423	3U0 PROC.		3U0 processing measurement before closing
	INEFFECTIVE	☐	Ineffective
	1-POLE WITH U0	☐	1-pole with U0
	1-POLE W/O U0	☐	1-pole without U0
3424	RAR T-ACT.		Rapid auto-reclose action time
	min. 0.01		s
	max. 320.00/∞	—	
3425	RAR T-3POL		RAR 3pole dead time
	min. 0.01		s
	max. 320.00	—	

3426	RAR T-1POL min. 0.01 max. 320.00	_____	RAR 1pole dead time s
3427	RAR T1POL2 min. 0.01 max. 320.00	_____	RAR accelerated 1pole dead time (U0 dependent) s
3428	EV.F.RECOG WITH FAULT DETEC [] WITH TRIP COMM. []		Evolving fault recognition with 1pole AR With fault detection With trip command
3429	EV.F.BLOCK ALWAYS [] NEVER [] >T-DISCR. []		Blocking with evolving faults Always Never >T-discrimination
3430	T-DISCRIM min. 0.01 max. 320.00	_____	Discrimination time for evolving faults s
3431	AR TRIP 3P YES [] NO []		3p trip when AR is blocked during 1p dead time yes no
3442	DAR PROG. NO DAR [] DAR WITHOUT RAR [] DAR AFTER RAR []		Delayed auto-reclose program No DAR DAR without RAR DAR only after RAR
3443	DAR No.1PH min. 0 max. 9	_____	Number of DAR shots after 1 pole initiation
3444	DAR No.3PH min. 0 max. 9	_____	Number of DAR shots after 3 pole initiation
3445	DAR T-ACT. min. 0.01 max. 320.00/∞	_____	Delayed auto-reclose action time s
3446	DAR T3POL1 min. 0.01 max. 1800.00	_____	DAR 3pole dead time for 1st shot s
3447	DAR T3POL2 min. 0.01 max. 1800.00	_____	DAR 3pole dead time for 2nd shot s
3448	DAR T3POL3 min. 0.01 max. 1800.00	_____	DAR 3pole dead time for 3rd and further shots s

3500 CHECK SYNCHRONISM

3501	SYNC-CHECK		Synchro-check function
	ON []		on
	OFF []		off

3502	U< min. 1 max. 60	——	Maximum voltage for dead line or busbar V
3503	U> min. 20 max. 125	——	Minimum voltage for live line or busbar V
3505	DELTA U< min. 1 max. 50	——	Maximum voltage difference V
3506	DELTA f< min. 0.03 max. 1.00	——	Maximum frequency difference Hz
3507	DELTA PHI< min. 1 max. 60	——	Maximum angle difference °
3508	DEL.f<SYNC min. 0.03 max. 0.10/∞	——	Maximum freq. difference for synchronous AR Hz
3515	SYNCHR. YES NO	☐ yes ☐ no	Synchronism-check before AR (U1>/U2>)
3516	U1>U2< NO YES	☐ no ☐ yes	Live line / dead bus check before AR (U1>/U2<)
3517	U1<U2> NO YES	☐ no ☐ yes	Dead line / live bus check before AR (U1</U2>)
3518	U1<U2< NO YES	☐ no ☐ yes	Dead line / dead bus check before AR (U1</U2<)
3519	OVERRIDE NO YES	☐ no ☐ yes	Override of any check before AR
3521	SYN.MAN.CL ON OFF	☐ on ☐ off	Synchro-check with manual close
3522	MC Df<SYNC min. 0.03 max. 0.10/∞	——	Frequency difference for synchronous MC Hz
3525	MC SYNCHR YES NO	☐ yes ☐ no	Synchro-check before MC (U1>/U2>)
3526	MC U1>U2< NO YES	☐ no ☐ yes	Live line/dead bus check before MC (U1>/U2<)

3527	MC U1<U2>		Dead line/live bus check before MC (U1</U2>)
	NO	[]	no
	YES	[]	yes
3528	MC U1<U2<		Dead line/dead bus check before MC (U1</U2<)
	NO	[]	no
	YES	[]	yes
3529	MC O/RIDE		Override of any check before MC
	NO	[]	no
	YES	[]	yes
3530	T-SYN.SUPV		Synchro-check supervision time
	min. 0.01		s
	max. 320.00	—	
3531	T IN-SYNC		Synchronism criteria maintained timer
	min. 0.00		s
	max. 32.00	—	

3600 BACK-UP OVERCURRENT PROT

3601	BACK O/C P		State of back-up overcurrent prot.: phase
	ON	[]	on
	OFF	[]	off
3602	I>>		Highset phase overcurrent threshold (DT) I>>
	min. 0.10		I/In
	max. 9.99		I/In ¹⁾
	max. 15.00	—	²⁾
3603	T-I>>		Delay time for I>> TI>>
	min. 0.00		s
	max. 32.00/∞	—	
3611	CHARACT.PH		Back-up phase overcurrent characteristic
	DEFINITE TIME	[]	Definite time
	NORMAL INVERSE	[]	Normal inverse
	VERY INVERSE	[]	Very inverse
	EXTREMELY INVERS	[]	Extremely inverse
3612	I>		Phase overcurrent threshold (DT) I>
	min. 0.10		I/In
	max. 4.00		I/In ¹⁾
	max. 15.00	—	²⁾
3613	T-I>		Delay time for I> TI>
	min. 0.00		s
	max. 32.00/∞	—	
3614	Ip		Phase o/c threshold (inverse time IDMT) Ip
	min. 0.10		I/In
	max. 4.00	—	
3615	T- _{Ip}		Time multiplier for Ip (inverse time IDMT) T _p
	min. 0.05		s
	max. 32.00/∞	—	

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

3616	MEA.FORM.P		Phase current measurement format
	WITHOUT HARMON.	[]	Without harmonics
	WITH HARMONICS	[]	With harmonics
3621	M/CLOSE PH		Phase overcurrent stage effect.: Manual close
	I>> UNDELAYED	[]	I>> undelayed
	I>/Ip UNDELAYED	[]	I>/Ip undelayed
	INEFFECTIVE	[]	Ineffective
3623	RAR ZONE P		Phase overcurrent stage effect.: Auto reclose
	I>> WITH AR	[]	I>> only with AR
	I>> ALWAYS	[]	I>> always
3631	BACK O/C E		State of back-up overcurrent prot.: earth
	ON	[]	on
	OFF	[]	off
3632	IE>>		Highset earth overcurrent threshold (DT) IE>>
	min. 0.10	——	I/In
	max. 4.00		
3633	T-IE>>		Delay time for IE>> TIE>>
	min. 0.00	——	s
	max. 32.00/∞		
3641	CHARACT. E		Back-up earth overcurrent characteristic
	DEFINITE TIME	[]	Definite time
	NORMAL INVERSE	[]	Normal inverse
	VERY INVERSE	[]	Very inverse
	EXTREMELY INVERS	[]	Extremely inverse
3642	IE>		Earth overcurrent threshold (DT) IE>
	min. 0.10	——	I/In
	max. 4.00		
3643	T-IE>		Delay time for IE> TIE>
	min. 0.00	——	s
	max. 32.00/∞		
3644	IEp		Earth o/c threshold (inverse time IDMT) IEp
	min. 0.10	——	I/In
	max. 4.00		
3645	T-IEp		Time multiplier for IEp (inv. time IDMT) TEp
	min. 0.05	——	s
	max. 32.00/∞		
3646	MEA.FORM.E		Earth current measurement format
	WITHOUT HARMON.	[]	Without harmonics
	WITH HARMONICS	[]	With harmonics
3651	M/CLOSE E		Earth overcurrent stage effect: Manual close
	IE>> UNDELAYED	[]	IE>> undelayed
	IE>/IEp UNDELAY.	[]	IE>/IEp undelayed
	INEFFECTIVE	[]	Ineffective
3653	RAR ZONE E		Earth overcurrent stage effect: Auto reclose
	IE>> WITH RAR	[]	IE>> with RAR
	IE>> ALWAYS	[]	IE>> always

3700 OVERVOLT. PROTECTION

3701	U> STAGE		Overvoltage protection stage is
	ON	[]	on
	OFF	[]	off
3703	U>		Overvoltage pick-up value U>
	min. 1.00		U/Un
	max. 1.90	—	
3704	U-RESET/U>		Overvoltage reset ratio: U> reset /U>
	min. 0.50		
	max. 0.99	—	
3705	T-U>		Trip time delay T-U>
	min. 0.00		s
	max. 32.00/∞	—	
3706	U>COMPOUND		Overvoltage compounding function
	OFF	[]	off
	ON	[]	on
3708	U> TRIP		Overvoltage trip action
	LOCAL TRIP	[]	Local trip
	TRIP SEND	[]	Trip send
	LOCAL AND SEND	[]	Local trip and send
3711	U>> STAGE		Highset overvoltage protection stage is
	ON	[]	on
	OFF	[]	off
3712	U>>SELECT		Highset overvoltage select
	PHASE-EARTH	[]	Phase-earth
	PHASE-PHASE	[]	Phase-phase
3713	U>>		Overvoltage pick-up value U>>
	min. 1.00		U/Un
	max. 1.90	—	
3714	URESET/U>>		Highset overvoltage reset: U>> reset/U>>
	min. 0.50		
	max. 0.99	—	
3715	U>> PHASES		Highset overvoltage fault detection action
	AND COMBINED	[]	AND-logic
	OR COMBINED	[]	OR-combined
3716	TU>>CB ON		Delay time with closed circuit breaker
	min. 0.00		s
	max. 32.00/∞	—	
3717	TU>>CB OFF		Delay time with open circuit breaker
	min. 0.00		s
	max. 32.00/∞	—	
3718	TBLOCK U>>		Time for block of highset overvoltage
	min. 0.00		s
	max. 32.00	—	

3720 U>> TRIP Highset overvoltage trip action
 LOCAL TRIP [] Local trip
 TRIP SEND [] Trip send
 LOCAL AND SEND [] Local trip and send

3721 T-SEN-IMP Duration of send signal
 min. 0.05 s
 max. 0.50 —

3800 FAULT LOCATION

3802 START Start condition for fault locator
 DROP-OFF or TRIP [] Drop-off or trip
 TRIP COMMAND [] Trip command

3805 PARAL.LINE Parallel line compensation
 NO [] no
 YES [] yes

3900 BREAKER FAILURE PROTEC.

3901 B/F PROT. Circuit breaker failure protection
 ON [] on
 OFF [] off

3902 I> B/F Pick-up threshold of current detector I>B/F
 min. 0.04 I/In
 max. 4.00 —

3903 T-B/F Delay time T-B/F
 min. 0.05 s ¹⁾
 min. 0.00 s ²⁾
 max. 1.00/∞ —

¹⁾ up to firmware version V3.2

²⁾ from firmware version V3.3 or higher

Tests and Commissioning Aids 7SA513

4000 TESTS

4200 DIRECTION/ IMPEDANCES

4201 DIREC. TEST	Direction test L1-E
4202 IMPEDANCES	Impedance test L1-E
4203 DIREC. TEST	Direction test L2-E
4204 IMPEDANCES	Impedance test L2-E
4205 DIREC. TEST	Direction test L3-E
4206 IMPEDANCES	Impedance test L3-E
4207 DIREC. TEST	Direction test L1-L2
4208 IMPEDANCES	Impedance test L1-L2
4209 DIREC. TEST	Direction test L2-L3
4210 IMPEDANCES	Impedance test L2-L3
4211 DIREC. TEST	Direction test L3-L1
4212 IMPEDANCES	Impedance test L3-L1

4300 CB TEST TRIP-CLOSE CYCLE

4301 CB TEST	Circuit breaker test with AR 1pole L1
4302 CB TEST	Circuit breaker test with AR 1pole L2
4303 CB TEST	Circuit breaker test with AR 1pole L3
4304 CB TEST	Circuit breaker test with AR 3pole
4305 CB TEST	Circuit breaker test with AR sequence L1-L2-L3

4400 CB TEST LIVE TRIP

4401 CB TRIP	Circuit breaker trip test 1pole L1
4402 CB TRIP	Circuit breaker trip test 1pole L2
4403 CB TRIP	Circuit breaker trip test 1pole L3
4404 CB TRIP	Circuit breaker trip test 3pole

4900 TEST FAULT RECORDING

4901 FAULT REC.	Initiation of fault recording

Annunciations, Measured Values etc. 7SA513

5000 ANNUNCIATIONS

5100 OPERATIONAL ANNUNCIATIONS

5200 LAST FAULT

5300 2nd TO LAST FAULT

5400 3rd TO LAST FAULT

5600 CB OPERAT. STATISTICS

5601 AR 1pole=	No. of auto-reclose commands:1p RAR
5602 AR 3pole=	No. of auto-reclose commands:3p RAR
5603 DAR 3pol=	No. of auto-reclose commands:3p DAR
5604 TripNo L1=	Number of trip commands: Phase L1
5605 TripNo L2=	Number of trip commands: Phase L2
5606 TripNo L3=	Number of trip commands: Phase L3
5607 $\sum IL1/In$ =	Summated current tripped IL1/In
5608 $\sum IL2/In$ =	Summated current tripped IL2/In
5609 $\sum IL3/In$ =	Summated current tripped IL3/In

5700 OPERATIONAL MEASURED VALUES

5701 IL1 =	Current in phase IL1 =
5702 IL2 =	Current in phase IL2 =
5703 IL3 =	Current in phase IL3 =
5704 UL1E=	Voltage UL1E =
5705 UL2E=	Voltage UL2E =
5706 UL3E=	Voltage UL3E =
5707 UL12=	Voltage UL12 =
5708 UL23=	Voltage UL23 =
5709 UL31=	Voltage UL31 =
5710 Pa=	Active power Pa =
5711 Pr=	Reactive power Pr =
5712 f [%]=	Frequency f [%] =
5713 IL1[%] =	Current in phase IL1 [%] =
5714 IL2[%] =	Current in phase IL2 [%] =
5715 IL3[%] =	Current in phase IL3 [%] =
5716 UL1E [%]=	UL1E [%]=
5717 UL2E [%]=	UL2E [%]=
5718 UL3E [%]=	UL3E [%]=
5719 UL12 [%] =	UL12 [%] =
5720 UL23 [%] =	UL23 [%] =
5721 UL31 [%] =	UL31 [%] =
5722 Pa [%] =	Active power Pa [%] =
5723 Pr [%] =	Reactive power Pr [%] =

Reference Table for Configuration Parameters 7SA513

6000 MARSHALLING

6100 MARSHALLING BINARY INPUTS

6101 BINARY INPUT 1 Binary input 1

_____	_____	_____
_____	_____	_____
_____	_____	_____

6102 BINARY INPUT 2 Binary input 2

_____	_____	_____
_____	_____	_____
_____	_____	_____

6103 BINARY INPUT 3 Binary input 3

_____	_____	_____
_____	_____	_____
_____	_____	_____

6104 BINARY INPUT 4 Binary input 4

_____	_____	_____
_____	_____	_____
_____	_____	_____

6105 BINARY INPUT 5 Binary input 5

_____	_____	_____
_____	_____	_____
_____	_____	_____

6106 BINARY INPUT 6 Binary input 6

_____	_____	_____
_____	_____	_____
_____	_____	_____

6107 BINARY INPUT 7

Binary input 7

6108 BINARY INPUT 8

Binary input 8

6109 BINARY INPUT 9

Binary input 9

6110 BINARY INPUT 10

Binary input 10

6111 BINARY INPUT 11

Binary input 11

6112 BINARY INPUT 12

Binary input 12

6113 BINARY INPUT 13

Binary input 13

6114	BINARY INPUT 14	Binary input 14	
6115	BINARY INPUT 15	Binary input 15	
6116	BINARY INPUT 16	Binary input 16	
6117	BINARY INPUT 17	Binary input 17	
6118	BINARY INPUT 18	Binary input 18	
6119	BINARY INPUT 19	Binary input 19	
6120	BINARY INPUT 20	Binary input 20	

6121 BINARY INPUT 21 Binary input 21

6122 BINARY INPUT 22 Binary input 22

6123 BINARY INPUT 23 Binary input 23

6124 BINARY INPUT 24 Binary input 24

6200 MARSHALLING SIGNAL RELAYS

6201 SIGNAL RELAY 1 Signal relay 1

6202 SIGNAL RELAY 2 Signal relay 2

6203 SIGNAL RELAY 3 Signal relay 3

6204	SIGNAL RELAY 4	Signal relay 4	
6205	SIGNAL RELAY 5	Signal relay 5	
6206	SIGNAL RELAY 6	Signal relay 6	
6207	SIGNAL RELAY 7	Signal relay 7	
6208	SIGNAL RELAY 8	Signal relay 8	
6209	SIGNAL RELAY 9	Signal relay 9	
6210	SIGNAL RELAY 10	Signal relay 10	

6211 SIGNAL RELAY 11

Signal relay 11

6212 SIGNAL RELAY 12

Signal relay 12

6213 SIGNAL RELAY 13

Signal relay 13

6214 SIGNAL RELAY 14

Signal relay 14

6215 SIGNAL RELAY 15

Signal relay 15

6216 SIGNAL RELAY 16

Signal relay 16

6217 SIGNAL RELAY 17

Signal relay 17

6218	SIGNAL RELAY 18	Signal relay 18	
6219	SIGNAL RELAY 19	Signal relay 19	
6220	SIGNAL RELAY 20	Signal relay 20	
6221	SIGNAL RELAY 21	Signal relay 21	
6222	SIGNAL RELAY 22	Signal relay 22	
6223	SIGNAL RELAY 23	Signal relay 23	
6224	SIGNAL RELAY 24	Signal relay 24	

6225 SIGNAL RELAY 25

Signal relay 25

6226 SIGNAL RELAY 26

Signal relay 26

6227 SIGNAL RELAY 27

Signal relay 27

6300 MARSHALLING LED INDICATORS

6301 LED 1

LED 1

6302 LED 2

LED 2

6303 LED 3

LED 3

6304 LED 4

LED 4

6305 LED 5

LED 5

6306 LED 6

LED 6

6307 LED 7

LED 7

6308 LED 8

LED 8

6309 LED 9

LED 9

6310 LED 10

LED 10

6311 LED 11

LED 11

6312 LED 12

LED 12

6313 LED 13

LED 13

6314 LED 14

LED 14

6315 LED 15

LED 15

6316 LED 16

LED 16

6317 LED 17

LED 17

6318 LED 18

LED 18

6319	LED 19	LED 19	
6320	LED 20	LED 20	
6321	LED 21	LED 21	
6322	LED 22	LED 22	
6323	LED 23	LED 23	
6324	LED 24	LED 24	

6400 MARSHALLING TRIP RELAYS

6401	TRIP RELAY 1	Trip relay 1	

6402 TRIP RELAY 2	Trip relay 2	
_____	_____	_____
_____	_____	_____
_____	_____	_____
6403 TRIP RELAY 3	Trip relay 3	
_____	_____	_____
_____	_____	_____
_____	_____	_____
6404 TRIP RELAY 4	Trip relay 4	
_____	_____	_____
_____	_____	_____
_____	_____	_____
6405 TRIP RELAY 5	Trip relay 5	
_____	_____	_____
_____	_____	_____
_____	_____	_____
6406 TRIP RELAY 6	Trip relay 6	
_____	_____	_____
_____	_____	_____
_____	_____	_____
7000 OP. SYSTEM CONFIGURATION		
7100 INTEGRATED OPERATION		
7101 LANGUAGE	Language	
DEUTSCH	[] German	
ENGLISH	[] English	
FRANCAIS	[] French	
ESPAÑOL	[] Spanish	
7102 DATE FORMAT	Date format	
DD.MM.YYYY	[] dd.mm.yyyy	
MM/DD/YYYY	[] mm/dd/yyyy	
7105 OPER. 1st L	Operational message for 1st display line	
_____	_____	_____

7106	OPER. 2nd L		Operational message for 2nd display line
7107	FAULT 1st L		Fault message for 1st display line
7108	FAULT 2nd L		Fault message for 2nd display line
7110	FAULT INDIC		Fault indication: LED and LCD
	WITH FAULT DETEC	[]	With fault detection
	WITH TRIP COMM.	[]	With trip command
7200	PC/SYSTEM INTERFACES		
7201	DEVICE ADD.		Device address
	min. 1		
	max. 254	—	
7202	FEEDER ADD.		Feeder address
	min. 1		
	max. 254	—	
7203	SUBST. ADD.		Substation address
	min. 1		
	max. 254	—	
7208	FUNCT. TYPE		Function type in accordance with VDEW/ZVEI
	min. 1		
	max. 254	—	
7209	DEVICE TYPE		Device type
	min. 1		
	max. 254	—	
7211	PC INTERF.		Data format for PC-interface
	DIGSI V3	[]	DIGSI V3
	ASCII	[]	ASCII
7214	PC GAPS		Transmission gaps for PC-interface
	min. 0.0		s
	max. 5.0	—	
7215	PC BAUDRATE		Transmission baud rate for PC-interface
	9600 BAUD	[]	9600 Baud
	19200 BAUD	[]	19200 Baud
	1200 BAUD	[]	1200 Baud
	2400 BAUD	[]	2400 Baud
	4800 BAUD	[]	4800 Baud
7216	PC PARITY		Parity and stop-bits for PC-interface
	DIGSI V3	[]	DIGSI V3
	NO 2 STOP	[]	No parity, 2 stopbits
	NO 1 STOP	[]	No parity, 1 stopbit

7221	SYS INTERF.		Data format for system-interface
	VDEW COMPATIBLE	[]	VDEW compatible
	VDEW EXTENDED	[]	VDEW extended
	DIGSI V3	[]	DIGSI V3
	LSA	[]	LSA
7222	SYS MEASUR.		Measurement format for system-interface
	VDEW COMPATIBLE	[]	VDEW compatible
	VDEW EXTENDED	[]	VDEW extended
7224	SYS GAPS		Transmission gaps for system-interface
	min. 0.0		s
	max. 5.0	—	
7225	SYS BAUDR.		Transmission baud rate for system-interface
	9600 BAUD	[]	9600 Baud
	19200 BAUD	[]	19200 Baud
	1200 BAUD	[]	1200 Baud
	2400 BAUD	[]	2400 Baud
	4800 BAUD	[]	4800 Baud
7226	SYS PARITY		Parity and stop-bits for system-interface
	VDEW/DIGSIV3/LSA	[]	VDEW/DIGSI V3/LSA
	NO 2 STOP	[]	No parity, 2 stopbits
	NO 1 STOP	[]	No parity, 1 stopbit
7227	SYS-SWITCH		Online-switch VDEW-DIGSI enabled
	NO	[]	no
	YES	[]	yes
7235	SYS PARAMET		Parameterizing via system-interface
	NO	[]	no
	YES	[]	yes

7400 FAULT RECORDINGS

7402	INITIATION		Initiation of data storage
	STORAGE BY FD.	[]	Storage by fault det
	STORAGE BY TRIP	[]	Storage by trip
	START WITH TRIP	[]	Start with trip
7403	SCOPE		Scope of stored data
	FAULT EVENT	[]	Fault event
	FAULT IN POW.SYS	[]	Fault in power syst.
7410	T-MAX		Maximum time period of a fault recording
	min. 0.30		s
	max. 5.00	—	
7411	T-PRE		Pre-trigger time for fault recording
	min. 0.05		s
	max. 0.50	—	
7412	T-POST		Post-fault time for fault recording
	min. 0.05		s
	max. 0.50	—	
7431	T-BINARY IN		Storage time by initiation via binary input
	min. 0.10		s
	max. 5.00/∞	—	

7432	T-KEYBOARD		Storage time by initiation via keyboard
	min. 0.10		s
	max. 5.00		
7490	SYS LENGTH		Length of fault record (former LSA)
	660 VALUES FIX	[]	660 values fix
	<=3000 VAL. VAR	[]	<=3000 val. var
7800	SCOPE OF FUNCTIONS		
7812	DIST. PROT.		Distance protection
	EXIST	[]	Existent
	NON-EXIST	[]	Non-existent
7813	DIST.F.DET.		Distance protection: Fault detection program
	IMPEDANCE ZONE	[]	Impedance zone FD.
	U/I/phi FAULT DET.	[]	U/I/phi fault detec
7820	POWER SWING		Power swing detection
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7821	PUTT		Teleprotection Permissive Underreach
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7822	POTT		Teleprotection Permissive Overreach
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7823	USER LOGIC		User definable logic functions
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7824	SWITCH-O-F		Switch-onto-fault protection
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7825	WEAK INFEEED		Weak infeed trip
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7826	EMERG. O/C		Emergency overcurrent protection
	EXIST	[]	Existent
	NON-EXIST	[]	Non-existent
7831	EARTH FAULT		Earth fault protection for earthed networks
	NON-EXIST	[]	Non-existent
	DIREC.COMPARISON	[]	Direc. comparison
	DIR/NON-DIR	[]	Directional/non-dir.
7834	INTERNAL AR		Internal auto-reclose function
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7835	SYNCH.CHECK		Internal synchronism and voltage check
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent

7836	BACK-UP O/C		Back-up overcurrent protection
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7837	OVERVOLT.		Overvoltage protection
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7838	FAULT LOCAT		Fault locator
	EXIST	[]	Existent
	NON-EXIST	[]	Non-existent
7839	BREAK. FAIL		Breaker fail protection
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7885	PARAM. C/O		Parameter change-over
	NON-EXIST	[]	Non-existent
	EXIST	[]	Existent
7899	FREQUENCY		Rated system frequency
	fN 50 Hz	[]	fN 50 Hz
	fN 60 Hz	[]	fN 60 Hz
7900	DEVICE CONFIGURATION		
7910	CB TEST BI		CB test via binary input program
	TRIP-CLOSE 3POLE	[]	Trip-close 3pole
	SEQU. L1-L2-L3	[]	Sequence L1-L2-L3
	THREE-POLE TRIP	[]	Three-pole trip
7912	AR w/ DIST.		Auto-reclose with distance protection
	YES	[]	yes
	NO	[]	no
7921	AR w/o TELE		Auto-reclose when teleprotect. is not operativ
	YES	[]	yes
	NO	[]	no
7924	AR w/S-O-F		Auto-reclose with switch-onto-fault protection
	YES	[]	yes
	NO	[]	no
	BLOCK-AR	[]	Block-AR
7925	AR w/ W/I		Auto-reclose with weak infeed tripping
	YES	[]	yes
	NO	[]	no
7926	AR w/ EMERG		Auto-reclose with emergency overcurrent prot.
	YES	[]	yes
	NO	[]	no
7931	AR w/ E/F		Auto-reclose with E/F protect. in earthed net
	YES	[]	yes
	NO	[]	no
7936	AR w/ BACK		Auto-reclose with back-up overcurrent prot.
	YES	[]	yes
	NO	[]	no
7941	AR w/ EXT.		Auto-reclose with ext. trip via binary input
	YES	[]	yes
	NO	[]	no

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8000 DEVICE CONTROL

8100 SETTING REAL TIME CLOCK

8101	DATE / TIME	Actual date and time
8102	DATE	Setting new date
8103	TIME	Setting new time
8104	DIFF. TIME	Setting difference time

8200 RESET

8201	RESET	Reset of LED memories
8202	RESET	Reset of operational annunciation buffer
8203	RESET	Reset of fault annunciation buffer
8204	RESET	Reset of CB operation counters
8205	RESET	Reset of the total of interrupted currents

8300 SYS-VDEW ANNUNC.-MEAS.VAL

8301	SYS TEST	Testing via system-interface
	OFF	[] off
	ON	[] on
8302	SYS BLOCK	Blocking of monitoring direction via sys.-int.
	OFF	[] off
	ON	[] on

8500 PARAMETER CHANGE-OVER

8501	ACTIV PARAM	Actual active parameter set
8503	ACTIVATING	Activation of parameter set
	SET A	[] Set a
	SET B	[] Set b
	SET C	[] Set c
	SET D	[] Set d
	SET BY BIN.INPUT	[] Set via binary input
	SET BY LSA CONTR	[] Set by lsa control
8510	COPY	Copy original parameter set to set A
8511	COPY	Copy original parameter set to set B
8512	COPY	Copy original parameter set to set C

8513 COPY	Copy original parameter set to set D
8514 COPY	Copy parameter set A to set B
8515 COPY	Copy parameter set A to set C
8516 COPY	Copy parameter set A to set D
8517 COPY	Copy parameter set B to set A
8518 COPY	Copy parameter set B to set C
8519 COPY	Copy parameter set B to set D
8520 COPY	Copy parameter set C to set A
8521 COPY	Copy parameter set C to set B
8522 COPY	Copy parameter set C to set D
8523 COPY	Copy parameter set D to set A
8524 COPY	Copy parameter set D to set B
8525 COPY	Copy parameter set D to set C

9800 OPERATING SYSTEM CONTROL

9802 MONITOR Monitor

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To

SIEMENS AKTIENGESELLSCHAFT

Dept. PTD PA D PSN

D – 13623 BERLIN

Germany

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printing errors can never be entirely eliminated:
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gestions for improvement that you may have.

From

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Address

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Corrections/Suggestions

Substantial alterations against previous issue:

Extensions with regard to firmware version V3.3

Subject to technical alteration

Siemens Aktiengesellschaft

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