SIEMENS

Numerical Line Differential Protection with 2 Pilot Wires

7SD502 V3.1

Instruction Manual Order No. C53000–G1176–C95–4

Figure 1 Illustration of the numerical line differential protection relay 7SD502 (in flush mounting case)

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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 57435 part 303 (corresponding to VDE 0435 part 303).

Contents

1 Introduction . . . 7

1.1 Application . . . 7

1.2 Features . . . 8

1.3 Implemented functions . . . 9

1.4 Operation with other differential relays . . . 9

2 Design . . . 10

2.1 Arrangements . . . 10

2.2 Dimensions . . . 12

2.3 Ordering data . . . 14

3 Technical Data . . . 15

3.1 General data . . . 15
3.1.1 Inputs/outputs . . . 15
3.1.2 Electrical tests . . . 17
3.1.3 Mechanical stress tests . . . 18
3.1.4 Climatic stress tests . . . 18
3.1.5 Service conditions . . . 19
3.1.6 Design . . . 19

3.2 Line differential protection . . . 20

3.3 External local and transfer trip . . . 23

3.4 Overcurrent time protection . . . 24

3.5 Thermal overload protection . . . 26

3.6 Ancillary functions . . . 28

4 Method of operation . . . 29

4.1 Operation of complete unit . . . 29

4.2 Current transformer connections and fault current sensitivity . . . 31
4.2.1 Standard connection L1 – L3 – E . . . 31
4.2.2 Connection for decreased earth current sensitivity L1 – L2 – L3 . . . 33
4.2.3 Connection for increased earth current sensitivity . . . 34
4.2.4 Unequal c.t. rated currents . . . 34
4.2.5 Two-phase connection . . . 35
4.2.6 Multi-system protection . . . 35

4.3 Line differential protection . . . 37
4.3.1 Principle of measurement . . . 37
4.3.2 Stabilized differential protection . . . 37
4.3.3 Measured value formation for differential protection using two pilot wires . . . 38
4.3.4 Measured value processing . . . 39
4.3.5 Add-on stabilization during current transformer saturation . . . 40

4.3.6 Local current threshold 40
4.3.7 Pick-up and trip delay 40
4.3.8 Intertripping (optional) 41
4.3.9 Pilot wire monitoring (optional) 42
4.3.10 Use on three-terminal lines 43
4.3.11 Pilot wire resistance and capacitance 44

4.4 External local and transfer trip 45
4.4.1 External local trip 45
4.4.2 Transfer trip (optional) 45

4.5 Back-up overcurrent time protection 46

4.6 Thermal overload protection 46

4.7 Circuit breaker trip test 47

4.8 Ancillary functions 47
4.8.1 Processing of annunciations 47
4.8.1.1 Indicators and binary outputs (signal relays) 47
4.8.1.2 Information on the display panel or to a personal computer 48
4.8.1.3 Information to a central unit (optional) 48
4.8.2 Data storage and transmission for fault recording 49
4.8.3 Operating measurements and conversion 49
4.8.4 Monitoring functions 49
4.8.4.1 Hardware monitoring 49
4.8.4.2 Software monitoring 50

5 Installation instructions **51**

5.1 Unpacking and repacking 51

5.2 Preparations 51
5.2.1 Mounting and connections 52
5.2.1.1 Model 7SD502★−★B★★★ for panel surface mounting 52
5.2.1.2 Model 7SD502★−★C★★★ for panel flush mounting or 7SD502★−★E★★★ for cubicle installation . . 52
5.2.2 Checking the rated data 52
5.2.2.1 Control d.c. voltage of binary inputs 52
5.2.3 Checking the transmission link to LSA 54
5.2.4 Connections 55
5.2.4.1 Standard connections L1−L3−E 55
5.2.4.2 Connection for decreased earth current sensitivity L1−L2−L3 55
5.2.4.3 Connection for increased earth current sensitivity 55
5.2.4.4 Unequal primary c.t. rated currents 56
5.2.4.5 Two-phase connection 56
5.2.4.6 Multi-system protection 57
5.2.4.7 Primary capacitances 58
5.2.5 Current transformer requirements 59
5.2.6 Pilot wire requirements 60
5.2.7 Checking the connections 61

5.3 Configuration of operation and memory functions 62
5.3.1 Operational preconditions and general 62
5.3.2 Settings for integrated operation − address block 71 63
5.3.3 Configuration of the serial interfaces − address block 72 65
5.3.4 Settings for fault recording − address block 74 68

5.4 Configuration of the protective functions 70
5.4.1 Introduction 70
5.4.2 Programming the scope of functions − address block 78 71
5.4.3 Setting the device configuration − address block 79 72

5.5 Marshalling of binary inputs, binary outputs and LED indicators ... 73
5.5.1 Introduction ... 73
5.5.2 Marshalling of the binary inputs − address block 61 ... 75
5.5.3 Marshalling of the signal output relays − address block 62 ... 77
5.5.4 Marshalling of the LED indicators − address block 63 ... 80
5.5.5 Marshalling of the command (trip) relays − address block 64 ... 82

6 Operating instructions ... 84

6.1 Safety precautions ... 84

6.2 Dialog with the relay ... 84
6.2.1 Membrane keyboard and display panel ... 84
6.2.2 Operation with a personal computer ... 85
6.2.3 Operational preconditions ... 85
6.2.4 Representation of the relay (front view) ... 86

6.3 Setting the functional parameters ... 87
6.3.1 Introduction ... 87
6.3.1.1 Parameterizing procedure ... 87
6.3.1.2 Selectable parameter sets ... 88
6.3.1.3 Setting of date and time ... 89
6.3.2 Initial displays − address blocks 00 and 10 ... 90
6.3.3 Power system data − address block 11 ... 90
6.3.4 Settings for the line differential protection − address block 15 ... 92
6.3.5 Settings for pilot wire monitoring − address block 16 ... 96
6.3.6 Settings for the external local trip facility − address block 21 ... 97
6.3.7 Settings for the transfer trip facility − address block 22 ... 98
6.3.8 Settings for the reaction on reception of a remote trip signal − address block 23 ... 99
6.3.9 Settings for back-up overcurrent time protection − address block 26 ... 100
6.3.10 Settings for thermal overload protection − address block 27 ... 102
6.3.11 Settings for measured value monitoring − address block 29 ... 104

6.4 Annunciations ... 105
6.4.1 Introduction ... 105
6.4.2 Operational annunciations − address block 51 ... 106
6.4.3 Fault annunciations − address block 52 to 54 ... 111
6.4.4 Circuit breaker operation statistics − address block 56 ... 114
6.4.5 Read-out of operational measured values − address blocks 57 and 59 ... 115

6.5 Operational control facilities ... 117
6.5.1 Adjusting and synchronizing the real time clock − address block 81 ... 117
6.5.2 Erasing stored annunciations and counters − address block 82 ... 118
6.5.3 Information to LSA during test operation − address block 83 ... 119
6.5.4 Selection of parameter sets − address block 85 ... 120
6.5.4.1 Read-out of settings of a parameter set ... 120
6.5.4.2 Change-over of the active parameter set from the operating panel ... 120
6.5.4.3 Change-over of the active parameter set via binary inputs ... 121

6.6 Testing and commissioning ... 122
6.6.1 General ... 122
6.6.2 Testing the differential protection ... 123
6.6.3 Testing the back-up overcurrent time protection ... 124
6.6.3.1 Testing the high-set overcurrent stage I>> ... 124
6.6.3.2 Testing the definite time overcurrent stage I> ... 124
6.6.3.3 Testing the inverse time overcurrent stage I_p ... 124
6.6.4 Testing the thermal overload protection function ... 125

6.7 Commissioning using primary tests 126
6.7.1 Measuring and setting of the pilot wire capacitance 127
6.7.2 Measuring and setting of the pilot wire resistance 129
6.7.3 Checking of the current transformer connections at one line end 131
6.7.4 Checking of the current transformer and pilot wire connections at both line ends 133
6.7.5 Checking of the current transformer and pilot wire connections at three-terminal lines 135
6.7.6 Pilot wire monitoring (if fitted) 138
6.7.7 Checking direct local and transfer trip facility 139
6.7.8 Tripping test including circuit breaker − address block 44 139
6.7.9 Switching tests and starting a test fault record − address block 49 140

6.8 Putting the relay into operation 141

7 Maintenance and fault tracing 142

7.1 Routine checks 142

7.2 Replacing the clock module 143

7.3 Fault tracing 144
7.3.1 Replacing the mini-fuse 145

8 Repairs 147

9 Storage 147

Appendix 148

A General diagrams 149

B Connection diagrams 151

C Tables 155

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

The numerical line differential protection is a fast and selective short-circuit protection for cables and overhead lines, independent of the treatment of the network neutral.

It is particularly suited to short lines, where, for example, zone 1 of the distance protection cannot be set sufficiently short. It can be used with lines down to any length. One set of current transformers is required at each end of the line. Voltage transformers are not required.

An essential advantage of the differential protection system is its ability to initiate the immediate disconnection of any short-circuit at any location in the protected zone. The current transformers at each end separate the protected zone from the rest of the network. This precise zone cut-off is the reason for the absolute selectivity of the differential protection principle. This eliminates the need to delay the trip signal which is necessary with time-graded protection.

The line differential protection system requires the installation of one 7SD502 unit at each end of the protected line. The two relays must be interconnected by two pilot wires. These pilot wires may have a maximum loop resistance of approximately 1800 Ohms. They must be adequately insulated from one another and to earth (refer to Section 5.2.6). 7SD502 is particularly designed to operate with existent pilot wire pairs. In case a brand-new comparison link is to be installed, the use of current comparison protection 7SD511 or 7SD512 with optical fibre link is advantageous for two-terminal lines.

Since any fault on the two pilot wires will cause failure of the protective devices, it is recommended that the pilot wire monitoring system be installed. If a pilot wire fault is detected, the differential protection system may be blocked (selectable), and an alarm is issued.

Since the comparison protection does not disconnect faults outside the protected zone, an additional time-graded protection must be installed at at least one end of the line to serve as superimposed back-up protection. For this purpose, the incorporated overcurrent time protection may be used which can operate optionally as definite time or inverse time protection.

In cases where a power transformer is directly connected (i.e. without a circuit-breaker) to a cable or to an overhead line, current transformers should be installed at the connection point and the 7SD502 relay should only be used as line protection. By use of the integrated second harmonic restraint feature (from firmware version V3.1 or later), 7SD502 is, in principle, suitable for the inclusion of a transformer in the protected zone, but, because of the high parasitic currents especially on cables, the advantage of high sensitivity cannot be exploited as with a transformer differential protection, e.g. 7UT51 which provides, additionally, an integrated matching of the transformer vector group.

A thermal overload protection is integrated for use on cables.

Throughout a fault in the network the magnitudes of the instantaneous values are stored for a period of max. 5 seconds (at 50 Hz) and are available for subsequent fault analysis. Fault inception is tagged with the real time provided the internal real time clock is available.

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 (optional). For data transmission a standardized protocol in accordance with IEC 60870−5−103 and VDEW/ZVEI is used, as well as according DIN 19244 (selectable). The device can therefore be incorporated in Localized Substation Automation networks (LSA).

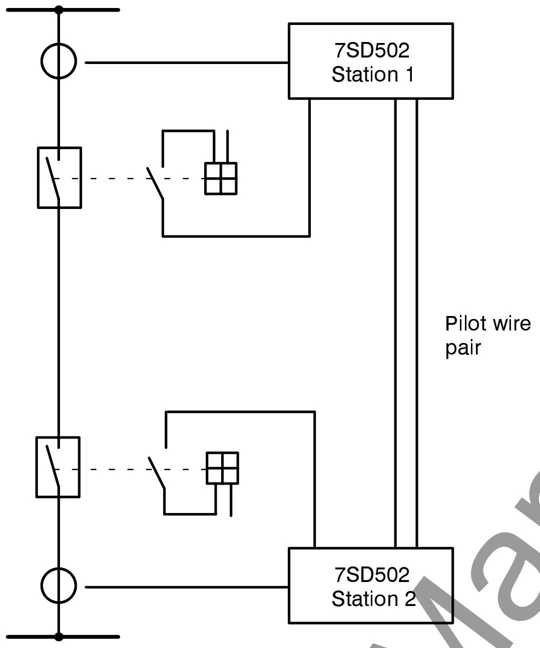


Figure 1.1 Line differential protection for use with 2 pilot wires 7SD502, scheme

1.2 Features

- Processor system with powerful 16–bit–microprocessor;
- Complete digital measured value processing and control from data acquisition and digitizing of the measured values up to the trip decisions for the circuit breakers;
- Complete galvanic and reliable separation of the internal processing circuits from the measurement, control and supply circuits of the system, with screened analog input transducers, binary input and output modules and DC converter;
- Separate measuring unit at each line end;
- Moderate current transformer requirements;
- Comprehensive supplementary functions (refer to Section 1.3);
- Continuous calculation of operational measured values and indication on the front display;
- Simple setting and operation using the integrated operation panel or a connected personal computer with menu-guided software;
- Storage of fault data, storage of instantaneous values during a fault for fault recording;
- Data exchange with opposite station via a symmetrical pilot wire pair allows to utilize existing pilot wires;
- Communication with central control and storage devices via serial interfaces is possible with optical fibre connection (optional);
- Continuous monitoring of the measured values and the hardware and software of the relay.
- Simple installation and commissioning, integrated commissioning aids;
- Low maintenance requirements.

1.3 Implemented functions

The numerical line differential protection relay 7SD502 contains the following functions:

Differential protection

– protection for all kinds of short-circuits in systems with earthed or non-earthed star-point;

– current restraint compensates for c.t. transformation errors under through-fault conditions;

– additional dynamic stabilization against different current transformer saturation;

– second harmonic stabilization for inclusion of a power transformer in the protected zone;

– one end tripping for fault fed from one end only; optionally tripping of the non-feeding end possible;

– data exchange with opposite station via a pair of symmetrical pilot wires;

– pilot wire resistance is adjusted by internal calculation;

– compensation of the pilot wire capacitance by internal calculation without external components;

– optional continuous pilot wire supervision with pulse coded voice frequency signal.

Overcurrent time protection

– operates as definite time or inverse time overcurrent protection with selectable characteristics;

– separate high current stage with definite time characteristic or instantaneous trip.

Direct local and transfer trip

– tripping of the local circuit breaker from an external source with adjustable delay and reset time;

– tripping of the remote end circuit breaker by an external signal, e.g. breaker failure protection (models with pilot wire monitor).

Thermal overload protection

– provides thermal replica of the current heat losses;

– true r.m.s. measurement of symmetrical currents;

– adjustable warning stages.

The standard functions also include:

– continuous self-monitoring right from the DC circuits, through the current 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 current;

– annunciation storage for the last three network faults, with real time clock;

– data storage and transmission for fault records giving
rapid fault analysis,
detailed fault records;

– counting of tripping commands as well as recording of fault data and accumulative addition of the interrupted fault currents;

– commissioning aids such as connection check, measurement of the pilot wire resistance and capacitance, and circuit breaker live test.

1.4 Operation with other differential relays

The numerical line differential protection relay 7SD502 is not suitable for use with other types of differential relays. The internal adjustment of the influence of the pilot wire resistance and the (optional) pilot wire supervision using a pulse code modulated voice frequency cannot operate with different types of differential relays with two pilot wires. Should it become necessary to divide a line which is protected by electromechanical or analog-statical relays into two sections, it is advisable to install 7SD502 at both ends of one of the line sections and to use the existing relay pair for the other line section (of course, both sections can be protected with 7SD502 protection systems).

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:

– **7SD502⋆–⋆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.

  Guide rails are built in for the support of plug-in modules. On the top and bottom plates of the housing, contact areas which are electrically connected to the housing are installed to mate with the earthing springs 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. With differential protection relays, trip may occur due to unequal contacting when modules are withdrawn or inserted.

  For the optional interface to a central control and storage unit, an additional coupling facility has been provided. For optical fibre connection (model 7SD502⋆–⋆⋆⋆⋆⋆–⋆**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.

– **7SD502⋆–⋆C⋆⋆⋆–** in housing 7XP2040–2 for **panel flush mounting** or **7SD502⋆–⋆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.

  Guide rails are built in for the support of plug-in modules. On the top and bottom plates of the housing, contact areas which are electrically connected to the housing are installed to mate with the earthing springs 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. With differential protection relays, trip may occur due to unequal contacting when modules are withdrawn or inserted.

  The optional interface to a central control and storage unit (7SD502⋆–⋆⋆⋆⋆⋆–⋆**B**) is led to a module with 2 F–SMA connectors for optical fibre connection.

  The plug modules are labelled according to their mounting position by means of a grid system (e.g. **1A**2). The individual connections within a module are numbered consecutively from left to right (when viewed from the rear), (e.g. 1A**2**); refer to Figure 2.1.

  Degree of protection for the housing is IP51 (IP30 for cubicle installation), for the terminals IP21. For dimensions please refer to Figure 2.3.

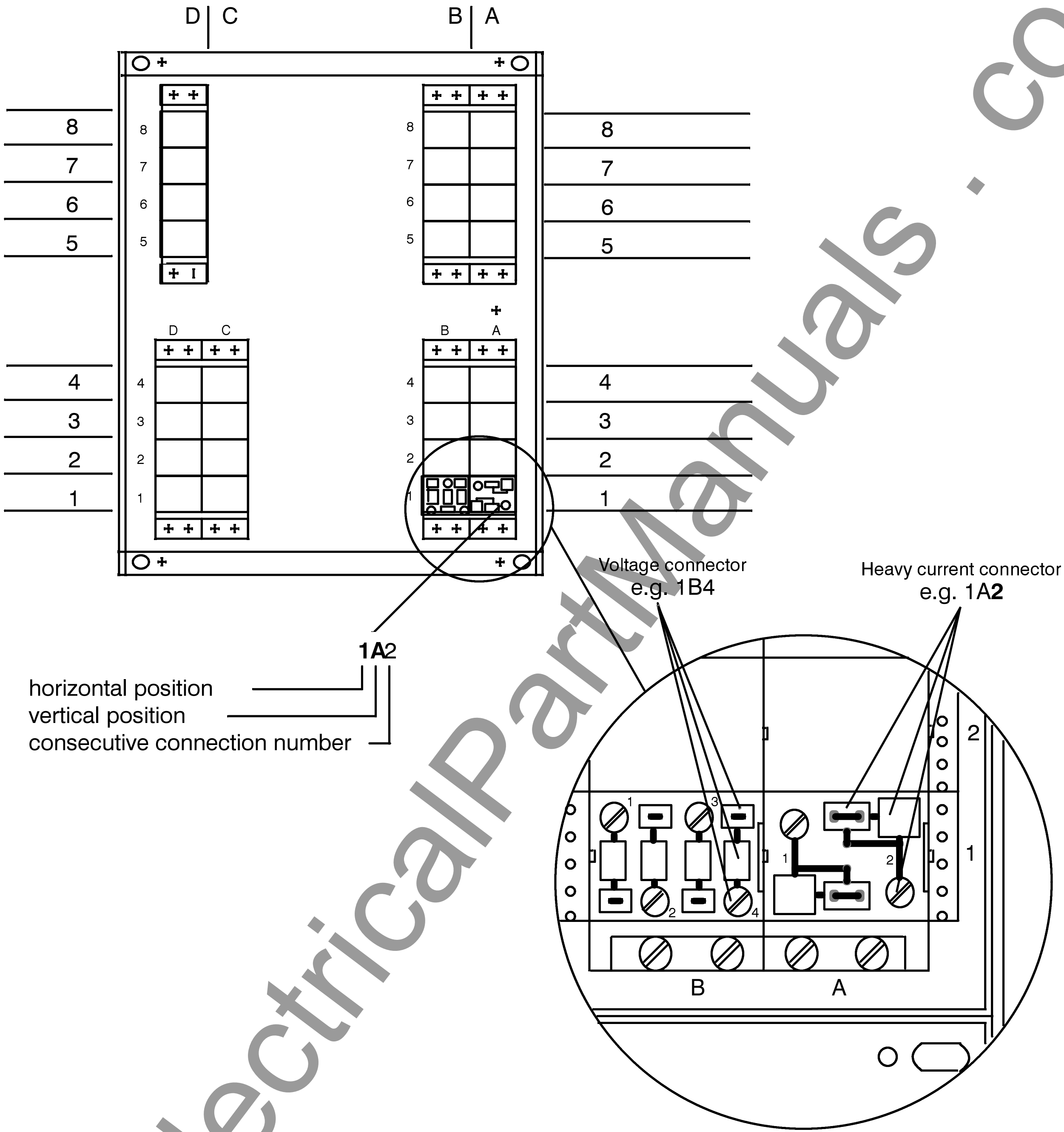
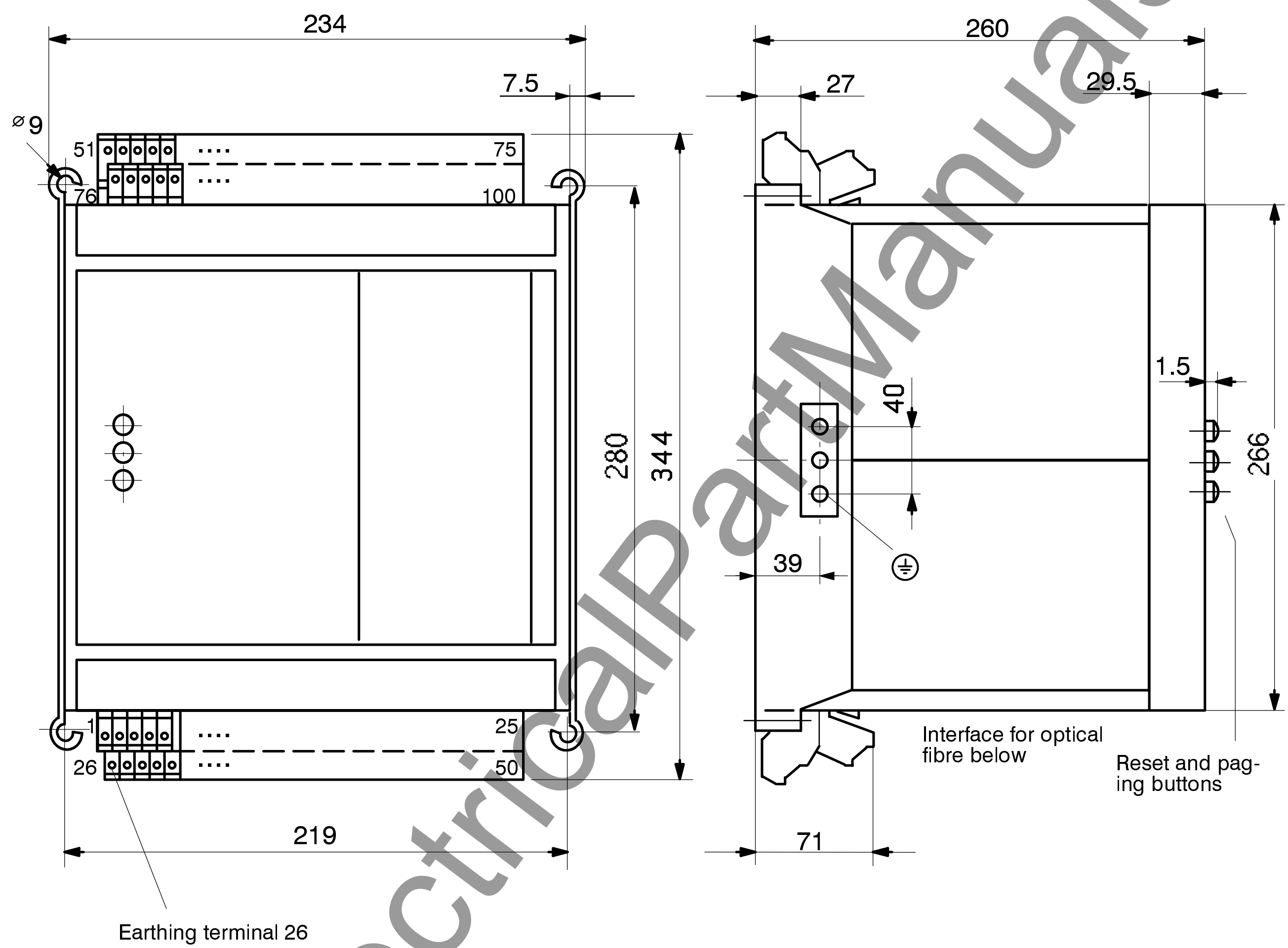


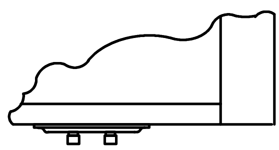
Figure 2.1 Connection plugs (rear view) – housing for flush mounting – example

2.2 Dimensions

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

7SD502 Housing for **panel surface mounting** 7XP2040−1





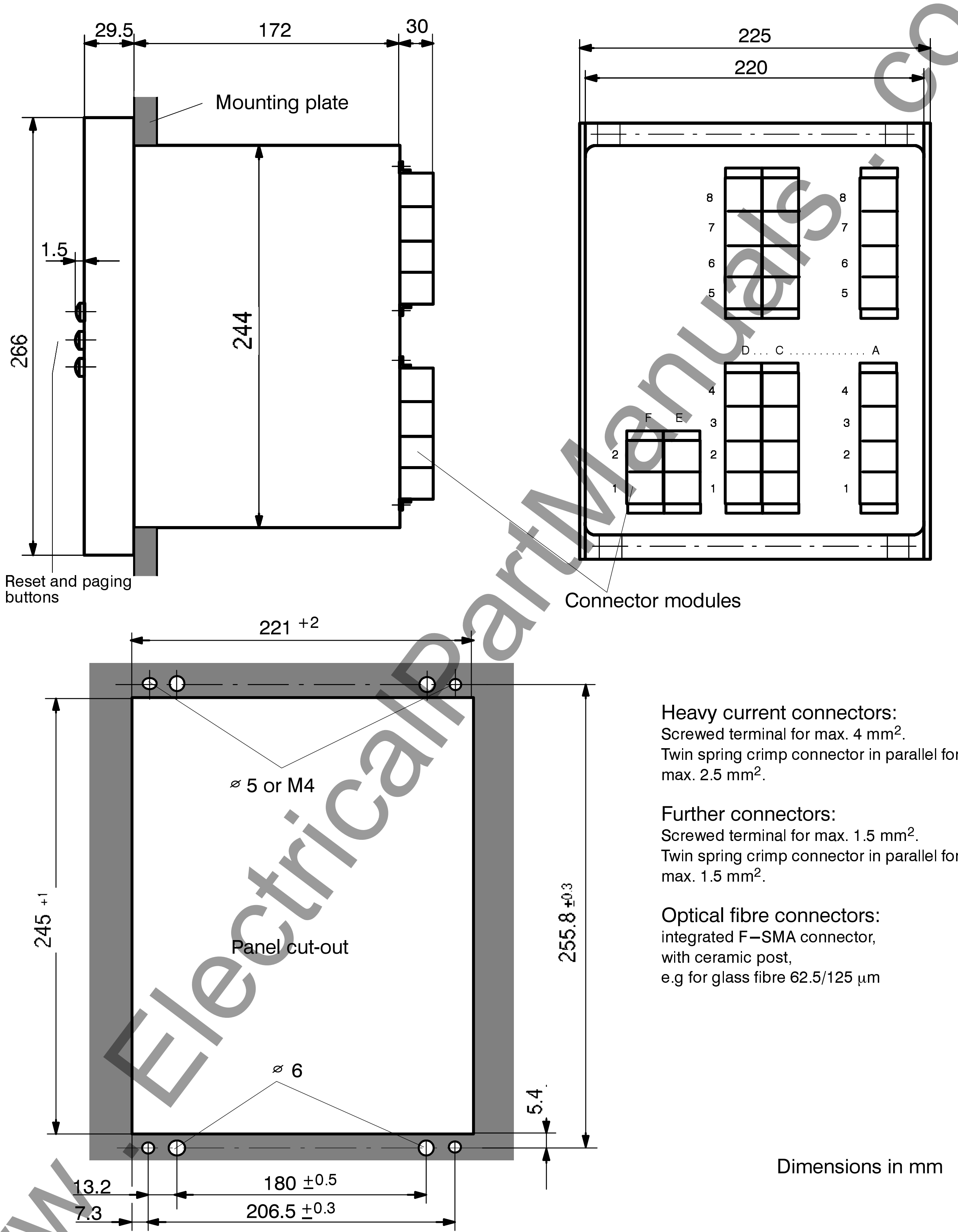
Optical fibre connectors:
integrated F−SMA connector,
with ceramic post,
e.g for glass fibre 62.5/125 µm

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

Dimensions in mm

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

7SD502 Housing for **panel flush mounting** or **cubicle installation** 7XP2040−2



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

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

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

Dimensions in mm

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

2.3 Ordering data

Numerical Line Differential Protection with 2 Pilot Wires **7 S D 5 0 2**

	7.		8.	9.	10.	11.	12.		13.	14.	15.	16.
7 S D 5 0 2	☐	–	☐	☐	A	1	1	–	0	☐	A	0

Rated current; rated frequency (position 7)

1 A; 50/60 Hz 1

5 A; 50/60 Hz 5

Auxiliary voltage (position 8)

24/48 V dc 2

60/110/125 V dc 4

220/250 V dc 5

Construction (position 9)

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

Pilot wire supervision, teleprotection, inputs/outputs (position 11)

with pilot wire supervision, intertripping, and remote trip
4 binary inputs, 5 signal relays, 4 trip relays 1

Serial interface for coupling to a control centre (position 14)

without serial interface . . . . A

with serial interface for optical fibre connection C

3 Technical data

3.1 General data

3.1.1 Inputs/outputs

Measuring circuits

Rated current I_N — 1 A or 5 A

Rated frequency f_N — 50 Hz/60 Hz (settable)

Power consumption in current path based on standard c.t. connection L1–L3–E (Figure 5.4) referred to through flowing rated current		in phase L1	L2	L3	
single-phase, approx.	I_N = 1 A	3.2	1.5	2.3	VA
three-phase symmetrical, approx.	I_N = 1 A	1.1	0.4	0.6	VA
single-phase, approx.	I_N = 5 A	4.0	1.8	2.9	VA
three-phase symmetrical, approx.	I_N = 5 A	1.5	0.5	0.7	VA

Overload capability in current path, for each input winding as well as for the output summation current

– thermal (rms)	$100 \times I_N$ for $\leq$1 s $20 \times I_N$ for $\leq$10 s $4 \times I_N$ continuous
– dynamic (pulse current)	$250 \times I_N$ one half cycle

Auxiliary voltage

Power supply via integrated dc/dc converter

Rated auxiliary voltage U_H	24/48 Vdc	60/110/125 Vdc	220/250 Vdc
Permissible variations	19 to 56 Vdc	48 to 144 Vdc	176 to 288 Vdc

Superimposed ac voltage, peak-to-peak	$\leq$ 12 % at rated voltage $\leq$ 6 % at limits of admissible voltage
Power consumption quiescent	approx. 6 W
energized	approx. 8 W
Bridging time during failure/short-circuit of auxiliary voltage	$\geq$ 50 ms at $U_{rated} \geq$ 110 Vdc

Heavy duty (command) contacts

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

Signal contacts

Signal/alarm relays		5
Contact per relays		1 CO
Switching capacity	MAKE/BREAK	20 W/VA
Switching voltage		250 V
Permissible current		1 A

Binary inputs, number — 2 or 4 (depending on model)

– Operating voltage	24 to 250 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 acc. ISO 2110 for connection of a personal computer
– Transmission speed	as delivered 9600 Baud min. 1200 Baud, max. 19200 Baud
Floating interface for data transfer to a control centre (optional)	via optical fibre
– Standards	Protocol acc. IEC 60870–5–103 and VDEW/ZVEI, or acc. DIN 19244 (selectable)
– Transmission speed	as delivered 9600 Baud min. 1200 Baud, max. 19200 Baud
– Transmission security	Hamming distance d = 4
– Connection optical fibre	integrated F–SMA connector for direct optical fibre connection, with ceramic post, e.g. glass fibre 62.5/125 μm for flush mounted housing: at the rear for surface mounted housing: on the bottom cover
Optical wave length	820 nm
Permissible line attenuation	max. 8 dB
Transmission distance	max. 1.5 km
Normal signal position	reconnectable; factory setting: ”light off”

3.1.2 Electrical tests

Insulation tests	
Standards:	IEC 60255−5
− High voltage test (routine test) except d.c. voltage supply input	2 kV (rms); 50 Hz
− High voltage test (routine test) only d.c. voltage supply input	2.8 kV dc
− Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 μs; 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; τ =15 μs; 400 shots/s; duration 2 s
− Electrostatic discharge IEC 60255−22−2 class III and IEC 1000−4−2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
− 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 1000−4−3, class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz
− Radio-frequency electromagnetic field, pulse modulated; IEC 1000−4−3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
− Fast transients IEC 60255−22−4 and IEC 1000−4−4, class III	2 kV; 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
− Conducted disturbances induced by radio-frequency fields, amplitude modulated IEC 1000−4−6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
− Power frequency magnetic field IEC 1000−4−8, 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 68−2
− Vibration IEC 60255−21−1, class 1 IEC 68−2−6	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 68−3−3	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:	IEC60255−21 and IEC 68−2
− Vibration IEC 60255−21−1, class 2 IEC 68−2−6	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 68−2−27	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 68−2−29	half sine acceleration 10 g, duration 16 ms, 1000 shocks each direction of 3 orthogonal axes

3.1.4 Climatic stress tests

− Permissible ambient temperature

during service	−5 °C to +55 °C
during storage	−25 °C to +55 °C
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 substations 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 substations of lower voltages.
- It is not permissible to withdraw or insert individual modules under voltage. In the withdrawn condition, some components are electrostatically endangered; during handling the standards for electrostatically endangered components must be observed. The modules are not endangered when plugged in.

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

3.1.6 Design

Housing	7XP20; refer to Section 2.1
Dimensions	refer to Section 2.2
Weight	
– in housing for surface mounting	approx. 14 kg
– in housing for flush mounting	approx. 12 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 Line differential protection

Setting ranges/steps

Current threshold I_1 (release by local current)			
	$I/I_{N\ line}$	0.20 to 2.50	(steps 0.01)
Differential current	$I/I_{N\ line}$	0.50 to 2.50	(steps 0.01)
Trip delay time	T	0.00 s to 60.00 s	(steps 0.01 s)
Pick-up characteristics		refer to Figure 3.1	
Second harmonic restraint	I_{2fN}/I_{fN}	10 % to 80 %	
Drop-off ratio		approx. 0.7 times pick-up (I_{stab} = 0)	

All current values are based on symmetrical current and standard c.t. connection according to Figure 5.4

Times

Pick-up time with double-ended infeed	
– with 4 x setting value	approx. 20 ms to 25 ms
Drop-off time	approx. 25 ms
additional drop-off delay time	0.00 s to 60.00 s (steps 0.01 s)

Tolerances with preset parameters under reference conditions

– local pick-up limit	3 % of theoretical value but min. 0.02 · I_N
– differential current	5 % of theoretical value but min. 0.02 · I_N

Influence variables

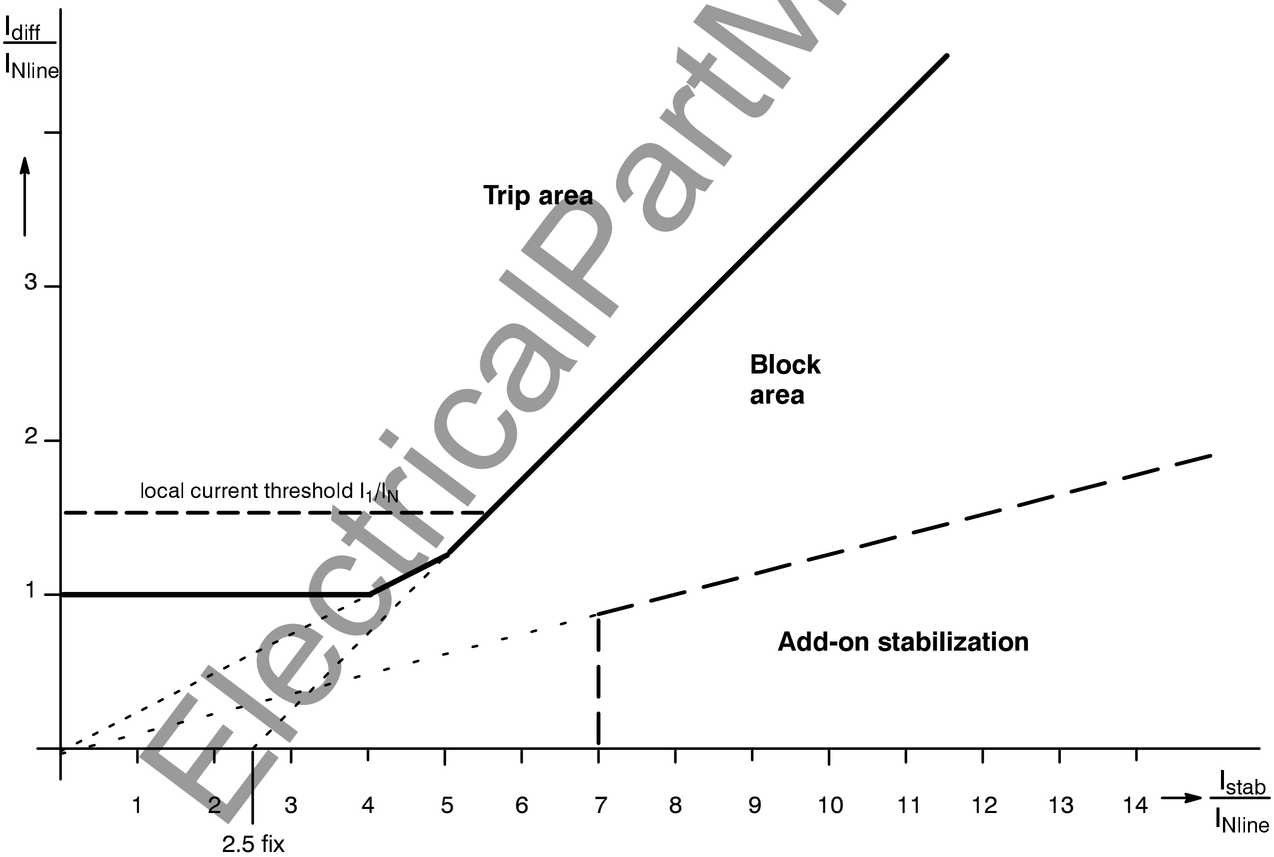
– pilot wire resistance	approx. 1 % per 100 Ω loop resistance
– auxiliary voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq$ 1%
– temperature in range $0\ °C \leq \vartheta_{amb} \leq 40\ °C$	$\leq$ 1 %/10 K
– frequency in range $0.9 \leq f/f_N \leq 1.1$	$\leq$ 4 %

Pilot wires

quantity	2 preferably symmetrical telephone pairs with 73 Ω/km loop resistance and 60 nF/km capacitance	
asymmetry core/core at 800 Hz	max. 10^{-3}	
max. loop resistance	1800 Ω	
permissible induced longitudinal voltage		
– direct connection of the pilot wires	$\leq$ 1.2 kV,	but max 60 % of the test voltage of the pilot cores
– connection via barrier transformers	$\geq$ 1.2 kV,	but max 60 % of the test voltage of the pilot cores and max. 60 % of the test voltage of the barrier transformers

Pilot wire monitoring and intertrip (optional)

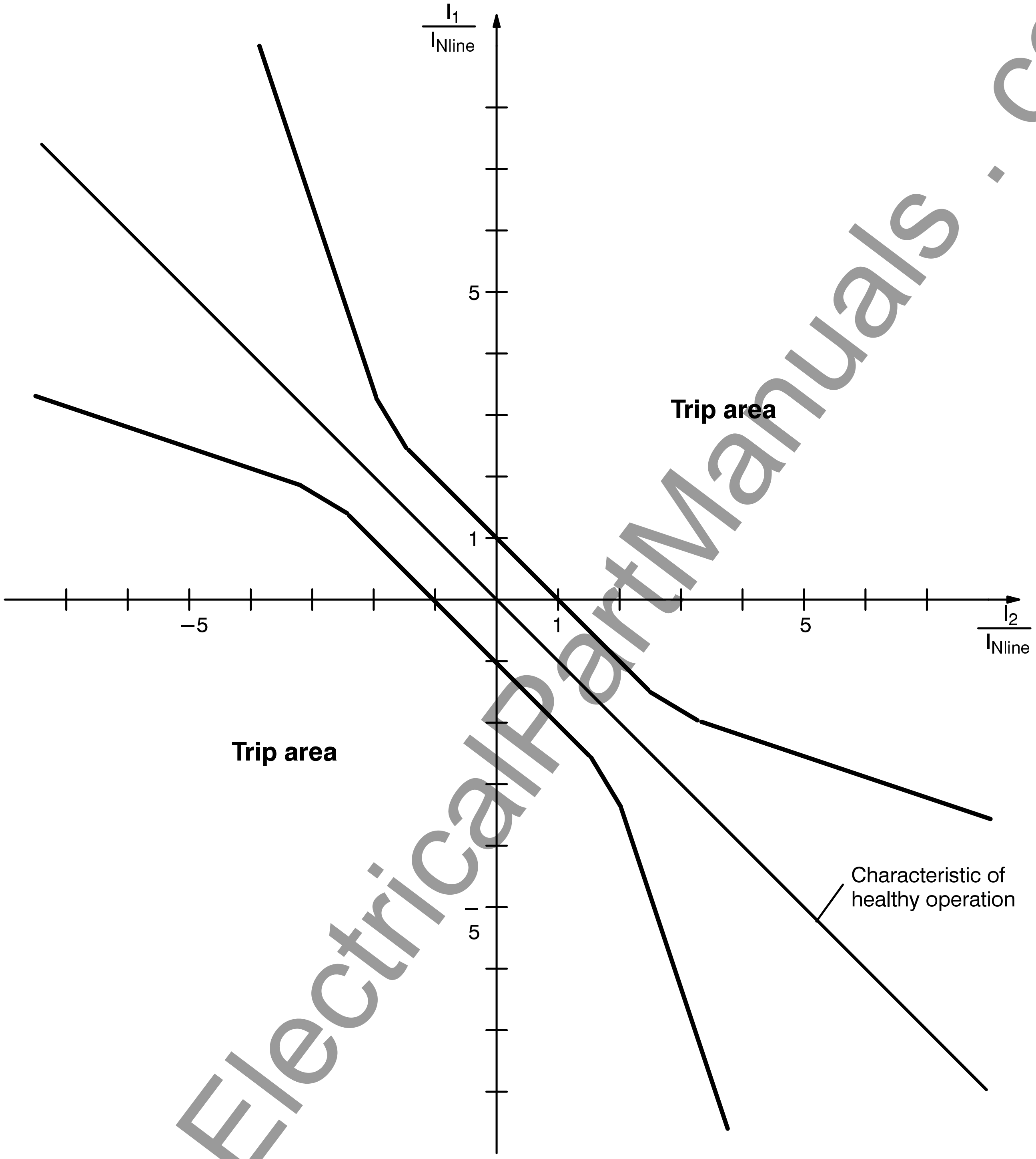
monitoring signal	2000 Hz, PCM	
monitoring current saturation voltage	approx. 10 mA $\geq$ 20 V	
alarm delay	2 s to 60 s	(steps 1 s)
operating time of intertrip function	approx. 65 ms	
intertrip signal prolongation	0.00 s to 60.00 s	(steps 0.01 s)



$I_{diff} = | I_1 + I_2 |$
$I_{stab} = | I_1 | + | I_2 |$

I_1 = local line end current, in direction of the line
I_2 = remote line end current, in direction of the line
I_{Nline} = nominal current of the line

Figure 3.1 Stabilization characteristic of line differential protection (illustrated with pre-set pick-up values)



I_1 = local line end current, in direction of the line
I_2 = remote line end current, in direction of the line
I_{Nline} = nominal current of the line

Figure 3.2 Operating characteristic: dependency of the line currents at both ends (illustrated with pre-set pick-up values); scale for symmetrical currents and standard c.t. connection according to Figure 5.4

3.3 External local and transfer trip

External local trip via binary input

Setting rages/steps

Trip delay	0.02 s to 60.00 s	(steps 0.01 s)
Drop-off delay	0.00 s to 60.00 s	(steps 0.01 s)
Tolerances	1 % or 10 ms	

Operating times

Pick-up time	approx. 20 ms
Drop-off time	approx. 10 ms

Transfer trip via binary input

Setting rages/steps

Send delay before transmission	0.00 s to 60.00 s	(steps 0.01 s)
Send prolongation time	0.00 s to 60.00 s	(steps 0.01 s)
Reception delay time	0.00 s to 60.00 s	(steps 0.01 s)
Reception prolongation time	0.00 s to 60.00 s	(steps 0.01 s)
Tolerances	1 % or 10 ms	

Operating times

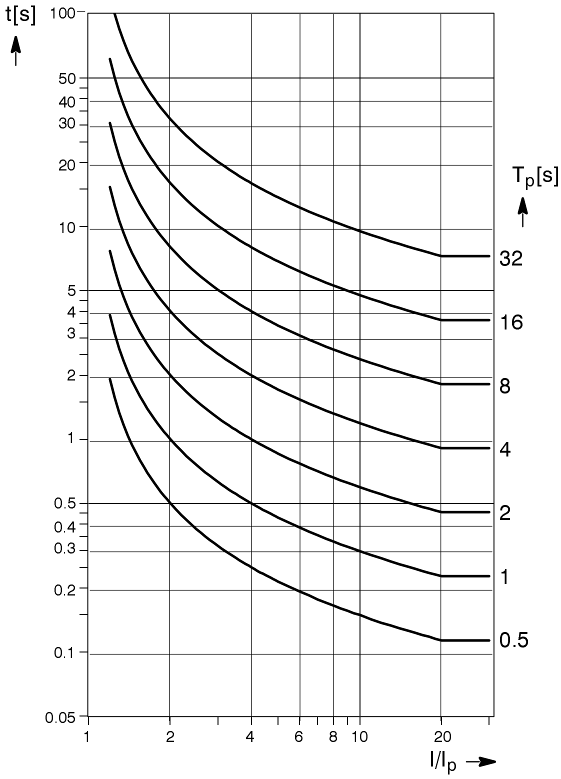
Pick-up time	approx. 65 ms
Drop-off time	approx. 60 ms

3.4 Overcurrent time protection

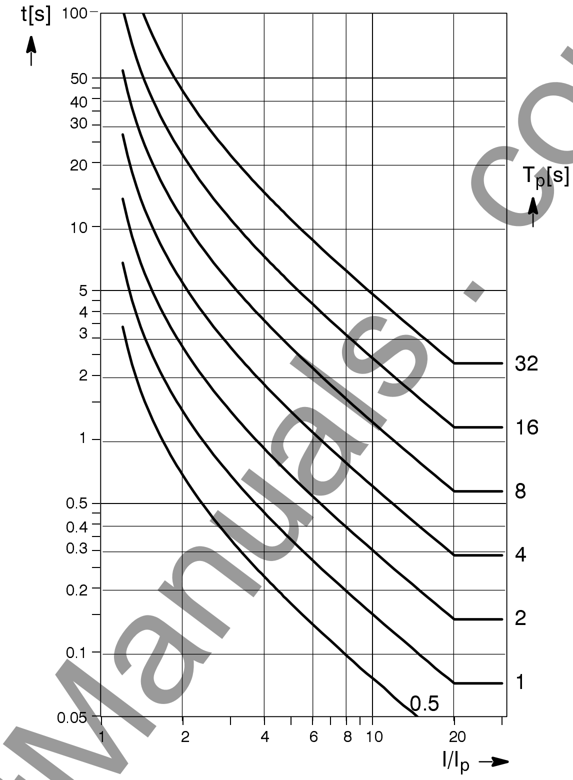
Characteristics (selectable)		definite time protection inverse time protection: normal, very or extremely
inverse (type A, B, or C according to IEC 60255−3)		refer Figure 3.3
Pick-up/Times		
high-current stage	$I>>/I_{Nline}$	0.10 to 30.00 (steps 0.01)
delay time $T_{I>>}$		0.00 s to 32.00 s (steps 0.01 s); or ∞ (stage ineffective)
overcurrent stage (phases) for **definite** time	$I>/I_{Nline}$	0.10 to 30.00 (steps 0.01)
delay time $T_{I>}$		0.00 s to 32.00 s (steps 0.01 s); or ∞ (stage ineffective)
overcurrent stage (phases) for **inverse** time	I_p/I_{Nline}	0.10 to 20.00 (steps 0.01)
time multiplier T_p		0.50 to 32.00 (steps 0.01); or ∞ (stage ineffective)
pick-up threshold		approx. 1.1 times I_p

All current values are based on symmetrical current and standard c.t. connection according to Figure 5.4

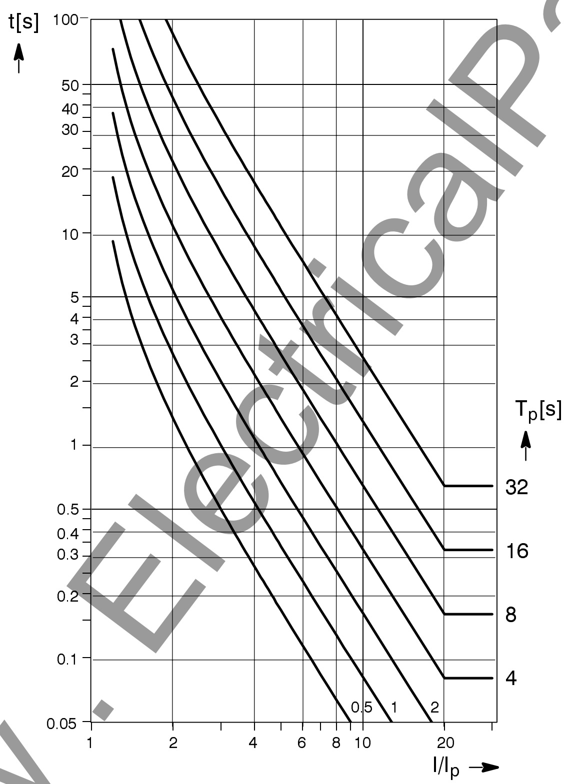
Measuring times	
I>>, I> at 2 times setting value	approx. 45 ms
I_p	refer to Figure 3.3
Drop-off times I>>, I>	approx. 35 ms
Drop-off ratios	approx. 0.95
Overshot time	approx. 35 ms
Tolerances	
− definite time stages, I>>, I>	3 % of set value $\pm$ 0.02 · I_N
− definite time delays	1 % of set value or 10 ms
− for inverse time stages I_p	pick-up at $1.05 < I/I_p < 1.15$
− inverse time delays	7 % of set value or 30 ms
Influencing variables	
Auxiliary voltage in range $0.8 \leq U/U_N \leq 1.15$	$\leq$ 1 %
Temperature in range 0 °C $\leq \vartheta_{amb} \leq$ 40 °C	$\leq$ 1 %/10 K
Frequency for definite time protection − in range $0.9 \leq f/f_N \leq 1.1$	$\leq$ 4 %
Frequency for inverse time protection − in range $0.95 \leq f/f_N \leq 1.05$	$\leq$ 8 % referred to the theoretical time



Normal inverse: $t = \frac{0{,}14}{(I/I_p)^{0{,}02} - 1} \cdot \frac{T_p}{10}$ [s]



Very inverse: $t = \frac{13{,}5}{(I/I_p) - 1} \cdot \frac{T_p}{10}$ [s]



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

t tripping time
T_p set time delay
I fault current
I_p set pick-up value

All current values are based on symmetrical current and standard c.t. connection according to Figure 5.4

Figure 3.3 Tripping time characteristics of inverse time overcurrent protection

3.5 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 $\Theta_{warn} / \Theta_{trip}$	50 to 100 % referred to trip temperature rise	(steps 1 %)
Current warning stage $I_{warn}/I_{N\ line}$	0.10 to 4.00	(steps 0.01)

Trip time characteristic

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

t	trip time
τ	time constant
I	load current
I_{pre}	preload current
k	factor according to IEC 60255−8
	refer also to Figures 3.4 and 3.5

Drop-off ratios

Θ/Θ_{trip}	approx. 0.99
Θ/Θ_{warn}	approx. 0.99
I/I_{warn}	approx. 0.97

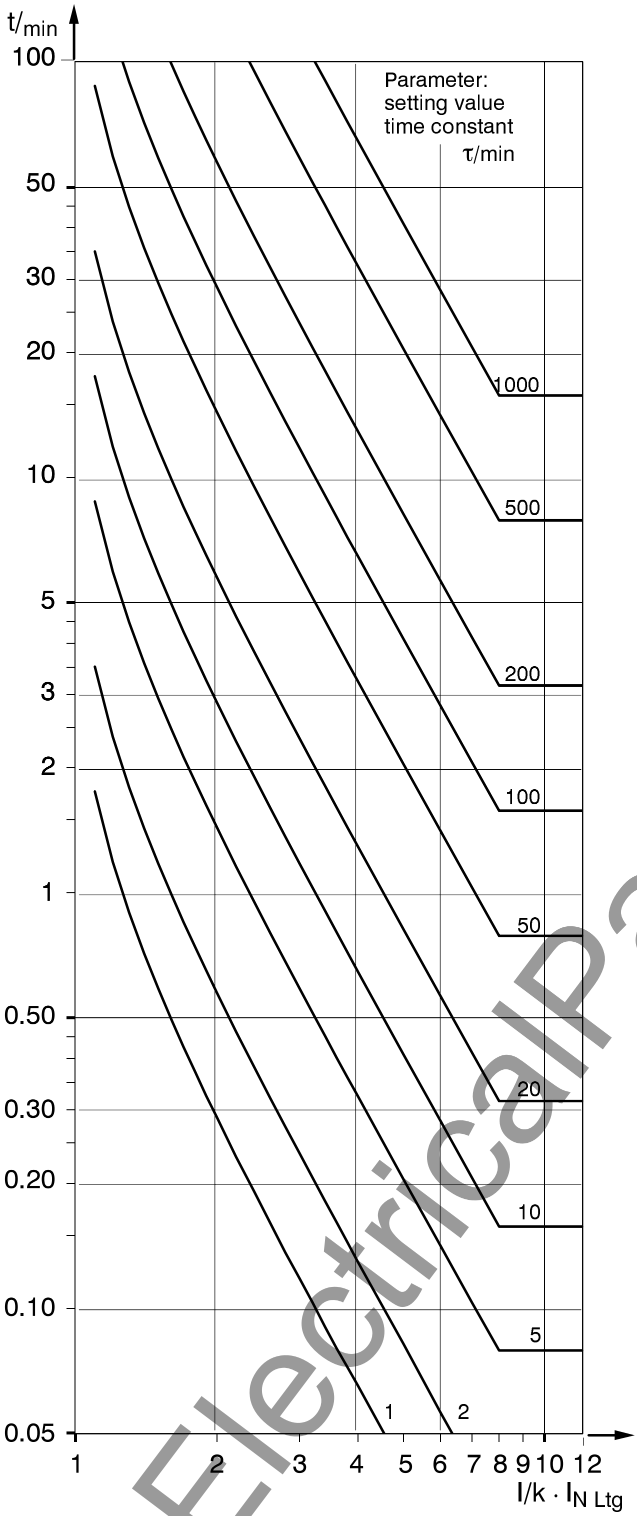
All current values are based on symmetrical current and standard c.t. connection according to Figure 5.4

Tolerances

− referring to $k \cdot I_N$	± 10 %
− referring to trip time	± 10 % ± 2 s

Influence variables referred to $k \cdot I_N$

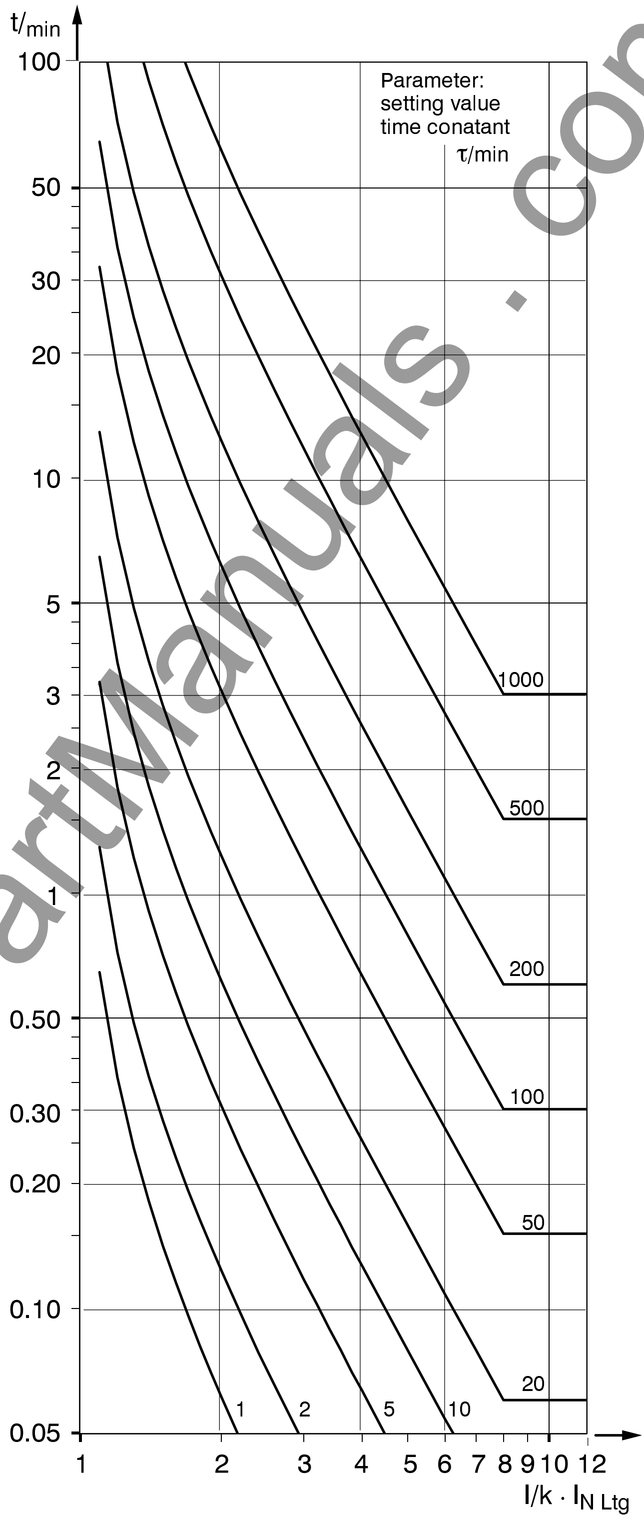
− Auxiliary dc voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 1 %
− Temperature in range $-5\ ^\circ C \leq \vartheta_{amb} \leq +40\ ^\circ C$	≤ 1 %/10 K
− Frequency in range $0.9 \leq f/f_N \leq 1.1$	≤ 4 %



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

All current values are based on symmetrical current and standard c.t. connection according to Figure 5.4

Figure 3.4 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 3.5 Trip time characteristic of overload protection – with 90 % preload –

3.6 Ancillary functions

Operational value measurements

− Operational current values	I1 (summation current at local line end) I2 (summation current at remote line end) I3 (summation current at the third line end for three-terminal lines) each transformed into the primary values and in % of the rated relay current
Tolerances	I1: 3 % of rated value $\pm$ 0.02 · I_N I2: 3 % of rated value $\pm$ 0.02 · I_N $\pm$ 0.7 % per 100 Ω I3: 3 % of rated value $\pm$ 0.02 · I_N $\pm$ 1.5 % per 100 Ω
− Differential protection measured values	I_{diff}, I_{stab} each transformed into the primary values and in % of the rated relay current
Tolerance	$\leq$ 10 % of respective rated value
− Overload protection measured values	
Calculated temperature rise	Θ/Θ_{trip}
Tolerance	3 % referred to Θ_{trip}

Measured values plausibility checks

− Sum of currents	in the node point of measured current inputs

Annunciations via binary input

− 4 user definable annunciations

Fault event data storage

Storage of annunciations of the last four fault events, three of which can be read out in the display

Real time clock

Resolution for operational annunciations	1 min
Resolution for fault event annunciations	1 ms
Clock module	DALLAS Type DS 138 − 32k RAMifield TIMEKEEPER Self-discharge time >10 years
Max time deviation	0.01 %

Data storage for fault recording	max. 8 fault events
Storage period	max 5 s per fault event, max. 20 s total, adjustable pre-fault an post-fault time
Sampling rate	1 instantaneous value per 1.67 ms at 50 Hz 1 instantaneous value per 1.38 ms at 60 Hz

Tripped current log

Number of stored trip events	max. 9 digits
Total of tripped currents I/I_N	max. 7 digits plus 1 decimal digit

4 Method of operation

4.1 Operation of complete unit

The numerical line differential protection 7SD502 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 summation transformer MT forms, under symmetrical current conditions, a 20 mA single-phase mixed current from the input currents of the three phases. Its windings ratio 2:1:3 ensures that with any kind of fault the secondary mixed current will have a defined proportion to the fault current. This current is used for all protection functions.

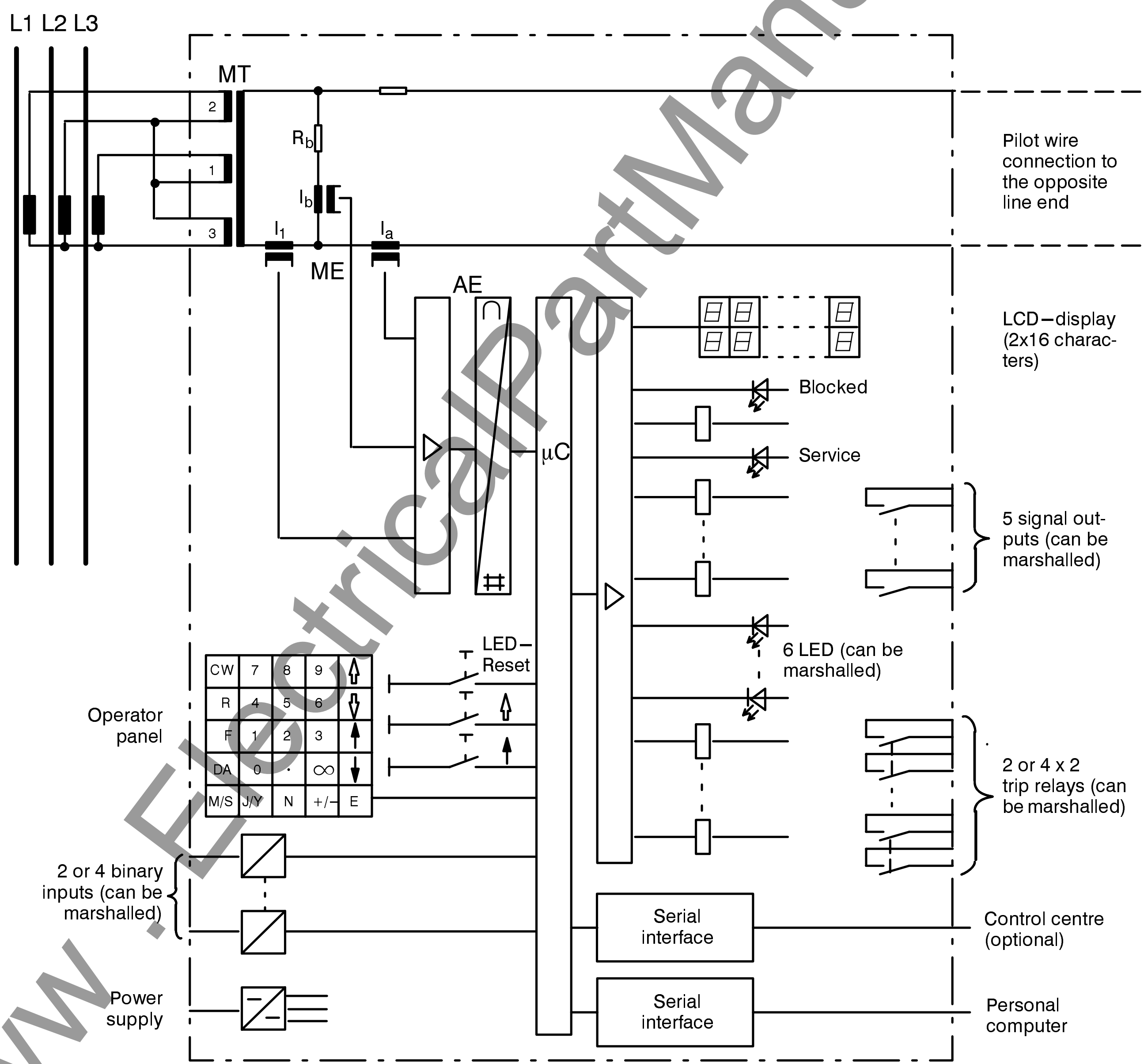


Figure 4.1 Hardware-structure of line differential protection relay 7SD502

The transformers of the measured value input portion ME transform the currents I_1 (mixed current of the local line end), I_b (shunt current through the shunt resistor R_b), and I_a (pilot wire current) and match them to the internal processing level of the unit. Apart from the galvanic and low-capacitive isolation provided by these transformers, filters are provided for the suppression of interference. The filters have been optimized with regard to bandwidth and processing speed to suit the measured value processing. The 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,

– calculation of the differential and restraint current values,

– analysis of the harmonics in the differential current value for detection of current transformer saturation and evolving faults,

– supervision of the pilot wires (models with pilot wire monitor),

– calculation of r.m.s. values for overload detection,

– scanning of limit values and time sequences,

– decision about trip commands,

– storage of measured quantities 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 operating interface by means of an operator panel or a personal computer.

Via a further serial interface (optional, refer Section 2.3 Ordering data), fault data can be transmitted to a central evaluation unit. During healthy operation, measured values can also be transmitted, e.g. the measured currents at the point of installation. This interface is suitable for optical fibre connection.

A power supply unit provides the auxiliary supply on the various voltage levels to the described functional units. +18 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 $\geq$ 110 V dc).

4.2 Current transformer connections and fault current sensitivity

The currents from the protected line are mixed in the summation transformer MT of the 7SD502 relay to a single-phase alternating current of 20 mA at rated symmetrical current. The asymmetrical ratio of the mixed current of 2:1:3 ensures that with any kind of fault a defined mixed current is produced which is relevant for all protection functions. The asymmetry entails – on the other hand – that the sensitivity of the protection functions is different and depends on the kind of fault. But this is of less importance in the field of application of this relay since the phase-fault currents normally exceed clearly the rated current.

Different options are available for the connection of the current transformers. But the same c.t. connection method should be used throughout a network and <u>must</u> be used at opposite line ends of a differential protection scheme.

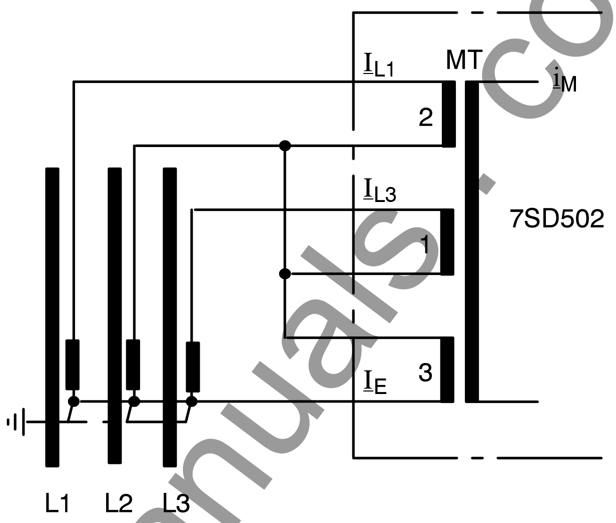


Figure 4.2 Standard c.t. connection L1 – L3 – E

4.2.1 Standard connection L1 – L3 – E

The scheme shown in Figure 4.2 is the most common. The input windings of the summation transformer are connected to the c.t. currents I_{L1}, I_{L3}, and I_E (residual current). This connection is suitable for all kinds of systems regardless of the treatment of the system neutral. It is characterized by a high sensitivity for earth faults.

For a symmetrical three-phase fault (where the earth return component, $I_E = 0$) the single-phase mixed current is, as illustrated in Figure 4.3, $\sqrt{3}$ times the winding unit value. That is, the summation flux (ampere turns) is the same as it would be for single-phase current $\sqrt{3}$ times the value flowing through the winding with the least number of turns (ratio 1). For three-phase symmetrical fault current equal to rated current I_N, the secondary single-phase current is $i_M = 20$ mA. All relay characteristic operating values are based on this type of fault and these currents.

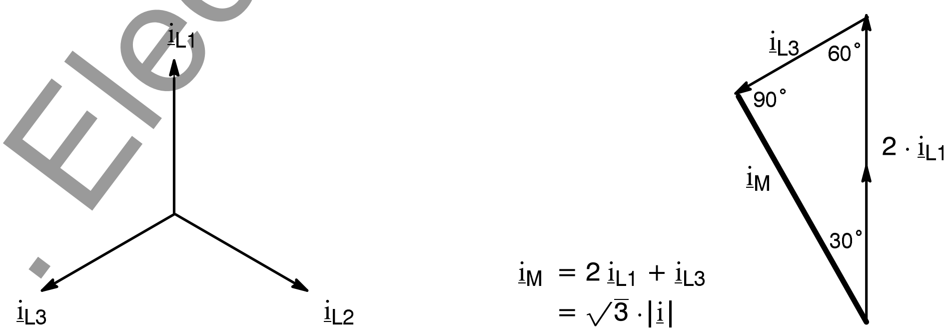


Figure 4.3 Summation of currents in the summation transformer with standard c.t. connection L1 – L3 – E

For the connection shown in Figure 4.2, the weighting factors W of the mixed currents for the various fault conditions and the ratios to that given by the 3-phase symmetrical faults are shown in Table 4.1. On the right hand side is the complementary multiple of rated current which $W/\sqrt{3}$ would have to be, in order to give the mixed current i_M = 20 mA in the secondary circuit. If the current setting values are multiplied with this factor, the actual pick-up values result.

The table shows that 7SD502 is more sensitive to earth faults than to those without earth path component. This increased sensitivity is due to the fact that the summation transformer winding in the c.t. star point connection (I_E, residual current, refer to Figure 4.2) has the largest number of turns, and thus, the weighting factor W = 3.

Fault type	W	$W/\sqrt{3}$	I_1 for i_M = 20 mA
L1–L2–L3 (sym.)	$\sqrt{3}$	1.00	1.00 x I_N
L1–L2	2	1.15	0.87 x I_N
L2–L3	1	0.58	1.73 x I_N
L3–L1	1	0.58	1.73 x I_N
L1–E	5	2.89	0.35 x I_N
L2–E	3	1.73	0.58 x I_N
L3–E	4	2.31	0.43 x I_N

Table 4.1 Types of fault and weighting factor with standard c.t. connection L1–L3–E

In earth-free networks or those with Peterson coil earthing it is not desirable to trip the line when a single earth fault occurs. If a double earth fault occurs, clearance of only one of the two fault conditions is often desired.

The deliberately different contributions of the three phase currents, due to the summation transformer primary ratios, effect a phase preferential clearance sequence which is determined by the way in which the c.t.s are connected. The line section which has the fault on the thus determined preferential phase will be cleared. The performance of the differential relay which protects a line on which one of the two earth faults lies, depends on the ratio of the current contributions at each end. To achieve properly selective double earth fault performance of the protective system in a network both the differential and distance relays should be operated with the same phase preference sequence.

In differential schemes which use summation current transformers, acyclic preference is possible. Figure 4.4 shows the connections for the most usual cases of acyclic preference. The other possibilities can be achieved by using alternative c.t. connections.

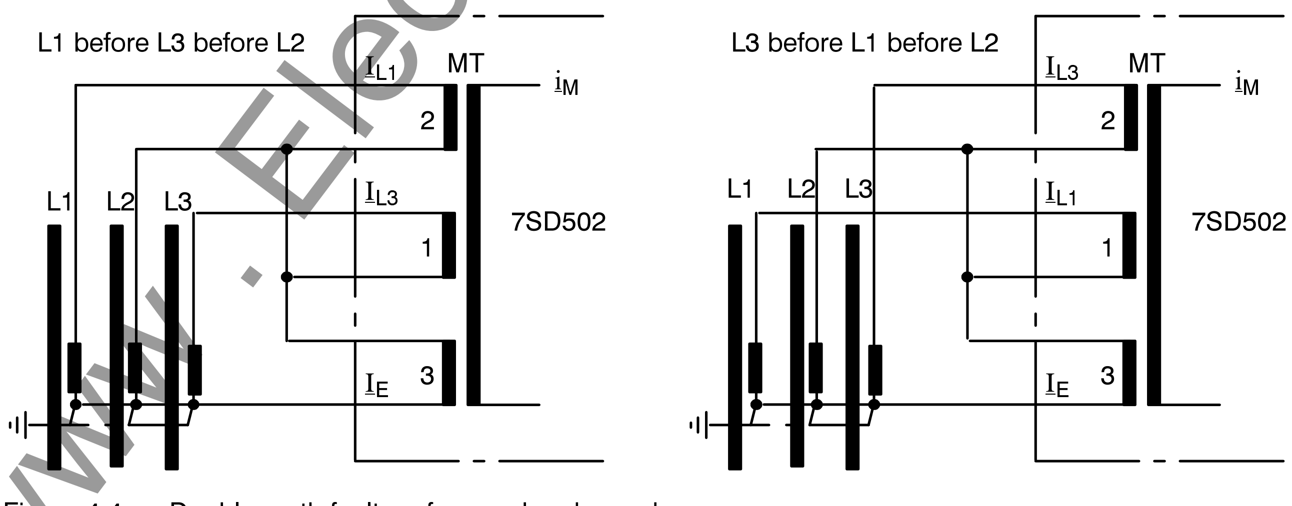


Figure 4.4 Double earth fault preference by phase change

4.2.2 Connection for decreased earth current sensitivity L1 – L2 – L3

In earthed systems with particularly low zero sequence impedance, earth fault currents can be larger than those under two phase fault conditions. With consideration of the thermal loading on the measuring circuits, the connections shown in Figure 4.5 can be used. With this connection, the values given in Table 4.2 can be recalculated for the seven possible fault conditions in solidly earthed networks.

Comparison with Table 4.1 shows that under earth fault conditions the weighting factor W is less than with the standard connection. Thus the thermal loading is reduced to 36 %, i.e. $(1.73/2.89)^2$.

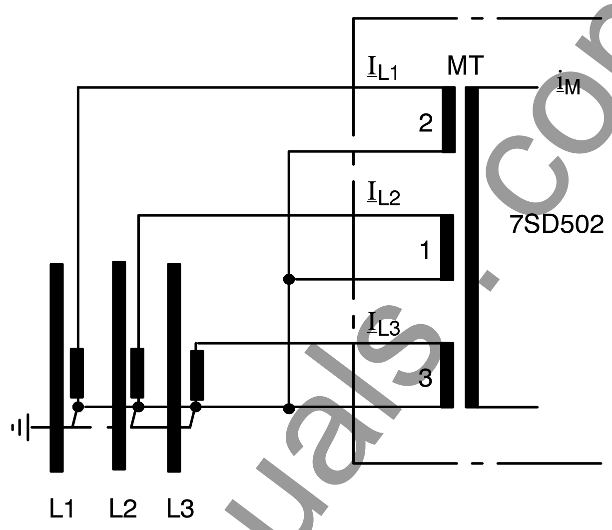


Figure 4.5 Connection L1 – L2 – L3 with decreased earth current sensitivity

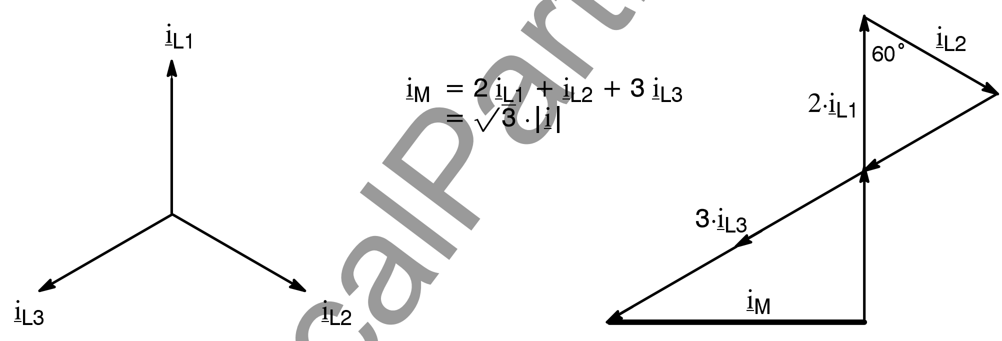


Figure 4.6 Addition of currents in the summation transformer with c.t. connection L1 – L2 – L3

Fault type	W	$W/\sqrt{3}$	I_1 for i_M = 20 mA
L1 – L2 – L3 (sym.)	$\sqrt{3}$	1.00	1.00 x I_N
L1 – L2	1	0.58	1.73 x I_N
L2 – L3	2	1.15	0.87 x I_N
L3 – L1	1	0.58	1.73 x I_N
L1 – E	2	1.15	0.87 x I_N
L2 – E	1	0.58	1.73 x I_N
L3 – E	3	1.73	0.58 x I_N

Table 4.2 Types of fault and weighting factor with c.t. connection L1 – L2 – L3

4.2.3 Connection for increased earth current sensitivity

In certain systems, earth fault currents of even lower values must be detected and cleared, as it is possible with the standard connection, e.g. because of an earthing resistance (resistance earthed systems). To a certain extent this can be achieved by using an intermediate transformer IT as shown in Figure 4.7. Dependent on the burden on the current transformers, the current in the star point conductor can be increased to approximately double the normal value. Phase fault sensitivity is the same as with the standard connection.

Earth fault sensitivity will then be increased according to the transformation ratio of the intermediate transformer IT. The intermediate transformer can be connected as an auto-transformer since no galvanic separation is necessary.

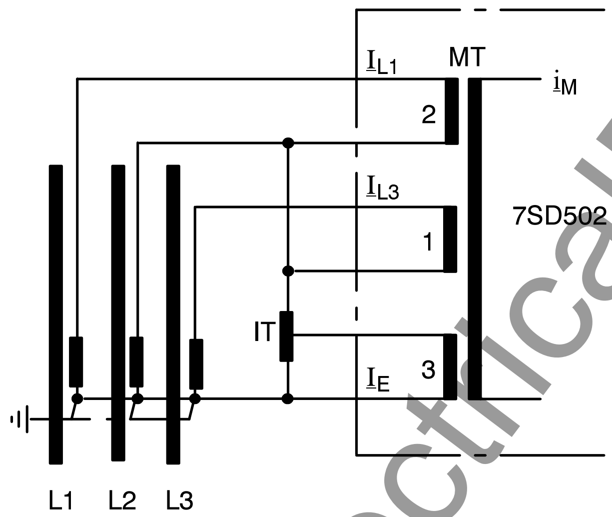


Figure 4.7 Connection L1 – L3 – E with increased earth current sensitivity

4.2.4 Unequal c.t. rated currents

The measuring circuits of the relay are designed for equal secondary outputs from the two summation transformers under healthy line conditions. This is automatic if the c.t.s have equal ratio at the two line ends, i.e. equal primary and equal secondary rating. Even if the c.t.s at the line ends have the same primary rating but the secondary at one end is 5 A and at the other 1 A, the use of the model 7SD502**5** for the **5** A c.t. at one end and model 7SD502**1** for **1** A at the other end will ensure correct operation.

If the c.t.s have different primary ratings, matching transformers must be used to correct the relationship. Conventionally, matching transformers are installed at the c.t.s with the lower primary rating. Siemens matching transformers 4AM5170 – 7AA are suitable, connected as shown in Figure 4.8.

If it is necessary to use matching transformers to correct the c.t. ratio at the same time as it is required to increase the sensitivity to earth faults according to Section 4.2.3, the circuit shown in Figure 4.8 is, of course, adequate. The transformation ratio of the intermediate transformer in the earth current path is then accordingly calculated. It is not necessary to use a further intermediate transformer.

Examples and hints for calculation of intermediate c.t.s are given in Section 5.2.4.4.

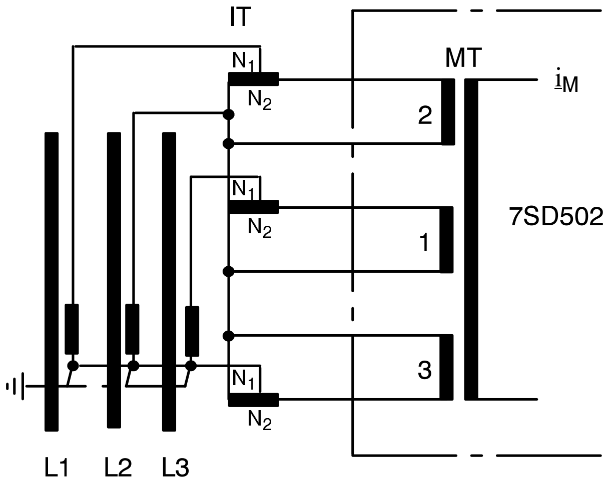


Figure 4.8 Matching of unequal primary currents

4.2.5 Two-phase connection

When a network is operated with isolated star point or arc suppression coil, where it is not required that the differential relay reacts to a single-phase earth fault, two current transformers are adequate for current summation (see Figure 4.9). In consideration of the possibility of double earth faults however, it is then essential to ensure that the c.t.s are fitted in the same two phases throughout the network. With this system, it is clear that under double earth fault conditions the differential relay will not react to a fault on the conductor without a c.t. If a double earth fault involves the other two conductors, the normal phase preference sequence will apply.

The weighting factor of the phase currents is the same as with the standard connection according to Section 4.2.1. Thus, the same sensitivities are valid as given in Table 4.1 for phase faults.

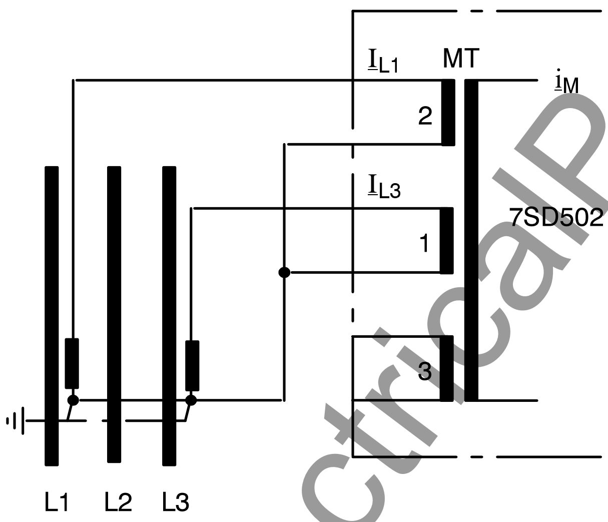


Figure 4.9 Two-phase connection L1 – L3

4.2.6 Multi-system protection

For particularly important lines and if sufficient pilot wires are available, an independent differential relay can be fitted to each phase. This results in threefold equipment investment and, normally, the necessity for three pairs of pilot wires. By using interposing transformers (model 7XR9513) which have a centre tapped, symmetrical secondary winding, one can create a phantom connection with two conductor pairs (cf. Section 5.2.4.6).

The first advantage given by separate protection of each phase is the definite identification of the concerned phase for single-pole auto-reclosing in earthed networks. For multi-phase faults, fully redundant back-up occurs, because a trip command is given for each concerned conductor. Further, the three-phase system gives equal sensitivity for all types of fault.

Equipping each phase of a three-phase line with its own differential relay means only a difference in connection of the c.t.s. In other respects the previous considerations apply.

Setting values for all protection functions are valid for symmetrical three-phase currents, with summation transformer connection (weighting factor = $\sqrt{3}$). For the connection in each phase, the effective weighting factor for the number of turns has to be divided by $\sqrt{3}$ in order to achieve the real sensitivity of the protection functions. If, for example, the connections are made as shown in Figure 4.10, the weighting factor of the input windings is 2. In that case, the setting values have to be multiplied with the factor $2/\sqrt{3}$. If the phase currents are connected to the input winding with weighting factor 1, then the sensitivity is reduced by the factor $1/\sqrt{3}$.

The sensitivity can be further increased by series connecting of input windings. In these cases it must be considered that the thermal capability of the summation c.t. windings is limited. The thermal limit values given in the technical data are valid for each input winding as well as for the summation (output) winding of the summation c.t.s. If more than 1 input winding weighting is used the permissible current is reduced according the factor $W/\sqrt{3}$; but if only one winding weighting is used then the permissible current is not increased!

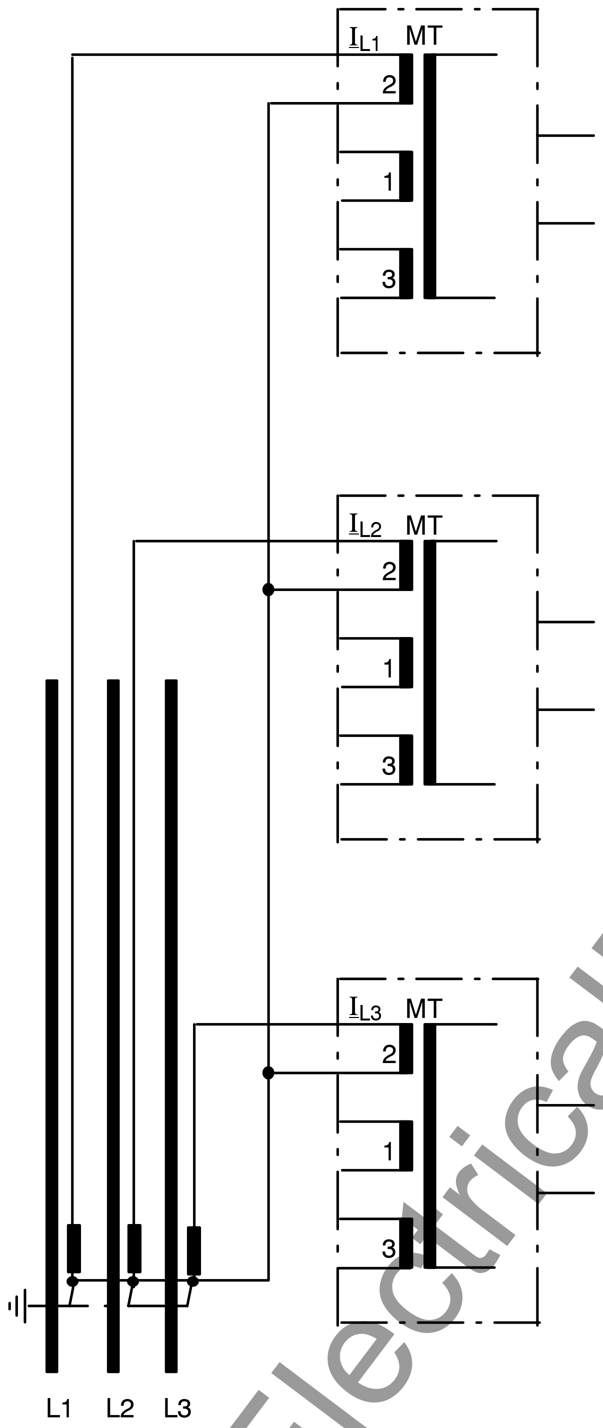


Figure 4.10 Three system protection: one differential protection relay for each of the phases

A further possible arrangement is given by combining the Figure 4.5 connection with a second differential relay which is connected only in the star point of the three c.t.s (Figure 4.11). Although this arrangement requires two differential relays it has the advantage that the second relay is limited to the detection of earth faults and, when necessary, can be made to be very sensitive (in the illustrated example $6/\sqrt{3}$). This system is used only in earthed networks.

It is, of course, also possible to use four differential protection schemes for one line: one for each of the phases and a further for the residual current path, i.e. to combine Figure 4.10 and 4.11.

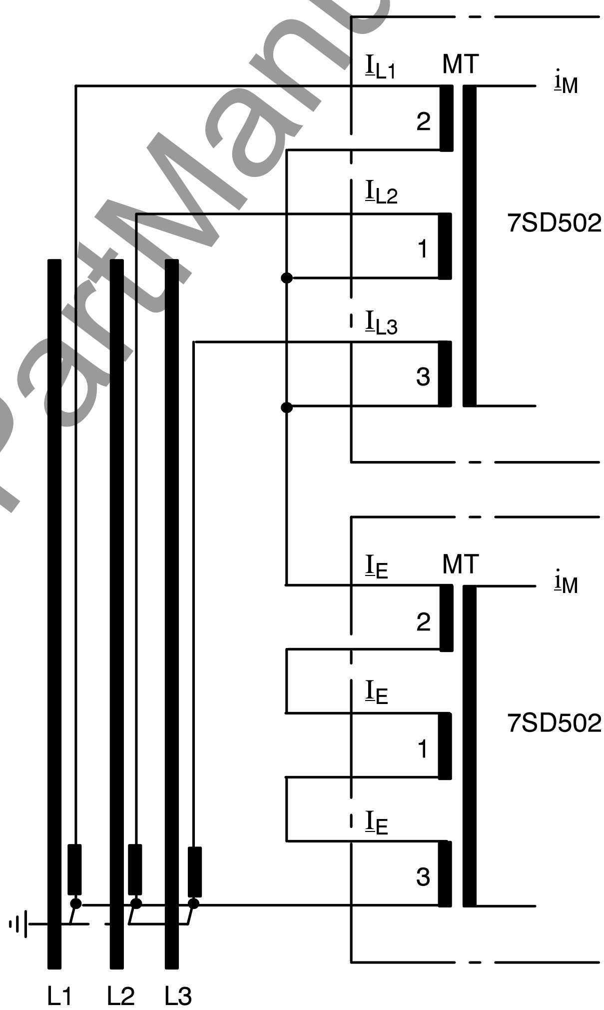


Figure 4.11 Separate earth fault relay

4.3 Line differential protection

The line differential protection system operates according to the principle of current comparison. The line protection requires the installation of one 7SD502 unit at each end of the protected line. The two relays must be interconnected by two pilot wires. The line differential protection system comprises the 7SD502 units to be installed at each end of the line and the pilot wire link between the units.

4.3.1 Principle of measurement

Differential protection systems operate according to the principle of current comparison and are therefore also known as current balance system. They utilize the fact (Figure 4.12) that the current $\underline{I}$ (dotted) leaving a healthy length of conductor L is the same as that which entered it. Any measured current difference is certain indication of a fault somewhere within the protected zone. The secondary windings of current transformers CT1 and CT2, which have the same transformation ratio, may be so connected that a closed circuit with the currents $\underline{i}$ as shown is formed. A measuring element M is connected at the electrical balance point. Under healthy conditions no current flows in the measuring element M. When, in the event of a fault in the section between the current transformers, the currents at the ends of the section are unequal the measuring element is subjected to a current $\underline{i}_1 + \underline{i}_2$, proportional to $\underline{I}_1 + \underline{I}_2$, the sum of the two inflowing fault currents. If this current $\underline{i}_1 + \underline{i}_2$ is of sufficient magnitude to be sensed by the element M, this simple system will provide discriminative protection for the line or item of equipment under consideration.

4.3.2 Stabilized differential protection

When an external fault causes a heavy current to flow through the protected zone, differences in the magnetic characteristics of the current transformers under conditions of saturation may cause a significant current to flow through the element M. If the magnitude of this current lies above the response threshold, the system would issue a trip signal. Stabilization prevents such erroneous operation.

In differential protection systems for protected objects with two terminals, a stabilizing quantity is normally derived from the current difference $|\underline{I}_1 - \underline{I}_2|$ or from the arithmetical sum $|\underline{I}_1| + |\underline{I}_2|$. Both methods are equal in the relevant ranges of the stabilization characteristics. In differential protection systems for protected objects with three terminals, e.g. teed lines, stabilizing is only possible with the arithmetical sum $|\underline{I}_1| + |\underline{I}_2| + |\underline{I}_3|$. The latter method is used in 7SD502 for all protected objects (i.e. for two or three terminal lines). This requires the formation of the vectorial sum and the arithmetical sum of the currents of each line end. The following definitions apply:

The tripping effect or differential current

$$I_{diff} = |\underline{I}_1 + \underline{I}_2|$$

and the stabilization or restraining current

$$I_{stab} = |\underline{I}_1| + |\underline{I}_2|$$

I_{diff} produces the tripping effect quantity, I_{stab} counteracts this effect. Processing of these quantities is described in Section 4.3.4.

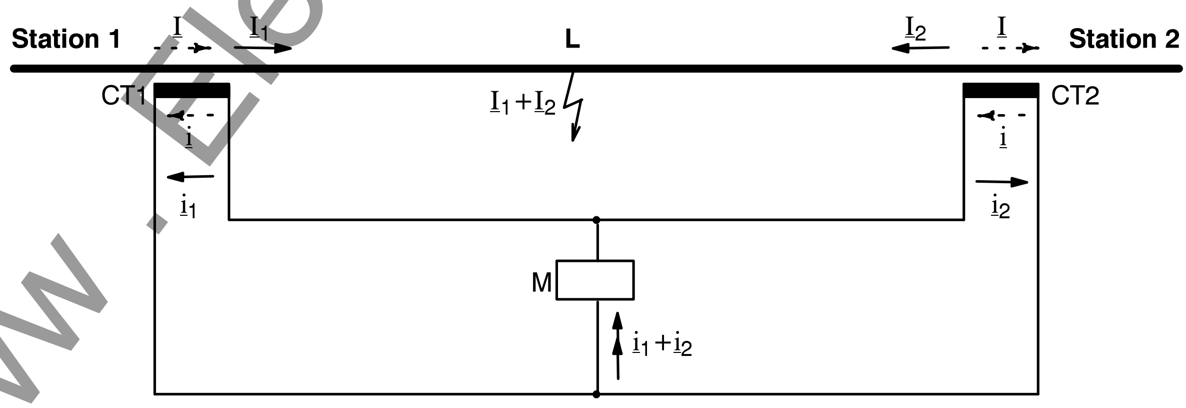


Figure 4.12 Base principle of differential protection

4.3.3 Measured value formation for differential protection using two pilot wires

Figure 4.13 illustrates a differential current comparison scheme with two pilot wires. At each end three currents are measured:

I_1 is the local current into the line,

I_b is the current flowing through the local shunt resistor R_b,

I_a is the current flowing through the pilot wire loop.

Two of these current are sufficient to calculate the third; but in 7SD502 all the three currents are measured in order to gain a plausibility check with these quantities.

Differential and stabilizing quantities can be calculated by means of the measured currents, the internal resistances R_a and R_b, and the pilot wire resistance R_x which must be entered to the device during setting, using the following formulae:

The loop equation of the loop which is illustrated by the dotted line gives us

$$(I_1 - I_a) \cdot R_b - I_a \cdot (R_x/2 + R_a) +$$
$$(I_2 - I_a) \cdot R_b - I_a \cdot (R_x/2 + R_a) = 0$$

The following simplifications should be agreed:

$R_b = R$	(reference resistance)
$R_x/2 + R_a = x \cdot R$	(longitudinal resistance)

Thus, the loop equation can be written

$$(I_1 - I_a) \cdot R - 2 \cdot I_a \cdot x \cdot R + (I_2 - I_a) \cdot R = 0$$

After reduction of the R−values and some rearrangement we obtain

$$(I_1 + I_2) - 2 \cdot I_a \cdot (1 + x) = 0$$

or

$$I_1 + I_2 = 2 \cdot (1 + x) \cdot I_a$$

This is directly the differential current. The current of the remote line end is required in order to obtain the stabilizing current. The following applies:

$$I_2 = (I_1 + I_2) - I_1 = 2 \cdot (1 + x) \cdot I_a - I_1$$

Finally, all quantities which are needed for the differential protection processing are available:

$$I_{diff} = |I_1 + I_2| = |2 \cdot (1 + x) \cdot I_a|$$

$$I_{stab} = |I_1| + |I_2| = |I_1| + |2 \cdot (1 + x) \cdot I_a - I_1|$$

For lines with three terminal (teed lines), each substation has two differential relays, each connected through a pilot wire pair to one of the other ends. In order to obtain the differential and stabilizing current for all the three line ends, each of the two local relays must be fed by the pilot wire current of the other relay. The differential and stabilizing current can be calculated in each of the relays from the pilot wire current I_a' and the local current I_1 using the same method as described above for two-terminal lines (cf. Section 4.3.10).

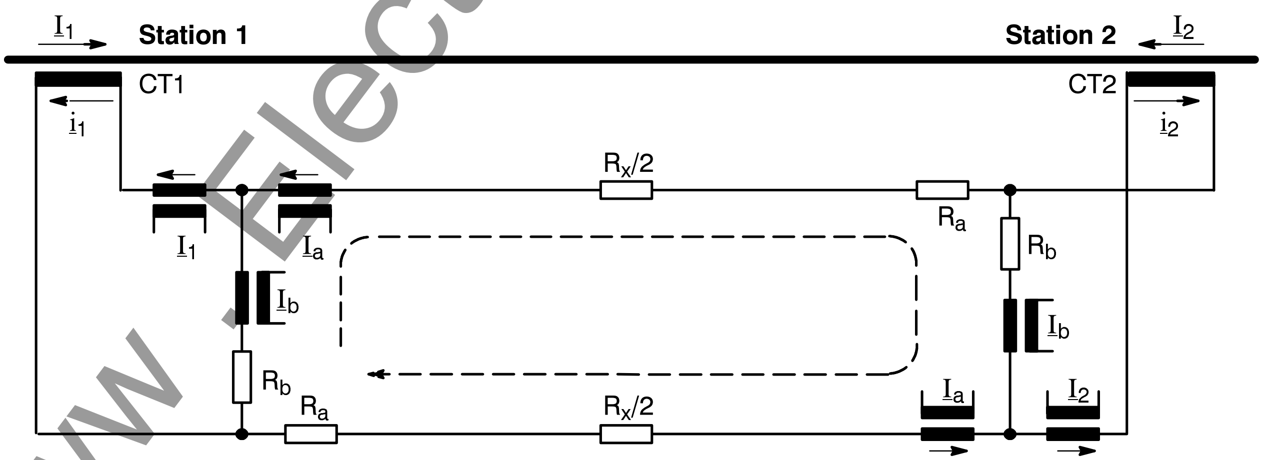


Figure 4.13 Differential protection using two pilot wires − function scheme

4.3.4 Measured value processing

The digitized currents are first filtered by numerical filters in order to suppress d.c. components and higher harmonics. The r.m.s. values of the fundamental wave of the differential and stabilizing currents are used for evaluation

To clarify the situation, three important operating conditions should be examined:

a) Through fault current in a healthy line or external fault:

$\underline{I}_2$ reverses its direction i.e. thus changes its sign, i.e. $\underline{I}_2 = -\underline{I}_1$ and consequently $|\underline{I}_2| = |\underline{I}_1|$

$I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$

$I_{stab} = |\underline{I}_1| + |\underline{I}_2| = |\underline{I}_1| + |\underline{I}_1| = 2 \cdot |\underline{I}_1|$

no tripping effect ($I_{diff} = 0$); stabilization (I_{stab}) corresponds to twice the through flowing current.

b) Internal short-circuit, e.g. fed with equal currents from each line end:

In this case $\underline{I}_2 = \underline{I}_1$ and consequently $|\underline{I}_2| = |\underline{I}_1|$

$I_{dif} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$

$I_{stab} = |\underline{I}_1| + |\underline{I}_2| = |\underline{I}_1| + |\underline{I}_1| = 2 \cdot |\underline{I}_1|$

tripping effect (I_{diff}) and stabilizing (I_{stab}) quantities are equal and correspond to the total fault current.

c) Internal short-circuit, fed from one line end only:

In this case $\underline{I}_2 = 0$

$I_{diff} = |\underline{I}_1 + \underline{I}_2| = |_1 + 0| = |\underline{I}_1|$

$I_{stab} = |\underline{I}_1| + |\underline{I}_2| = |\underline{I}_1| + 0 = |\underline{I}_1|$

tripping effect (I_{diff}) and stabilizing (I_{stab}) quantities are equal and correspond to the fault current fed from one side.

This result shows that for internal fault $I_{diff} = I_{stab}$. Thus, the characteristic of internal faults is a straight line with the slope 1 in the operation diagram as illustrated in Figure 4.14. The figure shows the complete operation characteristic of the relay. The branch a represents the sensitivity threshold of the differential protection. Branch b takes into consideration current proportional errors which may result from transformation errors of the main c.t.s, the summation transformers and the input transformers of the relay. In the range of high currents which may give rise to current transformer saturation, branch c causes stronger stabilization. A further evaluation in case of severe saturation (add-on stabilization) is described in Section 4.3.5.

The currents I_{diff} and I_{stab}, which are formed as described in Section 4.3.3, are compared by the differential protection with the operating characteristic according to Figure 4.14. If the quantities result into a locus in the tripping area, trip signal is given provided the local current threshold is exceeded, too (local current threshold, see Section 4.3.6).

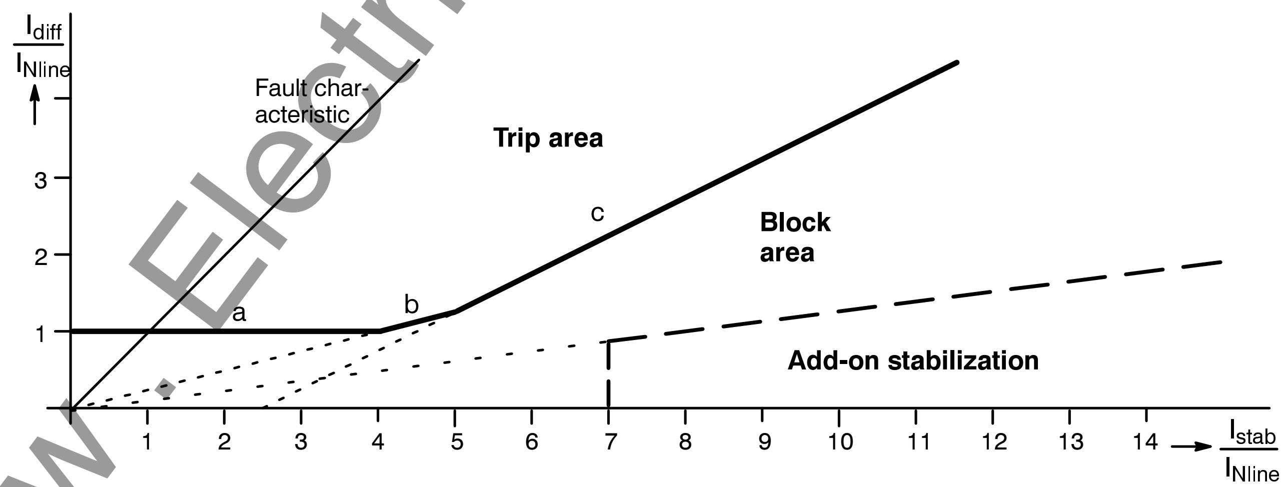


Figure 4.14 Operating characteristic of the differential protection

4.3.5 Add-on stabilization during current transformer saturation

Saturation of the current transformers caused by high fault currents and/or long system time constants are uncritical for internal faults (fault on the protected line), since the measured value deformation is found in the differential current as well in the stabilizing current, to the same extent. The fault characteristic as illustrated in Figure 4.14 is principally valid in this case, too. Of course, the fundamental wave of the current must exceed at least the pick-up threshold (branch a in Figure 4.14) and the local current threshold (refer to Section 4.3.6).

During an external fault which produces a high through flowing short-circuit current causing current transformer saturation, a considerable differential current can be simulated, especially when the degree of saturation is different at the two line ends. If the quantities I_{diff}/I_{stab} result in an operating point which lies in the trip area of the operating characteristic (Figure 4.14), trip signal would be the consequence if there were no special measures.

7SD502 provides a saturation indicator which detects such phenomena and initiates add-on stabilization measures. The saturation indicator operates dynamically in the area which is designated with ”add-on stabilization” in Figure 4.14.

Current transformer saturation during external faults is detected by a high initial stabilizing current which moves the operating point briefly into the ”add-on stabilization” area (Figure 4.14). In contrast, the operating point moves immediately along the fault characteristic when an internal fault occurs since the stabilization current will barely be higher then the differential current. The saturation indicator makes its decision within the first half period after fault inception.

When an external fault is detected, the differential protection is blocked for $7^1/_2$ periods (150 ms at 50 Hz) at the longest. This blocking is cancelled as soon as the operation point moves steadily (i.e. over two periods) on the fault characteristic. This allows to detect evolving faults on the protected line reliably even during an external fault with current transformer saturation.

4.3.6 Local current threshold

The line differential protection relay 7SD502 contains a local current threshold I1 RELEASE. This provides an additional trip criterion.

The local current threshold is independent on the threshold of the differential protection (branch a in Figure 4.14) and can independently set.

The local current threshold provides the effect that a single-end fed line fault current is interrupted only at the infeeding end. Nevertheless, tripping at all line ends is possible using the intertrip function (see Section 4.3.8) provided the unit is equipped with this feature (refer to Section 2.3 Ordering data).

It is, additionally, possible to output a trip command without interrogation of the local current threshold. If this is desired, assign the logical command ”`dir.Dif>Trip`” (see also logic diagram Figure 4.15) to a trip relay output.

4.3.7 Pick-up and trip delay

As soon as the fundamental wave of the differential current reaches 85 % of the set value or the stabilizing current exceeds 3 times the rated line current, the protection picks-up. Thus, pick-up occurs also in case of external faults, so that fault recording and saturation indicator can operate.

In special cases it may be desirable to delay the trip command of the differential protection. This is possible by setting a trip time delay T−DELAY.

Additionally, a drop-off time delay T−RESET can be set. This should ensure that the trip command is maintained for a sufficiently long time that the command is executed safely even when the circuit breakers at the two line ends have different operating times.

Figure 4.15 shows a simplified logic diagram of the differential protection tripping logic.

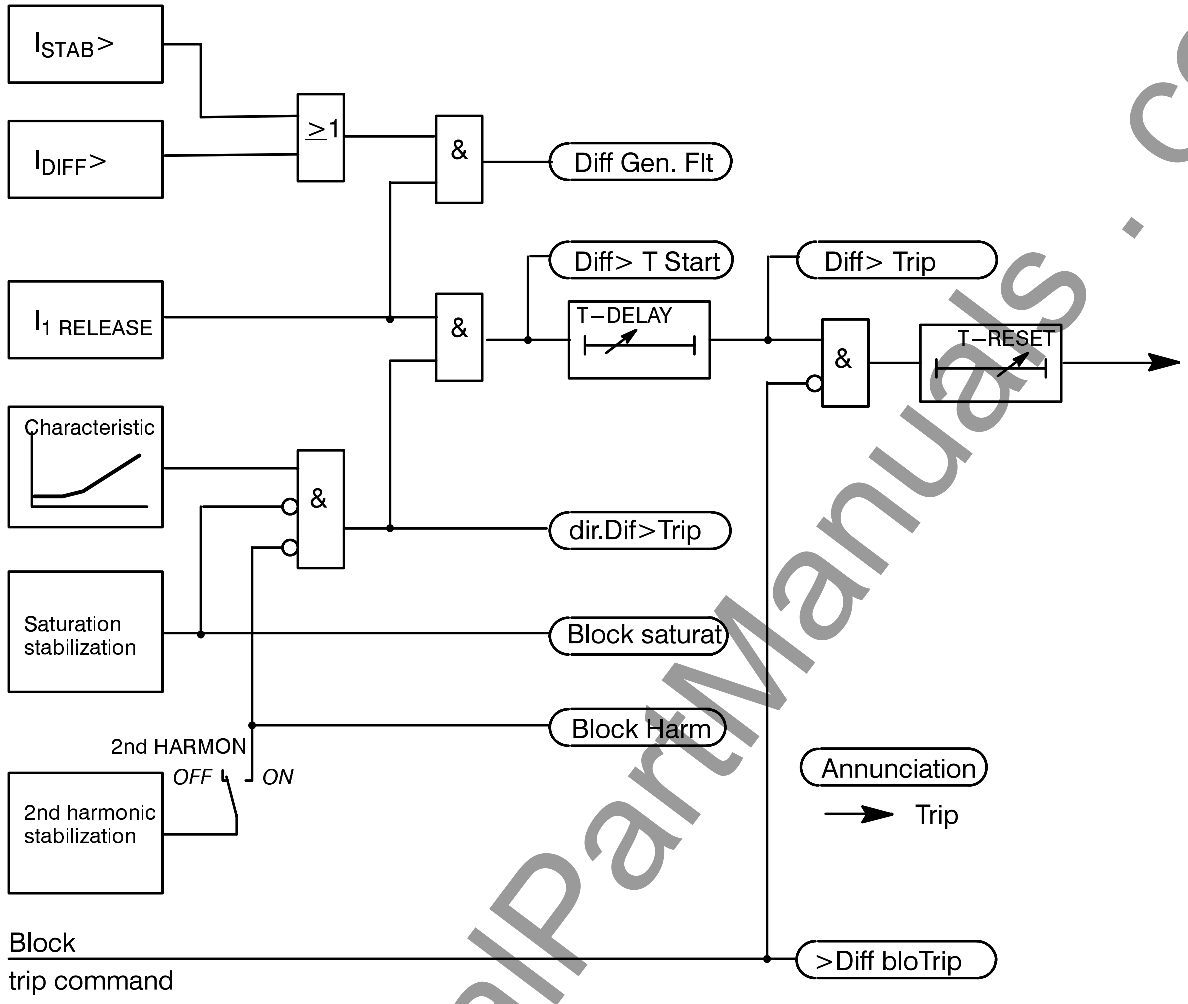


Figure 4.15 Simplified logic diagram of the tripping logic of the differential protection

4.3.8 **Intertripping** (optional)

When a line is fed from one end only, a line fault is cleared only at the feeding line end because the local current is a further condition for tripping, except the direct command of the differential protection without interrogation of the local current threshold is used for tripping (refer to Section 4.3.6).

If it is desired to trip also the non-feeding line end, then the intertrip function can be activated. This works with a pulse coded voice frequency of 2000 Hz via the pilot wires; thus, it is only available in models with the voice frequency generator which is also required for pilot wire monitoring (cf. Section 4.3.9). The puls code is the same as that for remote tripping (refer to Section 4.4.2).

4.3.9 **Pilot wire monitoring** (optional)

The pilot wires between the two differential relays at the ends of the protected line form an essential part of the scheme. Their proper installation and constant integrity is a prerequisite for satisfactory operation. A failure of the pilot wires disables the protection function. The pilot wires which are installed in the ground are mechanically endangered to a similar extend as the energy cable itself. For this reason it is always recommended that the pilot wires be supervised by the pilot wire monitoring option.

The pilot wire monitor is arranged on a separate printed circuit board PGA. This processor controlled monitor module carries also the intertripping and transfer trip functions (model 7SD502★– ★★★**1**★).

The pilot wire monitor is composed of a transmitter and a receiver for each direction in the relays which are connected by the pilot wires (Figure 4.16). It operates with a pulsed code which is modulated on a voice frequency signal of 2000 Hz. The monitoring code is transmitted alternately by one relay to the other and vice versa. In order to ensure a defined start-up of this hand-shake operation, one of the relays must be declared as ”master” and the other as ”slave”. The ”master”–device will always start with the communication, the ”slave”–device responds.

An interruption or short-circuit on the pilot wires is detected by both relays. When the pilot wires are interrupted, the differential protection cannot trip any more since no differential current can be present. If the pilot wires are short-circuited, a high through-fault current (external fault) may cause tripping. For this reason the differential protection can be blocked when a pilot wire fault is detected (selectable). The remaining protection functions – especially the overcurrent time protection, if it is set effective – will continue their operation even during pilot wire fault.

Since the pilot wire monitor is a ”slow” function it cannot always avoid that the relay trips on a through-fault current, when an external fault occurs just at that moment when the pilot wires are short-circuited. But this is extremely improbable since there is no coherence between a pilot wire short-circuit and an *external* power line fault.

The pilot wire monitor does not operate as long as a network fault is present because the differential current transmission with system frequency has priority now. The pilot wire monitor is also inoperative as long as a transfer trip signal (cf. Section 4.4.2) is transmitted because only one pilot wire pair and only one carrier frequency are available.

If the relays are used for the protection of three-terminal lines (teed lines) any pilot wire disturbance is indicated at all three ends. A pre-condition is that the two relays which are installed in one substation inform each other via binary outputs and inputs (refer to Section 4.3.10 for details).

Legend:
T – Transmitter (current source)
R – Receiver
C_K – Coupling capacitor

Figure 4.16 Coupling of the pilot wire monitoring circuits with differential protection using two pilot wires

4.3.10 Use on three-terminal lines

If the differential protection system is used on lines with three terminals (teed lines), i.e. with a branch point, each line end must be connect with each line end with a pair of pilot wires (refer to Figure 4.17). Each pair of pilot wires connects two relays. Thus, two adjacent relays are installed in each substation, from which each communicates with an opposite end relay at one of the remote ends.

The adjacent relays in one substation receive the same currents from the power line, so they must be connected in series in the current paths. The mixed current of relay 1 of substation 1 should be designated with $\underline{I}_1$, whereas the mixed current of relay 1' of substation 1 should be called $\underline{I}_1$'. Theoretically, both currents are equal. Relay 1 is connected via a pair of pilot wires with relay 2' of the substation 2, etc. so that a cyclic arrangement results.

An essential factor is that the adjacent relays of one station receive the currents of both outgoing pilot wires. Besides the pilot wire current of the connected pilot wires $\underline{I}_{a12}$, relay 1 receives also the current of the pilot wires to the third line end $\underline{I}_{a13}$. Similarly, relay 1' receives the currents $\underline{I}_{a13}$' and $\underline{I}_{a12}$'. Note that the figure shows the current flow, not the physical arrangement. The quantities with ' belong to relay 1', the quantities without ' to relay 1. A connection example is illustrated in Appendix B (Figure B.7).

Each of the relays can calculate the current of the opposite line end from the current of the own pilot wires (e.g. $\underline{I}_{a12}$) to the remote end (e.g. relay 2'), and the current of the third line end from the current of the pilot wires to the third end (e.g. $\underline{I}_{a13}$).

The trip commands of the two adjacent relays of a substation are connected in parallel.

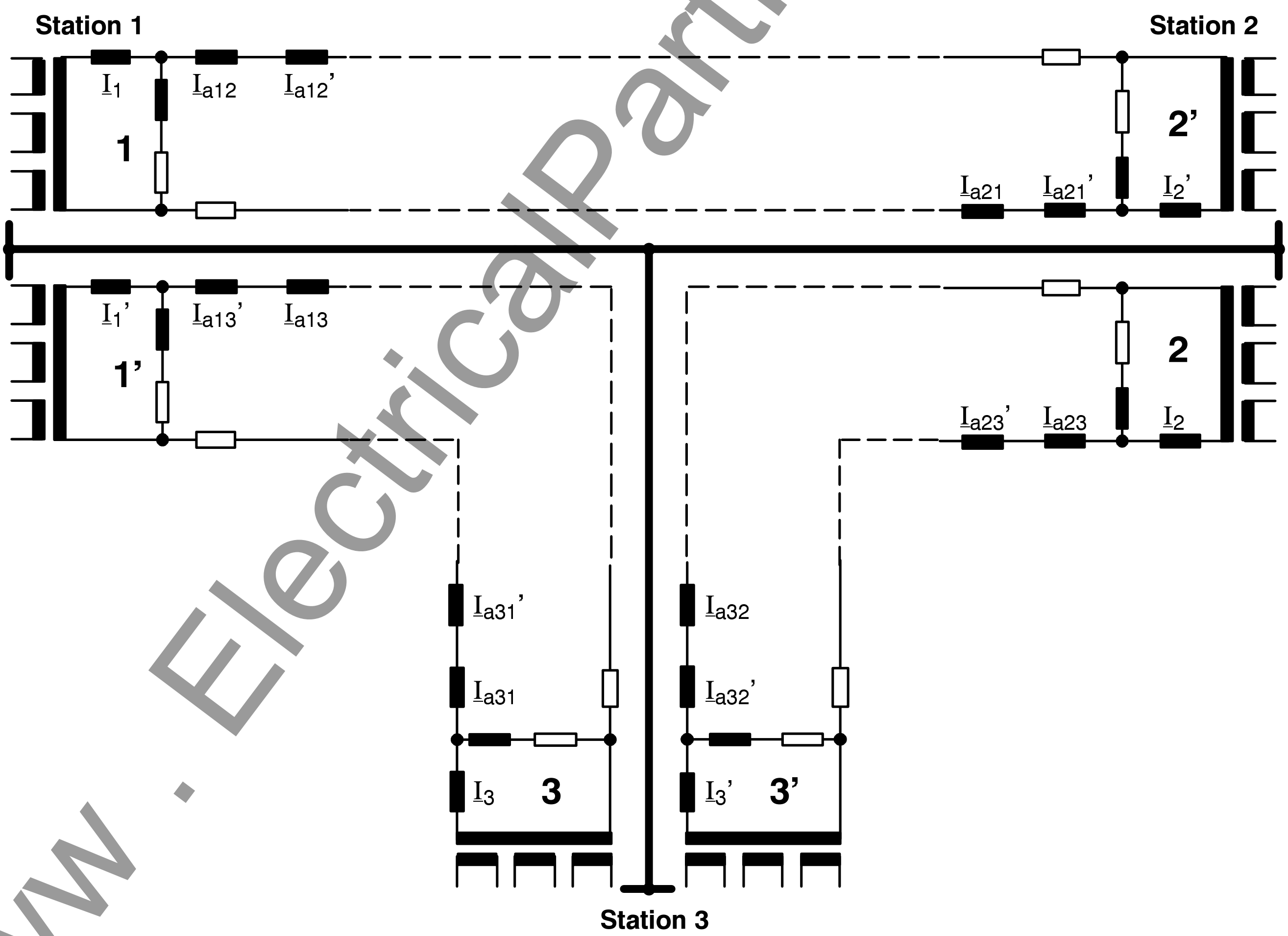


Figure 4.17 Pilot wire currents on three-terminal lines

If the relays are equipped with the pilot wire monitoring feature, each pair of pilot wires is provided with a transmitter and receiver at each line end. If a relay has recognized a pilot wire fault (e.g. relay 1 on the connection 1–2'), it must inform the adjacent relay (e.g. 1') about that, in order to ensure that the pilot wire fault is announced to all three line ends, and all six relays can be blocked (if desired). Therefore, the recognized pilot wire fault is given to the adjacent relay via binary outputs and inputs (refer to Figure 4.18).

Blocking is initiated by the relay which detects the pilot wire fault at first (e.g. relay 2'). Blocking signal is given to the adjacent relay (e.g. relay 2) which stops its transmission, so that its opposite relay (e.g. relay 3') recognizes pilot wire fault because of missing reception. In similar way the remaining relays operate (1, 1', and 3). In one of the three substation the blocking must be avoided (e.g. station 3); otherwise a ring-block would arise which prevents a re-start of the monitoring system after the pilot wire fault has been eliminated.

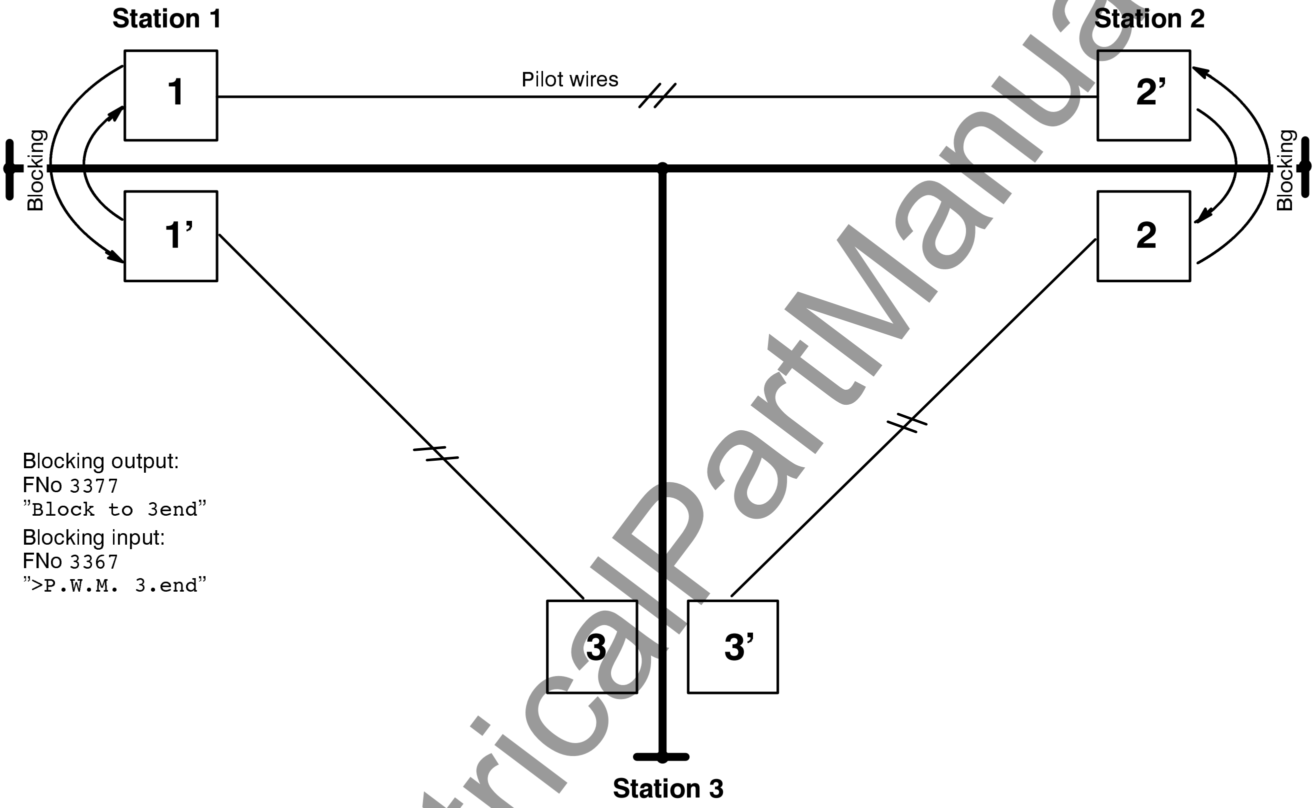


Figure 4.18 Pilot wire monitoring on three-terminal lines

4.3.11 Pilot wire resistance and capacitance

The distribution of the pilot wire current I_a and the shunt current I_b formed an essential part of the measuring principle with conventional differential protection schemes using two pilot wires. Thus, the ratio of the pilot wire resistance and the shunt resistor R_b had to be adjusted by means of additional resistors so that it became 3 : 1. Since, in 7SD502, the pilot wire resistance is internally adjusted by calculation methods according to Section 4.3.3, no external adjustment is necessary within the operation limit of the relay.

Furthermore, the capacitances of the pilot wires, which may produce essential erroneous currents (apparent differential currents) – especially in case of long distances – need not be compensated by additional components. Compensation is carried out internally by calculation, too. For this, the relay uses an equivalent T–circuit of the pilot wires and eliminates the influence of the pilot wire capacitances to a sufficient extent, even with long distances.

4.4 External local and transfer trip

4.4.1 External local trip

Any desired signal can be coupled into the processing of annunciations and trip commands via a binary input of the relay from an external protective or supervisory device. Like the internal trip signals, it can be delayed and given to one or more of the trip relays. The delay can, for example, bridge out bouncing periods of the energizing contact. A reset delay can be set in order to ensure that the breaker is safely tripped even in case the originating signal is very short.

4.4.2 Transfer trip (optional)

Line differential protection relay 7SD502 comprises an integrated transfer trip function (model with pilot wire supervision 7SD502★−★★★**1**★). This can be used to trip the circuit breaker at the remote line end by a command from an external source, e.g. a breaker failure protection.

The transfer trip command is entered to the relay via a binary input. It can be delayed before it is transmitted via the pilot wires, e.g. in order to bridge out bouncing periods. Once being transmitted, it can be maintained for a settable period in order to ensure that the signal is safely transmitted even in case the originating signal is very short.

The received signal can even be delayed and/or maintained for a settable period in order to ensure that the breaker is safely tripped even in case the received signal is very short.

Do not confuse the transfer trip facility and the intertrip function which latter is integral part of the differential protection as described in Section 4.3.8.

The pair of pilot wires is used for intertripping as well as for the transfer trip command by means of one carrier frequency (2000 Hz). For this reason different pulse codes must be used for pilot wire supervision on the one hand and for transfer of a trip signal on the other. As long as a trip signal is transmitted (either intertrip or transfer trip), the pilot wire monitoring signal is suppressed.

The receiver cannot discriminate between reception of an intertrip signal and reception of a transfer trip signal as the pulse code is the same. As well the reaction of the device is the same: trip on reception of the remote signal.

A transfer trip signal can be transmitted in each direction. But it is recommended to use transfer trip only in one direction, as in case of a coincidental transmission in both directions the signals may superimpose each other. Thus the pulse code conditions may not be fulfilled and trip may be prevented.

4.5 Back-up overcurrent time protection

7SD502 provides an integrated back-up overcurrent time protection. Whereas differential protection can operate only as long as the pilot wire link is properly available, the overcurrent time protection needs the local currents only. Thus, it is also operative in case of pilot wire failure. The overcurrent time protection can provide as well the ”emergency” function during pilot wire failure as the back-up protection during external faults.

The overcurrent time protection can be used as definite time or inverse time overcurrent protection. Three standardized inverse time characteristics according to IEC 60255−3 are available for inverse time mode. The trip time characteristics and the applied formulae are given in the Technical data, refer Figure 3.3, Section 3.4.

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

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

The overcurrent time protection processes the mixed current I_1 of the summation transformer. The facts concerning different connection methods as mentioned in Section 4.2 are valid, too. All current values are based on three-phase symmetrical current with standard connection. Different sensitivity dependent on different fault type is valid also for the overcurrent time protection.

Under conditions of manual closing onto fault, the overcurrent protection can also provide a rapid trip. A choice can be made whether the I>> stage or the I>/Ip stage is decisive for an undelayed trip, i.e. the associated time delay is by-passed for this condition. A pre-condition is that the closing command is repeated to a binary input of the device and that this binary input is allocated to the binary input function ”`>Manual Close`”.

4.6 Thermal overload protection

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

The overload protection processes the mixed current I_1 of the summation transformer. The facts concerning different connection methods as mentioned in Section 4.2 are valid, too. All current values are based on three-phase symmetrical current with standard connection. As overload is normally a symmetrical phenomenon the asymmetry factor do not influence this function.

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

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

with Θ – actual temperature rise related on the final temperature rise for the maximum permissible cable current $k \cdot I_{Nline}$

τ – thermal time constant for heating-up of the cable

I – actual cable current (r.m.s. value) related on the maximum permissible cable current $I_{max} = k \cdot I_{Nline}$

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 maximum permissible continuous thermal overload current I_{max} is described as a multiple of the nominal line current:

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

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

Apart from the temperature-dependent 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.

4.7 Circuit breaker trip test

Numerical line differential protection relay 7SD502 allows simple checking of the tripping circuit and the circuit breaker. By means of an external auto-reclosure device a TRIP–CLOSE cycle can be performed.

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, especially when an external auto-reclosure device is installed.

Initiation of the test cycle can be given from the operator keyboard or via the front operator interface. The relay issues a three-pole trip command.

The test sequence is supervised by 7SD502 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.

4.8 Ancillary functions

The ancillary functions of the line differential protection 7SD502 include:

– Processing of annunciations,

– Storage of short circuit data for fault recording,

– Operational measurements and testing routines,

– Monitoring functions.

4.8.1 Processing of annunciations

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

4.8.1.1 Indicators and binary outputs (signal relays)

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

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

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

– locally, by operation of the reset button on the relay,

– remotely by energization of the remote reset input,

– via one of the interfaces,

– automatically, on occurrence of a new general pick-up signal.

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

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

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

4.8.1.2 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. the protection function which has picked up 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 4.8.1.1.

The device also provides several event buffers, e.g. for operating messages, circuit breaker operation statistics etc. (refer 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 this feature 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 the trip signal is reset can be read out. The resolution is 1 ms.

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

The protection device stores the data of the last four network faults; if a fifth fault occurs the oldest fault is overwritten in the fault memory. The last three network faults can be read out in the display.

A network fault begins with the first recognition of the fault by pick-up of any fault detector and ends with the last fault detector drop-off of any protection function.

4.8.1.3 Information to a central unit (optional)

In addition, all stored information can be transmitted via an optical fibre connector 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. Alternatively the protocol is according DIN 19244 (selectable).

4.8.2 Data storage and transmission for fault recording

The instantaneous values of the measured values

i_1, i_2, i_3, i_{diff}, i_{stab}

(i_3 for teed lines) are sampled at 1.67 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 operating interface at the front and evaluated by the protection data evaluation program DIGSI®. The currents 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 optional serial system interface. Evaluation of the data is made in the control centre, using appropriate software programs. The currents 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, readout can proceed automatically, optionally after each pick-up of the relay or after 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.

4.8.3 Operating measurements and conversion

For local recall or transmission of data, the true r.m.s. values of the currents are always available as are the current(s) of the remote end(s). Additionally, the differential and stabilizing current and the temperature rise calculated from the r.m.s. current are presented.

The following is valid:

– I_1, I_2, I_3 mixed currents of line ends (i_3 for teed lines), in amps primary and in % of the rated relay current, based on symmetrical current with standard connection,

– I_{diff}, I_{stab} differential and stabilizing current, in amps primary and in % of rated relay current,

– Θ/Θ_{trip} temperature rise referred to the trip temperature rise.

4.8.4 Monitoring functions

The device incorporates comprehensive monitoring functions which cover both hardware and software; furthermore, the measured values are continuously checked for plausibility as far as possible.

4.8.4.1 Hardware monitoring

The complete hardware is monitored for faults and inadmissible functions, from the measured value inputs to the output relays. In detail this is accomplished by monitoring:

– Auxiliary and reference voltages

The processor monitors the offset and reference voltage of the ADC (analog/digital converter). The protection is blocked as soon as impermissible deviations occur. Permanent faults are annunciated.

Failure or switch-off of the auxiliary voltage automatically puts the system out of operation; this status is indicated by a fail-safe contact. Transient dips in supply voltage of less than 50 ms will not disturb the function of the relay.

– 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.

The three measured current I_1, I_a, and I_b lead to a node which is formed outside the module; the digitized sum of the outputs of these must always be zero. A fault in the current path is recognized when

$$|_1 - i_a - i_b| \geq \text{SUM.Ithres} \times I_N + \text{SUM.Fact.I} \times I_{max}$$

SUM.Ithres and SUM.Fact.I are setting parameters (see Section 6.3.11). The component SUM.Fact.I x 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 4.19).

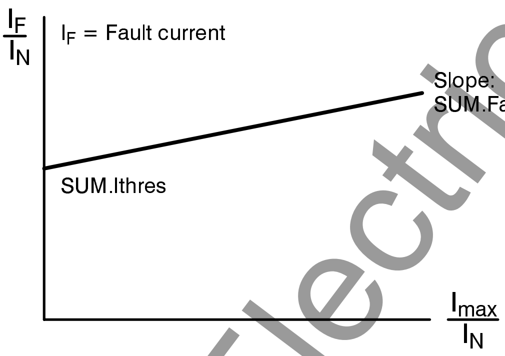


Figure 4.19 Current sum monitoring (current plausibility check)

– Command output channels:

The command relays for tripping are controlled by two command and one additional release channels. As long as no pick-up condition exists, the central processor makes a cyclic check of these command output channel for availability, by exciting each channels one after the other and checking for change in the output signal level. Change of the feed-back signal to low level indicates a fault in one of the control channels or in the relay coil. Such a condition leads automatically to alarm and blocking of the command output.

– Memory modules:

The memory modules are periodically checked for fault by:

- 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.

4.8.4.2 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.

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 **e**lectrostatically **e**ndangered **c**omponents (EEC) must be observed.

In installed conditions, the modules are in no danger.

5.2.1 Mounting and connections

5.2.1.1 Model 7SD502*−*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 7SD502*−*C*** for panel flush mounting or 7SD502*−*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.

If the current transformer sets at the line ends have different secondary currents, then all that must be checked is that the secondary rating of the respective current transformers complies with the rated current fo the connected unit. Different primary ratings require the use of a matching transformer set (refer to Section 5.2.4.4 for details).

5.2.2.1 Control d.c. voltage of binary inputs

When delivered from factory, the binary inputs are designed to operate in the total control voltage range from 19 V to 288 V. If the rated control voltage for 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 to a binary input, solder bridges must be removed. Figure 5.1 shows the assignment of these solder bridges and their location on the basic p.c.b. of the basic input/output module EPS. Figure 5.2 shows the assignment of these solder bridges and their location on the additional VF p.c.b. PGA (if fitted).

– Open housing cover.

– Loosen the basic module using the pulling aids provided at the top and bottom.

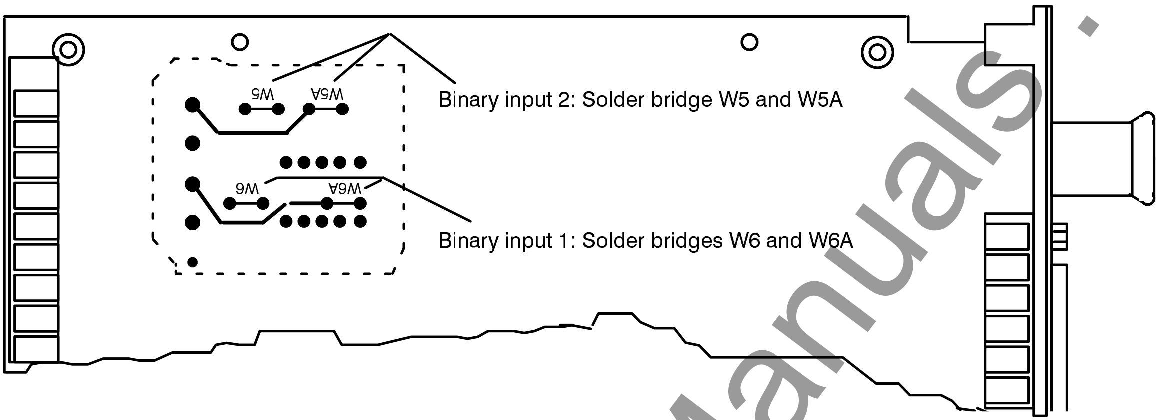
⚠ Caution!

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.

– Check the solder bridges according to Figure 5.1, remove bridges where necessary.

– Similarly check solder bridges on the VF p.c.b. (if fitted) according to Figure 5.2.
– Insert basic module into the housing; ensure that the releasing lever is pushed fully to the right before the module is pressed in.
– Firmly push in the module using the releasing lever.
– Close housing cover.



For rated voltages 24/48/60 Vdc: Solder bridges W* and W*A must be fitted (pick-up approx. 16 V)
For rated voltages 110/125 Vdc: Solder bridges W* may be removed (pick-up approx. 80 V)
For rated voltages 220/250 Vdc: Solder bridges W* and W*A may be removed (pick-up approx. 160 V)
Cut and bend aside
[1]) Bridges W*A in newer models only

Figure 5.1 Checking for control voltages for binary inputs 1 and 2 on basic p.c.b. EPS

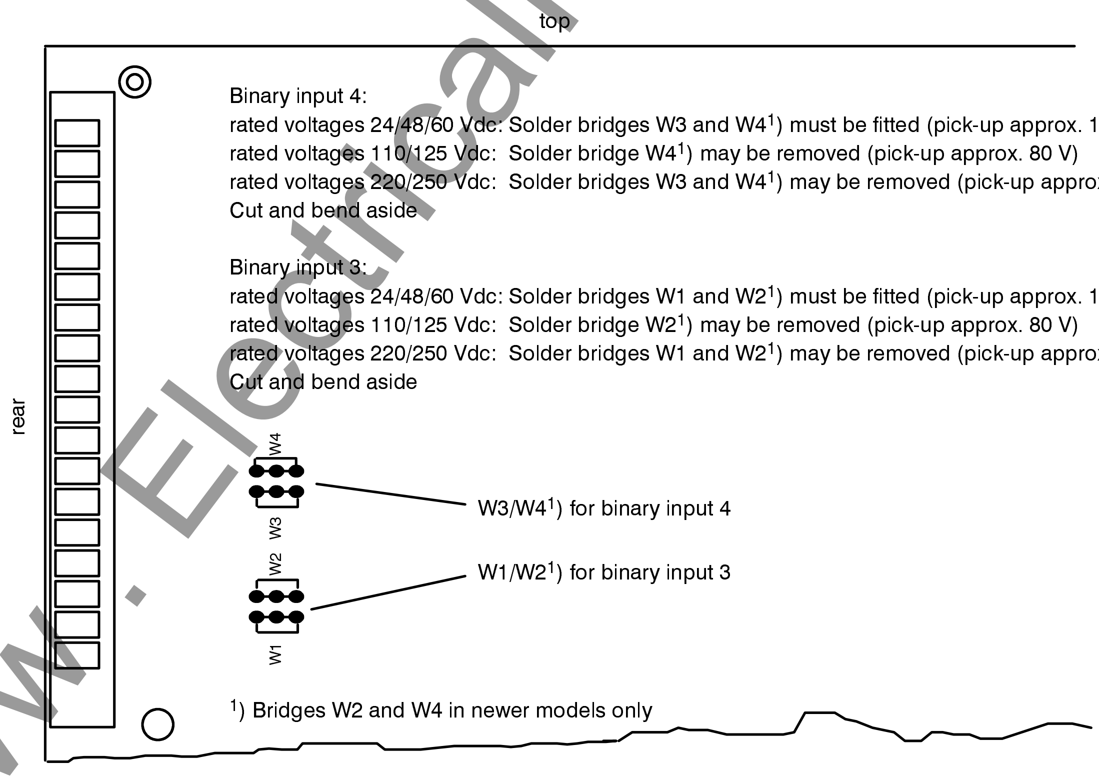


Figure 5.2 Checking for control voltages for binary inputs 3 and 4 on the voice frequency p.c.b. (PGA), if fitted

5.2.3 Checking the transmission link to LSA

For models with interface for a central data processing station (e.g. LSA) these connections must also be checked. It is important to visually check the allocation of the transmitter and receiver channels. Since each connection is used for one transmission direction, the transmit connection of the relay must be connected to the receive connection of the central unit and vice versa.

Transmission via optical fibre is particularly insensitive against disturbances and automatically provides galvanic isolation. Transmit and receive connector are designated with the symbols —●⟶ for transmit output and ⟶● 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 X91 which is accessible when the plug-in module is removed from the case. The jumper is situated in the centre rear area of the processor board (Figure 5.3).

Jumper	Position	Normal signal position
X91	90 – 91	”Light off”
X91	91 – 92	”Light on”

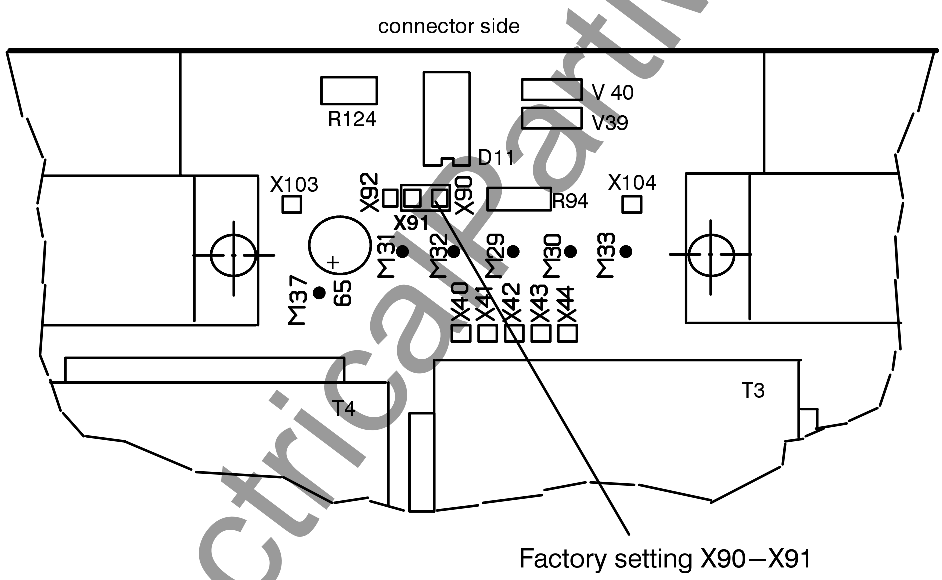


Figure 5.3 Position of the jumper X91 on the processor board

5.2.4 Connections

General and connection diagrams are shown in Appendix A and B. The three input windings of the summation transformer permit various connection possibilities to the current transformers, the most common are described in the following sub-sections. It is imperative that the connection mode is the same at the two (or three with teed lines) line ends. The marshalling possibilities of the binary inputs and outputs are described in Section 5.5.

5.2.4.1 Standard connection L1 – L3 – E

The standard connection is suited to all types of network regardless of the treatment of the system neutral. Figure 5.4 illustrates the measured current connections. The sensitivity for phase-to-phase faults lies between 0.58 and 1.15 times the sensitivity for symmetrical currents. For earth currents, the sensitivity is higher by the factor 1.73 to 2.89. In isolated or arc compensated systems, the relay can be adapted to the double earth fault preference of the system by cyclic or acyclic change of the phases. The preferred phase is then connected to the first summation transformer winding with the weighting factor 2, the phase with the least preference is not directly connected to the relay. Thus, the connection diagram according to Figure 5.4 corresponds to a double earth fault preference L1 before L3 before L2. The same connection method should be used throughout a galvanically interconnected system and must be used at the line ends of a differential protection scheme.

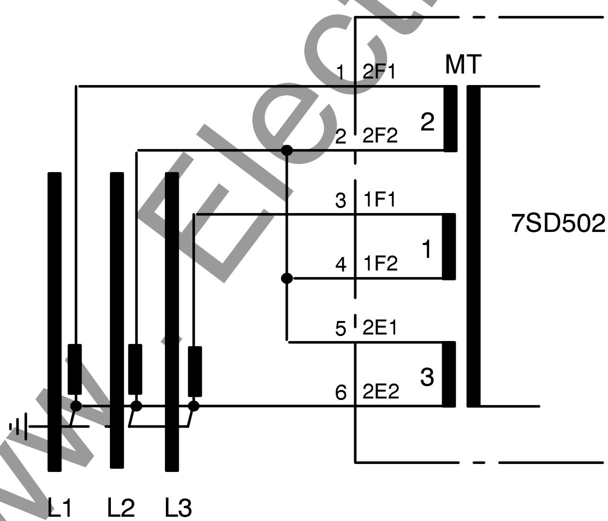


Figure 5.4 Standard connection L1 – L3 – E

5.2.4.2 Connection for decreased earth current sensitivity L1 – L2 – L3

In earthed systems with particularly low zero sequence impedance, earth fault currents can be larger than those under two-phase fault conditions. With consideration of the thermal loading on the measuring circuits, the connections shown in Figure 5.5 is used. With this connection, sensitivity for all types of faults lies between 0.58 and 1.73 times the sensitivity under symmetrical three-phase current conditions.

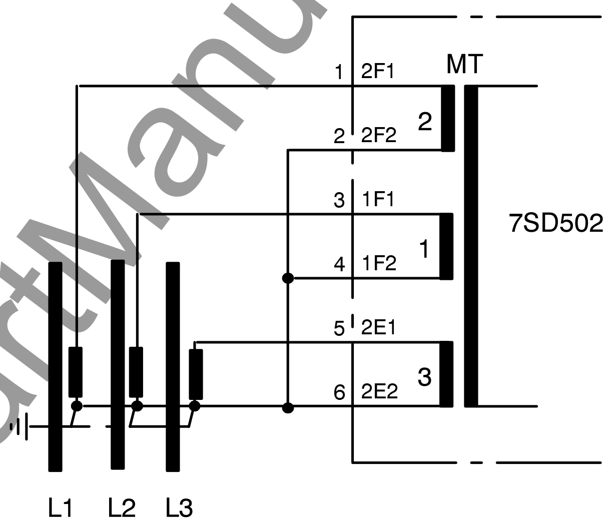


Figure 5.5 Connection L1 – L2 – L3 with decreased earth current sensitivity

5.2.4.3 Connection for increased earth current sensitivity

In certain systems, earth fault currents of even lower values must be detected and cleared, as it is possible with the standard connection, e.g. because of an earthing resistance (resistance earthed systems). To a certain extent this can be achieved by using an intermediate auto-transformer IT as shown in Figure 5.6. Dependent of the burden on the current transformers, the current in the star point conductor can be increased to approximately double the normal value. Earth fault sensitivity will then be increased to 3.46 to 5.77 times the sensitivity under symmetrical three-phase current conditions. Phase fault sensitivity is the same as with the standard connection.

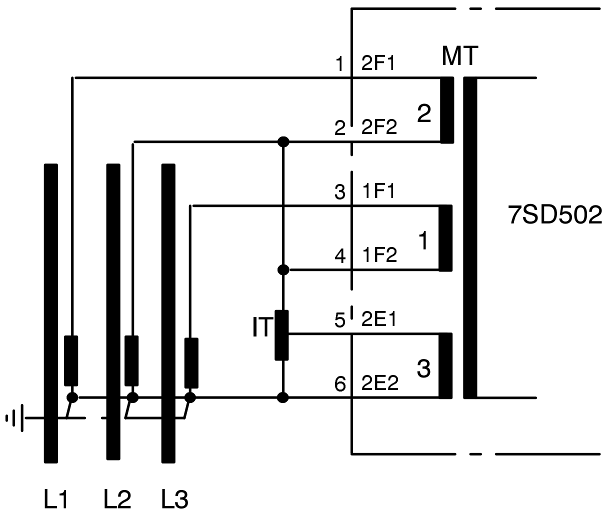


Figure 5.6 Connection L1−L3−E with increased earth current sensitivity

5.2.4.4 Unequal primary c.t. rated currents

If the c.t.s have different primary ratings, matching transformers must be used to correct the relationship. Conventionally, matching transformers are installed at the c.t.s with the lower primary rating. Since the current inputs of the 7SD502 are galvanically isolated from one another, auto-transformers can be used. The intermediate transformer output is then better utilized and the smaller model 4AM5170−7AA is sufficient. Figure 5.7 shows a connection example.

The transformation ratio of the intermediate transformers is calculated as follows:

$$TR_I = \frac{I_{N\ primary}\ \text{for the higher rated current}}{I_{N\ primary}\ \text{for the lower rated current}}$$

The turn number ratio is thus:

$$\frac{N_1}{N_2} = \frac{I_{N\ primary}\ \text{for the lower rated current}}{I_{N\ primary}\ \text{for the higher rated current}}$$

whereby

N_1 – Turns number at the side facing the main current transformers,

N_2 – Turns number at the side facing the 7SD502

Example:

Current transformers at line end I: 500 A/1 A
Current transformers at line end II: 400 A/1 A

Matching is performed at line end II:

$$\frac{N_1}{N_2} = \frac{I_{N\ primary}\ \text{for the lower rated current}}{I_{N\ primary}\ \text{for the higher rated current}}$$

$$= \frac{400\ A}{500\ A} = 0.8$$ which corresponds e.g. to 40/50 winding turns

If it is necessary to use matching transformers to correct the c.t. ratio at the same time as it is required to increase the sensitivity to earth faults according to Section 5.2.4.3, the circuit shown in Figure 5.7 is, of course, adequate. The transformation ratio of the intermediate transformer in the earth current path is then accordingly calculated. It is not necessary to use a further intermediate transformer.

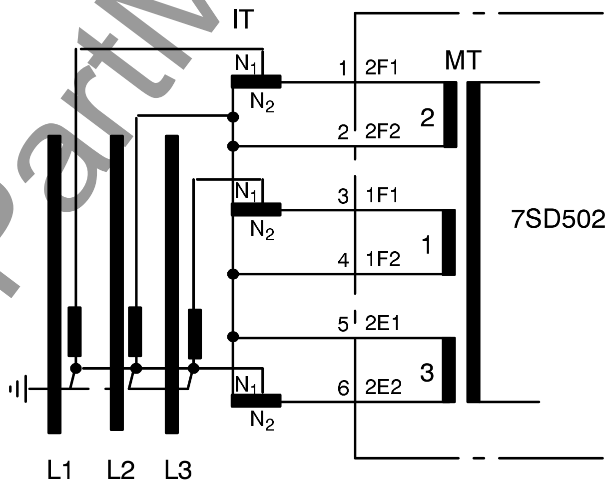


Figure 5.7 Matching of unequal primary currents

5.2.4.5 Two-phase connection

When a network is operated with isolated star point or arc suppression coil, where it is not required that the differential relay reacts to an earth fault, two current transformers are adequate for current summation (see Figure 5.8). In consideration of the possibility of double earth faults however, it is then essential to ensure that the c.t.s are fitted in the same two phases throughout the network. It must be ensured that at the opposite line end(s) the omitted phase must not be connected even if three c.t.s are available there.

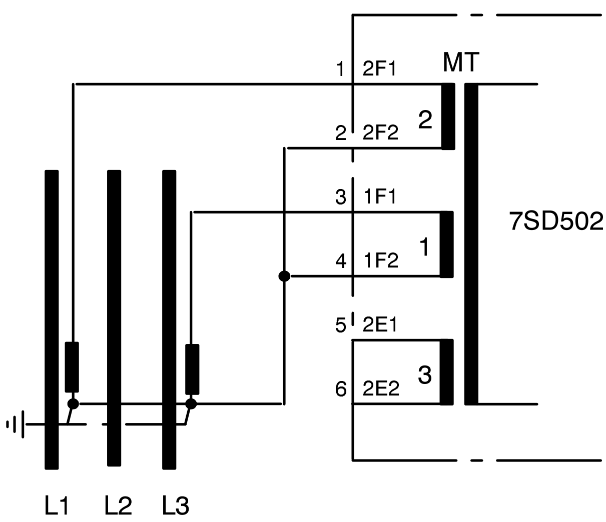


Figure 5.8 Two-phase connection L1 – L3

5.2.4.6 Multi-system protection

For particularly important lines and if sufficient pilot wires are available, an independent differential relay can be fitted to each phase. This results in threefold equipment investment and, normally, the necessity for three pairs of pilot wires. By using interposing transformers (model 7XR9513) which have a centre tapped, symmetrical secondary winding, one can create a phantom connection with two conductor pairs (Figure 5.9).

An advantage given by separate protection of each phase is the definite identification of the concerned phase for single-pole auto-reclosing in earthed networks. For multi-phase faults, fully redundant back-up occurs, because a trip command is given for each concerned conductor. Further, the three-phase system gives equal sensitivity for all types of fault.

Setting values for all protection functions are valid for symmetrical three-phase currents, with summation transformer connection (weighting factor = $\sqrt{3}$). For the connection in each phase, the effective weighting factor for the number of turns has to be divided by $\sqrt{3}$ in order to achieve the real sensitivity of the protection functions. If, for example, the weighting factor of the input windings is 2, the setting values have to be multiplied with the factor $2/\sqrt{3}$.

The use of the so-called phantom connection allows two pilot pairs to perform the same function as three pairs. It requires three interposing transformers at each end of the line. Where differential relays are used to protect extra high voltage lines, the use of interposing (barrier) transformers is recommended in any case, thus the two-pair pilot phantom circuit can be used without additional cost.

A further possible arrangement is given by combining the Figure 5.5 (L1 – L2 – L3) connection with a second differential relay which is connected only in the star point of the three c.t.s. Although this arrangement requires tow differential relays it has the advantage that the second relay is limited to the detection of earth faults and, when necessary, can be made to be very sensitive. This system is used only in earthed networks.

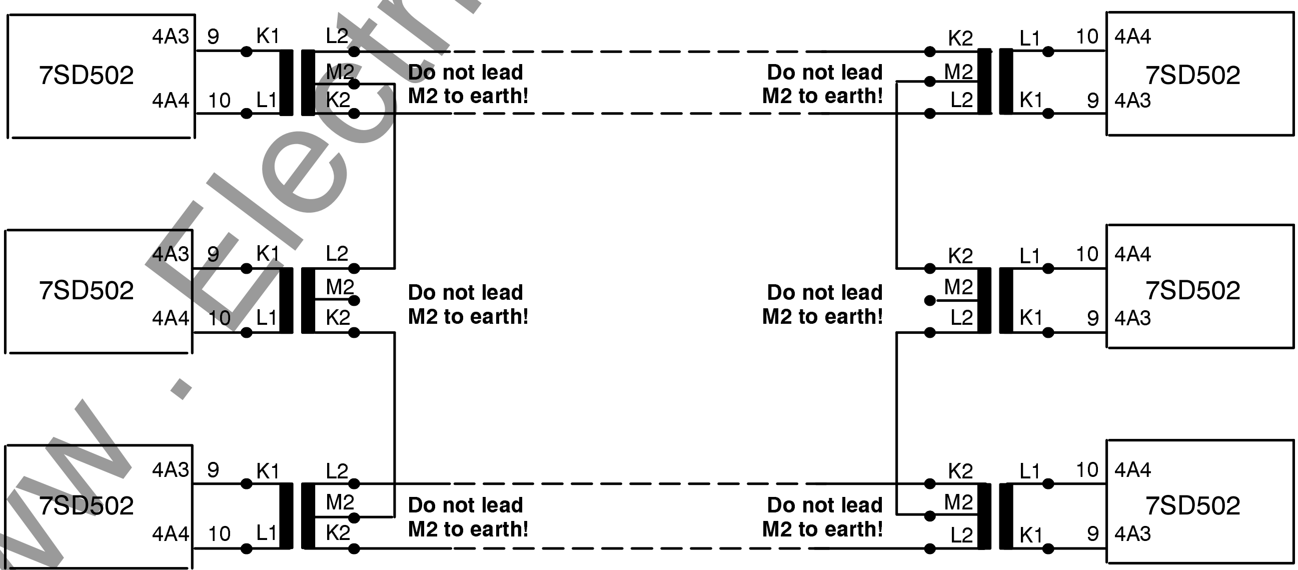


Figure 5.9 Phantom connection of 2 pilot wire pairs for three-system line differential protection

5.2.4.7 Primary capacitances

The assumption, used throughout descriptions of the basic principles of differential protection, that in healthy operation the current entering and leaving a protected section is identical is not entirely correct because of the effects of capacitance. For cables in particular, capacitive currents may reach considerable values. However, these currents usually lie within safe levels as far as the differential relay is concerned. For special cases, in which these factors could cause false operation of the relay, compensation circuits have been developed which make these charging currents ineffective. To connect these compensation circuits, at least one set of voltage transformers will be required at one end of the line.

An arrangement for compensation of the capacitance effects is shown in Figure 5.10. The line capacitances within the protected zone are represented by the capacitances C. Replica capacitances C' are shown connected to the secondary side of the voltage transformer set VT.

The secondary sides of the voltage transformers VT reproduce the voltage conditions on the line. Thus capacitances C' are subjected to the same conditions as the line capacitances C. The currents which flow in this replica have the same phase and bear a fixed relationship to the primary charging currents. In Figure 5.10, using the charging current for conductor L1 as an example, which is made up of the component I_{C1} from current transformer set CT1 and I_{C2} from CT2, the effect of the compensation circuit for the whole system is shown by the arrows which indicate the current flow. From this it can be seen that the component I_{C1} does not appear in the differential relay circuits since the compensation scheme is located at the end where this component flows into the line. The contribution from the opposite end, I_{C2}, certainly flows through the conductors but not through the tripping path as it is compensated by an equal high current in opposite direction fed from the compensation circuit. The fact that the charging current flowing in the protected zone flows in from both ends of the line is of no importance. It is only necessary to compensate at one end.

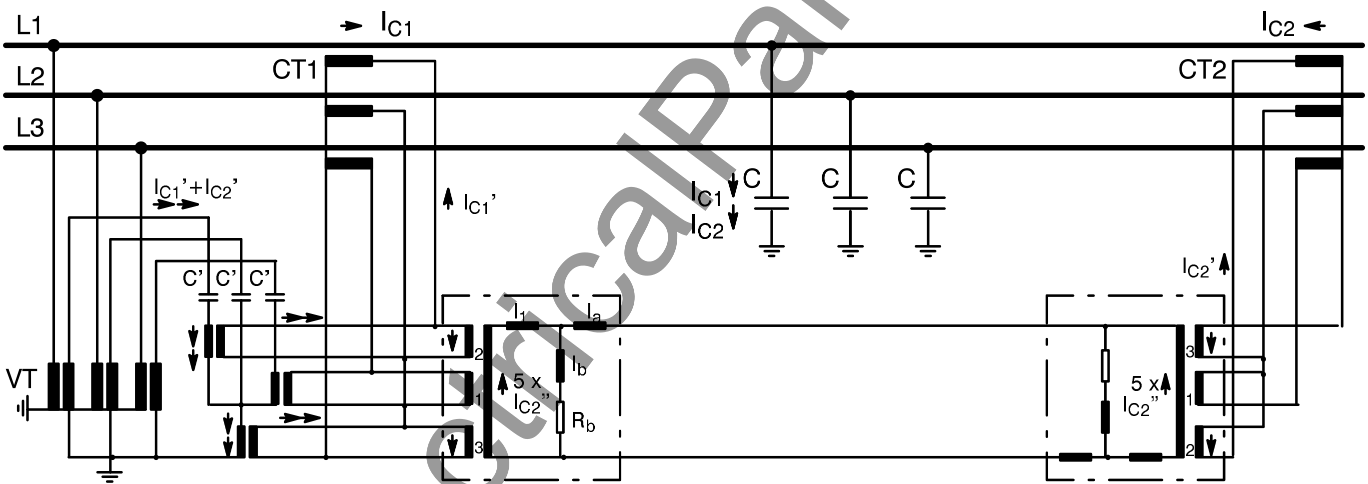


Figure 5.10 Compensation of the primary capacitances

5.2.5 Current transformer requirements

When very large fault currents pass through the current transformers to which protective relays are connected, magnetic saturation can cause errors in the transformation ratio and phase angle. The stabilizing circuits built into the differential relay ensure that these factors do not affect the performance of the comparison circuits to a significant extent. Nevertheless, current transformers used for this application must meet certain criteria even under the worst possible short circuit conditions.

If c.t.s with linear characteristics are available at both ends of the line section to be protected, it is necessary only to ensure that the total connected burden is not greater than the rated output of the c.t.s. For conventional c.t.s it is necessary to determine the accuracy limiting factor to ensure adequate response in the region of the highest operational fault currents. Values given on the rating plate for the nominal overcurrent factor *p* are minimum values.

The operational accuracy limiting factor *p*' is calculated from the current transformer data and the connected burden, using the formula:

$$p' = p \cdot \frac{P_N + P_I}{P_W + P_I}$$

where
- p' = operational accuracy limiting factor
- p = nominal accuracy limiting factor
- P_N = rated output of c.t.
- P_I = internal burden of c.t.
- P_W = connected burden (connecting conductors + relay + summation transformer)

The internal c.t. burden is rarely given on the c.t. rating plate. It must be determined from measurement of the resistance of the secondary winding of the c.t. There is no direct relation to the rated output. It is recommended that c.t.s with rated burden equal to or larger than the operational burden and with adequately large accuracy limiting factor *p* should be used. The use of c.t. sets with strongly differing characteristics is not permissible, e.g. linear c.t.s at one line end and closed iron cored c.t.s at the other.

Differential relay 7SD502 requires the following performance from the current transformers:

a) the c.t.s shall not saturate when the maximum fault current flows continuously:

$$p' \geq \frac{I_{sc\,max}}{I_{Npr}}$$

$I_{sc\,max}$ = max. steady state fault current
I_{Npr} = rated primary current of c.t.

b) the ratio of the operating overcurrent factors of the c.t.s at the two line ends (equal primary rated currents assumed) shall be such that:

$$2/3 \leq p_1' / p_2' \leq 3/2$$

Both conditions a) and b) must be fulfilled.

5.2.6 Pilot wire requirements

The measuring technique of the 7SD502 requires one pair of symmetrical wires to be connected between the two stations. The test voltages must exceed the max. induced longitudinal voltage caused by earth faults. It should be at least 500 V. The pilot wires must meet a symmetry wire/wire at 800 Hz = 10^{-3} (telephone pair).

It is absolutely necessary to reconsider the induced longitudinal voltage during earth faults. The pilot wires are not only stressed by the high currents which can be transmitted during a short-circuit and high surge voltages, but are also endangered mechanically to the same extent as the power cables themselves.

The largest electrical danger for pilot wire cables occurs during a short-circuit with earth connection. The fault current induces a longitudinal voltage into the pilot wire cable which is often led in parallel to the power line or cable.

The induced voltage in the pilot wires can be reduced by using good conductive covers (small reduction factor for pilot cable as well as power cable). Additionally, the pilot wires can be isolated by barrier transformers. Thus, a subdivision of the longitudinal voltage is achieved.

The induced voltage can be calculated according to the following equation:

$$U_i = 2\pi f \cdot M \cdot I_{sc1} \cdot l \cdot r_1 \cdot r_2$$

where

- U_i = induced longitudinal voltage in V,
- f = system frequency in Hz,
- M = mutual reactance between the power line and the pilot wires in mH/km,
- I_{sc1} = maximum single-phase earth fault current in kA,
- l = length of the section where the power line and the pilot wires are led in parallel in km,
- r_1 = reduction factor of the power cable (r_1 = 1 in case of overhead lines),
- r_2 = reduction factor of the pilot wire cable.

The mutual reactance can be inserted in mH/mile if the line length is also inserted in miles. Only the half of the calculated induced voltage need be recognized as it is shared out among the two ends of the pilot wires.

The 7SD502 is insulated to withstand 2 kV. Pilot wires with a max. 2 kV test voltage can be directly connected up.

⚠ Warning!

The induced longitudinal voltage must not exceed 60 % of the test voltage of the pilot wires!

If the longitudinal voltage exceeds 60 % of the relay insulation level of 2 kV, i.e. 1.2 kV, the use of insulated external barrier transformer 7XR9513 is required. The test voltage of the pilot wires can require further subdivisions. Even if barrier transformers are used, neither 60 % of the test voltage of the barrier transformer(s) nor 60 % of the test voltage of the pilot wires must be exceeded.

The barrier transformer should be mounted near the cable sealing end to prevent the induced voltage to enter the relay panel. The type 7XR9513 (Figure 5.11) is recommended which has a 20 kV insulation. The centre tapping of the barrier transformer windings are earthed at the relay side for safety reasons (refer to Figure 5.11). The pilot wire sided windings are floating against earth potential.

⚠ Caution!

The pilot wires must not be earthed nor provided with surge arresters.

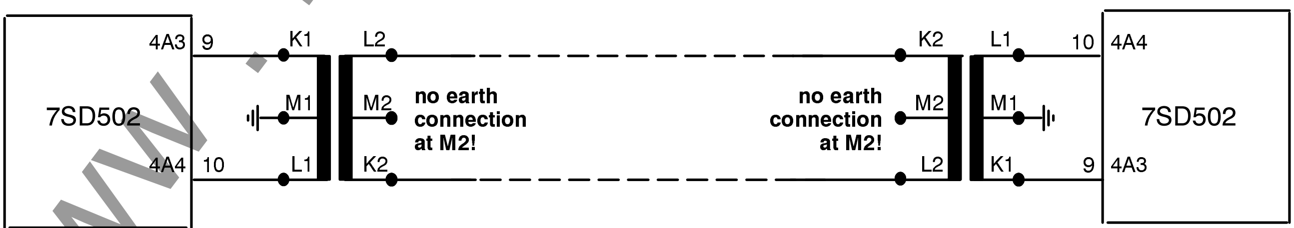


Figure 5.11 Connection of barrier transformers 7XR9513

5.2.7 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 d.c. supply!

– Check the continuity of all the current 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 and equal at all line ends?
  - Is the assignment of the current transformers to the input windings of the summation current transformer correct?

– 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 to Figure 6.1).

– Fit a d.c. 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 correspond to approximately 7 W. Transient movement of the ammeter pointer only indicates the charging current of the storage capacitors.

– 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 last 5 sec.

– Open the circuit breaker for the d.c. power supply.

– Remove d.c. ammeter; reconnect the auxiliary voltage leads.

– Check through the tripping circuits to the circuit breakers.

– Check through the control wiring to and from other devices.

– Check through the pilot wire connections. For reasons of symmetry the pilot wires are crossed over in the connection diagrams. The polarity changers (switches in the front plate, see also Figure 6.1) have then equal position at both line ends provided the current transformers at both line ends have equal polarity. It is permissible – as it was with conventional differential relays – to connect the pilot wires 1 : 1, i.e. to connect the terminals with equal terminal number at both ends. In this case, the polarity changers at both ends must have different position. The correct allocation of the pilot wires is re-checked during commissioning of the protection system (refer to Section 6.7.4).

– For lines with three terminals (teed lines) the polarity changers of the two adjacent relays in the same substation must be in the same position. Furthermore, the correct polarity of the pilot wires to the third line end of each relay must be checked (connection example in Appendix B).

– For lines with three terminals (teed lines), when pilot wire monitoring is used, ensure that in two of the three stations connection is made between the signal output "`Block to 3end`" (FNo `3377`) of each relay to the binary input "`>P.W.M. 3.end`" (FNo `3367`) of the other. This connection must not be made in the third station. Explanations are given in Section 4.3.10.

– 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 codeword is necessary. This applies for all entries via the membrane keyboard or front interface which concern the operation on the relay, for example

– configuration parameters for operation language, configuration of the interfaces and the device functions,

– allocation or marshalling of annunciation signals, binary inputs, optical indications, and trip relays,

– settings for 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. Operation via the integrated keyboard is described in detail in Section 6.2.

To indicate authorized operator use, press key **CW**, enter the six figure code **0 0 0 0 0 0** and confirm with **E**. Codeword entry can also be made retrospectively after paging or direct addressing to any setting address.

```
E N T E R   C O D E W O R D :
@ @ @ @ @ @
```

```
C W   A C C E P T E D
```

```
C O D E W O R D   W R O N G
```

The entered characters do not appear in the display, instead only a symbol @ appears. After confirmation of the correct input with **E** the display responds with **CW ACCEPTED**. Press the entry key **E** again.

If the codeword is not correct the display shows **CODEWORD WRONG**. Pressing the **CW** key allows another attempt at codeword entry.

Address blocks 70 to 79 are provided for configuration of the software operating system. These settings concern the operation of the relay, communication with external operating and processing devices via the serial interfaces, and the interaction of the device functions.

The simplest way of arriving at the beginning of this configuration blocks is to use key **DA**, followed by the address number **7 0 0 0** and ENTER, key **E**. The address 7000 appears, which forms the heading of the configuration blocks:

```
⇑ 7 0 0 0 █ O P .   S Y S T E M
⇓ C O N F I G U R A T I O N
```

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 presented 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 **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.

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 above.

When one exits the setting program, the altered parameters, which until then have been stored in buffer stores, are permanently secured in EEPROMs and protected against power outage. If configuration parameters have been changed the processor system will reset and re-start. During re-start the device is not operational.

5.3.2 Settings for the integrated operation − address block 71

Operating parameters can be set in address block 71. This block allows the operator language to be changed. The date format can be selected. Messages on the front display can be selected here for the quiescent state of the unit or after a fault event. To change any of these parameters, codeword entry is necessary.

When the relay is delivered from the factory, the device is programmed to give function names and outputs in the German language. This can be changed under address 7101. The operator languages available at present are shown in the boxes below. The date is displayed in the European format when the relay is delivered.

```
7100 INTEGRATED
OPERATION
```

Beginning of the block "Integrated operation"

```
7101 LANGUAGE
DEUTSCH
```

```
ENGLISH
```

The available languages can be called up by repeatedly pressing the "No"−key **N**. Each language is spelled in the corresponding country's language. If you don't understand a language, you should find your own language.

The required language is chosen with the enter key **E**.

```
7102 DATE FORMAT
DD.MM.YYYY
```

```
MM/DD/YYYY
```

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)

```
7105█ OPER.  1st L
I1[%]=
```
```
I2[%]=
```
```
etc.
```

Message to be displayed in the **1st** display line during operation. Any of the operational measured values according to Section 6.4.5 can be selected as messages in the 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.

```
7106█ OPER.  2nd L
I2[%]=
```
```
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.

```
7107█ FAULT  1st L
Prot.Pick-up
```

After a fault event, the **first** line of the display shows:

protection function which has picked up,

```
Prot.Trip
```

protection function, which has tripped,

```
T-Drop
```

the elapsed time from pick-up to drop-off,

```
T-Trip
```

the elapsed time from pick-up to trip command,

```
7108█ FAULT  2nd L
Prot.Trip
```
```
etc.
```

After a fault event, the **second** line of the display shows:

the possibilities are the same as under address 7107.

```
7110█ FAULT  INDIC
WITH  FAULT  DETEC
```
```
WITH  TRIP  COMM.
```

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 (dependent on model): 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.

```
7200 PC/SYSTEM
INTERFACES
```

Beginning of the block "Interfaces for personal computer and central computer system"

```
7201 DEVICE ADD.
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**

```
7202 FEEDER ADD.
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**

```
7203 SUBST. ADD.
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**

```
7208 FUNCT. TYPE
192
```

Function type in accordance with VDEW/ZVEI; for line differential protection no. 192.
This address is mainly for information, it should not be changed.

```
7209 DEVICE TYPE
26
```

Device type for identification of the device in Siemens LSA 678 and program *DIGSI®* . For 7SD502 V3 no. 26.
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*.

```
7211 PC INTERF.
DIGSI V3
```

Data format for the PC (operating) interface:

format for Siemens protection data processing program *DIGSI®* Version *V3*

```
ASCII
```

ASCII format

```
7215 PC BAUDRATE
9600 BAUD
```

```
19200 BAUD
```

```
1200 BAUD
```

```
2400 BAUD
```

```
4800 BAUD
```

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**.

```
7216 PC PARITY
DIGSI V3
```

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

```
NO 2 STOP
```

transmission with *NO* parity and *2 STOP*−bits

```
NO 1 STOP
```

transmission with *NO* parity and *1 STOP*−bit, e.g. for modem

---

Addresses 7221 to 7235 are valid for the system (LSA) interface (if fitted).

```
7221 SYS INTERF.
VDEW COMPATIBLE
```

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

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

```
VDEW EXTENDED
```

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

```
DIGSI V3
```

format for Siemens protection data processing program *DIGSI®* Version *V3*

```
LSA
```

format of the former Siemens *LSA* version

```
7 2 2 2█ S Y S   M E A S U R .
V D E W   C O M P A T I B L E
```

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

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

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

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

```
7 2 2 5█ S Y S   B A U D R .
9 6 0 0   B A U D
```

```
1 9 2 0 0   B A U D
```

```
1 2 0 0   B A U D
```

```
2 4 0 0   B A U D
```

```
4 8 0 0   B A U D
```

The transmission Baud−rate for communication via the system interface can be adapted to the system interface, e.g. LSA, if necessary. The available possibilities can be displayed by repeatedly depression of the "No"−key **N**. Confirm the desired Baud−rate with the entry key **E**.

```
7 2 2 6█ S Y S   P A R I T Y
V D E W / D I G S I V 3 / L S A
```

```
N O   2   S T O P
```

```
N O   1   S T O P
```

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

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

transmission with *NO* parity and *2 STOP*−bits

transmission with *NO* parity and *1 STOP*−bit, e.g. for modem

---

Address 7235 is relevant only in case the system interface is connected with a hardware that operates with the protection data processing program DIGSI® (address 7221 SYS INTERF. = *DIGSI V3*). This address determines whether it shall be permitted to change parameters via this interface.

```
7 2 3 5█ S Y S   P A R A M E T
N O
```

```
Y E S
```

Remote parameterizing via the system interface

NO − is not permitted

YES − is permitted

5.3.4 Settings for fault recording – address block 74

The line differential protection relay is equipped with a fault data store (see Section 4.8.2). 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. For differential protection, fault detection and trip command are the same instant, this distinction is useful only for overcurrent protection.

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 max. times are referred to a system frequency of 50 Hz. They are to be matched, accordingly, for different frequency.

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; 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).

```
7400
FAULT RECORDINGS
```

Beginning of block ”Fault recordings”

```
7402 INITIATION
STORAGE BY FD.
```

```
STORAGE BY TRIP
```

```
START WITH TRIP
```

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

```
7410 T-MAX
1.00 s
```

Maximum time period of a fault record
Smallest setting value: **0.30** s
Largest setting value: **5.00** s

```
7411 T-PRE
0.10 s
```

Pre-trigger time before the reference instant
Smallest setting value: **0.05** s
Largest setting value: **0.50** s

```
7412 T-POST
0.10 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.

Only for communication with a former LSA system:

```
7 4 9 0█ S Y S  L E N G T H
6 6 0  V A L U E S  F I X
```

Length of a fault record which is transmitted via the serial system interface:

660 values fix or

```
< = 3 0 0 0  V A L .  V A R .
```

variable length with a maximum of 3000 values

5.4 Configuration of the protective functions

5.4.1 Introduction

The **device** 7SD502 is capable of providing a series of **protection** and additional functions. 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.

Example for configuration of the scope of the device:

Assume a network comprising overhead lines and cable sections. The thermal overload protection is reasonable only for the cable sections. It will be "deconfigured" for the devices protecting the overhead line sections.

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 the 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 bock 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. 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 configuration parameters which can equally be confirmed or altered.

The configuration procedure can be ended at any time by the key combination **F E**, i.e. depressing the function key **F** followed by the entry key **E**. The display shows the question "SAVE NEW SETTINGS ?". Confirm with the "Yes"−key **J/Y** that the new settings shall become valid now. If you press the "No"−key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

If one tries to leave the setting range for the configuration blocks (i.e. address blocks 60 to 79) with keys ⇑ ⇓, the display shows the question "END OF CODEWORD OPERATION ?". Press the "No"−key **N** to continue configuration. If you press the "Yes"−key **J/Y** instead, another question appears: "SAVE NEW SETTINGS ?". Now you can confirm with **J/Y** or abort with **N**, as described above.

When one exits the setting program, the altered parameters, which until then have been stored in volatile memories, are then permanently secured in EEPROMs and protected against power outage. The processor system will reset and re-start. During restart 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 7SD502: 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.

```
7800 SCOPE OF
FUNCTIONS
```

Beginning of the block "scope of functions"

Differential protection:

```
7815 DIFF PROT.
EXIST
```

```
NON-EXIST
```

Transfer trip via binary input:

```
7822 TRANSF.TRIP
NON-EXIST
```

```
EXIST
```

Pilot wire monitoring:

```
7816 PILOT MON
NON-EXIST
```

```
EXIST
```

Trip on reception of a remote trip signal:

```
7823 TRIP RECV
NON-EXIST
```

```
EXIST
```

Local trip from external source via binary input:

```
7821 EXT. TRIP
NON-EXIST
```

```
EXIST
```

Back-up overcurrent time protection:

```
7826 BACK-UP O/C
NON-EXIST
```

```
EXIST
```

Thermal overload protection:

```
7827 THERMAL OL
NON-EXIST
```

```
EXIST
```

Change-over of parameter sets:

```
7885 PARAM. C/O
NON-EXIST
```

```
EXIST
```

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.

```
7899 FREQUENCY
fN 50 Hz
```

```
fN 60 Hz
```

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, for 7SD502, whether the differential system is used on a two- or three-terminal line.

```
7900 DEVICE
CONFIGURATION
```

Beginning of the block ”device configuration”

```
7901 No OF ENDS
TWO TERMINALS
```

```
THREE TERMINALS
```

The line differential protection system is used on two-terminal lines or on three-terminal lines?

5.5 Marshalling of binary inputs, binary outputs and LED indicators

5.5.1 Introduction

The functions of the binary inputs and outputs represented in the general diagrams (Appendix A) relate to the factory settings. The assignment of the inputs and outputs of the internal functions can be rearranged and thus adapted to the on-site conditions.

Marshalling of the inputs, outputs and LEDs is performed by means of the integrated operator panel or via the operating interface in the front. The operation of the operator panel is described in detail in Section 6.2. Marshalling begins at the parameter address 6000.

The input of the codeword is required for marshalling (refer Section 5.3.1). Without codeword entry, parameters can be read out but not be changed. During codeword operation, i.e. from codeword entry until the termination of the configuration procedure, the solid bar in the display flashes.

When the firmware 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: Trip command is registered from a protection function. This event is generated in the device as an "Annunciation" (logical function) and should be available at certain terminals of the unit as a N.O. contact. Since specific unit terminals are hard-wired to a specific (physical) signal relay, e.g. to the signal relay 1, the processor must be advised that the logical signal "`Device Trip`" should be transmitted to the signal relay 1. Thus, when marshalling is performed two statements of the operator are important: **Which** (logical) annunciation generated in the protection unit program should trigger **which** (physical) signal relay? Up to 20 logical annunciations can trigger one (physical) signal relay.

A similar situation applies to binary inputs. In this case external information (e.g. remote resetting) is connected to the unit via a (physical) input module and should initiate a (logical) function, namely resetting of the stored indications. The corresponding question to the operator is then: **Which** signal from a (physical) input element 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:

```
⇑ 6 0 0 0 █
⇓ M A R S H A L L I N G
```

Beginning of marshalling blocks

One can proceed through the marshalling blocks with the key ⇑ or go back with the key ⇓ . Within a block, one goes forwards with ↑ or backwards with ↓ . 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** ↑, i.e. depressing the function key **F** followed by the arrow key ↑, 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 ↑ key) the bar behind the address number is replaced by a ”F”. The display shows, in the upper line, the physical input/output unit, this time with a three digit index number. The second display line shows the logical function which is presently allocated.

On this selection level the allocated function can be changed by pressing the ”No”−key **N**. By repeated use of the key **N** all marshallable functions can be paged through the display. Back-paging is possible with the backspace key **R**. When the required function appears press the execute key **E**. After this, further functions can be allocated to the same physical input or output module (with further index numbers) by using the key ↑. **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** ↑ (i.e. depressing the function key **F** followed by the arrow key ↑). The display shows again the four digit address number of the physical input/output module. Now you can page with key ↑ to the next input/output module or with ↓ 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 execute key E**. Immediately the associated identification of the function appears for checking purposes. This can be altered either by entering another 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 execute key E**.

In the following paragraphs, allocation possibilities for binary inputs, binary outputs and LED indicators are given. The arrows uv or ↑↓ 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 ↑.

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 ⇑ ⇓, 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 2 or 4 binary inputs (depending on model) which are designated INPUT 1 and INPUT 2, or INPUT 1 to INPUT 4. They can be marshalled in address block 61. The address block is reached by paging in blocks uv 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 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**.

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 2. Table 5.2 shows all binary inputs as preset from the factory.

```
⇧  6100 MARSHALLING
⇩  BINARY INPUTS
```

Beginning of block "Marshalling binary inputs"

The second binary input is reached with the key ↑:

```
F↑  6102 BINARY
 ↓  INPUT 2
```

Allocations for binary input 2

Change over to the selection level with **F** ↑:

```
↑  001 INPUT 2
↓  >LED reset      NO
```

Reset of stored indications, FNo 5;
"normally open" operation: reset is carried out when control voltage present

```
↑  002 INPUT 2
↓  not allocated
```

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 ↑ or to the previous with the arrow key ↓.

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 8)
8	>ParamSelec.2	Parameter set selection 2 (in conjunction with 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
354	>CB Aux.3p cl	Circuit breaker all 3 poles closed (from CB aux. contact)
356	>Manual Close	Circuit breaker is manually closed (from discrepancy switch)
1156	>CB Test	Trigger circuit breaker test
1503	>O/L block	Block thermal overload protection
1504	>O/L annunc.	Switch overload protection to give only annunciations
1505	>O/L blo Trip	Block trip command of thermal overload protection
2303	>Backup block	Block back-up overcurrent time protection
2304	>Back bloTrip	Block trip command of back-up overcurrent time protection
2306	>I>> block	Block I>> stage of back-up overcurrent time protection
2307	>I>/Ip block	Block I> or I_P stage of back-up overcurrent time protection
3003	>Diff block	Block differential protection
3005	>Diff bloTrip	Block trip command of differential protection
3303	>TrTrip block	Block transfer trip function (transmitter for remote trip)
3306	>Trans.Trip	Trigger transfer trip
3333	>Recv. block	Block reception of remote trip
3335	>Recv.bloTrip	Block trip command of reception of remote trip
3363	>P.W.M. block	Block pilot wire monitor
3367	>P.W.M. 3.end	Pilot wire to third terminal faulty (for teed lines)
4503	>Ext block	Block external trip function
4505	>Ext blo Trip	Block trip command of external trip function
4506	>Ext Trip	Binary input for external trip function

Table 5.1 Marshalling possibilities for binary inputs

Note: Table 5.2 shows the pre-settings for the maximum complement of the device. Depending on the actual version, not all inputs are available.

Addr	1st display line	2nd display line	FNo	Remarks
6100	MARSHALLING	BINARY INPUTS		Heading of the address block
6101	BINARY INPUT 1	INPUT 1 >Ext Trip NO	4506	Direct local trip
6102	BINARY INPUT 2	INPUT 2 >LED reset NO	5	Acknowledge and reset of stored LED and display indications, LED−test
6103	BINARY INPUT 3	INPUT 3 [1]) >Diff bloTrip NO	3005	Block trip command of differential protection [1])
6104	BINARY INPUT 4	INPUT 4 [1]) >Trans.Trip	3306	Remote trip for opposite line terminal [1])

[1]) 7SD502★−★★★1★−★★ only

Table 5.2 Preset binary inputs

5.5.3 Marshalling of the signal output relays – address block 62

The unit contains 5 signal outputs (alarm relays). The signal relays are designated SIGNAL RELAY 1 to SIGNAL RELAY 5 and can be marshalled in address block 62. The block is reached by paging in blocks with ⇑ ⇓ 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 has been programmed out (”de-configured” – refer Section 5.4.2).

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 of signal relay 1. Table 5.4 shows all signal relays as preset from the factory.

Note as to Table 5.3: Annunciations with a leading ”>” sign are identical with those for binary inputs. They represent the direct confirmation of the binary input and are available as long as the corresponding binary input is energized.

Further information about annunciations see Section 6.4.

⇑ ⇓
```
6200█ MARSHALLING
SIGNAL RELAYS
```

Beginning of the block ”Marshalling of the output signal relays”

The first signal relay is reached with the key ↑:

F↑ ↓
```
6201█ SIGNAL
RELAY 1
```

Allocations for signal relay 1

Change over to the selection level with **F** ↑:

↑ ↓
```
001█ RELAY 1
Device Trip
```

Signal relay 1 has been preset for:
General trip of the device, FNo 511;

↑ ↓
```
002█ RELAY 1
not allocated
```

no further functions are preset for signal relay 1

Leave the selection level with key combination **F** ↑. You can go then to the next signal output relay with the arrow key ↑.

↑ ↓
```
6201█ SIGNAL
RELAY 1
```

Allocations for signal relay 1

FNo	Abbreviation	Description
1	not allocated	Binary output is not allocated to any annunciation 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 connection with 8)
8	>ParamSelec.2	Parameter set selection 2 (in connection with 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
51	Dev.operative	Protection relay operative
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
88	Param. Set C	Parameter Set C is activated
99	Param. Set D	Parameter Set D is activated
143	Failure 15V	Failure in 15 V internal dc supply circuit
144	Failure 5V	Failure in 5 V internal dc supply circuit
145	Failure 0V	Failure 0 V for A/D converter
150	Failure I/O	Failure in base input/output module
151	Failure I/O 1	Failure in additional input/output module
161	I supervision	Failure current supervision, general
162	Failure Σ I	Failure detected by current sum monitor
354	>CB Aux.3p cl	Circuit breaker all 3 poles closed (from CB auxiliary contact)
356	>Manual Close	Circuit breaker is manually closed (from discrepancy switch)
501	Device FltDet	General fault detection of the device
511	Device Trip	General trip of the device
561	Manual Close	Circuit breaker is manually closed (execution)
1156	>CB Test	Trigger circuit breaker test
1174	CB in Test	Circuit breaker test is in progress
1185	CB Test 3pol	Trip three-pole by internal circuit breaker test function
1503	>O/L block	Block thermal overload protection
1504	>O/L annunc.	Switch overload protection to give only annunciations
1505	>O/L blo Trip	Block trip command of 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 pick-up of trip stage
1521	O/L Trip	Thermal overload protection trip command
2303	>Backup block	Block back-up overcurrent time protection
2304	>Back bloTrip	Block trip command of back-up overcurrent time protection
2306	>I>> block	Block I>> stage of back-up overcurrent time protection
2307	>I>/Ip block	Block I> or I_p stage of back-up overcurrent time protection
2401	Backup off	Back-up overcurrent time protection is switched off
2402	Backup block	Back-up overcurrent time protection is blocked
2403	Backup active	Back-up overcurrent time protection is active
2411	Back Gen. Flt	General fault detection of back-up overcurrent protection
2421	Backup I>>	I>> stage of back-up overcurrent protection picked up
2422	Backup I>/Ip>	I> or I_p stage of back-up overcurrent protection picked up
2441	Backup TI>>	Delay time of I>> stage of overcurrent time protection expired
2442	Backup TI>/Tp	Delay time of I> or I_p stage of overcurrent time protection expired
2451	Back Gen.Trip	General trip by back-up overcurrent protection
3003	>Diff block	Block differential protection
3005	>Diff bloTrip	Block trip command of differential protection
3015	Diff off	Differential protection is switched off
3016	Diff blocked	Differential protection is blocked

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

FNo	Abbreviation	Description
3017	Diff active	Differential protection is active
3021	Diff> T start	Differential protection start of delay time (if applicable)
3022	Diff Gen. Flt	Differential protection general fault detection
3024	Block saturat	Differential protection blocked by saturation indicator
3026	Block Harm	Differential protection blocked by excess of second harmonic content
3027	Diff> Trip	Differential protection general trip
3028	Diff Intertr.	Differential protection intertrip signal transmitted
3029	dir.Dif>Trip	Direct command of differential protection without local current release
3303	>TrTrip block	Block transfer trip function (transmitter for remote trip)
3306	>Trans.Trip	Trigger transfer trip function
3311	TransTrip off	Transfer trip function is switched off
3312	TransTrip blo	Transfer trip function is blocked
3316	TrTrip Send	Transfer trip function send signal transmitted
3333	>Recv. block	Block reception of remote trip
3335	>Recv.bloTrip	Block trip command of reception of remote trip
3341	Receiver off	Receiver of remote trip is switched off
3342	Receive block	Receiver of remote trip is blocked
3343	Recv. active	Receiver of remote trip is active
3346	Recv Gen.Flt	General fault detection of remote trip reception
3347	Receiver Trip	Trip command of remote trip
3348	Receive recv.	Remote trip signal received
3363	>P.W.M. block	Block pilot wire monitor
3367	>P.W.M. 3.end	Pilot wire failure of adjacent relay (only with three-terminal lines)
3371	P.W.M. off	Pilot wire monitor is switched off
3372	P.W.M. block	Pilot wire monitor is blocked
3376	Pilot w. fail.	Pilot wire failure
3377	Block to 3end	Block signal for pilot wire monitor of adjacent relay (only with three-terminal lines)
4503	>Ext block	Block external trip function
4505	>Ext blo Trip	Block trip command of external trip function
4506	>Ext Trip	Trigger external trip function
4511	Ext off	External trip function is switched off
4512	Ext blocked	External trip function is blocked
4513	Ext active	External trip function is active
4516	Ext Gen.Fault	General fault detection signal of external trip function
4517	Ext Gen.Trip	Trip signal of external trip function

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 Device Trip	511	Trip signal given from either protection function of the device
6202	SIGNAL RELAY 2	RELAY 2 Diff Gen. Flt	3022	Fault detection of differential protection
6203	SIGNAL RELAY 3	RELAY 3 Back Gen. Flt	2411	Fault detection of differential protection
6204	SIGNAL RELAY 4	RELAY 4 Pilot w. fail.	3376	Pilot wire failure
6205	SIGNAL RELAY 5	RELAY 5 Dev.operative	51	The NC contact of this relay indicates "Device fault"

Table 5.4 Preset annunciations for signal relays

5.5.4 Marshalling of the LED indicators − address block 63

The unit contains 8 LEDs for optical indications, 6 of which can be marshalled. They are designated LED 1 to LED 6 and can be marshalled in address block 63. The block is reached by paging in blocks with ⇑ ⇓ 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 **m**emorized) or unstored mode (`nm` for "**n**ot **m**emorized"). 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).

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.

```
⇑ 6300█ MARSHALLING
⇓ LED INDICATORS
```

Beginning of the block "Marshalling of the LED indicators"

The first marshallable LED is reached with the key ↑:

```
F↑ 6301█ LED 1
 ↓
```

Allocations for LED 1

Change over to the selection level with **F** ↑:

```
↑ 001█ LED 1
↓ Device Trip        m
```

LED 1 has been preset for:
General trip of the device, memorized, FNo 511

```
↑ 002█ RELAY 1
↓ not allocated
```

no further functions are preset for signal relay 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 █ L E D   1
```

Allocations for LED 1

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	Device Trip m	511	Trip signal given from either protection function of the device
6302	LED 2 LED 2	Diff Gen. Flt m	3022	Fault detection signal of the indicated protection functions
6303	LED 3 LED 3	Backup I>> m	2421	
6304	LED 4 LED 4	Backup I>/Ip> m	2422	
6305	LED 5 LED 5	O/L Warn Θ m	1516	Thermal warning stage of thermal overload protection
6306	LED 6 LED 6	Pilot w. fail nm	3376	Pilot wire failure

Table 5.5 Preset LED indicators

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

The unit contains 2 or 4 trip relays (depending on the ordered model) which are designated TRIP RELAY 1 and TRIP RELAY 2 or TRIP RELAY 1 to TRIP RELAY 4. 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 ⇑ ⇓ 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).

Many 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 an example for marshalling of trip relay 1. Table 5.7 shows all trip relays as preset from the factory.

If further protection functions shall trip the same breaker, each command relay must be triggered by the corresponding command functions.

FNo	Abbreviation	Logical command function
1	not allocated	no annunciation allocated to trip relay
501	Device FltDet	General fault detection of the device
511	Device Trip	General trip of the device
1185	CB Test 3pol	Trip by internal circuit breaker test function
1517	O/L pickup Θ	Thermal overload protection pick-up of trip stage
1521	O/L Trip	Trip by thermal overload protection
2411	Back Gen. Flt	General fault detection of back-up overcurrent time protection
2441	Backup TI>>	Delay time of I>> stage of overcurrent time protection expired
2442	Backup TI>/Tp	Delay time of I> or I_P stage of overcurrent time protection expired
2451	Back Gen.Trip	General trip by back-up overcurrent time protection
3022	Diff Gen. Flt	Fault detection of differential protection
3027	Diff> Trip	Trip by differential protection
3029	dir.Dif>Trip	Direct command of differential protection without local current release
3346	Recv. Gen.Flt	General fault detection of remote trip reception
3347	Receiver Trip	Trip after reception by remote trip
4516	Ext Gen.Fault	General fault detection signal of external trip function
4517	Ext Gen.Trip	Trip by external trip function

Table 5.6 Command functions

```
⇑  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 ↑:

```
F↑  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** ↑:

```
↑  0 0 1 █  T R I P   R E L .   1
↓  O / L   p i c k u p   Θ
```

Trip relay 1 has been preset for:
1st: Thermal overload protection pick-up of trip stage, FNo 1517;

```
0 0 2█ T R I P   R E L .   1
B a c k   G e n .   F l t
```

Trip relay 1 has been preset for:
2nd: General fault detection of back-up overcurrent time protection, FNo 2411;

```
0 0 3█ T R I P   R E L .   1
D i f f   G e n .   F l t
```

Trip relay 1 has been preset for:
3rd: Fault detection of differential protection, FNo 3022;

```
0 0 4█ T R I P   R E L .   1
R e c v .   G e n . F l t
```

Trip relay 1 has been preset for:
4th: General fault detection of remote trip reception, FNo 3346;

```
0 0 5█ T R I P   R E L .   1
E x t   G e n . F a u l t
```

Trip relay 1 has been preset for:
5th: General fault detection signal of external trip function, FNo 4516;

Leave the selection level with key combination **F** ↑. You can go then to the next trip relay with the arrow key ↑.

```
6 4 0 1█ T R I P
R E L A Y   1
```

Allocations for trip relay 3:
"Fault detection of any protection function"

Addr	1st display line	2nd display line	FNo	Remarks
6400	MARSHALLING	TRIP RELAYS		Heading of the address block
6401	TRIP TRIP REL. 1 TRIP REL. 1 TRIP REL. 1 TRIP REL. 1 TRIP REL. 1	RELAY 1 O/L pickup Θ Back Gen. Flt Diff Gen. Flt Recv. Gen.Flt Ext Gen.Fault	 1517 2411 3022 3346 4516	General fault detection of any protection function
6402	TRIP TRIP REL. 2 TRIP REL. 2 TRIP REL. 2 TRIP REL. 2 TRIP REL. 2 TRIP REL. 2	RELAY 2 CB Test 3pol O/L Trip Back Gen.Trip Diff> Trip Receiver Trip Ext Gen.Trip	 1185 1521 2451 3027 3347 4517	General trip command by any protection function
6403	TRIP TRIP REL. 3	RELAY 3 [1]) not allocated	 1	no further command functions allocated to trip relays
6404	TRIP TRIP REL. 4	RELAY 4 [1]) not allocated	 1	

[1]) 7SD502★−★★★**1**★−★★ only

Table 5.7 Preset command functions for trip relays

Note: Depending on model not all trip relays may be available.

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:

0 to 9	Digits 0 to 9 for numerical input
•	Decimal point
∞	Infinity symbol
+/−	Change of sign (input of negative numbers)

Yes/No keys for text parameters:

J/Y	Yes key: operator affirms the displayed question
N	No key: operator denies the displayed question or rejects a suggestion and requests for alternative

Keys for paging through the display:

↑	Paging forwards: the next address is displayed
↓	Paging backwards: the previous address is displayed
⇑	Block paging forwards: the beginning of the next address block is displayed
⇓	Block paging backwards: the beginning of previous address block is displayed

Confirmation key:

E	Enter or confirmation key: each numerical input or change via the Yes/No keys must be confirmed by the enter key; only then does the device accept the change. The enter key can also be used to acknowledge and clear a fault prompt in this display; a new input and repeated use of the enter key is then necessary.

Control and special keys:

CW	Codeword: prevents unauthorized access to setting programs (not necessary for call-up of annunciations or messages)
R	Backspace erasure of incorrect entries
F	Function key; explained when used
DA	Direct addressing: if the address number is known, this key allows direct call-up of the address
M/S	Messages/Signals: interrogation of annunciations of fault and operating data (refer Section 6.4)

The three keys ↑ ; ⇑ ; 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 ⇑ is pressed.

6.2.2 Operation with a personal computer

A personal computer allows, just as the operator panel, all the appropriate settings, initiation of test routines and read-out of data, but with the added comfort of screen-based visualization and a menu-guided procedure.

All data can be read in from, or copied onto, magnetic data carrier (floppy disc) (e.g. for settings and configuration). Additionally, all the data can be documented on a connected printer. It is also possible, by connecting a plotter, to print out the fault history traces.

For operation of the personal computer, the instruction manuals of this device are to be observed. The PC program DIGSI® is available for setting and processing of all digital protection data. Note that the operating interface in the front of the relay is not galvanically isolated and that only adequate connection cables are applied (e.g. 7XV5100−2). Further information about facilities on request.

6.2.3 Operational preconditions

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

− setting of functional parameters (thresholds, functions),

− allocation or marshalling of trip relays, signals, binary inputs, LED indicators,

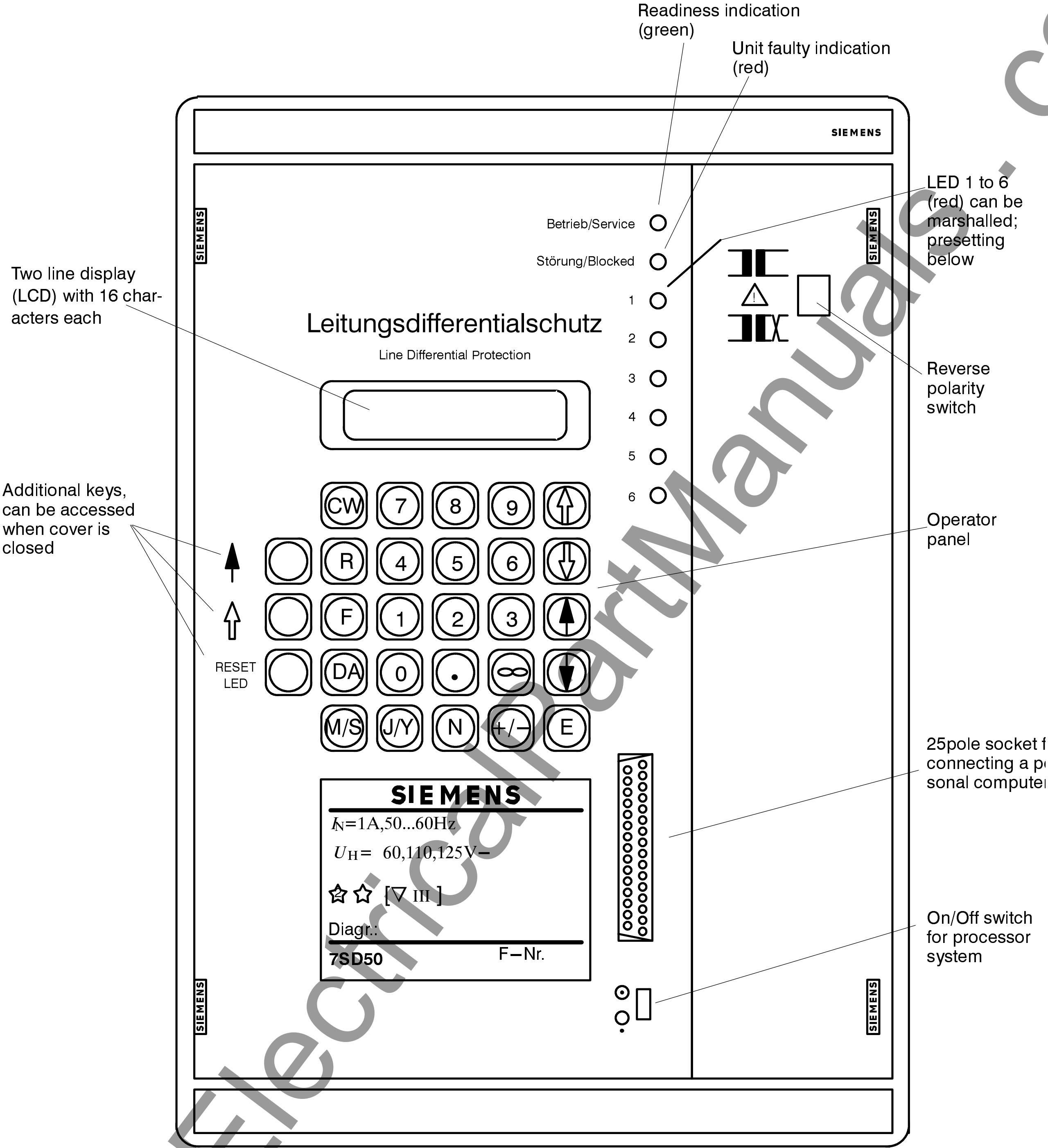
− configuration parameters for operator language, interface and device configuration,

− 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)



Factory presetting LEDs:

1 General trip of the relay
2 Pick-up of differential protection
3 Pick-up of overcurrent time protection stage I>>
4 Pick-up of overcurrent time protection stage I> (definite) or I_P (inverse)
5 Overload protection thermal warning stage
6 Pilot wire failure

Figure 6.1 Front view of 7SD502 with 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. **11**00 for block **11**). Displayed text forms the heading of this block. No input is expected. By using keys ⇑ or ⇓ the next or the previous block can be selected. By using the keys ↑ or ↓ 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. **1101** for block **11**, sequence number **1**). 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. **1501** for block **15**, sequence number **1**). Behind the bar appears the meaning of the required parameter, in the second display line, the applicable text. When the relay is delivered, a text has been preset. In the following sections, this text is shown. If it is to be retained, no other input is necessary. One can page forwards or backwards within the block or to the next (or previous) block. If the text needs to be altered, press the "No" key **N**. The next alternative text, also printed in the display boxes illustrated in the following sections, then appears. If the alternative text is not desired, the **N** key is pressed again, etc. The alternative which is chosen, **is confirmed with the entry key E.** The changed parameters are only saved after termination of parameterizing (refer below).

For each of the addresses, the possible parameters and text are given in the following sections. If the meaning of a parameter is not clear, it is usually best to leave it at the factory setting. The arrows uv or ↑↓ 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 ⇑ ⇓ and keys ↑ ↓ is possible.

The setting 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 **Y** that the new settings shall become valid now. If you press the "No"–key **N** instead, codeword operation will be aborted, i.e. all alterations which have been changed since the last codeword entry are lost. Thus, erroneous alterations can be made ineffective.

If one tries to leave the setting range for the function parameter blocks (i.e. address blocks 10 to 39) with keys ⇑ ⇓, the display shows the question ”END OF CODEWORD OPERATION ?”. Press the ”No”−key **N** to continue parameter setting. If you press the ”Yes”−key **J/Y** instead, another question appears: ”SAVE NEW SETTINGS ?”. Now you can confirm with **J/Y** or abort with **N**, as above.

After completion of the parameterizing process, the changed parameters which so far have only been stored in volatile memory, are then permanently stored in EEPROMs. The display confirms ”NEW SETTINGS SAVED”. After pressing the key **M/S** followed by RESET LED, the indications of the quiescent state appear in the display.

6.3.1.2 Selectable parameter sets

Up to 4 different sets of parameters can be selected for the functional parameters, i.e. the addresses above 1000 and below 4000. These parameter sets can be switched over during operation, locally using the operator panel or via the operating interface using a personal computer, or also remotely using binary inputs.

If this facility is not used then it is sufficient to set the parameters for the preselected set. The rest of this section is of no importance. Otherwise, the parameter change-over facility must be configured as *EXIST* under address 7885 (refer Section 5.4.2). The first parameter set is identified as set A, the other sets are B, C and D. Each of these sets is adjusted one after the other.

If the switch-over facility is to be used, first set all parameters for the normal status of parameter set A. Then switch over to parameter set B:

− Fist 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 6.5.4 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 ↑ key. The copying facilities are summarized in Table 6.1.

```
⇑  8 5 0 0 █ P A R A M E T E R
⇓  C H A N G E − O V E R
```

Beginning of the block ”Parameter change-over”; processing of parameter sets

Addr.	Copy from	Copy to
8510	ORIG.SET	SET A
8511	ORIG.SET	SET B
8512	ORIG.SET	SET C
8513	ORIG.SET	SET D
8514	SET A	SET B
8515	SET A	SET C
8516	SET A	SET D
8517	SET B	SET A
8518	SET B	SET C
8519	SET B	SET D
8520	SET C	SET A
8521	SET C	SET B
8522	SET C	SET D
8523	SET D	SET A
8524	SET D	SET B
8525	SET D	SET C

Table 6.1 Copying parameter sets

Following copying, only such parameters need be changed which are to be different from the source parameter set.

Parameterizing must be terminated for each parameter set as described in Section 6.3.1.1.

6.3.1.3 Setting of date and time

The date and time can be set as long as the real time clock is operational. Setting is carried out in block 81 which is reached by direct addressing **DA 8 1 0 0 E** or by paging with ⇑ and ⇓. Input of the codeword is required to change the data.

Selection of the individual addresses is by further scrolling using ↑ ↓ as shown below. Each modification must be confirmed with the enter key **E**.

The date and time are entered with dots as separator signs since the keyboard does not have a colon or slash (for American date).

The clock is synchronized at the moment when the enter key **E** is pressed following input of the complete time. The difference time facility (address 8104) enables exact setting of the time since the difference can be calculated prior to the input, and the synchronization of the clock does not depend on the moment when the enter key **E** is pressed.

```
8100█ SETTING
REAL TIME CLOCK
```

Beginning of the block ”Setting the real time clock” Continue with ↑.

```
16.01.1995
15:54:42
```

At first, the actual date and time are displayed. Continue with ↑.

```
8102█ DATE
```

Enter the new date: 2 digits for day, 2 digits for month and 4 digits for year (including century); use the order as configured under address 7102 (Section 5.3.2), but always use a dot for separator:
DD.MM.YYYY or **MM.DD.YYYY**

```
8103█ TIME
```

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

```
8104█ DIFF. TIME
```

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 00 and 10

When the relay is switched on, firstly the address 0 and the type identification of the relay appears. All Siemens relays have an MLFB (machine readable type number). When the device is operative and displays a quiescent message, any desired address can be reached e.g. by pressing the direct address key **DA** followed by the address number.

```
0█ 7SD502      V3.**
7SD502**********
```

The relay introduces itself by giving its type number and the version of firmware with which it is equipped. The second display line shows the complete ordering designation.

After address 1000, the functional parameters begin. Further address possibilities are listed under ”Annunciations” and ”Tests”.

```
 1000█
PARAMETERS
```

Commencement of functional parameter blocks

6.3.3 Power system data − address block 11

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

The primary rated current of the protected object (address 1101) and the primary rated current of the main current transformers (address 1102) can be set to the same value, in most cases. The correct setting of the rated c.t. current is a precondition for the calculation and indication of the primary measured current values (refer also to Section 6.4.5). The correct setting of the rated current of the protected object ensures that the characteristic of the differential protection is optimally matched to the protected object. That means that the pick-up values and the shape of the characteristic are referred to this rated object current.

The two current ratings should not differ from each other for more than the factor 4. In case of pilot wire loop resistance of more than 500 Ω (approx. 7 km or 4 miles), IN LINE should not be set smaller than $^1/_2$ times IN CT PRIM, above 1200 Ω (approx. 16 km or 10 miles) IN LINE should not be less than IN CT PRIM. If IN LINE < IN CT PRIM, then the differential protection should not be set more sensitive than the preset values (Section 6.3.4, addresses 1503 to 1508).

Example:

Rated current of the protected line:	1000 A
Rated c.t. current	2000 A

Pick-up value and characteristic shape are referred to a current which corresponds to 1000 A primary. The characteristic is thus referred to 1000 A primary.

Both parameters must be set equal at the line ends. In case the primary rated currents of the current transformer sets differ from each other, matching transformers must be used at the line end with the lower rated current. Refer to Section 5.2.4.4 for more details.

```
 1100█ ◆
POWERSYSTEM DATA
```

Beginning of the block ”Power system data”

```
 1101█ IN LINE
2000 A
```

Primary rated current of the protected line

Smallest setting value:	**1** A
Largest setting value:	**100000** A

```
  1 1 0 2█ I N   C T   P R I M
2 0 0 0   A
```

Primary rated current of the current transformers
Smallest setting value: **1** A
Largest setting value: **100000** A

Pilot wire resistance adjustment by additional resistors is not necessary in 7SD502 since the protection carries out the adjustment by internal calculation. For this, the protection must be informed about the pilot wire loop resistance by setting of address 1131 Rx. In addition to the real pilot wire loop resistance, 80 Ω must be calculated when the relay is equipped with pilot wire monitoring. For each barrier transformer 7XR95, further 60 Ω must be added. The pilot wire loop resistance can be measured by the relay itself during commissioning (refer to Section 6.7.2).

For three-terminal lines (teed lines), the loop resistances of both pilot wire pairs are required. It must be noted, that Rx (address 1131) is always the loop resistance of that pilot wire pair which is directly connected to the relay under consideration. Ry (address 1132) is the loop resistance of the pilot wire pair connected to the adjacent relay (in the same substation).

The capacitances of the pilot wires can also be compensated within the relay by calculation; no external measures are necessary. Compensation is recommended for pilot wire capacitances of approximately 0.3 μF and above; this corresponds to a length of ca. 5 kilometers (approx. 3 miles), for usual protection pilot wires. In addition to the pilot wire capacitance, 200 nF must be calculated when the relay is equipped with pilot wire monitoring. The pilot wire capacitance can be set under address 1133 Cx; it also can be measured by the relay itself during commissioning (refer to Section 6.7.1).

For three-terminal lines, the capacitances of both pilot wire pairs are required. The same definitions apply as for the resistances: Cx (address 1133) is the capacitance of that pilot wire pair which is directly connected to the relay under consideration, Cy (address 1134) for the adjacent relay.

The minimum trip command duration can be set under address 1141. It is valid for all protection functions of the relay which can lead to trip.

```
  1 1 3 1█ R x
0   Ω
```

Loop resistance of the pilot wire pair; for three-terminal lines, Rx is the loop resistance of the pilot wire pair directly connected to the relay
Smallest setting value: **0** Ω
Largest setting value: **2000** Ω

```
  1 1 3 2█ R y
0   Ω
```

Only for three-terminal lines:
Loop resistance of the pilot wire pair connected to the adjacent relay
Smallest setting value: **0** Ω
Largest setting value: **2000** Ω

```
  1 1 3 3█ C x
0   n F
```

Total capacitance of the pilot wire pair; for three-terminal lines, Cx is the capacitance of the pilot wire pair directly connected to the relay
Smallest setting value: **0** nF
Largest setting value: **2000** nF

```
  1 1 3 4█ C y
0   n F
```

Only for three-terminal lines:
Total capacitance of the pilot wire pair connected to the adjacent relay
Smallest setting value: **0** nF
Largest setting value: **2000** nF

```
  1 1 4 1█ T - T R I P
0 . 1 0   s
```

Minimum trip command duration
Smallest setting value: **0.01** s
Largest setting value: **32.00** s

6.3.4 Settings for the line differential protection – address block 15

A precondition for the operation of the differential protection is that it is configured as *EXIST* under address 7815 (refer to Section 5.4.2). Additionally, the differential protection function can be set to be operative (*ON*), or inoperative (*OFF*), or its trip command may be blocked whilst the protection function is operative (*BLOCK TRIP REL*). This setting is carried out in address 1501.

Attention! When delivered from factory, the differential protection is switched *OFF*. The reason is that this protection must not be in operation unless at least the pilot wire loop resistance(s) have been set before (refer to address 1131 and, if applicable, address 1132, Section 6.3.3). Without correct setting the relay may show unexpected reactions (incl. tripping)!

```
1500 PILOT WIRE
DIFF. PROTECTION
```

Beginning of block "Pilot wire differential protection"

```
1501 DIFF PROT.
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

Line differential protection

ON is switched on or

OFF is switched off or

BLOCK TRIP RELAY operates but trip relay is blocked

The parameters of the tripping characteristic are set in the addresses 1503 to 1518. Figure 6.2 illustrates the meaning of the different parameters. The numerical values correspond to the preset values. The numbers signify the addresses of the parameters.

I DIFF> (address 1503) is the pick-up value of the differential current. This is the total fault current, regardless of the way this is divided between the line ends. The pick-up value is referred to the rated current of the protected line as set under address 1101 (refer to Section 6.3.3). Dependent on the lowest possible currents which can occur under the different possible fault conditions and the sensitivity given by the chosen method of connection of the relay, an upper limit for the setting results.

The lower limit of the possible setting range is determined by the difference between the current outputs of the summation transformers under healthy conditions. This constant difference can result from the capacitive currents in the protected section. Large capacitive current which could endanger the stability of the protection occur in practice only on cable circuits, where the cable charging currents can cause differences of multiple mA on the secondary side of the summation transformers (apparent fault current = 5 mA is 25 % of the internal design current of the summation transformer).

Considering that even higher capacitive currents can be caused by transients which occur during switching operations, an even higher setting must be chosen. With the standard current transformer connection (Figure 5.4) experience indicates a lower limit equal to approximately 10 times the charging current which flows in each conductor under healthy conditions. For current transformer connections which give higher earth fault sensitivity, the lower setting limit increases accordingly. Conversely, connection giving less earth fault sensitivity, especially in solidly earthed networks, reduce the lower limit. In such cases a setting somewhat over 4 times the charging current in each phase is adequate.

The upper and lower limits thus determined give the permissible setting range. If the lower limit is higher than the upper limit, then the primary capacitances of the power cable must be compensated by means of external schemes (for details refer to Section 5.2.4.7).

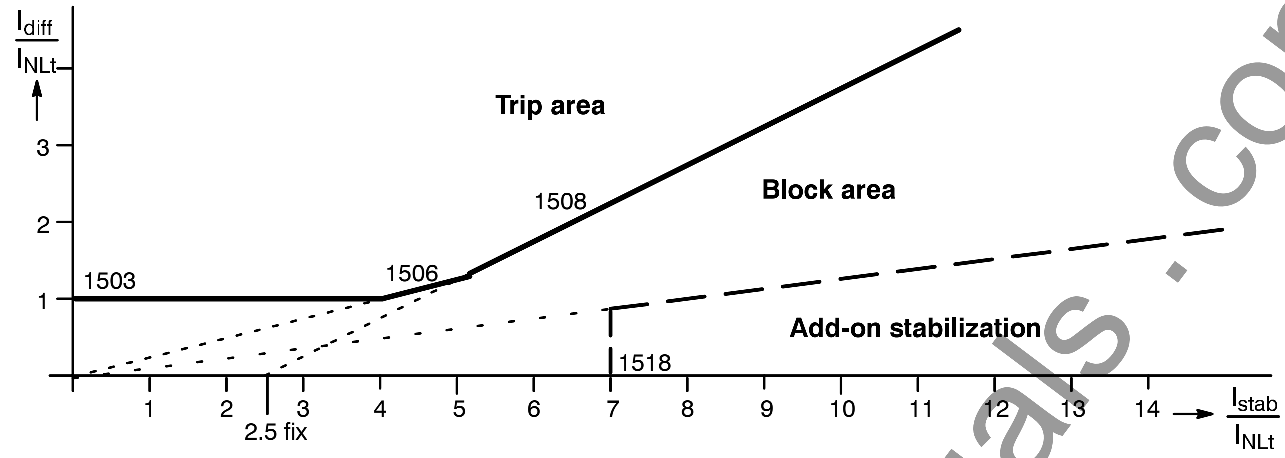


Figure 6.2 Shape of the tripping characteristic and relevant parameters

The tripping characteristic forms two more branches (Figure 6.2). The slope of the first branch is determined by the address 1506 SLOPE1. This branch covers current proportional errors. These are mainly transformation errors of the main current transformers and the summation transformer below the saturation limit. The presetting 0.25 should be reasonable in all cases.

The second branch produces a higher stabilization in the range of high currents which may lead to current transformer saturation. Its base point lies at 2.5 times rated line current as parameterized under address 1101 (see Section 6.3.3). The slope is set under address 1508 SLOPE2. The preset value results in somewhat more stable conditions compared with the analog relay types 7SD20, 7SD22, 7SD24, or 7SD76. The stability of the relay during current transformer saturation can be influenced by this parameter. A higher slope results in a higher stability. On the other hand, especially in systems with non-earthed star-point, it must be considered that a double earth fault (cross-country fault) is not always detected in phase L2 (with standard connection according to Figure 5.4) when the slope is set above 0.5.

In cases where a power transformer is directly connected (i.e. without current transformers and circuit breaker) to a line, an inrush stabilization using the second harmonic content in the differential current can be switched on under address 1510. The second harmonic content which blocks the protection is then set under address 1511. A ratio of I_{2fN}/I_{fN} = 20 % has been preset by the factory and can – as a rule – be retained without change. A smaller value leads to higher stabilization, a higher value means less stabilization.

During an external fault which produces a high through-flowing short-circuit current causing severe current transformer saturation, an "add-on" stabilization will become effective which is defined by address 1518 SAT–RESTR (saturation restraint). This value is referred to the rated line current as parameterized under address 1101 (see Section 6.3.3), too. It should be noted that the stabilizing quantity during through-flowing condition is the arithmetical sum of the currents at the line ends, i.e. twice the through-flowing current.

```
1 5 0 3 █ I   D I F F >
1 . 0 0   I / I n L n
```

Pick-up value of differential current, referred to the rated line current (address 1101)

Smallest setting:	**0.50** · $I_{N\ line}$
Largest setting:	**2.50** · $I_{N\ line}$

```
1 5 0 6 █ S L O P E   1
0 . 2 5
```

Slope of the first declined branch of the tripping characteristic

Smallest setting:	**0.10**
Largest setting:	**0.50**

```
 1508▌ SLOPE 2
0.50
```

Slope of the second declined branch of the tripping characteristic
Smallest setting: **0.25**
Largest setting: **0.95**

```
 1510▌ 2nd HARMON
OFF
```

```
ON
```

Inrush stabilization with the second harmonic is
OFF switched off
ON switched on or

```
 1511▌ 2nd HARMON
20 %
```

2nd harmonic content in differential current, which just initiates blocking, in % of fundamental wave of the differential current
Smallest setting: **10** %
Largest setting: **80** %

```
 1518▌ SAT-RESTR.
7.00 I/InLn
```

Stabilizing (restraining) current which is decisive for the add-on stabilization, referred to the rated line current (address 1101)
Smallest setting: **5.00** · $I_{N\ line}$
Largest setting: **15.00** · $I_{N\ line}$

The differential protection contains a local current threshold I1 RELEASE (address 1523) which provides an additional trip condition. Above all, the maximum current which is expected during operational conditions is decisive for this setting. Pick-up of this stage caused by symmetrical overload must be excluded. Therefore, the value should be set above the maximum expected (over)load current of the line (at least 1.2 times). The value is referred to the rated line current as set under address 1101 (refer to Section 6.3.3). This local current threshold provides the effect that the faulty line will be switched off only at that (those) line end(s) where a reasonable short-circuit current flows. If the circuit breaker at a non-feeding line end should also be tripped, the integrated intertrip facility can be used (see below). A precondition is that the relay is equipped with this facility (models with pilot wire monitor, intertrip, and transfer trip 7SD502★–★★★**1**★–★★). Furthermore, possibility exists to trip the breaker without release by the local current, when the command "`dir.Dif>Trip`" (FNo `3029`, see Section 5.5.5) is used for tripping.

In special cases it may be advantageous to delay the trip signal of the protection (e.g. for reverse interlocking). For this, an additional time delay can be set (address 1525). Under normal circumstances this time delay is set to zero.

Additionally, a drop-off delay after trip can be set under address 1527 T–RESET. This should ensure that the trip command is maintained for a sufficiently long time period even when the circuit breaker interruption times are different at the line ends.

If a trip time delay has been set in address 1525 then, nevertheless, instantaneous trip is desired in case of switching onto a dead fault (e.g. when an earthing isolator has happened to remain closed). Address 1535 allows to pass a trip time delay by. A prerequisite 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.

```
1523█ I1 RELEASE
1.50 I/InLn
```

Local current threshold for release of the differential protection, referred to the rated line current (address 1101)
Smallest setting: **0.20** · $I_{N\ line}$
Largest setting: **2.50** · $I_{N\ line}$

```
1525█ T-DELAY
0.00 s
```

Additional time delay for trip signal
Smallest setting: **0.00** s
Largest setting: **60.00** s
and ∞ (no trip with I_{DIFF}>)

```
1527█ T-RESET
0.10 s
```

Reset delay after trip signal has been disappeared
Smallest setting: **0.00** s
Largest setting: **60.00** s

```
1535█ MAN.CLOSE
INEFFECTIVE
```

```
UNDELAYED
```

Trip reaction of the line differential protection when the line is manually switched onto a dead fault:

INEFFECTIVE i.e. no special means or

UNDELAYED trip even if a delay has been set under address 1525

The 7SD502 may include an integrated intertrip function. As the intertrip signal is transmitted via the pilot wires, it is available only in the models with integrated pilot wire monitor, intertrip, and transfer trip (7SD502★–★★★**1**★–★★).

If there is no infeed or only weak infeed from one line end, a trip signal might not be initiated in the event of a short-circuit. In this case an intertrip signal can be transmitted by the other end, after the short-circuit has been recognized there, to the end with only weak infeed. Thus, immediate disconnection at both ends of the line is ensured even for these cases.

A received intertrip signal can initiate an alarm only (LED, or alarm relay or both), or give an additional trip command; depending on marshalling. Further details are given in Section 6.3.8.

```
1541█ INTERTRIP
OFF
```

```
ON
```

Intertrip send condition:

OFF intertrip send function is switched off

ON intertrip send signal is transmitted in case of trip by the differential protection

```
1542█ T-SEND-PRO
0.10◆ s
```

Prolongation of the intertrip send signal after the differential protection has dropped of
Smallest setting: **0.00** s
Largest setting: **60.00** s

6.3.5 Settings for pilot wire monitoring − address block 16

The pilot wires between the differential relays at the ends of the protected line form an essential part of the scheme. For this reason it is always recommended that the pilot wires be supervised by the pilot wire monitoring option. Model 7SD502★−★★★**1**★−★★ is equipped with this pilot wire monitor. A further precondition for this function is that, during configuration of the relay, address 7816 PILOT MON has been set to *EXIST* (refer to Section 5.4.2) and that the pilot wire monitor is switched *ON* under address 1601.

The pilot wire monitor operates with a pulsed code which is modulated on a voice frequency signal of 2000 Hz. The monitoring code is transmitted alternately by one relay to the other and vice versa. In order to ensure a defined start-up of this hand-shake operation, one of the relays must be declared as ”master” and the other as ”slave”. The ”master”−device will always start with the communication, the ”slave”−device responds. Address 1602 determines which relay operates as ”master” and which as ”slave”.

An interruption or short-circuit on the pilot wires may be annunciated only, or, additionally, the differential protection can be blocked (address 1603). When the pilot wires are interrupted, the differential protection cannot trip any more since no differential current can be present. If the pilot wires are short-circuited, a high through-fault current (external fault) may cause tripping. The overcurrent time protection, if it is set effective, will continue its operation even during pilot wire fault. Annunciation of pilot wire failure and blocking are delayed by T−PILOT (address 1604).

A certain reception level of the monitoring signal is necessary in order to ensure correct decoding of the received signal. This level is set under address 1605 LEVEL P.M. 100 % means that the full transmitted power is available, i.e. no attenuation on the pilots (pilot resistance equals 0). The reception level can be measured by the relay itself during commissioning (refer to Section 6.7.5). Setting should be 70 % of the measured reception level.

The pilot wire monitoring is not operational as long as a system fault is present or as long as an intertrip signal or a transfer trip signal is being transmitted.

```
1600 PILOT WIRE
MONITORING
```

Beginning of block ”Pilot wire monitoring”

```
1601 PILOT MON
OFF
```

```
ON
```

Pilot wire monitoring

OFF is switched off or

ON is switched on

```
1602 STATION
SLAVE
```

```
MASTER
```

Station identification for pilot wire communication

SLAVE device responds

MASTER device starts communication

```
1603 DIFF BLOCK
ON
```

```
OFF
```

Blocking of the differential protection during pilot wire failure

ON is switched on or

OFF is switched off

```
  1 6 0 4█ T - P I L O T
5   s
```

Time delay for the annunciation or blocking (if set) after pilot wire failure
Smallest setting: **2** s
Largest setting: **60** s

```
  1 6 0 5█ L E V E L   P . M .
2 0 . 0   %
```

Reception level of pilot wire monitoring
Smallest setting: **1.0** %
Largest setting: **100.0** %

6.3.6 Settings for the external local trip facility – address block 21

Any desired signal can be coupled into the processing of annunciations and trip commands via a binary input of the relay from an external protective or supervisory device. Like the internal trip signals, it can be delayed and annunciated, and/or routed to one or more of the trip relays.

A preconditions is that this function has been set to EXT. TRIP = *EXIST* under address 7821 during configuration of the device functions (refer Section 5.4.2). The function can be switched on and off under address 2101, or its trip command can be blocked.

```
  2 1 0 0█ E X T E R N A L
T R I P   F U N C T I O N
```

Beginning of block "External local trip function via binary input"

```
  2 1 0 1█ E X T . T R I P
O F F
```

```
O N
```

```
B L O C K   T R I P   R E L
```

External local trip facility via binary input, can be

ON switched on or

OFF switched off or

BLOCK TRIP REL trip relay is blocked but the function is operative

```
  2 1 0 2█ T - D E L A Y
0 . 0 3   s
```

Time delay for the external local trip facility
Smallest setting: **0.02** s
Largest setting: **60.00** s

```
  2 1 0 3█ T - R E S E T
0 . 2 0   s
```

Drop-off delay time for the external local trip facility
Smallest setting: **0.00** s
Largest setting: **60.00** s

6.3.7 Settings for the transfer trip facility − address block 22

Line differential protection relay 7SD502 comprises an integrated transfer trip function (model 7SD502⋆−⋆⋆⋆**1**⋆−⋆⋆ with pilot wire monitor, intertrip and transfer trip option). This can be used to trip the circuit breaker at the remote line end by a command from an external source, e.g. a breaker failure protection. The transfer trip command is entered to the relay via a binary input.

A precondition that this function has been set to TRANSF.TRIP = *EXIST* under address 7822 during configuration of the device functions (refer Section 5.4.2).

The parameters for processing of the received signal are set in address block 23 (refer to Section 6.3.8).

Do not confuse the transfer trip facility with the intertrip function which is integral part of the differential protection.

Transfer trip operates with the same voice frequency signal (2000 Hz) as pilot wire monitoring but with a different puls code. Transmission of a signal is possible for one direction at a certain time.

```
 2200█
TRANSFER TRIP
```

Beginning of block ”Transfer trip facility”

```
 2201█ TRIP SEND
OFF

ON
```

Transfer trip send signal, can be

OFF switched off or

ON switched on

```
 2202█ T-SEND-DEL
0.02 s
```

Send delay for transfer trip signal to the remote end
Smallest setting: **0.00** s
Largest setting: **60.00** s

```
 2202█ T-SEND-PRO
0.00 s
```

Send signal prolongation for transfer trip signal to the remote end
Smallest setting: **0.00** s
Largest setting: **60.00** s

6.3.8 Settings for the reaction on reception of a remote trip signal − address block 23

The device at the receiving end cannot distinguish between a received intertrip signal and a received transfer trip signal since the same carrier frequency and the same pulse code are used. The parameters concerning the reaction of the relay on reception of a remote signal are set in address block 23 regardless whether an intertrip or transfer trip signal is received. A precondition for operation on reception of a signal is that the relay is equipped with the transmission facility, i.e. model 7SD502⋆−⋆⋆⋆**1**⋆−⋆⋆ with pilot wire monitor, intertrip and transfer trip option and that the reception function has been set to TRIP RECV = *EXIST* under address 7823 during configuration of the device functions (refer Section 5.4.2).

For correct evaluation of the received signal it is imperative that the receiving level is set to the correct value (address 1605, refer to Section 6.3.5) even if the pilot wire monitoring feature is not used.

The reception circuit can be switched on or off under address 2301; additionally, the trip command can be blocked whilst the function remains operative.

```
  2 3 0 0█
T R I P   R E C E I V E R
```

Beginning of block ”Reaction on reception of a remote trip signal”

```
  2 3 0 1█  T R I P   R E C V
O F F
```

```
O N
```

```
B L O C K   T R I P   R E L
```

Trip receiver, can be

ON	switched on	or
OFF	switched off	or
BLOCK TRIP REL		trip relay is blocked but the function is operative

```
  2 3 0 2█  T − R E C V − D E L
0 . 0 0   s
```

Delay time after reception of the remote trip signal
Smallest setting: **0.00** s
Largest setting: **60.00** s

```
  2 3 0 2█  T − R E C V − P R O
0 . 0 2   s
```

Received signal prolongation after the received trip signal has disappeared
Smallest setting: **0.00** s
Largest setting: **60.00** s

6.3.9 Settings for back-up overcurrent time protection – address block 26

The back-up overcurrent time protection operates independent of the differential protection. A pre-condition is that the back-up protection has been configured under address 7826 as BACK–UP O/C = *EXIST* (refer Section 5.4.2).

The overcurrent time protection is even operative when the pilot wires are faulty.

The parameters of the back-up overcurrent time protection are set in block 26. The output current of the summation transformer is decisive since the relay cannot process the individual phase currents. This results in different sensitivity depending on the fault type with the same sensitivity factors as for the differential protection. All current values are based on the symmetrical three-phase currents with standard connection according to Figure 5.4.

At first, the high-set overcurrent stage I>> is set under addresses 2603 and 2604. This stage is always a definite time stage, independent on which characteristic is set for the overcurrent stage. It is referred to the rated line current as set under address 1101.

The overcurrent stage can be used as definite time overcurrent protection or inverse time overcurrent protection. This function mode can be selected in address 2611. For inverse time, a choice can be made between three tripping time characteristics defined in IEC 60255–3.

The pick-up value I> (address 2612 for definite time) or Ip (address 2614 for inverse time) must be set above the maximum expected (over)load current (approximately 1.2 times). It is referred to the rated line current as set under address 1101.

Together with the high-current stage I>>, a two-stage overcurrent time protection is achieved. The setting of the delay times must be in accordance with the grading plan of the galvanically interconnected system.

Generally, it must be noted that the set times for definite time stages are pure delay times which do not include the inherent operation time of the protection functions.

Display	Description
2600 BACK–UP OVERCURRENT TIME	Beginning of block "Back-up overcurrent time protection"
2601 BACKUP O/C OFF	Back-up overcurrent time protection, can be *OFF* switched off or
ON	*ON* switched on or
BLOCK TRIP REL	*BLOCK TRIP REL* trip relay is blocked but the protection is operative
2603 I>> 4.00 I/InLn	High–current pick-up threshold I>>, referred to the rated line current as set under address 1101. Smallest setting value: **0.10** $\cdot I_{N\ line}$ Largest setting value: **30.00** $\cdot I_{N\ line}$
2604 T–I>> 0.10 s	Time delay for the high-current stage I>> Smallest setting value: **0.00** s Largest setting value: **32.00** s and ∞ (no trip with I>> stage)
2611 CHARACT DEFINITE TIME	Characteristic of the overcurrent stage *DEFINITE TIME* characteristic
NORMAL INVERSE	*NORMAL INVERSE* time (type A acc. IEC 60255–3)
VERY INVERSE	*VERY INVERSE* time (type B acc. IEC 60255–3)
EXTREMELY INVERS	*EXTREMELY INVERSe* time (type C acc. IEC 60255–3)

```
 2612█ I>
2.00  I/InLn
```

Only for definite time protection:
Pick-up threshold I>, referred to the rated line current as set under address 1101
Smallest setting value: **0.10** · $I_{N\ line}$
Largest setting value: **30.00** · $I_{N\ line}$

```
 2613█ T-I>
0.30  s
```

Delay time for I> stage
Smallest setting value: **0.00** s
Largest setting value: **32.00** s
and ∞ (no trip with I> stage)

When setting to **inverse time** overcurrent protection, it must be considered that, according to IEC 60255−3, the protection picks up only when more than 1.1 times the set value is exceeded.

The time setting corresponds to 10 times the usual time multiplier TM, e.g.

T_P = 10 s means TM = 1, thus for normal inverse
t_{trip} = 10 s tripping time at 2 times set value I_p

With the definite time characteristic the fundamental waves of the measured currents are evaluated for pick-up. When one of the **inverse time** characteristics is selected, a choice can be made whether the fundamental waves *WITHOUT HARMONIC*s of the measured currents are formed for evaluation, or if the true r.m.s. values *WITH HARMONICS* are calculated. As the relay is used as short-circuit protection, the preset value is recommended. If the time grading is to be coordinated with conventional relays which operate with true r.m.s. values, then *WITH HARMONICS* can be advantageous.

```
 2614█ Ip
2.00  I/InLn
```

Only for inverse time protection:
Pick-up threshold Ip, referred to the rated line current as set under address 1101
Smallest setting value: **0.10** · $I_{N\ line}$
Largest setting value: **20.00** · $I_{N\ line}$

```
 2615█ T-Ip
0.50  s
```

Time multiplier
Smallest setting value: **0.50** s
Largest setting value: **32.00** s

```
 2616█ RMS FORMAT
WITHOUT HARMON.
```

Only for inverse time protection:

The fundamental waves of the measured currents are evaluated by a Fourier filter

```
WITH HARMONICS
```

The true r.m.s. values of the measured currents are evaluated (only for inverse time characteristics)

Address 2621 determines which stage is effective if the circuit breaker is manually closed. A pre-requisite is, that the manual close command for the breaker is repeated via a binary input to the relay so that it is informed about manual closing of the breaker. *INEFFECTIVE* means that the stages operate according to the settings in addresses 2602 to 2615.

```
 2621█ MAN.CLOSE
INEFFECTIVE
```

Overcurrent stage which is effective during manual closing of the circuit breaker:
INEFFECTIVE, i.e. stages operate as parameterized

```
I>> UNDELAYED
```

I>> i.e. I>> stage but without delay TI>>

```
I>/Ip UNDELAYED
```

I>/Ip i.e. I> stage (definite time) or I_p stage (inverse time) but without delay

6.3.10 Settings for thermal overload protection – address block 27

The relay includes a thermal overload protection function. 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. An overcurrent time protection as back-up 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 line differential protection relay 7SD502 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 parameters of the thermal overload protection are set in address block 27. The output current of the summation transformer is decisive since the relay cannot process the individual phase currents. Overloads are, generally, three-phase symmetrical occurrences; the current values are based on the symmetrical current with standard connection according to Figure 5.4.

The thermal overload protection can be set to be inoperative, to initiate alarms only or to initiate tripping (including alarm). Additionally, the trip command can be blocked whilst the overload protection function remains operative (address 2701).

The rated current of the line as parameterized in address 1101 (refer to Section 6.3.3) 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 of the line:

$$k = \frac{I_{max}}{I_{N\,line}}$$

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. by 0.5 in case of an 0.5 s current:

$$\text{Setting value } \tau \text{ [min]} = \frac{\mathbf{0.5}}{60} \cdot \left(\frac{\text{permissible } \mathbf{0.5} \text{ s current}}{\text{continuously permissible current}} \right)^2$$

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

⇧⇩ 2700 THERMAL OVERLOAD PROT.	Beginning of block ”Thermal overload protection”

```
2701 THERMAL OL
OFF
```
```
ON
```
```
ALARM ONLY
```
```
BLOCK TRIP REL
```

Thermal overload protection, can be

ON	switched on	or
OFF	switched off	or
ALARM ONLY	set to give only alarms or	
BLOCK TRIP REL	trip relay is blocked but the protection is operative	

```
2702 K-FACTOR
1.10
```

Setting value of k−factor = $I_{max}/I_{N\ line}$

Smallest setting: **0.10**

Largest setting: **4.00**

```
2703 T-CONSTANT
100.0 min
```

Time constant τ

Smallest setting: **1.0** min

Largest setting: **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.

A further current warning stage is available (address 2705). This can be set as a factor of the rated line 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 setting $\Theta_{warn}/\Theta_{trip}$ to 100 %, the temperature warning is practically ineffective.

```
2704 Θ warn
90 %
```

Warning temperature rise in % of trip temperature rise $\Theta_{warn}/\Theta_{trip}$

Smallest setting: **50** %

Largest setting: **100** %

```
2705 I warn
1.00 I/InLn
```

Current warning stage; set as a multiple of $I_{N\ line}$

Smallest setting: **0.10** $\cdot I_{N\ line}$

Largest setting: **4.00** $\cdot I_{N\ line}$

6.3.11 Settings for measured value monitoring − address block 29

The different monitoring functions of the protective relay are described in Section 4.8.4. They partly monitor the relay itself, partly the steady-state measured values of the transformer circuits.

The sensitivity of the measured values monitoring can be changed in block 29. The factory settings are sufficient in most cases.

The three measured current I_1, I_a, and I_b lead to a node which is formed outside the module. The current sum monitor calculates the digitized sum of the outputs of these which must always be zero. When test currents are injected into one or more of these current inputs, then the summation condition may not be fulfilled during those tests. The relay would output an alarm and block the differential protection in this case. In order to allow those tests, possibility is given to switch the current sum monitor off (address 2901).

```
 2900█ MEAS.VALUE
SUPERVISION
```

Beginning of block
"Measured value supervision"

```
 2901█ M.V.SUPERV
ON
```

```
OFF
```

Measured value supervision, can be

ON switched on or

OFF switched off (for testing)

```
 2905█ SUM.Ithres
0.10  I/In
```

Current threshold above which the summation monitoring (refer Figure 4.18) reacts (absolute content, referred to I_N of the device only)

Smallest setting value: **0.05**

Largest setting value: **2.00**

```
 2906█ SUM.Fact.I
0.10
```

Relative content (referred to the maximum of the three currents) for operation of the current summation monitoring (refer Figure 4.18)

Smallest setting value: **0.00**

Largest setting value: **0.95**

6.4 Annunciations

6.4.1 Introduction

After a network fault, annunciations and messages provide a survey of important fault data and the function of the relay, and serve for checking sequences of functional steps during testing and commissioning. Further, they provide information about the condition of measured data and the relay itself during normal operation.

To read out recorded annunciations, no codeword input is necessary.

The annunciations generated in the relay are presented in various ways:

– LED indications in the front plate of the relay (Figure 6.1),

– Binary outputs (output relays) via the connections of the relay,

– Indications in the display on the front plate or on the screen of a personal computer, via the operating interface,

– Transmission via the system interface to local or remote control facilities (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 had been entered in address block 72 (see Section 5.3.3).

The annunciations are arranged as follows:

Block 51 Operational annunciations; these are messages which can appear during the operation of the relay: information about condition of relay functions, measurement data etc.

Block 52 Event annunciations for the last fault; pick-up, trip, expired times, or similar. As defined, a network fault begins with pick-up of any fault detector and ends after drop-off of the last fault detection.

Block 53 Event annunciations for the previous network fault, as block 52.

Block 54 Event annunciations for the last but two network fault, as block 52.

Block 56 Annunciations for CB operation statistics, that is counters for tripping commands, together with accumulated short circuit currents.

Block 57 Indication of operational measured values (currents, differential current).

Block 59 Indication of values of thermal overload protection.

```
⇑ 5 0 0 0
⇓ A N N U N C I A T I O N S
```

Commencement of ”annunciation blocks”

A comprehensive list of the possible annunciations and output functions with the associated function number FNo is given in Appendix C. It is also indicated to which device each annunciation can be routed.

6.4.2 Operational annunciations – address block 51

Operational and status annunciations contain information which the unit provides during operation and about the operation. They begin at address 5100. Important events and status changes are chronologically listed, starting with the most recent message. Time information is shown in hours and minutes. Up to 50 operational indications can be stored. If more occur, the oldest are erased in sequence.

Faults in the network are only indicated as ”`System Flt`” together with the sequence number of the fault. Detailed information about the history of the fault is contained in blocks ”Fault annunciations”, refer to Section 6.4.3.

The input of the codeword is not required.

After selection of the address 5100 (by direct selection with **DA 5 1 0 0 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.

Next to the boxes below, the abbreviated forms are explained. It is indicated whether an event is announced on occurrence (**C** = ”**C**oming”) or a status is announced ”**C**oming” and ”**G**oing” (**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.

Display	Explanation
⇑⇓ `5100█ OPERATIONAL ANNUNCIATIONS`	Beginning of the block ”Operational annunciations”
↑↓ `12.01.95 23:46` / `Pilot w. fail: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:

Display	Explanation
`>Time Synchro`	Synchronize internal real time clock (C)
`>Start FltRec`	Fault recording started via binary input (C)
`>Annunc. 1`	User defined annunciation No 1 received via binary input (C/G)
`>Annunc. 2`	User defined annunciation No 2 received via binary input (C/G)
`>Annunc. 3`	User defined annunciation No 3 received via binary input (C/G)
`>Annunc. 4`	User defined annunciation No 4 received via binary input (C/G)
`>I>> block`	I>> stage of back-up overcurrent time protection is blocked from an external device (C/G)
`>I>/Ip block`	I> or I_p stage of back-up overcurrent time protection is blocked from an external device (C/G)

General operational annunciations of the protection device:

Dev.operative	Protection device is operative (C/G)
Initial start	Initial start of the processor system (e.g. after switching on the auxiliary voltage) (C)
LED reset	Stored LED indications reset (C)
Param.running	Parameters are being set (C/G)
Param. Set A	Parameter set A is active (C/G)
Param. Set B	Parameter set B is active (C/G)
Param. Set C	Parameter set C is active (C/G)
Param. Set D	Parameter set D is active (C/G)
System Flt	Network system fault with consecutive number (C/G), detailed information in the fault annunciations
Flt.Rec.viaBI	Fault recording started via binary input (C)
Flt.Rec.viaKB	Fault recording started via front keyboard (C)
Flt.Rec.viaPC	Fault recording started via operating (PC) interface (C)
Flt.RecDatDel	Fault recording data deleted (C)
Manual Close	Manual close command registered (impulse) (C)

Annunciations of monitoring functions:

Wrong SW-vers	Wrong software version (C)
Wrong dev. ID	Wrong device identification number (C)
Annunc. lost	Annunciations lost (buffer overflow) (C)
Annu. PC lost	Annunciations for operating (PC) interface lost (C)
Oper.Ann.Inva	Operational annunciations invalid (C/G)
Flt.Ann.Inval	Fault annunciations invalid (C/G)
Stat.Buff.Inv	Buffer for operation statistics invalid (C/G)

LED Buff.Inva	Buffer for stored LEDs invalid (C/G)
VDEW–StateInv	State of VDEW/ZVEI compatible annunciations (IEC 60870–5–103) at the system interface invalid (C/G)
Chs Error	Check-sum error detected (C/G)
Chs A Error	Check-sum error detected for parameter set A: no operation possible with this set (C/G)
Chs B Error	Check-sum error detected for parameter Set B: no operation possible with this set (C/G)
Chs C Error	Check-sum error detected for parameter set C: no operation possible with this set (C/G)
Chs D Error	Check-sum error detected for parameter set D: no operation possible with this set (C/G)
Failure 18V	Failure in internal supply voltage 18 V (C/G)
Failure 15V	Failure in internal supply voltage 15 V (C/G)
Failure 5V	Failure in internal supply voltage 5 V (C/G)
Failure 0V	Failure in offset voltage 0 V (C/G)
Failure I/O	Failure in trip relay circuit on base input/output p.c.b. (C/G)
Failure I/O 1	Failure on voice frequency p.c.b. for pilot-wire supervision, intertrip and transfer trip (7SD502★– ★★★**1**★ only) (C/G)
Failure RKA	Failure on output relay p.c.b. (C/G)
LSA disrupted	Serial system link to LSA disrupted (C/G)
Failure Σ I	Failure detected by current plausibility monitor Σ I (C/G)

Operational annunciations of differential protection:

Diff off	Differential protection is switched off (C/G)
Diff blocked	Differential protection is blocked (C/G)
Diff active	Differential protection is active (C/G)
dir.Dif>Trip	Direct command of differential protection without local current release (C/G)

Annunciations of pilot wire monitoring:

`P.W.M. off`	Pilot wire monitoring is switched off (C/G)
`P.W.M. block`	Pilot wire monitoring is blocked (C/G)
`Pilot w. fail`	Pilot wire failure (C/G)
`Block to 3end`	Differential protection blocks pilot wire monitoring of adjacent relay (for three-terminal lines) (C/G)

Operational annunciations of external local trip and transfer trip:

`Ext off`	External local trip function is switched off (C/G)
`Ext blocked`	External local trip function is blocked (C/G)
`Ext active`	External local trip function is active (C/G)
`TransTrip off`	External transfer trip function is switched off (C/G)
`TransTrip blo`	External transfer trip function is blocked (C/G)
`TrTrip Send`	External transfer trip signal transmitted (C/G)
`Receiver off`	Receiver circuit is switched off (C/G)
`Receive block`	Receiver circuit is blocked (C/G)
`Recv. active`	Receiver circuit is active (C/G)
`Receive recv.`	Receive signal received (C/G)

Operational annunciations of back-up overcurrent time protection:

`>I>> block`	I>> stage of back-up overcurrent time protection is blocked from an external device (C/G)
`>I>/Ip block`	I> or I_p stage of back-up overcurrent time protection is blocked from an external device (C/G)
`Backup off`	Back-up overcurrent time protection is switched off (C/G)
`Backup block`	Back-up overcurrent time protection is blocked (C/G)
`Backup active`	Back-up overcurrent time protection is active (C/G)

Operational annunciations of thermal overload protection:

`O/L Prot. off`	Thermal overload protection is switched off (C/G)
`O/L blocked`	Thermal overload protection is blocked (C/G)
`O/L active`	Thermal overload protection is active (C/G)
`O/L Warn I`	Thermal overload protection current warning stage picked up (C/G)
`O/L Warn Θ`	Thermal overload protection thermal warning stage picked up (C/G)
`O/L pickup Θ`	Thermal overload protection thermal trip stage picked up (C/G)

Annunciations of the circuit breaker test function:

`CB in Test`	Internal circuit breaker test in progress (C/G)
`CB Test 3pol`	Trip three-pole by internal circuit breaker test function (C)

Further messages:

`Table overflow`	If more messages have been received the last valid message is `Table overflow`.
`End of table`	If not all memory places are used the last message is `End of table`.

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 5 2 0 0 E** or by paging with the keys ⇑ or ⇓ . With the keys ↑ or ↓ one can page the individual annunciations forwards or backwards. Each annunciation is assigned with a sequence item number.

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.

```
5200█ LAST
FAULT
```

Beginning of the block "Fault annunciations of the last system fault"

```
001█ 12.01.95
System  Flt  9
```

under item 1, the date of the system fault is indicated, in the second line the consecutive number of the system fault

```
002█ 17:14:52.269
Fault          :C
```

under item 2, the time of the beginning of the fault is given; time resolution is 1 ms

```
003█ 0  ms
Diff  Gen. Flt: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.

```
004█ 0  ms
Diff>  Trip    :C
```

```
005█ 185  ms
Dev.  Drop-off:C
```

etc.

General fault annunciations of the device:

`Flt.Buff.Over`	Buffer for fault annunciations overflow
`System Flt`	System fault with consecutive number
`Fault`	Beginning of fault
`I/In =`	Interrupted fault current; the mixed current is measured, which depends on fault type and connection mode
`Dev. Drop-off`	Drop-off of the device, general

Fault annunciations of differential protection:

`Diff Gen. Flt`	Fault detection of differential protection
`Diff> T start`	Delay time of differential protection started (when a delay is set)
`Block saturat`	Differential protection blocked by current transformer saturation indicator
`Block Harm`	Differential protection blocked by excessive current harmonic content
`Diff> Trip`	Trip by differential protection
`Diff Intertr.`	Intertrip signal of differential protection transmitted

Fault annunciation of external local trip and transfer trip:

`Ext Gen.Fault`	General fault detection signal of external local trip function
`Ext Gen.Trip`	General trip by external local trip function
`Recv. Gen.Flt`	General fault detection signal of received remote trip signal
`Receiver Trip`	Trip by received remote trip signal

Fault annunciations of back-up overcurrent time protection:

`Back Gen. Flt`	General fault detection of back-up overcurrent time protection
`Backup I>>`	Pick-up of high current stage I>> of back-up overcurrent time protection
`Backup I>/Ip`	Pick-up of overcurrent stage I> (definite time) or Ip (inverse time) stage of overcurrent time protection

`Backup TI>>`	Time delay for high current stage I>> of back-up overcurrent protection expired
`Backup TI>/Tp`	Time delay for overcurrent stage I> (definite) or Ip (inverse) of back-up overcurrent protection expired
`Back Gen.Trip`	General trip by back-up overcurrent time protection

Fault annunciations of thermal overload protection:

`O/L Trip`	Trip by thermal overload protection

Further messages:

`Table empty`	means that no fault event has been recorded
`Table overflow`	means that other fault data have occurred, however, memory is full
`Table superceded`	a new fault event has occurred during read-out: page on with ↑ or ↓; the display shows the first annunciation in the actualized order
`End of table`	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.

⇧⇩ `5300 2nd TO LAST FAULT`	Beginning of the block "Fault annunciations of the second to last system fault"
etc.	

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.

⇧⇩ `5400 3rd TO LAST FAULT`	Beginning of the block "Fault annunciations of the third to last system fault"
etc.	

6.4.4 Circuit breaker operation statistics − address block 56

The number of trip commands initiated by 7SD502 is counted. Additionally, the interrupted currents are stated 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 under address block 56. The address can be reached by direct addressing **DA 5 6 0 0 E** or by paging with the keys ⇑ or ⇓ until address 5600 is reached. The counters can be called up using the key ↑ for forwards paging or ↓ for backwards paging.

Entry of the codeword is not required for read-off of counter states.

```
5600█ CB OPERAT
STATISTICS
```

Beginning of the block ”Circuit breaker operation statistics”

```
5601█ TRIP No=
```

Number of trip commands issued by the relay

Page on with key ↑ to get further counter states

```
5602█ ΣI/In=
```

Accumulated interrupted currents; the mixed currents are measured, which depend on fault type and connection mode

---

The maximum values of the counters are:

− *Trip No*	9 digits
− *ΣI/In*	7 digits plus 1 decimal digit

The counters can be reset to 0 in block 82 (see Section 6.5.2).

6.4.5 Read-out of operational measured values – address blocks 57 and 59

The steady state r.m.s. operating values can be read out at any time under the address block 57. The address can be called up directly using **DA 5 7 0 0 E** or by paging with ⇑ or ⇓. The individual measured values can be found by further paging with ↑ or ↓. 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 have been entered to the device under address block 11 as described in Section 6.3.3.

In the following example, some example values have been inserted. In practice the actual values appear.

Address block 59 shows further operational values: the calculated values of the overload protection.

```
⇑  5700█ OPERATIONAL
⇓  MEASURED  VALUES
```

Beginning of the block "Operational measured values"

Use ↑ key to move to the next address with the next measured value.

```
↑  5701█ MEAS.VALUE
↓  I1[%]=  81  %
```

Page on with the ↑ key to read off the next address with the next measured value, or page back with ↓; the indeces 1, 2, and 3 indicate the side of the protected object

```
↑  5702█ MEAS.VALUE
↓  I2[%]=  82  %
```

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**.

The percentage is referred to rated relay current

```
↑  5703█ MEAS.VALUE
↓  I3[%]=  0  %
```

Address 5703 is relevant only for three-terminal lines

```
↑  5704█ MEAS.VALUE
↓  ID[%]=  1  %
```

Differential current I_{diff}

```
↑  5705█ MEAS.VALUE
↓  IR[%]=  163  %
```

Restraining (stabilizing) current I_{stab}

```
5711█ MEAS.VALUE
I1=  486  A
```

The primary values (addresses 5711 to 5715) are referred to the primary rated c.t. current

```
5712█ MEAS.VALUE
I2=  491  A
```

```
5713█ MEAS.VALUE
I3=  0  A
```

Address 5713 is relevant only for three-terminal lines

```
5714█ MEAS.VALUE
ID=  5  A
```

Differential current I_{diff}

```
5715█ MEAS.VALUE
IR=  977  A
```

Restraining (stabilizing) current I_{stab}

```
5901█ MEAS.VALUE
Θ/Θtrip  =  54  %
```

The percentage is referred to the trip temperature rise

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. 7SD502 comprises facilities, e.g. to re-adjust the real time clock, to erase stored informations and event counters, or to change over preselected sets of function parameters. The scope of operational control facilities depends on the scope of functions of the device.

The functions can be controlled from the operating panel on the front of the device, via the operating interface in the front as well as via binary inputs.

In order to control functions via binary inputs it is necessary that the binary inputs have been marshalled to the corresponding switching functions during installation of the device and that they have been connected (refer Section 5.5.2 Marshalling of the binary inputs).

The control facilities begin with address block 8000. This address is reached

– by block paging with the keys ⇑ forwards or ⇓ backwards up to address 8000, or
– by direct selection with address code, using key **DA**, address **8 0 0 0** and execute with key **E.**

```
⇑ 8000█ DEVICE
⇓ CONTROL
```

Beginning of the block "Device control"

6.5.1 Adjusting and synchronizing the real time clock – address block 81

The date and time can be adjusted at any time during operation as long as the real time clock is operative. Setting is carried out in block 81 which is reached by direct addressing **DA 8 1 0 0 E** or by paging with ⇑ and ⇓. Input of the codeword is required to change the data.

Selection of the individual addresses is by further scrolling using ↑ ↓ as shown below. Each modification must be confirmed with the enter key **E**.

```
⇑ 8100█ SETTING
⇓ REAL TIME CLOCK
```

Beginning of the block "Setting the real time clock". Continue with ↑.

```
↑ 12.01.1995
↓ 15:54:42
```

At first, the actual date and time are displayed. Continue with ↑.

```
↑ 8102█ DATE
↓
```

Enter the new date: 2 digits for day, 2 digits for month and 4 digits for year (including century); use the order as configured under address 7102 (Section 5.3.2), but always use a dot for separator:
DD.MM.YYYY or **MM.DD.YYYY**

```
↑ 8103█ TIME
↓
```

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

```
↑ 8104█ DIFF. TIME
↓
```

Using the difference time, the clock is set forwards by the entered time, or backwards using the +/– key. The format is the same as with the time setting above.

6.5.2 Erasing stored annunciations and counters – address block 82

The statistical indications (Section 6.4.4, address 5600) 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 ⇑ or ⇓ 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 ↑ ↓. 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.

```
8200
RESET
```

Beginning of block "Reset"

```
8201 RESET
LED  ?
```

Request whether the LED memories should be reset

```
8202 RESET
OPERAT.ANNUNC.  ?
```

Request whether the operational annunciation buffer store should be erased

```
8203 RESET
FAULT ANNUNC. ?
```

Request whether the fault annunciation buffer and fault recording stores should be erased

```
8204 RESET
COUNTERS  ?
```

Request whether the CB operation counters should be set to zero

```
8205 RESET
TOTAL Isc  ?
```

Request whether the total of switched short-circuit currents should be set to zero

During erasure of the stores (which may take some time) the display shows TASK IN PROGRESS. After erasure the relay acknowledges erasure, e.g.

```
8202 RESET
SUCCESSFUL
```

6.5.3 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.

Entry of the codeword is necessary for this (refer to Section 5.3.1).

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.

In order to accomplish this switch-over, address block 83 is available provided the VDEW/ZVEI protocol (acc. IEC 60870−5−103) has been chosen during configuration of the serial system interface (Section 5.3.3, address 7221 and/or 7222 *VDEW COMPATIBLE* or *VDEW EXTENDED*). The block is called up by paging with the keys ⇑ or ⇓ or directly by keying in the code **DA 8 3 0 0 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 **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.

```
⇑  8300█ SYS-VDEW
⇓  ANNUNC.-MEAS.VAL
```

Beginning of block "Annunciations and measured values for the system interface with VDEW/ZVEI compatible protocol (IEC 60870−5−103)"

```
↑  8301█ SYS  TEST
↓  OFF

   ON
```

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"

Do not forget to switch address 8301 back to SYS−TEST = *OFF* **after having finished test operations!**

6.5.4 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.

6.5.4.1 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 ⇑ or ⇓. 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 set 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**.

6.5.4.2 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 ⇑ or ⇓. The heading of the block will appear:

Display	Explanation
⇑ 8500█ PARAMETER ⇓ CHANGE-OVER	Beginning of the block "Parameter change-over": processing of parameter sets

It is possible to scroll through the individual addresses using the ↑ key or to scroll backwards with ↓.

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 ↑ 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 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 **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.

```
8501 ACTIV PARAM
SET A
```

Address 8501 shows the actually active parameter set

```
8503 ACTIVATING
SET A
```

```
SET B
```

```
SET C
```

```
SET D
```

```
SET BY BIN.INPUT
```

```
SET BY LSA CONTR
```

Use the "No"−key **N** to page through the alternative possibilities. The desired possibility is selected by pressing the enter key **E**.

If you select *SET BY BIN.INPUT*, then the parameter set can be changed-over via binary inputs (see Section 6.5.4.3).

If you select *SET BY LSA CONTR*, then the parameter set can be selected via the system interface using the VDEW/ZVEI protocol (IEC 60870−5−103)

6.5.4.3 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 6.5.4.2).
- 2 logical binary inputs are available for control of the 4 parameter sets. These binary inputs are designated ">ParamSelec.1" (FNo 7) and ">ParamSelec.2" (FNo 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 6.3. Of course, the binary inputs must be declared in normally open ("NO") mode.

Binary input >ParamSelec.1	Binary input >ParamSelec.2	causes active set
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

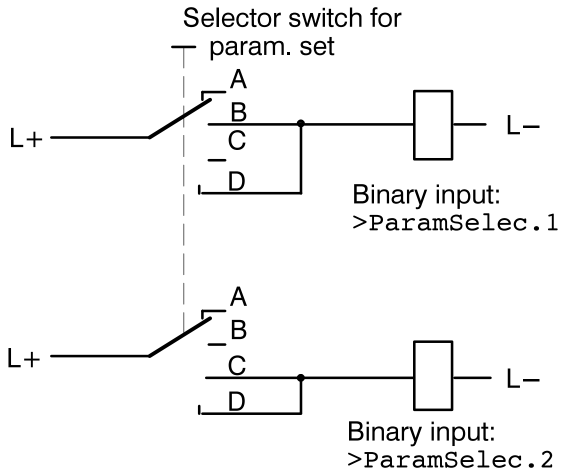


Figure 6.3 Connection scheme for parameter change-over via binary inputs

6.6 Testing and commissioning

6.6.1 General

Prerequisite for commissioning is the completion of the preparation procedures detailed in Chapter 5.

Warning

Hazardous voltages are present in this electrical equipment during operation. Non-observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

Particular attention must be drawn to the following:

- The earthing screw of the device must be connected solidly to the protective earth conductor before any other connection is made.
- Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- The limit values given in the Technical data (Section 3.1) must not be exceeded at all, not even during testing and commissioning.

When testing the unit with a secondary injection test set, it must be ensured that no other measured values are connected and that the tripping leads to the circuit breaker trip coils have been interrupted.

DANGER!

Secondary connections of the current transformers must be short-circuited before the current leads to the relay are interrupted!
If a test switch is installed which automatically short-circuits the current transformer secondary leads, it is sufficient to set this switch to the ”Test” position. The short-circuit switch must be checked beforehand (refer to Section 5.2.7).

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 single-phase current source is sufficient.

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 input (see connection diagrams, Appendix A). If the reset functions have been tested, resetting the stored indications is no more necessary as they are erased automatically with each new pick-up of the relay and replaced by the new annunciations.

6.6.2 Testing the differential protection

For testing the differential protection, this function must have been parameterized as operative, i.e. DIFF PROT = *ON* or DIFF PROT = *BLOCK TRIP REL* under address 1501. The pilot wire monitoring is switched off (address 1601 PILOT MON = *OFF*).

When testing an individual unit, the pilot wires terminals can be short-circuited.

When testing two units, the pilot wires are connected crosswise between the relay pair. Both units must be connected to the auxiliary voltage. In this case the second unit can run without a test current (thus simulating a line short-circuit with single-ended infeed) or the test current is injected into both units either in phase (internal short-circuit) or in phase opposition (external short-circuit).

The following description refers to testing an individual unit with the pilot wire terminals connected to each other via a resistor of approx. 470 Ω. It is, further, assumed that the parameters concerning the pilot wire characteristics have been left in the position as delivered, i.e. resistance Rx = 0 Ω (address 1131) and capacitance Cx = 0 nF (address 1133). In case the relay is configured for three-terminal lines, then additionally address 1132 Ry = 0 Ω and 1134 Cy = 0 nF.

When assessing the currents it must be considered that the current which is evaluated by the relay depends on the connection mode of the input windings of the summation transformer as well as on the setting parameters 1101 and 1102 (refer to Section 6.3.3). Additionally, all test currents must be sinusoidal injected currents.

The following applies:

$$I_P = I_M \cdot N_{MT} \cdot N_{par}$$

where

I_P – test current,

I_M – mixed current as it is evaluated by the relay

N_{MT} – factor caused by the mode of connection of the summation (mixing) transformer

N_{par} – factor caused by parameter setting

N_{MT} equals 1 for injection of three-phase symmetrical currents and standard connection according to Figure 5.4; when the relay is delivered, N_{par} equals 1 either.

The factors N_{MT} according to Table 6.3 are valid for single-phase injected currents, dependent of the fed windings of the summation transformer.

Winding (weighting)	Connection surface mounting	Connection flush mounting	N_{MT}
1	Tml. 3 – 4	1F1 – 1F2	1,73
2	Tml. 1 – 2	2F1 – 2F2	0,87
3	Tml. 5 – 6	2E1 – 2E2	0,58
6 (all in series)	Tml. 1 – 6 2–3, 4–5 bridged	2F1 – 2E2 2F2–1F1 1F2–2E1 bridged	0,29

Table 6.3 Current factors of summation transformer

The parameter factor can be derived from:

$$N_{par} = \frac{I_{N\,line}}{I_{N\,c.t.}}$$

where

$I_{N\,line}$ – the primary rated current of the line, as set under address 1101,

$I_{N\,c.t.}$ – the primary rated current of the main c.t.s, as set under address 1102

⚠ **Caution!**

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

The limits of the thermal capability must be observed for the input windings of the summation transformer as well as for its output current. When, during single-phase current test, the weighting factor is higher than 1, the permissible current is reduced by the factor N_{MT} (Table 6.3); but the permissible current is not increased when only one winding weighting is used!

Feed a test current I_P = 1.2 times the setting value I DIFF> (address 1503) and 1.2 times the setting value I1 RELEASE (address 1523); both parameter values must be exceeded. The differential protection picks up (LED 2 at delivery) and trips (LED 1 at delivery). Check that the associated tripping and signalling contacts close.

If a trip delay has been set (address 1525) then the trip signal appears correspondingly delayed.

6.6.3 Testing the back-up overcurrent time protection

For testing the back-up overcurrent time protection address 7826 BACK−UP O/C must be switched to *EXIST*. Additionally, this function must be switched effective, i.e. address 2601 BACK−UP O/C = *ON* or *BLOCK TRIP REL*, the latter means that no trip command is given to any trip relay.

6.6.3.1 Testing the high-set overcurrent stage I>>

Testing can be performed with single-phase, two-phase or three-phase test current. When assessing the currents it must be considered that the current which is evaluated by the relay depends on the connection mode of the input windings of the summation transformer as well as on the setting parameters 1101 and 1102. The same factors are valid as for testing the differential protection (refer to Section 6.6.2, Table 6.3 and the assigned formulae).

⚠ **Caution!**

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

The limits of the thermal capability must be observed for the input windings of the summation transformer as well as for its output current. Refer also to Section 6.6.2.

For testing the I>> stages, therefore, measurement shall be performed dynamically. It should be stated that the relay picks up at 1.1 times setting value and does not at 0.9 times setting value.

When the test current is injected, the pick-up indication appears (LED 3 at delivery and annunciation ”`Backup I>>`”). After expiry of the time delay, trip signal is given (LED 1 at delivery and annunciation ”`Back Gen.Trip`”). If the protection is switched *ON*, then the assigned trip contacts close.

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

6.6.3.2 Testing the definite time overcurrent stage I>

For this test the *DEFINITE TIME* mode must be selected in addresses 2611.

The current factors are to be considered.

When the set value for I> (address 2612) is exceeded, the pick-up indication ”`Backup I>/Ip`” appears (LED 4 at delivery).

After expiry of the time delay (address 2613 T−I>), trip signal is given (LED 1 at delivery and annunciation ”`Back Gen.Trip`”). If the protection is switched *ON*, then the assigned trip contacts close.

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

6.6.3.3 Testing the inverse time overcurrent stage I_p

For these tests, one of the *INVERSE* time modes must be selected in addresses 2611.

The current factors are to be considered.

⚠ **Caution!**

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

The limits of the thermal capability must be observed for the input windings of the summation transformer as well as for its output current. Refer also to Section 6.6.2.

When the test current is increased above 1.1 times the set value Ip (address 2614 Ip), pick-up indication appears (”`Backup I>/Ip`”, LED 4 at delivery).

The time delay depends on which characteristic has been selected in address 2611 and the set time multiplier in address 2615. The expected time delays can be calculated from the formulae given in the Technical data or read from the characteristic curves in Figure 3.3 (consider current factors!).

6.6.4 Testing the thermal overload protection function

The integrated overload protection can only be tested if it has been configured as THERMAL OL = *EXIST* (address 7827, refer Section 5.4.2) and parameterized as operative, i.e. it must be set under address 2701 THERMAL OL = *ON* or *BLOCK TRIP REL*. In the latter case the protection will operate, but no trip command is given to any trip relay.

The basis current for the detection of overload is the rated current of the line as parameterized under address 1101. Overload is a three-phase symmetrical occurrence, thus, the basis current is related to three-phase current conditions with standard connection of the summation transformer according to Figure 5.4.

When tests are performed with the standard connections or connections which form the same weighting factor, no further conditions are to be considered. During single-phase test it must be considered that the current which is evaluated by the relay depends on the connection mode of the summation transformer, besides on the rated line current:

$$I_P = I_M \cdot N_{MT} \cdot N_{par}$$

where

- I_P – test current,
- I_M – mixed current as it is evaluated by the relay
- N_{MT} – factor caused by the mode of connection of the summation (mixing) transformer
- N_{par} – factor caused by parameter setting

The factors N_{MT} and N_{par} are the same as defined and explained for testing of the differential protection (refer to Section 6.6.2, Table 6.3 and the associated formulae).

When applying a test current of

$$I_P = I_{N\ device} \cdot N_{MT} \cdot N_{par} \cdot k$$

tripping must not occur. After an appropriate time (approximately 5 x τ) a steady-state temperature rise according to the following relationship is established:

$$\frac{\Theta}{\Theta_{trip}} = \frac{1}{k^2}$$

This value can be read out in address block 59.

To check the time constant, the current input is simply subjected to 1.6 x the pick-up value, i. e. $1.6 \cdot I_{N\ device} \cdot N_{MT} \cdot N_{par} \cdot k$. 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 3.4). 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 x τ.

⚠ 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 x τ.

6.7 Commissioning using primary tests

All secondary testing sets and equipment must be removed. Reconnect current 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.)

Since the relay provides comprehensive measuring functions and commissioning aids, commissioning can be performed quickly and without use of external instruments. Ensure that the polarity switch in the front is situated in one of its end positions.

First, the line is still switched off and earthed at both sides.

The differential protection is switched to *BLOCK TRIP REL* (address 1501) or the trip commands to the circuit breakers are interrupted. The pilot wire monitor (if fitted) is switched *OFF* (address 1601), as are the external local trip facility (address 2101), the transfer trip function (address 2201), the receiver circuit of remote trip (address 2301, and the back-up overcurrent time protection (address 2601).

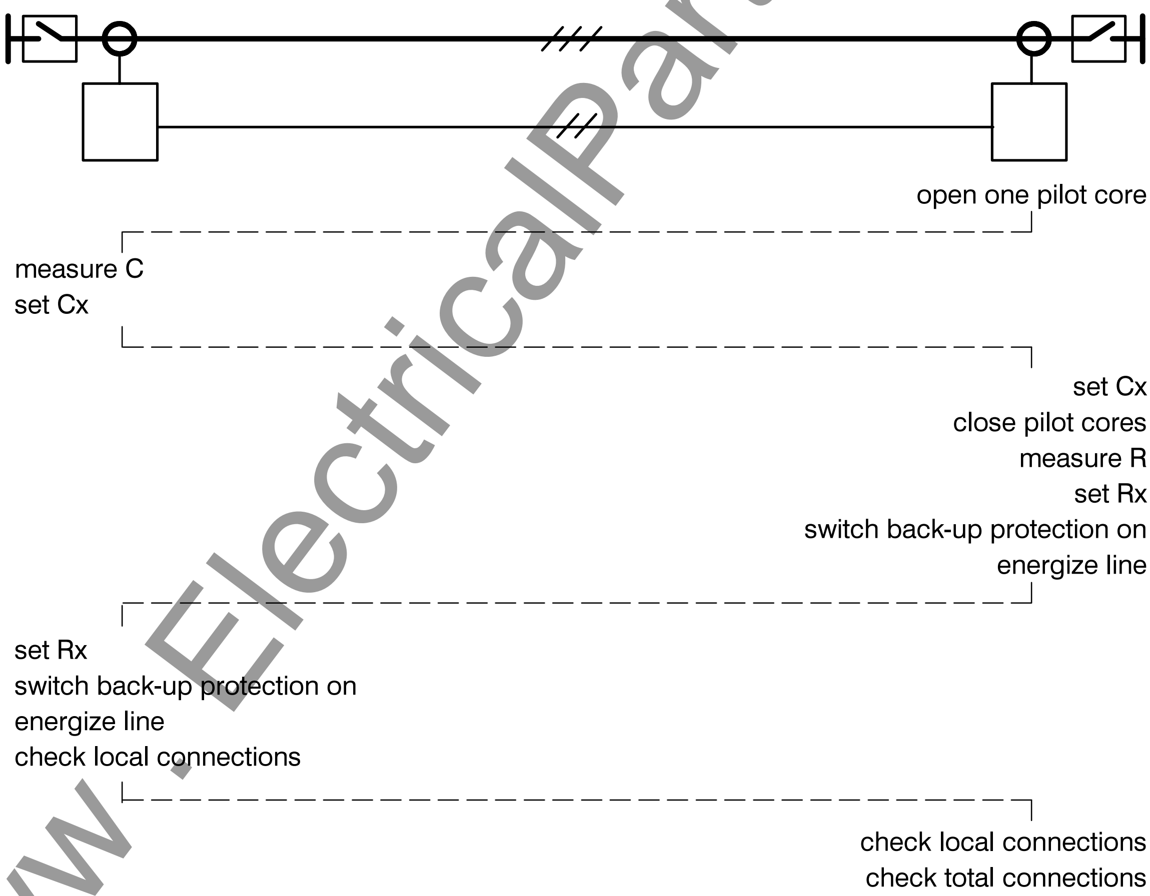


Figure 6.4 Commissioning scheme

Switching on of a particular function can be generally performed in two different ways. The setting addresses concerned are shown in the respective sections.

– *BLOCK TRIP REL*: The protection function is operative and outputs annunciations. However, the trip command is blocked and it is not transmitted to any trip relay even when assigned.

– Protection function *ON*: The protection function is operative and outputs annunciations. The trip command activates the trip relays which have been marshalled to the protection function according to Section 5.5.5. If the protection command is not marshalled to any trip relay, tripping does not occur.

Figure 6.4 shows a commissioning scheme for a line with two terminals. The individual steps are explained in the following sections. For three-terminal lines, each of the three connections must be checked according to the checking instructions.

6.7.1 Measuring and setting of the pilot wire capacitance

If the pilot wire capacitances exceed approximately 0.3 μF (corresponding to approximately 5 km or approximately 3 miles for usual protection cable), these capacitances must be compensated as they produce an additional differential current. Measuring of the capacitances is not recommended for shorter lengths since the result becomes inaccurate for smaller capacitance values.

The capacitances of the pilot wires can be calculated from the cable characteristics or even be measured by the relay itself.

The pilot wire pair must be connected to the relay which should carry out measurement; at the opposite end, the pilots must be isolated.

Measurement requires a current of at least 25 % of the rated relay current. It can be injected as a secondary current into the summation transformer. When assessing the current magnitude it must be considered that the current which is evaluated by the relay depends on the connection mode of the input windings of the summation transformer. The current must be kept constant during measurement.

Initiation of the test is made via operator keyboard or personal computer. It can be made from any line end. Tests are listed from address 4000, the commissioning measurements in address block 41. This is reached:

– directly with key **DA** followed by address number **4 1 0 0** and finally operation of the enter key **E** or

– by paging through the blocks with ⇑ or ⇓ until address 4100 is reached.

```
⇑ 4 0 0 0 █
⇓ T E S T S
```

Commencement of test blocks

```
⇑ 4 1 0 0 █
⇓ C O M M I S S I O N   T E S T
```

Block ”Commissioning tests”

Page on with key ↑.

```
4 1 0 1█ M E A S .   C x
T E S T   ?
```

After confirmation with the "Yes"–key **J/Y** the capacitance will be measured

Confirm with the "Yes"–key **J/Y**. The relay calculates the capacitance using the voltage drop across the shunt resistor R_b and the pilot current. The result is displayed immediately. But, if a system fault is detected no measurement can take place. A corresponding message is displayed.

```
4 1 0 1█ M E A S .   C x
C x   =   6 8 0   n F
```

The total capacitance of the pilot wires is displayed with a resolution of 1 nF; e.g. 680 nF

```
F L T .   I N   P R O G R E S S
```

A system fault is in progress

```
C U R R N T   T O O   S M A L L
```

The injected current is too small for evaluation

```
N O T   P O S S I B L E
```

measurement is not possible for different reason

```
A B O R T E D
```

measurement is aborted, e.g. because of occurrence of a system fault

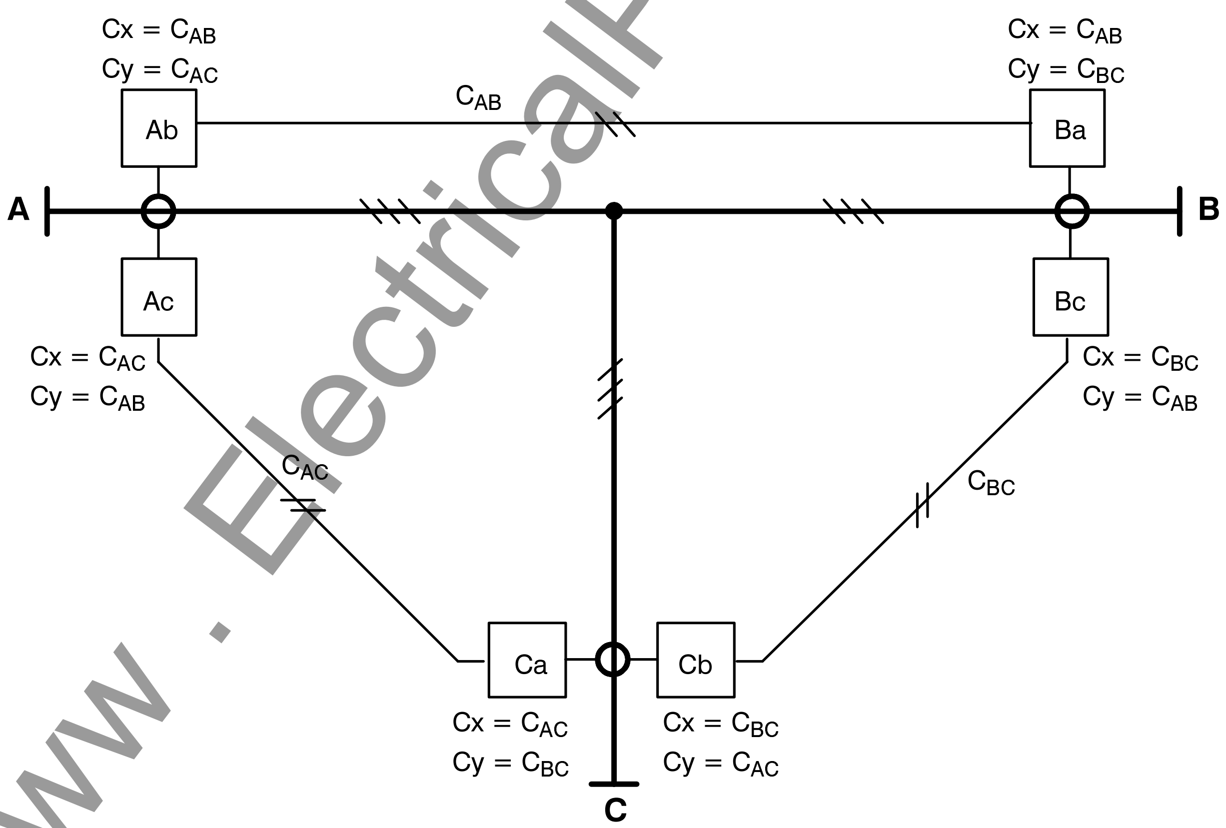


Figure 6.5 Identification scheme on three-terminal lines

Measurement is finished after the capacitance is displayed.

The pilot wire capacitance is then set under address 1133 Cx. The capacitance of the pilot wire monitor, if applicable, is automatically included in the displayed value, it need not be considered while setting Cx. Setting is equal at both line ends. It is sufficient to perform this measurement only from one line end.

The remaining of this sub-section is relevant only for three-terminal lines (teed lines). In this case, the pilot wire capacitances must be measured for both pilot wire pairs which are connected at a certain station. Cx (address 1133) is always the capacitance of the pilot wire pair which is connected immediately to the relay under consideration, i.e. with which the capacitance has been measured. Cy (address 1134) is the capacitance of the pilot wire pair which is connected to the adjacent relay (in the same station). Thus, for the adjacent relay, Cx and Cy are interchanged. The two opposite relays which are connected with the same pilot wire pair always get the same setting for Cx. Figure 6.5 illustrates this relation. The first (capital) letter of each relay in the figure indicates the station where the relay is built in, the second (small) letter indicates the opposite end station where the relay is connected.

6.7.2 Measuring and setting of the pilot wire resistance

The operation principle of the two-pilot-wire differential protection requires the adjustment of the ratio between the external pilot wire resistance R_x and the internal shunt resistance R_b. 7SD502 carries out the adjustment by internal calculation; thus, additional resistors are not necessary. For this, the protection must be informed about the pilot wire loop resistance (address 1131 Rx).

The loop resistance of the pilot wires can be calculated from the cable characteristics or even be measured by the relay itself.

The pilot wire pair must be connected to the relays at both line ends. Compensation of the pilot wire capacitance, if necessary, must have been set correctly beforehand (refer to Section 6.7.1).

Measurement requires a current of at least 2 times the rated relay current. It can be injected as a secondary current into the summation transformer. When assessing the current magnitude it must be considered that the current which is evaluated by the relay depends on the connection mode of the input windings of the summation transformer. The current must be kept constant during measurement.

Resistance measurement can be called up in address 4102:

```
4102 MEAS. Rx
TEST ?
```

After confirmation with the ”Yes”−key **J/Y** the resistance will be measured

Confirm with the ”Yes”−key **J/Y**. The relay calculates the resistance using the voltage drop across the shunt resister R_b and the pilot current. The result is displayed immediately. But, if a system fault is detected no measurement can take place. A corresponding message is displayed.

4102 MEAS. Rx Rx = 566 Ω	The total resistance of the pilot wire loop is displayed with a resolution of 1 Ω; e.g. 566 Ω
FLT. IN PROGRESS	A system fault is in progress
CURRNT TOO SMALL	The injected current is too small for evaluation
NOT POSSIBLE	measurement is not possible for different reason
ABORTED	measurement is aborted, e.g. because of occurrence of a system fault

Measurement is finished after the resistance is displayed.

The pilot wire loop resistance is then set under address 1131 Rx. The resistance of the pilot wire monitor, if applicable, is automatically included in the displayed value, it need not be considered while setting Rx. Setting is equal at both line ends. It is sufficient to perform this measurement only from one line end.

The remaining of this sub-section is relevant only for three-terminal lines (teed lines). In this case, the pilot wire resistances must be measured for both pilot wire pairs which are connected at a certain station. Rx (address 1131) is always the resistance of the pilot wire loop which is connected immediately to the relay under consideration, i.e. with which the resistance has been measured. Ry (address 1132) is the resistance of the pilot wire pair which is connected to the adjacent relay (in the same station). Thus, for the adjacent relay, Rx and Ry are interchanged. The two opposite relays which are connected with the same pilot wire pair always get the same setting for Rx. Figure 6.6 illustrates this relation.

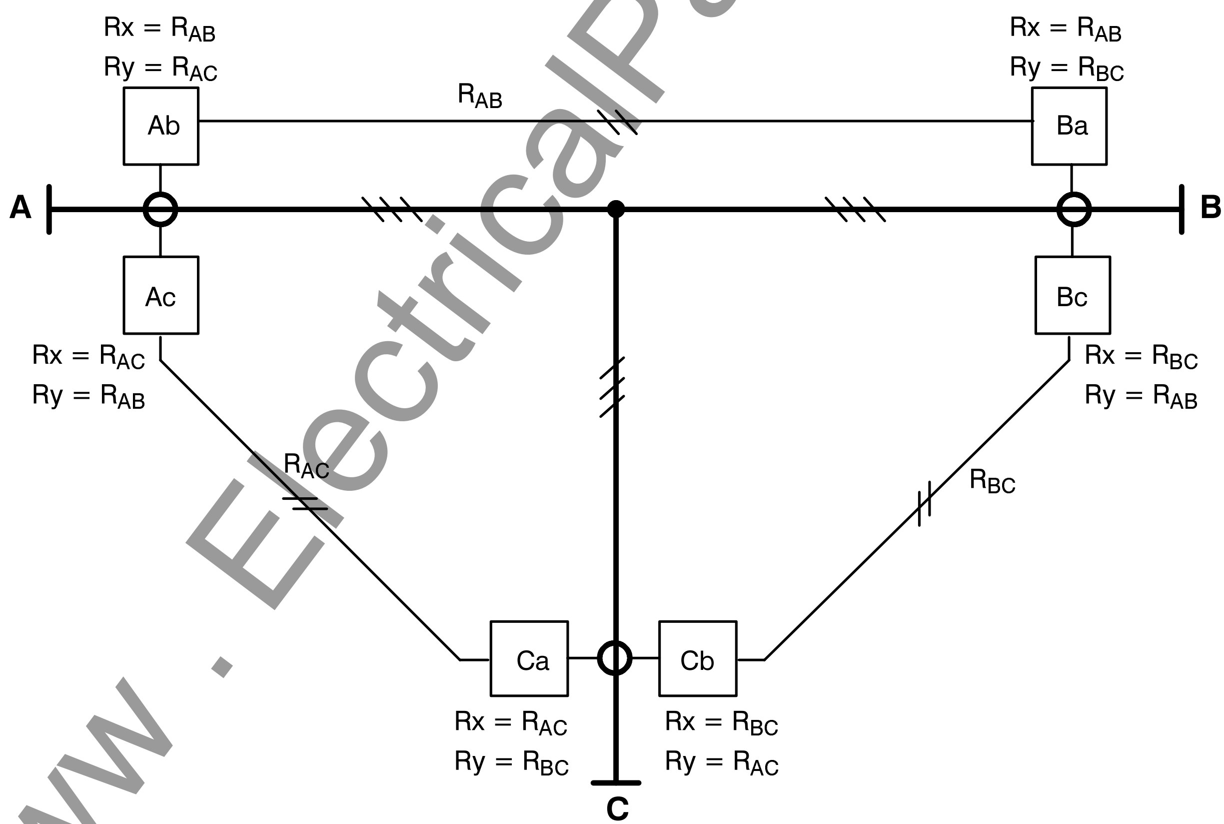


Figure 6.6 Identification scheme on three-terminal lines

6.7.3 Checking of the current transformer connections at one line end

The current transformer connections are checked with primary line current. This requires a load current of at least 25 % of the rated line current through the line. Ensure that the polarity switch in the front is situated in one of its end positions.

These checks support the visual checks of the correct c.t. connections but do not replace them, since the results of these tests do not identify the unequivocal causes of errors. A cyclic or acyclic change of the phases, for example, cannot be recognized! A precondition is, therefore, the completion of the checks according to Section 5.2.7.

Secondary injection test set, which have been used for the foregoing checks, must be removed. The relay must be connected to the current transformers.

Before the line is energized, it must be ensured that a short-circuit protection is effective at each line end. If a separate back-up protection is installed (e.g. an overcurrent time protection) this must be commissioned and switched effective.

If no separate back-up protection is available, then the integrated overcurrent time protection provided in 7SD502 is switched *ON* (address 2601). The trip command of the overcurrent time protection must be allocated to the trip relay which trips the line circuit breaker. **It must be expected, that the internal overcurrent time protection trips when a wrong current transformer connection simulates an increased mixed current which exceeds the overcurrent threshold! This is also applicable for the opposite line end**.

The differential protection remains blocked (address 1501 DIFF PROT = *BLOCK TRIP REL*).

- Switch off the earthing isolators at both line ends, close the circuit breakers at both line ends. Ensure that at least 25 % of the rated line current flows through the line; if necessary, achieve this by switching operations in the network. The direction of the load current is irrelevant.
- The summation transformer current can be read off on the display in the front or via the operating interface in address 5701. If the connections are correct, this value corresponds to the actually flowing line current referred to the rated relay current. Address 5111 shows the primary current in A.

```
4110 MEAS. I1
TEST ?
```

After confirmation with the "Yes"−key **J/Y** the current will be will be measured

Confirm with the "Yes"−key **J/Y**. The relay measures the mixed output current of the summation c.t. and calculates the secondary current referred to the rated relay current. The result is displayed immediately. But, if a system fault is detected no measurement can take place. A corresponding message is displayed.

```
4110 MEAS. I1
I1= 0.28 I/In
```

The current is displayed, referred to rated relay current, with a resolution of 0.01 · I_N, e.g. 0.28 · I_N

```
FLT. IN PROGRESS
```

A system fault is in progress

```
ABORTED
```

measurement is aborted

When deviations occur which cannot be explained by measuring tolerances or the mode of connection of the summation transformer, the operational current can be read out in primary value under address 5711. If intermediate transformers are used, their transformation ratio must be considered, too.

Furthermore, current transformer connections may be interchanged. Table 6.4 shows the measured current referred to the expected current caused by wrong polarities of current transformer connections:

- Switch off and earth the line at both ends.
- Recheck and correct the c.t. connections.
- Repeat test.

measured $I1/I_{expect}$	possible wrong connection
4.36	c.t. L2 wrong polarity *or* c.t. L1 and L3 wrong polarity
4.73	c.t. L3 wrong polarity *or* c.t. L1 and L2 wrong polarity
4.93	c.t. L1 wrong polarity *or* c.t. L2 and L3 wrong polarity
1.00	All c.t.s wrong polarity *or* cyclic phase exchange *or* acyclic phase exchange *or* correct connection

Table 6.4 Currents with wrong c.t. connections

The table shows on the one hand, that the deviations resulting from wrong polarity of individual phases do not differ from each other to a remarkable extent, which requires carefully recheck of all connections. On the other hand, interchanged phases are not detected. The latter is of no concern for the actual differential protection as long as the connections are equal at both line ends (refer also to Section 6.7.4). But, the sensitivity of the protection during double earth faults does not correspond to the desired phase preference which is essential in non-earthed systems.

Finally, switch off the line.

The correct polarity for earth currents is checked with missing current L2 according to Figure 6.7 (for standard connection according Figure 5.4).

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!

Current conductor I_{L2} is short-circuited at the current transformer and interrupted to the relay. The load current check as above is repeated.

The current which is read out now should amount approximately 2.65 times the current for symmetrical current injection.

If the measured current is practically the same as during symmetrical conditions then the earth path at the relay has wrong polarity.

For different results phases may be acyclically interchanged:

- Switch off and earth the line at both ends.
- Recheck and correct the c.t. connections.
- Repeat test.

Finally, disconnect the line. **Reinstall the proper current transformer circuit.**

Repeat the tests at the other line end, and, if applicable, at all six relays of a three-terminal line.

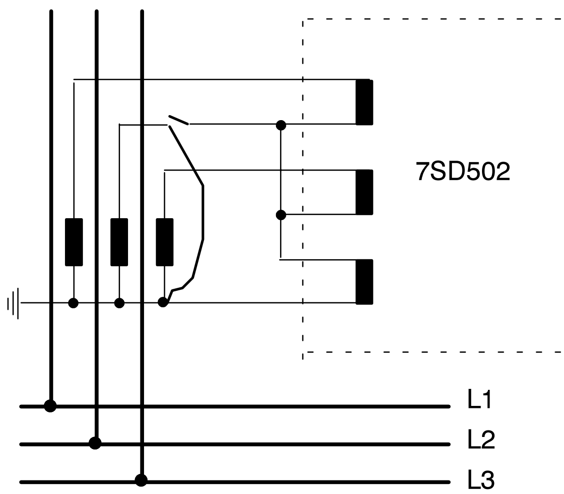


Figure 6.7 Checking the earth current path

6.7.4 Checking of the current transformer and pilot wire connections at both line ends

After completion of the current test according to Section 6.7.3 only few connection errors are possible: cyclic interchange of the current circuits, complete wrong polarity of the current connections or the pilot wires. The followings test is carried out at any desired line end of a two-terminal line.

The line is energized at both sides for these final checks. The through-flowing load current must amount at least 25 % of rated line current. The direction of the load current is of no concern. Test is initiated at any desired line end using address 4120:

```
4120 MEAS.  I1,I2
TEST  ?
```

After confirmation with the "Yes"−key **J/Y** the currents I_1, I_2, I_{diff} and the phase angle between I_1 and I_2 will be measured or calculated

Confirm with the "Yes"−key **J/Y**. The relay measures the mixed output current of the summation c.t. I_1 (local line end). By means of the pilot wire current I_a and the shunt current I_b, the current at the opposite line end I_2, the phase angle between I_1 and I_2, and the differential current I_{diff} are calculated. The results are displayed immediately. You can page through the values using the "No"−key **N**, or page back using the backspace key **R**. But, if a system fault is detected no measurement can take place. A corresponding message is displayed.

```
4120 MEAS.  I1,I2
I1=  0.28  I/In
```

The local measured current I_1 is displayed, referred to the rated relay current, e.g. 0.28; continue with the "No"−key **N**

```
4120 MEAS.  I1,I2
I2=  0.29  I/In
```

The measured current I_2 at the opposite line end is displayed, referred to the rated relay current, e.g. 0.29; continue with the "No"−key **N**

```
4120 MEAS.  I1,I2
α=  180  °
```

The phase displacement α between the measured currents at both line ends is displayed; should be 180°; continue with the "No"−key **N**

```
4120 MEAS.  I1,I2
ID=  0.02  I/In
```

The differential current I_{diff} is displayed, referred to the rated relay current; it should be negligible

```
4120 MEAS.  I1,I2
FLT.  IN  PROGRESS
```

When measurement was unsuccessful, a corresponding message is displayed:

A system fault is in progress

```
ABORTED
```

Measurement is aborted, e.g. because of occurrence of a system fault

```
CURRNT  TOO  SMALL
```

The injected current is too small for evaluation

Item No	α	possible connection error
1	0°	pilot wires interchanged *or* all c.t. connections interchanged
2	60°	counter-clockwise cyclic phase exchange at local line end *or* clockwise cyclic phase exchange at opposite line end
3	120°	acyclic phase exchange L2↔L3 at opposite line end
4	180°	correct connection
5	240°	acyclic phase exchange L2↔L3 at local line end
6	300°	clockwise cyclic phase exchange at local line end *or* counter-clockwise cyclic phase exchange at opposite line end

Table 6.5 Measured currents with connection errors

When the connections are correct, both currents I_1 and I_2 have nearly equal magnitude, the angle α is approximate 180°, the differential current is negligible.

If the angle differs considerably from 180° or a considerable differential current is indicated, then the polarity is wrong or phases are interchanged. Table 6.5 shows such cases.

The cases according to item 3 and 5 should already be recognized during the tests according to Section 6.7.3, so they should not occur.

But, even when the values I1, I2, α, and ID are correct, it is not sure that the pilot wires are correctly connected since the pilot current is zero with through-flowing line current. A counter-check is necessary, therefore.

For this, the polarity at the local relay is reverted by switching over the polarity reverter in the front (see also Figure 6.1). **Important! Ensure that the polarity switch in the front is always situated at one of its end positions.**

The current angle α is now 0°, and the differential current amounts to twice the test current, i.e. for the above example:

```
4120█ MEAS.   I1,I2
I1=   0.28  I/In
```

The local measured current I_1 is displayed, referred to the rated relay current, e.g. 0.28; continue with the ”No”−key **N**

```
4120█ MEAS.   I1,I2
I2=   0.29  I/In
```

The measured current I_2 at the opposite line end is displayed, referred to the rated relay current, e.g. 0.29; continue with the ”No”−key **N**

```
4120█ MEAS.   I1,I2
α =  0
```

The phase displacement α between the measured currents at both line ends is displayed; should be 0° because of reverted polarity;
continue with the ”No”−key **N**

```
4120█ MEAS.   I1,I2
ID=   0.58  I/In
```

The differential current I_{diff} is displayed, referred to the rated relay current; because of reverted polarity, approx. twice the through-flowing current is expected

Do not forget to switch the polarity reverter back to the correct position after this test!

If the values are equal to those of the former test, the pilot wires are interrupted.

- Recheck and correct the pilot wire connections.
- Repeat test.

Finally, switch off the line.

6.7.5 Checking of the current transformer and pilot wire connections at three-terminal lines

For three-terminal lines (teed lines), the previous test is carried out for two line ends as desired, e.g. for the line run A−B according to Figure 6.8. The load current flows only through the two line ends under test, i.e. A−B in this example. The current direction is irrelevant. The circuit breaker is left open at the remaining line end, i.e. terminal C.

After test initiation, the currents are read out under address 4120 at the relay Ab (Figure 6.8), as illustrated in Section 6.7.4. At first, the indication of the differential current is ignored because this is also dependent on the proper connections of the adjacent relay (Ac).

The connections of the relays Ab and Ba are verified after successful test and counter-check. This is a precondition for the further tests.

Next, at the same relay Ab, the indications of the measured current I_3 are read out under address 4121. If the connections of the relay Ac are correct, the current I_3 must be insignificant, as should be now the differential current:

```
4121█ MEAS.  I1,I3
I1 =  0.28  I/In
```

The local measured current I_1 is displayed, referred to the rated relay current, e.g. 0.28; continue with the ”No”−key **N**

```
4121█ MEAS.  I1,I3
I3 =  0.03  I/In
```

The measured current I_3 at the third line end is displayed, referred to the rated relay current, should be insignificant; continue with the ”No”−key **N**

```
4121█ MEAS.  I1,I3
α =  ****
```

The phase displacement α between the measured currents at the line ends is displayed; should be indefinite because $I_3 \approx 0$;
continue with the ”No”−key **N**

```
4121█ MEAS.  I1,I3
ID =  0.02  I/In
```

The differential current I_{diff} is displayed, referred to the rated relay current; it should be insignificant

If, in contrast, $I_3 \approx I_1$ and $\alpha \approx 180^\circ$, the pilot wires at the relay Ac are either interrupted or not connected to the additional current input of the relay Ab. The power line is switched off, and the connections of the pilot wires A−C between the relays Ac and Ca must be carefully checked and corrected.

If $I_3 \approx 2 \cdot I_1$ and $\alpha \approx 180^\circ$, connections are interchanged:

− either the current transformer connections at the relay Ac,

− or the pilot wire link between relay Ac and relay Ca,

− or the connection of the pilot wires A−C at the additional current input of the relay Ab.

Switch off the line and check and correct the connections in the sequence mentioned before. In the first case, the current polarity may be reversed by switching over the polarity switch in the front of the relay (refer to Figure 6.1), thus, work on the current transformer circuits is not necessary. **Important! Ensure that the polarity switch in the front is always situated in one of its end positions!**

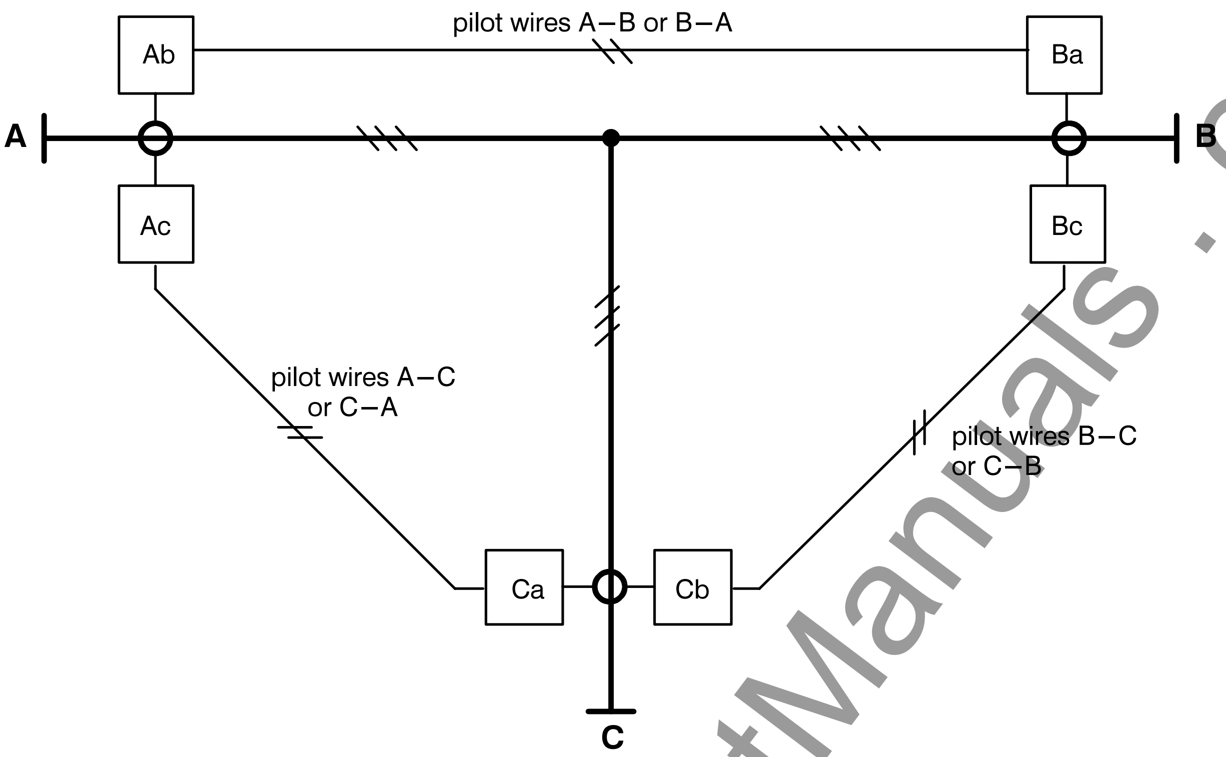


Figure 6.8 Identification scheme on three-terminal lines

The next measurement is carried out at the adjacent relay, in this example at relay Ac. The current keeps flowing through the line ends A−B.

The indices are interchanged for relay Ac: I_2 is now the current at line end C as this is the opposite end for relay Ac; I_3 is now the current at line end B. Thus, the measured value indications should be:

I_1 local current (A), example $I_1 \approx 0.28$

I_2 opposite current (C), example $I_2 \approx 0$

α_{12} = ★★★★, i.e. indefinite as $I_2 \approx 0$

I_3 third current (B), example $I_3 \approx I_1 \approx 0.28$

α_{13} $\approx 180^\circ$

When the previous measurements and checks had been completed successfully, no deviations should occur with this test.

Now, the line is de-energized. For the following test, current flow must be achieved from terminal A to C (in this example) or vice versa. This current should be again at least 25 % rated line current.

Measurement of the values I_1, I_3, and α is now started under address 4121. Address 4120 (I_1, I_2, α) need not be checked provided the previous tests have been completed successfully. Reversal of current transformer connections or pilot wire connections at the relay Ac is no more permissible since these connection are already checked and matched to the connections of the relay Ab! Consider again the indices of relay Ac: I_2 is the current at line end C, and I_3 is the current at line end B!

```
4121 MEAS.  I1,I3
I1 =  0.41  I/In
```

The local measured current I_1 is displayed, referred to the rated relay current, e.g. 0.41; continue with the ”No”−key **N**

```
4 1 2 1█ M E A S .   I 1 , I 3
I 3 =   0 . 0 4   I / I n
```

The measured current I_3 at the third line end is displayed, referred to the rated relay current, should be insignificant; continue with the "No"–key **N**

```
4 1 2 1█ M E A S .   I 1 , I 3
α =   * * * *
```

The phase displacement α between the measured currents at the line ends is displayed; should be indefinite because $I_3 \approx 0$;
continue with the "No"–key **N**

```
4 1 2 1█ M E A S .   I 1 , I 3
I D =   0 . 0 4   I / I n
```

The differential current I_{diff} is displayed, referred to the rated relay current

---

The differential current is ignored. This test checks only the correct connection of the pilot wires of the pilots A–B at the relay Ac.

If $I_3 \approx I_1$ and $\alpha \approx 180°$, the pilot wires at the relay Ab are not connected to the additional current input of the relay Ac. The power line is switched off, and the connections of the pilot wires A–B at the relay Ac must be carefully checked and corrected.

If $I_3 \approx 2{\cdot}I_1$ and $\alpha \approx 180°$, the connection of the pilot wires A–B at the additional current input of the relay Ac are interchanged:

Switch off the line and check and correct the connections of the pilot wires A–B at the additional current input of the relay Ac. Repeat the check.

The successful check completes the tests to be performed at line end A.

All of the tests described until now must be carried out accordingly at the line end C, with current flow from A to C or vice versa. If corrections become necessary, these are performed only at this line end C. No corrections must be performed at the line end A which is already checked; otherwise a complete recheck of all connections would become necessary.

Note that the indices of the line ends change cyclically (negative), i.e.

Measurement at relay Ca instead of Ab:
local line end C instead of A; measured current I_1
opposite line end A instead of B; measured current I_2
open line end B instead of C; measured current I_3

Measurement at relay Cb instead of Ac:
local line end C instead of A; measured current I_1
opposite line end B instead of C; measured current I_2
third line end A instead of B; measured current I_3

The connections at the relays Ca and Cb have been verified after successful completion of these check series.

The last series of checks refers to the line end B, with current flow from B to C or vice versa. If corrections become necessary, these are performed only at this line end B. No corrections must be performed at the line ends A and C which are already checked; otherwise a complete recheck of all connections would become necessary.

The indexing in this case is:

Measurement at relay Bc instead of Ab:
local line end B instead of A; measured current I_1
opposite line end C instead of B; measured current I_2
open line end A instead of C; measured current I_3

Measurement at relay Ba instead of Ac:
local line end B instead of A; measured current I_1
opposite line end A instead of C; measured current I_2
third line end C instead of B; measured current I_3

The connections at all relay have been verified after successful completion of these check series.

Finally, all circuit breakers may be opened.

6.7.6 **Pilot wire monitoring** (if fitted)

If the relay is equipped with the pilot wire monitoring feature (model 7SD502★–★★★**1**★–★★), this function is now switched effective: address 1601 PILOT MON = *ON*.

Since the pulsed signal of pilot wire monitoring is damped dependent of the pilot wire length and resistance, this attenuation must be measured during commissioning.

The reception level of the signal is measured at that line end where the transmitter identification is set as slave (address 1602 STATION = *SLAVE*); the opposite end relay must be set as *MASTER*. This ensured that the relay under test receives really a signal.

Reception level measuring is initiated under address 4130:

```
4130█ LEVEL  P.M.
TEST  ?
```

After confirmation with the "Yes"–key **J/Y** the the received level will be measured

---

Confirm with the "Yes"–key **J/Y**. The relay measures the received signal level of the pilot wire monitor.

The relay displays the received signal level in percent of the maximum level, after a few seconds. But, if a system fault is detected no signal level measurement can take place. A corresponding message is displayed.

```
4130█ LEVEL  P.M.
LEVEL=  65.8  %
```

Measured reception level in % of the max. reception level (i.e. for pilot resistance = 0); resolution 0.1 %, e.g. 65.8 %

```
FLT.  IN  PROGRESS
```

A system fault is in progress

```
LEVEL  TOO  SMALL
```

The received level is too small for evaluation, probably a fault on the pilot wires

---

Measurement is finished after the level is displayed.

Approximately 70 % of the displayed reception level is set under address 1605 LEVEL P.M. Setting is equal at both line ends. It is sufficient to perform this measurement only from one line end. For three-terminal lines, the reception level must be measured for each pilot wire pair. The result is decisive for both relays which are connected via the corresponding pilot wire pair.

6.7.7 Checking direct local and transfer trip facility

If the direct local trip or transfer trip facilities via binary inputs of the relay are used, these functions must be checked.

With direct local trip energization of the accordingly allocated binary input trips the local circuit breaker, influenced by the parameters of address block 21 (refer to Section 6.3.6). This function must be switched *ON* under address 2101. After the delay time T−DELAY (address 2102) following energization of the binary input, the breaker must be tripped.

With transfer trip, energization of the accordingly allocated binary input sends a transfer trip signal to the remote line end, influenced by the parameters of address block 22 (refer Section 6.3.7). Transmission must be switched *ON* under address 2201 for the sending relay, reception must be switched *ON* under address 2301 for the receiving relay. After the delay time T−SEND−DEL (address 2202) following energization of the binary input, transfer trip signal is transmitted; the breaker of the receiving end must be tripped. A precondition for correct transmission is that the signal level has been determined and set as described in Section 6.7.6.

6.7.8 Tripping test including circuit breaker − address block 44

Line differential protection relay 7SD502 allows simple checking of the tripping circuit and the circuit breaker. Tripping can also be performed using an external auto-reclosure device.

DANGER!

A successfully started test cycle can lead to closing of the circuit breaker, if an external auto-reclosure relay is connected!

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 to 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!

Initiation of the test can be performed from the operator keyboard or from the front operator interface. 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 ⇓.

Prerequisite for starting the test is that no protection function of the relay be picked up.

Display	Description
⇑⇓ 4400 CB TEST LIVE TRIP	Beginning of the block "trip circuit breaker"
↑ 4404 TRIP CB THREE-POLE ?	Trip circuit breaker three-pole? Confirm with "**J/Y**"− key or abort with page-on key ↑
CB CLOSED ?	Confirm with "**J/Y**"− key that circuit breaker is closed or abort with page-on Key ↑

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 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 confirmation valid.

6.7.9 Switching tests and 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 influence of these charging currents can be tested by energizing the line from one end several times.

The differential protection should be switched to *BLOCK TRIP REL* (address 1501) during these switching tests in order to avoid tripping.

The fault record is triggered via a binary input at the instant of the breaker closing command.

Conclusions as to the safety margin between the maximum inrush current and the pick-up values can be drawn from the recording of the summation current and the differential current. If necessary, the pick-up value of the differential protection at both line ends must be increased (address 1503, refer also to Section 6.3.4).

Manual starting of a fault record can be carried out in address block 49, which can be reached by paging with ⇑ or ⇓, or by direct dialling with **DA 4 9 0 0 E**. The start address is reached with ↑:

⇑ ⇓
```
4 9 0 0█ T E S T
F A U L T   R E C O R D I N G
```
Beginning of block "Test fault recording" page on with ↑ to address 4901

↑
```
4 9 0 1█ F A U L T   R E C .
S T A R T   ?
```
Start fault recording? Confirm with "**J**/**Y**"– key or abort with page-on key ↑

```
S U C C E S S F U L
```
The relay acknowledges successful completion of the test recording

---

After tests **do not forgot to switch the differential protection** *ON* **(address 1501)**.

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 had 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 all 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 line differential 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 clock module 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 x 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 6.7.8.

7.2 Replacing the clock module

The device annunciations are stored in NV−RAMs which are incorporated in the clock module. The clock module contains also the back-up battery so that the annunciations are retained even with a longer failure of the d.c. supply voltage.

The clock module should be replaced at the latest after 10 years of operation.

Recommended clock module:

– DALLAS
  DS 1386 – 32 K
  RAMified TIMEKEEPER

The module is located on the CPU cart. The complete draw-out module must be removed from the housing in order to replace the clock module.

The procedure when replacing the clock module is described below.

– 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 clock module. They are, therefore, neither lost when the clock module is replaced nor when the device is operated without a clock module.

⚠ 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 draw-out module using the pulling aids provided at the top and bottom. (Figure 7.3).

⚠ 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 the module and place onto the conductive surface.

– Get access to the CPU board.

– Pull out used clock module from the socket according to Figure 7.1; **do not place on the conductive surface!**

– Insert the prepared new clock module into the socket; observe correct mounting position.

– Remount PCB board to the draw-out module.

– Insert draw-out module into the housing; ensure that the releasing lever is pushed fully to the right before the module is pressed in.

– Firmly push in the module using the releasing lever. (Figure 7.3).

⚠ 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 clock module has thus been completed.

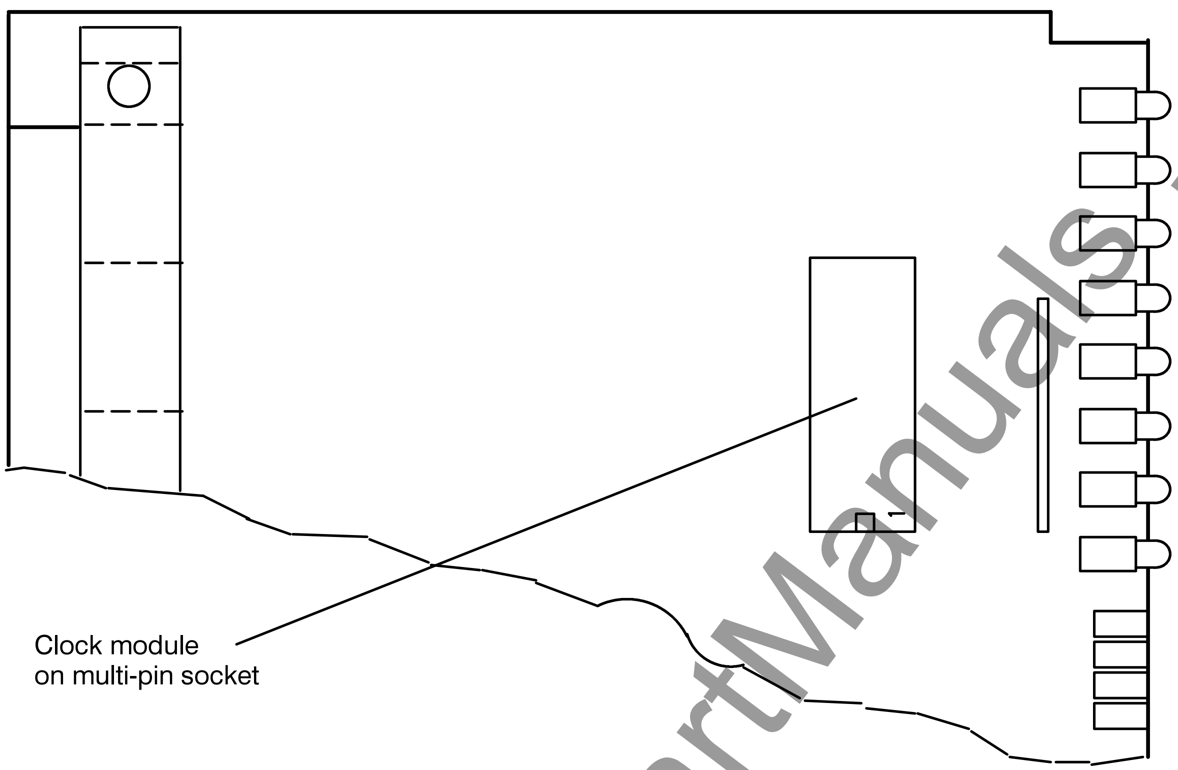


Figure 7.1 Position of the clock module

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 7.2)? 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 processor system off and on again (by means of the switch on the front plate). This, however, results in loss of fault data and messages if the relay is not equipped with the clock module, and, if a parameterizing process has not yet been completed, the last parameters are not stored.

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 7.2).

– 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 module using the pulling aids provided at the top and bottom. (Figure 7.3).

⚠ 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 the module and place onto the conductive surface.

– Remove blown fuse from the holder (Figure 7.2).

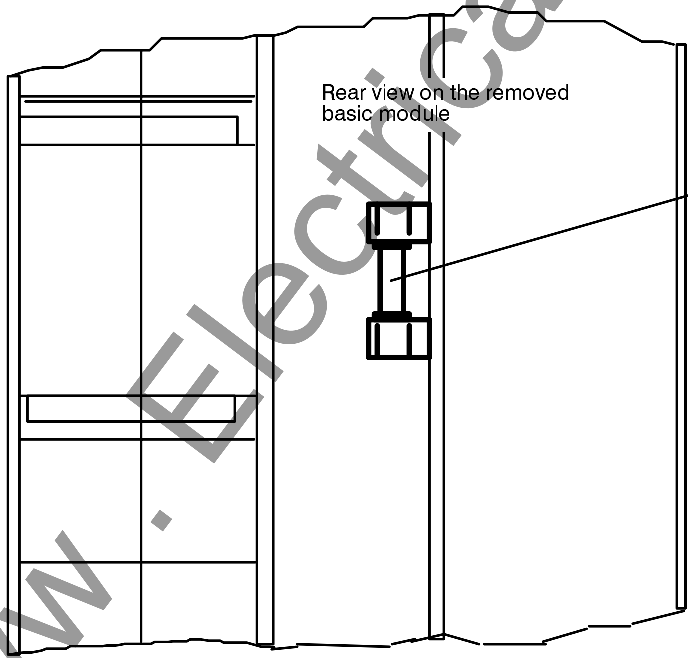
– Fit new fuse into the holder (Figure 7.2).

– Insert draw-out module into the housing; ensure that the releasing lever is pushed fully to the right before the module is pressed in (Figure 7.3).

– Firmly push in the module using the releasing lever. (Figure 7.3).

– 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).



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 7.2 Mini-fuse of the power supply

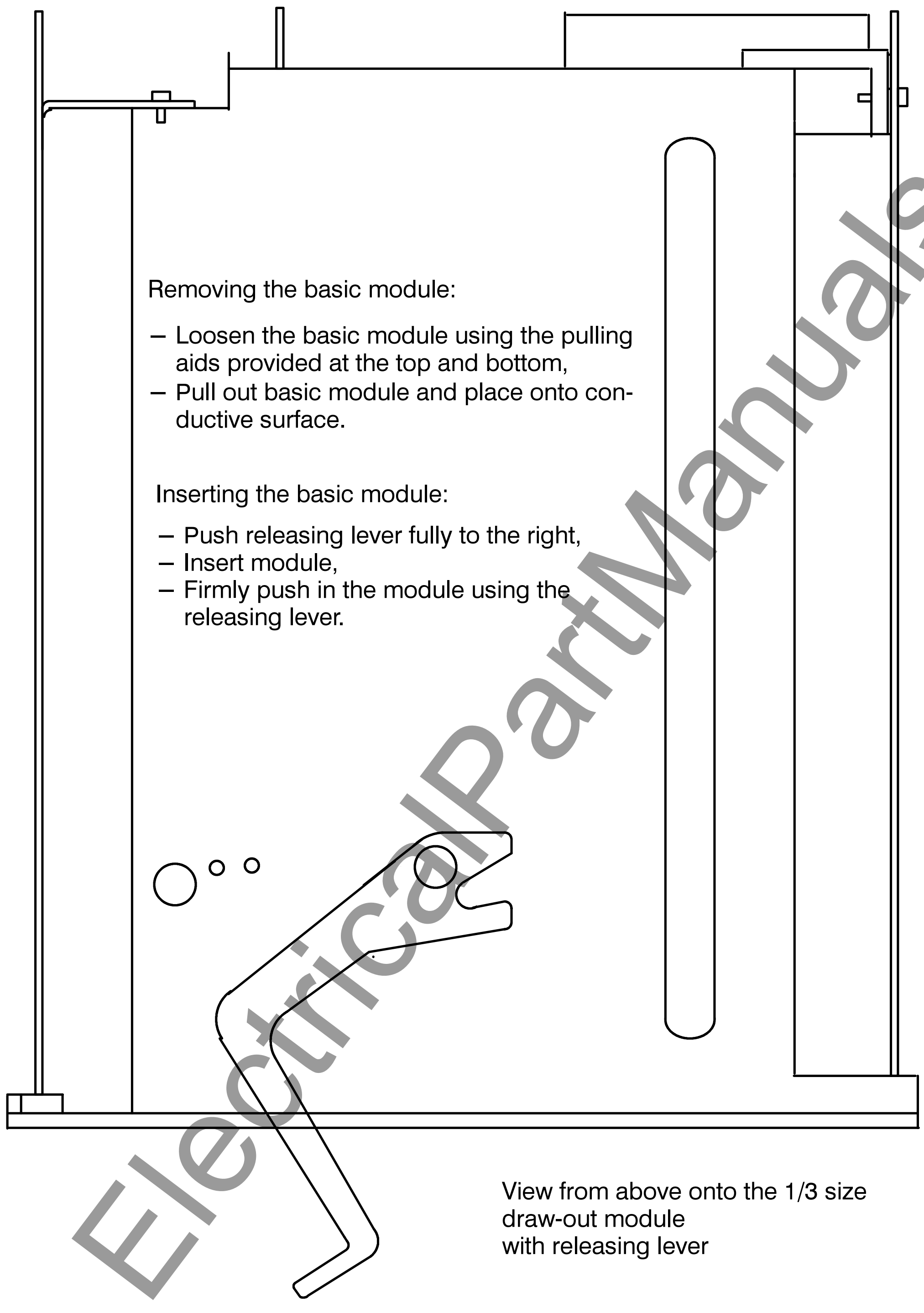


Figure 7.3 Aid for removing and inserting the draw-out module

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 **E**lectrostatically **E**ndangered **C**omponents (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 **E**lectrostatically **E**ndangered **C**omponents 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 °C to +55 °C (refer Section 3.1.4 under the Technical data), corresponding to −12 °F to 130 °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 °C to +35 °C (50 °F to 95 °F); this prevents from early ageing of the electrolytic capacitors which are contained in the power supply.

For very long storage periods, it is recommended that the relay should be connected to the auxiliary voltage source for one or two days every other year, in order to regenerate the electrolytic capacitors. The same is valid before the relay is finally installed. In extreme climatic conditions (tropics) pre-warming would thus be achieved and condensation avoided.

Before initial energization with supply voltage, the relay shall be situated in the operating area for at least two hours in order to ensure temperature equalization and to avoid humidity influences and condensation.

Appendix

A General diagrams

B Connection diagrams

C Tables

A General diagrams

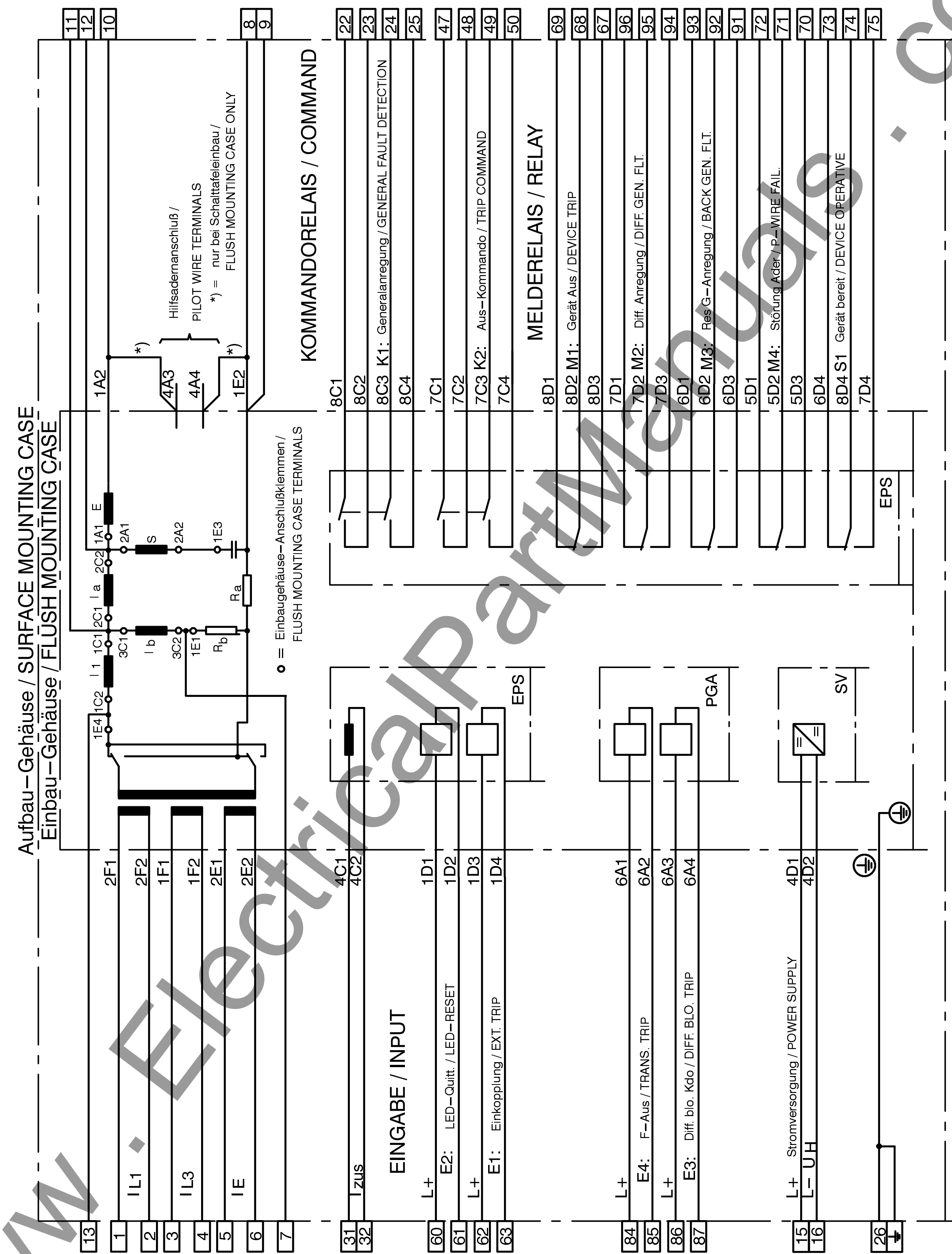


Figure A.1 General diagram of line differential protection relay 7SD502 (sheet 1 of 2)

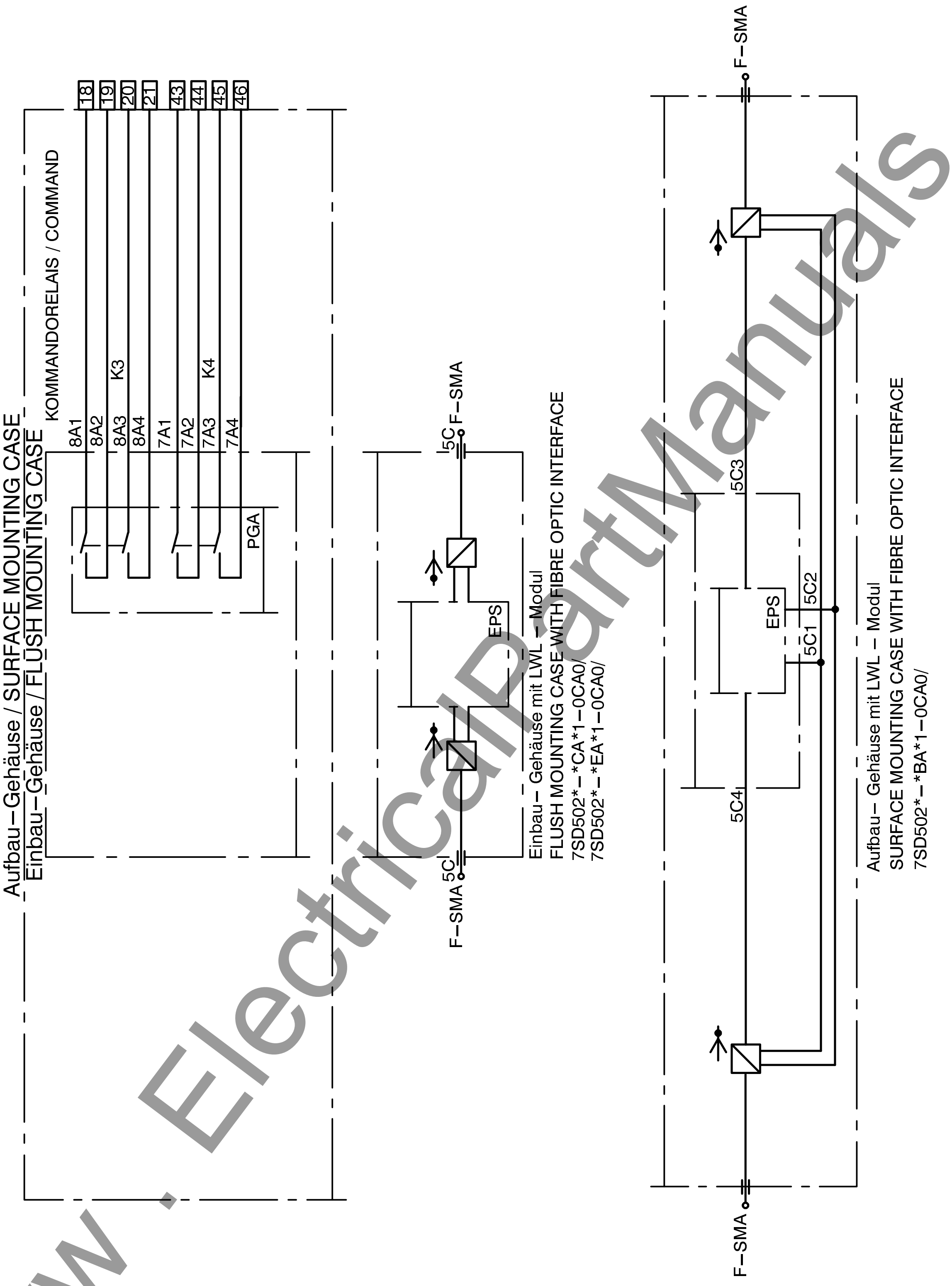


Figure A.2 General diagram of line differential protection relay 7SD502 (sheet 2 of 2)

B Connection diagrams

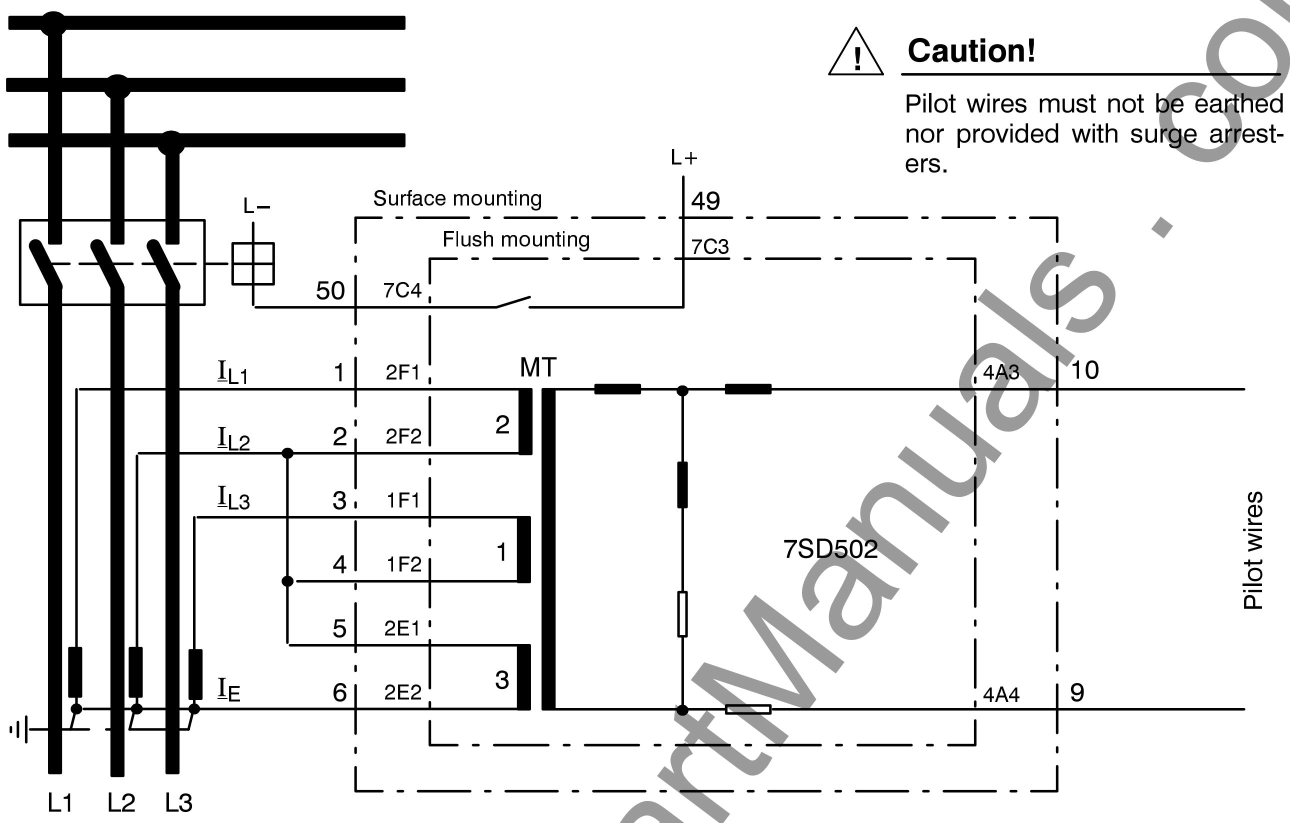


Figure B.1 Standard connection L1−L3−E, for all systems suitable

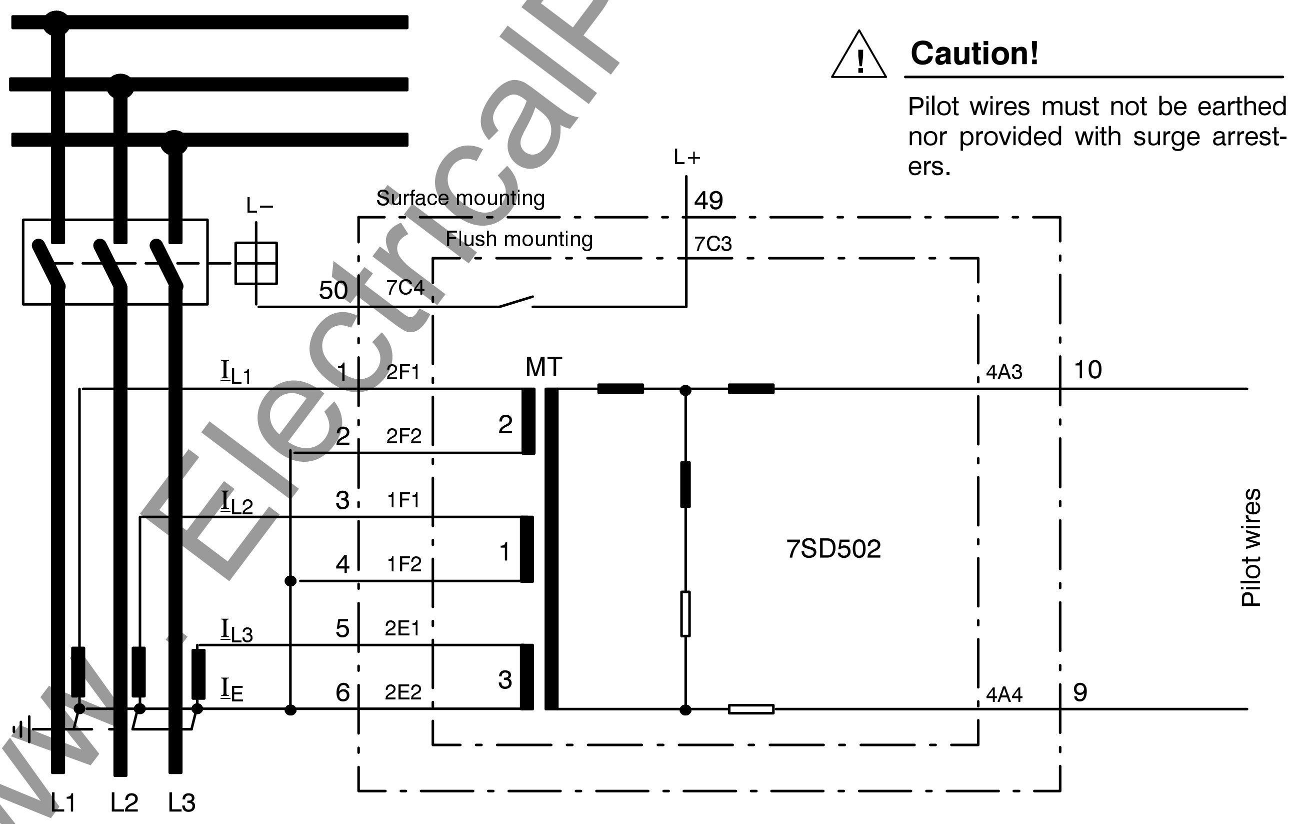


Figure B.2 Connection L1−L2−L3 with decreased earth current sensitivity, preferably for systems with solidly earthed star point with particularly low zero sequence impedance

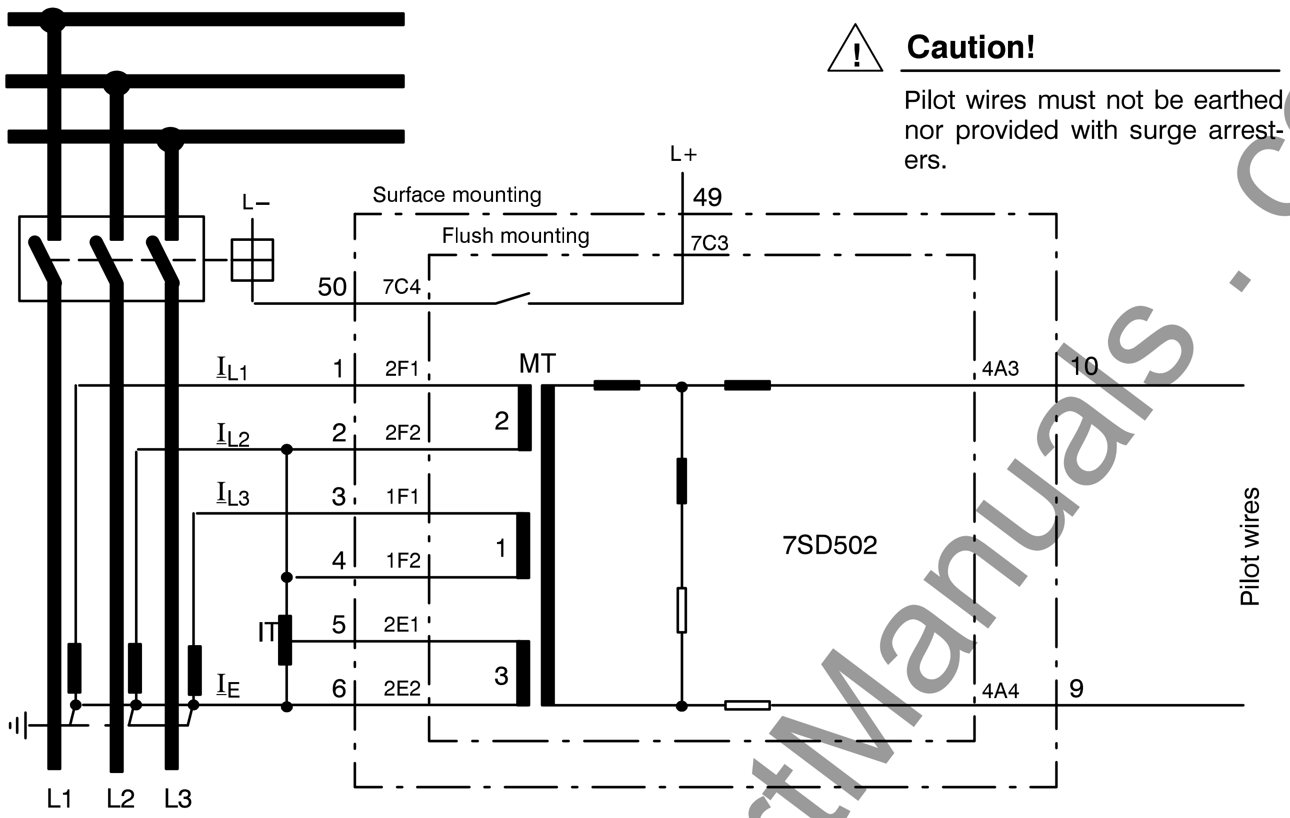


Figure B.3 Connection L1–L3–E with increased earth current sensitivity, preferably for systems with low–resistance earthed star point

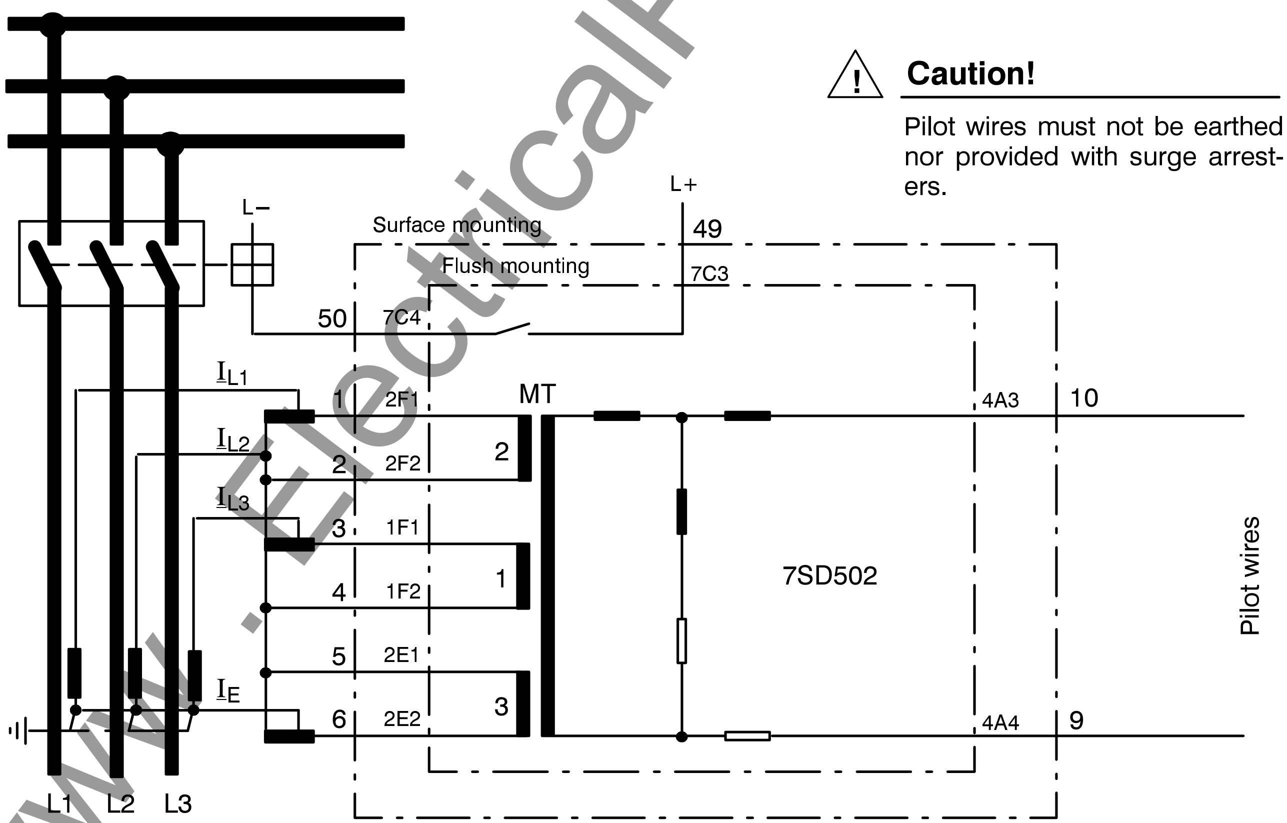


Figure B.4 Matching of unequal primary rated currents, example with standard connection L1–L3–E

Caution!

Pilot wires must not be earthed nor provided with surge arresters.

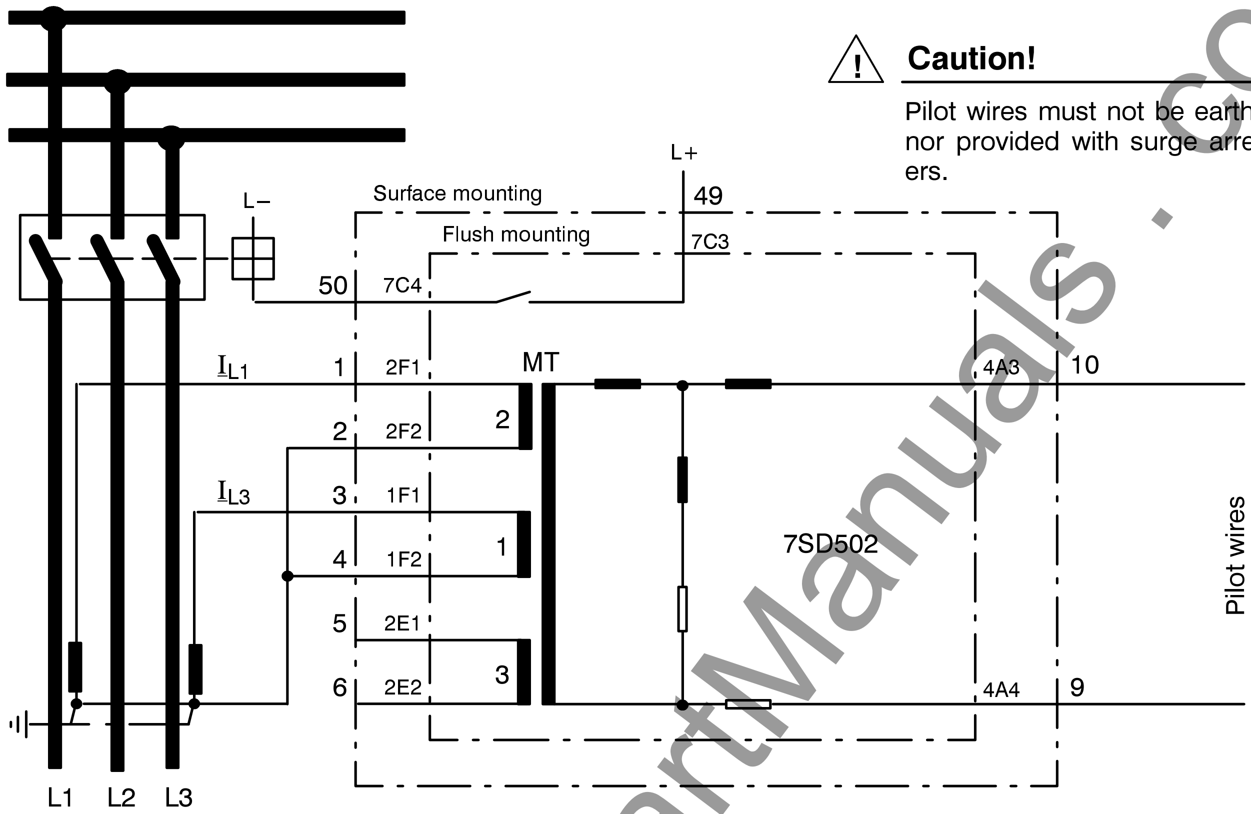


Figure B.5 Connection to two current transformers L1 – L3, only for systems with isolated or arc compensated star point

Caution!

Pilot wires must not be earthed nor provided with surge arresters.

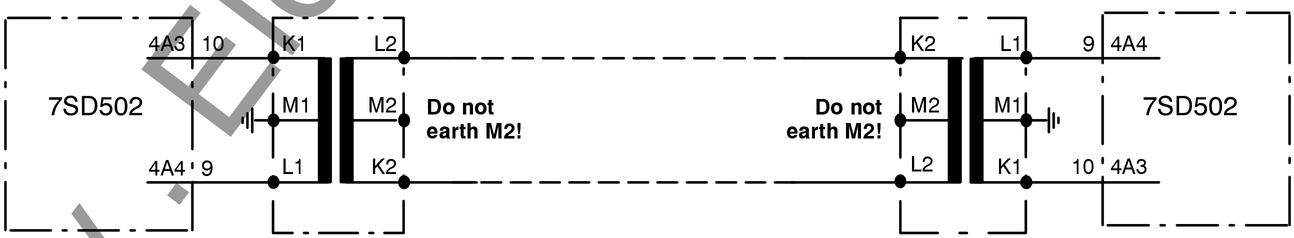


Figure B.6 Connection example for two barrier transformers 7XR9513

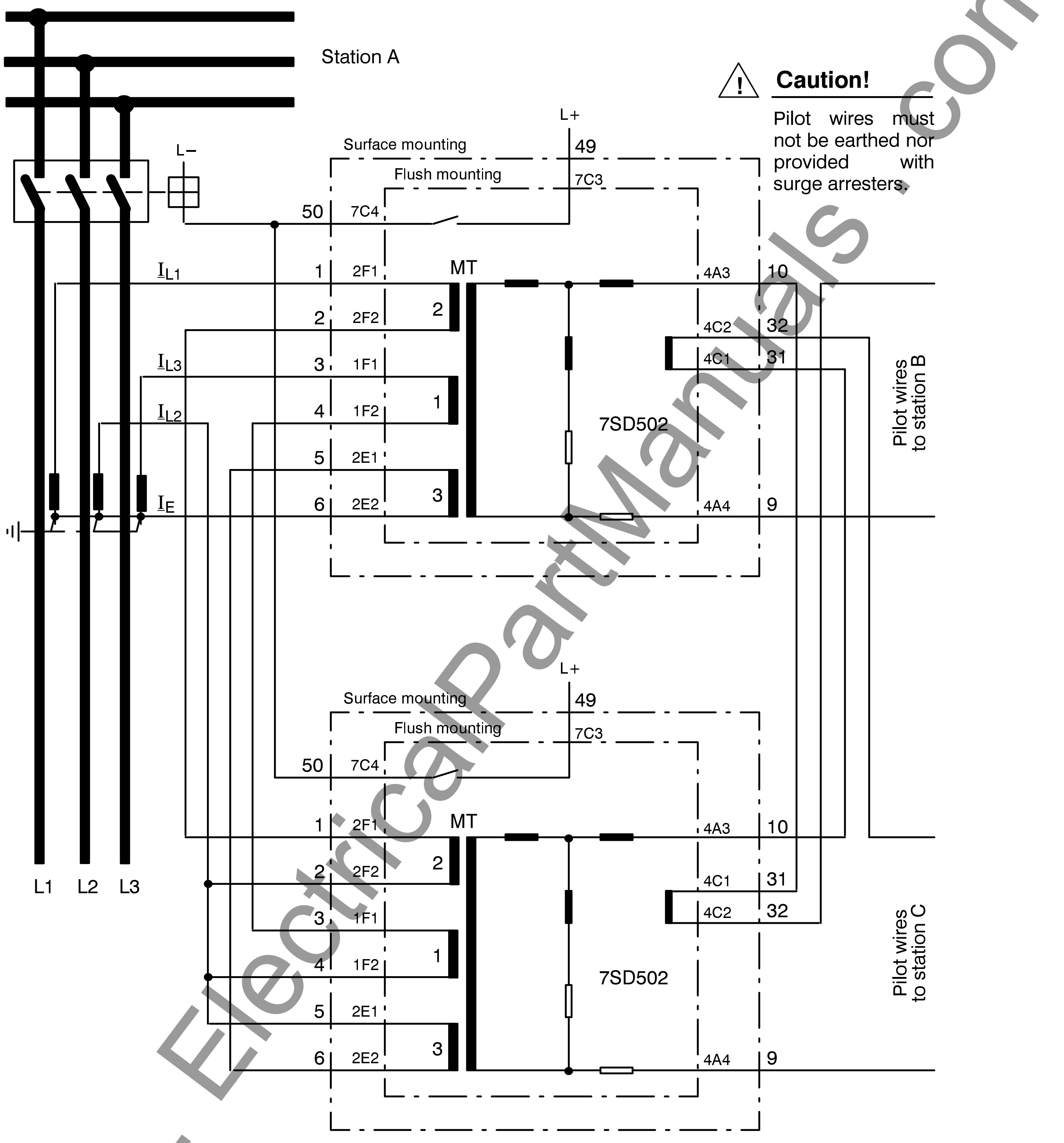


Figure B.7 Connection example L1−L3−E for one end of a three-terminal line

It is advisable to connect all line ends in the same way.

C Tables

Table C.1 Annunciations for LSA 156

Table C.2 Annunciations for PC, LC−display, and binary inputs/outputs 158

Table C.3 Reference table for functional parameters (address blocks 11 to 39) 161

Table C.4 Tests and commissioning aids (address blocks 40 to 49) 166

Table C.5 Annunciations, measured values, etc. (address blocks 50 to 59) 167

Table C.6 Reference table for configuration parameters (address blocks 60 to 79) 168

Table C.7 Operational device control facilities (address blocks 80 to 89) 174

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 7SD502 for LSA (DIN 19244 and according VDEW/ZVEI)

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 VDEW/ZVEI:
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. Op	Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
11	>User defined annunciation 1	CG		22	CA	GI	BT	p	27
12	>User defined annunciation 2	CG		23	CA	GI	BT	p	28
13	>User defined annunciation 3	CG		24	CA	GI	BT	p	29
14	>User defined annunciation 4	CG		25	CA	GI	BT	p	30
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		9	CA			p	5
59	Real time response to LSA	C		6					
60	LED Reset	C		30	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						135	83
95	Parameters are being set	CG		97	CA	GI		p	22
96	Parameter set A is active	CG		26	CA	GI		p	23
97	Parameter set B is active	CG		27	CA	GI		p	24
98	Parameter set C is active	CG		28	CA	GI		p	25
99	Parameter set D is active	CG		29	CA	GI		p	26
110	Annunciations lost (buffer overflow)	C		195				135	130
112	Annunciations for LSA lost	C		196				135	131
113	Fault tag lost						BT	135	136
140	General internal failure of device	CG			CA	GI		p	47
142	Failure of internal 18 VDC power supply	CG		83		GI		135	162
143	Failure of internal 15 VDC power supply	CG		90		GI		135	163
144	Failure of internal 5 VDC power supply	CG		89		GI		135	164
145	Failure of internal 0 VDC power supply	CG		84		GI		135	165
150	Failure in I/O module	CG		91		GI		135	170
151	Failure in I/O module 1	CG		92		GI		135	166
154	Failure in the RKA module	CG		80	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
204	Fault recording initiated via bin.input			86			BT	135	204
205	Fault recording initiated via keyboard			87			BT	135	205
206	Fault recording initiated via PC interf			88			BT	135	206
301	Fault in the power system		CG	2				135	231
302	Flt. event w. consecutive no.		C					135	232
354	>CB aux. contact:3poles closed (series)	CG		40		GI		150	4
501	General fault detection of device			140			BT	150	151
502	General drop-off of device		C	240				150	152
511	General trip of device		C	141			BT	150	161

		Ann.		LSA	VDEW/ZVEI				
FNo.	Meaning	Op	Ft	No.	CA	GI	BT	Typ	Inf
561	Circuit breaker manually closed (pulse)	C		18				150	211
605	Operat. meas. station 1 in %	M						134	130
606	Operat. meas. station 2 in %	M						134	130
607	Operat. meas. station 3 in %	M						134	130
608	Operat. meas. diff. current in %	M						134	130
609	Operat. meas. restr. current in %	M						134	130
1174	Circuit breaker test in progress	CG		21		GI		151	74
1185	Circuit breaker test: Trip 3pole	CG		142		GI		151	85
1513	Thermal overload protection is active	CG		145		GI		167	13
1515	Thermal overload prot.: Current warning	CG		11		GI		167	15
1516	Thermal overload prot.: Thermal warning	CG		12		GI		167	16
1517	Thermal overload prot.: Pick-up thermal	CG		146		GI		167	17
1521	Thermal overload protection trip		CG	10			BT	167	21
2306	>Block I>> stage of back-up overcurrent	CG		147		GI		62	6
2307	>Block I>/Ip stage of back-up overcurr.	CG		148		GI		62	7
2403	Back-up overcurrent prot. is active	CG		50		GI		62	103
2411	Back-up overcurrent: Gen. fault det.		C	210			BT	62	111
2421	Back-up overcurrent: Fault det. I>>		C	246				62	121
2422	Back-up overcurrent: Fault det. I>/Ip		C	247				62	122
2441	Back-up overcurrent: Time TI>> expired		C	217				62	141
2442	Back-up overcurrent: Time TI>/Tp exp.		C	218				62	142
2451	Back-up overcurrent: General trip		C	251			BT	62	151
3017	Differential protection is active	CG		151		GI		92	17
3022	Diff. prot.: General fault detection		CG	3	CA		BT	p	84
3024	Diff. prot.: Blocked by external fault			153			BT	92	24
3027	Differential prot.: Trip by IDIFF>		C	231	CA		BT	p	68
3306	>Transfer trip signal input	CG		39					
3311	Trans. trip transmitter is switched off	CG		57		GI		93	11
3316	Transfer trip transmission signal	CG		157		GI		93	16
3341	Trip receiver is switched off	CG		58		GI		93	41
3343	Trip receiver is active	CG		159		GI		93	43
3346	Trip receiver: General fault detection		CG	160			BT	93	46
3347	Trip receiver: General trip		CG	59			BT	93	47
3371	Pilot wire monitor is switched off	CG		162		GI		93	71
3376	Pilot wire monitor: Failure detected	CG		95		GI		93	76
4506	>External trip	CG		51					
4511	External trip is switched off	CG		53		GI		51	111
4513	External trip is active	CG		166		GI		51	113
4516	External trip: General fault detection			167			BT	51	116
4517	External trip: General trip		CG	52			BT	51	117

Annunciations 7SD502 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	C			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
51	Dev.operative	Device operative / healthy	CG			O
56	Initial start	Initial start of processor system	C			
60	LED reset	LED Reset	C			
95	Param.running	Parameters are being set	CG			O
96	Param. Set A	Parameter set A is active	CG			O
97	Param. Set B	Parameter set B is active	CG			O
98	Param. Set C	Parameter set C is active	CG			O
99	Param. Set D	Parameter set D is active	CG			O
100	Wrong SW-vers	Wrong software-version	C			
101	Wrong dev. ID	Wrong device identification	C			
110	Annunc. lost	Annunciations lost (buffer overflow)	C			
111	Annu. PC lost	Annunciations for PC lost	C			
115	Flt.Buff.Over	Fault annunciation buffer overflow		C		
120	Oper.Ann.Inva	Operational annunciations invalid	CG			
121	Flt.Ann.Inval	Fault annunciations invalid	CG			
123	Stat.Buff.Inv	Statistic annunciation buffer invalid	CG			
124	LED Buff.Inva	LED annunciation buffer invalid	CG			
129	VDEW-StateInv	VDEW state invalid	CG			
135	Chs Error	Error in check sum	CG			
136	Chs.A Error	Error in check sum for parameter set A	CG			
137	Chs.B Error	Error in check sum for parameter set B	CG			
138	Chs.C Error	Error in check sum for parameter set C	CG			
139	Chs.D Error	Error in check sum for parameter set D	CG			
142	Failure 18V	Failure of internal 18 VDC power supply	CG			
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
150	Failure I/O	Failure in I/O module	CG			OT
151	Failure I/O 1	Failure in I/O module 1	CG			OT
154	Failure RKA	Failure in the RKA module	CG			
159	LSA disrupted	LSA (system interface) disrupted	CG			
161	I supervision	Measured value supervision of currents				O
162	Failure ∑I	Failure: Current summation supervision	CG			OT
203	Flt.RecDatDel	Fault recording data deleted	C			
204	Flt.Rec.viaBI	Fault recording initiated via bin.input	C			

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
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		
354	>CB Aux.3p cl	>CB aux. contact:3poles closed (series)				IOT
356	>Manual Close	>Manual close				IOT
501	Device FltDet	General fault detection of device				OT
502	Dev. Drop-off	General drop-off of device		C		
511	Device Trip	General trip of device				OT
524	I/In=	Interrupted current (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
605	I1[%]=	Operat. meas. station 1 in %	M			
606	I2[%]=	Operat. meas. station 2 in %	M			
607	I3[%]=	Operat. meas. station 3 in %	M			
608	ID[%]=	Operat. meas. diff. current in %	M			
609	IR[%]=	Operat. meas. restr. current in %	M			
655	I1=	Operat. meas. station 1 in A	M			
656	I2=	Operat. meas. station 2 in A	M			
657	I3=	Operat. meas. station 3 in A	M			
658	ID=	Operat. meas. diff. current in A	M			
659	IR=	Operat. meas. restr. current in A	M			
801	Θ/Θtrip =	Temperat. rise for warning and trip	M			
1000	Trip No =	Number of trip commands issued	M			
1007	∑I/In=	Accumulated interrupted curr. I/In	M			
1156	>CB Test	>CB test start				IOT
1174	CB in Test	Circuit breaker test in progress	CG			OT
1185	CB Test 3p	Circuit breaker test: Trip 3pole	CG			OT
1503	>O/L block	>Block thermal overload protection				IOT
1504	>O/L alarm	>Thermal O/L protection: alarm only				IOT
1505	>O/L blo Trip	>Block trip signal of thermal O/L prot.				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	CG			OT
1515	O/L Warn I	Thermal overload prot.: Current warning	CG			OT
1516	O/L Warn Θ	Thermal overload prot.: Thermal warning	CG			OT
1517	O/L pickup Θ	Thermal overload prot.: Pick-up thermal	CG			OT
1521	O/L Trip	Thermal overload protection trip		CG		OT
2303	>Backup block	>Block back-up overcurrent time prot.				IOT
2304	>Back bloTrip	>Block trip signal of back-up overcurr.				IOT
2306	>I>> block	>Block I>> stage of back-up overcurrent	CG			IOT
2307	>I>/Ip block	>Block I>/Ip stage of back-up overcurr.	CG			IOT
2401	Backup off	Back-up overcurr. prot. is switched off	CG			OT
2402	Backup block	Back-up overcurrent prot. is blocked	CG			OT
2403	Backup active	Back-up overcurrent prot. is active	CG			OT
2411	Back Gen. Flt	Back-up overcurrent: Gen. fault det.		CG		OT
2421	Backup I>>	Back-up overcurrent: Fault det. I>>		C		OT
2422	Backup I>/Ip	Back-up overcurrent: Fault det. I>/Ip		C		OT
2441	Backup TI>>	Back-up overcurrent: Time TI>> expired		C		OT
2442	Backup TI>/Tp	Back-up overcurrent: Time TI>/Tp exp.		C		OT
2451	Back Gen.Trip	Back-up overcurrent: General trip		C		OT
3003	>Diff block	>Block differential protection				IOT
3005	>Diff bloTrip	>Block trip signal of diff. prot.				IOT
3015	Diff off	Differential protection is switched off	CG			OT
3016	Diff blocked	Differential protection is blocked	CG			OT
3017	Diff active	Differential protection is active	CG			OT

FNo.	Abbreviation	Meaning	Op	Ft	E	IOT
3021	Diff> T start	Diff. prot.: IDIFF> time delay started		CG		OT
3022	Diff Gen. Flt	Diff. prot.: General fault detection		CG		OT
3024	Block sat	Diff. prot.: Blocked by external fault		CG		OT
3026	Block Harm	Diff. prot.: Blocked by harmonics		CG		OT
3027	Diff> TRIP	Differential prot.: Trip by IDIFF>		C		OT
3028	Diff Intertr.	Diff. prot.: Intertrip send signal		CG		OT
3029	dirDif>Trip	Direct Trip IDIFF> without O/C release	CG			OT
3303	>TrTrip block	>Block transfer trip transmitter				IOT
3306	>Trans.Trip	>Transfer trip signal input				IOT
3311	TransTrip off	Trans. trip transmitter is switched off	CG			OT
3312	TransTrip blo	Transfer trip transmitter is blocked	CG			OT
3316	TrTrip Send	Transfer trip transmission signal	CG			OT
3333	>Recv. block	>Block of trip receiver				IOT
3335	>Recv.bloTrip	>Block the trip relay of trip receiver				IOT
3341	Receiver off	Trip receiver is switched off	CG			OT
3342	Receive block	Trip receiver is blocked	CG			OT
3343	Recv. active	Trip receiver is active	CG			OT
3346	Recv. Gen.Flt	Trip receiver: General fault detection		CG		OT
3347	Receiver Trip	Trip receiver: General trip		C		OT
3348	Receive recv.	Trip receiver: Trip signal received	CG			OT
3363	>P.W.M. block	>Block pilot wire monitor				IOT
3367	>P.W.M. 3.end	>P.wire failure det. by parallel device				IOT
3371	P.W.M. off	Pilot wire monitor is switched off	CG			OT
3372	P.W.M. block	Pilot wire monitor is blocked	CG			OT
3376	Pilot w. fail	Pilot wire monitor: Failure detected	CG			OT
3377	Block to 3end	Pilot wire failure to parallel device	CG			OT
4503	>Ext block	>Block external trip				IOT
4505	>Ext blo Trip	>Block trip signal of external trip				IOT
4506	>Ext Trip	>External trip				IOT
4511	Ext off	External trip is switched off	CG			OT
4512	Ext blocked	External trip is blocked	CG			OT
4513	Ext active	External trip is active	CG			OT
4516	Ext Gen.Fault	External trip: General fault detection		CG		OT
4517	Ext Gen. Trip	External trip: General trip		C		OT

Reference Table for Functional Parameters 7SD502

1000 PARAMETERS

1100 POWERSYSTEM DATA

```
1101 IN LINE                 Nominal current of line/cable
     min. 1             ____ A
     max. 100000        ____

1102 IN CT PRIM              Primary rated current of CT
     min. 1             ____ A
     max. 100000        ____

1131 Rx                      Pilot wire loop resistance to 2nd line end
     min. 0             ____ Ω
     max. 2000          ____

1132 Ry                      Pilot wire loop resistance to 3rd line end
     min. 0             ____ Ω
     max. 2000          ____

1133 Cx                      Pilot wire loop capacitance to 2nd line end
     min. 0             ____ nF
     max. 2000          ____

1134 Cy                      Pilot wire loop capacitance to 3rd line end
     min. 0             ____ nF
     max. 2000          ____

1141 T TRIP                  Minimum trip command duration
     min. 0.01          ____ s
     max. 32.00         ____
```

1500 PILOT WIRE DIFF. PROTECTION

```
1501 DIFF PROT.              State of the differential protection
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

1503 I DIFF>                 Pick-up value of differential current
     min. 0.50          ____ I/InLn
     max. 2.50          ____

1506 SLOPE 1                 Slope 1 of tripping characteristic
     min. 0.10
     max. 0.50          ____

1508 SLOPE 2                 Slope 2 of tripping characteristic
     min. 0.25
     max. 0.95          ____

1510 2nd HARMON              State of 2nd harmonic restraint
     OFF                 [ ] off
     ON                  [ ] on
```

```
1511 2nd HARMON           2nd harmonic contend in the different. current
     min. 10         ____ %
     max. 80

1518 SAT-RESTR.           Min. restraining current for block. at CT sat.
     min. 5.00       ____ I/InLn
     max. 15.00

1523 I1 RELEASE           Min. local current I1 to release trip by DIFF
     min. 0.20       ____ I/InLn
     max. 2.50

1525 T-DELAY              Time delay of differential protection
     min. 0.00       ____ s
     max. 60.00/∞

1527 T-RESET              Reset delay after trip has been initiated
     min. 0.00       ____ s
     max. 60.00

1535 MAN.CLOSE            Trip reaction after manual closing of CB
     INEFFECTIVE      [ ] Ineffective
     UNDELAYED        [ ] Undelayed

1541 INTERTRIP            State of the intertrip send function
     OFF              [ ] off
     ON               [ ] on

1542 T-SEND-PRO           Send signal prolongation for intertrip
     min. 0.00       ____ s
     max. 60.00
```

```
1600 PILOT WIRE MONITORING

1601 PILOT MON            State of pilot wire monitor function
     OFF              [ ] off
     ON               [ ] on

1602 STATION              Station identification
     SLAVE            [ ] Slave
     MASTER           [ ] Master

1603 DIFF BLOCK           Block. diff. funct. during pilot wire failure
     ON               [ ] on
     OFF              [ ] off

1604 T-PILOT              Time delay for blocking the diff. function
     min. 2          ____ s
     max. 60

1605 LEVEL P.M            Min. receive level of pilot wire monitoring
     min. 1.0        ____ %
     max. 100.0
```

```
2100 EXTERNAL TRIP FUNCTION

2101 EXT.TRIP               State of external trip function
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2102 T-DELAY                Time delay of external trip function
     min. 0.02         ____ s
     max. 60.00

2103 T-RESET                Reset delay after trip has been initiated
     min. 0.00         ____ s
     max. 60.00
```

```
2200 TRANSFER TRIP

2201 TRIP SEND              State of transfer trip send function
     OFF                [ ] off
     ON                 [ ] on

2202 T-SEND-DEL             Send signal delay for transfer trip
     min. 0.00         ____ s
     max. 60.00

2203 T-SEND-PRO             Send signal prolongation for transfer trip
     min. 0.00         ____ s
     max. 60.00
```

```
2300 TRIP RECEIVER

2301 TRIP RECV.             State of transfer trip receiver
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2302 T-RECV-DEL             Receive signal delay for transfer trip
     min. 0.00         ____ s
     max. 60.00

2303 T-RECV-PRO             Receive signal prol. for transf. trip receiver
     min. 0.00         ____ s
     max. 60.00
```

```
2600 BACK-UP OVERCURRENT PROT

2601 BACKUP O/C             State of back-up overcurrent protection
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2603 I>>                    Pick-up value for high current stage I>>
     min. 0.10         ____ I/InLn
     max. 30.00
```

```
2604 T-I>>                     Delay time for I>> TI>>
     min. 0.00          ____   s
     max. 32.00/∞       ____

2611 CHARACT                   Overcurrent time stage characteristic
     DEFINITE TIME     [ ] Definite time
     NORMAL INVERSE    [ ] Normal inverse
     VERY INVERSE      [ ] Very inverse
     EXTREMELY INVERS  [ ] Extremely inverse

2612 I>                        Pick-up value of overcurrent time stage I>
     min. 0.10          ____   I/InLn
     max. 30.00         ____

2613 T-I>                      Delay time for I> TI>
     min. 0.00          ____   s
     max. 32.00/∞       ____

2614 Ip                        Pick-up value of overcurrent time stage Ip
     min. 0.10          ____   I/InLn
     max. 20.00         ____

2615 T-Ip                      Time multiplier for Ip (inverse time IDMT) Tp
     min. 0.50          ____   s
     max. 32.00         ____

2616 RMS FORMAT                Method of RMS calculation for IDMT
     WITHOUT HARMON.   [ ] Without harmonics
     WITH HARMONICS    [ ] With harmonics

2621 MAN.CLOSE                 Effective stage after manual closing of CB
     INEFFECTIVE       [ ] Ineffective
     I>> UNDELAYED     [ ] I>> undelayed
     I>/Ip UNDELAYED   [ ] I>/Ip undelayed
```

```
2700 THERMAL OVERLOAD PROT.

2701 THERMAL OL                State of thermal overload protection
     OFF               [ ] off
     ON                [ ] on
     ALARM ONLY        [ ] Alarm only
     BLOCK TRIP REL    [ ] Block trip relay

2702 K-FACTOR                  K-factor for thermal overload protection
     min. 0.10          ____
     max. 4.00          ____

2703 T-CONSTANT                Time constant for thermal overload protection
     min. 1.0           ____   min
     max. 999.9         ____

2704 Θ WARN                    Thermal warning stage
     min. 50            ____   %
     max. 100           ____

2705 I WARN                    Current warning stage
     min. 0.10          ____   I/InLn
     max. 4.00          ____
```

```
2900 MEAS.VALUE SUPERVISION

2901 M.V.SUPERV              State of measured values supervision
     ON                  [ ] on
     OFF                 [ ] off

2905 SUM.Ithres              Summation threshold for current monitoring
     min. 0.05               I/In
     max. 2.00          ____

2906 SUM.Fact.I              Factor for current summation monitoring
     min. 0.00
     max. 0.95          ____
```

Tests and Commissioning Aids 7SD502

4000 TESTS

4100 COMMISSION TESTS

4101 MEAS. Cx	Measuring the pilot wire capacitance
4102 MEAS. Rx	Measuring of the pilot wire resistance
4110 MEAS. I1	Measuring the local current I1
4120 MEAS. I1,I2	Meas. local I1, remote I2, and angle I1, I2
4121 MEAS. I1,I3	Meas. local I1, remote I3, and angle I1, I3
4130 LEVEL P.M	Meas. of receive level (pilot wire monitor)

4400 CB TEST LIVE TRIP

4404 CB TRIP	Circuit breaker trip test 3pole

4900 TEST FAULT RECORDING

4901 FAULT REC.	Initiation of fault recording

Annunciations, Measured Values etc. 7SD502

5000 ANNUNCIATIONS

5100 OPERATIONAL ANNUNCIATIONS

5200 LAST FAULT

5300 2nd TO LAST FAULT

5400 3rd TO LAST FAULT

5600 CB OPERAT. STATISTICS

```
5601 Trip No =            Number of trip commands issued
5602 ∑I/In=               Accumulated interrupted curr. I/In
```

5700 OPERATIONAL MEASURED VALUES

```
5701 I1[%]=               Operat. meas. station 1 in %
5702 I2[%]=               Operat. meas. station 2 in %
5703 I3[%]=               Operat. meas. station 3 in %
5704 ID[%]=               Operat. meas. diff. current in %
5705 IR[%]=               Operat. meas. restr. current in %
5711 I1=                  Operat. meas. station 1 in A
5712 I2=                  Operat. meas. station 2 in A
5713 I3=                  Operat. meas. station 3 in A
5714 ID=                  Operat. meas. diff. current in A
5715 IR=                  Operat. meas. restr. current in A
```

5900 OVERLOAD MEASURED VALUES

```
5904 Θ/Θtrip =            Temperat. rise for warning and trip
```

Reference Table for Configuration Parameters 7SD502

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

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

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

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

7000 OP. SYSTEM CONFIGURATION

```
7100 INTEGRATED OPERATION

7101 LANGUAGE                Language
     DEUTSCH             [ ] German
     ENGLISH             [ ] English

7102 DATE FORMAT             Date format
     DD.MM.YYYY          [ ] dd.mm.yyyy
     MM/DD/YYYY          [ ] mm/dd/yyyy

7105 OPER. 1st L             Operational message for 1st display line
     _________________       _______________________________________

7106 OPER. 2nd L             Operational message for 2nd display line
     _________________       _______________________________________

7107 FAULT 1st L             Fault message for 1st display line
     _________________       _______________________________________

7108 FAULT 2nd L             Fault message for 2nd display line
     _________________       _______________________________________

7110 FAULT INDIC             Fault indication: LED and LCD
     WITH FAULT DETEC    [ ] With fault detection
     WITH TRIP COMM.     [ ] With trip command
```

```
7200 PC/SYSTEM INTERFACES

7201 DEVICE ADD.             Device address
     min. 1
     max. 254           ____

7202 FEEDER ADD.             Feeder address
     min. 1
     max. 254           ____

7203 SUBST. ADD.             Substation address
     min. 1
     max. 254           ____

7208 FUNCT. TYPE             Function type in accordance with VDEW/ZVEI
     min. 1
     max. 254           ____

7209 DEVICE TYPE             Device type
     min. 1
     max. 254           ____

7211 PC INTERF.              Data format for PC-interface
     DIGSI V3            [ ] DIGSI V3
     ASCII               [ ] ASCII
```

```
7215 PC BAUDRATE           Transmission baud rate for PC-interface
     9600 BAUD         [ ] 9600 Baud
     19200 BAUD        [ ] 19200 Baud
     1200 BAUD         [ ] 1200 Baud
     2400 BAUD         [ ] 2400 Baud
     4800 BAUD         [ ] 4800 Baud

7216 PC PARITY             Parity and stop-bits for PC-interface
     DIGSI V3          [ ] DIGSI V3
     NO 2 STOP         [ ] No parity,2 stopbits
     NO 1 STOP         [ ] No parity,1 stopbit

7221 SYS INTERF.           Data format for system-interface
     VDEW COMPATIBLE   [ ] VDEW compatible
     VDEW EXTENDED     [ ] VDEW extended
     DIGSI V3          [ ] DIGSI V3
     LSA               [ ] LSA

7222 SYS MEASUR.           Measurement format for system-interface
     VDEW COMPATIBLE   [ ] VDEW compatible
     VDEW EXTENDED     [ ] VDEW extended

7225 SYS BAUDR.            Transmission baud rate for system-interface
     9600 BAUD         [ ] 9600 Baud
     19200 BAUD        [ ] 19200 Baud
     1200 BAUD         [ ] 1200 Baud
     2400 BAUD         [ ] 2400 Baud
     4800 BAUD         [ ] 4800 Baud

7226 SYS PARITY            Parity and stop-bits for system-interface
     VDEW/DIGSIV3/LSA  [ ] VDEW/DIGSI V3/LSA
     NO 2 STOP         [ ] No parity,2 stopbits
     NO 1 STOP         [ ] No parity,1 stopbit

7235 SYS PARAMET           Parameterizing via system-interface
     NO                [ ] no
     YES               [ ] yes
```

```
7400 FAULT RECORDINGS

7402 INITIATION            Initiation of data storage
     STORAGE BY FD.    [ ] Storage by fault det
     STORAGE BY TRIP   [ ] Storage by trip
     START WITH TRIP   [ ] Start with trip

7410 T-MAX                 Maximum time period of a fault recording
     min. 0.30             s
     max. 5.00     ____

7411 T-PRE                 Pre-trigger time for fault recording
     min. 0.05             s
     max. 0.50     ____

7412 T-POST                Post-fault time for fault recording
     min. 0.05             s
     max. 0.50     ____

7431 T-BINARY IN           Storage time by initiation via binary input
     min. 0.10             s
     max. 5.00/∞   ____
```

```
7432 T-KEYBOARD            Storage time by initiation via keyboard
     min. 0.10             s
     max. 5.00      _____

7490 SYS LENGTH            Length of fault record (former LSA)
     660 VALUES FIX    [ ] 660 values fix
     <=3000 VAL. VAR   [ ] <=3000 val. var
```

```
7800 SCOPE OF FUNCTIONS

7815 DIFF PROT.            Differential protection
     EXIST             [ ] Existent
     NON-EXIST         [ ] Non-existent

7816 PILOT MON             Pilot wire monitor
     NON-EXIST         [ ] Non-existent
     EXIST             [ ] Existent

7821 EXT. TRIP             External trip function
     NON-EXIST         [ ] Non-existent
     EXIST             [ ] Existent

7822 TRANSF.TRIP           Transfer trip
     NON-EXIST         [ ] Non-existent
     EXIST             [ ] Existent

7823 TRIP RECV             Trip receiver
     NON-EXIST         [ ] Non-existent
     EXIST             [ ] Existent

7826 BACK-UP O/C           Back-up overcurrent protection
     NON-EXIST         [ ] Non-existent
     EXIST             [ ] Existent

7827 THERMAL OL            Thermal overload protection
     NON-EXIST         [ ] Non-existent
     EXIST             [ ] Existent

7885 PARAM. C/O            Parameter change-over
     NON-EXIST         [ ] Non-existent
     EXIST             [ ] Existent

7899 FREQUENCY             Rated system frequency
     fN 50 Hz          [ ] fN 50 Hz
     fN 60 Hz          [ ] fN 60 Hz
```

```
7900 DEVICE CONFIGURATION

7901 No OF ENDS            Number of line terminals
     TWO TERMINALS     [ ] Two terminals
     THREE TERMINALS   [ ] Three terminals
```

Operational Device Control Facilities 7SD502

8000 DEVICE CONTROL

8100 SETTING REAL TIME CLOCK

8101 DATE / TIME Actual date and time

8102 DATE Setting new date

8103 TIME Setting new time

8104 DIFF. TIME Setting difference time

8200 RESET

8201 RESET Reset of LED memories

8202 RESET Reset of operational annunciation buffer

8203 RESET Reset of fault annunciation buffer

8204 RESET Reset of CB operation counters

8205 RESET Reset of the total of interrupted currents

8300 SYS-VDEW ANNUNC.-MEAS.VAL

8301 SYS TEST Testing via system-interface
OFF [ ] off
ON [ ] on

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

To

SIEMENS AKTIENGESELLSCHAFT

Dept. EV S SUP 2

D−13623 BERLIN

Germany

Dear reader,

printing errors can never be entirely eliminated: therefore, should you come across any when reading this manual, kindly enter them in this form together with any comments or suggestions for improvement that you may have.

From

Name

Company/Dept.

Address

Telephone no.

Corrections/Suggestions

Substantial alterations against previous issue:

Errors in Section 4.2.4, Figure 4.8 and Section 5.2.4 Figure 5.7: wrong connections of matching transformer (Figure B.4 has been correct)

Subject to technical alteration

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