

Numerical Distance Protection Relay

SIPROTEC 7SA511 v3.2

Instruction Manual

Order No. C53000–G1176–C98–6



Figure 1 Illustration of the numerical distance protection relay 7SA511 (in housing for surface mounting)

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 SIPROTEC 7SA511 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 starpoint may be isolated, compensated (arc suppressed by Petersen coil), solidly earthed or low resistance earthed.

It contains all the vital functions for the protection of a 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 bus-bars.

Its fundamental function is determination of the distance of the short circuit by impedance measurement. This can be supplemented by a series of optional function modules which provide power swing supplement, teleprotection interface (for 100 % rapid clearance), thermal overload protection (for cables), earth fault detection (for isolated or compensated networks), highly sensitive earth fault protection (for high-resistance earth fault in earthed networks), automatic reclosure (for overhead lines), synchronism and voltage check, fault location (for speedy location of the damaged area). External accessories are therefore normally not required.

Throughout a fault in the network the magnitudes of the instantaneous values are stored for a period of at most 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 VDEW/ZVEI and IEC 60870-5-103 is used, as well as according DIN 19244 (selectable). The device can therefore be incorporated in Localized Substation Automation networks (LSA). The system interface is suited to communication via a modem link.

1.2 Features

- Processor system with powerful 16-bit-micro-processor;
- complete digital measured value processing and control from data acquisition and digitizing of the measured values up to the trip and close decision for the circuit breaker;
- complete galvanic and reliable separation of the internal processing circuits from the measurement, control and supply circuits of the system, with analog input transducers, binary input and output modules and d.c./d.c. converter;
- complete scope of functions required for the protection of a high voltage feeder circuit;
- overcurrent fault detection – optionally voltage controlled (U/I) or phase-angle dependent impedance fault detection;
- polygonal tripping characteristic with independent setting of reach along the R- and X-axis with separate R-setting for earth faults;
- directional determination using sound phase polarization and voltage memory, giving unlimited directional sensitivity;
- comprehensive supplementary functions can be ordered as an option;
- 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, optionally with 2 kV insulation or for connection of optical fibre;
- continuous monitoring of the measured values and the hardware and software of the relay.

1.3 Implemented functions

7SA511 contains the following functions:

Distance protection with

- phase selective overcurrent fault detection;
- optional voltage controlled (U/I) fault detection or impedance fault detection with polygonally shaped angle-dependent characteristic;
- five distance zones can be set to operate either in the forward direction or in the reverse direction or non-directional and two can be used as graded overreach zones;
- seven time stages;
- 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;
- phase segregated trip (for use with single-pole auto-reclosure).

Power swing supplement (optional with impedance fault detection)

- power swing detection by dR/dt measurement;
- avoids unwanted trip occurrences during power swings in the system;
- for use of power swing blocking or out-of-step tripping.

Universal teleprotection interface

programmable for different schemes of

- permissive underreach transfer tripping (PUTT);
- permissive overreach transfer tripping (POTT) in release or block mode.

Dead-fault protection

- provides high speed operation at either line end when switching manually onto a bolted fault.

Emergency overcurrent function

with two-stage definite time overcurrent characteristic and separate earth current stage,

- for “emergency operation” if voltage transformer m.c.b. trips or
- for “emergency operation” in case of voltage transformer secondary fuse failure.

Thermal overload protection

- provides thermal replica of the current heat losses;
- true r.m.s. measurement of all three conductor currents;
- adjustable warning stages.

Earth fault detection (optional)

for compensated or isolated networks with

- phase selective fault detection;
- sensitive directional determination.

Highly sensitive earth fault protection (optional)

- for high-resistive earth faults in networks with earthed starpoint;
- with two-stage earth current pick-up;
- directional determination using zero sequence components of currents and voltages;
- optionally with directional comparison via communication link (e.g. PLC or optical fibre);
- back-up function in case of voltage failure using definite time earth current protection;
- alternatively non-directional inverse time earth current protection with three selectable characteristics (not in conjunction with directional earth fault protection).

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 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 or dead-bus check also possible before manual close of the circuit breaker;
- measured voltages can be connected either phase-to-phase or phase-to-earth.

Distance-to-fault location

- can be started by fault detection or trip command or by external command;
- calculation of the fault distance;

- output of fault distance in ohms (primary and secondary), kilometers and % line length;
- optionally with parallel line mutual compensation.

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 and transmission of the last four network faults, with real time clock;
- storage of data of the last three earth faults in isolated or arc compensated systems;
- 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 two plug-in modules of Double Europa Format. These modules are installed in a housing 7XP20. Two different types of housings can be delivered:

– **7SA511★–★B★★–** in housing 7XP2040–1 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 26 is connected to the case.

All external signals are connected to 100 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 isolated interface to a central control and storage unit, an additional coupling facility has been provided. For the hard-wired V.24 (RS232C) serial interface (7SA511★–★★★★–★B), four screwed terminals are provided. For the interface for optical fibre connection (model 7SA511★–★★★★–★C), 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 Figure 2.2.

– **7SA511★–★C★★–** in housing 7XP2040–2 for **panel flush mounting** or **7SA511★–★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.

The isolated interface to a central control and storage unit (7SA511★–★★★★–★B) is led to a 4-pole connection module. In the interface for optical fibre connection (7SA511★–★★★★–★C), a module with 2 F–SMA connectors is provided instead.

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 to 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 Figure 2.3.

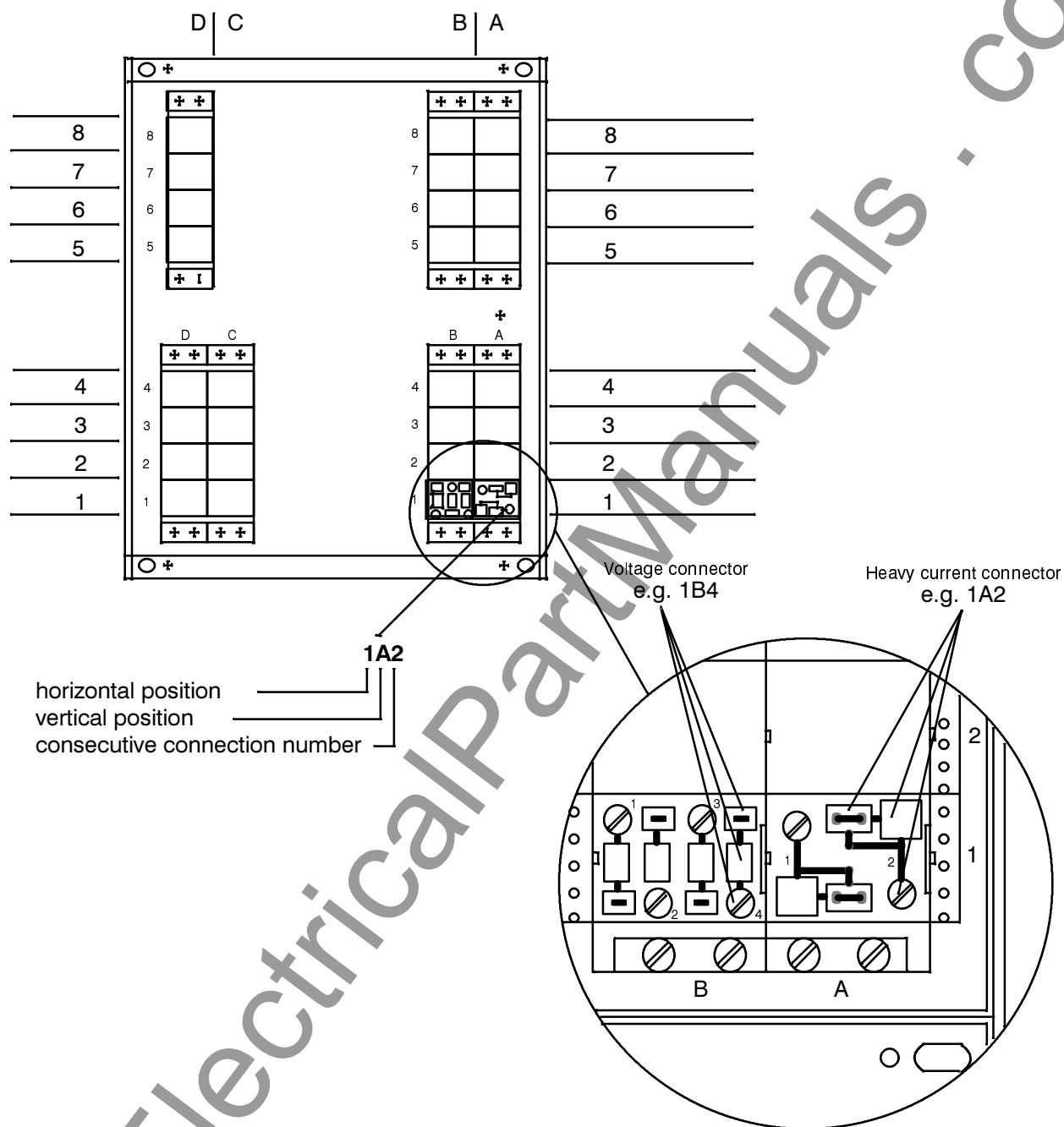
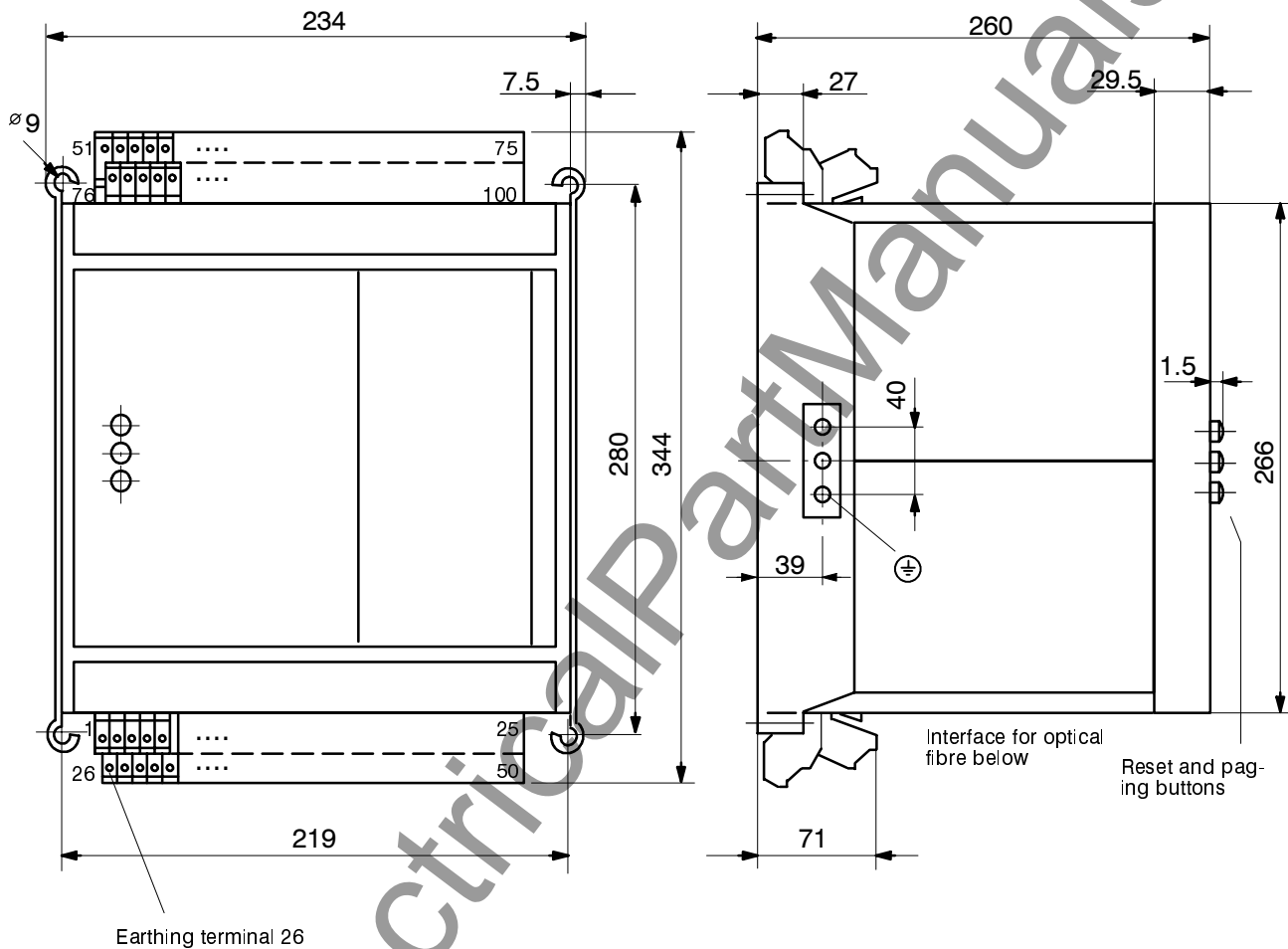


Figure 2.1 Connection plugs (rear view) – housing for flush mounting – example

2.2 Dimensions

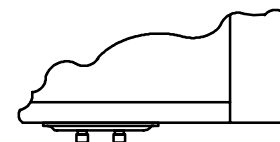
Figures 2.2 and 2.3 show the dimensions of the various types of housings available.

7SA511 Housing for panel surface mounting 7XP2040–1



Max. 100 terminals for cross-section max. 7 mm²

Dimensions in mm



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

Figure 2.2 Dimensions for housing 7XP2040–1 for panel surface mounting

7SA511 Housing for **panel flush mounting** or **cubicle installation** 7XP2040-2

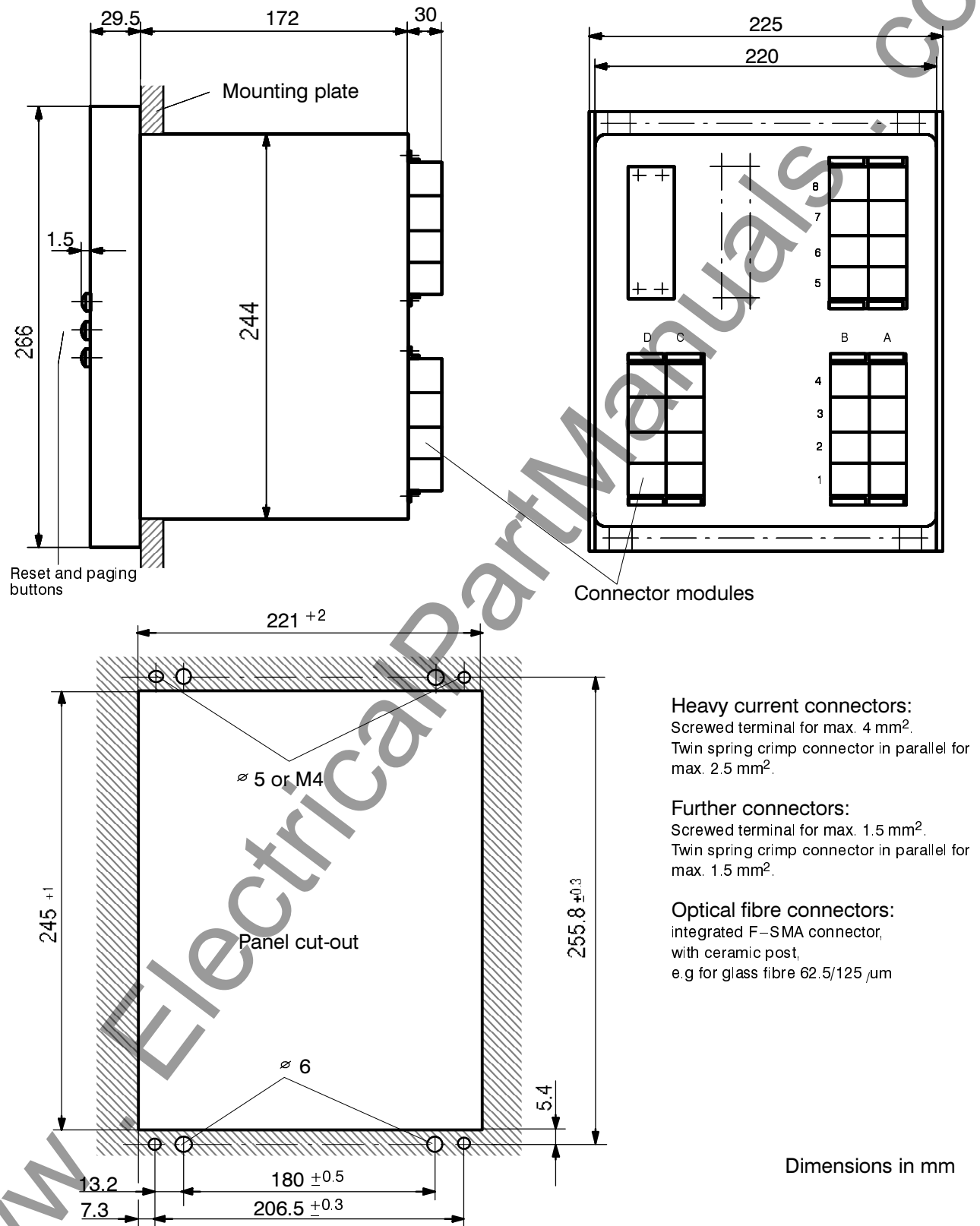


Figure 2.3 Dimensions for housing 7XP2040–2 for panel flush mounting or cubicle installation

2.3 Ordering data

Numerical distance protection

relay

7 S A 5 1 1

7.

8.

9.

10.

11.

12.

13.

14.

15.

16.

Rated current; rated frequency

1 A; 50/60 Hz 1

5 A; 50/60 Hz 5

Auxiliary voltage

24/48 V dc 2

60/110/125 V dc 4

220/250 V dc 5

Construction

in housing 7XP2040 for panel surface mounting B

in housing 7XP2040 for panel flush mounting C

in housing 7XP2040 for cubicle installation
(without glass front) E

Operating language

German A 6

English A 7

French B 7

Fault detection systems

Overcurrent fault detectors 1

Overcurrent and voltage controlled underimpedance (U/I)
and polygonal impedance fault detectors 2

Overcurrent and underimpedance (U/I) fault detectors 3

Measured current input for earth current

Input for I_E (residual current of protected line) 0

Input for highly sensitive earth fault detection in non-earthed systems 1

Input for I_{EP} (parallel line compensation for fault location) 2

Serial interface for coupling to a control centre

without serial interface A

with isolated serial interface (similar V.24 or RS 232 C) B

with serial interface for optical fibre connection C

(next page)

Numerical distance protection**relay****7 S A 5 1 1**

7.	8.	9.	10.	11.	12.	13.	14.	15.	16.

Supplements 1AR = **A**uto-**R**eclosurePCO = **P**arameter **C**hange-**O**ver facilitySC = **S**ynchronism and voltage **C**heck

without AR,	without SC,	without PCO	.....	A
with AR 3pole,	with SC,	without PCO	.....	B
with AR 1/3pole,	with SC,	without PCO	.....	C
without AR,	with SC,	with PCO	.....	E
with AR 3pole,	with SC,	with PCO	.....	F
with AR 1/3pole,	with SC,	with PCO	.....	G

Supplements 2PS = **P**ower **S**wing option ¹⁾EF = High-resistance **E**arth **F**ault protection for earthed systems ²⁾

without PS, without EF	.....	0
with PS, without EF	.....	1
without PS, with EF	.....	2
with PS, with EF	.....	3

¹⁾ only with polygonal impedance fault detectors (12th figure of ordering code = 2)²⁾ only with earth current input for I_E or I_{EP} (13th figure of ordering code = 0 or 2)

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 (settable)
Rated frequency f_N	50 Hz or 60 Hz (settable)
Burden: ct circuits per phase and residual path	
– at $I_N = 1$ A	approx 0.05 VA
– at $I_N = 5$ A	approx 0.2 VA
– for highly sensitive earth fault detection at 1 A	approx 0.05 VA
Burden: vt circuits	
– at 100 V	< 0.5 VA
– for earth fault detection or busbar voltage at 100 V	< 0.5 VA
Overload capability ct circuits, phases and earth	
– thermal (rms)	$100 \times I_N$ for 1 second $30 \times I_N$ for 10 seconds $4 \times I_N$ continuous
– dynamic (impulse)	$250 \times I_N$ (half cycle)
Overload capability ct circuit for highly sensitive earth fault detection	
– thermal (rms)	300 A for 1 second 100 A for 10 seconds 15 A continuous
Overload capability vt circuits	
– thermal (rms)	170 V continuous

Auxiliary DC supply

Auxiliary dc voltage supply via integrated dc/dc converter

Auxiliary voltage U_H	24/48 V dc	60/110/125 V dc	220/250 V dc
Operating ranges	19 to 56 V dc	48 to 144 V dc	176 to 288 V dc
Superimposed ac voltage, peak-to-peak	$\leq 12\%$ at rated voltage $\leq 6\%$ at the limits of the voltage ranges		
Power consumption quiescent picked up	approx 12 W approx 20 W		
Bridging time during failure/short-circuit of auxiliary dc voltage	≥ 50 ms at $U \geq 110$ V dc		

Heavy duty (trip) contacts

Trip relays, number	5
Contacts per relay	2 NO
Switching capacity	1000 W/VA
MAKE	30 W/VA
BREAK	250 V
Switching voltage	5 A continuous
Permissible current	30 A for 0.5 s

Signal contacts

Signal relays	11
Contacts per relay	1 CO or 1 NO
Switching capacityMAKE/BREAK	20 W/VA
Switching voltage	250 V
Permissible current	1 A

Binary inputs, number 10

Voltage range reconnectable 24 to 250 V dc, up to production series /GG in 2, from production series /HH or later in 4 ranges:

for rated control voltage	24/48 Vdc	60 Vdc	110/125 Vdc	220/250 Vdc
pick-up value, approx.	16 Vdc	44 Vdc	80 Vdc	160 Vdc

Max. control voltage 288 Vdc
Current consumption approx 1.7 mA independent of operating voltage

Serial interfaces

Operator terminal interface non-isolated
 – Connection at the front, 25-pole subminiature connector according ISO 2110 for connection of a personal computer or similar as delivered 9600 Baud;
 – Transmission speed min. 1200 Baud; max. 19200 Baud

Interface for data transfer to a control centre

– Standards similar V.24/V.28 to CCITT; RS 232 C to EIA;
 – Transmission speed Protocol according to IEC 60870–5–103 or DIN 19244 as delivered 9600 Baud;
 – Transmission security min. 1200 Baud; max. 19200 Baud
 Hamming distance $d = 4$

– Connection, directly at housing terminals;
 2 core pairs, with individual and common screening;
 e.g. LI YCY–CY/2 x 2 x 0.25 mm²
Transmission distance max. 1000 m
Test voltage 2 kV with rated frequency

– 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; $R_f = 330 \Omega$
– 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; $R_f = 50 \Omega$; 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 display contrast)
– permissible temperature during service	–20 °C to +70 °C	
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 Section 2.2
Weight from production series /HH or later (up to /GG in parenthesis)	
– in housing for surface mounting	approx. 10 kg (11.5 kg)
– in housing for flush mounting	approx. 8 kg (9.5 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 fault location with parallel line compensation (optional)
R_M/R_L	–7.00 to +7.00 (steps 0.01)
X_M/X_L	–7.00 to +7.00 (steps 0.01)

Phase preferences

for double earth faults in solidly earthed systems	phase to phase or leading phase to earth or lagging phase to earth
for double earth faults in isolated or arc compensated systems	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) cyclic
Displacement 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

Overcurrent fault detection, general fault detection parameters

Phase currents $I_{ph>} > I_N$	0.25 to 4.00	(steps 0.01)
Earth current $I_{e>} > I_N$	0.10 to 1.00	(steps 0.01)
Displacement voltage pick-up $U_{e>} (= \sqrt{3} \cdot U_0)$	2 V to 100 V	(steps 1 V); ∞
Drop-off ratios	approx. 0.95	
Measuring tolerances according VDE 0435 part 303	$\pm 5\%$	

Voltage controlled current fault detection (under-impedance fault detection) (optional)

Characteristic	two-stage with settable inclination
Voltage control	by U_{ph-e} or U_{ph-ph} (selectable)
Setting ranges:	
– minimum current pick-up $I_{ph>}$	0.10 to $1.00 \cdot I_N$ (steps $0.01 \cdot I_N$)
– Undervoltage pick-up $U_{ph-e}<$	20 V to 70 V (steps 1 V)
$U_{ph-ph}<$	40 V to 130 V (steps 1 V)
Drop-off ratios:	
– $I_{ph>}$	approx. 0.95
– $U_{ph-e}<$, $U_{ph-ph}<$	approx. 1.05
Measuring tolerances according VDE 0435 part 303	$\pm 5\%$

Impedance fault detection (fix-impedance) (optional)

Characteristic	polygonal, phase angle dependent R–section	
Setting values (based on $I_N = 1A^*$):		
$X+A$ = forwards reach (for all faults)	0.10 Ω to 200.00 Ω	(steps 0.01 Ω)
$X-A$ = reverse reach (for all faults)	0.10 Ω to 200.00 Ω	(steps 0.01 Ω)
RA_2 = resistance tolerance (phase-phase, $\varphi_{SC} > \varphi_A$)	0.10 Ω to 200.00 Ω	(steps 0.01 Ω)
RA_1 = resistance tolerance (phase-phase, $\varphi_{SC} < \varphi_A$)	0.10 Ω to 100.00 Ω	(steps 0.01 Ω)
φ_A = limit angle between RA_1 and RA_2	30.0° to 80.0°	(steps 0.1°)
RA_{2E} = resistance tolerance (phase-earth, $\varphi_{SC} > \varphi_{AE}$)	0.10 Ω to 200.00 Ω	(steps 0.01 Ω)
RA_{1E} = resistance tolerance (phase-earth, $\varphi_{SC} < \varphi_{AE}$)	0.10 Ω to 200.00 Ω	(steps 0.01 Ω)
φ_{AE} = limit angle between RA_{1E} and RA_{2E}	30.0° to 80.0°	(steps 0.1°)
$I_{ph>}$ = minimum operating phase current	0.10 to $4.00 \cdot I_N$	(steps $0.01 \cdot I_N$)
Drop-off ratios:		
– for R, X	approx. 1.06	
– for $I_{ph>}$	approx. 0.95 (for $I \geq I_N$)	

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

Measuring tolerances according VDE0435 part 303
with sinusoidal quantities

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

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

Distance measurement

Characteristic

polygonal, 3 independent + 2 controlled stages

Setting values (based on $I_N = 1A^*$)

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 according VDE0435 part 303
with sinusoidal quantities

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

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

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

Directional determination

For all types of faults

with quadrature voltages and
voltage memory

Sensitivity

dynamically unlimited

Times

Shortest tripping time

approx. 22 ms

Drop-off time

approx. 40 ms

Time stages:

Setting ranges

0.00 s to 32.00 s (steps 0.01 s)

for all stages

or ∞ (i.e. stage ineffective)

Time expiry tolerances

$\leq 1\%$ of set value or 10 ms

All stages can be set to operate in forward or reverse direction or non-directional. The set times are pure delay times.

Overcurrent emergency protection

with measured voltage failure, e.g. VT secondary mcb trip or detected fuse failure

High-set phase overcurrent $I_{>>} > I_N$

0.50 to 9.99 (steps 0.01)

Definite time delay $T_{I>>}$

0.00 s to 32.00 s (steps 0.01 s)

or ∞ (i.e. stage ineffective)

Phase overcurrent $I_{ph} > I_N$

0.10 to 4.00 (steps 0.01)

Definite time delay $T_{I_{ph}>}$

0.00 s to 32.00 s (steps 0.01 s);

or ∞ (i.e. stage ineffective)

Earth overcurrent $I_E > I_N$

0.10 to 4.00 (steps 0.01)

Definite time delay $T_{I_E>}$

0.00 s to 32.00 s (steps 0.01 s)

or ∞ (i.e. stage ineffective)

Drop-off ratios

– for $I \geq I_N$

approx. 0.95

– for $I \geq 0.25 \times I_N$

approx. 0.90

Measuring tolerances according VDE 0435 part 303

$\pm 5\%$

3.3 Power swing supplement (optional – only with impedance fault detection)

Power swing detection	rate of change of the impedance vector between “power swing polygon” and “fault detection polygon”
Setting the difference ΔR between the polygons (secondary based on $I_N = 1A$ *)	0.10 Ω to 50.00 Ω (steps 0.01 Ω)
Setting rate of change dR/dT	0 Ω/s to 200 Ω/s (steps 1 Ω/s)
Programs	block first distance zone only, block all zones but first zone, block all distance zones, out-of-step tripping
Action time	0.01 s to 32.00 s (steps 0.01 s) or ∞ (i.e. until drop-off of the power swing polygon)
*) Secondary values are related on $I_N = 1 A$; for $I_N = 5 A$ the values are to be divided by 5.	

3.4 Teleprotection interface

Teleprotection modes (selectable)

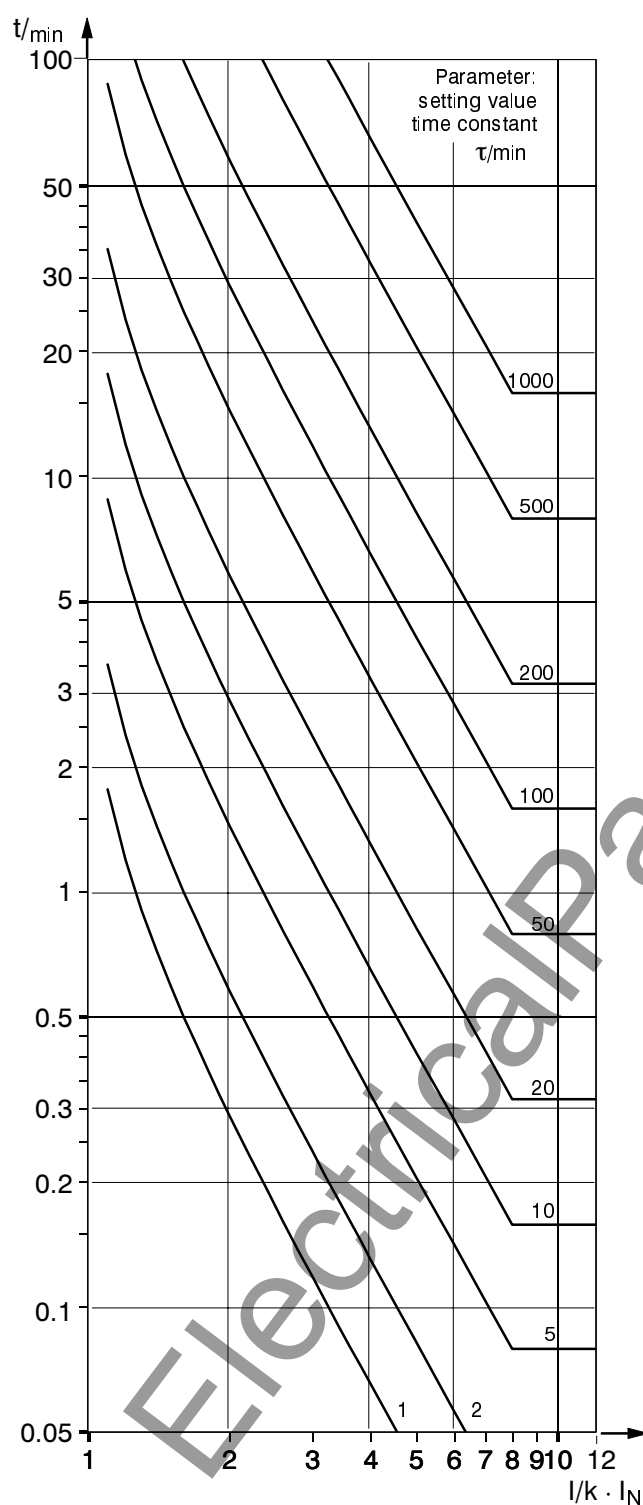
– Permissive underreach transfer trip	fault detection acceleration zone acceleration (special zone Z1B)
Transmit signal prolongation	0.01 s to 32.00 s (steps 0.01 s)
Transmit signal delay	0.00 s to 32.00 s (steps 0.01 s)
Received signal prolongation	0.00 s to 32.00 s (steps 0.01 s)
– Permissive overreach 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 and supplementary auxiliary relay
– 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
The delay times do not include the inherent operating times.	

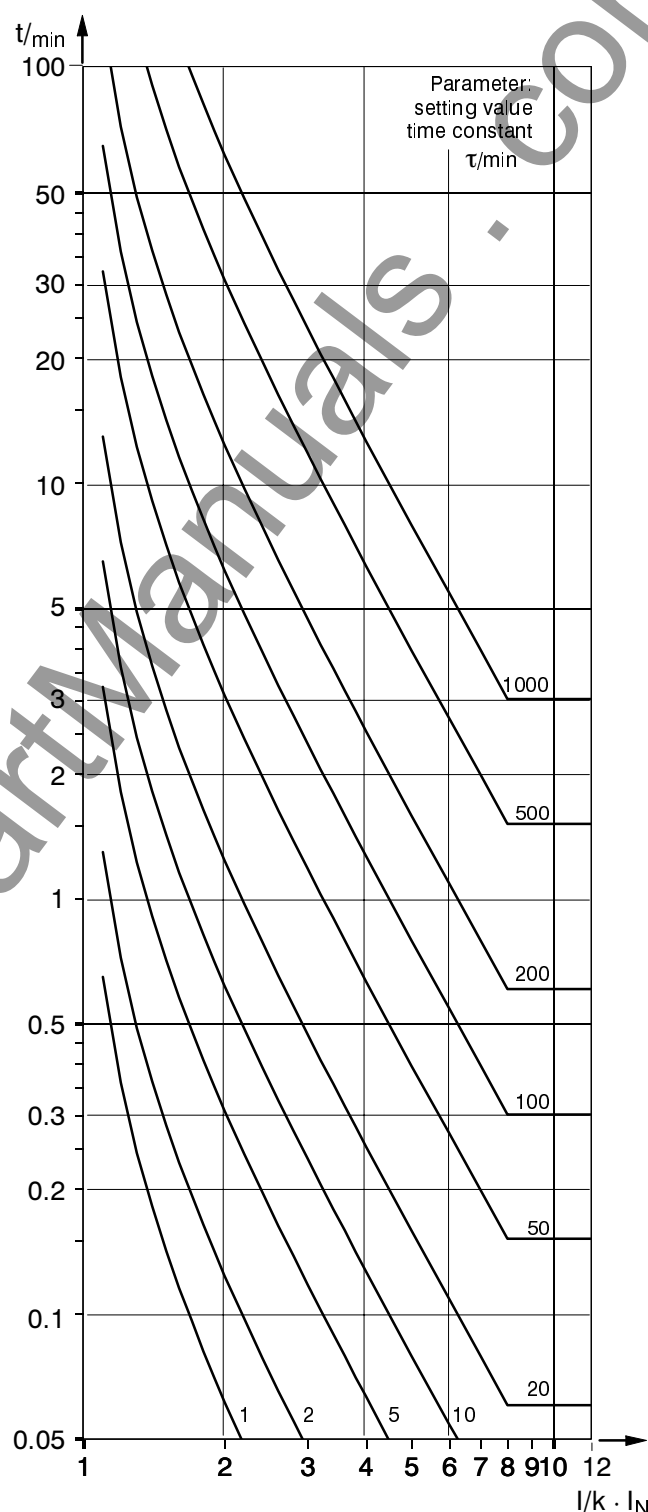
3.6 Thermal overload protection

Setting ranges/steps	
Factor k according to IEC 60255–8	0.10 to 4.00 (steps 0.01)
Time constant τ	1.0 to 999.9 min (steps 0.1 min)
Thermal warning stage $\Theta_{\text{warn}}/\Theta_{\text{trip}}$	50 % to 100 % referred to trip temperature rise (steps 1 %)
Current warning stage I_{warn}/I_N	0.10 to 4.00 (steps 0.01)
Trip time characteristic	
	$t = \tau \cdot \ln \frac{(I/(k \cdot I_N))^2 - (I_{\text{pre}}/(k \cdot I_N))^2}{(I/(k \cdot I_N))^2 - 1}$
	t trip time τ time constant I load current I_{pre} preload current k factor according to IEC 60255–8 refer also to Figures 3.1 and 3.2
Drop-off ratios	
$\Theta/\Theta_{\text{trip}}$	approx. 0.99
$\Theta/\Theta_{\text{warn}}$	approx. 0.99
I/I_{warn}	approx. 0.99
Tolerances	
– referring to $k \cdot I_N$	$\pm 10 \%$
– referring to trip time	$\pm 10 \% \pm 2 \text{ s}$
Influence variables referred to $k \cdot I_N$	
– Auxiliary dc voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq 1 \%$
– Temperature in range $-5 \text{ °C} \leq \vartheta_{\text{amb}} \leq +40 \text{ °C}$	$\leq 0.5 \%/10 \text{ K}$
– Frequency in range $0.95 \leq f/f_N \leq 1.05$	$\leq 1 \%$



$$t = \tau \cdot \ln \frac{(I/(k \cdot I_N))^2}{(I/(k \cdot I_N))^2 - 1}$$

Figure 3.1 Trip time characteristic of overload protection – without preload –



$$t = \tau \cdot \ln \frac{(I/(k \cdot I_N))^2 - (I_{pre}/(k \cdot I_N))^2}{(I/(k \cdot I_N))^2 - 1}$$

for 90 % preload

Figure 3.2 Trip time characteristic of overload protection – with 90 % preload –

3.7 Earth fault detection in non-earthed systems (optional)

Detection

Displacement voltage U_e	10 V to 100 V (steps 1 V)
Delay (optional trip)	approx. 1 s (settable up to 320 s)
Measuring tolerance according VDE 0435 part 303	$\leq 5\%$ of set value

Faulted phase determination

Measuring principle	voltage measurement phase to earth
$U_<$ (faulted phase)	10 V to 100 V (steps 1 V)
$U_>$ (unfaulted phases)	10 V to 100 V (steps 1 V)
Measuring tolerance according VDE 0435 part 303	$\leq 5\%$ of set value

Directional determination

Measuring principle	measurement of active and reactive power
Pick-up value I_e (active or reactive component)	3 mA to 1000 mA (steps 1 mA)
CT angle error correction	0.0° to 5.0° (steps 0.1°) for 2 operating points of the CT characteristic
Measuring tolerance according VDE 0435 part 303	$\leq 10\%$ of set value for $\tan \varphi \leq 20$ (with active component)

3.8 High-resistance earth fault protection in solidly earthed systems (optional)

Fault detection

Earth current pick-up $I_E > I_N$ (for trip)	0.10 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

Directional determination

Measuring principle	with $I_E (= 3 \cdot I_0)$ and $U_E (= \sqrt{3} \cdot U_0)$
Forwards angle	approx. -14° to $+166^\circ$
Measuring tolerances at U_N and I_N with sinusoidal quantities	$\leq 5^\circ$
Directional comparison	release mode

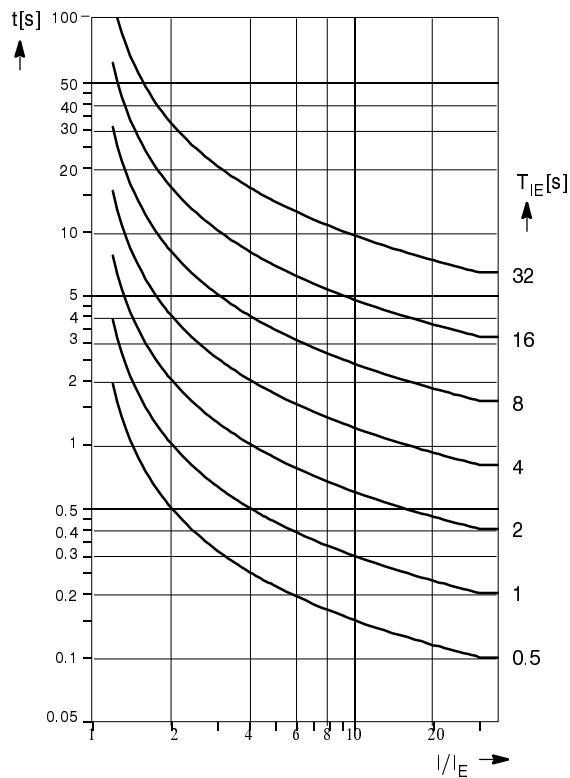
Times

Shortest tripping time	approx. 50 ms
Re-orientation time after change of direction	approx. 50 ms
Trip 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

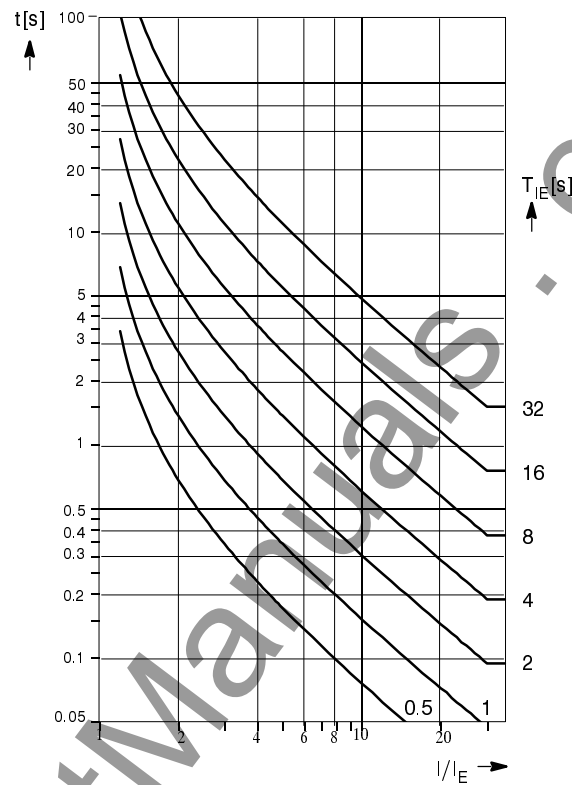
Inverse time earth fault back-up protection

can be used **instead** of the earth fault protection as described before

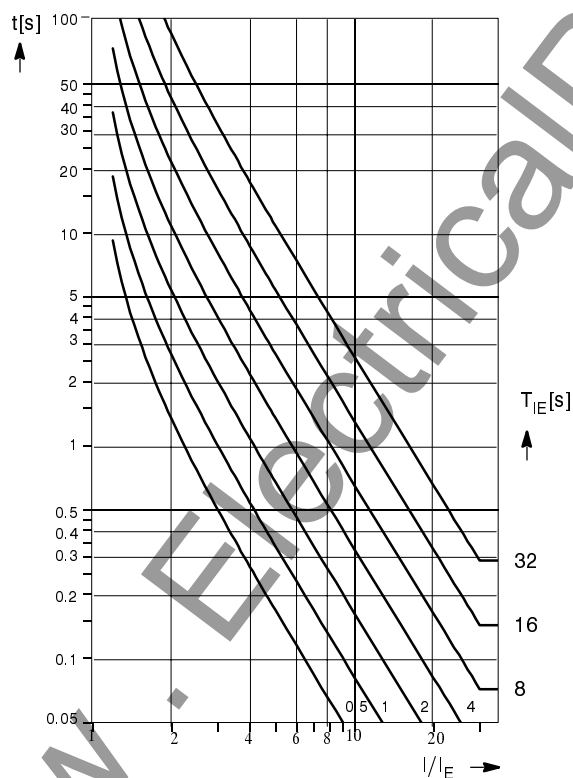
Characteristics	normal inverse or very inverse or extremely inverse (type A or B or C) according IEC 60255-3 or BS142; refer to Figure 3.3
Pick-up value $I_E > I_N$	0.10 to 4.00 (steps 0.01)
Time setting $T_{I_E >}$ corresponds to TM factor	0.00 s to 32.00 s (steps 0.01 s); ∞ 0.000 to 3.200 (steps 0.001); ∞
Measuring tolerances	
– earth current pick-up value	+ 5 % to + 15 %
– time expiry	$\leq 5\% \pm 15$ ms for $2 \leq I/I_E \leq 20$ and $1 \leq T_{I_E}/s \leq 20$



Normal inverse:
$$t = \frac{0.14}{(I/I_E)^{0.02} - 1} \cdot \frac{T_{IE}}{10} \text{ [s]}$$



Very inverse:
$$t = \frac{13.5}{(I/I_E) - 1} \cdot \frac{T_{IE}}{10} \text{ [s]}$$



Extremely inverse:
$$t = \frac{80}{(I/I_E)^2 - 1} \cdot \frac{T_{IE}}{10} \text{ [s]}$$

$T_{IE}/10$ corresponds to the usual time multiplier TM

t tripping time
 T_{IE} set time delay (parameter $T_{IE} >$)
 I earth fault current
 I_E set earth fault pick-up value (parameter $I_E >$)

Figure 3.3 Tripping time characteristics of inverse time earth fault protection

3.9 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)

3.10 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	2 V to 60 V	(steps 1 V)
U> for live-line or live-bus check	20 V to 125 V	(steps 1 V)
ΔU measurement		
setting range	2 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	0.01 Hz to 0.10 Hz	(steps 0.01 Hz); ∞
measuring tolerance	15 mHz	
min operating voltage	20 V	

Times

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

3.11 Fault location

Output of fault distance	in Ω primary in Ω 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	can be ordered as an option, setting of matching refer to Section 3.2
Measuring tolerances according VDE 0435 part 303 sinusoidal quantities	$\leq 2.5\%$ of line length (without intermediate infeed) for $30^\circ \leq \varphi_{sc} \leq 90^\circ$ and $U_{sc}/U_N \geq 0.1$

*) Secondary values are related on $I_N = 1$ 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 related reactance in Ω /mile, the output can be read in miles.

3.12 Ancillary functions

Output of measured values

Operational values of currents	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 $I > I_N$
– range	
– tolerance	
Operational values of voltages	$U_{L1-E}, U_{L2-E}, U_{L3-E}$ in kV primary and in % $U_N/\sqrt{3}$ 0 % to 120 % $U_N/\sqrt{3}$ 2 % of U_N
– range	
– tolerance	
Operational values of voltages	$U_{L1-L2}, U_{L2-L3}, U_{L3-L1}$ in kV primary and in % U_N 0 % to 120 % U_N 2 % of U_N
– range	
– tolerance	
Operational values of powers	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
– range	
– tolerance	
Operational value of frequency	f in % f_N 96 % to 104 % f_N 0.5 % of f_N
– range	
– tolerance	
Operational values of overload protection	calculated temperature rise related on trip temperature rise
Earth fault measured values in non-earthed systems (models with sensitive residual current input)	I_{Ea}, I_{Er} (active and reactive earth current) in A primary and mA at relay input

Measured values plausibility checks

– Sum of currents	phases and earth
– Sum of voltages	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)	$|U| < \text{limit voltage}$ as long as $|I_{\max}| > \text{limit current}$
Voltage failure (single-phase)	$U_E > \text{and } I_E < \text{limit}$
Phase sequence	clockwise phase rotation

Fault event data storage

Storage of annunciations of the last four fault events; the three last can be read out locally

Real time clock

Resolution for operational annunciations	1 min (1ms with personal computer)
Resolution for fault event annunciations	1 ms
Resolution for earth fault annunciations	1 ms
Max time deviation	0.01 %
Buffer battery	Lithium – Battery 3 V/1 Ah, Type CR 1/2 AA Self-discharge time > 10 years

Data storage for fault recording

Storage period (fault detection or trip command = 0 ms), max.	5 s, 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

Circuit breaker operation log

Number of stored trip events caused by 7SA511	up to 9 decimal digits; pole segregated
Number of stored reclose events	up to 9 decimal digits; for each kind of auto-reclosure
Total of tripped currents	up to 7 decimal digits plus 1 after decimal point pole segregated

Trip command and annunciations via binary input

– 1 user definable trip command	for annunciation processing and direct local trip
– 4 user definable annunciations	for annunciation processing

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 SIPROTEC 7SA511 is equipped with a powerful and proven 16-bit microprocessor. This provides 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 ME transform the currents and voltages from the measurement transformers of the switch-gear and match them to the internal processing level of the unit. Apart from the galvanic and low-capacitive isolation provided by the input transformers, filters are provided for the suppression of interference. The filters have been optimized with regard to bandwidth

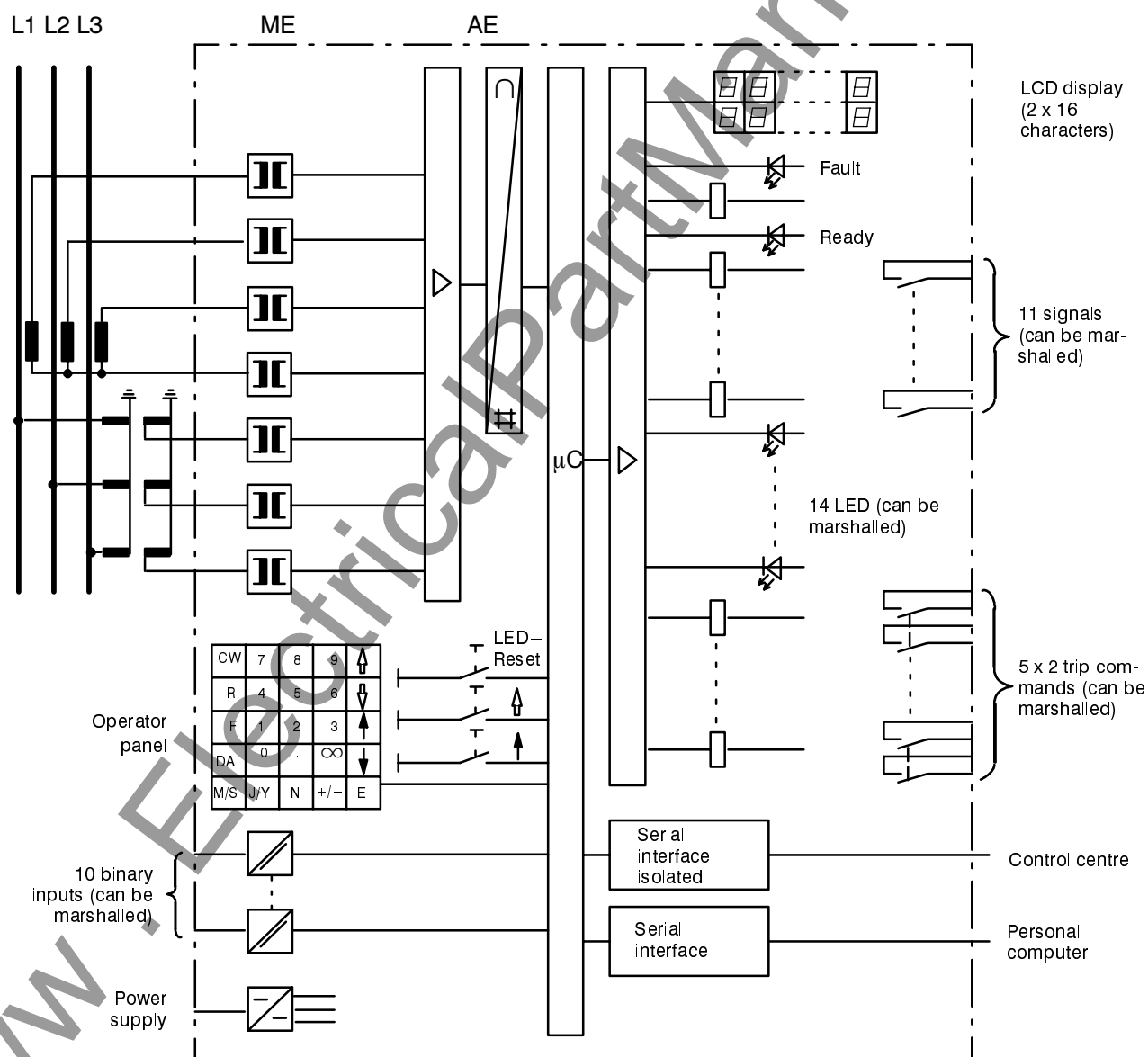


Figure 4.1 Hardware structure of distance protection relay 7SA511

and processing speed to suit the measured value processing. The matched analog values are then passed to the analog input section AE.

The analog input section AE contains input amplifiers, sample and hold elements for each input, analog-to-digital converters and memory circuits for the data transfer to the microprocessor.

Apart from control and supervision of the measured values, the microprocessor processes the actual protective functions. These include in particular:

- Filtering and formation of the measured quantities,
- Continuous calculation of the values which are relevant for fault detection,
- Determination of the faulted phases in case of a fault,
- Scanning of limit values and time sequences,
- Controlling of signals and sequences for teleprotection, auto-reclosure, etc.,
- Decision about trip and close commands,
- Storage of instantaneous current and voltage values during a fault for analysis.

Binary inputs and outputs to and from the processor are channelled via the input/output elements. From these the processor 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 as well as visual indicators (LEDs) and an alphanumerical display on the front.

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 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 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 second serial interface (option), fault data can be transmitted to a central evaluation unit. During healthy operation, measured values can also be transmitted, e.g. load currents. This second interface is isolated and thus satisfies the requirements for external signals, i.e. isolation and interference suppression comply with the requirements according to IEC 60255 and VDE 0435, part 303.

Communication via this interface is alternatively possible by means of fibre optic links, provided this interface is accordingly ordered (refer Section 2.3 Ordering data).

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 input requires ± 15 V whereas the processor and its 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 d.c. 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 function 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 auxiliary functions.

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,
- Selection of the measured values,
- Release of impedance calculation and directional identification,
- Release of tripping command,
- Initiation of auxiliary functions,
- Indication/output of the faulty conductor(s).

The distance protection relay has a variety of fault detection functions from which the optimum can be chosen for the system under consideration (refer to Section 2.3 Ordering data).

The overcurrent fault detection operates with high short circuit currents. If there is no significant difference between normal operation (including overload) and short-circuit, in terms of the current which will flow – e.g. in networks with highly fluctuating system impedance or, where short circuit current limiting devices are installed – then under-impedance fault detection (voltage controlled current) or impedance fault detection must be used. With these options comprehensive facilities are possible to match to the network conditions and the user's philosophy.

4.2.1.1 Earth fault detection and processing

An important element for all fault detection methods is the detection of an earth fault since the determination of the faulty line loops (Section 4.2.2) essentially depends on whether it is an earth fault or not. The model 7SA511 is equipped with stabilized measurement of the earth current (with delay facility) as well as 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.

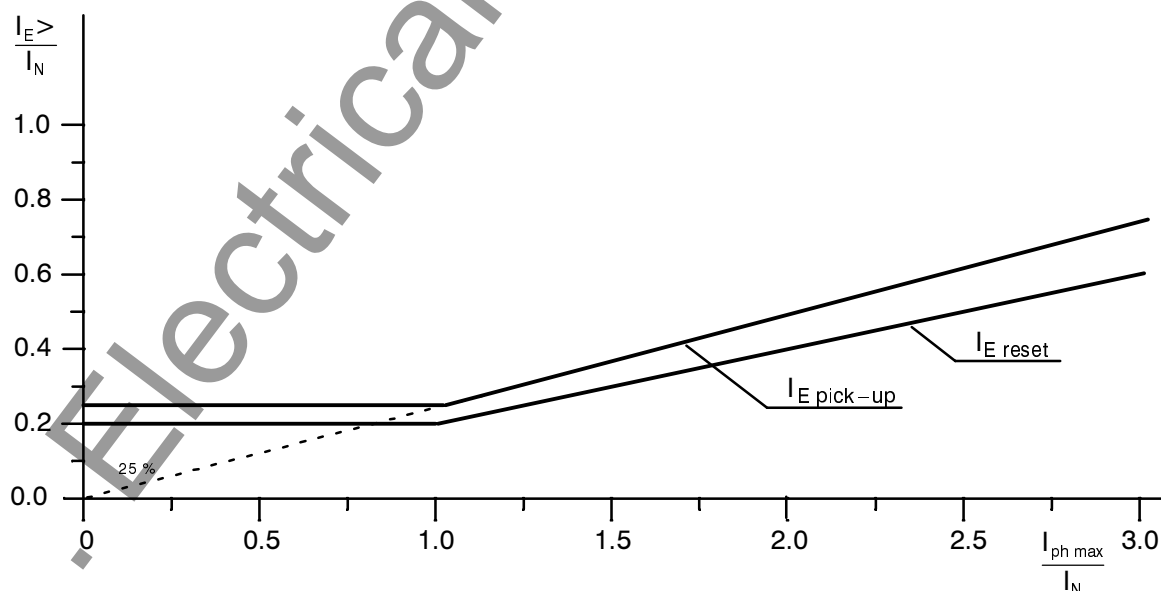


Figure 4.2 Earth current detector – pick-up/reset characteristic – example $I_E > / I_N$ set at 0.25

The earth current detector monitors the fundamental wave of the total of the phase currents ($I_E = 3 \cdot I_0$) in comparison with the threshold value. 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 0.25; the horizontal branch is shifted according different settings). The drop-off value is approx. 95 % of the pick-up value.

The displacement voltage detector monitors the fundamental wave of the displacement voltage ($U_E = \sqrt{3} \cdot U_0$) in comparison with the set threshold value. The drop-off value is approx. 95 % of the pick-up value.

In systems with an earthed starpoint (solidly earthed or low-resistance earthed), the pick-up of the earth current monitor as well as that of the displacement voltage monitor lead to pick-up of the earth fault detector. 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 adjust-

able delay time T_{IE} 1PHASE (address 1801); this is necessary so that the distance protection is still able to recognize a cross country double earth fault with one base point on a spur feeder. If, however, an earth fault is already present in the system, this is detected by the displacement voltage monitor; the delay is then not effective: an earth fault which now occurs in another phase can only be a double-phase earth fault.

4.2.1.2 Overcurrent fault detection

The overcurrent fault detection is a phase-dedicated fault detection procedure. Following numeric filtering, the currents in each phase are monitored in comparison with a set threshold value. A pick-up signal is output for that (those) phase(s) in which the set threshold has been exceeded.

To enable measured value selection (see Section 4.2.2), the phase-dedicated fault detection signals are converted into phase-loop information. This is carried out depending on the earth fault detection according Section 4.2.1.1 and – in earthed systems – on the parameter 1PH FAULTS (address 1705) according to Table 4.1. In non-earthed system, the phase-phase loop is always selected in the case of a single-phase fault detection without earth fault detection.

The faulty phases are annunciated. An earth fault is also annunciated if detected according to Section 4.2.1.1.

The overcurrent fault detector is reset when 95 % of the pick-up value is fallen below.

Fault detection module	Earth fault detection	Parameter 1PH FAULTS	Resultant loop	Annunciation
L1 L2 L3	no no no	<i>PHASE – PHASE</i>	L3 – L1 L1 – L2 L2 – L3	L1, L3 L1, L2 L2, L3
L1 L2 L3	no no no	<i>PHASE – EARTH</i> ¹⁾	L1 – E L2 – E L3 – E	L1 L2 L3
L1 L2 L3	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 overcurrent fault detection

4.2.1.3 Impedance fault detection (fix-impedance) (optional)

Impedance fault detection is a loop-dedicated fault detection procedure. Either the three phase-phase loops (without earth fault) or the three phase-earth loops (with earth fault) are monitored depending on the result of the earth fault detection (Section 4.2.1.1). A prerequisite for measurement of a loop impedance is that at least one of the assigned phase currents as well as the difference current decisive for the loop have exceeded an adjustable minimum value $I_{ph} >$.

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. 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 4.3. 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 4.3).

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 .

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

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 4.3.

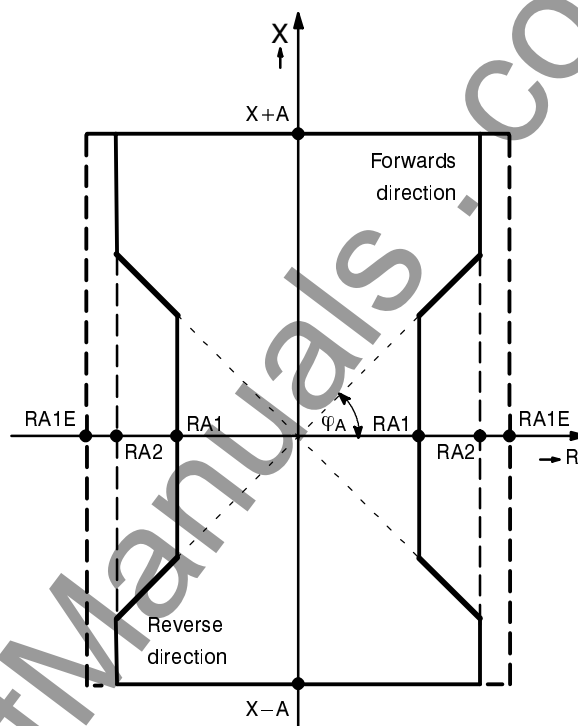


Figure 4.3 Impedance fault detection characteristics

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 the relay regards as valid all those loops whose impedance is not greater than 150 % of that smallest impedance. This avoids wrong pick-up signals which could be caused by the influence of the fault currents and voltages on the unfaulted line loops – especially in cases of small source impedances.

The impedance fault detection for phase-earth is supplemented by an overcurrent stage $I_{ph} >$ where pick-up of the overcurrent stage only leads to detection if the associated impedance loop has been eliminated as described in the previous paragraph. 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. Since the overcurrent stage can only re-establish eliminated loops for pick-up, erroneous fault detection as a result of an overcurrent is prevented at the same time if the short-circuit currents in the fault-free phases can exceed the set overcurrent value on non-earthed feeding transformers or earthed consumer transformers.

It is additionally possible to use the impedance fault detection just only for earth faults. In this case, the phase-earth measurement is enabled by means of the earth fault detection, it is not effective for phase-phase faults. Overcurrent detection is effective instead in this case. This detection program is of advantage in systems with limiters for earth currents (earthed at low impedance, so-called resistance earthing) where a short-circuit current sufficient for the overcurrent stage flows for phase-phase faults but not for phase-earth faults. Earth-free faults are thus detected by the overcurrent stage $I_{ph} >$.

4.2.1.4 Voltage controlled fault detection (Under-impedance fault detection) (optional)

The voltage controlled fault detection is a phase-dedicated fault detection procedure which also takes into consideration loop information. Decisive is the exceeding of phase currents, where the pick-up value depends on the magnitude of the loop voltages.

The basic characteristic can be gathered from the current/voltage characteristic shown in Figure 4.4. 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 effective whose slope is 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. The bold dots in Figure 4.4 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.

The device has three such fault detection modules, each of which is controlled by the phase-earth voltages or the phase-phase voltages. 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 6.3.4.5.

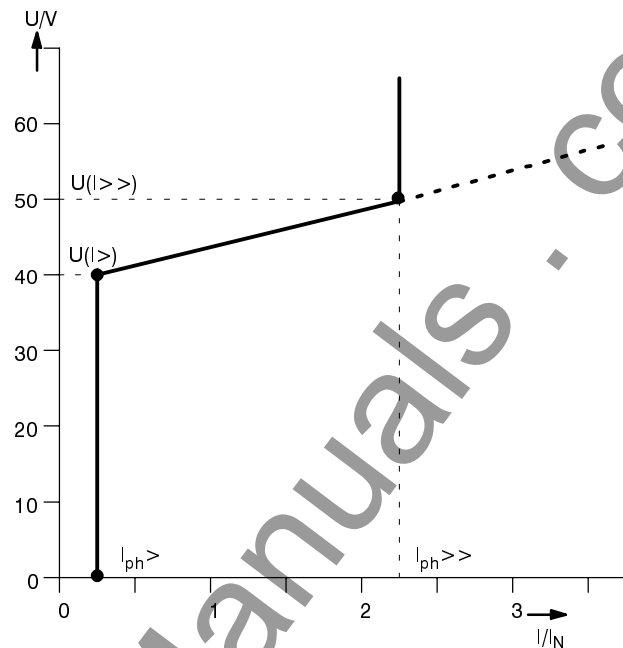


Figure 4.4 Voltage controlled fault detectors, U/I characteristic

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. Table 4.2 shows the assignment of the phase currents, loop voltages and output results with single-phase pick-up if control with phase-earth voltages is selected.

The measured line loop depends on the earth fault detection according to Section 4.2.1.1 and – in earthed systems – on the parameter 1PH FAULTS (address 1705) according to Table 4.2. In non-earthed systems, the phase-phase loop is always selected in the case of single-phase pick-up without earth fault detection.

The detected phase(s) are annunciated. 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-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 4.2 Line loops and phase annunciations with single-phase voltage controlled fault detection phase-earth

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. Table 4.3 shows the assignment of the phase currents, loop voltages and output results in the case of pick-up of only one fault detection module if control with phase-phase voltages is selected.

The measured line loop in this case is independent of the earth fault detection, and this method is therefore not suitable for earthed systems.

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 4.3 Line loops and phase annunciations with single-phase voltage controlled fault detection phase-phase

If the possibility of making the voltage loops dependent on the earth fault detection is used, the high sensitivity for phase-earth faults then also applies to phase-phase faults. This possibility is, in principle, independent of the treatment of the system star-

point; it assumes, however, that the earth fault criteria according to Section 4.2.1.1 have been satisfied safely for all earth faults. Table 4.4 applies to the fault detection program phase-earth or phase-phase voltages with single-phase pick-up.

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 4.4 Line loops and phase annunciations with single-phase voltage controlled fault detection, voltages phase-earth with earth fault, voltages phase-phase without earth fault

It is finally also possible to only control with the voltage loops U_{Ph-E} when an earth fault has been detected. Detection for phase-phase faults then only takes place with high-set overcurrent $I >>$. This is advantageous in systems with a low-impedance earthed starpoint, i.e. with earth fault limiting aids (so-called resistance earthing). In these cases only earth faults are to be detected by the voltage con-

trolled fault detection. It is usually even undesirable that phase-phase short-circuits lead to under-impedance fault detection.

The measured loop is independent of the parameter 1PH FAULTS. Table 4.5 shows the assignment of the phase currents, loop voltages and output results.

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	yes yes yes	irrelevant	L1–E L2–E L3–E	L1, E L2, E L3, E
L1 L2 L3	L1 L2 L3	L1–E L2–E L3–E	no no no	irrelevant	no pick-up and no annunciation by $U_{Ph-E} < /I >$	

Table 4.5 Line loops and phase annunciations with single-phase voltage controlled fault detection phase-earth, with earth fault detection only; without earth fault, overcurrent fault detection $I >>$ must pick up

4.2.2 Determination of the faulted loop

For calculation of the distance to fault, the currents and voltages of the faulty loop are decisive. The phase selective fault detector determines the faulted loop and releases the corresponding measurement values for impedance calculation.

For calculation of a phase-phase loop, for example, for a two phase short circuit L1–L2 (Figure 4.5) the following identity applies:

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

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

The line impedance is thus

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

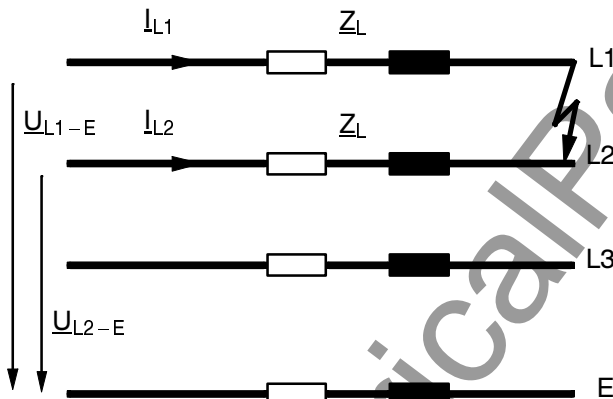


Figure 4.5 Phase-phase short circuit loop

For the calculation of a phase-earth loop, for example, for a short circuit L3–E (Figure 4.6) 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

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

whereby the factor $\frac{Z_E}{Z_L}$ is dependent only upon the line constants and not upon the distance to fault.

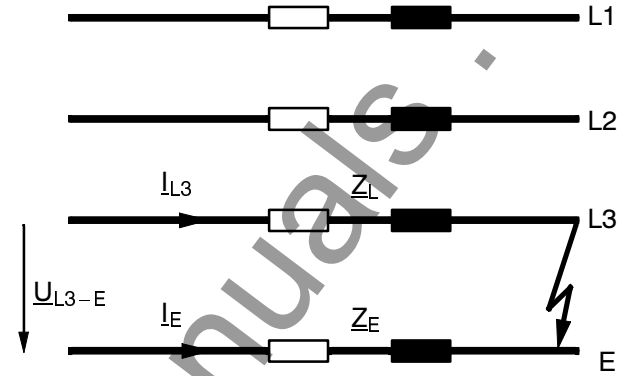


Figure 4.6 Phase-earth short circuit loop

Fault loop selection is such that for each type of fault the correct measured values are used for the calculation. For multiple faults (whereby more than two phases or earth are involved), one of the possible fault loops will be given preference.

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 starpoint has to be known before the device is put into operation (see Section 6.3.3.1).

4.2.2.1 Loop determination for solidly 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. If all power transformers feeding towards the short circuit are earthed, then the earth fault element will respond (4.2.1.1). The earth fault element is therefore used as an additional criterion for earth faults.

With double earth faults, pick-up normally occurs in two phases and earth (with overcurrent detection) or for two phase-earth loops (impedance detection). In this case it is possible to set the relay so that only the phase-phase loop (parameter PHPHE FLTS = PHASE-PHASE ONLY) or the loop of the leading phase to earth (PHPHE FLTS = LEADING PH-E) or

the loop of the lagging phase to earth (PHPHE FLTS = *LAGGING PH-E*) will be selected.

Tables 4.6 and 4.7 show the measurement quantities which will be selected for distance measurement in earthed networks.

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 transform-

ers shall be connected to the I_E current path of the relay. If the I_E current path of the relay is fed from the star point lead of the current transformer set of a parallel line (for parallel line compensation of the fault locator, if this option is available), 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 phases	Selected loop	Selected setting parameter
L1, E L2, E L3, E	L1-E L2-E L3-E	irrelevant
L1, L2 L2, L3 L1, L3	L1-L2 L2-L3 L3-L1	irrelevant
L1, L2, E L2, L3, E L1, L3, E	L1-L2 L2-L3 L3-L1	PHPHE FLTS = <i>PHASE-PHASE ONLY</i>
L1, L2, E L2, L3, E L1, L3, E	L1-E L2-E L3-E	PHPHE FLTS = <i>LEADING PH-E</i>
L1, L2, E L2, L3, E L1, L3, E	L2-E L3-E L1-E	PHPHE FLTS = <i>LAGGING PH-E</i>
L1, L2, L3, E L1, L2, L3, E	L3-L1 L3-E	3PH FAULTS = <i>E/F CONTROL</i>
L1, L2, L3, E L1, L2, L3, E	L3-L1 L3-L1	3PH FAULTS = <i>PHASE-PHASE ONLY</i>
L1, L2, L3, E L1, L2, L3, E	L3-E L3-E	3PH FAULTS = <i>PHASE-EARTH ONLY</i>

Table 4.6 Selected measurement quantities in **earthed** systems, with **overcurrent** or under-impedance fault detection

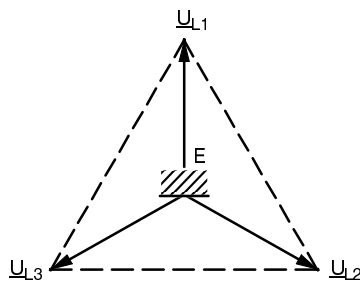
Fault detection phase loops	Selected loop	Selected setting parameter
L1-E L2-E L3-E	L1-E L2-E L3-E	irrelevant
L1-L2 L2-L3 L3-L1	L1-L2 L2-L3 L3-L1	irrelevant
L1-E, L2-E L2-E, L3-E L1-E, L3-E	L1-L2 L2-L3 L3-L1	PHPHE FLTS = <i>PHASE-PHASE ONLY</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E	L1-E L2-E L3-E	PHPHE FLTS = <i>LEADING PH-E</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E	L2-E L3-E L1-E	PHPHE FLTS = <i>LAGGING PH-E</i>
L1-L2, L2-L3, L2-L3, L3-L1, L3-L1, L1-L2,	L1-L2 L2-L3 L3-L1	irrelevant
L1-E, L2-E, L3-E L1-L2, L2-L3, L3-L1	L3-E L3-L1	3PH FAULTS = <i>E/F CONTROL</i>
L1-E, L2-E, L3-E L1-L2, L2-L3, L3-L1	L3-L1 L3-L1	3PH FAULTS = <i>PHASE-PHASE ONLY</i>
L1-E, L2-E, L3-E L1-L2, L2-L3, L3-L1	L3-E L3-E	3PH FAULTS = <i>PHASE-EARTH ONLY</i>

Table 4.7 Selected measurement quantities in **earthed** systems, with **impedance** fault detection

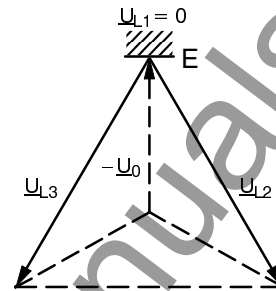
4.2.2.2 Loop determination for non-earthed systems

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 4.7). 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 7SA511 relay.



a) sound network, without earth fault



b) earth fault in phase L1

Fig. 4.7 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 can cause the earth current detector to pick up or, for the overcurrent element, in certain circumstances, even a phase current pick-up. 7SA511 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 the earth fault detection facility (see Section 4.8).

For unearthed networks, measuring quantities will be selected in accordance with Tables 4.8 and 4.9.

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 phases	Selected loop	Selected setting parameter
L1, E L2, E L3, E	L1–E L2–E L3–E	irrelevant
L1, L2 L2, L3 L1, L3	L1–L2 L2–L3 L3–L1	irrelevant
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L1–E L3–E L3–E L3–L1 L3–E	PHASE PREF = <i>L3(L1) ACYCLIC</i>
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L1–E L3–E L1–E L3–L1 L1–E	PHASE PREF = <i>L1(L3) ACYCLIC</i>
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L2–E L2–E L1–E L1–L2 L2–E	PHASE PREF = <i>L2(L1) ACYCLIC</i>
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L1–E L2–E L1–E L1–L2 L1–E	PHASE PREF = <i>L1(L2) ACYCLIC</i>
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L2–E L3–E L3–E L2–L3 L3–E	PHASE PREF = <i>L3(L2) ACYCLIC</i>
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L2–E L2–E L3–E L2–L3 L2–E	PHASE PREF = <i>L2(L3) ACYCLIC</i>
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L1–E L2–E L3–E L3–L1 L3–E	PHASE PREF = <i>L3(L1) CYCLIC</i>
L1, L2, E L2, L3, E L1, L3, E L1, L2, L3 L1, L2, L3, E	L2–E L3–E L1–E L3–L1 L1–E	PHASE PREF = <i>L1(L3) CYCLIC</i>

Table 4.8 Selected measurement quantities in **non-earthed** systems, with **overcurrent** fault detection or **underimpedance** fault detection

Fault detection phase loops	Selected loop	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-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L1-E L3-E L3-E L3-E L2-L3 L3-L1 L3-L1 L3-L1	PHASE PREF = <i>L3(L1) ACYCLIC</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E L1-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L1-E L3-E L1-E L1-E L1-L2 L3-L1 L3-L1 L3-L1	PHASE PREF = <i>L1(L3) ACYCLIC</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E L1-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L2-E L2-E L1-E L2-E L1-L2 L2-L3 L1-L2 L1-L2	PHASE PREF = <i>L2(L1) ACYCLIC</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E L1-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L1-E L2-E L1-E L1-E L1-L2 L3-L1 L1-L2 L1-L2	PHASE PREF = <i>L1(L2) ACYCLIC</i>
L1-E, L2-E L2-E, L3-E L1-E, L3-E L1-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L2-E L3-E L3-E L3-E L2-L3 L2-L3 L3-L1 L2-L3	PHASE PREF = <i>L3(L2) ACYCLIC</i>

continued next page

Fault detection phase loops	Selected loop	Selected setting parameter
L1-E, L2-E L2-E, L3-E L1-E, L3-E L1-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L2-E L2-E L3-E L2-E L2-L3 L2-L3 L1-L2 L2-L3	PHASE PREF = L2(L3) ACYCLIC
L1-E, L2-E L2-E, L3-E L1-E, L3-E L1-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L1-E L2-E L3-E L3-E L2-L3 L2-L3 L3-L1 L3-L1	PHASE PREF = L3(L1) CYCLIC
L1-E, L2-E L2-E, L3-E L1-E, L3-E L1-E, L2-E, L3-E L1-L2, L2-L3 L2-L3, L3-L1 L3-L1, L1-L2 L1-L2, L2-L3, L3-L1	L2-E L3-E L1-E L1-E L1-L2 L3-L1 L3-L1 L3-L1	PHASE PREF = L1(L3) CYCLIC

Table 4.9 Selected measurement quantities in **non-earthed** systems, with **impedance** fault detection

4.2.3 Fault impedance calculation

The relay calculates the resistance R and the reactance X of the fault loop separately, using the measured values determined by the selection described in Section 4.2.2. As long as a fault detector has picked up, the calculation is effected continuously. The algorithm evaluates all the updated instantaneous values of current and voltage throughout at least the last half cycle. With difficult measurement conditions, e.g. very small measurement voltages or near the balanced point, the data window and thus the number of evaluated values is automatically increased.

The calculation is an integration of the line identity:

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

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.

For calculation of a phase-to-phase loop values conforming to the selection 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 4.5)

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

For calculation of a phase-to-earth loop (according to Figure 4.6)

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

R and L are the required impedance components.

The calculated reactance 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 4.8 and 4.9).

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 allows 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.

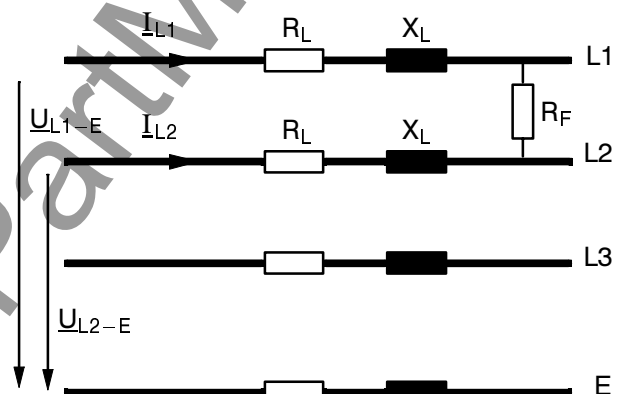


Figure 4.8 Phase-phase short circuit loop

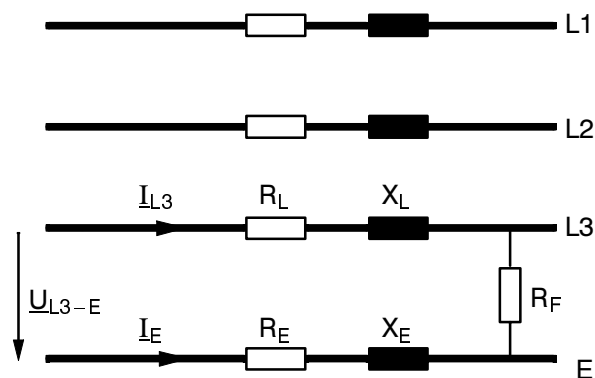


Figure 4.9 Phase-earth short circuit loop

4.2.4 Directional determination

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. It is thus ensured that the relay correctly determines the direction of all types of fault, even when the short-circuit voltage has collapsed. The depth of the stored voltage varies dependent on the measuring conditions. The stored voltage is only of importance, if the measuring-circuit voltage is not sufficient for a precise directional determination. Since the phase relationship of the stored voltages is frequency dependant, the frequency is measured and fed into the calculation.

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 4.10). This is considered in the calculation of the directional vector. Table 4.10 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 4.11. 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.

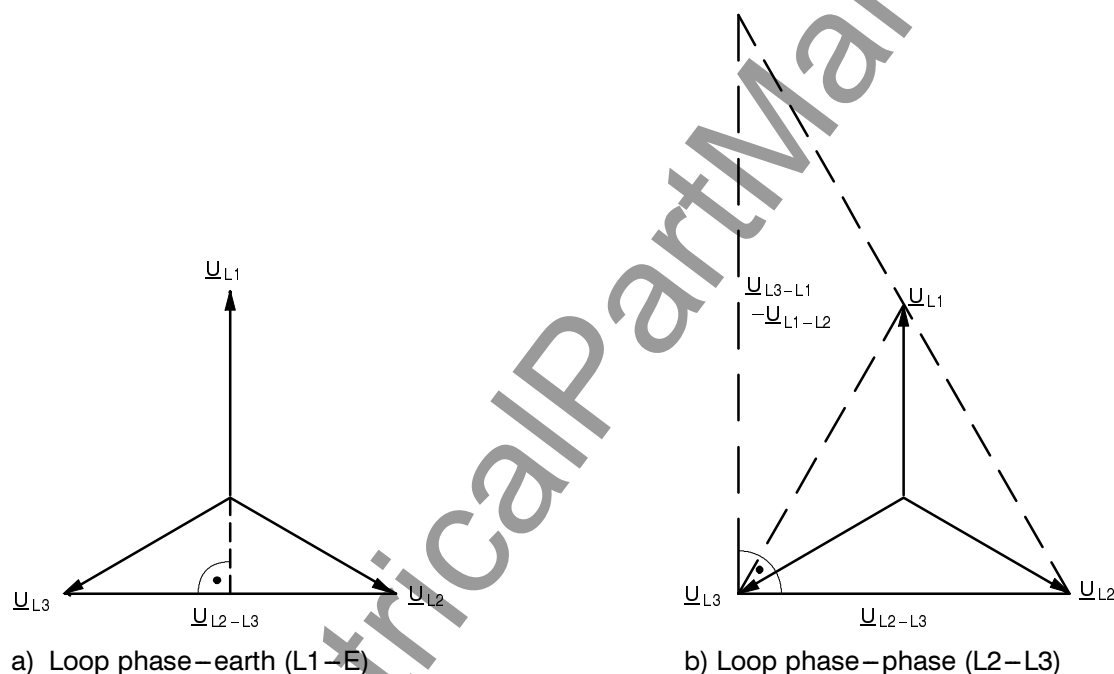


Figure 4.10 Reference voltages for directional determination

Faulted loop	Measuring current (distance/direction)	Measuring voltage (distance)	Measuring voltage (direction)
L1-E	$I_{L1} - k_E \cdot I_E$	U_{L1-E}	U_{L2-L3}
L2-E	$I_{L2} - k_E \cdot I_E$	U_{L2-E}	U_{L3-L1}
L3-E	$I_{L3} - k_E \cdot I_E$	U_{L3-E}	U_{L1-L2}
L1-L2	$I_{L1} - I_{L2}$	U_{L1-L2}	$U_{L2-L3} - U_{L3-L1}$
L2-L3	$I_{L2} - I_{L3}$	U_{L2-L3}	$U_{L3-L1} - U_{L1-L2}$
L3-L1	$I_{L3} - I_{L1}$	U_{L3-L1}	$U_{L1-L2} - U_{L2-L3}$

Note: $k_E = Z_E/Z_L$

Table 4.10 Measured values for distance calculation and directional determination

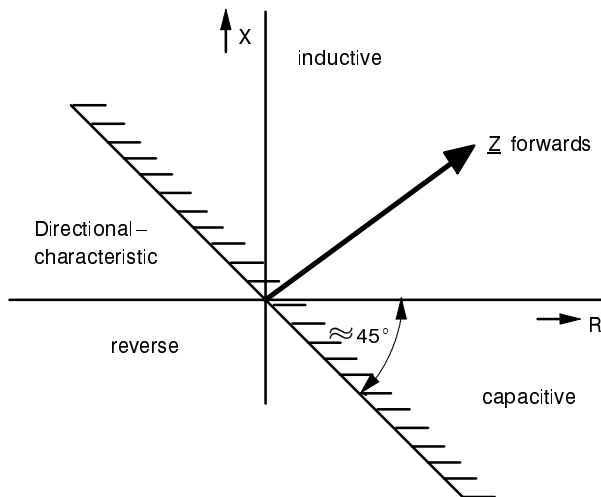


Figure 4.11 7SA511, directional characteristics

Figure 4.12 shows the directional characteristic, taking into consideration the source impedance, with-out load current. Since the unfaulted voltage equals the generator voltage and does not change after fault inception, the directional characteristic in the impedance diagram appears to be displaced by the source impedance. If the location of the fault is F1 (Figure 4.12a) 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 4.12b). When the current flows in the opposite direction, the directional characteristic changes immediately (Figure 4.12c). Then the reversed current, which is determined by the source impedance $Z_{S2} + Z_L$, flows through the measuring point (current transformer).

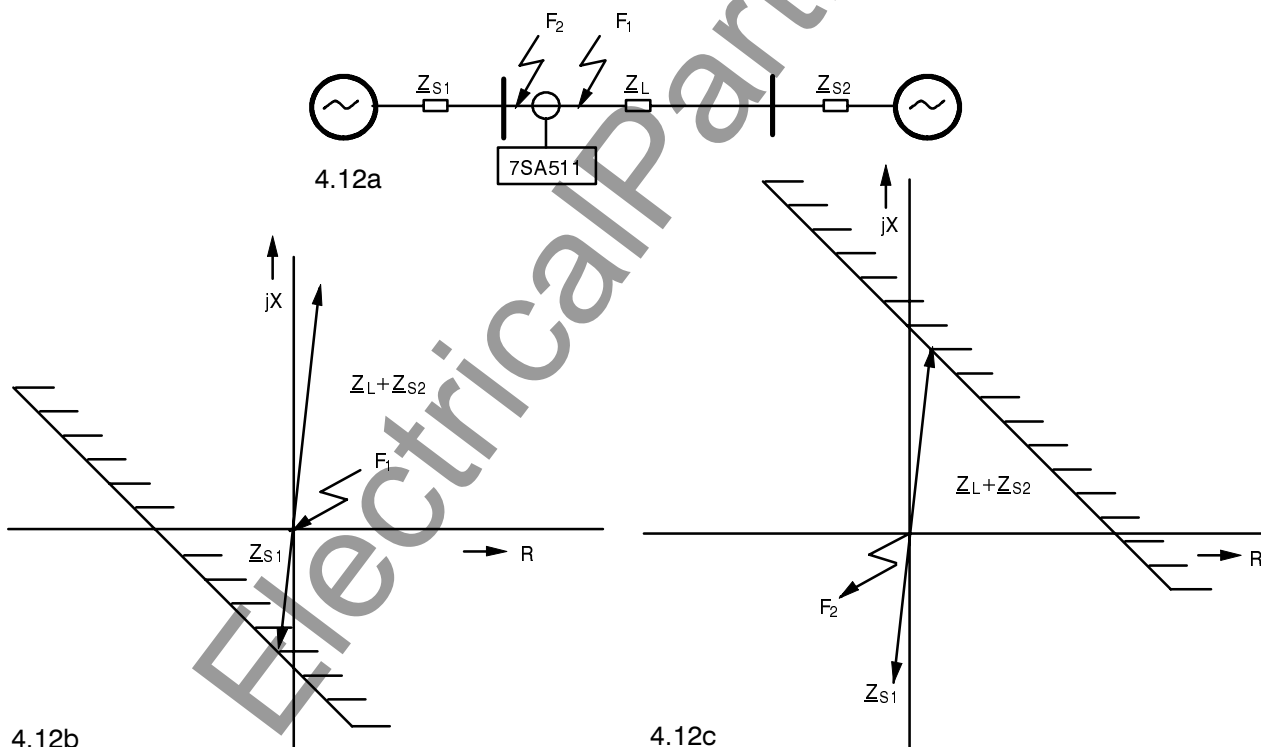
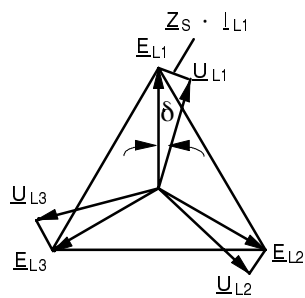


Figure 4.12 Directional characteristic with source impedance without load transport

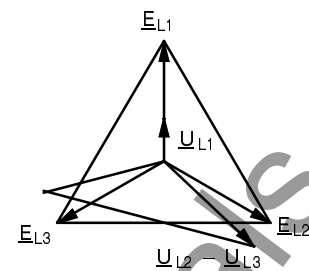
If load is carried by the line, then this results in a voltage drop at the source impedance (Figure 4.13a). Since, at the measuring point, the voltage U is measured, not generator voltage E , the directional characteristic suffers a rotation by the load angle δ (Fig-

ures 4.13b and 4.13c). Therefore, the directional characteristic has a safety distance from the limits of the first quadrant in the R - X -diagram (Figure 4.11).

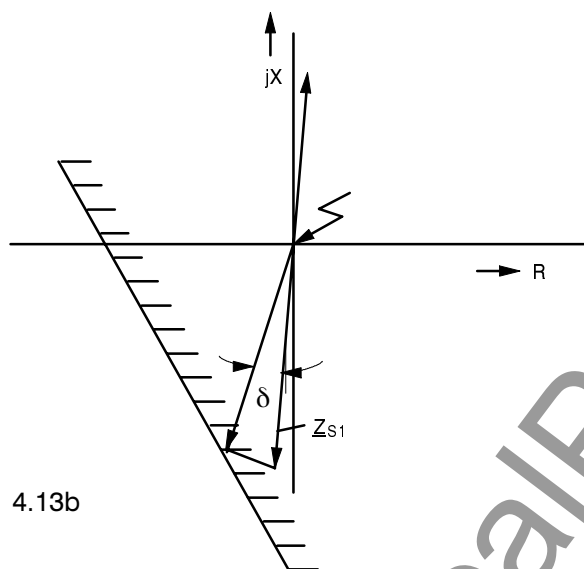


before fault inception

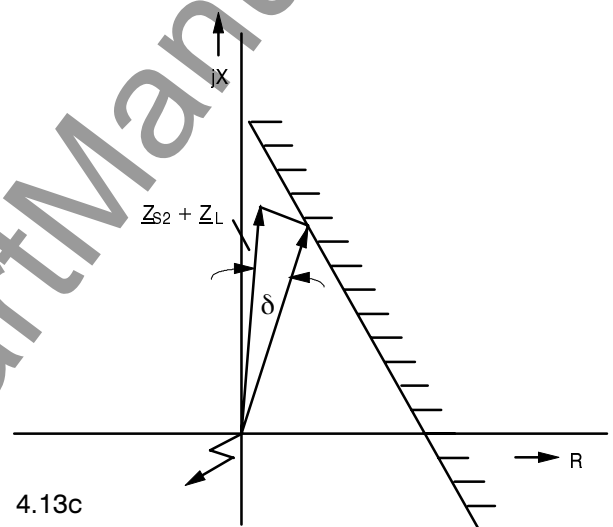
4.13a Voltage vector diagram for earth fault on loaded line



after fault inception



4.13b



4.13c

Figure 4.13 Directional characteristic with source impedance and load transport

4.2.5 Tripping characteristics

The tripping zones of the distance protection relay 7SA511 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 4.14 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
 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,
 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,
 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,
 T1B T1B = 0 or delayed, if required, separate time settings for single-phase and multi-phase faults.

- Overreach zone Z1L, activated by multi-shot AR (2nd and further cycles, so-called DAR) or controlled via binary input, with the setting parameters:

X1L Reactance = reach,
 R1L Resistance phase–phase,
 R1LE Resistance phase–earth,
 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 4.14 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 Section 4.2.1). For models with impedance fault detection (4.2.1.3), fault detection zone ZA is provided, as shown in Figure 4.3. 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.

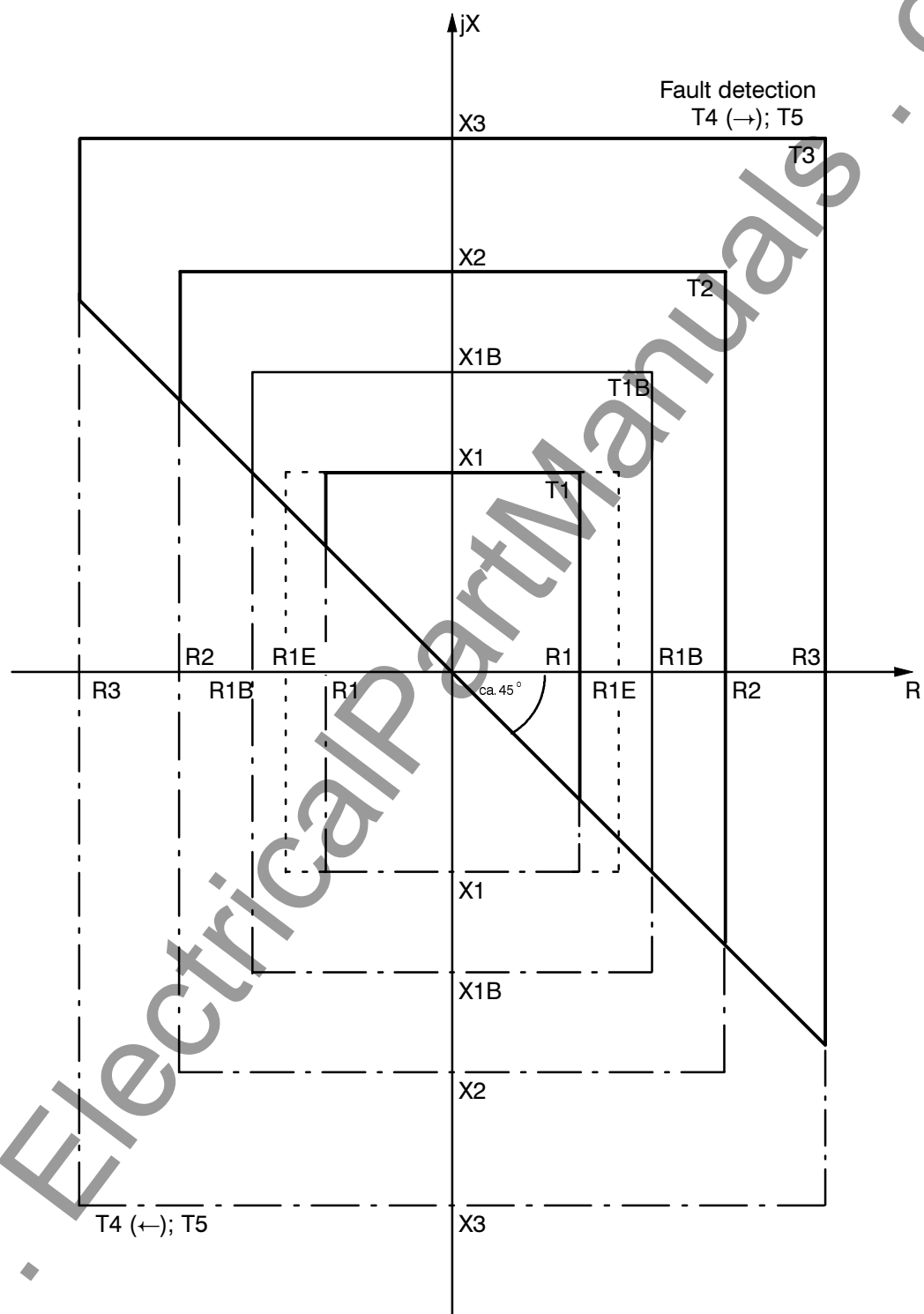


Figure 4.14 Tripping characteristics

4.2.6 Tripping logic

When the relay has detected a fault (see Section 4.2.1), the delay times are started. The impedance of the selected fault loop, 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 can equal zero, i.e. tripping occurs as soon as it has been confirmed that the fault lies within the zone. An automatic repetition of the measurement becomes effective near to the balanced point in order to prevent any transient overreach. This can lead to a slight increase in the reaction time.

In stages Z1 and 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 always result in three-pole clearance. 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 4.15 illustrates the block diagram of the tripping logic.

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

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 minimum current monitor $0.1 I_N$). Up to that point, the tripping circuit must be broken 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 distance protection will decide on “forwards” after connection of the line when the voltage signal is missing. 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 within an adjustable time (Figure 4.16). The fault is cleared either with pick-up of overreaching zone Z1B (directional), as illustrated in Figure 4.16 or pick-up of overreaching zone Z1B (non-directional), or pick-up of the fault detector (selectable) without delay.

The integrated switch-onto-fault logic of 7SA511 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 the switch-onto-fault protection shall not operate (e.g. external auto-reclose devices), the binary input “manual close” must be triggered by a separate auxiliary contact on the discrepancy switch.

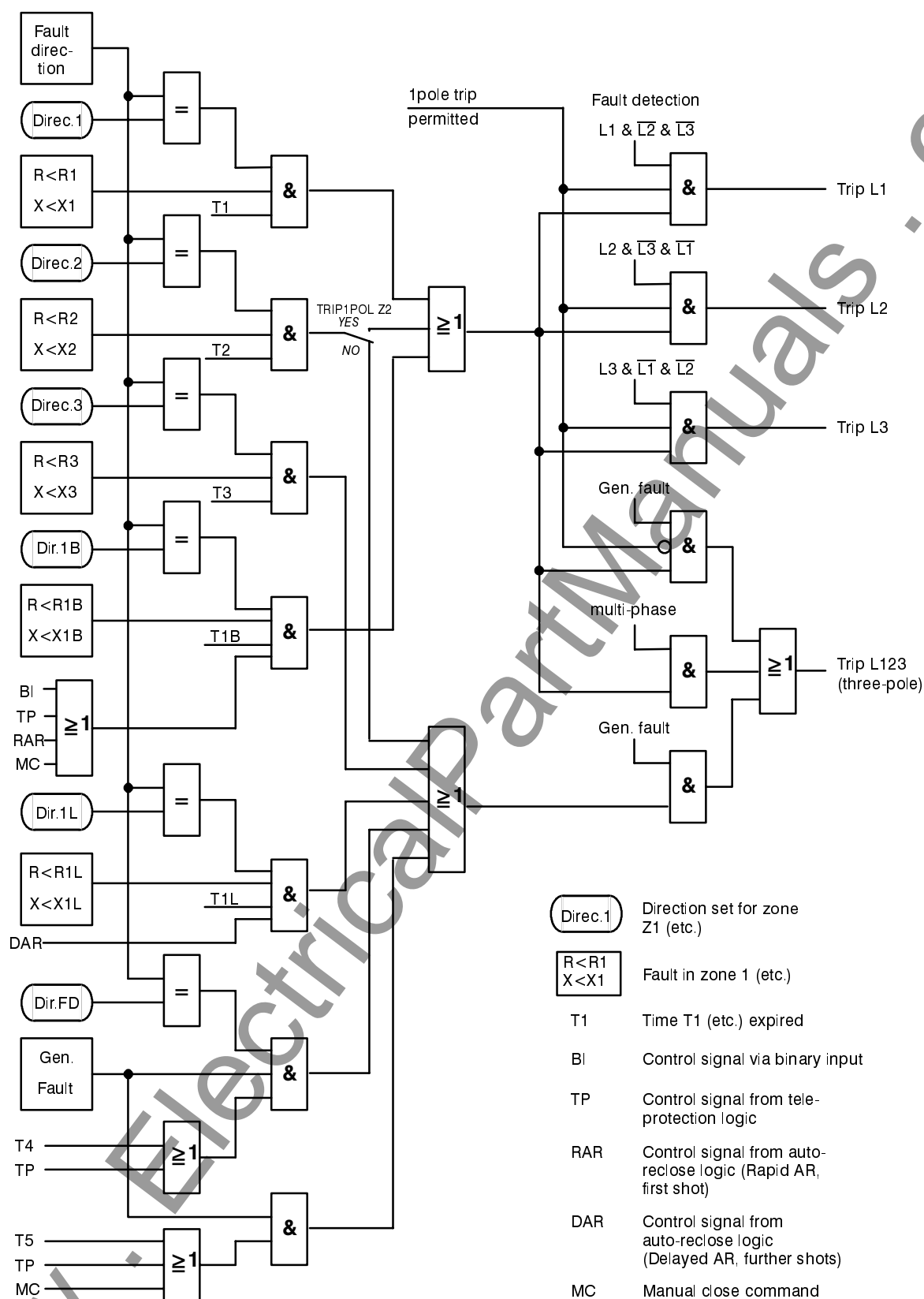


Figure 4.15 Schematic block diagram of the tripping logic of the distance protection

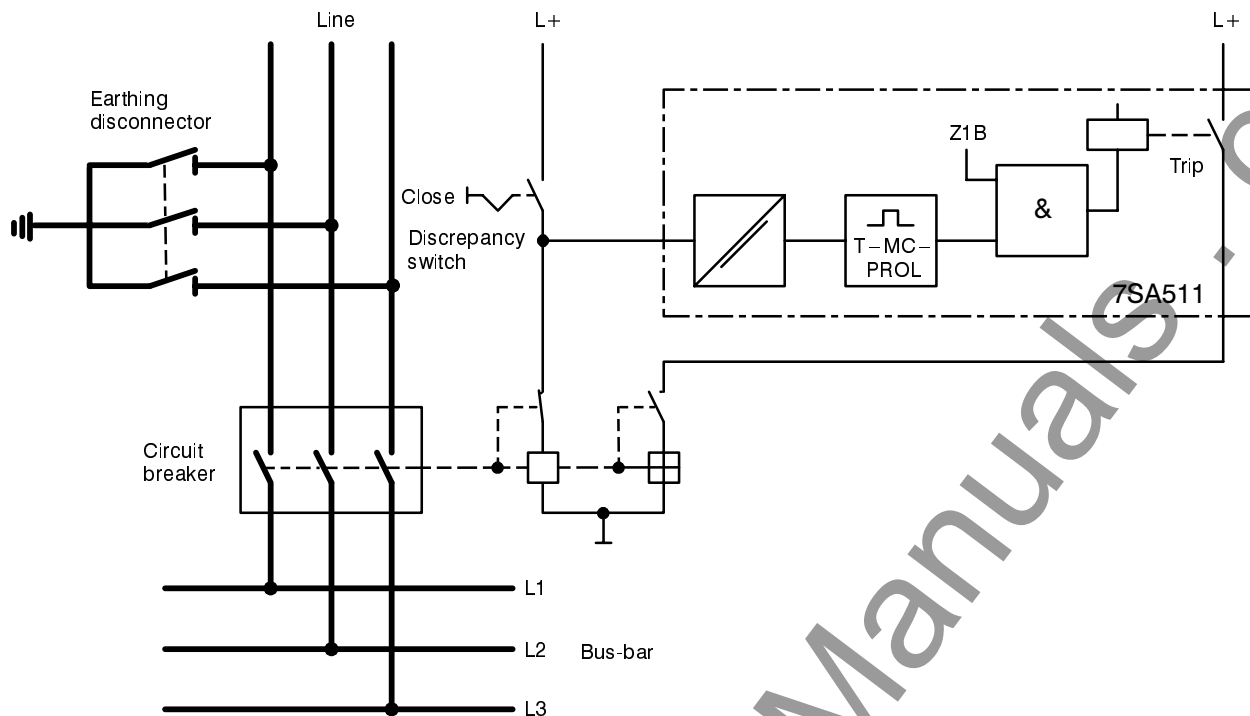


Figure 4.16 Functional diagram of the switch-onto-fault protection

4.2.8 Definite time overcurrent and emergency protection

7SA511 provides an overcurrent protection. This feature may, for example, be useful when, during first commissioning, voltage transformer output is not available.

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

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 (refer Section 4.14.4.3) or the signal "VT mcb tripped" is applied to an input relay.

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 types of overcurrent protection scheme.

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

For further details refer to Section 4.6.

4.3 Measures to be taken in the case of power swings (optional 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 4.17). 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.

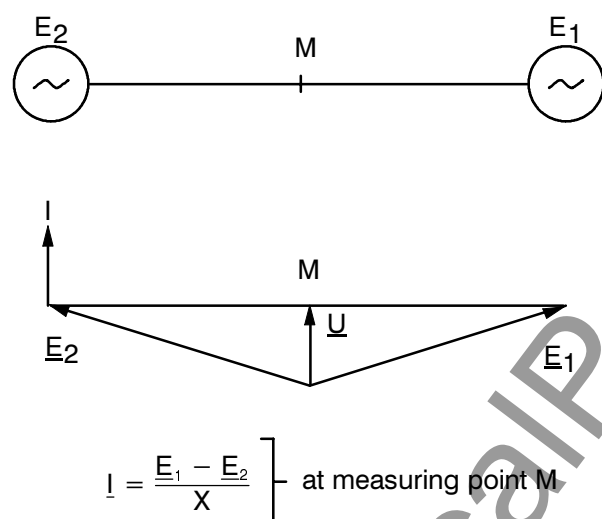


Figure 4.17 Power swing

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.

In models with impedance fault detector, the protection relay 7SA511 can be equipped with a powerful power swing supplementary function (dependent of the ordered model), 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).

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) or the three impedances phase-phase differ from each other by more than 25 %, power swings are not detected. 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. Because of the symmetry conditions, it is sufficient to limit the power swing detection to one loop ($L1-L2$). The measurement commences when the impedance vector moves into the power swing polygon PPOL (see Figure 4.18). 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.

If the rate of change of the impedance vector is smaller than a (selectable) value dR/dt , a power swing is recognized. The measuring time of the power swing detector is coordinated with the distance between power swing polygon PPOL and fault detection polygon APOL, so that the power swing is detected before the vector moves into the fault detection polygon.

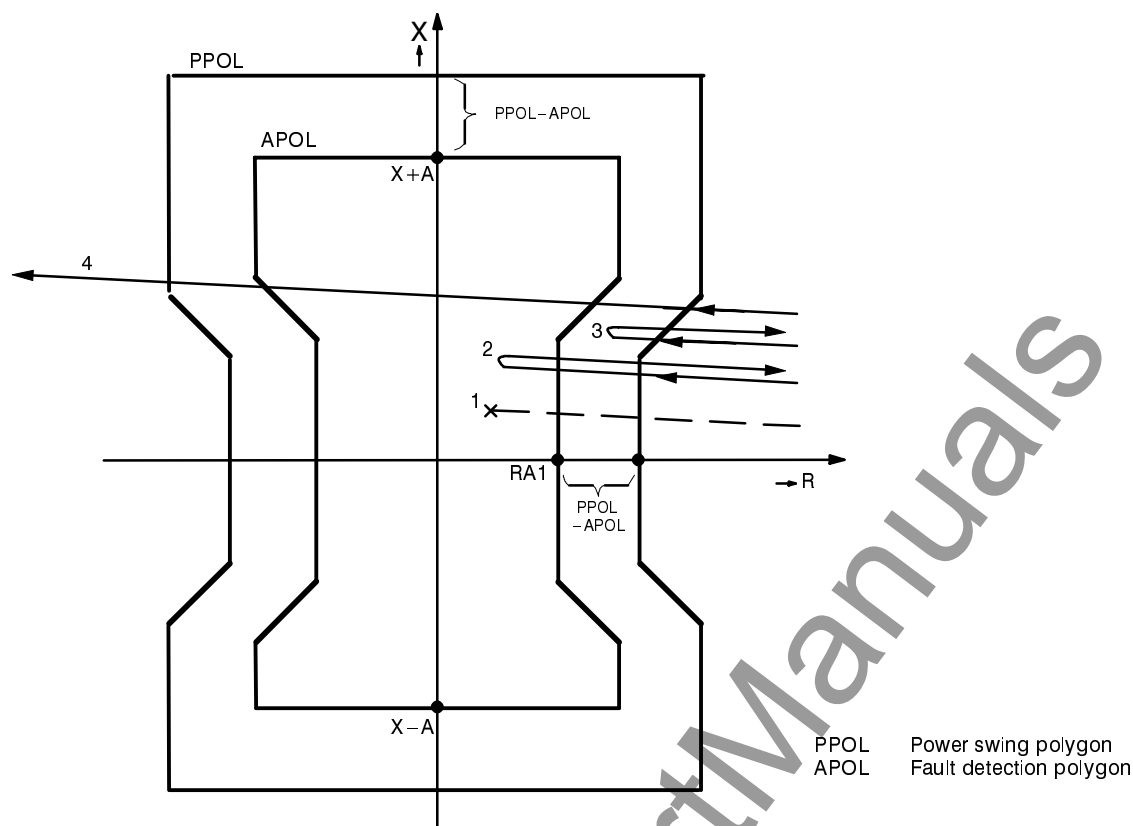


Figure 4.18 Pick-up characteristic for the detection of power swings

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 of the distance protection (Z1 and Z1B) cannot trip. Faults from the second stage onwards (T2 expired) are tripped after their delay time.
- Blocking of all stages but the first:
Only the first stage of the distance protection (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. The action time of the power swing blocking device can also be limited by a selectable time P/S T- Δ T.

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 4.18). The device issues a tripping command of adjustable duration. The out-of-step trip is announced. The impedance vector must have passed through the power swing polygon within an active time which is identical with P/S T- Δ T.

4.4 Universal teleprotection interface

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, 7SA511 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 modes (POTT).

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, as long as the relay at that end has picked up or has recognized a fault in its overreaching zone. 7SA511 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 in cable networks with short distances. 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. Alternatively, the signals can be transmitted via optical fibre connections.

If a fault occurs in the receiving device or on 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 7SA511, 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 4.19 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 4.20 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).

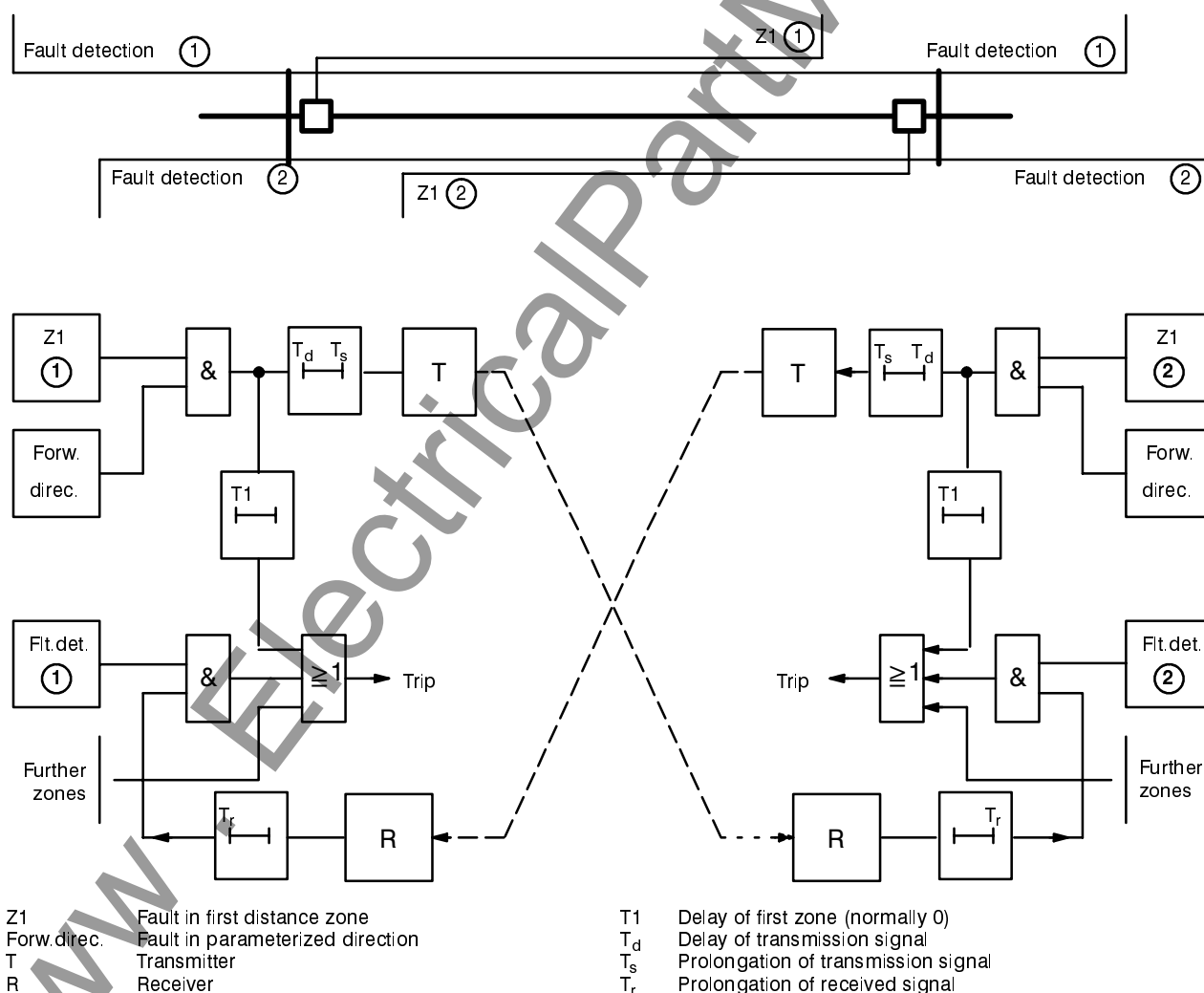


Figure 4.19 Permissive underreach transfer trip (FD acceleration) – block scheme

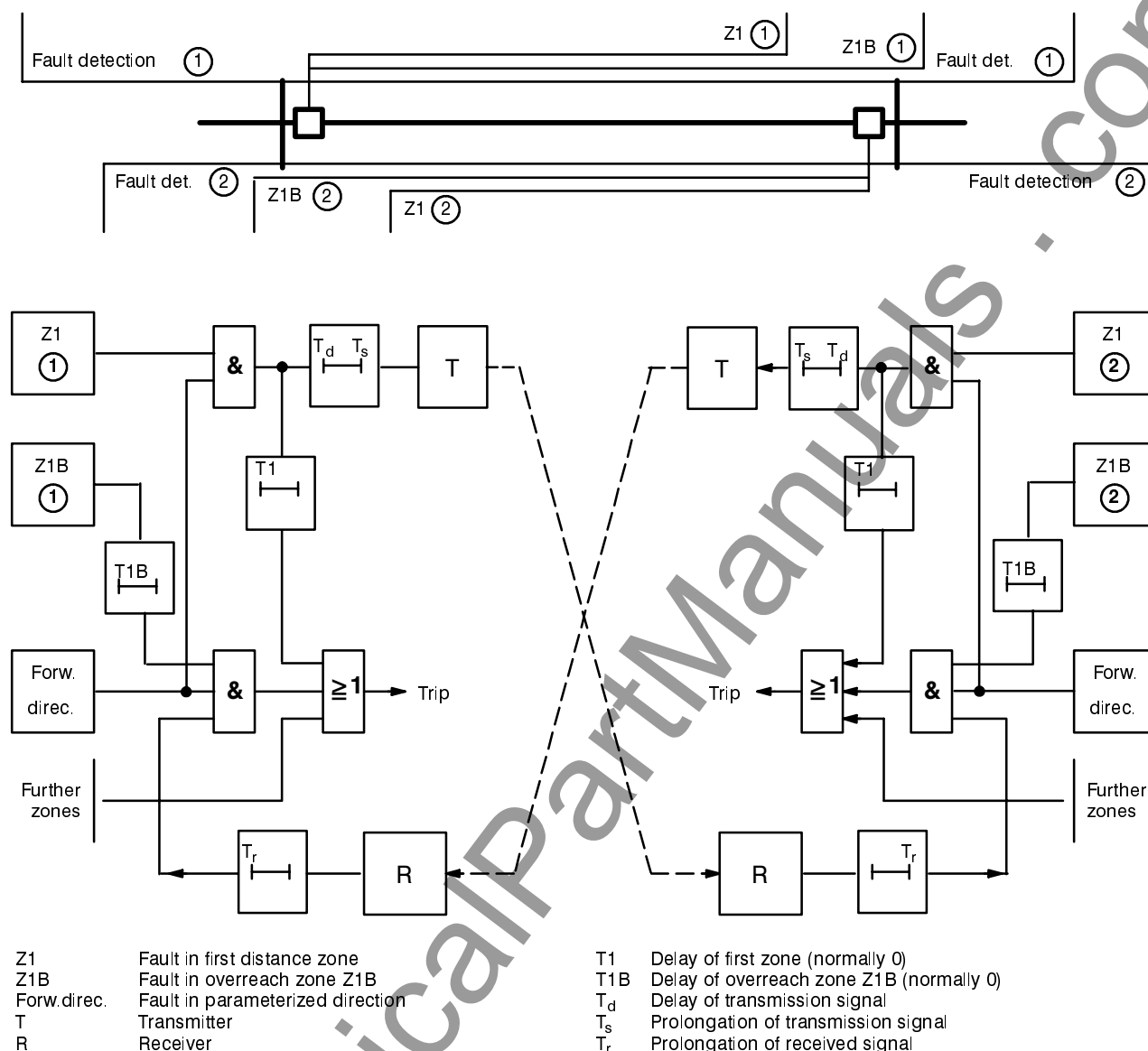


Figure 4.20 Zone acceleration Z1B – block scheme

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 4.21 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).

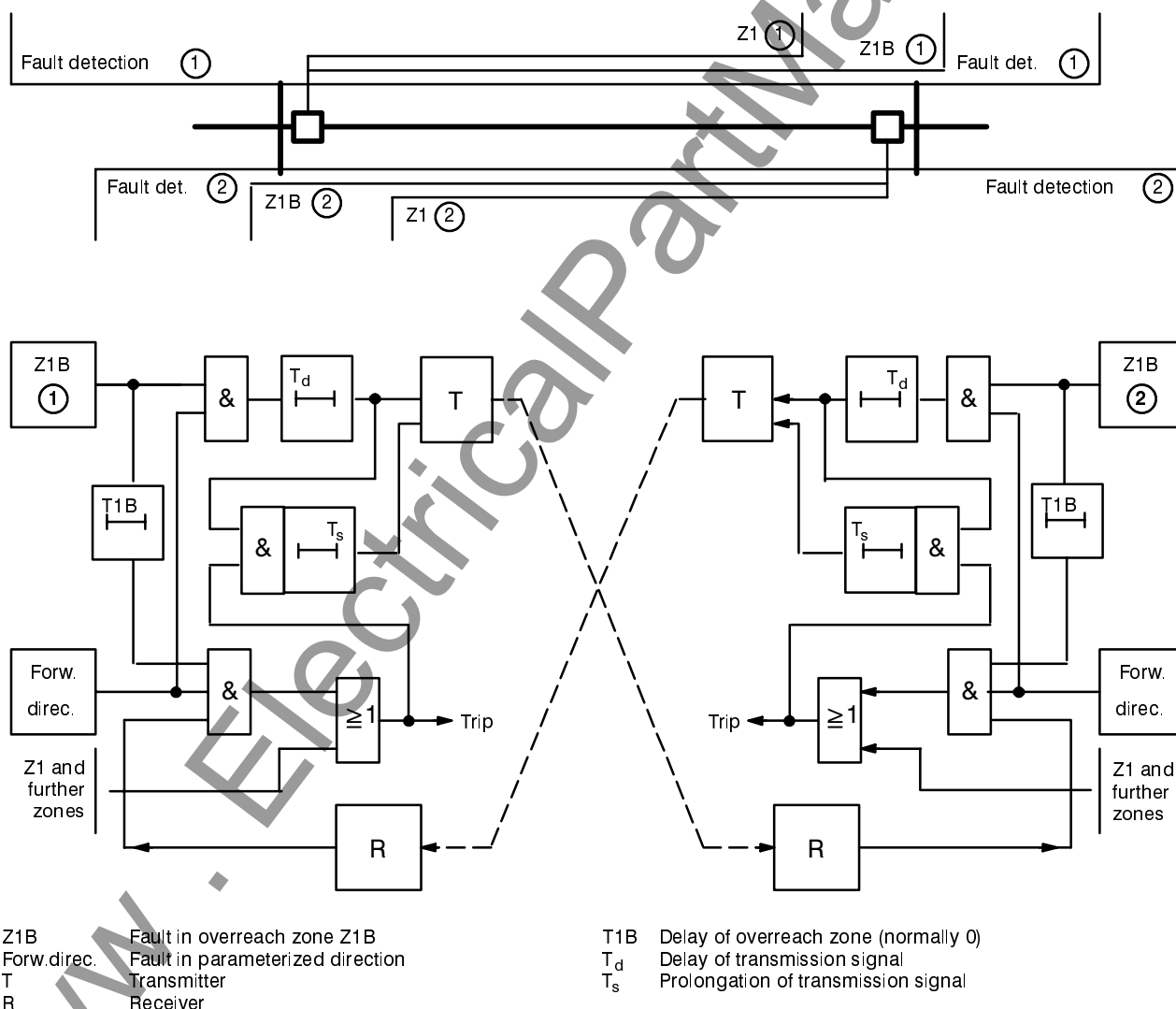


Figure 4.21 Permissive overreach transfer trip (release of Z1B) – block scheme

4.4.4 Directional comparison (fault detection zone release)

Directional comparison also performs a transfer release function.

Figure 4.22 shows a simplified block scheme.

If the relay detects a fault in the line direction it sends (after a settable time t_d 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 also 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).

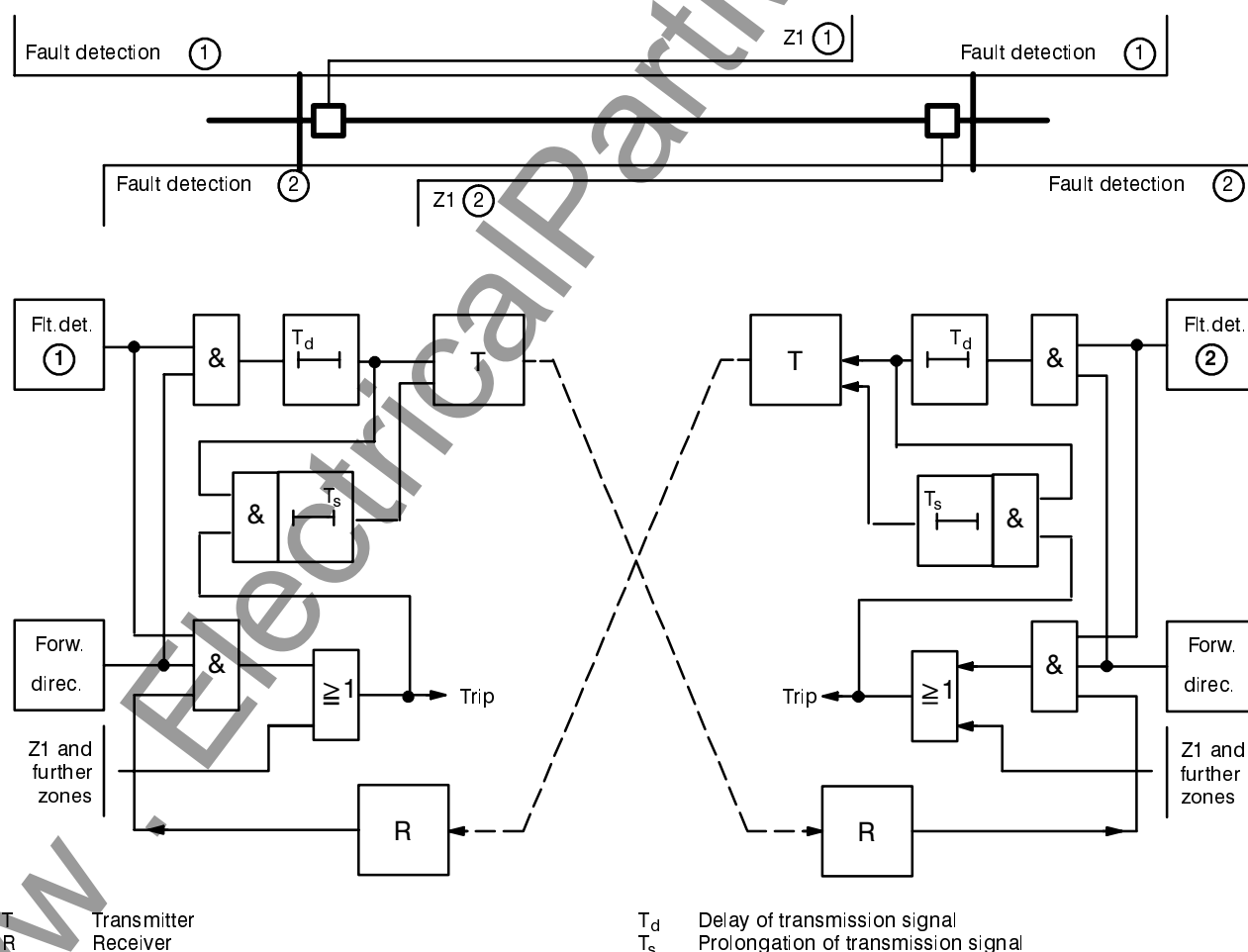


Figure 4.22 Directional comparison – block scheme

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.

Figure 4.23 shows a simplified block scheme of this function.

For signal transmission one requires two signal frequencies which are shifted over from the transmitter output in 7SA511. 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. 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 4.25.

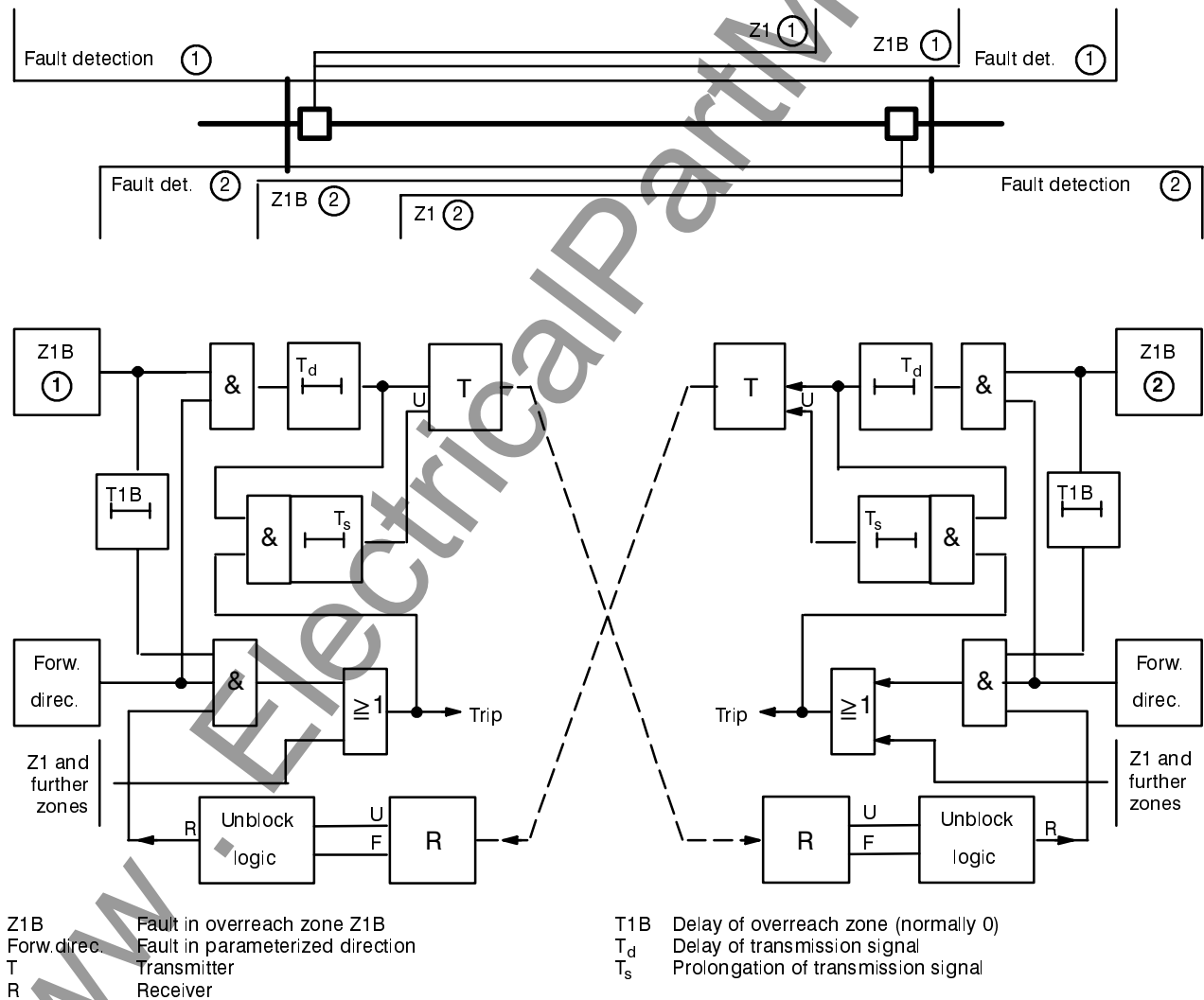


Figure 4.23 Unblocking mode with Z1B – block scheme

If the unblocking signal U is faultlessly received, then the release signal R is formed (in Figure 4.25 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 another 100 ms (reset delay of time stage 100/100 ms), that is, the upper release route in Figure 4.25 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. The overreach zone Z1B can then be initiated from the automatic reclosing system (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 4.26. Instead of the AND gate, an exclusive-OR gate can be incorporated. Standing transmission faults will be recognized by 7SA511 after approximately 10 s and annunciated.

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).

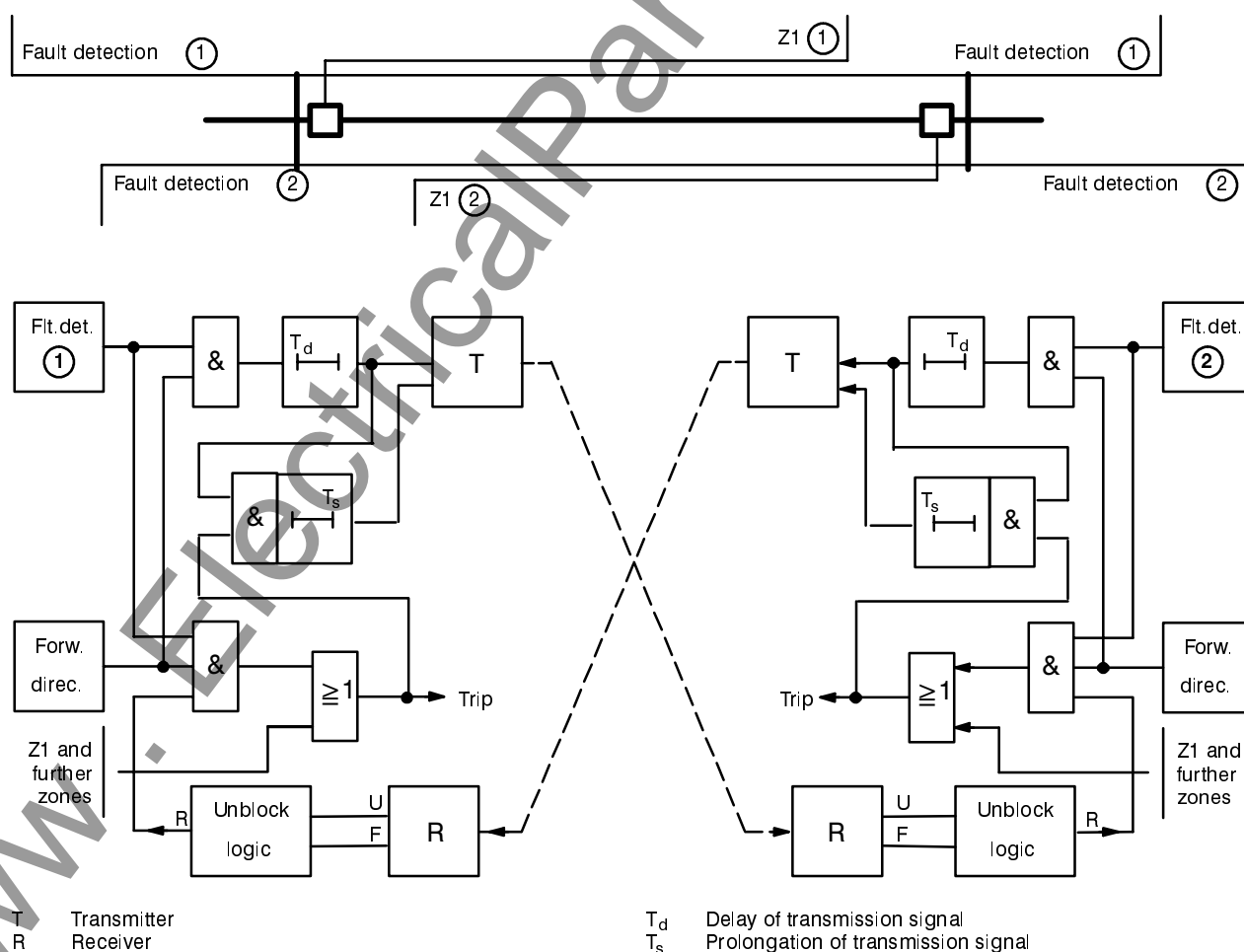


Figure 4.24 Directional comparison unblocking mode with fault detection – block scheme

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.

Figure 4.24 shows a simplified block scheme of this function.

For signal transmission one requires two signal frequencies which are shifted over from the transmitter output in 7SA511. 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). Under normal conditions or with a fault in the direction opposite to that set, the monitoring frequency f_0 is transmitted. 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 4.25.

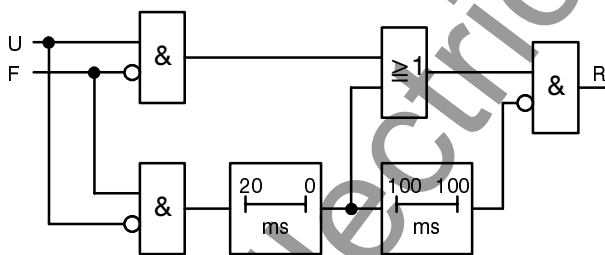


Figure 4.25 Unblocking Logic

If the unblocking signal U is faultlessly received, then the release signal R is formed (in Figure 4.25 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 another 100 ms (reset delay of time stage 100/100 ms), that is, the upper release route in Figure 4.25 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 4.26. Instead of the AND gate, an exclusive OR gate can be incorporated. Standing transmission faults will be recognized by 7SA511 after approximately 10 s and annunciated.

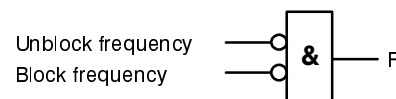


Figure 4.26 Producing the fault signal F

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 when the relay detects a fault in the reverse direction.

Figure 4.27 shows a simplified 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 with time T1B.

Equally, to avoid competition, a dispatched signal will be lengthened by the adjustable time T-SEND-PRL (T_s in Figure 4.27). Also the receive signal will be lengthened by the transient blocking time T-TRANSBLO (TB in Figure 4.27) provided it has been received for the waiting time (TW). 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. Also 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.

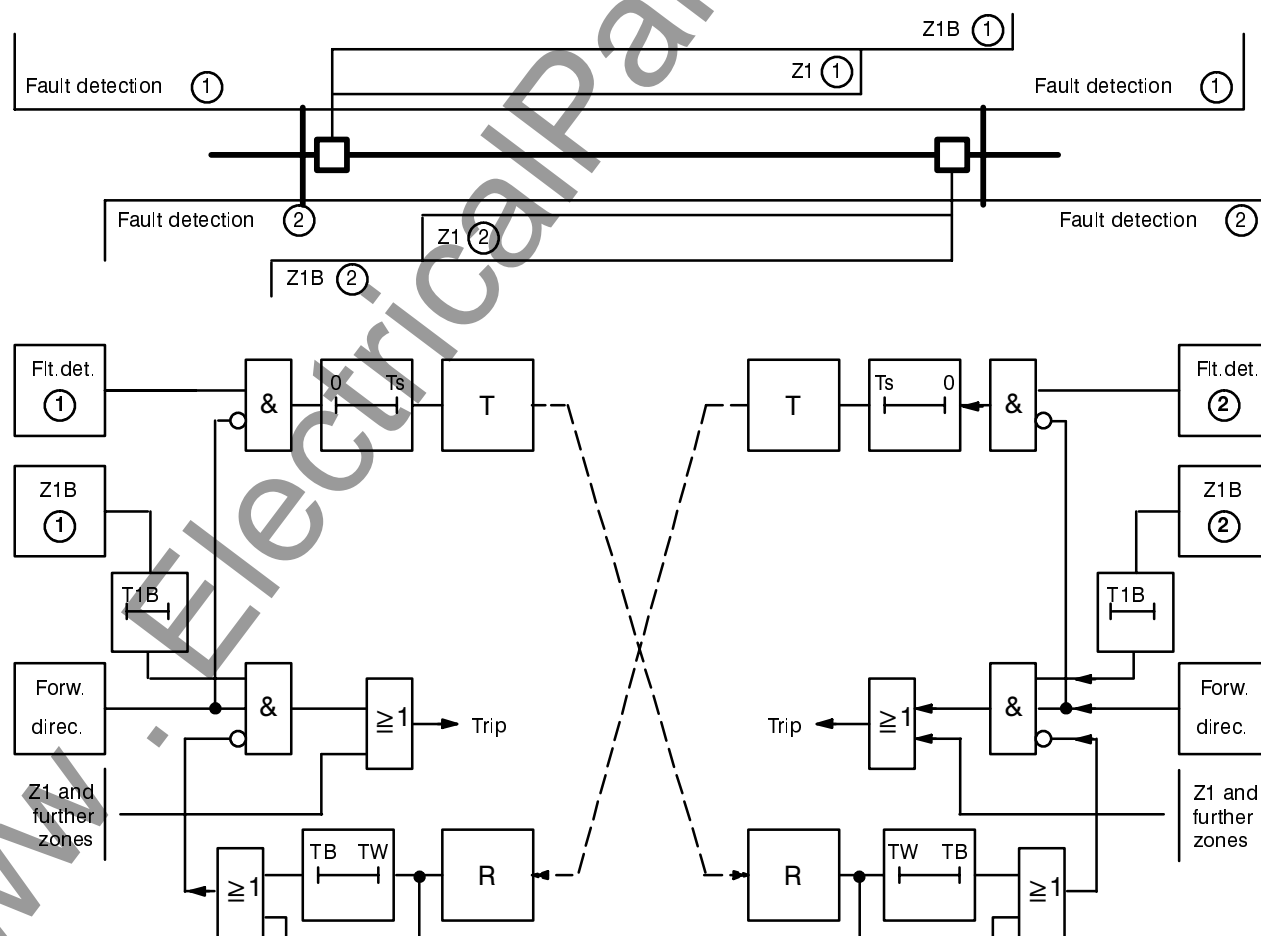


Figure 4.27 Blocking mode – block scheme

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 4.28). 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 4.28).

Distance protection pick-up at either line end will interrupt the wire loop via the send signal and 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 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. 7SA511 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 7SA511 is **not** used, because a pilot wire fault will be recognized within the relay itself.

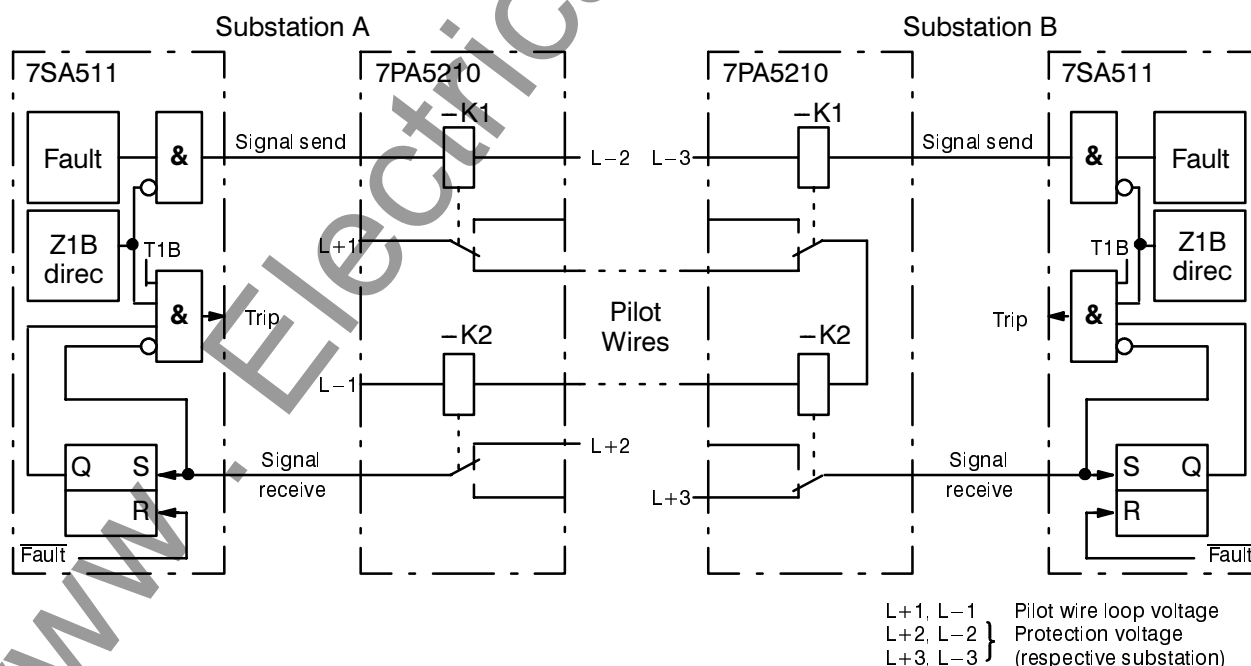


Figure 4.28 Overreaching zone comparison via pilot wires – schematic diagram

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 4.29. 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 4.29, 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 4.29) 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 T-TRANSBLO (TB in Figure 4.29) under reverse interlock conditions.

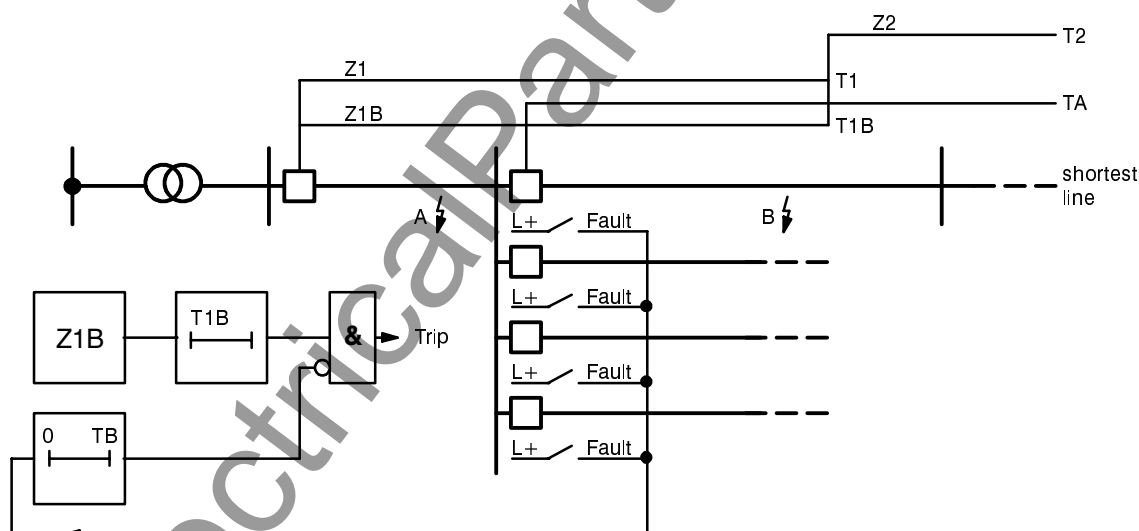


Figure 4.29 Reverse interlocking scheme, grading of distance zones (example)

4.4.10 Weak infeed measures (echo function)

In those cases, where at one line end there is no or only a weak infeed so that the protection device at that end cannot pick up and therefore cannot send any release signal, an echo intertrip signal can be sent in conjunction with overreaching modes with release signal. This feature can be made effective or ineffective by a software ON/OFF switch. Figure 4.30 shows the logic diagram.

In the event of pick-up failure at one line end, the echo function ensures that the received signal is sent back to the other line 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 some-

what later because of unfavourable short circuit current distribution. If, however, the circuit breaker at the non-feeding 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 4.30). 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 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.

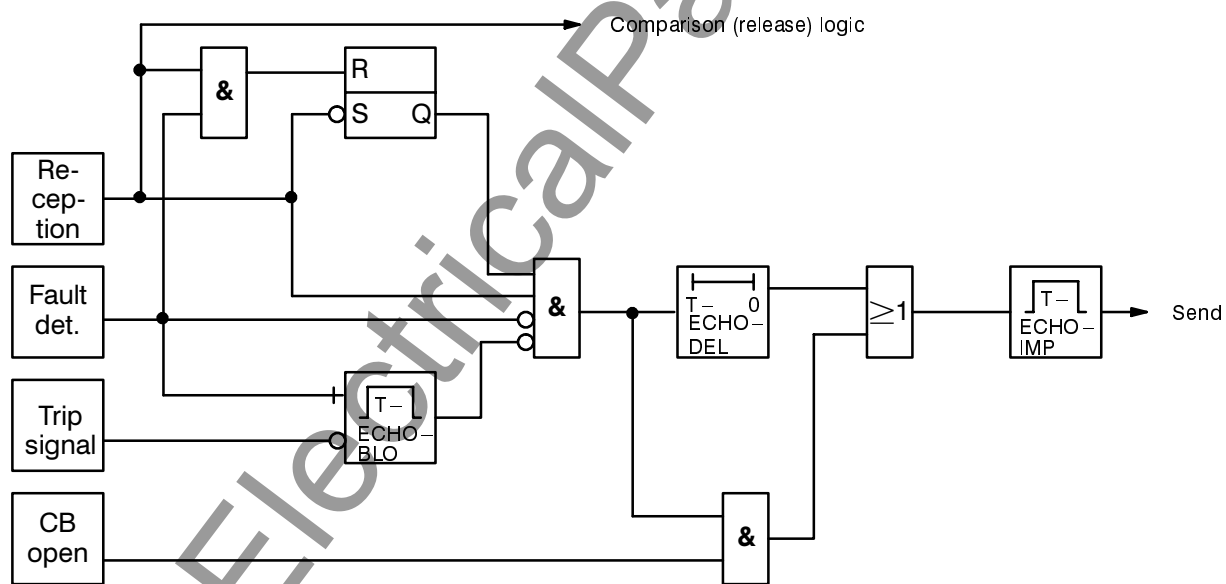


Figure 4.30 Block diagram of echo function (for release modes)

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 $T-TRANSBLO$. 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 4.31 shows the principle of transient blocking for a release mode. If, after fault detection, a fault is shown 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 of 40 ms. This blocking will be maintained for the transient blocking time

$T-TRANSBLO$ – identified in Figure 4.31 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 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 blocking signal must have been received for the waiting time TW. The transmission signal can be lengthened by the time $T-SEND-PRL$ (see also Section 4.4.7).

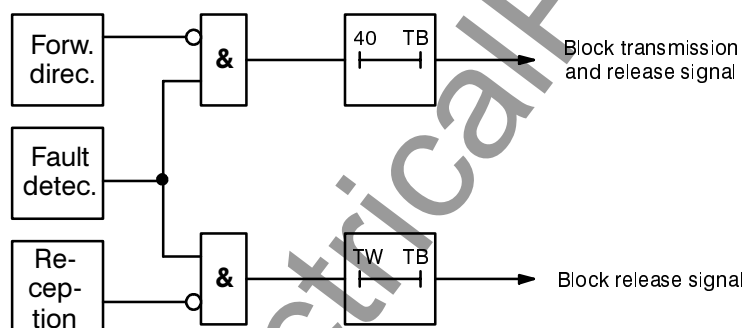


Figure 4.31 Transient blocking with release mode

4.5 User definable logic functions, trip commands, and annunciations

7SA511 contains two user definable logic modules. These comprise each a timer which can be started and blocked via a binary input (Figure 4.32). A pick-up time delay and a drop-off time delay can be set. The times can also be set to 0 or ∞ .

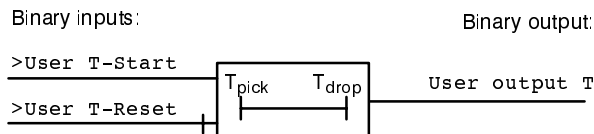


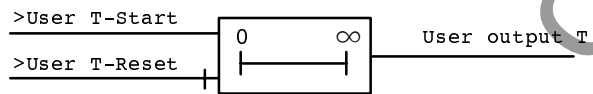
Figure 4.32 User definable logic, one module

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 4.33),
- flip-flop with delay.

Binary input:



Set memory with ">User T Start"
Reset memory with ">User T Reset"

Figure 4.33 Flip-flop

Any desired trip signal from an external protection or supervision unit can be incorporated into the processing of 7SA511. 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 Emergency overcurrent time protection

7SA511 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 comes automatically into operation 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 Section 4.14.4.3) 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 is designed two-stage for phase current, with an additional earth current stage. All stages are independent from each other and can be set individually:

- $I_{>>}$ high current limit value threshold for phase currents
- $T_{I_{>>}}$ corresponding delay time
- $I_{ph>}$ definite time limit value threshold for phase currents
- $T_{I_{>}}$ corresponding delay time
- $I_E>$ definite time limit value threshold for earth currents
- $T_{I_E>}$ corresponding delay time

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 $I_{>}$ 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.

4.7 Thermal overload protection

The thermal overload protection prevents the power line, particularly in case of cables, from damage caused by thermal overloading.

The unit computes the temperature rise according to a thermal single-body model as per the following thermal differential equation:

$$\frac{d\Theta}{dt} + \frac{1}{\tau} \cdot \Theta = \frac{1}{\tau} \cdot I^2$$

where

- Θ – instantaneous temperature rise related on the final temperature rise for the maximum permissible cable current $k \cdot I_N$
- τ – thermal time constant for heating-up of the cable
- I – instantaneous cable current (rms value) related on the maximum permissible cable current $I_{max} = k \cdot I_N$

When the temperature rise reaches the first set threshold, a warning alarm is given, in order to render possible an early load reduction. If the second temperature threshold is reached the line can be disconnected from the network (selectable).

The temperature rises are calculated separately for each individual phase. A choice can be made whether the maximum calculated temperature rise of the three phases, the average temperature rise, or the temperature rise calculated from the phase with maximum current should be decisive. A true r.m.s. value measurement is performed in order to include for the effect of harmonic content.

The maximum permissible continuous thermal overload current I_{max} is described as a multiple of the rated current I_N :

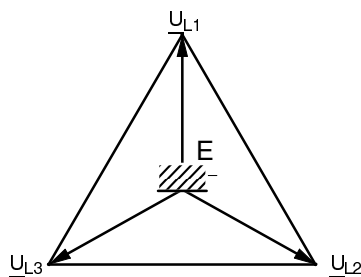
$$I_{max} = k \cdot I_N$$

In addition to this k -value, the time constant τ as well as the alarm temperature Θ_{warn} must be entered into the protection unit.

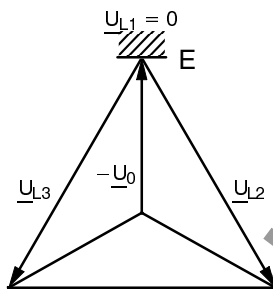
Apart from the thermal warning stage, the overload protection also includes a current-dependent warning stage. This latter alarm stage can give an early annunciation of an impending overload current even if the temperature rise has not yet reached the alarm or trip temperature rise values.

4.8 Earth fault detection in systems with non-earthed starpoint (optional)

In systems whose starpoint is either isolated or earthed through an arc suppression coil (Petersen coil), single phase earth faults will not be detected by the short circuit protection, since no significant earth fault current flows. Furthermore, since network operation is not immediately affected by an earth fault (the voltage triangle is maintained, Figure 4.34) rapid disconnection is not normally desired. It is more important that the earth fault be recognized, indicated and, when possible, located. After switching to alternative network routes it can then be cleared. But it is possible to trip on directional earth fault in non-earthed systems.



a) Healthy network, without earth fault



b) Earth fault in phase L1

Figure 4.34 Earth fault in non-earthed neutral network

Dependent upon the chosen model, the relay can be fitted with optional earth fault detection module, which includes the following functions:

- Detection of an earth fault (pick-up) by monitoring the displacement voltage,
- Determination of the faulted phase by measuring the phase to earth voltages,
- Determination of the direction of the earth fault (residual) current by high accuracy real and reactive component measurement.

4.8.1 Fault detection

The earth fault protection function can be switched on and off by parameter. When on, pick-up occurs when an adjustable threshold for the displacement voltage $U_E >$ is exceeded. To ensure measurement of stable values, all earth fault detection functions are delayed until 1 second (settable) after inception of voltage displacement. Further, each alteration of the earth fault conditions (e.g. altered direction) is recognized only after this delay. Earth fault annunciation is only issued after earth fault detection is ensured according 4.8.2.

4.8.2 Determination of the earth-faulted phase

After recognition of displaced voltage conditions the first objective of the device is selective detection of the earth-faulted phase. For this purpose the individual phase-to-earth voltages are measured. The affected phase is the one in which the voltage is below the settable threshold $U_{ph} <$ when simultaneously the other two voltages exceed an equally settable maximum threshold $U_{ph} >$.

4.8.3 Sensitive earth fault directional determination

The direction of the earth fault can be determined from the direction of the earth fault capacitive or ohmic current related to the displacement voltage. The only reservation is that the active or reactive current components must be available in sufficient magnitude at the point of measurement.

In networks with isolated starpoint, the earth fault current flows as capacitive current from the healthy lines via the measuring point to the point of fault. This capacitive current determines the direction.

In networks with arc suppression coils, the Petersen coil superimposes a corresponding inductive current on the capacitive earth fault current when an earth fault occurs, so that the capacitive current at the point of fault is compensated. Dependent upon the point of measurement in the network the resultant measured current can however be inductive or

capacitive and the reactive current is therefore not suitable for the determination of direction. In this case, only the ohmic residual current which results from the losses of the Petersen coil can be used for directional determination. This earth fault ohmic current is only a few percent of the capacitive earth fault current.

In 7SA511 the earth fault direction is determined from a highly accurate calculation of active and reactive power using the definitions:

Active power:

$$P_{Ea} = \frac{1}{T} \cdot \int_t^{t+T} u_E(t) \cdot i_E(t) \cdot dt$$

Reactive power:

$$P_{Er} = \frac{1}{T} \cdot \int_t^{t+T} u_E(t - 90^\circ) \cdot i_E(t) \cdot dt$$

where T equals period of integration.

The use of an efficient calculation algorithm and simultaneous numerical filtering allows the directional determination to be achieved with high accuracy and sharply defined threshold limits (see Figure 4.35) and insensitivity to harmonic influences – particularly the frequently strong third and fifth harmonics which occur particularly in ohmic earth fault currents. The directional decision results from the signs of active and reactive power.

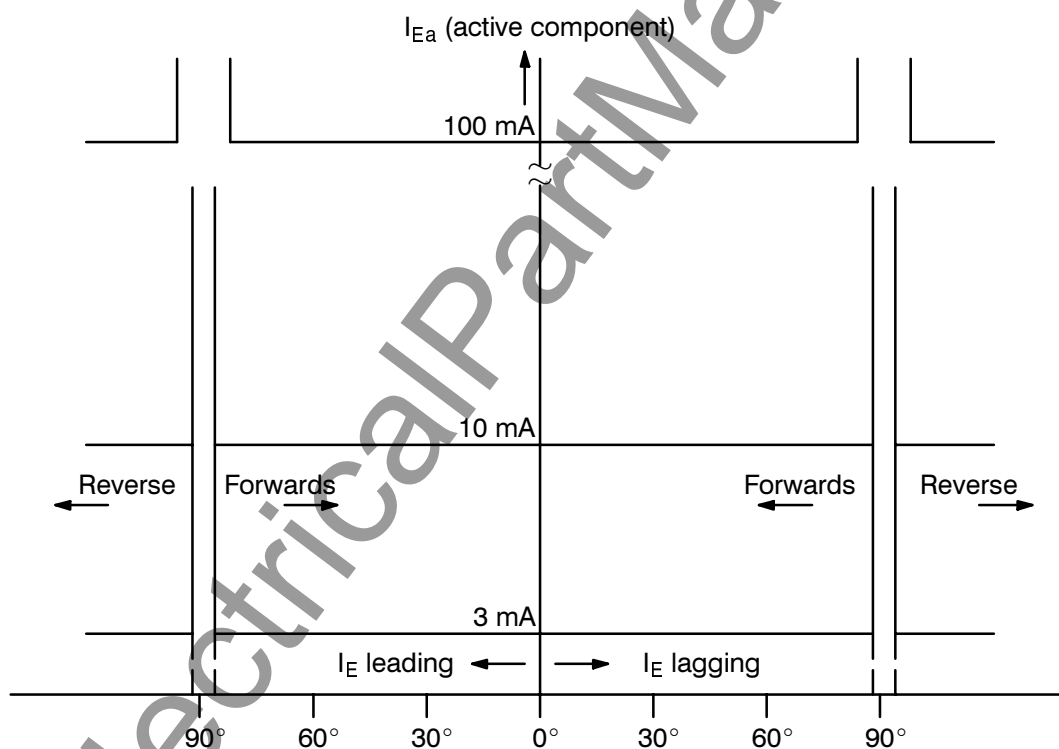


Figure 4.35 Directional earth fault measurement characteristic

Since the active and reactive component of the current – not the power – determine pick-up of the earth fault directional decision, these current components are calculated from the power components. Thus for determination of the direction of the earth fault active and reactive components of the earth fault current as well as the direction of the active and reactive power are evaluated.

In networks with **isolated starpoint** the following criteria apply

- earth fault forwards, when $P_{Er} > 0$ and $I_{Er} > \text{set value}$,
- earth fault backwards, when $P_{Er} < 0$ and $I_{Er} > \text{set value}$.

In **compensated networks** with **arc suppression coil** the following criteria apply

- earth fault forwards, when $P_{Ea} > 0$ and $I_{Ea} > \text{set value}$,
- earth fault backwards, when $P_{Ea} < 0$ and $I_{Ea} > \text{set value}$.

In the latter case it must be noted that, dependent upon the location of the protective relay, a considerable reactive component may be superimposed which, in the most unfavourable cases, can attain 50 times the active component. Even the extremely high accuracy of the calculation algorithm is then inadequate if the current transformers do not exactly convert the primary values.

The measurement input circuit of the relay model with earth fault detection is particularly designed for this purpose and permits an extremely high sensitivity for the directional determination of the wattmetric residual current. In order to utilize this sensitivity it is recommended that window-type current transformers be used for earth fault detection in compensated networks. As even the core balance transformers have an angle of error, the protection system allows the setting of factors which, dependent upon the reactive current, will correct the error angle.

4.8.4 Faulted line location

In radial networks, location of the faulted line is relatively simple. Since all circuits on a busbar (Figure 4.36) carry a capacitive partial current, the measuring point on the faulted line in an isolated network

sees almost the entire prospective earth fault current of the network; in compensated networks the wattmetric residual current from the Petersen coil flows through the measuring point. For the faulted line or cable, a definite “forwards” decision will result, whilst in the remaining circuits a “reverse” indication will be given unless the earth current is so small that no measurement can be taken. In any case the faulted cable can be clearly determined.

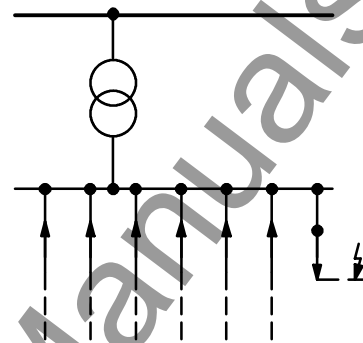


Figure 4.36 Faulted line location in radial network

In meshed or ring networks the measuring points at the ends of the faulted cable equally see a maximum of earth fault (capacitive or ohmic) current. Only in this cable will the direction “forwards” be indicated on both line ends (Figure 4.37). Even the remaining directional indications in the network can aid location of the earth fault. But under certain circumstances one or more indications may not be given due to insufficient earth current. Further advice can be found in the leaflet “Earth-fault detection in isolated neutral or arc-suppression coil earthed high voltage systems”.

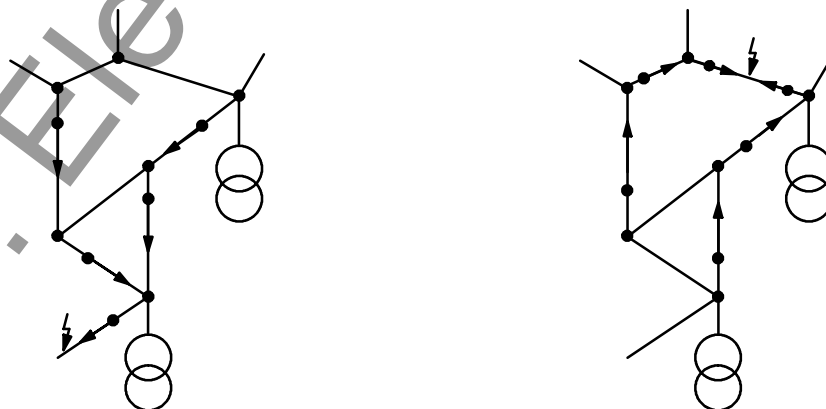


Figure 4.37 Location of earth fault based on the directional indicators in a meshed network

4.9 High-resistance earth fault protection in earthed systems (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 overcurrent – sometimes even the under-impedance – element will often not pick up, so that no phase selection is possible for the distance measurement. Even when using impedance fault detection, earth fault impedances can occur which appear to lie outside the pick-up characteristic of the distance relay.

Distance protection 7SA511, dependent upon the model ordered (see Section 2.3 Ordering data), can provide protective functions for such high resistance earth faults. One of the following features can then be selected:

- directional earth fault protection (definite time earth overcurrent protection) with non-directional back-up and stand-by protection function,
- non-directional inverse time lag overcurrent time protection for earth faults, with selectable characteristics.

The directional earth fault protection can be extended by an integrated directional comparison logic so that by means of a carrier channel fast and selective tripping for high resistance earth faults is also possible.

The non-directional inverse time protection is used mostly for highly interlinked, all-round earthed networks with high resistance earth faults, where the ends of the faulty line section carry the largest fault current and thus produce the shortest tripping time.

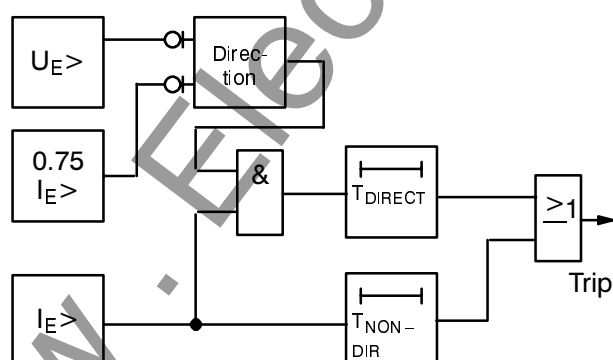


Figure 4.38 Directional earth protection with non-directional back-up stage

4.9.1 Directional earth fault protection

The directional earth fault protection (Figure 4.38) has an adjustable earth current detection element $I_{E>}$ and an adjustable delay time. Because of the possibility of directional comparison (see Section 4.9.2), detection is two-stage; a lower value $0.75 I_{E>}$ releases directional determination. For tripping, the high value stage must additionally be exceeded (corresponding to the set value of $I_{E>}$).

Directional determination requires a least value displacement voltage, for which the $U_{E>}$ setting is used. If the displacement voltage is too small, a directional determination and thus directional-dependent tripping is not possible. Directional determination is also suppressed and tripping prevented when the indication “voltage transformer protective device tripped” is signalled to the relay via a binary input.

The criterion for the delay time is the setting $T-DIRECT$.

A further time stage $T-NON-DIR$ will cause tripping without directional measurement. It can be set as a non-directional back-up stage for the directional stage. If the displacement voltage is too small or if the voltage transformer protective device has operated, 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 directional function is blocked from the distance protection or emergency overcurrent protection. When the fault is detected by the distance protection or emergency overcurrent time protection the earth fault protection does not operate. This gives selective fault determination by the distance protection preference over tripping by the earth fault protection. Additionally, the earth fault directional protection is blocked during a single-pole auto-reclose cycle to prevent from erroneous measurement with the zero sequence quantities which are now present. In case a fault is cleared by an external protection device, blocking of the earth fault protection can be extended by an adjustable time $T-BLOCK$ to allow a single phase auto-reclosing cycle to be carried out.

4.9.2 Directional comparison earth fault protection

With the aid of the integrated comparison logic, the directional earth fault protection 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 (4.4.3 Permissive overreach transfer trip with Z1B or 4.4.4 Directional comparison) has been selected at the distance protection element!

After the pick-up $0.75 I_E >$ the relay carries out directional determination using the earth current $I_E (= 3 \cdot I_0)$ and the displacement voltage $U_E (= \sqrt{3} \cdot U_0)$. 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 4.39). Transmission signal and tripping can both be made dependent on a delay time $T - \text{DELAY}$.

Delay by T-DELAY can be appropriate when an external protection relay shall operate in conjunction with single pole auto-reclosure. Since the earth fault directional comparison does not supply any information about the faulted phase(s), it can only initiate three-phase auto-reclose.

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 4.40). 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 of 40 ms. This blocking will be maintained for the transient blocking time T-TRANSBLO – in Figure 4.40 abbreviated to TB – even after the blocking criterion is removed.

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 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 4.41). 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 ($T-ECHO-IMP$).

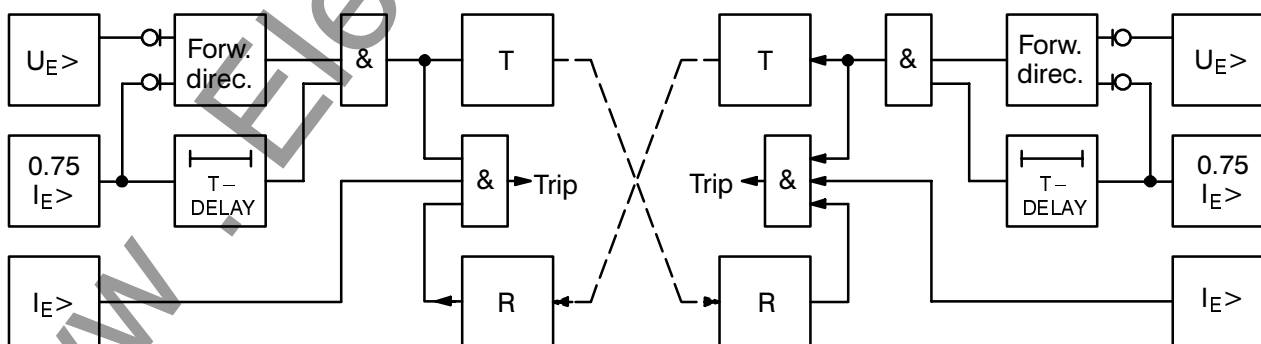


Figure 4.39 Earth fault directional comparison protection

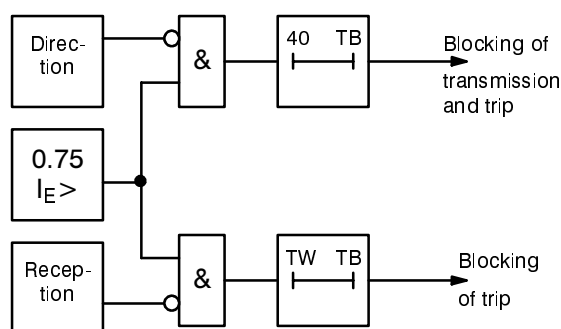


Figure 4.40 Transient Blocking

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-infeed 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 4.41). 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 stage described in section 4.9.1 is effective with the time $T-DIRECT$ and the non-directional back-up stage with the time $T-NON-DIR$. If one of these stages is not required, the corresponding time must be set to infinity.

The earth fault directional comparison protection function is blocked from the distance protection or emergency overcurrent protection. Therefore, if a fault is recognized by the distance protection or emergency overcurrent time protection then the earth fault protection does not operate. This gives selective fault evaluation by the distance protection preference over tripping via the earth fault protection. Additionally, the earth fault directional comparison protection is blocked during a single-pole auto-reclose cycle to prevent from erroneous measurement with the zero sequence quantities which are now present. In case a fault is cleared by an external protection device, blocking of the earth fault protection can be extended by an adjustable time $T-BLOCK$ to allow a single phase auto-reclosing cycle to be carried out.

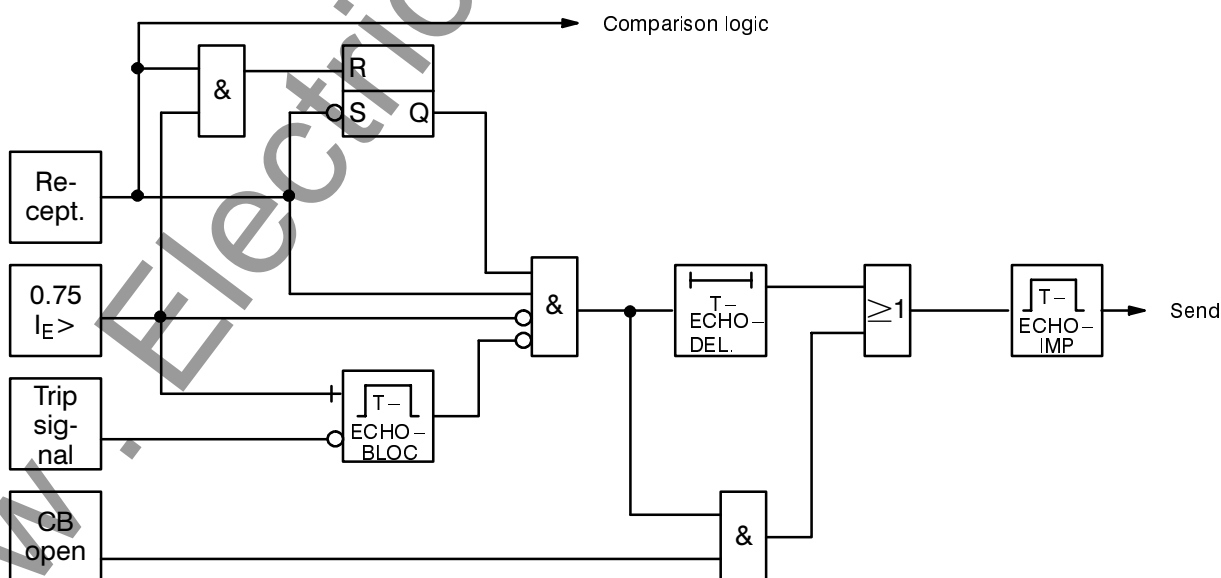


Figure 4.41 Block diagram of echo function for directional comparison

4.9.3 Inverse time overcurrent time protection for earth faults

The inverse time overcurrent time protection is non-directional. It can be used instead of the directional earth fault protection described in Section 4.9.1 or 4.9.2. The required characteristics can be chosen from the three which are available:

- normal inverse (type A) IEC 60255–3 / BS 142
- very inverse (type B) IEC 60255–3
- extremely inverse (type C) IEC 60255–3.

The shape of the characteristics and the formulae on which they are based are given in the Technical data (Section 3.8, Figure 3.3).

Tripping time is then 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 60 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.

The earth fault overcurrent time protection function is blocked from the distance protection or emergency overcurrent protection. Therefore, if a fault is recognized by the distance protection or emergency overcurrent time protection, then the earth fault protection does not operate. This gives selective fault evaluation by the distance protection preference over tripping via the earth fault protection. Additionally, the earth fault directional comparison protection is blocked during a single-pole auto-reclose cycle to prevent from erroneous pick-up on the zero sequence current which may now be present. In case a fault is cleared by an external protection device, blocking of the earth fault protection can be extended by an adjustable time T–BLOCK to allow a single phase auto-reclosing cycle to be carried out.

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 4.42 shows an example for the time sequence of such an auto-reclose 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 starpoint. 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 determination of 7SA511 (see Section 4.2.2) allows reliably single-pole auto-reclosure. The 7SA511 also allows automatic single- and three-pole as well as single- and multi-shot reclosure, if the AR function is accordingly ordered (refer Section 2.3 Ordering data).

7SA511 can also work in conjunction with an external auto-reclose system. In this case, the signal exchange between 7SA511 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 7SA511 with internal AR-function is also possible as well as the use of one 7SA511 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 fault (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 the AR-function is activated. 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).

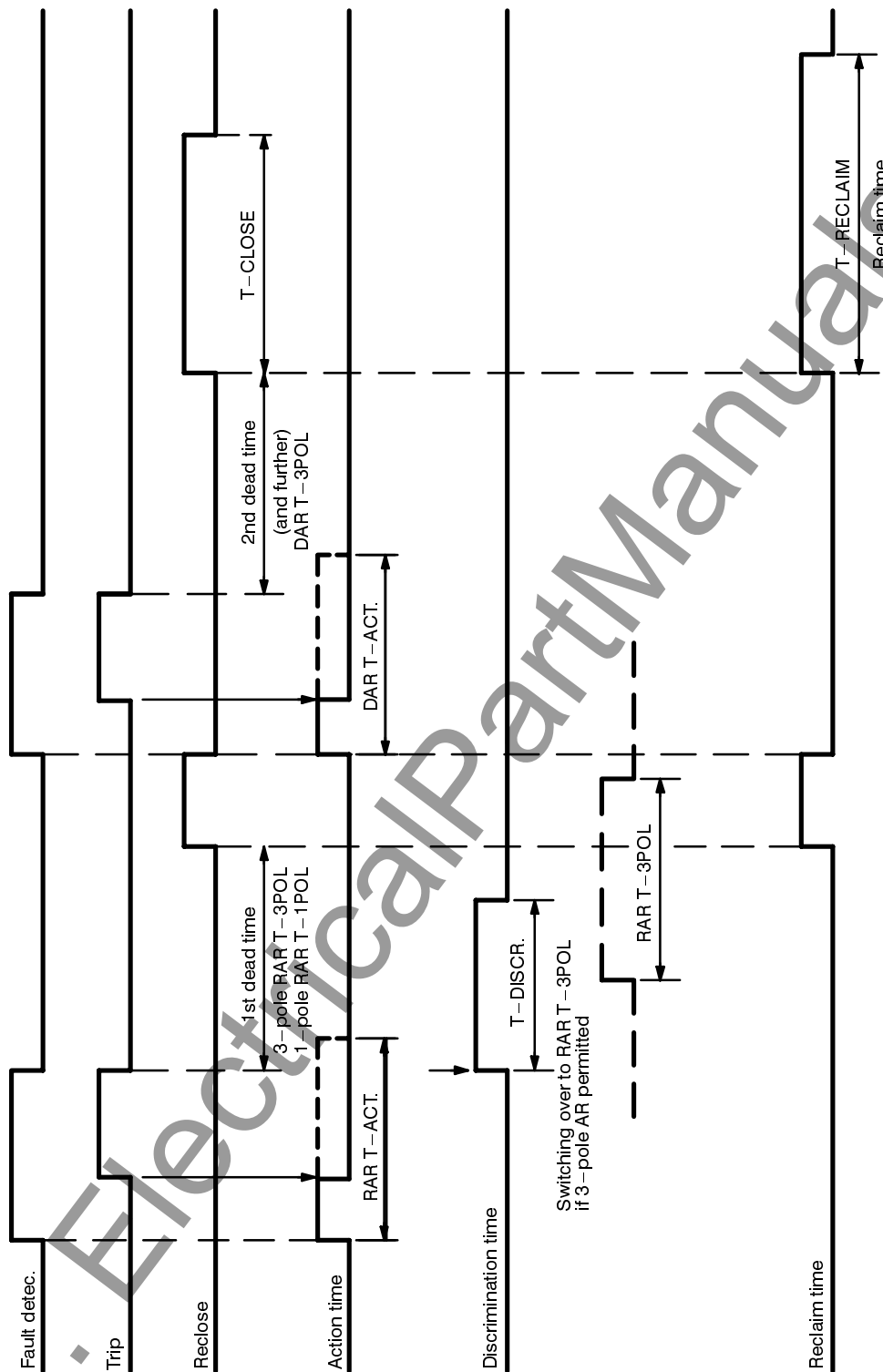


Figure 4.42 7SA511, Diagram of reclosure sequence

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, the short-circuit protection function of 7SA511 which can initiate the auto-reclose functions provide 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 final 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 Section 4.9.2)

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 4.43).

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

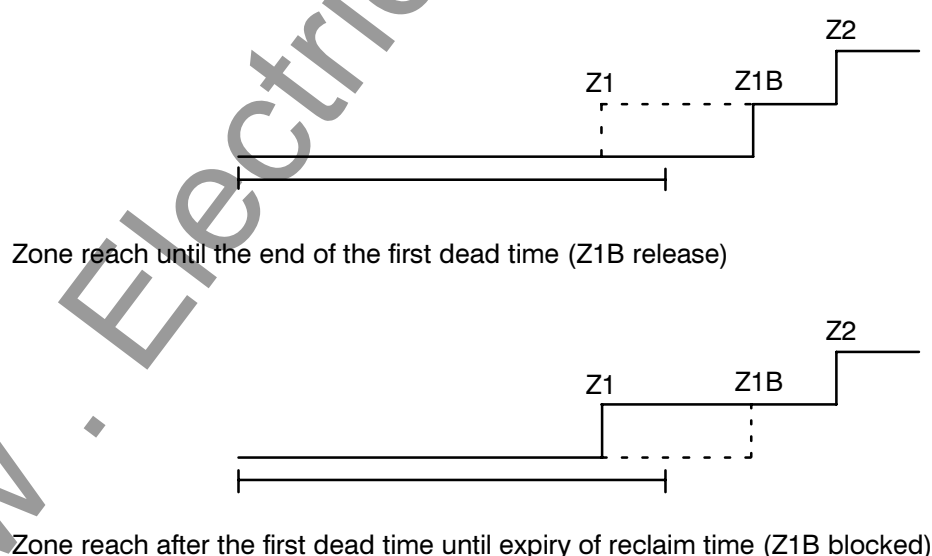


Figure 4.43 Zone reach control with the AR-function

7SA511 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 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 4.44). 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. 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 measuring time). The healthy lines are in operation very soon by this procedure.

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

Furthermore, 7SA511 presents the possibility to trip a remaining fault instantaneously over 100 % line length even after unsuccessful auto-reclosure: As 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 7SA511 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.

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 4.45), 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.

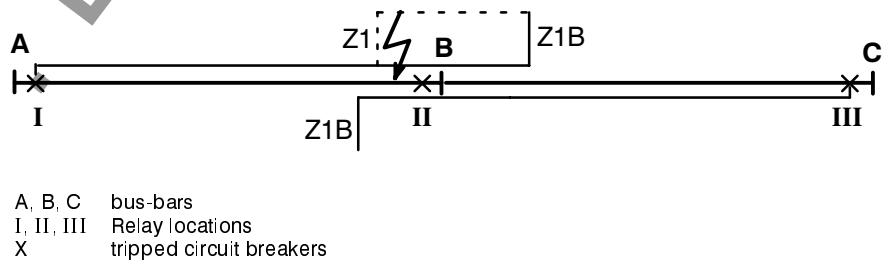


Figure 4.44 Example for the $3U_0$ procedure

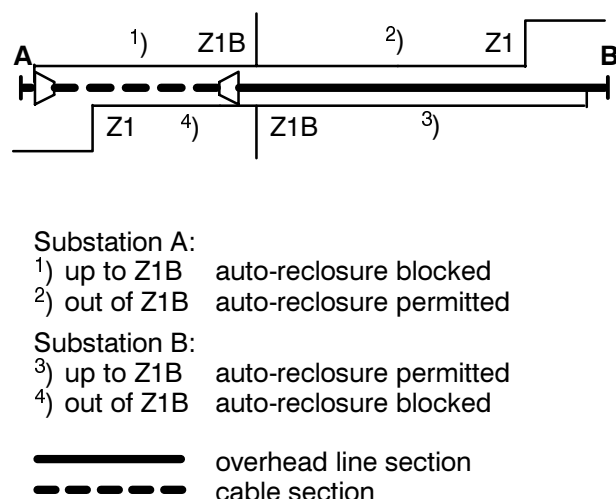


Figure 4.45 Line with overhead and cable section

For overcurrent time protection (emergency mode), stage I > > operates undelayed as 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 > after expiry of the delay time TI >. When the AR-function is blocked or switched off, I > > is also blocked. This can be changed in that the I > > stage is effective always, independent of the RAR.

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 also not result in an auto-reclosure.

The AR-functions of 7SA511 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 7SA511 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 7SA511 relay is blocked 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 after manual close, reclosure is blocked; any trip command will be a three-pole final trip.

4.10.3 Interrogation for readiness of the circuit breaker

A 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 7SA511 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 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 cleared.

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 7SA511 is locked.

The above sequence comes into effect with single-shot RAR. With 7SA511, multiple AR–attempts (up to 9 DAR–shots, refer 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 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 7SA511 is locked.

After a single-pole trip, the AR–function is initiated provided tripping occurs within the action time. 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 cleared.

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 7SA511 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 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 cleared.

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 7SA511 is locked.

The above sequence comes into effect with single-shot RAR. With 7SA511, multiple AR–attempts (up to 9 DAR–shots, refer 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 Section 4.10.8).

4.10.7 Treatment of evolving faults

When single-pole or single- and three-pole auto-reclosures are carried out in the network, special attention has to be directed to evolving faults. Evolving faults are those which, after clearance of the first-detected fault, occur during the dead time.

7SA511 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. A three-pole trip occurs. 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. The trip is three-pole and occurs regardless whether three-pole AR is permitted or not.

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

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, a three-pole trip is carried out and 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, a three-pole trip is carried out and reclosure is blocked, as under b).

4.10.8 Multi-shot auto-reclosure

The internal auto-reclose feature in 7SA511 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 7SA511 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 external auto-reclose system

7SA511 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 7SA511 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 7SA511 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 trip-

ping. The RAR stages of the short-circuit protection functions of 7SA511 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 but the normal grading stages are effective only.

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 controls the DAR stage Z1L of the distance protection (only relevant when multi-shot auto-reclosure is used).

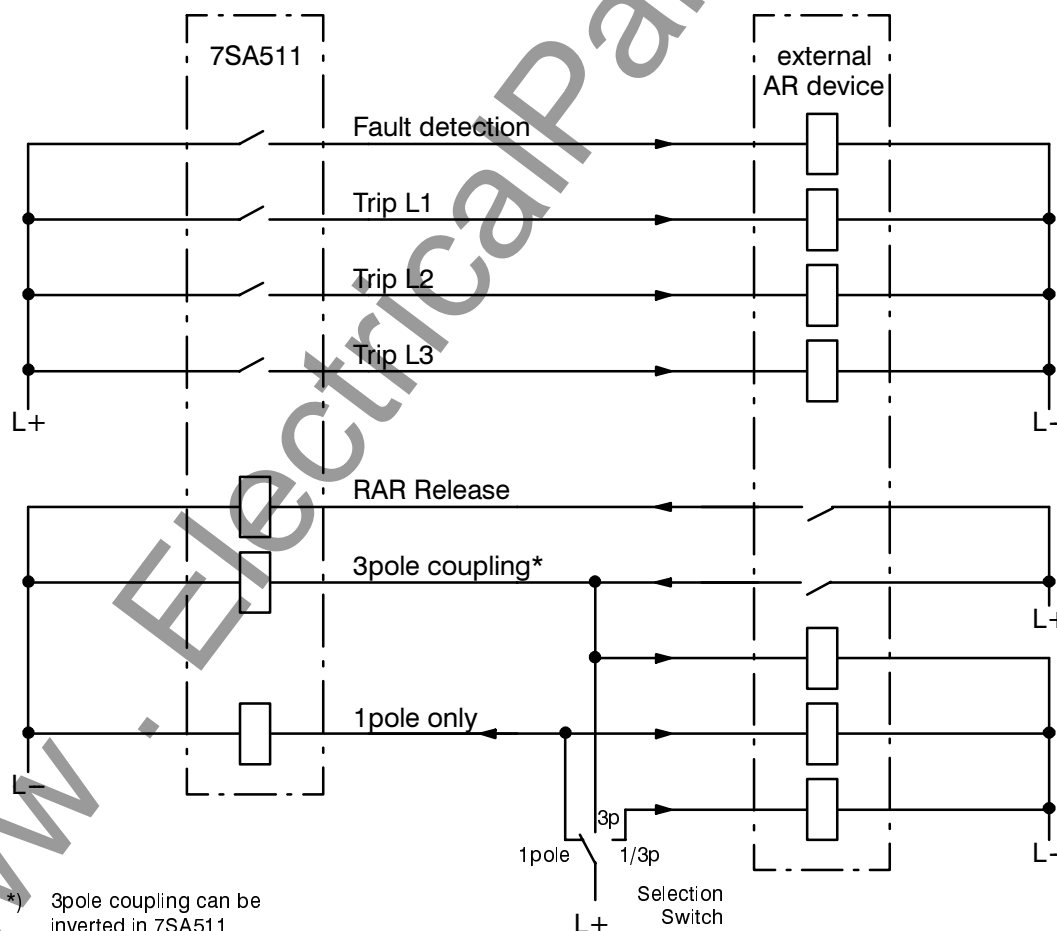


Figure 4.46 Example of connections with external AR-system

Binary outputs:

501 DeviceFltDet	General fault detection of the device.
515 Dev.Trip 3p	Three-pole trip command of the device.
512 Dev.Trip 1pL1	Single-pole trip command L1 of the device.
515 Dev.Trip 3p	Three-pole trip command of the device.
513 Dev.Trip 1pL2	Single-pole trip command L2 of the device.
515 Dev.Trip 3p	Three-pole trip command of the device.
514 Dev.Trip 1pL3	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, normally, sufficient.

Figure 4.46 shows a connection example for the interconnection between 7SA511 and an external AR – system using a program selector switch.

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

If 7SA511 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 7SA511.

Signal exchange between 7SA511 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, for example, 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. If *only* three-pole AR is to be carried out, all three binary input for the tripping signals must be allocated to a physical binary input module.

To couple the external relay three-pole and to release its overreach zone, 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 output may be omitted. For example, the "RAR Zone Rel" output (FNo 2817) is sufficient when only three-pole auto-reclosure is used.

4.10.11 Two protection relays with two AR 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 4.47. 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!

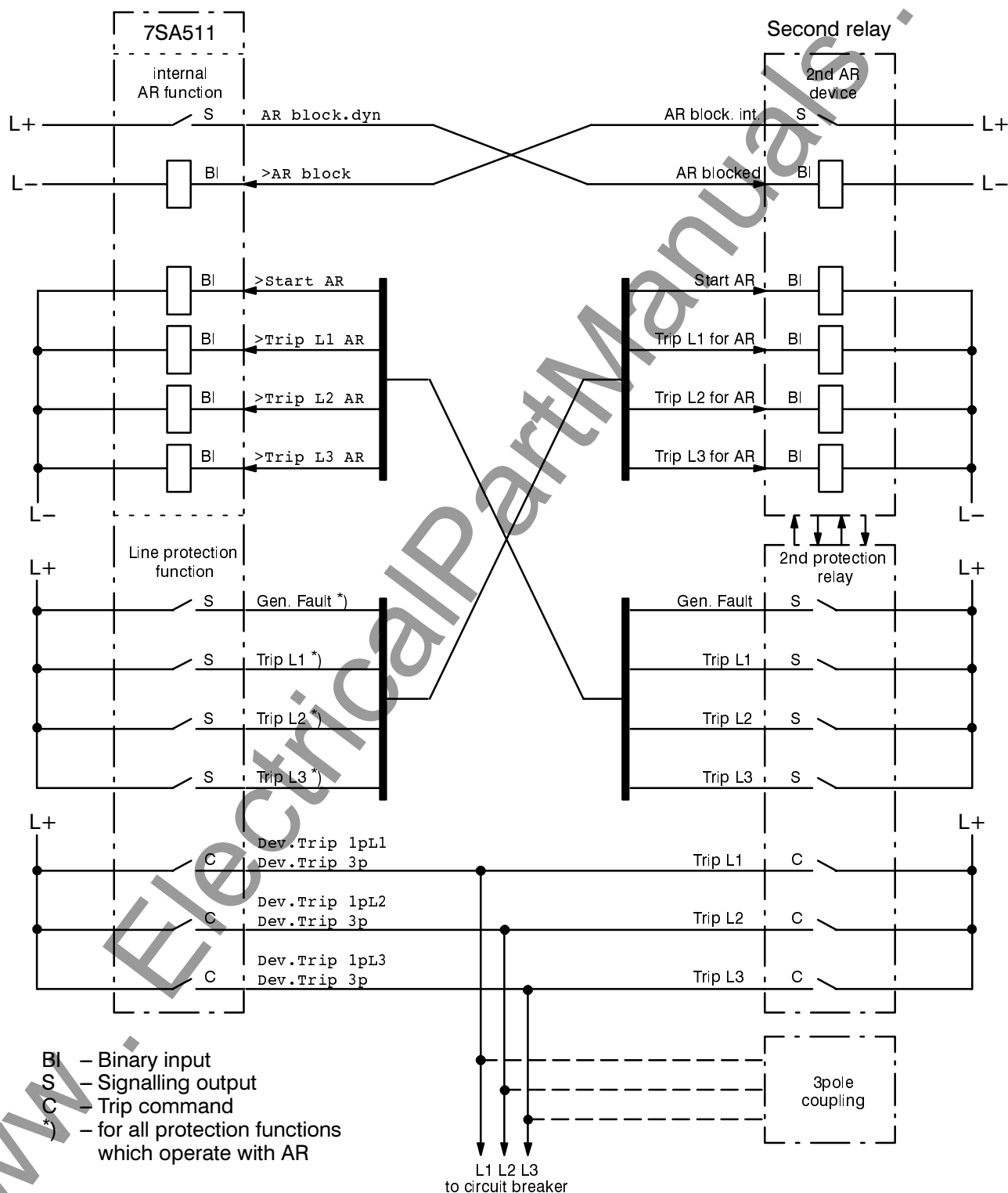


Figure 4.47 Connection example for 2 protection relays with 2 auto-reclosure devices

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 close and for manual close.

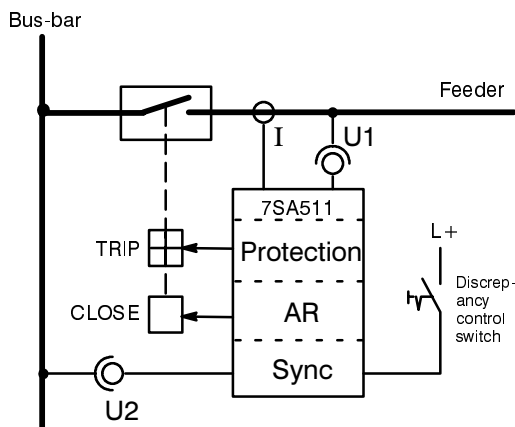


Figure 4.48 Synchronism and voltage check on closing

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.

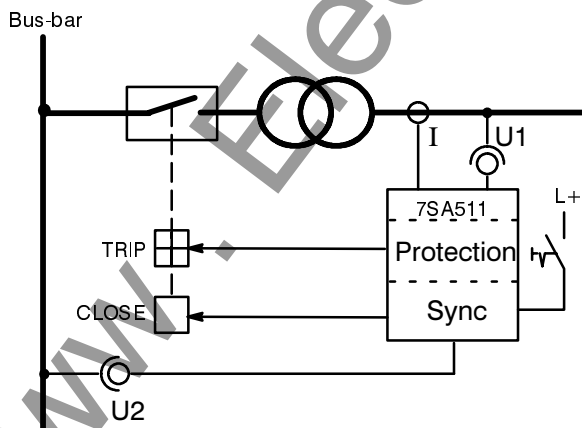


Figure 4.49 Synchronism and voltage check across transformer

When a power transformer lies between the feeder voltage transformer and the bus-bar voltage transformer (Figure 4.49), its vector group can be matched at the 7SA511 relay, so that no external matching transformers are necessary.

The synchro-check function in 7SA511 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 provided the feeder is current-free ($I < 0.1 I_N$). If not, either the breaker is not open or a fault is situated between the breaker and the current transformers.

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 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 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 Distance-to-fault location

Distance-to-fault measurement before clearance of the fault is an important addition to the function of a distance 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 distance protection relay 7SA511 is a function independent of distance protection. It possesses independent measured value stores and its own filter algorithms. Distance 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 distance protection. Paired values of short circuit current and short circuit voltage, taken at intervals of 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. 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 7SA511 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 for X. This average is taken as fault reactance.

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 can therefore be fitted with a parallel line compensation module for such fault location (see Section 2.3 Ordering data). This takes into account the earth current of the parallel line in the line equation and thus compensates for the influence of the coupling. For this purpose, this earth current must be fed into the relay. The loop equation in differential form is then as follows:

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

where i_E' is the earth current of the parallel line and the ratios X_M/X_L and R_M/R_L are line constants which result from the geometry of the double line and the characteristics of the earth return path. The line constants are input to the relay just as the other line data are also set.

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.

4.13 Circuit breaker trip test

Numerical distance protection relay 7SA511 allows simple checking of the tripping circuit and the circuit breaker. If the device incorporates an internal auto-reclose system, a TRIP–CLOSE test cycle is also possible; the latter can also be performed with an external auto-reclose device.

Prerequisite for the start of a test cycle is that no protective function has picked up. If the circuit breaker auxiliary contacts advise the relay, through a binary input, 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.

For starting a TRIP–CLOSE cycle a further condition is that the conditions for reclose (circuit breaker ready, AR not blocked) are fulfilled. This applies also for an external auto-reclose device.

Initiation of the test cycle can be given from the operator keyboard or via the front operator interface.

When a pure trip test is started, the relay issues a three-pole trip command.

A TRIP–CLOSE cycle can be performed three-pole or single-pole. Three-pole trip is initiated only when the AR function (internal or external) permits three-pole reclosure. Single-pole trip is initiated only when the AR function (internal or external) permits single-pole reclosure. Single-pole trip test can also be carried out with a sequence TRIP L1 – RECLOSE – TRIP L2 – RECLOSE – TRIP L3 – RECLOSE.

The test sequence is supervised by 7SA511 by means of the circuit breaker auxiliary contact position provided the auxiliary contact is connected to a binary input. If the breaker does not react correctly then the test sequence is aborted; a corresponding message is given in the display or on the PC screen.

Trip test can also be started by energization of a binary input. A pure trip test without reclosure (by internal or external auto-reclosure) is not recommended for safety reasons.

4.14 Ancillary functions

The ancillary functions of the distance protection 7SA511 include:

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

4.14.1 Processing of annunciations

After a fault in the network, 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.

4.14.1.1 Indicators and binary outputs (signal relays)

Important events and conditions are indicated by optical indicators (LED) on the front plates. The modules also contain signal relays for remote indication. 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 are saved 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 fault detection 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”, “emergency O/C”, 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.

4.14.1.2 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 4.14.1.1.

The device also has several event buffers, e.g. for operating messages, circuit breaker operation statistics etc. (see Section 6.4) which are 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 provided the real time clock is available. 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 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 four network faults; if a fifth fault occurs the oldest fault is overwritten in the fault memory. The annunciations of the last three network fault can be read out in the local display.

A network fault begins with recognition of the fault by pick-up of any fault detector and ends with 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.

4.14.1.3 Information to a central unit (optional)

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.

4.14.2 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. The maximum number of fault records within this time period is 8. These data are then available for fault analysis. For each renewed fault event, the actual new fault data are stored without acknowledgement of the old 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 (if fitted). 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.

4.14.3 Operating measurements and conversion

For local recall or transmission of data, the true r.m.s. values of the currents and 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 I_N ,
- $U_{L1E}, U_{L2E}, U_{L3E}$ 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,
- Θ/Θ_{trip} overload measured values, referred to trip temperature rise.

Additionally, the components of the earth fault current can be output for relays with highly sensitive earth fault detection in non-earthed systems:

- I_{Ea}, I_{Er} active and reactive component of earth fault current in non-earthed systems.

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).

4.14.4 Monitoring functions

7SA511 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.

4.14.4.1 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 switchoff 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 ($U_H \geq 110 \text{ V}$).

- 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 four input converters; the digitized sum of the outputs of these must always be zero. A fault in the current path is recognized when

$$|I_{L1} + I_{L2} + I_{L3} + k_I \times I_E| > \text{SUM.lthres} \times I_N + \text{SUM.Fact.I} \times I_{\max}$$

An adjustable factor k_I (parameter I_e/I_{ph}) can be set to correct the different ratios of phase and earth current transformers (e.g. window-type transformer for earth fault detection). If the residual earth current is derived from the current transformer starpoint, $k_I = 1$. $SUM.I_{thres}$ and $SUM.Fact.I$ are setting parameters (refer to 6.3.10). The component $SUM.Fact.I \times I_{max}$ takes into account permissible current proportional transformation errors in the input converters which may particularly occur under conditions of high short circuit currents (Figure 4.50).

Note: Current sum monitoring can operate properly only when the residual current of the protected line is fed to the I_E input of the relay.

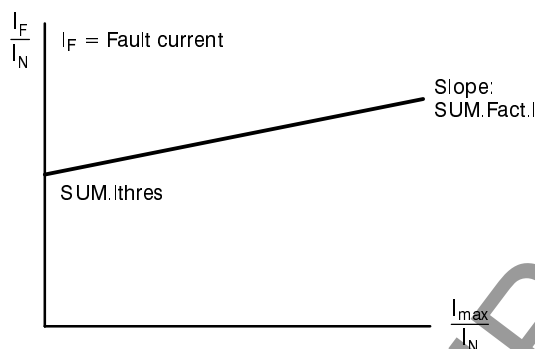


Figure 4.50 Current sum monitoring (current plausibility check)

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 connected to the displacement voltage U_{EN} or a bus-bar voltage. 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 channels for availability, by exciting each channel 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.

4.14.4.2 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 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.

4.14.4.3 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 4.51). Both parameters can be set (see Section 6.3.10).

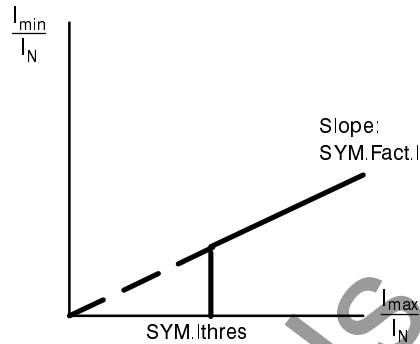


Figure 4.51 Current symmetry monitoring

– 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. Monitoring of the sum of the phase-to-phase voltages is not influenced by earth faults, which can be a lasting operating condition in non-earthed networks.

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 4.52). Both parameters can be set (see Section 6.3.10).

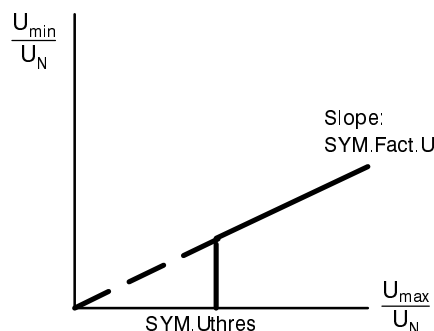


Figure 4.52 Voltage symmetry monitoring

– 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 real 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 may 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 dis-

tance function is then blocked and the relay can be switched to emergency overcurrent operation (see Section 4.6). 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 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 7SA511!

– Phase rotation

Since correct functioning of measured value selection 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 4.14.4.1 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 4.11 gives a survey of all the functions of the measured value monitoring system.

Monitoring	Failure covered, reaction
1. Plausibility check of currents $|i_{L1} + i_{L2} + i_{L3} + I_{E}/I_{ph} \times i_E| > \text{SUM.Ithres} \times I_N + \text{SUM.Fact.I} \times I_{max}$	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 $|u_{L1} + u_{L2} + u_{L3} + U_{ph}/U_{delta} \times u_{EN}| > 25 \text{ V}$	Relay failures in the signal acquisition circuits $u_{L1}, u_{L2}, u_{L3}, u_E$ delayed alarm "Failure ΣU_{ph-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 ΣU_{p-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 ΣU_{p-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 $|u_{L1} + u_{L2} + u_{L3}| > \text{FFM } 3 \cdot U_0$ 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 $|u_{L1}|, |u_{L2}|, |u_{L3}| > 40 \text{ V}/\sqrt{3}$	Swapped voltage connections or reverse rotation sequence delayed alarm "Fail.PhaseSeq"

Bolted figures are setting values.

Table 4.11 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 7SA511★--★B★★ for panel surface mounting

- Secure the unit with four screws to the panel. For dimensions refer to Figure 2.2.
- Connect earthing terminal (Terminal 26) of the unit to the protective earth of the panel.
- Make a solid low-ohmic and low-inductive 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 7SA511★--★C★★ for panel flush mounting or 7SA511★--★E★★ for cubicle installation

- Lift up both labelling strips on the lid of the unit and remove cover to gain access to 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 2.3.
- Connect earthing screw on the rear of the unit to the protective earth of the panel or cubicle.
- Make a solid low-ohmic and low-inductive 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

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.

5.2.2.1 Control d.c. voltage of binary inputs

When delivered from factory, the binary inputs are designed to operate with a control voltage which corresponds with the rated voltage of the power supply of the relay. In order to optimize the operation of the inputs, they should be matched to the real control voltage. It depends on the hardware state (production series) of the relay how this is carried out. This state is found on the name plate behind the complete order designation.

The following is valid for production series /GG:

The binary inputs react on control d.c. voltages in the total voltage range from 19 V to 288 V. The pick-up threshold lies near 17 V. If the rated control voltage for 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.

To fit a higher pick-up threshold of approximately 65 V to a binary input a solder bridge must be removed. Figure 5.1 shows the assignment of these solder bridges for the inputs BI 1 to BI 4, and their location on the basic p.c.b. of the basic input/output module GEA–1. Figure 5.2 shows the assignment of these solder bridges for the inputs BI 5 to BI 10 and their location on the additional input/output module ZEA–1.

The following is valid for production series /HH or later:

Table 5.1 shows the assignment of the presettings of the control voltage of the binary inputs against the rated supply voltage of the relay. If the control voltage of a binary input is of the same magnitude as the supply voltage of the relay, no matching is necessary. Even with higher control voltage the binary input will operate. But it is advisable to fit a higher pick-up threshold to increase stability against stray voltages. Refer to Table 5.2 for possibilities. If a binary input is to be controlled by a lower voltage, then the pick-up threshold must be matched! Otherwise it cannot be energized.

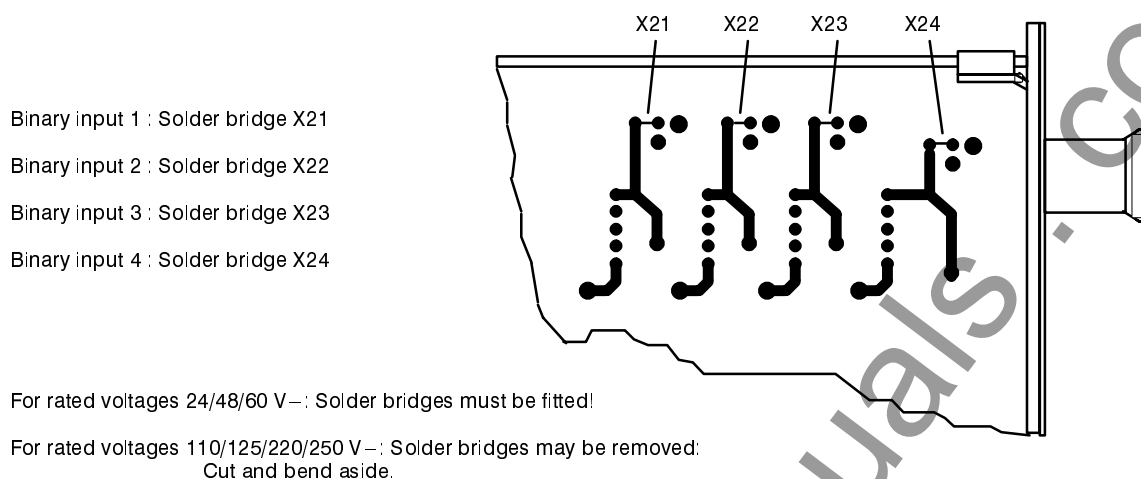


Figure 5.1 Checking for control voltages for binary inputs 1 to 4 on basic module GEA–1, up to production series /GG

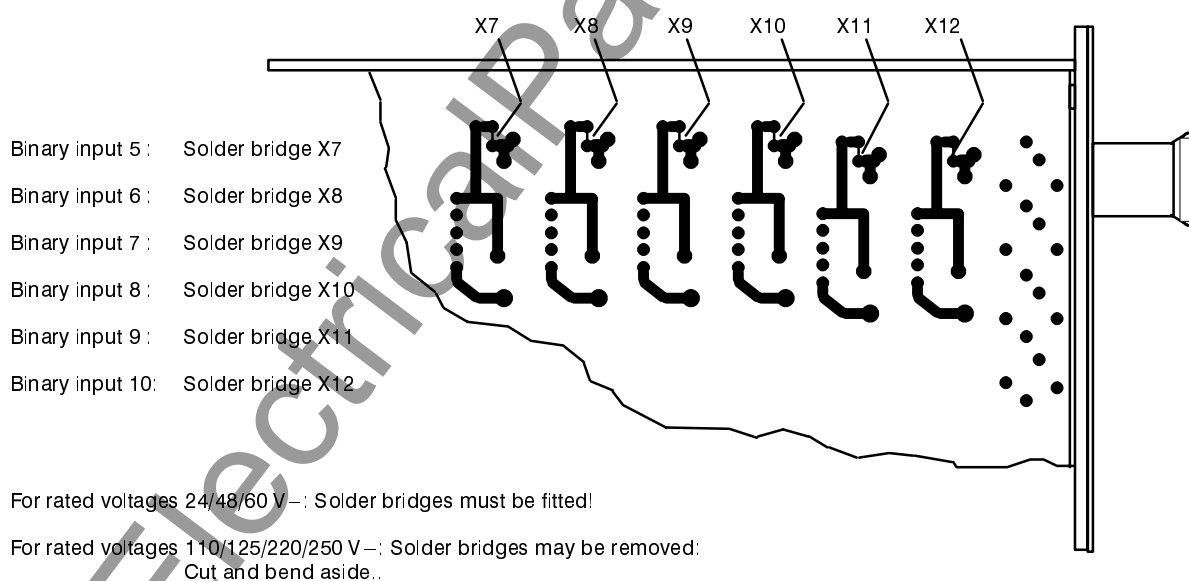


Figure 5.2 Checking for control voltages for binary inputs 5 to 10 on additional module ZEA–1, up to production series /GG

Order code 7SA511★–	Rated auxiliary voltage range	Presetting of binary inputs
2★–★–★–★	24/48 Vdc	24 Vdc
4★–★–★–★	60/110/125 Vdc	60 Vdc
5★–★–★–★	220/250 Vdc	220 Vdc

Table 5.1 Presetting of control voltage for binary inputs for production series /HH or later

Table 5.2 shows the setting possibilities for the binary inputs BI 1 to BI 4 on the basic p.c.b. of the basic input/output module GEA–2, Table 5.3 for the inputs BI 5 to BI 10 on the additional input/output module ZEA–1. The figures 5.3 and 5.4 show the printed circuits boards, viewed from the component side, with the setting plugs for the control voltage of the binary inputs. They are valid for relays from production series /HH. If the actual control voltage is not found on the p.c.b., select the setting for the next lower voltage. The figures show further plugs, which must not be changed.

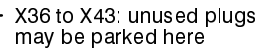
Binary input on GEA–2	Settings for rated control voltage			
	24/48 Vdc	60 Vdc	110/125 Vdc	220/250 Vdc
BI 1	plug X50–X51	plug X52–X53	plug X54–X55	no plug ¹⁾
BI 2	plug X56–X57	plug X58–X59	plug X60–X61	no plug ¹⁾
BI 3	plug X44–X45	plug X47–X48	plug X49–X62	no plug ¹⁾
BI 4	plug X75–X76	plug X77–X78	plug X79–X80	no plug ¹⁾

¹⁾ Unused plugs may be parked on the pins X36 to X43

Table 5.2 Checking for control voltages of binary inputs 1 to 4 on the basic module GEA–2, valid from production series /HH

Binary input on ZEA–2	Settings for rated control voltage			
	24/48 Vdc	60 Vdc	110/125 Vdc	220/250 Vdc
BI 5	plug 24 V	plug 60 V	plug 110 V	plug 220 V
BI 6	plug 24 V	plug 60 V	plug 110 V	plug 220 V
BI 7	plug 24 V	plug 60 V	plug 110 V	plug 220 V
BI 8	plug 24 V	plug 60 V	plug 110 V	plug 220 V
BI 9	plug 24 V	plug 60 V	plug 110 V	plug 220 V
BI 10	plug 24 V	plug 60 V	plug 110 V	plug 220 V

Table 5.3 Checking for control voltages of binary inputs 5 to 10 on the additional module ZEA–2, valid from production series /HH



53000-G1176-C98

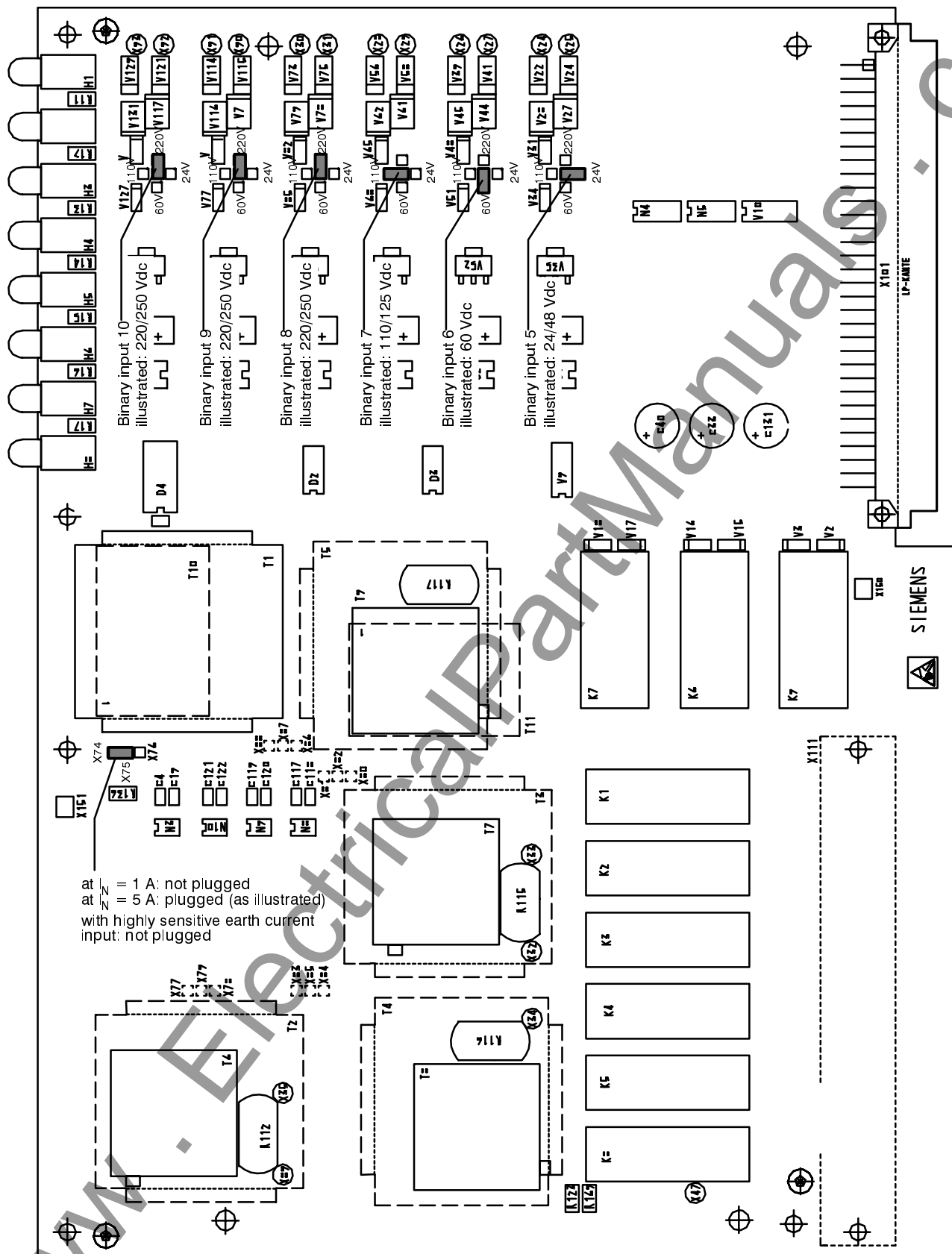


Figure 5.4 Setting plugs on additional input/output module ZEA-2, from production series /HH

- Open housing cover.
- Loosen the basic module using the pulling aids provided at the top and bottom.



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.

- Pull out basic module and place onto a conductive surface.
- For production series up to /GG: check the solder bridges according to Figure 5.1, remove bridges

where necessary.

For production series from /HH: check the plugs according to Figure 5.3.

- Insert basic module into the housing; ensure that the releasing lever is pushed fully to the left before the module is pressed in.
- Firmly push in the module using the releasing lever.
- Similarly check on the additional input/output module ZEA–2.
For production series up to /GG: check solder bridges according to Figure 5.2.
For production series from /HH: check the plugs according to Figure 5.4.
- Close housing cover.

5.2.3 Inserting the back-up battery

The device annunciations are stored in NV–RAMs. Even the fault recording data are stored in NV–RAMs for relays from production series /GG or later. A back-up battery is available 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 battery is supplied separately with relays of production series up to /GG. 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 /HH or later, the battery is installed at delivery so that no activities are necessary here.

5.2.4 Checking LSA transmission link

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 to the receive connection of the central unit and vice versa.

If data cables are used, the connections are marked in sympathy with ISO 2110 and DIN 66020:

TXD Transmit line of the respective unit
MT Frame reference for the transmit line

RXD Receive line of the respective unit
MR Frame reference for the receive line

The conductor screen and the common overall screen must be earthed at one line end only. This prevents circulating currents from flowing via the screen in case of potential differences.

Transmission via optical fibre is recommended. It is particularly insensitive against disturbances and automatically provides galvanic isolation. Transmit and receive connector 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 plug jumper X239 which is accessible when the basic input/output module is removed from the case. The jumper is situated in the rear area

of the power supply board (centre board) (Figure 5.5).

Jumper	Position	Normal signal position
X239	1 – 2	"Light off"
X239	2 – 3	"Light on"

The figure shows, additionally, the position of further plugs which are preset by the factory and must not be changed!

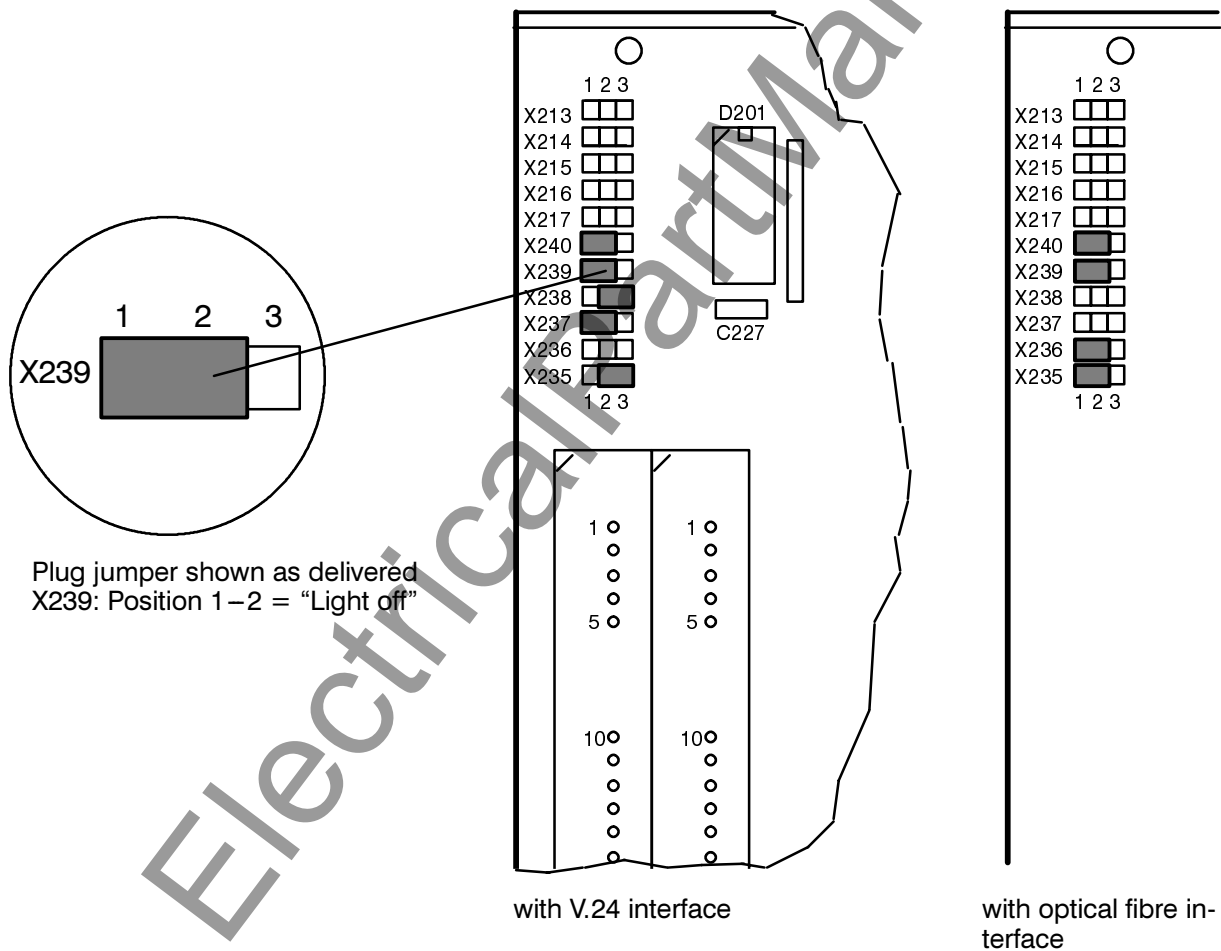


Figure 5.5 Position of the jumper X239 on the power supply board

5.2.5 Connections

General and connection diagrams are shown in Appendix A and B. The marshalling possibilities of the binary inputs and outputs are described in Section 5.5.



5.2.6 Checking the connections



Warning

Some of the following test steps are carried out in 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 them. 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 window-type summation current transformer correct (for the model with earth fault detection)?
- Is the polarity of the open delta winding on the voltage transformers and the connection correct (if fitted)?
- Are the polarities of the bus-bar voltage transformers correct (if used for synchronism or voltage check)?
- 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”  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 . The unit starts up and, on completion of the run-up period, the green LED on the front comes on, the red LED gets off after at most 7 sec.
- 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 breaker.
- Check through the control wiring to and from other devices.
- Check the signal circuits.
- Reclose 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 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 **000000** 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 **7000** and ENTER, key **E**. The address 7000 appears, which forms the heading of the configuration blocks:

↑	7000	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 **J/Y** that the new settings shall become valid now. If you press the "No" – key **N** in-

stead, 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 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, code-

word entry is necessary.

When delivered from factory, the date is shown in the European format.

$\uparrow \downarrow$ 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 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)

$\uparrow \downarrow$ 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 6.4.6 can be selected as messages in the 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 one or two serial interfaces: one PC interface in the front for operation by means of a personal computer and – dependent of the ordered model – 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	1													

Device type for identification of the device in Siemens LSA 678 and program DIGSI®. For 7SA511 V3 no. 21
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

Format of annunciations and fault records for the system (LSA) interface:

only data in accordance with VDEW/ZVEI (IEC 60870–5–103)

V D E W E X T E N D E D

data in accordance with VDEW/ZVEI (IEC 60870–5–103), extended by Siemens specified data

D I G S I V 3

format for Siemens protection data processing program DIGSI® Version V3

L S A

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

Format of measured values for the system (LSA) interface:

only data in accordance with VDEW/ZVEI (IEC 60870–5–103)

V D E W E X T E N D E D

data in accordance with VDEW/ZVEI (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

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**.

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

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

Parity and stop-bits for the system (LSA) interface:

format for VDEW–protocol (IEC 60870–5–103) or Siemens protection data processing program DIGSI® Version 3 and former LSA

N O 2 S T O P

transmission with NO parity and 2 STOP-bits

N O 1 S T O P

transmission with NO parity and 1 STOP-bit, e.g. modem

It is possible to switch the VDEW-protocol (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 (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 (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 (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 it 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

7	2	3	9	■	7	S	M	7	0	/	7	1
N O T C O N N E C T E D												
C O N N E C T E D												

If a fault location output device 7SM70 or 7SM71 is connected to the system interface, address 7239 7SM70/71 is to be set to *CONNECTED*. In all other cases the address remains *NOT CONNECTED*.

5.3.4 Settings for fault recording – address block 74

The distance protection relay is equipped with a fault data store (see Section 4.14.2). 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

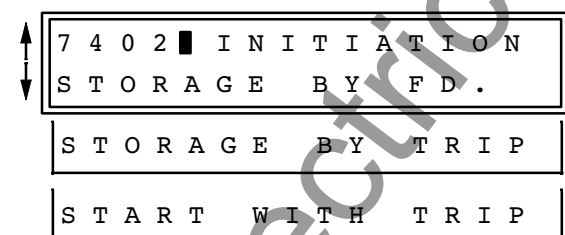
time T–PRE (address 7411) before the reference instant and ends with the post-fault time T–POST (address 7412) after the recording criterion has disappeared. The permissible recording time for each record is set under address 7410. Altogether 5 s are available for fault recording. In this time range 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. 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:

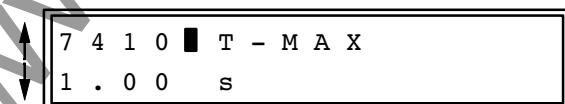
- fault detection is reference instant
fault detection is storage criterion
- fault detection is reference instant
trip command is storage criterion
- trip command is reference instant
trip command is storage criterion



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 (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.

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		

Only for communication with a former LSA system:

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** 7SA511 is capable of providing a series of **protection** and additional functions. The scope of the hard- and firmware 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-reclose 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 **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 **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 7SA511: 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 █ SCOPE OF
FUNCTIONS

Beginning of the block "Scope of functions"

Distance protection:

7 8 1 2 █ DIST. PROT.
EXIST
NON - EXIST

Teleprotection mode:

7 8 2 1 █ TELEPROTEC.
NON - EXIST
UNDERREACH
OVERREACH

Fault detection mode for distance protection:

7 8 1 3 █ DIST. F. DET.
OVERCURRENT
IMPEDANCE ZONE
U / I FAULT DET.

User definable logic functions:

7 8 2 3 USER LOGIC
NON - EXIST
EXIST

Power swing detection:

7 8 2 0 █ POWER SWING
NON - EXIST
EXIST

Emergency overcurrent time protection:

7 8 2 6 █ EMERG. O / C
EXIST
NON - EXIST

Thermal overload protection:

7 8 2 7 ■ T H E R M A L O L
N O N - E X I S T
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

Earth fault detection in non-earthed system:

7 8 3 0 ■ I S O L . E / F
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

High resistance earth fault protection in earthed system:

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 / N O N - D I R
D I R E C . C O M P A R I S O N
I N V E R S E T I M E

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

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 7SA511, 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 applicable 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				

When signal transmission is distorted or switched off

YES – AR operates as set
NO – AR is blocked

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 – AR is blocked

7 9 3 0	■	A R	w /	I S . E F
Y E S				
N O				

Earth fault detection in non-earthed systems

YES – AR works in accordance with the setting (only when tripping on earth fault is allowed)
NO – AR is blocked

7 9 3 1 ■ A R w / E / F
Y E S
N O

With earth fault protection (for earthed networks)

YES – AR will be carried out but only three-pole

NO – no AR will be carried out

7 9 4 1 ■ A R w / E X T .
Y E S
N O

With external trip via binary input

YES – AR will be carried out but only three-pole

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 to 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 7SA511 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 7SA511 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 7, the processor must be advised that the logical signal “Dist.Fault L1” should be transmitted to the signal relay 7. 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 (physi-

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 an "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 $\uparrow \downarrow$ or $\uparrow \downarrow$ 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 10 binary inputs which are designated INPUT 1 to INPUT 10. They can be marshalled in address block 61. The address block is reached by paging in blocks $\uparrow \downarrow$ or by direct addressing with **DA 6 1 0 0 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 5.1 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 to 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 assignment of the binary inputs as delivered from factory is shown in the general diagrams in Appendix A. The following boxes show, as an example, the allocation for binary input 1. Table 5.2 shows all binary inputs as preset from the factory.



6 1 0 0 ■ M A R S H A L L I N G
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 \uparrow :



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** \uparrow :



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
354	>CB Aux.3p cl	Circuit breaker is 3-pole closed (from CB auxiliary contact)
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
1251	>E/F Det. on	Switch on earth fault detection for non-earthed system
1252	>E/F Det. off	Switch off earth fault detection for non-earthed system
1253	>E/F Det.bloc	Block earth fault detection for non-earthed system
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
1501	>O/L on	Switch on overload protection
1502	>O/L off	Switch off overload protection
1503	>O/L block	Block overload protection
2003	>Emer. block	Block emergency overcurrent protection
2010	>I>> block	Block I>> stage of emergency 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 statically
2704	>AR reset	Reset internal auto-reclose function
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

Table 5.1 Marshalling possibilities for binary inputs (continued next page)

FNo	Abbreviation	Description
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
4004	>Dis. Recept	Carrier reception signal for distance protection
4005	>Dis.RecFail	Carrier reception for distance protection faulty
4011	>Dis.POTT on	Switch on permissive overreach transfer function
4012	>Dis.POTT off	Switch off permissive overreach transfer function
4021	>Dis.PUTT on	Switch on permissive underreach transfer function
4022	>Dis.PUTT off	Switch off permissive underreach transfer function
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 5.1 Marshalling possibilities for binary inputs

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 >CB Aux.3p cl NO	354	from circuit breaker auxiliary contact: CB position is ON
6104	BINARY INPUT 4	INPUT 4 >Manual Close NO	356	Manual close command from discrepancy switch
6105	BINARY INPUT 5	INPUT 5 >Dis. Recept NO	4004	from carrier device for teleprotection with distance protection
6106	BINARY INPUT 6	INPUT 6 >Dis.RecFail NO	4005	
6107	BINARY INPUT 7	INPUT 7 >CB ready NO	2730	Binary inputs 7 to 11 are only effective when the internal auto-reclose function is available in the relay and has been configured as <i>EXIST</i> (refer to Section 5.4.2).
6108	BINARY INPUT 8	INPUT 8 >AR block NO	2703	
6109	BINARY INPUT 9	INPUT 9 >AR on NO	2701	
6110	BINARY INPUT 10	INPUT 10 >AR off NO	2702	

Table 5.2 Preset binary inputs

5.5.3 Marshalling of the signal output relays – address block 62

The unit contains 11 signal outputs (alarm relays). The signal relays are designated SIGNAL RELAY 1 to SIGNAL RELAY 11 and can be marshalled in address block 62. The block is reached by paging in blocks with $\uparrow \downarrow$ or by directly addressing **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 physical signal relays (see also Section 5.5.1).

Table 5.3 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 to Section 5.4.2).

Note as to Table 5.3: 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 assignment of the output signal relays as delivered from factory is shown in the general diagrams in Appendix A. The following boxes show examples for marshalling. In the example for signal relay 4 the group annunciation for several annunciation functions on one signal relay is shown. Table 5.4 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 i s . S e n d

Signal relay 1 has been preset for:
Transmission signal for carrier for teleprotection
with distance protection, FNo 4056;

$\uparrow \downarrow$ 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 . Signal relay 4 represents – as preset from the factory – an example for a group annunciation, i.e. several logical annunciation functions are given to one output signal relay.

\uparrow 6 2 0 4 ■ S I G N A L
R E L A Y 4

Allocations for signal relay 4,
Meaning: "Failure in measured quantities"

$\uparrow \downarrow$ 0 0 1 ■ R E L A Y 4
> V T m c b T r i p

Signal relay 4 has been preset for:
1st: Voltage transformer secondary m.c.b. has
tripped, FNo 361;

0 0 2 ■ R E L A Y 4
F a i l u r e Σ I

Signal relay 4 has been preset for:
2nd: Failure detected by measured current sum monitor, FNo 162;

0 0 3 ■ R E L A Y 4
F a i l u r e Σ U p - e

Signal relay 4 has been preset for:
3rd: Failure detected by measured voltage sum monitor phase-to-earth, FNo 165;

0 0 4 ■ R E L A Y 4
F a i l u r e Σ U p - p

Signal relay 4 has been preset for:
4th: Failure detected by measured voltage sum monitor phase-to-phase, FNo 166;

0 0 5 ■ R E L A Y 4
F a i l u r e I s y m m

Signal relay 4 has been preset for:
5th: Failure detected by measured current symmetry monitor, FNo 163;

0 0 6 ■ R E L A Y 4
F a i l u r e U s y m m

Signal relay 4 has been preset for:
6th: Failure detected by measured voltage symmetry monitor phase-to-phase, FNo 167;

0 0 7 ■ R E L A Y 4
F a i l u r e U m e a s

Signal relay 4 has been preset for:
7th: Failure detected by measured voltage monitor (measured voltage collapsed), FNo 168;

0 0 8 ■ R E L A Y 4
F u s e - F a i l u r e

Signal relay 4 has been preset for:
8th: Failure detected by fuse failure monitor, FNo 169;

0 0 9 ■ R E L A Y 4
F a i l . P h a s e s e q

Signal relay 4 has been preset for:
9th: Failure detected by phase sequence monitor, FNo 171;

0 1 0 ■ R E L A Y 4
n o t a l l o c a t e d

no further functions are preset for signal relay 4

After input of all annunciation functions for signal relay 4, change back to the marshalling level is carried out with **F** ↑:

6 2 0 4 ■ S I G N A L
R E L A Y 4

Allocations for signal relay 4,
Meaning: "Failure in measured quantities"

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 device operative
52	Prot. operat.	At least one protection function is operative
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
151	Failure I/O 1	Failure in first input/output module (base module GEA)
152	Failure I/O 2	Failure in additional input/output module (additional module ZEA)
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
354	>CB Aux.3p cl	Circuit breaker position is ON (from CB auxiliary contact)
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 5.3 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
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 1p L1	Trip by internal circuit breaker test function single-pole L1
1183	CB Test 1p L2	Trip by internal circuit breaker test function single-pole L2
1184	CB Test 1p L3	Trip by internal circuit breaker test function single-pole L3
1185	CB Test 3p	Trip by internal circuit breaker test function three-pole L123
1251	>E/F Det. on	Switch on earth fault detection for non-earthed system
1252	>E/F Det. off	Switch off earth fault detection for non-earthed system
1253	>E/F Det.bloc	Block earth fault detection for non-earthed system
1261	E/F Det. off	Earth fault detection for non-earthed system is switched off
1262	E/F Det.block	Earth fault detection for non-earthed system is blocked
1263	E/F Det.activ	Earth fault detection for non-earthed system is active
1271	E/F Detection	Earth fault in non-earthed system detected
1272	E/F Detec. L1	Earth fault (non-earthed) in phase L1 detected
1273	E/F Detec. L2	Earth fault (non-earthed) in phase L2 detected
1274	E/F Detec. L3	Earth fault (non-earthed) in phase L3 detected
1276	E/F forwards	Earth fault (non-earthed) in forward direction detected
1277	E/F reverse	Earth fault (non-earthed) in reverse direction detected
1278	E/F undefined	Earth fault (non-earthed) direction undefined
1281	E/F Det. Trip	Trip by earth fault detection
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 (definite or inverse time)
1343	E/F Flt Ie ->	Earth fault protection directional stage I_E picked up
1344	E/F Ue>	Earth fault displacement voltage U_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)
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

Table 5.3 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
1501	>O/L on	Switch on thermal overload protection
1502	>O/L off	Switch off thermal overload protection
1503	>O/L block	Block thermal overload protection
1511	O/L Prot. off	Thermal overload protection is switched off
1512	O/L blocked	Thermal overload protection is blocked
1513	O/L active	Thermal overload protection is active
1515	O/L Warn I	Thermal overload protection current warning stage picked up
1516	O/L Warn Θ	Thermal overload protection thermal warning stage picked up
1517	O/L pickup Θ	Thermal overload protection fault detection of trip stage
1521	O/L Trip	Thermal overload protection trip by trip stage
2003	>Emer. block	Block emergency overcurrent time protection
2010	>I>> block.	Block I>> stage of 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
2054	Emer. mode	Emergency overcurrent time mode is running
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
2093	Emer. I>	Fault detection of I> stage of emergency O/C protection
2097	Emer. IE>	Fault detection of I _E > stage of emergency O/C protection
2121	Emer. TI>>	Emergency O/C protection time T-I>> expired
2123	Emer. TI>	Emergency O/C protection time T-I> expired
2127	Emer. TIE>	Emergency O/C protection time T-I _E > 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
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 (abort)
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

Table 5.3 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
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 evol.v.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
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

Table 5.3 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
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
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
3719	Dist. For.Dir	Distance protection: Fault in forward direction
3720	Dist. Rev.Dir	Distance protection: Fault in reverse direction
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) 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)

Table 5.3 Marshalling possibilities for signal relays and LEDs (continued next page)

FNo	Abbreviation	Description
4004	>Dis. Recept	Carrier reception signal for distance protection
4005	>Dis.RecFail	Carrier reception faulty signal for distance protection
4011	>Dis.POTT on	Switch on permissive overreach transfer function
4012	>Dis.POTT off	Switch off permissive overreach transfer function
4021	>Dis.PUTT on	Switch on permissive underreach transfer function
4022	>Dis.PUTT off	Switch off permissive underreach transfer function
4051	Dis.Tele. on	Teleprotection with distance protection is switched on
4052	Dis.Tele. off	Teleprotection with distance protection is switched off
4054	Dis. Recept	Carrier signal for distance protection received
4055	Dis. RecFail	Carrier reception for distance protection faulty
4056	Dis. Send	Transmission signal from distance protection
4067	Dis.POTT Echo	Echo signal (distance protection) transmitted
4068	Dis.TransBlo	Transient blocking (distance protection) is running
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
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 5.3 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 Dis. Send	4056	Transmission signal for carrier from teleprotection with distance protection
6202	SIGNAL RELAY 2	RELAY 2 AR inoperativ	2783	only when auto-reclose function is available and configured as EX/ST
6203	SIGNAL RELAY 3	RELAY 3 CB Alarm Supp	563	
6204	SIGNAL RELAY 4 RELAY 4 RELAY 4 RELAY 4 RELAY 4 RELAY 4 RELAY 4 RELAY 4 RELAY 4	RELAY 4 >VT mcb Trip Failure Σ I Failure Σ Up-e Failure Σ 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
6205	SIGNAL RELAY 5	RELAY 5 Dev.operative	51	The NC contact of this relay indicates "Device fault"
6206	SIGNAL RELAY 6	RELAY 6 Device Trip	511	Trip signal given by either protection function of the device
6207	SIGNAL RELAY 7 RELAY 7	RELAY 7 Dist.Fault L1 Emer. Flt L1	3672 2062	Fault detection annunciations of the distance protection function or emergency overcurrent time protection
6208	SIGNAL RELAY 8 RELAY 8	RELAY 8 Dist.Fault L2 Emer. Flt L2	3673 2063	
6209	SIGNAL RELAY 9 RELAY 9	RELAY 9 Dist.Fault L3 Emer. Flt L3	3674 2064	
6210	SIGNAL RELAY 10 RELAY 10	RELAY 10 Dist.Fault E Emer. Flt E	3675 2065	
6211	SIGNAL RELAY 11	RELAY 11 Dev.Trip Rev.	517	Fault in reverse direction

Table 5.4 Preset annunciations for signal relays

5.5.4 Marshalling of the LED indicators – address block 63

The unit contains 16 LEDs for optical indications, 14 of which can be marshalled. They are designated LED 1 to LED 14 and can be marshalled 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).

essary 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 **R**. 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 5.5 shows all LED indicators as they are preset from the factory.

With direct input of the function number it is not nec-

$\uparrow \downarrow$ 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,
Meaning: “Failure in measured quantities”

Change over to the selection level with **F** \uparrow :

$\uparrow \downarrow$ 0 0 1 ■ L E D 1
> V T m c b T r i p n m

LED 1 has been preset for:
1st: Voltage transformer secondary m.c.b. has tripped, FNo 361;

$\uparrow \downarrow$ 0 0 2 ■ L E D 1
F a i l u r e Σ I n m

LED 1 has been preset for:
2nd: Failure detected by measured current sum monitor, FNo 162:

0 0 3 ■ LED 1
Failure Σ Up - e n m

LED 1 has been preset for:
3rd: Failure detected by measured voltage sum monitor phase-to-earth, FNo 165;

0 0 4 ■ LED 1
Failure Σ Up - p n m

LED 1 has been preset for:
4th: Failure detected by measured voltage sum monitor phase-to-phase, FNo 166;

0 0 5 ■ LED 1
Failure I s y m m n m

LED 1 has been preset for:
5th: Failure detected by measured current symmetry monitor, FNo 163;

0 0 6 ■ LED 1
Failure U s y m m n m

LED 1 has been preset for:
6th: Failure detected by measured voltage symmetry monitor phase-to-phase, FNo 167;

0 0 7 ■ LED 1
Failure U m e a s n m

LED 1 has been preset for:
7th: Failure detected by measured voltage monitor (measured voltage collapsed), FNo 168;

0 0 8 ■ LED 1
Fuse - Failure n m

LED 1 has been preset for:
8th: Failure detected by fuse failure monitor, FNo 169;

0 0 9 ■ LED 1
Fail . Phase Seq n m

LED 1 has been preset for:
9th: Failure detected by phase sequence monitor, FNo 171;

0 1 0 ■ LED 1
not allocated

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** ↑:

6 3 0 1 ■ LED 1

Allocations for LED 1 ,
Meaning: "Failure in measured quantities"

The complete presettings for LED indicators are listed in Table 5.5.

Addr	1st display line	2nd display line	FNo	Remarks
6300	MARSHALLING	LEDs		Heading of the address block
6301	LED 1 LED 1 LED 1 LED 1 LED 1 LED 1 LED 1 LED 1 LED 1 LED 1	>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
6302	LED 2 LED 2 LED 2	Dist.Fault L1 m Emer. Flt L1 m	3672 2062	Fault detection annunciations of the distance protection function or the emergency overcurrent time protection
6303	LED 3 LED 3 LED 3	Dist.Fault L2 m Emer. Flt L2 m	3673 2063	
6304	LED 4 LED 4 LED 4	Dist.Fault L3 m Emer. Flt L3 m	3674 2064	
6305	LED 5 LED 5 LED 5	Dist.Fault E m Emer. Flt E m	3675 2065	
6306	LED 6 LED 6	AR not ready nm	2784	only when the internal auto-reclose function is available and configured as <i>EXIST</i>
6307	LED 7 LED 7 LED 7	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
6308	LED 8 LED 8	Dist. T2 m	3774	
6309	LED 9 LED 9	Dist. T3 m	3777	
6310	LED 10 LED 10	Dist. T4 m	3778	
6311	LED 11 LED 11 LED 11 LED 11	Dist. T5 m Emer. TI> m Emer. TIE> m	3779 2123 2127	
6312	LED 12 LED 12 LED 12	Dev.Trip 1pL1 m Dev.Trip 3p m	512 515	Trip signal given by either protection function of the device
6313	LED 13 LED 13 LED 13	Dev.Trip 1pL2 m Dev.Trip 3p m	513 515	
6314	LED 14 LED 14 LED 14	Dev.Trip 1pL3 m Dev.Trip 3p m	514 515	

Table 5.5 Preset LED indicators

5.5.5 Marshalling of the command (trip) relays – address block 64

The unit contains 5 trip relays which are designated TRIP RELAY 1 to TRIP RELAY 5. 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 5.3 can be marshalled to output command relays. But those listed in Table 5.6 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 assignment of the trip relays as delivered from

factory is shown in the general diagrams in Appendix A. The following boxes show examples for marshalling of trip relays 1 and 3. In the example for trip relay 3 the group command for several command functions on one trip relay is shown. Table 5.7 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. "Dev.Trip 1pL1" (FNo 512) for pole L1, as also the three-pole command "Dev.Trip 3p" (FNo 515) is 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 command 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"

The first trip relay is reached with the key \uparrow :

$\uparrow\downarrow$ 6 4 0 1 ■ T R I P
R E L A Y 1

Allocations for trip relay 1

Change over to the selection level with **F** \uparrow :

$\uparrow\downarrow$ 0 0 1 ■ T R I P R E L . 1
A R C l o s e C m d .

Trip relay 1 has been preset for:
Auto-reclose command by internal auto-reclose function, FNo 2851;

$\uparrow\downarrow$ 0 0 2 ■ T R I P R E L . 1
n o t a l l o c a t e d

no further functions are preset for trip relay 1

Leave the selection level with key combination **F** \uparrow . You can go then to the next trip relay with the arrow key \uparrow . Trip relay 3 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 3 ■ T R I P
R E L A Y 3

Allocations for trip relay 3:
"Trip circuit breaker pole L1"

0 0 1 ■ T R I P R E L . 3
D e v . T r i p 1 p L 1

Trip relay 3 has been preset for:
1st: General single-pole trip command of the device for breaker pole L1, FNo 512

0 0 2 ■ T R I P R E L . 3
D e v . T r i p 3 p

Trip relay 3 has been preset for:
2nd: General three-pole trip command of the device, FNo 515

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
1182	CB Test 1p L1	Trip by internal circuit breaker test function single-pole L1
1183	CB Test 1p L2	Trip by internal circuit breaker test function single-pole L2
1184	CB Test 1p L3	Trip by internal circuit breaker test function single-pole L3
1185	CB Test 3p	Trip by internal circuit breaker test function three-pole L123
1281	E/F Det. Trip	Trip by earth fault detection in non-earthed systems
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 (definite time or inverse time)
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)
1384	E/F Send	Carrier transmission signal for directional comparison E/F
1521	O/L Trip	Thermal overload protection trip by trip stage
2061	Emerg.Gen.Flt	General fault detection of 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
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

Table 5.6 Command functions (continued next page)

FNo	Abbreviation	Logical command function
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
4056	Dis. Send	Transmission signal from distance protection
4166	O/S Trip	Out-of-step trip command
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 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 5.6 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 when internal auto-reclose function is available and configured as <i>EXIST</i>
6402	TRIP TRIP REL. 2	RELAY 2 Device FltDet	501	General fault detection of the device
6403	TRIP TRIP REL. 3 TRIP REL. 3	RELAY 3 Dev.Trip 1pL1 Dev.Trip 3p	512 515	Trip command for circuit breaker pole L1
6404	TRIP TRIP REL. 4 TRIP REL. 4	RELAY 4 Dev.Trip 1pL2 Dev.Trip 3p	513 515	Trip command for circuit breaker pole L2
6405	TRIP TRIP REL. 5 TRIP REL. 5	RELAY 5 Dev.Trip 1pL3 Dev.Trip 3p	514 515	Trip command for circuit breaker pole L3

Table 5.7 Preset command functions for trip relays

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:



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:



Codeword: prevents unauthorized access to setting programs (not necessary for call-up of annunciations or messages)



Backspace erasure of incorrect entries



Function key; explained when used



Direct addressing: if the address number is known, this key allows direct call-up of the address



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

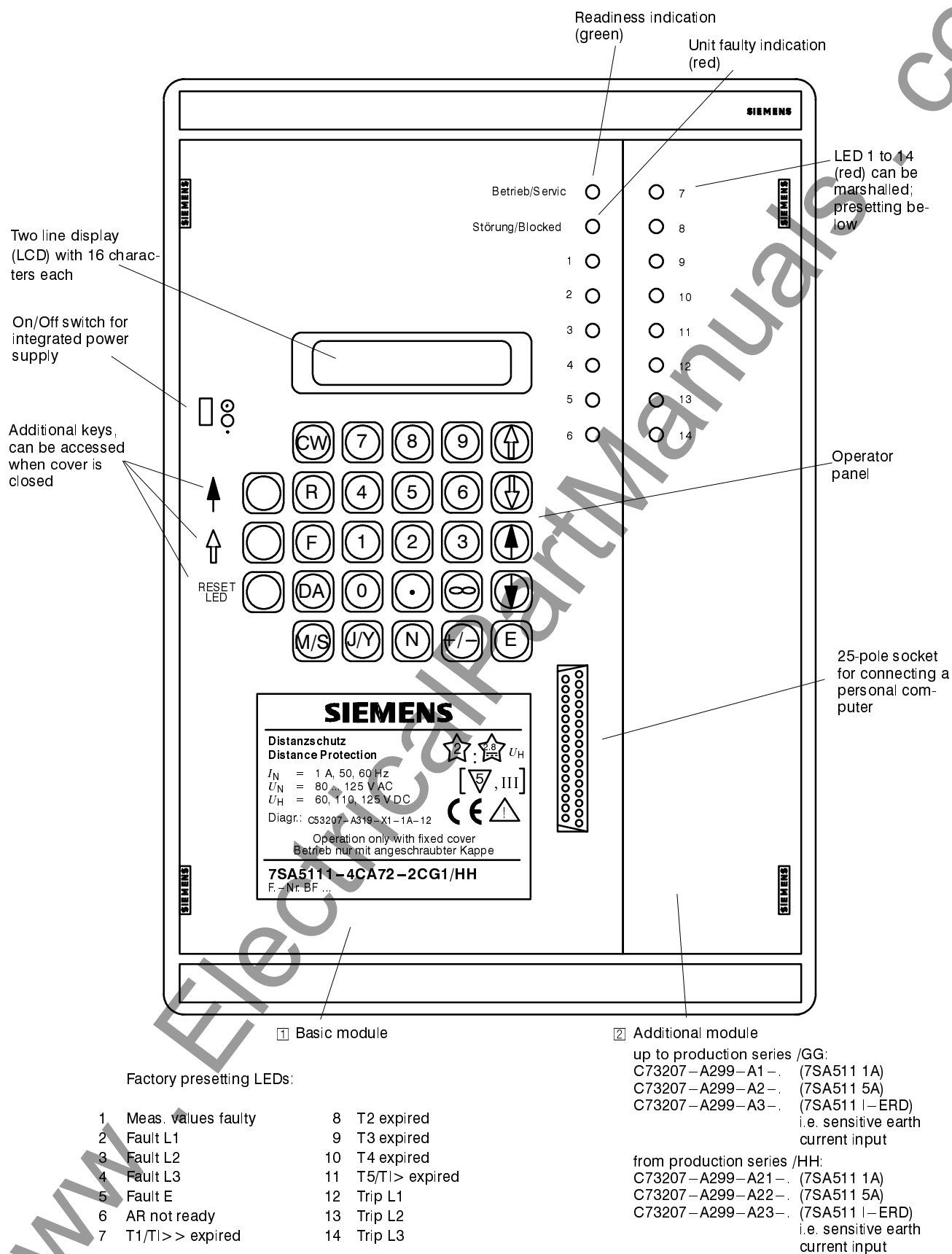
For most operational functions, the input of a codeword is necessary. This applies for all entries via the membrane keyboard or front interface which concern the operation on the relay, for example

- setting of functional parameters (thresholds, functions),
- allocation or marshalling of signals, binary inputs, LED indicators,
- configuration parameters for interface and device 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)



① Basic module

② Additional module

Factory presetting LEDs:

- | | |
|-----------------------|-------------------|
| 1 Meas. values faulty | 8 T2 expired |
| 2 Fault L1 | 9 T3 expired |
| 3 Fault L2 | 10 T4 expired |
| 4 Fault L3 | 11 T5/TI> expired |
| 5 Fault E | 12 Trip L1 |
| 6 AR not ready | 13 Trip L2 |
| 7 T1/TI>> expired | 14 Trip L3 |

up to production series /GG:
 C73207-A299-A1- (7SA511 1A)
 C73207-A299-A2- (7SA511 5A)
 C73207-A299-A3- (7SA511 I-ERD)
 i.e. sensitive earth current input

from production series /HH:
 C73207-A299-A21- (7SA511 1A)
 C73207-A299-A22- (7SA511 5A)
 C73207-A299-A23- (7SA511 I-ERD)
 i.e. sensitive earth current input

Figure 6.1 Front view of operating key board and display panel

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 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. **1102** for block **11**, sequence number **2**). 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 General trip of the device “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 functional 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 parameterizing. 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 (optional)

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 to 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 if the 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.

↑ ↓
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 ↑.

↑ ↓
0 9 . 0 4 . 1 9 9 7
0 9 : 1 9 : 5 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

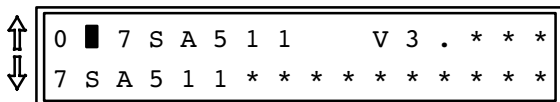
Enter the new time: hours, minutes, seconds, each with 2 digits, separated by a dot:
HH.MM.SS

↑ ↓
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.

6.3.2 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.



The relay introduces itself by giving its type number, the version of firmware with which it is equipped, and a hardware identifier. 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”.



Commencement of functional parameter blocks

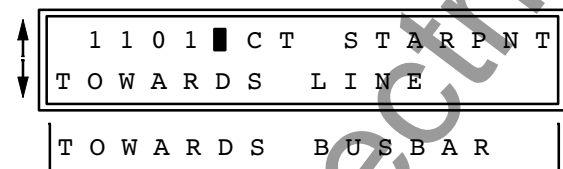
6.3.3 Power system data – address block 11

6.3.3.1 General data

The relay requests basic data of the power system and the switchgear.



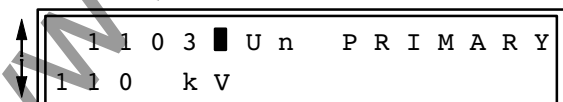
Beginning of the block “Power system data”



Current transformer polarity:
LINE – c.t. star-point towards line
BUSBAR – c.t. star-point towards busbar
 This setting determines the measurement direction of the relay (forwards = line direction)



System star-point condition:
 Important for earth fault and double earth fault conditions



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**

With addresses 1109 to 1116, the device is instructed as to how the additional current and voltage inputs are connected. This information is important for the treatment of earth faults (in earthed networks), earth leakage (in unearthed networks), parallel line compensation for fault location (if used), synchronism and voltage check (if used), and the monitoring of measured values.

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.6 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 Uph/Udelta (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.

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.9 in Appendix B). Under address 1116 the device must be informed to 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 and voltage check.

Three possibilities exist for the earth current path:

- Connection of the earth current from the star point of the current transformers (standard circuit arrangement, see also Appendix B, Figure B.2):

Address 1111 is then set as
 Ie CT = *PROTECTED LINE*

Address 1112 is set as Ie/Iph = 1.000

- Connection of the earth current from the transformer star point of a parallel line (compensation of fault location for parallel lines – only for type 7SA511★–★★★★–2★★, see also Appendix B, Figure B.3):

Address 1111 is then set as
 Ie CT = *PARALLEL LINE*

Address 1112 is set as Ie/Iph = 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 Ie/Iph, e.g.

current transformers protected line	1000A/1A
current transformers parallel line	1200A/1A

results in Ie/Iph = 1200/1000 = 1.200

- Connection of the earth current from a separate earth current detection transformer (e.g. window type current transformer for earth fault detection, see also Appendix B, Figure B.4).

Address 1111 is then set as
 Ie CT = *PROTECTED LINE*

For units with highly sensitive earth current input, address 1111 needs not be set; it is not available.

Address 1112 is set as

$$I_e/I_{ph} = \frac{\text{ratio of the earth current CT}}{\text{ratio of the phase current CT}}$$

Example:

Phase current transformers 400 A/5 A
Window type summation transformer 60 A/1 A

Relay type for highly sensitive earth fault detection

$$I_e/I_{ph} = \frac{60/1}{400/5} = 0.750$$

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 e n 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:

rated secondary voltage of v.t. phase winding

rated secondary voltage of open delta winding

normally 1.73

Smallest setting value:

0.10

largest setting value:

9.99

1 1 1 1	I 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		

Current which is connected to the I_E measuring input of the relay

Note: Address 1111 is only available in models with parallel line compensation (7SA511★–*****–2★★); in other cases, *PROTECTED LINE* is internally fixed

1 1 1 2	I e / I p h
1 . 0 0 0	

Matching factor for earth current:

1 for connection in c.t. starpoint;

(window–type) earth c.t. ratio

(phase) c.t. ratio

for connection to separate earth current transformer

Smallest setting value:

0.100

Largest setting value:

20.000

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 and voltage 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 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

110 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 600 A/5 A

Voltage transformers 110 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 7SA511 when it incorporates the parallel line fault location feature and has been ordered with parallel line compensation. This compensation can only be effective for fault location when, additionally, address 3805 is set as PARALLEL LINE = YES (Section 6.3.15).

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 systems

X_1 – positive sequence reactance of the lines

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	XE / XL
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 fault locator is used with parallel line compensation:

1 1 1 9	RM / RL
0 . 0 0	

Matching of mutual impedance, resistance ratio

Smallest setting value: **-7.00**Largest setting value: **7.00**

1 1 2 0	XM / XL
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 1122 to 1132.

Where N_{ct} – c.t. ratio N_{vt} – v.t. ratio I_N/A – rated current of the current transformers = rated current of the device

The reactance per unit line length (address 1122) is entered as secondary value. This can be derived from the primary value using the formula

$$X_{sec} = \frac{N_{ct}}{N_{vt}} \cdot X_{prim} \cdot \frac{I_N}{A}$$

Finally, the line length is entered under address 1124. It is used for fault location.

1 1 2 2	X SEC
0 . 5 0 0	Ω/ km

Line reactance per unit line length, secondary, only for fault location (refer to Section 6.3.15)

Smallest setting value: **0.010** Ω/kmLargest setting value: **5.000** Ω/km

1 1 2 4	LINE LENGTH
1 0 0 . 0	km

Length of the total line, secondary, only for fault location (refer to Section 6.3.15)

Smallest setting value: **1.0** kmLargest setting value: **550.0** km

Note: When the line length is entered in miles instead of kilometers, and the line constants are entered in ohms per mile, then the relay will operate properly.

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) ($I > 0,1 I_N$) and the duration without current flow T TRIP I < (address 1131).

1	1	3	0	T - T R I P 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 - T R I P 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 110 kV primary
110 V secondary

A power transformer should be installed between bus-bar voltage transformers and feeder voltage transformers:

Power transformer 400 kV/110 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°

1	1	3	2	U 1 - U 2 A N G L
0	.			°

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 1150, 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 of any of the protection functions.

The phase(s) in which fault detection is registered, are decisive for the selected line loop and thus, for the trip command being single-pole or three-pole, in 7SA511. Another pick-up during output of the trip command results in three-pole coupling of the trip

command. This corresponds to the presetting of address 1136 3–P. COUPL = *WITH FAULT DETEC*. If address 1137 is set to *WITH TRIP COMM*, three-pole coupling of the trip command is suppressed when pick-up in another phase is registered only after the single-pole trip is initiated. This setting is reasonable when it can be assumed that a further pick-up after initiation of the trip command must arise from a different, independent fault event. This setting is valid for all protection functions of the relay which can trip single-pole.

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.

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 protection closing (e.g. over-reach zone of the distance protection).

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
- after initiation of a single-pole *TRIP* decision, no three-pole coupling is effective

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

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 stage 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**

1 1 5 0 ■ F I L T E R
 N O R M A L

L O N G

Filter for measured quantities

NORMAL filter

LONG filter for difficult measuring conditions

6.3.4 Settings for distance protection

Since the main function of 7SA511 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

7SA511 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.

In address block 12, the direction of the directional stage and the delay times T4 and T5 are set.

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!

↑

↓

1

2

0

0

■

D

I

S

T

.

P

R

O

T

.

G

E

N

E

R

A

L

S

E

T

T

I

N

G

S

Beginning of the block
"Distance protection general settings"

↑

↓

1

2

0

1

■

D

I

S

T

.

P

R

O

T

.

O

N

O

F

F

Distance protection is
ON switched on
or
OFF switched off

↑

↓

1

2

0

2

■

D

I

R

.

F

D

&

T

4

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 directional trip with fault detection, which can be set
FORWARDS (line direction) or
REVERSE (busbar direction) or
NON-DIRECTIONAL (either direction)

↑

↓

1

2

0

3

■

T

4

0

.

9

0

s

Delay for T4 (fault detection directional trip)
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ (no directional trip)

↑

↓

1

2

0

4

■

T

5

1

.

2

0

s

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) *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.

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-reclosure. 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*.

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:

- Z1B DIRECTIONAL* i.e. the overreach zone, directional as set in address 1414
- Z1B NON-DIRECT* i.e. the overreach zone, non-directional
- FD EFFECTIVE* i.e. fault detection zone, non-directional
- Z1 EFFECTIVE* i.e. the normal first zone: no special measures

1 2 1 6	R A R - > Z 1 B
Y E S	
N O	

Zone *Z1B* is effective before RAR

YES or

NO

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

Zone Z1L is effective before DAR
YES or

NO

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 pole faults higher than that of an associated differential earth fault protection (T1 1PHASE grater than T1 >1PHASE) or, set a shorter reserve time for multi-pole 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 1 A. 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

110 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 600 A/5 A

Voltage transformers 110 kV/0.1 kV

Maximum overload:

$P_{\text{max}} = 130 \text{ MVA}$ corresponding

$I_{\text{max}} = 680 \text{ A}$

Figure 6.2 shows a sample network section with primary grading plan.

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

$X_{1\text{prim}} = 0.85 \cdot X_a = 0.85 \cdot 23.4 \, \Omega = 19.89 \, \Omega$

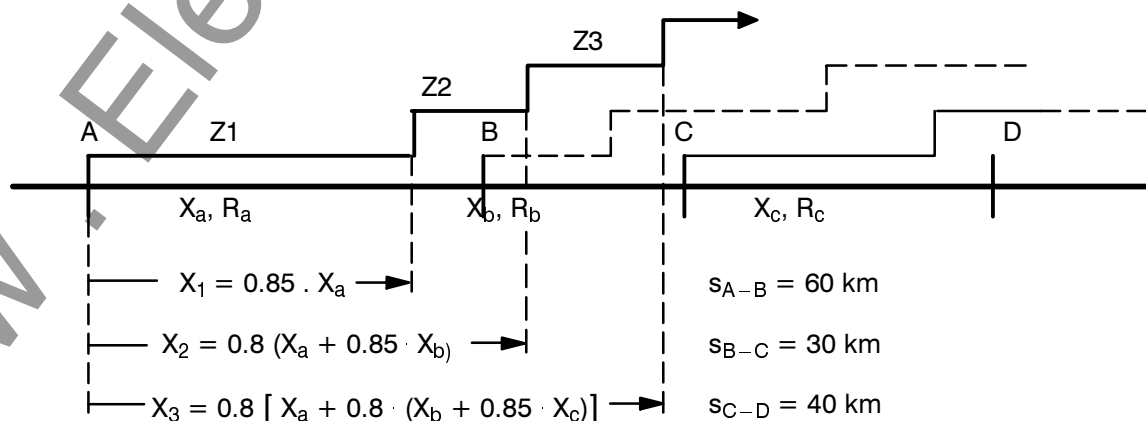


Figure 6.2 Grading plan related to above calculation example

Zone 1 secondary

$$X1_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X1_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{600/5}{110/0.1} \cdot 19.89 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 10.85 \, \Omega$$

Zone 2 primary 80 % up to Z1 of the next line b

$$X2_{\text{prim}} = 0.8 \cdot (X_a + 0.85 X_b)$$

$$= 0.8 \cdot (23.4 \, \Omega + 0.85 \cdot 11.7 \, \Omega)$$

$$= 26.68 \, \Omega$$

Zone 2 secondary

$$X2_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X2_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{600/5}{110/0.1} \cdot 26.68 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 14.55 \, \Omega$$

Zone 3 primary 80 % up to Z2 of the next line b

$$X3_{\text{prim}} = 0.8 \cdot [X_a + 0.8 \cdot (X_b + 0.85 X_c)]$$

$$= 0.8 \cdot [23.4 \, \Omega + 0.8 \cdot (11.7 \, \Omega + 0.85 \cdot 15.6 \, \Omega)]$$

$$= 34.69 \, \Omega$$

Zone 3 secondary

$$X3_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X3_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{600/5}{110/0.1} \cdot 34.69 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 18.92 \, \Omega$$

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

$$R1_{\text{prim}} = R1_{\text{line}} + \frac{1}{2} \cdot R_{\text{arc}}$$

$$= 6.63 \, \Omega + \frac{1}{2} \cdot 12 \, \Omega = 12.63 \, \Omega$$

$$R1_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot R1_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{600/5}{110/0.1} \cdot 12.63 \, \Omega \cdot \frac{5 \, \text{A}}{A}$$

$$= 6.9 \, \Omega$$

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

$$R1E_{\text{prim}} = R1_{\text{line}} + R_{\text{arc}} + R_{\text{tower}}$$

$$= 6.63 \, \Omega + 9 \, \Omega + 25 \, \Omega$$

$$= 40.63 \, \Omega$$

$$R1E_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot R1E_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{600/5}{110/0.1} \cdot 40.63 \, \Omega \cdot \frac{5 \, \text{A}}{A}$$

$$= 22.2 \, \Omega$$

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

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

Smallest setting value:

0.05 Ω

Largest setting value:

65.00 Ω

1	3	0	2	█	X 1
2	.	5	0		Ω

Reactance value (reach)

Smallest setting value:

0.05 Ω

Largest setting value:

130.00 Ω

1	3	0	3	█	R 1 E
2	.	5	0		Ω

Resistance for phase–earth

Smallest setting value:

0.05 Ω

Largest setting value:

130.00 Ω

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:

130.00 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:

130.00 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:
 Largest setting value:
 and ∞ (no trip in zone Z3)

0.00 s
 32.00 s

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 the corresponding settings are irrelevant.

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.

Both stages can also be used for selection between cable and overhead line sections in case of mixed lines (refer to Section 6.3.4.1 for more details). 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 > 1PHAS).

Measurement direction can also be set individually for the overreach zones.

NOTE: The directions set for zone Z1B and Z1L apply in general for this stage, independent of the cause which leads to activation of one of these zones.

1	4	0	0	■	D	I	S	T	.	P	R	O	T	.
C	O	N	T	R	O	L	L	E	D	Z	O	N	E	S

Beginning of block
 "Distance protection, controlled zones
 Z1B and Z1L"

Overreach zone Z1B (controlled by RAR, teleprotection signals or binary input)

1	4	0	1	■	R	1	B
1	.	5	0	Ω			

Resistance for phase–phase
 Smallest setting value: 0.05 Ω
 Largest setting value: 65.00 Ω

1	4	0	2	■	X	1	B
3	.	0	0	Ω			

Reactance value (reach)
 Smallest setting value: 0.05 Ω
 Largest setting value: 130.00 Ω

1	4	0	3	■	R	1	B	E
3	.	0	0	Ω				

Resistance for phase–earth
 Smallest setting value: 0.05 Ω
 Largest setting value: 130.00 Ω

1 4 0 4	■	D I R E C .	Z 1 B
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 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 E
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)

Normally, addresses 1405 and 1406 are set to the same value.

Overreach zone Z1L (controlled by DAR or 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: **130.00 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 – address block 15

The distance protection relay has a variety of fault detection functions from which the optimum can be chosen for the system under consideration (refer to Section 2.3 Ordering data).

The possible fault detection methods are individually described in Section 4.2.1. If the device is

equipped with more than one fault detector, selection has been 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).

↑↓ 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
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

L E : U p h e / L L : U p h e

L E : U p h e / L L : I > >

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-ph} without detected earth fault

U_{ph-E} with detected earth fault

U_{ph-E} without detected earth fault

U_{ph-E} with detected earth fault

$I > >$ without detected earth fault overcurrent pick-up only

NOTE: Measurement control with $LE:Uphph/LL:Uphph$ excludes measurement of phase-to-earth loop; thus it is not used for systems with earthed starpoint unless a different protective relay or function is activated for earth faults.

↑↓ 1 5 0 3 ■ P R O G . Z A
L E : Z p h e / L L : Z p h p h

L E : Z p h e / L L : I > >

only for impedance fault detection

(fix impedance ZA): Measurement control

Z_{ph-E} with detected earth fault

Z_{ph-ph} without detected earth fault

Z_{ph-E} with detected earth fault

$I > >$ without detected earth fault overcurrent pick-up only

6.3.4.4 General setting for fault detection – address block 16



Beginning of the block "Fault detection for distance protection"

Parameters for **overcurrent detection** are set in address 1601 (for phase currents) and 1602 (for earth currents). The determining factor for overcurrent setting is the maximum possible operating current. Pick-up under conditions of permissible overload must be excluded! The threshold value $I_{ph}>>$ (Address 1601) must therefore be set above the maximum anticipated (over-)load current (approx. 1.2 times). It must then be checked that the minimum short circuit current is above this limit. If that is not the case, a relay with voltage controlled (U/I) fault detection or impedance detection is necessary.

For the earth fault current, a separate setting value $I_{e>}$ (Address 1602) is provided. In solidly earthed networks this would be 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.

Calculation example

For the line used in the example in Section 6.3.4.2 the maximum operating current is 680 A with 600 A/5 A current transformers and the minimum short circuit current is assumed to be 1200 A. The following setting would therefore be used:

$$\frac{I_{>>}}{I_N} = \frac{I_{Lmax}}{I_N} \cdot 1.2 = \frac{680 \text{ A}}{600 \text{ A}} \cdot 1.2 = 1.36$$

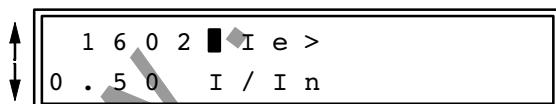
This value lies adequately below the minimum short circuit current of $1200 \text{ A} / 600 \text{ A} = 2 \cdot I_N$.

The condition for the minimum short circuit current is also valid for earth fault currents in solidly earthed networks, equally for double earth faults in either system.

If **impedance fault detection** is used, the $I_{>>}$ – stage can be set more sensitive because this is not an independent stage but supplements the impedance fault detection phase-to-earth, when a line loop would be eliminated as described in Section 4.2.1.3. For long lines, it can be set such that it does not operate in case of reverse fault because of the damping effect of the line itself.



Overcurrent detection threshold value $I_{ph}>>$
 Smallest setting value: **0.25** $\cdot I_N$
 Largest setting value: **4.00** $\cdot I_N$



Threshold value for earth current detection $I_{e>}$
 Smallest setting value: **0.10** $\cdot I_N$
 Largest setting value: **1.00** $\cdot I_N$

6.3.4.5 Setting for voltage controlled fault detection (U/I)

NOTE: This section applies only for models with voltage controlled fault detection facility (7SA511★-★★★2- or -★★★3-) and when this 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 6.3. $I_{ph>}$ (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 branch can be set either for phase-to-earth voltages in addresses 1612 and 1613 or for phase-to-phase voltages under addresses 1614 and 1615. This depends on whether voltage control is selected with U_{phph} or with U_{phe} . The characteristic must be set such that it has a sufficient safety distance from the maximum operation current at minimum operation voltage. In cases of doubt one should check the pick-up conditions against the characteristic. With comprehensive networks, short-circuit calculations may be useful.

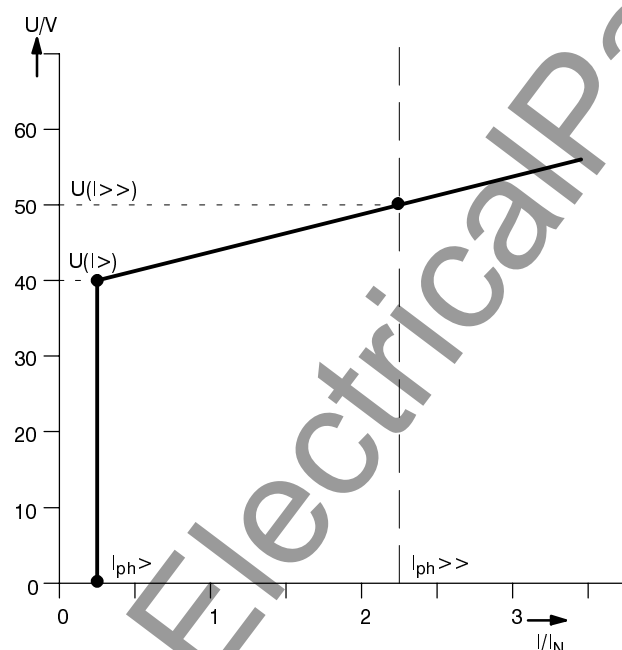


Figure 6.3 Voltage controlled fault detectors, U/I characteristic

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 $LE:Uphe/LL:Uphe$). 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 functions $I_{ph>}$.

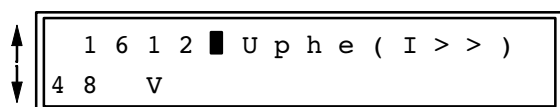
The possibility to control with the voltage loops U_{Ph-E} only when an earth fault has been detected is advantageous in systems with a **low-impedance earthed** starpoint, i.e. with earth fault limiting aids (so-called resistance earthing). In these systems, only earth faults are to be detected by the voltage controlled fault detection. For phase-phase faults the high-set overcurrent fault detectors $I_{ph>}$ will pick up. (address 1501 $LE:Uphe/LL:I>>$).

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 T_{le} 1PHASE (address 1801, refer Section 6.3.4.7). If the earth current could exceed the earth fault threshold even under steady-state conditions, T_{le} 1PHASE should be set to ∞ : pick-up on one single-phase fault is then no more possible even when 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 6.3.4.7).

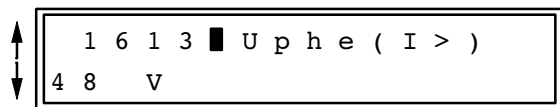
Additionally, it is possible to make voltage control with phase-to-phase voltages only (address 1501 $LE:Uphe/LL:Uphe$). The measured line loop in this case is independent of the earth fault detection; this method excludes pick-up on earth faults absolutely, however, correct double earth fault preference is not possible.

1	6	1	1	■	I	p	h	>
0	.	2	0		I	/	I	n

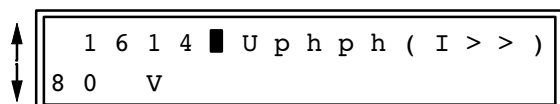
Minimum operating current for fault detection $I_{ph>}$
 Smallest setting value: **0.10** · I_N
 Largest setting value: **1.00** · I_N



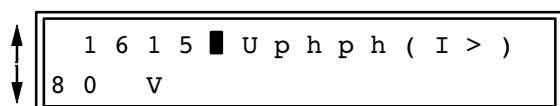
Undervoltage pick-up value at $I_{ph}>>$ (address 1601)
(Figure 6.3); phase-to-earth voltage
Smallest setting value: 20 V
Largest setting value: 70 V



Undervoltage pick-up value at $I_{ph}>$ (address 1611)
(Figure 6.3); phase-to-earth voltage
Smallest setting value: 20 V
Largest setting value: 70 V



Undervoltage pick-up value at $I_{ph}>>$ (address 1601)
(Figure 6.3); phase-to-phase voltage
Smallest setting value: 40 V
Largest setting value: 130 V



Undervoltage pick-up value at $I_{ph}>$ (address 1611)
(Figure 6.3); phase-to-phase voltage
Smallest setting value: 40 V
Largest setting value: 130 V

6.3.4.6 Settings for impedance fault detection

NOTE: This section applies only for models with impedance detection facility (7SA511★-★★★2-★★★) and when this method has been selected (Section 5.4.2). Otherwise it can be passed over.

The impedance fault detection for phase–earth is supplemented by an overcurrent stage $I_{ph}>>$ where pick-up of the overcurrent stage only leads to detection if the associated impedance loop has been eliminated (refer Section 4.2.1.3). The respective parameters have been set in Section 6.3.4.4..

The meaning of the parameters can be gathered from the impedance characteristic shown in Figure 6.4. The bold dots identify the setting parameters which determine the geometry of the fault detection polygon. $I_{ph}>$ 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 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.

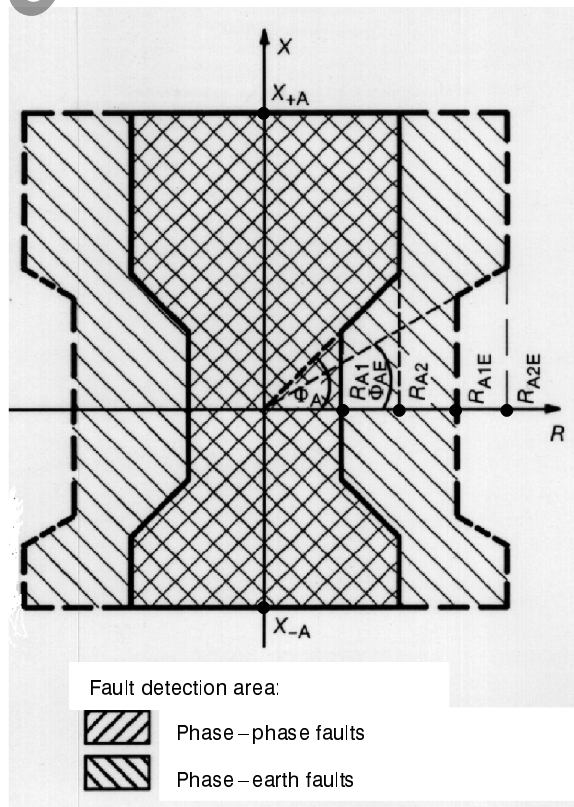


Figure 6.4 Impedance fault detection characteristic

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:

$$X + A_{\text{sec}} = \underline{38 \, \Omega}$$

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.

$$X - A_{\text{sec}} = \underline{19 \, \Omega}$$

For the resistance setting there is a lower and an upper limit. The setting RA1 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 $X - A$.

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

$$R_{\text{Lprim}} = \frac{U_{\text{min}}}{\sqrt{3} \cdot I_{\text{Lmax}}} = \frac{0.9 \cdot 110 \, \text{kV}}{\sqrt{3} \cdot 680 \, \text{A}} = 84.06 \, \Omega$$

or secondary

$$R_{\text{Lsec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot R_{\text{Lprim}} \cdot \frac{I_{\text{N}}}{A} = \frac{600/5}{110/0.1} \cdot 84.06 \, \Omega \cdot \frac{5 \, \text{A}}{A} = 45.85 \, \Omega$$

A safety margin of at least 20 % should be maintained with respect to this value:

$$R_{\text{max}} = 0.8 \cdot 45.85 \, \Omega = 36.6 \, \Omega$$

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 that 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.

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 detection
 Smallest setting value: **0.10** · I_{N}
 Largest setting value: **4.00** · 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: **200.00** Ω

<div> <div>1 6 2 3 ■ X - A</div> <div>6 . 0 0 Ω</div> </div>	Reactance value (reach) reverse Smallest setting value: 0.10 Ω Largest setting value: 200.00 Ω
<div> <div>1 6 2 4 ■ R A 1</div> <div>6 . 0 0 Ω</div> </div>	Resistance for phase–phase; phase angle below ANGLE PHIA (address 1628) (load area) Smallest setting value: 0.10 Ω Largest setting value: 200.00 Ω
<div> <div>1 6 2 5 ■ R A 2</div> <div>6 . 0 0 Ω</div> </div>	Resistance for phase–phase; phase angle above ANGLE PHIA (address 1628) (fault area) Smallest setting value: 0.10 Ω Largest setting value: 200.00 Ω
<div> <div>1 6 2 6 ■ R A 1 E</div> <div>1 2 . 0 0 Ω</div> </div>	Resistance for phase–earth; phase angle below ANG. PHIAE (address 1629) Smallest setting value: 0.10 Ω Largest setting value: 200.00 Ω
<div> <div>1 6 2 7 ■ R A 2 E</div> <div>1 2 . 0 0 Ω</div> </div>	Resistance for phase–earth; phase angle above ANG. PHIAE (address 1629) Smallest setting value: 0.10 Ω Largest setting value: 200.00 Ω
<div> <div>1 6 2 8 ■ A N G L E P H I A</div> <div>4 5 . 0 °</div> </div>	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°
<div> <div>1 6 2 9 ■ A N G . P H I A E</div> <div>4 5 . 0 °</div> </div>	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.

6.3.4.7 Settings for determination of the faulted loop – address blocks 17 and 18

The selection of valid short-circuited loops varies considerably, dependent upon whether the system starpoint 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). Fault loop selection for double earth faults can be programmed under address 1703. Normally, the *PHASE–PHASE* loop will be selected. If high footing resistances are expected then *LAGGING PH–E* loop may be more favourable because the leading phase–earth loop tends to overreach. In

some cases (fault resistance phase–phase larger than phase–earth) *LEADING PH–E* can be more favourable.

For three phase pick-up, the setting of address 1704 determines the type of loop which will be selected. *3PH FAULTS = E/F CONTROL* means that if there is no earth fault detected then a phase–phase loop will be measured but with earth fault detection a phase loop phase–earth. The other possibilities *PH–PH ONLY* and *PH–E ONLY* are independent of the I_E pick-up.

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.

1700 ■ F A U L T
E A R T H E D N E T W O R K S

Beginning of block
"Determination of the fault loop in solidly earthed networks"

1701 ■ $U_e >$
20 V

Displacement voltage ($U_e = \sqrt{3} \cdot U_0$) for earth fault detection in earthed systems. *Note:* Address 1110 has no influence on this pick-up value

Smallest setting value: 2 V
Largest setting value: 100 V
or ∞ (no earth fault detection based on displacement voltage measurement)

1703 ■ P H P H E F L T S
P H A S E - P H A S E O N L Y
L E A D I N G P H - E
L A G G I N G P H - E

For double earth faults in earthed networks, measurement is carried out in
PHASE–PHASE loop ONLY

*PH*ase–Earth loop of the *LEADING* phase

*PH*ase–Earth loop, of the *LAGGING* phase

1704 ■ 3 P H F A U L T S
E / F C O N T R O L
P H A S E - P H A S E O N L Y
P H A S E - E A R T H O N L Y

With fault detection in all 3 phases

E/F CONTROLLED – fault loop is selected dependent on earth fault detection

PHASE–PHASE ONLY – fault loop phase-to-phase is selected even with earth fault detection

PHASE–EARTH ONLY – fault loop phase-to-earth is selected even without earth fault detection

1 7 0 5	1 P H F A U L T S
P H A S E - E A R T H	
P H A S E - P H A S E	

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

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). 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 T_{Ie} 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 T_{Ie} 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	F A U L T
N O N - E A R T H E D N E T	

Beginning of block
“Determination of the fault loop in non-earthed (isolated or compensated) networks”

1 8 0 1	T I e 1 P H A S E
0 . 0 4 s	

Delay for I_E detection with single-phase pick-up in non-earthed systems

Smallest setting value:

0.00 s

Largest setting value:

0.50 s

and ∞ (I_E pick-up totally avoided)

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	

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.

6.3.5 Settings for the power swing supplement – address block 20

NOTE: This section applies only for models with power swing option (model 7SA511★-★★★-★★★1/3). Otherwise it can be passed over. The power swing supplement only operates if it is configured (address 7820 POWER-SWING = *EXIST*, refer Section 5.4.2) and if the device has impedance fault detection.

Three possible programs can be selected for the power swing blocking function; in addition, a tripping function in the case of unstable power swings (asynchronism) can be programmed. For the detection of power swings, the following considerations are of importance (see also Section 4.3):

The distance between power swing polygon and fault detection polygon (phase-phase) should be as large as possible; the R-intersection is decisive. On the other hand, the power swing polygon must not extend into the operational impedance!

To set the rate of change of the impedance vector, both the maximum power swing frequency in the instant of entry of the impedance vector into the power swing polygon and the time required by 7SA511 for the detection of the power swing must be taken into consideration. Under the most difficult conditions, at least 35 ms should be allowed for the detection of a power swing.

↑ ↓

2 0 0 0 ■
P O W E R S W I N G

Beginning of block
"Power swing detection"

↑ ↓

2 0 0 2 ■ 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
O U T - O F - S T E P T R I P

Functional program of the power swing supplement:

- blocking of all distance zones
- blocking of the first zone only
- blocking of the higher (delayed) zones only, Z1 is released
- trip in the event of unstable power swing (asynchronism), all zones are blocked

↑ ↓

2 0 0 3 ■ D e l t a R
5 . 0 0 Ω

Distance ΔR between power swing polygon and fault detection polygon (secondary, see 6.3.4.6), in Ω

Smallest setting value: **0.10 Ω**

Largest setting value: **50.00 Ω**

↑ ↓

2 0 0 4 ■ d R / d T
2 0 Ω / s

Rate of change of the power swing vector between the power swing polygon and fault detection polygon, in Ω/s , below which the power swing is detected.

Smallest setting value: **0 Ω/s**

Largest setting value: **200 Ω/s**

↑ ↓

2 0 0 5 ■ P / S T - A C T .
∞ s

Power swing action time:

The function can be limited to the time P/S T-ACT.

With the setting ∞ , the power swing function is effective until the impedance vector has left the power swing polygon again

Smallest setting value: **0.01 s**

Largest setting value: **32.00 s**

and ∞ (only after discontinuation of the power swing criterion)

6.3.6 Settings for teleprotection – address blocks 21 and 22

In programming of the scope of the functions (Section 5.4.2) one selects whether a permissive underreach transfer scheme (*UNDERREACH*) or a permissive overreaching transfer scheme (*OVERREACH*) shall be used for the teleprotection (address 7821). If the teleprotection is programmed as *NON-EXIST*, this Section is irrelevant.

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

TELEPROTEC

PERM. UNDERREACH

Beginning of block
“Teleprotection, permissive underreach transfer schemes”

↑

↓

2101

PUTT

ON

OFF

Permissive underreach transfer trip 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. If the distance protection devices at the two line ends have significantly different command times (more than approximately 40 ms difference), the first zone with delay T1 shall be appropriately delayed (addresses 1305 and 1306) for the release procedures *Z1B RELEASE*, *FD DIREC RELEASE*, *Z1B UNBLOCK* and *FD UNBLOCK*.

For the blocking procedures *Z1B BLOCKING* and *REVERS INTERLOCK*, T1B (addresses 1405 and 1406) must be sufficiently delayed that the blocking signal is safely transmitted under conditions of external fault. For *PILOT WIRE COMP* 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 reclosed (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 Section 4.4.11). If set to ∞ , no blocking takes place for this case.

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. In the blocking procedure *Z1B BLOCKING* the transmission signal is always prolonged by this time.

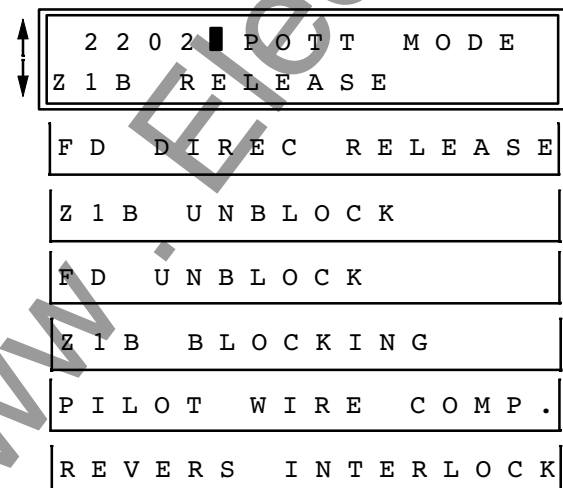
If a delay T1B is set for the overreach zone Z1B, this does not lead to delay of the transmit signal but transmission can be delayed by the time T–SEND DEL (address 2212).



Beginning of block
“Teleprotection, permissive overreach transfer schemes”



Permissive overreach transfer trip is
ON switched on
OFF switched off



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
Attention! In blocking mode (address 2202 POTT MODE = *Z1B BLOCKING*), the waiting time must be set to the smallest value in order to ensure transient blocking after 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* or 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 DI-REC RELEASE* and *FD UNBLOCK*) (not relevant for the other POTT modes)
FORWARDS Normal application
REVERSE } for special application only
NON-DIRECTIONAL

↑

2 2 1 2 ■ T - S E N D D E L

0 . 0 0 s

↓

Delay of transmission signal in permissive over-reach 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
O N		
O F F		

The echo function for weak-infed 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.

2 3 0 0	█	U S E R
L O G I C F U N C T I O N S		

Beginning of block

“User definable logical functions”

2 3 0 2	█	T - P I C K U P
1 0 . 0 0 s		

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

2 3 0 3	█	T - D R O P 1
0 . 0 0 s		

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

2	3	0	5	█	T - P I C K U P	2
0	.	0	0	s		

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

2	3	0	6	█	T - D R O P	2
0	.	0	0	s		

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 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 overcurrent protection (emergency overcurrent function). A pre-condition is that the emergency protection has been configured under address 7826 as EMERG. O/C = *EXIST* (refer to Section 5.4.2).

The parameters of the overcurrent time protection are set in block 26. The pick-up value $I>$ (address 2612) must be set above the maximum expected (over)load current (approximately 1.2 times). The pick-up value $I>>$ (address 2602) allows a current grading. The corresponding delay times $T-I>$ (address 2613) and $T-I>>$ (address 2603) 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 definite time overcurrent protection.

For earth faults, both the pick-up value $IE>$ (address 2642) and the delay time $T-IE>$ (address 2643) can be set separately. In this way, it is often possible to achieve a separate grading with shorter times for earth faults.

During emergency operation teleprotection communication is not possible.

If the distance protection system is required to oper-

ate exceptionally for a certain time period (e.g. because of missing voltage transformers), **only** as definite time overcurrent protection, the distance protection elements can be blocked by input of the external signal "v.t. protective m.c.b. tripped".

If parts of the overcurrent protection are not required at all, then the corresponding delay times can be set at ∞ .

Addresses 2621 and 2651 determine which stages are 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.

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 to Section 5.4.3). In this case, the $I>>$ stage with $T-I>>$ is decisive for the auto-reclosure. Final disconnection is carried out via $I>$ with $T-I>$ delayed. $I>>$ and $I>$ should then be set to the same value; $T-I>>$ is set undelayed (= 0).

Address 2623 determines whether the $I>>$ stage is effective only in conjunction with auto-reclosure or whether it operates independently.

Note that the set times are pure delay times which do not include the inherent operating times.

2 6 0 0 ■ E M E R G E N C Y
O V E R C U R R E N T P R O T

Beginning of block
"Emergency overcurrent time protection"

2 6 0 1 ■ E M E R G . O / C
O N
O F F

Emergency overcurrent time protection is

ON switched on

OFF switched off

2 6 0 2 ■ I > >
2 . 0 0 I / I_n

High overcurrent detection value I>> for phase currents

Smallest setting value: **0.50** · I_N

Largest setting value: **9.99** · I_N

2 6 0 3 ■ T - I > >
0 . 3 0 s

Delay for I>> phase currents

Smallest setting value: **0.00** s

Largest setting value: **32.00** s

and ∞ (no trip with I>> phases)

2 6 1 2 ■ I >
1 . 0 0 I / I_n

Overcurrent detection value I> for phase currents

Smallest setting value: **0.10** · I_N

Largest setting value: **4.00** · I_N

2 6 1 3 ■ T - I >
0 . 5 0 s

Delay for I> phase currents

Smallest setting value: **0.00** s

Largest setting value: **32.00** s

and ∞ (no trip with I> phases)

2 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 > U N D E L A Y E D

I> i.e. I> stage but without delay T-I>

I N E F F E C T I V E

INEFFECTIVE, i.e. phase current stages operate as parameterized

2 6 2 3 ■ R A R Z O N E P
I > > W I T H A R

AR function 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

I > > A L W A Y S

2 6 4 2 ■ I E >
0 . 2 0 I / I_n

Overcurrent detection value 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 for $I_E >$ (earth current)
 Smallest setting value: **0.00 s**
 Largest setting value: **32.00 s**
 and ∞ (no trip with $I >$ earth)

2	6	5	1	■	M	/	C	L	O	S	E	E
I	E	>			U	N	D	E	L	A	I	E
I	N	E	F	F	E	C	T	I	V	E		

Earth overcurrent time stage which is effective during manual close of the circuit breaker:
 $I_E >$ **UNDELAYED** i.e. the $I_E >$ – stage but without delay
INEFFECTIVE earth current stage operates as parameterized even during manual closure

6.3.9 Settings for thermal overload protection – address block 27

The relay includes a thermal overload protection function (refer to Section 4.7). This can operate only when it is configured to THERMAL OL = *EXIST* under address 7827 during configuration of the device functions (refer Section 5.4.2).

Cables are particularly endangered by overloads of longer duration. These overloads cannot and should not be detected by the short-circuit protection. A back-up stage of the distance protection, for example, must be set sufficiently high so as to only detect short-circuits. Only short delays are permitted for short-circuit protection. These short time delays, however, do not permit measures to unload the overloaded cable nor to utilize its (limited) overload capacity.

The protection relay 7SA511 includes an overload function with a thermal trip characteristic which can be matched to the overload capacity of the protected cable. This function is usually not required for overhead lines as the current carrying capacity of overhead lines is generally not defined.

The overload protection function can be set to be inoperative, to initiate alarms only or to initiate tripping (including alarm) (address 2701).

The rated current of the current transformers is used as the base current for the overload measurement. The setting factor k is determined by the ratio of the continuously permissible thermal current I_{\max} to the rated current:

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

The permissible continuous current depends on cross-section, insulation material, type of construction and method of installation of the cable, etc. In general, the magnitude of the current can be taken from widely available tables or otherwise is to be stated by the manufacturer.

The heating-up time constant τ depends on the cable data and the cable surroundings. If the time constant is not readily available, it can be calculated from the short-term overload capacity of the cable. Frequently, the 1 s current, i.e. the maximum permissible current for 1 s duration, is known or can be taken from tables. The time constant can then be calculated according to the following formula:

$$\text{Setting value } \tau [\text{min}] = \frac{1}{60} \cdot \left(\frac{\text{permissible 1 s current}}{\text{continuously permissible current}} \right)^2$$

If the short-time overload capacity is stated for a duration other than 1 s, then that short-term current is inserted into the above formula instead of the 1 s current. However, the result is then multiplied with the stated duration, i.e. in case of an 0.5 s current:

$$\frac{0.5}{60} \cdot \left(\frac{\text{permissible 0.5 s current}}{\text{continuously permissible current}} \right)^2$$

It should be noted that the result becomes more inaccurate the longer the stated duration of the current becomes.

2 7 0 0 ■ T H E R M A L
O V E R L O A D P R O T .

Beginning of block "Thermal overload protection"

2 7 0 1 ■ T H E R M A L O L
A L A R M O N L Y
O N
O F F

Thermal overload protection can be set to
issue *ALARMS ONLY* or
be switched *ON* i.e. trip and alarms or
be switched *OFF*

2 7 0 2 ■ K - F A C T O R
1 . 1 0

Setting value of k-factor = I_{\max}/I_N
Setting range: **0.10 to 4.00**

2 2 0 3 ■ T - C O N S T A N T
1 0 0 . 0 m i n

Time constant τ
Setting range: **1.0 to 999.9 min**

By setting a warning temperature rise (address 2704), an alarm can be output before the trip temperature rise is reached, so that, for example, by prompt load shedding tripping may be prevented.

Setting $\Theta_{\text{warn}}/\Theta_{\text{trip}}$ to 100 %, the temperature warning is practically ineffective.

A further current warning stage is available (address 2705). This can be set as a factor of the rated current and should be equal or less than the continuously admissible current. It can be used besides the temperature warning stage or instead of that. When set-

A choice can be made whether the temperature rise which is decisive for the threshold stages, is the maximum calculated temperature rise of the three conductors, the mean value of the calculated temperature rises of the three conductors, or the temperature rise calculated from the maximum current of the three conductors (address 2706).

2 7 0 4 ■ Θ W A R N
9 0 %

Thermal warning stage, in % of trip temperature rise
 $\Theta_{\text{warn}}/\Theta_{\text{trip}}$
Setting range: **50 % to 100 %**

2 7 0 5 ■ I W A R N
1 . 0 0 I / I n

Current warning stage; set as a multiple of I_N
Setting range: **$0.10 \cdot I_N$ to $4.00 \cdot I_N$**

2 7 0 6 ■ O / L C A L C U L
Θ M A X
Θ M E A N
Θ F R O M I M A X

Calculation method decisive for thermal stages
maximum of the *temperature* rises of the three conductors
mean value of the *temperature* rises of the three conductors
temperature rise calculated *from* the *maximum* conductor *current*

6.3.10 Settings for measured value monitoring – address block 29

The different monitoring functions of the protective relay are described in Section 4.14.4. 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 block 29. The factory settings are sufficient in most cases. If particularly high operational asymmetries of the currents and/or voltages are ex-

pected, 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.

2900 MEAS. VALUE
SUPERVISION

Beginning of block
"Measured value supervision"

2901 SYM. Uthres
50 V

Voltage threshold (phase–phase) above which the symmetry monitoring is effective (refer Figure 4.52)

Smallest setting value: **10 V**
Largest setting value: **100 V**

2902 SYM. Fact. U
0.75

Symmetry factor for the voltage symmetry = slope of the symmetry characteristic (refer Figure 4.52)

Smallest setting value: **0.58**
Largest setting value: **0.95**

2903 SYM. Ithres
0.50 I / I_N

Current threshold above which the symmetry monitoring is effective (refer Figure 4.51)

Smallest setting value: **0.10 · I_N**
Largest setting value: **1.00 · I_N**

2904 SYM. Fact. I
0.50

Symmetry factor for the current symmetry = slope of the symmetry characteristic (see Figure 4.51)

Smallest setting value: **0.10**
Largest setting value: **0.95**

2905 SUM. Ithres
0.10 I / I_N

Current threshold above which the summation monitoring (refer Figure 4.50) reacts (absolute content, referred to I_N only)

Smallest setting value: **0.10**
Largest setting value: **2.00**

2906 SUM. Fact. I
0.10

Relative content (related to the maximum conductor current) for operation of the current summation monitoring (refer Figure 4.50)

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 7SA511. The fuse failure monitor can be switched off under address 2910.

2	9	1	0	■	F	U	S	E	-	F	A	I	L
O	N												
O	F	F											

Fuse failure monitor is

ON switched on

OFF switched off

2	9	1	1	■	F	F	M	3	*	U	0	>
3	0	V										

Displacement voltage $3 \cdot U_0$, above which fuse failure should be detected

Smallest setting value: **10 V**

Largest setting value: **100 V**

2	9	1	2	■	F	F	M	I	e	<
0	.	5	0	I / I _n						

Earth current, above which no fuse failure is assumed

Smallest setting value: **0.10 · I_N**

Largest setting value: **1.00 · I_N**

6.3.11 Settings for earth fault detection in systems with isolated or compensated star-point – address block 30

This section applies only for relay models with earth fault detection module (7SA511★-★★★★-1★★, see Section 2.3 Ordering data) and only when these are used in networks with isolated or compensated star-point. In other cases, this section can be passed over.

Earth fault detection is only possible if the respective configuration parameter (Section 5.4.2, address 7830) is set to *EXIST*. If the device is equipped with earth fault detector but supposed to operate in an earthed network, configuration parameter 7830 ISOL. E/F **must** be set to *NON-EXIST*.

The function “earth fault detection” comprises residual voltage detection, determination of the earth-faulted phase and the determination of the earth fault direction. The latter is only possible when both earth current and residual voltage are available to the relay.

The residual voltage $U_e >$ initiates earth fault detection and is set in address 3002. Since, for earth faults in isolated or compensated networks, the full displacement voltage appears, the setting value is not critical; it should lie between 30 V and 60 V. Earth fault is detected and annunciated only when the displacement voltage has been stayed for the duration T-E/F (address 3010).

For phase determination $U_{ph} <$ (address 3003) is the criterion for the earth-faulted phase, when simultaneously the other two phase voltages have exceeded $U_{ph} >$ (address 3004). Accordingly, $U_{ph} <$ must be set lower than the minimum operational phase-earth voltage. This setting is, however, also not critical, 40 V (factory setting) should always be adequate. $U_{ph} >$ must lie above the maximum operational phase-earth voltage, but below the minimum operational phase-phase voltage, therefore, for example, 75 V at $U_N = 100$ V. The identification of the faulty phase is a further precondition for annunciation of an earth fault.

For determination of the direction of the earth fault, in principle, the threshold current (address 3005) should be set as high as possible to prevent faulty operation due to asymmetrical currents in the network and through the current transformers (particularly in Holmgreen connection). Dependent upon the treatment of the network star point, the magnitude of the capacitive earth fault current (for isolated networks) or the wattmetric residual current (for

compensated networks) is important.

In **isolated networks** an earth fault in a cable will allow the total capacitive earth fault currents of the entire electrically connected network, with the exception of the faulted cable itself, to flow through the measuring point. It is normal to use half the value of this earth fault current as the threshold value.

Example: A 24 kV bus-bar feeds seven cable circuits. Each circuit has a current transformer set 300 A/1 A. The earth fault current is 2.5 A/km. The cables might be as follows:

Cable 1	3.0 km	7.5 A
Cable 2	5.0 km	12.5 A
Cable 3	2.6 km	6.5 A
Cable 4	5.0 km	12.5 A
Cable 5	3.4 km	8.5 A
Cable 6	3.4 km	8.5 A
Cable 7	2.6 km	6.5 A
Total	25.0 km	62.5 A

With an earth fault on cable 2, $62.5 \text{ A} - 12.5 \text{ A} = 50 \text{ A}$ earth fault current will flow through the measuring point, since 12.5 A flows direct from cable 2 into the fault. Since that cable is amongst the longest, this is the most unfavourable case (smallest earth fault current flows through the measuring point). On the secondary side, flows:

$$50 \text{ A} / 300 = 0.167 \text{ A.}$$

The relay should be set at approximately half this value, e.g. 0.080 A.

In **compensated networks** directional determination is made more difficult since a much larger reactive current of capacitive or inductive character is superimposed on the critical wattmetric current. The total earth current available to the relay can therefore, dependent upon the network configuration and location of the compensation coil, assume very different values in magnitude and phase angle. The relay, however, must evaluate only the real component of the earth fault current, that is, $I_E \cdot \cos \varphi$. This demands extremely high accuracy, particularly with regard to phase angle accuracy of all the instrument transformers. Also, the relay should not be set unnecessarily sensitive. When used in compensated networks therefore, reliable directional determination is only expected when core balance or window-

type transformers are used. Here also, use the thumb rule: setting at half the expected measured current, whereby only the residual wattmetric current is applicable. This residual wattmetric current is provided principally by the losses in the Petersen coil.

Example: The same network, as in the previous example, is considered to be compensated by a Petersen coil. The coil is matched to the total network. The compensation current is thus 62.5 A. The losses should be 4 %. For earth fault directional determination, window-type current transformers 60 A/1 A are fitted.

Since the residual wattmetric current is derived principally from the coil losses, it is, independent of earth fault location, approximately the same:

$$4 \% \text{ of } 62.5 \text{ A} = 2.5 \text{ A.}$$

This real current is superimposed by a reactive cur-

rent which can amount to up to 62.5 A for earth faults near the Petersen coil! On the secondary side we have

$$2.5 \text{ A}/60 = 0.0417 \text{ A.}$$

As setting value 0.020 A is selected.

The high reactive current component in compensated networks and the unavoidable air gap of the window-type current transformers often make compensation of the angle error of the current transformer necessary. This is possible through addresses 3006 to 3009. The max. angle error F1 of the c.t. with its associated current I1 as well as another c.t. operating point I2/F2 above which the angle error remains practically constant, are entered, for the actually connected burden. The relay then approximates, with adequate accuracy, to the characteristic of the transformer. In isolated networks this angle error compensation is not necessary.



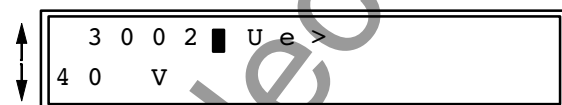
Beginning of block
"Earth fault detection in non-earthed system"



Earth fault detection in non-earthed systems is required to give ALARM ONLY (no trip)

ON switched on and will trip

OFF switched off



Threshold value for displacement voltage $U_e > (= \sqrt{3} \cdot U_0)$. *Note:* Address 1110 has no influence on this pick-up value

Smallest setting value: 10 V

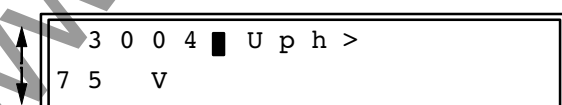
Largest setting value: 100 V



Phase-earth voltage of a faulted phase which will be certainly undershot under earth fault conditions

Smallest setting value: 10 V

Largest setting value: 100 V



Phase-earth voltage of healthy phases which will certainly be exceeded under earth fault conditions

Smallest setting value: 10 V

Largest setting value: 100 V

3 0 0 5 ■ I e >
 0 . 0 5 0 A

Threshold value for directional determination
 For isolated network: capacitive earth fault current
 For compensated network: ohmic (wattmetric) earth fault residual current
 Smallest setting value: **0.003 A**
 Largest setting value: **1.000 A**

3 0 0 6 ■ C T E R R . I 1
 0 . 0 5 0 A

Secondary current for max. error angle of current transformer
 Smallest setting value: **0.003 A**
 Largest setting value: **1.600 A**

3 0 0 7 ■ C T E R R . F 1
 0 . 0 °

Error angle of current transformer at I1
 Smallest setting value: **0.0 deg**
 Largest setting value: **5.0 deg**

3 0 0 8 ■ C T E R R . I 2
 1 . 0 0 0 A

Secondary current above which the angle error is practically constant
 Smallest setting value: **0.003 A**
 Largest setting value: **1.600 A**

3 0 0 9 ■ C T E R R . F 2
 0 . 0 °

Error angle of current transformer at I2
 Smallest setting value: **0.0 deg**
 Largest setting value: **5.0 deg**

3 0 1 0 ■ T - E / F
 1 . 0 s

Duration of displacement voltage after which earth fault is detected and annunciated; this delay is also valid for annunciations when the earth fault conditions change (e.g. alteration of direction)
 Smallest setting value: **0.0 s**
 Largest setting value: **320.0 s**

6.3.12 Settings for high-resistance earth fault protection – address blocks 31 to 33

If the device is equipped with protection for high-resistance earth faults in an earthed network (type 7SA511★-★★★-★★2/3, see Section 2.3 Ordering data), the following possibilities are available for the detection of high-resistance earth faults:

- **directional** definite time overcurrent protection with non-directional back-up stage,
- directional definite time overcurrent protection with **directional comparison** and non-directional back-up stage,
- **non-directional** overcurrent protection with inverse time characteristic.

In 7SA511, one of these three possibilities can be programmed or earth fault protection can be made ineffective (see Section 5.4.2).

6.3.12.1 Directional earth fault protection (definite time) – address block 31

For directional overcurrent time protection with non-directional back-up stage the parameters are set in

address block 31. The pick-up value $I_{e>}$ (address 3103) should be set somewhat below the minimum expected earth fault current. 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

$$U_e = (U_{L1} + U_{L2} + U_{L3}) / \sqrt{3}.$$

The directional dependent tripping time $T-DIRECT$ (address 3106) is independent of 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.

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 mcb has tripped out. It thus also performs the emergency function for earth fault protection as well as a back-up stage.

3 1 0 0 ■ E A R T H F A U L T
D I R E C / N O N - D I R E C

Beginning of block
“Earth fault directional definite time protection with non-directional back-up stage”

3 1 0 1 ■ E / F D . T .
O N
O F F

Earth fault definite time protection is

ON switched on

OFF switched off

3 1 0 3 ■ I $e>$
0 . 2 0 I / I n

Pick-up value for earth current detection
($0,75 \times I_{e>}$ for transmit signal)

Smallest setting value:

0.10 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 - D I R E C T .
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

D I R E C T I O N
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 directional stage;
can be set to trip

FORWARDS in line direction

REVERSE in busbar direction

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 directional trip)

3 1 0 9

T - B L O C K
0 . 0 1 s

Time during which earth-fault protection is blocked after distance protection has reset; when a second external protection relay with AR is present, this time must be longer than a single-pole auto-reclose cycle
Smallest setting: **0.00 s**
Largest setting value: **320.00 s**

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 time T-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-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 tran-

sient blocking time T-TRANSBLO (refer also to Section 4.9.2). If set to ∞ , no blocking takes place for this case.

For lines with one **weak-infeed** or non-infeed end, 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-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-ECHO-IMP (address 3212) 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 3213) is set. This should include the echo delay time T-ECHO-DEL plus the echo impulse duration T-ECHO-IMP plus twice the transmission time plus a safety margin.

3 2 0 0 ■ E A R T H F A U L T
D I R E C . C O M P A R I S O N

Beginning of block
"Earth fault directional comparison"

3 2 0 1 ■ E / F C O M P A R
O N
O F F

Directional comparison for earth fault definite time protection is

ON switched on

OFF switched off

3 2 0 2 ■ T - D E L A Y
0 . 0 0 s

Delay time for transmission and trip on reception for directional comparison

Smallest setting value: **0.00 s**

Largest setting value: **32.00 s**
and ∞ (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 1 0 ■ E / F E C H O
O N
O F F

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 is 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**

6.3.12.3 Non-directional earth fault protection (inverse time) -- address block 33

Instead of the above mentioned functions, a non-directional earth fault protection can be set. A choice of three characteristics is given: normal inverse, very inverse and extreme inverse. $I_{e>}$ shall be set below the minimum expected earth fault current, at 75 % or less since, according to IEC 60255–3, the protection shall **not** operate for currents up to 1.05 times the setting value and the characteristics are defined only from 2 times the setting value onwards. In any event, 7SA511 already trips for currents above approximately 1.2 times the setting value in accordance with the formulae valid for the characteristics

(Figure 3.3, Section 3.8).

When setting the time $T-I_{e>}$ (address 3304) one must consider that the setting value corresponds to 10 times the time factor of the tripping time formula, e.g.

$$\begin{aligned} T-I_{e>} &= 10 \text{ s} \\ &\text{for normal inverse } TM = 1, \text{ thus} \\ t_{\text{trip}} &= 10 \text{ s tripping time at 2 times the set value } I_{e>} \end{aligned}$$

3 3 0 0 ■ E A R T H F A U L T
N O N - D I R E C T I O N A L

Beginning of block
“Earth fault non-directional inverse time overcurrent protection”

3 3 0 1 ■ E / F I . T .
O N
O F F

Non-directional inverse time earth fault protection is
ON switched on
OFF switched off

3 3 0 2 ■ E / F C H A R A C
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

Trip time characteristic for the non-directional inverse time overcurrent protection according IEC 60255–3 or BS 142
NORMAL INVERSE time characteristic (type A)
VERY INVERSE time characteristic (type B)
EXTREMELY INVERSE time characteristic (type C)

3 3 0 3 ■ I e >
0 . 2 0 I / I n

Pick-up value for earth current detection
Smallest setting value: **0.10** I_N
Largest setting value: **4.00** I_N

3 3 0 4 ■ T - I e >
0 . 5 0 s

Delay time corresponds 10 x TM
Smallest setting value: **0.00** s
Largest setting value: **32.00** s
and ∞ (no trip by $I_{e>}$)

3 3 0 5 ■ T - B L O C K
0 . 0 1 s

Time during which earth-fault protection is blocked after distance protection has reset; when a second external protection relay with AR is present, this time must be longer than a single-pole auto-reclose cycle
Smallest setting value: **0.01** s
Largest setting value: **320.00** s

6.3.13 Settings for auto-reclosure – address block 34

NOTE: This section is valid only for models with integrated auto-reclose function (7SA511★–★★★★–★★B/C/F/G★). 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 distance 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. 7SA511 does not process the AR function. No corresponding annunciations 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 7SA511, e.g. release of RAR or DAR stages and single/three-pole tripping (if necessary); the fault detection and trip signal outputs of 7SA511 must be connected to the external AR device. The internal AR function must be set as *NON-EXIST* (Section 5.4.2, address 7834), in this case.

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 7SA511 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 a fault 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 7SA511 are blocked. If the manual close command is led via the 7SA511 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 ∞ , breaker close commands 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 7SA511 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 shall be checked by the synchronism and voltage 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.

↑

↓

3400

■

AUTO -

RECLOSE FUNCTION

Beginning of block
“Auto-reclosure functions”

↑

↓

3401

■

AR FUNCTION

ON

OFF

Auto-reclose function is

ON switched on
OFF switched off

↑

↓

3402

■

AR BLOCK REVERSE

YES

NO

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*

↑

↓

3403

■

MC BLOCK

YES

NO

Blocking of reclosing after manual close of the circuit breaker

normal setting: *YES*

↑

↓

3405

■

T - RECLAIM

3.00 s

Reclaim time after successful AR cycle
Smallest setting value: **0.50 s**
Largest setting value: **320.00 s**

↑

↓

3406

■

T - LOCK

3.00 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 synchronism or voltage 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 = *T-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.

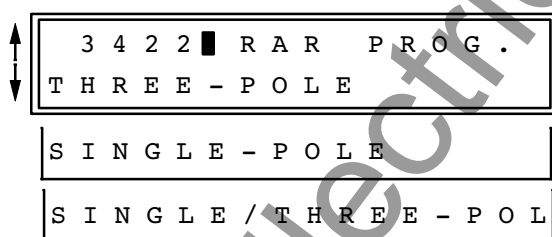
With three-pole auto-reclosure (address 3425), the stability of the network is the most important consideration. Since the disconnected line can no longer produce any synchronizing power, only a short dead time is permitted in most cases. Conventional values lie between 0.3 s and 0.6 s. If the device 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!

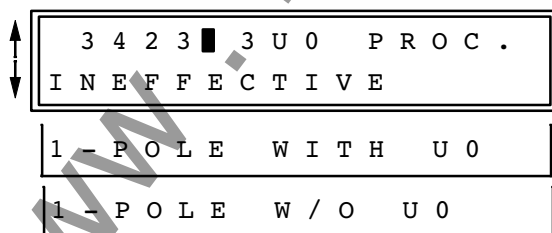
Also, for the treatment of evolving faults and for the discrimination time T-DISCRIM the stability of the network is of the utmost importance. In addition, the dynamic burden of the generators must be taken into account in the case of faults close to a power station. For the discrimination time T-DISCRIM (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 1pole 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

YES or

N O

NO

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	DAR	PROG.
NO	DAR				

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

DAR	WITHOUT	RAR
-----	---------	-----

DAR	AFTER	RAR
-----	-------	-----

3	4	4	3	DAR	NO. 1 PH
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	DAR	NO. 3 PH
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	DAR	T–ACT.
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	DAR	T 3 POL 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	DAR	T 3 POL 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	DAR	T 3 POL 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 (7SA511★–★★★★–★★B/C/E/F/G★) 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. Generally, a closure command is not released as long as a current keeps flowing ($I \geq 0.1 I_N$).

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 $\text{PHI} <$.



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:

2 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:

2 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 7SA511 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 Δf for synchronous auto-reclosure

Smallest setting value:

0.01 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 address 3503), the bus-bar (U2) must be dead (U<, refer address 3502);
3517 U1<U2>	dead-line check: the feeder (U1) must be dead (U<, refer

3518 U1<U2<

address 3502), the bus-bar (U2) must be live (U>, refer address 3503);

dead-line and dead-bus check: the feeder (U1) and the bus-bar (U2) must both be dead (U<, refer 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 and 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 $\Delta \varphi$ 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 address 3502), the bus-bar (U2) must be live (U>, refer 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.

3 5 2 1 ■ S Y N . M A N . C L
O N
O F F

Synchro-check before manual close command is ON switched on

OFF switched off

∞ Hz 3 5 2 2 ■ M C D f < S Y N

Limit value $\Delta f <$ for synchronous manual closure

Smallest setting value: **0.01 Hz**

Largest setting value: **0.10 Hz**

and ∞ (no asynchronous manual switching)

3 5 2 5 ■ M C S Y N C H R
Y E S
N O

Synchronism check before manual closure

YES synchro-check is done before manual closure

NO manual closure without synchro-check

3 5 2 6 ■ M C U 1 > U 2 <
N O
Y E S

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 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:

$$X_{\text{prim}} = 0.39 \, \Omega/\text{km}$$

$$X_{\text{sec}} = \frac{N_{\text{ct}}}{N_{\text{vt}}} \cdot X_{\text{prim}} \cdot \frac{I_N}{A}$$

$$= \frac{600/5}{110/0.1} \cdot 0.39 \, \Omega/\text{km} \cdot \frac{5 \, \text{A}}{A} = 0.213 \, \Omega/\text{km}$$

$$\text{Length} = 60 \, \text{km}$$

If, for example, a fault reactance of 2.29 Ω primary is calculated, this example gives us the fault location data

$$\begin{aligned} X_{\text{pri}} &= 2.29 \, \Omega \\ d &= 5.86 \, \text{km} \\ d &= 9.78 \% \end{aligned}$$

If the relay is equipped with parallel line compensation (7SA511★-★★★-2★★, see Ordering data, Section 2.3), this can only function correctly if

- the earth current of the parallel line is connected with the correct polarity to the earth current path and
- in the power system data (see Section 6.3.3.1) the parameter le CT is set as *PARALLEL LINE* (address 1111) and
- in the line data (see Section 6.3.3.2) the coupling impedances RM/RL and XM/XL (addresses 1119 and 1120) are correctly set and
- for the fault location the compensation is switched to effective, under address 3805.

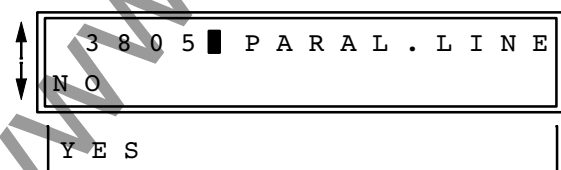


Beginning of block "Fault location"



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

6.4 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 plates 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 (if available).

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 automatically 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).



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.

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-reclose 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 55 Annunciations of an earth fault report (models with earth fault detection in non-earthed systems only).
- 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).
- Block 58 Indication of earth fault values (models with earth fault detection in non-earthed systems only).
- Block 59 Indication of measured values of the thermal overload protection.

Commencement of “Annunciation blocks”

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.

If the device is equipped with earth fault detection for non-earthed systems, an earth fault is indicated with “E/F Det.”; detailed information can be found in the earth fault report (refer Section 6.4.4).

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 4 . 9 7 1 4 : 2 3
E m e r . M o d e : 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
> A n n u n c . 1
> A n n u n c . 2
> A n n u n c . 3
> A n n u n c . 4
> C l o s e C m d . B l o

Fault recording started via binary input (C)

User definable annunciation No 1 received via binary input (C/G)

User definable annunciation No 2 received via binary input (C/G)

User definable annunciation No 3 received via binary input (C/G)

User definable annunciation No 4 received via binary input (C/G)

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 overcurrent protection from an external device (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	Carrier signal for teleprotection with distance protection received (C)
> D i s . R e c F a i l	Carrier reception for teleprotection with distance protection faulty (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)
> 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)

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 a s 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

E / F D e t .	Earth fault detected (in non-earthed system) (C/G, detailed information in the earth fault report)
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)

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)
E / F . P r o t I n v a	Earth fault report (for non-earthed systems) 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 (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 u r e I / O 1	Failure on first input/output module GEA (C/G)
F a i l u r e I / O 2	Failure on second input/output module ZEA (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 Σ I	Failure detected by current plausibility monitor Σ I (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 Σ U p - e	Failure detected by voltage plausibility monitor ΣU_{ph-e} (C/G)
F a i l u r e Σ U p - p	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 annunciation of distance protection and teleprotection features:

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 m e r . m o d e	Emergency overcurrent time mode is running (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)
D i s . T e l e . o f f	Teleprotection function with distance protection is switched off (C/G)

> D i s . R e c e p t	Carrier signal for teleprotection with distance protection received (C)
D i s . R e c F a i l	Reception signal for teleprotection with distance protection is faulty (C/G)
D i s . P O T T E c h o	Echo signal for teleprotection with distance protection transmitted (C)

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 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 emergency overcurrent time protection:

E m e r . o f f	Emergency overcurrent time protection 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 . m o d e	Emergency overcurrent time mode is running (C/G)
> I > > b l o c k	Block I>> stage of emergency overcurrent time protection from an external device (C/G)

Operational annunciations of thermal overload protection:

O / L P r o t . o f f	Thermal overload protection is switched off (C/G)
O / L b l o c k e d	Thermal overload protection is blocked (C/G)
O / L W a r n I	Thermal overload protection: current warning stage (C/G)
O / L W a r n Θ	Thermal overload protection: thermal warning stage (C/G)
O / L P i c k u p Θ	Thermal overload protection: pick-up of thermal trip stage (C/G)

Operational annunciations of earth fault detection for non-earthed systems:

E / F D e t . o f f	Earth fault detection is switched off (C/G)
E / F D e t . b l o c k	Earth fault detection is blocked (C/G)

Detailed information about the earth fault are given in the earth fault report (address block 55), refer Section 6.4.4.

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 annunciation 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 annunciation 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 fault location:

> S t a r t F l t L o c	Start fault locator via binary input (C/G)
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Operational annunciations from 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 latest 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 ■ 1 3 . 0 4 . 9 7
S y s t . F l t 2 7

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 6 : 5 4 : 1 4 . 3 9 7
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 to 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 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
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
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 . R e c e p t	Carrier signal for teleprotection with distance protection received
D i s . S e n d	Carrier send signal for teleprotection with distance protection transmitted
D i s . T r a n s B l o	Transient blocking function of teleprotection with distance protection has operated

Fault annunciation of power swing supplement:

O / S T r i p	Out-of-step trip signal issued
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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 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 >	Fault detection emergency overcurrent protection on phase overcurrent stage I>
E m e r . I E >	Fault detection emergency overcurrent protection on earth overcurrent stage I _E >
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

Fault annunciation of thermal overload protection:

O / L T r i p	Trip by thermal overload protection
---------------	-------------------------------------

Fault annunciation of earth fault detection in non-earthed systems:

Note: These annunciation occur only in the fault annunciations when the high-sensitivity earth fault protection is configured to trip on earth fault (address 3001 EARTH FAULT = ON, refer also to Section 6.3.11). Otherwise, the annunciations are stored only in the earth fault report (refer to Section 6.4.4).

E / F D e t e c t i o n	Earth fault detection in non-earthed systems
E / F D e t . T r i p	Trip by earth fault detection in non-earthed systems

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 non-directional

E / F F l t I e - >	Fault detection earth fault protection directional
E / F T r i p	Trip by earth fault protection
E / F S e n d	Directional comparison earth fault protection, carrier signal transmitted
> E / F R e c e p t .	Directional comparison earth fault protection, carrier signal received
E / F T r a n s B l o c	Transient blocking function of directional earth fault protection has operated

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 close release
---------------------------	---

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)

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 \uparrow or \downarrow ; 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.

\uparrow \downarrow	5 3 0 0 ■ 2 n d T O L A S T F A U L T
	etc.

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.

\uparrow \downarrow	5 4 0 0 ■ 3 r d T O L A S T F A U L T
	etc.

Beginning of the block "Fault annunciations of the third to last system fault"

6.4.4 Data of earth faults in non-earthed systems – address block 55

For earth faults in isolated or compensated networks a special earth fault data store is available under address 5500. Up to 80 messages can be stored for each of the last three earth faults. Input of the code-word is not required.

The earth fault reports can be called up by direct addressing, using **DA 5 5 0 0 E** or by paging with the

keys ↑ or ↓ to the address 5500. With the keys ↑ or ↓ one can page forwards or backwards within the indications.

In the following list, the available earth fault annunciations are attached to the box with main heading. In a specific case, of course, only the associated indications appear in the display.

↑
↓
5 5 0 0 ■ I S O L A T E D
E A R T H F L T D A T A

Beginning of block "Earth fault event data for non-earthed system"

↑
↓
0 0 1 ■ 2 7 . 0 5 . 9 7
E / F D e t . 1 7

under item No. 1, the date and the sequence number of the earth fault are displayed

↑
↓
0 0 2 ■ 1 0 : 3 2 : 4 7
E / F D e t e c t i o n : C

Item No. 2 shows the time of commencement of the earth fault

The following items show the earth fault data

E / F D e t e c . L 1

Earth fault detected in phase L1

E / F D e t e c . L 2

Earth fault detected in phase L2

E / F D e t e c . L 3

Earth fault detected in phase L3

E / F f o r w a r d s

Earth fault in forward direction

E / F r e v e r s e

Earth fault in reverse direction

E / F u n d e f i n e d

Earth fault direction undefined (e.g. current too small)

I e a 1 8 m A

Active component of earth fault current

I e r 1 2 6 m A

reactive component of earth fault current

E / F D e t . T r i p

Trip on earth fault (only when earth fault detection is configured to trip)

E / F B u f f . O v e r

Earth fault annunciations lost (buffer overflow)

T a b l e e m p t y

means that no earth fault has been recorded (yet)

Reports of further earth faults begin with item number 101 and 201, e.g.:

↑
↓
1 0 1 ■ 1 9 . 0 7 . 9 4
E / F D e t . 1 5

under Item No. 101, the date of another earth fault can be displayed, followed by the respective data

6.4.5 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.

$\uparrow \downarrow$ 5 6 0 0 ■ C B O P E R A T .
S T A T I S T I C S

Beginning of the block "Circuit breaker operation statistics"

$\uparrow \downarrow$ 5 6 0 1 ■ A R 1 p o l e =
1 4

Number of auto-reclose attempts after single-pole trip, e.g. 14

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

9 digits

– Trip No L1, Trip No L2, Trip No L3

9 digits

– $\Sigma IL1/In$, $\Sigma IL2/In$, $\Sigma IL3/In$

7 digits plus 1 decimal digit

The counters can be reset to 0 in block 82 (see Section 6.5.2).

6.4.6 Read-out of operational measured values – address blocks 57 and 59

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 = 4 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 = 4 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 = 4 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 = 6 4 . 5 k V

$\uparrow \downarrow$ 5 7 0 5 ■ M E A S . V A L U E
U L 2 E = 6 3 . 9 k V

$\uparrow \downarrow$ 5 7 0 6 ■ M E A S . V A L U E
U L 3 E = 6 4 . 3 k V

$\uparrow \downarrow$ 5 7 0 7 ■ M E A S . V A L U E
U L 1 2 = 1 1 0 . 2 k V

5 7 0 8 ■ M E A S . V A L U E
U L 2 3 = 1 1 1 . 0 k V

5 7 0 9 ■ M E A S . V A L U E
U L 3 1 = 1 1 1 . 5 k V

5 7 1 0 ■ M E A S . V A L U E
P a = 7 9 . 1 M W

5 7 1 1 ■ M E A S . V A L U E
P r = 4 4 . 8 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 to Section 5.4.2)

5 7 1 3 ■ M E A S . V A L U E
I L 1 [%] = 7 6 . 6 %

The percentage is referred to rated current

5 7 1 4 ■ M E A S . V A L U E
I L 2 [%] = 8 0 . 8 %

5 7 1 5 ■ M E A S . V A L U E
I L 3 [%] = 7 8 . 8 %

5 7 1 6 ■ M E A S . V A L U E
U L 1 E [%] = 1 0 1 . 6 %

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 0 . 6 %

5 7 1 8 ■ M E A S . V A L U E
U L 3 E [%] = 1 0 1 . 2 %

5 7 1 9 ■ M E A S . V A L U E
U L 1 2 [%] = 1 0 0 . 2 %

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 0 . 9 %

5 7 2 1 ■ M E A S . V A L U E
U L 3 1 [%] = 1 0 1 . 3 %

5 7 2 2 ■ M E A S . V A L U E
P a [%] = 6 9 . 1 %

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 [%] = 3 9 . 2 %

The calculated temperature rise for the overload protection can be read out in address block 59. The address can be called up directly using **DA 5900 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 are available as long as the thermal overload protection is configured as THERMAL OL = EX-IST (address 7827) and switched on (address 2701). Page on with the \uparrow key to read off the next address with the next measured value, or page back with \downarrow .

5 9 0 1 ■ M E A S . V A L U E
 $\Theta / \Theta_{trip L1} = 4 9 \%$

The calculated temperature rises of the individual phases are not presented if the measuring method Θ with I_{max} has been selected (address 2706)

5 9 0 2 ■ M E A S . V A L U E
 $\Theta / \Theta_{trip L2} = 5 4 \%$

5 9 0 3 ■ M E A S . V A L U E
 $\Theta / \Theta_{trip L3} = 5 1 \%$

5 9 0 4 ■ M E A S . V A L U E
 $\Theta / \Theta_{trip} = 5 4 \%$

The percentage is referred to the trip temperature rise according to the measurement method as selected in address 2706

6.4.7 Read-out of earth fault measured values in non-earthed systems – address block 58

The measured values during an earth fault can be read out in address block 58. The address can be directly called up using **DA 5800 E** or by paging with keys \uparrow or \downarrow . The individual values can be found then by further paging with \uparrow or \downarrow . Entry of the code-word is not necessary. The values are recorded only if the relay is equipped with the earth fault detection function and when this is configured to *EXIST*.

The displayed values are: the active component I_{ea} and the reactive component I_{er} of the earth current, as primary values and as secondary values at the relay terminals. Pre-requisite for correct output of the current values is that the rated data are correctly parameterized in address block 11 (refer to Section 6.3.3.1).

In the following example, some typical values have been inserted. In practice the actual values appear.

$\uparrow \downarrow$ 5 8 0 0 ■ I S O L . E / F
M E A S U R E D V A L U E S

Beginning of the block "Measured values of earth fault detection in non-earthed systems"

$\uparrow \downarrow$ 5 8 0 1 ■ M E A S . V A L U E
I e a = 0 . 0 A

Use \uparrow key to display the next address with the next measured value, or use \downarrow key for the previous address.

$\uparrow \downarrow$ 5 8 0 2 ■ M E A S . V A L U E
I e r = 1 . 2 A

Each measured value is assigned to one address; each address, alternatively, can be reached by direct addressing, using key **DA** followed by the address number.

$\uparrow \downarrow$ 5 8 0 3 ■ M E A S . V A L U E
I e a [m A] = 0 . 5 m A

The primary values (addresses 5801 and 5802) are based on the primary rated values as parameterized under addresses 1112 and 1105 (refer to Section 6.3.3.1).

$\uparrow \downarrow$ 5 8 0 4 ■ M E A S . V A L U E
I e r [m A] = 2 0 . 0 m A

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. 7SA511 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 to 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 re-

quired 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 ↑.

↑
2 5 . 0 4 . 1 9 9 7
↓
1 6 : 5 3 : 4 7

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 6.4.5, 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

$\uparrow \downarrow$ 8 2 0 6 ■ R E S E T
E / F A N N U N C . ?

Request whether the earth fault report buffer store (for earth faults in non-earthed systems) should be erased

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.

7SA511 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) 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')
<div> <div> <div>1 2 0 1 ■ D I S T . P R O T .</div> <div>O N</div> </div> <div> <div>O F F</div> </div> </div>	Distance protection (without emergency O/C prot.)	3651 Dist. off
<div> <div> <div>2 1 0 1 ■ P U T T</div> <div>O N</div> </div> <div> <div>O F F</div> </div> </div>	Permissive underreach transfer trip mode for distance protection	4021 >Dis.PUTT on 4022 >Dis.PUTT off 4052 Dis.Tele off
<div> <div> <div>2 2 0 1 ■ P O T T</div> <div>O N</div> </div> <div> <div>O F F</div> </div> </div>	Permissive overreach transfer trip mode for distance protection	4011 >Dis.POTT on 4012 >Dis.POTT off 4052 Dis.Tele off
<div> <div> <div>2 2 2 0 ■ E C H O</div> <div>O N</div> </div> <div> <div>O F F</div> </div> </div>	Echo function for teleprotection with distance protection (is switched off also together with 2201)	
<div> <div> <div>2 6 0 1 ■ E M E R G . O / C</div> <div>O N</div> </div> <div> <div>O F F</div> </div> </div>	Emergency overcurrent time protection	2051 Emer. off
<div> <div> <div>2 7 0 1 ■ T H E R M A L O L</div> <div>A L A R M O N L Y</div> <div>O N</div> <div>O F F</div> </div> </div>	Thermal overload protection	1501 >O/L on 1502 >O/L off 1511 O/L Prot off
<div> <div> <div>2 9 1 0 ■ F U S E - F A I L</div> <div>O N</div> <div>O F F</div> </div> </div>	Fuse failure monitor	

3 0 0 1 ■ E A R T H F A U L T
A L A R M O N L Y

O N

O F F

Earth fault detection for non-earthed systems

1251 >E/F Det. on

1252 >E/F Det. off 1261 E/F Det. off

3 1 0 1 ■ E / F D . T .
O N

O F F

High-resistance earth fault protection for earthed systems; directional definite time with non-directional back-up stage

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 3 0 1 ■ E / F I . T .
O N

O F F

High-resistance earth fault protection for earthed systems; non-directional inverse time

1331 E/F Prot. off

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)

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 (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 using the VDEW/ZVEI –protocol (IEC 60870–5–103). If the desired set or possibility appears in the display, press the en-

ter 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 **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 5 0 1 ■ A C T I V P A R A M
S E T A

Address 8501 shows the actually active parameter set

8 5 0 3 ■ A C T I V A T I O N
S E T A

Use the “No” – key **N** to page through the alternative possibilities. The desired possibility is selected by pressing the enter key **E**.

S E T B

S E T C

S E T D

S E T B Y B I N . I N P U T

S E T B Y L S A C O N T R

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), ACTIVATION must be switched to *SET BY BIN.INPUT* (refer 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 6.5. 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

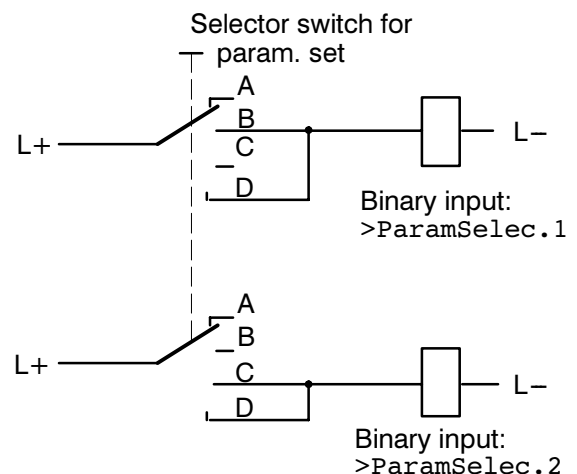


Figure 6.5 Connection scheme for parameter change-over via binary inputs

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 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 and power swing detector. 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 connected 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.

NOTE: When the relay is configured such that the position of the auxiliary contact of the circuit breaker is processed, i.e. the corresponding input is marshalled, the trip command of the relay is maintained as long as the circuit breaker is signalled to be closed. But, the trip command is de-energized after 5 s provided the fault current is switched off.

6.6.2 Testing the overcurrent fault detection stage and emergency overcurrent time protection

Apply symmetrical rated voltages to all three phases to avoid immediate trip after pick-up.

Testing can be performed with single-phase, two-phase or three-phase test current without difficulties.

Setting parameter $I_{ph} > >$ (address 1601) is decisive for the phase currents. 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!

For tests currents above $4 \times I_N$ measurement shall be performed dynamically. It should be ensured that the relay picks up at 1.1 times setting value and does not pick up at 0.9 times setting value. The reset value should lie at 95 % of the pick-up value.

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 $I_E >$ (LED 5 at factory setting) and pick-up indication appears for the tested phase (LED 2 for L1 or LED 3 for L2 or LED 4 for L3 at factory setting). When testing phase–phase, pick-up indication appears for the associated phases.

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> (address 2613), T–I>> (address 2603), T–IE> (address 2643). A prerequisite is that the function EMERG. O/C = EXIST is selected under address 7826 in the scope of functions (Section 5.4.2) and this function is switched ON under address 2601.

6.6.3 Testing the voltage controlled fault detection U/I (if fitted)

Close voltage transformer mcb.

Testing can be performed with single-phase, two-phase or three-phase test current without difficulties.

Set test voltage to 0 V.

Slowly increase test current of one phase 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. L1" and LED 2 when delivered for phase L1; for a different phase accordingly (LED 3 for L2, LED 4 for L3).

Switch off test current.

The voltage dependent branch of the pick-up characteristic is shown in Figure 6.6. When delivered the slope of the voltage dependent branch is 0.

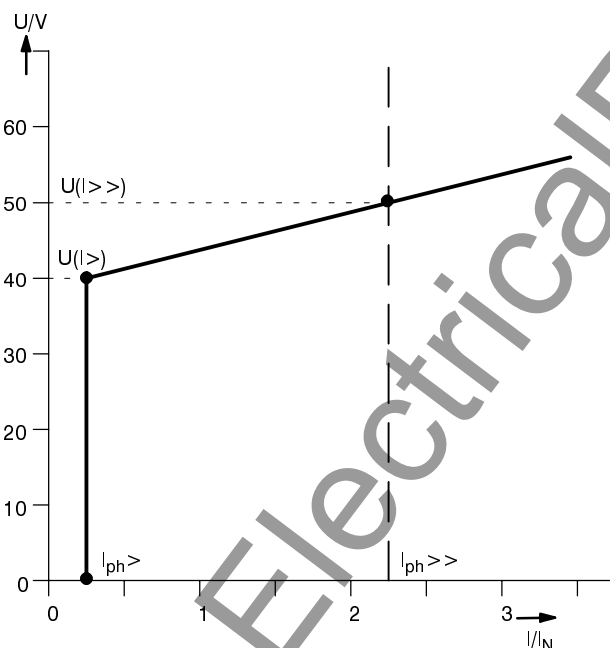


Figure 6.6 Voltage controlled fault detection, U/I characteristic

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.

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. L1" and LED 2 at delivery for phase L1; for a different phase accordingly ("Dist.Flt. L2" and LED 3 for L2, "Dist.Flt. L3" and LED 4 for L3).

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 relationship of test voltage and test current is irrelevant. 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 2 and LED 3 at delivery for phase loop L1–L2; for a different loop accordingly "Dist.Flt.L23" and LED 3 and LED 4 for phase loop L2–L3, "Dist.Flt.L13" and LED 2 and LED 4 for phase loop L1–L3.

The procedure described above is valid for the pre-set values of $U_{phe(I>>)}$ (address 1612), $U_{phe(I>)}$ (address 1613), $U_{phph(I>>)}$ (address 1614) and $U_{phph(I>)}$ (address 1615). In this case the slope of the voltage dependent branch of the pick-up characteristic is 0, i.e. $U_{phe(I>>)} = U_{phe(I>)}$ and $U_{phph(I>>)} = U_{phph(I>)}$.

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 $I_{ph>}$:

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 $U_{phe(I>)}$ (address 1613) with U_{ph-e} control but $U_{phph(I>)}$ (address 1615) with U_{ph-ph} control,

$U(I>>)$ is the setting value $U_{phe(I>>)}$ (address 1612) with U_{ph-e} control but $U_{phph(I>>)}$ (address 1614) with U_{ph-ph} control.

6.6.4 Testing the impedance fault detection (if fitted)

Close voltage transformer m.c.b.

Always apply three-phase test voltage; ensure clockwise phase rotation!

Feed a test current $I_P = 2 \times I_N$ 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!

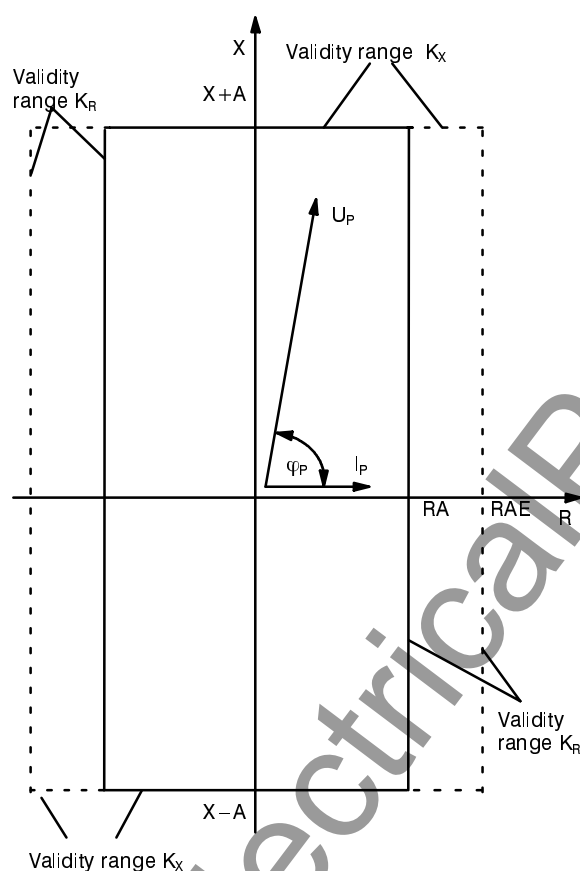


Figure 6.7 Impedance fault detection characteristic

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 6.7) 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

$X_{\pm A}$ – 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

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. 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.

For the factory set values and $I_P/I_N = 2$ the resultant voltages will be as Table 6.3.

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	$1 + X_E / X_L$	$\frac{1 + X_E / X_L}{\sin \varphi_P}$	$1 + R_E / R_L$	$\frac{1 + R_E / R_L}{\cos \varphi_P}$

Table 6.4 Test factors K_X and K_R for individual settings

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 different 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.

6.6.5 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 overcurrent detection (address 1601) or of the minimum current detection, $I_{ph} >$ is guaranteed (address 1611 or 1621). The test current must be kept constant during a test!

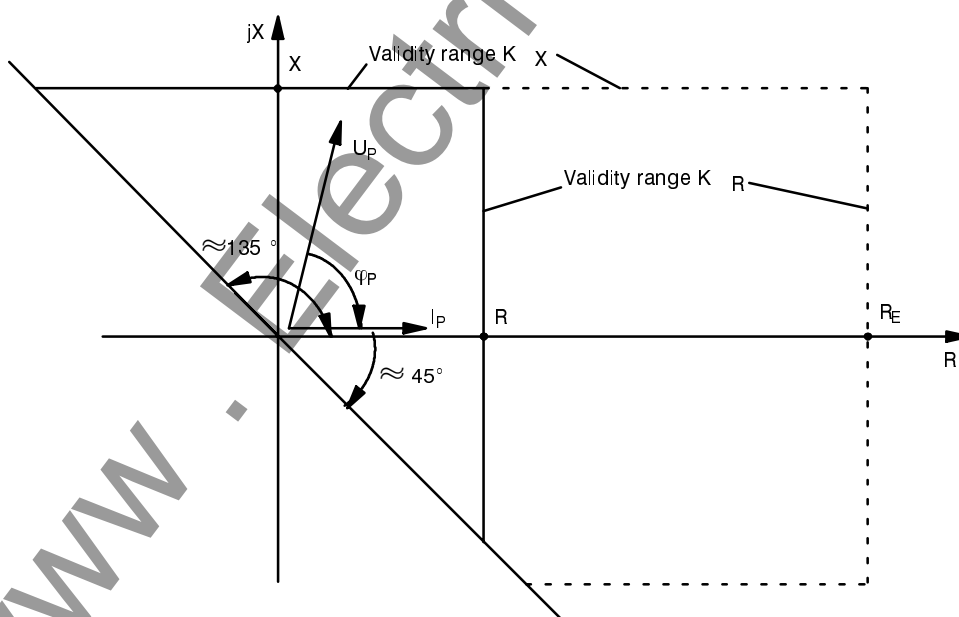


Figure 6.8 Distance zone characteristics

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 6.8), 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
 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

6.6.6 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.

6.6.7 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 intertrip facility or comparison protection, 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 fitted – should be switched off (address 3401). Communication between the devices and the carrier channel will be checked during commissioning with primary values (see Section 6.7.6).

6.6.7.1 Permissive underreach procedures

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" (FNo 4004) 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 = *FD ACCELERATION*) the relay must trip immediately upon receipt of the signal ">Dis. Recept" (FNo 4004), as long as it has already picked up.

6.6.7.2 Permissive overreach procedures

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" (FNo 4004) 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.

6.6.8 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.

6.6.9 Testing the thermal overload protection function

The overload function can only be tested if it has been configured as THERMAL OL = *EXIST* (address 7827, refer Section 5.4.2) and parameterized as operative, under address 2701.

The basis current for the detection of overload is always the rated current of the device. Overload data are calculated for each individual phase. If the tests are performed with three-phase currents no further conditions are to be considered. When testing with a single-phase current it must be noted, that the average value differs from the expected result when Θ_{mean} has been set for the operation mode under address 2706 (refer to Section 6.3.9).

When applying a test current

$$k \cdot I_N$$

tripping must not occur. After an appropriate time (approximately $5 \times \tau$) a steady-state temperature rise according to the following relationship is established:

$$\frac{\Theta}{\Theta_{\text{trip}}} = \frac{1}{k^2}$$

This value can be read out in address block 59 for each phase.

To check the time constant, the current input is simply subjected to $1.6 \times$ the pick-up value, i. e.

$$1.6 \times k \times I_N$$

Tripping will then be initiated after a time interval which corresponds to half the time constant.

It is also possible to check the trip characteristic (Figure 3.1). It must be noted, that before each measurement, the temperature rise must be reduced to zero. This can be achieved by either de-activating and re-activating the overload function (address 2701) or by observing a current free period of at least $5 \times \tau$.



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!

If testing with preload is performed, then it must be ensured that a condition of thermal equilibrium has been established before time measurement commences. This is the case, when the preload has been applied constantly for a period of at least $5 \times \tau$.

6.6.10 Testing the earth fault detection function (for non-earthed systems, if fitted)

Testing of the earth fault protection is not completely possible with conventional test sets, since the simulation of an earth fault requires a complete displacement of the voltage triangle. The correct relationship

and polarity of the measuring transformer connections, essential for proper earth fault detection, can only be tested when primary load current is available during commissioning (see Section 6.7.3).

6.6.11 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 or as non-directional inverse time overcurrent (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 blocks the earth fault protection!).

If the directional earth fault protection (definite time overcurrent) is selected, then firstly, its non-directional back-up 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 but is connected so that it would detect the earth fault current in a parallel line (address 1111 $I_{e-CT} = PARALLEL LINE$), 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!

After passing the value 75% of the set value $I_{e>}$ (address 3103) the annunciation "E/F Flt 75% $I_{e>}$ " appears (FNo 1341, not allocated in the factory setting) and after passing the set value, the annunciation "E/F Flt $I_{e<->}$ " (FNo 1342, not allocated in the factory setting).

After expiry of the time $T-NON-DIR$ (address 3108) the annunciation "E/F T<->" (FNo 1353, not allocated in the factory setting) and trip "E/F Trip" (FNo 1361) appear.

To test the directional stage a residual voltage is necessary. If address 1109 is set as $U_x CONNECT = U_{delta} TRANSFORM$, the voltage from the residual voltage winding is applied to the measured value input or, a single-phase voltage is 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, not allocated in the factory setting).

If directional comparison is also carried out the transmission circuit can be simultaneously checked: transmitting relay "E/F Send" (FNo 1384, not allocated in factory setting).

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.

For non-directional earth fault protection one working point on the inverse time characteristic (see Figure 3.3) is checked, normally at 2 times the set value $I_{e>}$ (address 3303). Pick-up indication "E/F Flt $I_{e<->}$ " (FNo 1342, at approximately 1.1 times set value, not allocated in the factory setting), trip after time delay expiry "E/F Trip" (FNo 1361, allocated in the factory setting to the three tripping relays).



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)!

6.6.12 Testing the internal auto-reclose functions (if fitted)

The internal AR function can be – depending on the ordered model – programmed to single-pole, three-pole or single/three-pole AR (address 3422), provided it is configured under address 7834 as INTERNAL AR = EX/ST (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) or 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 the circuit breaker is not ready before beginning of a test, a re-close attempt must not result; clearance of short circuits beyond Z1 is delayed by T2 or in a later stage.

Reclosing is even blocked when – at the moment of AR initiation (trip command) – the circuit breaker is signalled to be open, i.e. the breaker auxiliary contact is marshalled to a binary input (FNo 354) and this input indicates an open breaker. For security reasons, automatic reclosure shall only be carried out when the *closed* circuit breaker has been opened before.

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. For multi-shot AR (DAR), zone Z1L is decisive from the second shot on.

Note that each new test can begin only after the re-claim time or lock-out time for the previous test has expired; otherwise an auto-reclose cannot result: LED “AR not ready” (FNo 2784, LED 6, as delivered) must not be illuminated.

When multi-shot auto-reclosure is used, the sequence according to the desired programs and number of reclose attempts is to be checked.

6.6.13 Testing the internal synchronism and voltage check functions (if fitted)

The 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 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 U_x must be parameterized as connected to the bus-bar voltage U₂ (i.e. address 1109 U_x 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 U_x-input of the relay. No test current must be applied during this test.

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 U_x-voltage, close command is released, if the voltages are in counter-phase no release occurs.

U1 > U2 < = YES If the measured feeder voltage (U1) is present but the U_x-voltage (U2) switched off, close command is released.

U1 < U2 > = YES If the U_x-voltage (U2) is present but the measured feeder voltage (U1) switched off, close command is released.

U1 < U2 < = YES If the U_x-voltage (U2) and the measured feeder voltage (U1) are 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.

6.7 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 5100).

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 6.3.10).

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-clockwise 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 6.3.4.7) or for double earth fault treatment (in earthed networks, address 1703, Section 6.3.4.7) and, when appropriate, in the allocation of the individual phase pick-up indications and trip commands (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 miniature circuit breaker 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 "V2 mcb Trip C" must occur.

Switch the m.c.b.s on. The above message(s) must occur in address block 51 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 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 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.

\uparrow
 \downarrow
4 0 0 0 ■
T E S T S

Beginning of block "Tests"

\uparrow
 \downarrow
4 2 0 0 ■ D I R E C T I O N
I M P E D A N C E S

Block "Directional test"

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:

\uparrow
 \downarrow
4 2 0 1 ■ D I R E C . T E S T
L 1 E ?

Make directional test L1 – E? Confirm with **J/Y**

F o r w a r d D i r

Load flow forwards

R e v e r s e D i r

or

load flow backwards

u n d e f i n e d

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 6.9).

\uparrow
 \downarrow
4 2 0 2 ■ I M P E D A N C E S
L 1 E ?

After confirmation with the "Yes" – key **J/Y** the load impedance will be calculated and displayed:

↑	R r	=	Ω
	X r	=	Ω

Continue with ↑.

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, addresses 4209 and 4210 for L2–L3, addresses 4211 and 4212 for L3–L1, e.g.

↑	4 2 1 1	■	D I R E C .	T E S T
↓	L 3 L 1	?		

↑ ↓	4 2 1 2 ■ I M P E D A N C E S
	L 3 L 1 ?

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 6.9).

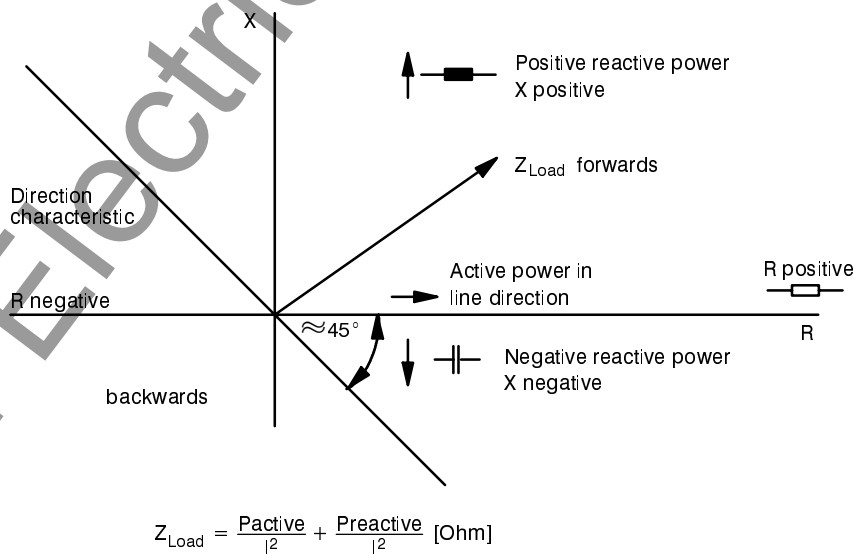


Figure 6.9 Load impedance vector

6.7.3 Earth fault checks for non-earthed systems (if used)

The primary current test allows determination of the correct polarity of transformer connections for the earth fault direction determination.



DANGER!

Operations in primary area must only be performed with plant sections voltage-free and earthed!

The most reliable test is to apply a primary earth fault. The procedure is as follows:

- Disconnect the line and earth at both ends; the line must remain disconnected at the remote end throughout the whole test.
- Apply a bolted single phase earth bridge to the line. On overhead lines, this can be done at any convenient point, but in any case behind the current transformers (looked at from the direction of the bus-bar of the circuit under test). For cables, the earth should be applied at the remote end (termination).
- Open the line earthing switches.
- Close the circuit breaker at the line end to be tested.
- Check the directional indication given (appropriately allocated LED).
- In the earth fault report on the operator terminal (address 5500, see also Section 6.4.4) the earth faulted phase and the line direction, i.e. “E/F forwards” (FNo 1276) will be indicated. Active and reactive current are equally indicated: for isolated networks the reactive current, for resonant earthed networks the active current is critical. If the display indicates “E/F reverse” (FNo 1277) then there is a crossed connection in the earth circuit of voltage or current transformers. If the display shows “E/F undefined” (FNo 1278) the earth fault current is probably too small.
- Disconnect the line and earth it; remove the bolted earth connection.
- The test is thus completed.

6.7.4 Direction check for directional earth fault protection (if used)

The primary current test allows determination of the correct polarity of transformer connections for the earth fault direction protection. If this function is not fitted, or if it is set as EARTH FAULT = *NON EXIST* (address 7831), or if the non-directional earth cur-

rent option is used (address 7831 EARTH FAULT = *INVERSE TIME*, then this directional check becomes superfluous. The distance protection shall be switched off (address 1201), so that it will not interfere with the earth fault protection.

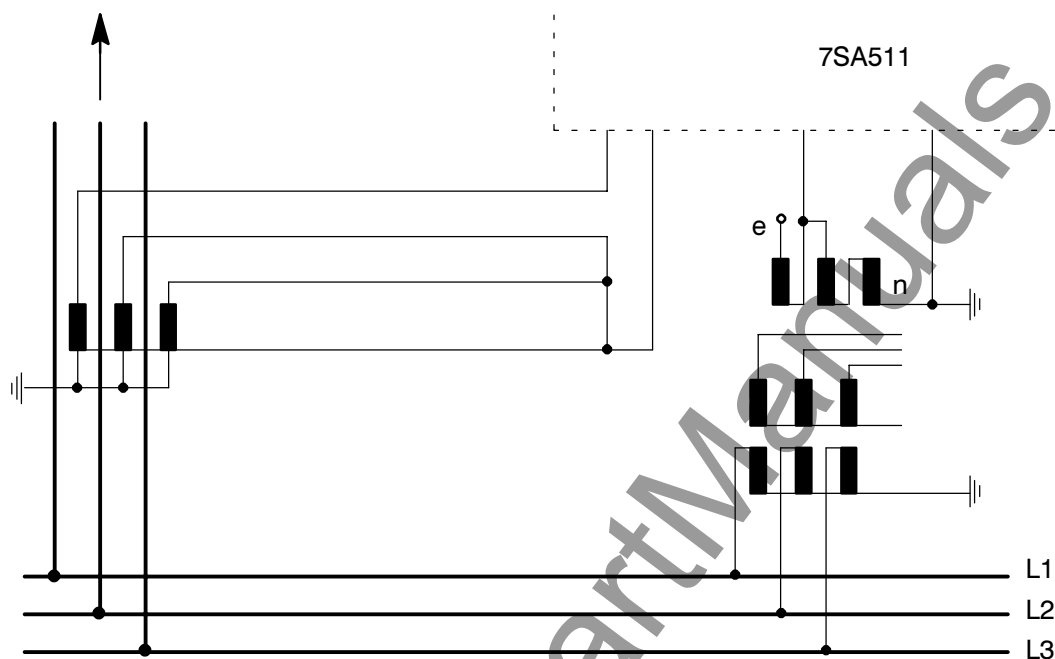


Figure 6.10 Earth fault direction test with Holmgreen connection

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 6.10). 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 current 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 following fault annunciations must be indicated: "E/F Flt 75%I_e>" (FNo 1341), "E/F Flt I_e ->" (FNo 1343) and "E/F Trip" (FNo 1361). Should directional trip 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 U_e>) has not been reached.

Finally, **properly reconnect all the transformer connections! Switch distance protection on** (address 1201 DIST.PROT = ON)!

6.7.5 Checking the voltage polarity for synchronism check

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 Section 6.3.3.1).

At first, 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 Section 5.4.2 and 6.3.14.

Next, open the line isolator and close the circuit breaker as to Figure 6.11. Thus, both voltage transformer sets receive the same voltage.

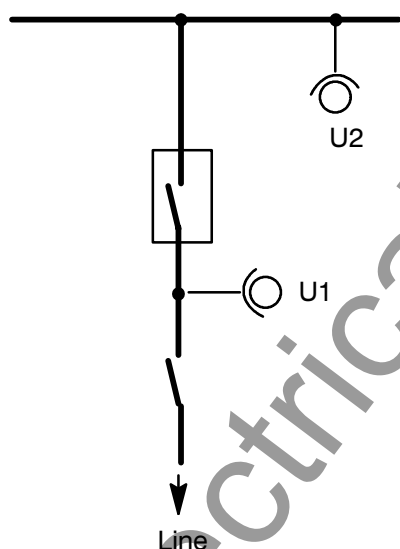


Figure 6.11 Measured voltages for synchronism check

Set the synchronism check function to the synchro-check program, i.e. address 3515 SYNCHR = YES and 3519 OVERRIDE = NO. 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 connection matching under address 1116 U_2 CONNECT (refer 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 (refer to Section 6.3.3.3). If the parameters are correct, check and correct the polarity of the voltage transformer connection from the bus-bar voltage.

Open circuit breaker. Set the synchronism check function to the dead-line check program, i.e. address 3517 $U_1 < U_2 >$ = 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.

Re-check addresses 3515 to 3519 (in case they were altered for the tests).

If asynchronous switching is to be allowed the circuit breaker closing time is measured and set correctly in address 1133 (see also Section 6.3.3.3). A suitable arrangement is shown in Figure 6.12.

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 U_1 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.

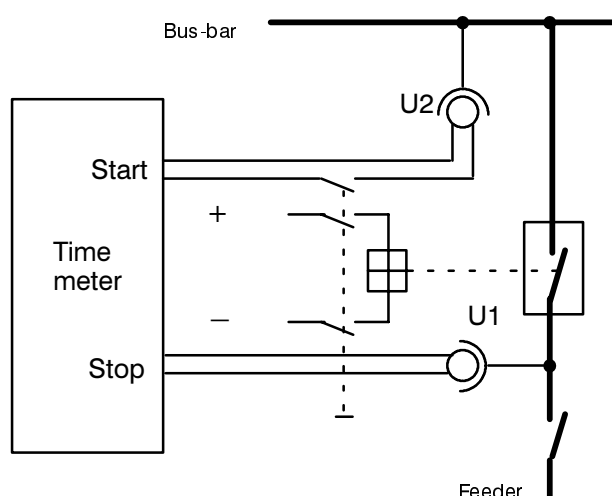


Figure 6.12 Measuring the circuit breaker closing time

6.7.6 Checking the carrier transmission system

All the equipment associated with transmission of signals should be commissioned in accordance with the appropriate documents.

6.7.6.1 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 7821 must be set *TELEPROTEC. = OVERREACH* (refer Section 5.4.2) and *POTT MODE* (address 2202) must be parameterized as *PILOT WIRE COMP.* (refer Section 6.3.6.2). The distance 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 not energized.

Simulate a short circuit beyond Z1 but within the overreach zone Z1B. Because of the presence of the block signal the relay first trips in one of the upper 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 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. All other tests described in this Section 6.7.6 become superfluous.

6.7.6.2 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 7821 must be set *TELEPROTEC. = OVERREACH* (refer Section 5.4.2) and *POTT MODE* (address 2202) must be parameterized as *REVERS INTERLOCK* (refer Section 6.3.6.2). 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. Because of the absence of the receive signal the relay trips in the (delayed) time T1B.

Now switch on the d.c. voltage for the reverse interlocking. The test as described above is repeated, with the same result.

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. All other tests described in this Section 6.7.6 become superfluous.

6.7.6.3 Checking carrier transmission with release signal

With permissive overreach transfer trip (POTT) using release signal transmission: *POTT MODE = Z1B RELEASE* or *FD DIREC RELEASE* or *Z1B UNBLOCK* or *FD UNBLOCK* (address 2202), 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 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 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 Section 5.5.2): When delivered from factory, the input for the CB auxiliary contact is INPUT 3, assigned to the function ">CB Aux. 3p c1" (refer Section 5.5.2). Change the function mode from NO to NC: ">CB Aux. 3p c1 NC". With different allocation change the mode accordingly.

Open circuit breaker. Repeat these tests for the other line end.

6.7.6.4 Checking carrier transmission with blocking signal

With overreaching transfer mode using blocking signal: POTT MODE = *Z1B BLOCKING* (address 2202), and 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) plus the transient blocking time T-TRANSBLO (address 2203) of the receiving side.

Repeat test for the other transmission direction.

6.7.6.5 Checking carrier transmission with underreach transfer signal

With permissive underreach transfer trip (PUTT), the scope of devices is set TELEPROTEC. = *UNDER-REACH* in address 7821. 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.

6.7.6.6 Checking carrier transmission for directional comparison earth fault protection

If 7SA511 is equipped with directional comparison earth fault protection and this function 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 Section 6.7.6.3. 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)!

6.7.7 Tripping test including circuit breaker

Distance protection 7SA511 allows simple checking of the tripping circuit and the circuit breaker. If the device incorporates an internal auto-reclose system, a trip–close test cycle is also possible. The test can be initiated either via a binary input.

6.7.7.1 TRIP–CLOSE test cycle – address block 43

Prerequisite for the start of a trip–close test cycle is that the relay has an integrated auto-reclose function which is programmed as *EXIST* (address 7834) and 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, 7SA511 only gives the tripping command, the procedure shall be followed as described in Section 6.7.7.2.

If the circuit breaker auxiliary contacts advise the relay, through a binary input, 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 Section 5.5.2) the relay has been informed which binary

input indicates the circuit breaker position. If the auxiliary contact is assigned to a binary input it must be connected, too. If it is not 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 will lead to closing of the circuit breaker!

Initiation of the test cycle can be given from the operator keyboard or via the operating interface. A code-word 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	Y	C	L	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 by 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, the circuit breaker auxiliary contact is assigned to a binary input and connected, the relay rejects the test cycle as

long as the 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 7SA511 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 a binary input, 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 Section 5.5.2) the relay has been informed which binary input indicates the circuit breaker position. If the auxiliary contact is assigned to a binary input it must be connected, too. If it is not 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 can lead to closing of the circuit breaker, when an external auto-reclosure device is connected!

Initiation of the test can be given from the operator keyboard or via the operating 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 "trip circuit breaker"

↑
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, the circuit breaker auxiliary contact assigned to a binary input and connected, the relay rejects the test cycle as

long as the 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 4900 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.

Check that the modules are properly inserted. 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 distance 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 10 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.
- Simulation of an internal short-circuit with $4 \times I_N$ for checking the analog input at high currents.



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 /GG,
 - VARTA Order No. 6127 101 501 for relays from production series /HH or later.

The battery is located at the rear edge of the processor board of the basic module. The basic module must be removed from the housing in order to replace the battery.

- Prepare area of work: provide conductive surface for the basic module.
- 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.

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.

- **Only for relay until production series /GG:** Prepare the battery as in Figure 7.1:



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).

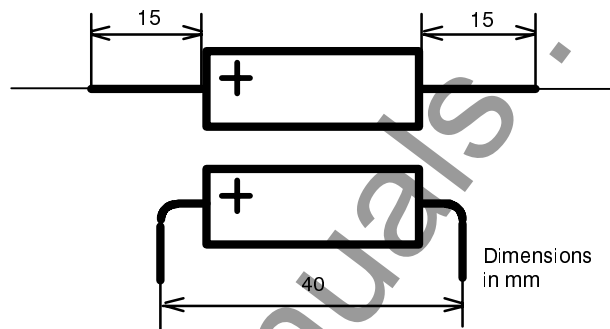


Figure 7.1 Bending the back-up battery

Relays from production series /HH or later have no axial legs.

- Loosen the basic module using the pulling aids provided at the top and bottom. (Figure 7.5).



Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the modules 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.

- Pull out basic module 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 7.2 for relay until production series /GG and to Figure 7.3 from production series /HH.
- Insert the prepared battery into the terminals or holder as in Figure 7.2 (until production series /GG) and tighten the screws or as in Figure 7.3 (from production series /HH).

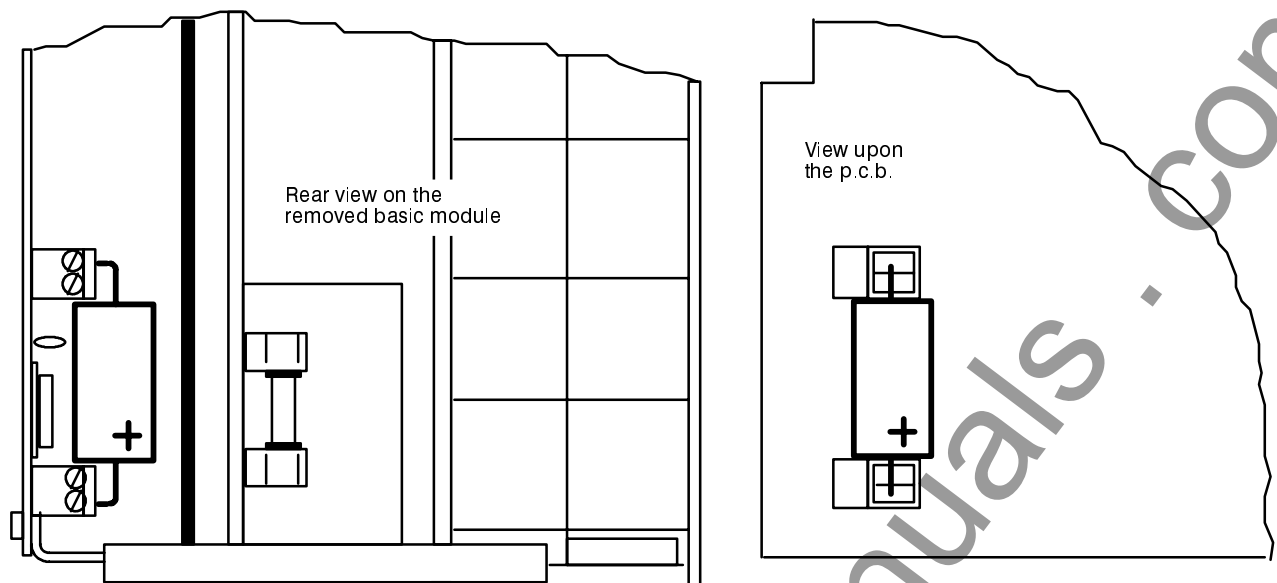


Figure 7.2 Installation of the back-up battery for relay until production series /GG

- Insert basic module into the housing; ensure that the releasing lever is pushed fully to the left before the module is pressed in.
- Firmly push in the module using the releasing lever. (Figure 7.5).



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!

- 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.

The replacement of the back-up battery has thus been completed.

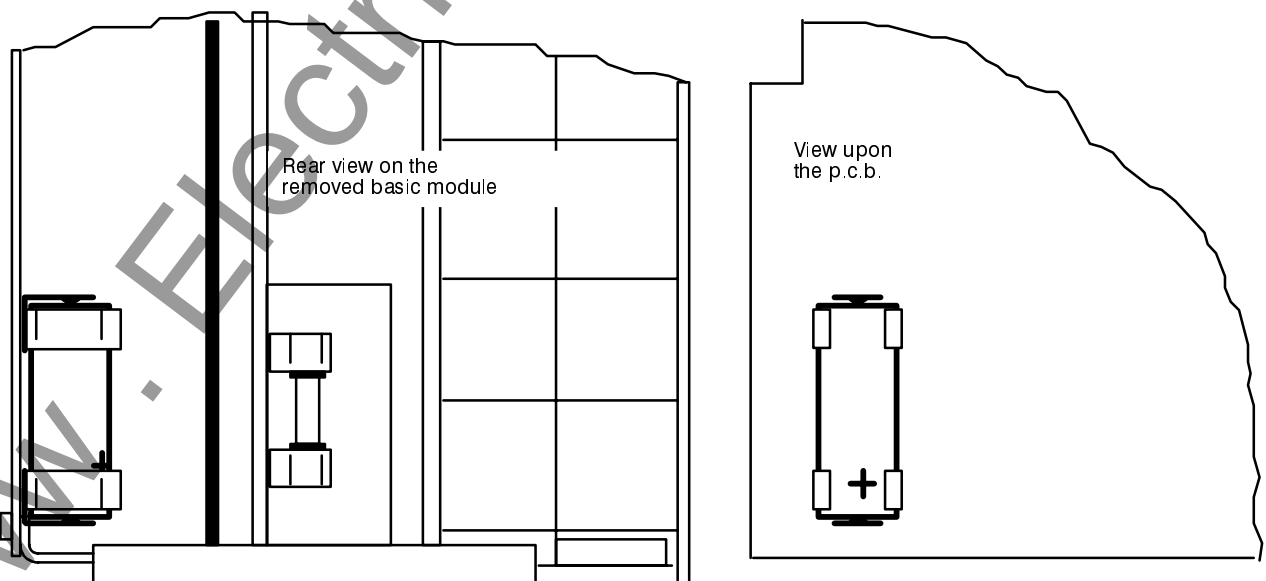


Figure 7.3 Installation of the back-up battery for relay from production series /HH

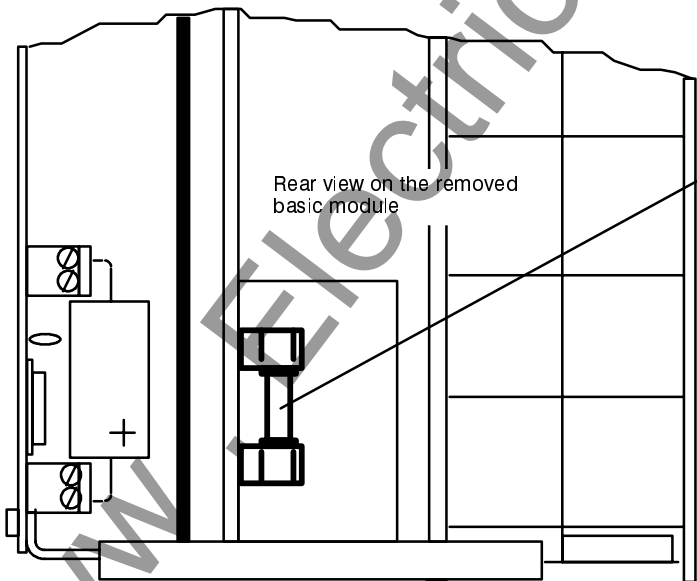
7.3 Fault tracing

If the protective device indicates a defect, the following procedure is suggested:

If none of the LEDs on the front plate of the module is on, then check:

- Have the modules been properly pushed in and locked?
- 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)?
- Has the mini-fuse in the power supply section blown (see Figure 7.4)? If appropriate, replace the fuse according to Section 7.3.1.

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.



Mini-fuse of the power supply; medium slow (M)

at U _{HN} /V–	rated value
24/48	2 A/E
60/110/125	1,6 A/E
220/250	1 A/G

Figure 7.4 Mini-fuse of the power supply

7.3.1 Replacing the mini-fuse

- Select a replacement fuse 5 × 20 mm. Ensure that the rated value, time lag (medium slow) and code letters are correct. (Figure 7.4).
- Prepare area of work: provide conductive surface for the basic module.
- Open housing cover.



Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the modules from the housing (storage capacitors)!

- Loosen the basic module using the pulling aids provided at the top and bottom. (Figure 7.5).



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.

- Pull out basic module and place onto the conductive surface.
 - Remove blown fuse from the holder (Figure 7.4).
 - Fit new fuse into the holder (Figure 7.4).
 - Insert basic module into the housing; ensure that the releasing lever is pushed fully to the left before the module is pressed in (Figure 7.5).
 - Firmly push in the module using the releasing lever. (Figure 7.5).
 - Close housing cover.
- Switch on the device again. If a power supply failure is still signalled, a fault or short-circuit is present in the internal power supply. The device should be returned to the factory (see Chapter 8).

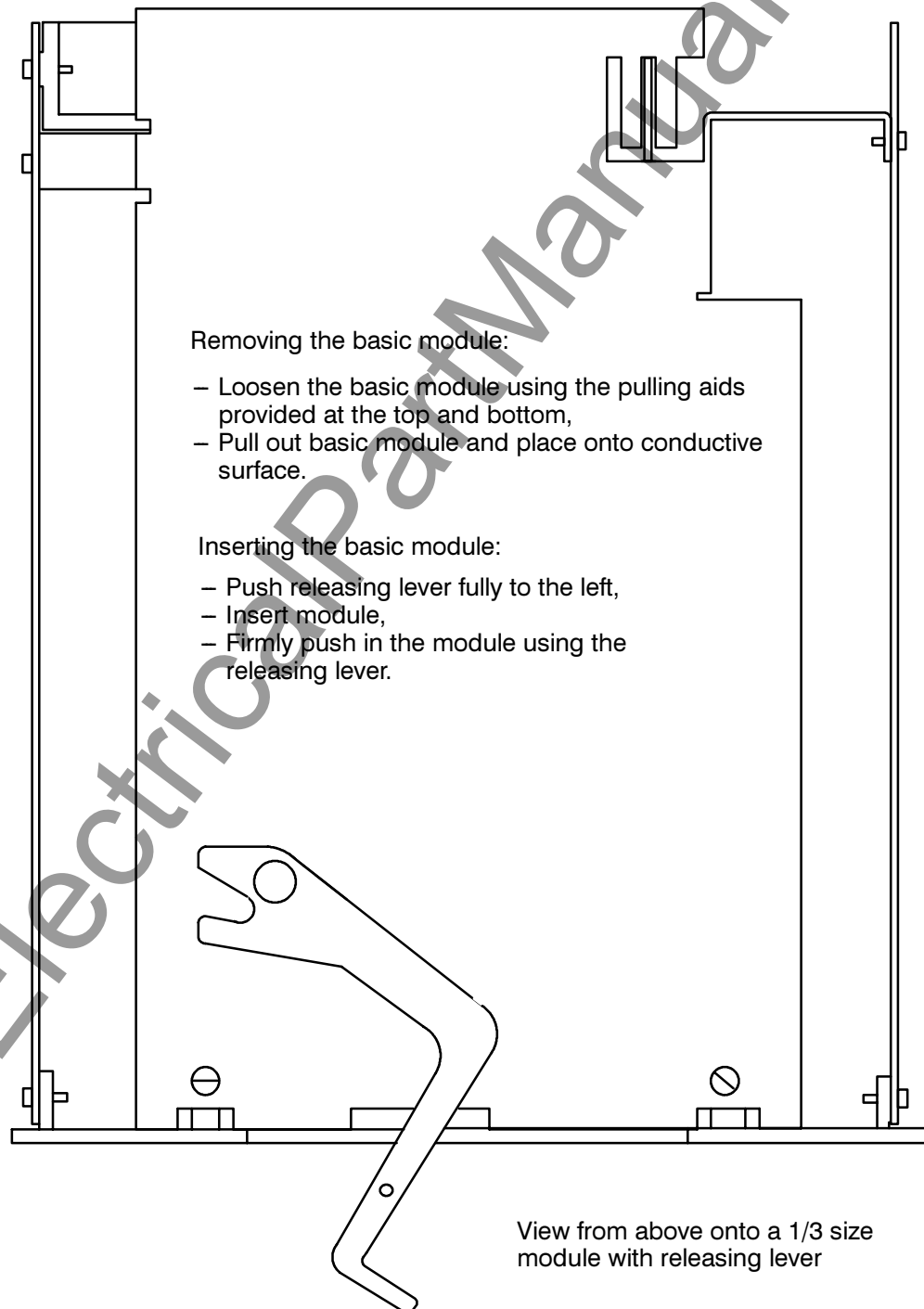


Figure 7.5 Aid for removing and inserting basic module

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

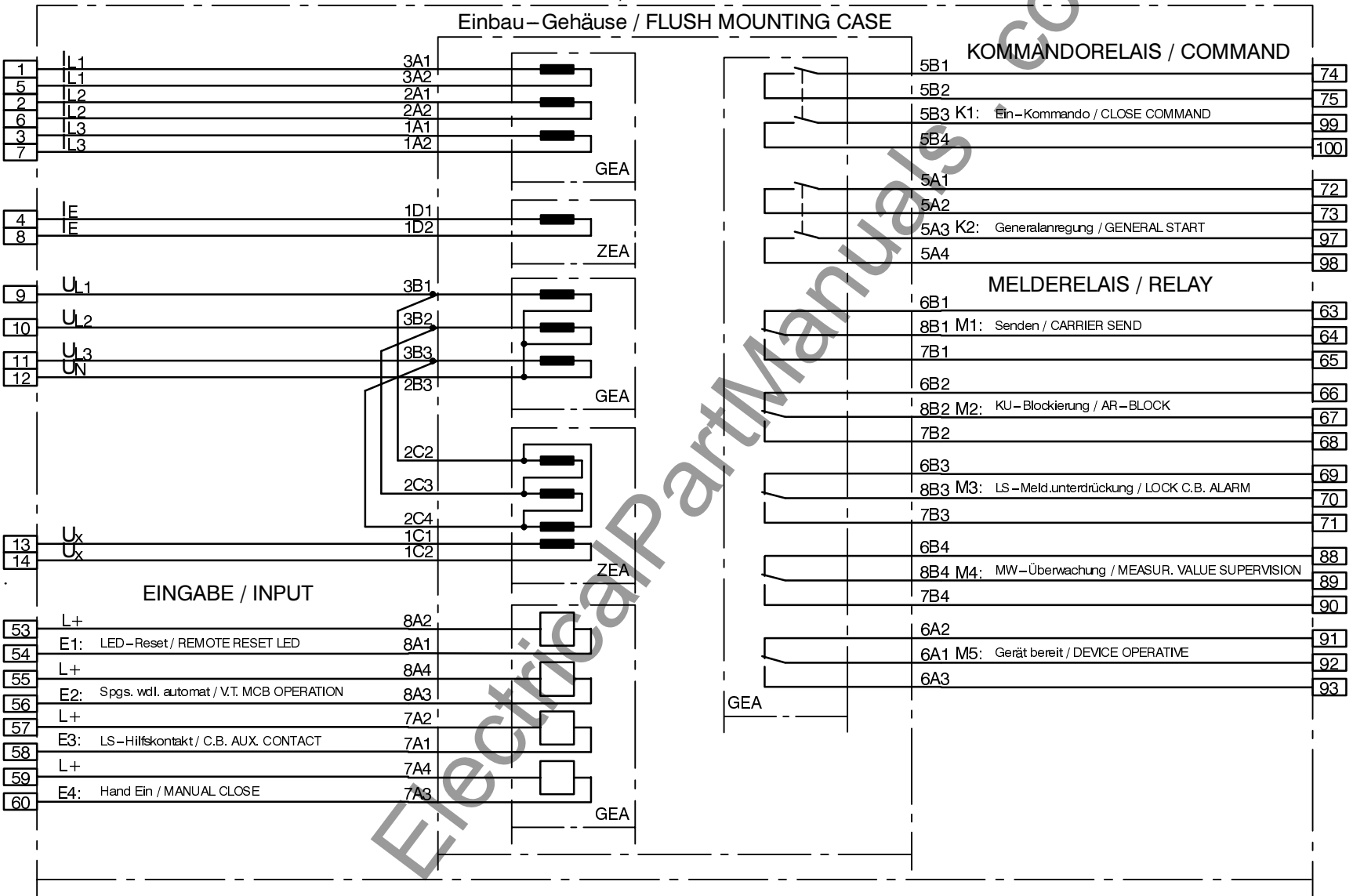


Figure A.1 General diagram 7SA511 (sheet 1 of 3)

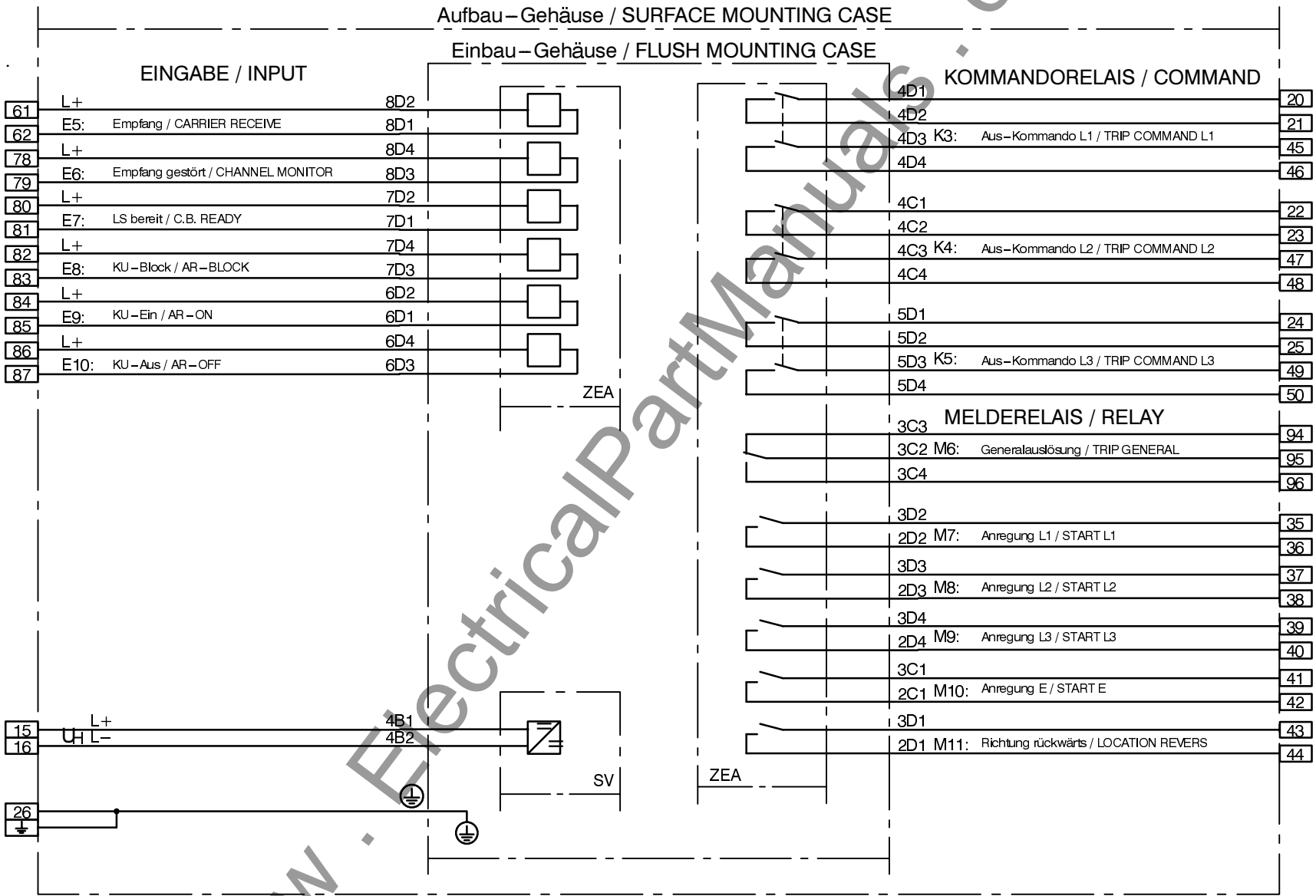
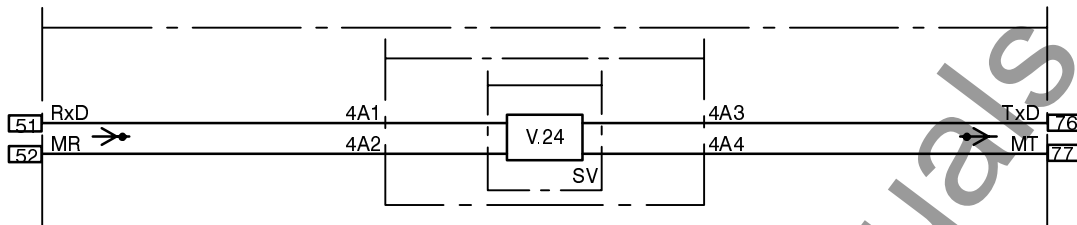
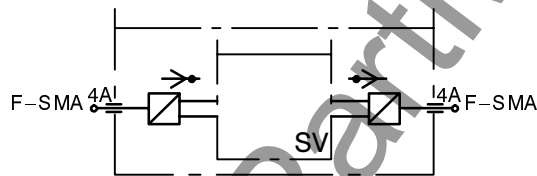


Figure A.2 General diagram 7SA511 (sheet 2 of 3)

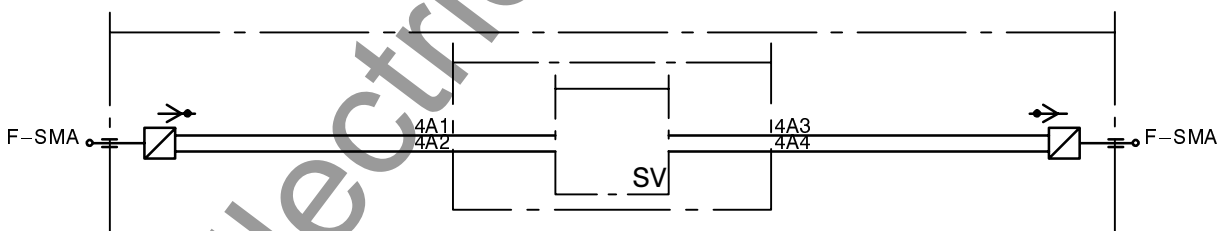


Einbau- und Aufbaugehäuse mit V24–
Schnittstelle

FLUSH AND SURFACE MOUNTING CASE WITH
V24–SERIAL DATA LINK
7SA511*–**A**–*B**/



Einbaugehäuse mit LWL–Modul
FLUSH MOUNTING CASE WITH FIBRE
OPTIC INTERFACE
7SA511*–*1)A**–*C**/
1) C,E,F,G



Aufbaugehäuse mit LWL–Modul
SURFACE MOUNTING CASE WITH FIBRE
OPTIC INTERFACE
7SA511*–*BA**–*C**/

Figure A.3 General diagram 7SA511 (sheet 3 of 3)

B Connection diagrams

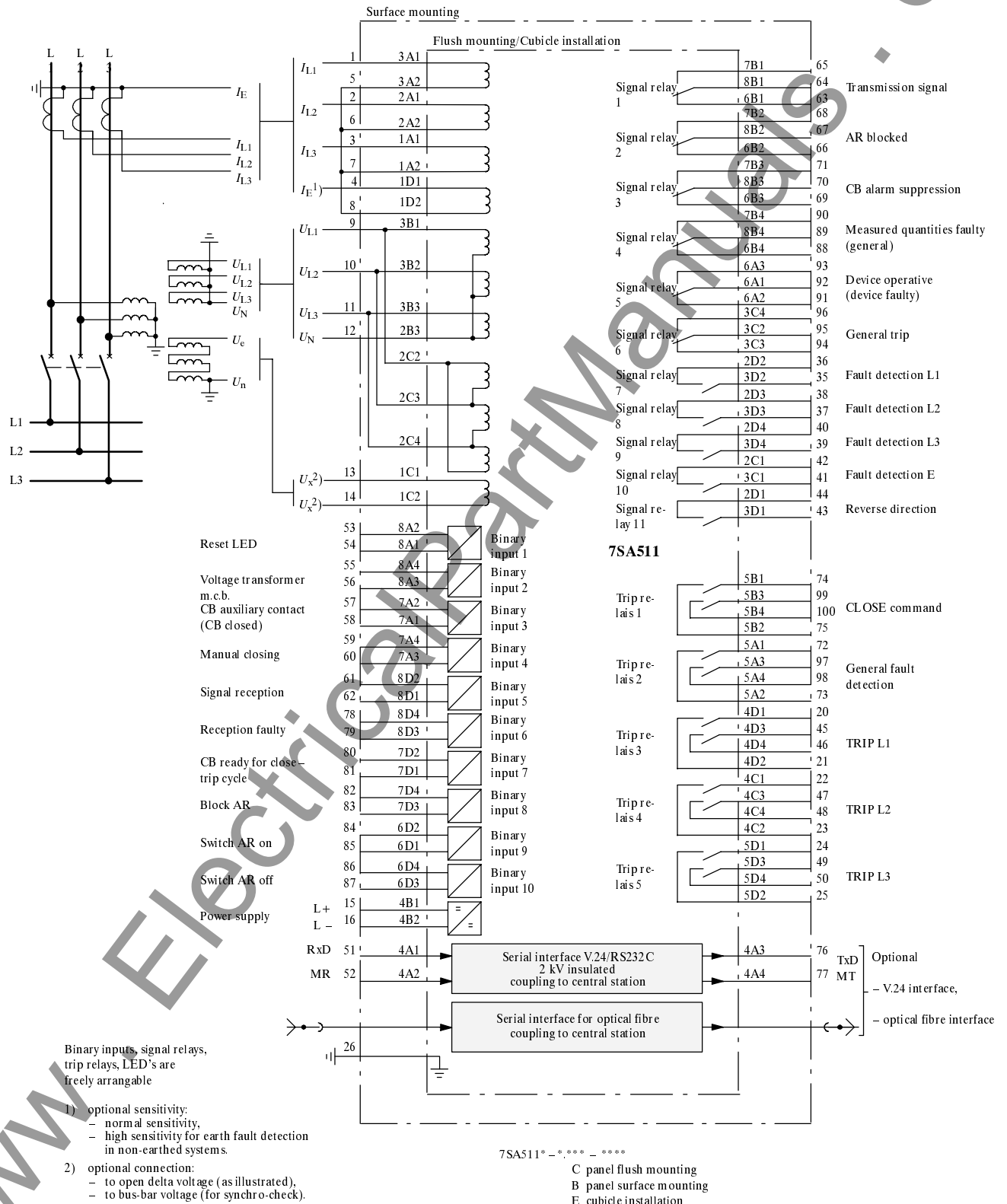


Figure B.1 Connection example 7SA511

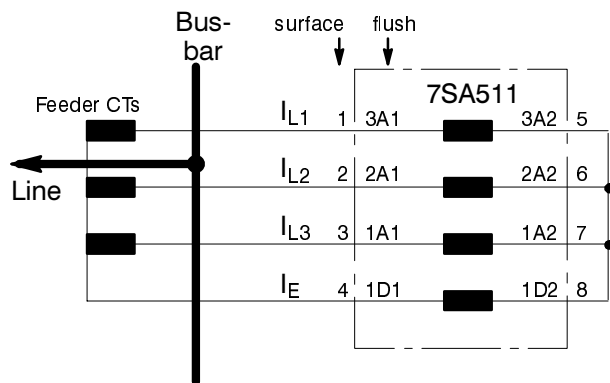
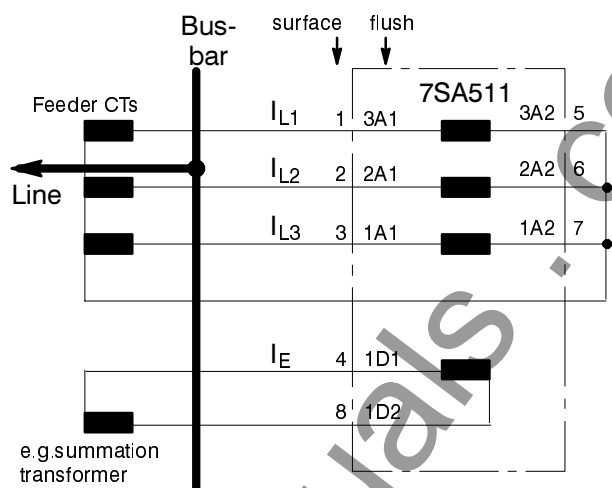


Figure B.2 CT circuits with 3 CTs



Note: If the current polarity is changed under address 1101), this changes also the polarity of the current input I_E !

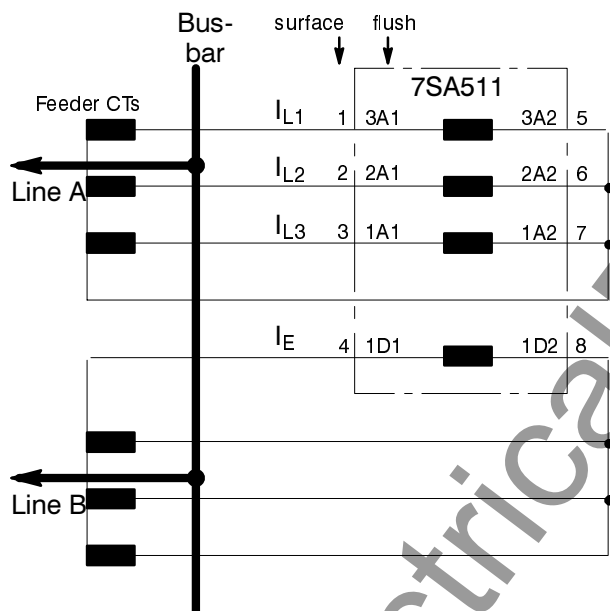
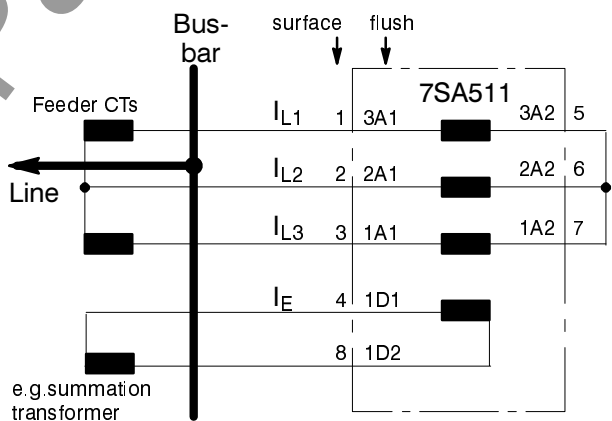
Figure B.4 CT circuits with 3 CTs and additional I_E summation CT

Figure B.3 CT circuits with 3 CTs and earth current of a parallel line B



Note: If the current polarity is changed under address 1101), this changes also the polarity of the current input I_E !

Figure B.5 CT circuits with 2 CTs and additional I_E summation CT (not for earthed systems)

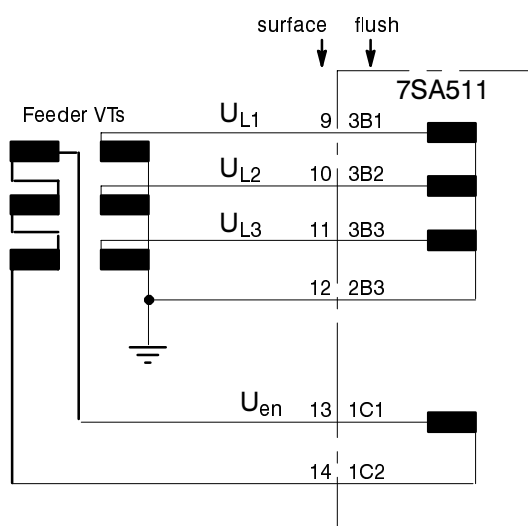


Figure B.6 VT circuits with 3 VTs with open-delta windings (e–n)

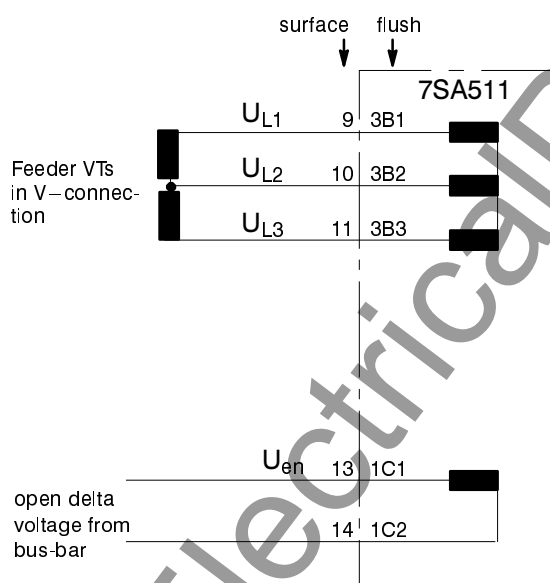


Figure B.7 VT circuits with 2 VTs and open-delta voltage from a bus-bar voltage transformer set (not for earthed systems)

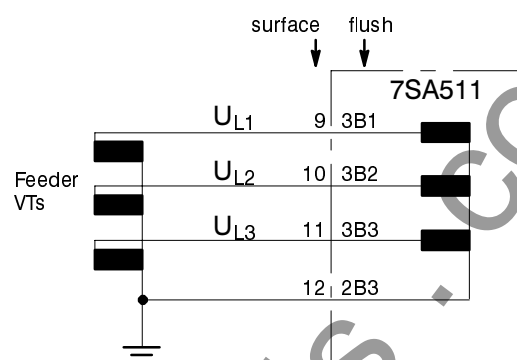
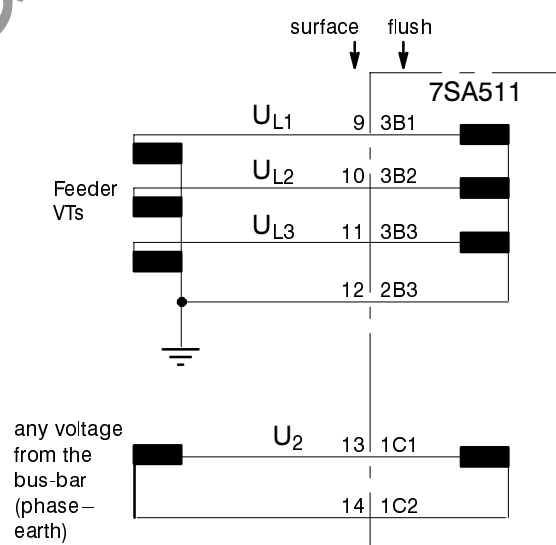


Figure B.8 VT circuits with 3 VTs

Note:

If open-delta voltage is not available (neither from feeder VTs nor from bus-bar VTs) the appropriate input on the relay remains unconnected. Nevertheless, the relay is able to detect earth faults provided three star-connected and earthed voltage transformers are available (refer Figure B.8).



or

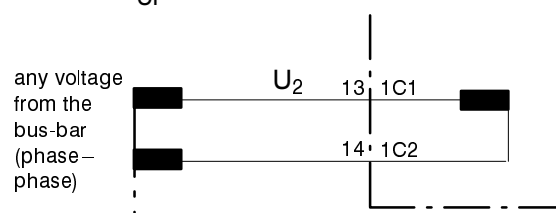


Figure B.10 VT circuits with 3 VTs and any desired voltage from the bus-bar VTs

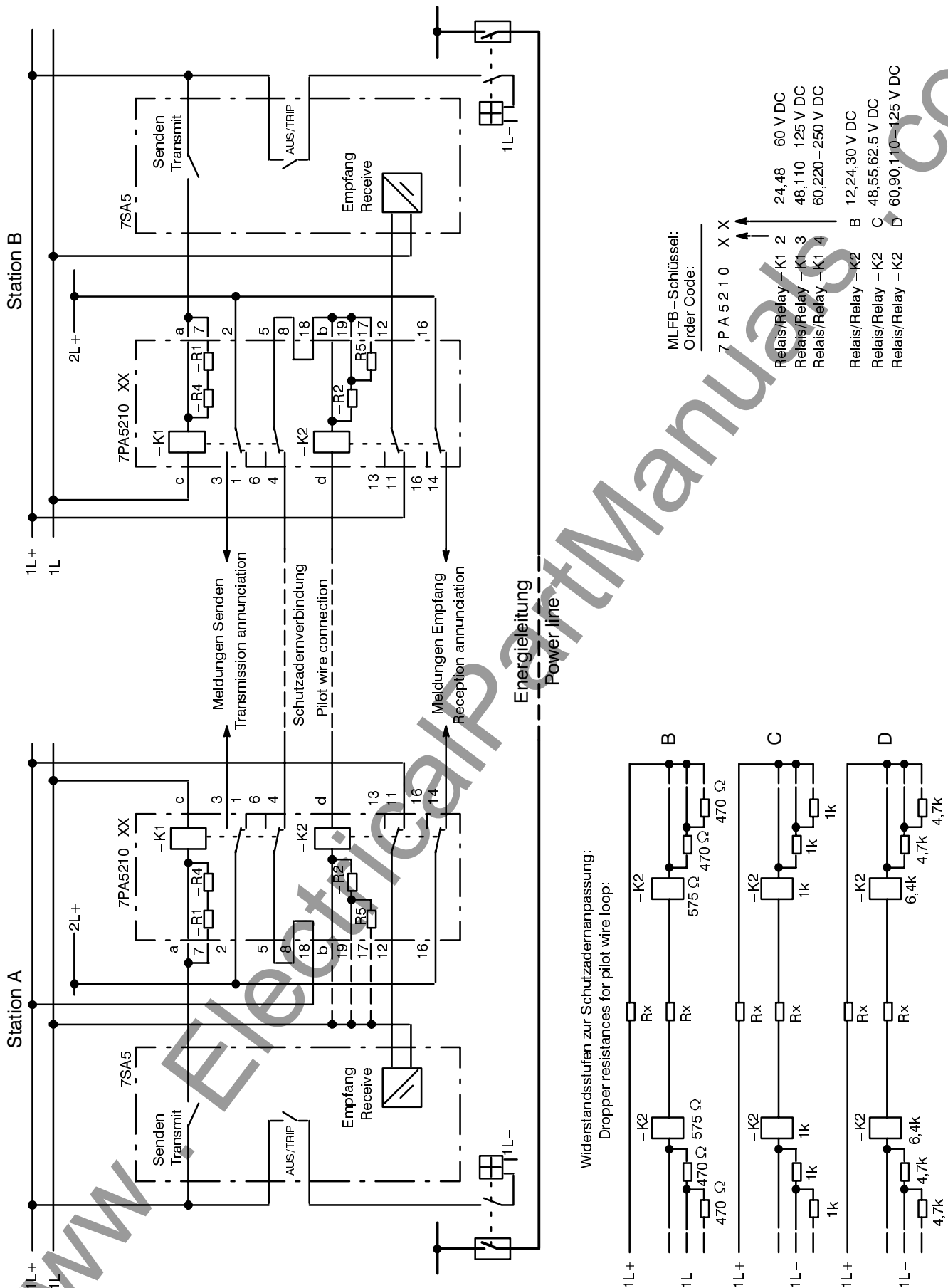


Figure B.10 Pilot wire connection scheme for overreach transfer via pilot wires, with 7SA5 at both line ends

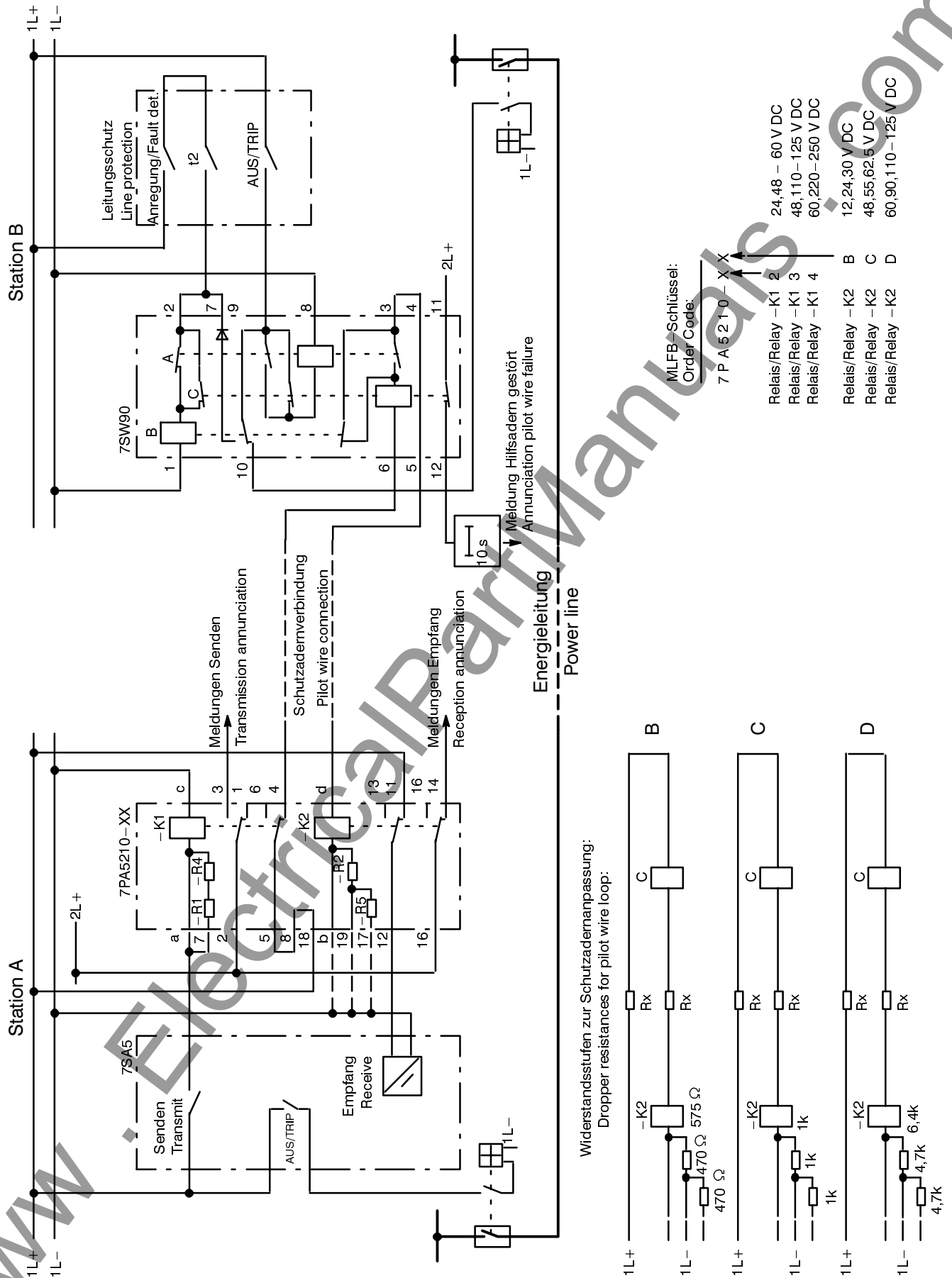


Figure B.11 Pilot wire connection scheme for overreach transfer via pilot wires, with 7SA5 at one line end and 7SW90 at the other line end

C Tables

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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 7SA511 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.	VDEW/ZVEI				
		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
151	Failure in I/O module 1	CG		100		GI		135	166
152	Failure in I/O module 2	CG		101		GI		135	167
154	Supervision trip circuit	CG			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

FNo.	Meaning	Ann.		LSA No.	VDEW/ZVEI				
		Op	Ft		CA	GI	BT	Typ	Inf
171	Failure: Phase sequence supervision	CG		111	CA	GI		p	35
204	Fault recording initiated via bin.input						BT	135	204
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
303	E/Flt.det. in isol./comp.netw.	CG				GI		135	233
361	>U Line side VT MCB tripped	CG		20	CA	GI		p	38
362	>U2 Busbar side VT MCB tripped	CG				GI		150	12
501	General fault detection of device		CG	221	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.		C	242				150	166
517	General trip for fault in reverse dir.		C	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						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
701	Iea [mA] =	M						134	128
702	Ier [mA] =	M						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						151	81
1261	E/F det. (isol./comp. net) switched off	CG		95		GI		151	161
1262	E/F detection (isol./comp. net) blocked	CG				GI		151	162
1263	E/F detection (isol./comp. net) active	CG				GI		151	163
1272	Earth fault (isol./comp.) L1 detected	CG		89	CA	GI		p	48
1273	Earth fault (isol./comp.) L2 detected	CG		90	CA	GI		p	49
1274	Earth fault (isol./comp.) L3 detected	CG		91	CA	GI		p	50
1276	Earth fault (isol./comp.) forward dir.	CG		92	CA	GI		p	51
1277	Earth fault (isol./comp.) reverse dir.	CG		93	CA	GI		p	52
1278	Earth fault (isol./comp.) undef. dir.	CG		94		GI		151	178

FNo.	Meaning	Ann.		LSA No.	VDEW/ZVEI				
		Op	Ft		CA	GI	BT	Typ	Inf
1281	Trip by earth fault det. (isol./comp.)		C					151	181
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				GI		166	32
1333	Earth fault protection is active	CG				GI		166	33
1334	Earth fault prot. direct.stage blocked	CG		64		GI		166	34
1341	Earth fault detection 75% Ie picked up		CG	208			BT	166	41
1342	Earth fault detection non-direct. Ie		CG	208				166	42
1343	Earth fault detection directional Ie		CG	209				166	43
1352	Earth fault prot. dir. time expired		C	246				166	52
1353	Earth fault prot. non-dir. time expired		C	247				166	53
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
1511	Thermal overload prot. is switched off	CG				GI		167	11
1512	Thermal overload protection is blocked	CG				GI		167	12
1513	Thermal overload protection is active	CG				GI		167	13
1515	Thermal overload prot.: Current warning	CG				GI		167	15
1516	Thermal overload prot.: Thermal warning	CG				GI		167	16
1517	Thermal overload prot.: Pick-up thermal	CG				GI		167	17
1521	Thermal overload protection trip		C				BT	167	21
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				GI		61	53
2054	Emergency O/C protection is running	CG		50	CA	GI		p	37
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					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						61	91
2093	Emerg. O/C phase fault detection I>	CG						61	93
2097	Emerg. O/C earth fault detection IE>	CG						61	97
2121	Emerg. O/C prot.: Time TI>> expired		C	153				61	121
2123	Emerg. O/C prot.: Time TI> expired		C	157				61	123
2127	Emerg. O/C prot.: Time TIE> expired		C	157				61	127
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

FNo.	Meaning	Ann.		LSA No.	VDEW/ZVEI				
		Op	Ft		CA	GI	BT	Typ	Inf
2145	Emerg. O/C protection: Trip 3pole		C	241				61	145
2704	>AR: Reset auto-reclose function	CG				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		233		GI		40	85
2787	AR: Circuit breaker not ready	CG		78		GI		40	87
2801	AR: Auto-reclose in progress	CG	CG	228		GI		40	101
2813	AR: 1pole dead time for RAR is running	CG	CG	230		GI		40	113
2814	AR: 3pole dead time for RAR is running	CG	CG	230		GI		40	114
2833	AR: 3pole dead time 1 for DAR running	CG	CG	230		GI		40	133
2834	AR: 3pole dead time 2 for DAR running	CG	CG	230		GI		40	134
2835	AR: 3pole dead time 3 for DAR running	CG	CG	230		GI		40	135
2851	AR: Close command from auto-reclose	C		248	CA		BT	p	128
2854	AR: Close command after 3pole DAR cycle	C			CA			p	129
2863	AR: Definitive trip		C	74				40	163
2871	AR: Trip during 1pole AR cycle		C					40	171
2931	Synchro-check function is switched off	CG				GI		41	31
2932	Synchro-check function is blocked	CG				GI		41	32
2934	Synchro-check function faulty	CG				GI		41	34
2935	Synchro-check supervision time expired	C						41	35
2941	Synchro-check function is running	CG				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						41	51
2961	Close command from synchro-check	C						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
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

FNo.	Meaning	Ann.		LSA No.	VDEW/ZVEI				
		Op	Ft		CA	GI	BT	Typ	Inf
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
4051	Dist. teleprotection is switched on	CG			CA	GI		p	17
4052	Dist. teleprotection is switched off	CG		63		GI		29	52
4054	Dist. teleprotection: Carrier reception		C	57	CA			p	77
4055	Dist. teleprotection: Carrier faulty	CG		60	CA	GI		p	39
4056	Dist. teleprotection: Carrier send		C	244	CA			p	76
4067	POTT teleprotection: Carrier echo send		C	59				29	67
4068	POTT teleprotection: Transient block		C	198				29	68
4164	Power swing detection	CG		80		GI		29	164
4166	Out-of-step trip 3pole		C	81				29	166
4431	Ext. trip via binary input: Trip		C					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 7SA511 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		
116	E/F Buff.Over	E/F buffer overflow			E	
120	Oper.Ann.Inva	Operational annunciations invalid	CG			
121	Flt.Ann.Inval	Fault annunciations invalid	CG			
122	E/F.Prot Inva	Earth 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
151	Failure I/O 1	Failure in I/O module 1	CG			OT
152	Failure I/O 2	Failure in I/O module 2	CG			OT
154	Fail. TripRel	Supervision trip circuit	CG			

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
159	LSA disrupted	LSA (system interface) disrupted	CG			
161	I supervision	Measured value supervision of currents				O
162	Failure Σ I	Failure: Current summation supervision	CG			OT
163	Failure Isymm	Failure: Current symmetry supervision	CG			OT
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		
303	E/F Det.	E/Flt.det. in isol/comp.netw.	CG		E	
354	>CB Aux.3p cl	>CB aux. contact:3poles closed (series)				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			

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
626	UL31[%]=	UL31 [%] =	M			
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			
701	Iea[mA]=	Iea [mA] =	M			
702	Ier[mA]=	Ier [mA] =	M			
711	Iea =	Iea =	M			
712	Ier =	Ier =	M			
801	@/@trip =	Temperat. rise for warning and trip	M			
802	@/@tripL1=	Temperature rise for phase L1	M			
803	@/@tripL2=	Temperature rise for phase L2	M			
804	@/@tripL3=	Temperature rise for phase L3	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	ΣIL1/In=	Summated current tripped IL1/In	M			
1005	ΣIL2/In=	Summated current tripped IL2/In	M			
1006	ΣIL3/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		
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
1251	>E/F Det. on	>Switch on E/F det. for isol./comp. net				IOT
1252	>E/F Det. off	>Switch off E/F det. for isol./comp.net				IOT
1253	>E/F Det.bloc	>Block E/F det. for isol./comp. net				IOT
1261	E/F Det. off	E/F det. (isol./comp. net) switched off	CG			OT
1262	E/F Det.block	E/F detection (isol./comp. net) blocked	CG			OT
1263	E/F Det.activ	E/F detection (isol./comp. net) active				OT
1271	E/F Detection	Earth fault in isol./comp. net detected		C	E	OT
1272	E/F Detec. L1	Earth fault (isol./comp.) L1 detected			E	OT
1273	E/F Detec. L2	Earth fault (isol./comp.) L2 detected			E	OT
1274	E/F Detec. L3	Earth fault (isol./comp.) L3 detected			E	OT
1276	E/F forwards	Earth fault (isol./comp.) forward dir.			E	OT
1277	E/F reverse	Earth fault (isol./comp.) reverse dir.			E	OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
1278	E/F undefined	Earth fault (isol./comp.) undef. dir.			E	OT
1281	E/F Det. Trip	Trip by earth fault det. (isol./comp.)		C	E	OT
1289	Iea	Active component Iea			E	
1290	Ier	Reactive component Ier			E	
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
1344	E/F Ue>	Earth fault displacement voltage Ue>				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		C		OT
1381	E/F Dir off	Earth fault dir. comp. is switched off	CG			OT
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
1501	>O/L on	>Switch on thermal overload protection				IOT
1502	>O/L off	>Switch off thermal overload protection				IOT
1503	>O/L block	>Block thermal overload protection				IOT
1511	O/L Prot. off	Thermal overload prot. is switched off	CG			OT
1512	O/L blocked	Thermal overload protection is blocked	CG			OT
1513	O/L active	Thermal overload protection is active				OT
1515	O/L Warn I	Thermal overload prot.: Current warning	CG			OT
1516	O/L Warn @	Thermal overload prot.: Thermal warning	CG			OT
1517	O/L pickup @	Thermal overload prot.: Pick-up thermal	CG			OT
1521	O/L Trip	Thermal overload protection trip		C		OT
2003	>Emer. block	>Block emergency overcurrent protection				IOT
2010	>I>> block	>Block I>> stage of emerg. O/C protec.	CG			IOT
2051	Emer. off	Emergency O/C protect. is switched off	CG			OT
2052	Emer. block	Emergency O/C protection is blocked	CG			OT
2053	Emer. active	Emergency O/C protection is active				OT
2054	Emer. mode	Emergency O/C protection is running	CG			OT
2061	Emer.Gen.Flt	Emerg. O/C prot.: General fault detect.				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		

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
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 L23E	Emerg. O/C fault detection L123E		C		
2091	Emer. I>>	Emerg. O/C phase fault detection I>>		C		OT
2093	Emer. I>	Emerg. O/C phase fault detection I>		C		OT
2097	Emer. IE>	Emerg. O/C earth fault detection IE>		C		OT
2121	Emer. TI>>	Emerg. O/C prot.: Time TI>> expired				OT
2123	Emer. TI>	Emerg. O/C prot.: Time TI> expired				OT
2127	Emer. TIE>	Emerg. O/C prot.: Time TIE> expired				OT
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
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
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

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
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.Req	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. phidif>	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				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		
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.L123E	Dist.: Fault detection phase L1,2,3,E		C		
3701	Loop L1-E f	Dist.: Loop L1E selected forward		CG		OT
3702	Loop L2-E f	Dist.: Loop L2E selected forward		CG		OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
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
3719	Dist. For.Dir	Dist.: Fault det. in forward direction				OT
3720	Dist. Rev.Dir	Dist.: Fault det. in reverse direction				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
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				OT
3812	Dis.TripZ1/3p	Dist.: Trip 3pole in zone Z1/T1				OT
3813	Dis.TripZ1B1p	Dist.: Trip 1pole in zone Z1B/T1B				OT
3814	Dis.TripZ1B3p	Dist.: Trip 3pole in zone Z1B/T1B				OT
3815	Dis.Trip Z1L	Dist.: Trip for fault in zone Z1L/T1L				OT
3816	Dis.TripZ2/1p	Dist.: Trip 1pole in zone Z2/T2				OT
3817	Dis.TripZ2/3p	Dist.: Trip 3pole in zone Z2/T2				OT
3818	Dis.TripZ3/T3	Dist.: Trip for fault in zone Z3/T3				OT
3819	Dis.Trip FD->	Dist.: Trip by fault detection, direct				OT
3820	Dis.Trip <->	Dist.: Trip by fault detec., non-direct				OT
4004	>Dis. Recept	>Dist. teleprotection: Carrier receive	C	C		IOT
4005	>Dis.RecFail	>Dist. teleprotection: Carrier faulty	CG			IOT
4011	>Dis.POTT on	>Dist.:Switch on teleprotection POTT				IOT
4012	>Dis.POTT off	>Dist.:Switch off teleprotection POTT				IOT
4021	>Dis.PUTT on	>Dist.:Switch on teleprotection PUTT				IOT
4022	>Dis.PUTT off	>Dist.:Switch off teleprotection PUTT				IOT
4051	Dis.Tele.on	Dist. teleprotection is switched on				OT
4052	Dis.Tele.off	Dist. teleprotection is switched off	CG			OT
4054	Dis. Recept	Dist. teleprotection: Carrier reception				OT
4055	Dis. RecFail	Dist. teleprotection: Carrier faulty	CG			OT
4056	Dis. Send	Dist. 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
4164	Power Swing	Power swing detection	CG			OT
4165	P/S T-action	Power swing action time running				OT
4166	O/S Trip	Out-of-step trip 3pole	C	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.Trip.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

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
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 7SA511

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	—	
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. 0.10		
	max. 9.99	—	
1111	Ie CT		Ie current transformer
	PROTECTED LINE	[]	Protected line
	PARALLEL LINE	[]	Parallel line
1112	Ie/Iph		Matching factor Ie/Iph for earth current
	min. 0.100		
	max. 20.000	—	
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 min. -7.00 max. 7.00	—	Mutual compensating factor RM/RL
1120	XM/XL min. -7.00 max. 7.00	—	Mutual compensating factor XM/XL
1122	X SEC min. 0.010 max. 5.000	—	Secondary reactance per unit line length Xsec Ω/km
1124	LINELENGTH min. 1.0 max. 550.0	—	Line length km
1130	T-TRIP I> min. 0.00 max. 32.00	—	Trip command min.duration for I > I-RES s
1131	T-TRIP I< min. 0.01 max. 32.00	—	Trip command min.duration for I < I-RES s
1132	U1-U2 ANGL min. -179 max. 180	—	Phase angle between U1 and U2 °
1133	T-CB CLOSE min. 0.01 max. 0.50	—	Closing (operating) time of circuit breaker s
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
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
1150	FILTER NORMAL [] LONG []		Filter for measured quantities Normal Long

1200 DIST.PROT. GENERAL SETTINGS

1201	DIST.PROT.		Distance protection function
	ON	<input type="checkbox"/>	on
	OFF	<input type="checkbox"/>	off
1202	DIR. FD&T4		Direction for fault detection directional trip
	FORWARDS	<input type="checkbox"/>	Forwards
	REVERSE	<input type="checkbox"/>	Reverse
	NON-DIRECTIONAL	<input type="checkbox"/>	Non-directional
1203	T4		Delay T4 fault detection directional trip
	min. 0.00		s
	max. 32.00/∞	_____	
1204	T5		Delay T5 fault detection non-directional trip
	min. 0.00		s
	max. 32.00/∞	_____	
1205	MAN. CLOSE		Distance zone effective with manual close
	Z1B DIRECTIONAL	<input type="checkbox"/>	Z1B directional
	Z1B NON DIRECT.	<input type="checkbox"/>	Z1B non-directional
	FD EFFECTIVE	<input type="checkbox"/>	Fault detection
	Z1 EFFECTIVE	<input type="checkbox"/>	Z1 effective
1216	RAR -> Z1B		Distance zone Z1B effective before 1st RAR
	YES	<input type="checkbox"/>	yes
	NO	<input type="checkbox"/>	no
1217	DAR BLOCK		Effective zone if DAR is blocked
	Z1; T1	<input type="checkbox"/>	Z1; T1
	Z1; T1B	<input type="checkbox"/>	Z1; T1B
1218	DAR -> Z1L		Distance zone Z1L effective before DAR
	YES	<input type="checkbox"/>	yes
	NO	<input type="checkbox"/>	no
1221	BLK.AR Z1B		Autoreclosure is blocked for Z1B faults
	NO	<input type="checkbox"/>	no
	WITHIN	<input type="checkbox"/>	Within
	OUTSIDE	<input type="checkbox"/>	Outside
1222	BLK.AR Z1L		Autoreclosure is blocked for Z1L faults
	NO	<input type="checkbox"/>	no
	WITHIN	<input type="checkbox"/>	Within
	OUTSIDE	<input type="checkbox"/>	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. 130.00	_____	
1303	R1E		Zone 1: Resistance (phase-earth) R1E
	min. 0.05		Ω
	max. 130.00	_____	

1304	DIREC. Z1		Zone 1: Direction
	FORWARDS	<input type="checkbox"/>	Forwards
	REVERSE	<input type="checkbox"/>	Reverse
	NON-DIRECTIONAL	<input type="checkbox"/>	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. 130.00	——	
1313	R2E		Zone 2: Resistance (phase-earth) R2E
	min. 0.05		Ω
	max. 130.00	——	
1314	DIREC. Z2		Zone 2: Direction
	FORWARDS	<input type="checkbox"/>	Forwards
	REVERSE	<input type="checkbox"/>	Reverse
	NON-DIRECTIONAL	<input type="checkbox"/>	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	<input type="checkbox"/>	no
	YES	<input type="checkbox"/>	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. 130.00	——	
1323	R3E		Zone 3: Resistance (phase-earth) R3E
	min. 0.05		Ω
	max. 130.00	——	
1324	DIREC. Z3		Zone 3: Direction
	FORWARDS	<input type="checkbox"/>	Forwards
	REVERSE	<input type="checkbox"/>	Reverse
	NON-DIRECTIONAL	<input type="checkbox"/>	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 min. 0.05 max. 65.00	_____	Zone 1B: Resistance (phase-phase) R1B Ω
1402	X1B min. 0.05 max. 130.00	_____	Zone 1B: Reactance (reach) X1B Ω
1403	R1BE min. 0.05 max. 130.00	_____	Zone 1B: Resistance (phase-earth) R1BE Ω
1404	DIREC. Z1B FORWARDS REVERSE NON-DIRECTIONAL	[] [] []	Zone 1B: Direction Forwards Reverse Non-directional
1405	T1B 1PHASE min. 0.00 max. 32.00/ ∞	_____	Zone 1B: Delay for single phase faults T1B 1PH s
1406	T1B >1PHAS min. 0.00 max. 32.00/ ∞	_____	Zone 1B: Delay for multi-phase faults T1B s
1411	R1L min. 0.05 max. 65.00	_____	Zone 1L: Resistance (phase-phase) R1L Ω
1412	X1L min. 0.05 max. 130.00	_____	Zone 1L: Reactance (reach) X1L Ω
1413	R1LE min. 0.05 max. 130.00	_____	Zone 1L: Resistance (phase-earth) R1LE Ω
1414	DIREC. Z1L FORWARDS REVERSE NON-DIRECTIONAL	[] [] []	Zone 1L: Direction Forwards Reverse Non-directional
1415	T1L min. 0.00 max. 32.00/ ∞	_____	Zone 1L: Delay for all faults T1L s

1500 DIST.PROT. FAULT DETEC.PROG

1501	PROG. U/I		Program for U/I fault detection
	LE:Uphe/LL:Uphph	[]	LE:Uphe/LL:Uphph
	LE:Uphph/LL:Uphp	[]	LE:Uphph/LL:Uphp
	LE:Uphe/LL:Uphe	[]	LE:Uphe/LL:Uphe
	LE:Uphe/LL:I>>	[]	LE:Uphe/LL:I>>
1503	PROG. ZA		Program for impedance fault detection
	LE:Zphe/LL:Zphph	[]	LE:Zphe/LL:Zphph
	LE:Zphe/LL:I>>	[]	LE:Zphe/LL:I>>

1600 DIST.PROT. FAULT DETECTION

1601	Iph>> min. 0.25 max. 4.00	Overcurrent detection Iph>> I/In
1602	Ie> min. 0.10 max. 1.00	Earth fault detection Ie> 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
1621	Iph> min. 0.10 max. 4.00	Minimum current for fault detection Iph> I/In
1622	X+A min. 0.10 max. 200.00	Fault detection forward reach X+A Ω
1623	X-A min. 0.10 max. 200.00	Fault detection reverse reach X-A Ω
1624	RA1 min. 0.10 max. 200.00	Fault det. resistance (ph-ph, phi<PHI A) RA1 Ω
1625	RA2 min. 0.10 max. 200.00	Fault det. resistance (ph-ph, phi>PHI A) RA2 Ω
1626	RA1E min. 0.10 max. 200.00	Fault det. resistance (ph-e, phi<PHI AE) RA1E Ω
1627	RA2E min. 0.10 max. 200.00	Fault det. resistance (ph-e, phi>PHI AE) RA2E Ω
1628	ANGLE PHIA min. 30 max. 80	Fault det. ph-ph angle betw. RA1/RA2 PHI A °

1629	ANG. PHIAE		Fault det. ph-e angle betw. RA1E/RA2E PHI AE
	min. 30		
	max. 80	—	
<hr/>			
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
	PHASE-PHASE ONLY	[]	Phase to phase only
	LEADING PH-E	[]	Leading phase-earth
	LAGGING PH-E	[]	Lagging phase-earth
1704	3PH FAULTS		Loop selection with 3phase faults
	E/F CONTROL	[]	Dependent on E/F det
	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
<hr/>			
1800	FAULT NON-EARTHED NET		
1801	Tie 1PHASE		Delay time for single phase flt. det. Tie 1PH
	min. 0.00		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
<hr/>			
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
	OUT-OF-STEP TRIP	[]	Out-of-step trip
2003	Delta R		Distance between P/S and fault detect. polygon
	min. 0.10		Ω
	max. 50.00	—	

2004	dR/dT min. 0 max. 200	_____	Rate of change of P/S vector dR/dT Ω/s
2005	P/S T-ACT. min. 0.01 max. 32.00/∞	_____	Power swing action time P/S T-ACT. s
<hr/>			
2100	TELEPROTEC PERM. UNDERREACH		
2101	PUTT ON OFF	[] []	Permissive underreach transfer trip on off
2102	PUTT MODE Z1B ACCELERATION FD ACCELERATION	[] []	Permissive underreach transfer trip mode Z1B acceleration FD acceleration
2103	T-SEND-PRL min. 0.01 max. 32.00	_____	Send signal prolongation for PUTT s
2104	T-REC-PROL min. 0.00 max. 32.00	_____	Receive signal prolongation for PUTT s
2106	T-SEND-DEL min. 0.00 max. 32.00	_____	Send signal delay for PUTT s
<hr/>			
2200	TELEPROTEC PERM. OVERREACH		
2201	POTT ON OFF	[] []	Permissive overreach transfer trip on off
2202	POTT MODE Z1B RELEASE FD DIREC RELEASE Z1B UNBLOCK FD UNBLOCK Z1B BLOCKING PILOT WIRE COMP. REVERS INTERLOCK	[] [] [] [] [] [] []	Permissive overreach transfer trip mode Z1B release Direct. comparison Unblocking with Z1B Unblocking with FD Blocking with Z1B Comp. via pilot wire Reverse interlocking
2203	T-TRANSBLO min. 0.01 max. 32.00	_____	Transient blocking time after external fault s
2204	T-WAIT min. 0.01 max. 32.00/∞	_____	Waiting time for trans.block. (missing receipt) s
2206	T-SEND-PRL min. 0.01 max. 32.00	_____	Send signal prolongation for POTT s

2210	POTT DirFD		Effect. direction for directional comparison
	FORWARDS	[]	Forwards
	REVERSE	[]	Reverse
	NON-DIRECTIONAL	[]	Non-directional
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	—	
<hr/>			
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		2nd user logic function: Pick-up time
	min. 0.00		s
	max. 32.00/∞	—	
2306	T-DROP 2		2nd user logic function: Drop-off time
	min. 0.00		s
	max. 32.00/∞	—	
<hr/>			
2600	EMERGENCY OVERCURRENT PROT		
2601	EMERG. O/C		Emergency overcurrent definite time protection
	ON	[]	on
	OFF	[]	off
2602	I>>		Highset phase overcurrent threshold (DT) I>>
	min. 0.50		I/In
	max. 9.99	—	
2603	T-I>>		Delay time for I>> TI>>
	min. 0.00		s
	max. 32.00/∞	—	

2612	I> min. 0.10 max. 4.00	_____	Phase overcurrent threshold (DT) I> I/In
2613	T-I> min. 0.00 max. 32.00/∞	_____	Delay time for I> TI> s
2621	M/CLOSE PH I>> UNDELAYED I> UNDELAYED INEFFECTIVE	[] [] []	Phase overcurrent stage effect.: Manual close I>> undelayed I> undelayed Ineffective
2623	RAR ZONE P I>> WITH AR I>> ALWAYS	[] []	Phase overcurrent stage effect.: Auto reclose I>> only with AR I>> always
2642	IE> min. 0.10 max. 4.00	_____	Earth overcurrent threshold (DT) IE> I/In
2643	T-IE> min. 0.00 max. 32.00/∞	_____	Delay time for IE> TIE> s
2651	M/CLOSE E IE> UNDELAYED INEFFECTIVE	[] []	Earth overcurrent stage effect: Manual close Ie> undelayed Ineffective

2700 THERMAL OVERLOAD PROT.

2701	THERMAL OL ALARM ONLY ON OFF	[] [] []	State of thermal overload protection Alarm only on off
2702	K-FACTOR min. 0.10 max. 4.00	_____	K-factor for thermal overload protection
2703	T-CONSTANT min. 1.0 max. 999.9	_____	Time constant for thermal overload protection min
2704	Θ WARN min. 50 max. 100	_____	Thermal warning stage %
2705	I WARN min. 0.10 max. 4.00	_____	Current warning stage I/In
2706	O/L CALCUL Θ MAX Θ MEAN Θ FROM IMAX	[] [] []	Calculation method for thermal stages Theta max Theta mean Theta from Imax

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. 0.10 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 ON OFF	[] on [] off	Fuse failure monitoring (FFM)
2911	FFM 3*Uo> min. 10 max. 100	—	Displacement voltage level for FFM V
2912	FFM Ie< min. 0.10 max. 1.00	—	Earth current for fuse failure monitoring I/In

3000 EARTHFAULT NON-EARTHED NET

3001	EARTHFAULT ALARM ONLY ON OFF	[] Alarm only [] on [] off	Sensitive earth fault det. in non-earthed net
3002	Ue> min. 10 max. 100	—	Displacement voltage level Ue> V
3003	Uph< min. 10 max. 100	—	Phase-earth voltage of faulted phase Uph< V

3004	Uph> min. 10 max. 100	_____	Phase-earth voltage of healthy phases Uph> V
3005	Ie> min. 0.003 max. 1.000	_____	Current level for directional determination A
3006	CT ERR. I1 min. 0.003 max. 1.600	_____	Second. current I1 for max error angle of C.T. A
3007	CT ERR. F1 min. 0.0 max. 5.0	_____	Error angle of C.T. at I1 °
3008	CT ERR. I2 min. 0.003 max. 1.600	_____	Second. current I2 for max error angle of C.T. A
3009	CT ERR. F2 min. 0.0 max. 5.0	_____	Error angle of C.T. at I2 °
3010	T-E/F min. 0.0 max. 320.0	_____	Duration of displacement voltage for E/F det. s
<hr/>			
3100	EARTHFAULT DIREC/NON-DIREC		
3101	E/F D.T. ON OFF	[] on [] off	Earth fault definite time protection
3103	Ie> min. 0.10 max. 4.00	_____	Pick-up value for earth current detection I/In
3104	Ue> min. 1.0 max. 10.0	_____	Minimum voltage for directional determination V
3106	T-DIRECT. min. 0.00 max. 32.00/∞	_____	Delay time for directional trip s
3107	DIRECTION FORWARDS REVERSE NON-DIRECTIONAL	[] Forwards [] Reverse [] Non-directional	Direction for directional stage
3108	T-NON-DIR. min. 0.00 max. 32.00/∞	_____	Delay time for non-directional trip s
3109	T-BLOCK min. 0.01 max. 320.00	_____	Blocking time after dist.prot. has dropped off s

3200 EARTHFAULT DIREC.COMPARISON

3201	E/F COMPAR		Directional comparison for E/F def. time prot
	ON	<input type="checkbox"/> on	
	OFF	<input type="checkbox"/> off	
3202	T-DELAY		Delay time for transmission and trip on receipt
	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/∞	_____	
3210	E/F ECHO		Echo function for directional comparison
	ON	<input type="checkbox"/> on	
	OFF	<input type="checkbox"/> 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	_____	

3300 EARTHFAULT NON-DIRECTIONAL

3301	E/F I.T.		Non directional inverse time E/F protection
	ON	<input type="checkbox"/> on	
	OFF	<input type="checkbox"/> off	
3302	E/F CHARAC		Trip time characteristic
	NORMAL INVERSE	<input type="checkbox"/> Normal inverse	
	VERY INVERSE	<input type="checkbox"/> Very inverse	
	EXTREMELY INVERS	<input type="checkbox"/> Extremely inverse	
3303	Ie>		Pick-up value for earth current detection
	min. 0.10		I/In
	max. 4.00	_____	
3304	T-Ie>		Delay time multiplier
	min. 0.00		s
	max. 32.00/∞	_____	
3305	T-BLOCK		Blocking time after dist.prot. has dropped off
	min. 0.01		s
	max. 320.00	_____	

3400 AUTORECLOSE FUNCTION

3401	AR FUNCT		Auto-reclose function
	ON	<input type="checkbox"/>	on
	OFF	<input type="checkbox"/>	off
3402	AR BLO REV		Auto-reclose block with reverse faults
	YES	<input type="checkbox"/>	yes
	NO	<input type="checkbox"/>	no
3403	MC BLOCK		Auto-reclose block with manual close
	YES	<input type="checkbox"/>	yes
	NO	<input type="checkbox"/>	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	<input type="checkbox"/>	yes
	NO	<input type="checkbox"/>	no
3413	CB? CLOSE		CB ready interrogation before reclosing
	CB? NEVER	<input type="checkbox"/>	CB? never
	CB? WITH EACH AR	<input type="checkbox"/>	CB? with each AR
	CB? WITH 2nd AR	<input type="checkbox"/>	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	<input type="checkbox"/>	Before 3pole AR
	ONLY BEFORE DAR	<input type="checkbox"/>	Only before DAR
	BEFORE 2nd DAR	<input type="checkbox"/>	Before second DAR
	NEVER	<input type="checkbox"/>	Never
3422	RAR PROG.		Rapid auto-reclose program
	THREE-POLE	<input type="checkbox"/>	Three-pole
	SINGLE-POLE	<input type="checkbox"/>	Single-pole
	SINGLE/THREE-POL	<input type="checkbox"/>	Single/three-pole
3423	3U0 PROC.		3U0 processing measurement before closing
	INEFFECTIVE	<input type="checkbox"/>	Ineffective
	1-POLE WITH U0	<input type="checkbox"/>	1-pole with U0
	1-POLE W/O U0	<input type="checkbox"/>	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. 2 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. 2 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. 0.01 max. 0.10/∞	——	Maximum freq. difference for synchronous AR Hz
3515	SYNCHR. YES NO	<input type="checkbox"/> yes <input type="checkbox"/> no	Synchronism-check before AR (U1>/U2>)
3516	U1>U2< NO YES	<input type="checkbox"/> no <input type="checkbox"/> yes	Live line / dead bus check before AR (U1>/U2<)
3517	U1<U2> NO YES	<input type="checkbox"/> no <input type="checkbox"/> yes	Dead line / live bus check before AR (U1</U2>)
3518	U1<U2< NO YES	<input type="checkbox"/> no <input type="checkbox"/> yes	Dead line / dead bus check before AR (U1</U2<)
3519	OVERRIDE NO YES	<input type="checkbox"/> no <input type="checkbox"/> yes	Override of any check before AR
3521	SYN.MAN.CL ON OFF	<input type="checkbox"/> on <input type="checkbox"/> off	Synchro-check with manual close
3522	MC Df<SYNC min. 0.01 max. 0.10/∞	——	Frequency difference for synchronous MC Hz
3525	MC SYNCHR YES NO	<input type="checkbox"/> yes <input type="checkbox"/> no	Synchro-check before MC (U1>/U2>)
3526	MC U1>U2< NO YES	<input type="checkbox"/> no <input type="checkbox"/> yes	Live line/dead bus check before MC (U1>/U2<)

3527	MC U1<U2>		Dead line/live bus check before MC (U1</U2>)
	NO	<input type="checkbox"/>	no
	YES	<input type="checkbox"/>	yes
3528	MC U1<U2<		Dead line/dead bus check before MC (U1</U2<)
	NO	<input type="checkbox"/>	no
	YES	<input type="checkbox"/>	yes
3529	MC O/RIDE		Override of any check before MC
	NO	<input type="checkbox"/>	no
	YES	<input type="checkbox"/>	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	_____	

3800 FAULT LOCATION

3802	START		Start condition for fault locator
	DROP-OFF or TRIP	<input type="checkbox"/>	Drop-off or trip
	TRIP COMMAND	<input type="checkbox"/>	Trip command
3805	PARAL.LINE		Parallel line compensation
	NO	<input type="checkbox"/>	no
	YES	<input type="checkbox"/>	yes

Tests and Commissioning Aids 7SA511

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
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Annunciations, Measured Values etc. 7SA511

5000 ANNUNCIATIONS

5100 OPERATIONAL ANNUNCIATIONS

5200 LAST FAULT

5300 2nd TO LAST FAULT

5400 3rd TO LAST FAULT

5500 ISOLATED EARTH FLT DATA

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 Σ IL1/In=	Summated current tripped IL1/In
5608 Σ IL2/In=	Summated current tripped IL2/In
5609 Σ 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 [%] =

5800 ISOL. E/F MEASURED VALUES

5801	Iea =	Iea =
5802	Ier =	Ier =
5803	Iea[mA]=	Iea [mA] =
5804	Ier[mA]=	Ier [mA] =

5900 OVERLOAD MEASURED VALUES

5901	@/@tripL1=	Temperature rise for phase L1
5902	@/@tripL2=	Temperature rise for phase L2
5903	@/@tripL3=	Temperature rise for phase L3
5904	@/@trip =	Temperat. rise for warning and trip

Reference Table for Configuration Parameters 7SA511

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	
<hr/>		
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

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

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

7000 OP. SYSTEM CONFIGURATION

7100 INTEGRATED OPERATION

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 ICD
	WITH FAULT DETEC []	With fault detection
	WITH TRIP COMM. []	With trip command

7200 PC/SYSTEM INTERFACES

7201	DEVICE ADD. min. 1 max. 254	Device address
7202	FEEDER ADD. min. 1 max. 254	Feeder address
7203	SUBST. ADD. min. 1 max. 254	Substation address
7208	FUNCT. TYPE min. 1 max. 254	Function type in accordance with VDEW/ZVEI
7209	DEVICE TYPE min. 1 max. 254	Device type
7211	PC INTERF. DIGSI V3 [] ASCII []	Data format for PC-interface DIGSI V3 ASCII
7214	PC GAPS min. 0.0 max. 5.0	Transmission gaps for PC-interface s

7215	PC BAUDRATE		Transmission baud rate for PC-interface
	9600 BAUD	<input type="checkbox"/>	9600 Baud
	19200 BAUD	<input type="checkbox"/>	19200 Baud
	1200 BAUD	<input type="checkbox"/>	1200 Baud
	2400 BAUD	<input type="checkbox"/>	2400 Baud
	4800 BAUD	<input type="checkbox"/>	4800 Baud
7216	PC PARITY		Parity and stop-bits for PC-interface
	DIGSI V3	<input type="checkbox"/>	DIGSI V3
	NO 2 STOP	<input type="checkbox"/>	No parity,2 stopbits
	NO 1 STOP	<input type="checkbox"/>	No parity,1 stopbit
7221	SYS INTERF.		Data format for system-interface
	VDEW COMPATIBLE	<input type="checkbox"/>	VDEW compatible
	VDEW EXTENDED	<input type="checkbox"/>	VDEW extended
	DIGSI V3	<input type="checkbox"/>	DIGSI V3
	LSA	<input type="checkbox"/>	LSA
7222	SYS MEASUR.		Measurement format for system-interface
	VDEW COMPATIBLE	<input type="checkbox"/>	VDEW compatible
	VDEW EXTENDED	<input type="checkbox"/>	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	<input type="checkbox"/>	9600 Baud
	19200 BAUD	<input type="checkbox"/>	19200 Baud
	1200 BAUD	<input type="checkbox"/>	1200 Baud
	2400 BAUD	<input type="checkbox"/>	2400 Baud
	4800 BAUD	<input type="checkbox"/>	4800 Baud
7226	SYS PARITY		Parity and stop-bits for system-interface
	VDEW/DIGSIV3/LSA	<input type="checkbox"/>	VDEW/DIGSI V3/LSA
	NO 2 STOP	<input type="checkbox"/>	No parity,2 stopbits
	NO 1 STOP	<input type="checkbox"/>	No parity,1 stopbit
7227	SYS-SWITCH		Online-switch VDEW-DIGSI enabled
	NO	<input type="checkbox"/>	no
	YES	<input type="checkbox"/>	yes
7235	SYS PARAMET		Parameterizing via system-interface
	NO	<input type="checkbox"/>	no
	YES	<input type="checkbox"/>	yes
7239	7SM70/71		Fault location output with 7SM70/7SM71
	NOT CONNECTED	<input type="checkbox"/>	Not connected
	CONNECTED	<input type="checkbox"/>	Connected

7400 FAULT RECORDINGS

7402	INITIATION		Initiation of data storage
	STORAGE BY FD.	<input type="checkbox"/>	Storage by fault det
	STORAGE BY TRIP	<input type="checkbox"/>	Storage by trip
	START WITH TRIP	<input type="checkbox"/>	Start with trip
7403	SCOPE		Scope of stored data
	FAULT EVENT	<input type="checkbox"/>	Fault event
	FAULT IN POW.SYS	<input type="checkbox"/>	Fault in power syst.

7410	T-MAX min. 0.30 max. 5.00	_____	Maximum time period of a fault recording s
7411	T-PRE min. 0.05 max. 0.50	_____	Pre-trigger time for fault recording s
7412	T-POST min. 0.05 max. 0.50	_____	Post-fault time for fault recording s
7431	T-BINARY IN min. 0.10 max. 5.00/∞	_____	Storage time by initiation via binary input s
7432	T-KEYBOARD min. 0.10 max. 5.00	_____	Storage time by initiation via keyboard s
7490	SYS LENGTH 660 VALUES FIX ≤3000 VAL. VAR	[] []	Length of fault record (former LSA) 660 values fix ≤3000 val. var
<hr/>			
7800	SCOPE OF FUNCTIONS		
7812	DIST. PROT. EXIST NON-EXIST	[] []	Distance protection Existent Non-existent
7813	DIST.F.DET. OVERCURRENT IMPEDANCE ZONE U/I FAULT DET.	[] [] [] []	Distance protection: Fault detection program Overcurrent FD. Impedance zone FD. U/I fault detection
7820	POWER SWING NON-EXIST EXIST	[] []	Power swing detection Non-existent Existent
7821	TELEPROTEC. NON-EXIST UNDERREACH OVERREACH	[] [] [] []	Teleprotection for distance protection Non-existent Underreach Overreach
7823	USER LOGIC NON-EXIST EXIST	[] []	User definable logic functions Non-existent Existent
7826	EMERG. O/C EXIST NON-EXIST	[] []	Emergency overcurrent time protection Existent Non-existent
7827	THERMAL OL NON-EXIST EXIST	[] []	Thermal overload protection Non-existent Existent
7830	ISOL. E/F NON-EXIST EXIST	[] []	Earth fault detection for isol./comp. networks Non-existent Existent

7831	EARTH FAULT		Earth fault protection for earthed networks
	NON-EXIST	[]	Non-existent
	DIR/NON-DIR	[]	Directional/non-dir.
	DIREC.COMPARISON	[]	Direc. comparison
	INVERSE TIME	[]	Inverse time
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
7838	FAULT LOCAT		Fault locator
	EXIST	[]	Existent
	NON-EXIST	[]	Non-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
<hr/>			
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
7926	AR w/ EMERG		Auto-reclose with emergency overcurrent prot.
	YES	[]	yes
	NO	[]	no
7930	AR w/ IS.EF		Auto-reclose with E/F det. in isol./comp. net
	YES	[]	yes
	NO	[]	no
7931	AR w/ E/F		Auto-reclose with E/F protect. in earthed net
	YES	[]	yes
	NO	[]	no
7941	AR w/ EXT.		Auto-reclose with ext. trip via binary input
	YES	[]	yes
	NO	[]	no

Operational Device Control Facilities 7SA511

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
8206	RESET	Reset of earth fault report buffer

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

www.ElectricalPartManuals.com

To

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Dept. EV S SUP 21

D – 13623 BERLIN

Germany

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